RENEWABLE ENERGY TECHNOLOGY

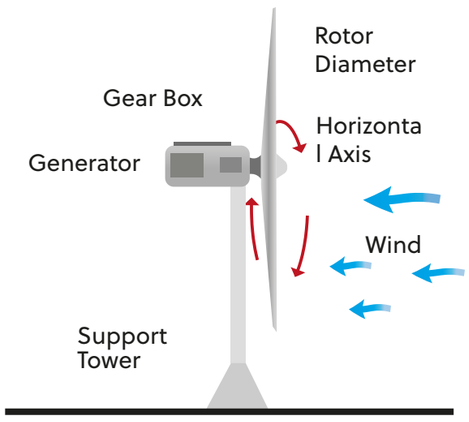
WIND ENERGY

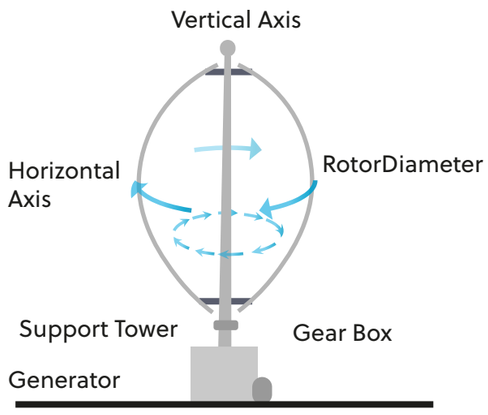
TECHNOLOGY DESCRIPTION

Wind results from the movement of air caused by atmospheric pressure gradients. The uneven heating of the atmosphere causes the expansion of warmer air. The wind blows from higher-pressure to lower-pressure zones. The wind turbine is an energy-converting machine to convert wind's kinetic energy into mechanical energy and, in turn, into electrical power.

WIND TURBINE CLASSIFICATION

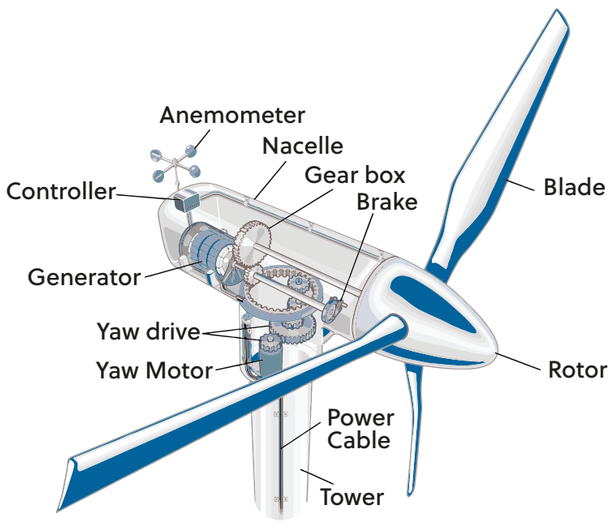
HORIZONTAL-AXIS (HAWT)	POINTS TO CONSIDER
• The rotating axis of blades is parallel to the wind stream	• Rotate with respect to their Vertical-Axis (VAWT) that are perpendicular to the ground.
• It needs to be placed in the wind direction	• Can receive and process wind from any direction
• The design is more complex and expensive	• The maintenance is more manageable with lower cost
• Outstanding performance due to sufficient starting speed	• Start at a lower wind speed which results in less productive performance





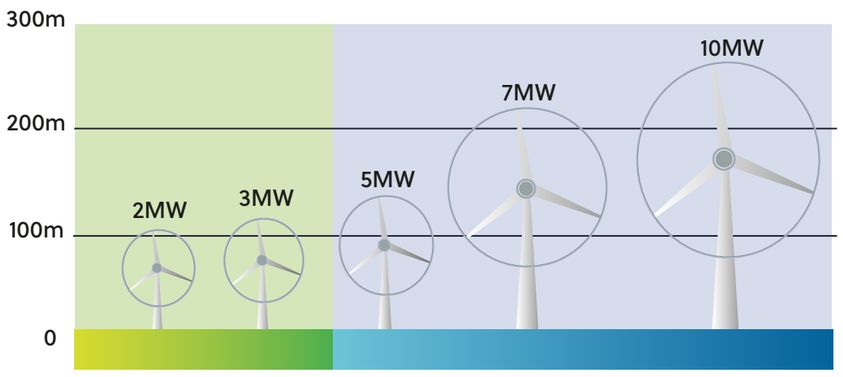
WIND TURBINE COMPONENTS

- The tall tower supports the structure and raises the wind turbine high above the ground, so the blades are safely clear and can reach the stronger winds at higher elevations.
- The nacelle generally houses a set of gears mounted on the top of the tower.
- The gearbox helps increase the speed of the rotor (blades) to generate electricity.
- Control system for starting, stopping, and monitoring the wind turbine operation.
- The yaw drive is utilized to maintain the rotor orientation facing the wind.



WIND ENERGY GENERATION PROCESS

Wind flows across the blades of the horizontal wind turbine, which causes the air pressure on one of the sides to decrease. Therefore, the air pressure difference across the two sides of the blades creates lift and drag forces. Due to the strong lift force, the rotor, which is connected directly to a gearbox, spins the shaft; thus, it speeds up the rotation convenient for a small generator.



WIND TURBINE SIZE AND POWER RATINGS

DESIGN CONSIDERATIONS

- **Wind speed and statistics**

A detailed wind resource site assessment should be performed for the selected sites.

- **Operation characteristics of wind turbine**

The power curve identifies the relationship between wind speed and the generator output power.

Cut-in speed represents the minimum speed to start producing power.

Rated power output: the generator produces electrical power proportional to the cube wind speed (V3) until it reaches its maximum rated power output.

The cut-out speed: limit speed where sensor can be used to apply a brake to prevent generators' damage

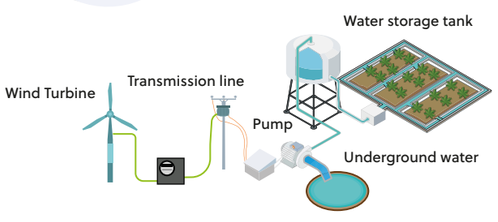
Rated power

$$W = \frac{(w \times h)}{(365 \text{ days} \times 24 \text{ hours} \times \text{Capacity Factor})}$$

(W) Wind turbine rated power
(wxh) Annual energy output required

ADVANTAGES	POINTS TO CONSIDER
• Does not release pollutants and emissions • Have a small footprint • Can serve off-grid and on-grid applications • Cost-effective	• Low variable costs and relatively high fixed costs • Poorly sited facilities threaten wildlife • Create visual and sound pollution • Best fit in rural areas, which require transporting electricity over long cable distances

APPLICATIONS



- Water pumping

- Residential applications

- Off-grid applications

- On-grid application

- Large scale applications

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