

# Wind Energy

## Definition of Wind Energy

Wind energy is energy from moving air.

Air has mass. When it moves, it has kinetic energy. Kinetic energy is the energy of motion.



## How does wind form?

Wind forms when the sun heats one part of the atmosphere differently than another part. The heat warms the air causing it to expand. The heated air has less pressure than cooler air. Air always moves from high pressure to lower pressure. The movement of air is wind.

## What is wind energy used for?

Wind energy can be converted into mechanical force or used to generate electricity.

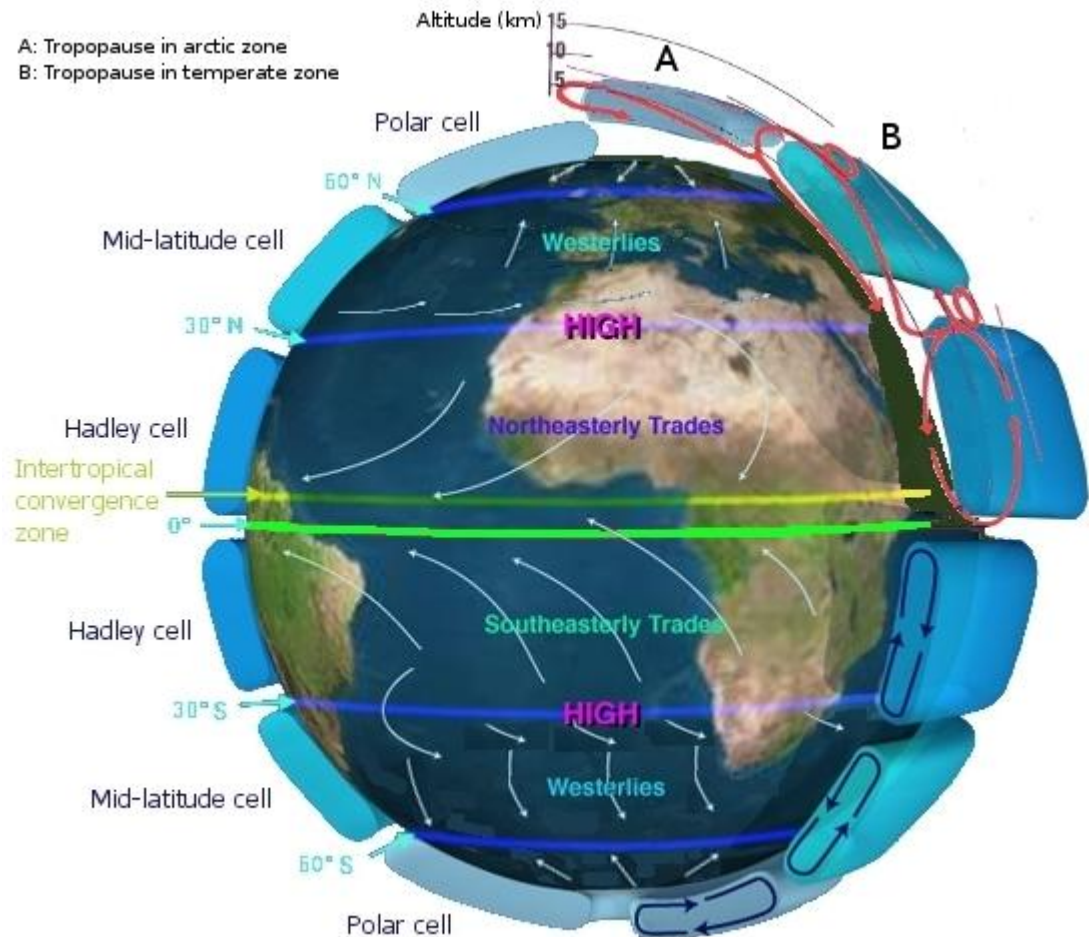
## Wind on a Global Scale

Global air movements make steady winds called trade winds that blow all the time.

**EQUATOR and TROPICS:** Air from the mid-latitudes moves along the Earth's surface toward the equator to take the place of the air that rises there, making a loop of air movement called a *Hadley cell*. Air expands and rises at the equator and tropics because the sun heats that area the most.

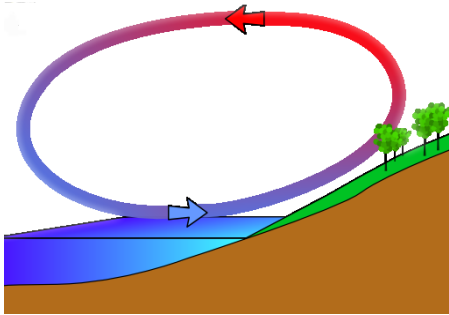
**THE POLES:** The poles are cold because they do not receive a lot of heat from the sun. Therefore, air sinks down and moves away from the poles and rises again at about 60 degrees latitude.

**EARTH'S ROTATION:** The Earth is in constant motion turning from west to east. Since the Earth continually rotates, the trade winds are subject to the Coriolis force which affects wind direction. This means the winds—called geostrophic winds—are deflected away from the rotation axis in a perpendicular direction. In other words, in the northern hemisphere, trade winds veer to the right. In the southern hemisphere, trade winds veer to the left.

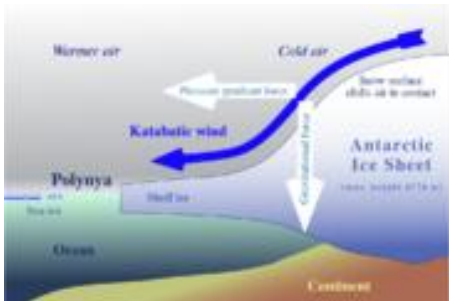


## Wind on a Local Scale

There are other, more local ways that wind forms as well.



**Wind along the coast:** Because of the differing heat capacity of land and water, winds consistently blow along coasts. During the day, the sun heats up the land while the ocean water stays the same temperature. The hot air rises. Cool air comes in off the ocean to take the place of the rising hot air. At night, the land cools more than the adjacent water resulting in a land breeze where air rises over the sea and sinks over coastal land.



**Wind in the mountains:** Mountain valleys can have very strong, steady winds called katabatic winds. The term comes from the Greek word *katabatikos* which means “going downhill.” Air is cooled by the mountaintops and gravity pulls the high density air downhill into the valleys and lowlands below.



**Wind on the plains:** Wind can build up between large air masses. In the Great Plains region, cool air masses from the arctic meet warm air masses from the tropical waters of the Gulf of Mexico causing a great deal of wind. This region is a substantial contributor of U.S. wind energy.

### DID YOU KNOW?

As the wind moves over the Earth’s terrain, friction with the ground can impact wind speed and direction. The faster the wind, the greater the frictional force. Wind machines are built tall to minimize the impact of ground friction and capture faster, stronger winds.



## Brief History of Wind Energy

People have harnessed the wind and used its energy for many centuries.

### Windmills



The famous, old Dutch windmills were used for grinding grain and doing other things that needed power in their society.

### Wind pumps



The American pioneers took advantage of steady winds on the great plains to drive water wells that brought water from deep underground to the surface for cattle and others to drink.

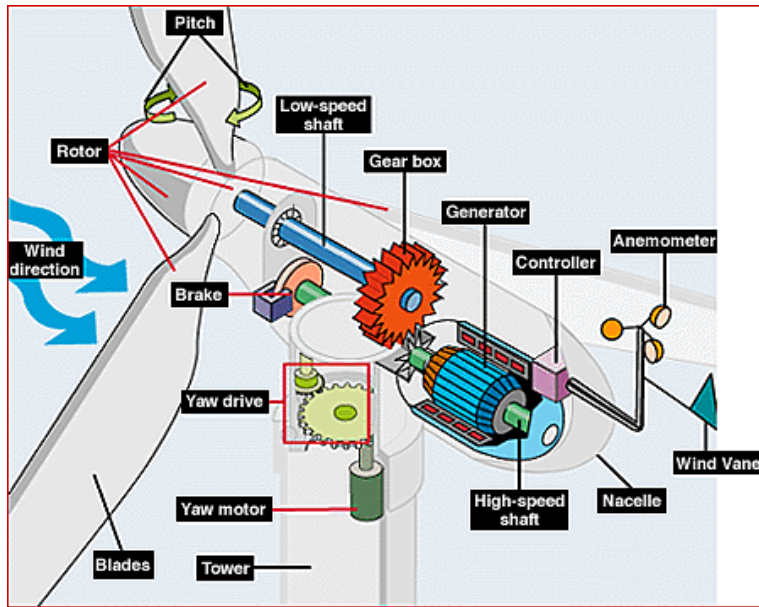
### Wind turbines



In modern times, wind farms consist of dozens of new and aerodynamically designed wind turbines which are used to generate electricity for towns and cities.

## Generating Electricity Using Wind

Wind energy can be turned in to electricity that can be used in homes and businesses. To make electricity, energy is needed to turn a generator. Moving air supplies the energy. A wind turbine is used to turn the generator.



### How wind turbines work

The wind flows over the blades which creates lift and causes the blades to turn.

The turning blades convert the wind's energy into low-speed rotational energy causing the gears to turn.

The turning gears spin the generator which increases the rotational energy in order to generate electricity.

The electricity is sent to the electrical grid for use by the public.

## Harnessing Lots of Wind Energy

In order to generate a lot of electrical power, wind turbines are often grouped together.



A group of turbines is called a *wind power plant* or a *wind farm*. Wind farms supply electrical energy to the utility grid so it can be widely distributed. Ranging in size and capacity, wind farms can easily be expanded to include additional turbines to meet growing electricity demands.



Locating wind farms takes careful planning. Many wind farms are located on land usually on rounded hills or open plains because there are no obstacles to reduce wind speed. Mountain valleys also work well because they funnel the wind. Some farms are even located off-shore to capitalize on coastal winds.

## Getting Wind Energy to your Home

Although not unique to wind energy, electricity that is generated from wind may have to travel long distances to reach the place where it is needed, such as your home or school.



Electricity is transported through wires that can be seen across the countryside. These wires transmit the high-voltage electrical energy to transformers in regional locations that lower the voltage so the energy can be used in homes.



Due to the resistance of the wires, about 10% of the energy is lost during transport as heat. The energy loss in trans-continental electricity transmission is minimized by using thick wires made of copper and metal alloys that have very low resistance.



In some cases, wind energy does not have to travel far to a location. Anyone can build and mount a windmill on their home, property or building. Windmills are even used on sailboats to generate electricity for lights and other machinery.

# Benefits and Challenges of Wind Energy

## BENEFITS

Wind energy offers many significant benefits, which include:

- Wind is a sustainable energy source and widely available.
- Wind energy is clean; it does not pollute the water or air.
- Harnessing wind energy is essentially free. After the initial investment, the wind's energy is virtually free.
- Wind turbines can be located in many regions, such as along coasts, and in areas that are already used for traditional farming.



## CHALLENGES

There are challenges to using wind energy, which include:

- Wind is not constant. It is intermittent and varies greatly, hour by hour, day by day. This can cause issues in terms of meeting supply and demand.
- Wind farms have an audible impact. The spinning blades generate noise. Additionally, birds and bats can be killed by flying into the moving blades, but thousands more are killed by flying into buildings.
- Wind farms also have a visual impact. Some people complain that they are not aesthetically pleasing while others prefer their appearance over other types of power generating facilities.
- Good wind farm sites are often far from the main electrical grid.