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SUSTAINABLE HYBRID SOLAR POWER ENERGY

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Abstract - Now a day's electricity is very important facility for the human being. All the conventional energy resources are changing day by day. So we have to move from conventional to non-conventional energy resources. So we move toward solar energy. This process converts the sustainable energy resources without damaging the nature. Solar energy converted into electricity by using solar panels. This electrical power can utilize for various application. Generation of electricity will be takes place at low cost. Without damaging the nature balance, this paper deals with the generate electricity with affordable cost.

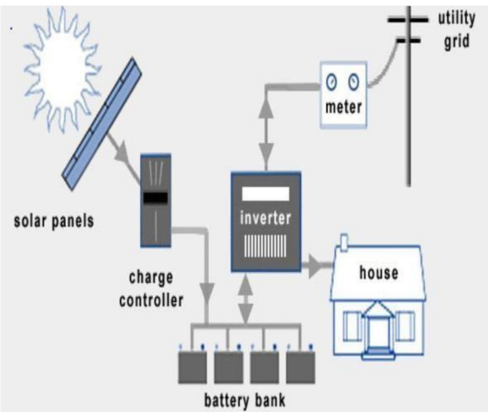
Key Words**:** Solar Panels, Wind Power System, Hybrid Power System

INTRODUCTION

Solar energy systems come in various configurations, and the choice is yourswhether you go off the grid or stay on the grid. This paper discusses the advantages of a Solar hybrid system, grid tied solar systemand standalone solar systems (or Off-Grid solar systems). Grid-tied, on-grid, utility- interactive, grid intertie and grid back feeding are all terms used to describe the same concept – a solar system that is connected to the utility power grid.

A. Grid-Tied Solar System

Grid-tied, on-grid, utility-interactive, grid intertie and grid back feeding are all terms used to describe the same concept – a solar system that is connected to the utility power grid.



(Fig 1: Grid-Tied Solar System)

Advantages:

- As it does not require battery banks and other standalone components, it is relatively cheaper than Off-Grid or hybrid systems.
- It facilitates you to take advantage of net metering. Any extra electricity that you produce can be sold back to the utility. This means that by the end of the month, you only pay for the net kWH electricity used.

Disadvantages:

- Since you do not have a battery bank, you can't store electricity. If during the night your grid is down, you will not have any electricity.
- Utility companies charge monthly fees thatyou'll need to pay.

A. Off-Grid Solar Systems

To always ensure access to electricity, off-grid solar systems require battery storageand a backup generator (if you live off-the- grid). On top of this, a battery bank typicallyneeds to be replaced after 10 years. Batterie are complicated, expensive and decreaseoverall system efficiency.

Advantages

- Only option if you live in a remote area with no grid access
- Feeling of being self-sufficient for your energy demands is great. Grid failures and downtime won't affect your power supply

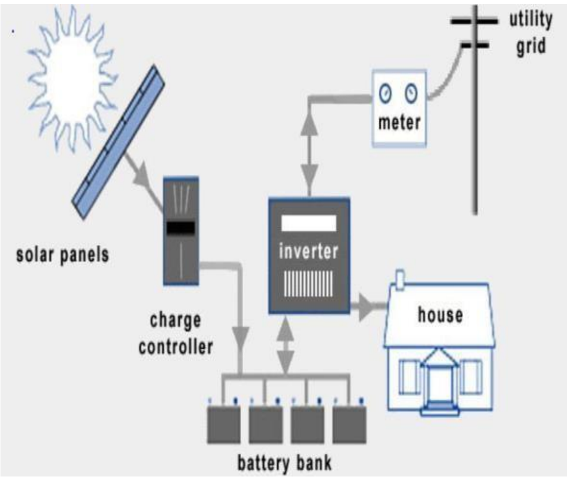
Disadvantages

- The additional costs of installing a battery bank, and in some cases an alternative source of power like a diesel generator, makes these systems more expensive than a grid tied system.
- Standalone systems have more components and therefore need moremaintenance. Especially the batteries need regular care.

- Replacement of battery banks is another problem. Battery banks are designed to last for 7-10 years after which they need to be replaced. This is a cost that you need to take into account.

B. Hybrid Solar Systems

Hybrid solar systems combines the best from grid-tied and off-grid solar systems.These systems can either be described as off-grid solar with utility backup power, or grid-tied solar with extra battery storage.



(Fig 2: Hybrid Solar Systems)

Advantages:

- You can switch between power from the grid or power from your battery bank at you own will.
- Less expensive than a complete standalonesystem, as there is no need for a backupgenerator. The possibility to connect to the grid serves as the backup power.
- Availability of the grid means that you canlikely downsize your battery bank capacity.
- Less maintenance and higher reliability IF the grid is reliable.

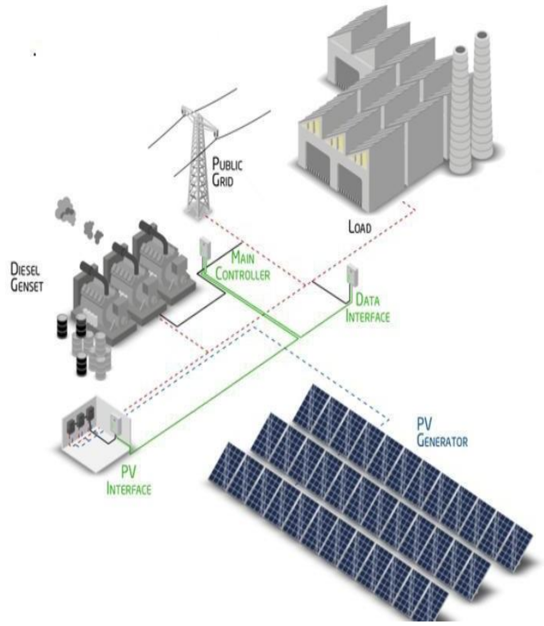
Disadvantages:

- Cannot be used in remote areas wherethere is no grid power

EXISTING HYBRID SOLAR SYSTEMS

C. PV-diesel-hybrid-power plants

PV-diesel-hybrid-power plants without storage have rather low capital requirements.In the picture there is an option to connect the plant to the grid, which is applied inregions with an unstable grid. In the typical off-grid solution, the electricity from the solarpower plant is used with priority, the diesel gensets generate the missing gap between the solar output and the load from the mine

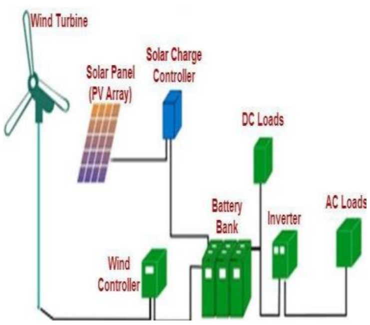


(Fig 3: PV-diesel-hybrid-power plants)

The hybrid off-grid power plant without storage requires rather low investment costs.As neither solar nor wind energy are a stablesource of energy and diesel gensets need a certain time for start-up, this solution normally requires the gensets to run constantly at least at a minimum load

D. Solar-Wind hybrid Power system

Solar-Wind hybrid Power system is the combined power generating system by wind mill and solar energy panel. It also includesa battery which is used to store the energy generated from both the sources.



(Fig 4: Solar-Wind hybrid Power system)

Using this system power generation by windmill when wind source is available and generation fromPV module when light radiation is available can be achieved. Both units can be generatedpower when both sources are available. By providing the battery uninterrupted powersupply is possible when both sources areidle

A solar-wind hybrid power system is an ingenious combination of two renewable energy sources: solar panels (photovoltaic or PV panels) and wind turbines. By harnessing the strengths of both wind and solar power, these hybrid systems maximize energy production. Here's what you need to know about them:

Why Hybrid Solar-Wind Systems?

The word "hybrid" signifies a combination of two different types of varieties. In the context of renewable energy, hybrid systems can generate electricity using a mix of PV panels, wind turbines, or even water turbines.

The most common hybrid power generation system involves combining solar panels with wind turbines.

The rationale behind this hybrid approach is that solar energy and wind energy often don't deliver simultaneously. For instance:Solar panels produce energy during the day when the sun shines.Wind turbines can supply power during the night when the sun doesn't shine.

In off-grid situations, where maintaining a reliable electricity supply is crucial, integrating wind turbines can be more cost-effective than adding additional battery banks.

How Does a Solar-Wind Hybrid System Work?

The components in a hybrid power system differ from a standard PV solar array installation.

Here's how it works:

Solar panels capture sunlight and convert it into electricity during daylight hours.Wind turbines harness wind energy and generate electricity, regardless of the time of day.

These two energy sources are connected through a battery system.The battery stores excess energy from both solar and wind sources.When one source (e.g., solar) is less productive, the other (e.g., wind) compensates.

The combined output provides a more stable and reliable energy supply.

Advantages of Solar-Wind Hybrid Systems:

Continuous Energy Production: Hybrid systems allow round-the-clock energy production by leveraging both solar and wind power.

Reduced Battery Costs: Instead of relying solely on batteries, wind turbines can contribute power during non-sunny hours, potentially reducing the need for expensive battery banks.

Fluctuating Weather Adaptability: Hybrid systems are especially useful in regions with varying weather patterns.

In summary, solar-wind hybrid systems offer the best of both worlds, ensuring a more reliable and sustainable energy supply.

CURRENT PV / DIESEL HYBRID INSTALLATIONS

Uganda Presently, hybrid systems in the 5 kWp range have been implemented at rural district headquarters and at a few industries. The deployment of this technology is still at the infant stage. The Rural Electrification Strategy and Plan established in 2011 aims

to connect over 500,000 new electricity customers to the main grid, independent grids, and to solar PV systems, with the support of local institutions (RuralElectrification Fund, Rural Electrification Board and Rural Electrification Agency). These institutions are willing to promote PV

/ diesel hybrid technology. REA has budgeted for feasibility studies in 2011-2012for hybrid solutions in Koome and Buvuma Islands (hybrid systems with wind, solar anddiesel sources). Kenya In 2011, a PV / diesel hybrid power plant was implemented (10 kWp PV, 80 kVA diesel).

It was the first of its kind in the country,with the implementation managed by KPLC. Burkina Faso Burkina Faso's Fund for the Development of Electrification has initiated a project in 2012 to add a solar PV component to existing diesel power plants inthe Sahel region. A previously installed PV array at the diesel plant in a remote locality in Sahel will soon be connected to the main grid. Madagascar In 2010, two hybrid systems based on PV were implemented: One funded by the government (7 kWp PV,

12 kW diesel) and one by the African Development Bank (8 kWp PV, 100 kW diesel).

V/Diesel hybrid systems combine the power of solar photovoltaic (PV) panels with diesel generators to create an efficient and sustainable energy solution. Let's delve into the details:

Advantages of Solar Diesel Hybrid Systems:

Reduced Diesel Costs: Solar power is more cost-effective and predictable in the long term compared to diesel-generated power.

Quick Return on Investment (ROI): The substantial savings potential makes investing in a photovoltaic system worthwhile.

Lower Carbon Footprint: Generating solar power helps reduce your environmental impact.

How a Solar Diesel Hybrid System Works:

Photovoltaic Modules: These modules, mounted on roofs or open spaces, generate solar power when exposed to sunlight. An inverter converts the direct current (DC) produced by the modules into alternating current (AC).

Inverter: The control center of the PV system, it supplies the self-contained network (MicroGrid) with as much solar power as possible.

PV System Controller: Measures energy flows in the PV/diesel system, optimizing photovoltaic power usage.

Diesel Generator: The primary energy source for hybrid systems. The more solar power generated, the lower the fuel costs.

Loads: Supplied with a mix of solar energy and fossil energy through the combination of a diesel generator and photovoltaic system.

Current Sensors: Measure power in the system.

Backup Feedback Contact: Facilitates the operation of the photovoltaic system, adapting to energy fed into the grid or parallel generator events1.

Applications:

Solar diesel hybrid systems are used in areas with unstable or non-existent mains supply, such as Orissa, Assam, Sikkim, Jammu and Kashmir, and Uttarakhand2.

These systems help save fuel costs, reduce CO2 emissions, and provide reliable energy supply.

Remember, every unused diesel kWh saves money, making the transition to solar/diesel hybrid systems a financially sound investment!

Hybrid Solar Cell

Hybrid solar cells combine advantages of both organic and inorganic semiconductors. Hybrid photovoltaics have organic materials that consist of conjugated polymers that absorb light as the donor and transport holes. Inorganic materials in hybrid cells are used as the acceptor and electron transporter in the structure. The hybrid photovoltaic devices have a potential for not only low-cost by roll-to-roll processing but also for scalable solar power conversion.

Solar cells are devices that convert sunlight into electricity by the photovoltaic effect. Electrons in a solar cell absorb photon energy in sunlight which excites them to the conduction band from the valence band. This generates a hole-electron pair, which is separated by a potential barrier (such as a p-n junction), and induces a current. Organic solar cells use organic materials in their active layers. Molecular, polymer, and hybrid organic photovoltaics are the main kinds of organic photovoltaic devices currently studied.

In hybrid solar cells, an organic material is mixed with a high electron transport material to form the photoactive layer.[2] The two materials are assembled together in a heterojunction-type photoactive layer, which can have a greater power conversion efficiency than a single material.[3] One of the materials acts as the photon absorber and exciton donor. The other material facilitates exciton dissociation at the junction. Charges are transferred and then separated after an exciton created in the donor is delocalized on a donor-acceptor complex.

The acceptor material needs a suitable energy offset to the binding energy of the exciton to the absorber. Charge transfer is favorable if the following condition is satisfied:

$$E_A^A - E_A^D > U_D$$

where superscripts A and D refer to the acceptor and donor respectively, EA is the electron affinity, and U the coulombic binding energy of the exciton on the donor. An energy diagram of the interface is shown in figure 1. In commonly used photovoltaic polymers such as MEH-PPV, the exciton binding energy ranges from 0.3 eV to 1.4 eV.

The energy required to separate the exciton is provided by the energy offset between the LUMOs or conduction bands of the donor and acceptor. After dissociation, the carriers are transported to the respective electrodes through a percolation network.

The average distance an exciton can diffuse through a material before annihilation by recombination is the exciton diffusion length. This is short in polymers, on the order of 5–10 nanometers. The time scale for radiative and non-radiative decay is from 1 picosecond to 1 nanosecond. Excitons generated within this length close to an acceptor would contribute to the photocurrent.

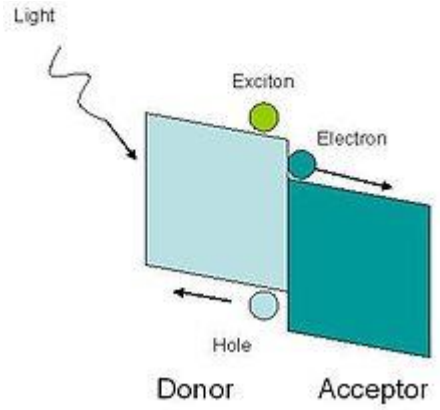


Figure. Energy diagram of the donor and acceptor. The conduction band of the acceptor is lower than the LUMO of the polymer, allowing for transfer of the electron.

To deal with the problem of the short exciton diffusion length, a bulk heterojunction structure is used rather than a phase-separated bilayer. Dispersing the particles throughout the polymer matrix creates a larger interfacial area for charge transfer to occur. Figure 2 displays the difference between a bilayer and a bulk heterojunction.

Types of interfaces and structures

Controlling the interface of inorganic-organic hybrid solar cells can increase the efficiency of the cells. This increased efficiency can be achieved by increasing the interfacial surface area between the organic and the inorganic to facilitate charge separation and by controlling the nanoscale lengths and periodicity of each structure so that charges are allowed to separate and move toward the appropriate electrode without recombining. The three main nanoscale structures used are mesoporous inorganic films infused with electron-donating organic, alternating inorganic-organic lamellar structures, and nanowire structures.

Mesoporous films

Mesoporous films have been used for a relatively high-efficiency hybrid solar cell.[9] The structure of mesoporous thin film solar cells usually includes a porous inorganic that is saturated with organic surfactant. Organic absorbs light, and transfers electrons to the inorganic semiconductor (usually a transparent conducting oxide), which then transfers the electron to the electrode. Problems with these cells include their random ordering and the difficulty of controlling their nanoscale structure to promote charge conduction.

Ordered lamellar films

Recently, the use of alternating layers of organic and inorganic compounds has been controlled through electrodeposition-based self-assembly.[10] This is of particular interest because it has been shown that the lamellar structure and periodicity of the alternating organic-inorganic layers can be controlled through solution chemistry. To produce this type of cell with practical efficiencies, larger organic surfactants that absorb more of the visible spectrum must be deposited between the layers of electron-accepting inorganic.

Films of ordered nanostructures

Researchers have been able to grow nanostructure-based solar cells that use ordered nanostructures like nanowires or nanotubes of inorganic surrounding by electron-donating organics utilizing self-organization processes. Ordered nanostructures offer the advantage of directed charge transport and controlled phase separation between donor and acceptor materials.[11] The nanowire-based morphology offers reduced internal reflection, facile strain relaxation and increased defect tolerance. The ability to make single-crystalline nanowires on low-cost substrates such as aluminum foil and to relax strain in subsequent layers removes two more major cost hurdles associated with high-efficiency cells. There have been rapid increases in efficiencies of nanowire-based solar cells and they seem to be one of the most promising nanoscale solar hybrid technologies.[12]

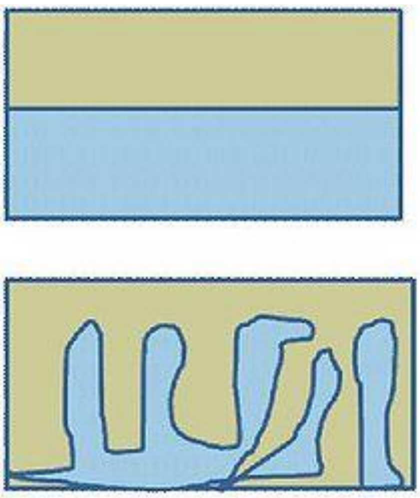


Figure : Two different structures of heterojunctions, a) phase separated bi-layer and b) bulk heterojunction. The bulk heterojunction allows for more interfacial contact between the two phases, which is beneficial for the nanoparticle-polymer compound as it provides more surface area for charge transfer.

Fundamental challenge factors

Hybrid cell efficiency must be increased to start large-scale manufacturing. Three factors affect efficiency.[2][13] First, the bandgap should be reduced to absorb red photons, which contain a significant fraction of the energy in the solar spectrum. Current organic photovoltaics have shown 70% of quantum efficiency for blue photons. Second, contact resistance between each layer in the device should be minimized to offer higher fill factor and power conversion efficiency. Third, charge-carrier mobility should be increased to allow the photovoltaics to have thicker active layers while minimizing carrier recombination and keeping the series resistance of the device low.

TECHNOLOGY OPTIONS TO INDIA

Among the three options that are available, the grid tied captive systems are the most prevalent in India. These are available up toa capacity of 100 kW, and typically do not use batteries. At the same time, standalone/captive based power plants in Indiaare evolving fast. Globally, most people do not run their entire load solely off their PV system. The majority of systems use a hybrid approach by integrating another power source. The most common form of hybrid system incorporates a gas or diesel powered engine generator, which can greatly reduce the initial cost. Meeting the full load with a PV system means the array and batteries need to support the load under worst-case weather conditions. This also means the battery bank must be large enough to power large loads. These requirements will make the system unviable owing to the high costs of battery storage.

Hence, a diesel-solar PV generator provides the optimal power supply source for India aswell, as the generator provides the extra energy needed during cloudy weather and during periods of heavier than normal electricity use and can also be charging the batteries at the same time. A hybrid system provides increased reliability because there are two independent charging systems at work. Another hybrid approach is a PV system integrated with a wind turbine.Adding wind turbines makes sense in the locations where the wind blows when the sun does not shine. In this case, consecutive days of cloudy weather are not a problem, so long as the wind turbine is spinning. While in theory this combination appears good, in practice this

combination has not delivered the benefits expected out of it, primarily owing to the less-than-optimal efficienciesof micro wind turbines. For even greater reliability and flexibility while using wind and solar, there are experimentations where a third source – diesel generator – has been included in a PV/Wind system. A generator system will act as a third charging source forthe batteries. This three-source hybrid is in its nascent stages in India.

CONCLUSION

The hybrid system will bring enormous benefit to the rural and remote areas of Indiawhere there is severe crisis of reliable supply of electricity. The study clearlyshows that the optimized wind-PV-diesel hybrid system is more cost effective in termsof Cost. The system will reduce the CO2 emission by several percentage thus bringing a local as well as a global carbon benefit. The potential of the system will promote socio-economic development to the local people by getting longer hours of electricity supply after sunset which will help the students to study more as well as local businessman to earn more. Technologytransfer and capacity building have also been developed in implementing combined renewable-fossil fuel power plants. However, the effectiveness of the hybrid system is promising enough that further analysis can be made to collect the additional data to perform a more detailed analysis.

Paper Submitted by Rohan Lad, Shubhangi Raut, Dhanashree Gund, Pavan Mudgade,Shweta Yadav

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