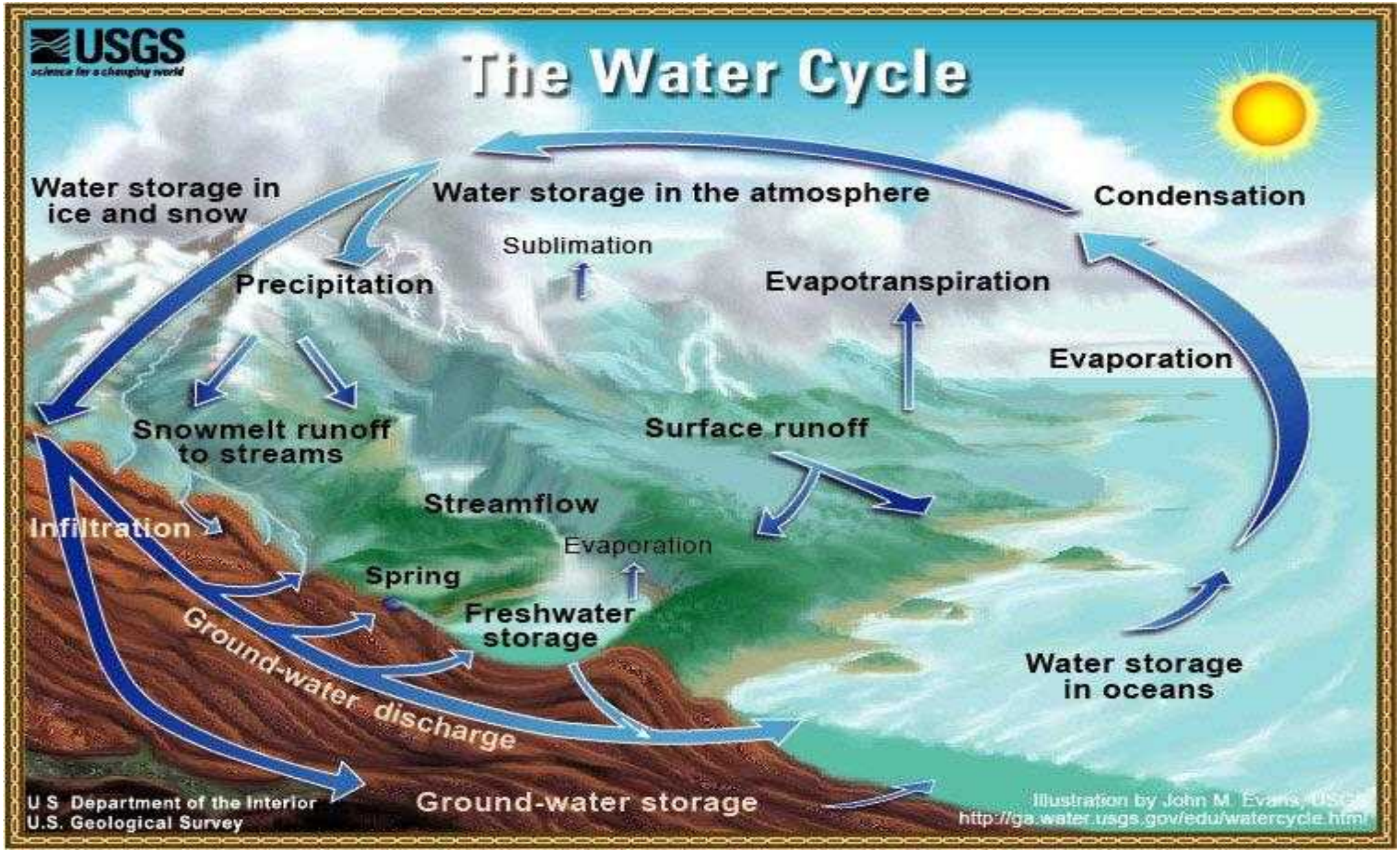
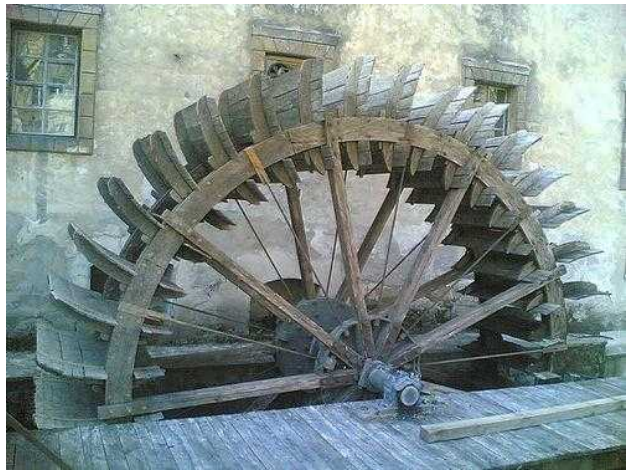
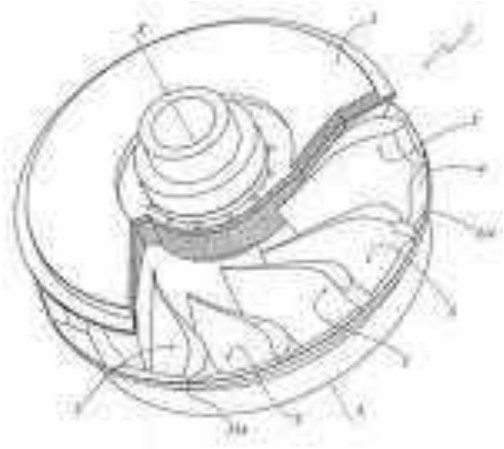
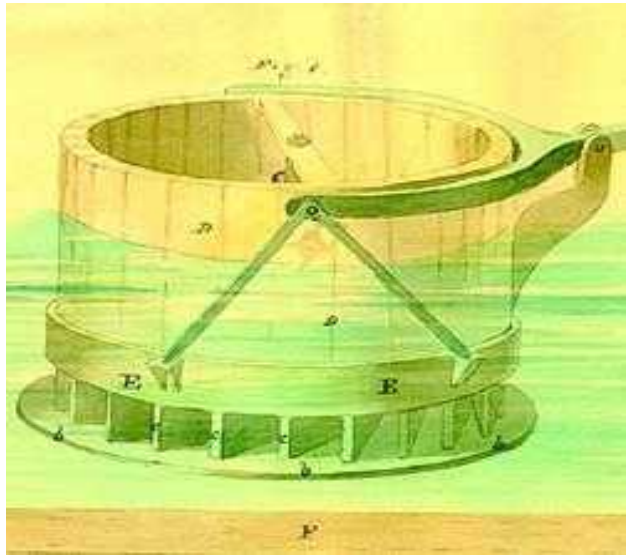
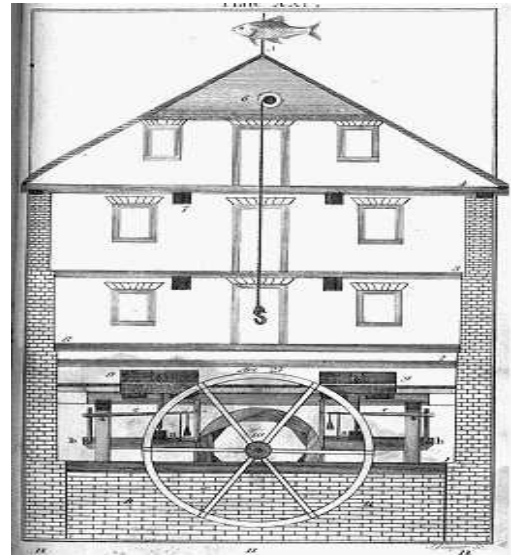

USGS
science for a changing world
The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
U S Department of the Interior
U.S. Geological Survey
Ground-water storage
Illustration by John M. Evans, USGS
http://ga.water.usgs.gov/edu/watercycle.html

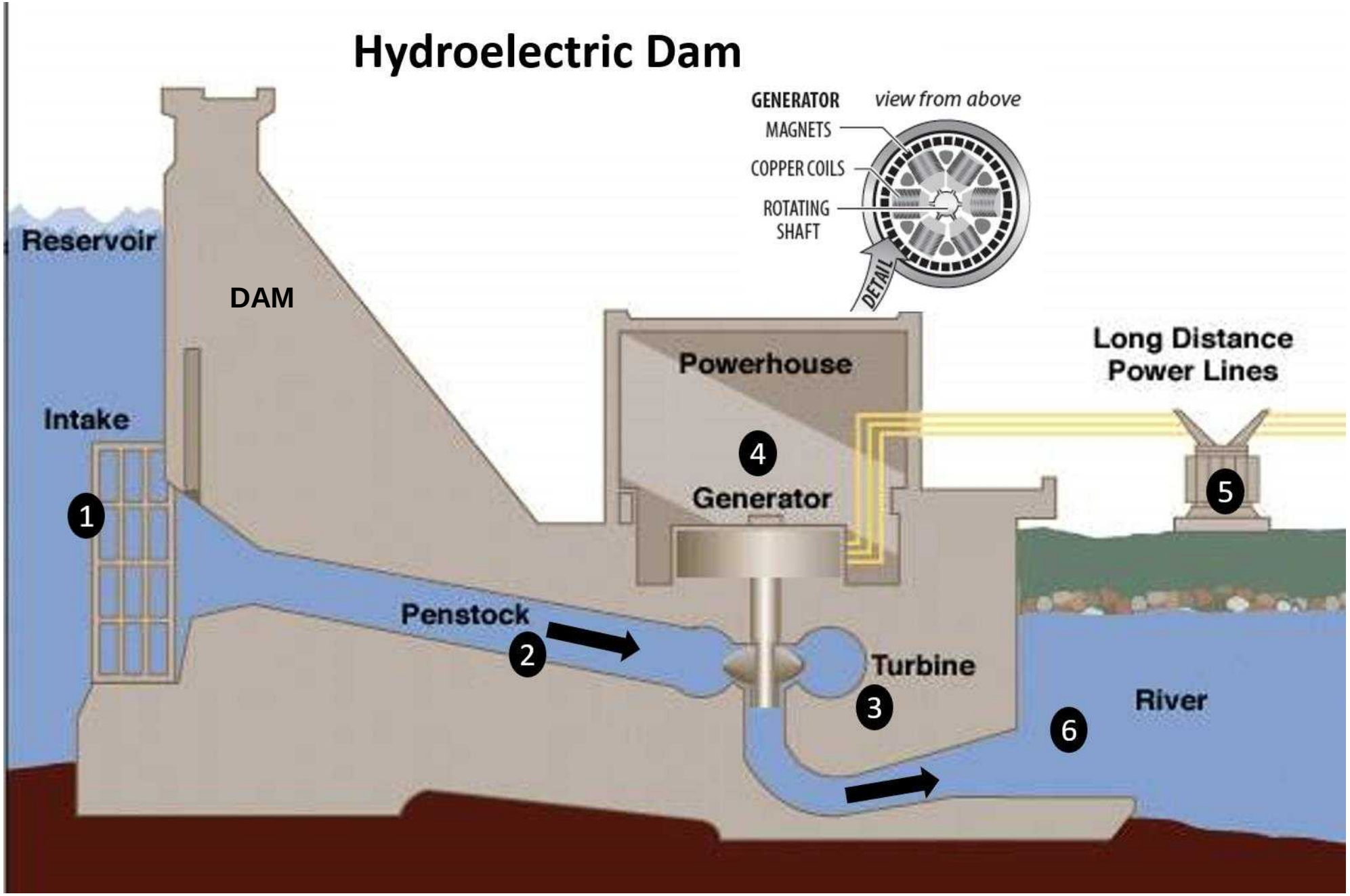
Harnessing Water Power



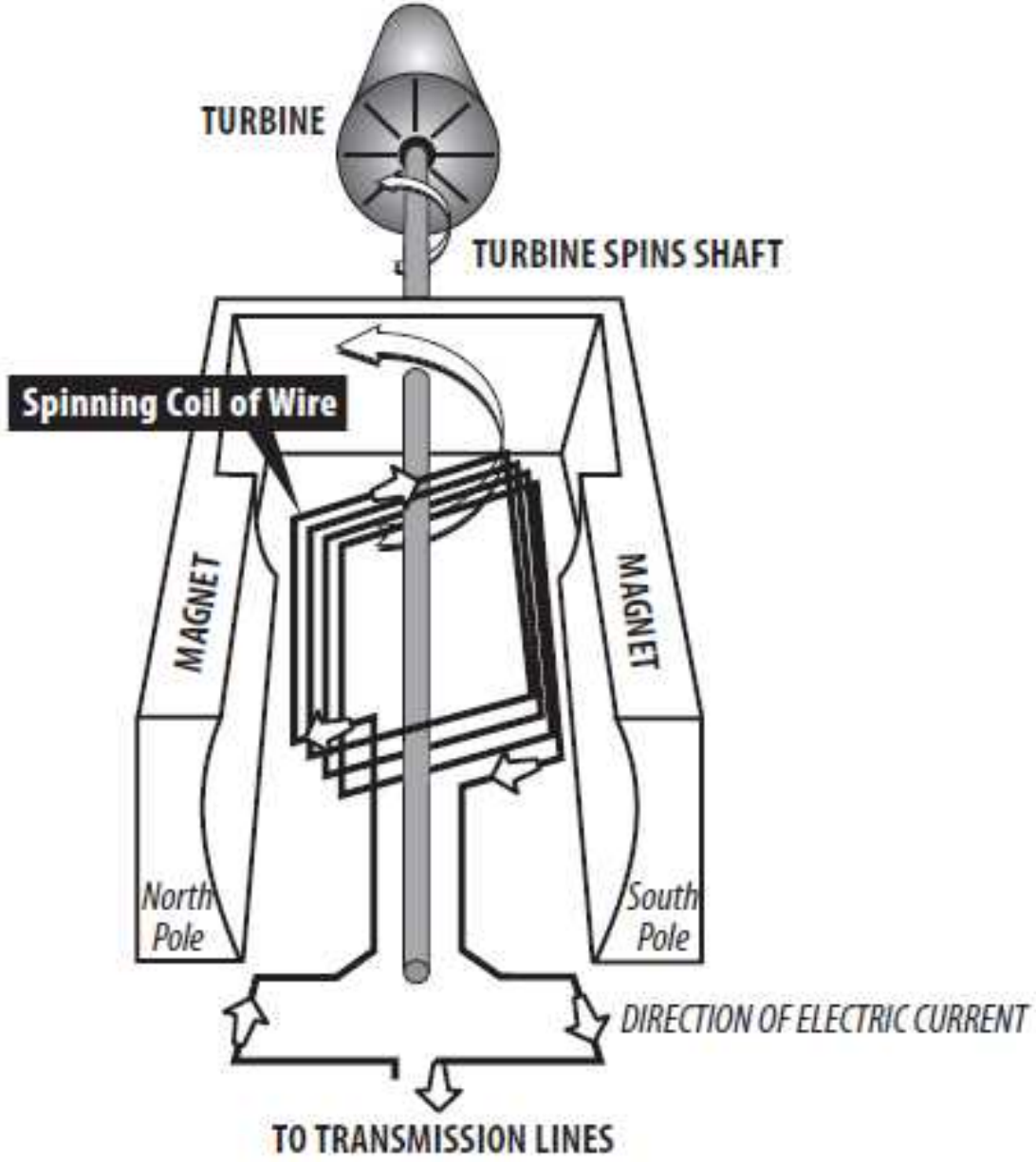







Hydroelectric Dam
GENERATOR
view from above
MAGNETS
COPPER COILS
ROTATING SHAFT
DETAIL
Reservoir
DAM
Powerhouse
Long Distance Power Lines
Intake
4
Generator
5
1
Penstock
2
Turbine
3
River
6

Turbine Generator



HYDROPOWER TURBINE GENERATORS

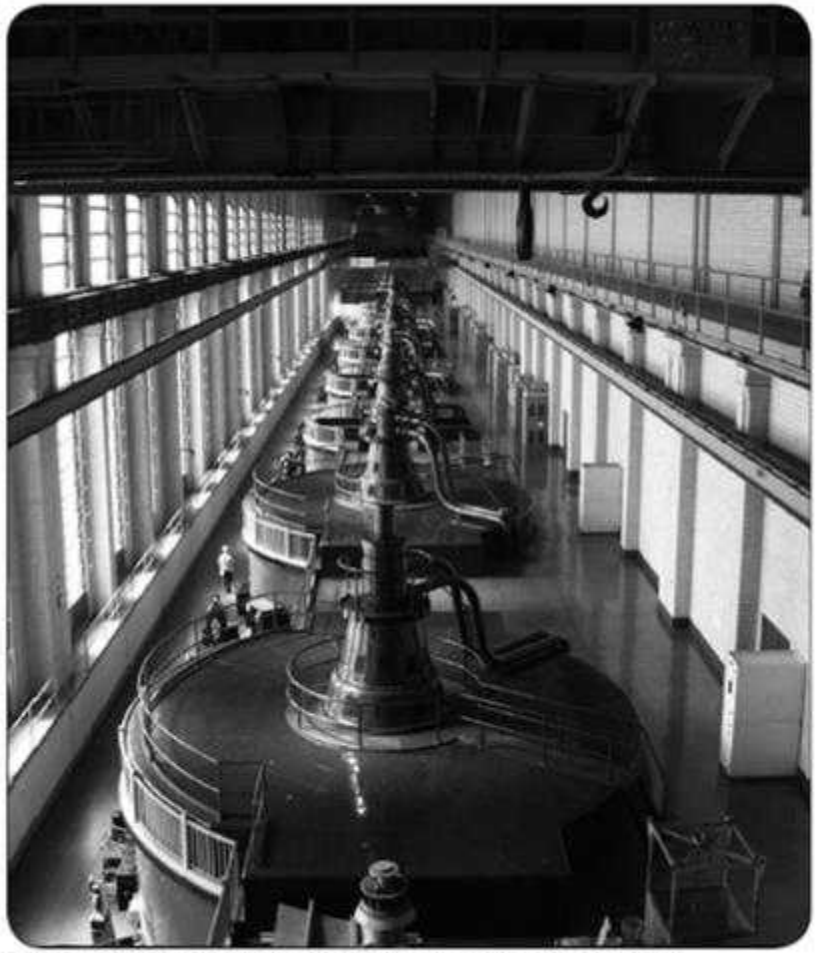
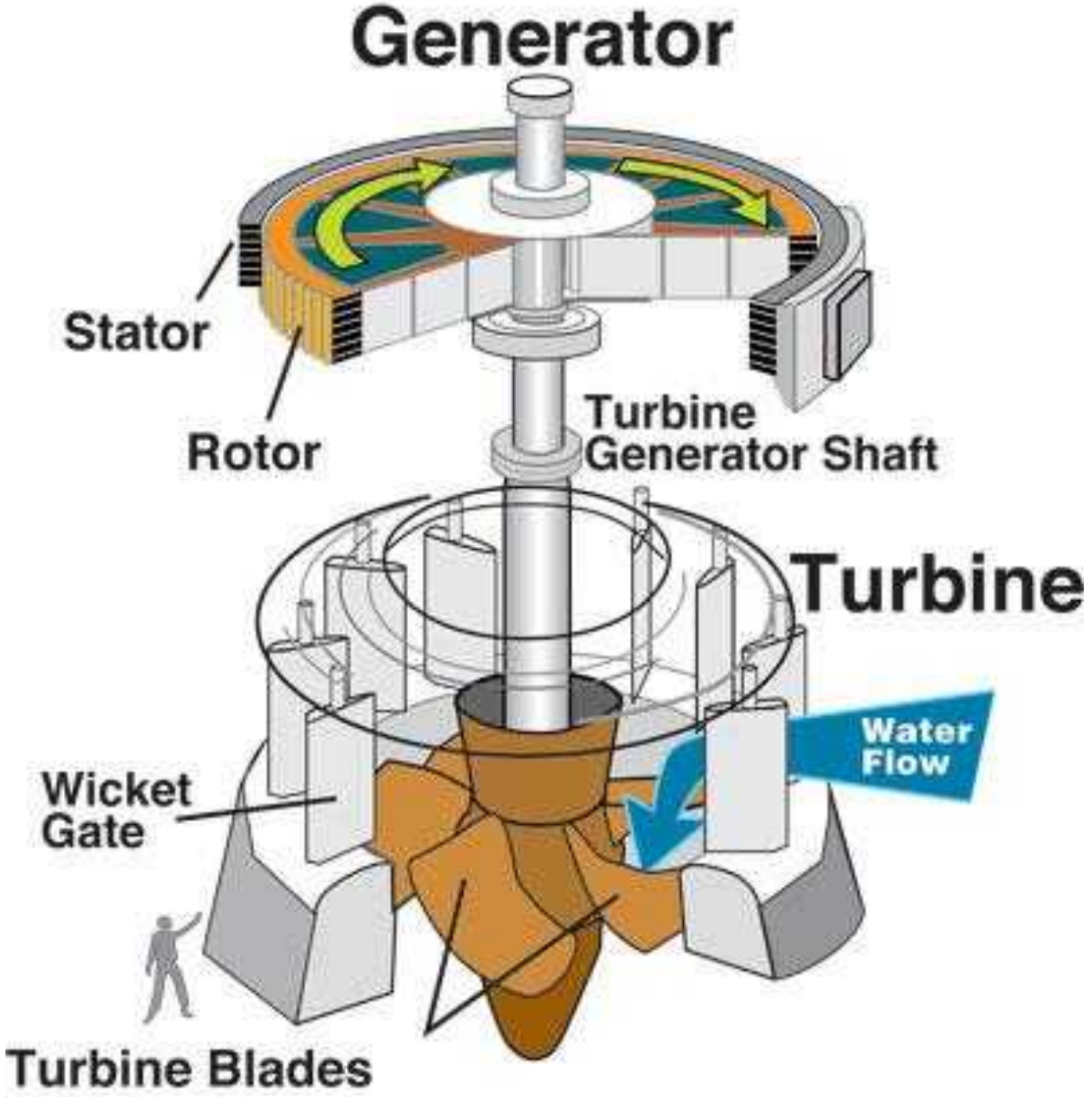


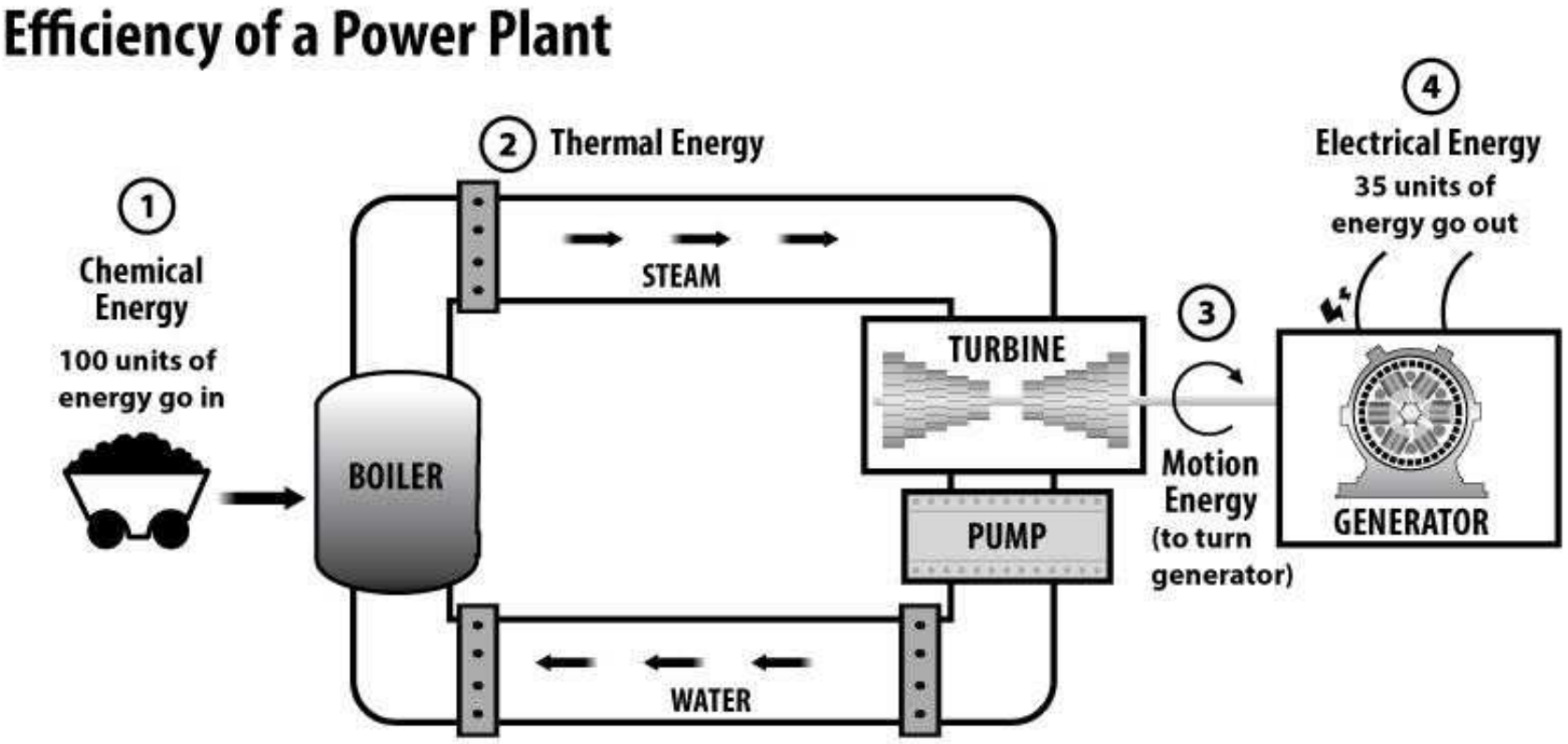
Photo of Safe Harbor Water Power Corporation on the Lower Susquehanna River in Pennsylvania.



Advantages

- Renewable Energy
- Clean Energy Source
- Domestic Energy Source
- Generally Available As Needed
- Provides Recreational Opportunities
- Water Supply and Flood Control

Power Plant Efficiency



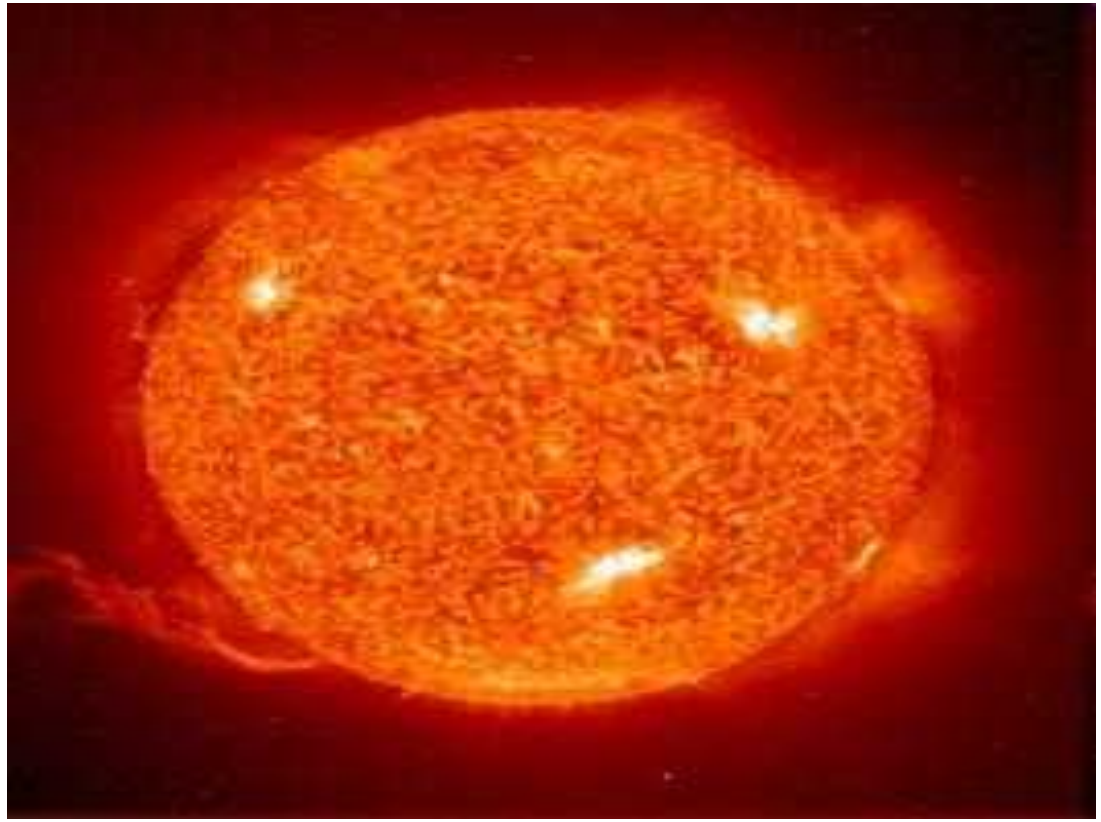
Most thermal power plants are about 35% efficient. For every 100 units of energy that go into a plant, 65 units are lost as one form of energy is converted into other forms. Most of the lost energy is in the form of heat from friction and heat that escapes the system. Thirty-five units are left to do usable work.

What is Solar Energy?

Originates with the thermonuclear fusion reactions occurring in the sun.

Represents the entire electromagnetic radiation (visible light, infrared, ultraviolet, x-rays, and radio waves).

Radiant energy from the sun has powered life on Earth for many millions of years.



Advantages and Disadvantages

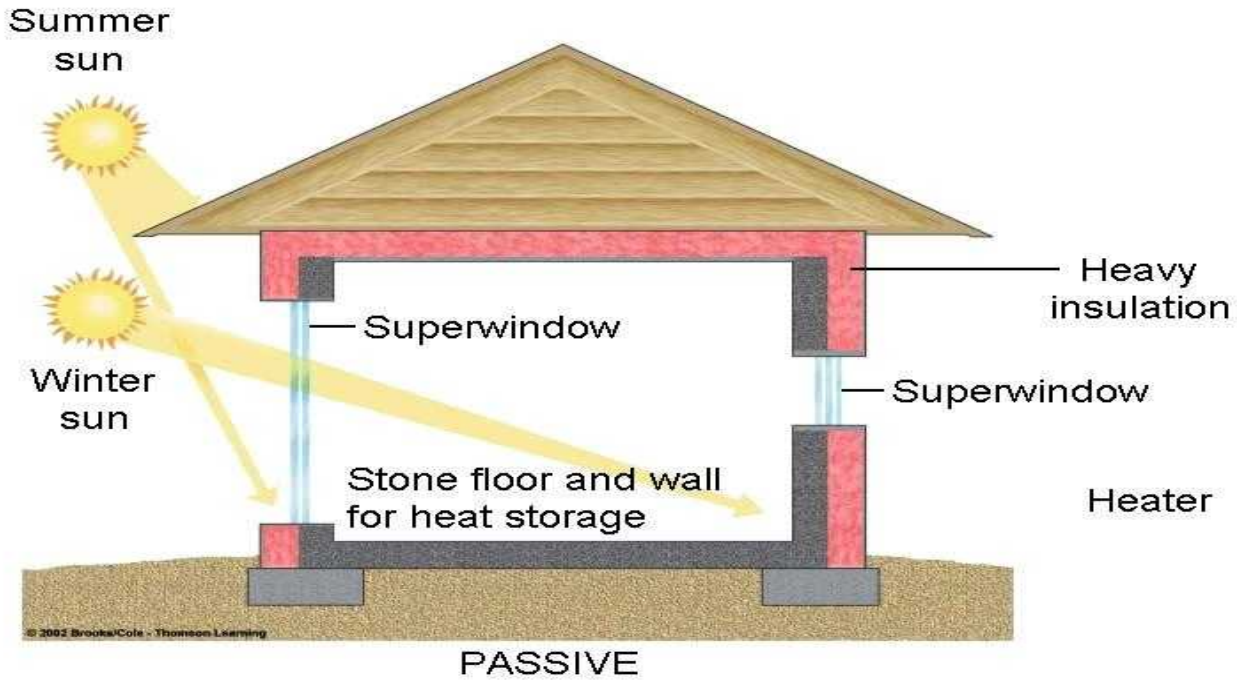
Advantages

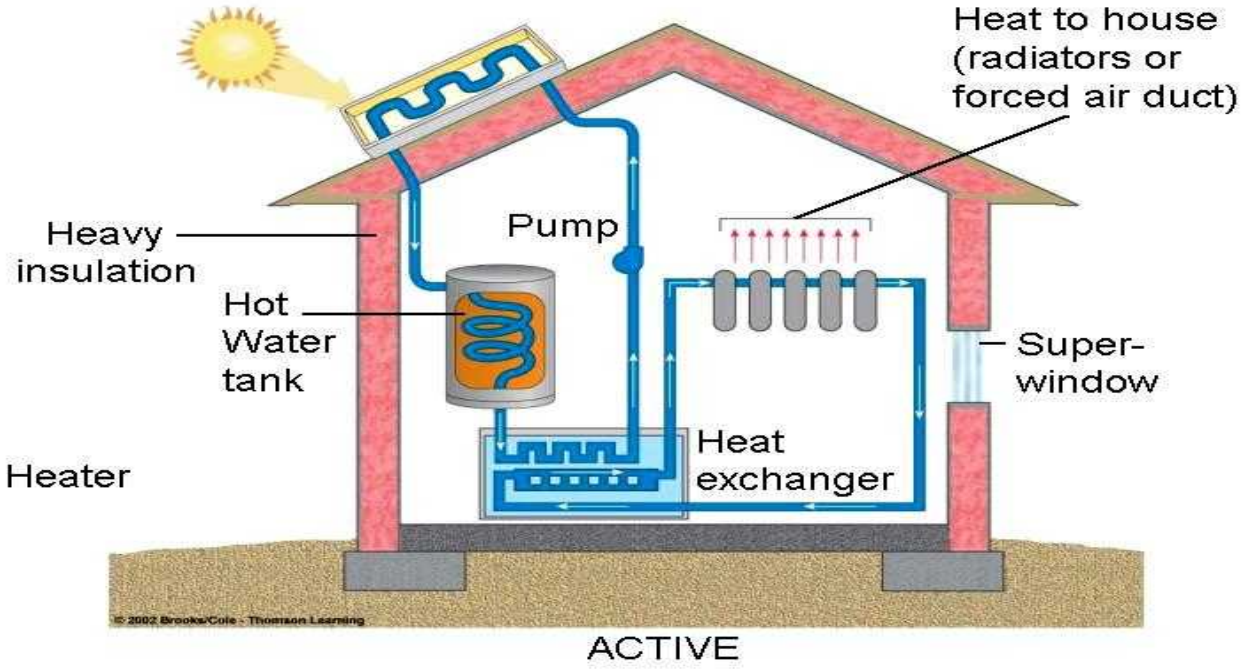
- All chemical and radioactive polluting byproducts of the thermonuclear reactions remain behind on the sun, while only pure radiant energy reaches the Earth.
- Energy reaching the earth is incredible. By one calculation, 30 days of sunshine striking the Earth have the energy equivalent of the total of all the planet's fossil fuels, both used and unused!

Disadvantages

- Sun does not shine consistently.
- Solar energy is a diffuse source. To harness it, we must concentrate it into an amount and form that we can use, such as heat and electricity.
- Addressed by approaching the problem through:
  1) collection, 2) conversion, 3) storage.

Solar Energy to Heat Living Spaces





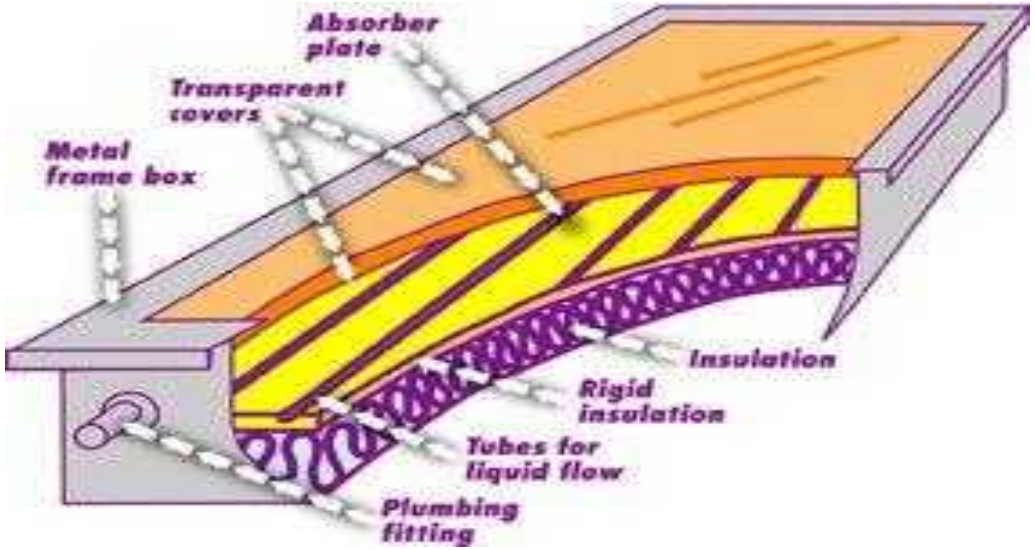
- **Proper design of a building is for it to act as a solar collector and storage unit. This is achieved through three elements: insulation, collection, and storage.**

Solar Energy to Heat Water

A flat-plate collector is used to absorb the sun's energy to heat the water.

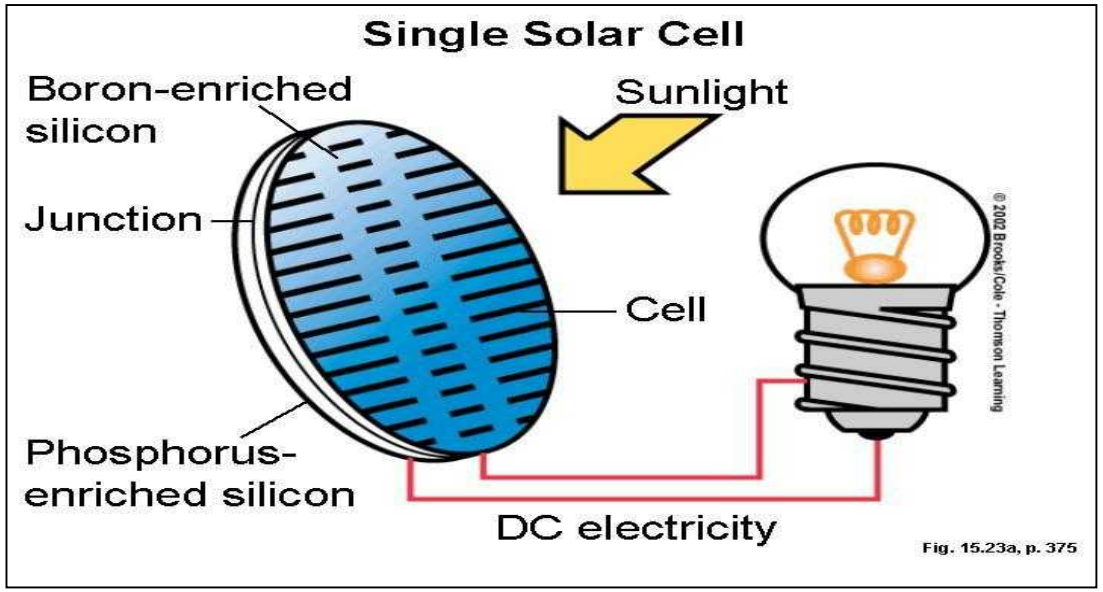
The water circulates throughout the closed system due to convection currents.

Tanks of hot water are used as storage.

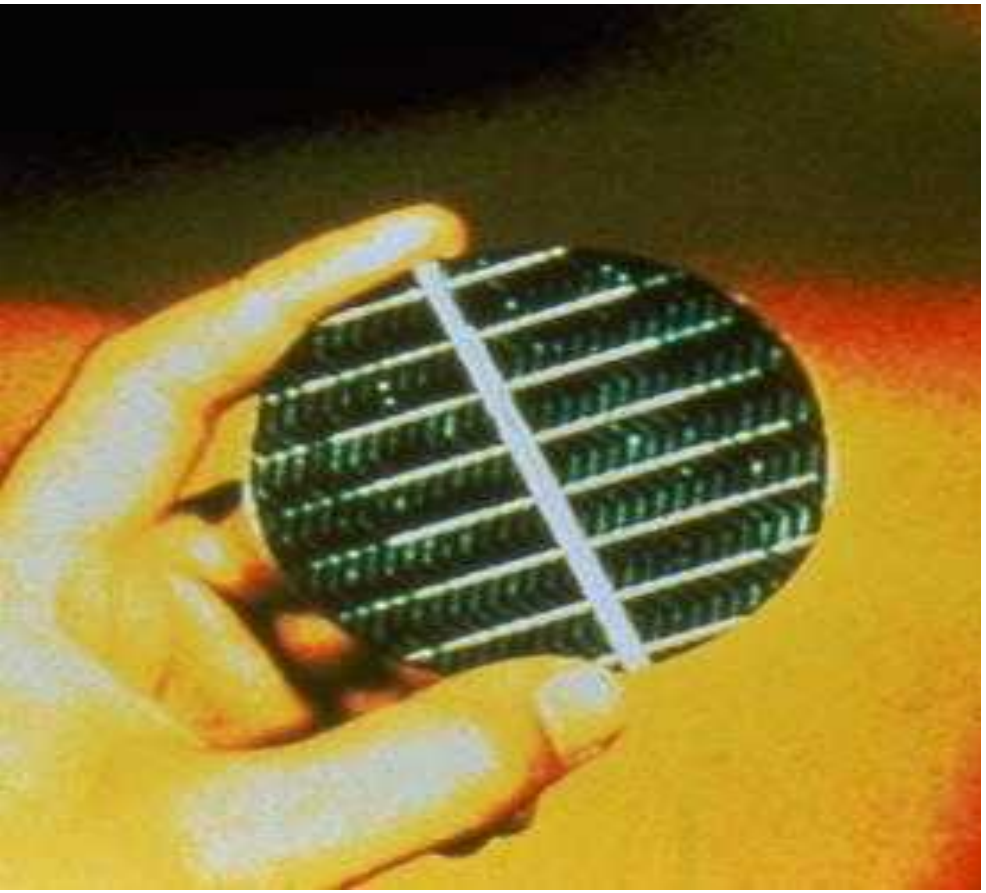


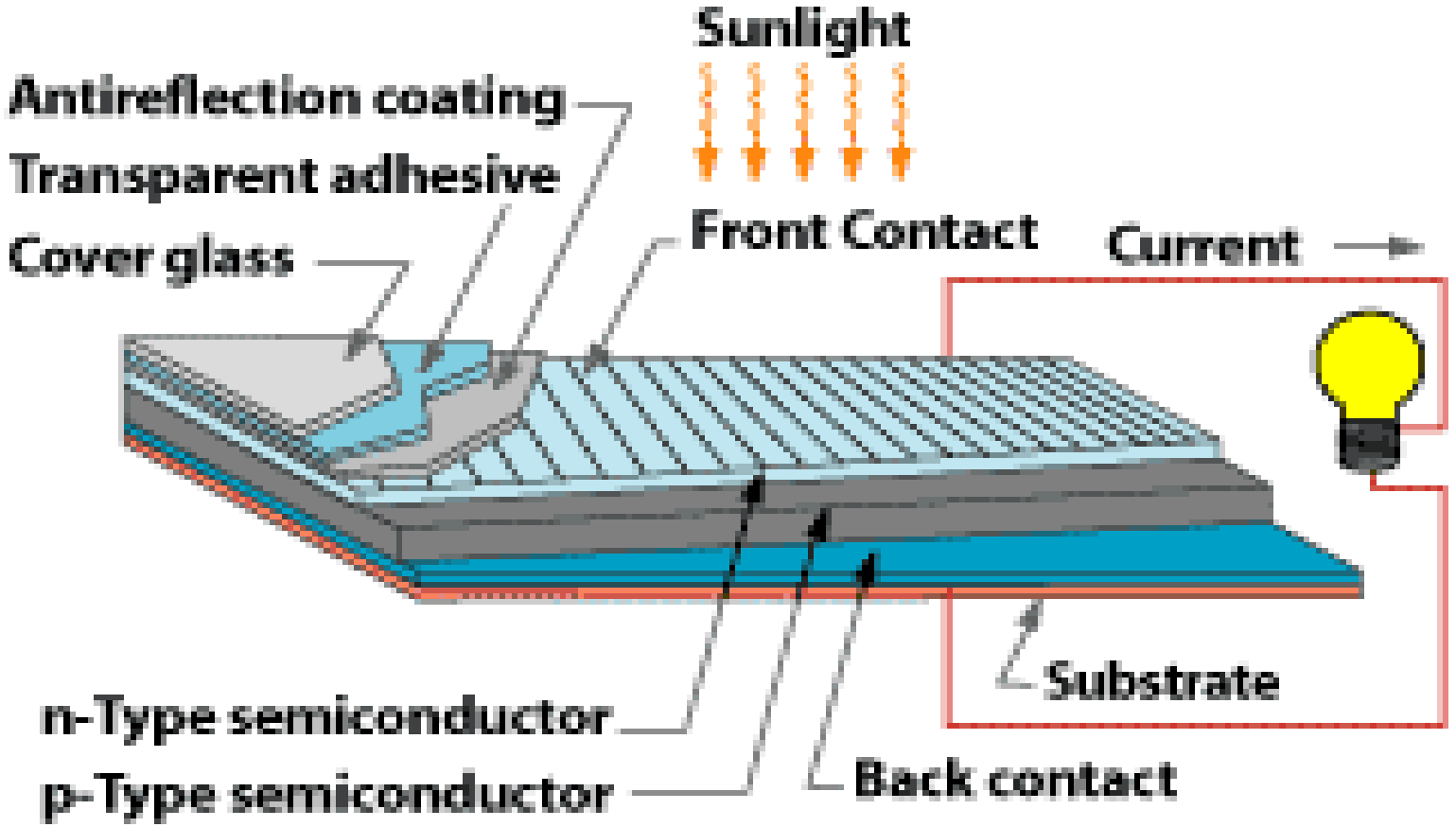
Photovoltaics

- **Photo+voltaic = convert light to electricity**



How does it work





The heart of a photovoltaic system is a solid-state device called a solar cell.

IT WORKS

Wind is a form of Solar energy

Wind is caused by the uneven heating of
the earth's surface and rotation of the Earth

Wind Turbines convert the kinetic energy in the wind to
mechanical power

A generator can convert the mechanical power into electricity

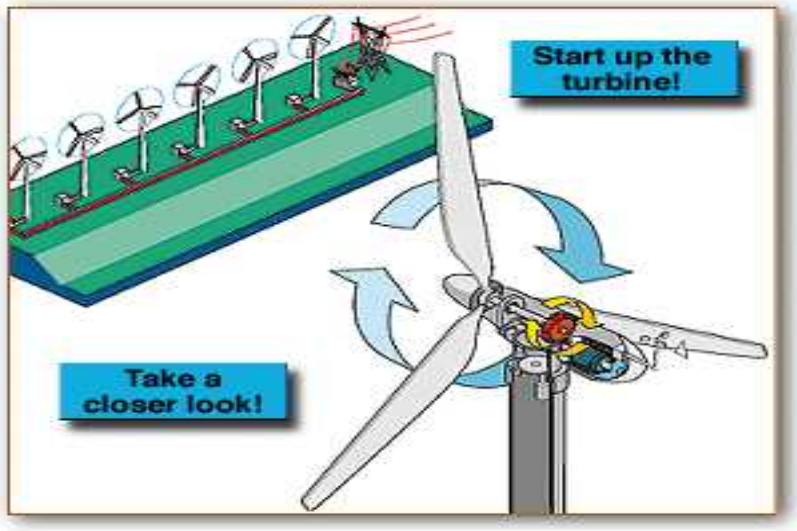
www1.eere.energy.gov

How it works cont.

A wind turbine works the opposite of a fan

The wind turns the blades, which spin a shaft,

Which connects to a generator and makes electricity.



www1.eere.energy.gov

The Parts

Anemometer

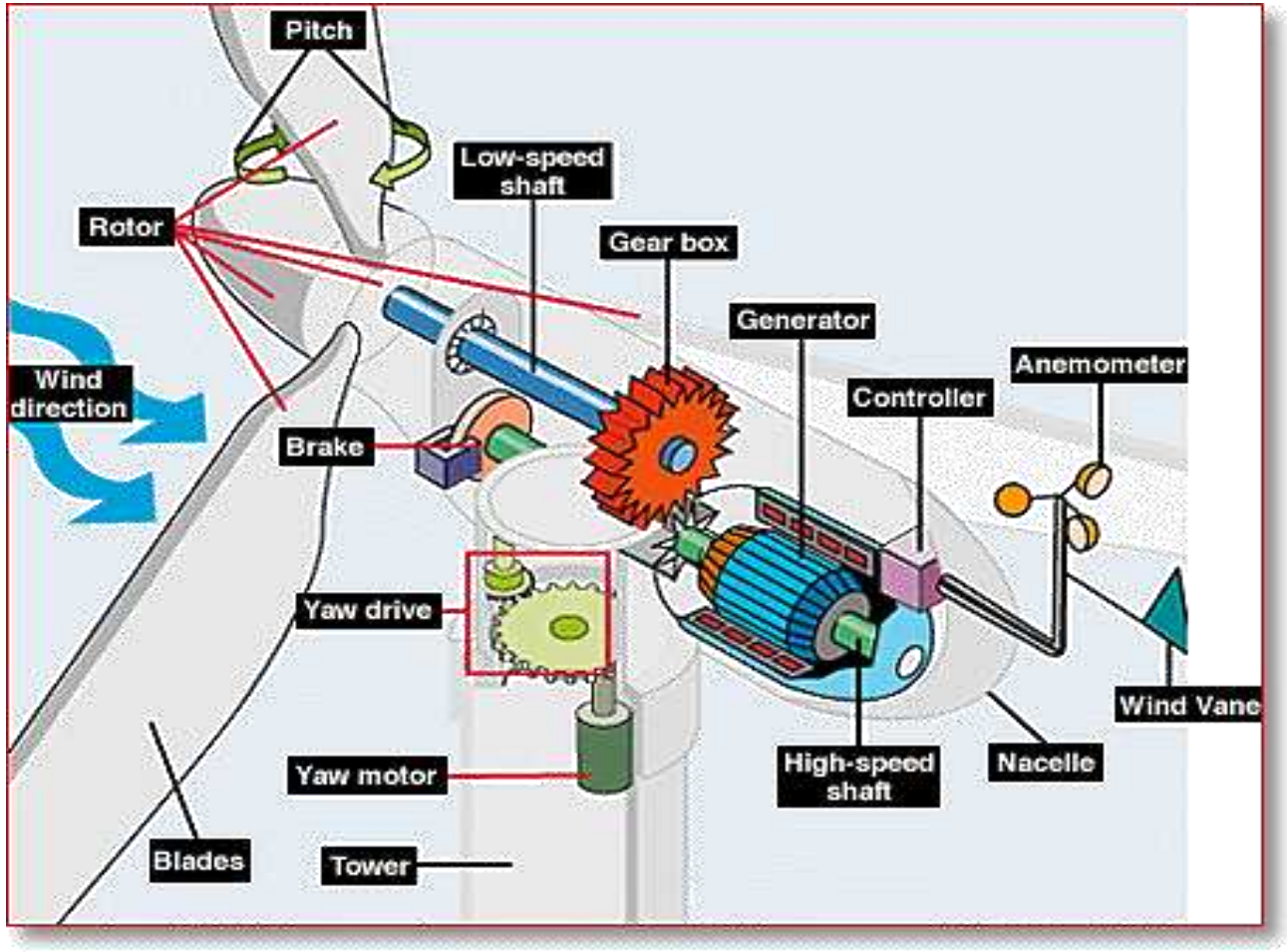
-measures the wind speed

Blades

-most turbines have 2 or 3. Wind blowing over the blades causes the blades to lift and rotate

Brake

-A disc brake can be used to stop the rotor in emergencies



www1.eere.energy.gov

The Parts

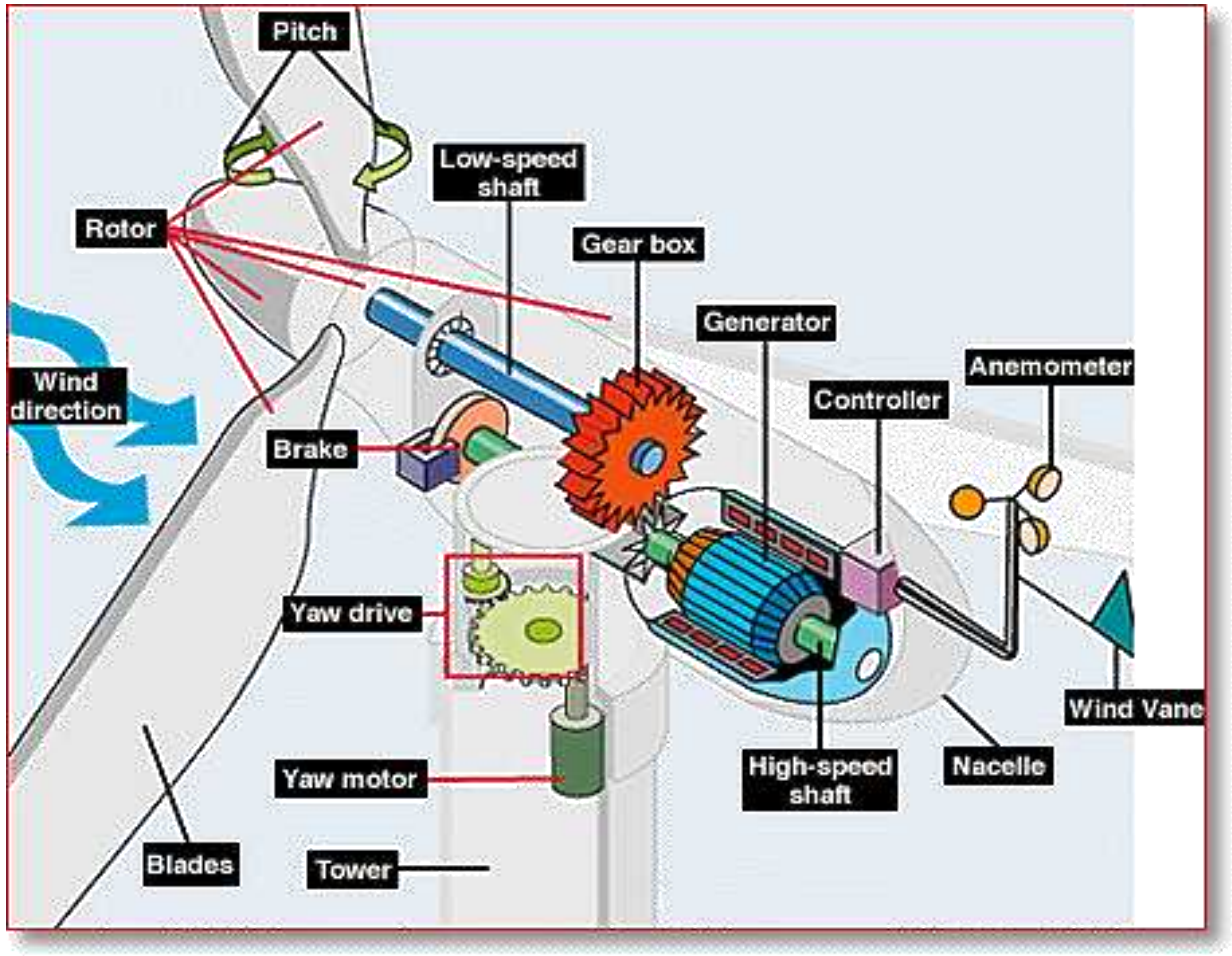
Controller

-The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Turbines do not operate at wind speeds above about 55 mph because they might be damaged by the high winds.

Gear box

Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm, the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear

boxes.



www1.eere.energy.gov

The Parts

Generator

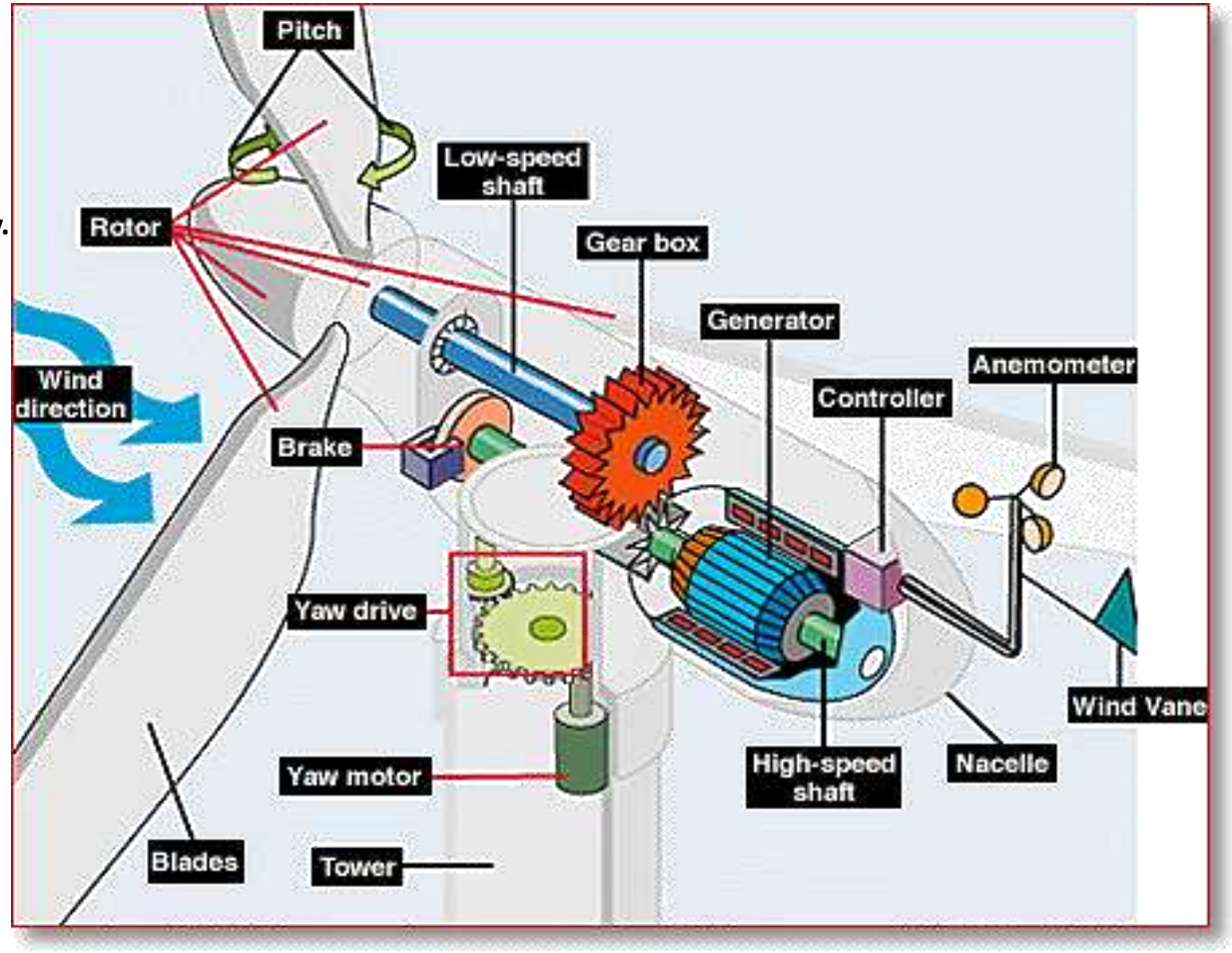
-Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.
Gear box

Low-speed shaft

-The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

Nacelle

-The nacelle sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.



www1.eere.energy.gov

The Parts

Pitch

-Blades are turned, or pitched, out of the wind to control the rotor speed and keep the rotor from turning in winds that are too high or too low to produce electricity.

Rotor

-The blades and the hub together are called the rotor.

Tower

-Towers are made from tubular steel (shown here), concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

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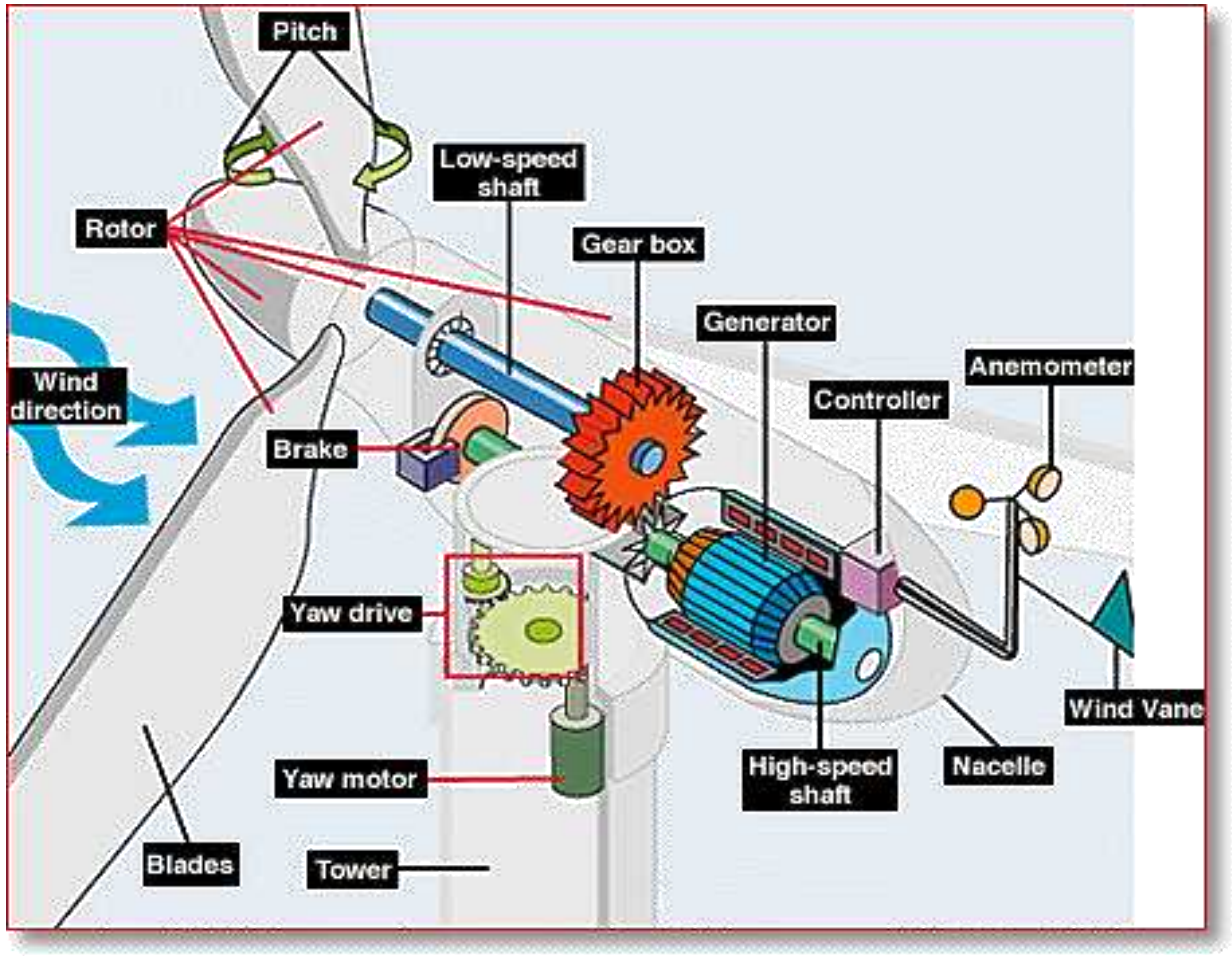


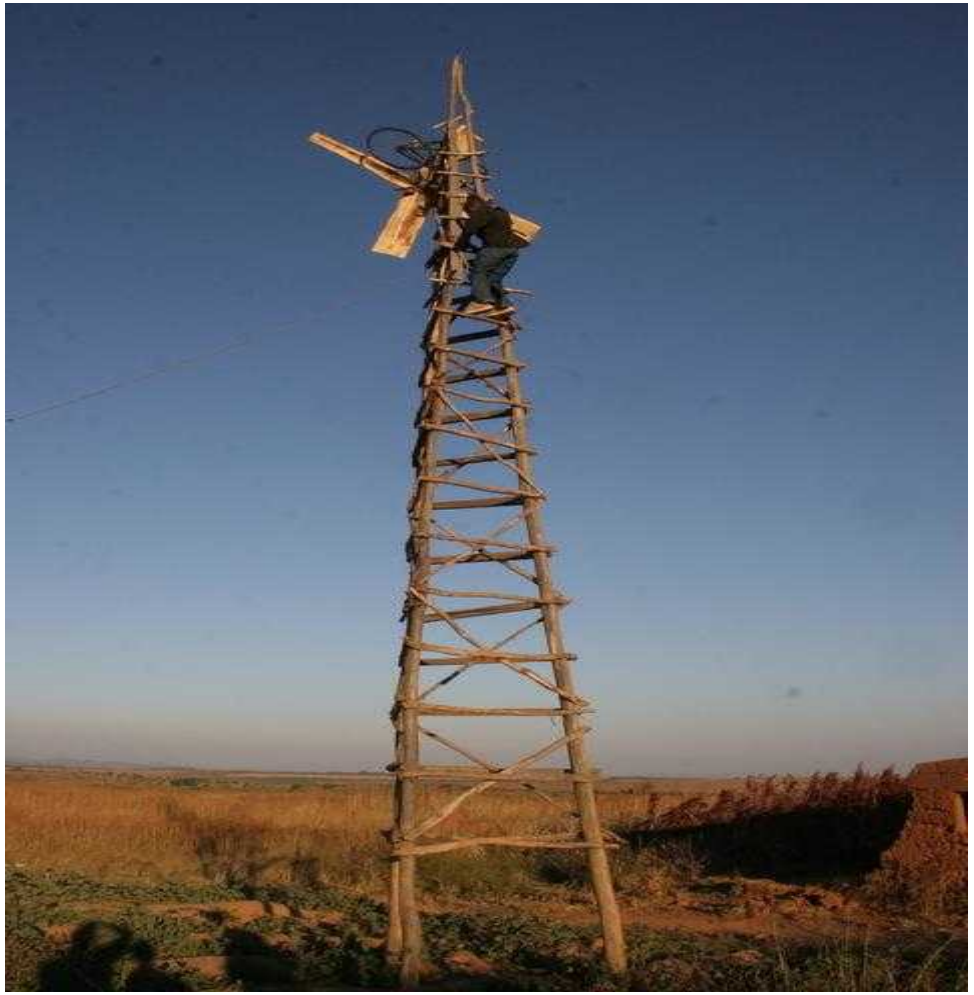
www1.eere.energy.gov

Where Wind is Headed

Developments and investments in wind energy

High Altitude Wind – Hotspots 4 miles high

D.I.Y. Wind Power



www.peternjenga.com

Investment -
Throwing Money into the Wind

The British Wind Energy Association predicts wind to overtake nuclear in U.K. in the next decade.

9 GW of electricity from offshore wind farms by 2015 in U.K.

www.finfacts.com

www.bwea.com

Investment – cont.

eetd.lbl.gov

images.businessweek.com

China expects wind output to exceed nuclear by 2020.

Currently has 12 GW of capacity. Plans to increase capacity by 20% per year.

Has targeted goal of 100 GW from wind by 2020.

Why High Altitude

The amount of power a wind turbine can generate is expressed by the function:

Wind Power Density =

$$\frac{1}{2} pV^3$$

p = wind density

V = wind speed

(The wind blows faster = more power even though air is less dense higher up)

Each hemisphere has 2 jet streams –

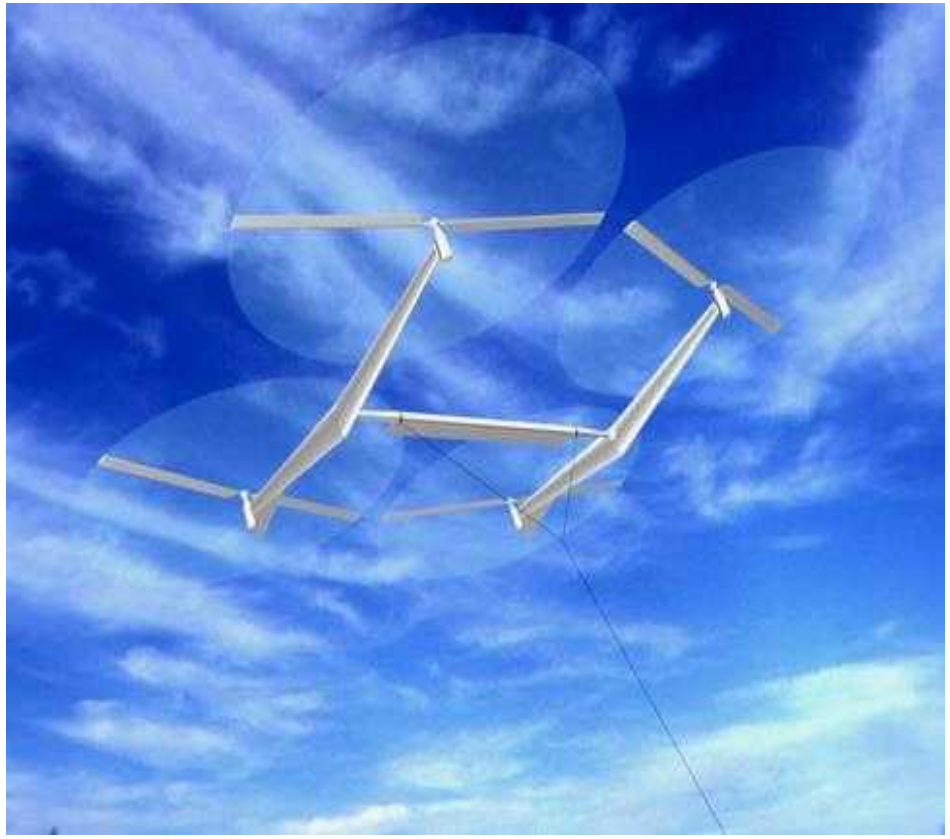
the polar jet stream and the sub-tropical jet stream

The jet streams provide consistent, strong and abundant winds

Energy available in the jet stream is roughly 100 times the global demand

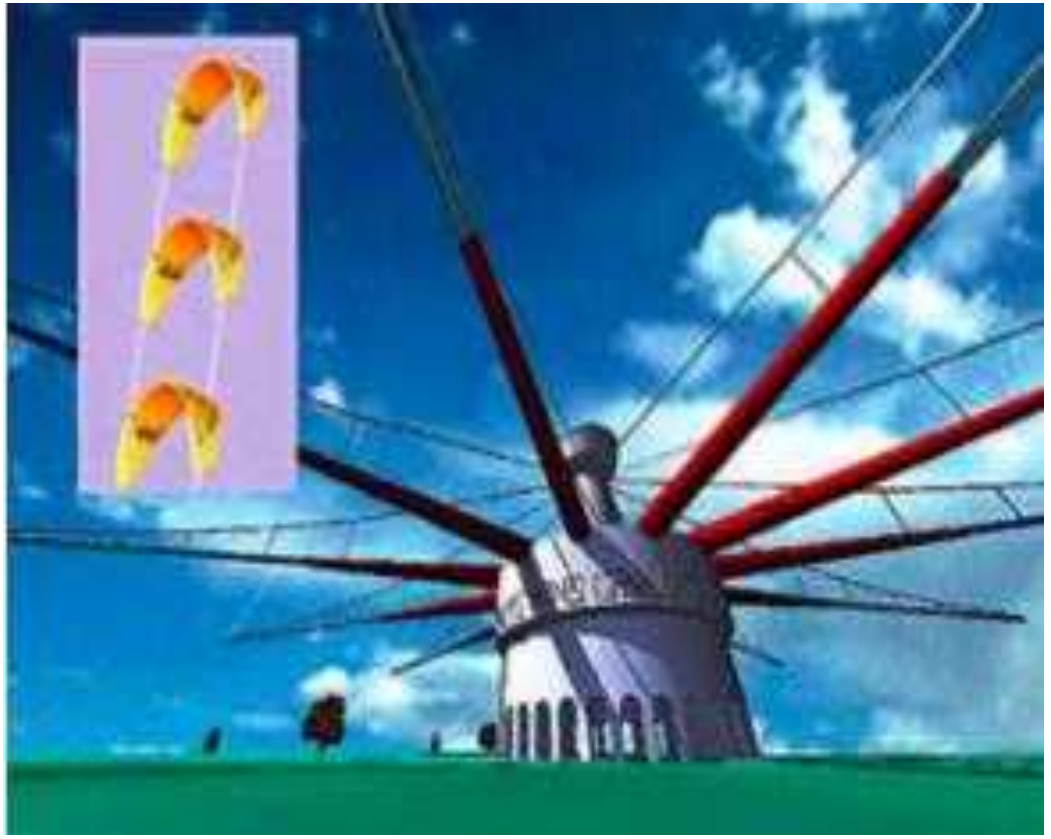
Making High Altitude Wind into Sea Level Energy

Flying Electric Generators



http://www.popsci.com/scitech/article/2009-06/

Kite Generators



http://www.mdpi.com/1996-1073/2/2/307/