Optimal Integrated Design of Standalone Solar- Wind Hybrid Power System

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Abstract

Integration of renewable energy has garnered a lot of interest due to its low fuel cost, availability, cleanliness, and ease of installation. Photovoltaic (PV) and wind turbines have grown to be two of the most appealing renewable energy sources due to their local abundance in nature, technological advancements, and financial advantages. Because of their antagonistic nature, the hybrid combining of the two distributed energy supplies removes mutual intermittentness, which will increase system reliability. The main goal of this project is to produce electricity utilising clean, renewable energy while minimising pollutants. To overcome the limitations of renewable free-standing generation[1,2], we use a hybrid system.

Keywords: Continuous Power Supply, Combined Power Generation, Hybrid Energy Systems, Solar Energy Applications, and Wind Energy Applications.

I.INTRODUCTION:

Solar-Wind Solar panels and turbine generators are used in hybrid energy systems to generate electricity. Experts in renewable energy will clarify that a small hybrid system that combines solar energy technologies and energy offers various benefits to home applications[3]. Future power will be absolutely essential to our way of life; we cannot even envisage a world without electricity. The idea behind combined power generation is to create constant power for small power applications with an accumulator both during the day and at night.

We all know that the most promising renewable energy sources for energy generation are wind and solar. So many studies have been funded for the sole purpose of using these energy resources. The purpose of this project is to create the best possible hybrid wind-solar energy design. Using both renewable energy sources, the facility will be built with the intention of lowering construction costs, making the most use of the site available, and creating a healthy environment on Earth. The project's mission is to deliver electricity in an environmentally responsible manner by utilising renewable energy sources.

II. SOLAR SYSTEM POWER GENERATION

Due to the earth's geography, the sun's energy reaches the planet in various amounts and at various locations[4]. The most abundant renewable energy sources are those that may be used for a variety of purposes, such as choice energy, such as solar lighting, water heaters, etc.

Rule of the Solar Panel

Solar cells are used in solar panels to convert energy into voltage. Similar to how PN junction diodes function, cells are regulated. Every particle is initially immobile in their orbit because the device may be a semi-conductor[5,6]. Because semiconductors have a limited supply of electrons, an energy gap forms between the P-type and N-type regions. In N-type and P-type areas, the dominant carriers are electrons and holes, respectively. Excited electrons from the N-type region that are permitted to move to the P-type region create a flow of current as photon energy strikes the solar panels. The battery keeps getting urged to charge through this method. Recombination between electrons and holes occurs. To add up the voltage, solar cells are placed in a serial fashion. These serially connected batteries store energy by making the electrical gadget behave like another battery. If we had some form of three phase power supply, energy from the solar battery is also connected to the inverter.

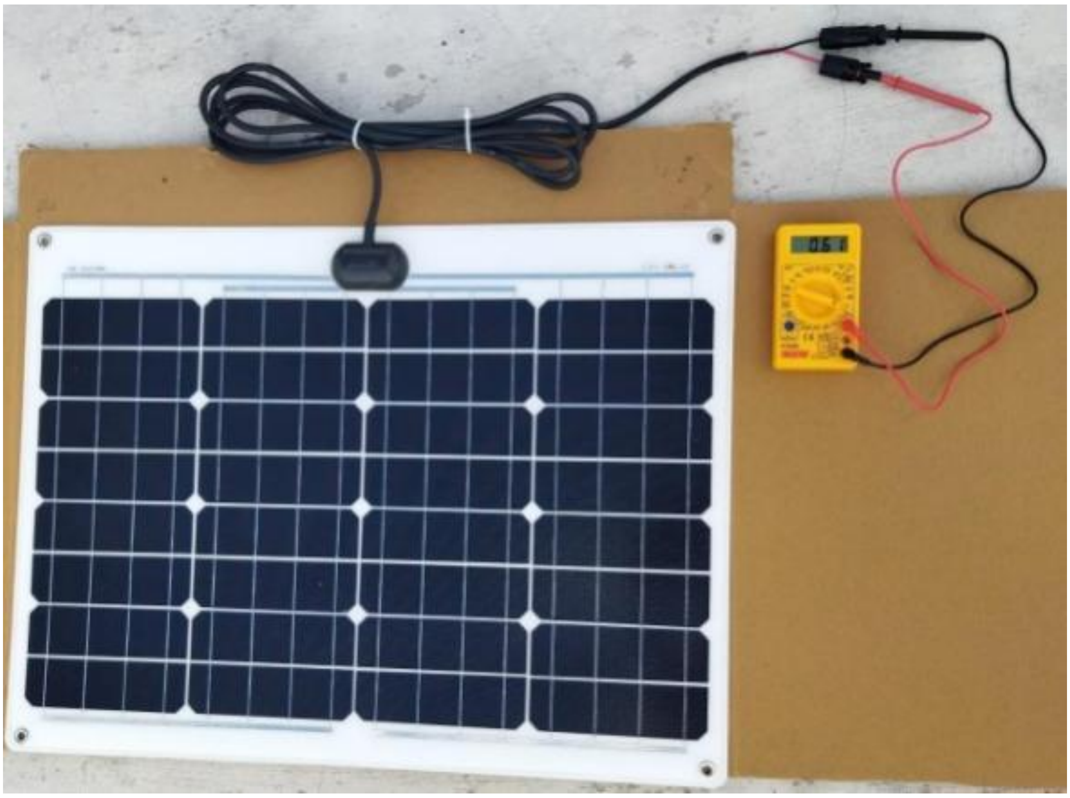

FIGURE 1. Solar Output (without Radiation)

It has PN junction diode similarities. Electrons in the solar battery are activated as a result of the photon energy falling on it[7]. The P- type channel is where this is headed. If the load is linked, this counts as a flow. The weight is propelled by the electros flowing continuously along the confined route. To ensure consistent power, the battery is connected. This energy will be used to power DC-operated equipment. This Inverter is needed if the linked load is an AC load.

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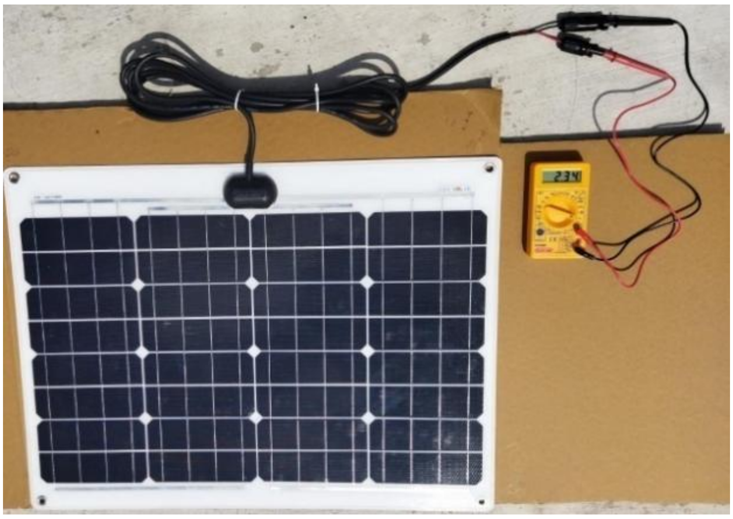

FIGURE 2. Solar Output (with Radiation)

B. Tracking of the largest electric outlet

The Maximum Point Tracking System is a tool for monitoring the most abundant energy source, which enhances the output capability and effectiveness of solar PV panels. The output has a nonlinear behaviour and frequently fluctuates as a result of weather variables[8]. This tool aids in locating the available power in the atmosphere and operates at its most effective level, enhancing efficiency. Maximum receptacle refers to the voltage in an extremely PV panel at which maximum power is realised.

Curve of I-V and P-V Power Characteristics

The MPP fluctuates in response to both the temperature and sun irradiation. Voltage source region and current source region are among the properties of PV cells. The internal impedance of the electric cell will be high in the current source region and low near the voltage source region[9]. Maximum power is transmitted to the load when the inner impedance matches the load impedances. MPP is used to track the maximum power between the PV cells and the load. The MPP is designed to have quick response, dependable Ceti Voyage [V] performance with minimal changes because the temperature and irradiance affect the panel efficiency as a result of the fluctuating atmospheric conditions[10].

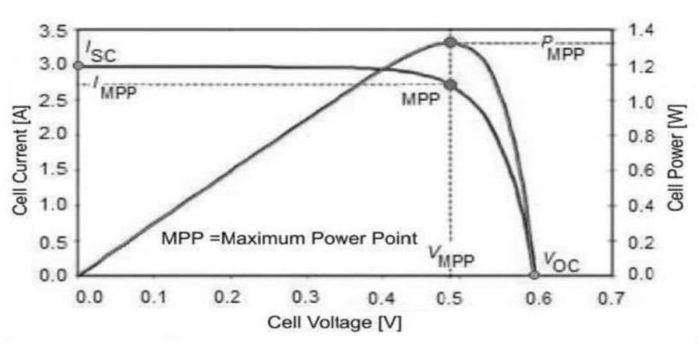

FIGURE 3. VI Characteristics

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Due to balancing concerns, this system cannot be connected to a load; as a result, it is connected to a DC-DC converter. With careful management, the converter matches the source and cargo impedances to send the maximum amount of power from the PV cell to the load. Step-down converters or DC-DC improvers are frequently utilised. The MPPT techniques employed vary, but the ones most frequently used in PV generation are the incremental conductance method, perturb and observe, constant voltage and current method, fuzzy logic, curve fitting method, electrical circuit voltage method, short current method, etc. The Perturb & Observe and incremental conductance methods are the two most often utilised approaches among these. These methods are simple to adopt and require minimal time for tracking.

III. WIND TURBINE MODELLING

The aerodynamic force characteristics of a wind turbine depends on air density(ρ), power Coefficient(Cp),swept area of the wind turbines blade(A) m2 and speed of wind(V) m/s. The power Coefficient is a function of tip speed ratio (λ) and blade pitch angle(β). The equation for power(Pw) can be written as

$$P_w = 0.5\ \rho A V^3 Cp\ (\beta, \lambda)$$

The tip speed ratio (λ) is defined as the ratio of Wind turbine rotational speed(w) and blade radius of wind turbine(R) to the velocity of wind (V).

$$\lambda = wR \backslash V$$

FIGURE 4. Hybrid Model

The greatest value of the power coefficient (Cp) according to theoretical concepts is 0.59. Wind turbines' fixed rotor blades capture the Cp, a small portion of the upstream wind's power, while discharging the remainder downstream. The wind turbines' maximum torque is achieved by maintaining a constant blade pitch angle of zero.

Wind turbine power plants

Wind energy is a sustainable resource that is widely accessible today and can supply energy demands without depleting fossil fuels or threatening their ability to meet future demands. Nature has provided us with the purest source of energy. Systems for converting wind energy rely on the turbines, generators, or alternators that are used to generate electricity. The two types of wind turbines are variable wind turbines and fixed wind turbines. While fixed speed wind turbines get their greatest efficiency at a constant wind speed, variable speed wind turbines can achieve maximum efficiency over a wide range of wind speeds. The direct driven permanent magnet synchronous generator is the most widely used device for converting wind energy because of its great efficiency and dependability.

A. Synchronous Permanent Magnet Generator

The mechanical energy generated by the wind turbine is transformed into electrical energy by the permanent magnet synchronous generators. Later, through power electronic devices, this power is supplied to the grid or a load. In a PMSG, the dynamic model is derived using two phases. In terms of rotational direction, the q-axis is 90° ahead of the d-axis. The mathematical model in a d-q reference frame revolving at synchronous speed is given by

$$di_d / dt = 1/L_{ds} + L_{ls}(-R_s I_d + \omega_e(L_{qs} + L_{ls})i_q + u_d)$$

The terms "d" and "q" refer to the d-q reference frame, "rs" stands for stator resistance, "Ld" and "Lq" stand for the generator's d and q axis inductances, "Lld" and "Llq" stand for the generator's d and q axis leakage inductance, "ti/f" stands for permanent magnetic flux, and "weare" stands for the generator's electrical rotating

The torque equation for a PMSG

$$t_e = 1.5p(((L_{ds} - L_{ls})i_d i_q + i_q \Psi_f)$$

IV . HYBRID SOLAR WIND ENERGY SYSTEMS

The best way to satisfy future demand growth will be to use hybrid power producing technologies. A hybrid energy system is one that produces electricity by combining two or more energy sources. The use of renewable energy is dependent on the weather. The temperature will typically be high when solar radiation is higher, which is sufficient to provide solar energy, but the wind energy will be weak at that time. Similar to when there is wind, there will likely be clouds and a probability of rain, and visibility will be dim with little sunlight. As a result, relying on a single energy source does not make sense for continuous power generation. While wind is present both day and night, the energy from the sun is only available during the day. Although the wind is more intense at night, there will always be a power source available because of this. According to seasonal fluctuations, solar energy is more beneficial during the summer and wind energy more advantageous during the winter because the weather will be windier. So, during any cycle of the power generation system, the integration of renewable energy sources offers greater performance and consistent output than standalone systems. The goal of hybrid energy systems is to integrate grid-connected solar and wind energy with controlling strategies to provide the most power possible. The advantage of having a power generation unit connected to the grid is that, in the event that there is ever a disruption in the production of solar or wind energy, the grid can serve as a source or a backup system. The grid stores the extra energy produced by renewable resources, which is then used to supply the load demand. Because the seasonal changes for the sun and wind may be resolved on the basis of combining the energy and output performance is enhanced, hybrid power generation is the greatest option in the foreseeable future.

In this arrangement, power supply continuity also occurs; if one failed to generate power, the other would supply the load. The relevant control algorithms performed this load monitoring. Under this, the power is produced by both power generation systems. The whole system performance is improved and will receive constant power supply thanks to this SWHES.

V. APPLICATIONS

Solar Wind Hybrid Energy Systems use tiny amounts of electricity in practically every field. The applications are listed below, to name a few.

Grid-connected and independent

• Grid-connected: SWHES with high power ratings can be connected to the grid in areas with more access to wind and sunlight. In these types of generation, the Grid will provide the load if the system fails to generate electricity.

• Stand-alone: The majority of SWHES applications are not connected to the grid and operate independently.

• Street lighting: Solar street lighting is the main use of SWHES. SWHES illumination is being used in solar street lights. Utilizing this lessens the demand placed on conventional power plants.

• Home: Appliances in your home may be powered by a hybrid solar-wind energy system. SWHES are utilised to reliably supply electricity to various offices or other areas of the building.

• Remote Applications: These SWHES systems are helpful for military forces where it is impossible to provide conventional power supply.

• Ventilation system: The suggested systems are also used to ventilate buildings; they assist in the operation of bathroom fans, floor fans, and ceiling fans. —I Power Pump: SWHES is able to assist with water pumping to any building. A pump powered by DC current can move water around your house. Village Power: In communities located in valleys and on hills, where it is impossible to supply energy, the proposed method is particularly helpful.

• On land: Because coastal locations receive more wind, SWHES are installed there as well as on boats for power production.

• Commercial: SWHES provide the necessary electric power in hotels and other tourist destinations.

VI. RESULT & CONCLUSION

For small power applications, solar wind hybrid energy systems become reliable. A hybrid energy system is created by integrating wind energy to increase the efficiency of solar photovoltaic power output. The suggested systems contribute to lowering air pollution from the traditional power generation system. The burden on the conventional power generating system is reduced by installing SWHES in every home. Even if this system does not produce any energy, the battery storage will provide electricity for a while. The SWHES are utilised in almost every area of electric power utilisation. It gives power to remote convention power locations. SWHES are an energy generation system that is more dependable, efficient, and nearly maintenance-free.

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