ANKARA UNIVERSITY
DEPARTMENT OF ENERGY ENGINEERING
RENEWABLE ENERGIES

<u>INSTRUCTOR</u>

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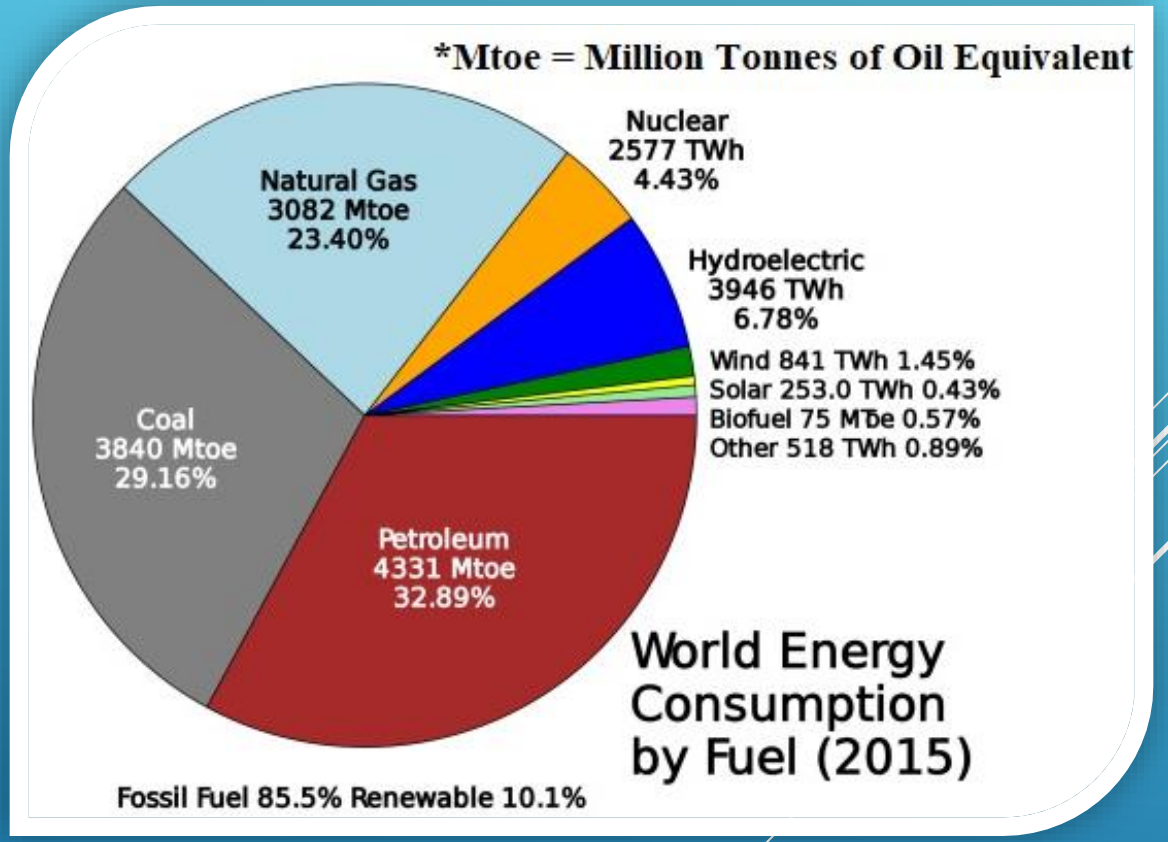
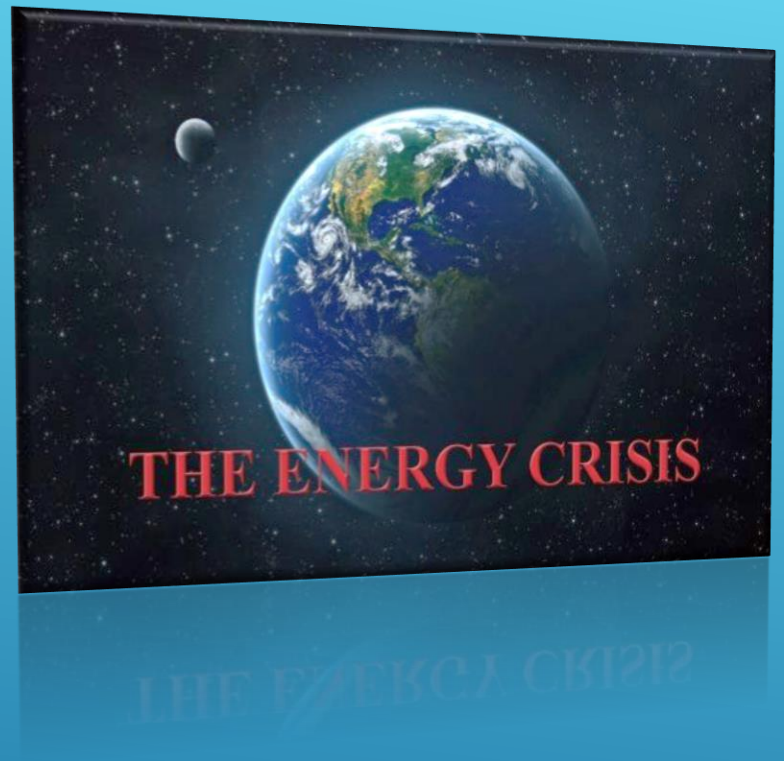
WHAT IS RENEWABLE ENERGY ?

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, waves and geothermal heat, which are renewable (naturally replenished). For example, sunlight or wind keep shining and blowing, even if their availability depends on time and weather. While renewable energy is often thought of as a new technology, harnessing nature’s power has long been used for heating, transportation, lighting, and more.

Reliable energy supply is essential in all economies for lighting, heating, communications, computers, industrial equipment, transport, etc. Purchases of energy account for 5–10 % of gross national product in developed economies. However, in some developing countries, energy imports may have cost over half the value of total exports; such economies are unsustainable and an economic challenge for sustainable development.





• The problem that arises when the consumption of energy is very high and the available sources are limited is called energy crisis which is also known as ‘run out’ of energy.

• In other words, the acute scarcity of energy sources due to overuse by growing population is called energy crisis.

Causes of energy crisis:

• Rapid consumption and over use of fossil fuels by the growing population.

• Lack of developing and using alternative and renewable sources of energy.

• Improvement or advancement in industrial and agricultural sector due to technological inventions.

• Misuse of energy and less efficiency of fuel consuming devices and machines

Some ways of conservation of energy:

- Reduce our dependence on non-renewable sources of energy.
- Developing and using alternative sources of energy like solar energy, hydro-power, wind energy etc. to replace the conventional energy sources.
- Developing and using devices which can be operated by renewable sources of energy.
- Wise and economic use of existing and available sources of energy.

SOLUTIONS FOR SUSTAINABLE ENERGY

- Improve energy efficiency
- Increase local availability of renewable energy resources
- Find transitional resources (natural gas, nuclear)
- Government must promote R&D for alternative renewable energy resources.
- Educate the public
- All energy resources should compete in an open, free-market with NO government control!
- Government needs to implement constructive subsidies not destructive subsidies to promote change, this will lead to conservation of resources and less over-consumption.

ADVANTAGES AND DISADVANTAGES OF RENEWABLE ENERGY RESOURCES

Advantages:

- ✓ Renewable energy won't run out
- ✓ Renewables save Money
- ✓ Renewable energy has numerous health and environmental benefits
- ✓ Renewables lower reliance on foreign energy sources

Disadvantages:

- ✓ Higher upfront cost
- ✓ Storage capabilities
- ✓ Geographic limitations

Renewable Energy	
Advantages	**Disadvantages**
Easily Regenerated	Weather Dependency
Boost Economic Growth	High Installation Cost
Easily Available	Noise caused by Wind Energy
Support Environment	Fluctuation problem (Solar)
Low Maintenance Cost	Intermittency Issue (Wind)

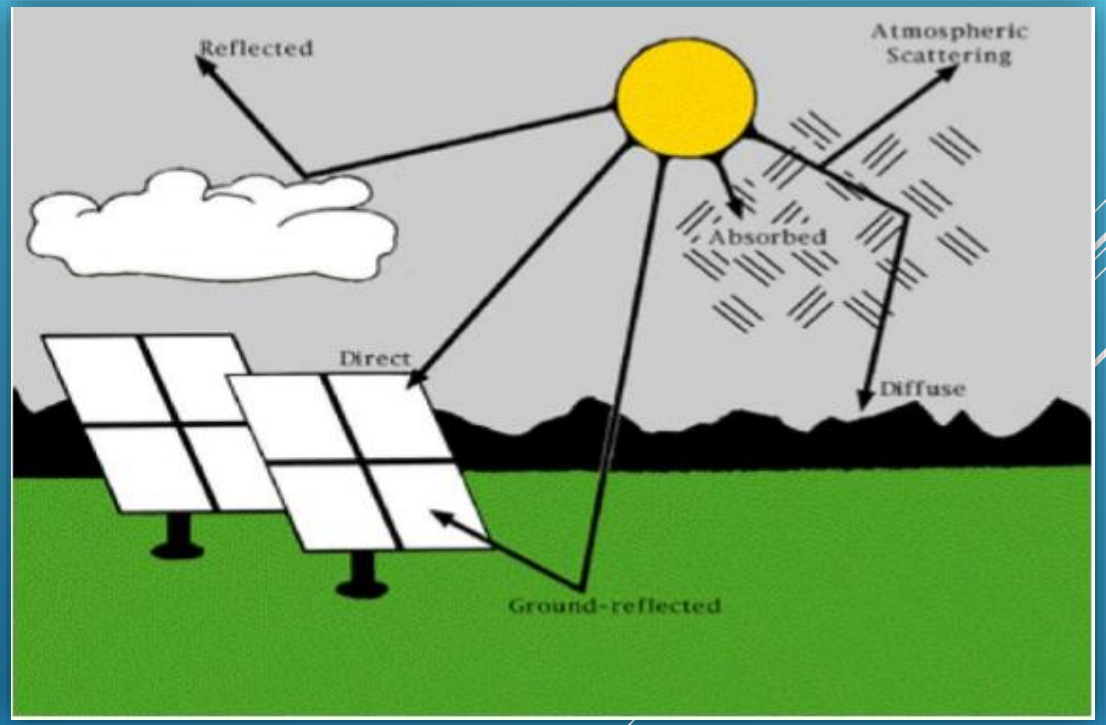
When it comes to renewable energy, the positives outweigh the negatives. Renewable energy has more benefits than drawbacks

SOLAR ENERGY

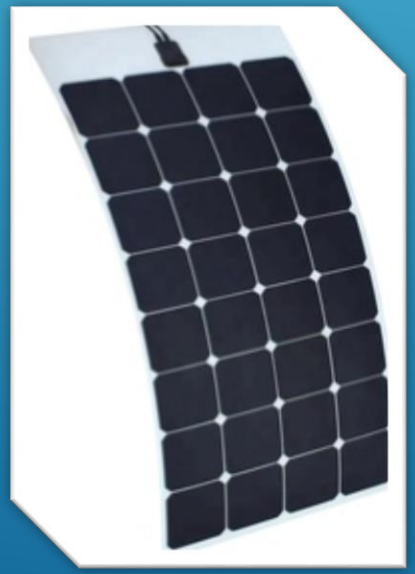
Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy. Solar energy has immense theoretical potential. The amount of solar radiation intercepted by the Earth is much higher than annual global energy use. Large scale availability of solar energy depends on a region's geographic position, typical weather conditions and land availability .

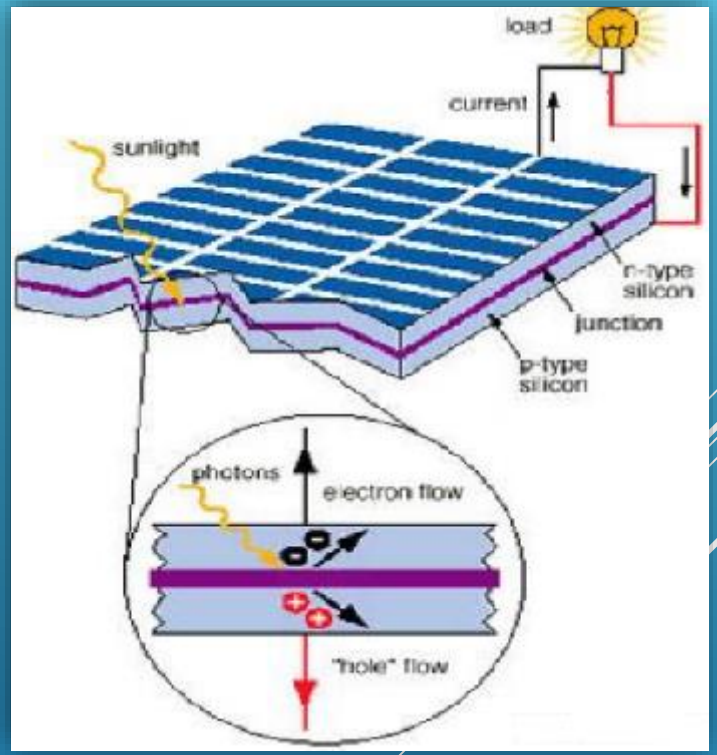
The earth receives the solar energy in the form of solar radiation. These radiations comprising of ultra-violet, visible and infrared radiation. The amount of solar radiation that reaches any given location is dependent on several factors like geographic location, time of day, season, land scope and local weather. Because the earth is round, the sun rays strike the earth surface at different angles (ranging from 0° to 90°). When sun rays are vertical, the earth's surface gets maximum possible energy.

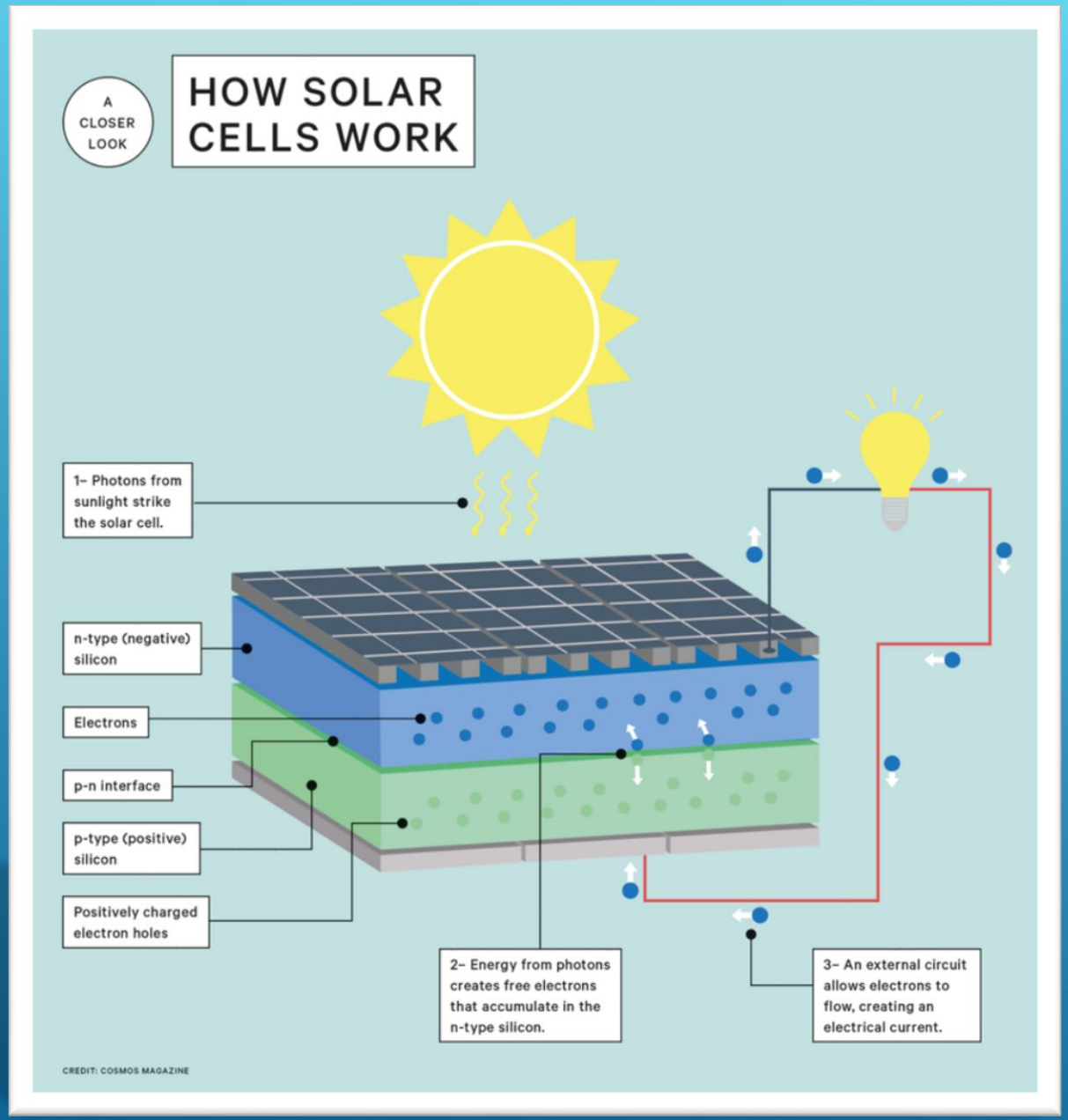
The solar radiation that reaches the surface of the earth without being diffused is called direct beam solar radiation. It is measured by instrument named as pyrheliometer. As sun light passes through the atmosphere, some part of it is absorbed, scattered and reflected by air molecule, water vapours, clouds, dust and pollutants. This is called diffuse solar radiation. The diffuse solar radiation does not have unique path.

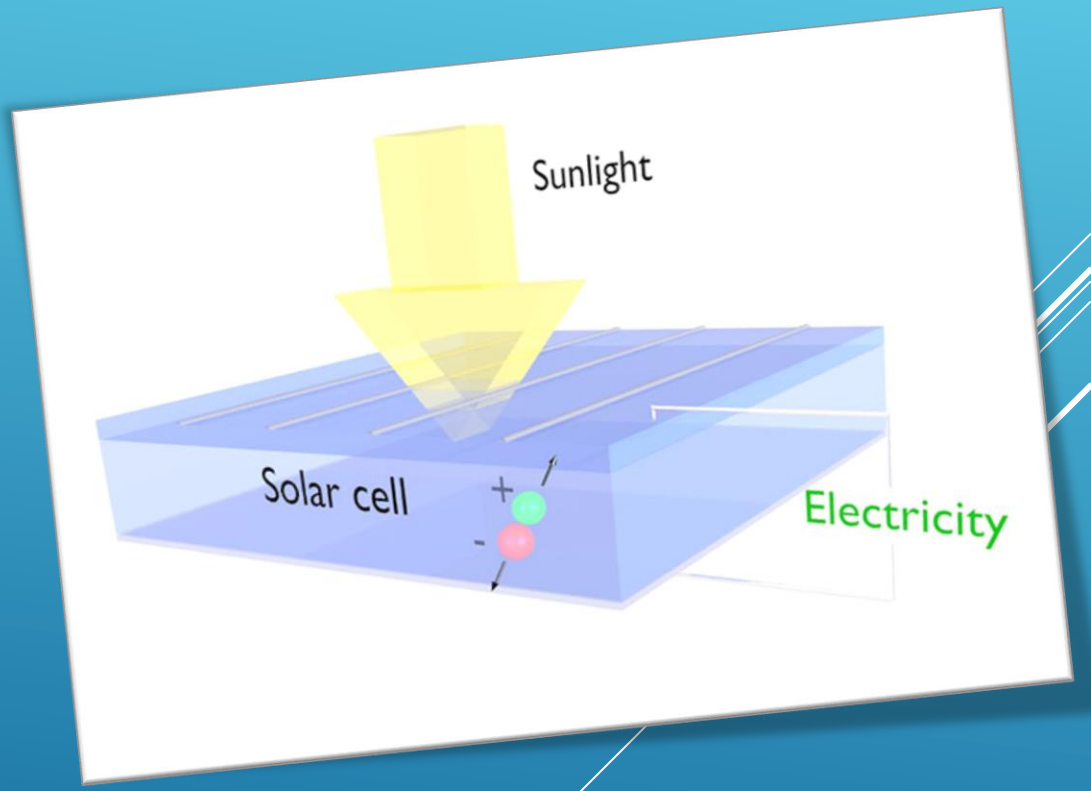


Solar energy is versatile and can be used to generate electricity, heat, cold, steam, light, ventilation or hydrogen. These include the availability of efficient and low-cost technologies, effective energy storage technologies and high efficiency end-use technologies






A CLOSER LOOK
HOW SOLAR CELLS WORK
1– Photons from sunlight strike the solar cell.
n-type (negative) silicon
Electrons
p-n interface
p-type (positive) silicon
Positively charged electron holes
2– Energy from photons creates free electrons that accumulate in the n-type silicon.
3– An external circuit allows electrons to flow, creating an electrical current.
CREDIT: COSMOS MAGAZINE


Sunlight
Solar cell
Electricity

1. When the sun is shining, the panels of a solar power system capture sunlight and convert it into solar DC power.

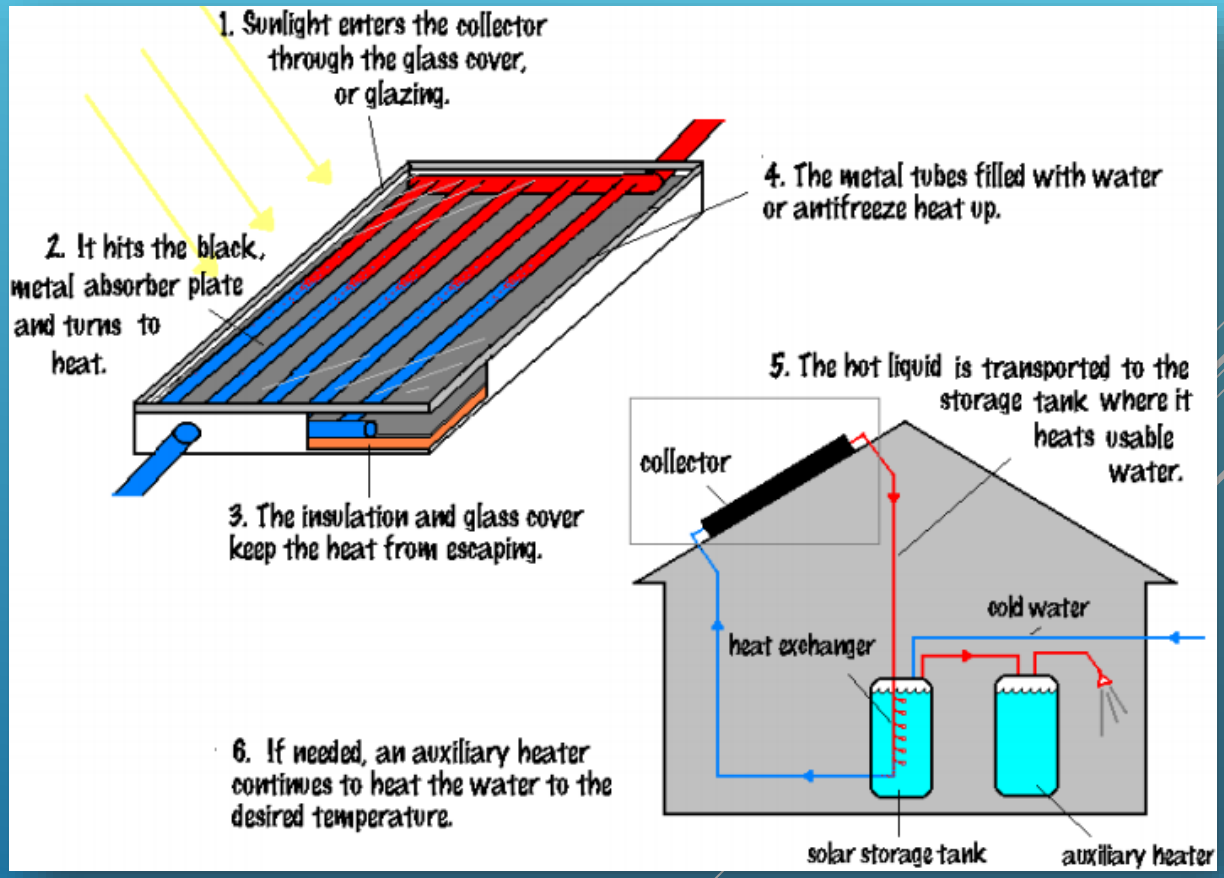
2. The system converts this power into 240V AC electricity you can use around your home, using what's called an inverter.

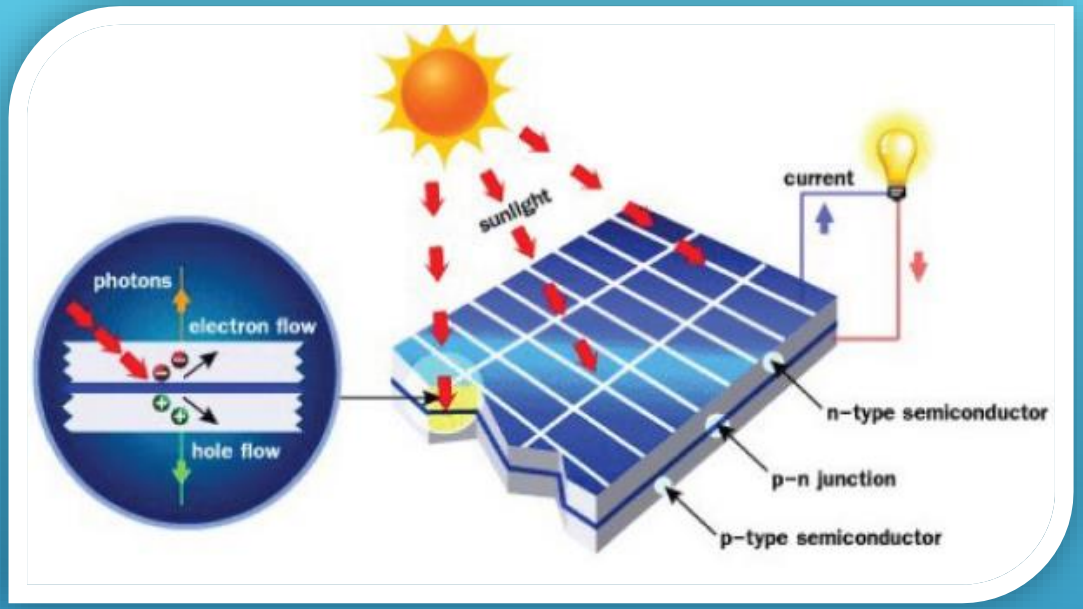
3. Under a net feed–in system this electricity then gets distributed for use around your property, and any electricity that is not

used, is fed into the electricity grid through your electricity meter.

4. Under a gross feed–in system all of the electricity generated is fed into the electricity grid through your electricity meter.

Solar thermal energy is used for water heating, space heating, electric power generation, solar cooker for cooking of food





Solar photovoltaic (PV) energy conversion

Table 2.3 *Annual global solar energy resources*

Region	*Minimum EJ*	*Maximum EJ*
North America	181	7410
Latin America and Caribbean	112	3385
Western Europe	25	914
Central and Eastern Europe	4	154
Former Soviet Union	199	8655
Middle East and North Africa	412	11,060
Sub-Saharan Africa	371	9528
Pacific Asia	41	994
South Asia	38	1339
Central Asia	115	4135
Pacific OECD	72	2263
TOTAL	**1575**	**49,837**

A solar cell is nothing but a PN junction diode under light illumination. Sun light can be converted into electricity due to photovoltaic effect. Sun light composed of photons (packets of energy). These photons contain various amount of energy corresponding to different wave lengths of light. When photons strike a solar cell they may be reflected or absorbed or pass through the cell. When solar radiation is absorbed in PN junction diode, electron-hole pairs (EHP) are generated.

WIND ENERGY

Winds develop when solar radiation reaches the Earth, meeting clouds and uneven surfaces and creating temperature, density and pressure differences. The atmosphere circulates heat from the tropics to the poles, also creating winds.

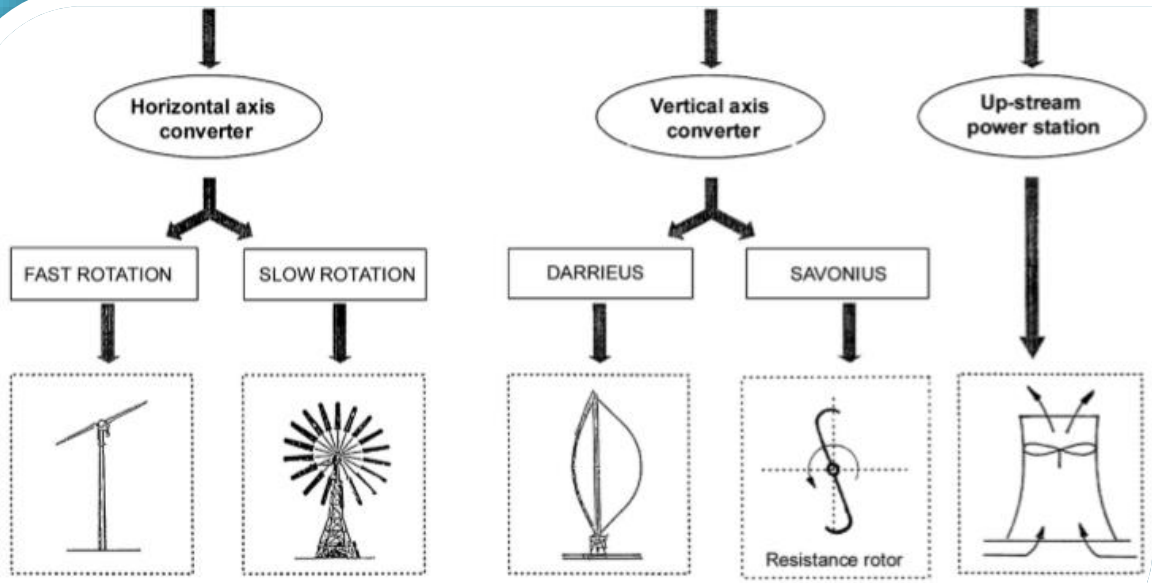


Fig. 1. – Overview of the different types of wind turbines.

Today there are various types of wind turbines in operation. The most common device is the horizontal-axis wind turbine. This turbine consists of only a few aerodynamically optimised rotor blades, which for the purpose of regulation usually can be tumbled about their long axis

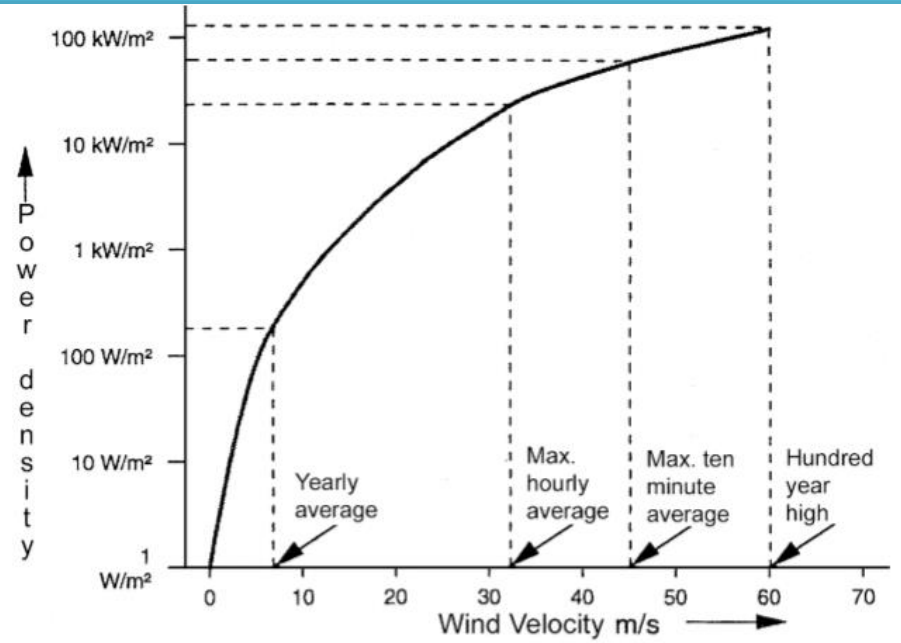
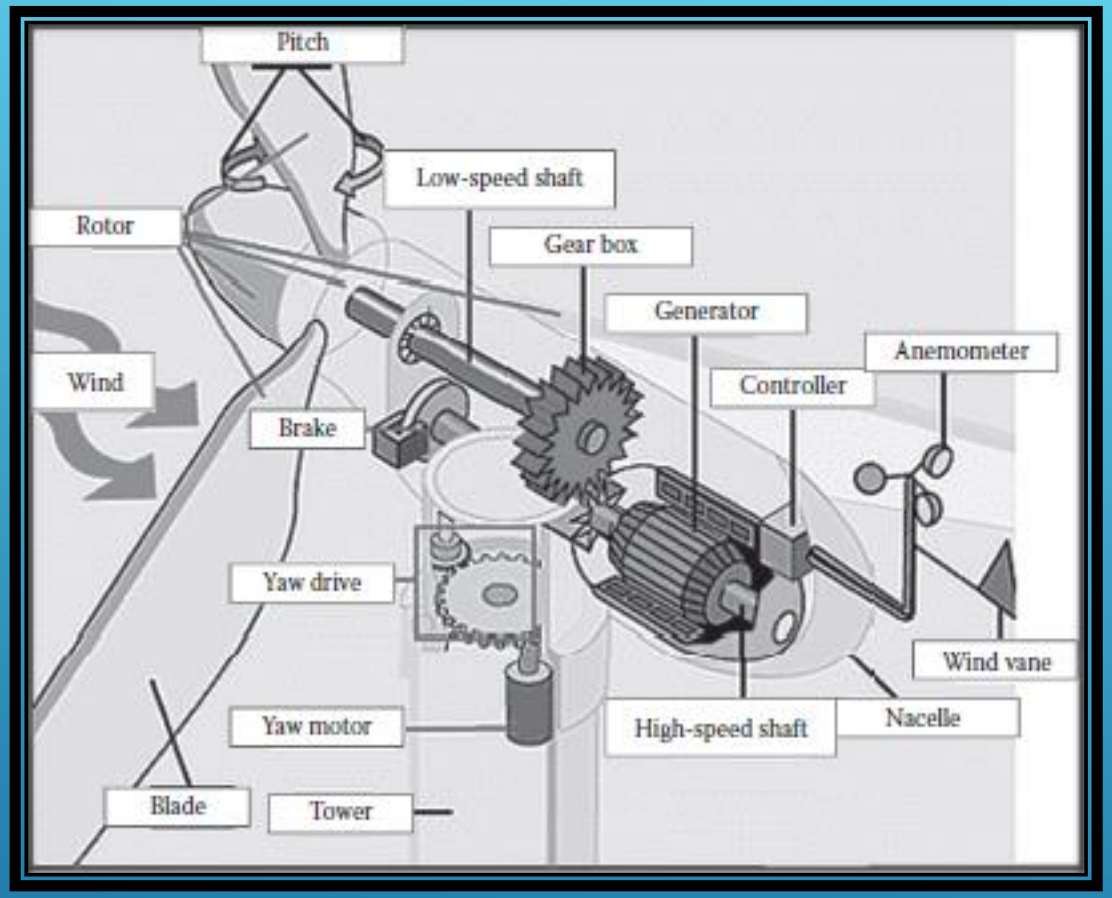


Fig. 2. – Relationship between wind velocity and power output (yearly average valid for Germany)([1]).



Components of a typical wind turbine

The main aspect of the classic design is the split shaft system, where the main shaft turns slowly with the rotor blades and the torque is transmitted through a gearbox to the high-speed secondary shaft that drives the few-pole pair generator.

Winds develop when solar radiation reaches the Earth, meeting clouds and uneven surfaces and creating temperature, density and pressure differences. The atmosphere circulates heat from the tropics to the poles, also creating winds. A region's mean wind speed and its frequency distribution have to be taken into account to calculate the amount of electricity that can be produced by wind turbines.

Table 2.4 *Annual global wind energy resources*

Region	*Land surface with sufficient wind conditions*		*Wind energy resources without land restrictions*	
	%	*Thousands km²*	*TWh*	*EJ*
North America	41	7876	126,000	1512
Latin America and Caribbean	18	3310	53,000	636
Western Europe	42	1968	31,000	372
Eastern Europe and former Soviet Union	29	6783	109,000	1308
Middle East and North Africa	32	2566	41,000	492
Sub-Saharan Africa	30	2209	35,000	420
Pacific Asia	20	4188	67,000	804
China	11	1056	17,000	204
Central and South Asia	6	243	4000	48
TOTAL	**27**	**30,200**	**483,000**	**5800**

TABLE II. – *World wind power production*

Land/Region	Total installed rated power up to the end of 2015 [GW]
China	145
USA	74
Germany	45
Spain	23
India	25
UK	14
Italy	9
France	10
Canada	11
Brazil	9
Remaining countries	67
Total	432

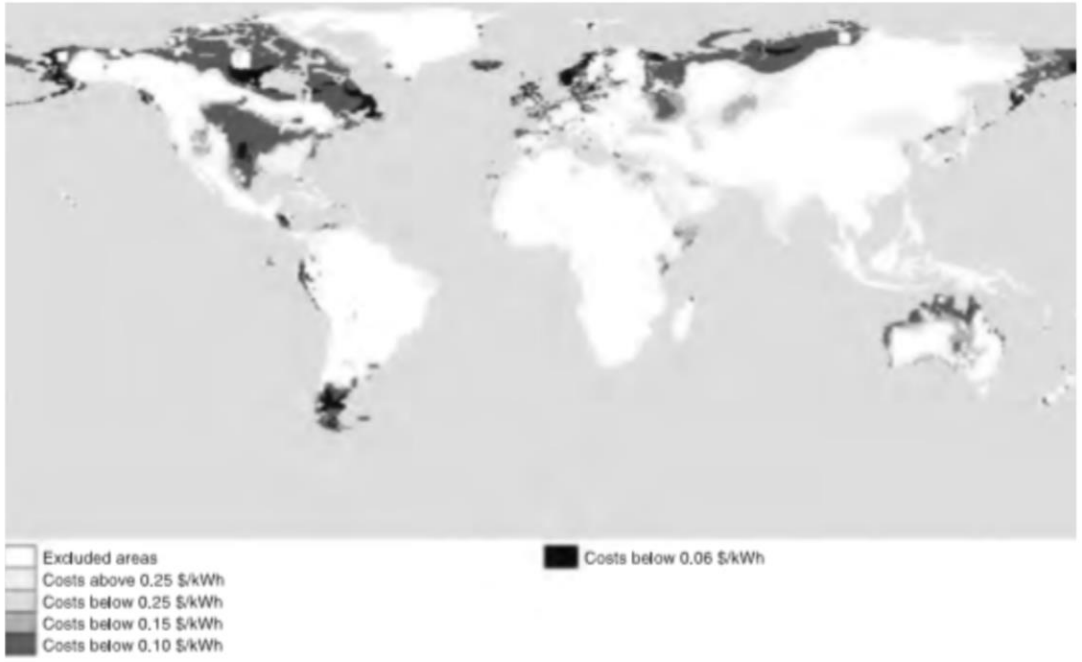


Figure 2.4 *Geographical distribution of present costs for wind energy*

Wind Power is defined as

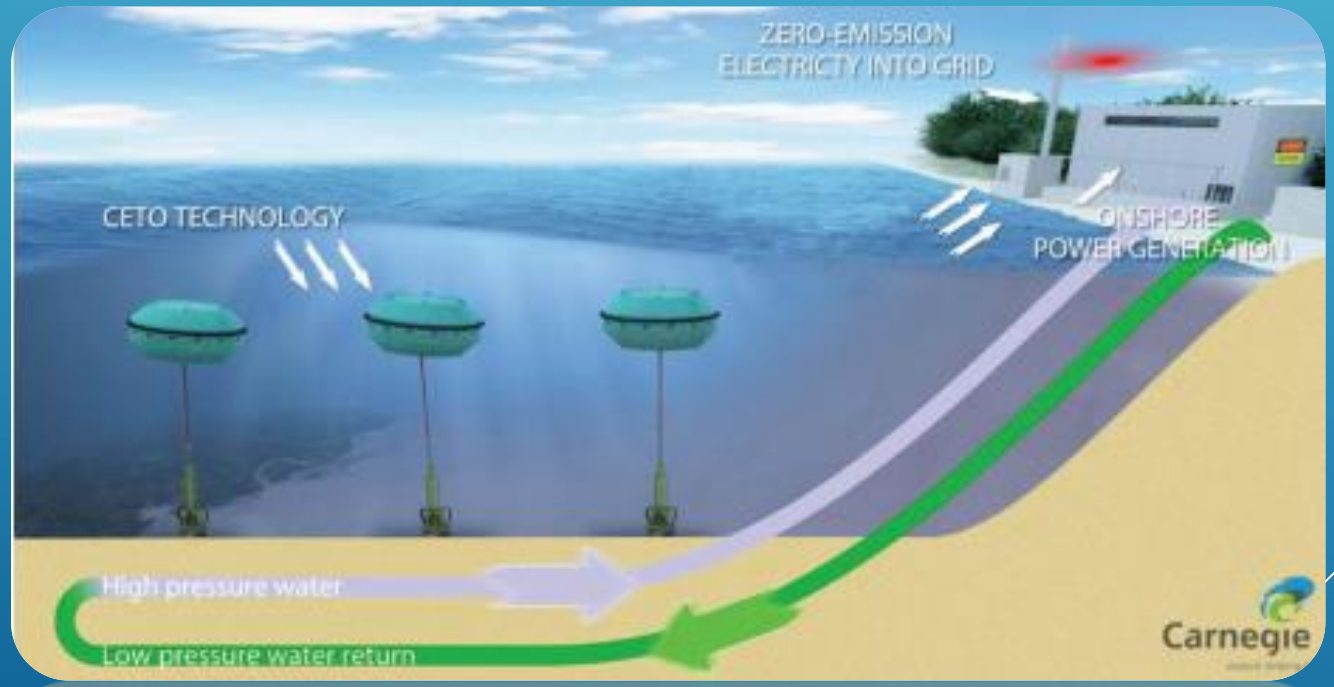
$$P = \frac{E}{t} = \frac{1}{2}.A.\rho_a.\upsilon^3$$

E: kinetic energy, A: area, ρ_a :specific density of the air, υ : wind velocity.

Therefore, it is also proportional to the cube of the wind speed, υ^3

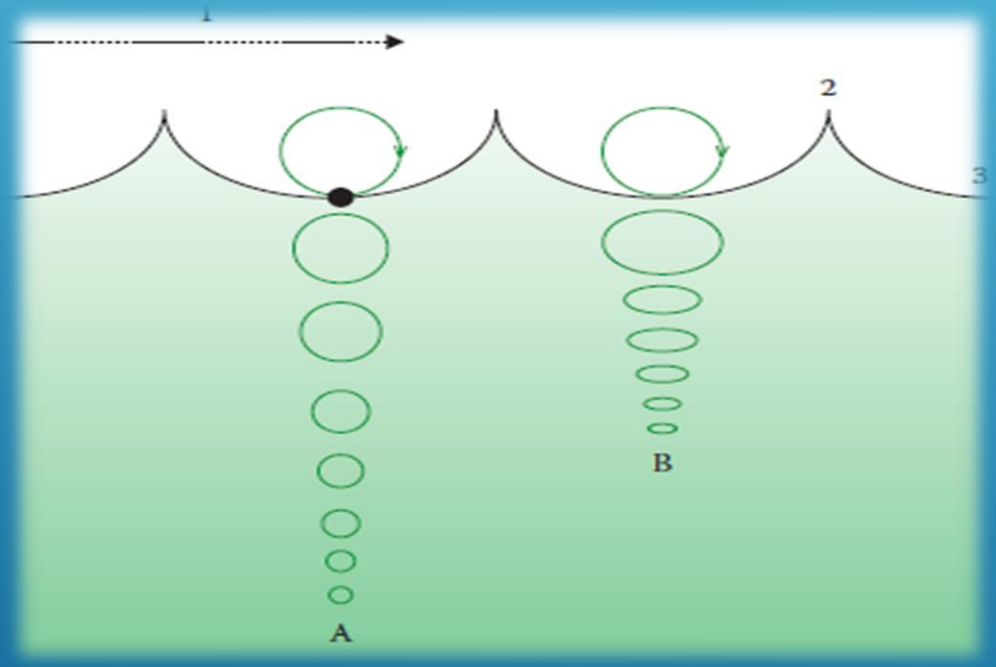
MARINE ENERGY

The energy of the oceans is stored partly as kinetic energy from motion of the waves and currents, and partly as thermal energy from the sun. The rise and fall of the tides creates, in effect, a low-head hydropower system. Tidal energy has been exploited in this way for centuries in the form of water mills. The largest modern scheme was built in France in the 1960s.



Wave Motion and Wave Energy and Power

Sizable ocean waves can be generated when the wind acts for a sustained period and interacts with the surface of the water. The height of the waves depends on the wind speed, how long a time it has been blowing, and various other factors.



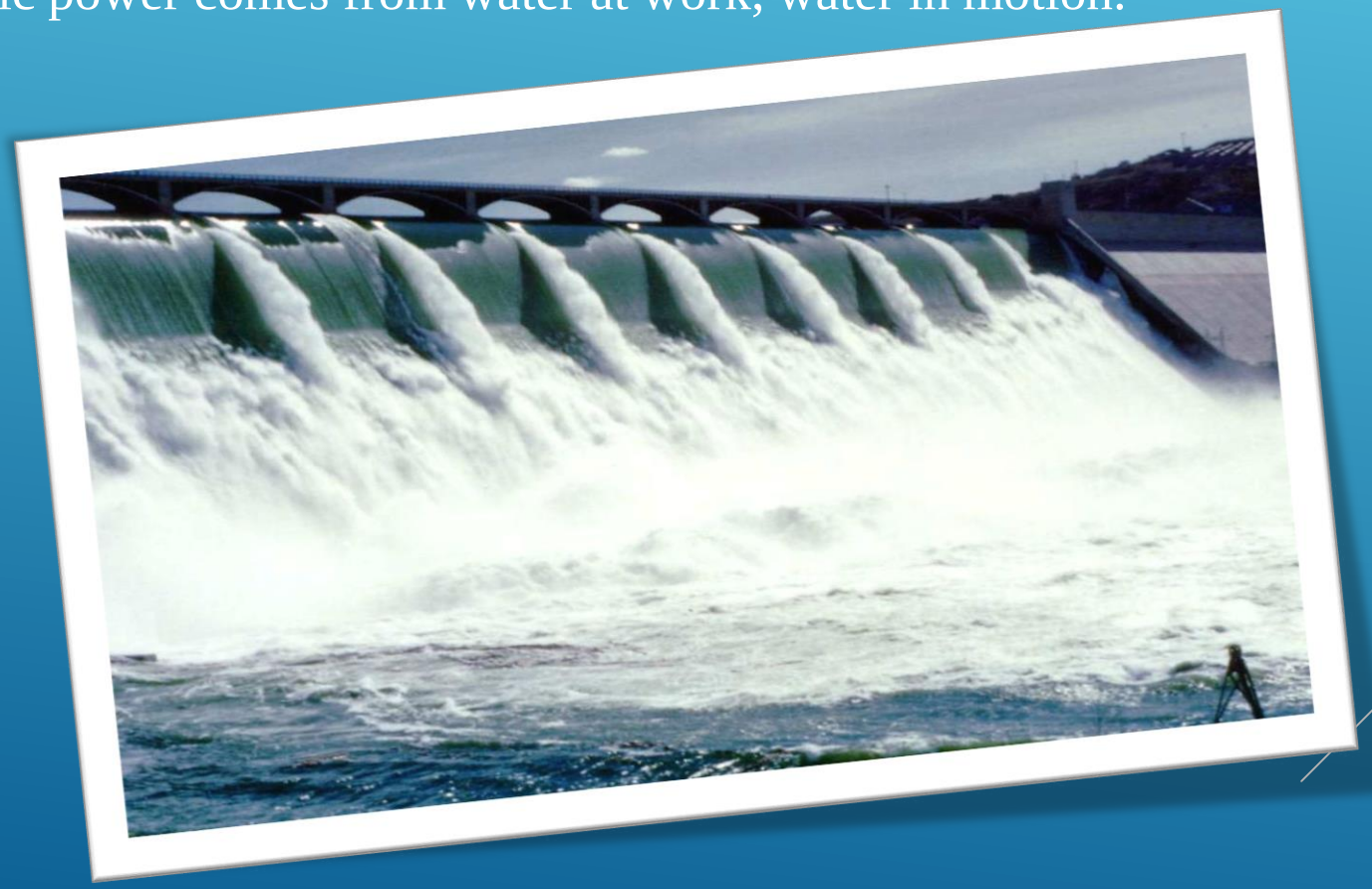
Simplified motion of a water molecule at various depths as a wave passes

Tidal Current Generator

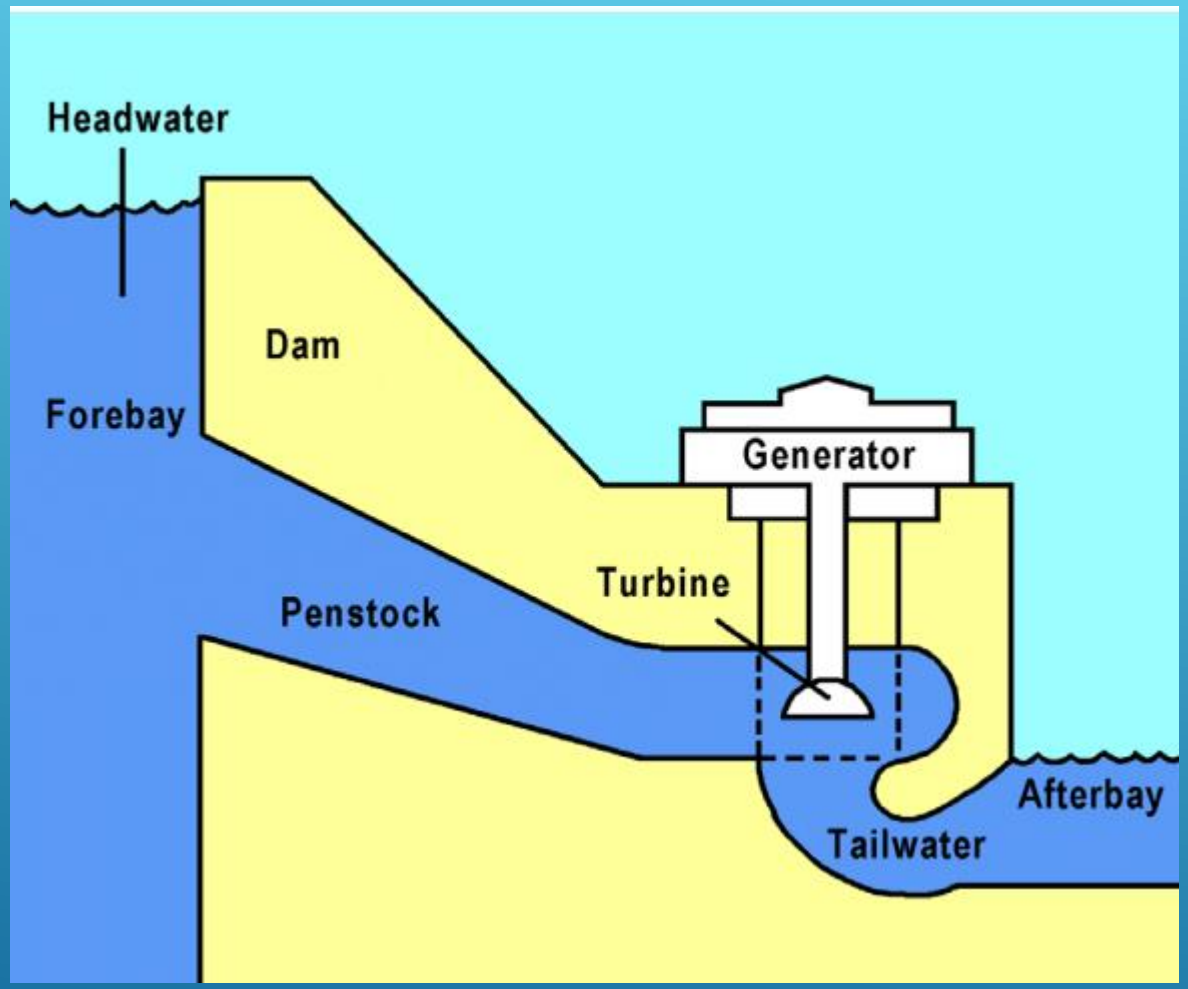
Accompanying the variations in sea level, the daily tides produce oscillating currents known as tidal streams. The tidal current, of course, is not simply along the water surface, and the underwater currents can be harnessed to power turbines.

HYDRO ENERGY

Hydropower is obtained by mechanical conversion of the potential energy of water in high elevations. An assessment of its energy potential requires detailed information on the local and geographical factors of run off water. Hydroelectric power comes from water at work, water in motion.

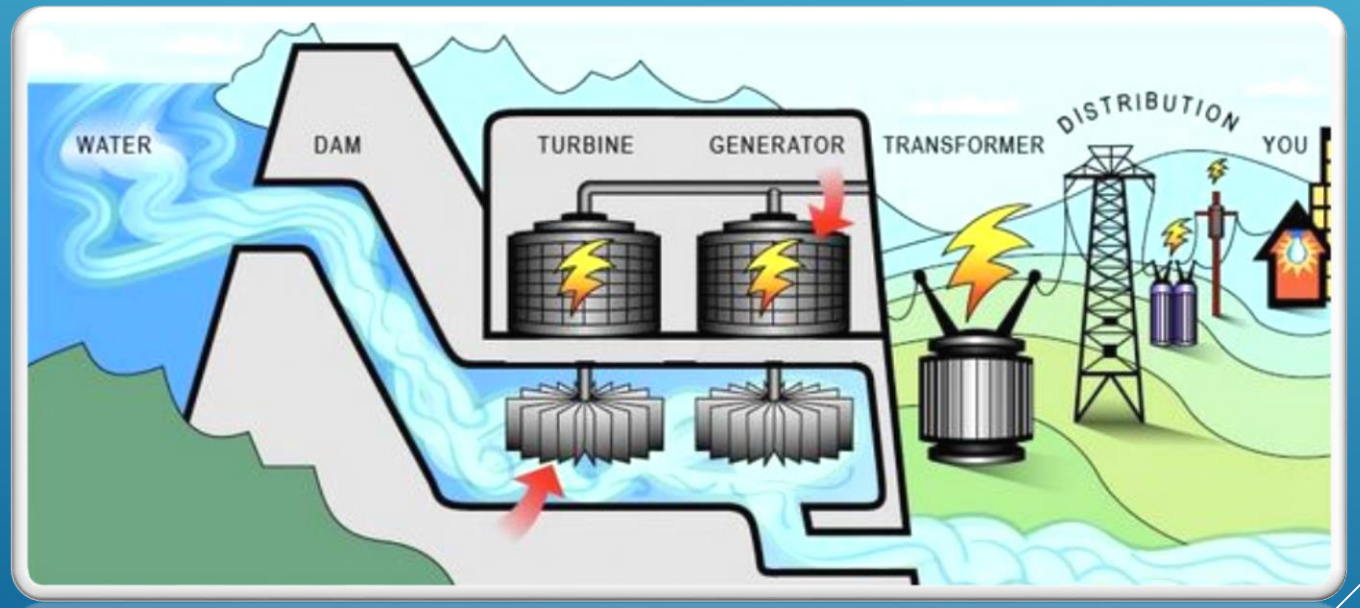


Hydroenergy, is a form of renewable energy that uses the water stored in dams, as well as flowing in rivers to create electricity in hydropower plants. The falling water rotates blades of a turbine, which then spins a generator that converts the mechanical energy of the spinning turbine into electrical energy. Hydroelectric power is a significant component of electricity production worldwide.



The dam creates a ‘head’ or height from which water flows. A pipe (penstock) carries the water
from the reservoir to the turbine. The fast-moving water pushes the turbine blades, something
like a pinwheel in the wind. The waters force on the turbine blades turns the rotor, the moving
part of the electric generator. When coils of wire on the rotor sweep past the generator = s
stationary coil (stator), electricity is produced.

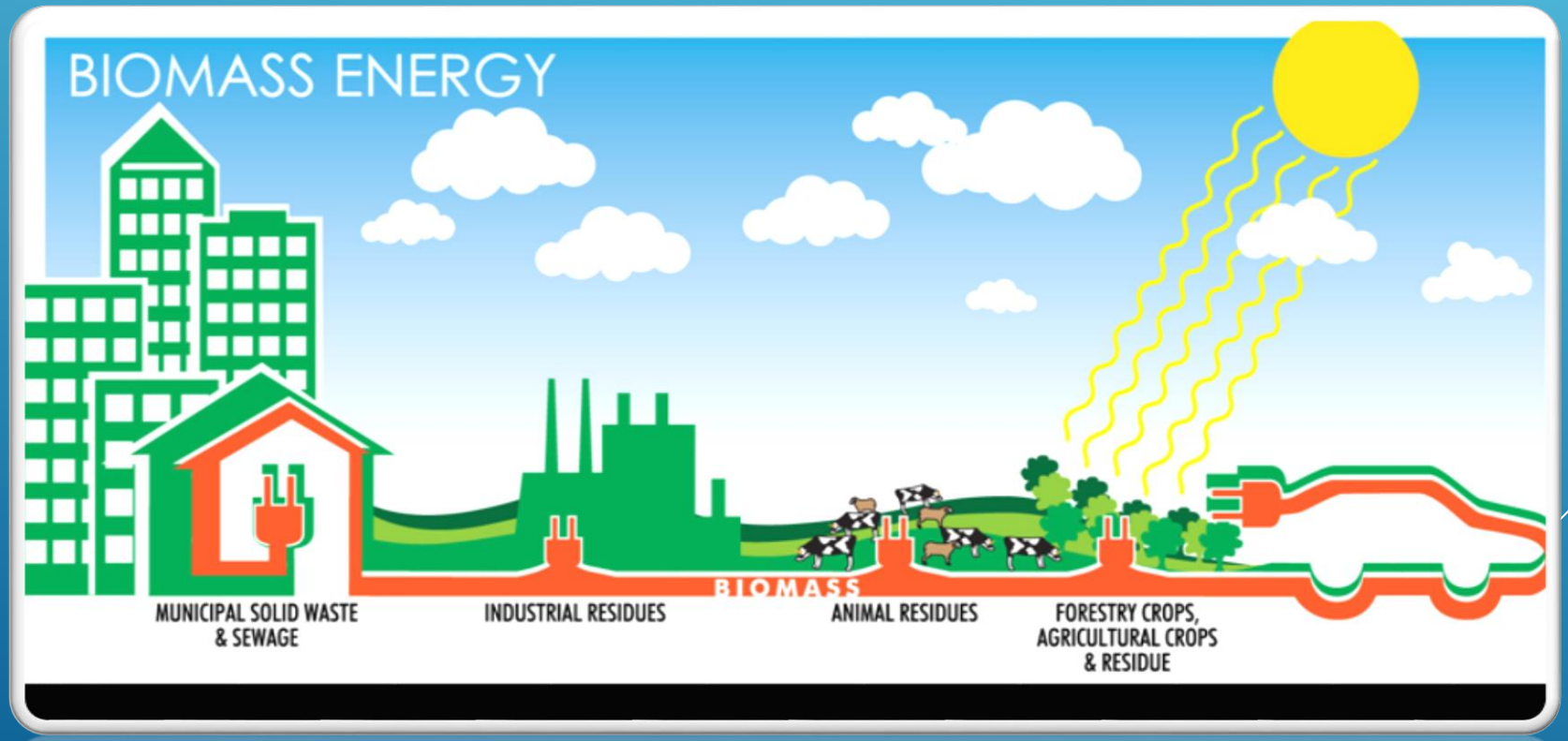
A hydro energy system is considered to be a renewable as well as a nonrenewable energy system. The characterization of a small hydro energy system changes but an electrical energy-producing capacity of up to 10 megawatts (MW) is generally established as the higher limit of what can be termed a small hydro energy power plant. This may be extended up to 30 MW in the United States and 50 MW in Canada. A hydro power plant can be further subdivided into a mini hydro, which is defined as < 1000 kW, and a micro hydro, which is < 100 kW.



BİOFUEL ENERGY

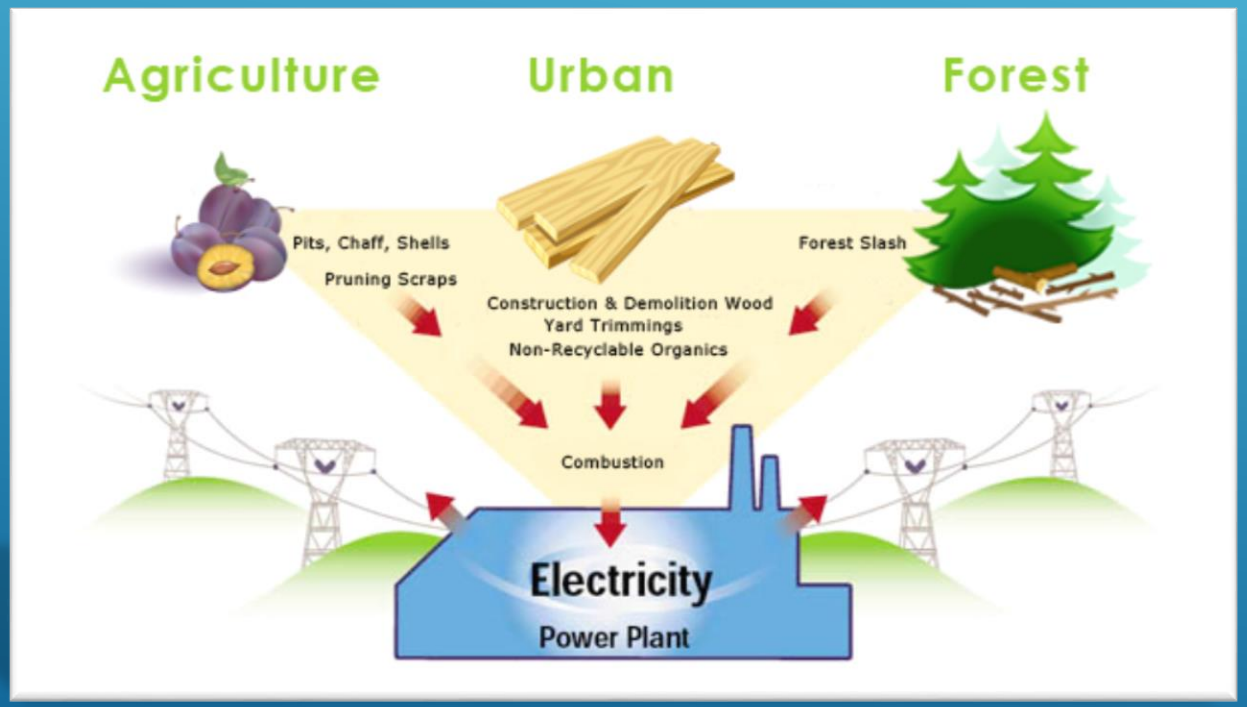
Biofuel is organic material that comes from plants and animals, and it is a renewable source of energy. Biofuel contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. When biofuel is burned, the chemical energy in biofuel is released as heat.

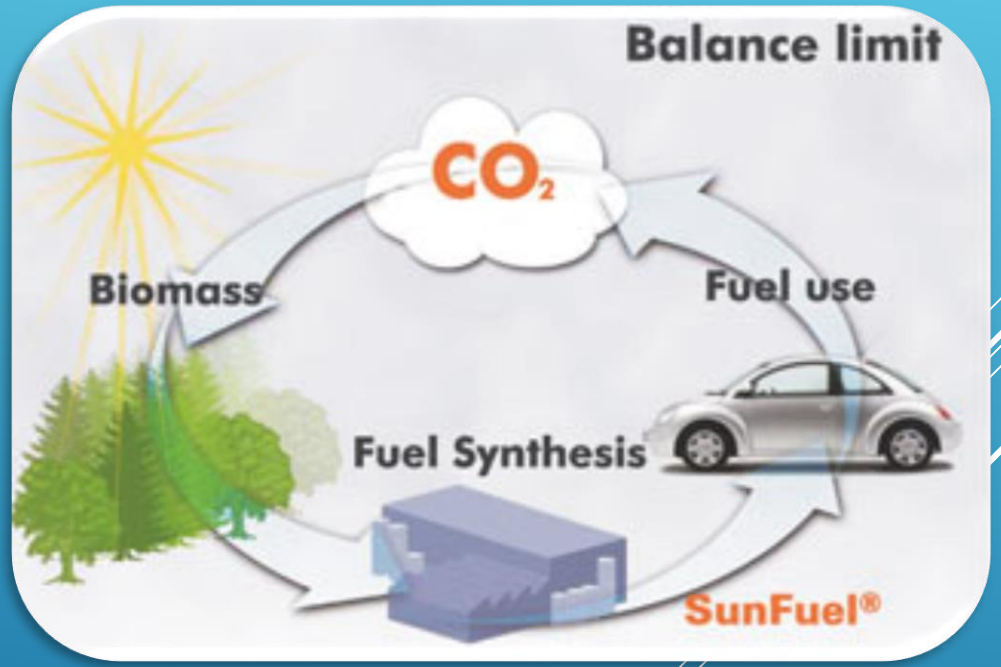
Biomass energy used in direct combustion of wood, charcoal, leaves, agricultural residues, animal or human waste and urban waste, for cooking, drying and charcoal production. Improved biomass technologies refers to improved and efficient Technologies for direct combustion of biomass such as improved cooking stoves and improved biofuel kilns.

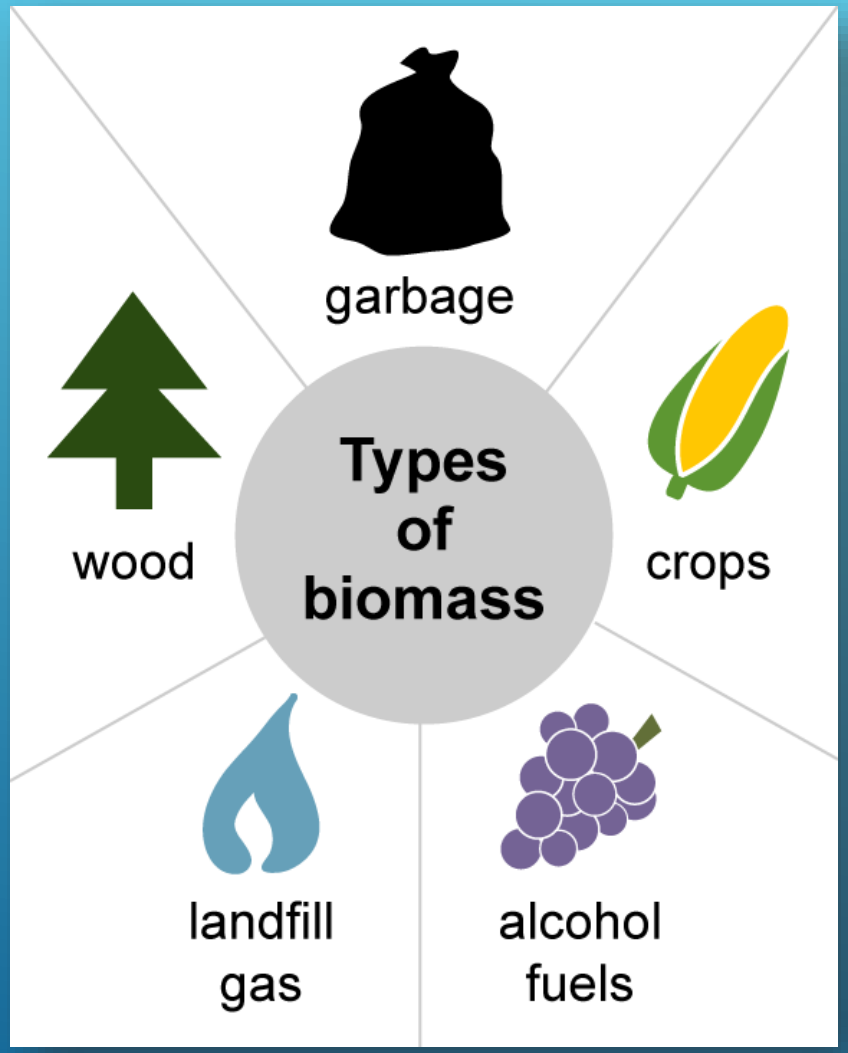


Modern biomass energy use' refers to the conversion of

biomass energy to advanced fuels, namely liquid fuels, gas and electricity






garbage
wood
Types of biomass
crops
landfill gas
alcohol fuels

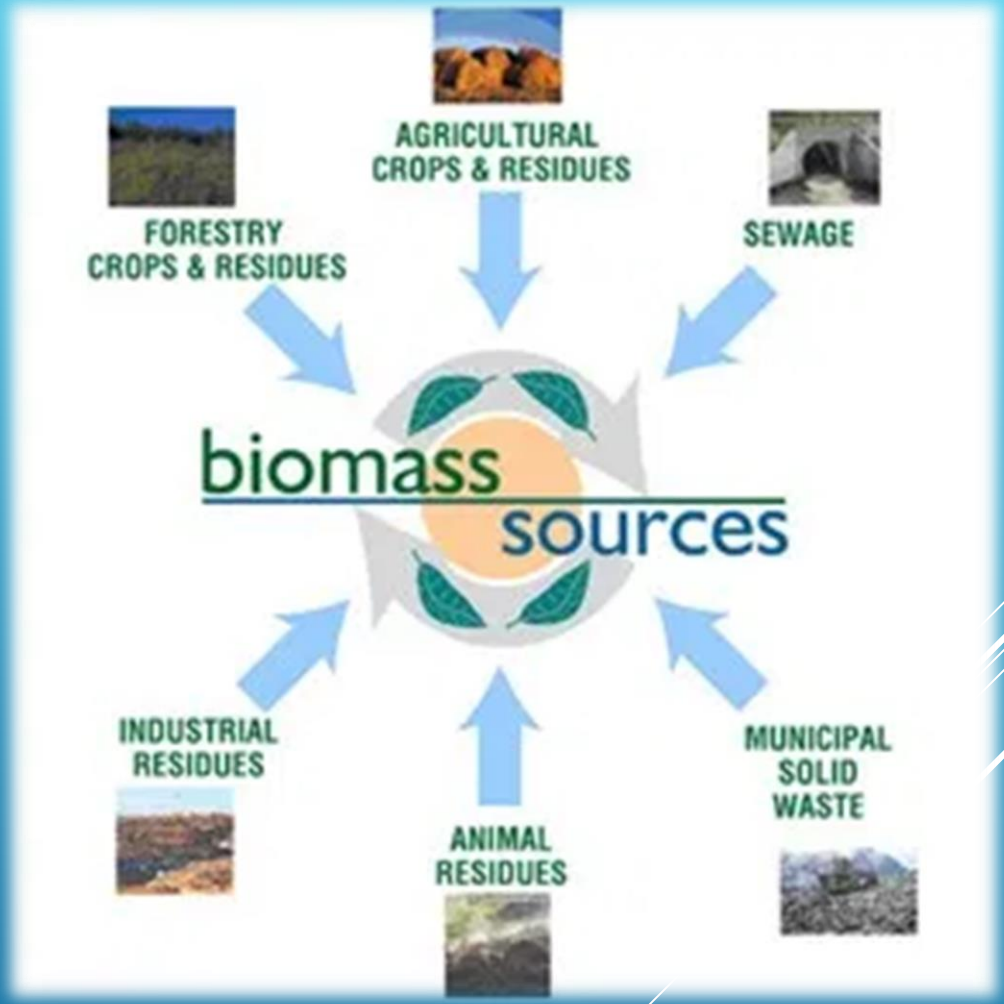

AGRICULTURAL CROPS & RESIDUES
FORESTRY CROPS & RESIDUES
SEWAGE
biomass sources
INDUSTRIAL RESIDUES
ANIMAL RESIDUES
MUNICIPAL SOLID WASTE

Table 11.1 *Biomass supply as a percentage of total primary energy supply, 1971 and 2002*

Region	1971 (%)	2002 (%)
OECD	2	3
Non-OECD Europe	4	5
Latin America	31	18
Asia	59	31
Africa	62	49

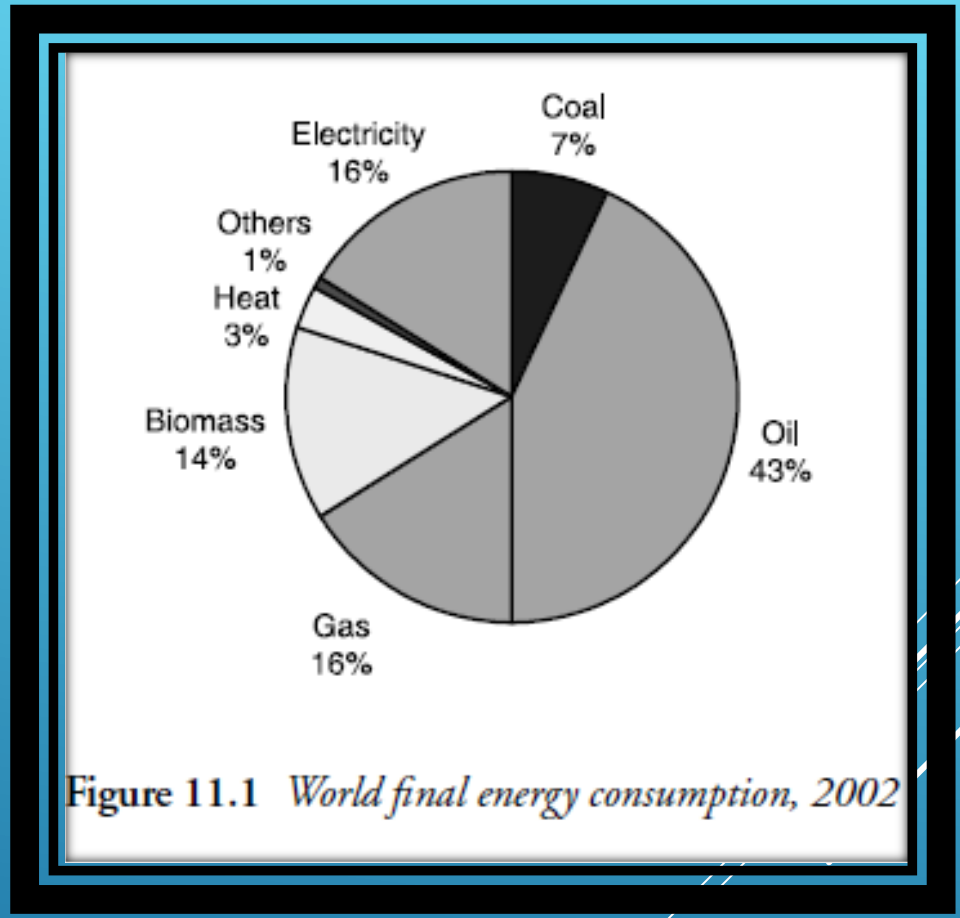


Figure 11.1 *World final energy consumption, 2002*

Biomass energy plays a vital role in meeting local energy demand in many regions of the developing world. Modern biomass energy is widely used in many developed countries as well as in parts of the non-industrialized world.

Figure 2.6 *Geographical distribution of present costs for biomass energy*

Table 11.7 *Biomass electricity production in selected industrialized countries, 2001*

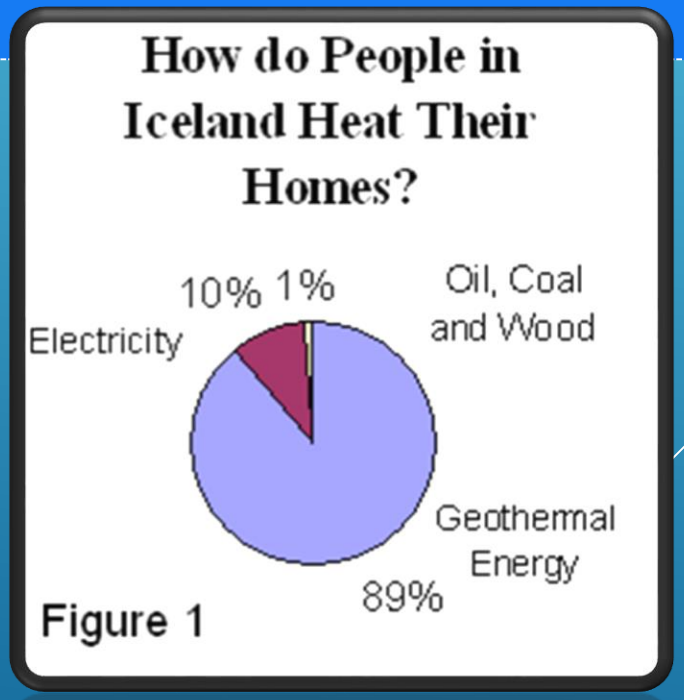
Country	*Biomass electricity (TWh)*	*Percentage of total electricity*
US	70.60	1.80
Japan	12.83	1.24
Germany	12.97	2.23
Finland	8.69	11.67
Brazil	9.40	2.87
UK	5.08	1.32
Canada	7.21	1.23
Netherlands	3.46	3.70
Australia	1.36	3.00
Sweden	3.52	2.18

GEOTHERMAL ENERGY

It is a renewable energy source because the water is replenished by rainfall and the heat is continuously produced inside the earth.

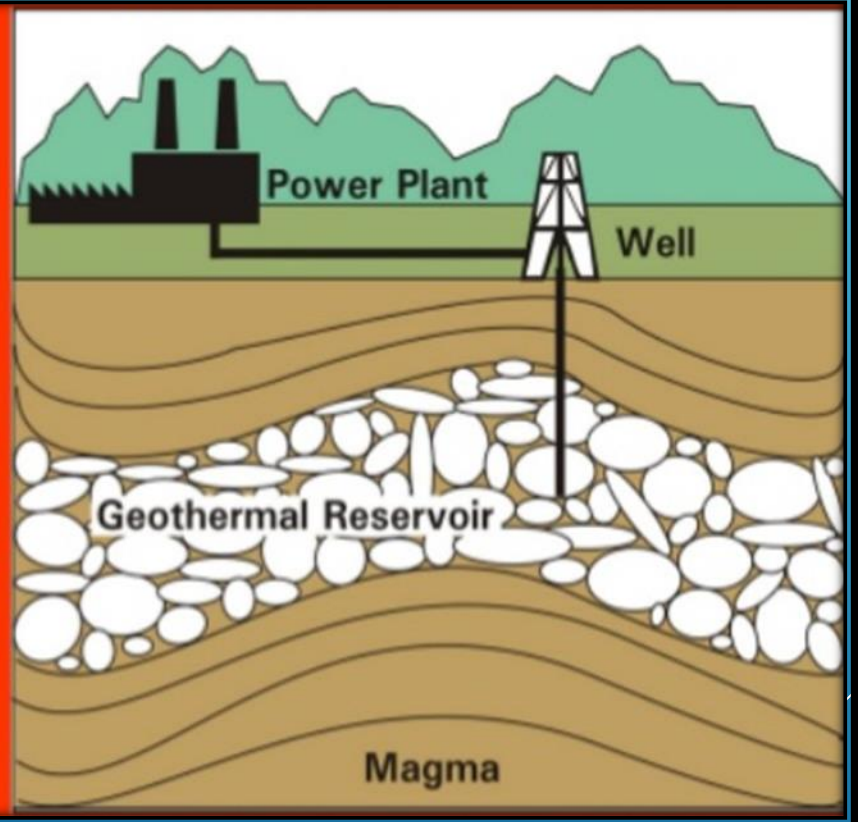
People around the world use geothermal energy to heat their homes and to produce electricity by digging deep wells and pumping the heated underground water or steam to the surface. Or, we can make use of the stable temperatures near the surface of the earth to heat and cool buildings.

Japan, Iceland, New Zealand are largest users of geothermal.
Very little potential in east and mid west.



- Heat from the earth. The inside of the earth is very hot. We can use this heat to warm our houses and produce electricity.
- Uses the steam and hot water produced inside the earth to turn turbine for heating buildings or generating electricity.

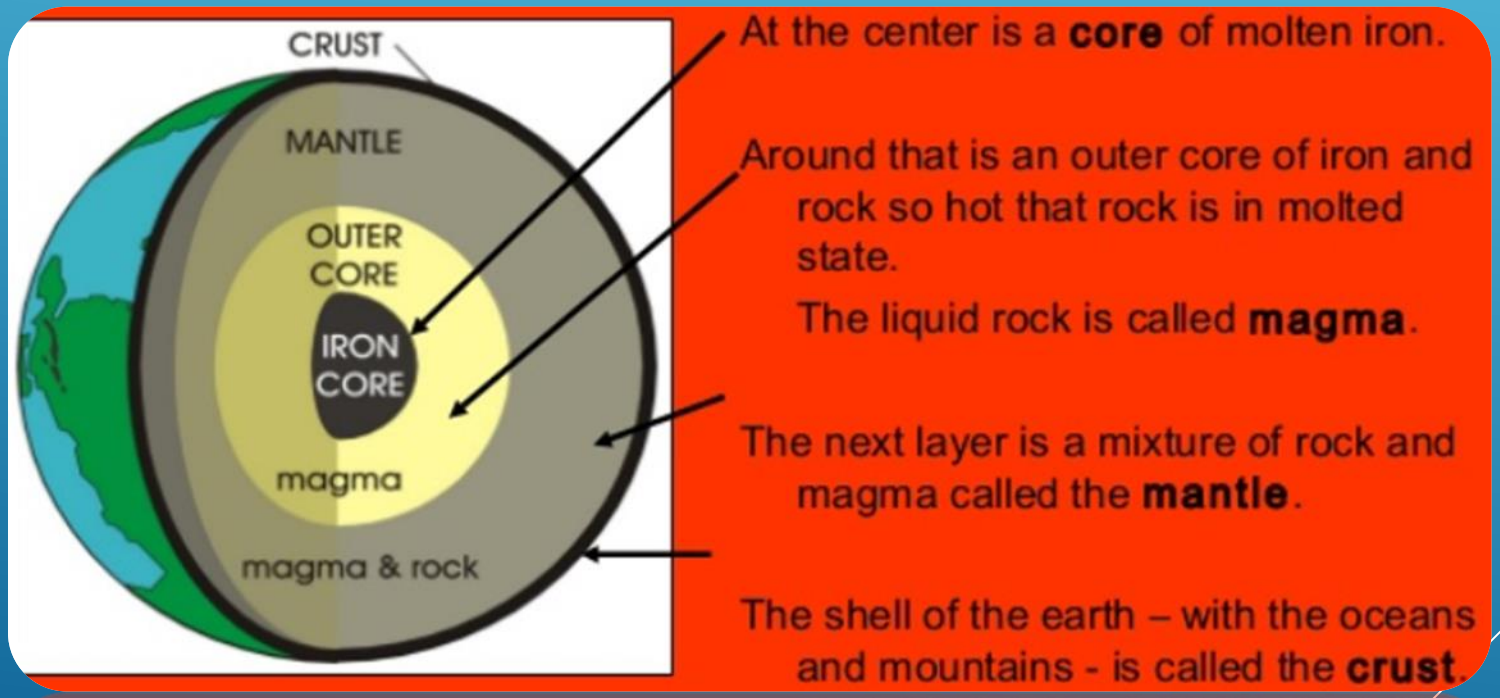
- Today, power plants use **steam** from geothermal wells to make electricity.
- The steam is used to spin **turbines**.
- The turbines spin magnets in coils of copper wire to make **electricity**.



Geothermal energy is generated in the earth's core, about 4,000 miles below the surface. Temperatures hotter than the sun's surface are continuously produced inside the earth by the slow decay of radioactive particles, a process that happens in all rocks.

The earth has a number of different layers:

The core itself has two layers: a solid iron core and an outer core made of very hot melted rock, called magma.



- The mantle which surrounds the core and is about 1,800 miles thick. It is made up of magma and rock.
- The crust is the outermost layer of the earth, the land that forms the continents and ocean floors. It can be three to five miles thick under the oceans and 15 to 35 miles thick on the continents.
- The earth's crust is broken into pieces called plates. Magma comes close to the earth's surface near the edges of these plates. This is where volcanoes occur. The lava that erupts from volcanoes is partly magma. Deep underground, the rocks and water absorb the heat from this magma. The temperature of the rocks and water get hotter and hotter as you go deeper underground.

Some applications of geothermal energy use the earth's temperatures near the surface, while others require drilling miles into the earth. The three main uses of geothermal energy are:

1) Direct Use and District Heating Systems which use hot water from springs or reservoirs near the surface.

2) Electricity generation in a power plant requires water or steam at very high temperature (300 to 700 degrees Fahrenheit). Geothermal power plants are generally built where geothermal reservoirs are located within a mile or two of the surface.

3) Geothermal heat pumps use stable ground or water temperatures near the earth's surface to control building temperatures above ground.

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