International Journal of Scientific Research & Engineering Trends
Volume 8, Issue 6, Nov-Dec-2022, ISSN (Online): 2395-566X

A Review on Solar Wind Hybrid Renewable Energy System

Twinkle Kumari ,Prof. Neeti Dugaya, Dr. Geetam Richhariya, Dr. Manju gupta
Oriental Institute of Science Technology,Bhopal, India
Ktwinkle723@gmail.com,neetidugaya@oriental.ac.in,geetamrichhariya@gmail.com, manjugupta@oriental.ac.in

Abstract- Renewable Energy System comprising of solar and wind energy, is eco-friendly, and cost-effective option for powering the rural areas compared to conventional sources. The drawback of these systems is they are less reliable as the generated power depends on meteorological conditions. A properly designed hybrid renewable energy system (HRES) that combines two or more renewable energy sources like wind turbine and solar system with battery back-up increases the reliability of these systems in standalone modeThis Paper provides a succinct and well-organized overview of different maximum power point tracking (MPPT) algorithms used in photovoltaic (PV) generating systems that may operate in partial shade. To far, a broad range of algorithms, PV modelling methods, PV array designs, and controller topologies have been investigated. However, every method has both benefits and drawbacks; as a consequence, while building a PV generating system (PGS) under partial shade conditions, a thorough literature study is required. The thorough review of MPPT algorithms has been done in this article. The review of MPPT methods has been divided into four major categories. The first group consists of entirely new MPPT optimization algorithms, the second group consists of hybrid MPPT algorithms, the third group consists of novel modelling approaches, and the fourth group consists of different converter topologies. This article offers an accessible reference for doing large-scale research in PV systems under partial shadowing conditions in the near future.

Keywords- PV systems; Maximum Power Point Tracking (MPPT) Techniques; Hybrid MPPT Techniques.

I. INTRODUCTION

Renewable energy is power derived from natural possessions, such as solar, wind, waves, or geothermal energy. These resources are renewable and can be recycled naturally. Therefore, compared to the depletion of traditional fossil fuels [1], these sources of information are considered inexhaustible. The global power crunch provides a new impetus for the development or maturity of clean or renewable energy. In addition to the decline in fossil fuel transportation worldwide, another major reason fossil fuels do not work is the pollution associated with burning fossil fuels. In contrast, it is well known that compared to traditional energy sources, renewable energy sources are cleaner, or energy produced has no adverse effects on pollution.

Wind turbines can be used to harness the power generated by the airflow [3]. The power of turbines used per day is around 600 kW to 5 MW [4]. Because power output is a function of wind speed, it amplifies hastily as wind speed increases. Recent advances have become wind turbines, which are more resourceful than better aerodynamic construction. The current trend in the developing economy has led to the expansion of renewable power. Over the past three years, that renewable energy and biomass energy account for a significant part of current renewable energy consumption. The recent development of solar photovoltaic knowledge or reliable introductions of projects in countries/regions such as Germany and Spain have also brought significant growth in the solar photovoltaic market. It is expected that there will be more than other renewable energy sources in the solar photovoltaic market. In 2019, more than 115 countries set political goals to achieve their predetermined role through renewable energy compared to 45 countries in 2005. Most of the objective is ambitious, reaching 30-90% of national production through renewable energy [7].

The electricity grid connects power plants, transmission lines, or allotment lines to provide power to users. In power plants, electricity comes from renewable or non-renewable energy sources. The current is then transmitted from one place to another through the transmission line. Finally, the power is distributed among the users using distribution feeders. A micro-grid is defined as a “local grid that connects distributed energy sources with organized loads and is usually connected to the traditional central grid synchronously” [17].

Micro grid sources are called micro-sources: battery storage, solid oxide fuel cells, wind energy, solar energy, diesel generators, etc. Each source is proscribed in its way to connect it to the distribution network. The load is connected to a distributed network, and the micro-power source and the mains meet the power supply to the circulated network.

1. Solar Photovoltaic:
Correspondingly, the solar power generation system is proposed in Figure 1. A solar cell or panel comprises a model derived from solar cells connected in series or parallel to provide the required currents and energy. Solar intertie photovoltaic (PV) systems are not particularly complex. First there are panels, which collect the sunlight and turn it into electricity. The DC signals are fed into an inverter, which converts the DC into grid-compatible AC power (which is what you use in your home). Various switch boxes are included for safety reasons, and the whole thing is connected via wires and conduit.

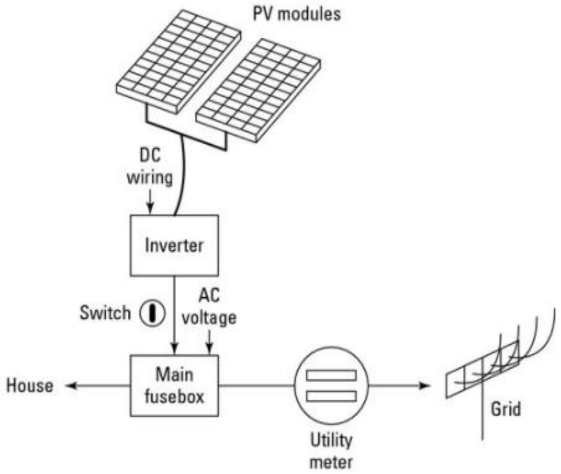

Fig 1. Basic Solar (Photovoltaic) System. [6]

Storage batteries can provide protective power during periods of free sunlight by storing more or part of the power from solar panels. Solar power generation systems are used for private power consumption, weather stations, and radio or television stations, entertainment venues, such as cinemas, hotels, restaurants, villages, and islands. The traditional p-n junction solar cell is the most advanced solar energy collection technology. The fundamental physics of energy input and carrier output functions the physical properties and the associated electrical properties (i.e., the band distance). The electron needs to have energy greater than the band gap to excite electrons from the valence band to the conduction band. An ideal solar cell has a direct band gap of 1.4 eV to absorb the maximum number of photons from the sun's radiation.

The seemingly infinite lattice creates bands of allowed energy states; silicon creates a band gap where no electrons exist (a band gap that is 1.1 eV wide. However, the sun's radius is close to the black spectrum of about 6000 K. Therefore, most of the rays from the sun reaching the earth have a source of energy greater than the radius of the sun silicon group. These high-energy phonons will be cured by solar cells. Still, the distance between the phonons and the silicon band will be converted to heat (via an overflow called phonons) instead of usable energy. For a single meeting cell, this will set a maximum efficiency of around 20%. Current research methods to perform multi-node photovoltaic design to overcome efficiency limits do not seem to be an expensive solution. Even a built-in PV device can only be used during the day and needs direct sunlight (directly connected to the interior) for optimum performance.

II. LITERATURE REVIEW

Marina Babayeva et.al (2020) In this paper, wind energy is considered as a promising trend for the development of alternative energy. The physical implementation of a wind generator based on the Magnus effect is explained, as well as its mathematical model. The relationship between the rotation speed of the blades of a wind generator, the rotation speed of the rotor of the generator and wind speed is considered. The influence of the parameters on the mechanical power coefficient is evaluated. Algorithms for tracking the maximum power point and the effect of mechanical power coefficient on the amount of generated power are considered. Changes in the mechanical power coefficient during mathematical modelling under various conditions are analyzed.

Chao Xing;et.al (2020) This article briefly analyzes the technical advantages of the wind-solar hybrid power generation system, builds models of wind power generation systems, photovoltaic systems, and storage batteries, focusing on the key to wind and photovoltaic power generation systems-maximum power point tracking (MPPT) control, and detailed analysis of the maximum wind and solar power. The principle of power tracking and several commonly used MPPT methods, and the simulation and analysis of the MPPT control strategy of wind and photovoltaic in the wind-solar hybrid power generation system on Matlab / Simulink.

Guyuan Ji et.al (2020) Maximum power point tracking (MPPT) performance is an important control target for wind energy conversion systems. There is an optimal generator speed that allows the system to capture maximum wind energy at a certain wind velocity. This paper proposes a variable speed wind power generation system (VSWPGS) using a switched reluctance generator (SRG) and AC-AC converter. For the theoretical verification of the proposed system, the mathematical formulas that including the wind turbine, SRG, the AC-AC converter, and the control system were constructed. The MPPT control strategy of the optimal tip speed ratio method is adopted to the whole system. It was a simulation with changing wind velocities in Matlab/Simulink.

Khouloud Bedoud et.al (2020) this paper presents the description, modeling, and control of an electrical energy production system based on a wind power system operating at variable speed. Such energy production systems are inevitably called upon for randomly varying wind speeds. Moreover, MPPT control using fuzzy logic observer (FLO) for rotational speed estimation without using wind speed data is adopted. To improve and verify this approach's effectiveness, a quantitative and qualitative analysis of the energy generation system with a power of 1.5 MW is investigated by numerical simulation using Matlab/Simulink software. Thus, simulation tests validate the technique and improve the dynamic behavior of the system.

Krunalkumar R. Prajapati et.al (2019) in this paper, application of fuzzy logic in the function of artificial intelligence technology is applied for the tracking down the point of maximum power in a stand-alone wind power system having PMSG as a generating machine. With the purpose of tracking the maximum power that can be extracted from wind energy with wind alteration, the hill climb search (HCS) algorithm is implemented using fuzzy logic control (FLC) method. In a stand-alone wind energy conversion system along with a predetermined load, a battery as an electrical energy storage device is used for the storage of excessive power. This proposed scheme has been simulated in Matlab/Simulink and obtained results for the same.

Hayat Elaissaoui et.al (2020) in this paper we have studied a hybrid system that combines two photovoltaic and wind energy system. For the purpose of improving the performance of this system, we have proposed a new Maximum Power point tracking MPPT. The proposed algorithm is based on fuzzy logic (FL) and ANN artificial neural network. For the photovoltaic system (PV), ANN is used to estimate the maximum output voltage of the photovoltaic generator (PVG) under different environmental conditions (Temperature and Solar irradiance). The fuzzy logic is used to control the DC-DC boost converter. For the wind turbine system (WT), the ANN is employed to estimate the maximum output voltage for different wind speed values and the Fuzzy Logic Controller (FLC) is used to control the DC-DC boost converter. To verify the effectiveness of the proposed MPPT, the simulation is done under MATLAB/SIMULINK.

Jyotismita Mishra et.al (2018) this paper proposes a load voltage based maximum power point tracking (MPPT) algorithm for a standalone wind generation system (WGS). The algorithm uses the slope of change in load voltage to duty cycle for extracting the optimum power. The MPPT performance at steady-state and during wind speed change condition is verified through experiment. The proposed algorithm uses only one voltage sensor which makes the system less costly, simple to implement and robust. Moreover, it neither requires the knowledge of any system parameter nor the speed sensor. The controller is implemented in DS1103 digital platform with the developed laboratory setup.

Tomas Syskakis et.al (2019) To increase the adoption of micro- and pico-grid systems, easy to use and commercially viable distributed generation solutions are required. The proliferation of distributed generation systems has accelerated the research and implementation of small wind turbines (SWTs) as viable renewable energy solutions. Sophisticated Maximum Power Point Tracking (MPPT) algorithms, used for large wind turbine installations, are not implemented with SWTs as they require turbine parameterization and costly sensors such as anemometers. Due to financial considerations, traditional SWTs implement either no MPPT or very simple algorithms such an Incremental Conductance (InCond) or Perturb and Observe (P&O). In this work, a novel and computationally efficient SWT MPPT algorithm, derived from the InCond method, is proposed.

A control-oriented model of the SWT system is also presented which facilitates fast simulations using conventional power electronics software. The proposed MPPT algorithm offers 3 key advantages: 1) elimination of algorithm confusion due to change in wind velocity, 2) fast and accurate tracking of the maximum power point (MPP) and 3) improved steady state efficiency. The behavior of the proposed algorithm is presented and corroborated in simulations and experimental validation, using a custom-built Turbine Emulation Platform (TEP), is also included.

Shefali Jagwani et.al (2018) For utilizing the wind energy to its full potential and to ensure the reliable power across critical loads, a Switched Reluctance Generator (SRG) with grid interactive inverter is presented for wind energy conversion systems (WECS). A wind turbine is emulated using Maximum Point Power Tracking (MPPT) algorithm in which tip speed ratio is controlled to obtain the reference speed for SRG. In order to control the SRG, the reference current, turn-on angle and turn-off angle are controlled. A single-phase grid interactive inverter is used which operates in both grid connected (current control) and off-grid (voltage control) modes. Robust power flow control for various cases in on-grid and off-grid modes are presented which depends upon the state of charge (SOC) of generation bus battery.

Chenghao Fu et.al (2018) Wind energy is a promising renewable energy resource which is cheap, eco-friendly and inexhaustible. A wind energy generating system with wind turbine, generator and converters is established to capture and integrate wind energy and transfer it to the grid. This paper discusses the modeling of the wind energy generating system, including wind speed, wind turbine, generator, generator side converter, grid side converter. After the introduction of the three traditional MPPT methods (TSR, PSF, HCS), a fuzzy slope HCS method is proposed to ensure the rapidity and accuracy of the system. Finally, simulation in Simulink shows that the method is feasible and able to capture most wind energy.

.

III. HYBRID ENERGY SYSTEM CONFIGURATION

Integration Schemes RE/AE sources have different operating characteristics; it is, therefore, essential to have a well-defined and standardized framework/procedure for connecting them to form a hybrid system, or more widely a Micro grid, where a local cluster of DG sources, energy storage, and loads are integrated together and capable of operating autonomously .A robust Micro grid should also have "plug-and-play" operation capability. Adapted from the concept widely used in computer science and technology, plug-and-play operation here means a device (a DG, an energy storage system, or a controllable load) capable of being added into an existing system (Micro grid) without requiring system reconfiguration to perform its designed function, namely, generating power, providing energy storage capacity, or carrying out load control.

A suitable system configuration and a proper interfacing circuit [also called power electronic building block (PEBB)] may be necessary to achieve the plug-and-play function of a DG system. There are many ways to integrate different AE power generation sources to form a hybrid system. The methods can be generally classified into three categories: 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. These methods are briefly reviewed below.

1. DC-Coupled Systems:
In a dc-coupled configuration, shown in Fig. 1, the different AE sources are connected to a dc bus through appropriate power electronic (PE) interfacing circuits.

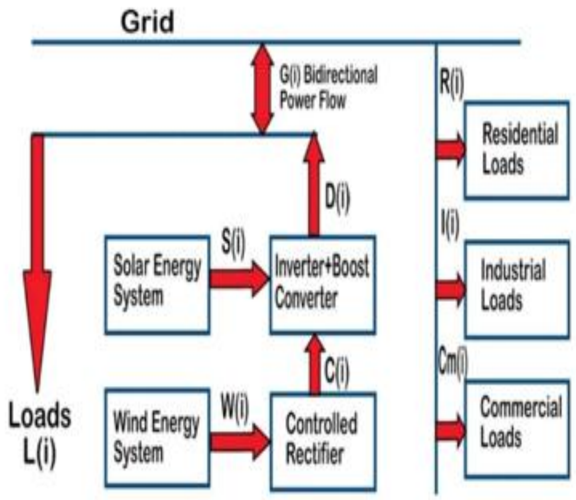

Fig 2. Architecture Diagram.

The dc sources may be connected to the dc bus directly if appropriate. If there are any dc loads, they can also be connected to the dc bus directly, or through dc/dc converters, to achieve appropriate dc voltage for the dc loads. The system can supply power to the ac loads (50 or 60 Hz), or be interfaced to a utility grid through an inverter, which can be designed and

2. Maximum Power Point Tracking:
Most of the MPPT algorithms residential in recent years have been discussed in the preceding sections. Some of them are related, using the same rules, but in different ways, like the last three algorithms listed in Hill Climbing Technique. According to the number of releases, the most popular MPPT algorithms are P&O, InCond, and Fuzzy Logic. However, they have a few disadvantages, as mentioned earlier. In the next chapter, we will examine the effectiveness of these three algorithms. They were chosen for their plainness or reputation. In the case of P&O and InCond, a few suggestions are offered, which overcome the limitations of the original method of tracking MPP below the water's edge. The FLC was designed according to reference, and its active efficacy was tested and compared with the MPPT scaling method. As explained previously there is a significant gain in efficiency to be achieved if the solar cell is operating near its MPP. MPP tracking methods can be applied for both wind and solar power.

Though, the methods utilized for wind and solar differs slightly. The next section intends to give an introduction to the most common methods used for both resources, which aims to illustrate their differences. The P&O method, also known as the trial and error method, operates through changing the terminal voltage of the solar array by a small step, ΔV. It then compares if the power output of the array increases or decreases. Depending on the outcome, the ΔV of the next perturbation cycle is either deducted or added. Furthermore since the step size ΔV is a fixed value. Assigning a small value for the step size results in slow tracking but good accuracy, and vice versa if the step size is too large. Moreover, the P&O method will never achieve the exact MPP since it continuously checks for a better power output, i.e. raises and lower the terminal voltage. Instead it will oscillate around the MPP. The overall performance of the P&O method is good. Though, the tracking and accuracy ability varies depending on step size. More so, erratic behavior has been observed when tracking rapid changes, resulting in the MPP searching in the wrong direction. [10]

The incremental conductance method achieves the MPP through measuring the power and voltage output of the photovoltaic cell. It then calculates the derivative of power with respect to voltage. With the knowledge on how power varies as a function of voltage for a photovoltaic cell, i.e. the PV- curve. The maximum power point can be found when is set to zero. Accordingly, if the derivative is not zero, the controller changes the duty cycle so that the equation is fulfilled with the constraint of being zero. The IC method is better than the P&O in the sense that it does not oscillate around the MPP due to the fact that it measures the changes in current and voltage. For example, if the insolation is fixed the voltage and current would remain steady, resulting in the IC method eventually settling at the MPP (10).

The constant voltage and current method is based on the fact that for a given insolation the ratio between the array´s V_{MPP} and V_{OC} is close to constant. Accordingly, if the value of V_{OC} is obtained the value of V_{MPP} can be calculated through equation above. The voltage level of the array is then varied until the voltage level corresponds to the V_{MPP}. Acquiring the value of V_{OC} is done through measurements during a small period were the MPPT is briefly isolated from the array.

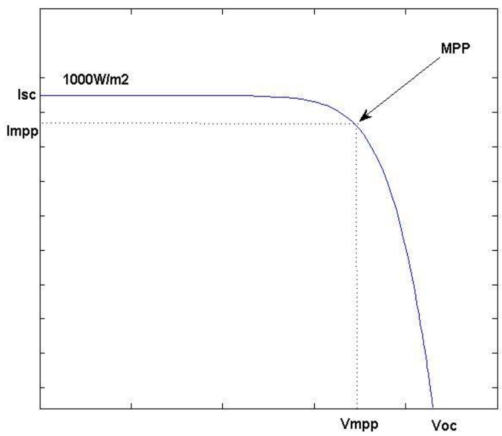

Fig 3. Voltage and current Impp & Vmpp at the MPP.

The following methods are commonly used for finding the MPP for wind energy systems Tip Speed Ratio (TSR)

Storage 1: Storage Diversity: Storage technology is critical for ensuring high levels of power quality and energy management of stationary hybrid RE systems. The ideal storage technology would offer fast access to power whenever needed, provide high capacity of energy, have a long life expectancy, and is available at a competitive cost. However, there is no energy storage technology currently available that can meet all these desirable characteristics simultaneously. In this section, the different types of energy storage devices and systems are covered without going into the details of operation of any specific device. The operational performance and applications of energy storage devices for advanced power applications (also, equally suited for hybrid RE/AE power generation system applications) are, for example, discussed in [7] and [8].

Storage Types: In analogy to data storage in computer engineering, a classification in terms of access and capacity orientation may also be considered for energy. Super capacitors, flywheels, and SMES offer fast access to the stored energy, have a very high cycle life of charge and discharge operations, and very high round-trip efficiency on the order of 95%. However, the cost per unit of stored energy is also very high. Therefore, all three technologies can be classified as access-oriented and support power quality. The usage of SMES can here only be economically justified for applications involving comparatively high levels of power. Batteries could also be classified as high-power and/or high-energy types depending on their design. However, in general, their cycle life of charge/discharge is shorter than the high-access energy storage devices explained above.

A promising capacity-oriented energy storage technology is the flow battery. In conventional batteries, chemical energy is stored in reactants, placed near the electrodes inside the battery cell, but in flow batteries, chemical energy is stored in the electrolyte solutions stored in two tanks outside the battery cell stacks. As the solution is pumped to circulate from one storage tank, through a cell stack, to the second tank, ion exchange takes place through the cell porous membrane, and electrons flow through the load to generate electrical power.

Several different flow battery chemistries have been developed for MW/MWh-level utility applications. The available electrolyte chemistries include zinc-bromine flow batteries (ZBFB) and vanadium redox batteries (VRB). Other chemistries are under development. An advantage of flow batteries is that their power and energy capacity can be designed independently.

A battery power rating can be increased by increasing the cell area where energy conversion takes place, i.e., by increasing the number of cell stacks, while its energy capacity can be increased by using larger volume of electrolyte solutions in larger tanks. Furthermore, flow batteries can be stored and shipped completely discharged as the reaction only takes place when the electrolyte circulation pumps are turned ON. Conventional lead-acid batteries are the least expensive for hybrid energy system applications, but they suffer from a low cycle life. Nickel metal hydride (Ni-MH) batteries and those with sodium sulfur (NaS) chemistry offer significant improvements over lead-acid batteries.

Popular commercial applications for Ni-MH batteries have included usage in hybrid electric vehicles (HEVs) and distributed RE systems. NaS batteries have been used in Japan in distributed energy systems and to firm up wind energy in the grid on a large scale, up to 34 MW of power and 245 MWh of energy [60]. The operating temperature of NaS batteries is of the order of 300 C to 350 C, which does not make them attractive for mobile applications. This is in contrast with zinc–bromine batteries that operate near ambient temperature.

IV. CONTROLS AND ENERGY MANAGEMENT

Proper control of hybrid energy systems with multiple RE/AE/conventional-DGs and energy storage (operating as micro grids) is critical to achieving the highest system reliability and operation efficiency [32]. 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. A brief description of each control paradigm follows.

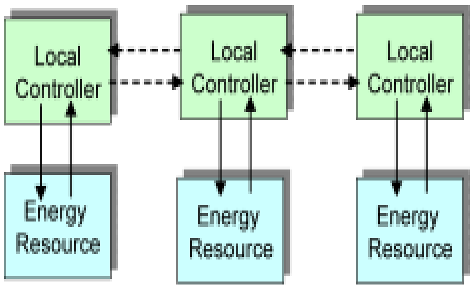

Fig 4. Illustration of a distributed control paradigm.

the trade-off information among the multiple objectives effectively [68]. The control signals are then sent to the corresponding energy sources to output proper power. The advantage of this control structure is that the multiobjective energy management system can achieve global optimization based on all available information. However, the scheme suffers from heavy computation burden and is subject to single-point failures.

V. CONCLUSION

A MATLAB MPPT system model for Photovoltaic's was developed in order to compare the performance of the Constant Voltage, Perturb and Observe, Power Increment, Hybrid of Constant Voltage with P&O and Hybrid of Power Increment with P&O under different weather conditions. This study was conducted in order to compare and evaluate the performance of each implemented individual MPPT technique and to demonstrate how Hybrid MPPT techniques outperform individual techniques when working on their own without any added complexity since Hybrid techniques combine the merits of each algorithm and eliminate their drawbacks. The Hybrid of Constant Voltage with P&O achieved the higher tracking accuracy of a small step size P&O with the faster convergence peed of the Constant Voltage. Whereas, the Hybrid of Power Increment with P&O achieved better accuracy peed than the two individual algorithms along with the ability of tracking the GMPP under partial shading conditions provided by the Power Increment.

Also, the performance of the Hybrid algorithms under both sudden and dynamic compared to their performance individually; as the presence of the P&O provided high performance under dynamic weather conditions.

Moreover, the addition of the P&O to the Power Increment improved the speed of the latter under sudden changes in irradiance, while the convergence speed of the former under sudden irradiance changes was also boosted when hybridized with the fast Constant Voltage.

REFERENCES

[1] Marina Babayeva; Artur Abdullin; Nikolay Polyakov; Stanislav Aranovskiy MPPT Algorithms for Magnus Effect Wind Turbine Control System 2020 XI International Conference on Electrical Power Drive Systems (ICEPDS) Year: 2020.
[2] Chao Xing; Xinze Xi;Xin He; Mingqun Liu Research on the MPPT Control Simulation of Wind and Photovoltaic Complementary Power Generation System 2020 IEEE Sustainable Power and Energy Conference (iSPEC) Year: 2020
[3] Guyuan Ji;Kazuhiro Ohyama MPPT control of Variable Speed Wind Power Generation System using Switched Reluctance Generator and AC-AC converter 2020 23rd International Conference on Electrical Machines and Systems (ICEMS) Year: 2020.
[4] Khouloud Bedoud; Hichem Merabet; Tahar Bahi; Djalel Drici Fuzzy Observer for MPPT Control of Variable Wind Energy Conversion System Assoiled to AC-DC Converters 2020 20th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA) Year: 2020.
[5] Krunalkumar R. Prajapati Application of fuzzy logic for MPPT control in stand-alone wind energy conversion system with a battery storage system 2019 IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS) Year: 2019.
[6] Hayat Elaissaoui; Mohammed Zerouali; Abdelghani El Ougli; Belkassem Tidhaf MPPT Algorithm Based on Fuzzy Logic and Artificial Neural Network (ANN) for a Hybrid Solar/Wind Power Generation System 2020 Fourth International Conference On Intelligent Computing in Data Sciences (ICDS) Year: 2020.

[7] Jyotismita Mishra; Monalisa Pattnaik; Susovan Samanta Load Voltage based MPPT Algorithm for a Stand-alone Wind Generation System 2018 15th IEEE India Council International Conference (INDICON) Year: 2018.
[8] Tomas Syskakis; Martin Ordonez MPPT for Small Wind Turbines: Zero-Oscillation Sensorless Strategy 2019 IEEE 10th International Symposium on Power Electronics for Distributed Generation Systems (PEDG) Year: 2019.
[9] Shefali Jagwani; Gyanendra Kumar Sah;L. Venkatesha MPPT Based Switched Reluctance Generator Control for a Grid Interactive Wind Energy System 2018 7th International Conference on Renewable Energy Research and Applications (ICRERA) Year: 2018.
[10] Chenghao Fu; Tinglong Pan;Hui Liu; Dinghui Wu;Yanxia Shen; Zeliang Hao MPPT Control Based Fuzzy for Wind Energy Generating System 2018 37th Chinese Control Conference (CCC) Year: 2018.