

# A Review of Hybrid Solar PV and Wind Energy System

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**Abstract**— In Today’s scenario, conventional energy are resources depleting rapidly as every work requires or needs energy. But energy resources are depleting whereas demands for energy is increasing therefore we are guided towards renewable energy resources namely solar energy, wind energy, nuclear energy and other renewables. Among these solar and wind plays a major role in generation of energy and almost everywhere can be made available so our main focus is on solar and wind energy. In this paper we present a review of hybrid system of solar PV and wind as a substitute of conventional energy system for environment friendly power generation and sustainable development for future.

**Key words:** Wind Energy, PV System, Power, Renewable Energy, PV Cell

**Nomenclature:** AC: Alternating current

DC: Direct current

PV: Photovoltaic

WT: Wind turbine

## I. INTRODUCTION

Electrical energy is the basic necessity for the economic development of a country. The availability of energy at large scale in the modern times is fulfilled by the generation of electrical energy from various resources such as coal, wind, solar, water and tidal, etc. energy. Solar and wind are the major renewable resources to generate electricity. We have abundant amount of solar light and wind energy. We can fulfill our demand of electrical energy by generating electricity from solar and wind energy.

The hybrid solar wind energy systems are using the combination of solar panels techniques and wind turbine generator to generate electrical power.

The idea of the combined power generation is used to get continuous power during day and night for power applications. It consists of two types of small units fitted to the roof of buildings. We adjust the combination of series and parallel connection of solar cell and also position panels to appropriate inclination angle so that maximum light intensity can be capture and fall a solar panels so that we get continuous amount of electricity generation.

Global demand for renewable energy is increasing day by day specially for solar and wind energy. As these energies are renewable they can be renewed or recycled and are available at large amount. We are focusing on these renewable energy as the non-renewable energy or conventional energy resources are depleting day by day. On the other hand, our demand for energy is increasing rapidly.

Renewables are not only substitute for major conventional energy system but are also major key for sustainable development.

### A. Solar energy

From the solar energy we can generate electricity by producing high temperature heat produce power an engine, which further produces mechanical work to drive an electrical

generator. We use the PV cell to produce electricity from the solar energy. The solar panels are installed at the roof top.

### B. Wind energy

By the use of wind we can generate the electricity. To generate electricity from wind energy has been made since the late nineteenth century when professor James Blyth of the Royal College of Science and Technology, now Strathclyde University, built a range of wind energy devices to generate electricity his first being in 1887. By the use of wind power we can generate the electricity in wide range without harming the atmosphere and wind power is a renewable energy sources which was present mostly all over the world. A total of over 194 GW of wind generating capacitor has been installed by the end of 2010. But we know that, electricity generate from solar energy are used in the day only it is costly and from the wind power electricity generate in night only, because the efficiency of wind is present in night times only. That is why hybrid energy is best method to produce electricity in whole day without harming the atmosphere and it is cost effective.

Wind energy and solar energy are complementary to each other, which makes system to generate electricity almost throughout year. We are focusing on solar energy and wind energy but not separately, but as a whole. Wind energy and solar energy system are combined to form hybrid system. Hybrid of solar and wind in a grid is more economical and reliable.

The wind power generation, is the natural source of energy. As the wind flows, it exerts pressure from high pressure to low pressure. It is caused due to solar radiation falling on the earth surface. The wind flows from cold area to hot air area for balancing the equilibrium. As the wind flow, it carries kinetic energy and this energy can be converted into electrical energy by using a wind turbine. The wind turbine is connected to alternator which produce AC current after then the AC signal is converted to DC using rectifier and the rectified fixed DC is step up into variable DC by using boost-chopper and again change into AC signal by using three phase inverter so that then high AC can be used for the electrical applications.

## II. GENERATION OF ELECTRICITY IN INDIA

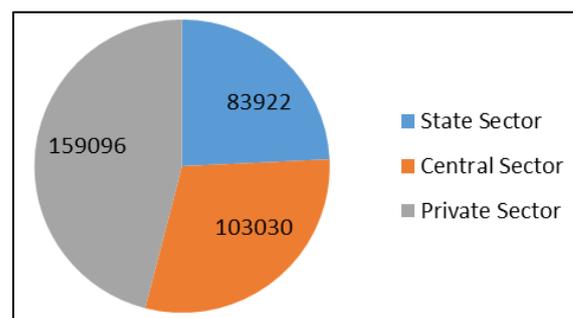


Fig. 1: Power Sector at a glance ALL INDIA

- 1) Total Installed Capacity (As on 31. 10.2018)- Source : Central Electricity Authority (CEA) with measurement in MW
- 2) On the basis on fuel type with measurement in MW

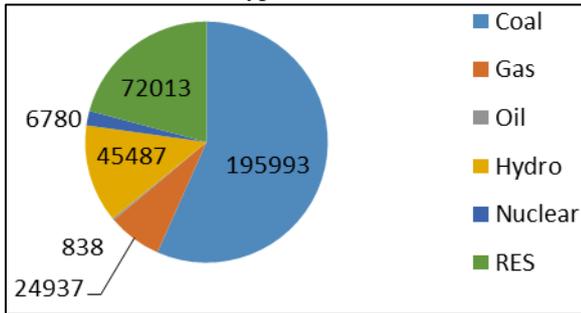


Fig. 2:

### III. HYBRID ENERGY SYSTEM

The combination of renewable energy sources wind and solar are used for generating power called as wind solar hybrid system.

The integration of solar wind energy forms a sophisticated way to meet the required demand of electricity. This system uses two renewable energy sources which produces electricity to charge various types of batteries.

The combination of these two sources improves the overall efficiency of the system. This system is far suitable as compared to other source of electricity generation. The weakness of one can be fulfilled by strength of other.

The integration of solar and wind energy creates an interrelation for the better reliability of power generation.

The integrated network generates the electric power with the help of various respective controllers. The overall generated power may be supplied to load and other electrical appliances.

### IV. OPTIMIZATION

The most effective use of these two hybrid resources solar and wind energy is known as optimization of resources. If there is not a proper optimization installed in this hybrid system then the combination of solar and wind energy system will not provide a continuous supply as this system will generate electrical energy only during sunny and windy climate. The optimization is also important if the system is connected to grid for better efficiency. So that integration should be proper optimized and well executed so that proper continuous supply of electricity can be maintained. The proper optimization can be done by selecting the proper size of solar panels and size of wind turbines. The proper maintenance of positioning of solar panel and its modules may increase intensity of light which can be captured by them. The size of wind turbine and types of wind turbine material are being chosen in such a way that it will rotate throughout the day and night and gives the continuous supply of electricity. For maximizing the total present values of the hybrid solar and wind system, this system is connected to electrical grid.

The solar panels should implement using solar tracking techniques. As when the intensity of solar light changes from day to night, the solar panel automatically tracks the maximum light intensity path so that intensity of

light on the solar panel and modules may maintain the required level of intensity of light throughout the day.

#### A. Diagram and Working:

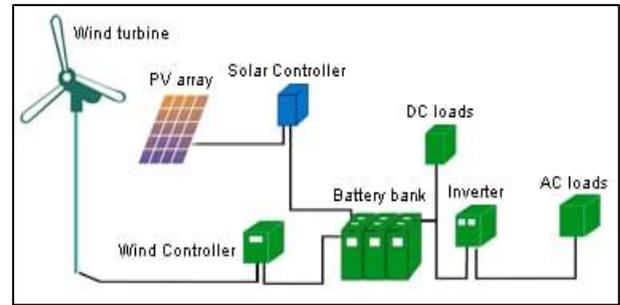


Fig. 3:

WT can be defined as fan consisting of two or three blades that rotate due to blowing wind. Gear box is required for converting energy from one device to another device using mechanical method hence called high precision mechanical system. There are different types of wind turbine such as horizontal axis turbines and vertical axis turbines. Solar Power system has three major blocks that is solar panels, solar PV cells and battery lamps. Solar panels generate DC power which can be stored in batteries and can be used to supply DC loads and after conversion using inverter, it can be used for AC too.

Main component of this system are:

- 1) Aero generator
- 2) Tower
- 3) Solar PV panels
- 4) Battery bank
- 5) Charge controller
- 6) Inverter

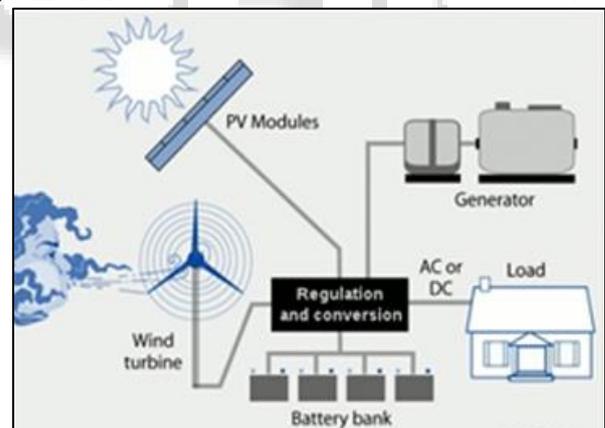


Fig. 4: Representation of Hybrid system

### V. CABLES

One common factor for most of PV power systems is outdoor use which is characterized by high temperature and UV radiation. Single core cables with a maximum permissible DC voltage of 1-8 KV max phase to ground DC voltages rating must be U01KV DC and a temperature range from -40 degree Celsius to 90 degree Celsius ambient, 120 degree service life against thermal ageing.

DC string cables must be class 2 double insulated to protect against short circuit and ground faults.

- 1) PV PANELS: Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A number of panels are connected in series or in parallel to generate DC output out of irradiance.  
Cell → Module → PV array
- 2) BATTERY BANK: As per the requirement of voltage and current we use one or more batteries connected together.
- 3) INVERTER: A solar or PV inverter is a type of electrical converter which converts variable DC output of PV solar fed into utility frequency AC that can be fed into commercial electrical network.
- 4) It is critical balance of system (BOS) - component in PV system, allowing use of ordinary AC powered equipment. Solar power inverter has special function adapted for use with PV arrays, including maximum power point tracking and anti-islanding protection.
- 5) CONTROLLER: A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from the electric batteries.

## VI. CALCULATIONS

### A. Calculation involved

The total power generated by this hybrid solar PV and wind energy is given by:

$$P_t = N_w * P_w + N_s * P_s$$

Where,

$P_t$  - total power generator

$P_w$  - power generated via wind turbines

$P_s$  - power generated via solar panels

$N_w$  - no. of wind turbine

$N_s$  - no. of solar panels used

### B. Wind energy evaluation:

The power generated by wind energy is given by,

$$P_w = \frac{1}{2} \cdot \rho \cdot (A_w) \cdot (V^3)$$

Where,

$P_w$  - Power in watts (W)

$\rho$  - Air density in kilograms per cubic meter (kg/m<sup>3</sup>)

$A_w$  - swept area by air in square meters (m<sup>2</sup>)

$V$  - wind speed in meters per second (m/s).

### C. Solar energy evaluation:

To determine the size of PV modules, the required energy consumption must be considered. Therefore, the power is calculated as

$$P_s = I_{ns}(t) * A_s * \text{Eff}(pv)$$

Where,

$I_{ns}(t)$  = isolation at time t (kw/ m2)

$A_s$  = area of single PV panel (m2)

$\text{Eff}(pv)$  = overall efficiency of the PV panels and dc to dc converters.

The overall efficiency is given by,

$$\text{Eff}(pv) = H * P_r$$

Where,

$H$  = Annual average solar radiation on tilted panels.

$P_r$  = Performance ratio, coefficient for losses.

### D. Cost

The total cost of the solar-wind hybrid energy system is depends upon the total number of wind turbines used and total number of solar panels used. Therefore the total cost is given as follows:-

Total cost=(No. of Wind Turbine \* Cost of single Wind Turbine) + (No. of Solar Panels \* Cost of single Solar Panel) + (No. of Batteries used in Battery Bank \* Cost of single Battery)

$$C_T = (N_w * C_{WT}) + (N_s * C_{SP}) + (N_B * C_B)$$

Where,

$C_T$  - total cost in Rupees

$C_{WT}$  - cost of single wind turbine in Rupees

$C_{SP}$  - cost of single solar panel in Rupees

$C_B$  - Cost of single Battery in Rupees

$N_w$  - number of wind turbine used

$N_s$  - number of solar panels used

$N_B$  - number of Batteries used in Battery Bank.

Solar-wind hybrid energy systems needs only initial investment. It will efficiently work with the conventional energy sources. The cost of the system is based on the factors such as system chosen, wind resource on the site, electric costs in the area, and the battery bank required. Cost of the Wind-Solar Hybrid system is minimized using non-conventional energy sources.

## VII. CONCLUSIONS

This review paper has provided a summary of the integration of solar and wind energy system for generation of electricity. The integration of systems has impact of the variable nature both the resources can be resolved partially and overall system becomes more economical. Reliability increases if intermittence nature problem of solar PV and wind are resolved. This integration increases daily electrical capacity with low fabricated cost. Its maintenance should be in proper regular way and it is saving fuel up to 50%. Voltages and frequency fluctuation produce harmonics are major demerits of power quality. It will require high storage and synchronization and intermittent nature of solar and wind energy.

## ACKNOWLEDGMENT

For the well preparation of this review paper, we are thankful to Dr. Deepika Chauhan (Professor of Electrical Department) for the required and valuable guidance in completion of our review paper successfully.

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