Hybrid Energy Generation System using Solar Wind Combined System and Synchronization with Normal Supply

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Arun Kumar Yadav*, [1], Rachit Srivastava*, Abhisht Upadhyay*, and Abhishek Bharti*

Abstract – *Hybrid energy production systems combining solar and wind energy have gained popularity in recent years. These systems offer several advantages over stand-alone solar or wind systems, including greater reliability, better efficiency, and better power generation capabilities. This topic explores the design principles and essential components of solar-wind hybrid systems, focusing on their integration and synchronization with a conventional energy source. Designing an efficient and reliable solar-wind hybrid system requires careful consideration of various factors. These factors include local climate, available resources, energy demand and system capacity. These systems are classified according to different criteria. It provides a brief overview of the current state of their design, modeling, simulation and optimization. A corresponding analysis was also performed. In short, a summary of the future directions of research and development was made. This study reports on an energy and economic analysis of a hydrogen tank electrolytic energy storage system, solar modules, wind turbines, and fuel cells used in a hybrid power generating system (HPGS). Real measurement data for three distinct household loads, local solar radiation, and local wind speed were used to conduct the analysis.*

Keywords – Hybrid energy, Hybrid system, Renewable energy, Simulation and optimization, Synchronization, Solar Radiation.

1. INTRODUCTION

Alternative sustainable and sources of are obviously needed as the attempts issues like climate change and the depletion of fossil. In this context, producing energy sun's energy the and wind has popped up as a feasible means of reducing greenhouse emissions while simultaneously satisfying the world's expanding energy demands. This article provides a detailed explanation of each energy source and discusses the principles, procedures, advantages, and disadvantages of hybrid wind and solar power production. The process of turning solar light into heat or power is known as solar energy. It is noticed to be among the finest and most abundant renewable energy sources. The method of producing solar energy utilizes photovoltaic (PV) panels, which convert sunlight into electricity.

2. LITRATURE REVIEW

The demand of sustainable energy solutions gradually increase globally. There is a growing interest in hybrid power generation systems. This combines multiple renewable energy sources to enhance efficiency and dependability while decreasing environmental impact. The Combining traditional energy sources with wind and solar energy of these promising methods [1]. The literature review is focused upon the integration of solar and wind energy with traditional electrical networks, the testing and observing to important findings and developments in hybrid energy systems. There are Solar and wind power renewable energy sources. Those are abundant and complementary each with unique characteristics/ challenges [2]. The increasing demand for sustainable energy optimized worldwide sparked interest in hybrid power production systems, which combine multiple renewable energy sources to enhance efficiency and dependability while reducing environmental impact. Combining solar and wind energy with traditional energy sources is one of these promising technologies [3]. The integration of solar and wind energy in tandem with traditional electrical networks is the focus of this literature review, which examines important findings and developments in hybrid energy systems. Wind and solar energy are complementary and abundant renewable energy sources, each with unique characteristics and challenges.

The wind energy is weather-dependent. The Solar electricity production peaks during the day of solar system. The hybrid energy systems idea is presented in this research paper that give the importance of hybrid energy systems for addressing energy supply issues, improving reliability, and reducing environmental impacts [4]. Because this is the combining multiple sources into a hybrid system can reduce their unpredictable and erratic nature. The Identifying primary challenges is that renewable energy sources, like as solar energy, must overcome including issues with grid integration, intermittency, and variability [5]. The Analyze of this research discusses performance analysis, optimization strategies, and technical specifics of integrating solar and wind energy systems. The Examine studies that address how solar and wind power complement one others including of their fluctuations in space and time [6]. That is lessened by hybridization. Examine ways to incorporate renewable energy

* Department of Electrical Engineering, Bansal Institute of Engineering and Technology, Lucknow, India.

[1] Corresponding author;
Tel: +91-9935640624
E-mail dr.arunkumaryadavee@gmail.com

technologies into traditional power grids through synchronization. For steady synchronization, grid stability and seamless power transfer between the hybrid system and the grid. In the literature read of on grid-connected inverters, power electronics, and control algorithms. The experimental research articles is to be describe power management algorithms. The power flow control methods are use for maximum power point tracking (MPPT) as well as other control strategies for hybrid power systems. In the literature topic the energy storage technologies like as capacitors and batteries. They are reduce intermittency and increase system reliability. For the Future developments of power system management, smart grid technology, and energy storage integration present chances to enhance. The efficiency and adaptability of hybrid energy systems are to be used. The hybrid energy generation systems that integrate solar, wind, and conventional energy sources can be crucial in addressing technical, financial, and regulatory obstacles [7].

3. COMPONENTS USED IN THE SYSTEM

The following is a list of the system's components:

1. Solar Panel
2. Solar Charge controller
2. Wind Turbine
3. MPPT
4. DC Generator
5. Stepdown Transformer
6. Rectifier Circuit
7. Battery
8. Inverter Circuit

4. DETAILS OF USED COMPONENTS IN THE SYSTEM

4.1 Solar Panel

In this system, 50 Watt solar panel has been used. Figure 1 shows picture view of solar panel. Here are the specifications usually associated with such a panel:

4.1.1 Wattage

Refers to output from the solar panel as decided by standard test conditions (STC). In this specific instance, it is 50 watts, indicating that the panel could produce 50 watts of power under standard conditions. Voltage: The output voltage of photovoltaic array, commonly indicated in volts (V). For a 50 watt panel, the voltage range is 16 to 18 volts[8].

4.1.2 Current

The electric current produced by the solar panel, measured in amperes (A). This panel can draw about 3.5 amps.

4.1.3 Dimensions

The physical size of the solar panel, usually measured in inches or centimeters. This panel dimension is 26 inches by 21 inches and area is about $0.28m^2$.

4.1.4 Efficiency

The efficiency of a solar panel refers to how efficiently it converts sunlight into electricity. More efficient panels can produce more power for a given area. This used panel efficiency is about 17.5%.

4.1.5 Temperature coefficient

It shows how much the efficiency of the panel decreases as the temperature increases. Lower temperature coefficients are desirable because they mean the panel will perform better in hot weather.

$$\text{Peak hour required} = \frac{V_{BATT} * \text{Capacity of battery}}{\text{Peak hour required}}$$

$$= \frac{12*20Ah}{8}$$

$$= 30\ W$$

Power output of solar panel = solar irradiance * Panel Area * Efficiency

$$= 1000W/m^2 * 0.28m^2 * 0.175$$

$$= 50W$$

Fig. 1. - 50Watt Solar Panel.

4.2 Solar Charge controller

A 50-watt panel solar charge controller regulates electricity moving from the panel to the battery. By keeping an eye on the battery voltage and modifying the charging current as necessary, it avoids overcharging. To maximize power transfer, it usually makes use of maximum power point tracking (MPPT) or pulse width modulation (PWM). A 12-volt battery system is work with a minimum 10-amp driver for a 50-watt panel. It ought to feature safeguards against reverse polarity, short circuits, overcharging, and overcharging. Real-time status updates are provided by digital displays or LED indicators. Durability is ensured by efficient heat evacuation and waterproof construction. All things considered, this guarantees the PV system's lifetime and functionality [9]. Figure 2 shows Solar Charge controller.

Fig. 2. Solar Charge controller.

4.3 Wind Turbine

There are various types of wind turbines, each of them are designed for specific applications and environment conditions. Here is a brief overview of common types of wind turbines:

4.3.1 Horizontal Axis Wind Turbines (HAWT)

The most prevalent kind. Like a typical windmill, the blades revolve around a horizontal axis. installed on towers primarily to capture stronger winds. categorized as either a three- or two-blade model. Suitable for common and small-scale uses [10].

4.3.2 Vertical Axis Wind Turbines (VAWT)

The axis on which blades rotate is vertical. Without a revolving mechanism, wind can be captured from any direction. Compared to HAWT, lower profile and simpler maintenance. However, they are often weaker and less prevalent than HAWTs. Its compact design makes it appropriate for usage in both urban and suburban settings [11]. Fig. 3.shows the wind turbine

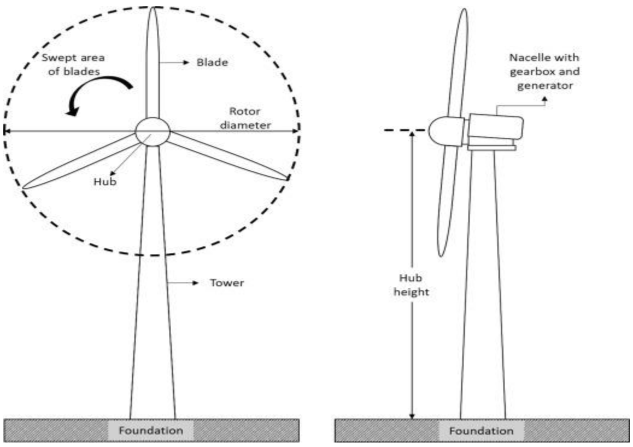

Fig. 3. Wind Turbine

4.4 MPPT

In the solar power systems efficiency is to maximize so Maximum Power Point Tracking, or MPPT, is a crucial technology utilized in solar charge controllers and inverters. Through constant monitoring and adjustment of the panels' electrical working point, the MPPT is engineered to optimize solar panel output. The maximum power point (MPP) of solar panels is the amount of energy they can generate. This point fluctuates based on elements like temperature and the amount of sunlight. In order to maximize energy yield, MPPT algorithms dynamically modify voltage and current to guarantee that solar panels run at or near MPP levels [12].

It functions by continually sampling the output voltage and current of the solar panels through the employment of sophisticated algorithms using MPPT controllers. The controller determines the ideal operating voltage and current by analyzing these factors, resulting in the highest possible power output. It then modifies the solar panels' output voltage and current to keep them operating at or close to MPP [13].

4.4.1 Types of MPPT Controllers

PWM MPPT Controllers

These controllers control the battery charging process by pulse width modulation, or PWM. They are less effective than other types, while being simpler and less expensive, particularly in colder climates or with less light.

DC-DC MPPT Converters

These controllers use DC-DC conversions to optimize the output of solar panels. They offer greater efficiency and better performance over a wider range of operating conditions than PWM controllers.

MPPT Charge Controllers with Inverters

Some MPPT controllers are integrated with inverters in grid-connected or off-grid PV systems, providing an all-in-one solution to maximize energy performance and power management [14]. Figure 4 shows lock diagram of MPPT

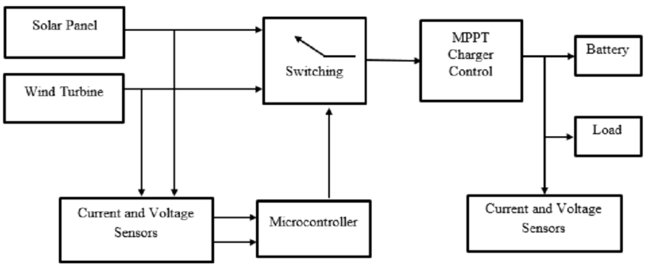

Fig. 4. Block Diagram of MPPT.

4.5 DC Generator

Direct current generators are electromechanical devices that transform mechanical energy into electrical energy. They are usually employed in situations where a controlled and consistent voltage output is needed [15].

4.5.1 Types of DC Generators

Permanent Magnet DC Generators

These generators use permanent magnets to create a magnetic field in the generator. They are simple in structure, compact and light. Often used in small-scale applications such as portable generators, small wind turbines and automotive systems [16, 17].

Separately Excited DC Generators

In these generators, the magnetic field is produced by a separate DC power source, such as a battery or another generator. The excitation current is supplied to the field winding through slip rings and brushes. Separately excited generators offer precise control over the output voltage and are commonly used in industrial applications where voltage regulation is critical.

Self-Excited DC Generators

Self-excited generators create the magnetic field necessary for operation using the output voltage of the generator itself[18,19]. The Fig. 5 shows general diagram of dc generator

Generator voltage rating = 24 v
Max RPM = 3000

RPM to voltage ratio of generator = RPM / Voltage

=3000/24v
=125

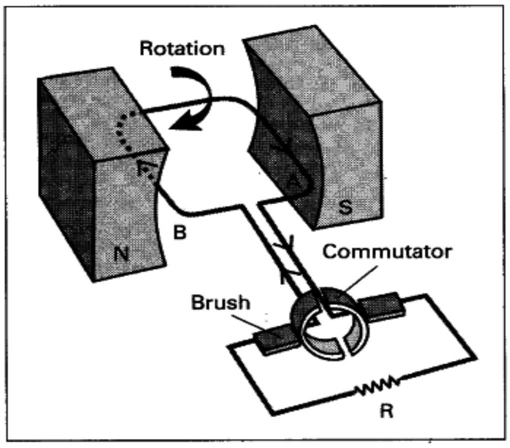

Fig.5. General diagram of dc generator.

4.6 *Stepdown Transformer*

A transformer reduces the level of voltage from the main winding or input to the secondary winding (output) is known as a step-down transformer [20]. A primary winding and a secondary winding are the two sets of windings that make up an installation transformer [21]. Less turns are on the secondary winding in an installation transformer than there are on the main winding. The field of the transformer core is created when an alternating voltage is applied to the primary winding; this field then creates a voltage in the secondary winding. The number of turns between the main and secondary windings determines the voltage induced in the secondary winding[22]. The secondary voltage in a fixed transformer is less than the primary voltage. Figure 6 shows the diagram of 12-0-12 Transformer

Input Voltage: 220 volts AC
Output Voltage: 12 volts AC

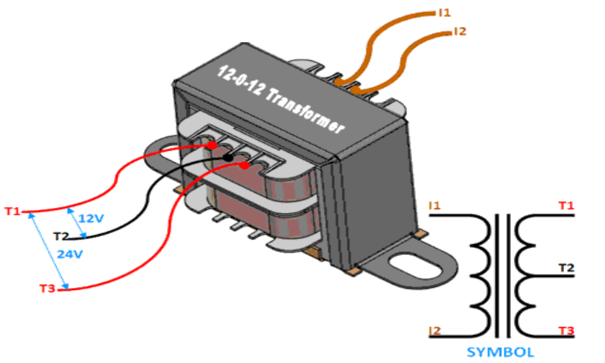

Fig. 6. Diagram of 12-0-12 Transformer.

4.7 *Rectifier Circuit*

The rectifier circuit is need to convert alternating current (AC) to direct current (DC). It is often made up of diodes placed in a particular order to correct alternating current. To maximize efficiency, a full-wave rectifier circuit is typically utilized for converting 12 volts AC to 12 volts DC. The AC input voltage is reduced by the transformer to 12 volts AC. Diodes convert alternating current into pulsating direct current, allowing current to flow in only one direction. The filter capacitor smooths the output voltage, reducing ripple. Charge a device or circuit that consumes direct current [23]. Figure 7 shows diagram of Bridge Rectifier circuit

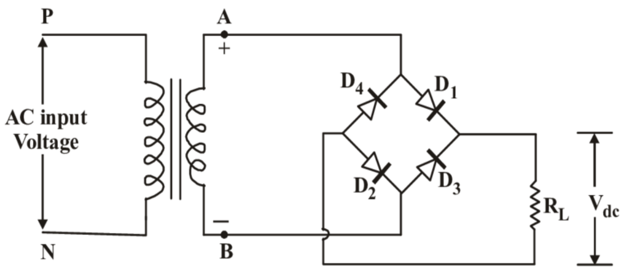

Fig. 7. Diagram of Bridge Rectifier circuit.

4.8 *Battery*

There are Rectifier circuits to convert alternating current (AC) to direct current (DC). When rectifying alternating current, it often consists of diodes arranged in a particular way. For maximum efficiency, a full-wave rectifier circuit is typically utilized for converting 12 volts AC to 12 volts DC. 12 volts AC is the lowest voltage that the transformer can produce. Diodes convert alternating current into pulsating direct current, allowing current to flow in only one direction. The filter capacitor smooths the output voltage, reducing ripple. Charge a device or circuit that consumes direct current [24].

4.9 *Inverter Circuit*

An inverter is an important component of electrical systems and is responsible for converting direct current (DC) to alternating current to accomplish efficient conversion, the inverter goes through a complex process including pulse width modulation (PWM) or sinusoidal pulse width modulation (SPWM) using semiconductor devices like MOSFETs or IGBTs. At its core, the inverter produces an AC output waveform that mirrors the desired frequency and voltage parameters by fast and carefully adjusting the DC input voltage [25]. The modulation index, switching frequency, and output waveform distortion are the key technical terms in order to comprehend how this operates. Solar energy systems, UPS power supplies, electric car energy systems, and grid-connected inverters for renewable energy integration are just a few of the various uses for the inverters. Inverters are mostly used in following different applications, including solar energy systems, UPS power supplies, electric vehicle energy systems and grid-connected inverters for renewable energy integration [26, 27]. Fig. 8 shows the Inverter Circuit.

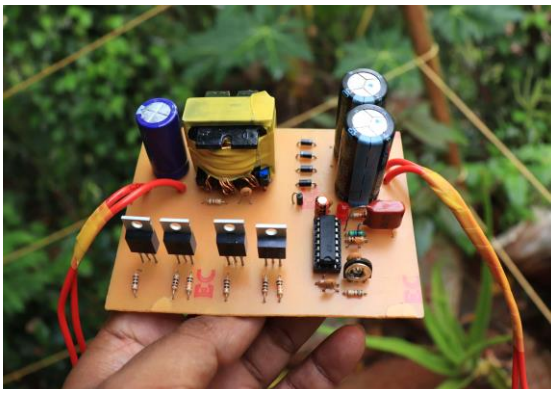

Fig. 8. Inverter Circuit.

5. BLOCK DIAGRAM

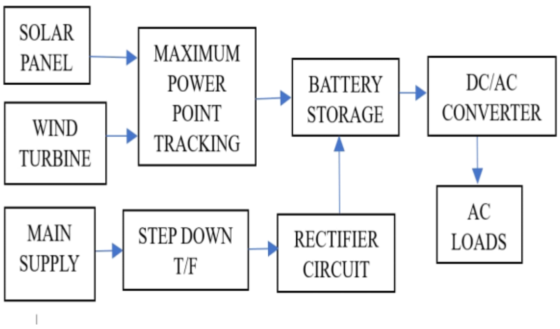

Fig. 9. Block diagram of Hybrid Energy Generation System using Solar Wind Combined System and Synchronization with Normal Supply.

6. WORKING

In this system we use solar panel as the first energy source [27]. which produce 12v DC and go to the MPPT solar terminal. And wind turbines are used as the second input source and connect the highest power point of the tracking wind connectors. By increasing the voltage level of each source individually, the MPPT combines these two current sources and outputs a steady 12 volts. It is thought of as a regular supply coming from the third source. which generate 12 volts AC after passing through a 12-0-12 clamp-on transformer. This 12volt AC source generates 12 volt DC by way of a rectifier circuit. The output of the MPPT and rectifier are both 12volt DC, and when these two sources are connected in parallel, they produce a 12volt DC output. This 12volt DC battery is used to charge and feed the inverter circuit, which uses it to convert the 12volt direct voltage to a 220volt alternating current source at a frequency of 50 Hz[28]. The Fig. 9. shows block diagram of hybrid energy generation system using solar wind combined system and synchronization with normal supply and [29,30] Fig. 10. shows model diagram.

7. MODEL DIAGRAM

The Figure 10 shows model diagram of the system.

Fig. 10. Model Diagram.

8. BENEFITS OF SYNCHRONISED HYBRID SYSTEM

There are various benefits to connecting a solar wind hybrid energy system to a traditional energy grid.

8.1 Reliability

Integrating wind and solar energy can increase system dependability. Combining solar and wind power can result in a more consistent output than using just one source since they complement each other [31]. The sun generates energy during the day, and the wind often blows at night.

8.2 Stability

Grid stability can be enhanced by a hybrid system that synchronizes with a traditional energy source. Weather-related changes in solar and wind power can occur, but they can be mitigated and the risk of blackouts or blackouts reduced with appropriate synchronization and energy management.

8.3 Reduction in Carbon Emissions

Carbon dioxide emissions are decreased when renewable energy sources like solar and wind power are used instead of fossil fuels [32,33]. It keeps the environment cleaner and aids in the fight against climate change.

8.4 Cost Savings

Integrating a solar-wind hybrid system can result in cost savings over time, depending on variables including regional subsidies, energy rates, and installation expenses. Unlike fossil fuels, whose prices are subject to fluctuations, solar and wind power are essentially free once deployed[34].

8.5 Energy Independence

Energy independence is increased by incorporating renewable energy sources since they lessen reliance on imported fossil fuels. This can be especially helpful for areas where energy imports are a major source of income.

8.6 Grid Support

In order to improve the overall stability and effectiveness of the electricity grid, hybrid solar wind systems can offer extra services like frequency and voltage management [35]. Technological Advancements: Technology advancements in energy storage, grid management, and renewable energy technologies are fostered by the integration of solar-wind hybrid systems into the conventional grid, which benefits the industry as a whole.

9. CALCULATION

9.1 Efficiency Calculation of System

Input Voltage = 13.2V
Input Current = 4.2A
Input Power = Input Current * Input Power
= 13.2 * 4.2
= 56.76W

Output Voltage = 12.23V
Output Current = 3.268A
Output Power = Output Voltage * Output Current
= 12.23 * 3.268
= 39.77W

$$\text{Efficiency of System} = \frac{output\,power}{input\,power}$$

$$= \frac{39.977}{56.76}$$

Efficiency = 0.7043

Percentage Efficiency = Efficiency * 100
= 0.7043 * 100
= 70.43%

9.2 Cost Calculation of Project

Panel Cost Calculation

Cost of panel 〈₹〉 = 1850
No of panel = 1
Life of panel = 25 Years
25 Years cost 〈₹〉 = 1850

$$1 \text{ Year cost } 〈₹〉 = \frac{1850}{25}$$

= 74

Battery Cost Calculation

Cost of Battery = 1800
Life of Battery = 10 Years
10 Year cost = 1800
1 Year cost = 1800/10
= 180

Wind Turbine Cost Calculation

Cost of wind turbine = 2200
Life of turbine = 10 Years
10Year cost = 2200
1 Year cost = 2200/10
= 220

Capital Cost Calculation

Let annual cost of solar panel = C_P
Let annual cost of battery = C_B
Let annual cost of turbine = C_T
Let total annual capital cost of the system = CA
$C_A = C_P + C_B + C_T$
= 74+180+220
= 474/Year

10. CONCLUSION

To put it succinctly, the study has highlighted the solar-wind hybrid energy production systems' encouraging potential to address the problems associated with sustainable energy production. By combining the complementing qualities of wind and solar energy, these systems are more stable and dependable than standalone ones. Furthermore, a crucial first step toward a seamless integration with the current infrastructure is synchronizing such hybrid systems with a traditional distribution network. The hybrid system can dynamically alter its output to react to variations in demand by using sophisticated control algorithms and grid synchronization techniques, which helps to maintain the flexibility and stability of the grid. The study's findings highlight how crucial it is to keep investing in and developing innovative renewable energy technology.

Hybrid solar and wind systems, along with effective grid synchronization techniques, show great promise to fulfill the world's increasing energy demand while mitigating environmental damage as we move towards a cleaner and more sustainable energy future. Prospective investigations and advancements need to concentrate on refining the efficaciousness, economical viability, and regulatory impediments to the extensive implementation of these systems. Through the optimal utilization of solar-wind hybrid generation and their smooth integration into current power networks, we may create a more egalitarian, sustainable, and sustainable energy environment for coming generations.

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