iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: II Month of publication: February 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue II, February 2018- Available at www.ijraset.com

Hybrid Solar and Wind Energy System-Review

R.Dhanya[1], Dr. A. Amudha[2]
[1, 2] *Department of Electrical and Electronics Engineering, Karpagam Academy of Higher Education*

Abstract: This paper focuses on alternative/renewable energy sources. There are so many issues and challenges facing in this field. Issues based on intermittent climatic conditions and the technology used to overcome these issues. This paper specifically focuses on hybrid solar/wind standalone system in remote area where grid connection is impossible. System configurations, control scenario, storage, energy management are discussed. Energy management with advanced fuzzy logic are highlighted.
Keywords: Energy management, configuration, energy storage, control, Fuzzy.

I. INTRODUCTION

This century has tremendous challenges and growth in the field of Renewable / Alternative energy sources. power generation technologies plays a major role due to increase in awareness of clean energy and less dependence on fossil fuels. The technology of power generation from alternative energy sources are wind, photovoltaic (PV), micro hydro (MH), biomass, geothermal, ocean wave and tides, and clean alternative energy (AE) power generation technologies [such as fuel cells (FCs) and micro turbines (MTs)].Renewable energy generation sources often come in the form of distributed generation (DG) system in grid connected or standalone configuration. Fuel cell and micro turbine are considered as renewable sources when their input fuel is from renewable energy sources. This paper focuses on solar and wind due to intermittent climatic conditions hybrid solar/wind standalone energy system satisfy the demand of the customers in remote area where grid connection is impossible. Here we are focusing on photovoltaic technology where sun's radiation is directly converted into electricity. Hybrid photovoltaic generation combines PV with one or more renewable energy sources which increases system efficiency and provide balance in the energy supply. But in case of wind, mechanical energy is converted into electrical energy.

Furthermore, the wind energy systems may not be technically viable at all sites because of low wind speeds and being more unpredictable than solar energy. To solve this drawback, the complementary combination of each component characteristic may lead to enhancement of system efficiency and reliability. In addition, combined utilization of these renewable energy sources are becoming increasingly attractive and are being widely used as alternative of oil-produced energy. Hybrid renewable energy systems are becoming popular for remote area power generation applications due to advances in renewable energy technologies and subsequent rise in prices of petroleum products, and due to the possibility of attenuating fluctuations in produced power. Economic aspects of these technologies are sufficiently promising to include them in developing power generation capacity for developing countries. Hybrid systems can be considered as a reasonable solution, capable to support systems that cover the energy demands of both stand-alone and grid connected consumers [1].But in this paper we are focussing only on standalone system

For operation performance and system reliability optimal sizing which plays a major role and we discuss in detail below. Battery storage is the important criteria which fulfil the needs of the customers without any interruption. When handling a battery good care and safety caution must be taken into account at all times by reading through the type of battery before using them as improper use of battery will result in an explosion. Deep cycle battery is chosen as the most ideal backup battery because it has much thicker lead plate to make them last longer thus it is commonly used in solar power system [2]. Unit sizing and technology selection can sometimes be as straightforward. By considering environment factor, cost of the system selection of generation technology is more important which does not exceed the equipment power rating which directly affects the reliability of the system [3]. Energy management is the best solution for direct and immediate reduction of energy consumption. For the last few decades we have been exploring various alternatives to conventional sources of energy like solar, wind and biomass energy. However, due attention must also be given to best utilization of energy, improvement in energy efficiencies and optimum management of energy resources. In fact, energy management deals with already existing sources and actual consumption. It includes planning and operation of energy-related production and consumption units. Fuzzy logic energy management for a residential power system is also discussed in this paper. Hybrid energy system configurations are discussed in section II. Optimizations are discussed in Section III. Energy management in Section IV .control of photovoltaic and wind in section V. Section VI concludes the paper.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue II, February 2018- Available at www.ijraset.com

II. SOLAR/WIND HYBRID ENERGY SYSTEM CONFIGURATION

A. Photovoltaic

Solar photovoltaic is the most important renewable energy source in terms of globally installed capacity. Solar panels convert

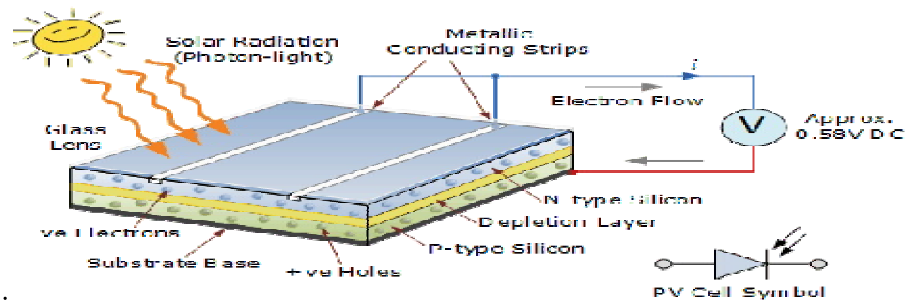

Fig -2.1 A schematic of a typical Photovoltaic solar cell

solar energy from the sun directly into useable electrical energy. When light shines on a photovoltaic (PV) cell, it may be reflected, absorbed, or pass right through it. The PV cell is composed of semiconductor material, which combines some properties of metals and some properties of insulators. That makes it uniquely capable of converting light into electricity. When light is absorbed by a semiconductor, photons of light can transfer their energy to electrons, allowing the electrons to flow through the material as electrical current. This current flow out of the semiconductor to metal contacts and then makes its way out to power your home and the rest to the electric grid. The efficiency of a cell is simply the amount of electrical power coming out of a cell divided by the energy from sunlight coming in. The amount of electricity produced from PV cells depends on the quality (intensity and wavelengths) of the light available and multiple performance characteristics of the cell.

1) Photovoltaic modelling: There are several models available for modelling of a practical photovoltaic cell. The general model consists of a current source,

a parallel diode, a parallel resistor expressing leakage current, and series resistor describing an internal resistance to the current flow. In an ideal photovoltaic cell, there is no series loss and there is no leakage to the ground. That is, the series resistor has a value of zero while the parallel resistor has a value of infinity.

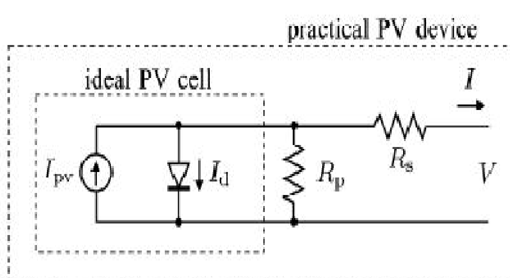

Fig .2.2 A schematic of a typical practical PV device

The current obtained from a photovoltaic module consisting of a number of cells (Ns) connected in series is represented by

$$I_{PV} = I_{gC-I_0}\left[exp\left(ev_{d/KFT_C}\right) - 1\right] - v_{d/R_P} \qquad (1)$$

Where *Igc* is the light generated current, *Io* is the dark saturation current dependant on the cell temperature, *e* is the electric charge = 1.6 x 10^{-19} Coulombs, *K* is Boltzmann's constant = 1.38 x 10-23 J/K, *F* is the cell idealizing factor, *Tc* is the cell's absolute temperature, *vd* is the diode voltage, and *Rp* is the parallel resistance. The photocurrent (*Igc*) mainly depends on the solar irradiation and cell temperature, which is described as [4]

$$I_{gc=}\left[\mu_{sc}\left(T_C - T_{ref}\right) + I_{SC}\right]G \qquad (2)$$

Where μsc is the temperature coefficient of the cell's short circuit current, *Tref* is the cell's reference temperature, *Isc* is the cell's short circuit current at a 25^{oC} and 1kW/m2, and *G* is the solar irradiation in kW/m2. Furthermore, the cell's saturation current (*Io*) varies with the cell temperature, which is described as [4]

$$I_{O}= I_{O\alpha}\left(\frac{T_c}{T_r}\right)^3 exp\left[e\frac{vg}{KF}\left(\frac{1}{T_r}-\frac{1}{T_C}\right)\right] \quad (3)$$

$$I_{O\alpha} = I_{SC} / \exp^{\left(\frac{ev_{OC}}{KFT_C}\right)} \quad (4)$$

Where *Ioα* is the cell's reverse saturation current at a solar radiation and reference temperature, *Vg* is the band-gap energy of the semiconductor used in the cell, and *Voc* is the cells open circuit voltage

B. Wind power

Wind is forms of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity. The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power to electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools etc.

1) Wind Resource Assessment: Wind speed data of a nearby station was collected from National Metrological Agency (NMA). NMA records wind data using data logger attached to anemometer .consider it is fixed at 2 m height. The annual average wind speed measured at 2 m is found to be 2.6 m/s. Consider the measurement made at 2 m is extrapolated to hub height (25 m) using the logarithmic law, which assumes that the wind speed is proportional to the logarithm of the height above ground as given by equation 1 [5, 6]

$$V = \frac{V_{ref*}\ln\left(\frac{Z}{Z_0}\right)}{\ln\left(\frac{Z_{ref}}{Z_0}\right)} \quad (5)$$

Where V_{ref} Reference height (m), Z is Height where wind speed is to be determined (m), $Z_0$is Measure of surface roughness (0.1 to 0.25 for crop land),*V* is Wind speed a hub height (m/s), and V_{ref}→ Wind speed at the reference height (m/s)

C. Types of Integration

Renewable energy sources have different operating characteristics; it is, therefore, essential to have a well-defined and standardized procedure for connecting them to form a hybrid system where a local cluster of DG sources, energy storage, and loads are integrated so that they can operate autonomously. There are so many ways to integrate a hybrid system. They are divided into three types: dc-coupled, ac-coupled, and hybrid-coupled .The ac-coupled scheme can further be classified into power frequency ac (PFAC)-coupled and high-frequency ac (HFAC)-coupled systems.

D. Unit Sizing and Technology Selection

Component sizing of hybrid RE/AE plays an important role for minimizing the operating cost. sizing of the system with respect to selection of generation technologies for a particular application plays a significant role in the hybrid energy system. For example, with the aid of HOMER software, developed at the National Renewable Energy Laboratory (NREL) [7], [8] a hybrid renewable system can be designed. Unit sizing will not exceed the equipment power rating or it is as complex as satisfying several constraints in order to achieve several objectives. Based on statistical information such load, financial factor, environmental impact, system reliability, cost requirements and other information sizing of the system can be optimized in order to achieve specific objective [8].optimal sizing of different renewable energy sources is optimized in order to calculate the net present cost of the selected site.

E. Storage

Battery stores excess energy produced by the photovoltaic panel .The stored energy is used when sun is not available during days or night time. Deep cycle batteries are mostly used in photovoltaic system because depth of discharge is 50 % or more before it is charged up. Storage technology plays a vital role for power quality and energy management of hybrid renewable energy system. The ideal storage technology would offer fast access to power whenever needed. It provides high capacity of energy, have a long life expectancy. consider if Battery is connected to DC-DC converter. It has two modes. Buck mode and Boost mode .Buck mode charge the battery, Boost mode connect to the DC bus. The discharging level cannot exceed a minimum limit known as depth of discharge. The capacity of the battery is so designed so as to supply the ultimate load during the non-wind hours, and non- sunny hours. The storage for hybrid energy system is classified into two they are access oriented storage class and capacity oriented storage class. There are different types of battery storage. The li-ion battery used for distributed network. For a single residential hybrid energy system, the Ni-MH battery technology would be an appropriate. For larger-scale applications involving the compensation of power from wind farms or multiple residences, flow batteries or NaS batteries would be an appropriate [8].

F. Power electronics topologies and control

A device for altering the nature of an electric current or signal, especially from AC to DC or vice versa, or from analogue to digital or vice versa. The power conversion systems can be classified according to the type of the input and output powerThere are two topologies for grid-connected solar PV and wind hybrid system as can be seen from Fig. 1 and Fig. 2. Fig. 1 shows that the DC outputs' voltages from individual solar PV, wind and battery bank stream, through individual DC/DC and AC/DC units, are integrated on the DC side and go through one common DC/AC inverter which acts as an interface between the power sources and the grid to provide the desired power even with only one source available. Hence, the renewable energy sources act as current sources and can exchange power with the grid and the common DC/AC inverter controls the DC bus voltage. The individual units can be employed for maximum power point tracking (MPPT) systems to have the maximum power from the solar PV and wind systems and the common DC/AC inverter will control the DC bus voltage. The battery bank is charged when there is an extra power and discharged (by supplying power) when there is shortage of power from the renewable energy sources. On the other hand, Fig. 2 shows that renewable energy sources are injecting power directly to the grid through individual DC/AC and AC/DC-DC/AC units. Many researchers have proposed and presented experimental results of PV-wind-battery hybrid systems along with power management schemes and control systems [9-11]. Their proposed systems were capable to operate in different modes of operation and able to transfer from one mode to another easily. Ahmed et al. [12] presented a utility hybrid PV/wind/fuel cell power system with MPPT. With the DC bus line output voltage from each converter is set to be fixed and controlled independently in that system, the controller of wind and PV has MPPT functionality whereas the controller of the fuel cell (FC) takes care of compensations of the system for the load power fluctuation. The voltage converters play an important role in controlling the amount and the type of voltage whether AC or DC and the duty cycle of those converters can be used to improve the quality of power. Huang et al. [13] highlighted that the response of the duty cycle of a DC/DC converter is relatively fast in MPPT control process. They added that the charging current of a battery is changing with the automatic adjustment of duty cycle. Liu et al. [14] proposed a hybrid AC-DC micro grid in order to reduce multiple DC/AC/DC or AC/DC/AC conversions in an individual AC or DC grid. The authors concluded that although the hybrid grid could reduce the processes of DC/AC and AC/DC conversions in an individual grid, there were many practical problems for applying the hybrid grid based on current AC dominated infrastructure. A controller was designed by Hossain et al. [15] to ensure both dynamic voltage and transient stability for a specific PV integration level that can lead to a higher potential penetration of PV units without requiring network reinforcements or violating system operating constraints. A fuzzy control was used for grid-connected hybrid PV/FC/battery power system in [16] to control flow of power via DC/DC and DC/AC converters.

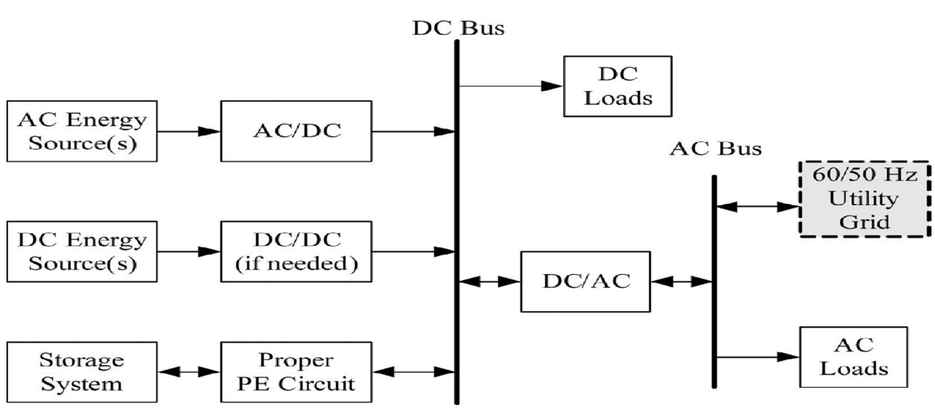

Fig. 2.3 Schematic diagram of a dc-coupled hybrid energy system.

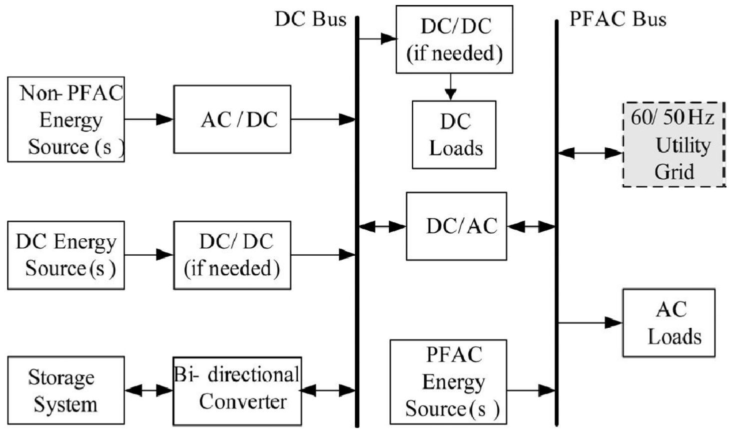

Fig.2.4 Schematic diagram of a hybrid-coupled hybrid energy system.

III. OPTIMIZATION

A solar PV and wind systems can't provide a continuous supply due to the fact that those systems will generate electricity only during sunny and windy days. Hence, a combination of these two sources improves overall energy output especially if they are connected to grid. A proper optimization is required to ensure having optimal number and size of Photovoltaic and wind turbine. The traditional sizing method for hybrid solar PV and wind systems was based on availability of long term weather data, such as solar radiation and wind speed [17]. Since long-term weather data is not always available, artificial intelligence techniques such as fuzzy logic [18], genetic algorithms and artificial neural network are used. Furthermore, optimization performance indicators such as Net Present Value [19], Energy Index Reliability and Energy Expected Not Supplied [20], Cost of Energy [21], etc. have been used and reported. Those indicators are used to decide whether to proceed with a particular project or not and how reliable is a project will be. With the aim of maximizing the Net Present Value of a hybrid PV-wind systems connected to electrical grid, Dufo-López et al. [22] concluded that only with high wind speed rate and current prices of components, intermittent hydrogen could be economically viable for external selling .Tina and Gagliano [24] presented and analyzed a probabilistic model of a PV/WT system using a fixed tilt angle, a one-axis, and a two-axis tracking system.

They found out that the two-axis tracking system has a better performance in terms of monthly power generation in comparison with single-axis tracker which reached a maximum of 7% in particular at summer. Another probabilistic method was proposed by Niknam et al. [25]. It was for energy and operation management of micro-grids that cover uncertainties in load demand, market price and available output powers from WT and PV units. Essalaimeh et al. [26] conducted a feasibility study using payback period for hybrid PVwind system to utilize its energy for heating and cooling purposes for Amman city in Jordan. They pointed out that clean PV panels could produce extra power, with 31% to 35% on the maximum solar intensity, compared to panels with dust. Ahmed et al. [26] simulated and controlled a hybrid PV-wind generation system connected to a grid. They highlighted that as a result of constant rotational speed, the DC voltage at high wind speed is almost constant. Kolhe et al. [26] described a hybrid PV, wind and battery storage energy system that can be interfaced with different remote monitoring and control components.

IV. CONTROL OF PHOTOVOLTAIC AND WIND

A. *Photovoltaic-Maximum power point tracking control*

The hybrid energy system is controlled by the specific controllers. There are various types of controller's .The most promising technology for today's scenario is the integration of solar and wind. For control of Photovoltaic side Maximum power point tracking (MPPT) mode are more appropriate. There are different MPPT algorithms presented in literature,

Perturb and Observe method (P&O)is most practically used method, because of the sirnplicity of its algorithm, and thus the facility of implementation. In MPPT operation, the PV-array produces maximum power under variable conditions of the solar irradiance and environmental temperature .The maximum power point tracking algorithm P&O which gives maximum efficiency of the grid connected PV system.

B. *Wind-operation Modes*

Depending upon the wind speed available and amount of power output needed from the wind turbine system; There are three distinct operating modes 1.Maximum power point tracking 2.Pitch control 3.Power limitation.

V. ENERGY MANAGEMENT

The supervisory controller is a system which supervises the modes of operation and manages the power flow in the power system [28][30]. Furthermore, the supervisory controller also sets the local controllers of the different components for several functioning modes in order to ensure their optimum operation [28][29].The system characteristics for these modes would be

held in specific constraints. Furthermore, the energy flow would be balanced between the system components. Proper control of hybrid energy systems with multiple Renewable energy conventional-Distributed generation and energy storage (operating as micro grids) is critical to achieving the highest system reliability and operation efficiency [31]. Typically, a control (or energy management) system needs to determine and assign active and reactive output power dispatch of each energy source while keeping its output voltage and frequency at the desired level. Generally, the control structure of such systems can be classified into three categories; centralized, distributed, and hybrid control paradigms. In all three cases, each energy source is assumed to have its own (local) controller which can determine optimal operation of the corresponding unit based on current information. If multiple (and at times conflicting) objectives need to be met, and all energy sources cannot operate optimally, a compromised (global optimal) operating decision may be achieved. They are further classified into centralised controller, Distributed Controller, Hybrid Centralized and Distributed Controller.

VI. FUZZY LOGIC BASED ENERGY MANAGEMENT SYSTEM

There are quite a big number of researches implementing fuzzy logic in the energy management system [32]. It seems to be very appropriate since it determines the condition as in a state. The ability to determine the output based on a condition is what makes it flexible, making it close to human decision. It operates based on lingual 'if..then' rules [33] and considering uncertainties that usually incur when determining output, fuzzy logic is considered reasonable and logic. Fuzzy logic controller is used as the energy management system for the hybrid energy sources. In order to determine the conditions, the input and output variables have to be verified first. Implementation of fuzzy logic controller, the three major stages have to be determined prior to the design of the fuzzy logic. These three stages are (1) fuzzification, (2) inference, and (3) defuzzification. Fuzzification is the process of creating fuzzy sets, where the input and outputs are defined and the membership functions are formed. Inference is the stage where the set of rules are created according to the input and output variables. Defuzzification is the process of producing a single crisp to represent the fuzzy sets.

VII. CONCLUSIONS

This paper has provided a review of challenges and possible ways on integrating solar Photovoltaic and wind energy sources for electricity. The main objective for grid-connected system and the stand-alone system is the intermittent nature of solar Photovoltaic and wind sources. By integrating the two resources into an optimum combination, the output of the variable nature of solar and wind resources can be resolved partially and the overall system becomes more reliability. This definitely has bigger impact for a stand-alone system. Integration of renewable energy generation such as solar/wind with battery storage and diesel generator back-up systems is economic for stand-alone system. The solar/wind battery-diesel hybrid configuration can meet the load demand including peak times. Energy management should provide high system efficiency with high reliability and economical cost. Proper planning with accurate forecasting of weather pattern, solar radiation and wind speed can help in reducing the challenges of intermittent energy Voltage and frequency fluctuation, and harmonics are major power quality issues for grid-connected and stand-alone systems with higher impact in case of weak grid. Proper design can be resolved to a larger extent which includes advanced fast response control facilities, and good optimization of the hybrid systems. The paper provides an overview of different research works related to optimal sizing design, power electronics topologies and control for grid-connected and stand-alone hybrid solar PV and wind systems. Solar PV and wind hybrid system can be connected in a common DC or common AC bus whether they are working in a grid-connected mode or a stand-alone mode.

REFERENCES

[1] R. Ramakumar, H. J.Allison, andW. L. Hughes, "Prospects for tapping solar energy on a large scale," Solar Energy, vol. 16, no. 2, pp. 107–115, Oct. 1974.
[2] R. Ramakumar, H. J. Allison, and W. L. Hughes, "Solar energy conversion and storage systems for the future," IEEE Trans. Power App.Syst., vol. PAS-94, no. 6, pp. 1926–1934, Nov./Dec. 1975
[3] S. Hozumi, "Development of hybrid solar systems using solar thermal, photovoltaics, and wind energy," Int. J. Solar energy, vol. 4, no. 5, Pp.257–280, 1986.
[4] Getachew Bekele, Gelma Boney, "Design of a Photovoltaic-Wind Hybrid Power Generation System for Ethiopian Remote Area "2nd International Conference on Advances in Energy Engineering," Energy Procedia 14 1760 – 1765, 2012
[5] Danish Wind Industry Association (Jan., 2011), http://www.windpower.org/en/tour

[6] HOMER, the micro power optimization model, ver. 2.67 Beta (April, 2008), http://www.nrel.gov/homer
[7] Homer, National Renewable Energy Laboratory [Online]. Available: https://analysis.nrel.gov/homer/
[8] S. Hozumi, "Development of hybrid solar systems using solar thermal,photovoltaics, and wind energy," Int. J. Solar Energy", vol. 4, no. 5, pp.257–280, 1986
[9] M. Dali, J. Belhadj, and X. Roboam, "Hybrid solar-wind system with battery storage operating in grid-connected and standalone mode: Control and energy management - Experimental investigation" Energy, **35**, 2587-2595 (2010)
[10] H. Ghoddami, M. B. Delghavi, and A. Yazdani, "An integrated wind-photovoltaic-battery system with reduced power-electronic interface and fast control for grid-tied and off-grid applications" Renewable Energy, **45**, 128-137 (2012)
[11] S. Bae and A. Kwasinski, "Dynamic modelling and operation strategy for a micro grid with wind and photovoltaic resources," IEEE Transactions on smart Grid, 3, 1867-1876 (2012
[12] N. A. Ahmed, A. K. Al-Othman, and M. R. AlRashidi, "Development of an efficient utility interactive combined wind/photovoltaic/fuel cell powersystem with MPPT and DC bus voltage regulation" Electric Power Systems Research, 81, 1096-1106 (2011)
[13] Y. Huang, Y. Xu, and X. Zhou, "Study on wind-solar hybrid generating system control strategy," International Conference on Multimedia Technology (ICMT 11), IEEE Press, pp. 773-776, July (2011)
[14] X. Liu, P. Wang, and P. C. Loh, "A hybrid AC/DC micro grid and its coordination control" IEEE Transactions on Smart Grid, 2, 278-286 (2011)
[15] M. J. Hossain, T. K. Saha, N. Mithulananthan, and H. R. Pota "Robust control strategy for PV system integration in distribution systems," Applied Energy, 99, 355-362, (2012)
[16] T. P. Kumar, Y. Chandrashekar, N. Subrahmanyam, and M. Sydulu, "Control strategies of a fuzzy controlled grid connected hybrid PV/PEMFC/Battery distributed generation system," 2015 IEEE Power and Energy Conference at Illinois (PECI), IEEE Press, pp. 1-6, February (2015)
[17] M. Esteban, Q. Zhang, A. Utama, T. Tezuka, and K. N. Ishihara, "Methodology to estimate the output of a dual solar-wind renewable energy system i
[18] H. H. Chen, H. Y. Kang, and A. H. I. Lee, "Strategic selection of suitable projects for hybrid solar-wind power generation systems" Renewable and Sustainable Energy Reviews, 14, 413-421 (2010)
[19] R. Dufo-López, J. L. Bernal-Agustín, and F. Mendoza, "Design and economical analysis of hybrid PV-wind systems connected to the grid for the Intermittent production of hydrogen" Energy Policy, 37, 3082-3095 (2009)
[20] G. M. Tina and S. Gagliano, "Probabilistic modelling of hybrid solar/wind power system with solar tracking system" Renewable Energy, 36, 1719-1727
[21] S. Bhattacharjee and S. Acharya, "PV-wind hybrid power option for a low wind topography" Energy Conversion and Management, 89, 942-954 (2015)
[22] T. Niknam, F. Golestaneh, and A. Malekpour, "Probabilistic energy and operation management of a micro grid containing wind/photovoltaic/fuel cell generation and energy storage devices based on point estimate method and self-adaptive gravitational search algorithm" Energy, 43, 427-437 (2012
[23] Rashid Al Badwawi,Tapas K Mallick "A Review of Hybrid Solar PV and Wind Energy System", Smart Science Vol. 3, No. 3, pp. 127-13 8(2015
[24] S. Essalaimeh, A. Al-Salaymeh, and Y. Abdullat, "Electrical production for domestic and industrial applications using hybrid PV-wind system" Energy Conversion and Management, 65, 736-743 (2013)
[25] A. A. Ahmed, L. Ran, and J. Bumby, "Simulation and control of a hybrid PV-wind system," Proc. 4th IET International Conference on Power Electronics, Machines and Drives (PEMD 08), pp. 421-425, April (2008)
[26] P. Kolhe, B. Bitzer, S. P. Chowdhury, and S. Chowdhury, "Hybrid power system model and TELELAB," Proc. 47th International Universities Power Engineering Conference (UPEC 12), IEEE Press, pp. 1-5, September (2012)
[27] M. Brower, E. M. Galán, J. F. Li, D. Green, R. Hinrichs-rahlwes, S. Sawyer, M. Sander, R. Taylor, H. Kopetz, and S. Gsänger, "Renewables 2014 global status report," REN21 2014 (2014
[28] J. H. R. Enslin, "The role of power electronics and storage to increase penetration levels of renewable power," Power and Energy Society General
[29] Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, IEEE Press, pp. 1-2, July (2008) DOI: 10.1109/PES.2008.4596958
[30] P. Komor, "Wind and solar electricity: challenges and opportunities," University of Colorado at Boulder, Pew Center on Global Climate Change, June (2009
[31] GWEC, "Global wind report annual market update 2012," http://www.gwec.net/wp-content/uploads/2012/06/Annual_report_2012_LowRes.pdf, GWEC Report, April (2013
[32] S. G. Li, S. M. Sharkh, F. C. Walsh, and C. N. Zhang, "Energy and battery management of a plug-in series hybrid electric vehicle using fuzzy logic," IEEE Transactions on Vehicular Technology, vol. 60, pp. 3571-3585, 2011.
[33] B. Sofiane and M. Kamal, "Hybrid system energy management and supervision based on fuzzy logic approach for electricity production in remote areas," presented at the First International Conference on Renewable Energies and Vehicular Technology, 2012.