Module-5
Wind Power Generator
And
Solar Power Generator

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Module-5

Wind power Generator –Basic components of wind energy conversion system, types of wind generators- Horizontal and vertical axis. Advantages and disadvantages of WECS.

Solar power generator - principle of solar cell, Basic Solar Photo voltaic, system for power generation, Advantages and disadvantages.

What is Wind?

- Wind is the stabilization movement of air between areas of high and low atmospheric pressure, created by the uneven heating of the Earth's surfaces: land, water, and air.
- The greater the pressure difference in these areas, the harder the wind blows. Wind also exists as the circulation of air around a high or low-pressure area.

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What is Wind Energy?

- Wind energy is the converting of wind power to electrical power through the use of windmills or turbines.
- Electricity produced is sent to transformers where voltage is increased and sent to the power grid via transmission lines.

Basic components of wind energy conversion system

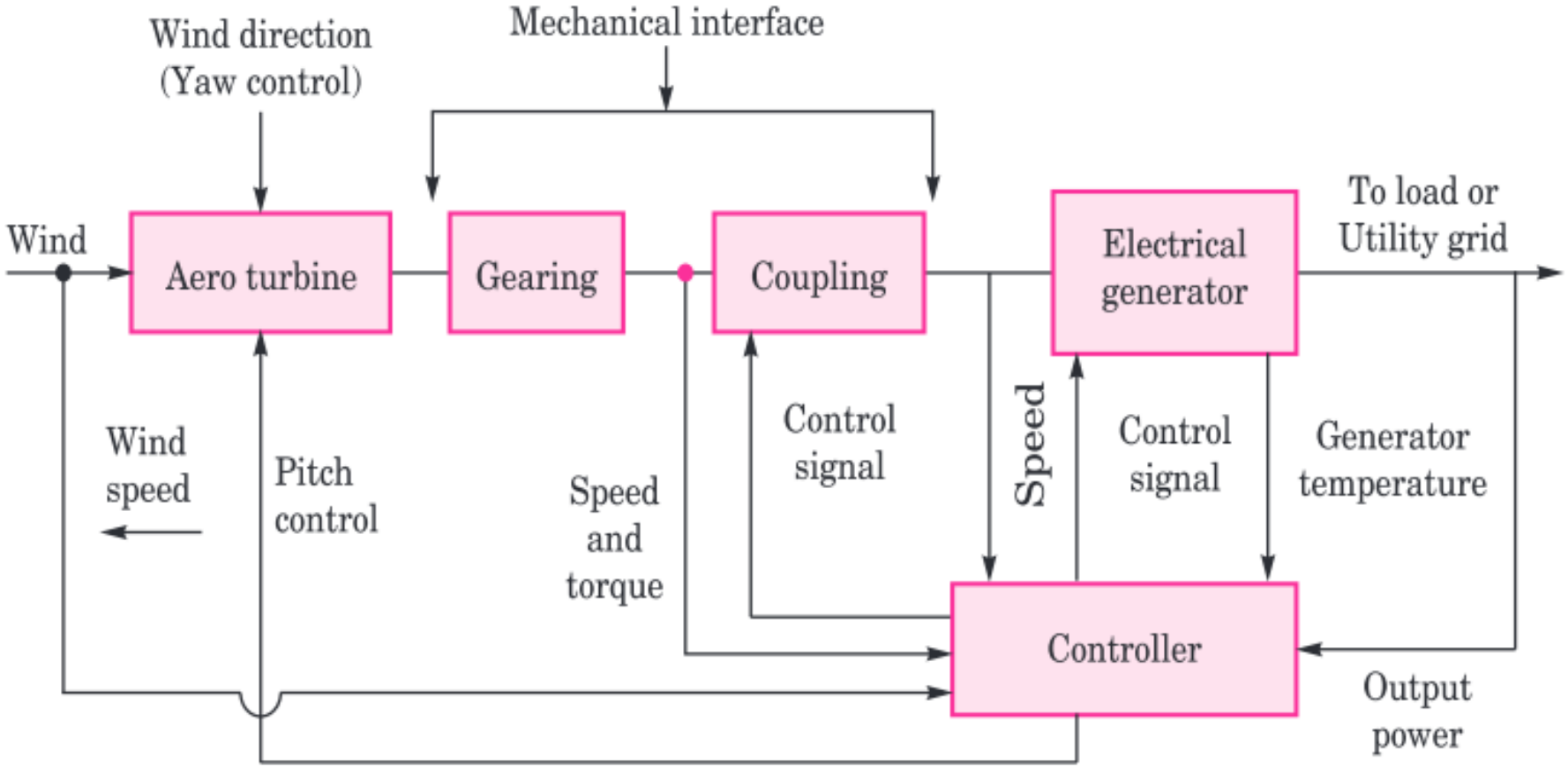
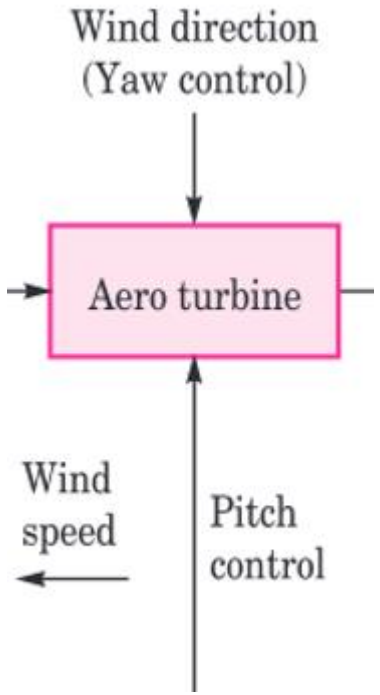


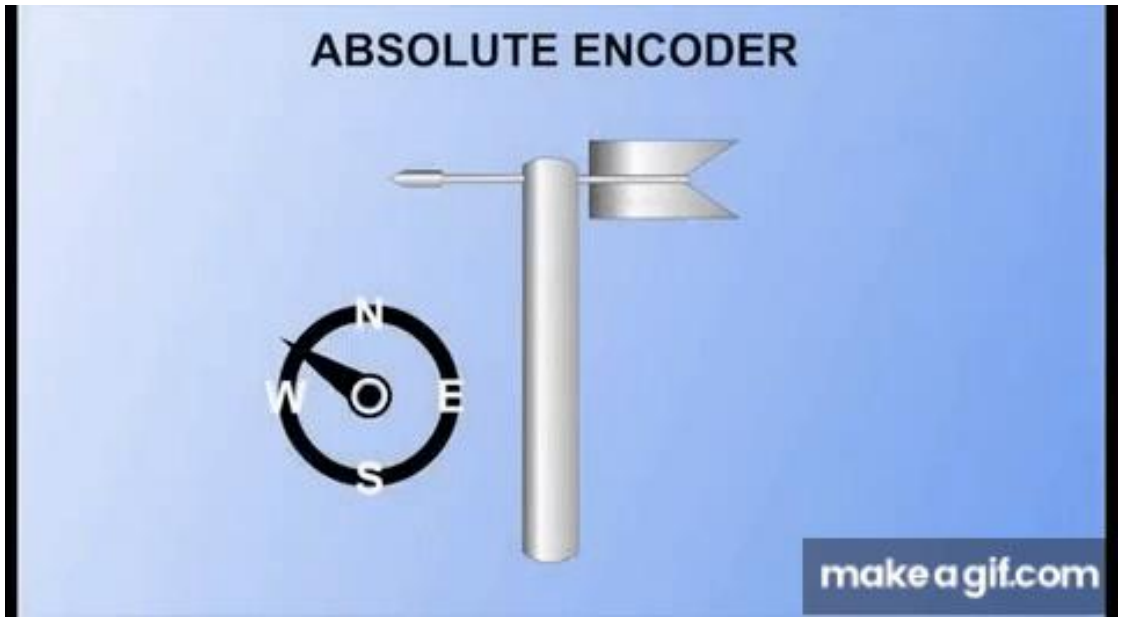
Fig. 6.12. Basic components of a wind electric system.

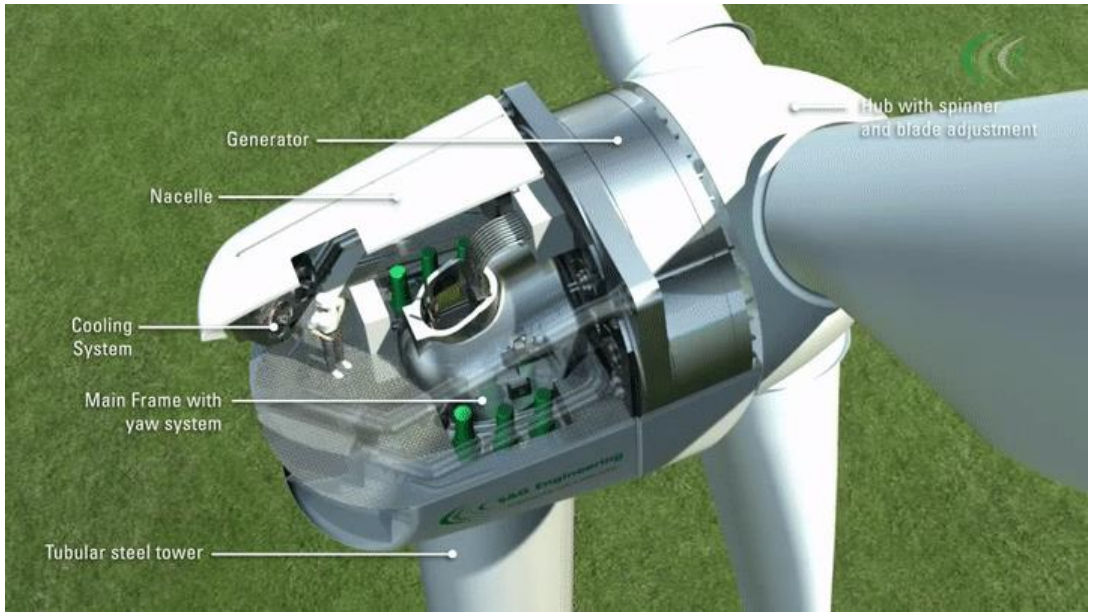
Aero turbine:



Aero turbines convert energy in moving air to rotary mechanical energy.

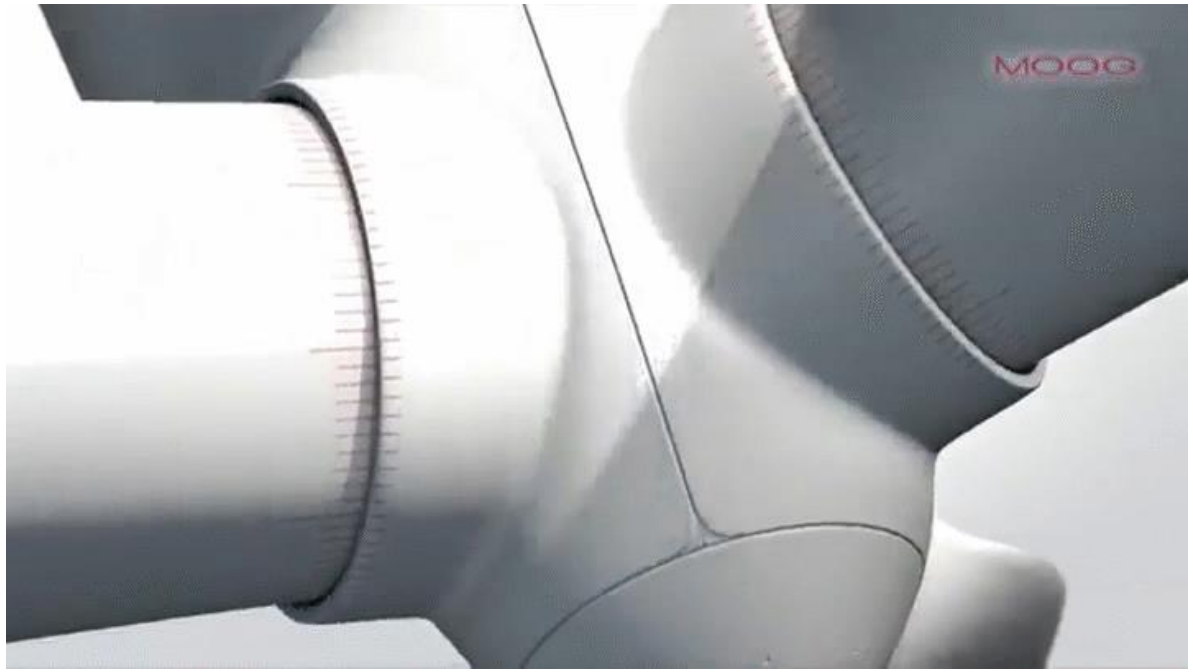
Yaw Control:





The yaw control mechanism comprises a motor and drive. The main purpose of this arrangement is to move the nacelle and blades according to the wind direction. It enables the wind turbine to capture the maximum available wind.

Pitch Control:

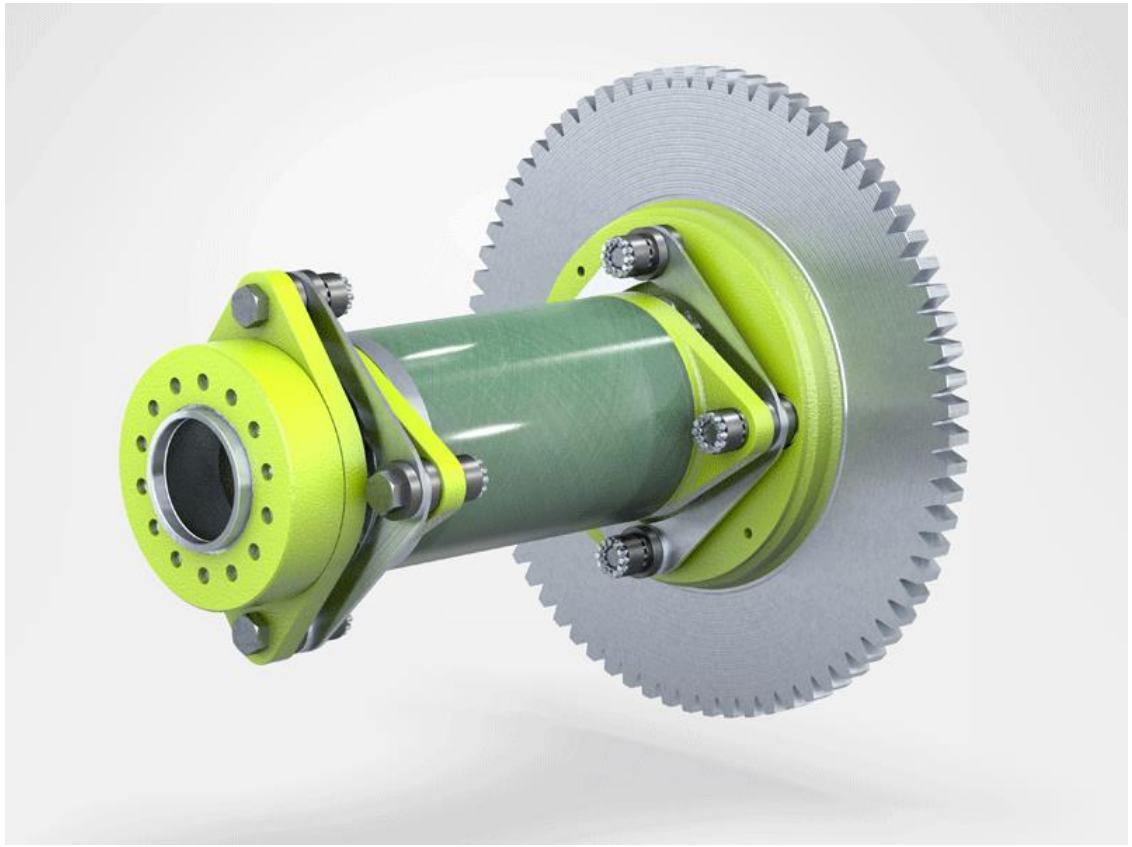


The pitch control monitors and adjusts the angle of the wind turbine's rotor blades, which can measure up to 65 meters long, and thus controls the rotational speed of the turbine.

Gearing:

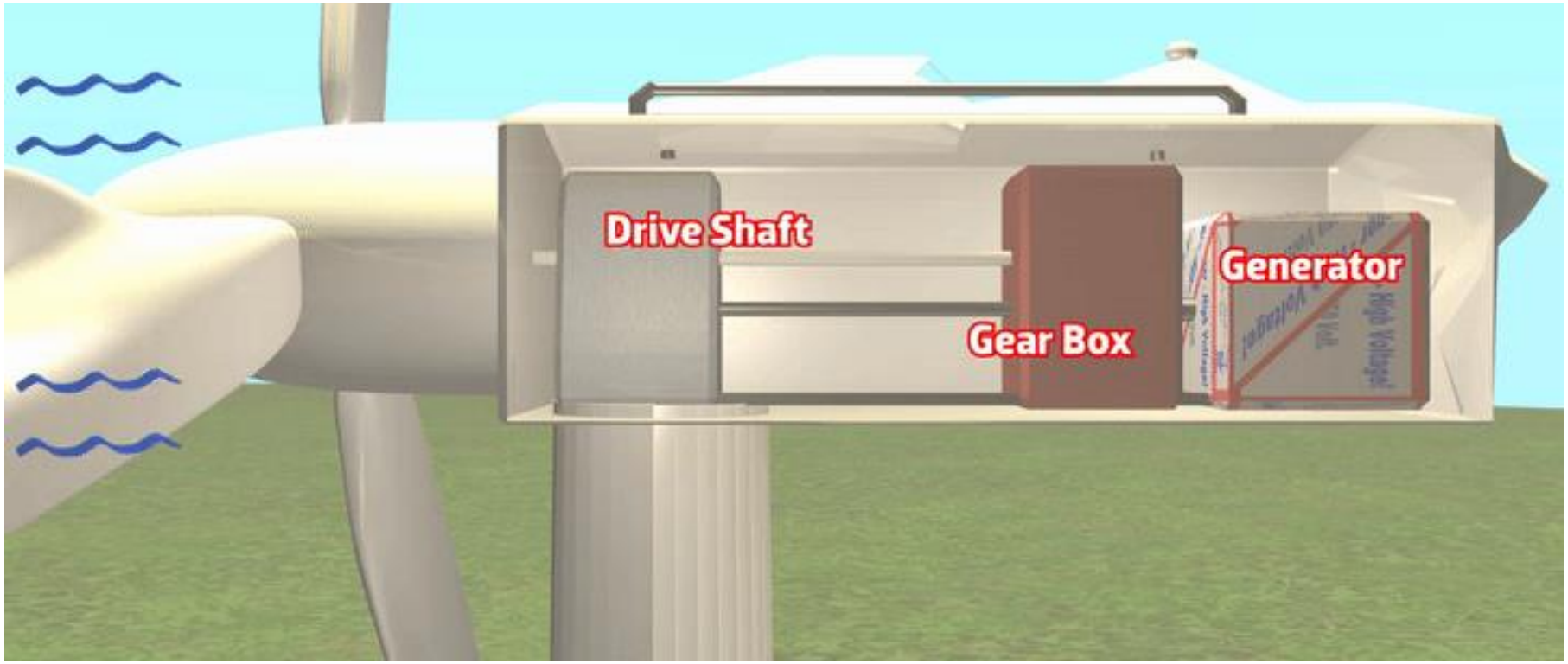
A gearbox is often used in a wind turbine to increase the rotational speed from a low-speed main shaft to a high-speed shaft connecting with an electrical generator

Coupling:



- A coupling is a device used to connect two shafts at their ends for the purpose of transmitting power. The primary purpose of couplings is to join two pieces of rotating equipment while permitting some degree of misalignment end movement or both.to transmit.
- Located between the rotor shaft and gear unit, the coupling protects the gear unit and drive train against bending and thrust loads from the rotor – thus significantly increasing the lifetime of bearings and gears.

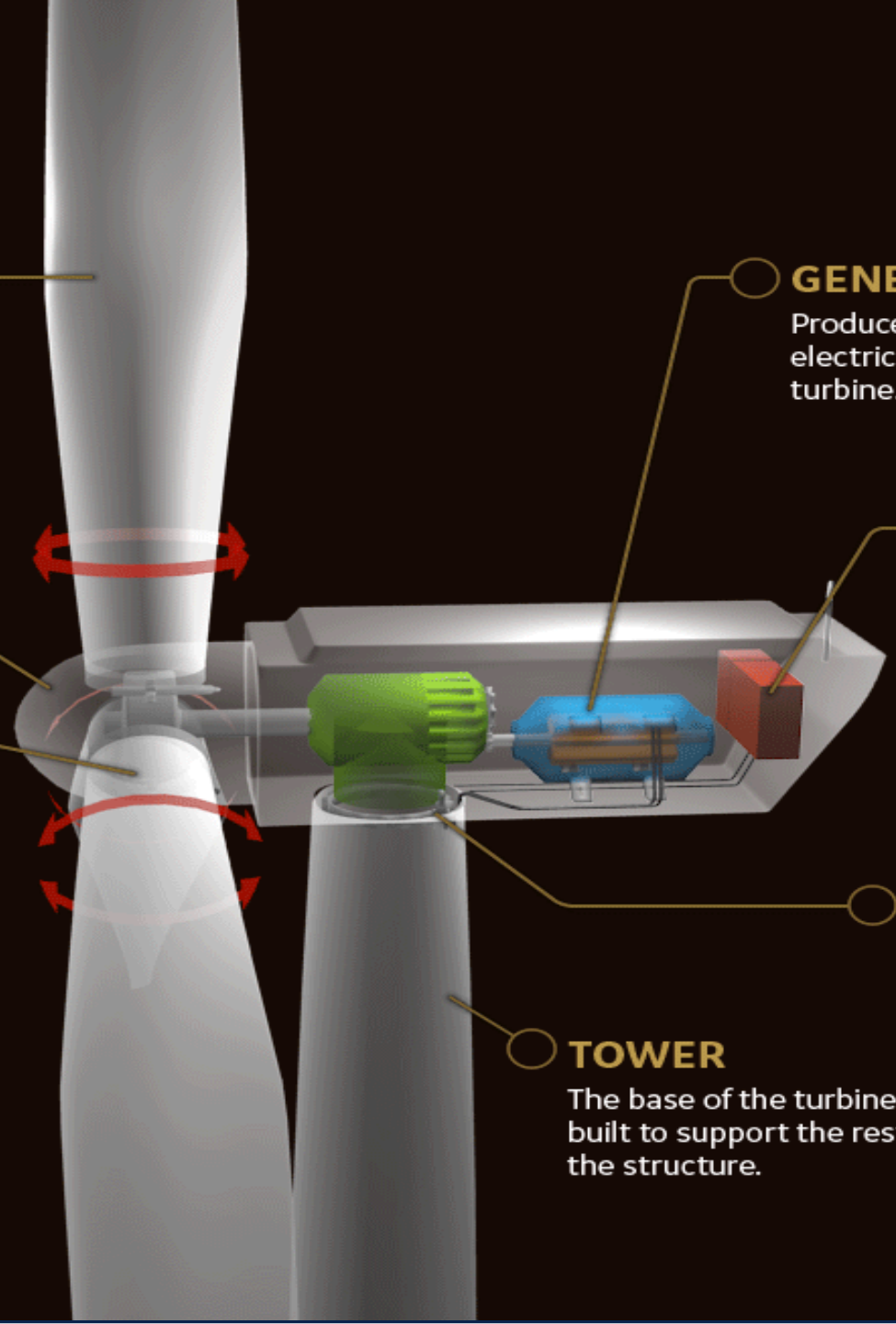
Electric Generator:



Controller:

Controls the variable speed operation allowing to achieve maximum power and system stability.

GE WIND TURBINE



BLADES
Lift and rotate when hit by wind, causing the rotor to spin.

ROTOR
Combination of the blades and hub.

PITCH SYSTEM
Turns blades out of the wind to control rotor speed. Also, stops the rotor from spinning in conditions where wind is blowing too slow or too fast.

GENERATOR
Produces 60-cycle AC electricity within the turbine.

CONTROLLER
Starts and stops the turbine from working, depending on conditions.

YAW DRIVE
Controls upwind turbines to orient them should wind direction change.

TOWER
The base of the turbine, built to support the rest of the structure.

BASIC COMPONENTS OF WIND ENERGY CONVERSION SYSTEMS (WECS)

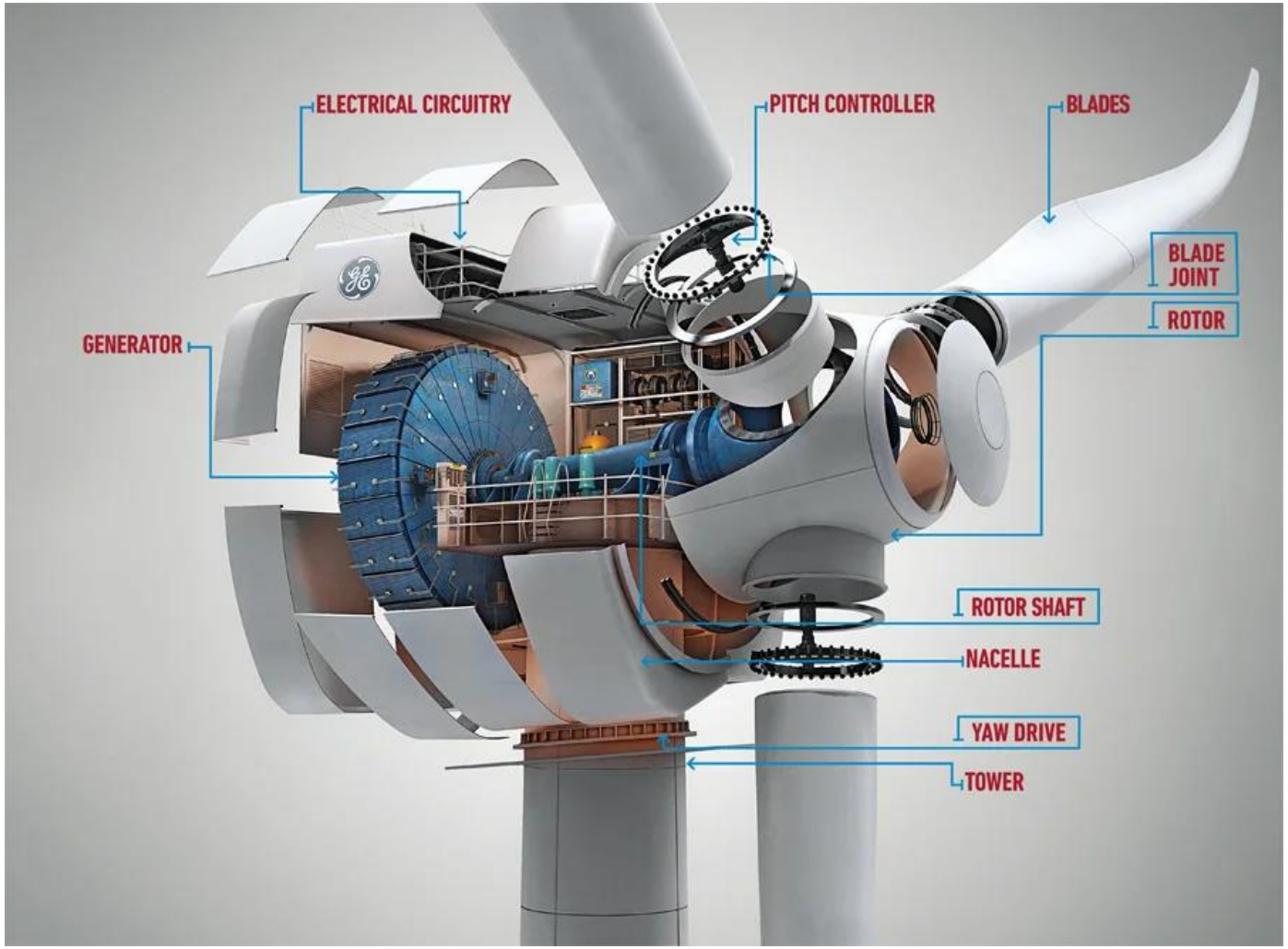
- Aero turbine – convert energy in moving air to rotary mechanical energy.
- They require pitch control and yaw control
- Gearing and Coupling – transmits the rotary mechanical energy into electrical generator
- Controller – sense the wind speed, wind direction shafts speeds and torque at one or more points
- The physical embodiment for such an aero generator is shown in generalized form in fig.

Mechanical Components	Electrical Components
1. Rotor	1. Generator
2. Main Shaft	2. Power Converter
3. Gearbox	3. Step-up Transformer
4. Mechanical Break	4. Wind Farm Collection Points or Point of Common Coupling
5. Nacelle	
6. Pitch and Yaw Drives	
7. Wind Measuring Equipment	

Mechanical Components

The mechanical components of a WECS include the rotor, the main shaft, gearbox, mechanical breaks, nacelle, pitch and yaw drives, and wind measuring equipment,

1. Rotor: It is the most important component of a WECS. It is a large wheel that has blades attached to it. The rotor is what captures the wind and turns it into mechanical energy.
2. Main Shaft: The main shaft is the shaft attached to the rotor. It is made of steel or aluminum and connected to the gearbox.
3. Gearbox: The gearbox is a device that increases the rotational speed of the rotor. It is made of gears, and it is located in the nacelle.



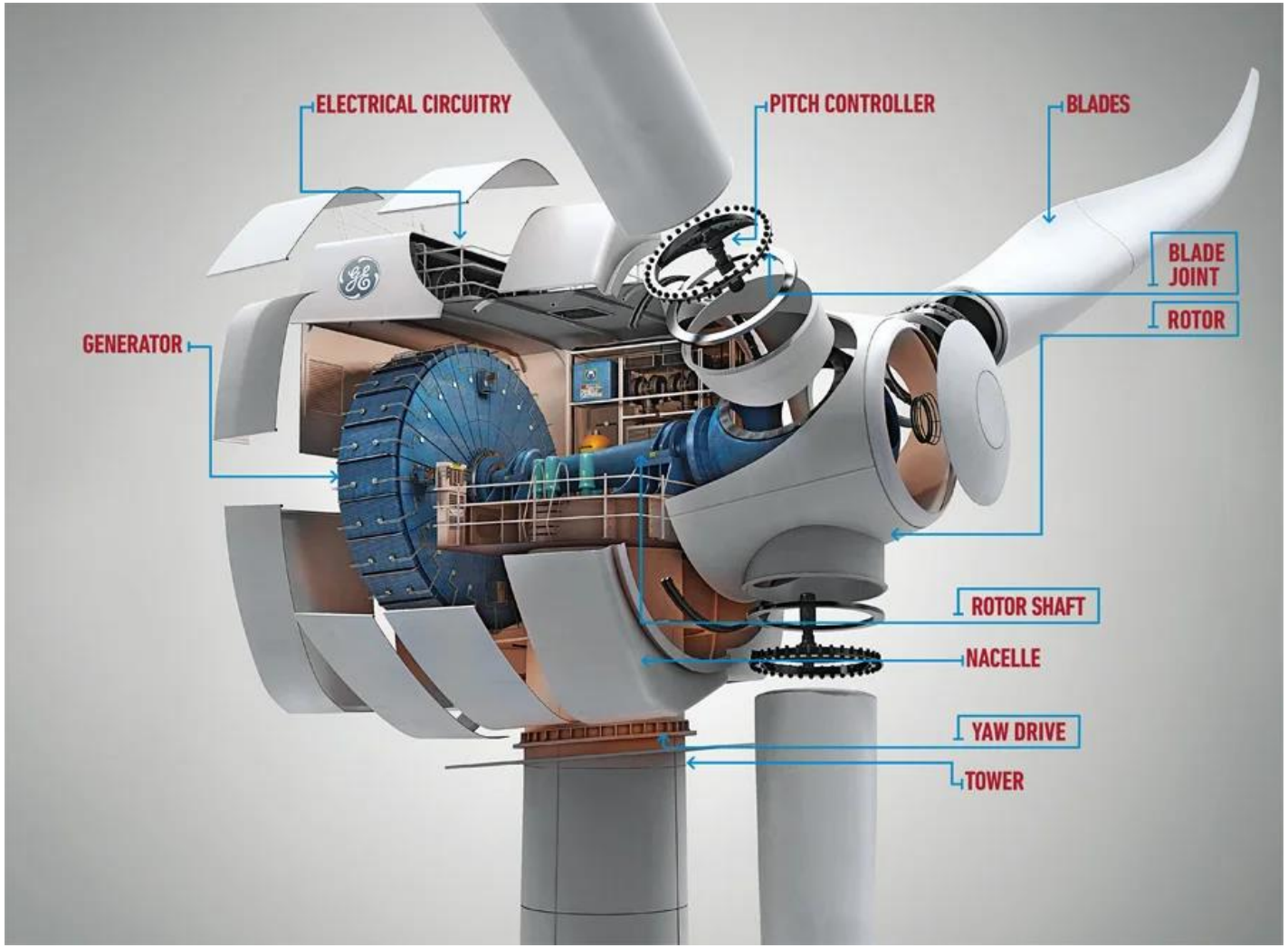
Mechanical Components

4. Mechanical Breaks: Mechanical breaks are used to stop the rotor from spinning. They are located in the nacelle and activated when the wind speed is too high.

5. Nacelle: The nacelle is the housing that contains all of the electrical and mechanical components of the WECS. It is located at the top of the turbine, and it is made of steel or aluminum.

6. Pitch and Yaw Drives: Pitch and yaw drives are used to adjust the angle of the blades. They are located in the nacelle, and a computer operates them.

7. Wind Measuring Equipment: Wind measuring equipment is used to measure wind speed and direction. It is located in the nacelle and consists of anemometers and wind vanes.



Electrical Components

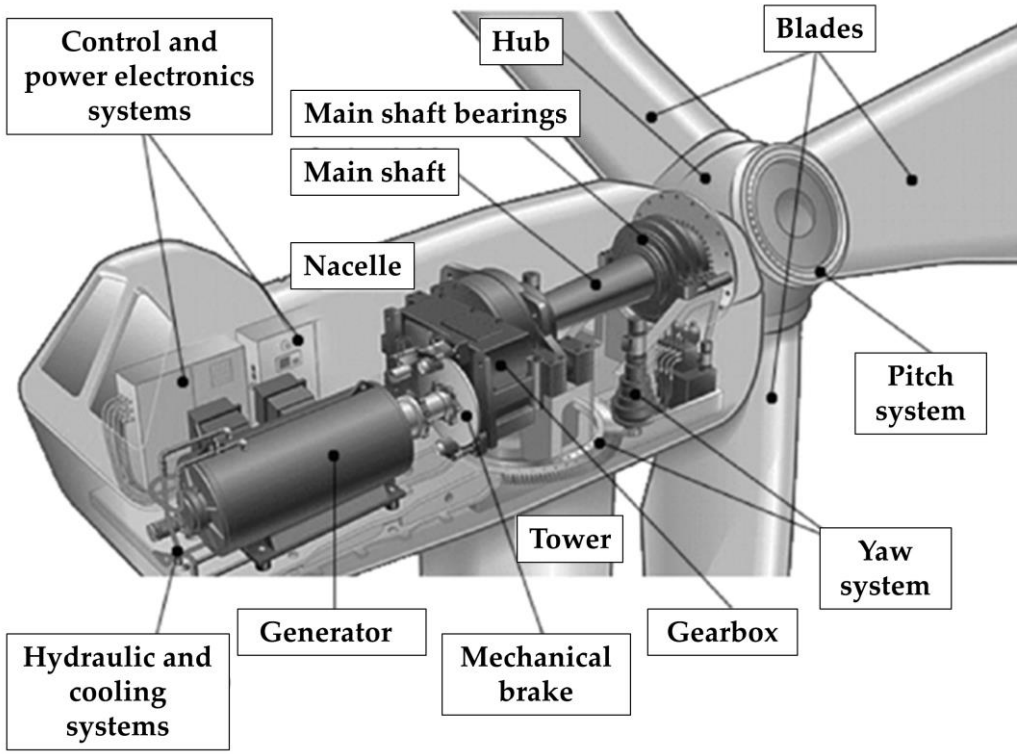
The electrical components of a WESC include the generator, power converter, step-up transformer, and wind farm collection points or points of common coupling.

1.Generator: A device that converts mechanical energy into electrical energy. It is located in the nacelle and is connected to the main shaft.

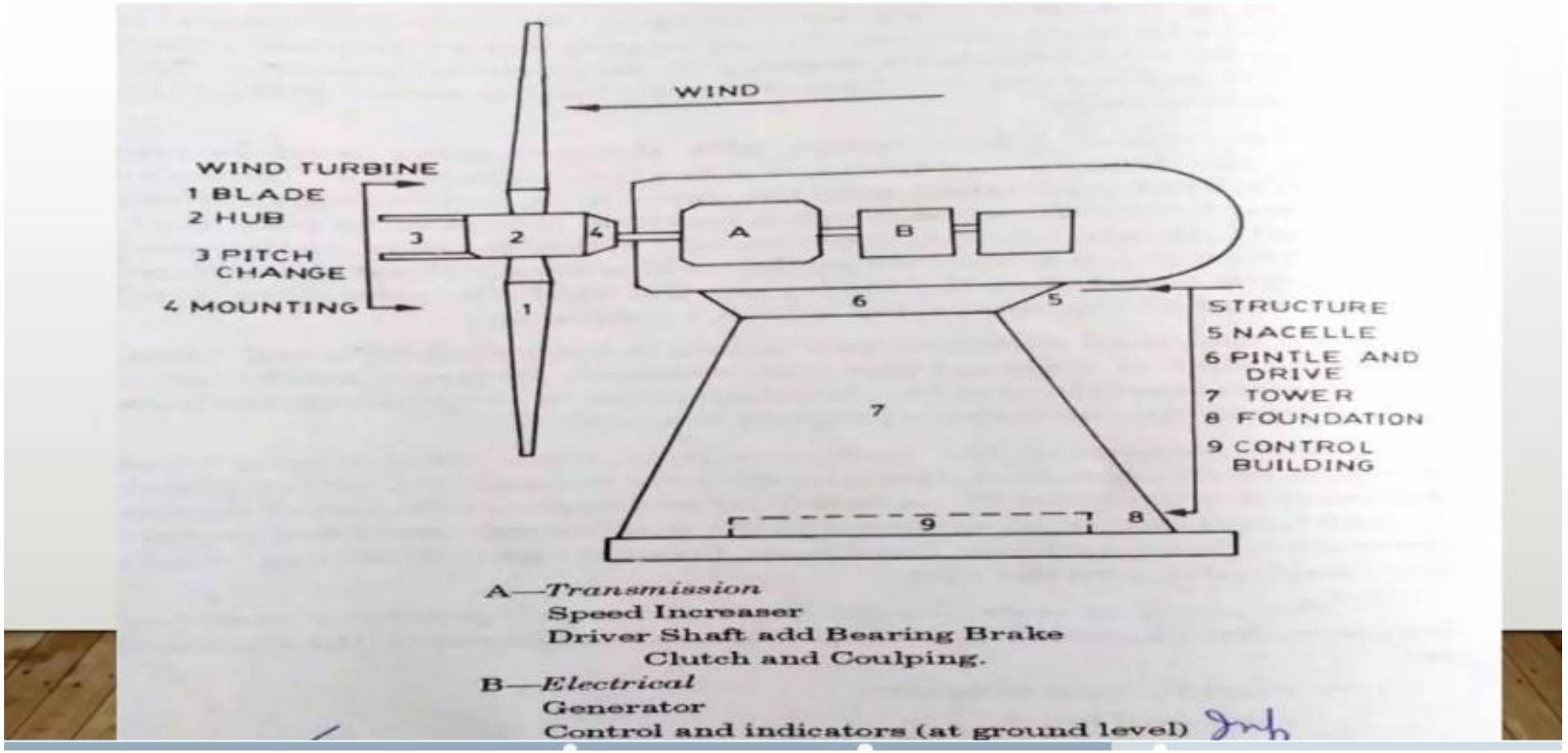
2.Power Converter: The power converter is a device that converts DC into AC. It is located in the nacelle, connected to the generator.

3.Step-up Transformer: The step-up transformer is a device that increases the voltage of the electricity. It is located in the nacelle, connected to the power converter.

4.Wind Farm Collection Points or Point of Common Coupling: Are used to collect the electricity from the turbines. They are located at the turbine's base, and they are connected to the power converter.



BASIC COMPONENTS OF WIND ENERGY CONVERSION SYSTEMS (WECS)



BASIC COMPONENTS OF WIND ENERGY CONVERSION SYSTEMS (WECS)

1) **Rotors** are mainly of two types:
   - Horizontal axis rotor
   - Vertical axis rotor
- One advantage of vertical axis machines is that they operate in all wind directions
- The portion of the wind turbine that collects energy from the wind is called the rotor.

2) **Windmill head**
   - Supports the rotor, housing the rotor bearings
   - Also incorporated like changing the pitch of the blades for safety devices and tail vane to orient the rotor to face the wind

3) Transmissions:

- 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.

4) Control:

- The modern large wind turbine generator requires a versatile and reliable control system to perform the following functions:
  - Orientation of the wind in the rotor
  - Generator output monitoring – status, data computation and storage

5. Towers:

Four types of supporting towers deserve consideration, these are:
(1) the reinforced concrete tower,
(2) the pole tower,
(3) the built up shell-tube tower, and
(4) the truss tower.

Turbine

Turbines can also be classified by their electrical output. The size of the wind farm is determined by its production power. The current turbine system technology may be categorized into three groups based on the following:

1.Low Power turbines: These are turbine systems with a maximum output of 30 kW on average. These devices are used in distant areas to meet home electrical needs and charge batteries. They're also employed in emergencies to lessen reliance on primary power sources.

2. Medium Power turbines: This category includes turbines with 30 to 300 kW outputs. They are, however, primarily utilized to provide electricity to houses in small communities. They are used with other renewable energy sources or power storage systems.

3.High Power turbines: These are systems in which a considerable amount of power is produced. These are integrated into large-scale wind farms connected to the power systems that transmit electricity across towns.

Power Control

The wind energy converted by the turbine must be managed appropriately to maintain a constant output of power. The two main ways to control power are active and reactive power control.

Active power control is the most common type of power control, and it involves regulating the amount of wind that goes through the turbine blades. This is accomplished by using a pitch control mechanism, which regulates the angle of the blades.

Reactive power control is less common, and it involves regulating the amount of electricity generated by the turbine. This is done using a generator, which converts mechanical energy into electrical energy.

ADVANTAGES AND DISADVANTAGES

Advantages:

- Renewable source
- Non polluting
- Avoid fuel provision and transport
- Less costly power generation

Disadvantages

- Fluctuating in nature
- Needs storage capacity
- Noisy in operation
- Large areas are required

Classification of WECS

1. Two broad classifications:

i. **Horizontal Axis Machines:** The axis of rotation is horizontal and the aero turbine plane is vertical facing the wind.

ii. **Vertical Axis Machines:** The axis of rotation is vertical. The sails or blades may also be vertical.

2. Based on size:

i. **Small Size** –up to 2kW

ii. **Medium Size-** 2 to 100kW

iii. **Large Size** -100kW and above:

2 Subtypes: a. Single Generator b. Multiple Generators

3. Based on Output Power:

i. DC output

a. DC generator

b. Alternator rectifier

(ii) AC output

a. Variable frequency, variable or constant voltage AC.

b. Constant frequency, variable or constant voltage AC.

4. Based on rotational speed of the aero turbines

i. **Constant Speed with variable pitch blades:** This made implies use of synchronous generator with its constant frequency output.

ii. **Nearly Constant Speed with fixed pitch blades**: This mode implies an induction generator.

iii. **Variable Speed with fixed pitch blades:** This mode could imply, for constant frequency output

5. Based on utilization of output :

i. **Battery storage.**

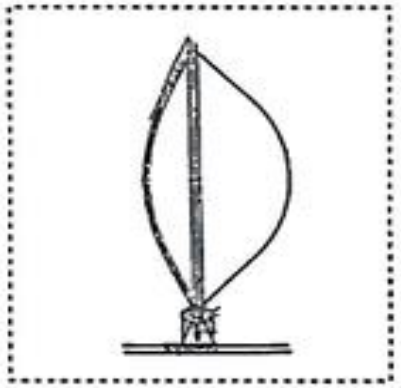
ii. **Direct connection to an electromagnetic energy converter.**

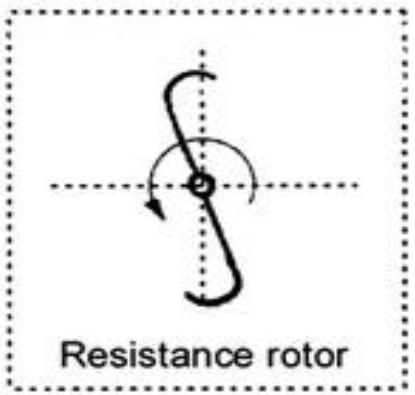
iii. **Other forms (thermal potential etc.) of storage.**

iv. **Interconnection with conventional electric utility grids.**

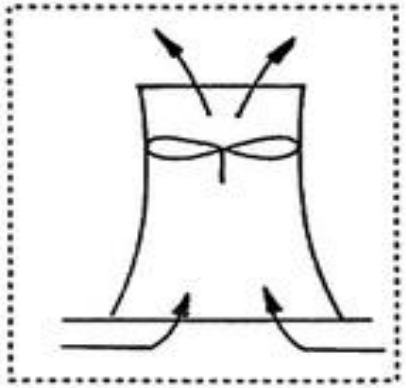
Wind Collectors

- Horizontal axis converter
  - FAST ROTATION
  - SLOW ROTATION
- Vertical axis converter
  - DARRIEUS
  - SAVONIUS
- Up-stream power station





Resistance rotor



Rotational Axis

There are two types of rotational axis: **horizontal and vertical.**

1.A **horizontal axis wind turbine (HAWT):** is the most commonly used type. The rotor blades are mounted on a horizontal shaft perpendicular to the ground.

2. **A vertical axis wind turbine (VAWT):** has its rotor blades mounted on a vertical shaft parallel to the ground. VAWT is less common than HAWT because it is more expensive and complicated to build and is not as efficient in converting wind energy into electricity.

Horizontal Axis Wind Turbines (HAWT)

- It has blades that look like a propeller that spins on the horizontal axis
- Small turbines are pointed by a simple wind vane placed square with the rotor (blades), while large turbines generally use a wind sensor coupled with a servo motor to turn the turbine into the wind.
- Most large wind turbines have a gearbox.
- Wind turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds.

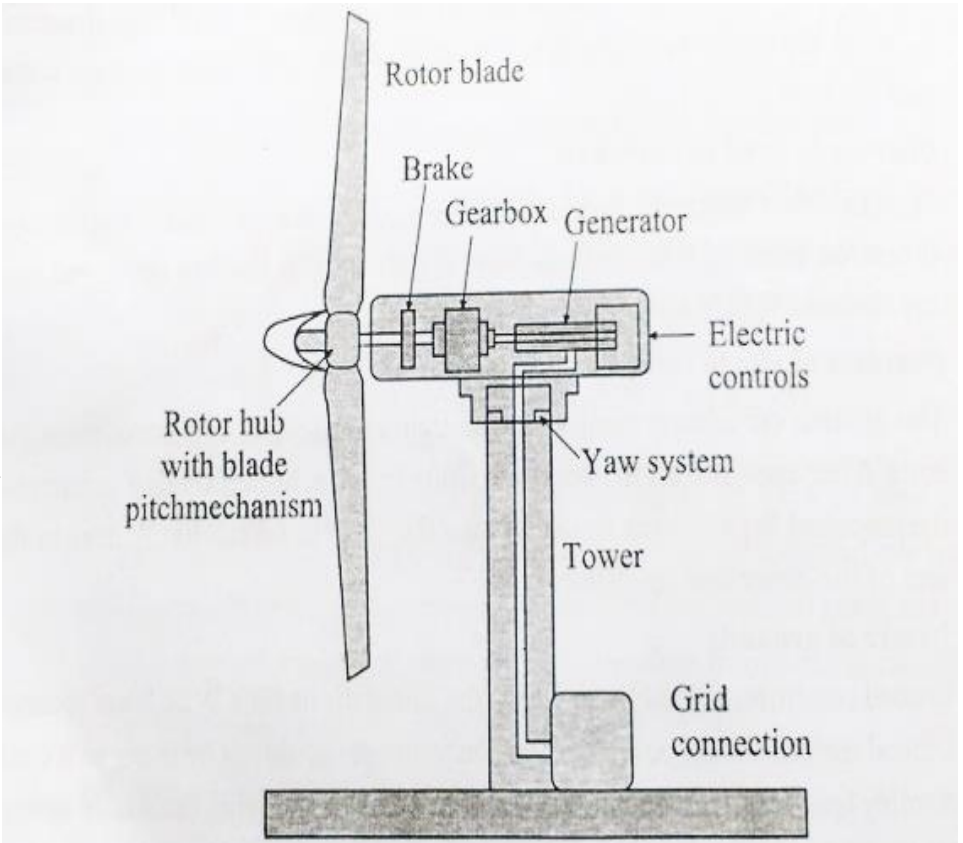


Fig. 5.8 Schematic Structure ofHorizontal Axis Wind Turbines

Classification of HAWT

Single-Blade Turbines

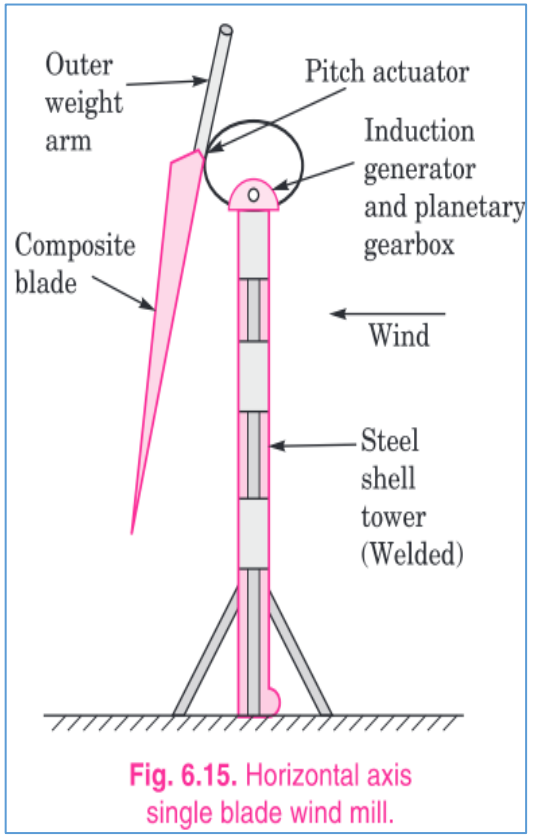
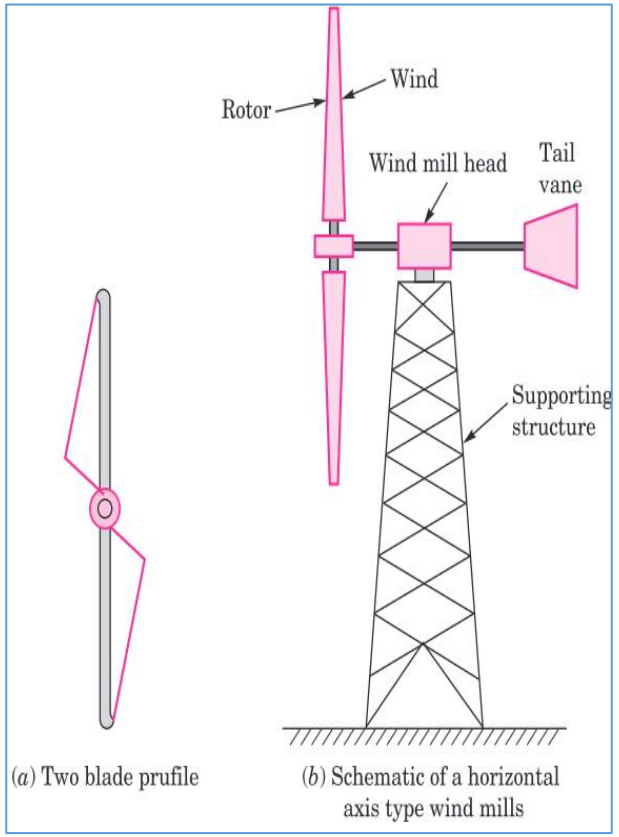


Fig. 6.15. Horizontal axis single blade wind mill.

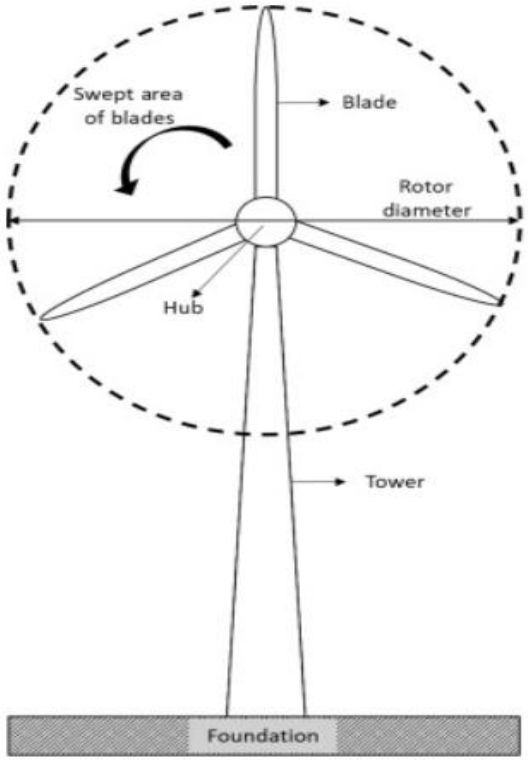
Two-Blade Wind Turbines



(*a*) Two blade prufile

(*b*) Schematic of a horizontal axis type wind mills

Three- blade Wind Turbine



Horizontal axis multibladed type

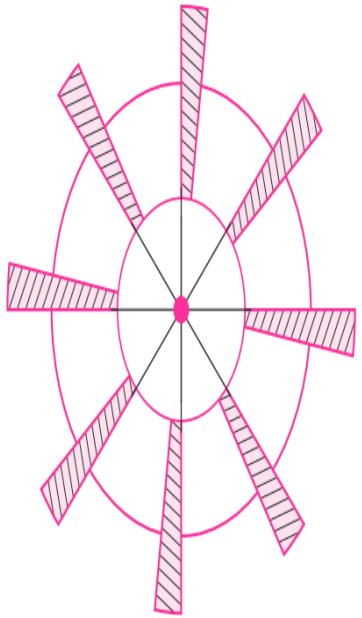


Fig. 6.16. Multiblade propeller.

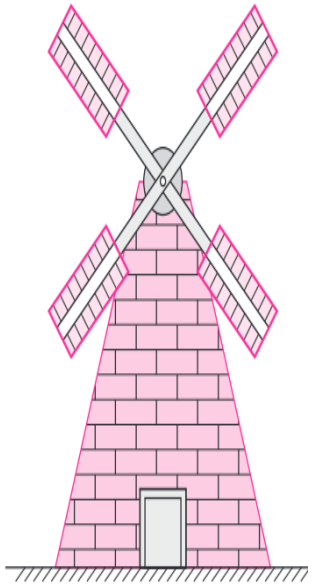


Fig. 6.17. Horizontal axis, Dutch type wind mill.

Sail type

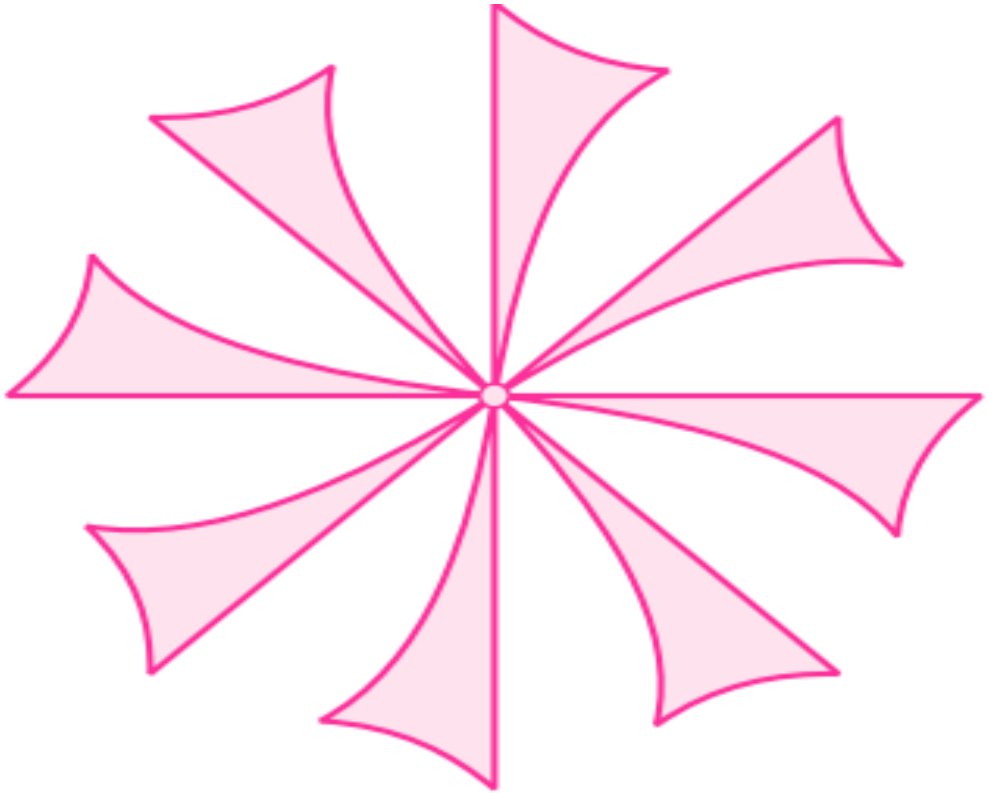
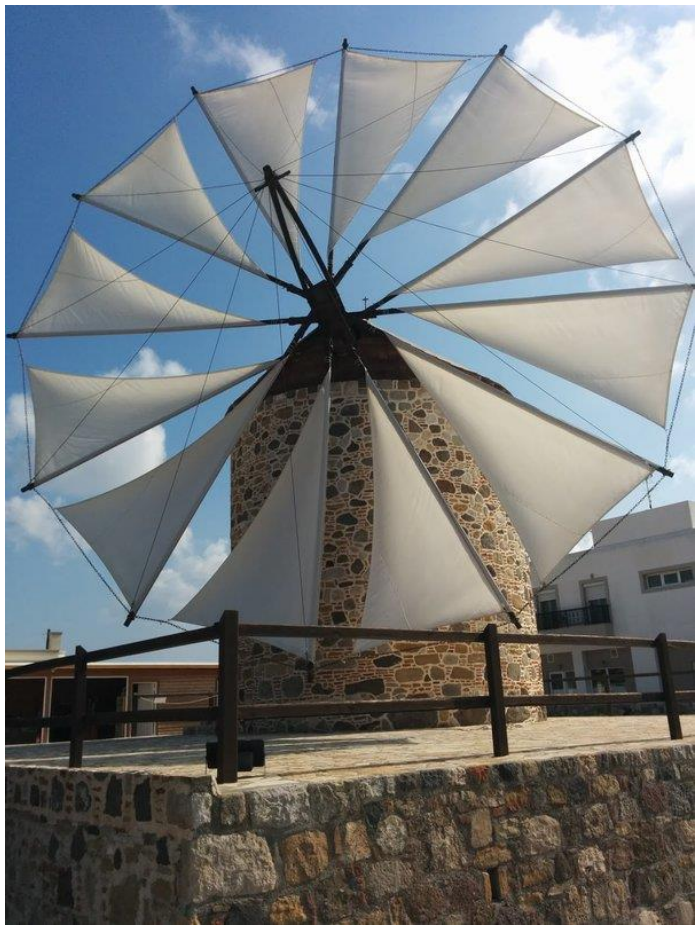


Fig. 6.18. Blades of sail type wind mill.



HAWT Advantages

- ✓ It includes high output power as compared to the vertical wind turbine.
- ✓ A tall tower gets stronger winds once the wind shear alters.
- ✓ High efficiency.
- ✓ It is not expensive as compared to a vertical-type turbine.
- ✓ It has high reliability.
- ✓ It has a high rate of capacity.
- ✓ Its rotational speed is high.
- ✓ It is more consistent.
- ✓ The blade can also tilt the rotor during a storm to reduce damage

HAWT Disadvantages

- ✓ These are available in large size
- ✓ Weight is high
- ✓ We cannot move easily
- ✓ Installation is difficult
- ✓ High noise
- ✓ To design this wind turbine, large machinery is needed
- ✓ Its maintenance is difficult as compared to other wind turbines.

Applications

The applications of horizontal-axis wind turbines include the following.

- ✓ These are the most frequently used wind turbines for commercial and industrial purposes due to their large power output and high efficiency.
- ✓ These are mostly used in wind farms
- ✓ Horizontal axis wind turbines achieve better power output & higher energy efficiency, so used in large-scale wind power plants & also for electricity generation.
- ✓ In industrial plants, large-scale wind farms, or national projects, these wind turbines are most frequently seen. So they are the perfect solution for the production of mass electricity.

Vertical Axis Wind Turbines(VAWT)

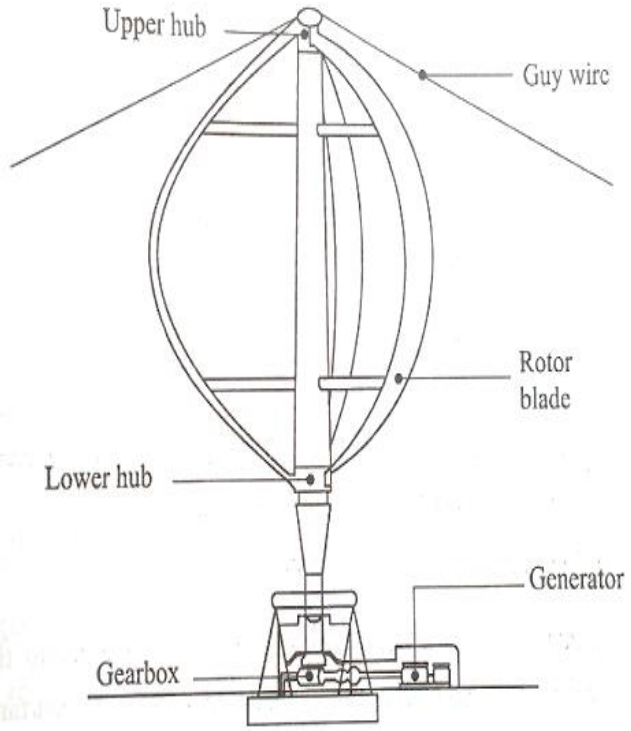
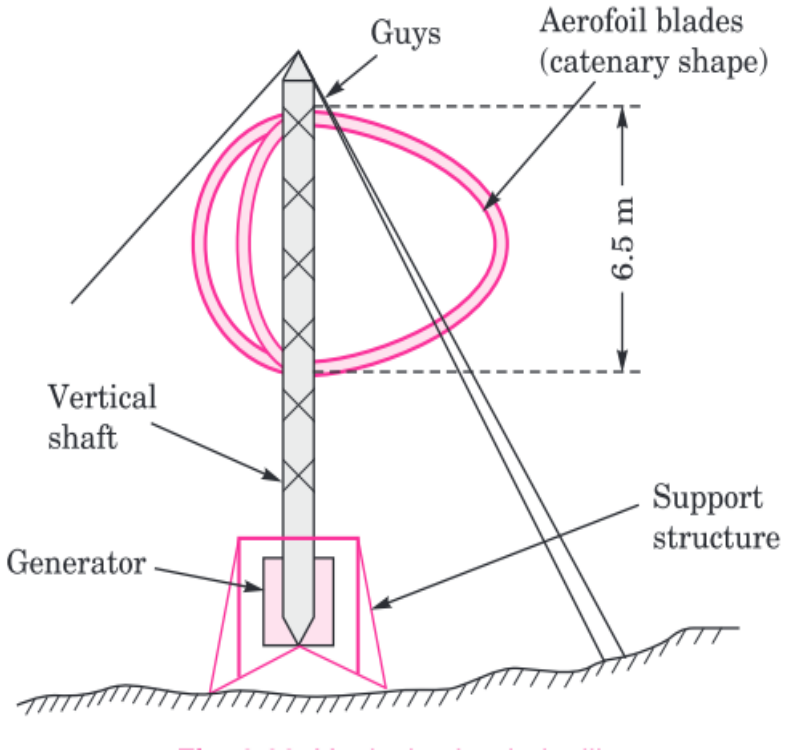
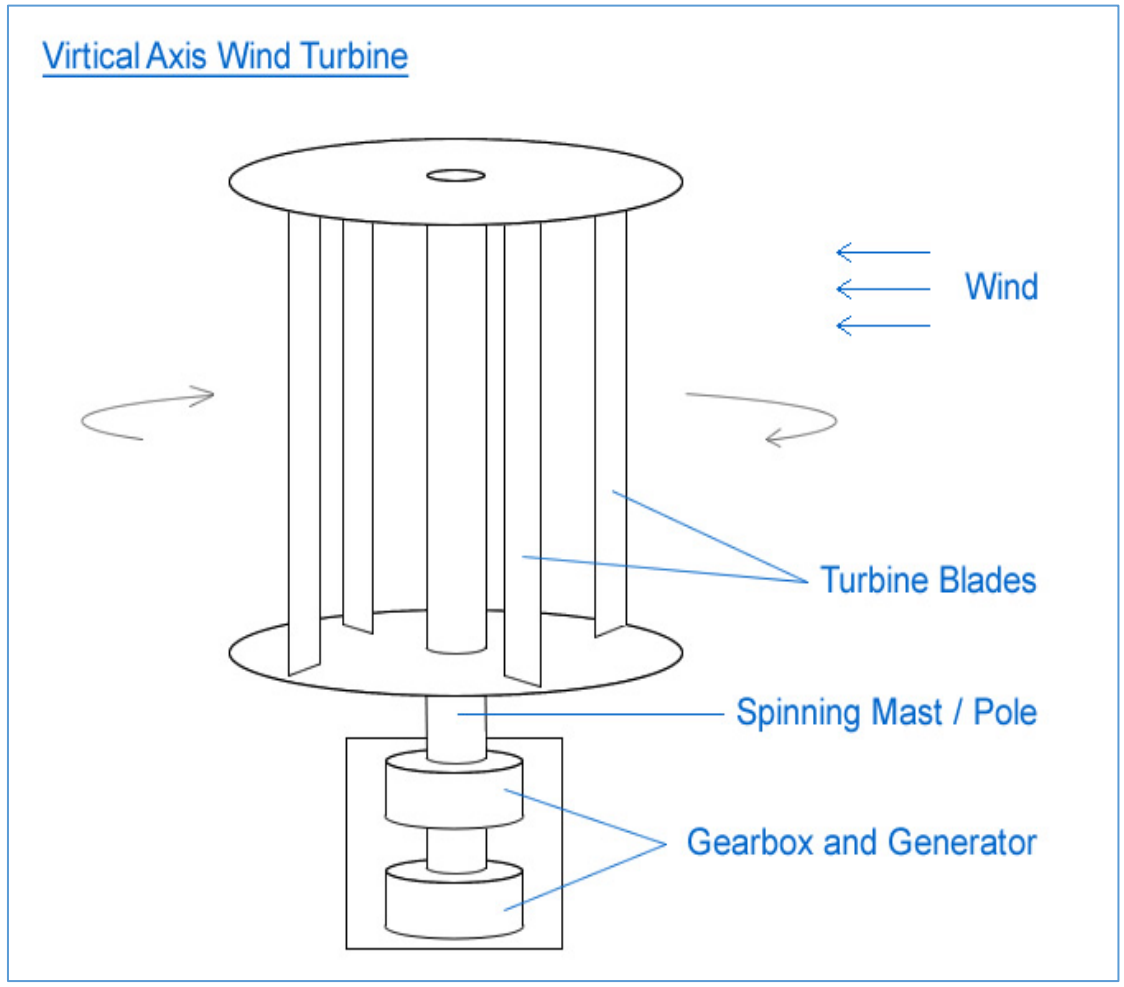


Fig. 5.9 Schematic Structure of Vertical Axis Wind Turbines (Darrieus wind turbine)

Darrius Wind Turbine



Savonius wind turbine



VAWT Advantages

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

VAWT Disadvantage

1. Most VAWTs have an average decreased efficiency from a common HAWT, mainly because o 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.
2. Having rotors located close to the ground where wind speeds are lower and do not take advantage of higher wind speeds above.
3. Because VAWTs are not commonly deployed due mainly to the serious disadvantage mentioned above, they appear novel to those not familiar with the wind industry. This has often made them the subject of wild claims and investment scams over the last 50 years.

Solar Cell Principles:

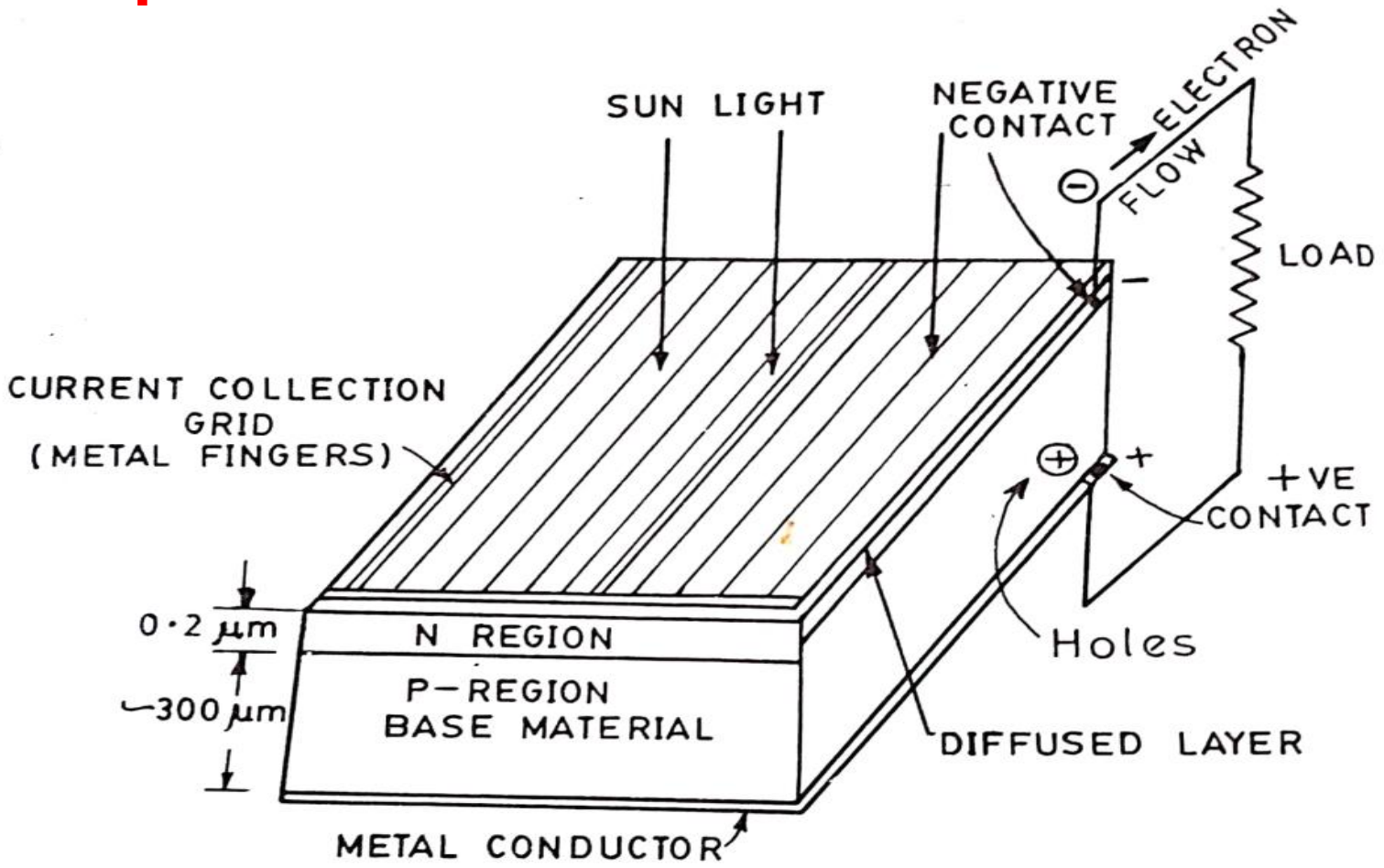


Fig. 5.6.1. Schematic view of a typical solar cell.

A Basic Photovoltaic System for Power Generation

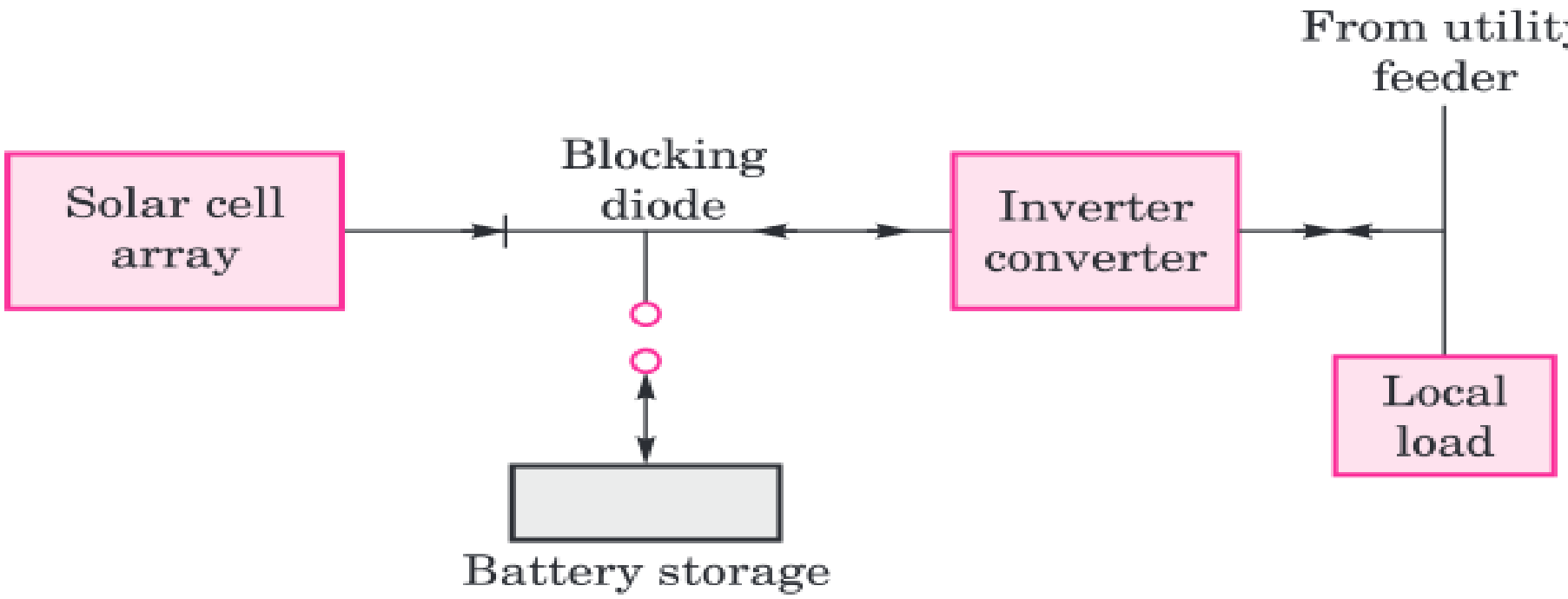


Fig. 5.25. Basic photovoltaic system integrated with power grid.

Applications of Solar Photovoltaic System

(i) water pumping sets for micro irrigation and drinking water supply,

(ii) radio beacons for ship navigation at ports,

(iii) community radio and television sets,

(iv) cathodic protection of oil pipe lines,

(v) weather monitoring,

(vii) battery charging,

(vi) railway signalling equipment,

(viii) street lighting.


thank
you