EE3014-POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS
UNIT1-INTRODUCTION
1.3-QUALITATIVE STUDY OF DIFFERENT RENEWABLE ENERGYRESOURCES

Solar energy

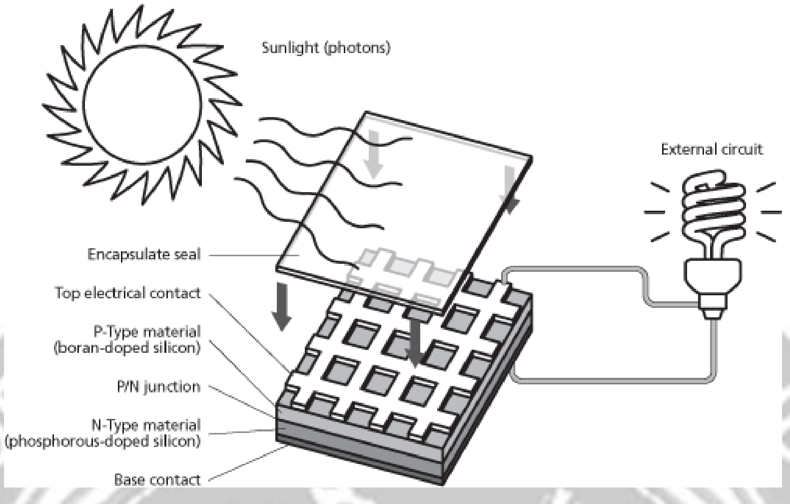
Concentrating solar power (CSP) technologies

Concentrating Solar Power (CSP) technologies use mirrors to concentrate (focus) thesun's light energy and convert it into heat to create steam to drive a turbine that generateselectrical power. CSP technology utilizes focused sunlight. CSP plants generate electric powerby using mirrors to concentrate (focus) the sun's energy and convert it into high-temperatureheat. That heat is then channeled through a conventional generator. The plants consist of twoparts: one that collects solar energy and converts it to heat, and another that converts the heat energy to electricity.

Solar photovoltaic technology basics

Solar cells, also called photovoltaic (PV) cells by scientists, convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the PV effect. Traditional solar cells are made from silicon, are usually flat-plate, and generally are the most efficient. Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or non-silicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights. Third-generation solar cells are being made from a variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics. Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto a very small piece of high efficiency PV material. The PV material is more expensive, but because so little is needed, these systems are becoming cost effective for use by utilities and industry.

Solar PV array module

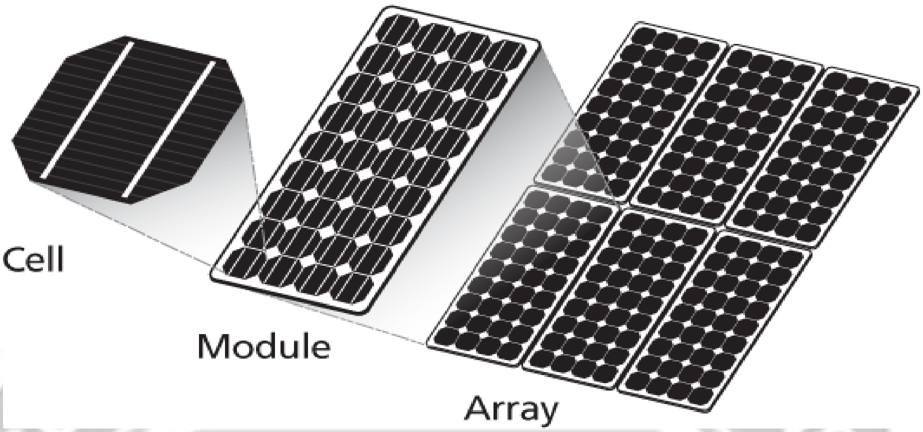


Construction and Working of PV / Solar Cell

The basic element of a PV System is the photovoltaic (PV) cell, also called a Solar Cell. An example of a PV / Solar Cell made of Mono-crystalline Silicon. This single PV / Solar Cell are like a square but with its four corners missing (it is made this way). A PV / Solar Cell is a semiconductor device that can convert solar energy into DC electricity through the Photovoltaic effect (Conversion of solar light energy into electrical energy). When light shines on a PV / Solar Cell, it may be reflected, absorbed, or passes right through. But only the absorbed light generates electricity.

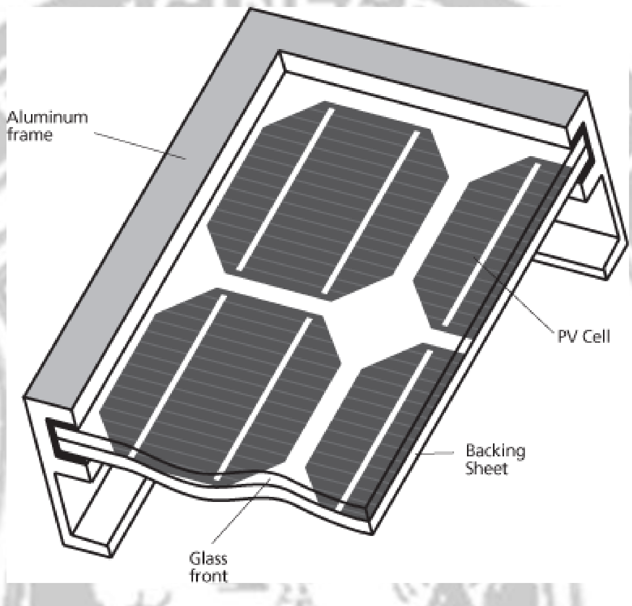
PV module / panel and PV array

To increase their utility, a number of individual PV cells are interconnected together in a sealed, weatherproof package called a Panel (Module). For example, a 12 V Panel (Module) will have 36 cells connected in series and a 24 V Panel (Module) will have 72 PV Cells connected in series To achieve the desired voltage and current, Modules are wired in series and parallel into what is called a PV Array. The flexibility of the modular PV system allows designers to create solar power systems that can meet a wide variety of electrical needs.



PV Cell, Module and Array

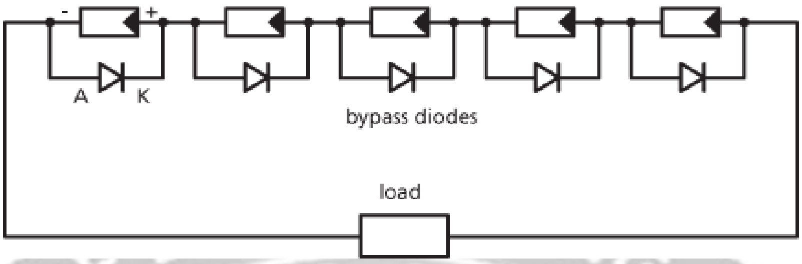
The cells are very thin and fragile so they are sandwiched between a transparent front sheet, usually glass, and a baking sheet, usually glass or a type of tough plastic. This protects them from breakage and from the weather. An aluminum frame is fitted around the module to enable easy fixing to a support structure.



Construction of a typical Mono-crystalline PV / Solar Panel

Bypass diodes

As mentioned, PV / Solar cells are wired in series and in parallel to form a PV / Solar Panel (Module). The number of series cells indicates the voltage of the Panel (Module), whereas the number of parallel cells indicates the current. If many cells are connected in series, shading of individual cells can lead to the destruction of the shaded cell or of the lamination material, so the Panel (Module) may blister and burst. To avoid such an operational condition, Bypass Diodes are connected anti-parallel to the solar cells as in Figure. As a result, larger voltage differences cannot arise in the reverse-current direction of the solar cells. In practice, it is sufficient to connect one bypass diode for every 15-20 cells. Bypass diodes also allow current to flow through the PV module when it is partially shaded, even if at a reduced voltage and power. Bypass diodes do not cause any losses, because under normal operation, current does not flow through them.



Parallel PV cell with bypass diodes

Photovoltaic Power Systems

Photovoltaic (PV) technology converts one form of energy (sunlight) into another formof energy (electricity) using no moving parts, consuming no conventional fossil fuels, creatingno pollution, and lasting for decades with very little maintenance. The use of a widely availableand reasonably reliable fuel source—the sun—with no associated storage or transportationdifficulties and no emissions makes this technology eminently practicable for powering remotescientific research platforms. The completely profitable nature of the technology also lends itselfwell to varying power requirements–from the smallest autonomous research platforms toinfrastructure-based systems. Based on semiconductor technology, solar cells operate on theprinciple that electricity will flow between two semiconductors when they are put into contactwith each other and exposed to light (photons). This phenomenon is known as the photovoltaic effect.

Wind energy

Wind energy is energy from moving air, caused by temperature (and therefore pressure) differences in the atmosphere. Irradiance from the sun heats up the air, forcing the air to rise. Conversely, where temperatures fall, a low pressure zone develops. Winds (i.e. air flows) balance out the differences. Hence, wind energy is solar energy converted into kinetic energy of moving air.

Characteristics

As the wind power is proportional to the cubic wind speed, it is crucial to have detailed knowledge of the site-specific wind characteristics. Even small errors in estimation of wind speed can have large effects on the energy yield, but also lead to poor choices for turbine and site. An average wind speed is not sufficient. Site-specific wind characteristics related to wind turbines include:

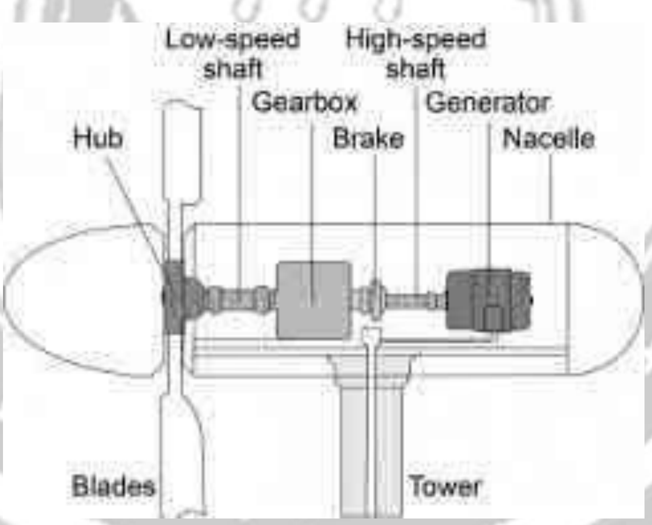
- Mean wind speed: Only interesting as a headline figure, but does not tell how often highwind speeds occur.

- Wind speed distribution : diurnal, seasonal, annual patterns
- Turbulence: short-term fluctuations
- Long-Term Fluctuations
- Distribution Of Wind Direction
- Wind Shear (Profile)

Wind turbine types

Horizontal Axis Wind Turbines (HAWT)

Horizontal axis wind turbines, also shortened to HAWT, are the common style that mostof us think of when we think of a wind turbine. A HAWT has a similar design to a windmill; ithas blades that look like a propeller that spin on the horizontal axis. Horizontal axis windturbines have the main rotor shaft and electrical generator at the top of a tower, and they must bepointed into the wind. Small turbines are pointed by a simple wind vane placed square with therotor (blades), while large turbines generally use a wind sensor coupled with a servo motor toturn the turbine into the wind. Most large wind turbines have a gearbox, which turns the slow rotation of the rotor into a faster rotation that is more suitable to drive an electrical generator.



Horizontal Axis Wind Turbine

Since a tower produces turbulence behind it, the turbine is usually pointed upwind of the tower. Wind turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted up a small amount.

Advantages

- The tall tower base allows access to stronger wind in sites with wind shear.

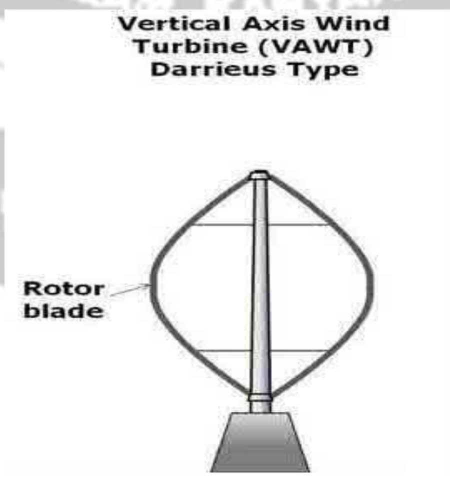
- High efficiency since the blades always moves perpendicularly to the wind, receiving power through the whole rotation.
- In contrast, all vertical axis wind turbines, and most proposed airborne wind turbine designs, involve various types of reciprocating actions, requiring airfoil surfaces to backtrack against the wind for part of the cycle.
- Backtracking against the wind leads to inherently lower efficiency.

Disadvantages

- Massive tower construction is required to support the heavy blades, gearbox, and generator.
- Components of a horizontal axis wind turbine (gearbox, rotor shaft and brake assembly) being lifted into position.
- Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes creating local opposition.
- HAWTs require an additional yaw control mechanism to turn the blades toward the wind.

Vertical Axis Wind Turbines (VAWT)

Vertical axis wind turbines, as shortened to VAWTs, have the main rotor shaft arranged vertically. The main advantage of this arrangement is that the wind turbine does not need to be pointed into the wind. This is an advantage on sites where the wind direction is highly variable or has turbulent winds. With a vertical axis, the generator and other primary components can be placed near the ground, so the tower does not need to support it, also makes maintenance easier. The main drawback of a VAWT generally creates drag when rotating into the wind.



Vertical Axis Wind Turbine

It is difficult to mount vertical-axis turbines on towers, meaning they are often installed nearer to the base on which they rest, such as the ground or a building rooftop. The wind speedis slower at a lower altitude, so less wind energy is available for a given size turbine. Air flow near the ground and other objects can create turbulent flow, which can introduce issues of vibration, including noise and bearing wear which may increase the maintenance or shorten its service life. However, when a turbine is mounted on a rooftop, the building generally redirects wind over the roof and these can double the wind speed at the turbine. If the height of the rooftop mounted turbine tower is approximately 50% of the building height, this is near the optimum for maximum wind energy and minimum wind turbulence.

Advantages

- No yaw mechanisms are needed.
- A VAWT can be located nearer the ground, making it easier to maintain themoving parts.
- VAWTs have lower wind startup speeds than the typical the HAWTs.
- VAWTs may be built at locations where taller structures are prohibited.
- VAWTs situated close to the ground can take advantage of locations where rooftops, mesas, hilltops, ridgelines, and passes funnel the wind and increase wind velocity.

Disadvantages

- Most VAWTs have an average decreased efficiency from a common HAWT, mainly because of the additional drag that they have as their blades rotate into the wind.
- Versions that reduce drag produce more energy, especially those that funnel wind into the collector area.
- Having rotors located close to the ground where wind speeds are lower and donot take advantage of higher wind speeds above.

Component of a wind turbine

Rotor

The part of the wind turbine that collects energy from the wind is called the rotor. The rotor usually consists of two or more wooden, fiberglass or metal blades which rotate about an axis (horizontal or vertical) at a rate determined by the wind speed and the shape of the blades. The blades are attached to the hub, which in turn is attached to the main shaft.

Drag Design

Blade designs operate on either the principle of drag or lift. For the drag design, the wind literally pushes the blades out of the way. Drag powered wind turbines are characterized by slower rotational speeds and high torque capabilities. They are useful for the pumping, sawing or grinding work. For example, a farm-type windmill must develop high torque at start- up in order to pump, or lift, water from a deep well.

Lift Design

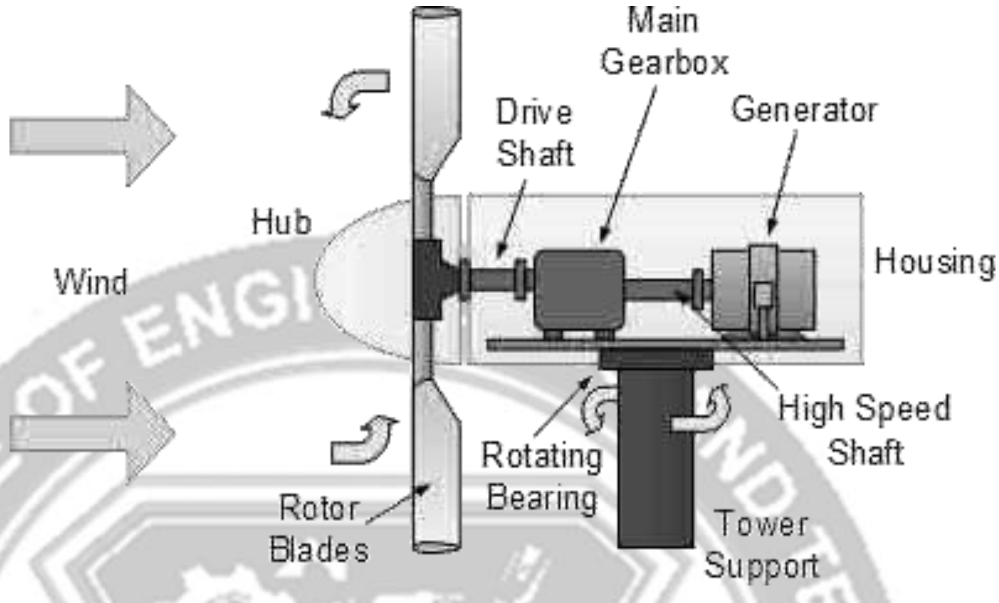
The lift blade design employs the same principle that enables airplanes, kites and birds to fly. The blade is essentially an airfoil, or wing. When air flows past the blade, a wind speed and pressure differential is created between the upper and lower blade surfaces. The pressure at the lower surface is greater and thus acts to "lift" the blade. When blades are attached to a central axis, like a wind turbine rotor, the lift is translated into rotational motion. Lift-powered wind turbines have much higher rotational speeds than drag types and therefore well suited for electricity generation.

Tip Speed Ratio

The tip-speed is the ratio of the rotational speed of the blade to the wind speed. The larger this ratio, the faster the rotation of the wind turbine rotor at a given wind speed. Electricity generation requires high rotational speeds. Lift-type wind turbines have maximum tip-speed ratios of around 10, while drag-type ratios are approximately 1. Given the high rotational speed requirements of electrical generators, it is clear that the lift-type wind turbine is most practical for this application.

Generator

The generator is what converts the turning motion of a wind turbine's blades into electricity. Inside this component, coils of wire are rotated in a magnetic field to produce electricity. Different generator designs produce either alternating current (AC) or direct current (DC), and they are available in a large range of output power ratings. The generator's rating, or size, is dependent on the length of the wind turbine's blades because more energy is captured by longer blades. It is important to select the right type of generator to match your intended use. Most home and office appliances operate on 120 volt (or 240 volt), 60 cycle AC. Some appliances can operate on either AC or DC, such as light bulbs and resistance heaters, and many others can be adapted to run on DC. Storage systems using batteries store DC and usually are configured at voltages of between 12 volts and 120 volts. Generators that produce AC are generally equipped with features to produce the correct voltage (120 or 240 V) and constant frequency (60 cycles) of electricity, even when the wind speed is fluctuating.



Components of a wind turbine

Transmission

The number of revolutions per minute (rpm) of a wind turbine rotor can range between 40 rpm and 400 rpm, depending on the model and the wind speed. Generators typically require rpm's of 1,200 to 1,800. As a result, most wind turbines require a gear-box transmission to increase the rotation of the generator to the speeds necessary for efficient electricity production. Some DC-type wind turbines do not use transmissions. Instead, they have a direct link between the rotor and generator. These are known as direct drive systems. Without a transmission, wind turbine complexity and maintenance requirements are reduced, but a much larger generator is required to deliver the same power output as the AC-type wind turbines.

Towers

The tower on which a wind turbine is mounted is not just a support structure. It also raises the wind turbine so that its blades safely clear the ground and so it can reach the stronger winds at higher elevations. Maximum tower height is optional in most cases, except where zoning restrictions apply. The decision of what height tower to use will be based on the cost of taller towers versus the value of the increase in energy production resulting from their use.

ADVANTAGES AND DISADVANTAGES OF WIND POWER

ADVANTAGES

- The wind is free and with modern technology it can be captured efficiently.
- Once the wind turbine is built the energy it produces does not cause green house gases or other pollutants.

- Although wind turbines can be very tall each takes up only a small plot of land.
- Many people find wind farms an interesting feature of the landscape.
- Remote areas that are not connected to the electricity power grid can use windturbines to produce their own supply.

DISADVANTAGES

- More noise
- Threatening to Wildlife.
- Wind is Unpredictable.
- Limited Resource.
- Inefficient.
- Poor Television Reception.
- Installation Cost is high.