DAYANANDA SAGAR UNIVERSITY

ELEMENTS OF MECHANICAL ENGINEERING

MODULE-1 - Energy Conversion

5 hours Lectures

Renewable & Nonrenewable energy resources – Introduction to Steam, Hydro & Nuclear power plants, solar, wind and biomass energy based power plants, Effect of power generation on environment

Thermodynamics- First and second laws of thermodynamics, Efficiency, COP, Carnot theorem, Numericals

Session No.	Topic
1	Renewable & Nonrenewable energy resources - Introduction to Steam, Hydro & Nuclear power plants
2	solar, wind and biomass energy based power plants
3	Effect of power generation on environment
4	Thermodynamics- First and second laws of thermodynamics, Efficiency
5	COP, Carnot theorem, Numericals

Prepared by -
Prof. Abhilash O
Dept. of Mechanical Engineering
DSU-SOE

Session - 1

Energy Sources

Description of energy

Energy, in physics, the capacity for doing work. It may exist in potential, kinetic, thermal, electrical, chemical and nuclear.

Examples : light energy, heat energy, mechanical energy, gravitational energy, electrical energy, sound energy, chemical energy, nuclear or atomic energy and so on.

Kinetic energy is the energy in moving objects or mass. Examples include mechanical energy, electrical energy etc.

Potential energy is any form of energy that has stored potential that can be put to future use.

Classification of Energy Resources

1. Based on Usability of Energy
   a) Primary Resources
   b) Intermediate Resources
   c) Secondary Resources

2. Based on Traditional Use
   a) Conventional Energy
   b) Non-conventional Energy

3. Based on Long time Availability
   1) **Renewable Resources**
   2) **Non- renewable Resources**

4. Based on Commercial Application
   1) Commercial Energy Resources
   2) Non-commercial Energy Sources

- Based on Utilization of Energy

(a) Primary Resources: These are resources embodied in nature prior to undergoing any human made conversions (raw energy sources). Ex: sunlight, wood, wind.

(b) Secondary Resources: The form of energy which is finally supplied to a consumer for utilization is known as Secondary Resource. Ex: Electrical Energy, thermal energy (in the form of steam or water)

- Based on Traditional use

(a) Conventional: energy resources which have been traditionally used for many decades & also called Nonrenewable. Ex: fossil fuels, nuclear & hydro resources

(b) Non-conventional: energy resources which are considered for large scale & also called renewable. Ex : solar, wind & bio-mass

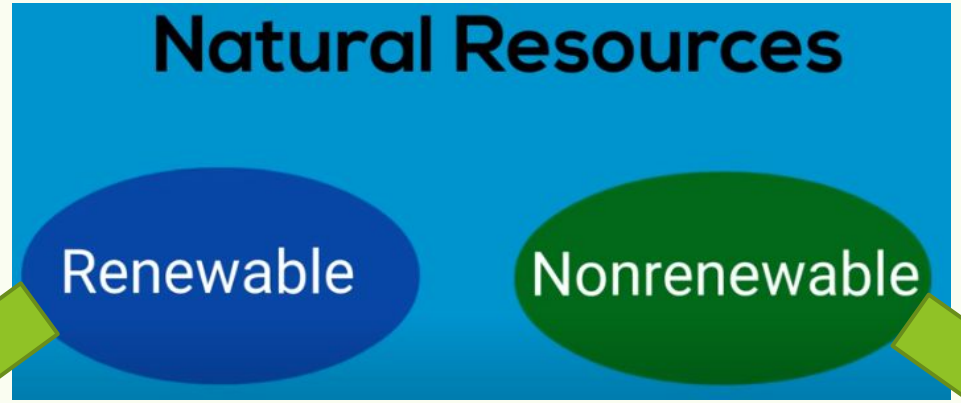
- Based on Commercial application

(a) Commercial energy resources: the secondary useable energy forms such as electricity, petrol, and diesel are essential for commercial activities. The economy of a country depends on its ability to convert natural raw energy into commercial energy. Ex : coal, oil, gas, uranium, & hydro

(b) Non-commercial energy resources: the energy derived from nature & used –directly without passing through commercial outlet. Ex: wood, animal dung cake, crop residue.

Renewable & Nonrenewable energy resources

- Natural Resources can be classified as Renewable and Nonrenewable Resources based on their availability



A renewable resource can be replaced at the same rate in which the resource is used

A nonrenewable resource is a resource that forms at a rate that is much slower than the rate that it is consumed

Renewable resources

- resources which are renewed by nature again & again & their supply are not affected by the rate of their consumption.

Ex : solar, wind, bio-mass, ocean (thermal, tidal & wave), geothermal, hydro

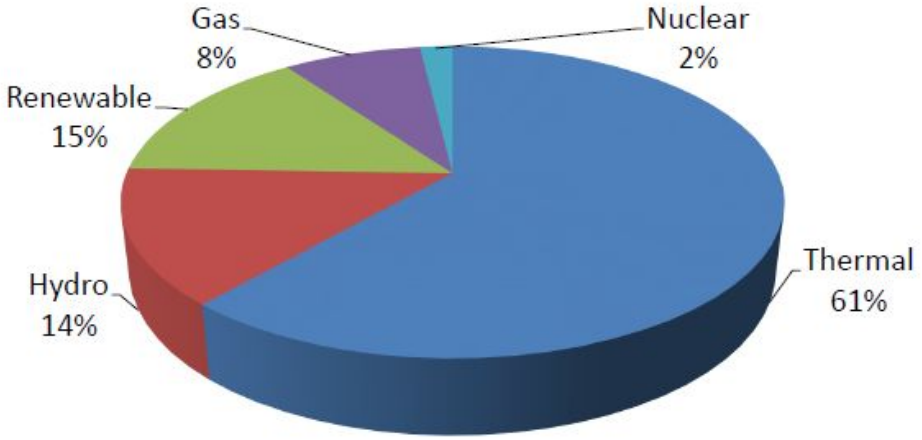
Nonrenewable resources

- resources which are finite, & do not get replenished after their consumption.
- Ex : fossil fuels (CON ‘’Coal, oil, natural gas’’), uranium

Video - Conversion of nonrenewable to renewable

Indian Power Sector

- Total Installed Capacity- 304.5 GW

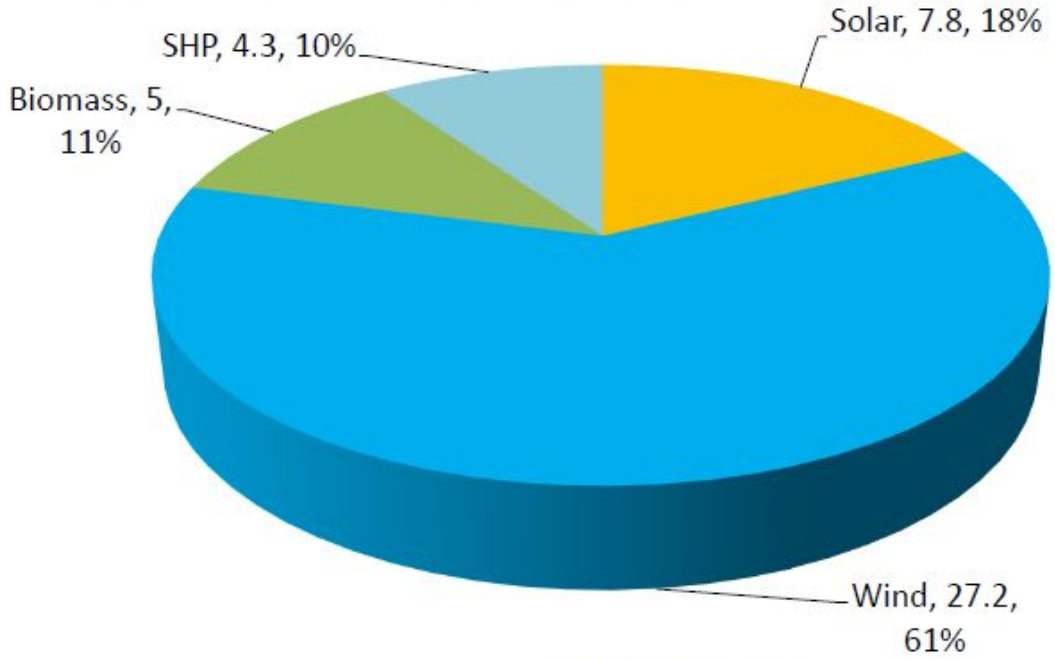


Thermal	Hydro	Renewable	Gas	Nuclear
187.2	42.8	44.2	24.5	5.8

Source: Central Electricity Authority (CEA) as on 30.06.2016

Indian Renewable Sector

- Total Installed Capacity- 44.2 GW



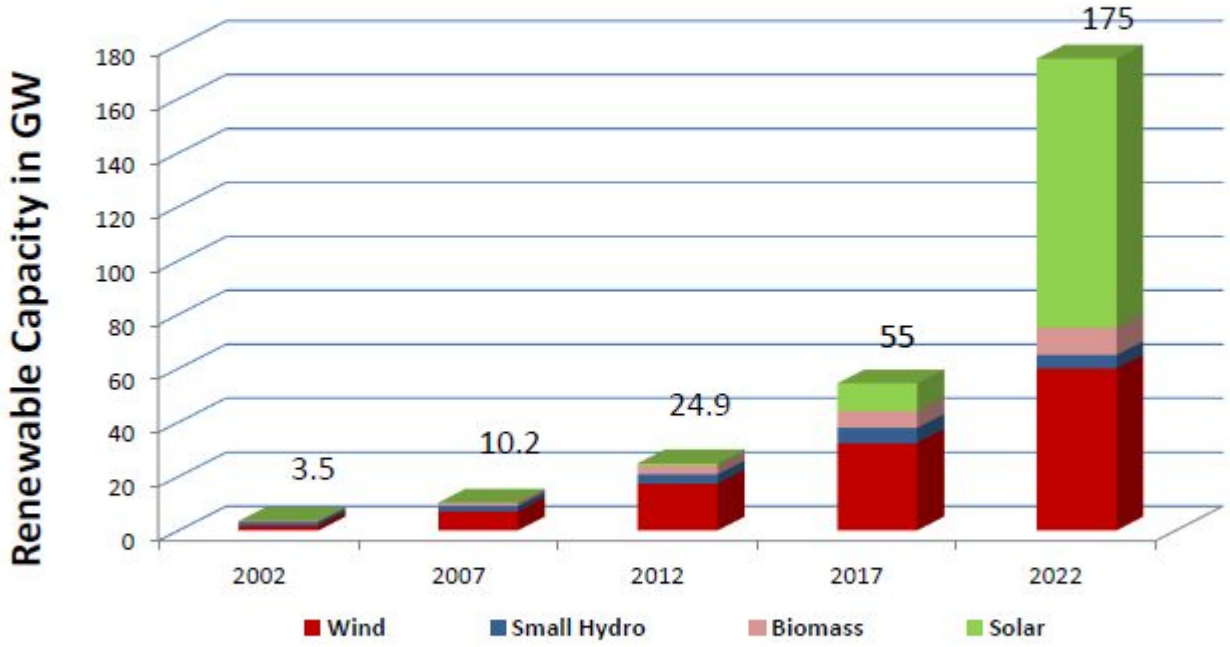
Source: MNRE 30.06.2016

India's Global Position-Overall Ranking

(Year 2015 – Capacity in GW)

Technology	India		First Position	
	Global Position	Capacity	Country	Capacity
RE Capacity World total = 785 GW	5th	36	China	199
Solar Energy (PV) World Total = 227 GW	9th	5.2	China	44
Solar Energy (CSP) World total = 4.8 GW	3th	0.23	Spain	2.3
Wind Energy World total = 433 GW	4th	25	China	145
Bio power generation World total = 106 GW	4th	5.6	USA	16.7
Hydro Power (incl large HP) World total = 1064 GW	6th	47	China	296
Source- Renewable 2016 - Global Status Report, Renewable Energy Policy Network (called REN, 21)				

Exponential Growth of Renewable Power



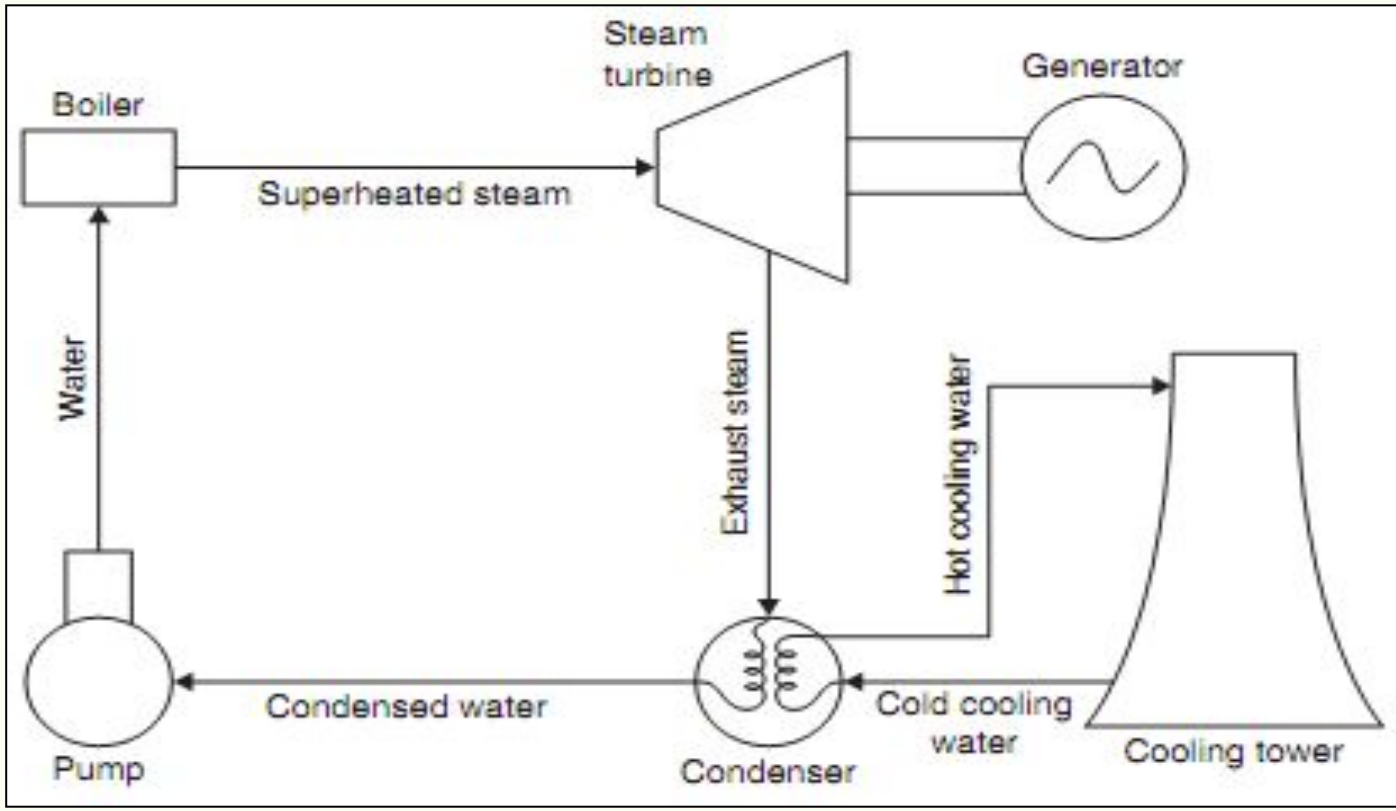
Budget Speech 2015 *"The Ministry of New Renewable Energy has revised its target of renewable energy capacity to 1,75,000 MW till 2022, comprising 100,000 MW Solar, 60,000 MW Wind, 10,000 MW Biomass and 5000 MW Small Hydro."*

Introduction to Steam, Hydro, Nuclear Power plants

- In steam/thermal power plant, coal, diesel, petrol, natural gas, and kerosene oil are used as fuel and chemical energy of these fuels is converted into mechanical energy and then mechanical energy into electrical energy.
- In hydroelectric power plant, the potential energy of water is converted into mechanical energy as shaft power and then mechanical energy into electrical energy.
- In the case of nuclear energy, nuclear power is used to generate the heat required to produce superheated steam and then the heat energy is converted into mechanical energy and the mechanical energy is converted into electrical energy.

Steam/Thermal Power Plant

- Steam power plants are located at the water and coal available places. Steam is utilized
- to run the turbines, in turn gives the power to generator and generator produces the electricity,
- the electricity is utilized for lighting, running the industries, for lighting of offices, schools, etc.
- Boiler is an important component of the power plants, it produces the steam.



Pros:

- Cheap coal is used.
- Requires less construction space
- Can be installed anywhere near fuel and water

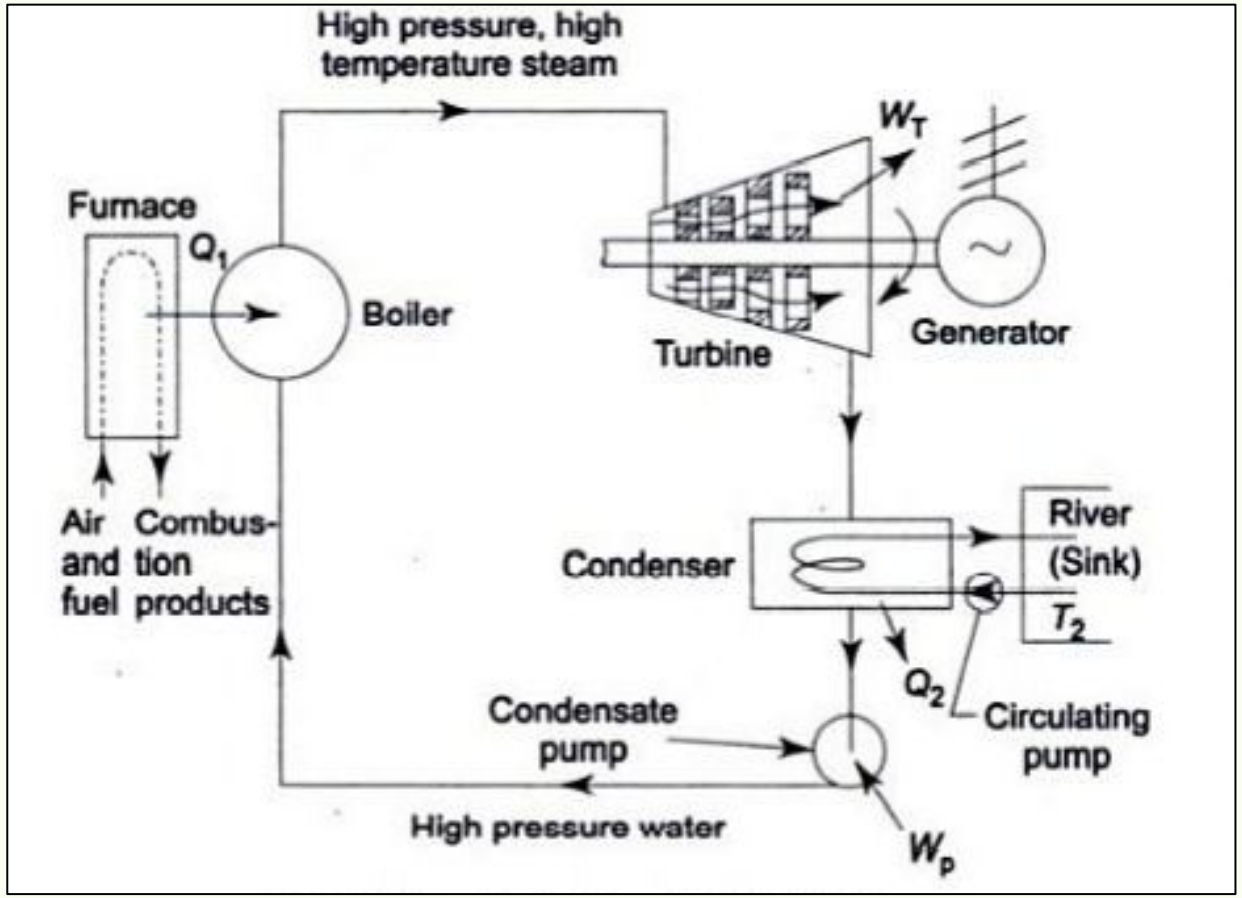
Cons:

- Air pollution from smoke fumes
- Costs more to run compared with other types of power stations

Essentials of Steam Power Plant Equipment

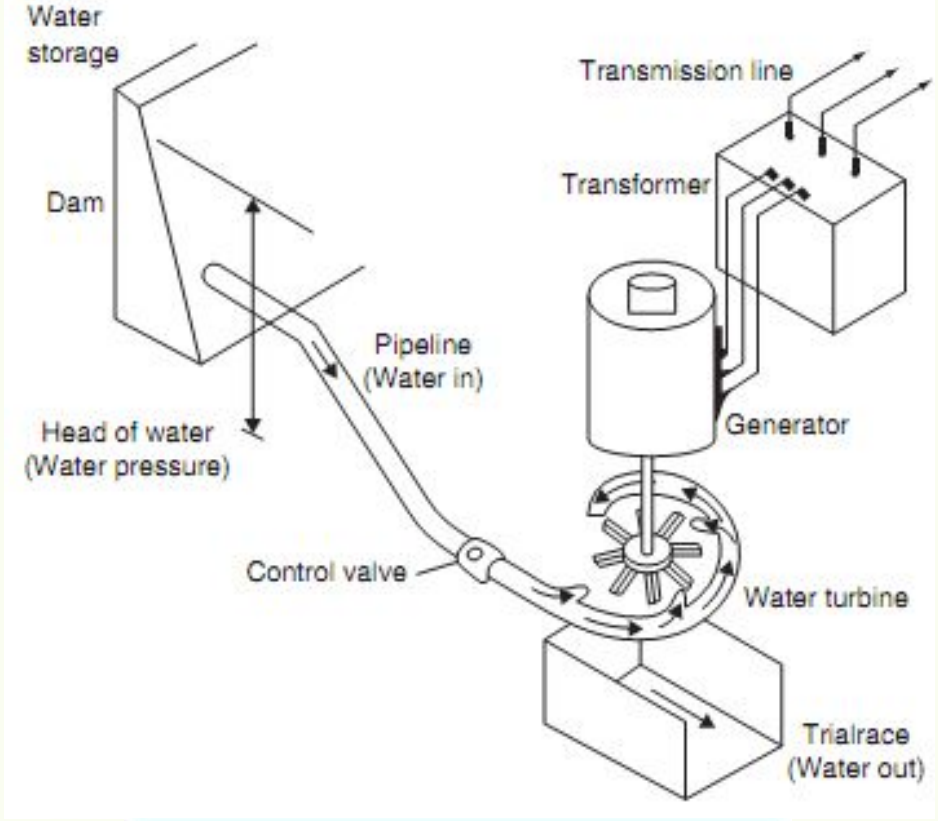
A steam power plant must have following equipment :

- A furnace to burn the fuel.
- Steam generator or boiler containing water. Heat generated in the furnace is utilized to convert water into steam.
- Main power unit such as an engine or turbine to use the heat energy of steam and perform work.
- Piping system to convey steam and water.



Hydro Power Plant

- In hydroelectric power plant, the potential energy of water is converted into mechanical energy as shaft power and then mechanical energy into electrical energy.

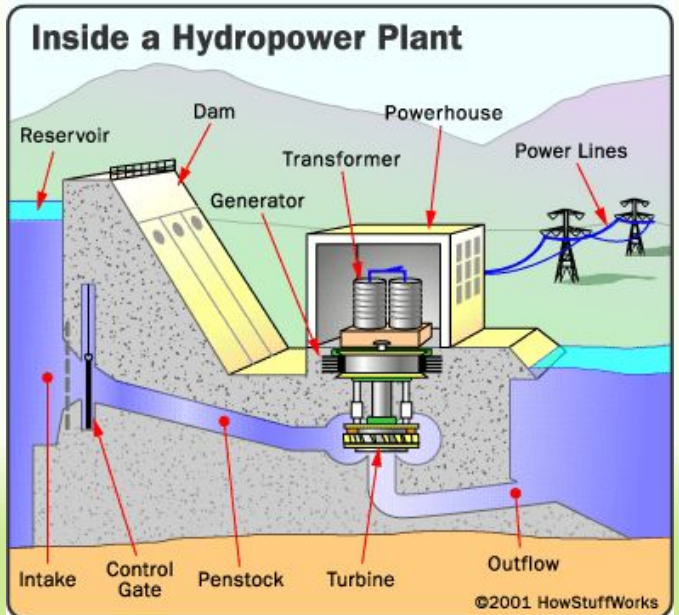


Pros:

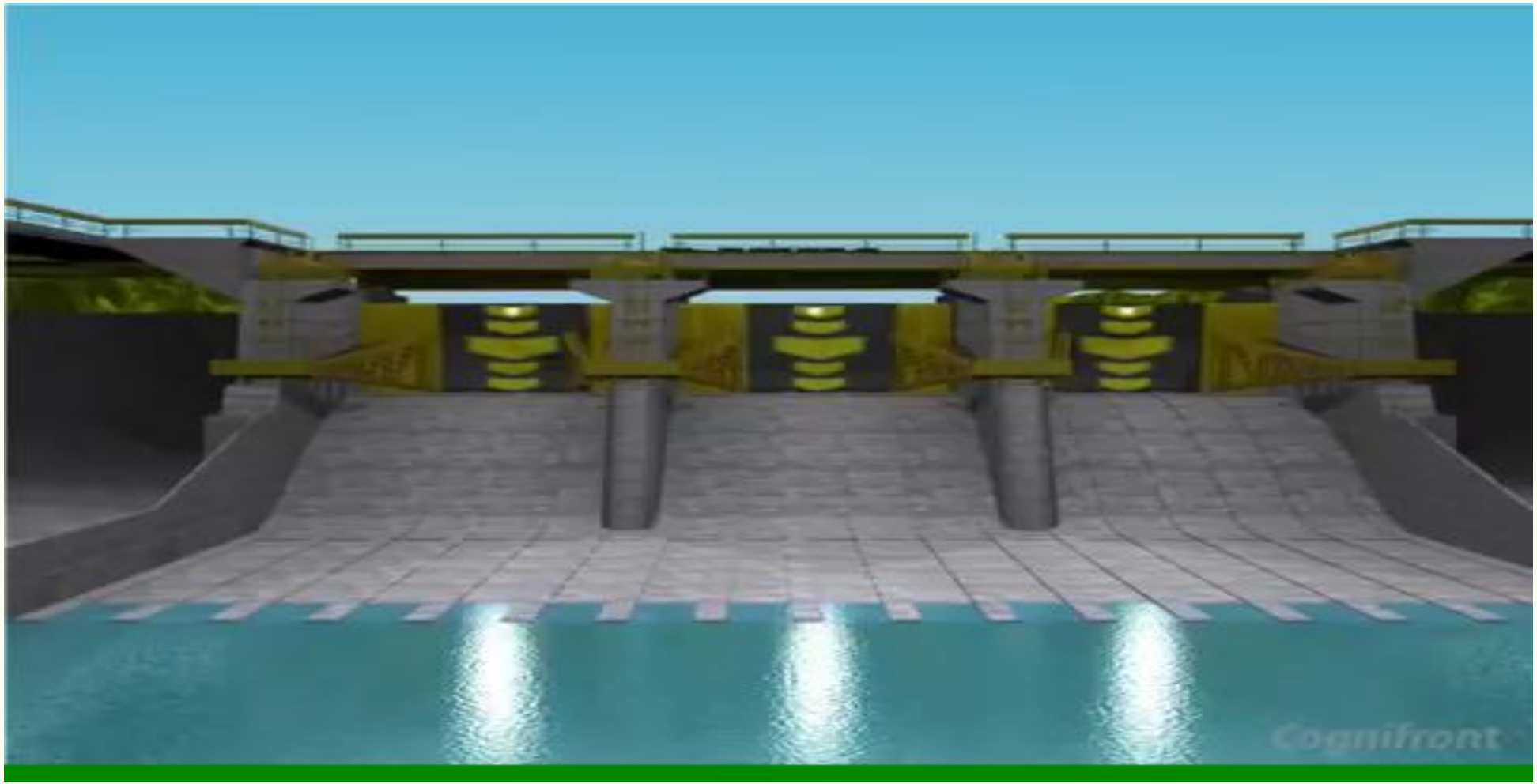
- No greenhouse gases
- Can generate lots of electricity
- Renewable

Cons:

- Can damage environment where dam is built (can change the natural water temperatures, chemistry, flow characteristics, and silt loads, all of which can lead to significant changes in the ecology (living organisms and the environment) and rocks and land forms of the river upstream and downstream.
- Expensive to build

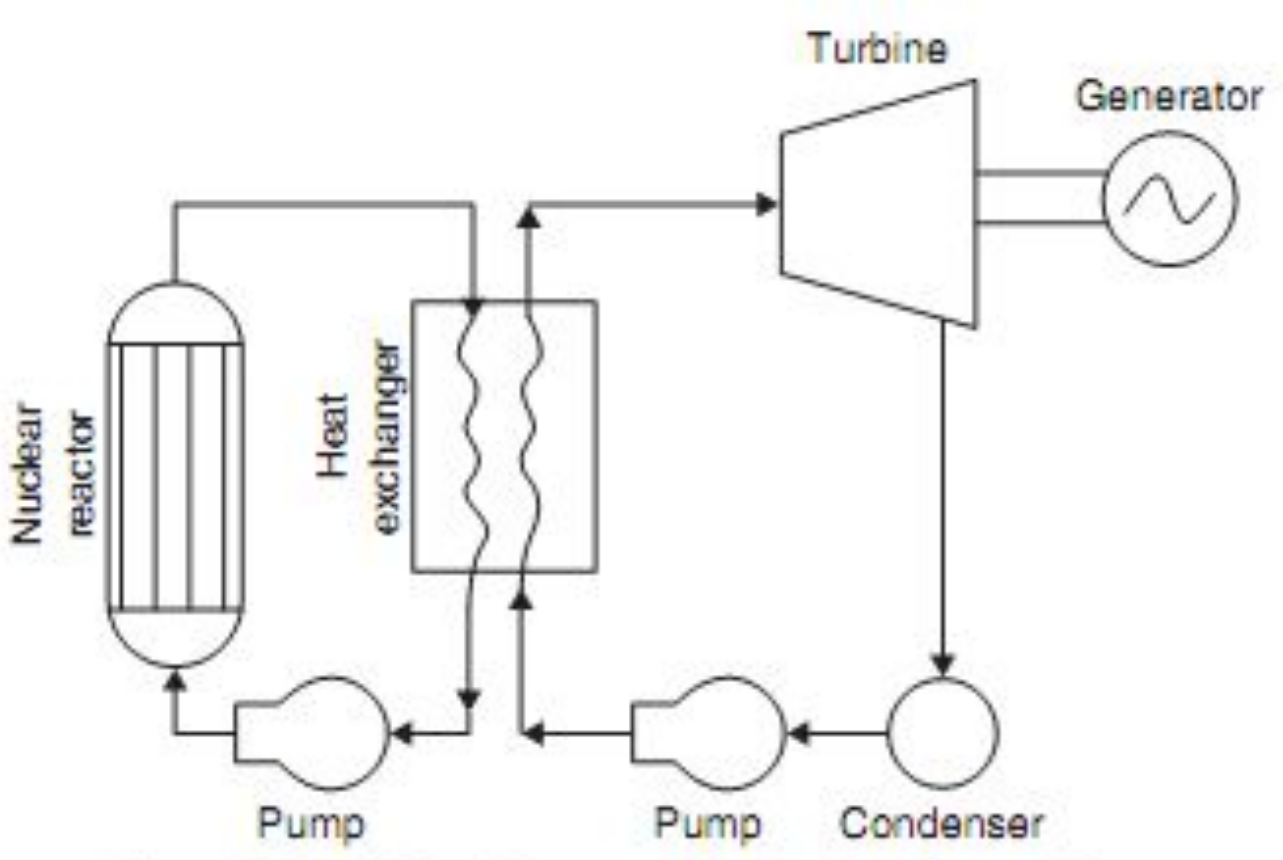


Hydroelectric power plant



Nuclear Power Plant

- In the case of nuclear energy, nuclear power is used to generate the heat required to produce superheated steam and then the heat energy is converted into mechanical energy and the mechanical energy is converted into electrical energy.
- nuclear fission, atoms are split apart to form smaller atoms, releasing energy.

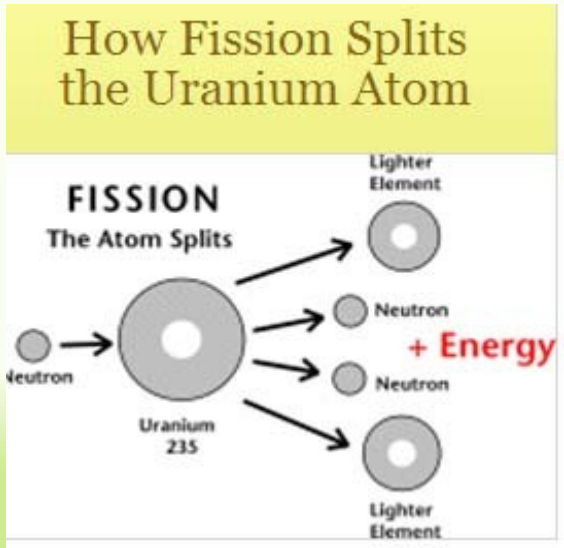


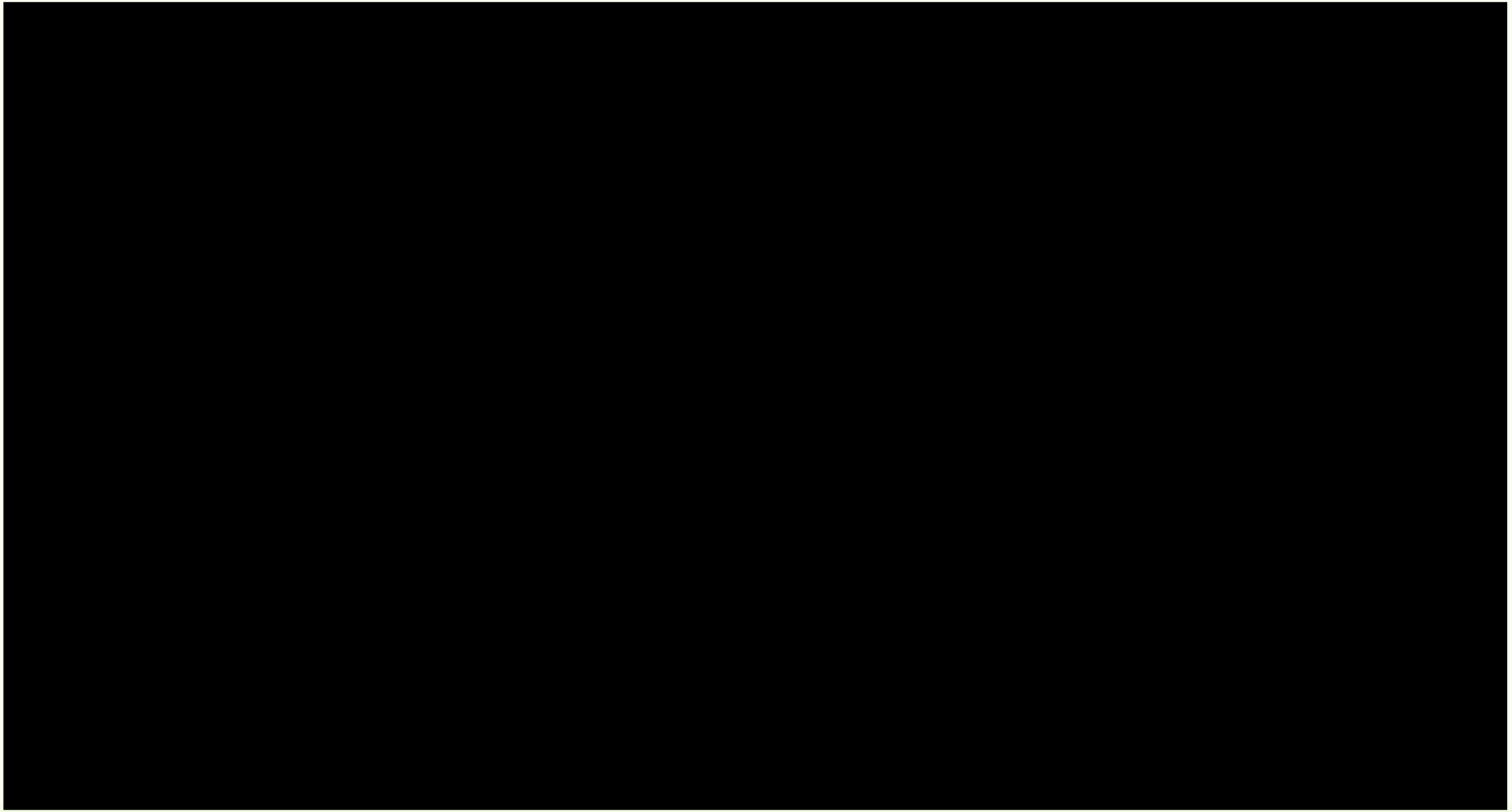
Pros:

- No greenhouse gases
- Very efficient energy producer
- abundant

Cons

- Expensive to build and maintain reactors
- Produces radioactive waste
- Difficult to dispose of waste
- Heated waste water is harmful to aquatic life
- Terrorism threat with spent fuel (nuclear weapons)





Solar Power Plant

A solar power plant is any type of facility that converts sunlight either directly, like Photovoltaics, or indirectly, like Solar Thermal plants, into electricity.
Photovoltaic power plants use large areas of photovoltaic cells, known as PV or solar cells, to directly convert sunlight into usable electricity.
These cells are usually made from silicon alloys
Crystalline solar panels are made from crystalline silicon
When photons from sunlight hit the semiconductor material free electrons are generated which can then flow through the material to produce a direct electrical current, This is known as the photo-effect in physics. The DC current then needs to be converted to alternating current (AC) using an inverter before it can be directly used or fed into the electrical grid.
PV panels are distinct from other solar power plants as they use the photo-effect directly without the need for other processes or devices. For example, no liquid heat-carrying agent, like water, is needed as in solar thermal plants.

Wind power plant

- Wind turbines work on a simple principle: instead of using electricity to make wind—like a fan—wind turbines use wind to make electricity. Wind turns the propeller-like blades of a turbine around a rotor, which spins a generator, which creates electricity
- Wind is a form of solar energy caused by a combination of three concurrent events:

The sun unevenly heating the atmosphere

Irregularities of the earth's surface

The rotation of the earth.

- A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which work like an airplane wing or helicopter rotor blade.
- When wind flows across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag

Biomass based powerplants

- Biomass is renewable fuel used in nearly every corner of the developing countries as a source of heat, particularly in the domestic sector.
- Biomass energy includes energy from all plant matter (tree, shrub, and crop) and animal dung.
- Biomass, unlike other renewables, is a versatile source of energy, which can be converted to modern forms such as liquid and gaseous fuels, electricity, and process heat.
- The different methods of biomass extraction can be broadly be classified as:

Anaerobic Digestion

Gasification.

Fermentation.

- **Anaerobic Digestion** is a biochemical degradation process that converts complex organic material, such as animal manure, into methane and other byproducts

Anaerobic digester (commonly referred to as an AD) is a device that promotes the decomposition of manure or “digestion” of the organics in manure to simple organics and gaseous biogas products

Biogas is formed by the activity of anaerobic bacteria. Microbial growth and biogas production are very slow at ambient temperatures

These bacteria occur naturally in organic environments where oxygen is limited.

Biogas is comprised of about 60% methane, 40% carbon dioxide, and 0.2 to 0.4% of hydrogen sulfide.

Manure is regularly put into the digester after which the microbes break down the manure into biogas and a digested solid.

The digested manure is then deposited into a storage structure.

The biogas can be used in an engine generator or burned in a hot water heater. AD systems are simple biological systems and must be kept at an operating temperature of 100 degrees F in order to function properly

Biogas is very corrosive to equipment and requires frequent oil changes in an engine generator set to prevent mechanical failure.

Because of the low energy content and its corrosive nature of biogas, storage of biogas is not practical.

There are two major types of biogas designs promoted in India a) Floating Drum b) Fixed Dome

Gasification

- Gasification is a process that exposes a solid fuel to high temperatures and limited oxygen, to produce a gaseous fuel.
- This is a mix of gases such as carbon monoxide, carbon dioxide, nitrogen, hydrogen and methane.
- Gasification has several advantages over burning solid fuel.
- One is convenience – one of the resultant gases, methane, can be treated in a similar way as natural gas, and used for the same purposes.
- Another advantage of gasification is that it produces a fuel that has had many impurities removed and will therefore cause fewer pollution problems when burnt.

fermentation

- For centuries, people have used yeasts and other microorganisms to ferment the sugar of various plants into ethanol.
- Producing fuel from biomass by fermentation is just an extension of this old process, although a wider range of plant material can now be used, from sugar cane to wood fiber.

Assignment - Module -1

- 1- India's Global position – Overall Ranking – Year 2020