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# A Review on Hybrid Power Systems Energy Management Using ANN Controller

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**Abstract: -**
Due to the fact that solar and wind power is intermittent and unpredictable in nature, higher penetration of their types in existing power system could cause and create high technical challenges especially to weak grids or stand-alone systems without proper and enough storage capacity. By integrating the two renewable resources into an optimum combination, the impact of the variable nature of solar and wind resources can be partially resolved and the overall system becomes more reliable and economical to run. This paper provides a review of challenges and opportunities / solutions of hybrid solar PV and wind energy integration systems. Voltage and frequency fluctuation, and harmonics are major power quality issues for both grid-connected and stand-alone systems with bigger impact in case of weak grid. This can be resolved to a large extent by having proper design, advanced fast response control facilities, and good optimization of the hybrid systems. The paper gives a review of the main research work reported in the literature with regard to optimal sizing design, power electronics topologies and control. The paper presents a review of the state of the art of both grid-connected and stand-alone hybrid solar and wind systems.

***Keywords***: Hybrid, Renewable, Less complexity, Economical, Efficient.

## 1. 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 its 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.

## 2. 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 converts 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 is 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 environmentally friendly and pollution free which reduces the greenhouse effect [2].

**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 [3]. 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.

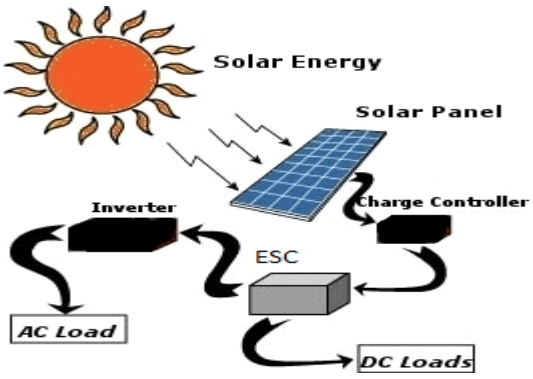


**Fig. 1 Solar system.**

**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.[4] The net effects on the environment are far less problematic than those of nonrenewable power sources.

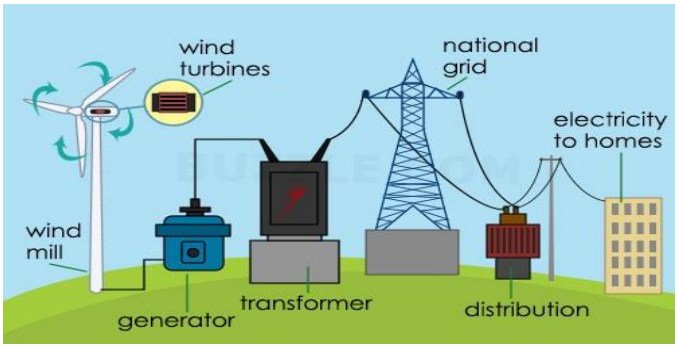


**Fig. 2 Wind power generation.**

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]

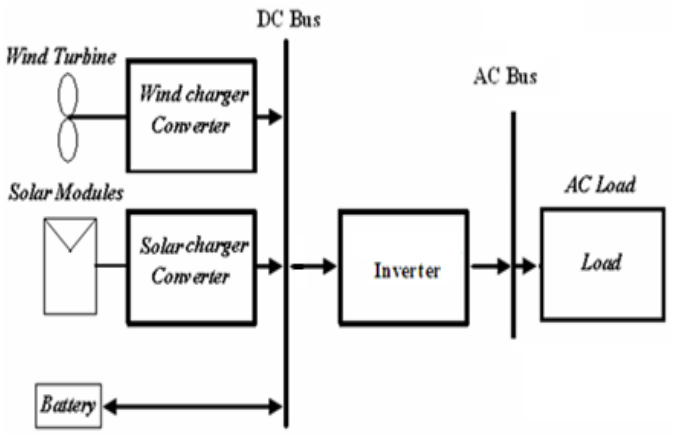


**Fig. 3 Solar and Wind generation.**

## 3. MOTIVATION

In the past, typical applications of distribution generation generally included reciprocating Engines or small hydro plants, where AC power injection was relatively constant. The wind/pv hybrid power system has the intermittent resource characteristics that vary the power output throughout the day and requires the conversion of DC-AC power through inverters and having higher power Rating with sophisticated control. The proliferation of wind/pv hybrid power system represents a less familiar challenge for distribution utilities and gives rise to various impacts which are different from that of the conventional DGs because of its different characteristics. So there is requirement for in depth investigation of potential dynamic impact of PV system on the distribution network under various load and generating conditions. The major motivation of the thesis, is to identify the oscillations occurring in the grid-connected wind/pv hybrid power system. To develop a technique, to achieve damping of these oscillations to provide a stable power system. Despite the need, there is no standard bench mark model of large-scale wind/pv hybrid power system for power System simulation studies.

## 4. PROBLEM IDENTIFICATION

The solar emission varies in excess of period and is dependent on ecological surroundings (irradiance, temperature, etc.). Therefore, it becomes hard to dig up a usual production all

through. Also, at night we cannot have the solar power supply so we have to go for supplementary energy.

Challenges of wind power

- Wind power must still compete with conventional generation sources on a cost basis. Even though the cost of wind power has decreased dramatically in the past several decades, wind projects must be able to compete economically with the lowest-cost source of electricity, and some locations may not be windy enough to be cost competitive.
- Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed. Transmission lines must be built to bring the electricity from the wind farm to the city. However, building just a few already-proposed transmission lines could significantly reduce the costs of expanding wind energy.
- Wind resource development might not be the most profitable use of the land. Land suitable for wind-turbine installation must compete with alternative uses for the land, which might be more highly valued than electricity generation.
- Turbines might cause noise and aesthetic pollution. Although wind power plants have relatively little impact on the environment compared to conventional power plants, concern exists over the noise produced by the turbine blades and visual impacts to the landscape.
- Wind plants can impact local wildlife. Birds have been killed by flying into spinning turbine blades. Most of these problems have been resolved or greatly reduced through technology development or by properly siting wind plants. Bats have also been killed by turbine blades, and research is ongoing to develop and improve solutions to reduce the impact of wind turbines on these species. Like all energy sources, wind projects can alter the habitat on which they are built, which may alter the suitability of that habitat for certain species.

## 5. LITERATURE SURVEY

*Qiuyan Zhang, "A Short-Term Optimal Scheduling Model for Wind-Solar-Hydro-Thermal Complementary Generation System Considering Dynamic Frequency Response":* This paper proposes a model to realize the coordinated optimal dispatch of wind-solar-hydro-thermal hybrid power generation system, aiming at minimizing the power generation cost of thermal generators and maximizing the water storage value of hydropower stations at the end of the scheduling periods, while considering the dynamic frequency response of wind/solar/hydro/thermal generators. Considering the virtual inertia and droop control of wind farms and PV stations, the dynamic frequency response model of wind-solar-hydro-thermal multi-energy complementary system is derived and the metrics that evaluate the frequency dynamic characteristics of the generation system are presented. Then the dynamic frequency response constraints are incorporated into the traditional optimal scheduling model and the Mixed Integer Linear Programming (MILP) method is used to solve it. Finally, the validity and applicability of the proposed model are verified by simulation examples.

*Miswar A. Syed, "Moving Regression Filtering With Battery State of Charge Feedback Control for Solar PV Firming and Ramp Rate Curtailment":* The surge in energy demand needs to be met with environmentally pleasant resources to reduce the production of greenhouse gases. Solar Photovoltaic (PV) power is a widespread choice as it is accessible in plenty and is comparatively inexpensive. However, the large-scale penetration of intermittent PV power causes multiple variabilities in the grid such as frequency issues and voltage deviations. To counteract these instabilities, Battery Energy Storage System (BESS) is integrated into the grid as it reduces the PV fluctuations and promotes optimal operation.

*Jun Xie, "A Short-Term Optimal Scheduling Model for Wind-Solar-Hydro Hybrid Generation System With Cascade Hydropower Considering Regulation Reserve and Spinning Reserve Requirements":* In order to meet the challenges brought by the high penetration of intermittent and fluctuating wind and solar power, a short-term optimal scheduling model for wind-solar-hydro hybrid generation system with cascade hydropower is established with the objective of minimizing the amount of abandoned wind, solar and hydro power and maximizing the stored energy of hydro stations. Cascade hydropower is considered to provide spinning reserve and regulation reserve to ensure the security of system. Mixed Integer Linear Programming (MILP) method is used for the short-term optimal schedule of wind-solar-hydro hybrid generation system. The case studies show that spinning reserve and regulation reserve are beneficial to the hybrid generation system, and verify the practical applicability of the proposed model.

*Shakti Singh, "Feasibility of Grid-connected Solar-wind Hybrid System with Electric Vehicle Charging Station":* Recently, renewable power generation and electric vehicles (EVs) have been attracting more and more attention in smart grid. This paper presents a grid-connected solar-wind hybrid system to supply the electrical load demand of a small shopping complex located in a university campus in India. Further. an EV charging station is incorporated in the system. Economic analysis is performed for the proposed setup to satisfy the

charging demand of EVs as well as the electrical load demand of the shopping complex. The proposed system is designed by considering the cost of the purchased energy, which is sold to the utility grid, while the power exchange is ensured between the utility grid and other components of the system. The sizing of the component is performed to obtain the least levelized cost of electricity (LCOE) while minimizing the loss of power supply probability (LPSP) by using recent optimization techniques. The results demonstrate that the LCOE and LPSP for the proposed system are measured at 0.038 $/kWh and 0.19% with a renewable fraction of 0.87, respectively. It is determined that a cost-effective and reliable system can be designed by the proper management of renewable power generation and load demands. The proposed system may be helpful in reducing the reliance on the over-burdened grid, particularly in developing countries.

*Silvia Sekander, "Statistical Performance Modeling of Solar and Wind-Powered UAV Communications":* We develop novel statistical models of the harvested energy from renewable energy sources considering harvest-store-consume (HSC) architecture. We consider three renewable energy harvesting scenarios, i.e., (i) harvesting from the solar power, (ii) harvesting from the wind power, and (iii) hybrid solar and wind power. In this context, we first derive the closed-form expressions for the density functions and moments of the harvested power solar and wind power. Then, we calculate the probability of energy outage at UAVs and signal-to-noise ratio (SNR) outage at ground cellular users. The energy outage occurs when the UAV is unable to support the flight consumption and transmission consumption from its battery power and the harvested power. Due to the intricate distribution of the hybrid solar and wind power, we derive novel closed-form expressions for the moment generating function (MGF) of the harvested solar power and wind power. Then, we apply Gil-Pelaez inversion to evaluate the energy outage at the UAV and SNR outage at the ground users. In addition, we formulate the SNR outage minimization problem and obtain closed-form solutions for the transmit power and flight time of the UAV.

*Pranoy Roy, "Cost Minimization of Battery-Supercapacitor Hybrid Energy Storage for Hourly Dispatching Wind-Solar Hybrid Power System":* This study demonstrates a dispatching scheme of wind-solar hybrid power system (WSHPS) for a one-hour dispatching period for an entire day utilizing battery and supercapacitor hybrid energy storage subsystem (HESS). A frequency management approach is deployed to extend the longevity of the batteries through extensively utilizing the high energy density property of batteries and the high power density property of supercapacitors in the HESS framework. A low-pass filter (LPF) is employed to decouple the power between a battery and a supercapacitor (SC). The cost optimization of the HESS is computed based on the time constant of the LPF through extensive simulations in MATLAB/SIMULINK platform. The curve fitting and Particle Swarm Optimization approaches are applied to seek the optimum value of the LPF time constant. Several control algorithms as a function of the battery state of charge are developed to achieve accurate estimation of the grid reference power for each one-hour dispatching period.

*Hongming Yang, "Optimal Wind-Solar Capacity Allocation With Coordination of Dynamic Regulation of Hydropower and Energy Intensive Controllable Load":* With the increasing penetration of renewable energy, it becomes challenging to smoothen highly fluctuant and intermittent power output only through the conventional thermal units. In this paper, by exploiting the dynamic regulating ability of hydropower and energy intensive controllable load to reduce the power output uncertainties, an optimal wind-solar capacity allocation method is proposed. The power regulation characteristics of hydropower stations based on hydraulic head and energy intensive controllable load based on complex production process are modelled. A bi-level (including planning and operation layers) optimization model for wind-solar capacity allocation is proposed, which is subject to the system dynamic regulation constraints

*Ahmad F. Tazay, "Modeling, Control, and Performance Evaluation of Grid-Tied Hybrid PV/Wind Power Generation System: Case Study of Gabel El-Zeit Region, Egypt":* The potential for utilizing clean energy technologies in Egypt is excellent given the abundant solar irradiation and wind resources. This paper provides detailed design, control strategy, and performance evaluation of a grid-connected large-scale PV/wind hybrid power system in Gabel El-Zeit region located along the coast of the Red Sea, Egypt. The proposed hybrid power system consists of 50 MW PV station and 200 MW wind farm and interconnected with the electrical grid through the main Point of Common Coupling (PCC) busbar to enhance the system performance. The hybrid power system is controlled to operate at the unity power factor and also the Maximum Power Point Tracking (MPPT) technique is applied to extract the maximum power during the climatic conditions changes. Modeling and simulation of the hybrid power system have been performed using MATLAB/SIMULINK environment. Moreover, the paper presented a comprehensive case study about the realistic monthly variations of solar irradiance and wind speed in the study region to validate the effectiveness of the proposed MPPT techniques and the used control strategy. The simulation results illustrate that the total annual electricity generation from the hybrid power system is 1509.85 GWh/year, where 118.15 GWh/year (7.83 %) generates from the PV station and 1391.7 GWh/year (92.17%) comes from the wind farm. Furthermore, the hybrid power system successfully operates at the unity power factor since the injected reactive power is kept at zero.

*Murli Manohar, "Stochastic Weather Modeling-Based Protection Scheme for Hybrid PV–Wind System With Immunity*

*Against Solar Irradiance and Wind Speed":* The intermittency in weather complicates the task of determining the optimal setting of protective relays in hybrid photovoltaic (PV)-wind-based microgrids. Classical overcurrent relays quite often maloperate during fluctuations in wind speed and solar irradiance. Motivated by the significance of reducing the sensitivity of microgrid protection against weather intermittency, this article proposes a protection scheme based on the combined framework of stochastic modeling of weather intermittency using probability distribution function and ensemble-based classifier. Considering the possible similar weather scenario to which both the distributed energy resources are subjected to, the covariability has been considered to develop the joint probabilistic model of variation in wind speed and solar irradiance. The model derived using the historical data allows incorporating the weather intermittency in the formulation of the protection algorithm. The data generated under intermittency are processed using a wavelet transform to derive discriminatory attributes. Using the derived attributes, a rotation forest-based classifier has been developed to perform fault detection/classification and faulty section identification.

## 6. CONCLUSION

This paper has provided a review of challenges and opportunities on integrating solar PV and wind energy sources for electricity generation. The main challenge for grid-connected system as well as the stand-alone system is the intermittent nature of solar PV and wind sources. By integrating the two resources into an optimum combination, the impact of the variable nature of solar and wind resources can be partially resolved and the overall system becomes more reliable and economical to run. This definitely has bigger impact on the stand-alone generation. Integration of renewable energy generation with battery storage and diesel generator back-up systems is becoming a cost-effective solution for stand-alone type. The windbattery-diesel hybrid configuration can meet the system load including peak times. Energy management strategies should ensure high system efficiency along with high reliability and least cost. Good planning with accurate forecasting of weather pattern, solar radiation and wind speed can help in reducing the impact of intermittent energy.

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