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Utilizing Hybrid Power Generation System Making Smart EV Charging Station for Sustainable Transportation

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Abstract: ***In today's technology-driven world, electricity is one of the most important things in our daily lives. Because we all don't know that renewable energy sources run out immediately. So it is time for us to shift our focus from conventional energy sources to unconventional energy production. The hybrid system can be used both in industry and at home. In this project we will generate electricity from unconventional and conventional sources. All renewable energy sources, such as solar energy, wind energy, are used to produce electricity in industry. This paper deals with the use of a solar-electric-wind system in the design of a hybrid energy system. Use of Battery can reduce the need to maintain electrical cables and we can manage the load demand at very high times. The project shows that the renewable hybrid energy system using Supercapacitor. It creates a pollution-free environment.***

Keywords: Solar energy, wind energy, Hybrid power system, Battery, power saving etc.

I. INTRODUCTION

Renewable energy sources provide clean energy that is sufficient on earth. These renewable sources are obtained from land, water, sun, plants, etc. These sources are widely used in the production of electricity. Solar and wind power generation are attractive sources because they are environmentally friendly. A hybrid system is a mixture of different renewable energy sources such as solar energy, biomass electricity, wind energy, etc. In hybrid energy production, the produced power is first stored in the battery and then used to meet the energy demand. Today, the wind and solar energy system is growing rapidly, and the traditional energy source is depleting every day and disappearing in the coming years. So we must look for a new source of energy that is non-polluting and easily accessible. On sunny days you get energy from the sun and on cloudy days from the wind system.

A growing global problem related to rapid economic development and a relative lack of energy, because we all do not know that renewable energy sources are quickly running out. So it is time for us to use both conventional and non-conventional sources of energy to generate electricity. Today,

Supercapacitors are widely used. These high pressure and efficient energy storage devices are also known as ultracapacitors or electrochemical double layer capacitors (EDLC). Their favorable properties make them ideal for use in energy storage systems, including the ability to charge and discharge quickly without losing efficiency in the long term. The supercapacitor package can be used in a HESS (battery-supercapacitor system), which integrates various energy storage technologies with a specific control strategy that maximizes the benefits of each energy source used for overall efficiency.

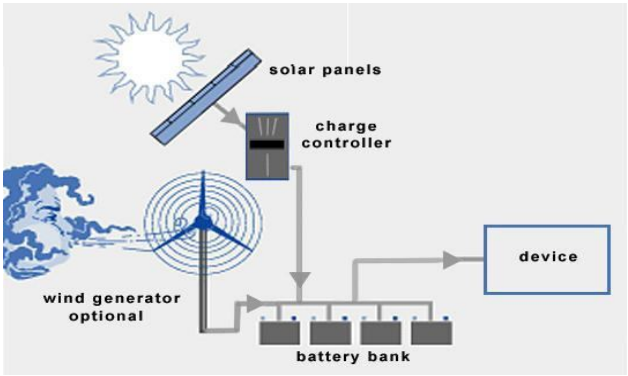


Fig. 1 Schematic of a conventional photovoltaic Hybrid System.

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II. PROBLEM STATEMENT

The use of renewable energy as a source of energy is expanding as the price of petroleum fluctuates. Therefore, it is crucial that engineering and technological students have a grasp of and awareness of technology related to renewable energy at the educational level. Solar energy is one of the most popular renewable energy sources. There is a lot of research being done to develop alternatives to improve the efficiency of photovoltaic systems (solar panels). One such method is to employ a solar panel tracking system.

Key Statement:

- Install sources such as horizontal axis wind turbines to increase power outages.
- Also add a solar system to generate electricity.
- Create a similar model that will be able to reflect system features and functionality as needed.

III. BEHIND RESEARCH

Fast charging as an indoor electric vehicle board is hindered by the cost of the electronic components needed to convert the electricity, which increases the overall cost of the electric car. However, built-in chargers cannot ensure fast EV charging due to the high cost of EV-related electronics and increasing the charging capacity of the car.

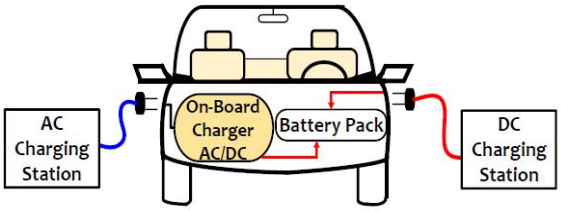


Fig.2. Hybrid EV Charging Station

To ensure faster charging of electric vehicles, external chargers are used that provide high direct current. It is worth noting that in external chargers, the entire conversion from AC/DC is done by an independent inverter. That is why it is important to increase the power of the converters to ensure faster charging of the car. The results of several published studies have been used in the design and development of efficient and reliable electric vehicle charging systems at electric vehicle charging stations.

A. Hybrid Power

A hybrid power tool combines two energy sources to supply electricity efficiently. It is a system designed to generate power using multiple sources, ensuring reliability, efficiency, and low emissions at a minimal cost. In the proposed system, solar and wind energy are utilized for electricity generation. These renewable sources offer significant advantages over conventional power, providing a sustainable and cost-effective solution. The system requires minimal investment and can be installed anywhere without location constraints. By integrating solar and wind power, the hybrid system ensures continuous energy availability, making it an ideal choice for various applications. In this proposed gadget, solar and wind power are employed to generate electricity. Sun and wind strength have distinct advantages as compared to all other unconventional electricity sources. Each power asset is required in all areas. It desires a low fee. There is no need to identify a specific area to put in this gadget.

B. Solar Power

Solar energy is power generated by the sun's radiation, which is constantly and readily available on the earth. It is freely accessible, does not emit pollutants, has minimal upkeep expenses, and is cost-effective. However, it has difficulty producing power in bad weather conditions. Solar energy is more efficient than conventional sources, requiring an upfront investment but having a longer lifespan and lower emissions.

C. Wind Power

Wind power is generated from the wind utilizing a windmill, which is a sustainable energy source with minimal production and maintenance costs. Wind energy is accessible virtually 24 hours a day and produces little emissions. The starting cost is cheaper than for solar energy, and the amount of power produced is determined by the direction of the air flow.

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The recommended Hybrid Energy System mixes solar and wind power to solve the short-term nature of individual renewable energy sources. This provides continuous power generation, increases dependability, and overcomes the limitations of individual sources. The system may be deployed in remote places, lowering gearbox costs while providing a dependable, low-emission, and cost-effective option providing continuous power delivery.

IV. PROJECT DESCRIPTION

A. Block Diagram

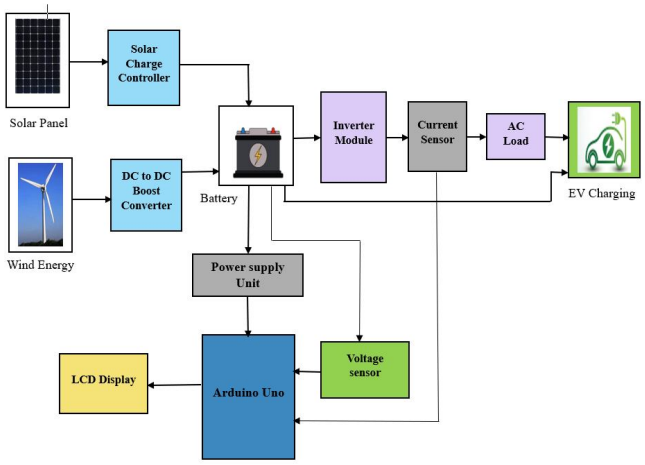


Fig. 3. Block Diagram of system

V. WORKING

- The system uses a hybrid renewable energy source consisting of a solar panel and a wind energy generator.
- Solar PV output is regulated through a solar charge controller to ensure safe and efficient battery charging.
- Wind energy output is conditioned using a DC–DC boost converter to maintain a constant DC voltage level.
- Both solar and wind sources charge the battery bank, which acts as an energy storage and buffering unit.
- The stored DC power from the battery is supplied to an inverter module to convert DC into AC power when required.
- AC output is used for EV charging or other AC loads, while DC power can be directly utilized for DC charging.
- Voltage and current sensors continuously monitor battery voltage, load current, and power flow.
- Sensor data is processed by the Arduino Uno controller for real-time monitoring and control.
- Measured parameters such as voltage, current, and battery status are displayed on the LCD screen.
- An energy management algorithm prioritizes renewable sources and uses grid power only when batteries are depleted.

A hybrid energy system for Smart EV Charging Stations integrates solar panels and wind turbines to ensure a continuous power supply. The energy generated by both sources is stored in batteries, which then supply power to charging stations. Wind turbines generate electricity when there is wind, while solar panels harness energy during daylight hours. Both systems can operate simultaneously, maximizing power generation.

Batteries play a crucial role in maintaining an uninterrupted power supply, ensuring that EVs can be charged even during low energy production periods. Although the initial investment in a hybrid system is high, its durability, long lifespan, and low maintenance costs make it a cost-effective and sustainable solution.

The wind turbine produces DC power, which is converted into AC using an inverter, making it compatible with EV charging stations. The system dynamically adjusts power generation based on real-time environmental conditions, utilizing both energy sources or prioritizing the most efficient one at any given moment.

By integrating renewable energy sources, hybrid-powered EV charging stations reduce dependence on fossil fuels, lower carbon emissions, and support green transportation. This approach ensures a reliable, eco-friendly, and self-sustaining energy solution for the growing demand for electric vehicles.

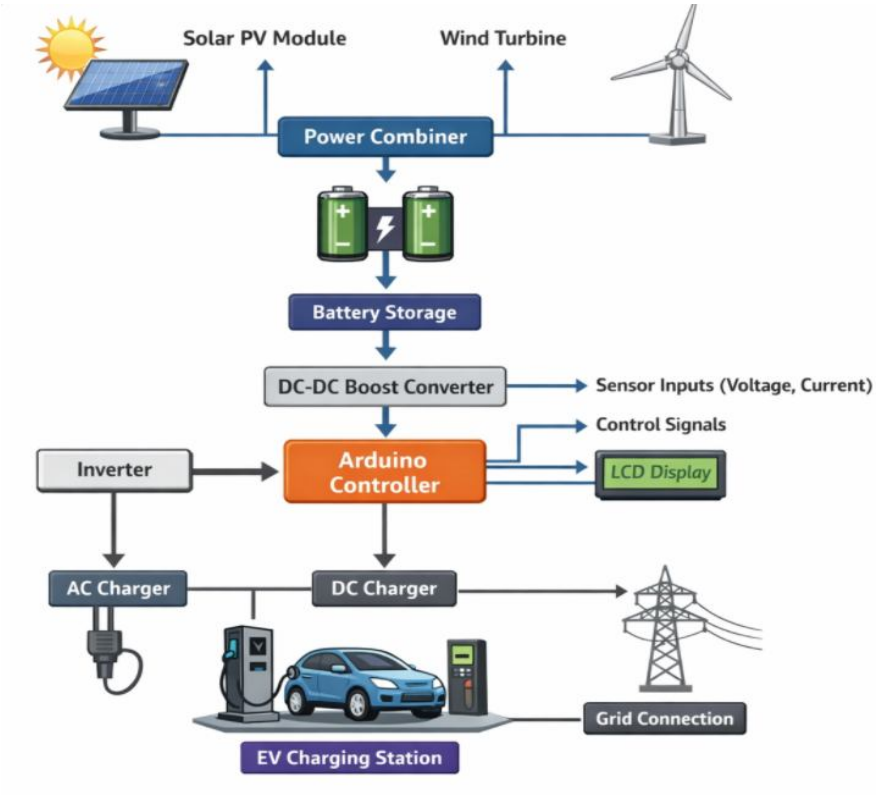


Fig.4. Flow chart of working system

Solar PV Module :
- Converts solar energy into electrical power for EV charging.
- Provides clean, renewable energy and reduces grid dependency.

Wind Energy Generator :
- Generates power during windy conditions, complementing solar energy.
- Enhances system reliability under varying weather conditions.

Battery Energy Storage System :
- Stores excess energy generated from solar and wind sources.
- Ensures uninterrupted EV charging during low renewable availability.

DC–DC Boost Converter :
- Maintains constant DC voltage from variable renewable inputs.
- Improves charging efficiency and system stability.

Inverter Module :
- Converts stored DC power into AC power for AC charging needs.
- Enables both AC and DC charging options.

Arduino Microcontroller Unit :
- Acts as the central control and decision-making unit.
- Executes energy management and source selection algorithms.

Voltage and Current Sensors :
- Continuously monitor power flow, battery voltage, and load current.
- Provide real-time feedback for safe and efficient operation.

LCD Display :
- Displays system parameters such as voltage, current, and battery status.
- Enhances user interaction and system monitoring.

VI. COMPONENTS

1) Wind Generator
2) Solar Panel
3) Solar Charge Controller
4) LCD Display
5) Development Board
6) Inverter Module
7) Voltage Sensor
8) AC Load
9) Charging Socket
10) Adapter
11) LED Indicator
12) Others

VII. COMPONENTS SPECIFICATION

A. *Solar Panel (12v25w)*

Solar energy is that energy which we get from the sun in form of radiation. It does not cause any kind of pollution, it is inexhaustible. It is available free of cost. A solar cell is used to convert solar energy into electric energy, it is also known as photovoltaic cell.



B. *DC Generator (12v)*

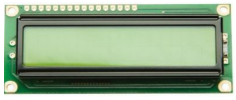
A DC generator is an electrical machine whose main function is to convert mechanical energy into electricity.



C. *LCD Display (5v)*

A liquid crystal display (LCD) is a thin, flat panel used for electronically displaying information such as text, images, and moving pictures.

LCD stands for **L**iquid **C**rystal **D**isplay. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs)



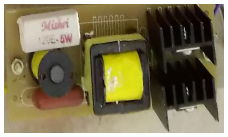
D. *DC to DC boost Converter (Regulated 12v)*

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination.



E. Inverter (12v DC to 220v AC)

As we know that most of the electrical appliances require AC voltage, so first the DC output of the batteries will be converted into AC voltage with the help of an inverter and then it will be transferred to the loads. The inverter must be having over voltage protection, reverse polarity and short circuit protection.



F. Inverter

An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.



G. SMPS Unit (220v AC to 12v DC)

SMPS is an electronic power supply system that makes use of a switching regulator to transfer electrical power effectively. It is a PSU (power supply unit)



H. PCB's Board



A printed circuit board (PCB) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate.

VIII. PROPOSED CALCULATIONS

Total energy generated by the system is the total energy generated by the solar PV panel and the power generated by the wind turbine. According to statistics, it can be represented by,

PT = NW * Pw + Ns * PS

There,

Total energy generated = PT

Power generated by wind turbines = PW

Energy produced by solar panels = PS

Wind turbine number = NW

Number of solar panels used = NS

A. Calculations for wind Energy

The energy produced by wind power is provided by,
Energy = (air density * swept area * cubed velocity) / 2
PW = ½. ρ (AW) (V) 3
There,
P is the power in watts (W)
ρ air pressure per kilogram per cubic meter (kg / m³) AW area of air per square meter (m²) V wind speed per meter (m / s).

B. Calculations for Solar Energy

To determine the size of the PV modules, the required power consumption should be measured. Therefore, power is calculated as
PS = Ins (t) * AS * Eff (pv)
There,
Ins (t) = separation at t (kw / m2)
AS = one PV panel area (m2)
Effpv = full efficiency of PV panels and dc / dc converters.
The overall efficiency is provided by,
Eff (pv) = H * PR
There,
H = Annual rate of solar radiation on oblique panels.
PR = Performance rate, loss coefficient.

C. Cost

The total cost of a solar-wind energy system depends on the total number of wind turbines used and the total number of solar panels used. The total cost is therefore provided as follows
Total Cost = (Wind Turbine Number * Cost of One Wind Turbine) + (Solar Panel Number * Cost of One Solar Panel) + (Number of Batteries Used in Battery Bank * Cost of One Battery)
CT = (NW * CWT) + (NS * CSP) + (NB * CB)
There,
CT is the total cost per Rs
CWT is the cost of a single wind turbine
CSP costs one day panel per Rs
CB One Battery Cost Rs
NW is the amount of wind turbine used
NS is the number of solar panels used
NB is the number of batteries used in the Battery Bank.

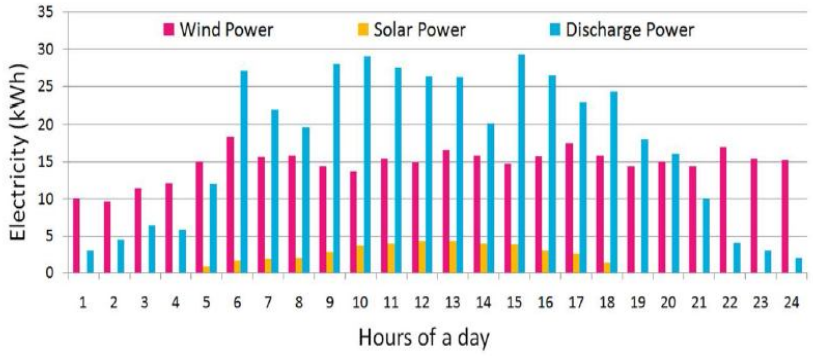


Fig. 5. Hourly generated electricity by both wind and solar from the proposed method.

The hourly required load, the total power generated by the recharging station, and the power supplied to the grid are shown in Fig. 5. In some cases such as hour 1-3.5 and 12-16.5 the station supplies few kilowatt of power to the grid.

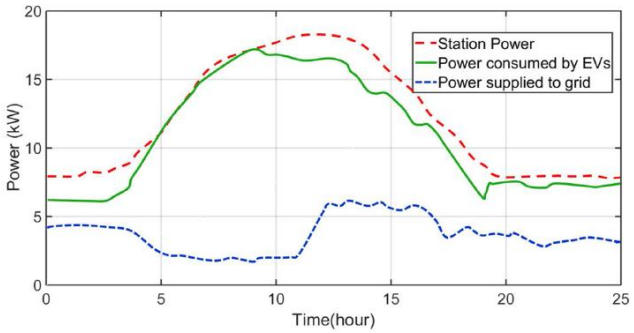


Fig. 6. Hourly power measured during a day.

IX. ADVANTAGES WITH HYBRID SYSTEM

1) During the rainy season and winter the amount of sunlight is insufficient as this season energy is complemented by the wind energy system.
2) Due to climate change when there is a lack of wind power beyond the power provided by solar panels.
3) Low operating costs and maintenance costs make you a savings.
4) Used in any place whether it is remote or crowded.
5) Efficient power generation
6) Solar and wind sites benefit the environment as they will reduce carbon and other harmful pollutants by about 90% in the area.

X. APPLICATIONS

1) Distributed electricity generation
2) Hospital, Hotels, Guest House etc.
3) Electricity installation in remote and rural areas.
4) Street lighting.
5) Transfer and contact Tower with multiple application.

XI. CONCLUSION

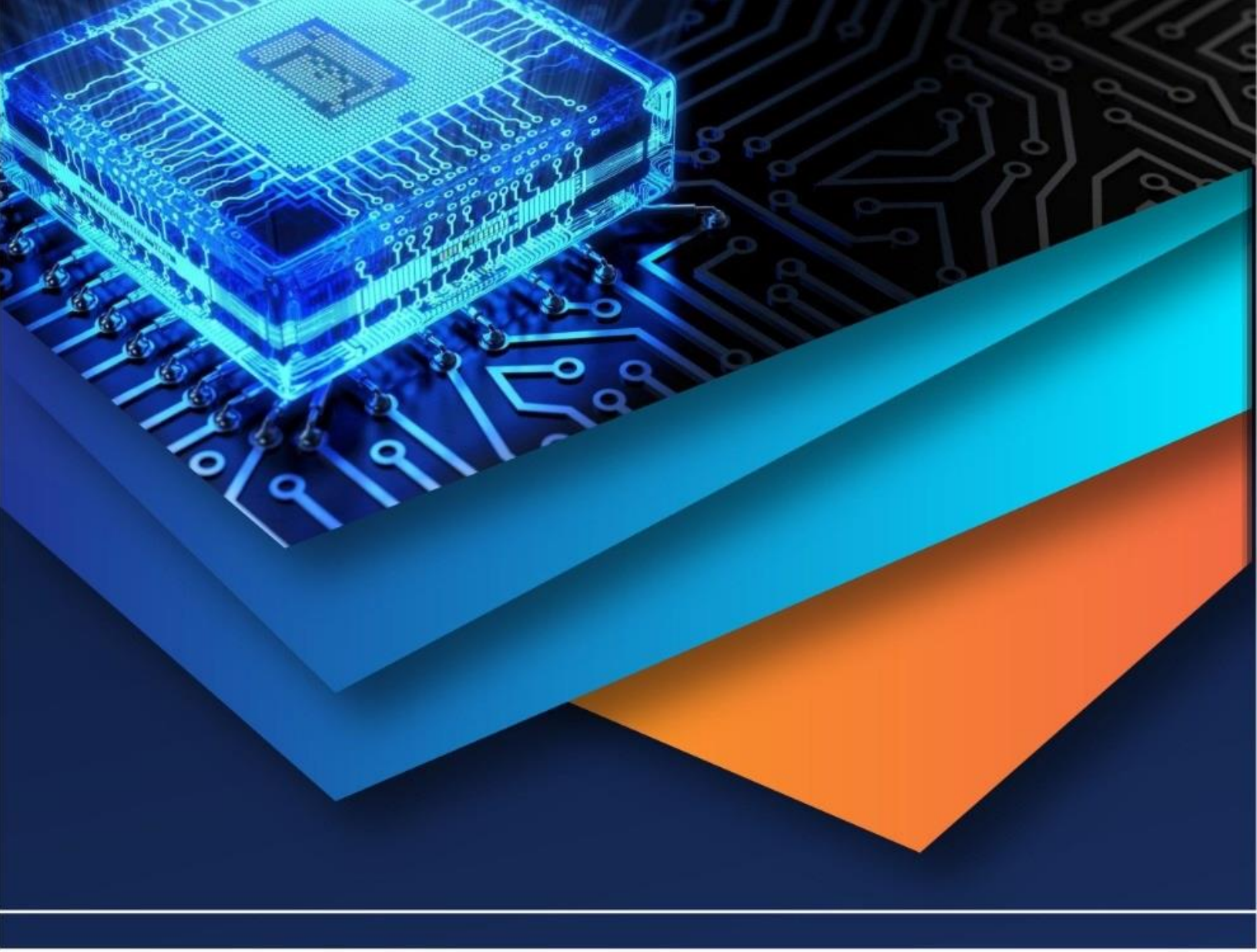
The easiest and most effective method for producing electricity needs portable hybrid systems to generate power from supercapacitors instead of using non-renewable energy sources. The product incurs high costs because it requires expensive materials which result in no environmental harm. The system enables power generation in mountainous regions which experience challenges in conventional electricity distribution. The user has the ability to choose their preferred operational environment. People worldwide need to embrace exceptional energy resources which enable them to produce dependable electricity. Your preferred location provides the best experience through its enduring quality which requires only basic maintenance. The system requires a greater expense at the beginning of the project. The mixed system produces extra costs for each unit of production but effectively utilizes its available resources according to our understanding. The Hybrid program possesses the ability to recover from any unexpected incidents or undesired outcomes. The hybrid system provides power solutions for people living in isolated locations and remote countryside regions. The Hybrid system represents the optimal solution according to all available information.

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