Nadar Saraswathi College of Engineering & Technology

# NSCET E-LEARNING PRESENTATION

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# ELECTRICAL AND ELCTRONICS ENGINEERING

**IVth YEAR / VIIIth SEMESTER**

## EE6009 – POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

**G.Sujitha M.E**
**Assistant Professor**
**Nadar Saraswathi College of Engineering & Technology,**
**Vadapudupatti, Annanji (po), Theni – 625531.**

# UNIT 05 – Hybrid Renewable Energy systems

Respect is the key determinant of high-performance leadership. How much people respect you determines how well they perform.

**--Brian Tracy**

# UNIT-5

- Need for Hybrid Systems
- Range and type of Hybrid systems
- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).

# Hybrid System

***Introduction***

- The renewable energy technologies include power generation from renewable energy sources, such as wind, PV(photovoltaic), MH (micro hydro), biomass, ocean wave, geothermal and tides.

- The RE resources are intermittent in nature therefore, hybrid combinations of two or more power generation technologies, along with storage can improve system performance.

- Hybrid Renewable Energy System (HRES) combines two or more renewable energy resources with some conventional source (diesel or petrol generator) along with storage, in order to fulfill the demand of an area.

## ***Methodology***

It is essential to have a well-defined and standardized frame work/steps taken for hybrid system based power generation for rural electrification.

These steps are as follows:

- Demand Assessment
- Resource Assessment

## Demand Assessment

Using accurate load forecasting of remote villages, the load demand can be fetched. During load survey, following factors may be considered:

- Demand for street lighting
- Number of houses, schools, health centers, commercial establishment and their energy requirement
- Number of small scale industries and their energy demand
- Miscellaneous demand

## Resource Assessment

- Resource assessment can be done by calculating potential available in wind, MHP, solar, Biomass, Biogas, and other renewable energy resources using meteorological data available.

- This can be done by combining one or more renewable energy sources with conventional energy sources.

## Some Hybrid Renewable system configuration

- PV/Wind/diesel generator HRES
- PV/wind/fuel cell HRES
- Wind/battery HRES
- Biomass/wind/diesel generator HRES
- PV/Wind/Biomass/fuel cell HRES

# Need for Hybrid System

- Hybrid systems can address limitations in terms of fuel flexibility, efficiency, reliability, emissions and / or economics.
- Incorporating heat, power, and highly efficient devices (fuel cells, advanced materials, cooling systems, etc.) can increase overall efficiency.
- Conserve energy for a hybrid system when compared with individual technologies.
- Achieving higher reliability can be accomplished with redundant technologies and/or energy storage.

- Some hybrid systems typically include both, which can simultaneously improve the quality and availability of power.
- Hybrid systems can be designed to maximize the use of renewable.
- Resulting in a system with lower emissions than traditional fossil-fueled technologies.
- Hybrid systems can be designed to achieve desired attributes at the lowest acceptable cost, which is the key to market acceptance.

# Range and type of Hybrid systems

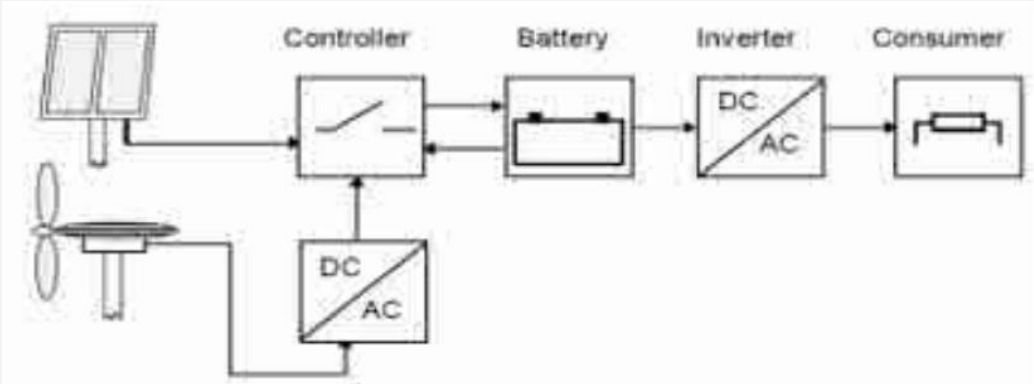
***Hybrid system characteristics***

- Hybrid energy systems are open, they can have the characteristics of a closed system if a subsystem with the function of monitoring is introduced as a feedback between output (consumer) and input (controller).
- As inputs of particular hybrid system cannot be changed. However, the load may be changed.
- With a backup system as another energy source the system can be designed as a partial closed-loop feedback system.
- There are various possibly to make combination of different energy sources.

## ***Types of Hybrid system***

## ***Wind PV hybrid system***

- A typical hybrid energy system consists of solar and wind energy sources.




- The power produced by the wind generators is an AC voltage but have variable amplitude and frequency that can then be transformed into DC to charge the battery.

- The controller protects the battery from overcharging or deep discharging.

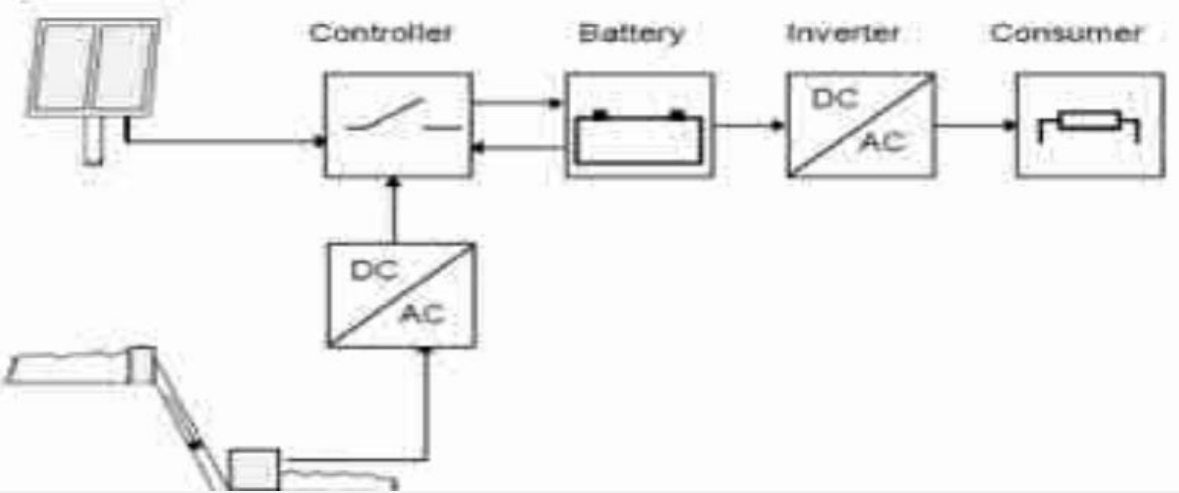
- The hybrid PV-wind generator system has been designed to supply continuous power of 1.5 kW

**Capabilities**

- Maximizes the electric power produced by the PV panels or by the wind generator by detecting and tracking the point of maximum power stores the electric energy in lead-acid batteries for a stable repeater operation.

## ***PV/Hydro Hybrid System***

- In this system there is a small reservoir to store the water.
- System capacity is depends upon at the water quantity and solar radiation.



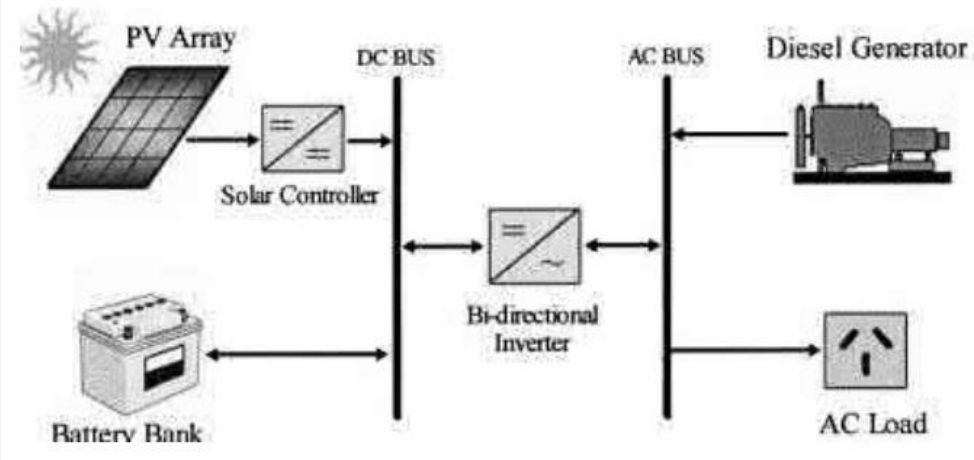
- The power supplied by falling water is the rate at which it delivers energy, and this depends on the flow rate and water head.
- Hydropower available is may be of runoff river type hence produces variable amplitude and frequency voltage.
- It can be use to charge the battery after converting it into DC.

## ***Biomass-PV-Diesel Hybrid System***

- In this hybrid system diesel energy is only work as a backup source.
- When the demand on its peak, the available sources are insufficient for that then the diesel back is required.
- There is a controller, which maintains the energy balance during the load variation.
- It assigns the priority among the energy sources.
- It also maintains the synchronizing the voltage signal coming from the different sources.

## ***Hybrid PV diesel system***

- A photovoltaic diesel hybrid system ordinarily consists of a PV system, diesel generator sets and intelligent management to ensure that the amount of solar energy fed into the system exactly matches the demand at that time.



- The excess energy could optionally be stored in batteries, making it possible for the hybrid system to use more solar power even at night.

- Intelligent management of various system components ensures optimal fuel economy and minimizes CO2 emissions.

**Advantages**

- Lower fuel costs
- Reduced risk of fuel price increases and supply shortages
- Minimal CO2 .

## Components of Hybrid PV Diesel system

PV inverters

- PV inverters are the central components of the fuel Save Solution. Designed specifically to be used in weak utility grids, they are suitable for high voltage and frequency fluctuations. They also remain extremely productive in harsh ambient conditions such as heat, moisture, salty air, among others.

PV array

- The solar power is generated in the PV modules, which can be mounted on the ground or on a roof, depending on local conditions. Inverters are compatible with all PV module types and technologies currently available on the market.

Fuel save Controller

- It provides the perfect interface between the generator sets, PV systems and loads, managing demand-based PV feed-in into the diesel-powered grid.

Diesel Generator

- In grid-remote regions, pure diesel systems often provide the energy for industrial applications. They constitute the local grid, ensuring a constant power supply to all connected users.

Optional storage batteries

- To boost the efficiency of the entire energy supply system, it is advisable to include a storage battery.

# Case study of Wind PV Systems

***Case study-1 Marriott Heathrow hybrid solar-wind system***

- The Marriott Heathrow hotel has become the first hotel in the Marriott Group to be fitted with a hybrid wind turbine and solar panel system as part of their ongoing 'Green Initiative'.

## Equipment Used:

- 1 x Leading Edge LE-600 12V 600W wind turbine
- 2 x Cleversolar CS-100 high efficiency monocrystalline solar panels
- 4 x Numax 110Ah 12V deep-cycle batteries
- 1 x Merlin M-Power 700W puresine inverter
- 3 x Leading Edge DL300 300W diversion load charge controllers
- 1 x turbine start/stop switch
- 1 x 20A automatic mains / inverter changeover unit
- 20m twin-core 4mm solar cable

- After reviewing all possibilities settled on a solution using a 600W turbine and two of our 100W high-efficiency monocrystalline solar panels.

- Given that the average wind speed at ground level is 10-knots (5.1m/s), the LE-600 will produce between 1.5 and 2.5kWh per day; mounted at 25m where wind speeds will be 15-25% higher should result in more than this.

- To supplement the wind turbine, the two 100W panels will produce additional electricity even on overcast days.

- In the summer months, the panels will be adding at least 1.2kWh to the power supply, although this is likely to be less in the winter (0.6 - 0.8kWh).

- As an added backup, the system uses 440Ah of leisure batteries, running through a 700W pure sine wave inverter from 'Merlin', so the sign can be safely operated for up to 16-hours with the panels and turbine disconnected.

- In the event that the sign needs to be operated from the mains, we also built in an changeover unit, which will automatically transfer the supply from the inverter to the national grid at the flick of a switch.

## ***Case study -2 wind and PV installed at Deokjeokdo island***

Geographical location of the island

- The experimental HRES consists of two Darrieus type vertical axis wind turbines (VAWT) and photovoltaic (PV) panels.

## HRES facility installed in the island

- The total capacity of this system is 24 kW, with each wind turbine rated at 1.5 kW and solar panels of 3 kW capacity, respectively.

- In order to record the wind conditions such as wind speed and wind direction, a vertical tower called the “wind master” has been installed at the local site.

- Anemometer and anemoscope are attached on wind master to record wind speed and wind angle, respectively.

- Solar panels are inclined at 30° to capture the maximum radiations from sun. This system was being monitored for two consecutive years, i.e., 2016 and 2018.

# Maximum Power Point Tracking(MPPT)

- MPPT is a technique used commonly with wind turbines and photovoltaic (PV) solar systems to maximize power extraction under all conditions.

- Although solar power is mainly covered, the principle applies generally to sources with variable power: for example, optical power transmission and thermo-photovoltaic.

- PV solar systems exist in many different configurations with regard to their relationship to inverter systems, external grids, battery banks, or other electrical loads.

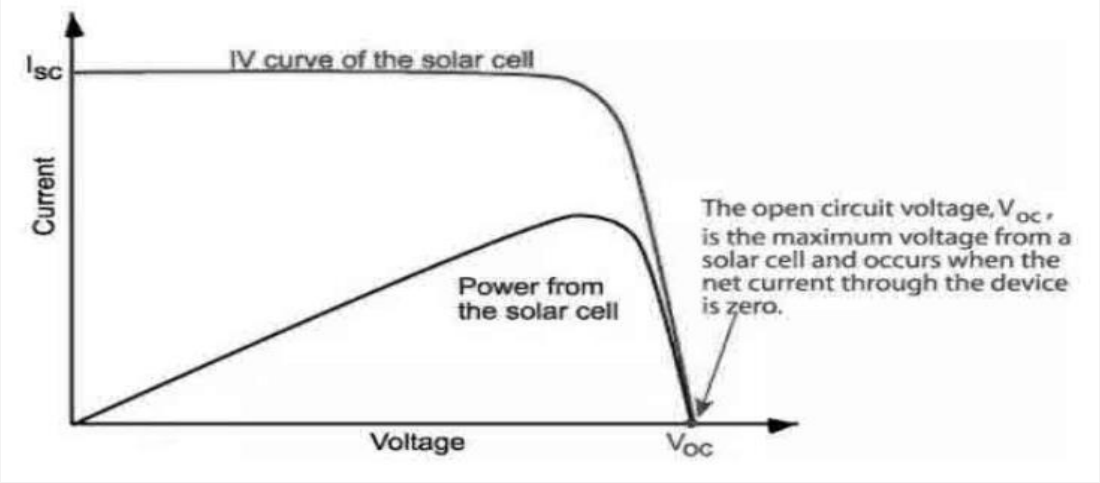
- Regardless of the ultimate destination of the solar power, though, the central problem addressed by MPPT is that the efficiency of power transfer from the solar cell depends on both the amount of sunlight falling on the solar panels and the electrical characteristics of the load.

- As the amount of sunlight varies, the load characteristic that gives the highest power transfer efficiency changes, so that the efficiency of the system is optimized when the load characteristic changes to keep the power transfer at highest efficiency.

- This load characteristic is called the maximum power point and MPPT is the process of finding this point and keeping the load characteristic there.

## ***Working of MPPT***

- Maximum Power Point Tracking (MPPT) is a technology approach used in solar PV inverters to optimize power output in less-than-ideal sunlight conditions. Most modern inverters are equipped with at least one MPPT input.



## ***Maximum Power Point Tracking Algorithms***

### ***Hill-climbing techniques***

- It consists of moving the operation point of the PV array in the direction in which power increases.

- Hill-climbing techniques are the most popular MPPT methods due to their ease of implementation and good performance when the irradiation is constant.

- The advantages of these methods are the simplicity and low computational power they need

## ***Incremental conductance***

- The incremental conductance algorithm is based on the fact that the slope of the curve power vs. voltage (current) of the PV module is zero at the MPP, positive (negative) on the left of it and negative (positive) on the right.

$$\frac{\Delta V}{\Delta P} = 0 \left(\frac{\Delta I}{\Delta P} = 0\right) \textit{at the MPP}$$

$$\frac{\Delta V}{\Delta P} > 0 \left(\frac{\Delta I}{\Delta P} < 0\right) \textit{on the left}$$

$$\frac{\Delta V}{\Delta P} < 0 \left(\frac{\Delta I}{\Delta P} > 0\right) \textit{on the right}$$

## ***Fuzzy Logic control***

- The use of fuzzy logic control has become popular over the last decade because it can deal with imprecise inputs, does not need an accurate mathematical model and can handle nonlinearity.

Three stages:

- Fuzzification
- Inference system
- Defuzzification

- The number of membership functions used depends on the accuracy of the controller, but it usually varies between 5 and 7.

## ***Current sweep***

- In this method the V-I characteristic curve is obtained using a sweep waveform for the PV array current.
- The sweep is repeated at fixed time intervals so the V-I curve is updated periodically and the MPP voltage (VMPP) can be determined from it at these same intervals.
- On the other hand, the sweep takes certain time during which the operating point is not the MPP, which implies some loss of available power.

## ***PARTICLE SWARM OPTIMIZATION(PSO)***

- This algorithm is used to reduce the steady state oscillation to practically zero once the maximum power point is located.

- It has ability to track the MPP for the extreme environmental conditions like large fluctuations of insolation and partial shading condition.

- MPP tracker based on PSO is capable of tracking global MPPs of multi-peak characteristic curves where the fixed values were adopted for weighing within the algorithm, the tracking performance lacked robustness, causing low success rates when tracking the global MPPs.

- ***MAXIMUM POWER POINT TRACKING IN HYBRID PHOTO-VOLTAIC AND WIND ENERGY CONVERSION SYSTEM***

- The Wind-solar complementary power supply system is a reasonable power supply which makes good use of wind and solar energy.

- This kind of power supply system can not only provide a bargain of low cost and high dependability for some inconvenient regions.

- In addition, the Wind/Solar complementary generation is more economical than a single PV or wind power generation in terms of both the cost and the protection of energy storage components.

- In standalone systems, sizing is extremely important since an adequate design lead to an efficient operation of the components with a minimum investment.

- combining the photovoltaic generation with wind power generation, the instability of an output characteristic each other was compensated. Photovoltaic generation and wind generation use Maximum Power Point Tracker (MPPT).

# Thank You