Generation Of Electrical Power

Subject Code : 26751

Electrical Technology, 5th Semester

Presented By-

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1. **Understand types of energy.**
2. **Understand the types and characteristics of power plants.**
3. **Understand the principle of operation of a steam power plant.**
4. **Understand the principle of operation of a diesel power plant.**
5. **Understand the principle of operation of gas turbine power plant.**
6. **Understand the operation of a hydro-electric power plant.**
7. **Understand the principle of operation of a nuclear power plant.**
8. **Understand the process of selection of a power plant and its site.**
9. **Understand the concept of power plant economics.**
10. **Recognize authority for generating bulk and consumer supply of electrical power.**
11. **Understand the concept of non conventional renewable energy sources.**
12. **Understand the concept of solar power generation.**
13. **Understand wind energy generation.**
14. **Understand non conventional sources of energy.**

Energy and its types

ENERGY

WHAT IS ENERGY…???

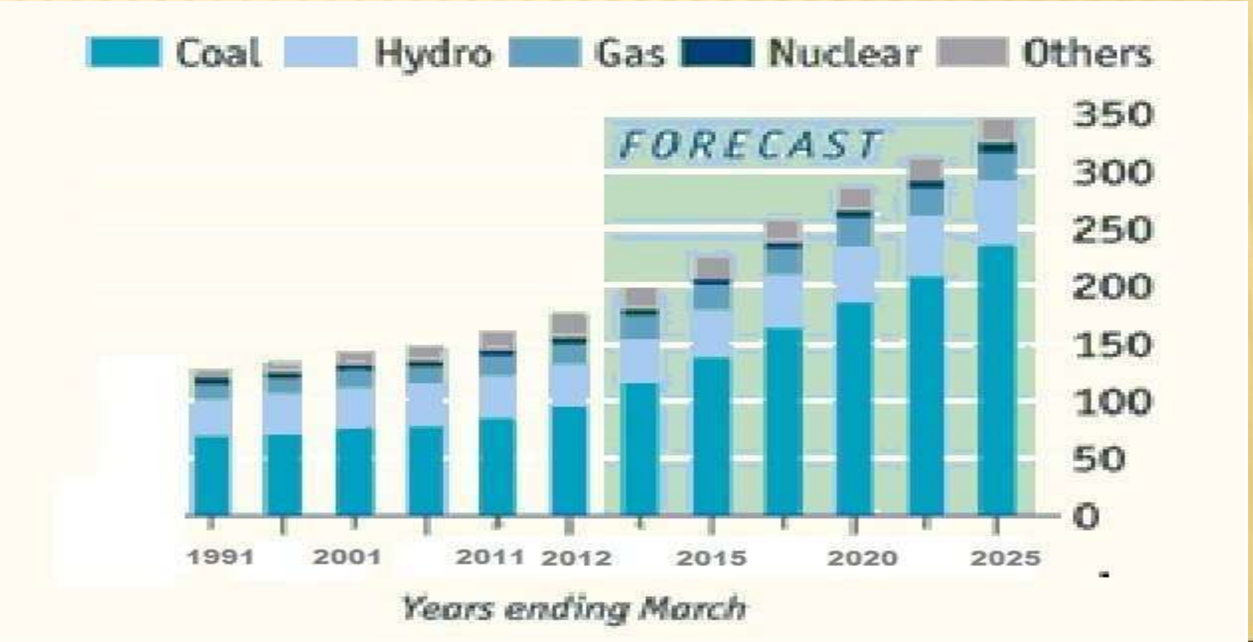
- Energy is defined as the ability to do work ..
- Energy can be store and transported in variety of ways
- Energy is the one of the basic need of human beings…

e.g.

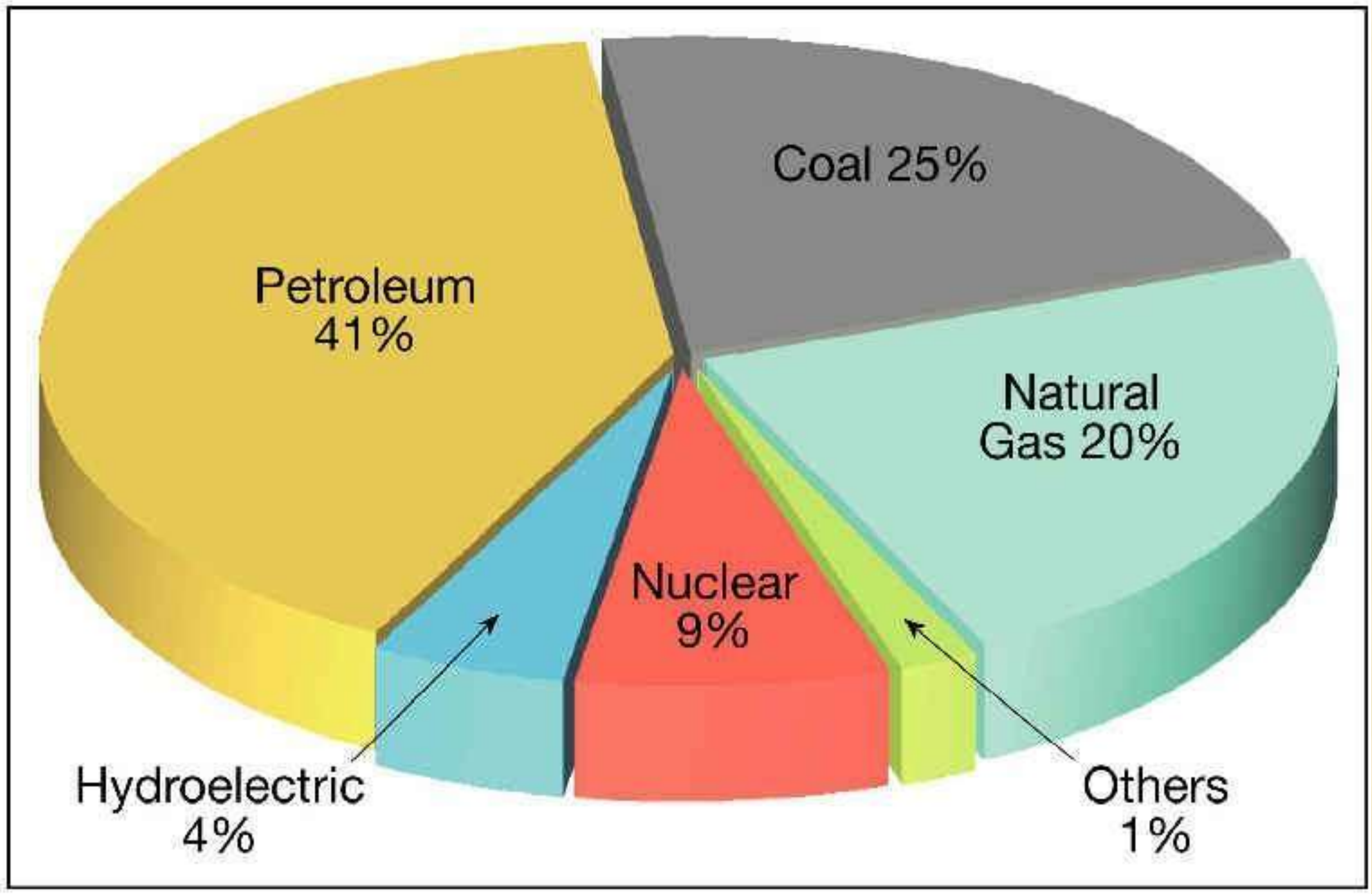
Chemical, electrical ,mechanical, heat…etc

GROWTH IN NEED OF ENERGY

- In the recent years, India's energy consumption has been increasing at one of the fastest rates in the world due to population growth and economic development. Primary commercial energy demand grew at the rate of 8% between 1991 and 2011.
- India ranks fifth in the world accounting for about 4.5% of the world commercial energy demand in the year 2011. Despite the overall increase in energy demand, in India is still very low compared to other developing countries.



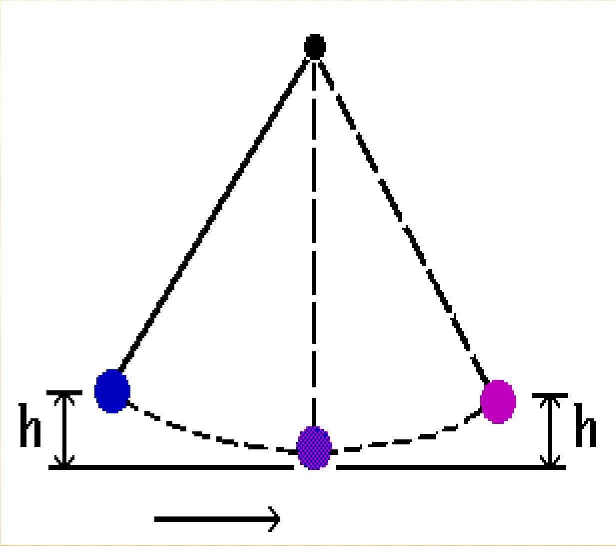
PERCENTAGE OF ENERGY USED



ENERGY CONSERVATION LAW

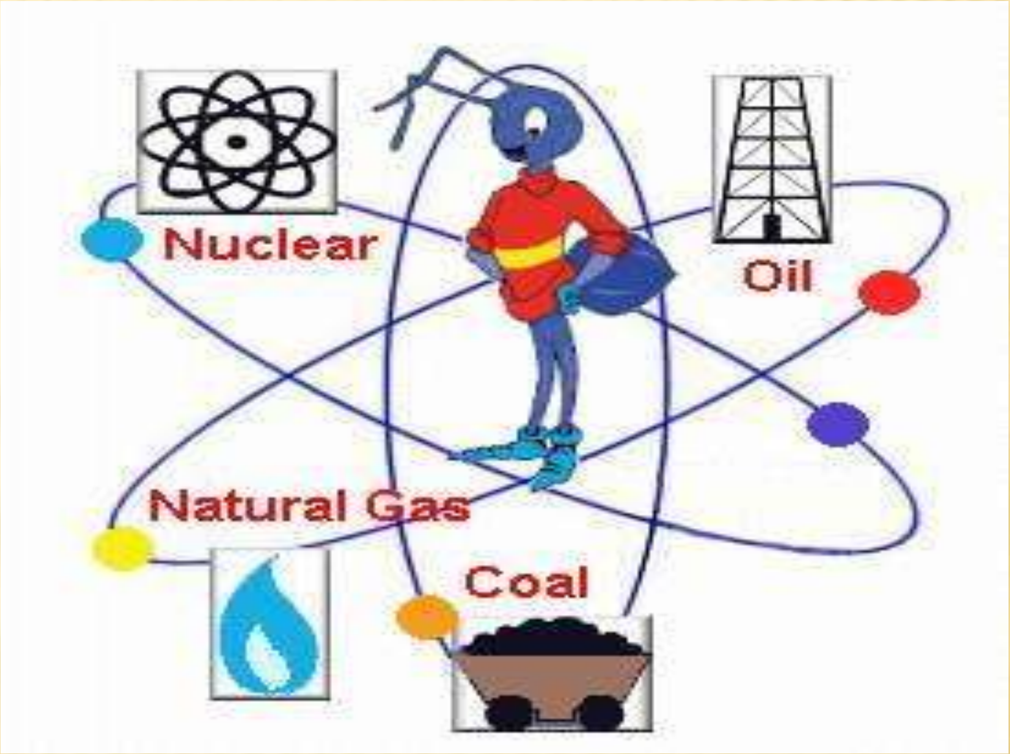
Energy in a system may take on various forms.The law of conservation of energy states that energy may neither be created nor destroyed. Therefore the sum of all the energies in the system is a constant.

The most commonly used example is the pendulum:



ENERGY RESOURCES

- The means or the origins by which get the energy are called as energy resources.



Renewable Resources

- The resources that can produce energy again and again in small time span

I. Hydroelectric
II. Solar
III. Wind
IV. Biomass
V. Biofuels

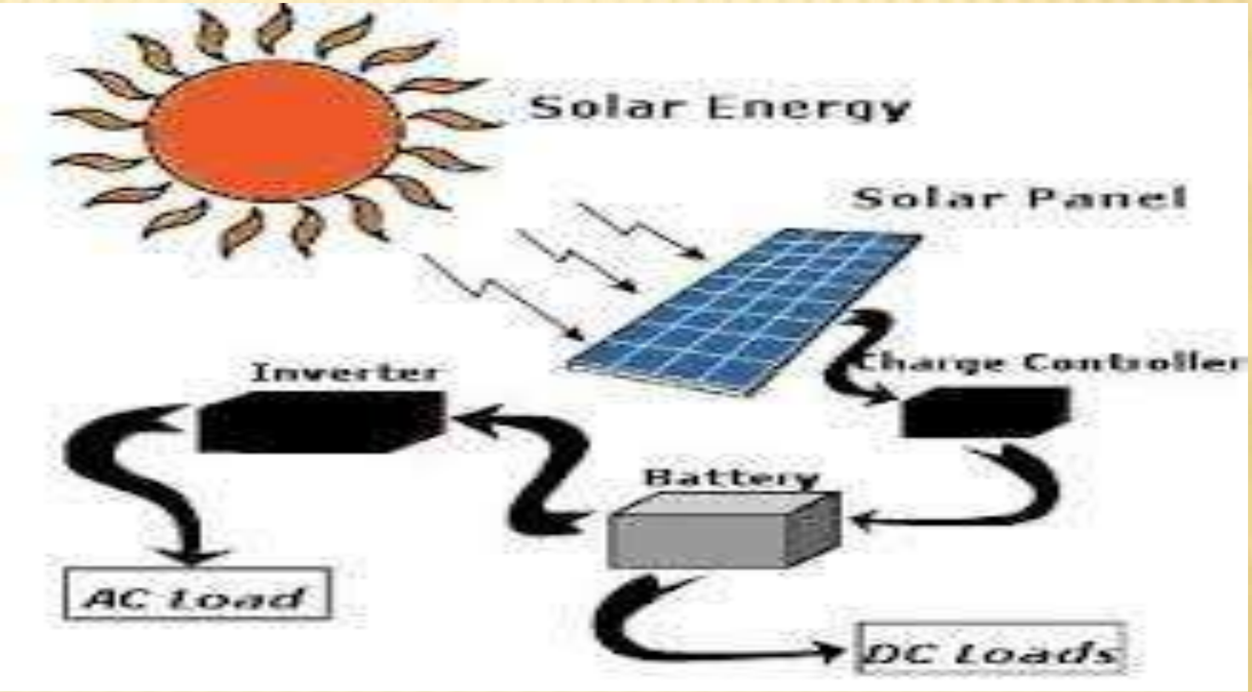
Non-Renewable Resources

- The resources that can not produce energy again and again

I. Coal
II. Petrol
III. LPG

RENEWABLE RESOURCES
SOLAR ENERGY

Solar energy is the energy received by the earth from the sun. This energy is in the form of solar radiation, which makes the production of solar electricity possible.



WIND ENERGY

- Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use
- The power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically up to the maximum output for the particular turbine.
- Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms
- Typical capacity factors are 20-40%, with values at the upper end of the range in particularly favorable sites

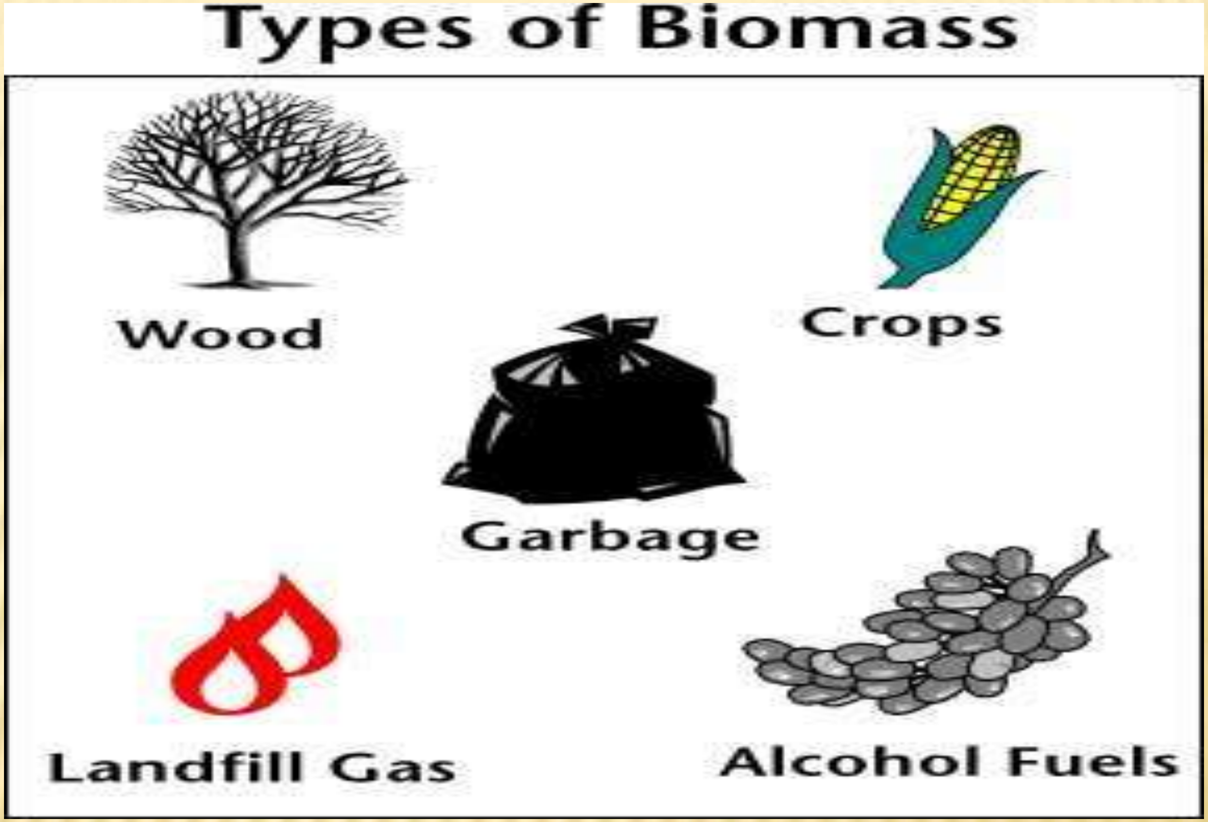
Pawan Urja Prakalp At Satara

BIOMASS ENERGY

- In the developed world biomass is becoming more important for dual applications such as heat and power generation.

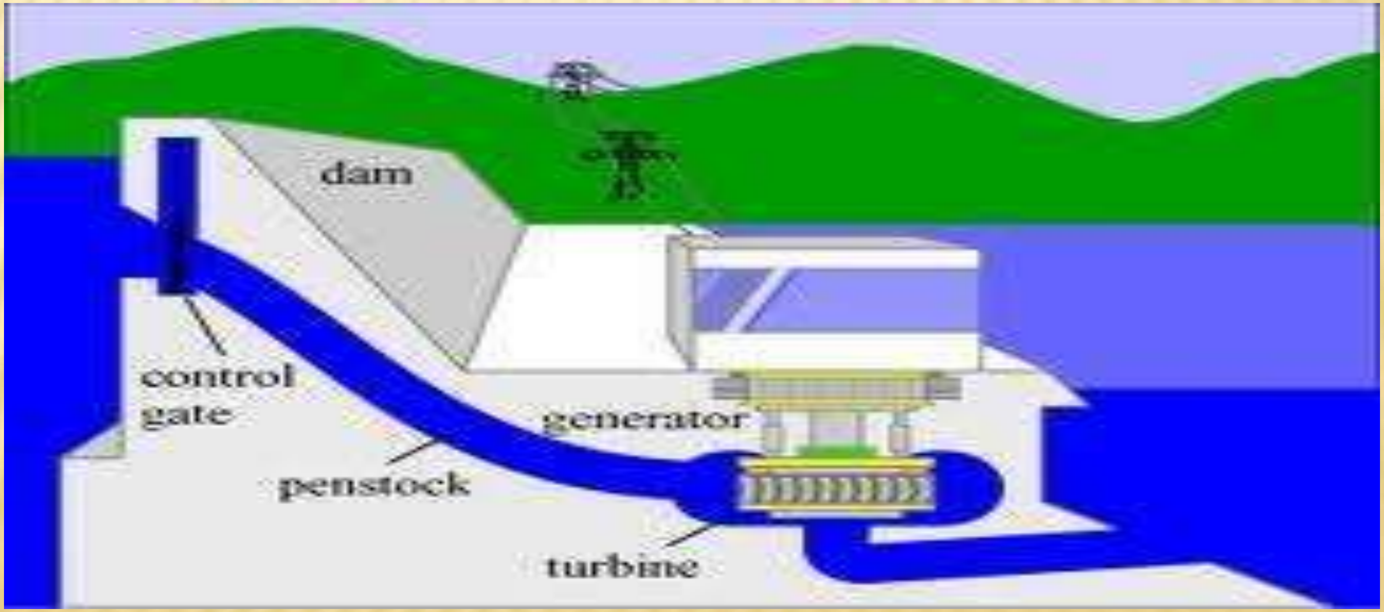
- Biomass is a clean renewable energy resource derived from the waste of various human and natural activities.

- It excludes organic material which has been transformed by geological processes into substances such as coal or petroleum.


Types of Biomass
Wood
Crops
Garbage
Landfill Gas
Alcohol Fuels

HYDRO-ELECTRIC ENERGY

- Energy produced by using the potential of water resources is termed Hydro-electric energy.
- Electricity is generated by running turbines installed in the downstream of dams.



ADVANTAGES OF RENEWABLE ENERGY

•One major advantage with the use of renewable energy is that as it is renewable it is therefore sustainable and so will never run out.
•Renewable energy facilities generally require less maintenance than traditional generators. Their fuel being derived from natural and available resources reduces the costs of operation.
•Even more importantly, renewable energy produces little or no waste products such as carbon dioxide or other chemical pollutants, so has minimal impact on the environment.
•Renewable energy projects can also bring economic benefits to many regional areas, as most projects are located away from large urban centres and suburbs of the capital cities. These economic benefits may be from the increased use of local services as well as tourism.

DISADVANTAGES OF RENEWABLE ENERGY

- One disadvantage with renewable energy is that it is difficult to generate the quantities of electricity.
- We need to reduce the amount of energy we use or simply build more energy facilities.
- Another disadvantage of renewable energy sources is the reliability of supply.
- Renewable energy often relies on the weather for its source of power. Hydro generators need rain to fill dams to supply flowing water.
- Wind turbines need wind to turn the blades, and solar collectors need clear skies and sunshine to collect heat and make electricity.

NON-RENEWABLE RESOURCES

•A non-renewable resource is a natural resource which cannot be reproduced, grown, generated, or used on a scale which can sustain its consumption rate, once depleted there is no more available for future needs.

• There are really only two main categories under which non renewable resources fall, fossil fuels and nuclear energy.

•. However, within the category of fossil fuels energy is produced by burning petroleum products such as oil, coal and natural gas.

Petroleum Products

•Petroleum products are the number one source of fuel at the moment and this group includes such products as oil, gasoline, diesel fuel and propane.

•Of this group, only oil occurs naturally in a liquefied form as propane is a gas and is liquefied during processing.

•Further, this group of non renewable resources is held to be responsible for the bulk of damage to the ecology but that only stands to reason as it is the largest group of fuels used for energy and in the production of electricity.

COAL

Although coal is not used in concentrations that it was in years past, it is still the most copious fossil fuel that is produced within the United States. Coal is a combustible sedimentary rock that takes literally millions of years to create from decayed plants. It is composed primarily of carbon and hydrocarbons and even though there is currently an adequate supply, there is a limit to this most abundant of non renewable resources.

NATURAL GAS

•Most people aren't aware of the fact that natural gas is comprised largely of methane that resulted from decaying plants and animals millions of years ago.

•Over time the earth built up around this decaying organic matter and trapped the gasses between layers of earth and rock.

•An interesting fact here is that some of the organic material was changed by heat and pressure into petroleum oil and coal while pockets of natural gas remained trapped within the earth's crust which is where we find it today.

NUCLEAR ENERGY

•**Nuclear power** is the use of sustained nuclear fission to generate heat and electricity. Nuclear power plants provide about 6% of the world's energy and 13–14% of the world's electricity, with the U.S., France, and Japan together accounting for about 50% of nuclear generated electricity.

•Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources of electricity.

ADVANTAGES & DISADVANTAGES OF NON-RENEWABLE ENERGY

Advantages

Ample supply for 42–93 years

Low cost (with huge subsidies)

High net energy yield

Easily transported within and between countries

Low land use

Disadvantages

Need to find substitute within 50 years

Artificially low price encourages waste and discourages search for alternatives

Air pollution when burned

Releases CO_2 when burned

Moderate water pollution

Fig. 14.21, p. 340

Slide 29

OUR OPINION

•Use renewable energy as much as possible

•Use public transport

•Avoid deforestation

•Control on population is required

•Use Biofuels mix fuels for individual

THANK YOU……!!!!!!

TYPES OF POWER PLANT

PRESENTED BY: Md. Jakirul Islam

DEFINITION

A power station (also referred to as a generating station, power plant, powerhouse or generating plant) is an industrial facility for the generation of electric power.

Hydraulic Energy / Thermal Energy -> Mechanical Energy -> Electrical Energy

TYPES OF POWER PLANTS

TYPES OF POWER PLANTS

1.BASED ON INPUT ENERGY/FUEL

(a.)COAL thermal Power Plants

(b.) HYDRAULIC Power Plants

(c.) NUCLEAR Power Plants

(d.) GEOTHERMAL Power Plants

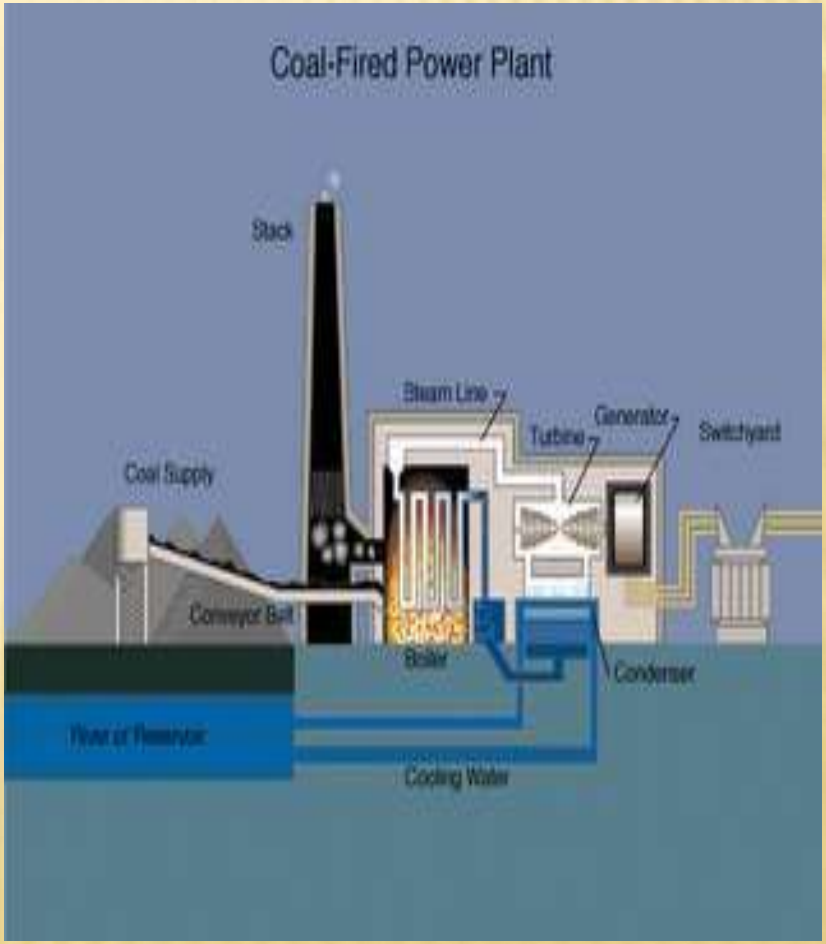
(e.) SOLAR Power Plants

(f.)WIND power plants

(g.)BIOMASS power plant

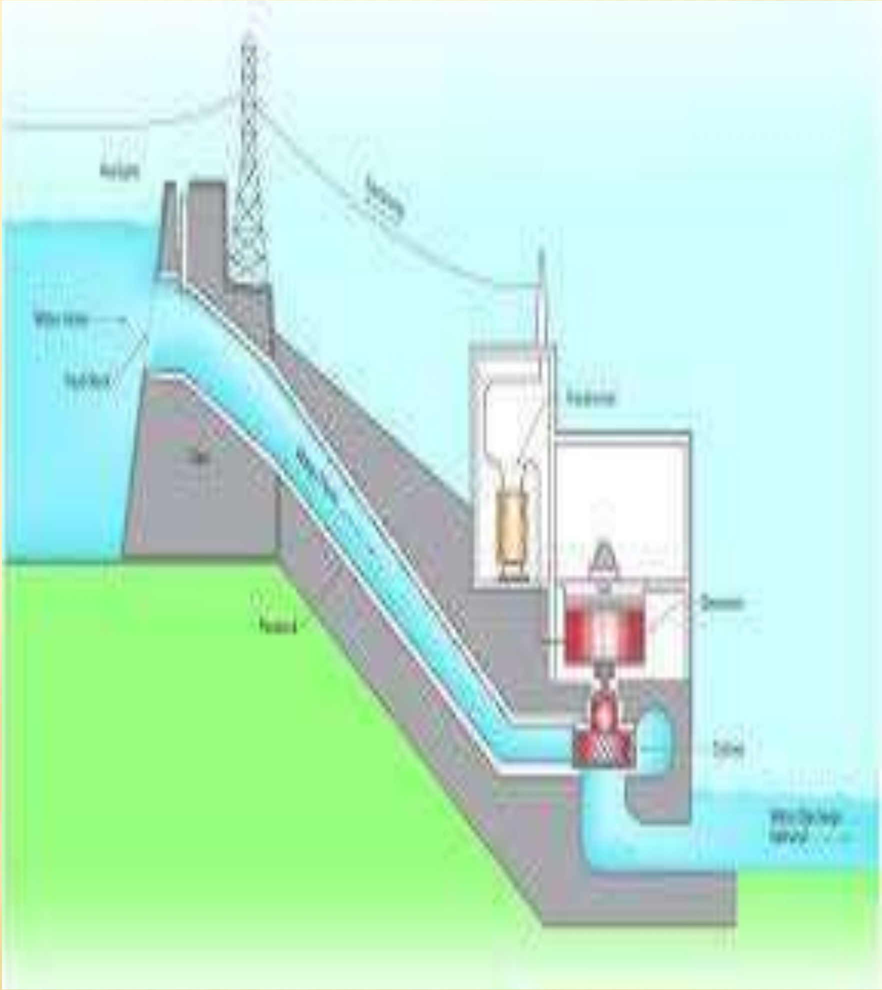
COAL THERMAL POWER PLANT

- In coal thermal power plants The heat produce by burning fossil fuel materials boils water and transform it into steam.
- The steam is then piped to a turbine. -The impulses of turbine moves the turbine. - Finally, steam is condensed and move into the boiler to repeat the cycle.
- Rotation of the turbine rotates the generator to produce electricity.



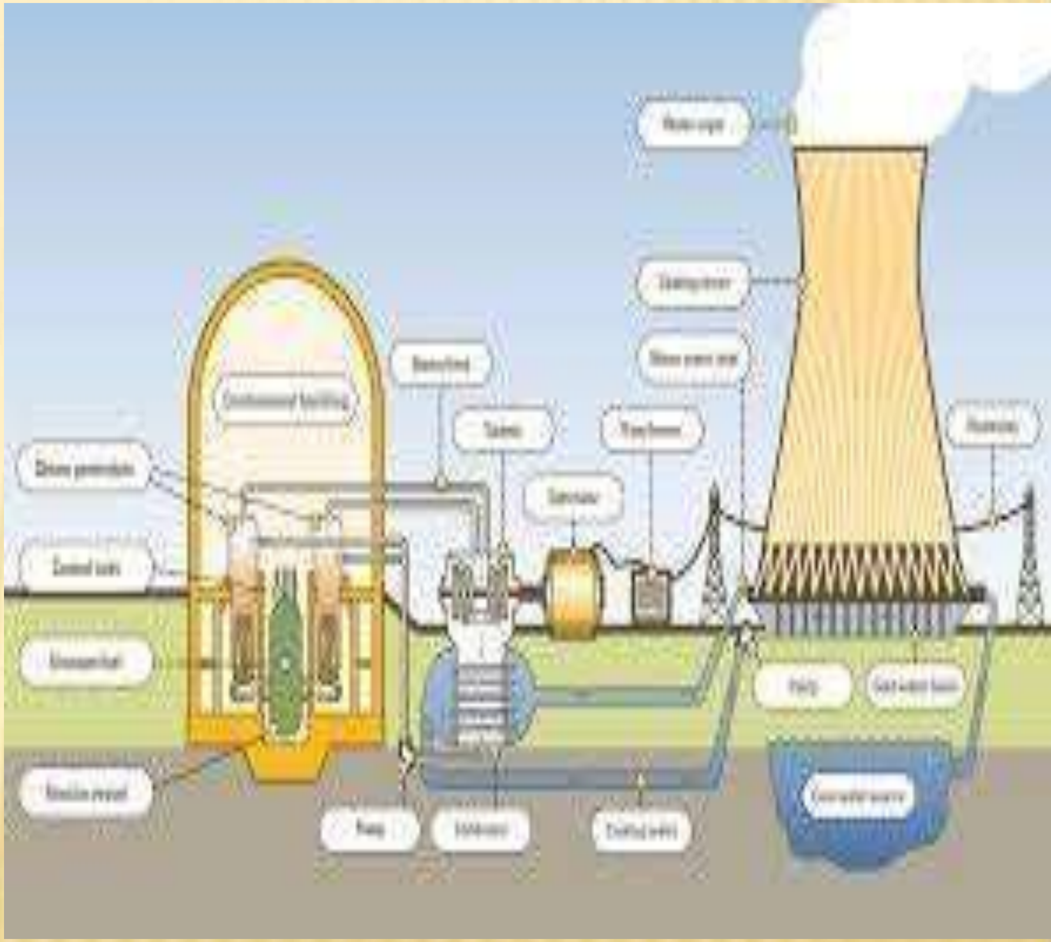
HYDRAULIC POWER PLANT

- The hydroelectric power plants are stations where energy is produced by the force of falling water
- The water moves a turbine connected to a generator that collect the energy that water creates



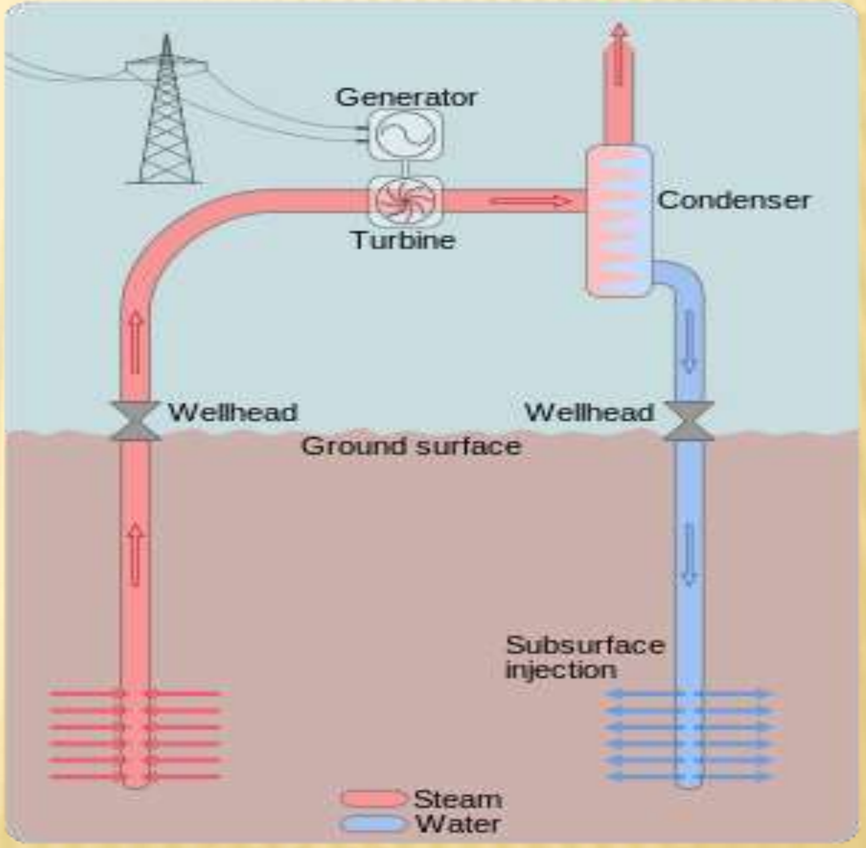
NUCLEAR THERMAL POWER PLANT

- The heat is produced by fission in a nuclear reactor (a light water reactor). Directly or indirectly, water vapour (steam) is produced. The pressurized steam is then usually fed to a multi-stage steam turbine.



GEOTHERMAL POWER PLANT

- Geothermal electricity is electricity generated from geothermal energy. Technologies in use include dry steam power plants, flash steam power plants and binary cycle power plants.



SOLAR POWER PLANT

- That kind of power plants creates energy by transforming the heat and light from the sun.
- There are Two types:-

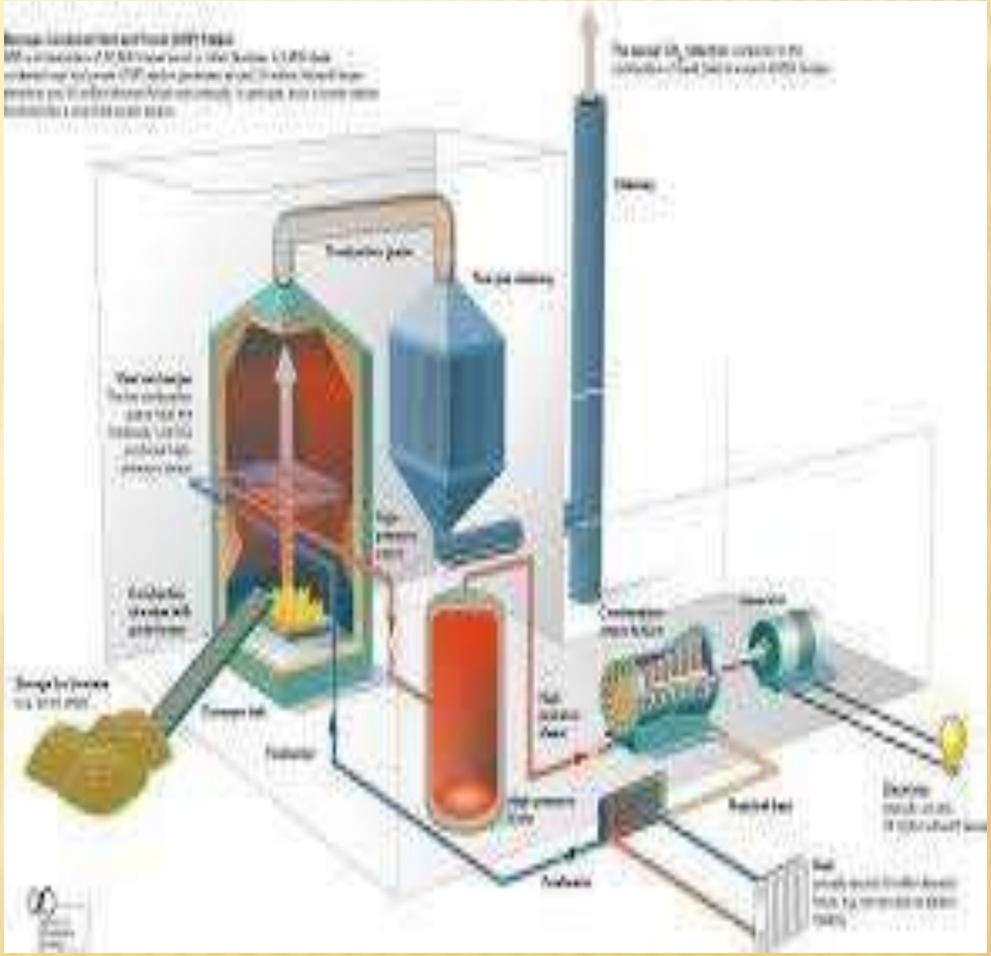
- **Solar Thermal Energy** :- It stores the heat of the sun, which transforms water into steam, that moves turbines which are connected to a generator that collect energy.
- **Photovoltaic Energy** :- Is a method of generating electrical power by converting solar radiation into direct current electricity.

WIND POWER PLANT

- Wind station are the ones that transform wind energy into another usefull kind of energy
- A wind form consist of almost a hundred of winds turbines connected to electric power transmission network

BIOMASS POWER PLANT

- The Biomass thermal energy consist in buring the natural waste and rubish, such as plants animals, food.
- It produces natural gases that provides heat to water and wich transforms it into steam, that later will move a turbine connected to a genertor that collects energy



Steam Power Plant

Md. Jakirul Islam

Contents

- Layout of Steam Power Plant
- Coal Handling
- Ash Handling

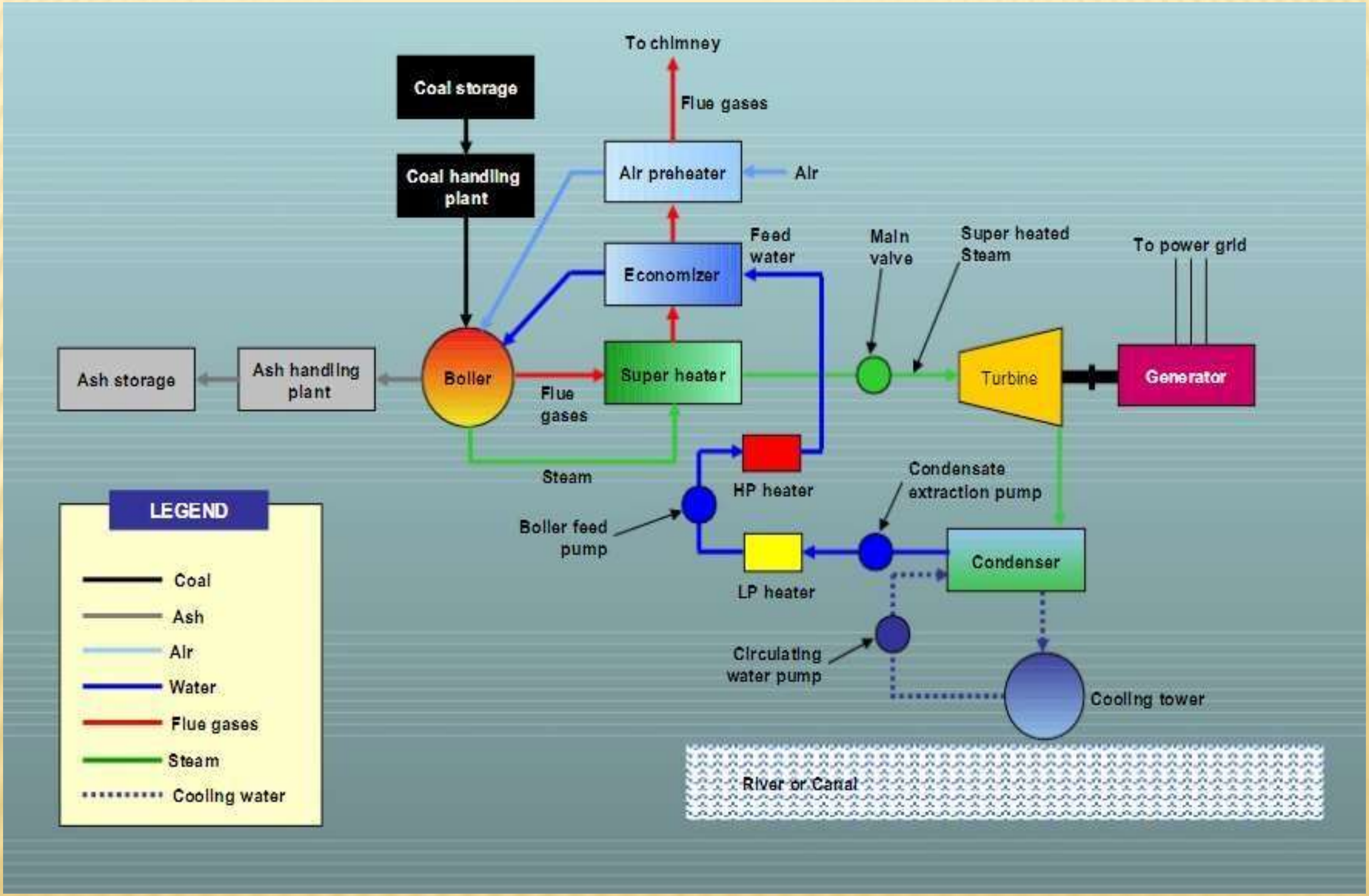
Introduction

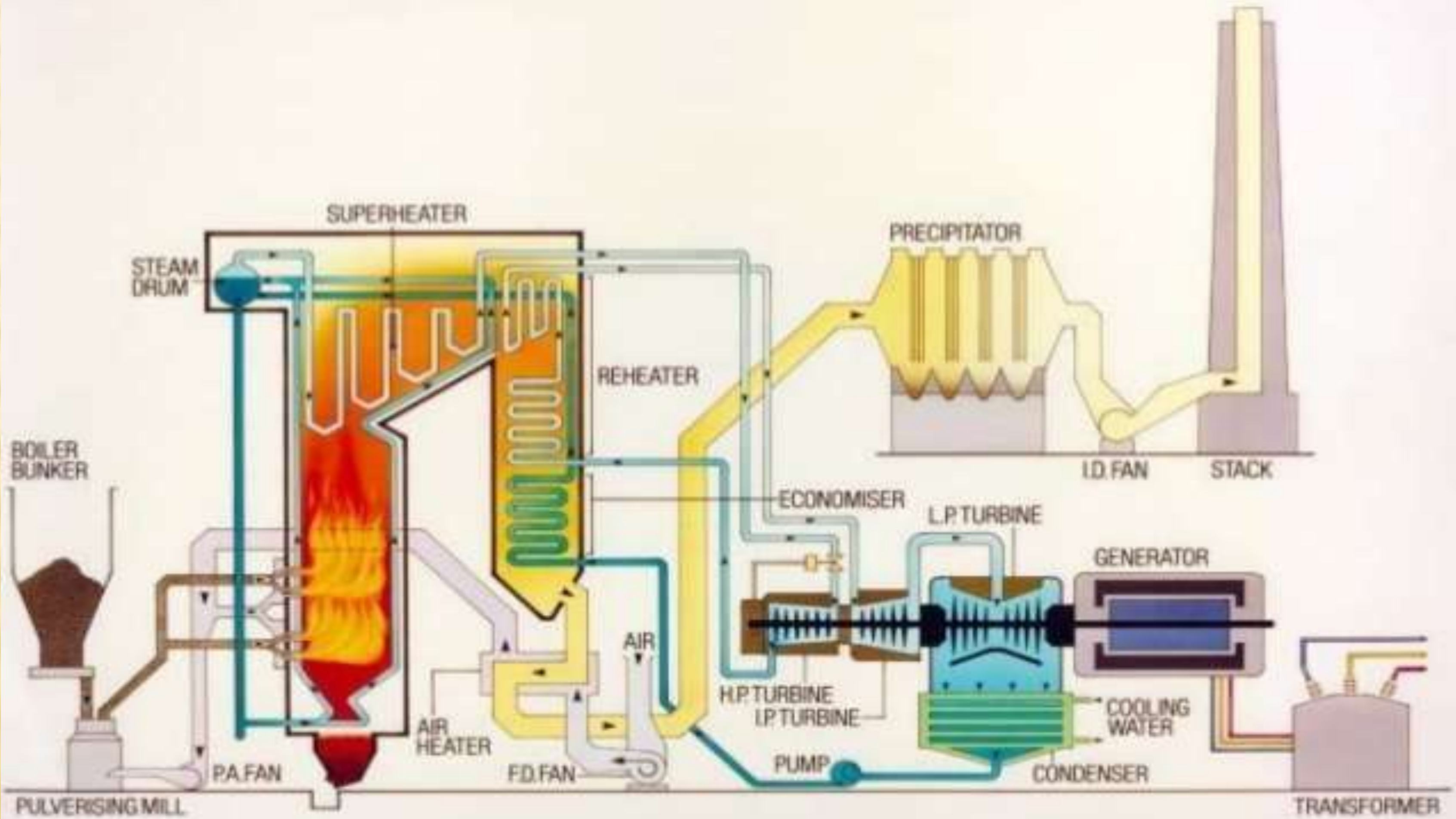
- A steam power plant converts the chemical energy of the fossil fuel (Coal) into mechanical energy/electrical energy.
- This is done by raising the steam in the boilers, expanding it through the turbines and coupling the turbines to the generators which converts mechanical energy to electrical energy.
- Purposes of Steam Power Plant
- 1. to produce electric power
- 2. to produce steam for industrial processes like textile, food manufacturers, paper mills etc.

Layout of Steam Power Plant

The Layout consists of four circuits namely

1. Coal and ash circuit.
2. Air and gas circuit.
3. Feed water and steam flow circuit.
4. Cooling water circuit.


To chimney
Flue gases
Coal storage
Coal handling plant
Air preheater
Air
Feed water
Economizer
Main valve
Super heated Steam
To power grid
Ash storage
Ash handling plant
Boiler
Super heater
Flue gases
Turbine
Generator
Steam
HP heater
Condensate extraction pump
Boiler feed pump
LP heater
Condenser
Circulating water pump
Cooling tower
River or Canal
LEGEND
Coal
Ash
Air
Water
Flue gases
Steam
Cooling water



Layout of a Pulverized Fuel Power Plant

Diagram of a typical coal-fired thermal power station

- How coal power plants produce electricity

  The conversion from coal to electricity takes place in three stages.
- Stage 1: The first conversion of energy takes place in the boiler. Coal is burnt in the boiler furnace to produce heat. Carbon in the coal and Oxygen in the air combine to produce Carbon Dioxide and heat.
- Stage 2: The second stage is the thermodynamic process. The heat from combustion of the coal boils water in the boiler to produce steam. In modern power plant, boilers produce steam at a high pressure and temperature. The steam is then piped to a turbine. The high pressure steam impinges and expands across a number of sets of blades in the turbine. The impulse and the thrust created rotates the turbine. The steam is then condensed to water and pumped back into the boiler to repeat the cycle.
- Stage 3: In the third stage, rotation of the turbine rotates the generator rotor to produce electricity based of Faraday's Principle of electromagnetic induction.

- Coal and ash handling circuit:

Coal arrives at the storage yard and after necessary handling passes to the furnace through fuel feeding device. Ash after combustion collects at the back of the boiler and is removed to the ash storage yard.

- Air and Gas circuit:

Air is taken in from the atmosphere through the action of a forced or induced draught fan and passes on to the furnace through the air preheater, where it has been preheated by the flue gases which pass to the chimney via preheater.

- Feed water and steam flow circuit:

Condensate leaving the condenser is first heated in a closed feed water heater through extracted steam from the lowest pressure extraction point of turbine. ----deaerator----economiser -----boiler.

- In Boiler the water circulates due to difference in density of water in the lower temp. and higher temperatures of boiler
- Wet steam from boiler is heated up in Superheater----Prime mover---HP turbine---Superheater----LP turbine-----condenser ---hot well.
- Cooling water circuit:
- The cooling water supply to the condenser helps in maintaining a low pressure in it. Water may be taken from a natural source.

Components of Steam Power Plant

1. Boiler
   - Superheater
   - Reheater
   - Economiser
   - Air-heater
2. Steam Turbine
3. Generator
4. Condenser
5. Cooling Tower
6. Circulating Water Pump
7. Boiler feed pump
8. Wagon Tippler
9. Crusher house
10. Coal Mill
11. Induced draught fan
12. Ash Precipitators
13. Boiler Chimney
14. Forced draught fan
15. Water treatment plant
16. Control room
17. Switch yard

Selection of Site

1. Availability of raw material.
2. Nature of land.
3. Cost of land.
4. Availability of water.
5. Transport facilities
6. Ash disposal facilities
7. Availability of labour
8. Size of plant
9. Load centre
10. Public Problems
11. Future Extension

Fuels used for steam generation

- The primary fuels which are burned to release heat and generate steam in boilers are the fossil fuels – coal, fuel oil and natural gas.

- In India, coal is the main source of energy because of its large deposits and availability.
- According to geological order of formation, coal may be of the following types with increasing carbon content:

- Peat, Lignite, Sub-bituminous, Bituminous, Sub-anthracite, Anthracite ,Graphite
- Each type of coal has a certain set of physical parameters which are mostly controlled by moisture, volatile content (in terms of aliphatic or aromatic hydrocarbons) and carbon content.

- Peat contains up to 90% moisture and is not attractive as a utility fuel. Coal ‘Ranking’ is a measure of carbon content in the coal. Lignite is considered to be low rank and anthracite to be high rank.

Requirements of Good Coal Handling

1. It should need minimum maintenance
2. It should be reliable
3. Simple and sound
4. It should require minimum of operatives
5. Should be able to deliver requisite quantity of coal at destination during peak period.
6. There should be minimum wear in running the equipment due to abrasive action of coal particles.

Coal Handling System

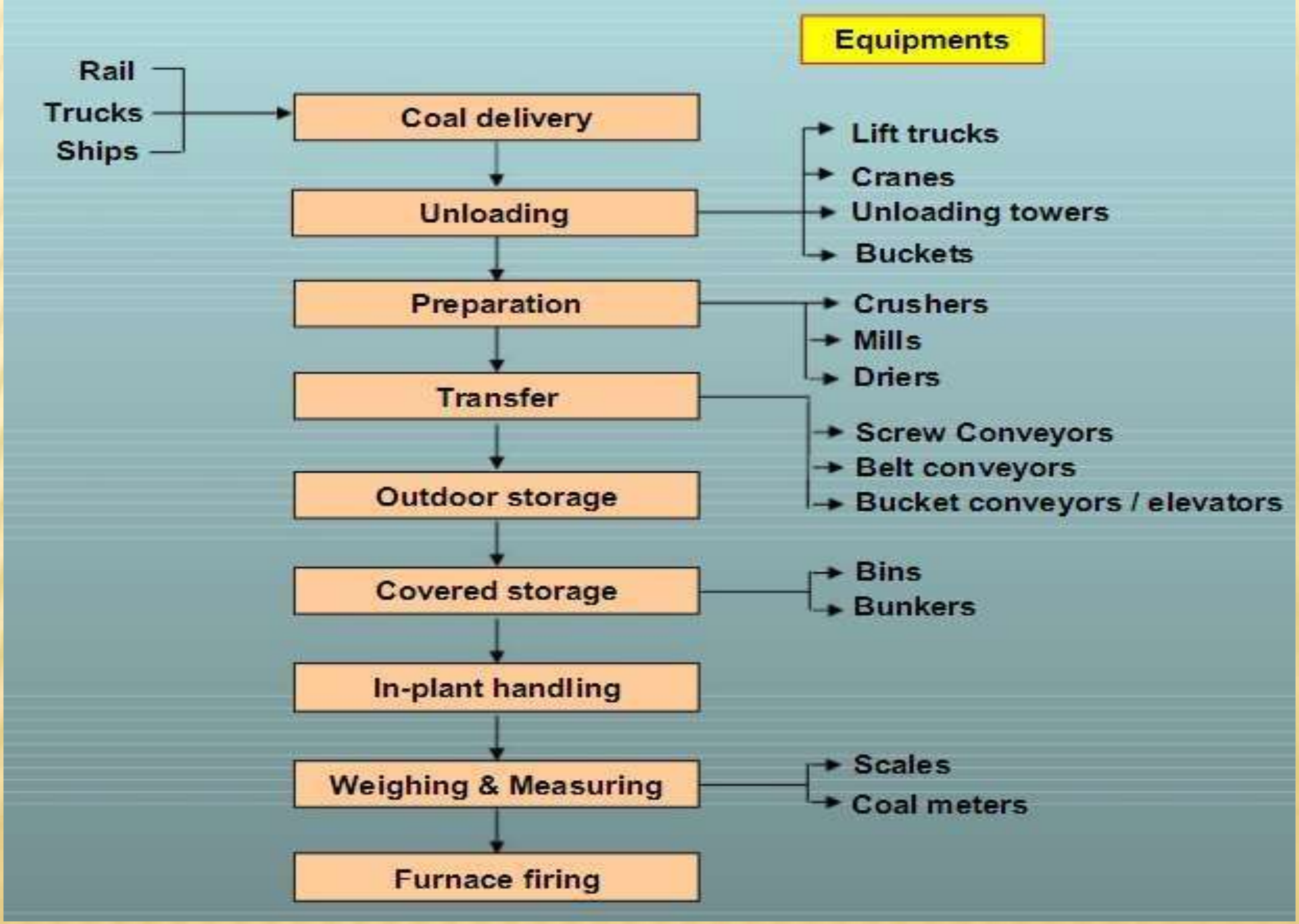
- Mechanical Handling is preferred over mannual handling.
- Advantages:

1.High raliabilty
2.Less labour
3. Economical for medium ad large capacity plants.
4. Operation is easy and smooth
5. Can be easily started
6. Management and control of plant is easy.
7.Losses in transport are reduced.

Disadvantages:

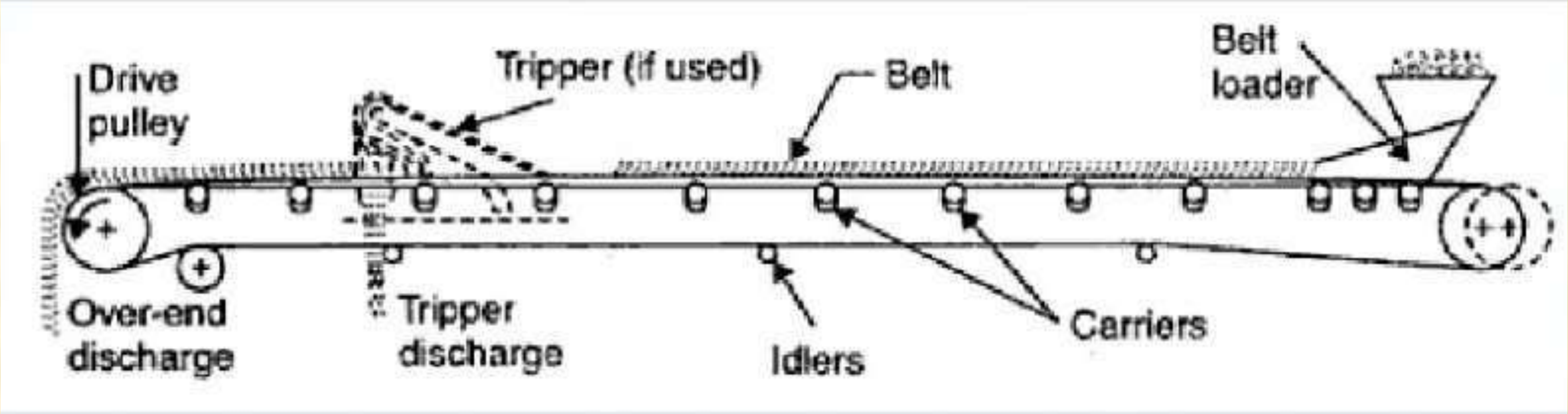
1.Needs continuous maintenance and repair.
2. Capital cost of plant is increased.
3. In mechanical handling some power generated is used.

Coal Handling

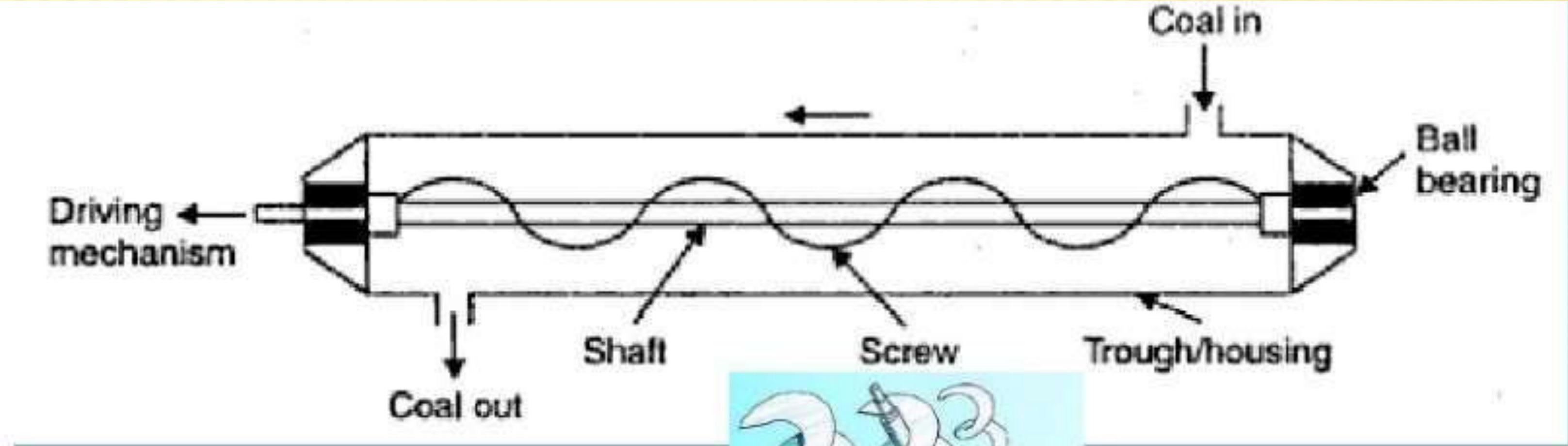


Wagon Tippler

Belt Conveyor

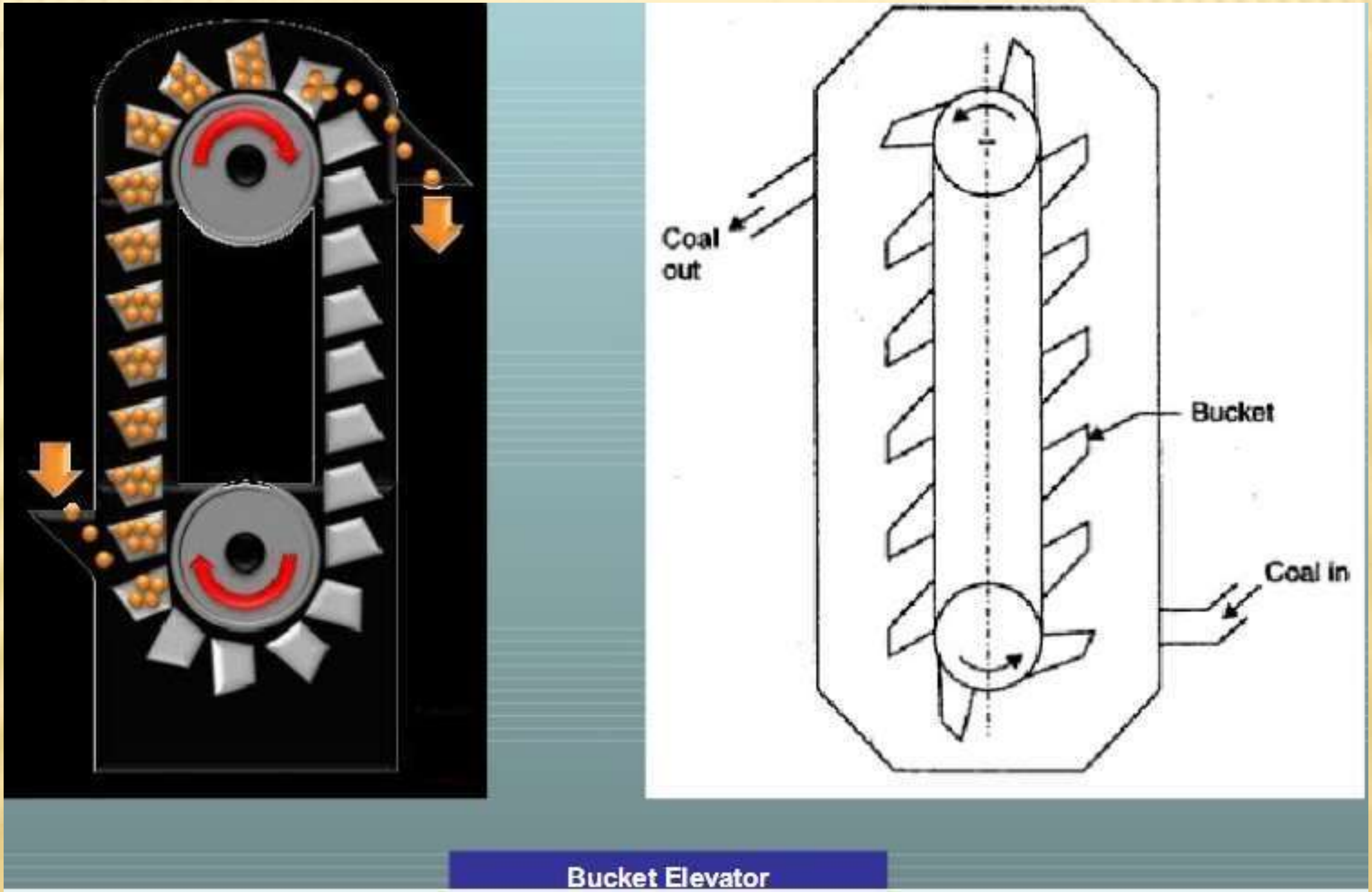


Screw Conveyor

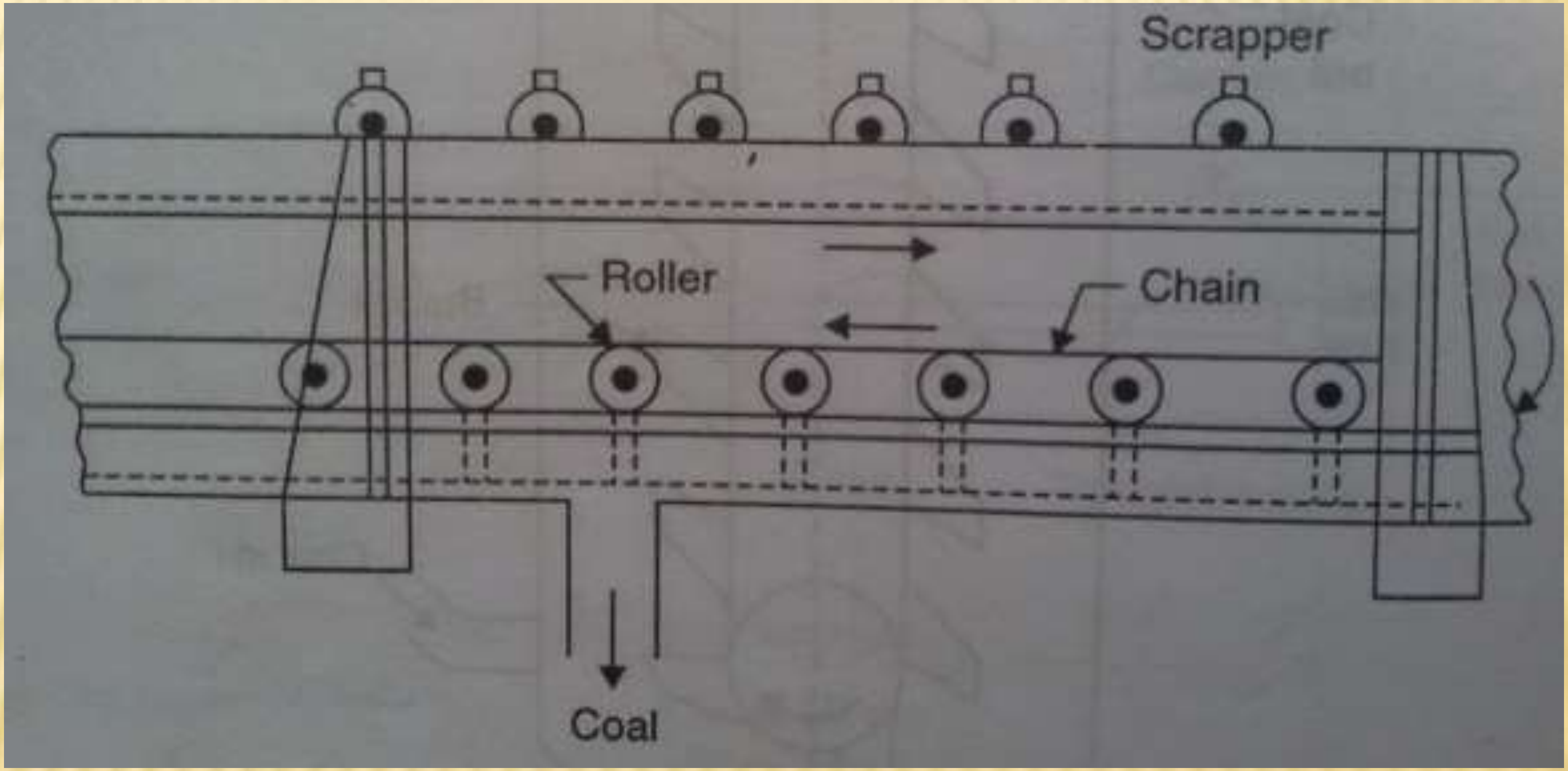


Screw Conveyor

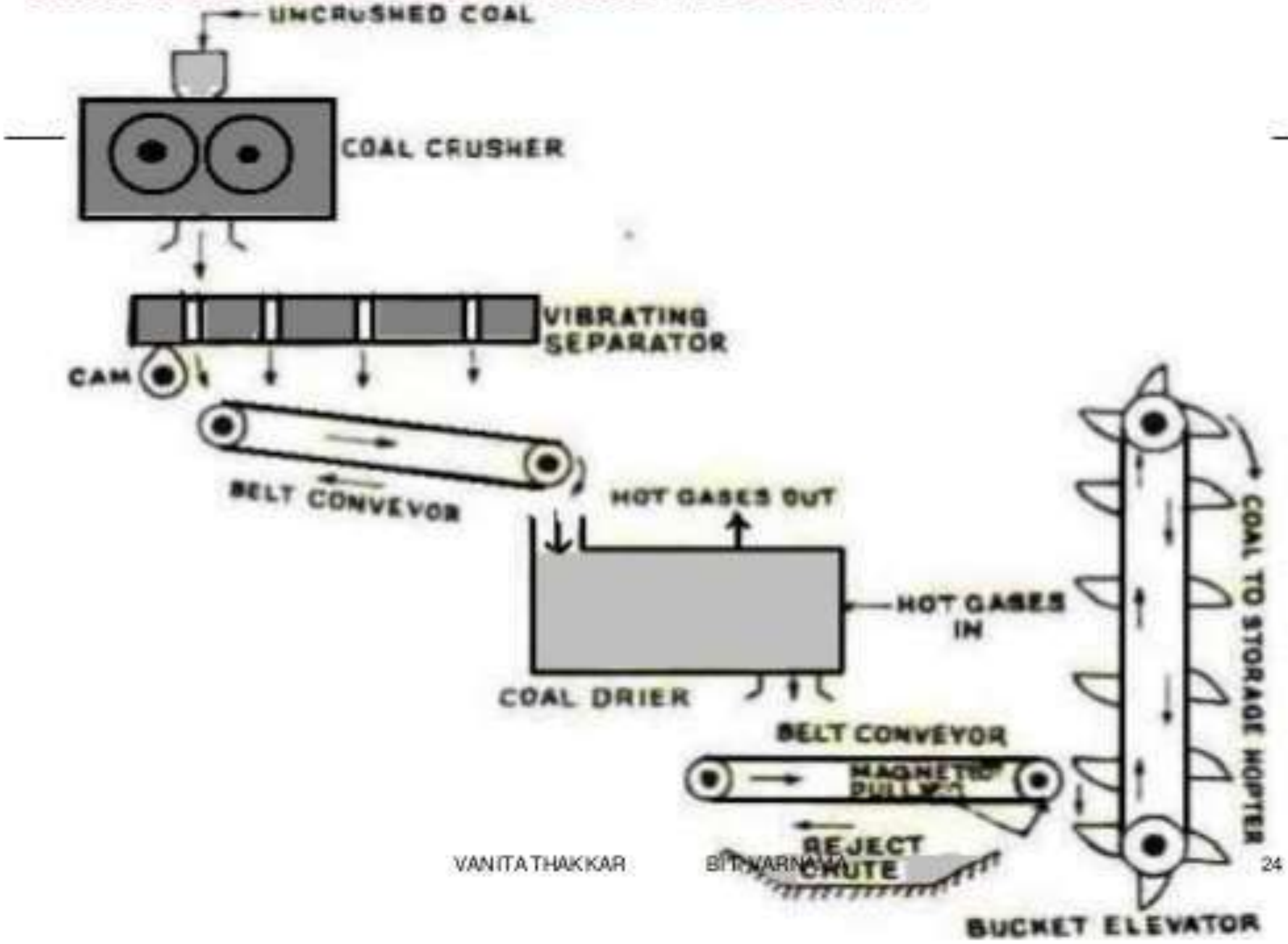
Vee Bucket



Flight Conveyor



COAL PREPARATION PLANT



Combustion equipment for burning coal

Coal burning methods are classified into two types:

- Stoker firing – used for solid coal
- Pulverized fuel firing – used for pulverized coal

Selection of one of the above methods depends upon

1. Characteristics of the coal available
2. Capacity of the plant
3. Load fluctuations
4. Efficiency / Reliability of combustion equipments.

The boiler furnaces that burn coal can be classified as follows:

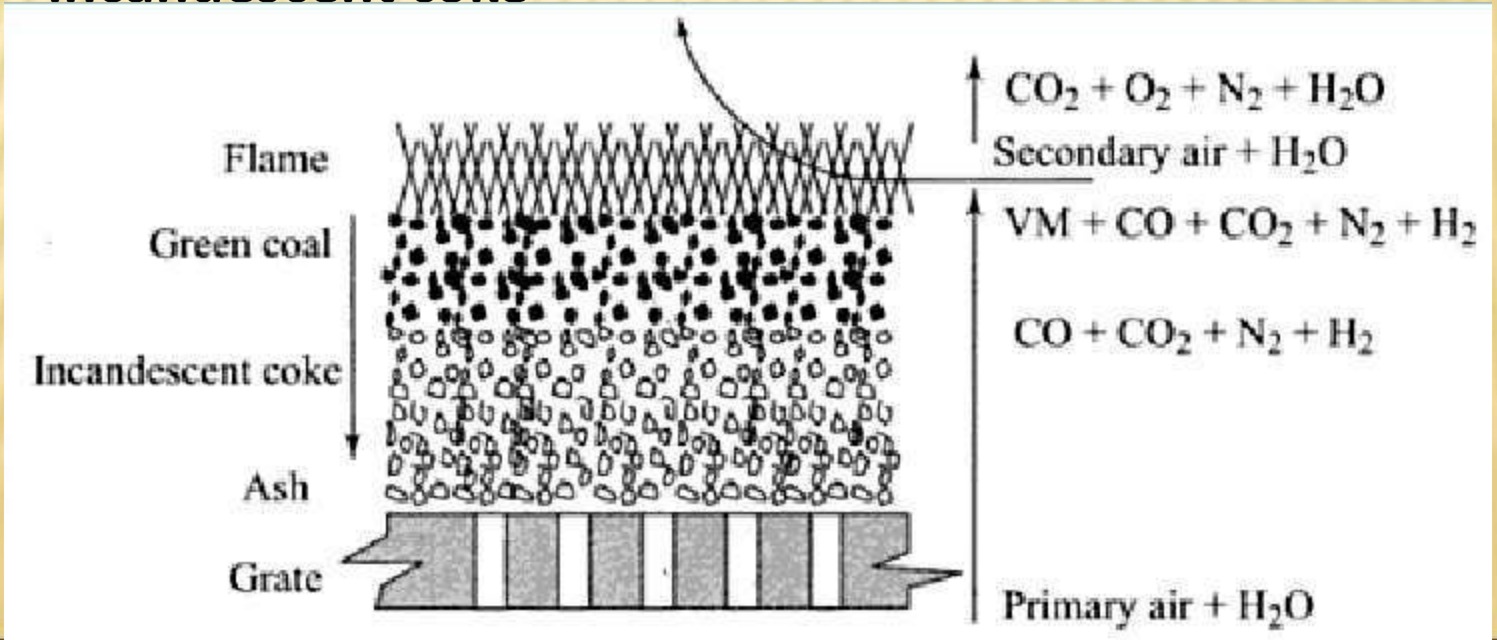
- Fuel bed furnaces (coarse particles)
- Pulverized coal furnaces (fine particles)
- Cyclone furnaces (crushed particles)
- Fluidized bed furnaces (crushed small particles)

- **Stoker firing**
- In small boilers, coal is fed manually on to a stationary grate. But in large boilers, to attain uniform operating condition, higher burning rate and better efficiency, mechanical stokers are employed.
- A stoker consists of a power operated coal feeding mechanism and grate.

•Mechanical stokers are of two types:

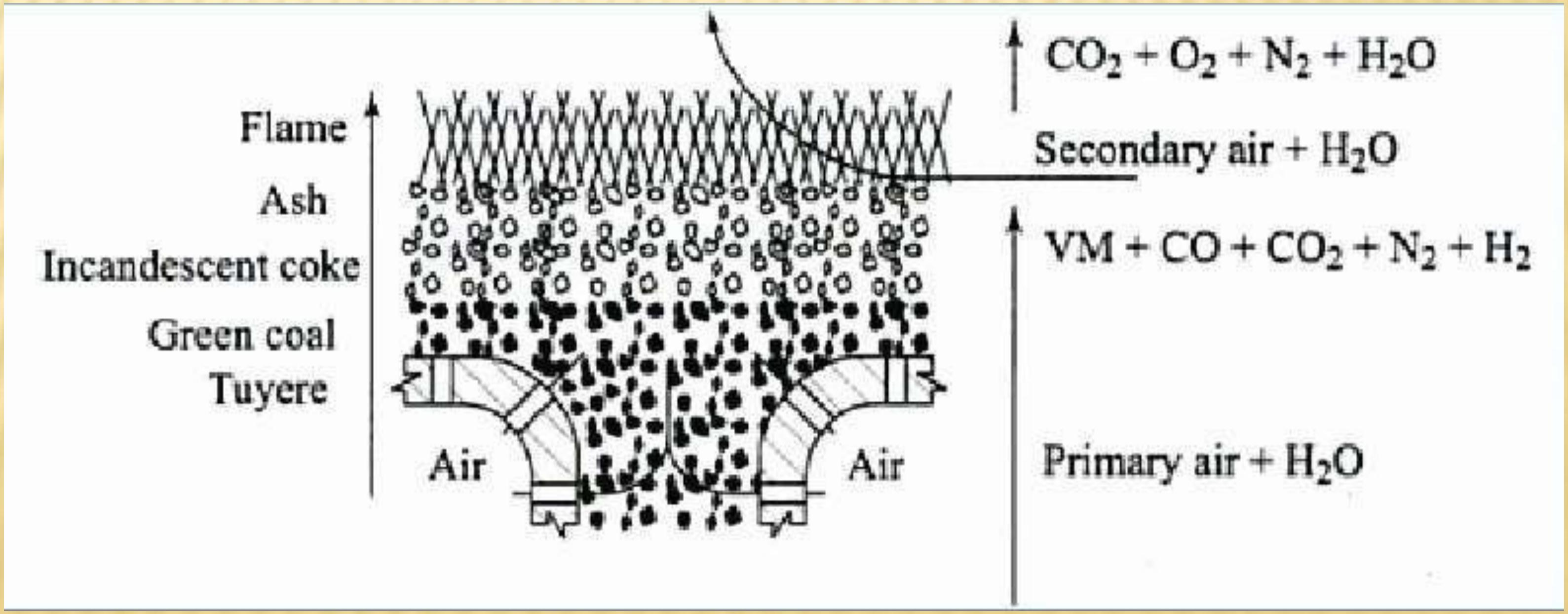
1.Overfeed stoker 2.Underfeed stoker

- **Overfeed stoker**
- **Overfeed stokers are used for large capacity boilers where coal is burnt as lumps (i.e., without pulverization). In this type of stoker, the fuel bed receives fresh coal on top surface; ignition plane lies between green coal and incandescent coke**



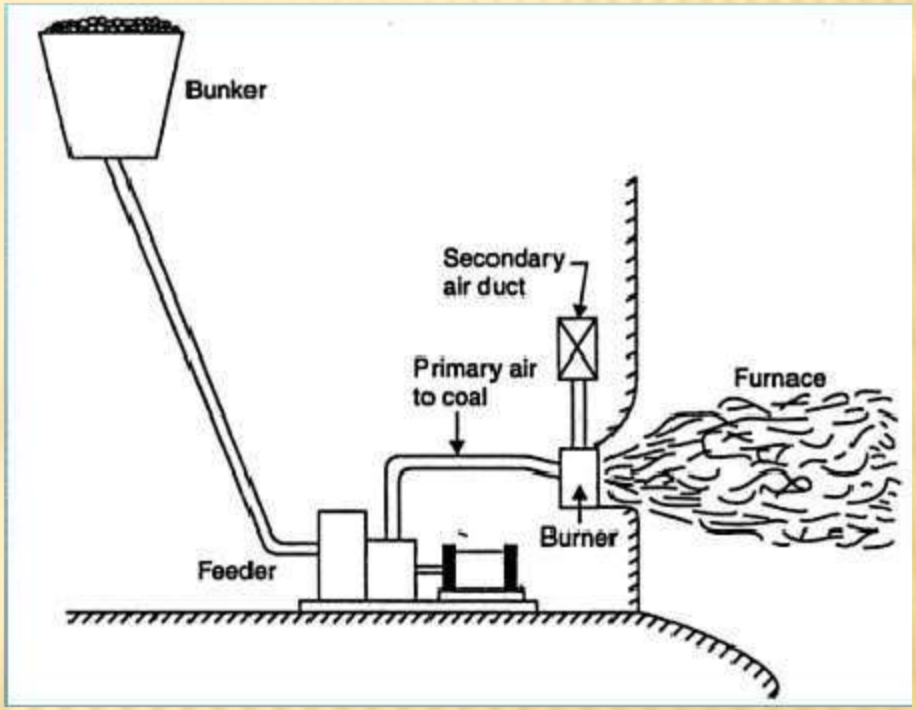
- Overfeed stoker - Processes
- In the first layer (top layer), fresh coal is added
- Second layer is the drying zone, where coal loses moisture
- Third layer is distillation zone, where coal loses volatile matter
- Fourth layer is the combustion zone, where the fixed carbon in coal is consumed.
- Fifth layer is the ash cooling zone

- **Underfeed stoker**
- **In the case of underfeed stoker, the coal is fed into the grate below the point of air admission, or air entering the stoker comes in contact with fresh coal before reaching the incandescent coke.**



Pulverized coal firing system

- In the pulverized coal firing system, the coal is reduced to a fine powder with the help of grinding mill and then admitted into the combustion chamber with the help of primary hot air.
- The primary air also helps to dry the coal before entering the combustion chamber.
- Secondary air required to complete the combustion process is supplied separately to the combustion chamber.
- The resulting turbulence in the combustion chamber helps in uniform mixing of fuel and air and good combustion.
- Elements of a pulverized coal firing system



Pulverized coal

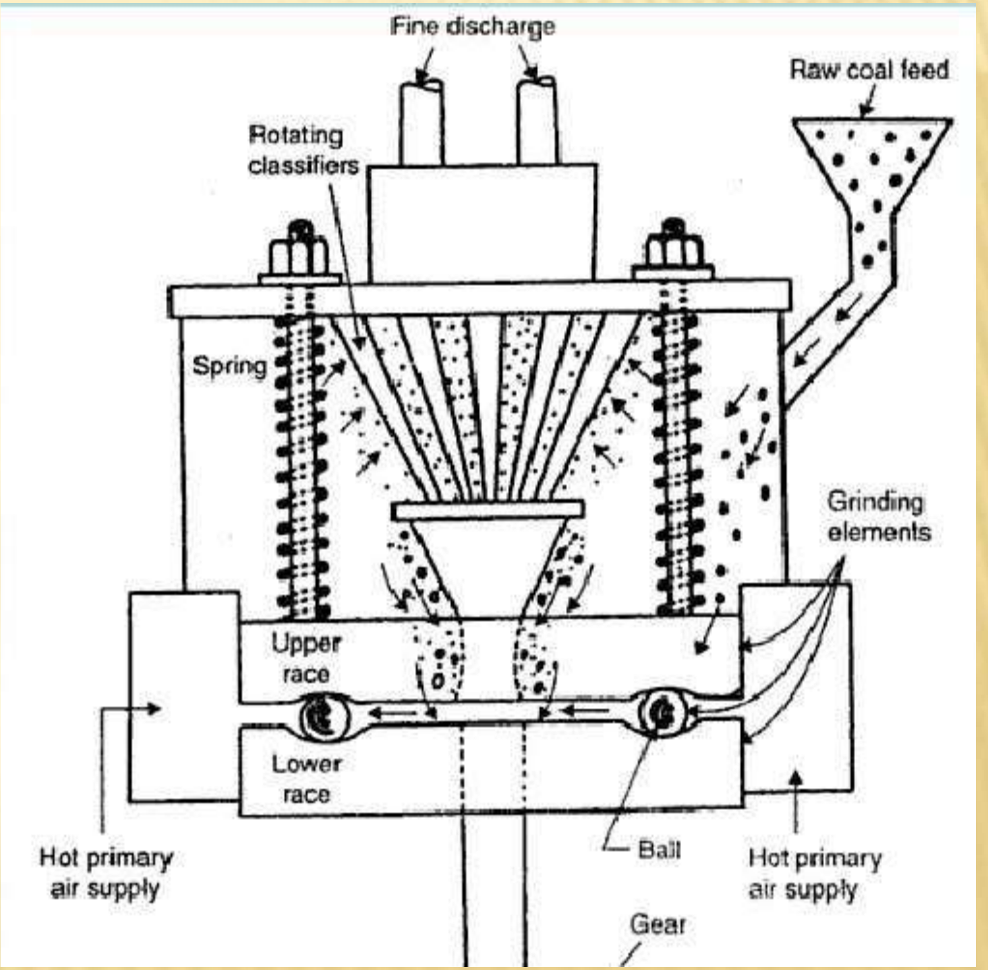
- Coal is pulverized (powdered) to increase its surface area (and therefore exposure) thus permitting rapid combustion.
- The pulverized coal is obtained by grinding the raw coal in pulverizing mills. Various types of pulverizing mills are:
- Ball mill
- Ball and race mill
- Hammer mill
- Bowl mill

Essential functions of pulverizing mills are:

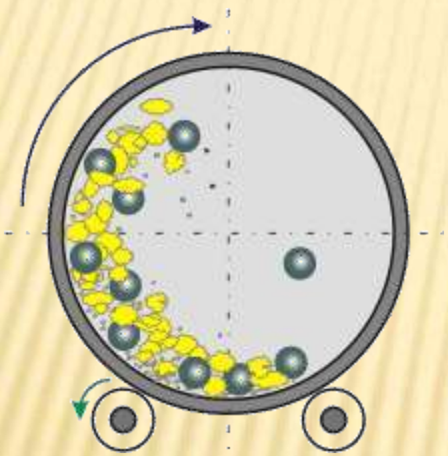
- Drying of the coal
- Grinding
- Separation of particles of a desired size.
- Coal pulverizing mills reduce coal to powder by any (or all) action such as
- Impact, Abrasion and Crushing

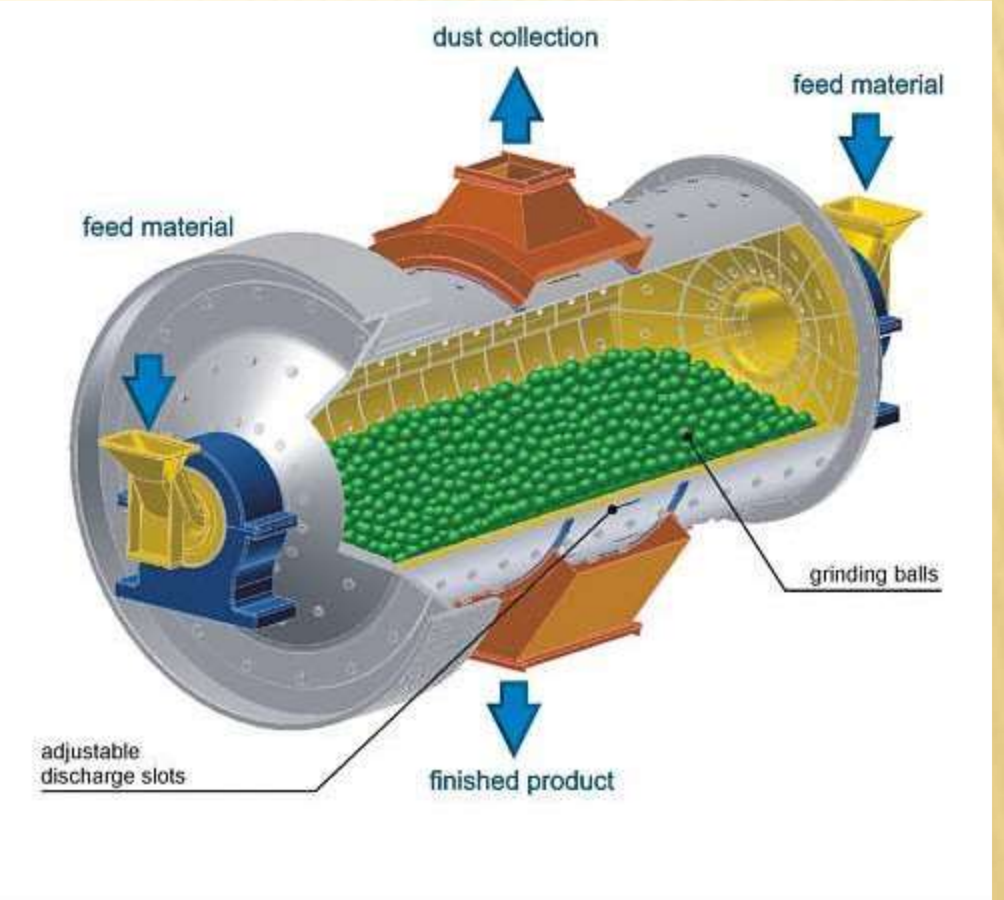
Ball and race mill for pulverizing coal

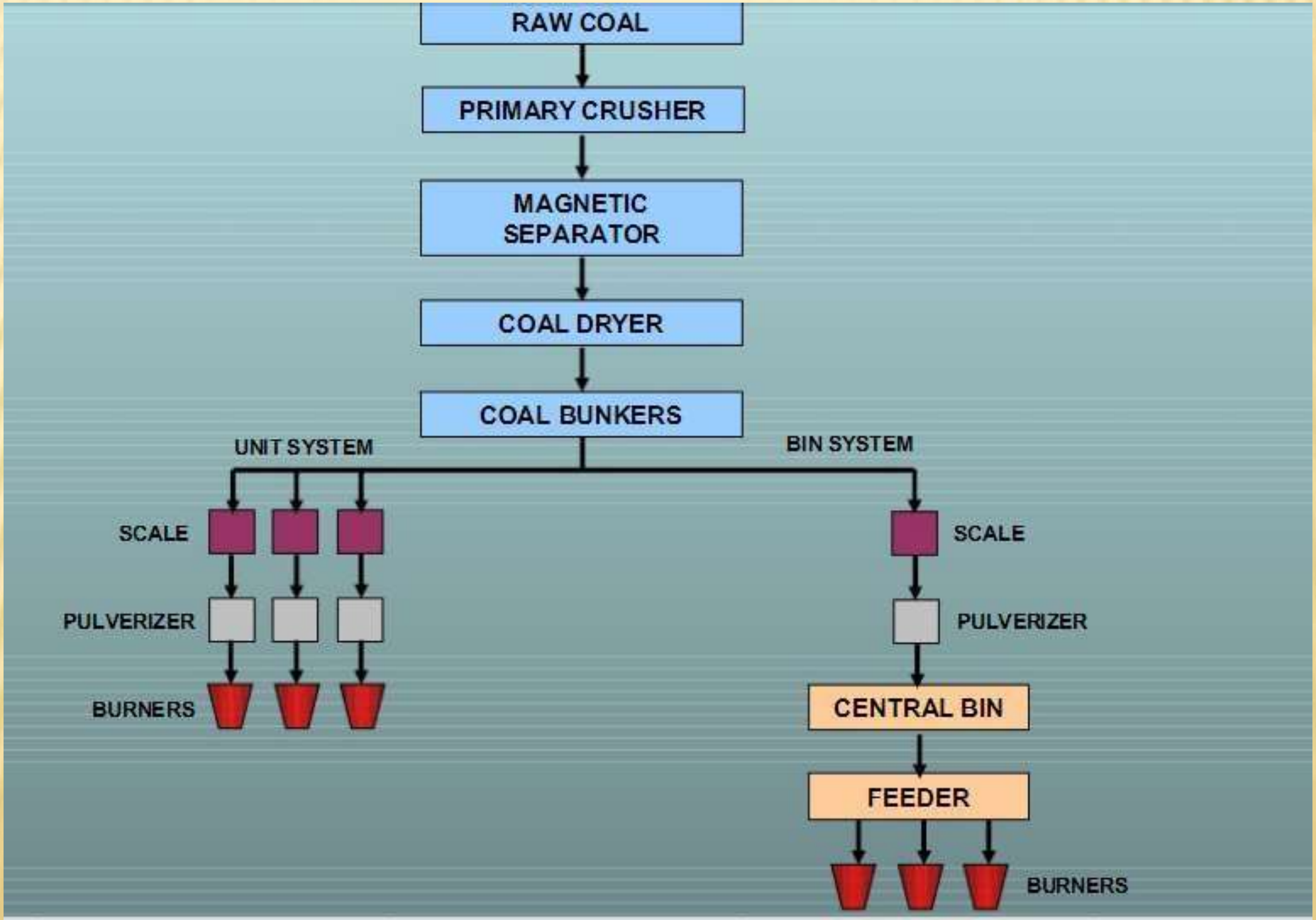
- This is a low speed unit in which grinding pressure is maintained by adjustable springs.
- The coal passes between the two rotating elements again and again until it has been pulverized to desired degree of fineness.



Ball Mill

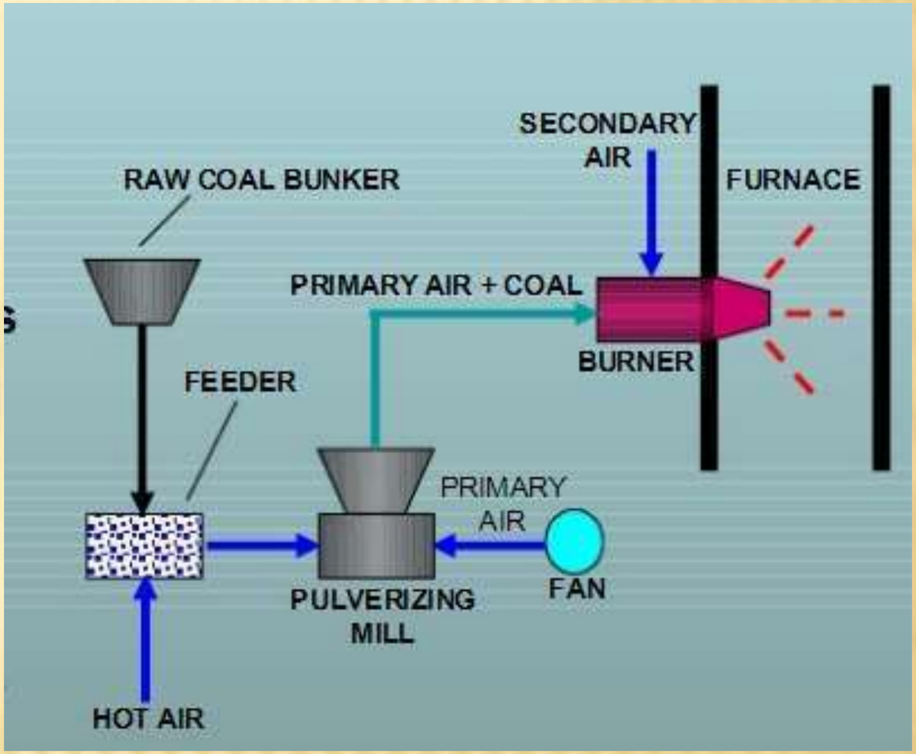



dust collection
feed material
feed material
grinding balls
adjustable
discharge slots
finished product


RAW COAL
PRIMARY CRUSHER
MAGNETIC SEPARATOR
COAL DRYER
COAL BUNKERS
UNIT SYSTEM
BIN SYSTEM
SCALE
PULVERIZER
BURNERS
SCALE
PULVERIZER
CENTRAL BIN
FEEDER
BURNERS

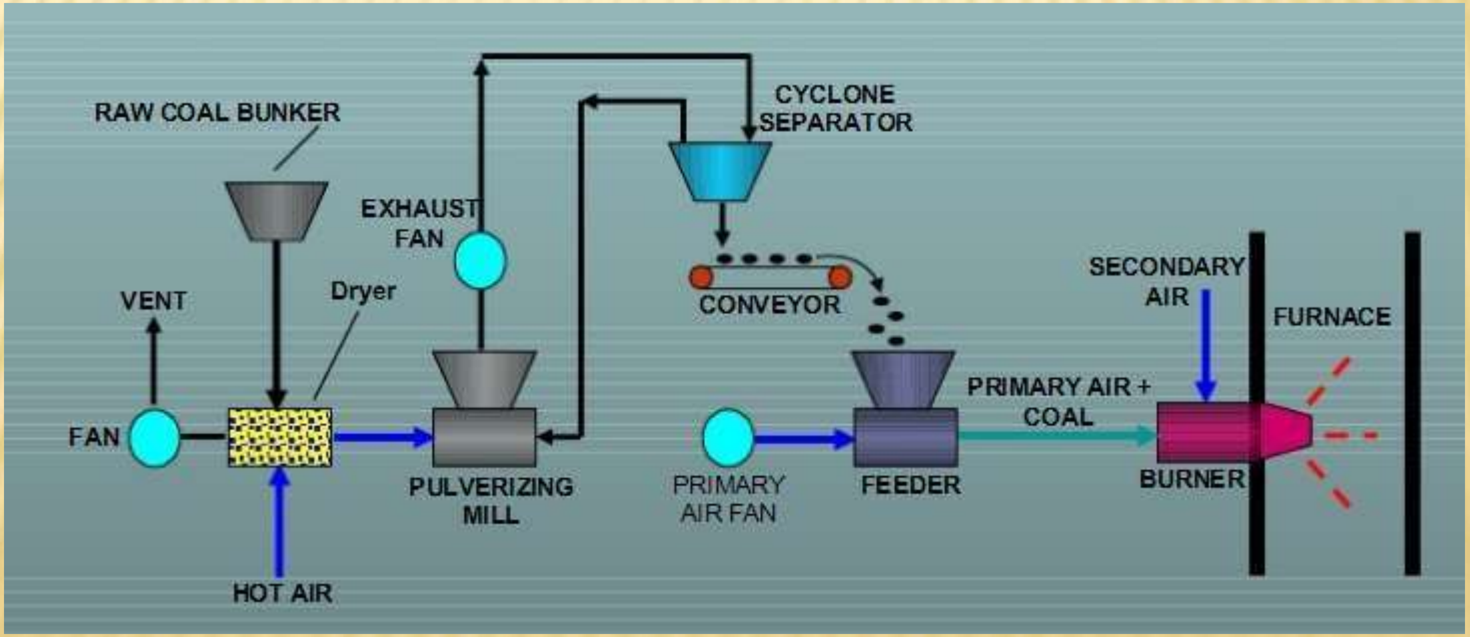
Basically, pulverized fuel plants may be divided into two systems based on the method used for firing the coal:

- Unit System or Direct System
- Bin System or Central System
- Unit or Direct System: This system works as follows:
- Coal from bunker drops on to the feeder.
- Coal is dried in the feeder by passage of hot air.
- The coal then moves to a mill for pulverizing.
- A fan supplies primary air to the pulverizing mill.
- Pulverized coal and primary air are mixed and sent to a burner where secondary air is added.



• Bin or Central System:

- Coal from bunker is fed by gravity to a dryer where hot air is admitted to dry the coal.
- Dry coal is then transferred to the pulverizing mill.
- Pulverized coal then moves to a cyclone separator where transporting air is separated from coal.
- Primary air is mixed with coal at the feeder and supplied to the burner.
- Secondary air is supplied separately to complete the combustion



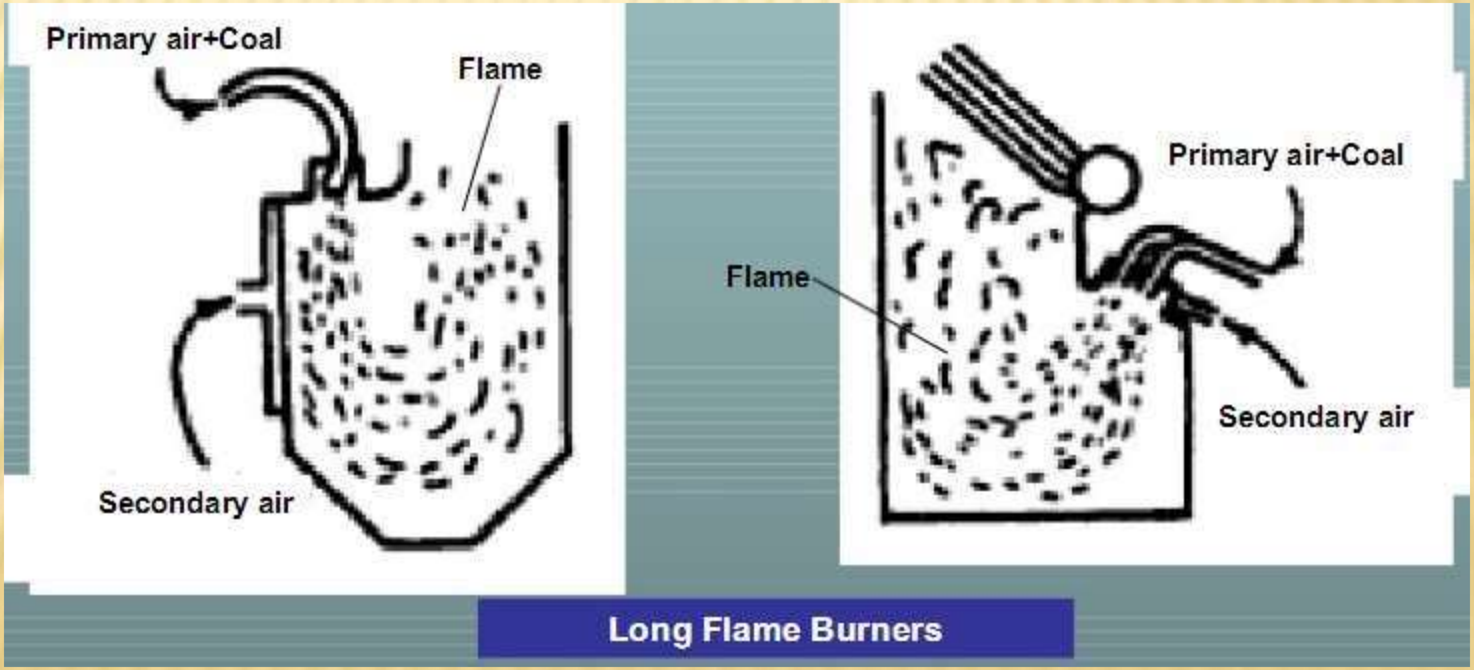
Advantages of Pulverized coal firing system

- Any grade of coal can be used because coal is powdered before use.
- Rate of feed of fuel can be easily regulated – better fuel economy.
- Since there is almost complete combustion of fuel, there is increased rate of evaporation and hence better boiler efficiency.
- Greater capacity to meet peak load.
- System is free from sagging and clinkering troubles associated with lump coal.
- Practically no ash handling problems.
- No moving parts within the furnace that is subjected to high temperatures.
- This system works successfully in combination with gas and oil.
- Requires much less air compared to stoker firing
- Furnace volume is considerably small.

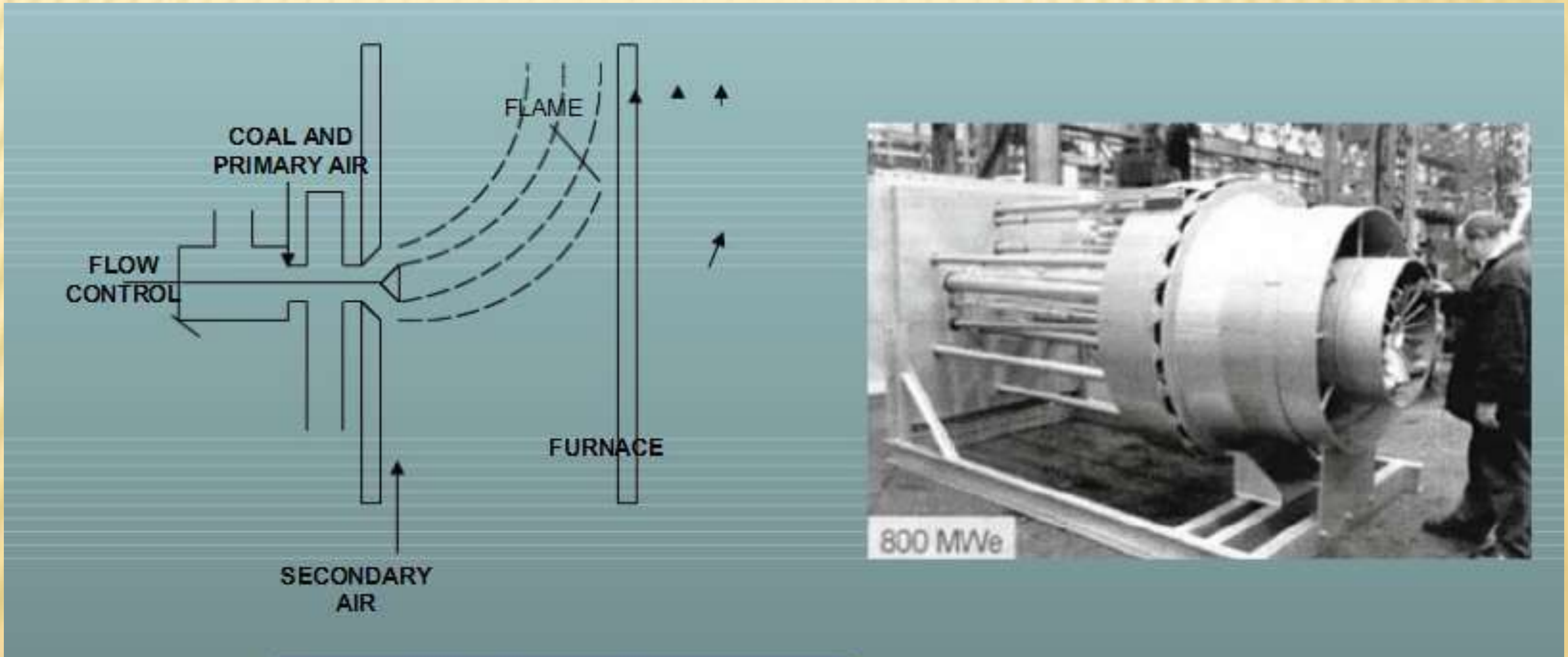
Disadvantages of Pulverized coal firing system

- **High capital cost.**
- **Lot of fly-ash in the exhaust – removal of fine dust is expensive.**
- **Possibility of explosion is high because pulverized coal burns like gas.**
- M**aintenance of furnace brickwork is costly because of high temperatures.**
- **Special equipment's required to start the system.**
- **Skilled operators are required.**
- **Separate coal preparation plant is necessary.**
- **Periodic maintenance of pulverized coal dispensing system is needed.**

- **Types of Burners for Pulverized Coal**
- **Various types of burners are used for combustion of pulverized coal.**
- **Long Flame (U-Flame) Burner: In this burner, air and coal mixture travels a considerable distance thus providing sufficient time for complete combustion**

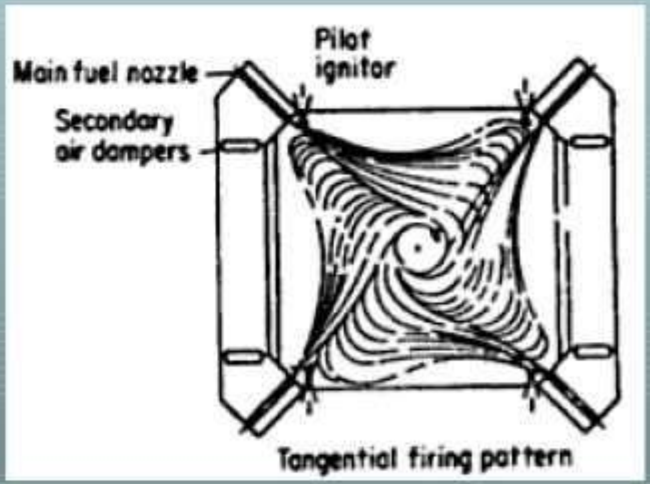


- **Types of Burners for Pulverized Coal**
- **Short Flame (Turbulent) Burner: The burner is fitted in the furnace wall and the flame enters the furnace horizontally with great turbulence**

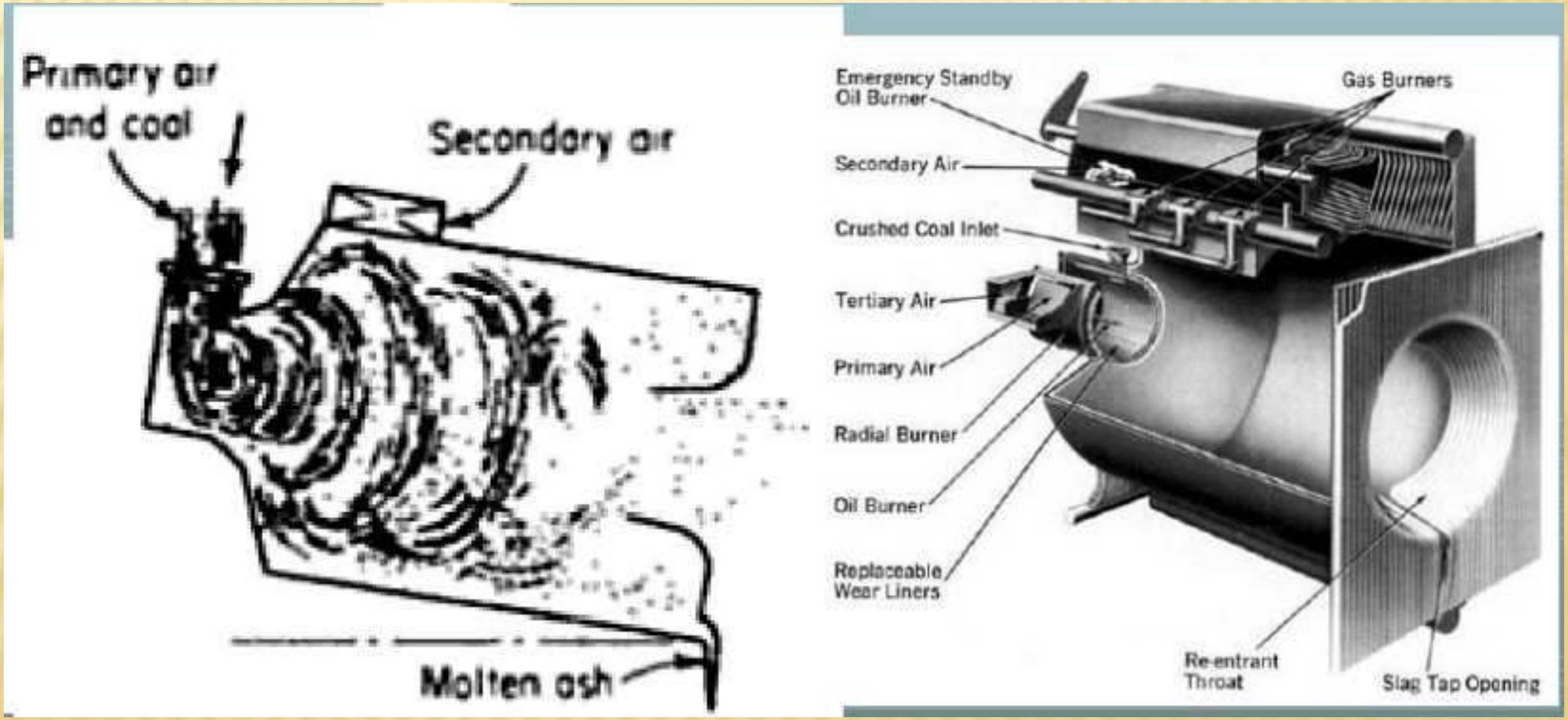


Short Flame Burner

- **Tangential Burner: In this system, one burner is attached at each corner of the furnace. The inclination of the burners is so made that the flame produced is tangential to an imaginary circle at the centre.**



- **Cyclone Burner: In this system, the cyclonic action whirls coal and air against the wall of the furnace to facilitate thorough mixing of coal and air. Advantage of this burner is that it can also use crushed coal in addition to pulverized coal thus providing an option. When crushed coal is used, ash is collected in molten form for easy disposal.**



Ash Handling

- Large power plants produce a huge quantity of ash, sometimes as much as 10 to 20% of the coal burnt per day. Therefore, mechanical devices are used for effective collection and disposal of ash.

Ash handling includes:

- Removal of ash from furnace
- Loading to conveyors and delivery to fill or dump from where it can be disposed off.
- Handling of ash is a problem because it is too hot when it comes out of furnace, dusty and sometimes poisonous and corrosive . Ash needs to be quenched before handling due to following reasons:
- Quenching reduces corrosive action of ash
- It reduces the dust accompanying the ash
- It reduces the temperature of ash
- Fused clinkers will disintegrate making it easier to handle

Ash Handling Equipment

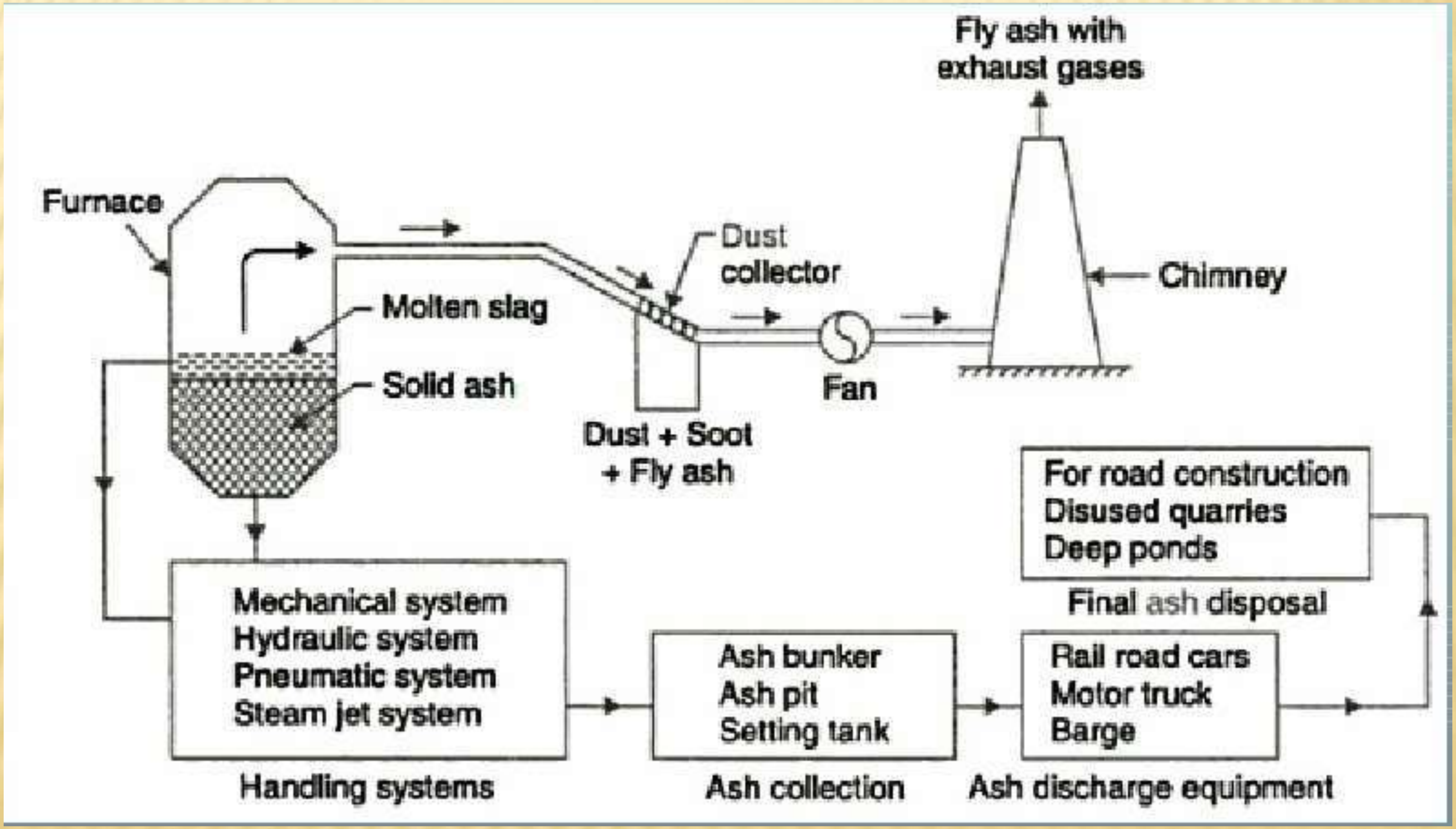
- **A good ash handling equipment should have the following characteristics:**
- **It should have enough capacity to cope with the volume of ash that may be produced in a station.**
- **It should be able to handle large clinkers, boiler refuse, soot etc., with little attention from workers.**
- **It should be able to handle hot and wet ash effectively and with good speed.**
- **It should be possible to minimize the corrosive or abrasive action of ash.**
- **Operation of the plant should be easy, economical, simple and noiseless.**
- **It should be able to operate effectively under all variable load conditions.**
- **It should also remove fly ash and smoke to control air pollution.**

Ash Handling Equipment

The commonly used equipment for ash handling in large and medium size plants may comprise of:

- **Bucket elevator**
- **Bucket conveyor**
- **Belt conveyor**
- **Pneumatic conveyor**
- **Hydraulic sluicing equipment**
- **Trollies and Rail cars etc.** These are mainly classified into:

- **Mechanical handling systems**
- **Hydraulic systems**
- **Pneumatic systems**
- **Steam jet systems**


Fly ash with
exhaust gases
Furnace
Dust
collector
Chimney
Molten slag
Solid ash
Fan
Dust + Soot
+ Fly ash
For road construction
Disused quarries
Deep ponds
Final ash disposal
Mechanical system
Hydraulic system
Pneumatic system
Steam jet system
Ash bunker
Ash pit
Setting tank
Rail road cars
Motor truck
Barge
Handling systems
Ash collection
Ash discharge equipment

Mechanical

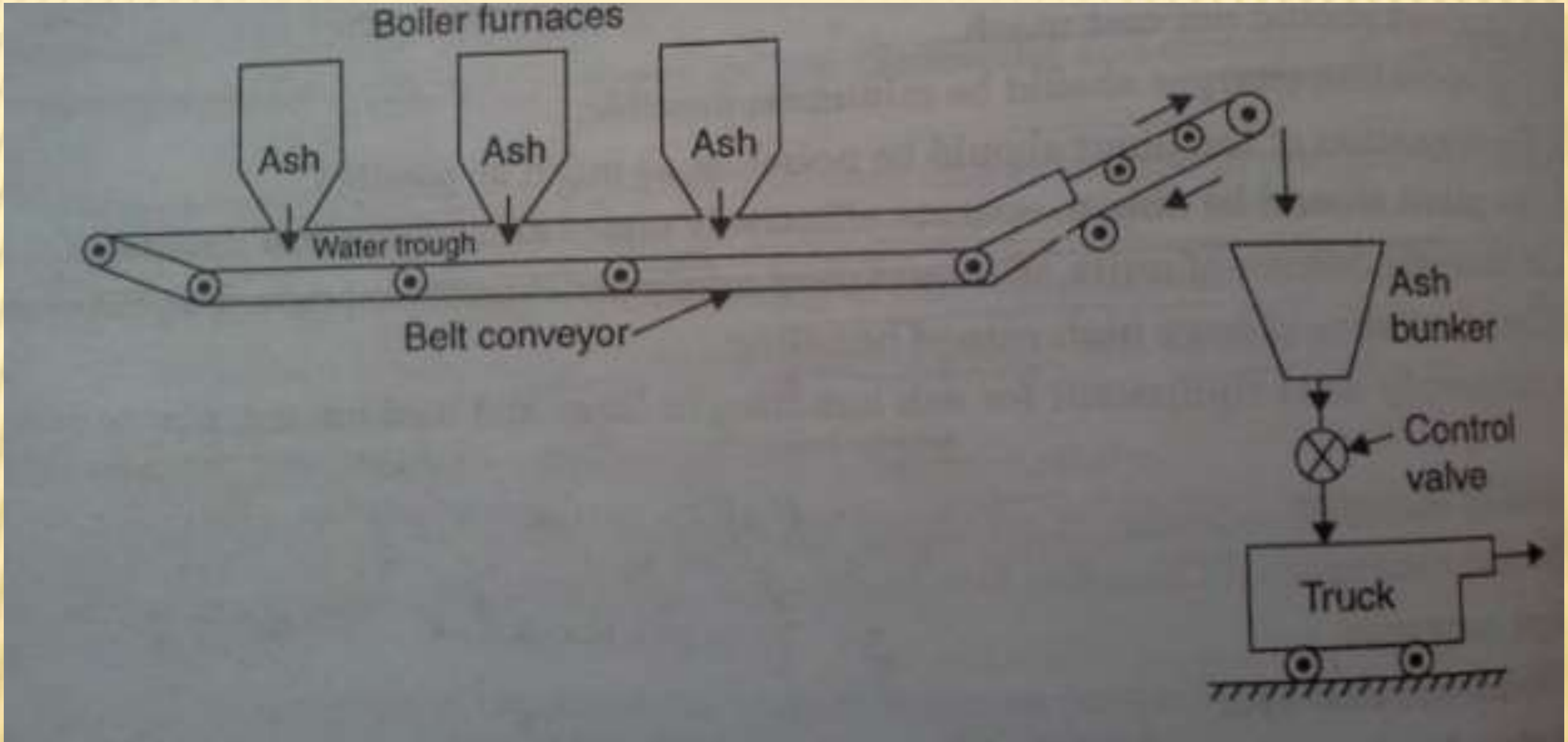
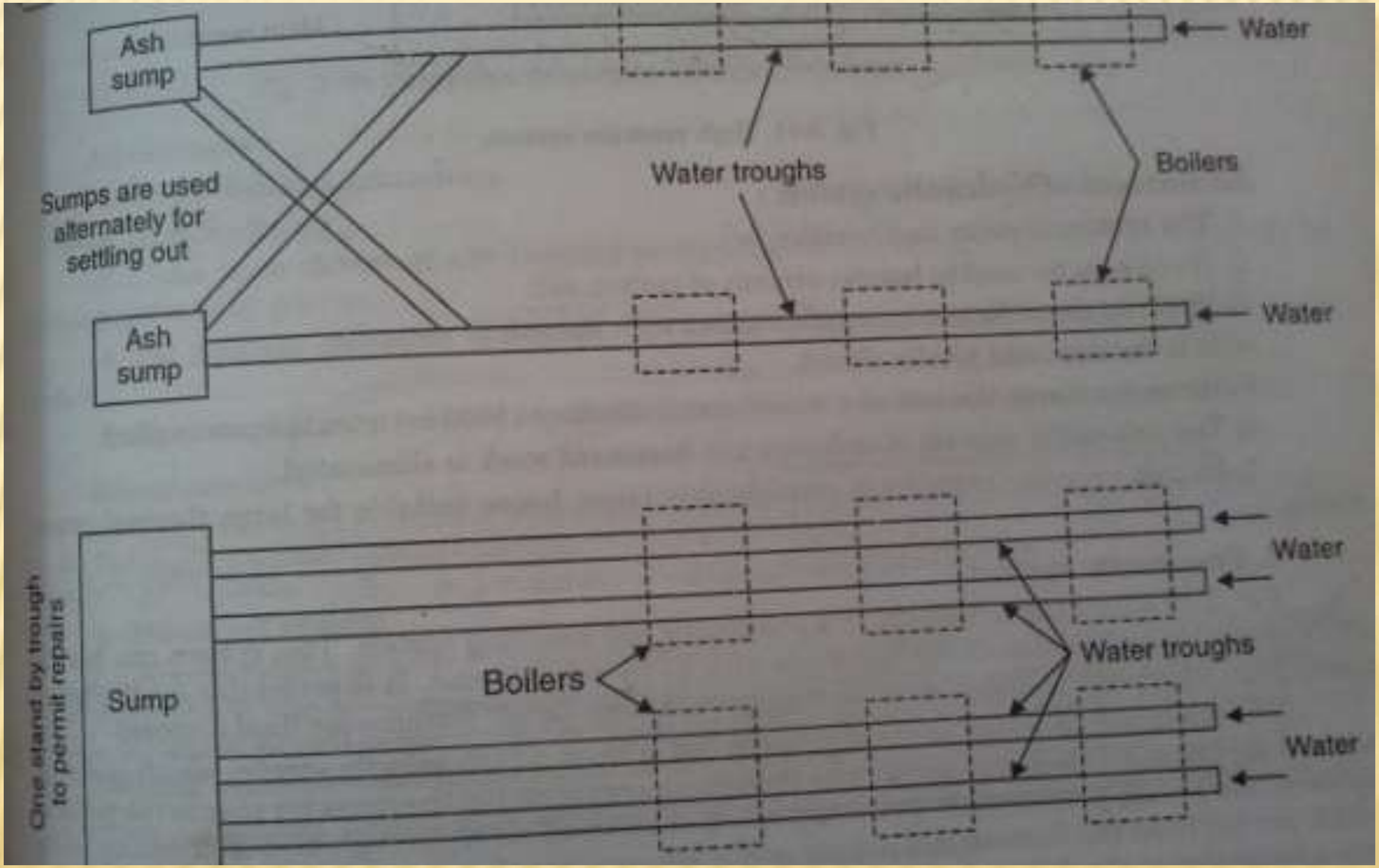


Fig. 3.39. Mechanical handling system.

Hydraulic System

- In this system ash is carried with the flow of water with high velocity. Through a channel and finally dumped in the sump.
- Low Pressure system
- High Pressure system

Low Pressure



High Pressure System

- The hoppers below boiler are fitted with water nozzles at the top and on the sides. The top nozzle quenches the ash while the side ones provide he driving force for ash. The cooled ash is carried to the sump through the trough/drain. The water is again separated and recirculated.

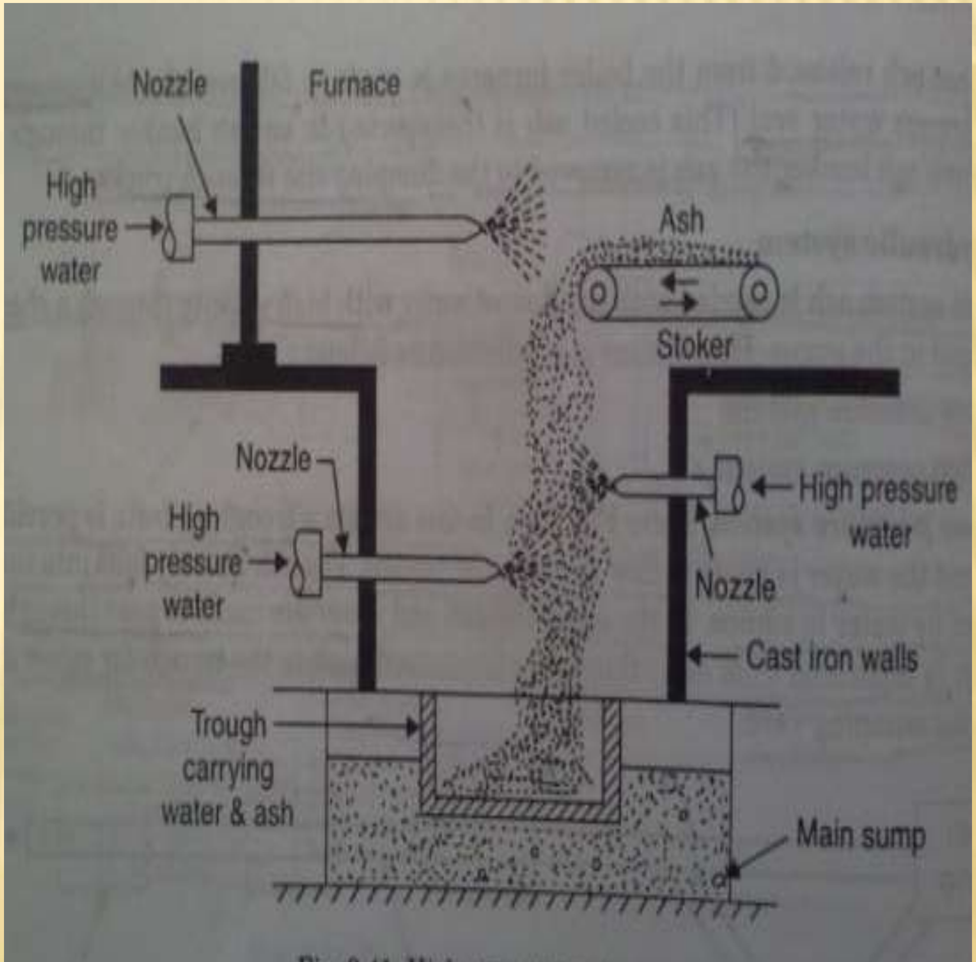


Fig. 3.41. High pressure system.

Advantages

- The system is clean and healthy
- Working parts don’t come in contact with ash
- It is dustless and totally closed.
- It can discharge the ash at a considerable distance (1000m) from the power plant.
- Ash carrying capacity is generally large hence suited for large thermal plants.

Pneumatic System

- This system can handle abrasive as well as fine dusty materials like fly ash and soot.

1. Separator: Works on the cyclone principle removes dust and ash which pass out into the ash hopper at the bottom while clean air is discharged from top.
2. Exhauster: may be mechanical or may use steam jet or water jet for its operation. It creates a high velocity stream which picks up ash and dust from all discharge points and then these are carried to delivery end.

Pneumatic System

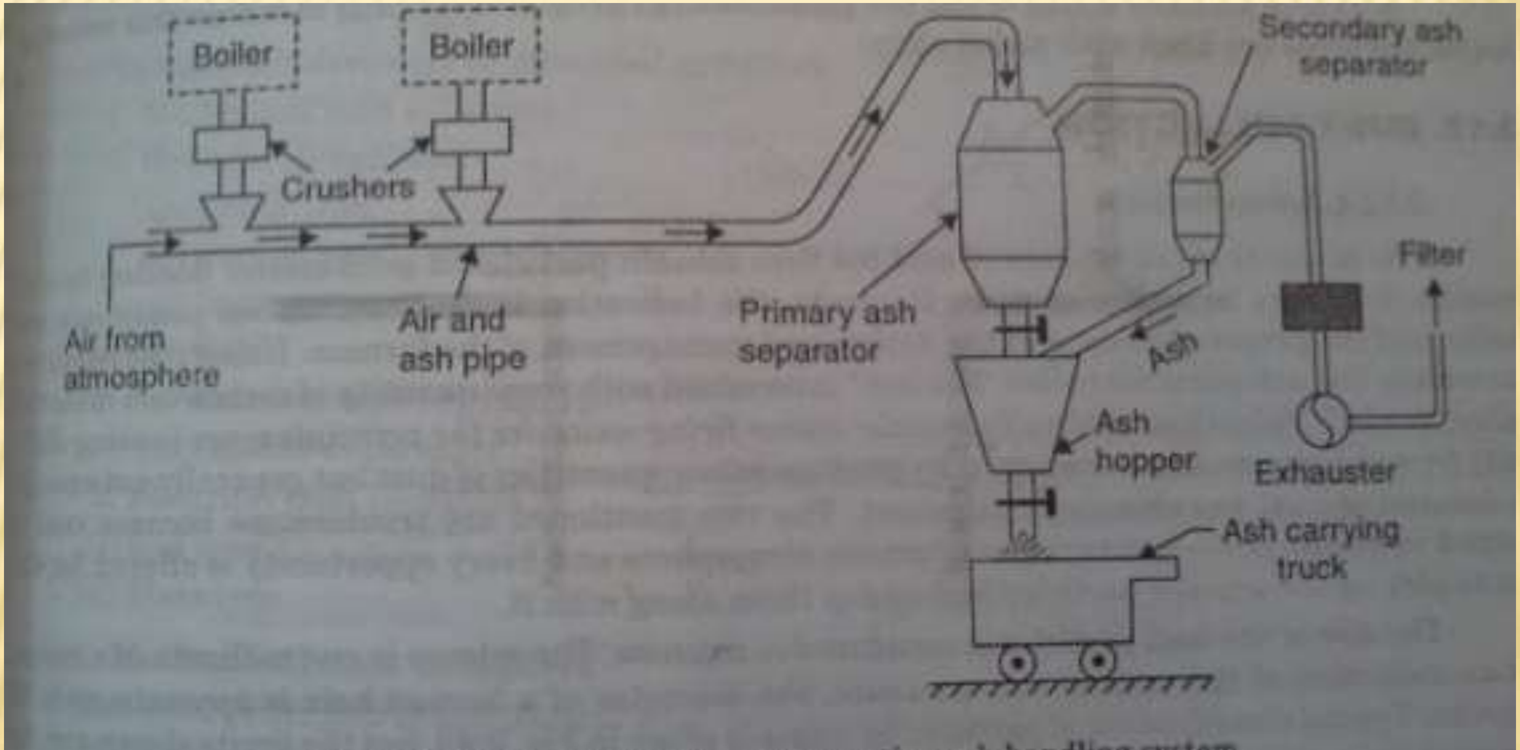
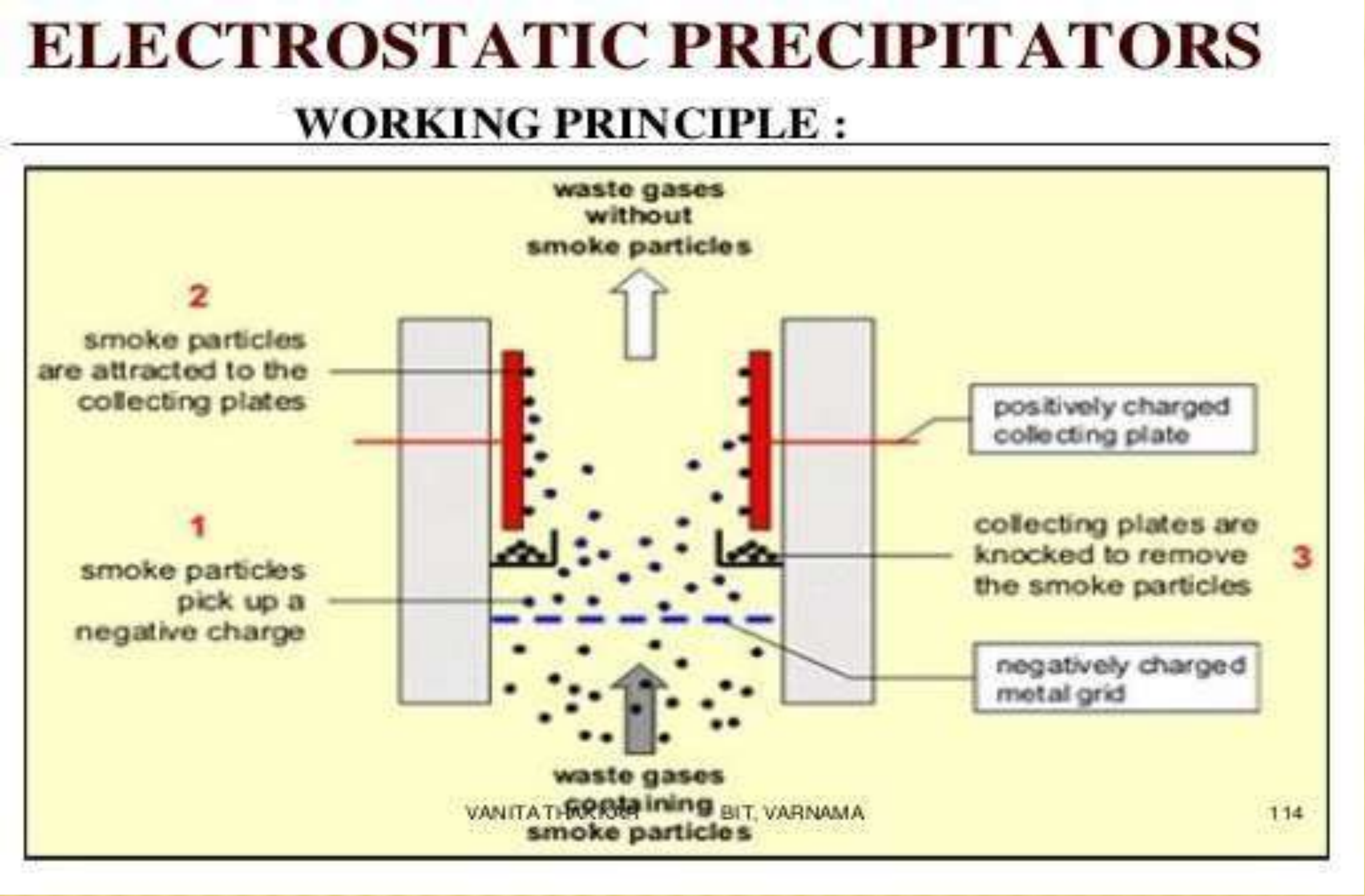


Fig. 3.42. Pneumatic or vacuum extraction ash handling system.

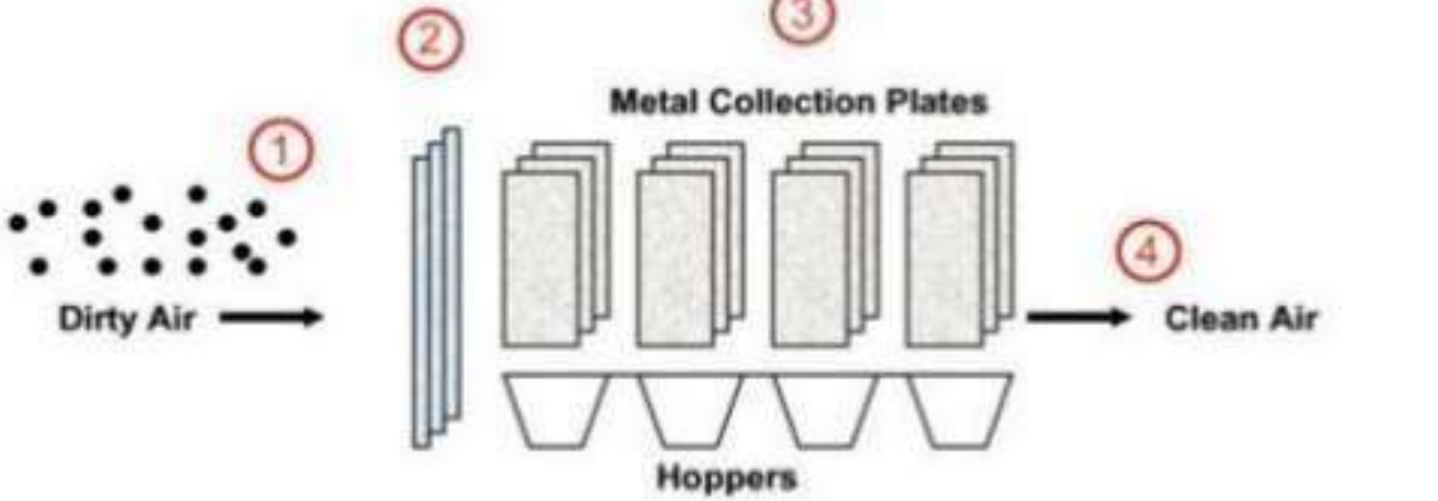
Steam Jet System

- In this steam at sufficiently high velocity is passed through a pipe and dry solid materials of considerable size are carried along with it.
- It is passed in direction of ash travel through conveyer pipe in which ash from boiler ash hopper is fed. Ash is deposited in the ash hopper.

Dust


ELECTROSTATIC PRECIPITATORS
WORKING PRINCIPLE :
waste gases without smoke particles
2
smoke particles are attracted to the collecting plates
positively charged collecting plate
1
smoke particles pick up a negative charge
collecting plates are knocked to remove the smoke particles
3
negatively charged metal grid
waste gases containing smoke particles
BIT, VARNAMA
114

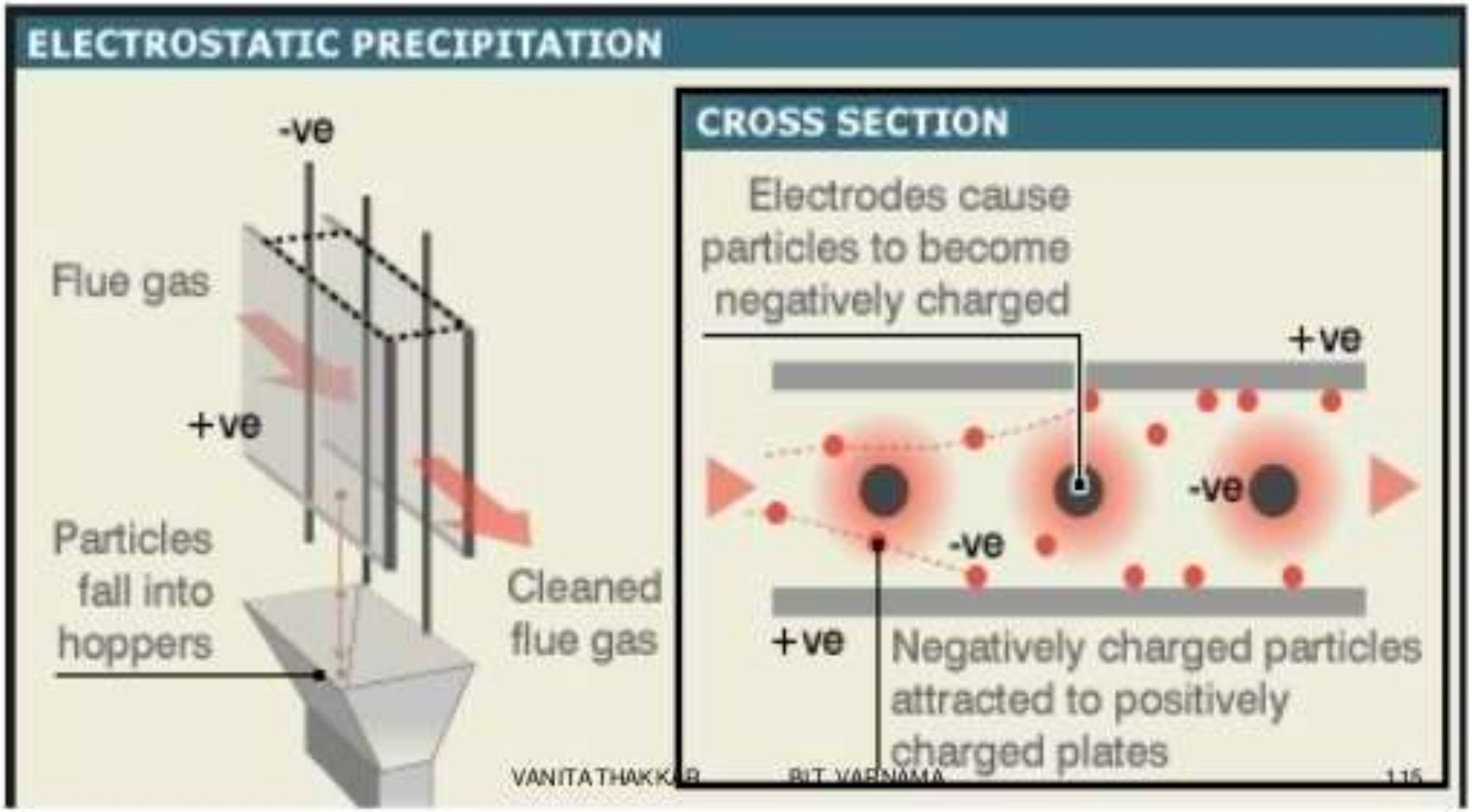
WORKING PRINCIPLE (contd.):

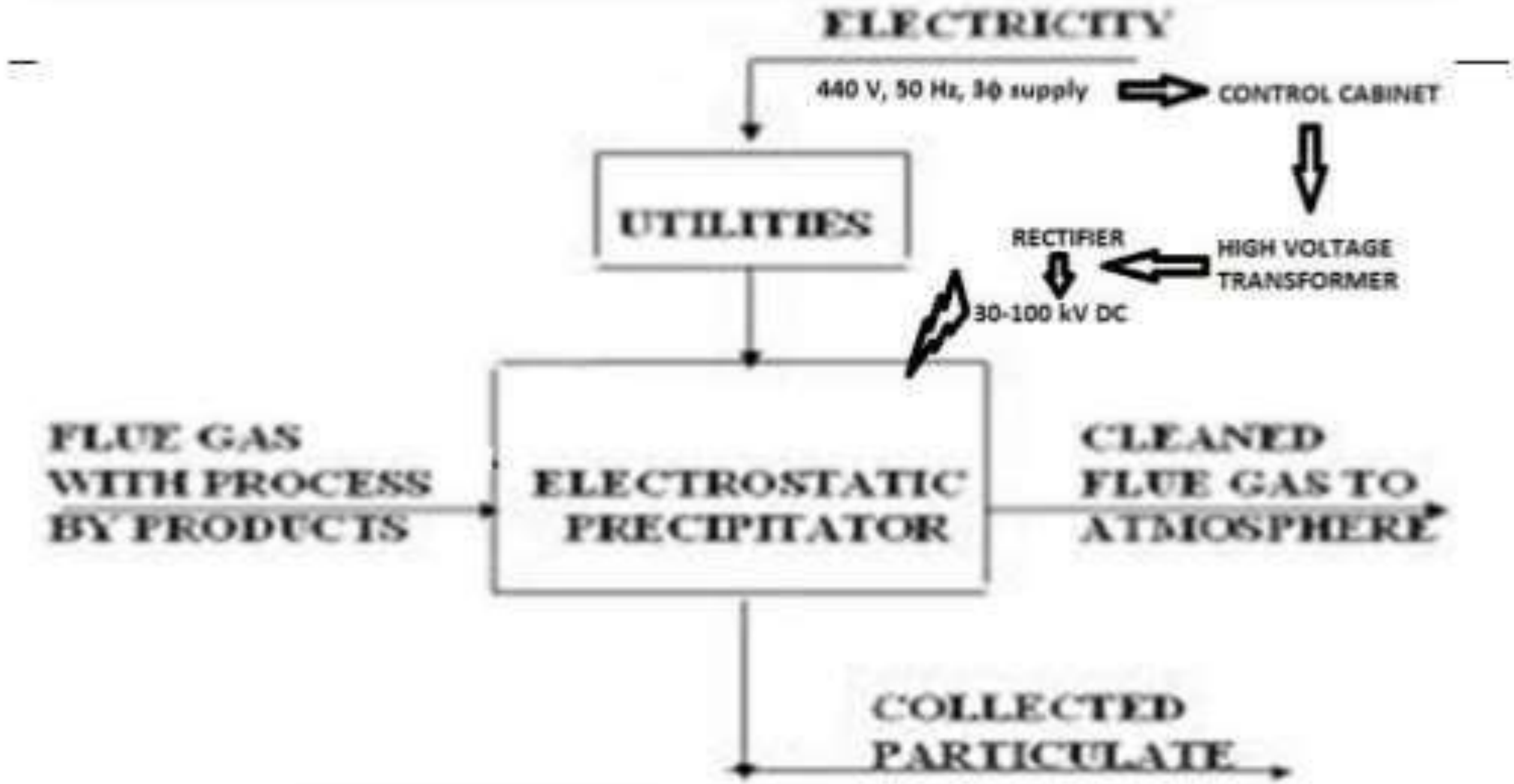


1. Dirty (polluted) air from the factory enters the electrostatic precipitator.
2. The dirty air passes by negatively-charged plates, which give the pollution particles a negative charge.
3. The negatively-charged pollutant particles are attracted to the positively-charged metal collection plates. Periodically, the plates are discharged and the pollution particles fall into the hoppers.
4. Clean air is released from the electrostatic precipitator system.

ELECTROSTATIC PRECIPITATORS

WORKING PRINCIPLE (contd.):





SCHEMATIC DIAGRAM OF ESP :

Typical input and output for a 500 MW boiler

- 225 tons/hr coal
- 5400 tons/day coal (54 rail cars)
- Bottom Ash – 108 tons/hr
- Fly Ash – 432 tons/hr
- SOx – 228 tons/day
- NOx – 20 tons/day
- Steam – 2000 tons/hr

Diesel Power Plant

Md. Jakirul Islam

Introduction

- Diesel power plants produce power in the range of 2 to 50 MW, are used as central stations for supply authorities and work.
- They are used as standby sets for continuity of supply such as hospitals, telephone exchanges, radio stations, cinema theatres and industries.
- They are suitable for mobile power generation and widely used in railways and ships.
- Used as Peak Load Plants, Mobile Plants, Stand By Units, Emergency Plants, Starting Stations, Central Stations, Industries where power requirement is small 500kW.

- Advantages of Diesel power plant :
- It can respond to varying loads without any difficulty.
- It occupies less space.
- For the same capacity diesel power plant is compact and smaller than a thermal power plant.
- Diesel power plants are more efficient than steam power plants in the range of 150 MW capacity.

- Disadvantages of Diesel power plant :
- High operating cost.
- High maintenance and lubrication cost.
- The capacity of a diesel plant is limited. They cannot be constructed in large sizes.
- In a diesel plant noise is a serious problem.
- Diesel power plants cannot supply over loads continuously where as steam power plants can work under 25% overload continuously.

Heat Engine: **any type of engine or device that derives heat energy from combustion of fuel and converts to mechanical energy.**

- In an Internal combustion engine, combustion takes place within working fluid of the engine, thus fluid gets contaminated with combustion products.
- Petrol engine is an example of internal combustion engine, where the working fluid is a mixture of air and fuel .
- In an External combustion engine, working fluid gets energy using boilers by burning fossil fuels or any other fuel, thus the working fluid does not come in contact with combustion products.
- Steam engine is an example of external combustion engine, where the working fluid is steam.

Classification of IC Engines.

1. According to cycle of operation
- Two Stroke Engine
- Four Stroke Engine

2. According to cycle of combustion
- Otto Cycle Engine(combustion at constant volume)
- Diesel Cycle Engine(combustion at constant pressure)
- Dual Combustion or semi – diesel cycle engine.

3. According to arrangement of Cylinder.
- Horizontal Engine
- Vertical Engine
- V-Type Engine
- Radial Engine

4. According to their Uses

- Stationary Engine
- Portable Engine
- Marine Engine
- Automobile Engine
- Aero Engine

5. According to fuel employed and method of fuel supply to the engine.

- Oil Engine
- Petrol Engine
- Gas Engine

6. According to method of ignition

- Spark ignition
- Compression ignition

7. According to speed of the engine

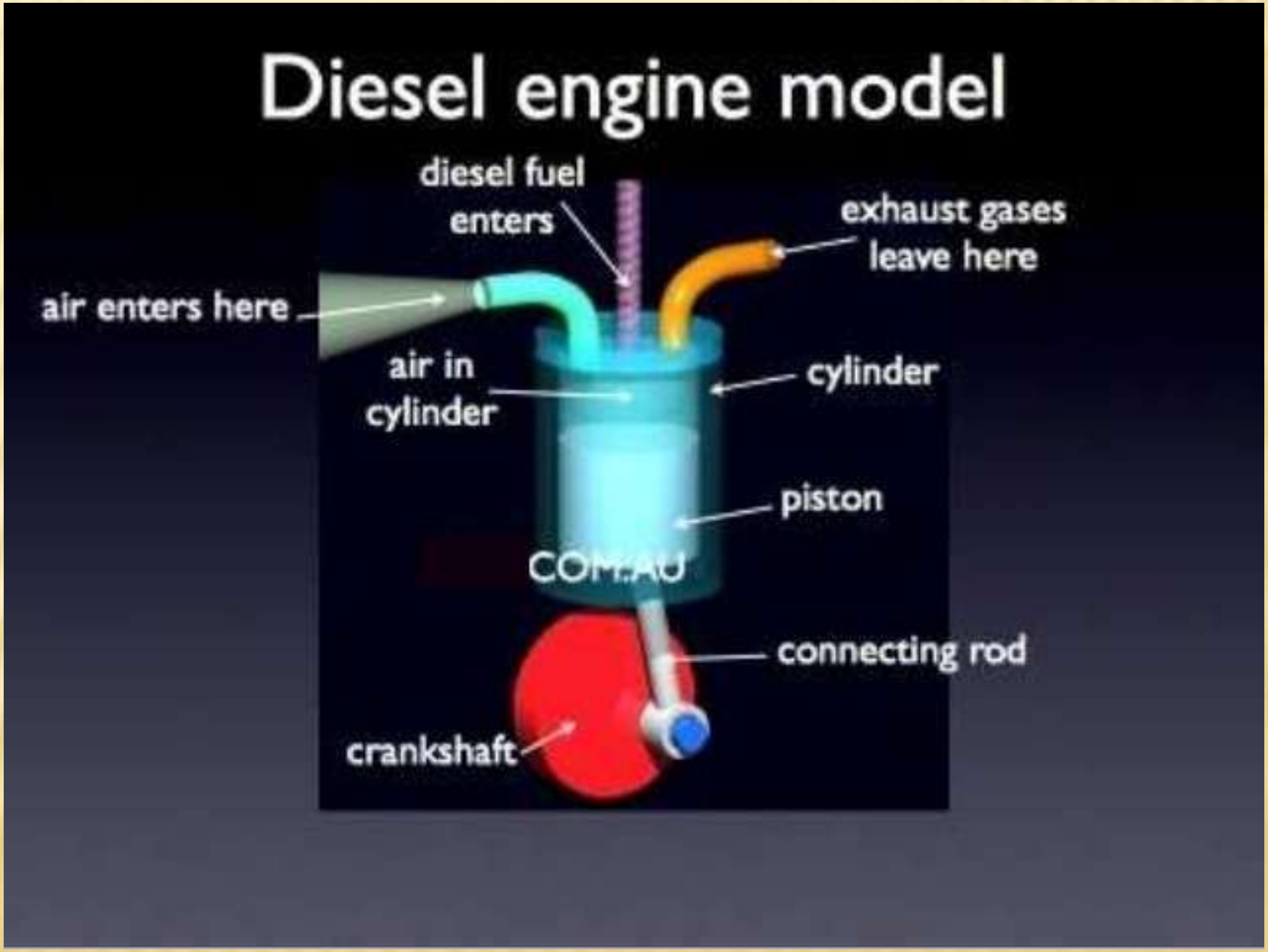
- Low speed
- Medium Speed
- High Speed

8. According to method of cooling

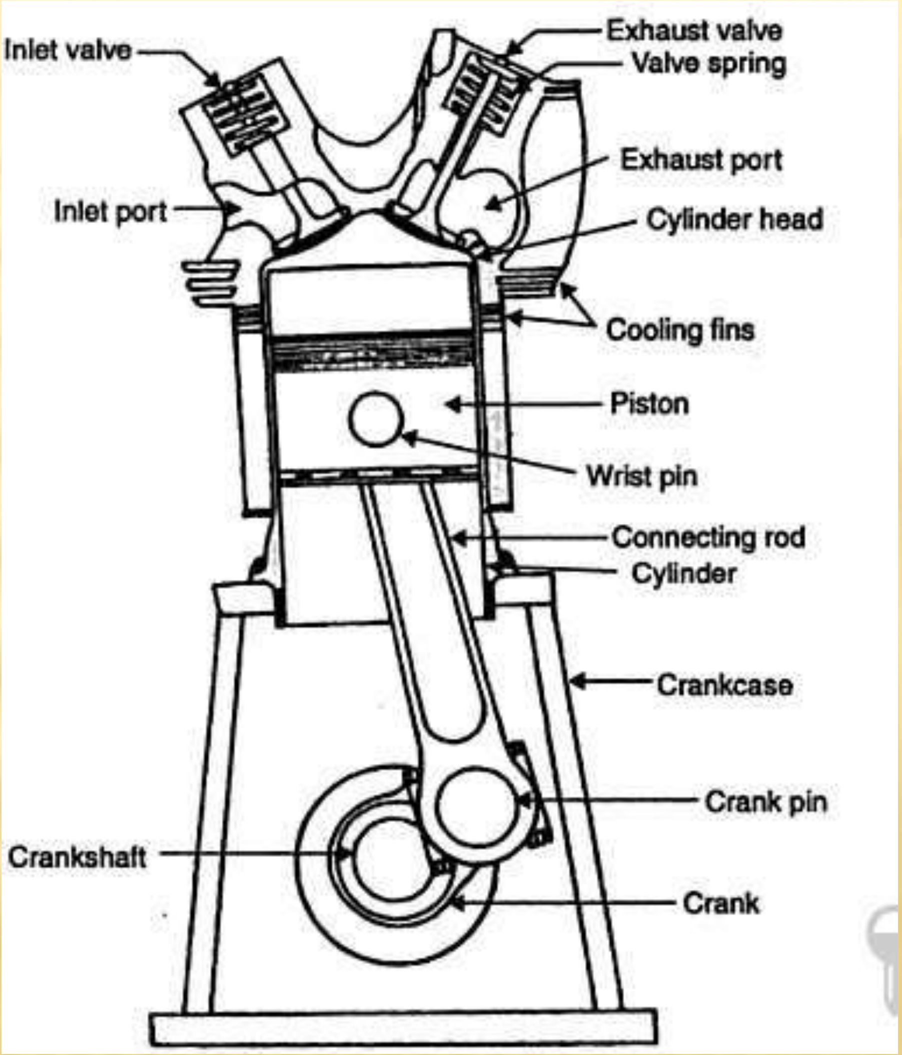
- Air Cooled
- Water Cooled

9. According to number of cylinders

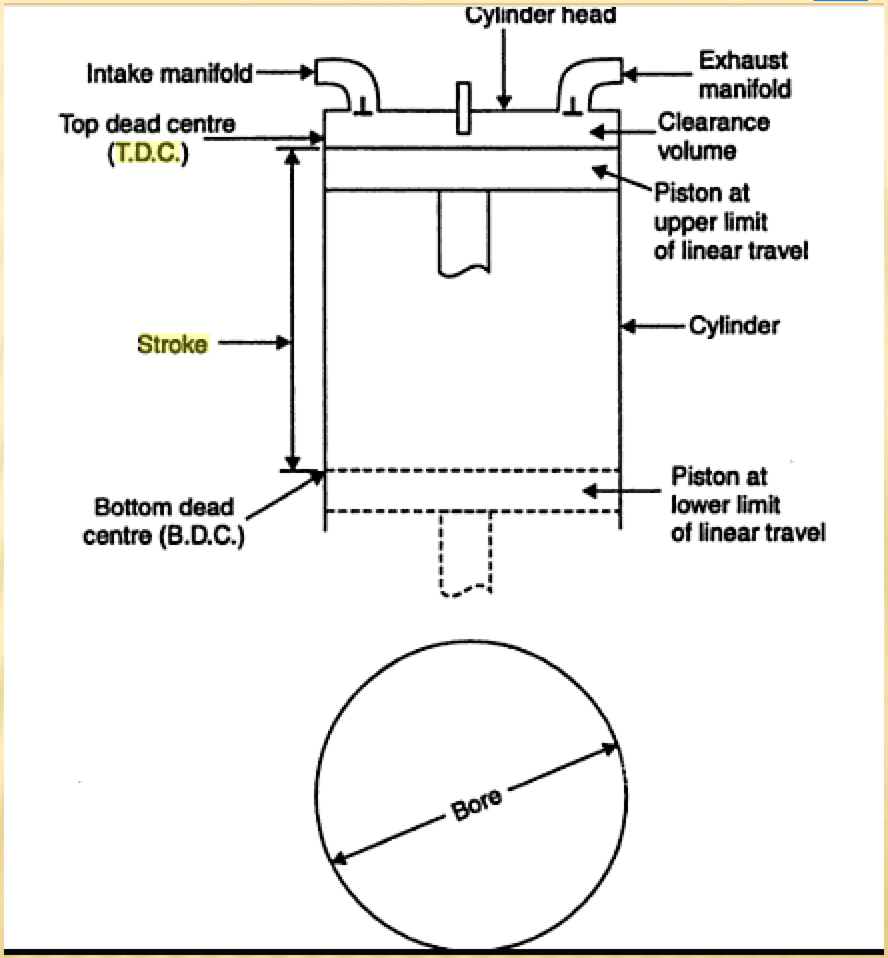
- Single cylinder
- Multi Cylinder


Diesel engine model
diesel fuel enters
exhaust gases leave here
air enters here
air in cylinder
cylinder
piston
COM.AU
connecting rod
crankshaft

Air Cooled


Inlet valve
Exhaust valve
Valve spring
Exhaust port
Inlet port
Cylinder head
Cooling fins
Piston
Wrist pin
Connecting rod
Cylinder
Crankcase
Crank pin
Crankshaft
Crank

Terms Relating to



Bore. *The inside diameter of the cylinder is called "bore".*

Stroke. As the piston reciprocates inside the engine cylinder, it has got limiting upper and lower positions beyond which it cannot move and reversal of motion takes place at these limiting positions.

The linear distance along the cylinder axis between two limiting positions, is called "stroke".

Top Dead Centre (T.D.C.). *The top most position of the piston towards cover end side of the cylinder is called "top dead centre".* In case of horizontal engines, this is known as *inner dead centre.*

Bottom Dead Centre (B.D.C.). *The lowest position of the piston towards the crank end side of the cylinder is called "bottom dead centre".* In case of horizontal engines it is called *outer dead centre.*

Clearance volume. *The volume contained in the cylinder above the top of the piston, when the piston is at top dead centre, is called the "clearance volume".*

- Bore sizes of engines range from 0.5 m down to 0.5 cm. The ratio of bore of stroke D/L, for small engines is usually from 0.8 to 1.2.

Swept volume. *The volume swept through by the piston in moving between top dead centre and bottom dead centre, is, called "swept volume or piston displacement".* Thus, when piston is at bottom dead centre, total volume = swept volume + clearance volume.

Compression ratio. *It is ratio of total cylinder volume to clearance volume.*

Compression ratio (r) is given by

$$r = \frac{V_s + V_c}{V_c}$$

where V_s = Swept volume, V_c = Clearance volume.

The compression ratio varies from 5 : 1 to 11 : 1 (average value 7 : 1 to 9 : 1) in *S.I. engines* and from 12 : 1 to 24 : 1 (average value 15 : 1 to 18 : 1) in *C.I. engines*.

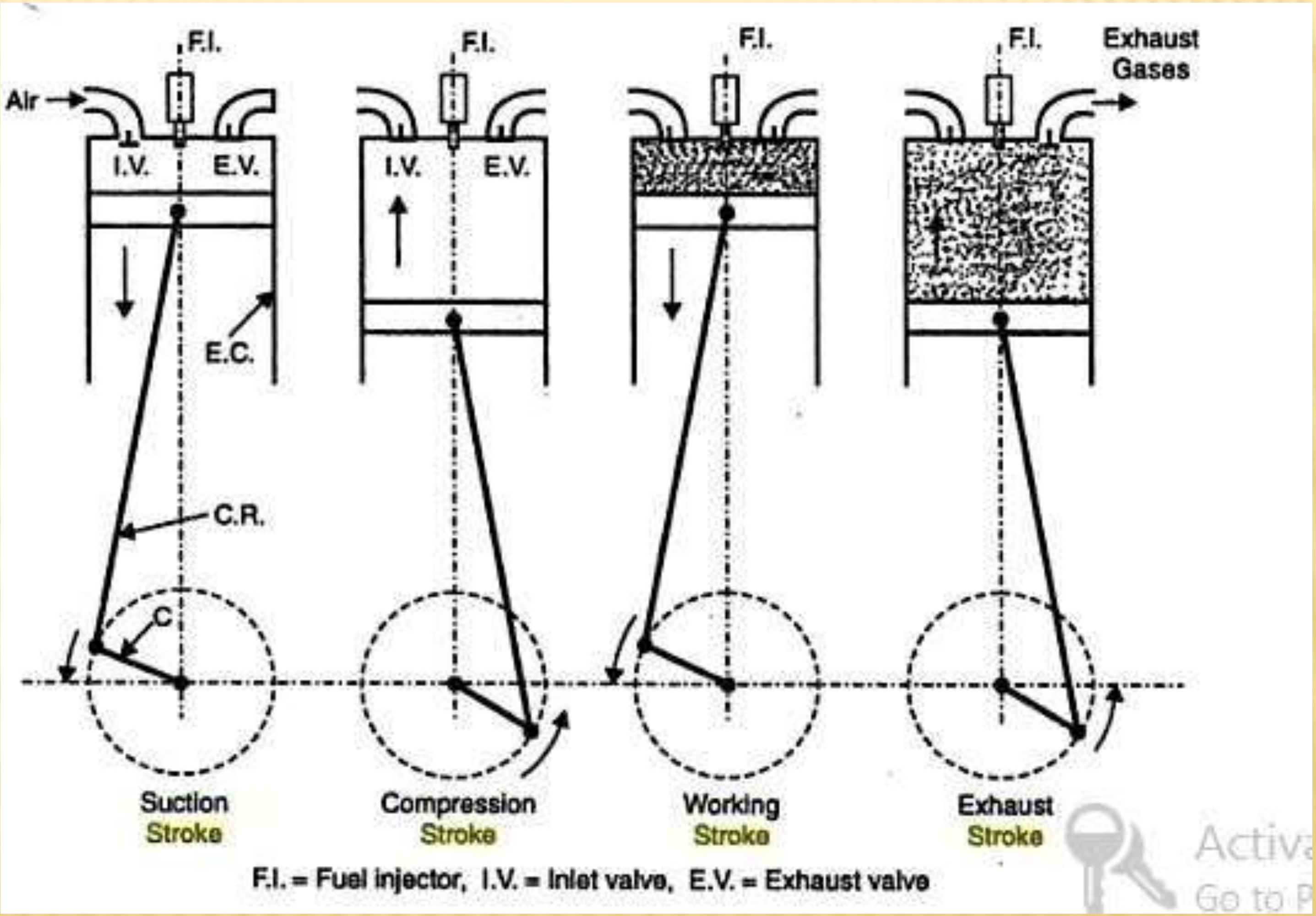
Piston speed. *The average speed of the piston is called "piston speed".*

Piston speed = 2 LN

where L = Length of the stroke, and

N = Speed of the engine in r.p.m.

Four Stroke Diesel



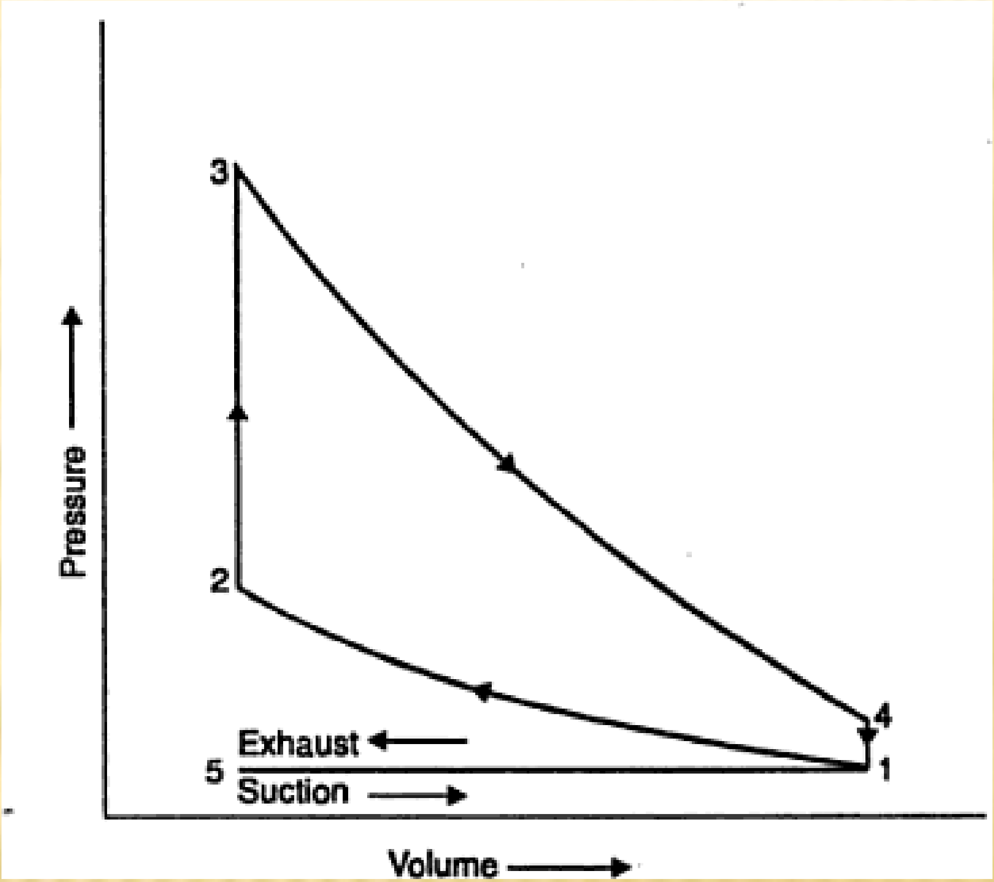
1.Suction Stoke: With the movement of piston from TDC to BDC, inlet valve opens and air at atmospheric pressure is drawn inside the engine.(5-1)

2.Compression stroke: It raises pressure to about 35kg/cm2. and temp 600deg C. piston moves from BDC to TDC(1-2)

3.Expansion or Working Stroke: Fuel injection starts at or near end of compression stroke. Fuel starts burning at constant pressure. (2-3) High air temperature caused by compression ignites fuel. Burning mixture expands, pushing piston down on working stroke. At 3 fuel supply is cut. Hot gases expand to point 4 (3-4)

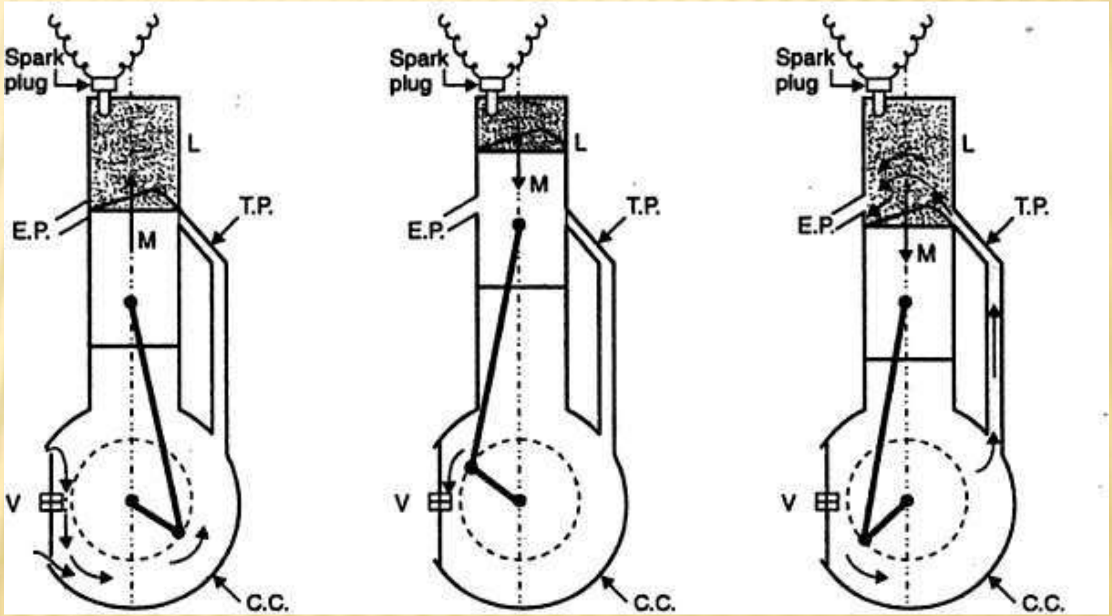
4.Exhaust stroke: The piston moves from BDC to TDC and exhaust gases escape to atmosphere through exhaust valve. When piston reaches TDC exhaust valve closes and cycle is complete.

PV diagram of four stroke engine.



Two Stroke Engine

- Like the four-stroke engine, the two-stroke engine must go through the same four events: intake, compression, power, and exhaust. But a two-stroke engine requires only two strokes of the piston to complete one full cycle(crankshaft). Figure shows Two Stroke Petrol Engine, in Deisel Engine there is no spark plug.



- A two stroke engine has a cylinder L connected to the closed crank chamber CC. During upward stroke of the piston M, the gases in L are compressed and at the same time fresh air enters the crank chamber through the valve V.
- When the piston moves downward, V closes and air in the CC is compressed.
- The piston is moving upward and is compressing the air which has previously been supplied to L and before it reaches the TDC the fuel injector supplies fuel to the engine cylinder. Ignition takes place due to high temp and pressure.
- These gases expand and piston then travel downward and near the end of stroke it uncover the exhaust port.
- Exercise: Difference between Two Stroke Engine and Four Stroke Engine.

Essential Components of Diesel Power Plant

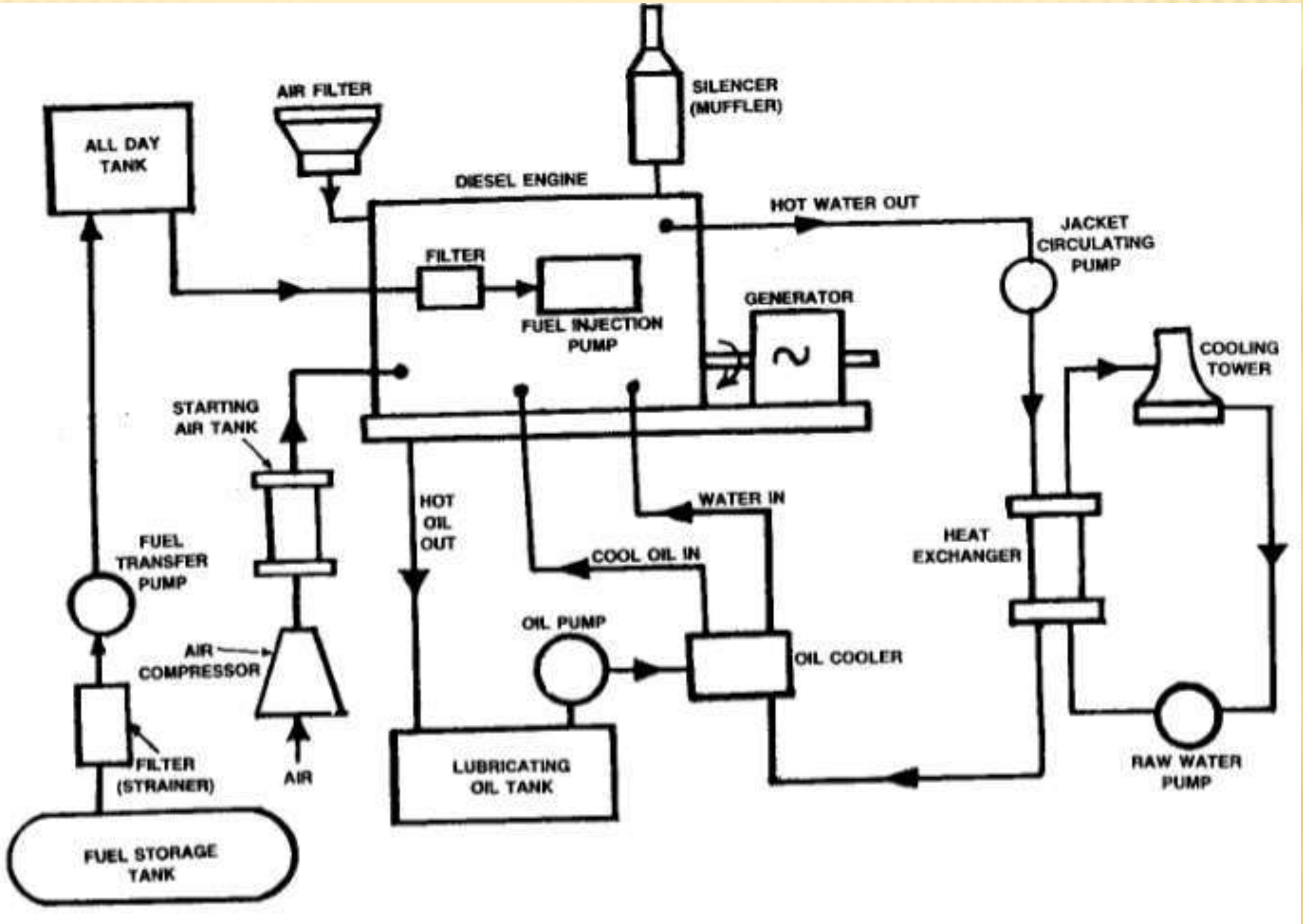


Fig. 3.11: LAYOUT OF DIESEL POWER PLANT

1. Diesel engine :
Diesel engine is a compression ignition(CI) engine. It is the main component which develops the required power.

2. Air intake system :

The air required for the combustion of fuel inside the diesel engine cylinder is drawn through the air filter. The purpose of the filter is to remove dust from the incoming air. The dry filter may be made of felt, wood or cloth.

In wet filter, oil bath is used. In this the air passes over a bath of oil where the dust particles get coated on the oil.

3. Exhaust System:

The purpose of exhaust system is to discharge the engine cylinder exhaust to the atmosphere.

4. Fuel supply system:

Fuel from the storage tank is pumped through a filter into a smaller tank called all day tank. This tank supplies the daily requirements of the diesel engine.

The all day tank is placed high so that the fuel flows to the engine under gravity with sufficient pressure.

5. Starting system:

- Diesel engine used in diesel power plants is not self starting. The engine is started from cold condition with the help of an air compressor.

6. Lubricating System:

- This circuit includes lubricating oil tank, oil pump and oil cooler.
- The purpose of the lubrication system is to reduce the wear of the engine moving parts. Part of the cylinder such as piston, shafts, valves must be lubricated.
- Lubrication also helps to cool the engine.
- In the lubrication system the oil is pumped from the lubricating oil tank through the oil cooler where the oil is cooled by the cold water entering the engine.
- The hot oil after cooling the moving parts return to the lubricating oil tank

7. Cooling System

- The temperature of the burning fuel inside the engine cylinder is in the order of 2750deg Celsius. In order to lower this temperature water is circulated around the engine.
- The water envelopes(water jacket) the engine. The heat from the cylinder, piston, combustion chamber etc., is carried by the circulating water.
- The hot water leaving the jacket is passed through the heat exchanger
- The heat from the heat exchanger is carried away by the raw water circulated through the heat exchanger and is cooled in the cooling system.

Operation of a diesel Power Plant

- This condition occurs due to the resonance between periodic disturbing forces of the engine and natural frequency of the system.
- The engine forces result from uneven turning moment on the
- When diesel alternator set is put in parallel “Hunting” or “Phase swinging” may be produced due to resonance unless care is taken by manufacturer.

  engine crank, which are corrected by flywheel.
- Hunting results from the tendency of each set trying to pull other into synchronism.
- To ensure most economical operation of diesel engines of different sizes working in parallel and sharing load it is necessary that they should carry the same percentage of their full load capacity a all the times as the fuel consumption would be lowest in this condition.

For Good Performance of diesel power plant

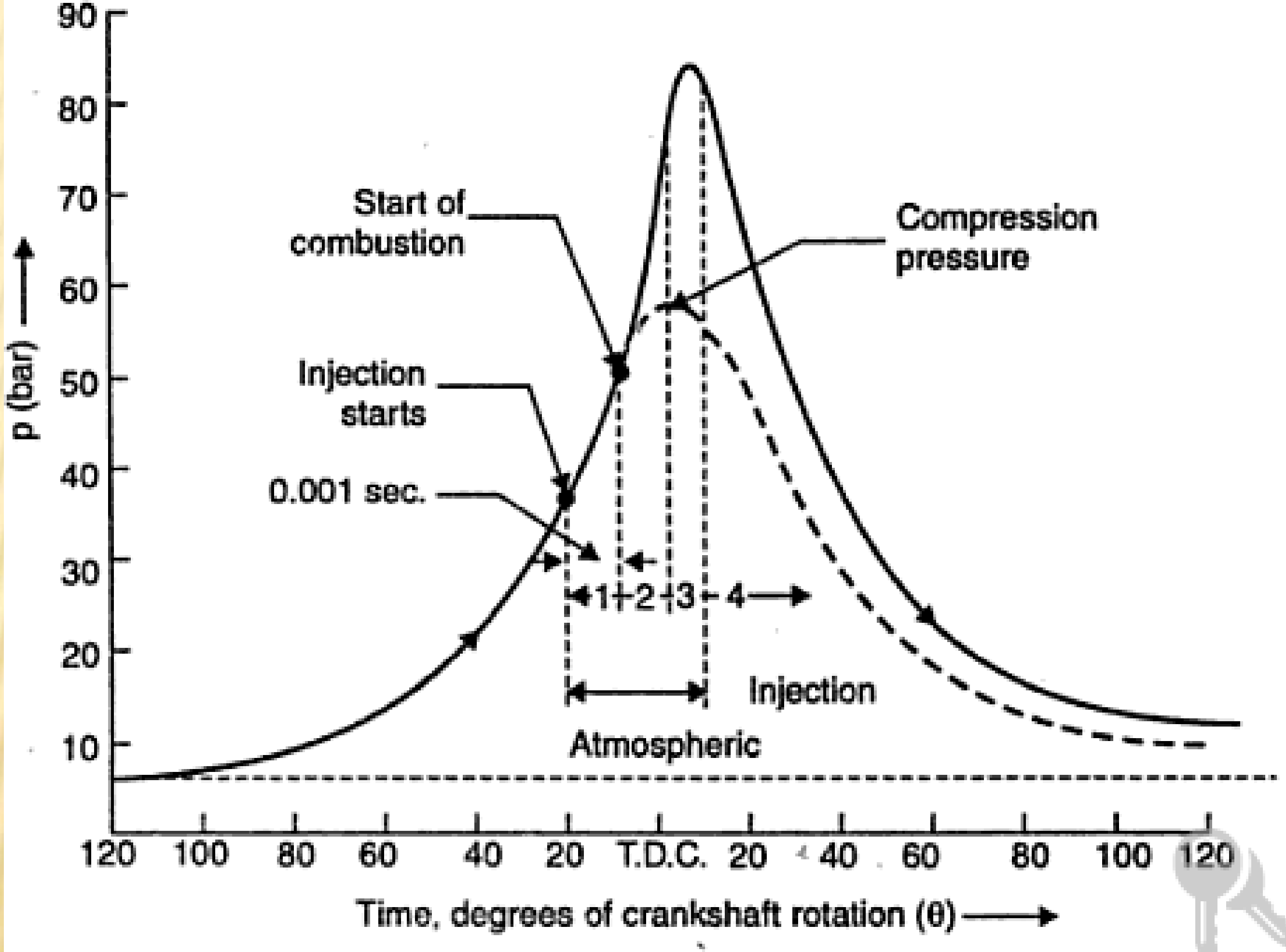
- 1. Necessary to maintain the cooling temp within prescribed limits.
- 2. Lubricating system should work effectively and required temp and pressure should be maintained.
- 3. The engine should be periodically run even when not required, should not stand idle for more than 7 days.
- 4. Air filters, oil filters and fuel filters should be periodically serviced.
- 5. Periodic checking of engine compression and firing pressure and exhaust temp.

Combustion Phenomenon in C.I.Engine

- In C.I. engine combustion occurs by the high temperature produced by the compression of air, it is an auto ignition. Minimum compression ratio required is 12.
- The efficiency of the cycle increases with higher values of compression ratio but maximum pressure in cylinder also increases.
- Normal compression ratio lies in range 14 to 17, but may go upto 23.
- Air fuel ratio lie between 18 and 25. in CI and 14 in SI.

PHASES IN C.I ENGINE COMBUSTION:

- Ignition delay period
- Period of rapid or uncontrolled combustion
- Period of controlled combustion
- After burning



Combustion phenomenon of C.I. engine.

Ignition Delay

- The ignition delay in a diesel engine is defined as the time interval between the start of injection and the start of combustion. This delay period consists of

(a) physical delay, wherein atomization, vaporization and mixing of air fuel occur and

(b)of chemical delay attributed to pre-combustion reactions.

- Physical and chemical delays occur simultaneously.

- Due to the delay period the pressure reached during second stage will depend up on the duration of delay period.
- The longer delay will cause rough running and may cause **diesel knock**.
- Delay period should be **as short as** possible both for the sake of smooth running and in order to maintain control over the pressure changes.
- But , some delay period should be necessary other wise the droplets would not disappear in the air for complete combustion.

PERIOD OF RAPID OR UNCONTROLLED COMBUSTION

- It is the second stage of combustion in C.I engine.
- This period is counted from end of the delay period to the point of maximum pressure on the indicator diagram.
- The rise of pressure is rapid because during the delay period the droplets of fuel have had time to spread themselves over a wide area and they have fresh air all around them.
- About 1/3 of heat is evolved during this period

PERIOD OF CONTROLLED COMBUSTION

- At the end of the second stage of combustion , the temperature and pressure are so high that the fuel droplets injected in third stage burn almost as they enter and any further pressure rise can be controlled by injection rate .
- The heat evolved at the end of the compression is about 70 to 80 percent.

AFTER BURNING

- The combustion continues even after the fuel injection is over , because of poor distribution of particles
- This burning may be continue in the expansion stroke up to 70 to 80(deg) of crank revolution from TDC.
- The total heat evolved by the entire combustion process is 95 to 97%; 3 to 5% of heat goes as un burnt fuel in exhaust.

Delay Period

- It is the time immediately following injection of the fuel during which the ignition process is being initiated and pressure does not rise beyond the value it would have due o the compression of the air.
- The delay period extend for about 13deg C, movement of the crank.
- Delay period depends upon following:
- Temperature and pressure in the cylinder at time of injection.
- Nature of the fuel mixture strength.
- Presence of residual gases.
- Rate of fuel injection.
- It should be as short as possible

Diesel Knock

- If the delay period of C.I. engine is long a large amount of fuel will be injected and accumulated in he chamber. The auto ignition of this large amount of fuel may cause high rate of pressure rise and high maximum pressure which may cause knocking in the diesel engine.

Cetane Number

- Cetane rating of a diesel fuel is the measure of its ability to auto ignite quickly when it is injected into the compressed and heated air in he engine.
- Reference mixture of cetane($C_{16}H_{34}$)(high ignitability) and alpha methyl napthalene($C_{11}H_{10}$)(low ignitability) are used, *The mixture is made by volume and ignitability of the test fuel is quoted as the percentage of cetane in the reference mixture which has same ignitability.*
- For higher speed engines: cetane number is 50
- For medium speed engines: cetane number is 40
- For slow speed engines: cetane number is 30
- Cetane number effect the following :
- Exhaust emissions: more if C.N is less
- Noise: More if C.N is less
- Start ability of diesel engine: lessens if C.N. is less

Supercharging

- The purpose of supercharging is to raise the volumetric efficiency above that value which can be obtained by normal aspiration.
- The engine is an air pump, increasing the air consumption permits greater quantity of fuel to be added, and results in greater potential output.
- The power output is almost directly prop. To the air consumption.
- Three methods to increase the air consumption are
- 1. Increasing the piston displacement: leads to more size and weight, cooling problems
- 2. Running the engine at higher speeds leads to mechanical wear and tear.
- 3. Increasing the density of the charge, so that greater mass of charge is introduced in same volume. {Widely Used}

- The apparatus used to increase the air density is called **supercharger**. It is similar to a compressor(centrifugal type), which provides greater mass of charge with same piston displacement.
- The supercharger produces following effects:

1. Provides better mixing of air fuel mixture due to turbulent effect of supercharger.
2. The temperature of charge is raised as it is compressed, resulting in higher temperature within the cylinder, so better vaporization of fuel, but dec in density of charge.
3. Power required to run the supercharger is obtained from engine

Effects of Supercharging

- The Power output is high than naturally aspirated engine.
- The mechanical efficiencies are better than naturally aspirated engines.
- It has higher specific fuel consumption that naturally aspirated engines.

Performance of I.C. Engines

1. Power and Mechanical Efficiency
2. Effective Pressure and Torque
3. Volumetric Efficiency
4. Specific Output
5. Fuel Air-Ratio
6. Specific Fuel Consumption
7. Thermal Efficiency and Heat Balance
8. Exhaust Smoke and Emissions

Power and Mechanical Efficiency

i) Indicted Power: The total power developed by the consumption of fuel in the combustion chamber is called indicated power.

$$\text{I.P.} = \frac{n p_{mi} LANk \times 10}{6} \text{ kW}$$

n = Number of cylinders,

p_{mi} = Indicated mean effective pressure, bar,

L = Length of stroke, m,

A = Area of piston, m^2, and

$k = \frac{1}{2}$ for 4-stroke engine

= 1 for 2-stroke engine.

- ii) Brake Power(B.P.) The power developed by engine at the output shaft is called brake power.

$$B.P. = \frac{2\pi NT}{60 \times 1000} \text{ kW}$$

where, N = Speed in r.p.m., and

T = Torque in N-m.

- The difference between I.P. and B.P. is called frictional power, F.P.
- F.P. = I.P. – B.P.
- The ratio of B.P. to I.P. is called mechanical efficiency.
- η_{mech} **= B.P. / I.P.**

Effective Pressure and Torque

- It is defined as the average pressure acting over piston throughout a power stroke.
- If mean effective pressure is based on brake power(BP) then it is referred to as brake mean effective pressure(B_{mep}).
- If it is based on indicated power(IP) it is called indicated mean effective pressure(I_{mep}).
- Friction mean effective power is the difference of I_{mep} and B_{mep}.
- Mean effective power is the true indication of the relative performance of different engines.

Specific output

- It is defined as break output per unit of piston displacement.

$$= \frac{B.P.}{A \times L}$$

$$= \text{Constant} \times p_{mb} \times \text{r.p.m.}$$

- p_{mb} is mean effective pressure. Higher the speed higher is the specific output.

Volumetric Efficiency

- It is the ratio of the actual volume of the charge drawn in during the suction stroke to the swept volume of the piston.
- The amount of air taken inside the cylinder is dependent on the volumetric efficiency of an engine and hence puts a limit on the amount of fuel which can be efficiently burned and the power output.
- The value of volumetric efficiency of a normal engine lies between 70 to 80 percent, but for engines with forced induction it may be more than 100 percent.

Air Fuel Ratio

- It is the ratio of mass of fuel to mass of air in mixture. It effects the phenomenon of combustion and used for determining flame propagation velocity, the heat released in combustion chamber.

Specific Fuel Consumption

- It is defined as the amount of fuel consumed for each unit of brake power per hour it indicates the efficiency with which the engine develops the power from fuel. it is used to compare performance of different engines.

$$\text{s.f.c.} = \frac{m_f}{\text{B.P.}} \text{ kg/kWh.}$$

Thermal Efficiency and Heat Balance

- It is the ratio of output to that of energy input in the form of fuel.

If, $\dot{m}_f$ = Mass of fuel used in kg/sec., and

C = Calorific value of fuel (lower),

Then *indicated thermal efficiency* (based on I.P.),

$$\eta_{th.\ (I)} = \frac{\text{I.P.}}{\dot{m}_f \times C}$$

and *brake thermal efficiency* (based on B.P.)

$$\eta_{th.\ (B)} = \frac{\text{B.P.}}{\dot{m}_f \times C}$$

- **Heat Balance Sheet**: The performance of an engine is generally given by heat balance sheet.
- Heat Supplied by Fuel= mf X C
- mf = mass used per min in kg, C= calorific value of fuel
- Heat absorbed by I.P. = heat eqivalent of I.P.(per min) = I.P. X 60 kJ
- Heat taken away by cooling water= mwXcpwX(t2-t1), mw = mass of coolng water per minute, cpw=specific heat of water.
- Heat taken away by exhaust gases = meXcpgX(te-tr), me= mass of exhaust gases(kg/min), cpg=mean specific heat at constant pressure

Exhaust Smoke and Emissions

- Smoke is an indication of incomplete combustion. It limits the output of an engine if the air pollution control is the consideration.
- It is defined as the weight of the engine in kg for each B.H.P. Developed.
- Specific Weight

Gas Turbine Power Plant

By

Md. Jakirul Isl;am

Gas turbine power plant

Working principle :

- Air is compressed(squeezed) to high pressure by a fan-like device called the compressor.
- Then fuel and compressed air are mixed in a combustion chamber and ignited.
- Hot gases are given off, which spin the turbine wheels.
- Most of the turbine's power runs the compressor. Part of it drives the generator/machinery.

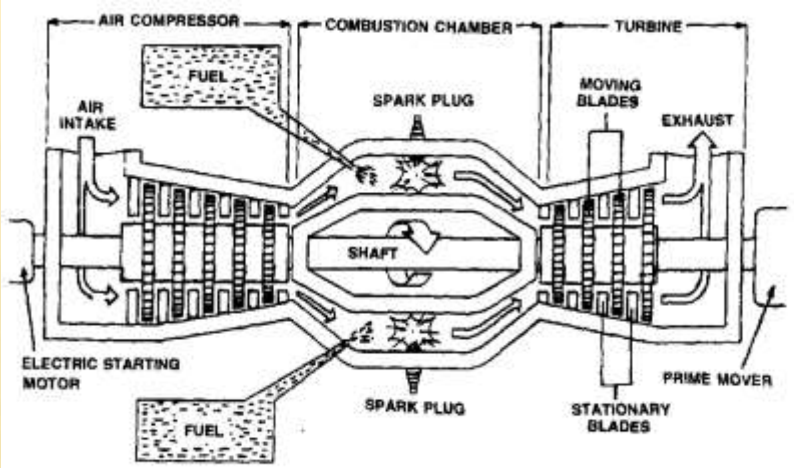


Fig. 2.28: HOW A GAS TURBINE SYSTEM WORKS

Description:

- Gas turbines burn fuels such as oil, nature gas and pulverised(powdered) coal.
- Instead of using the heat to produce steam, as in steam turbines, gas turbines use the hot gases directly to turn the turbine blades.
- Gas turbines have three main parts:

i) Air compressor

ii) Combustion chamber

iii) Turbine

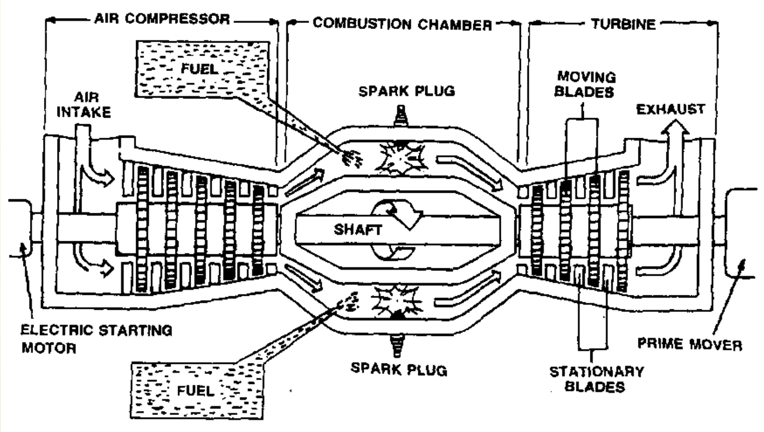
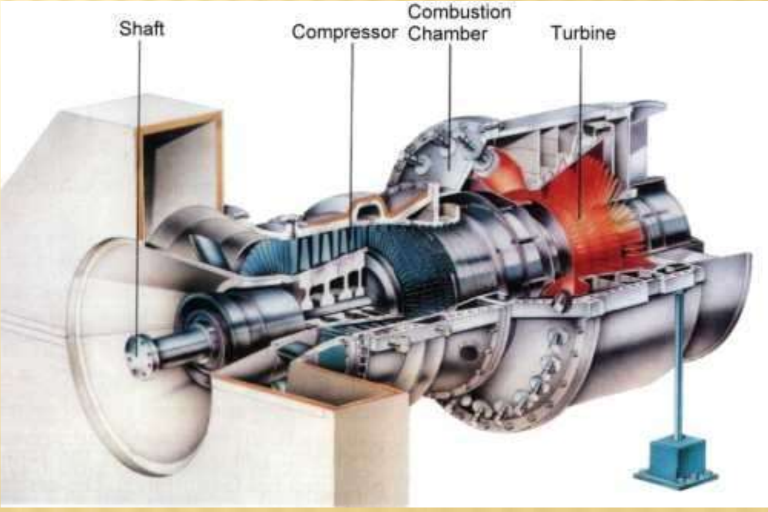


Fig. 2.28: HOW A GAS TURBINE SYSTEM WORKS



Air compressor:

- The air compressor and turbine are mounted at either end on a common horizontal axle(shaft), with the combustion chamber between them.
- Gas turbines are not self starting. A starting motor initially drives the compressor till the first combustion of fuel takes place, later, part of the turbine's power runs the compressor.
- The air compressor sucks in air and compresses it, thereby increasing its pressure.

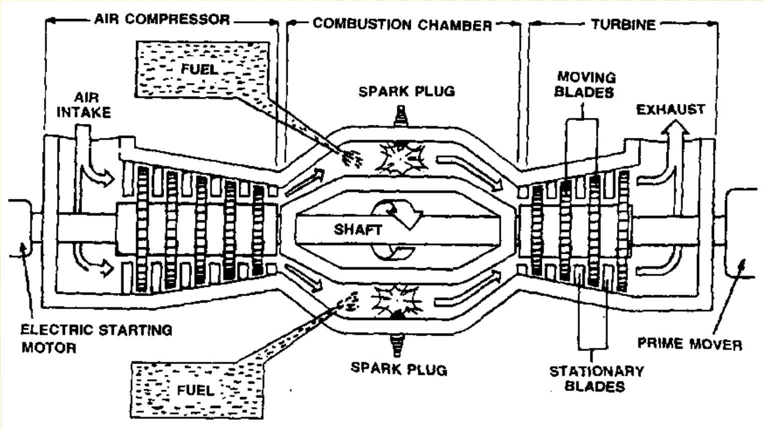
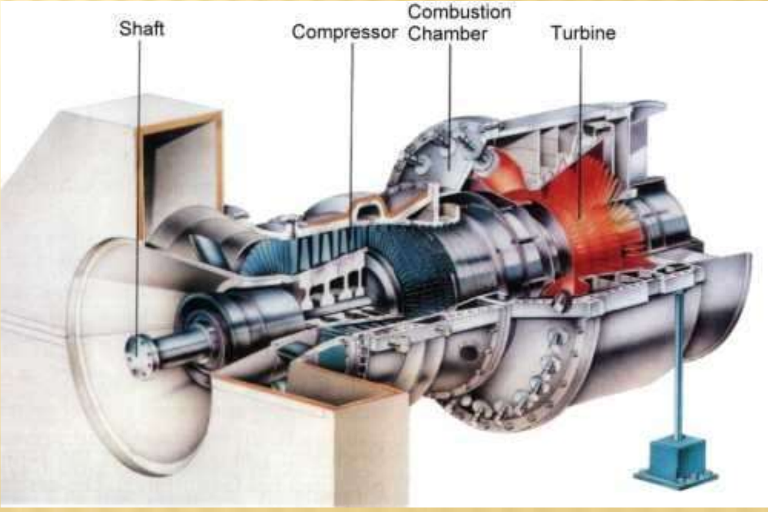


Fig. 2.28: HOW A GAS TURBINE SYSTEM WORKS



Combustion chamber:

- In the combustion chamber, the compressed air combines with fuel and the resulting mixture is burnt.
- The greater the pressure of air, the better the fuel air mixture burns.
- Modern gas turbines usually use liquid fuel, but they may also use gaseous fuel, natural gas or gas produced artificially by gasification of a solid fuel.

Note :

The combination of air compressor and combustion chamber is called as gas generator.

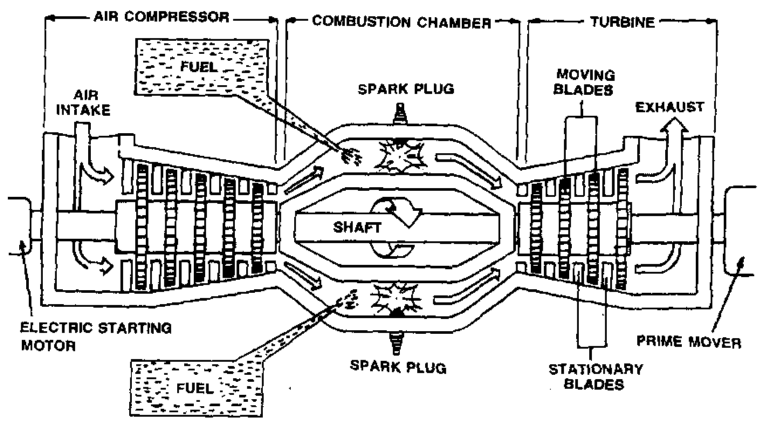
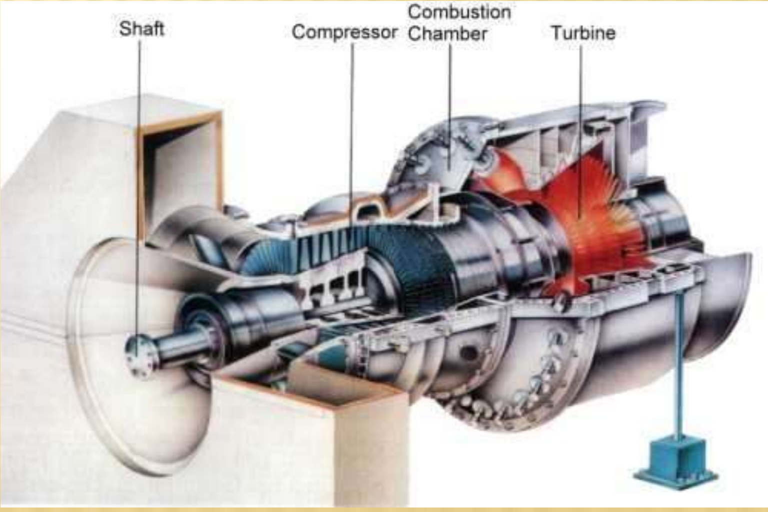


Fig. 2.28: HOW A GAS TURBINE SYSTEM WORKS



Turbine:

- The burning gases expand rapidly and rush into the turbine, where they cause the turbine wheels to rotate.
- Hot gases move through a multistage gas turbine.
- Like in steam turbine, the gas turbine also has fixed(stationary) and moving(rotor) blades.
- The stationary blades guide the moving gases to the rotor blades and adjust its velocity.
- The shaft of the turbine is coupled to a generator or machinery to drive it.

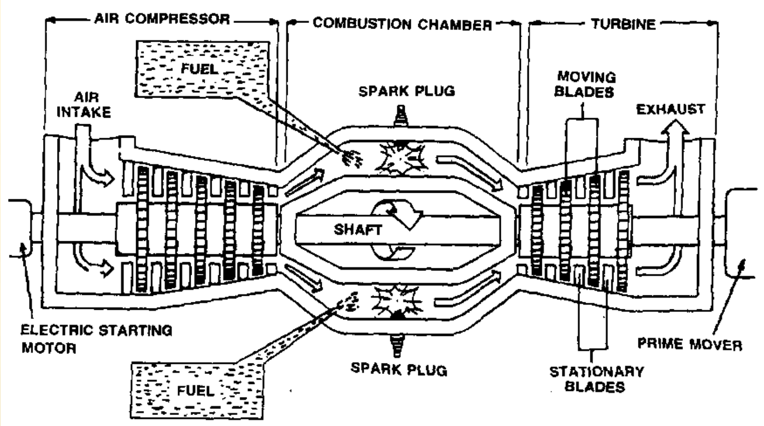
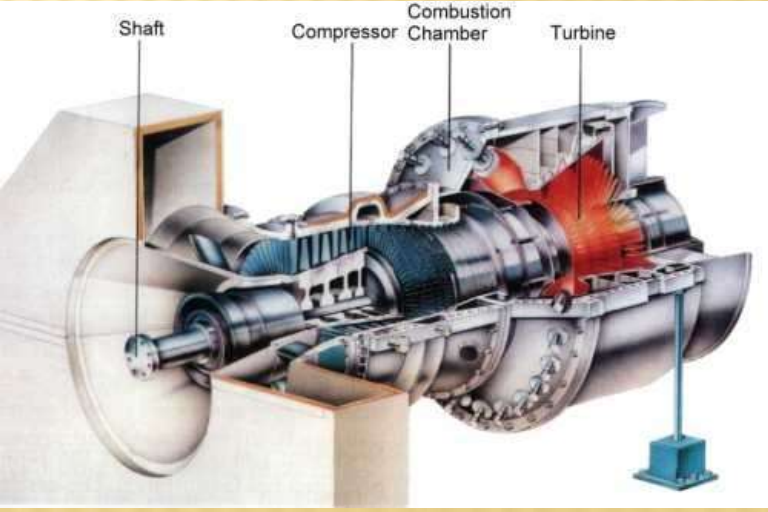


Fig. 2.28: HOW A GAS TURBINE SYSTEM WORKS



Applications of gas turbine:

- Gas turbines are used to drive pumps, compressors and high speed cars.
- Used in aircraft and ships for their propulsion. They are not suitable for automobiles because of their very high speeds.
- Power generation(used for peak load and as stand-by unit).

Note :

- Gas turbines run at even higher temperatures than steam turbines, the temperature may be as high as 1100 – 1260^{0}C.
- The thermal efficiency of gas turbine made of metal components do not exceed 36%.
- Research is underway to use ceramic components at turbine inlet temperature of 1350^{0}C or more, and reach thermal efficiencies over 40% in a 300 kW unit.

Layout of a gas turbine power plant

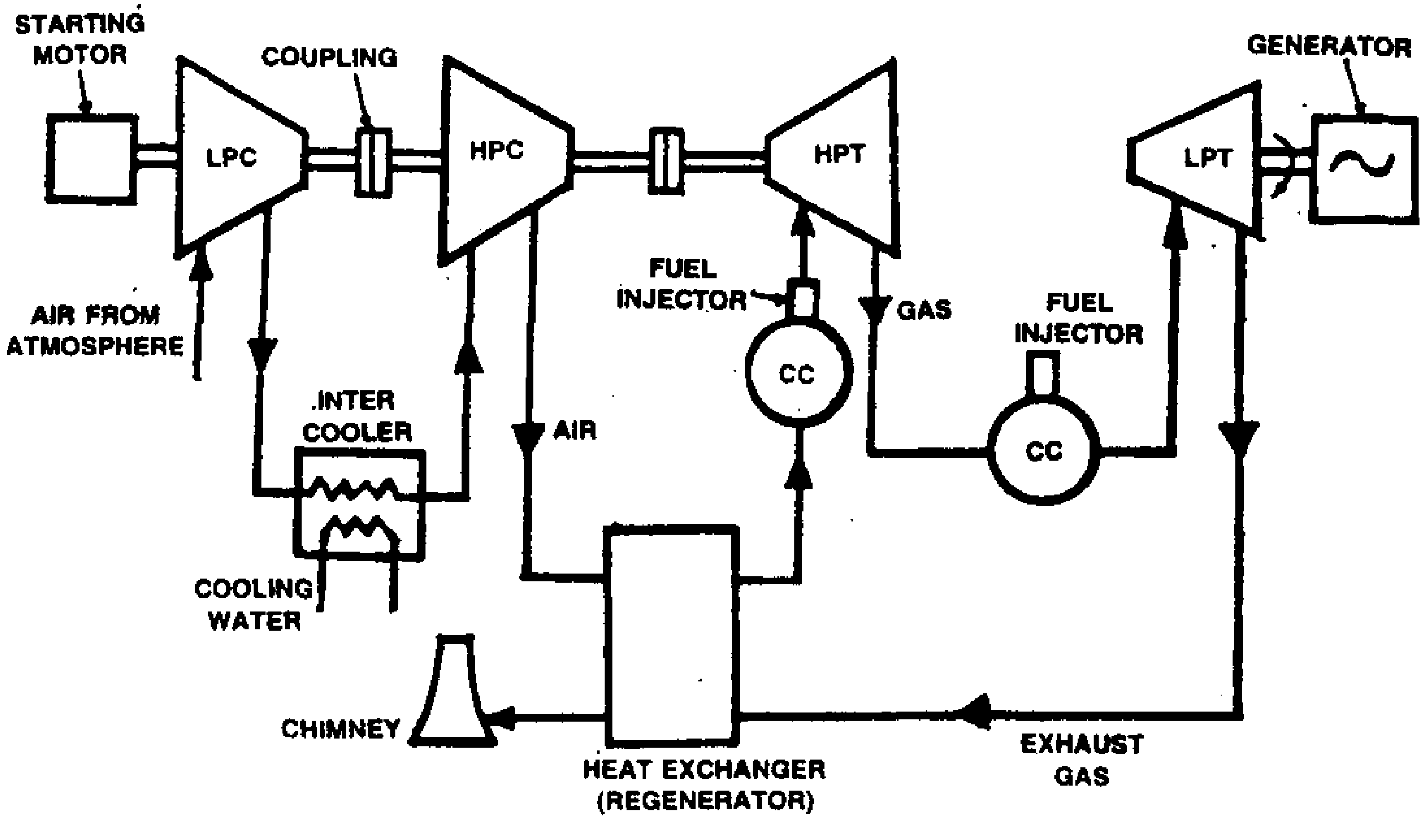


Fig. 3.12: OPEN CYCLE GAS TURBINE POWER PLANT

Layout of gas turbine power plant…

θ Starting motor:

¬ Gas turbines are not self starting. They require a starting motor to first bring the turbine to the minimum speed called coming –in speed, for this purpose a starting motor is required.

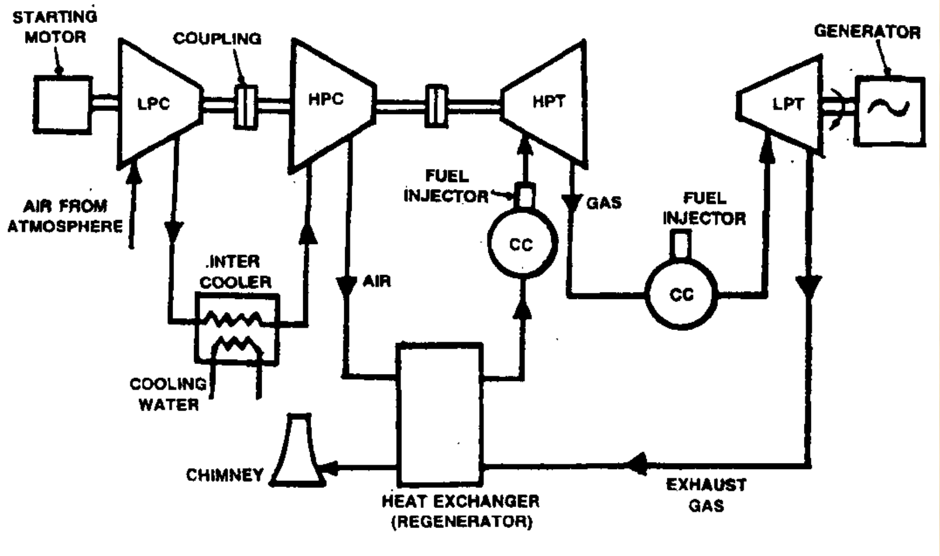


Fig. 3.12: OPEN CYCLE GAS TURBINE POWER PLANT

θ Low pressure compressor(LPC):

⌉ The purpose of the compressor is to compress the air. Air from the atmosphere is drawn into the LPC and is compressed.

θIntercooler:

♣The air after compression in the LPC is hot. It is cooled by the intercooler. The intercooler is circulated with cooling water.

Layout of gas turbine power plant…

θ High pressure compressor(HPC):

¬ The air from the intercooler enters the HPC where it is further compressed to a high pressure. The compressed air passes through a regenerator.

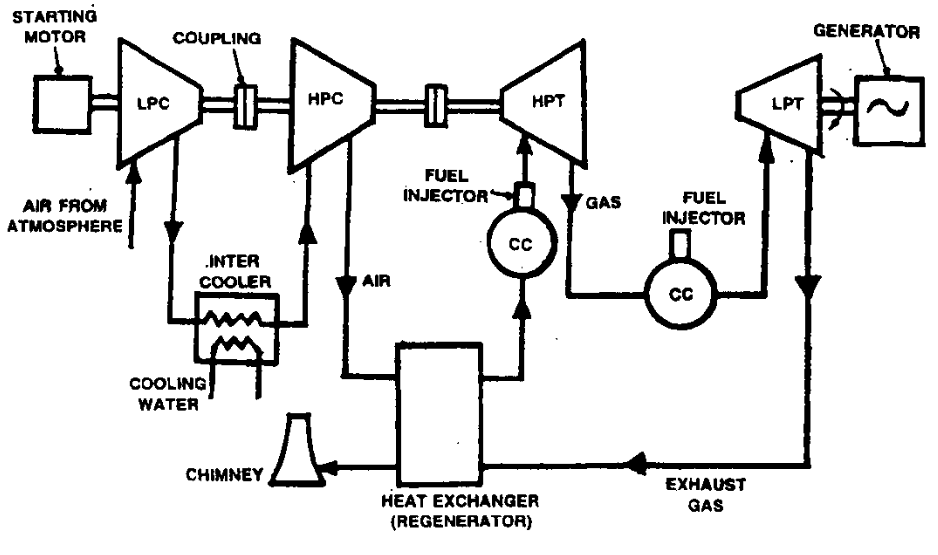


Fig. 3.12: OPEN CYCLE GAS TURBINE POWER PLANT

θ Regenerator(Heat exchanger):

⌉ The air entering the combustion chamber(CC) for combustion must be hot. The heat from the exhaust gases is picked up by the compressed air entering the combustion chamber.

θ Combustion chamber:

♣The fuel(natural gas, pulverized coal, kerosene or gasoline) is injected into the combustion chamber.

♣The fuel gets ignited because of the compressed air.

♣The fuel along with the compressed air is ignited sometimes with a spark plug.

Layout of gas turbine power plant…

- High pressure turbine (HPT):
  - In the beginning the starting motor runs the compressor shaft.
  - The hot gases(products of combustion) expands through the high pressure turbine.
  - It is important to note that when the HPT shaft rotates it infact drives the compressor shaft which is coupled to it. Now the HPT runs the compressor and the starting motor is stopped.

Note :

- A bout 66% of the power developed by the gas turbine power plant is used to run the compressor.

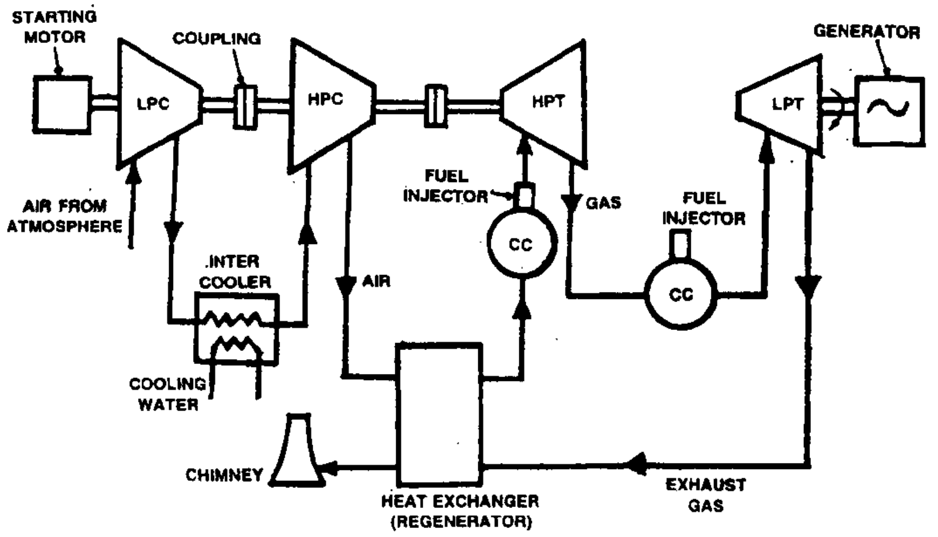


Fig. 3.12: OPEN CYCLE GAS TURBINE POWER PLANT

- Only 34% of the power developed by the plant is used to generate electric power.

Layout of gas turbine power plant…

θ Low pressure turbine(LPT):

- The purpose of the LPT is to produce electric power.
- The shaft of the LPT is directly coupled with the generator for producing electricity.
- The hot gases(products of combustion) after leaving the HPT is again sent to a combustion chamber where it further undergoes combustion.
- The exhaust gases after leaving the LPT passes through the regenerator before being exhausted through the chimney into the atmosphere.

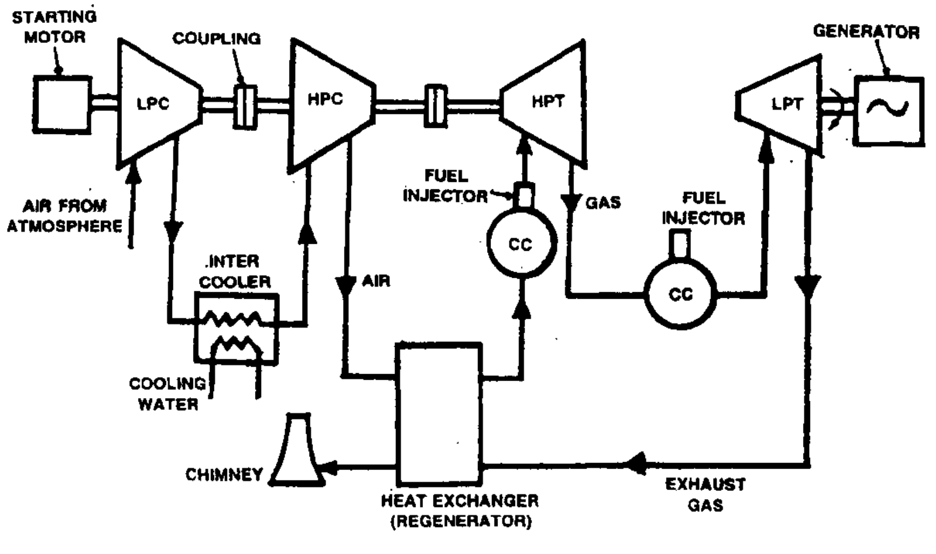


Fig. 3.12: OPEN CYCLE GAS TURBINE POWER PLANT

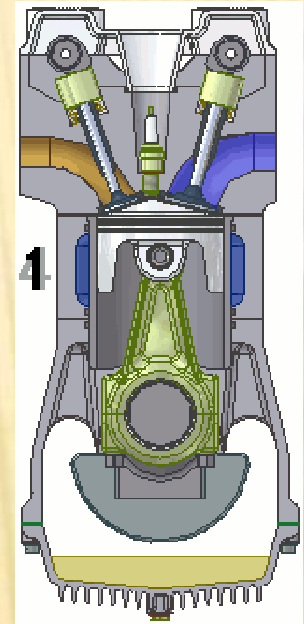
- The heat from the hot gases is used to preheat the air entering the combustion chamber. This preheating of the air improves the efficiency of the combustion chamber.

Advantages of gas turbine power plant :

- Storage of fuel requires less area and handling is easy.
- The cost of maintenance is less.
- It is simple in construction. There is no need for boiler, condenser and other accessories as in the case of steam power plants.
- Cheaper fuel such as kerosene , paraffin, benzene and powdered coal can be used which are cheaper than petrol and diesel.
- Gas turbine plants can be used in water scarcity areas.
- Less pollution and less water is required.

Disadvantages of gas turbine power plant :

- 66% of the power developed is used to drive the compressor. Therefore the gas turbine unit has a low thermal efficiency.
- The running speed of gas turbine is in the range of (40,000 to 100,000 rpm) and the operating temperature is as high as 1100 – 1260^{0}C. For this reason special metals and alloys have to be used for the various parts of the turbine.
- High frequency noise from the compressor is objectionable.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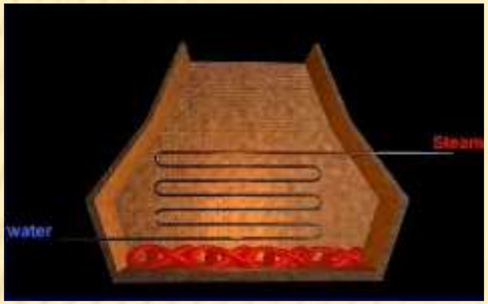
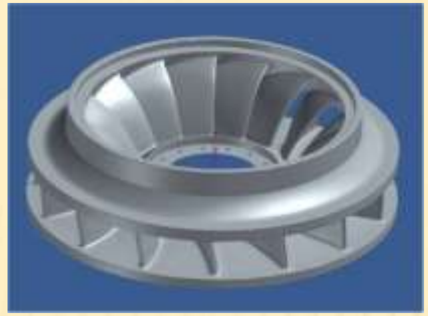
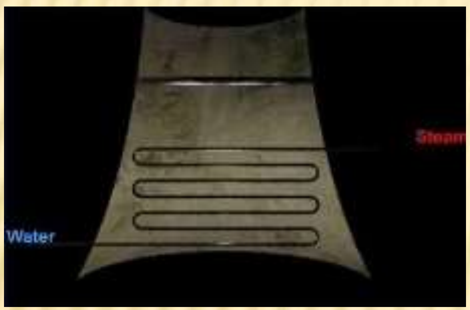
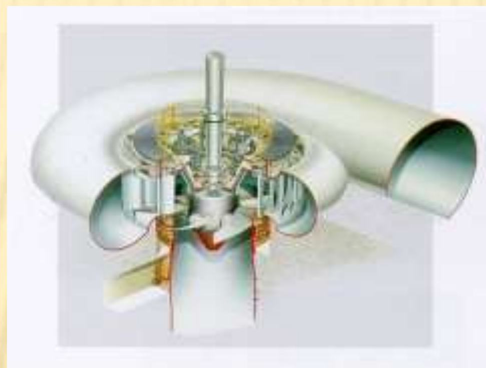
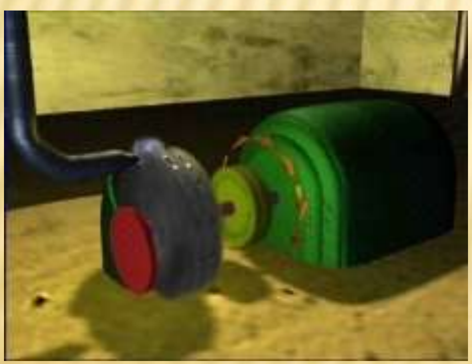

Steam
water



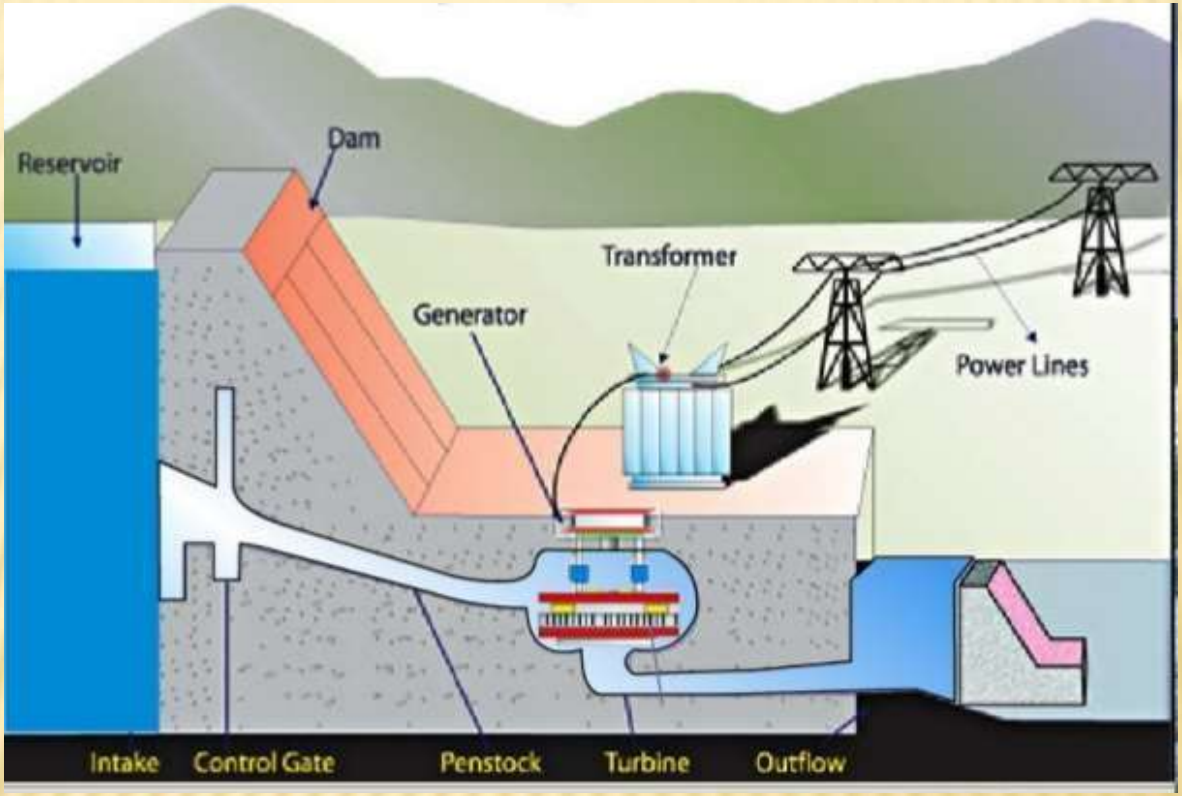

Steam
Water





Thank You

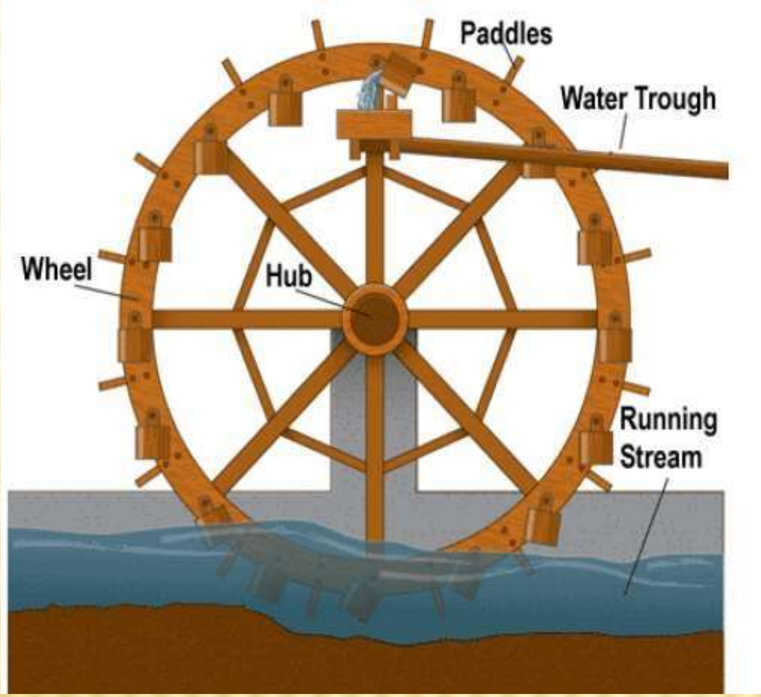
Hydro-Electric Power Plant



Content:

- Concept, Classification, types of Hydro-electric Power plant
- Multipurpose Hydro Project
- Advantages and disadvantages
- Basic elements of Hydro-electric Power plant
- Water turbines used in Hydro power plant
- Factors for selecting hydraulic turbines
- Auxiliaries of Hydro-electric Power plant
- Governing of water turbine

Use of Hydro Energy



Concept

- Human Civilization grew besides river all across the world.
- Water is one of the primary need of humans.
- Energy stored in water in terms of kinetic energy or potential energy can be utilised in hydro power plant.
- Hydro electric power plant provides 25% of the total electricity world's requirement.
- In Norway, 99% is provided by hydro power plant.
- In India, huge capability is there for hydro power plant due to mountains and large rivers.
- In 2008, Three Gorges Dam in China was built. This is the largest power plant at current date, generating 22,500 MW, adding to China's installed hydroelectric capacity of 196.79 GW.

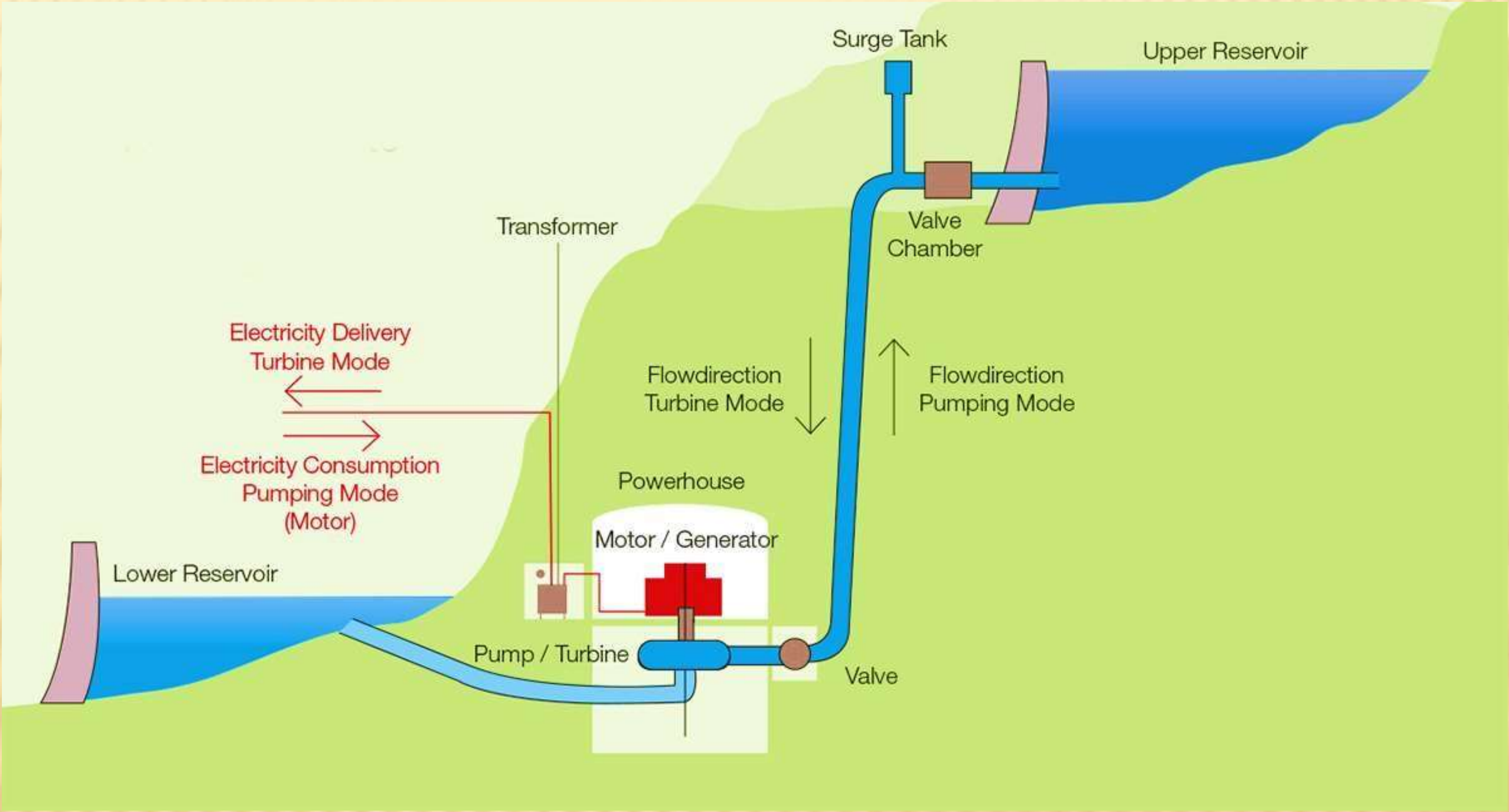
The Three Gorges Dam

Classification of Hydro Power Plant

- **As per Availability of water**

1. **Run-off river power plant without pond** (Storage)
   – Not desirable, but used in remote location
2. **Run-off river power plant with pond**
   –with small dam to store water, excess water is stored for week or months only
3. **Storage Reservoir Plant**
   – Water is stored for electricity production through out a year
4. **Pump Storage Plant**
   –excess electricity is utilized for storing fluid to higher level and when needed this water is released to fulfil peak load requirement

Pump Storage Power Plant



Classification of Hydro Power Plant

- **As per Head Available**
  1. Low Head Plant (up to 30 meter)
  2. Medium Head Plant (30 – 100 meter)
  3. High Head Plant (more than 100 meter)

- **As per Electricity Load Connection**
  1. Base Load Plant
  2. Peak Load Plant

Classification of Hydro Power Plant

- **As per Plant Capacity**
  1. MicroHydel Plant (up to 5 MW)
  2. Medium Capacity Plant (5 – 100 MW)
  3. High Capacity Plant (more than 100 MW)
  4. Super Plant (more than 1000 MW)

- **As per Location of Plant**
  1. Surface Power Plant
  2. Underground Power Plant

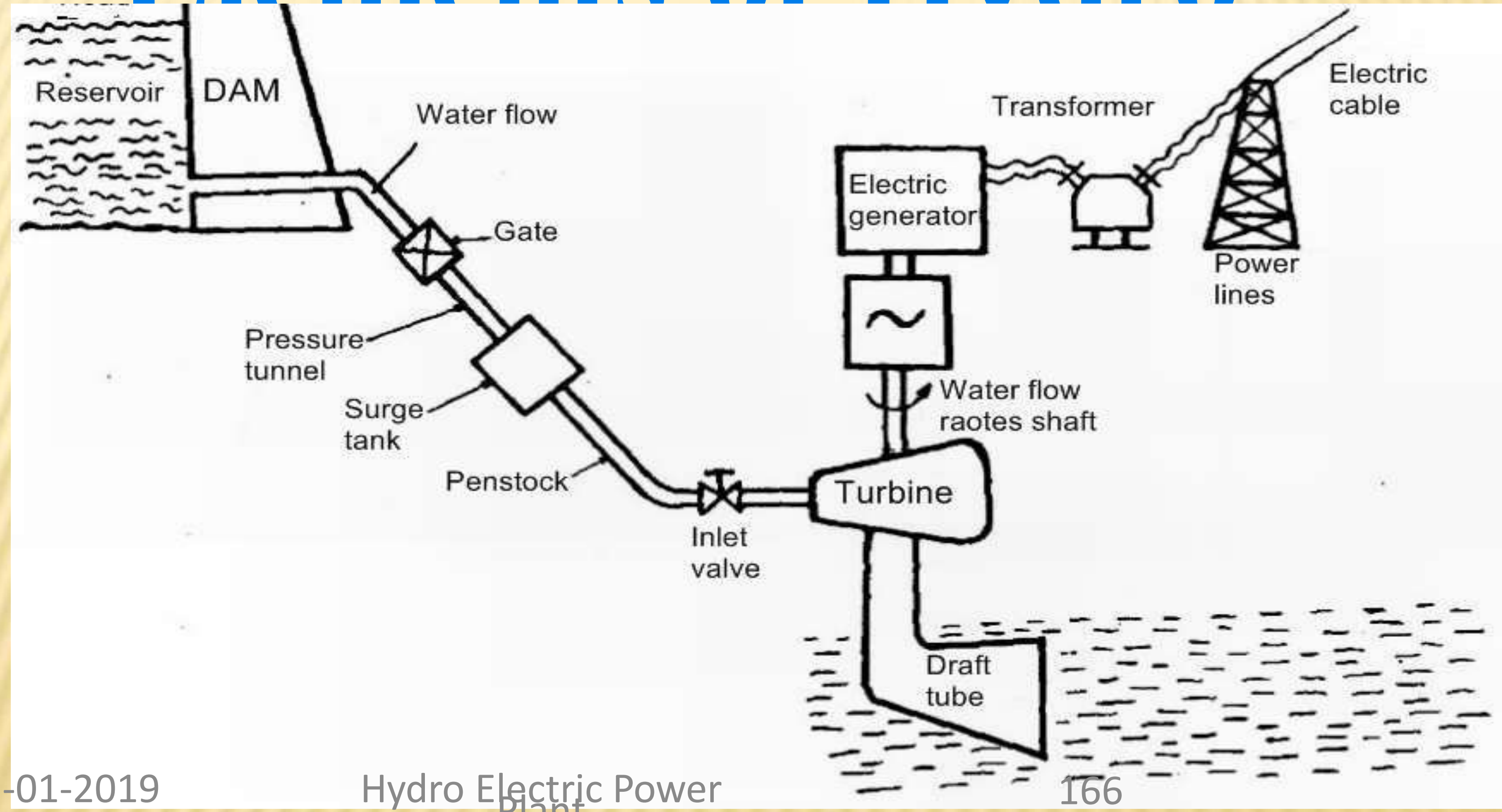
- **As per Turbine Specific Speed**
  1. High Specific Speed Plant (Ns >340)
  2. Medium Specific Speed Plant (50 < Ns < 340)
  3. Low Specific Speed Plant (Ns<50)

Multi Purpose Hydro Project

- Contrasted to a single-purpose project that serves only one purpose, a multipurpose project is designed for any combinations of two or more from below mentioned functions.

1. Irrigation
2. Hydro Electric power
3. Flood control
4. Municipal and Industrial water use
5. Navigation
6. Water Quality Control
7. Recreation
8. Tourism
9. Fish and wildlife benefits

Elements of Hydro



Elements of Hydro Electric Power Plant

- **Reservoir –** To store water in huge amount for running turbine throughout year.
- **Dam –** To act as resistance to flow of water and to increase head of water available.
- **Trace Rack –** A metal net used to remove garbage, fish or any marine creature from entering the turbine.
- **Fore Bay –** A temporary storage space for water acts as natural surge tank. Controls flow of water during sudden variations.

Elements of Hydro Electric Power Plant

- **Surge Tank –** A tank constructed near turbine to avoid water hammering and cavitation inside penstock is known as surge tank.

- **Penstock –** A pipeline connecting turbine to water body is known as penstock. Gates are provided at the entrance of penstock for maintenance work requirement, if any.

- **Spill way –** A curvature portion provided at the end of exit of water to avoid damage to dam due to high velocity water is known as spill way.

Elements of Hydro Electric Power Plant

- **Power House –** A structure constructed enclosing electricity generating devices like turbine, generator, etc.

- **Prime mover –** A device converting hydraulic energy to mechanical energy is known as prime mover. Turbines like Francis, Kaplan and Pelton wheel are used as prime mover in Hydro electric Power plant

- **Draft Tube -** draft tube at the end of the turbine increases the pressure of the exiting fluid at the expense of its velocity. This means that the turbine can reduce pressure to a higher extent without fear of back flow from the tail race.

Advantages of Hydro Electric Power Plant

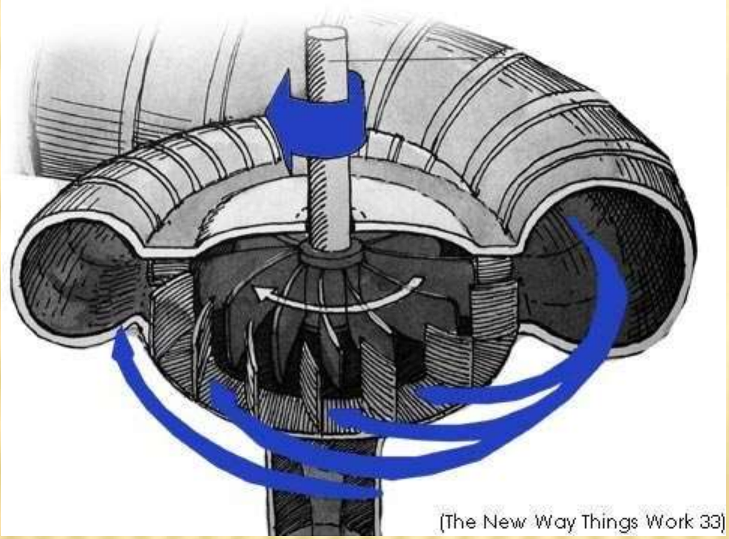
- Operating cost is low.
- Working fluid is water so it is known as clean fuel power plant which don’t produces any air pollution elements.
- Can work as per Current electricity demand.
- Start and stop time is less.
- Can last up to 50 years of lifetime.
- Can be used as base load as well as peak load plant.

Disadvantages of Hydro Electric Power Plant

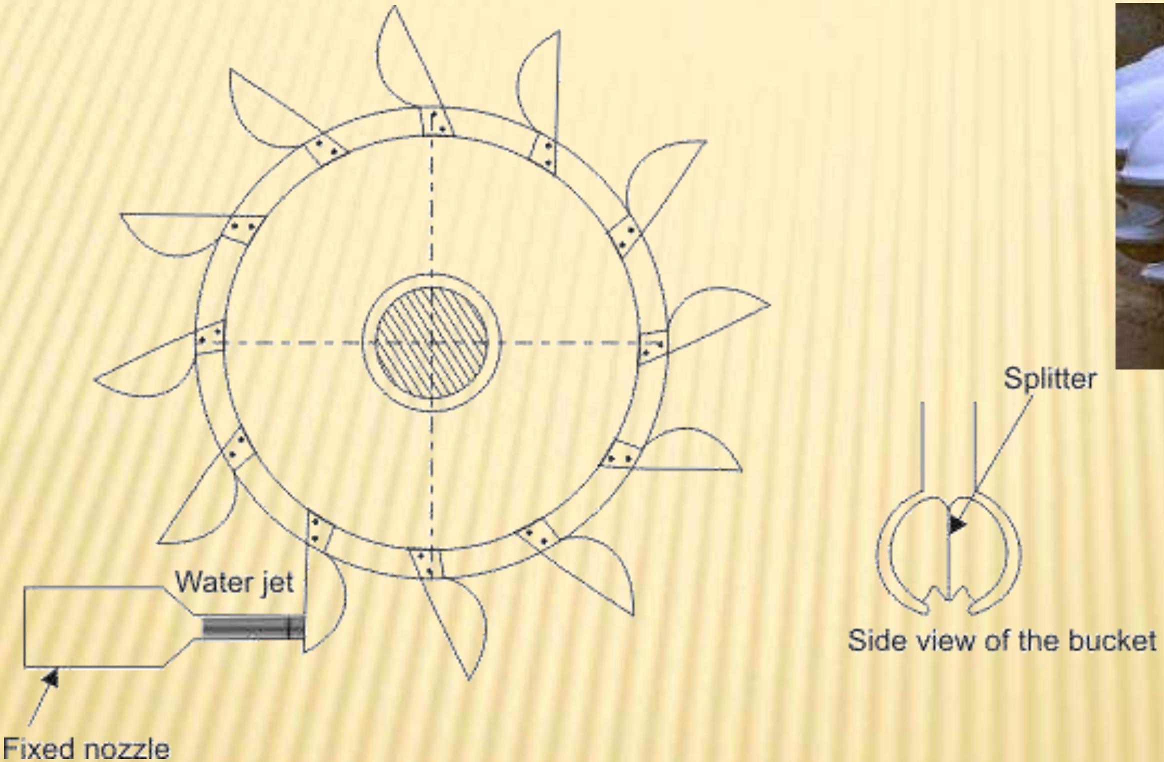
- Highly dependable on availability of water.
- Can cause environmental damage.
- Initial cost is much higher.
- May cause draught.
- Set up time is higher.
- Load center is far from plant so transmission loss is high.
- Needs large amount of space.

Types of Turbines in Hydro Electric Power Plant

1. Pelton Wheel turbine
2. Francis turbine
3. Kaplan turbine



Pelton Wheel Turbine

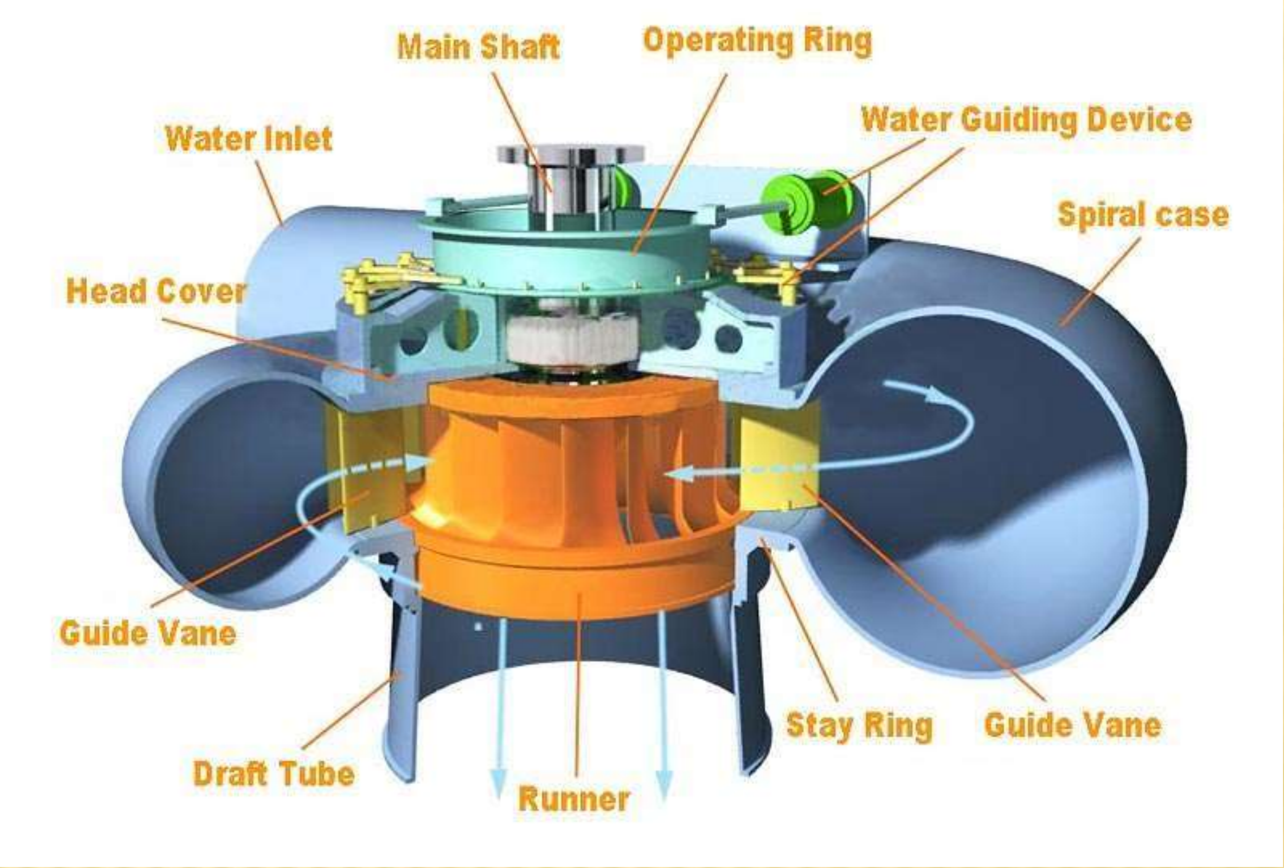


How It Works???

Pelton Wheel Turbine

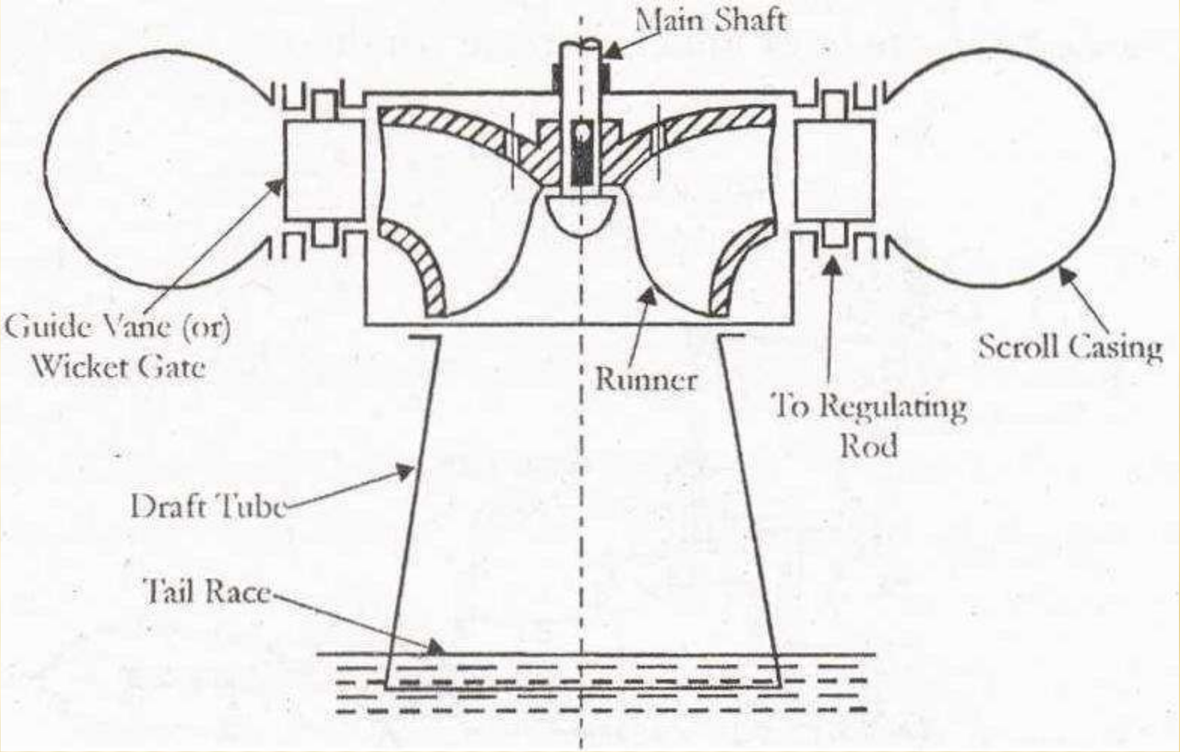
- Impulse turbine
- Set of nozzles and runner with bucket shaped blades
- Nozzles converts fluid energy into kinetic energy by creating fluid jet
- This high velocity fluid strikes with blades (Runner) and creates mechanical energy
- Maximum power and efficiency are achieved when the velocity of the water jet is twice the velocity of the rotating buckets
- Jets are directed in reverse direction by blades so as to get maximum utilization of momentum transfer
- Pelton wheels are the preferred turbine for hydro-power where the available water source has relatively high hydraulic head at low flow rates

Francis Turbine



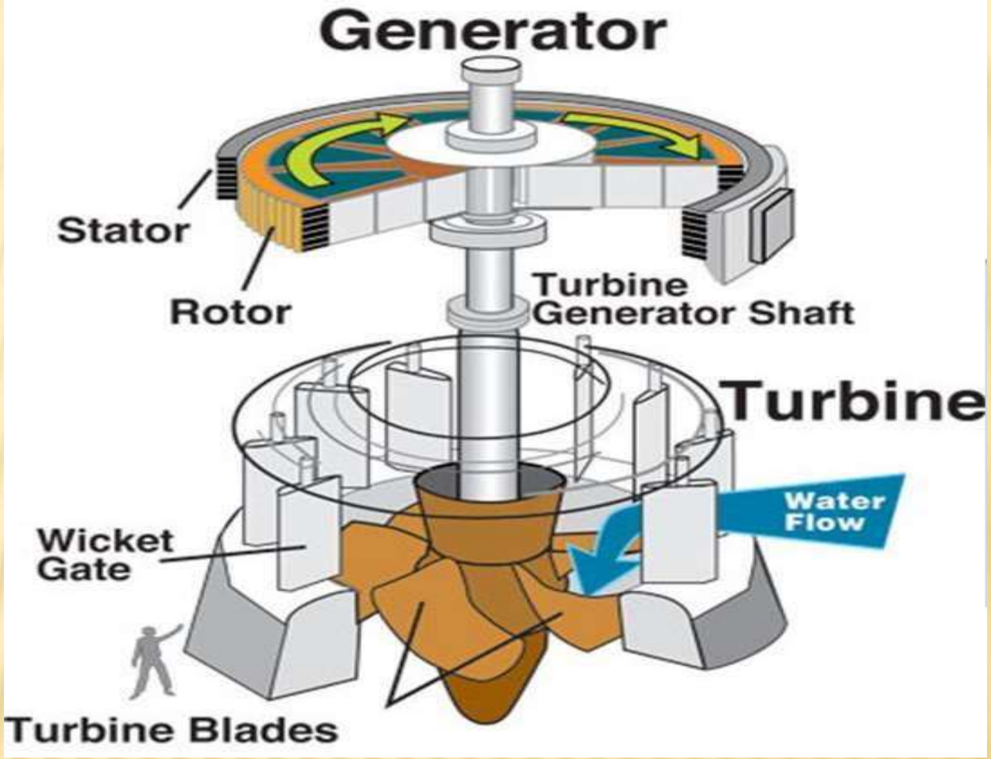
How it works?

Francis Turbine

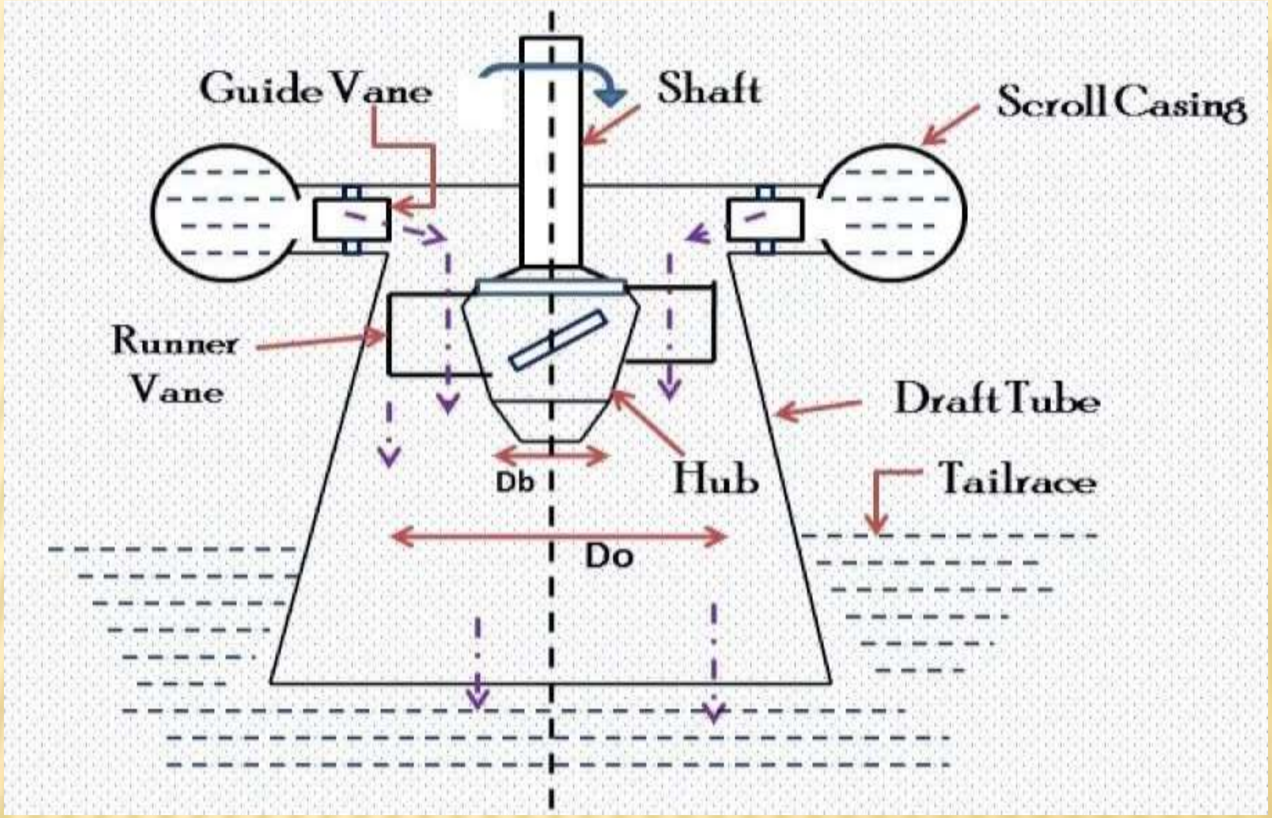


- It is an inward-flow reaction turbine that combines radial and axial flow concepts.
- A part of the energy is given up by the fluid because of pressure changes occurring in the blades of the turbine, quantified by the expression of degree of reaction
- Major components are spiral casing, guide and stay vanes, runner blades and draft tube
- Francis turbines may be designed for a wide range of heads and flows. This, along with their high efficiency, has made them the most widely used turbine in the world. Francis type units cover a head range from 40 to 600 m

Kaplan Turbine



Kaplan Turbine



Kaplan Turbine

- The Kaplan turbine is a propeller-type water turbine which has adjustable blades.
- The Kaplan turbine is an inward flow reaction turbine.
- Water is directed tangentially through the wicket gate and spirals on to a propeller shaped runner, causing it to spin.
- The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy.
- They are used where low head and high flow rate of fluid is available.

Auxiliaries of Hydro electric power plant

- Lubrication system for generator and turbine bearings.
- Drainage pumps for removing leakage water.
- Air compressors for governor, brakes and other system.
- Cooling water system for generator.
- Fire detection and extinguishing system
- Intake gate
- Level monitoring
- Heating, ventilation and AC

Governing of Hydro Electric Power Plant

- Use of governing system is to regulate the flow of water according to current load requirement.
- As per change in demand load, flow rate must be changed as RPM should be constant, so governing system should check the requirement of power and automatically controls the flow rate of power plant.

Nuclear (Atomic) Power Plant

By

Md. Jakirul Islam

Nuclear (Atomic) Power Plant

θ Working principle :

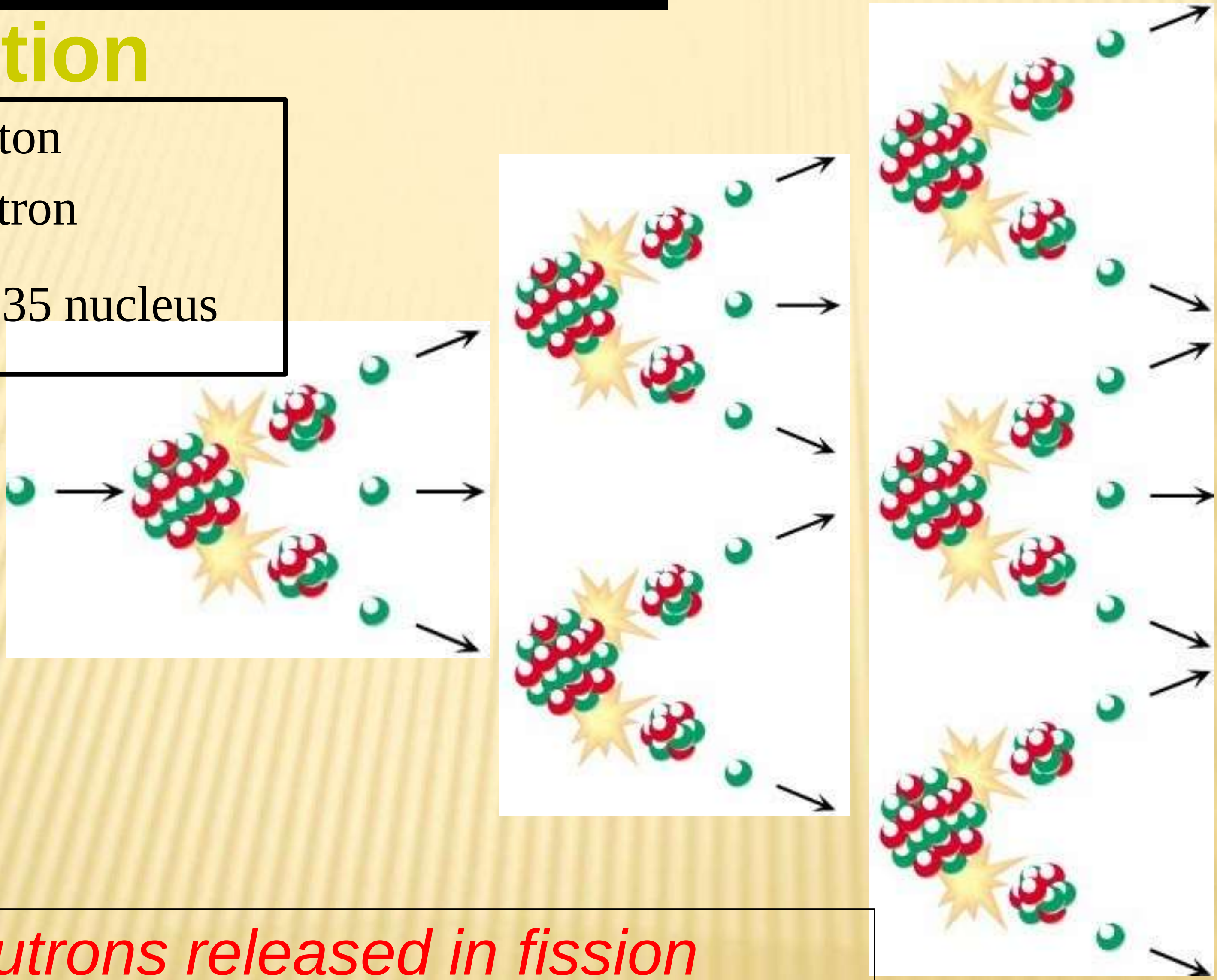
ϖ A nuclear power plant works in a similar way as a thermal power plant. The difference between the two is in the fuel they use to heat the water in the boiler(steam generator).

ϖ Inside a nuclear power station, energy is released by nuclear fission in the core of the reactor.

ϖ 1 kg of Uranium U^{235} can produce as much energy as the burning of 4500 tonnes of high grade variety of coal or 2000 tonnes of oil.

Nuclear chain reaction

- proton
- neutron
- U-235 nucleus



- *Neutrons released in fission* trigger the fissions of other nuclei

Nuclear (Atomic) Power Plant…

θ Chain Reaction…

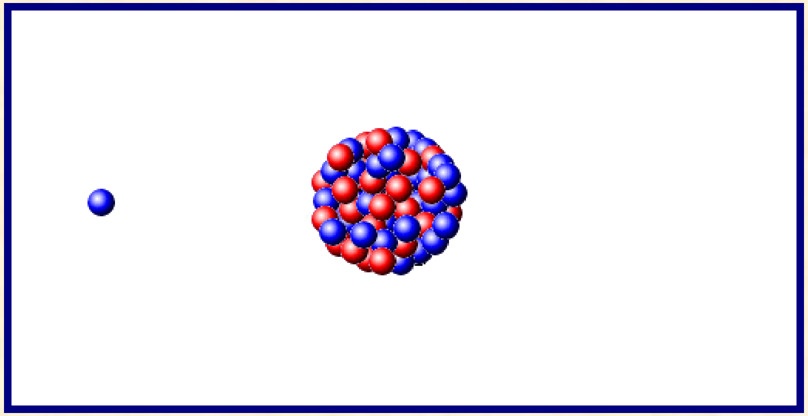
¬ Uranium exists as an isotope in the form of U^{235} which is unstable.

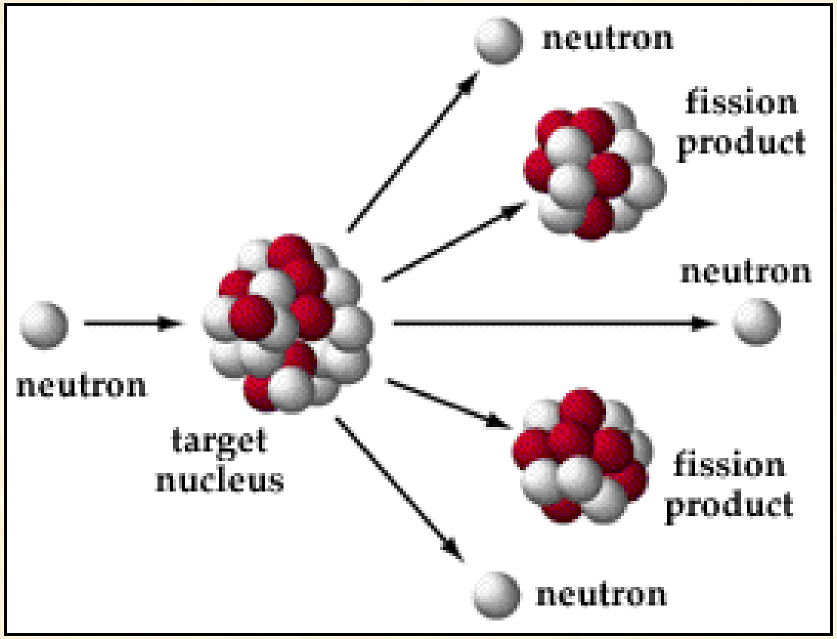
¬ When the nucleus of an atom of Uranium is split, the neutrons released hit other atoms and split them in turn. More energy is

released each time another atom splits. This is called a chain reaction.

Nuclear (Atomic) Power Plant…

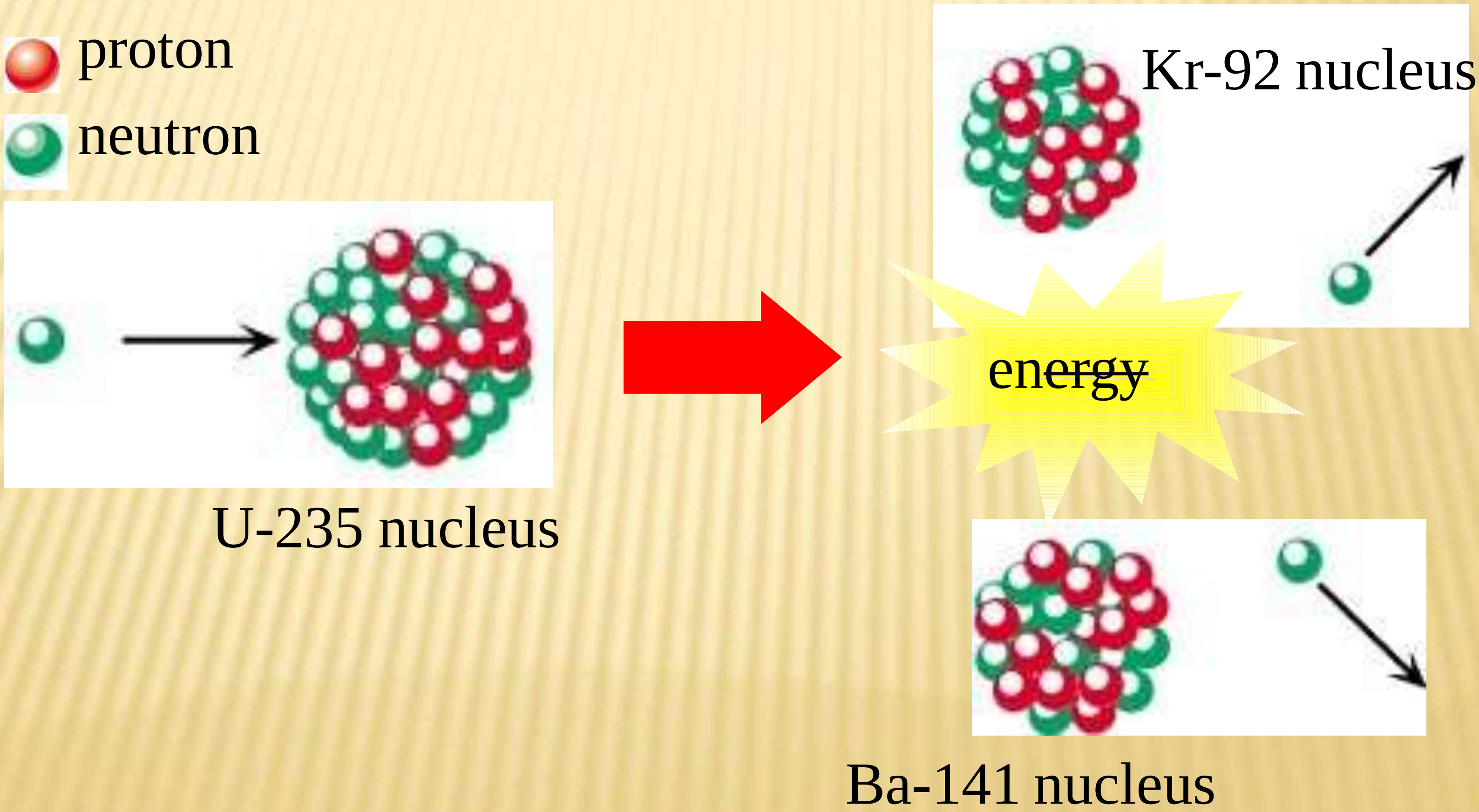
- Nuclear fission:





Nuclear fission

- Nuclear fission: heavy nuclei split into two smaller parts in order to become more stable



Nuclear Fission…

- It is a process of splitting up of nucleus of fissionable material like uranium into two or more fragments with release of enormous amount of energy.
- The nucleus of U^{235} is bombarded with high energy neutrons

$$U^{235} + {}_0n^1 \longrightarrow Ba^{141} + Kr^{92} + 2.5\,{}_0n^1 + 200 \text{ MeV energy.}$$

- The neutrons produced are very fast and can be made to fission other nuclei of U^{235}, thus setting up a chain reaction.
- Out of 2.5 neutrons released one neutron is used to sustain the chain reaction.

$1 \text{ eV} = 1.6 \times 10^{-19}$ joule.

$1 \text{ MeV} = 10^{6} \text{ eV}$

Nuclear (Atomic) Power Plant…

Nuclear fission…

- U^{235} splits into two fragments (Ba^{141} & K^{92}) of approximately equal size.
- About 2.5 neutrons are released. 1 neutron is used to sustain the chain reaction. 0.9 neutrons is absorbed by U^{238} and becomes Pu^{239}. The remaining 0.6 neutrons escapes from the reactor.
- The neutrons produced move at a very high velocity of 1.5×10^{7} m/sec and fission other nucleus of U^{235}. Thus fission process and release of neutrons take place continuously throughout the remaining material.
- A large amount of energy(200 Million electron volts, Mev) is produced.

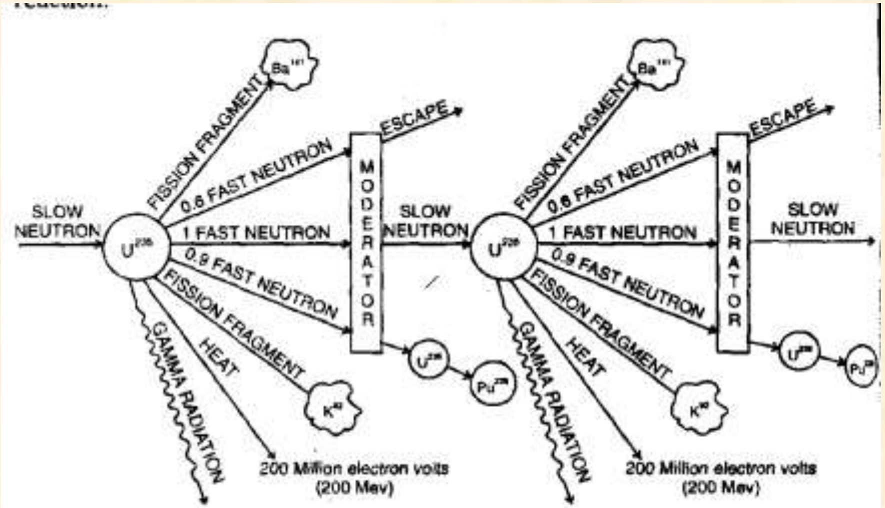
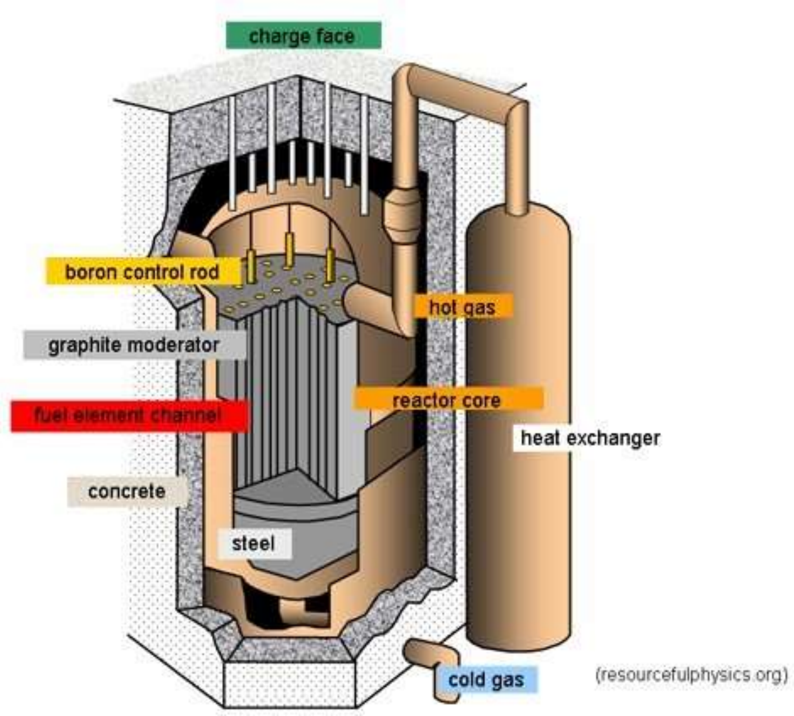


Fig. 3.7: CONTROLLED CHAIN REACTION IN A NUCLEAR REACTOR

- Note : Moderators are provided to slow down the neutrons from the high velocities but not to absorb them.

Nuclear (Atomic) Power Plant…

- Principal parts of a nuclear reactor:



Core : Here the nuclear fission process takes place.

Moderator : This reduces the speed of fast moving neutrons. Most moderators are graphite, water or heavy water.

Nuclear (Atomic) Power Plant…

θ Principal parts of a nuclear reactor…

Control rods :

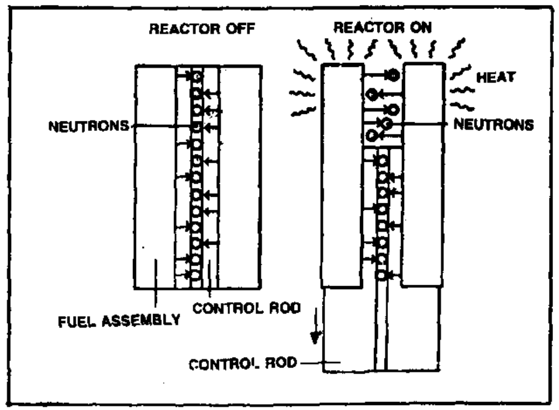


Fig. 3.8: CONTROL RODS

Control rods limit the number of fuel atoms that can split. They are made of boron or cadmium which absorbs neutrons

Coolant : They carry the intense heat generated. Water is used as a coolant, some reactors use liquid sodium as a coolant.

Fuel : The fuel used for nuclear fission is U235 isotope.

Radiation shield : To protect the people working from radiation and (thermal shielding) radiation fragments.

Uncontrolled nuclear reaction

The chain reaction is not slowed down

the rate of fission increases rapidly

a huge amount of energy is released very quickly

Nuclear bomb

Nuclear reactors

- Nuclear power plant: Rate of fission is controlled by artificial means to generate electricity

The Daya Bay Nuclear Power Station

Nuclear (Atomic) Power Plant…

θ Types of Nuclear power plant:

Main two types are :

* Pressurised Water Reactor (PWR)
* Boiling Water Reactor (BWR)

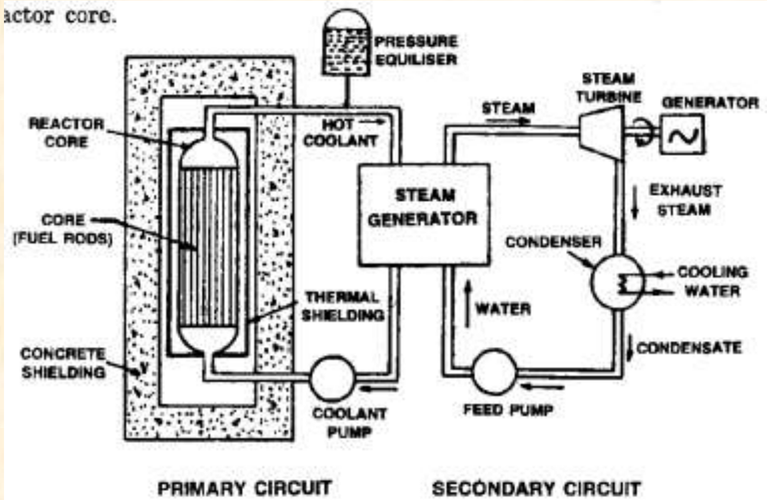


Fig. 3.9: PRESSURISED WATER REACTOR PLANT

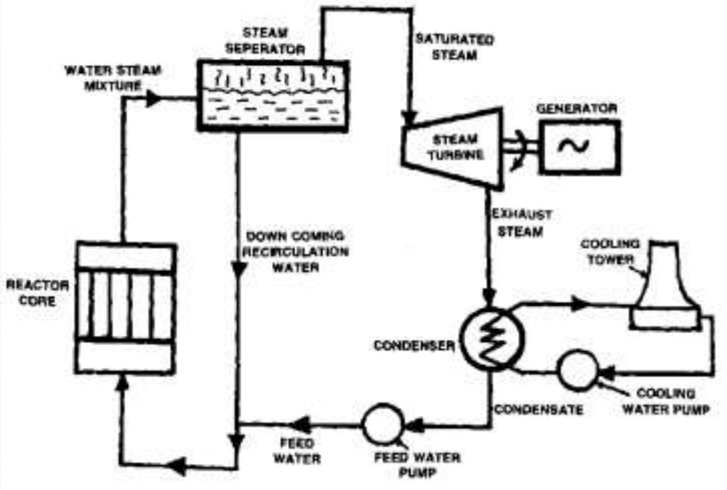


Fig. 3.10: BOILING WATER REACTOR PLANT

Nuclear (Atomic) Power Plant…

- Pressurised Water Reactor (PWR)
  - Heat is produced in the reactor due to nuclear fission and there is a chain reaction.
  - The heat generated in the reactor is carried away by the coolant (water or heavy water) circulated through the core.
  - The purpose of the pressure equalizer is to maintain a constant pressure of 14 MN/m[2]. This enables water to carry more heat from the reactor.
  - The purpose of the coolant pump is to pump coolant water under pressure into the reactor core.

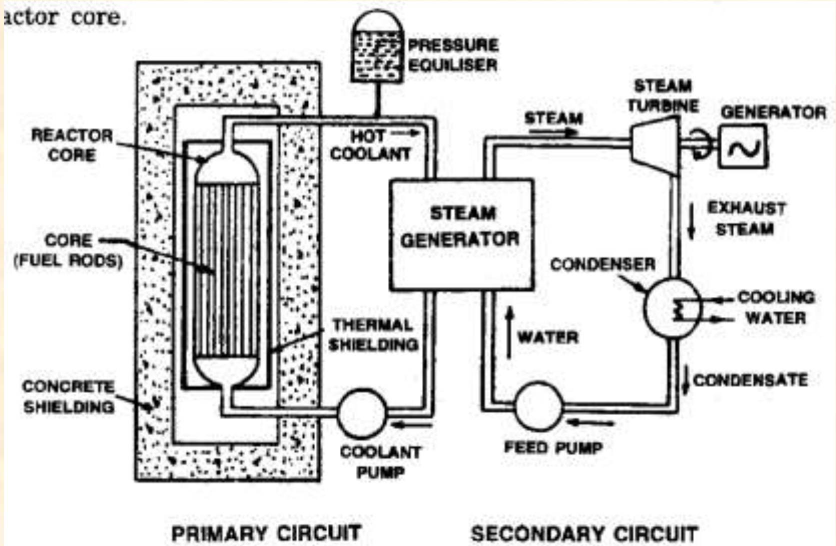
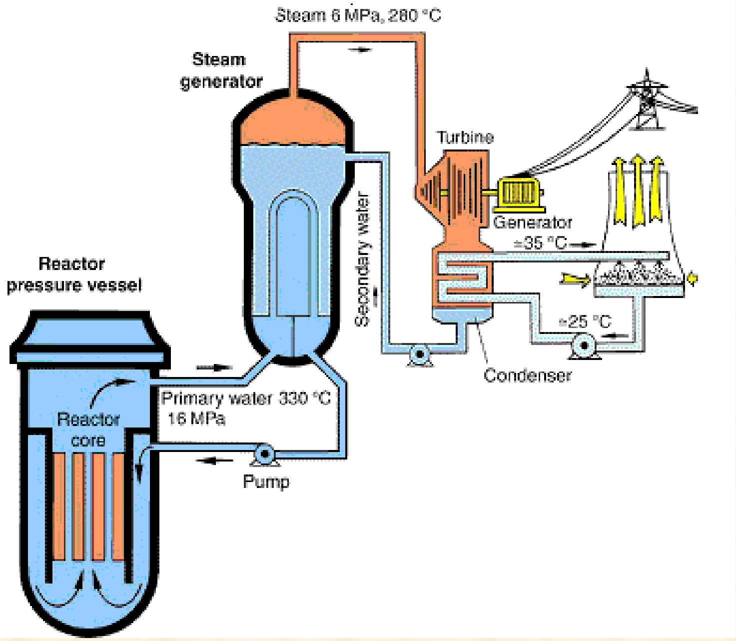


Fig. 3.9: PRESSURISED WATER REACTOR PLANT



Nuclear (Atomic) Power Plant…

- Pressurised Water Reactor (PWR)

- The steam generator is a heat exchanger where the heat from the coolant is transferred on to the water that circulates through the steam generator. As the water passes through the steam generator

  it gets converted into steam.
- The steam produced in the steam generator is sent to the turbine. The turbine blades rotate.
- The turbine shaft is coupled to a generator and electricity is produced.
- After the steam performing the work on the turbine blades by expansion, it comes out of the turbine as wet steam. This is converted back into water by circulating

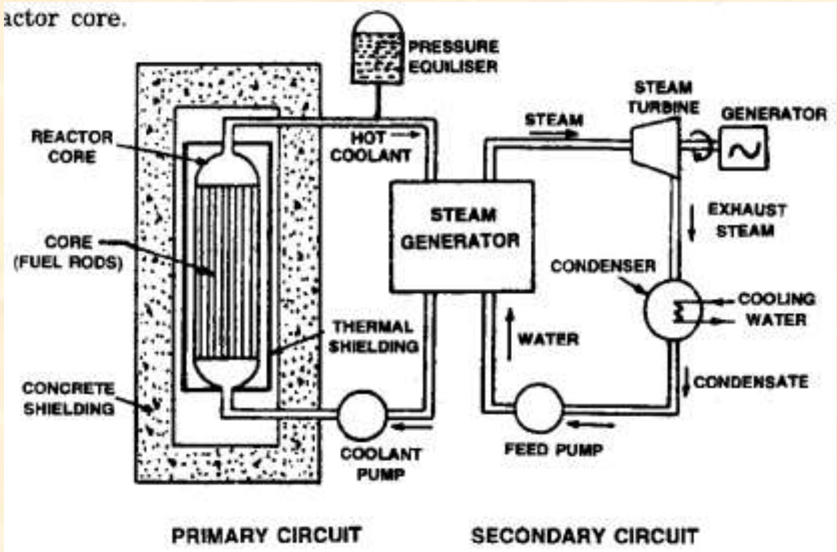
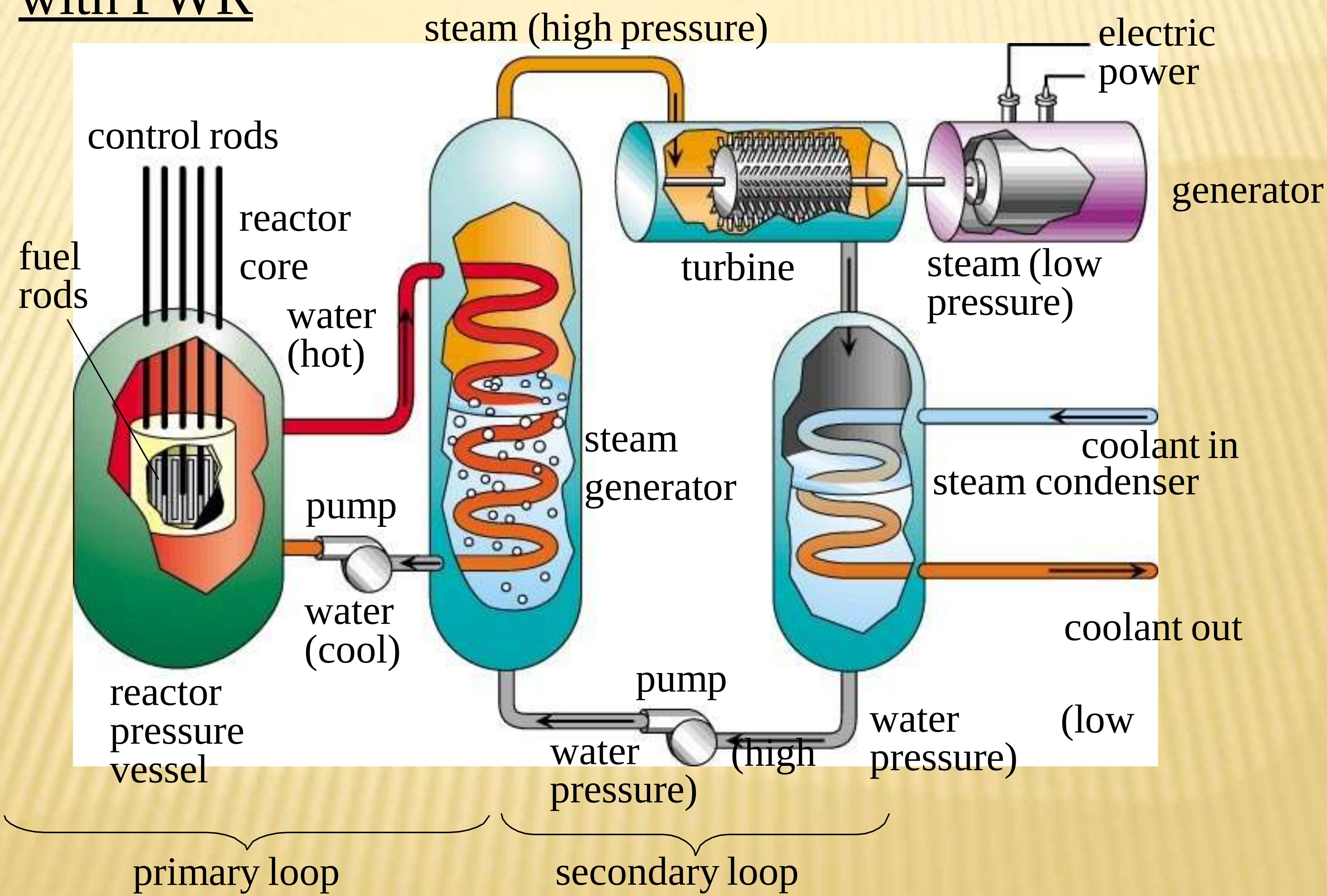


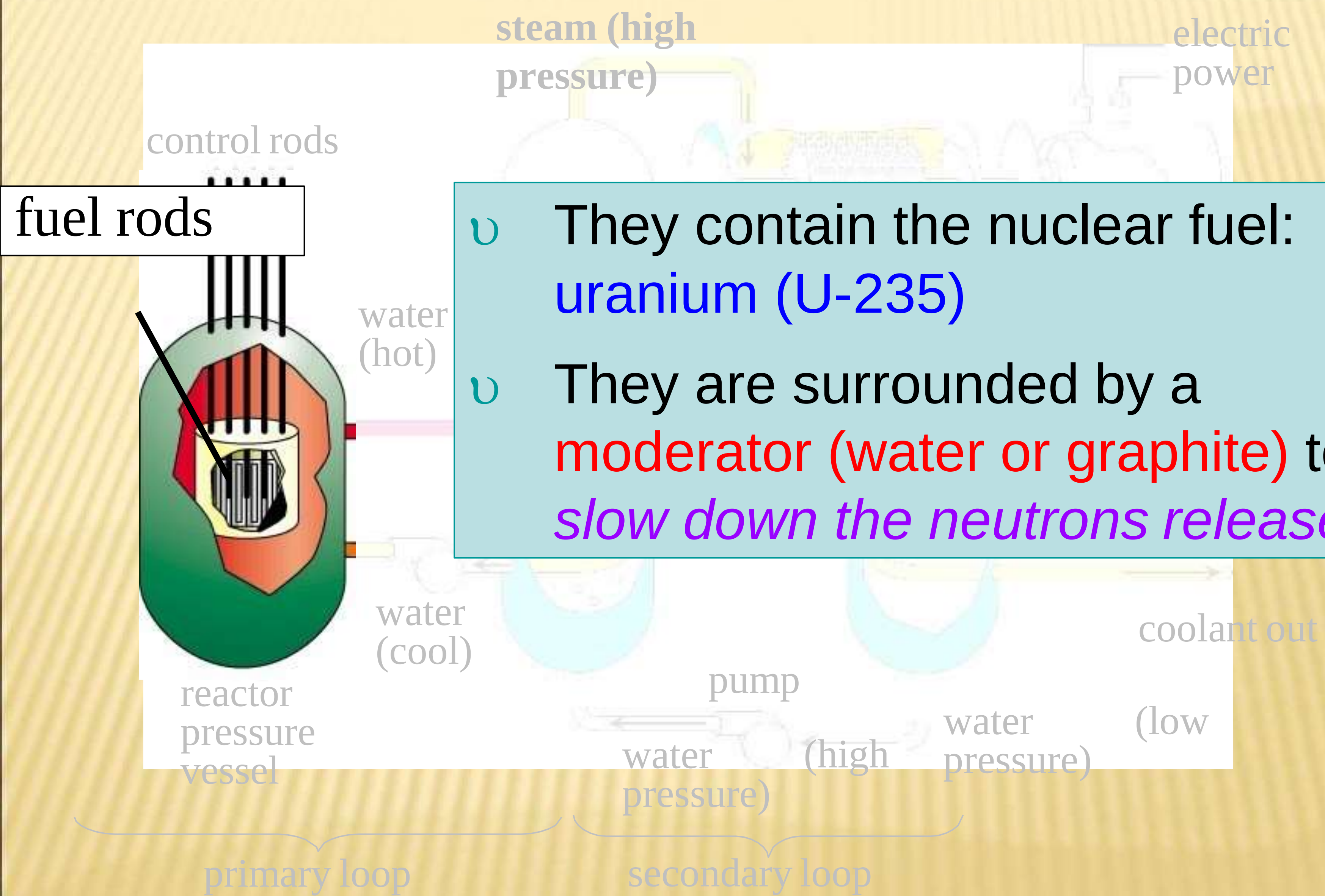
Fig. 3.9: PRESSURISED WATER REACTOR PLANT

- The feed pump pumps back the condensed water into the steam generator.

Schematic diagram of a nuclear power plant

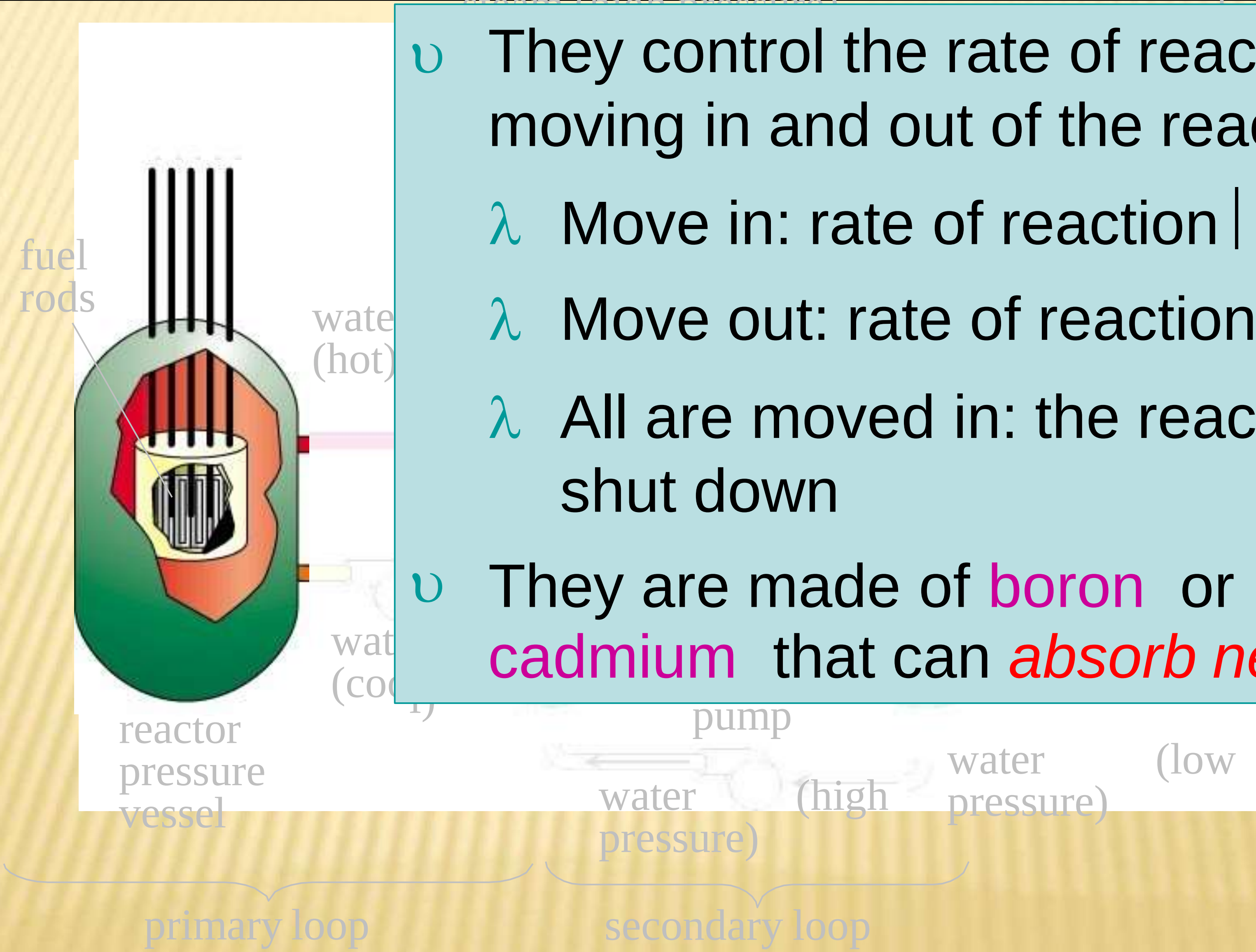
with PWR



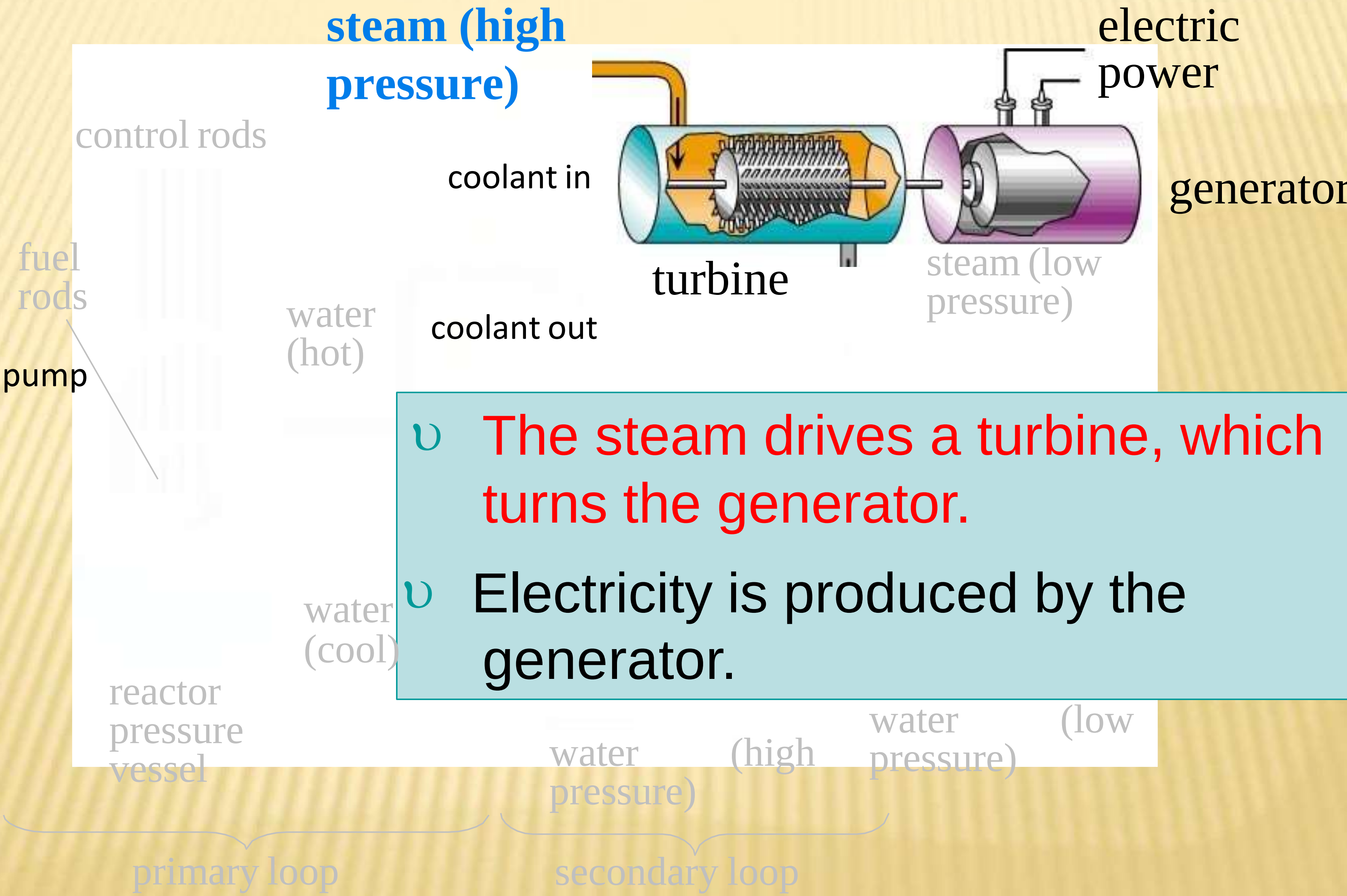


- They contain the nuclear fuel: uranium (U-235)
- They are surrounded by a moderator (water or graphite) to *slow down the neutrons released.*

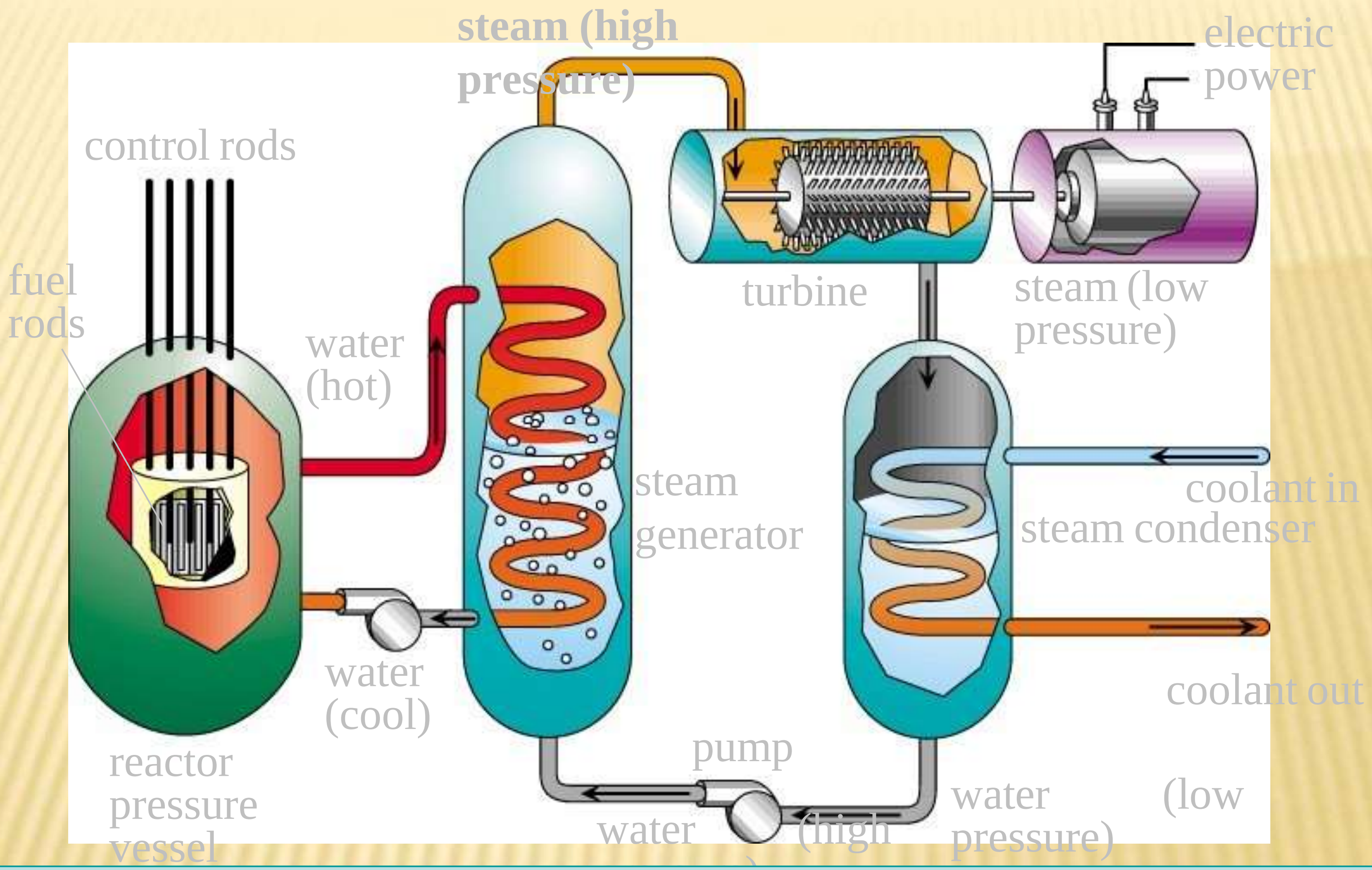
control rods



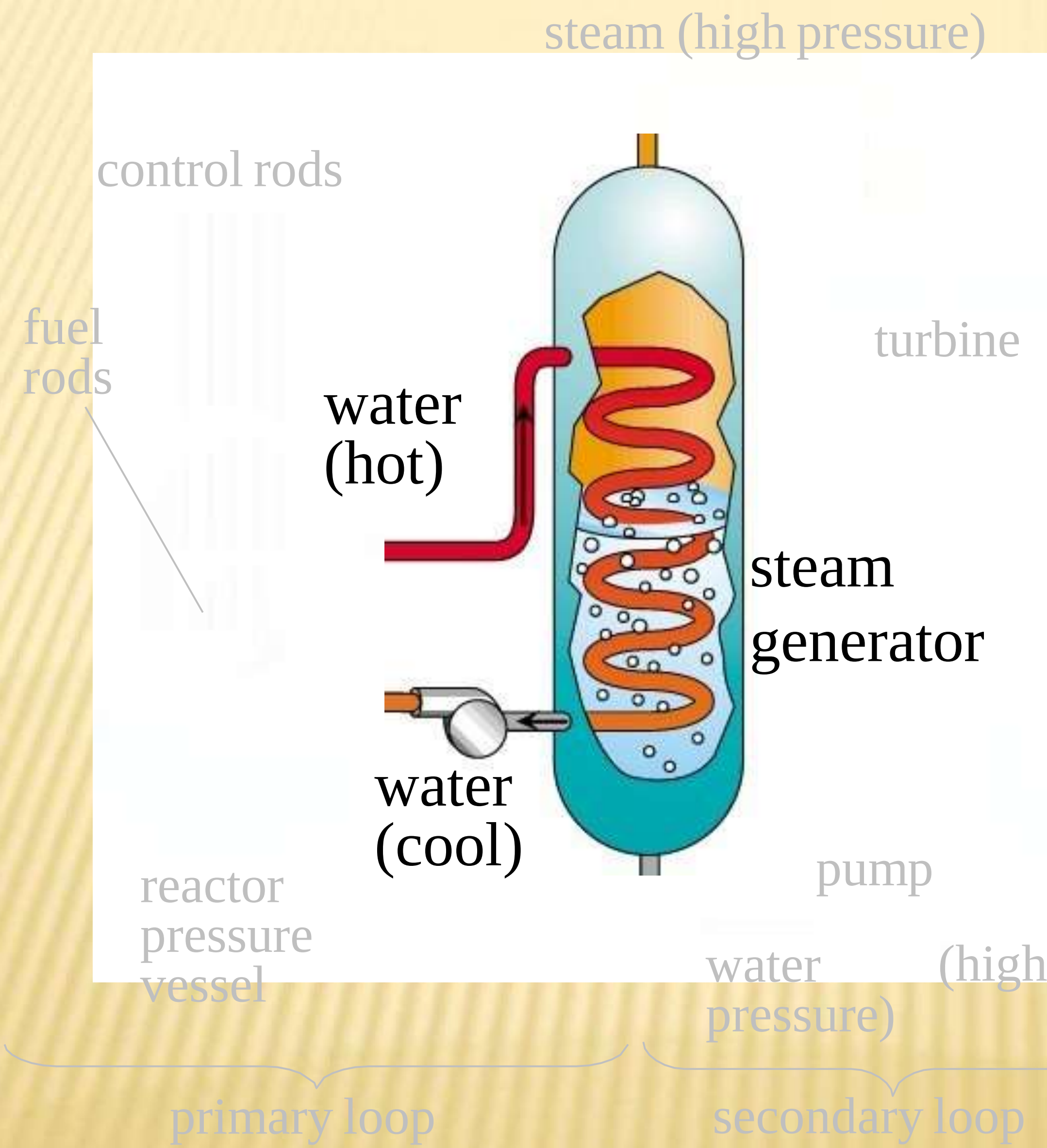
- They control the rate of reaction by moving in and out of the reactor.
  - Move in: rate of reaction ⏐
  - Move out: rate of reaction ⎡
  - All are moved in: the reactor is shut down
- They are made of boron or cadmium that can *absorb neutrons.*



- The steam drives a turbine, which turns the generator.
- Electricity is produced by the generator.



- *Two separate water systems* are used to avoid radioactive substances to reach the turbine.



- The energy released in fissions heats up the water around the reactor.
- The water in the secondary loop is boiled to steam.

Nuclear (Atomic) Power Plant…

θ **Boiling Water Reactor (BWR)**

¬The water is circulated through the reactor where it converts to water steam mixture.

¬ The steam gets collected above the steam separator.

¬ This steam is expanded in the turbine which turns the turbine shaft.

¬The expanded steam coming out of the turbine is condensed and is pumped back as feed water by the feed water pump into the reactor core.

¬Also the down coming recirculation water from the steam separator is fed back to the reactor core.

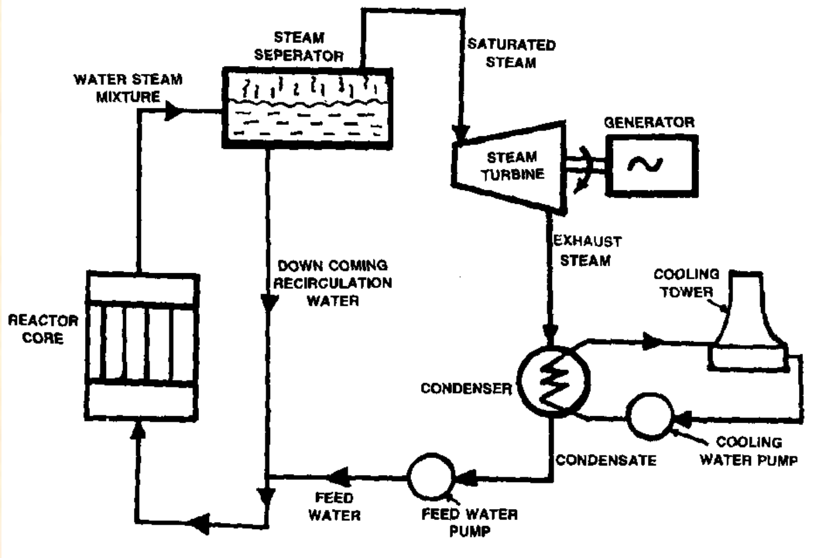


Fig. 3.10: BOILING WATER REACTOR PLANT

Nuclear (Atomic) Power Plant…

Steam power plant means any plant that uses steam to produce electricity.

E.g. Thermal and Nuclear power plants.

Nuclear (Atomic) Power Plant…

θ Advantages of Nuclear power plant:

- ♣ Space required is less when compared with other power plants.
- ♣ Nuclear power plant is the only source which can meet the increasing demand of electricity at a reasonable cost.
- ♣ A nuclear power plant uses much less fuel than a fossil-fuel plant.
  1 metric tonne of uranium fuel = 3 million metric tonnes of coal = 12 million barrels of oil.

θ Disadvantages of Nuclear power plant:

- o Radioactive wastes must be disposed carefully, otherwise it will adversely affect the health of workers and the environment as a whole.
- o Maintenance cost of the plant is high.

Nuclear waste

- They are highly radioactive
- Many of them have very long half-lives.

Radioactive waste must be stored carefully.

Low level radioactive waste

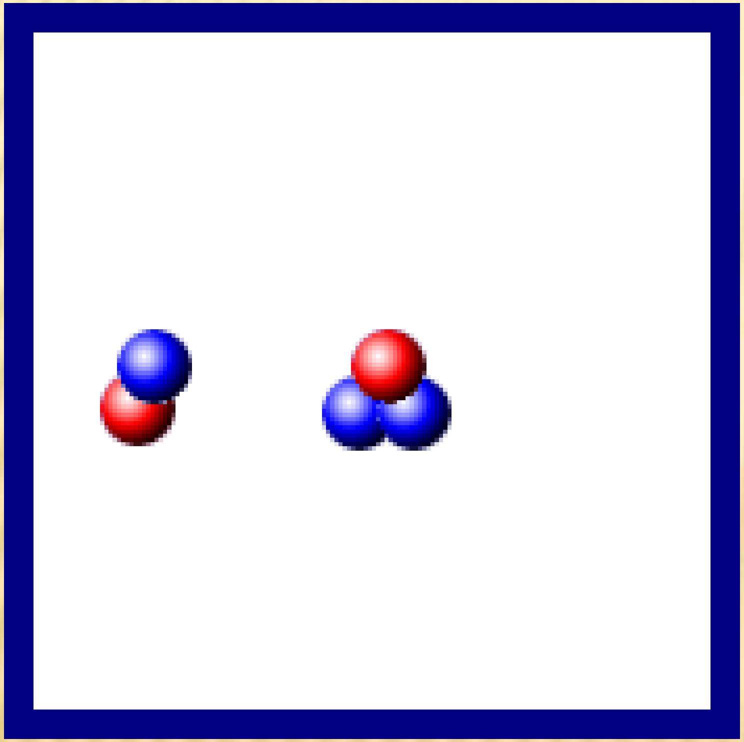
- cooling water pipes, radiation suits, etc.
- stored in storage facilities
- radioactivity will fall to a safe level after 10 to 50 years.

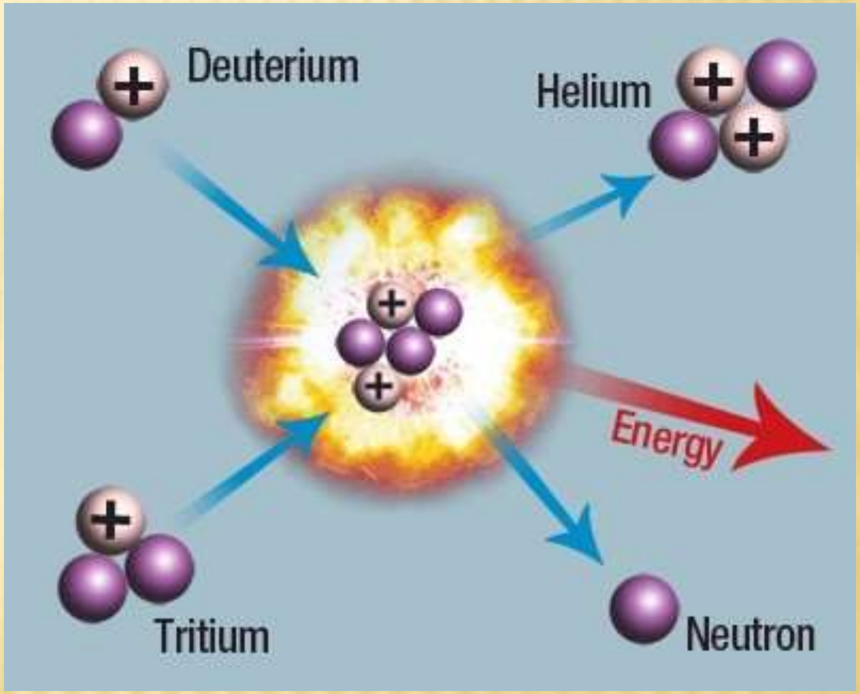
High level radioactive waste

- used nuclear fuel
- highly radioactive
- embedded in concrete and stored deep underground for several thousand years

Nuclear fusion

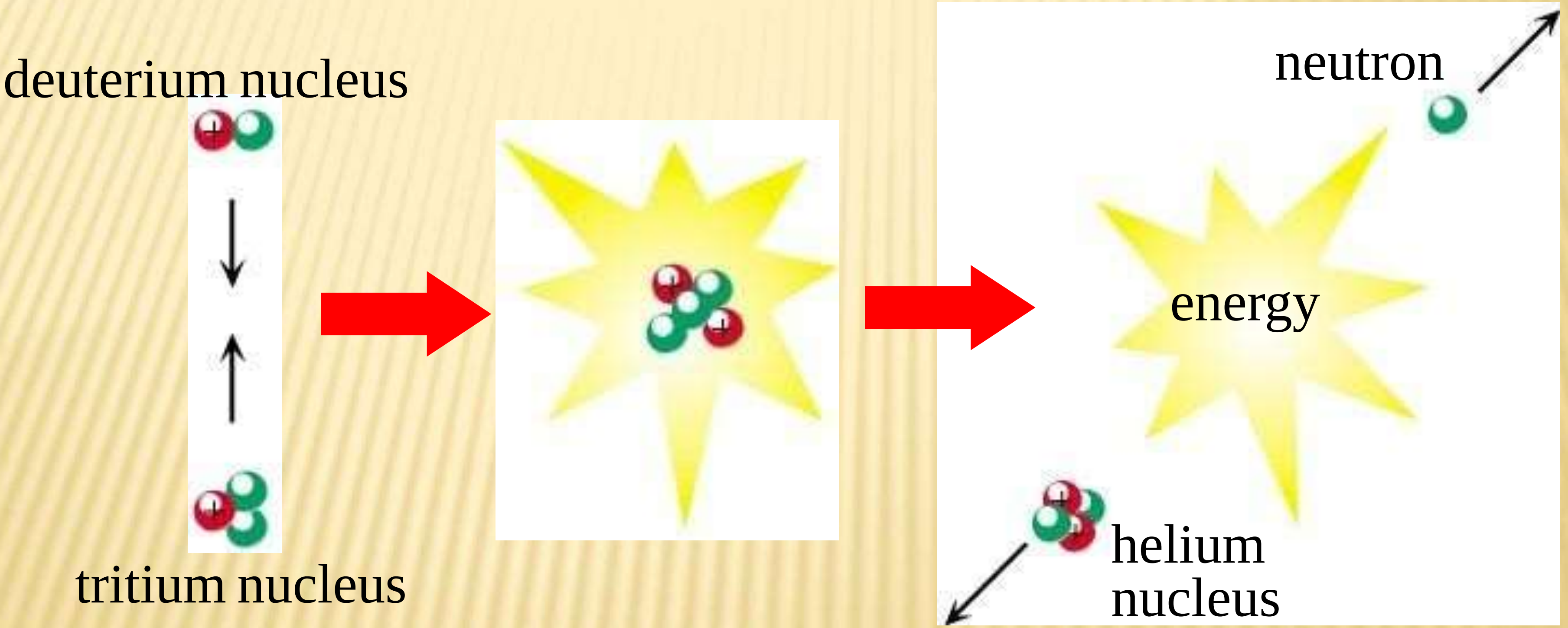
- Nuclear fusion: light nuclei fuse together to form a heavier nucleus

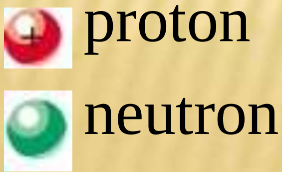




Nuclear fusion…

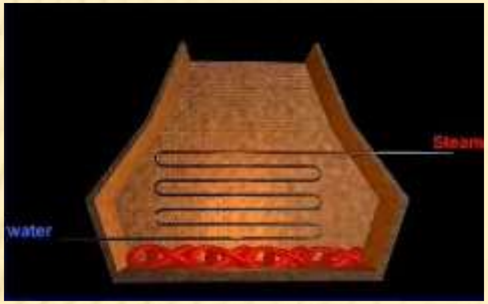
- Nuclear fusion: light nuclei fuse together to form a heavier nucleus

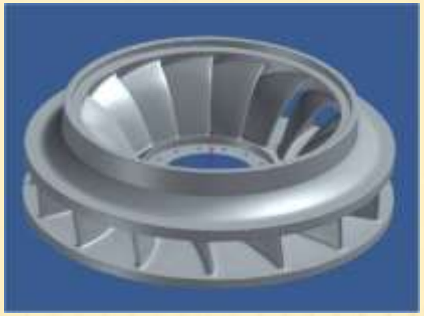


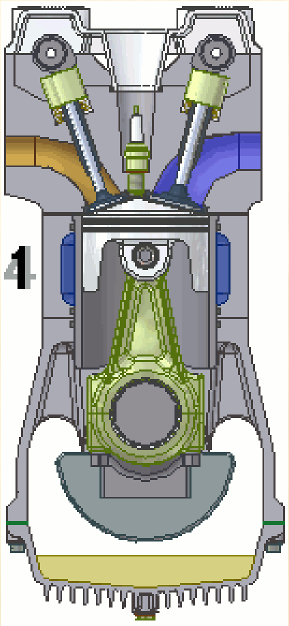


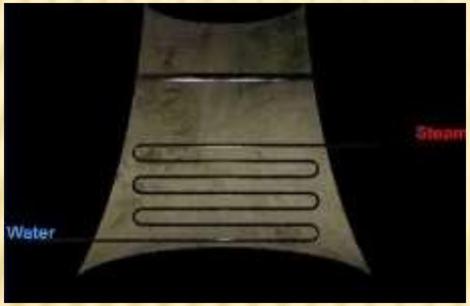
H-2 + H-3 → He-4 + n + energy

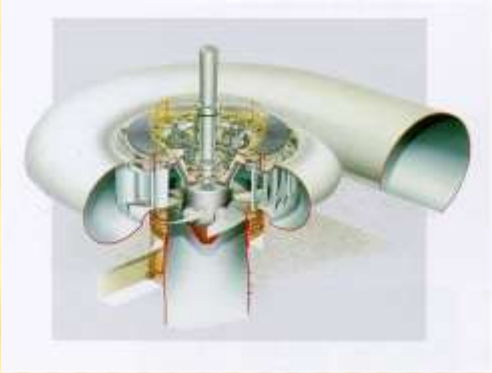
Thank You

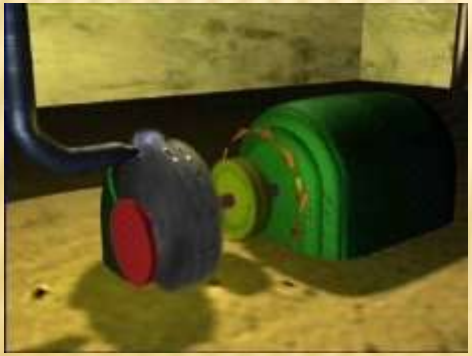












POWER PLANT ECONOMY

- ***The main purpose of design and operation of the plant is to bring the cost of energy produced to minimum.***

TERMS AND DEFINITIONS

Connected Load

The connected load on any system, or part of a system, *is the combined continuous rating of all the receiving apparatus on consumers' premises, which is connected to the system, or part of the system, under consideration.*

Demand

The demand of an installation or system *is the load that is drawn from the source of supply at the receiving terminals averaged over a suitable and specified interval of time*. Demand is expressed in kilowatts (kW), kilovolt-amperes (kVA), amperes (A), or other suitable units.

Maximum Demand or Peak Load

The maximum demand of an installation or system *is the greatest of all the demands that have occurred during a given period*. It is determined by measurement, according to specifications, over a prescribed interval of time.

Demand Factor

The demand factor of any system, or part of a system, is *the ratio of maximum demand of the system, a part of the system, to the total connected load of the system, or of the part of the system, under consideration*. Expressing the definition mathematically,

$$\text{Demand factor} = \frac{\text{Maximum demand}}{\text{Connected load}}$$

Land Factor

The load factor is *the ratio of the average power to the maximum demand*. In each case, the interval of maximum load and the period over which the average is taken should be definitely specified, such as a "half-hour monthly" load factor. The proper interval and period are usually *dependent upon local conditions and upon the purpose for which the load factor is to be used*. Expressing the definition mathematically,

$$\text{Load factor} = \frac{\text{Average load}}{\text{Maximum demand}}$$

Diversity Factor

The diversity factor of any system, or part of a system, *is the ratio of the maximum power demands of the subdivisions of the system, or part of a system, to the maximum demand of the whole system, or part of the system, under consideration, measured at the point of supply*. Expressing the definition mathematically,

$$\text{Diversity factor} = \frac{\text{Sum of individual maximum demands}}{\text{Maximum demand of entire group}}$$

Types of Loads

Residential Load

This type of load includes domestic lights, power needed for domestic appliances such as radios, television, water heaters, refrigerators, electric cookers and small motors for pumping water.

Commercial Load

It includes lighting for shops, advertisements and electrical appliances used in shops and restaurants, etc.

Industrial Load

It consists of load demand of various industries.

Municipal Load

It consists of street lighting, power required for water supply and drainage purposes.

Irrigation Load

This type of load includes electrical power needed for pumps driven by electric motors to supply water to fields.

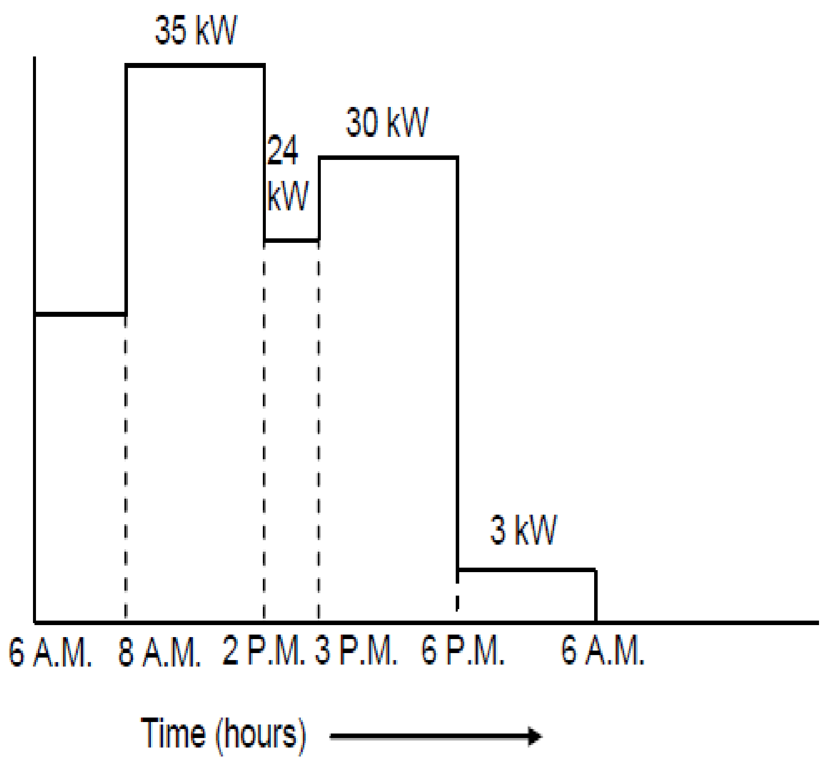
Traction Load

It includes terms, cars, trolley, buses and railways.

Load Duration Curve

A load duration curve represents re-arrangements of all the load elements of chronological load curve in order of descending magnitude. This curve is derived from the chronological load curve.

Figure 7.2 shows a typical daily load curve for a power station. It may be observed that the maximum load on power station is 35 kW from 8 AM to 2 PM. This is plotted in Figure 7.3. Similarly, other loads of the load curve are plotted in *descending order* in the same figure. This is called *load duration curve* (Figure 7.3).



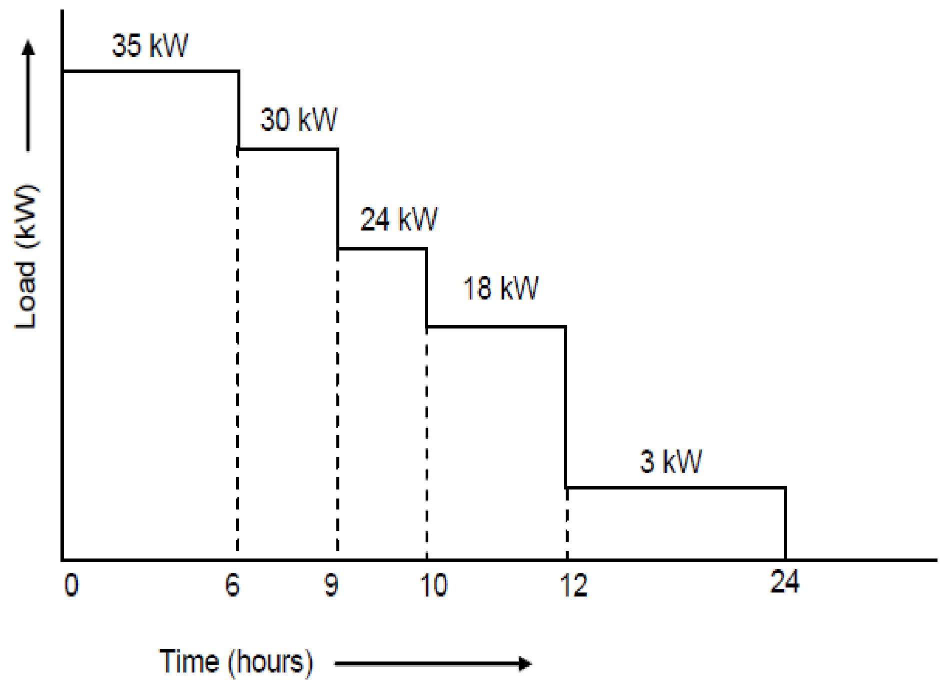


Figure 7.3 : Load Duration Curve

The following points are worth noting :

(a) The area under the load duration curve and the corresponding chronological load curve is equal and represents total energy delivered by the generating station.

(b) Load duration curve gives a clear analysis of generating power economically. Proper selection of base load power plants and peak load power plants becomes easier.

FIXED COST

Initial Cost of the Plant

Initial cost of the plant, which includes :

(a) Land cost

(b) Building cost

(c) Equipment cost

(d) Installation cost

(e) Overhead charges

7.5 OPERATIONAL COST

The elements that make up the operating expenditure of a power plant include the following costs :

(a) Cost of fuels.

(b) Labour cost.

(c) Cost of maintenance and repairs.

(d) Cost of stores (other than fuel).

(e) Supervision.

(f) Taxes.

ECONOMICS IN PLANT SELECTION

- **Selection of the design and size of the equipment is primarily based upon economic consideration and a *plant that gives the lowest unit cost of production is usually chosen.***

- ***The working efficiency is generally higher with larger sizes of plants and with high load factor operation.***

- ***Also, the capital cost per unit installation reduces as the plant is increased in size.***

- ***Bigger size of plant would require greater investment and possibilities of lower than optimum, load factor usually increase with larger size of the plant.***

Steam Power Plants

•*As throttle pressure and temperature are raised the capital cost increases but the cycle efficiency is increased. The advantages of higher pressures and temperatures is generally not apparent below capacity of 10,000 kW unless fuel cost is very high.*

•Heat rates may be improved further through *reheating and regeneration, but again the capital cost of additional equipment has to be balanced against gain in operating cost.*

•The use of heat reclaiming devices, such as air pre-heaters and economisers, has to be considered from the point of economy in the consumption of fuel.

Internal Combustion Engine Plants

•*The efficiency of the engine improves with compression ratio but high pressures necessitate heavier construction of equipment which increases cost.*

•The choice may also have to be made between *four-stroke and two-stroke engines, the former having higher thermal efficiency and the latter lower weight and cost.*

•The cost of the *supercharger may be justified if there is a substantial gain in engine power which may balance the additional supercharger cost.*

Gas Turbine Power Plant

•The cost of the gas turbine power plant increases as the simple plant is modified by inclusion of other equipment such as *intercooler, regenerator, re-heater, etc.*

•*But the gain in thermal efficiency and thereby a reduction in operating cost may justify this additional expense in first cost.*

•As compared with thermal stations an hydro-electric power plant has little operating cost and if sufficient water is available to cater to peak loads and special conditions for application of these plants justify, *power can be produced at a small cost.*

• *Plant Economy :-*

•**The *capital cost per unit installed is higher if the quantity of water is small.***

•***Also, the unit cost of conveying water to the power house is greater if the quantity of water is small.***

•***The cost of storage per unit is also lower if the quantity of water stored is large.***

FACTORS AFFECTING ECONOMICS OF GENERATION AND DISTRIBUTION OF POWER

- The economics of power plant operation is greatly influenced by :

(a) Load factor

(b) Demand factor

(c) Utilisation factor

Load Factor :-

•In a *hydro-electric power station with water available and a fixed staff for maximum output, the cost per unit generated at 100% load factor would be half the cost per unit at 50% load factor.*

•*In a steam power station the difference would not be so pronounced since fuel cost constitutes the major item in operating costs and does not vary in the same proportion as load factor. The cost at 100% load factor in case of this station may, therefore, be about 2/3rd of the cost 50% load factor.*

•*For a diesel station the cost per unit generated at 100% load factor may be about 3/4th of the same cost at 50% load factor.*

• *From the above discussion it follows that :*

(a)Hydro-electric power station should be run at its maximum load continuously on all units.

(b)Steam power station should be run in such a way that all its running units are economically loaded.

Demand Factor and Utilisation Factor:-

•A higher efficient station, if worked at low utilisation factor, may produce power at high unit cost.

•The time of maximum demand occurring in a system is also important. In an interconnected system, a study of the curves of all stations is necessary to plan most economical operations.

•The endeavour should be to load the most efficient and cheapest power producing stations to the greatest extent possible. Such stations, called “base load stations” carry full load over 24 hours, i.e. for three shifts of 8 hours.

 The stations in the medium range of efficiency are operated only during the two shifts of 8 hours during 16 hours of average load.

 The older or less efficient stations are used as peak or standby stations only, and are operated rarely or for short periods of time.

- Presently there is a tendency to use units of large capacities to reduce space costs and to handle larger loads.

- However, *the maximum economical benefit of large sets occurs only when these are run continuously at near full load.*

- *Running of large sets for long periods at lower than maximum continuous rating increase cost of unit generated.*

Conventional & Non-conventional energy sources

Presented by…

Md. Jakirul Islam

CONTENT

- Introduction
- Conventional energy sources
  - Commercial energy sources
  - Non-commercial energy sources
- Non-conventional energy sources

INTRODUCTION

- Energy is an important input for development.
- It aims to the natural resources, energy resources are also renewable as well as non renewable.
- **Renewable energy resources :** Energy sources that are easily replaced after being consumed.
- **Non-renewable energy resources :** Energy sources that are not replaced or replenished after being used. (May take several years to replace).

Sources of energy

Conventional sources

Commercial

- Coal
- Oil & natural gas
- Thermal power

Non-commercial

- Firewood (Fuel wood)
- Hydro power
- Nuclear power

Non-conventional sources

- Solar energy
- Wind energy
- Tidal energy
- Geotherma l energy
- Biomass - based energy

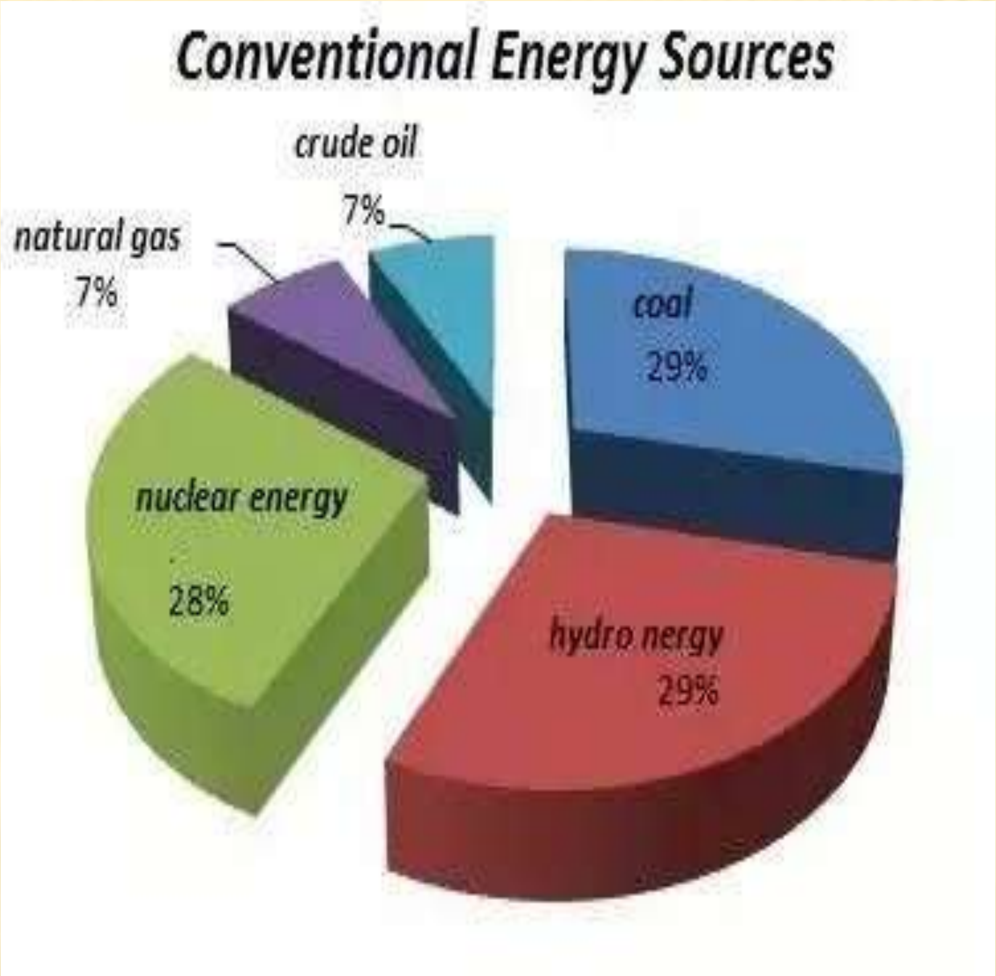
CONVENTIONAL ENERGY SOURCES

- Energy that has been used from ancient times (natural resources) is known as **conventional energy**.

- A conventional resources are the ones that are commonly used. (like pen or a pencil).

- These are available in limited amount and develop over a longer period. As a result of unlimited use, they are likely to be exhausted one day.

- Thase are also known as a non-renewable (or exhaustible) energy sources.



- **Conventional energy sources have two type of source like…**
  1) Commercial energy sources
  2) Non-commercial energy sources

- **Commercial energy sources: The sources of energy that are usually available in costly to the users are reffered to as Commercial energy sources.**

- **Non-commercial energy sources : The sources of energy that are usually availably free of cost to the users are reffered to as non-commercial energy sources.**

1) COMMERCIAL ENERGY SOURCES

i) Coal :

- Coal releages large amounts of energy it is borned because of the density of hydrocarbon in the material.
- Coalification : Coal is formed by dead plants being put under significant pressure and temparature for million of years.
- There are four grades of coal : lignite, subbituminous, bituminous and anthracite.




- **Lignite :** A brownish-black coal of low quality with inherent moisture and volatile matter. Energy content is lower 4000 Btu/lb.
- **Subbituminous :** Black lignite is dull black and generally content is 8,300 Btu/lb.
- **Bituminous :** Most common coal is dense & black. It’s moisture content usually is less than 20 %. Energy content about 10,500 Btu/lb.
- **Anthracite :** A hard, black, lustrous coal, often reffered to as hard coal. Energy content of about 14,000 Btu/lb.

ii) Oil & Natural gas :

- Sedimentary rocks containing plants, animals remains about 10 to 20 crore year old are the source of mineral oil.

- Mineral oil is very unevenly distributed over space like any other mineral.

- There are six regions in the world which are rich in mineral oil. USA, Mexico, former USSR and West Asian region are the major oil reproducing countries.

- Natural gas is really a mixture of gases that formed from the fossils remains of ancient plants and animals buried deep in the earth.
  - In india – gas is a natural gift.

- The main ingredient in natural gas is methane.

- Natural gas can be used both as energy source and also an industrial raw material in petrochemical industry. The gas is also used for fertiliser plants.

- Through pipe line, the gas from Bombay and Gujarat gas fields is now taken to M.P., Rajasthan and U.P.

- Hazira-Bijaipur-Jagdishpur (HBJ) gas pipe line is 1,730 km long carries 18 million cubic meters of gas everyday.

- It feeds six fertiliser and three power plants. There are already 12 refineries in India.

- The liquefied petroleum gas (LPG), also called the cooking gas is now a very common domestic fuel.

iii) Thermal power :

- A thermal power station is a power station in which heat energy converted to electric power.
- Thermal power plants use coal, petroleum and natural gas to produce thermal electricity.
- These sources are of mineral origin and also called fossil fuels.
- They are exhaustible and polluting.

- This is in great demand in industry, agriculture, transport and domestic sectors.

2) NON-COMMERCIAL ENERGY SOURCES

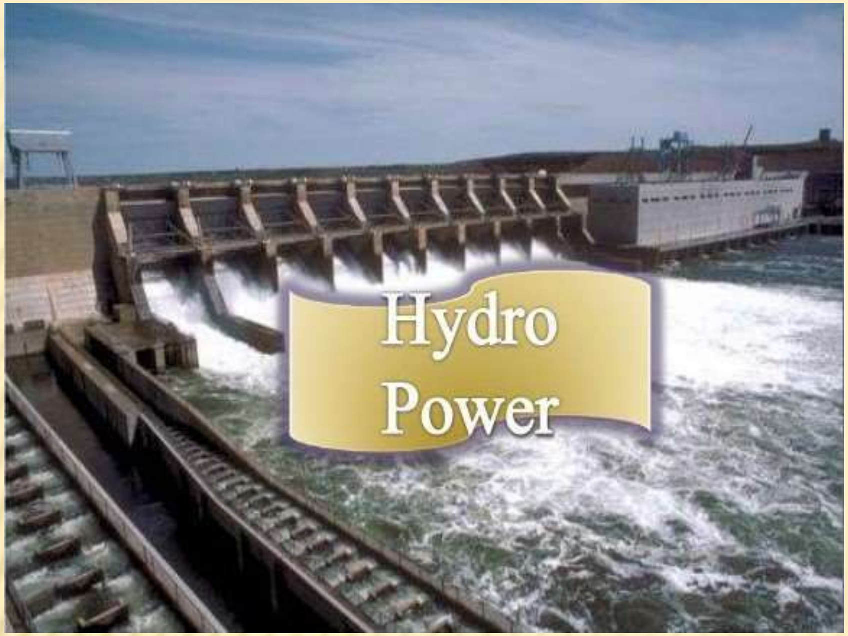
i) Fire wood (Fuel wood) :

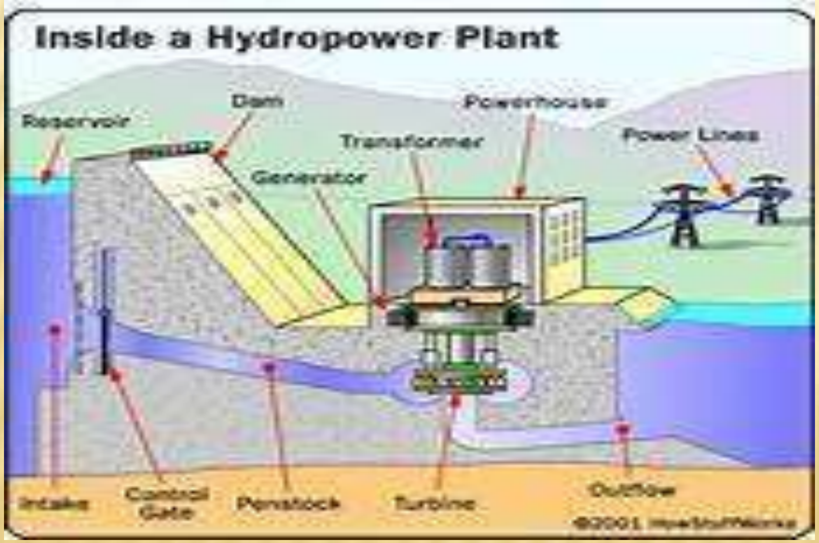
- One must combine supply of fire wood and other biomass energy sources.

- Besides, we need technologies for total utilisation of biomass and or conversion to solid (densification), liquid (liquification) and gaseous (gasification) fuel.

ii) Hydro power :

- Water energy is most conventional renewable energy sources and obtained from water flow, water falling from a height.
- Hydro power is a clean, non polluting sources of energy. It can be transmitted to long distance through wires and cables.
- In South America about 75% of the total electricity consuption comes from water. Japan, USA and former USSR are the leading countries in production of hydro power.





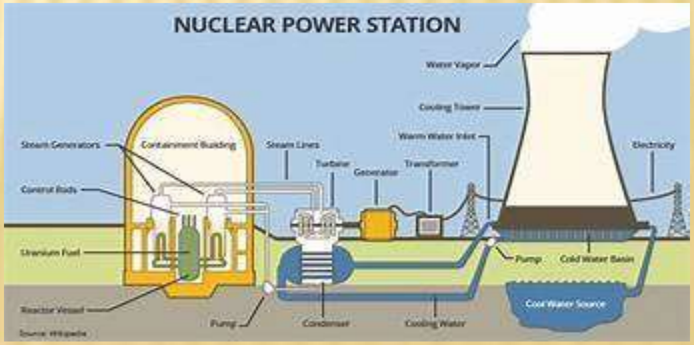
- **In India the generation of hydro elctric power was emphasised from the first five year.**

- **We have referred to the dams earlier in chapter on “natural Resources and their Conservations” under Land use Resources.**

iii) Nuclear power :

- A small quantity of radioactive material can produce abnormal amount of energy. For instance, one ton of Uranium^{235} would provide as much energy by three million ton of coal or 12 million barrels of oil.

- Atomic power is also used as fuel for marine vessels, heat generation for chemical and food processing plants and for spacicrafts.
- For atomic energy, we need a nuclear reactor.



- There are different types of nuclear :

(a) Light water reactor (LWR) : Here we use ordinary water for cooling & moderation.

- These are of two basic types :

(i) Boiling Water Reactor (BWR)

(ii) Pressurised Water Reactor (PWR).

(b) Heavy Water Reactor (HWR) : Here we use heavy water.

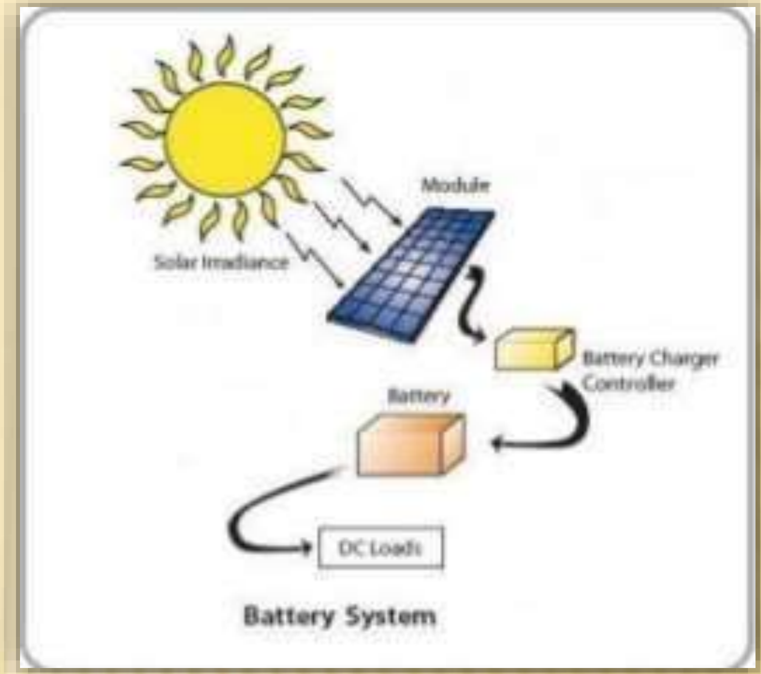
(c) Liquid metal fast breeder reactor (LMFBR) : Here, we use liquid sodium as the coolant.

NON-CONVENTIONAL ENERGY SOURCES

- Energy that has been used from natural resources which made by artificial is known as Non-conventional energy resources.
- A non-conventional resources are one that work but are not commonly used. (like an ionic laser).
- These are available in unlimited amount in nature since these can be renewed over relatively short period of time. It can reproduce themselves in nature.
- These are also known as renewable (or inexhaustible) energy resources.

1) Solar energy :

- Energy obtained from the sun in the form of heat and light.
- Energy derived in the form of solar radiation.
- The solar energy received by the near earth space is approximately 1.4 kilojoules/second known as solar constant.



- The heat energy is used in solar heating devices like solar cooker, solar water heater, solar furnaces etc. The light energy is used in solar cells.

- Using photosynthetic and biological process for energy trapping. In the process of photosynthesis, green plants absorb solar energy and convert it into chemical energy, stored in the form of carbohydrate.

2) Wind energy :

- Air flows can be used to run wind turbines.

- Wind energy is used in wind mills which convert the kinetic energy of the wind into mechanical or electrical energy.

- A single wind mill produces only a small amount of electricity.

- Large number of wind mills in a large area coupled together to produse more electricity in wind energy farms.

- The minimum wind speed required is 15 km/hr.
- At present wind power potential of India is 1020 MW.
- Largest wind farm is near kanyakumari in Tamilnadu generate 380 MW electricity.

3) Tidal energy :

- The energy associated with the tides of the ocean can be converted into electrical energy.First tidal power plant is in France (1996).

- India could take up ocean thermal energy conversion (OTEC) and by the process it will be capable of generating 50,000 Mwot electricity, to meet the power requirements of remote oceanicislands & costal towns.

4) Geothermal energy :

- The geothermal energy may be defined as the heat energy obtainable from hot rocks present inside the earth crust.
- At the core temperatures may reach over 9,000° F.
- This heat comes from the fission of radioactive material naturally present in the rocks.
- The deeper regions of the earth’s crust is very hot. This heat melts the rocks & forms magma.

- The magma moves up and collects below at some places called Hot spots.
- The under ground water in contact with hot spot gets heated into steam at high pressure.
- By drilling holes into hot spots the steam coming out can be used to rotate turbines of generators to produce electricity.

5) Biomass - based energy :

- **The organic matters originated from living**

  organisms like wood , cattle dung, sewage, agricultural wastes etc. are called as biomass.

- These substances can be burnt to produce heat energy which can be used in the generation of electricity.

- Thus, the energy produced from the biomass is known as biomass energy.


Biomass Sources
Sewage
Municipal Solid Waste
Agricultural Crops & Residue
Animal Residues
Forestry Crops & Residue
Industrial Residues
Biomass Innovation Centre

SOLAR POWER GENERATION

(RENEWABLE ENERGY SOURCE)

BY,

Md. Jakirul Islam

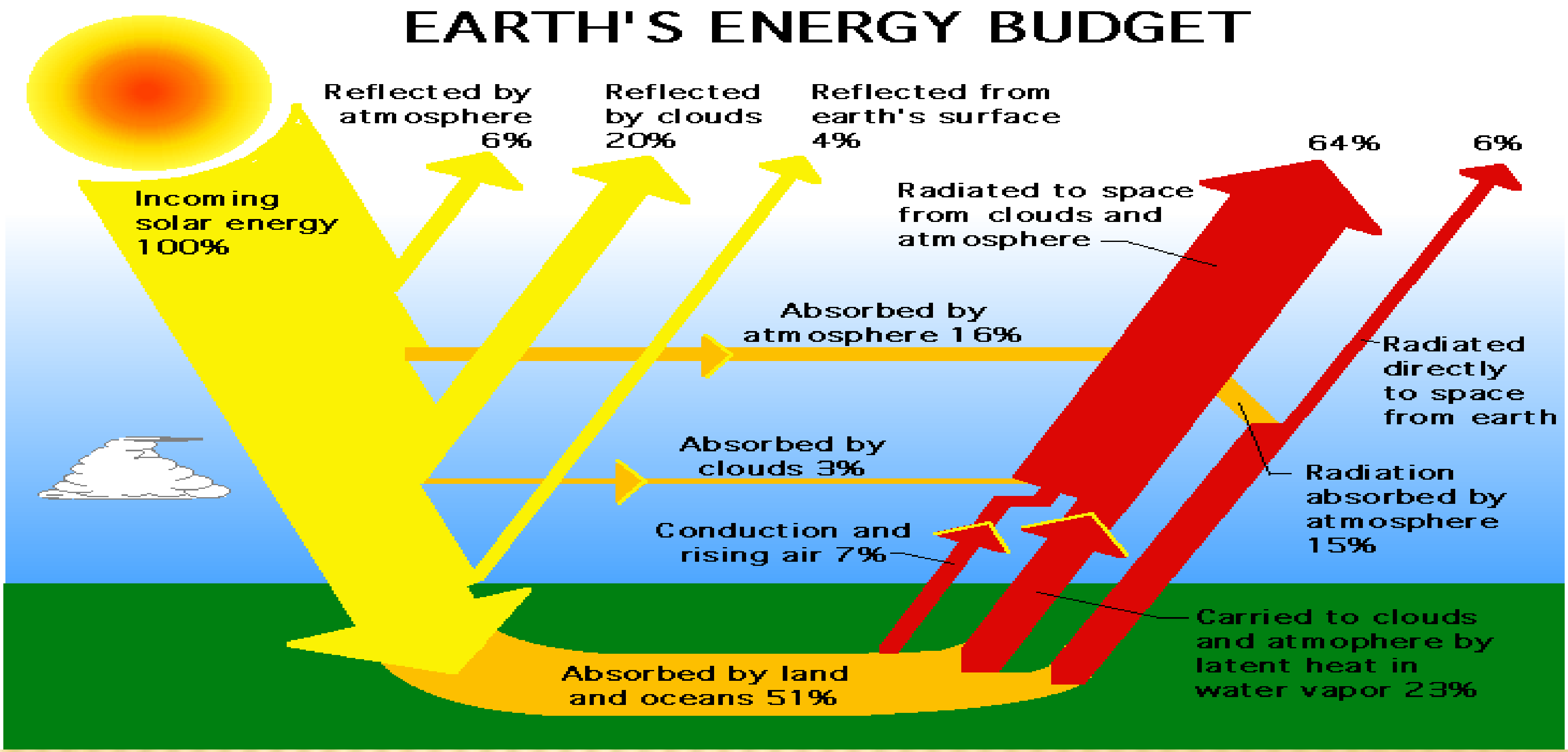
SOLAR ENERGY:

- The energy that is produced from sun is known as solar energy.

- The Sun's energy comes from nuclear fusion reaction that takes place deep in the sun, where hydrogen nucleus fuse into helium nucleus.

- When such a reaction takes place then tremendous amount of energy is produced which is escaped into the space.

HOW MUCH SOLAR ENERGY REACHES EARTH?



- About 51% of sun’s energy is absorbed by earth’s atmosphere, some part is absorbed by earth’s surface and rest is reflected back to space.

TYPES OF TECHNOLOGIES IN SOLAR POWER GENERATION:

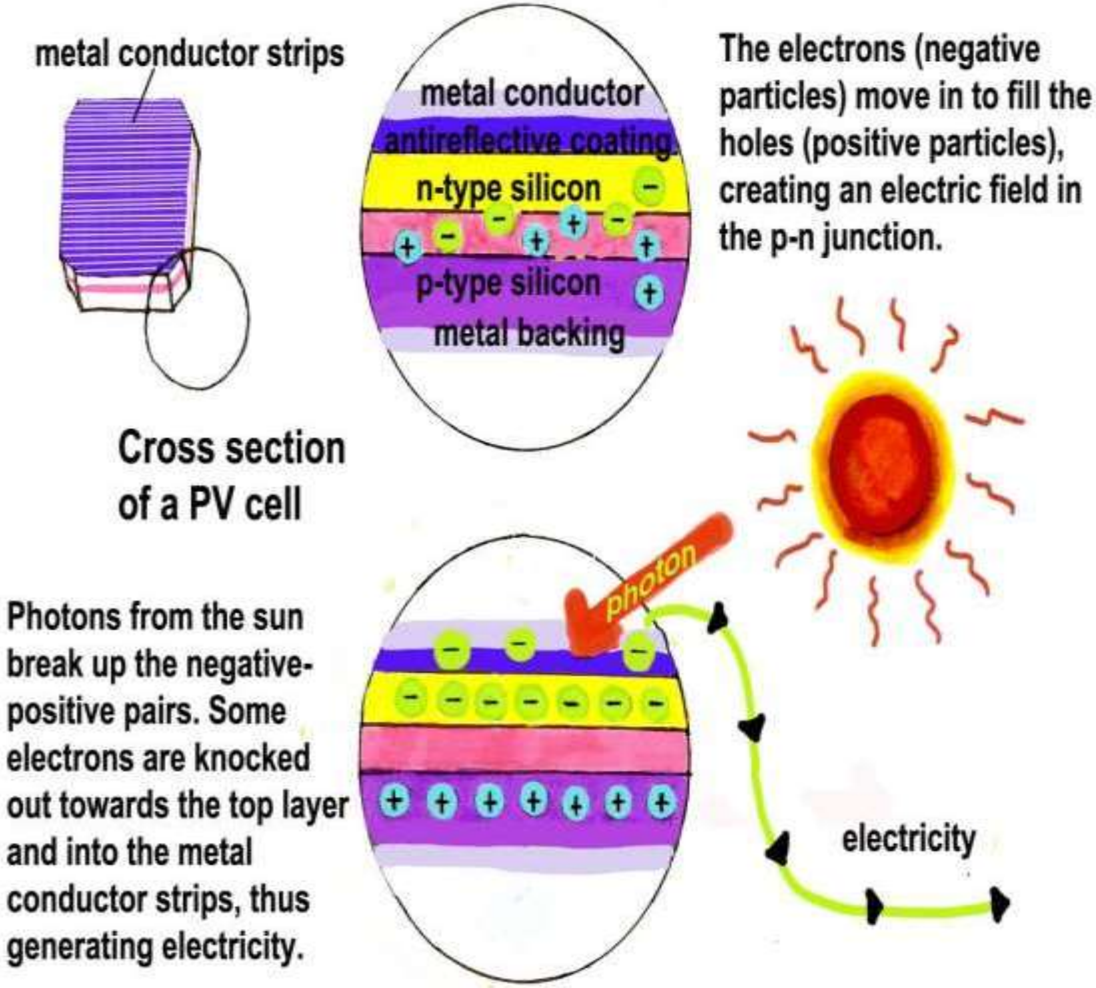
There are two types of technologies in generating power through solar energy,
They are:

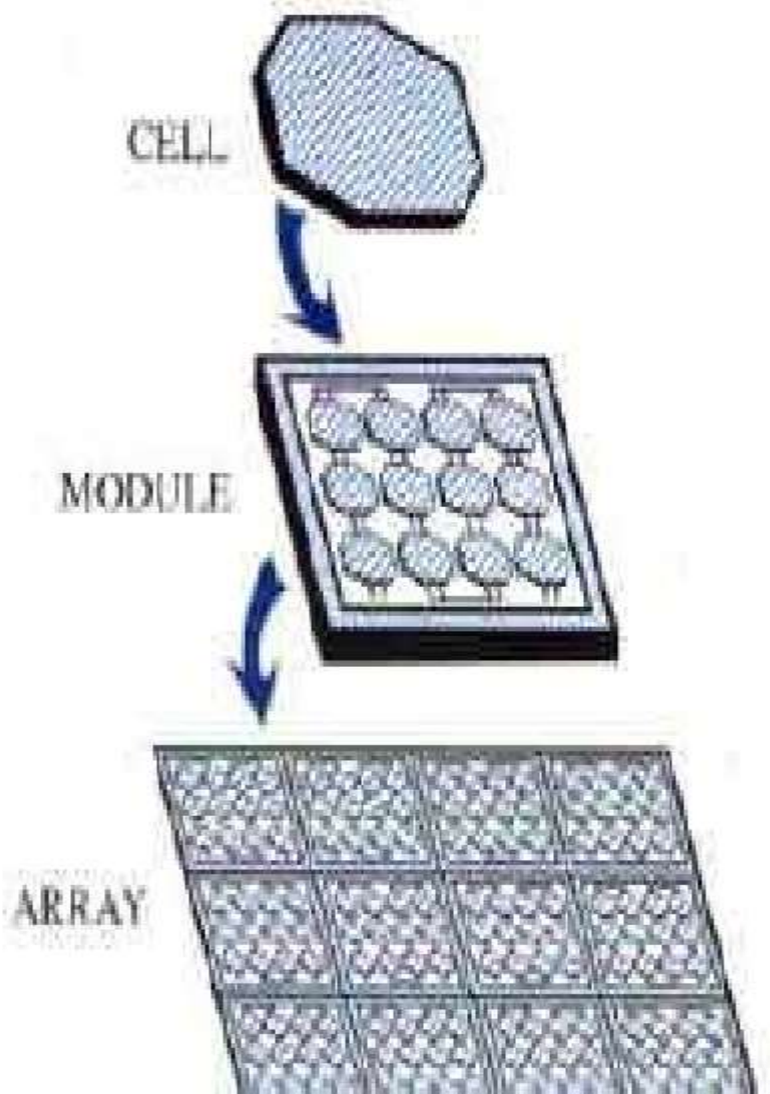
1. Solar Photovoltaic Technology
   (a)Ground mounted solar photovoltaic system
   (b)Space based solar photovoltaic system

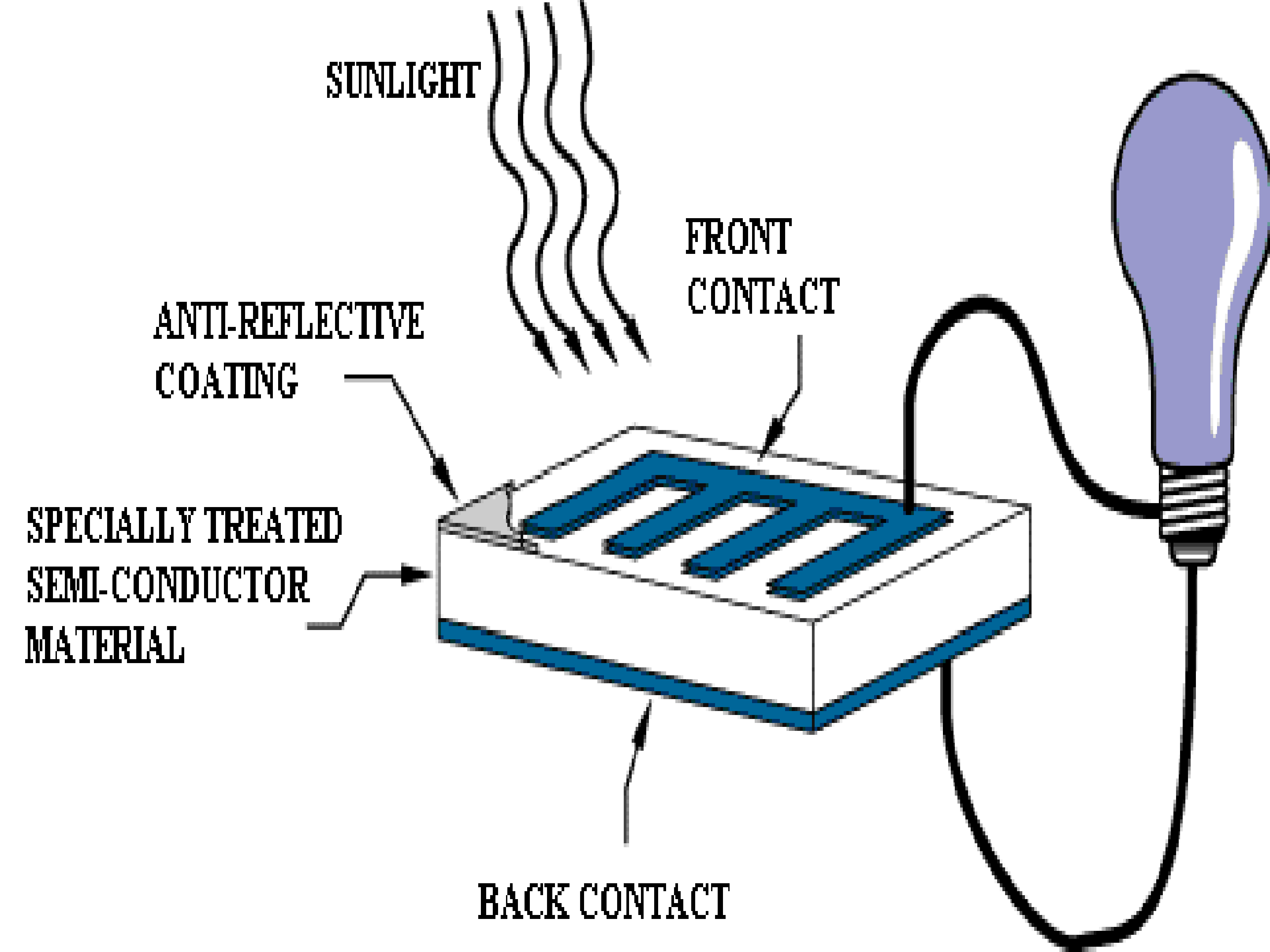
2.Floating solar chimney technology

SOLAR PHOTOVOLTAIC TECHNOLOGY:

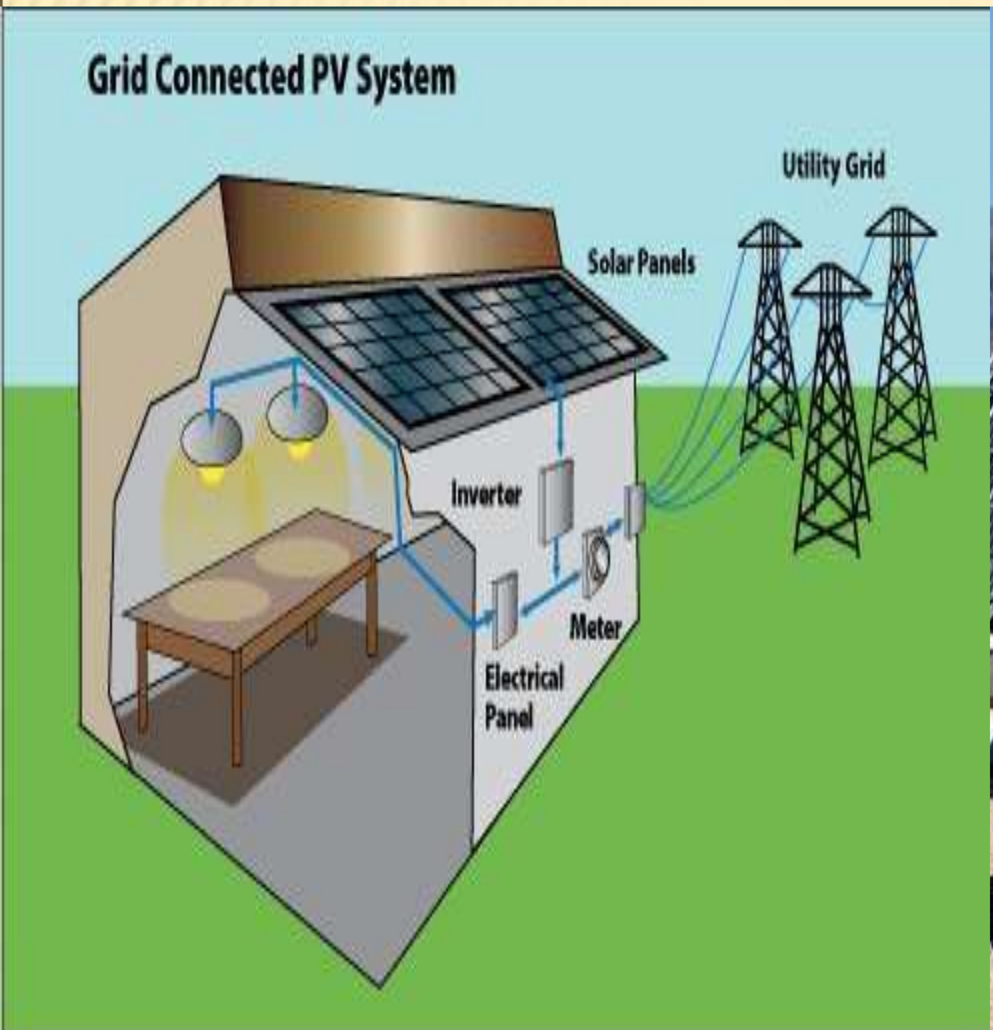
Working of solar Photovoltaic cell:



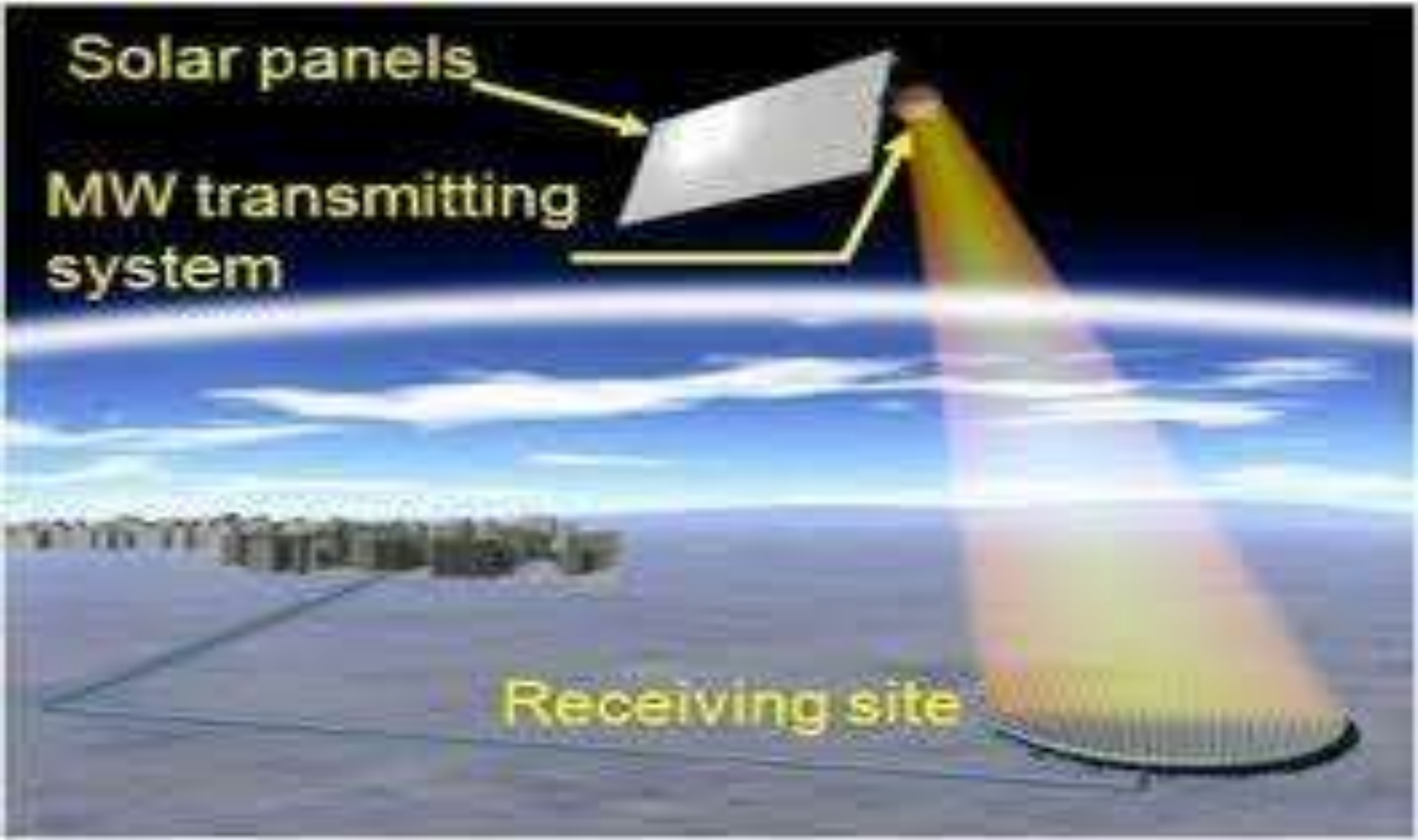



SUNLIGHT
FRONT CONTACT
ANTI-REFLECTIVE COATING
SPECIALLY TREATED SEMI-CONDUCTOR MATERIAL
BACK CONTACT

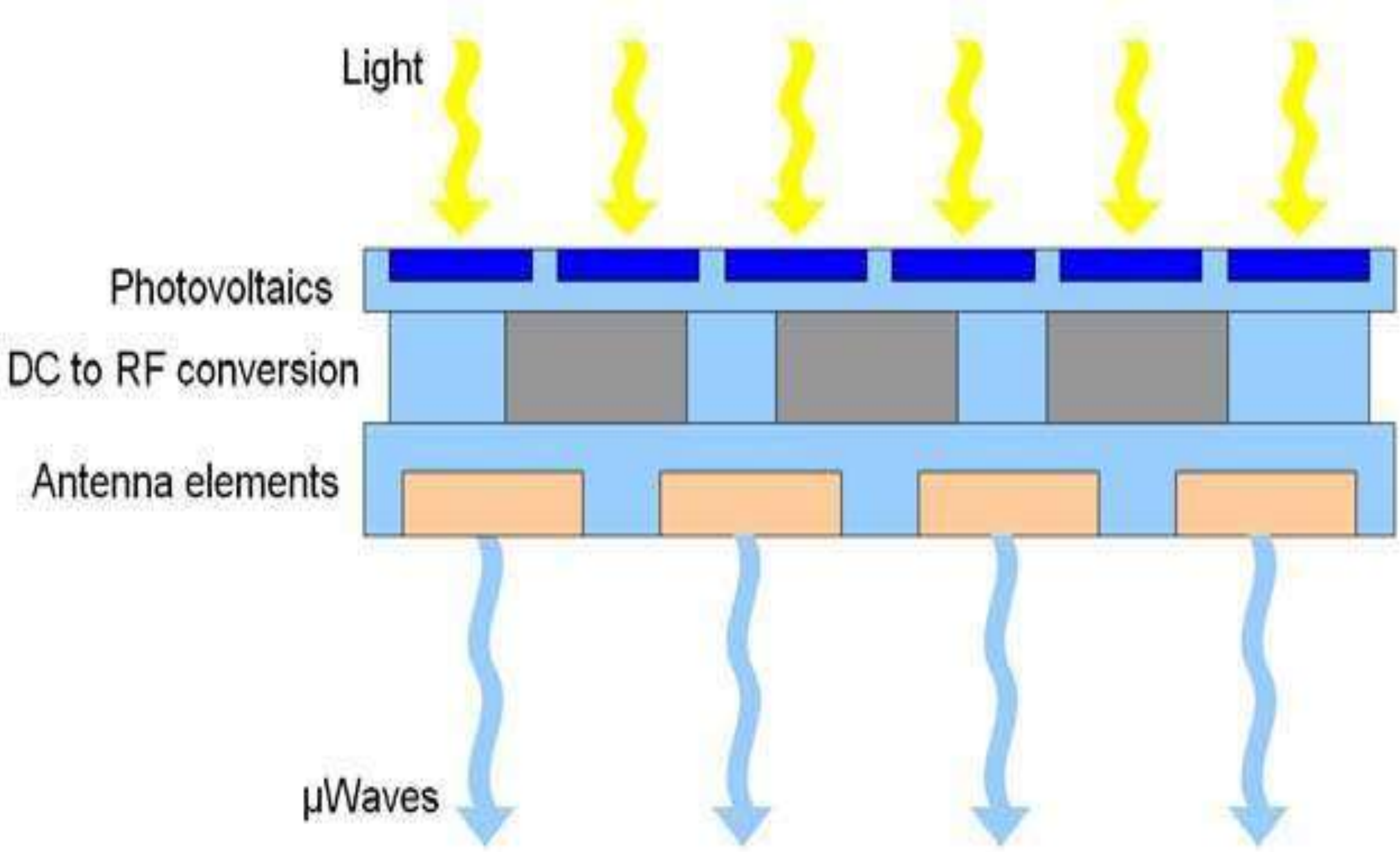
•GROUND MOUNTED SOLAR PHOTOVOLTAIC SYSTEM :



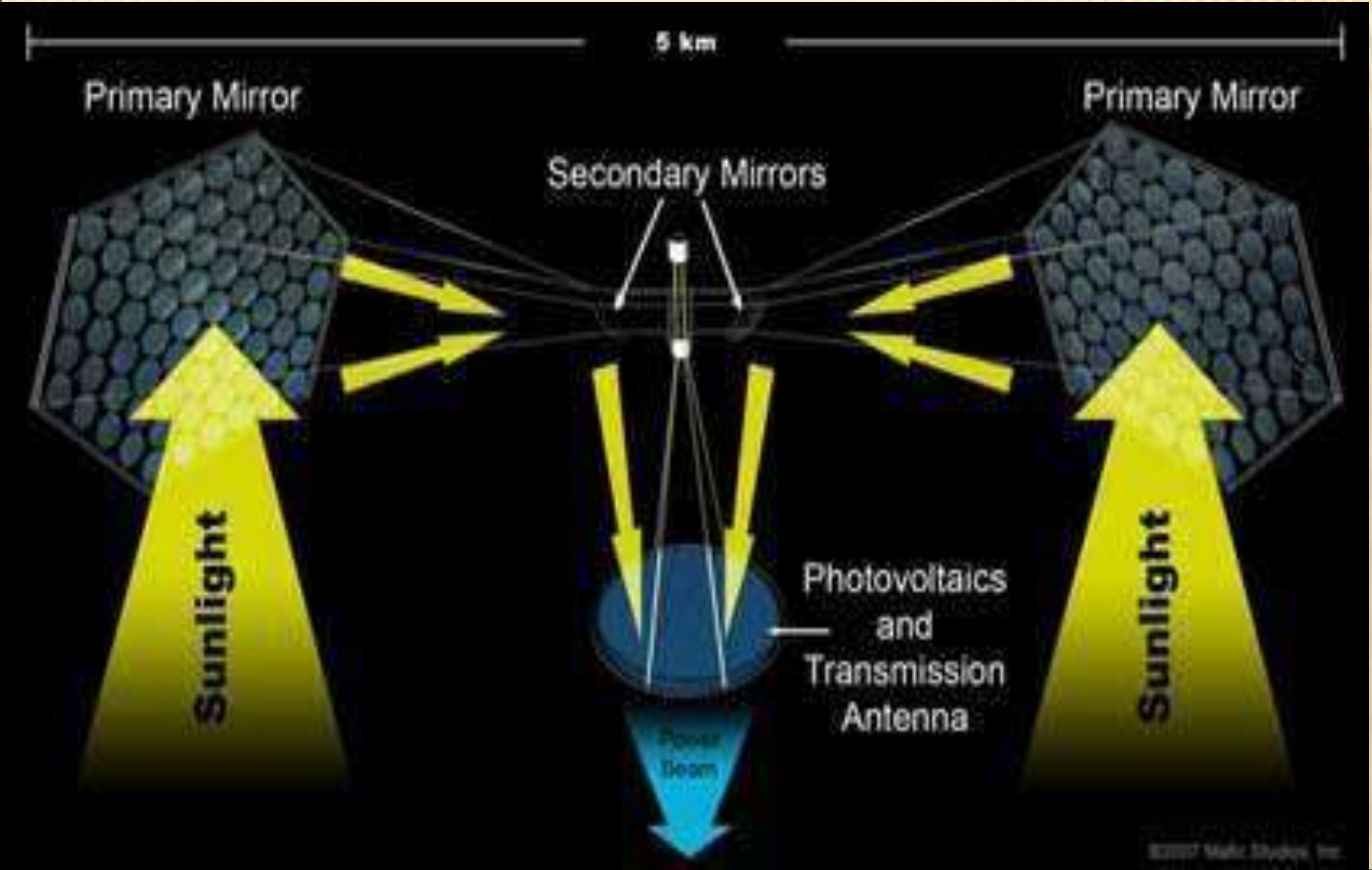
•SPACE BASED SOLAR PHOTOVOLTAIC SYSTEM:



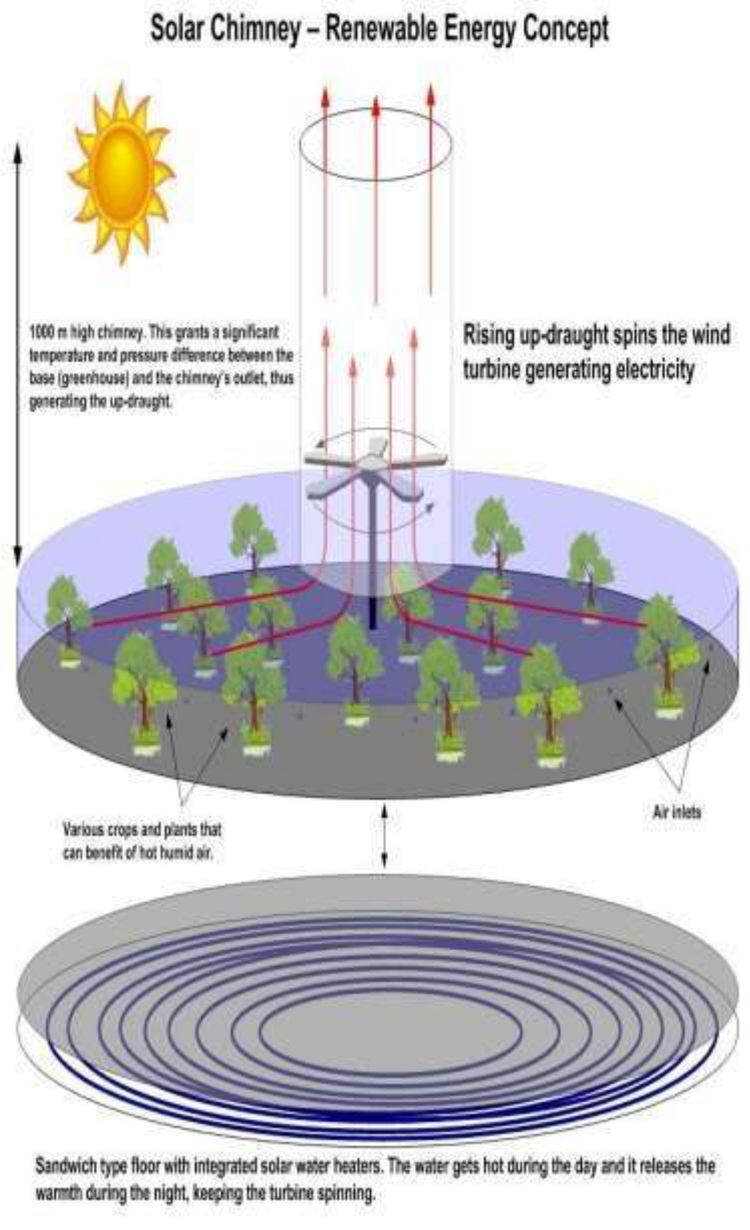
FUNCTIONING
:

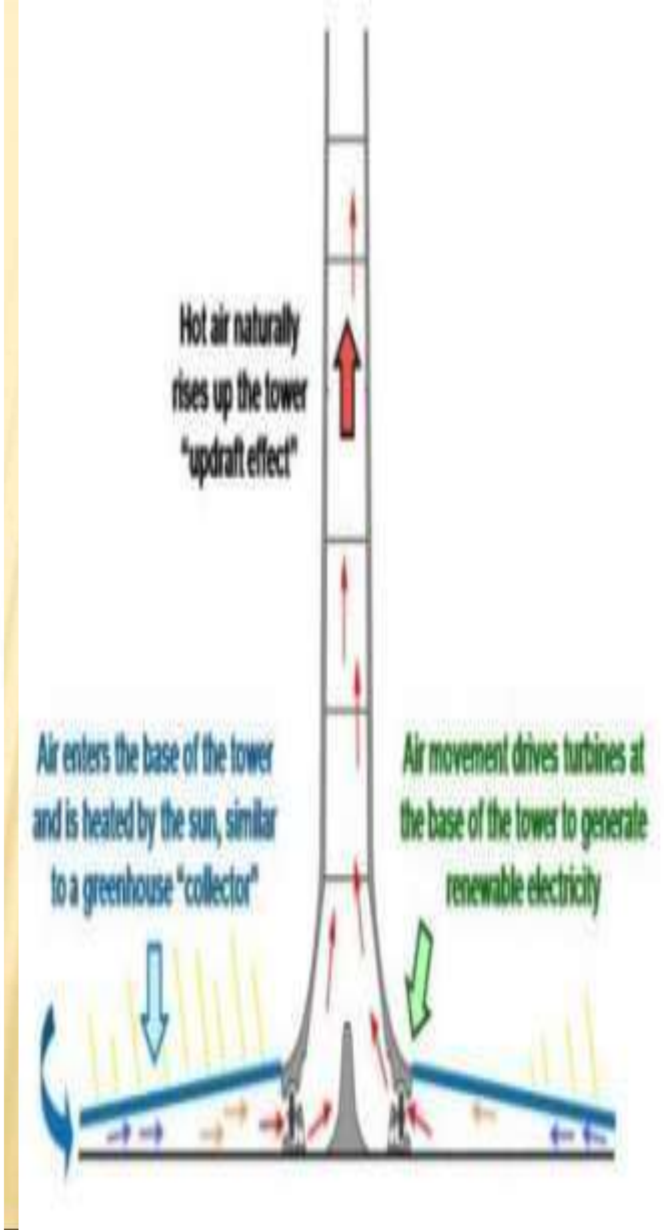


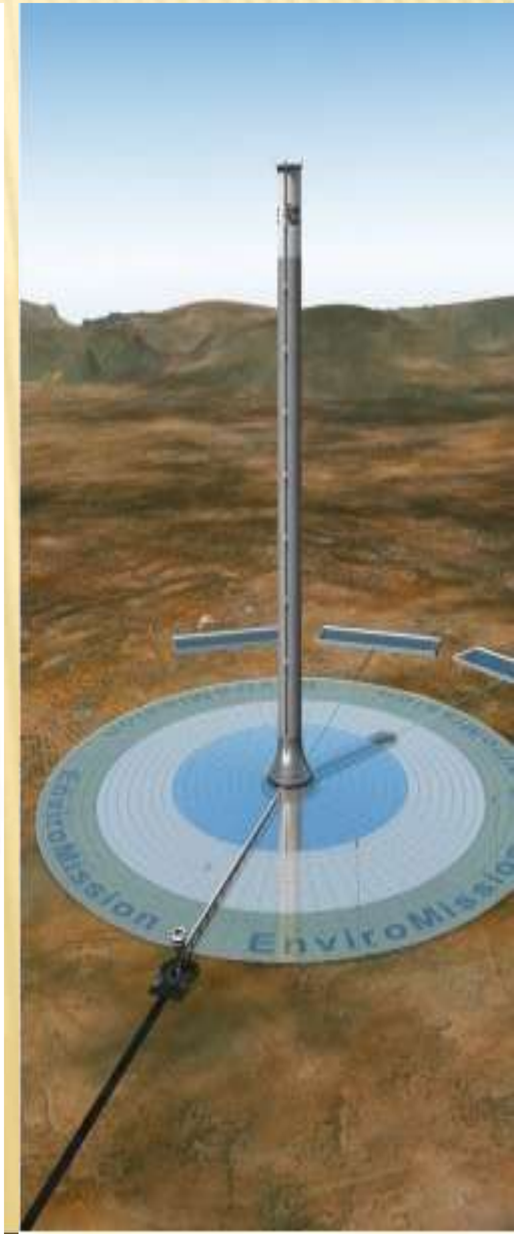
○ SANDWICH CONCEPT OF SPACE SOLAR POWER:



FLOATING SOLAR CHIMNEY TECHNLOGY:



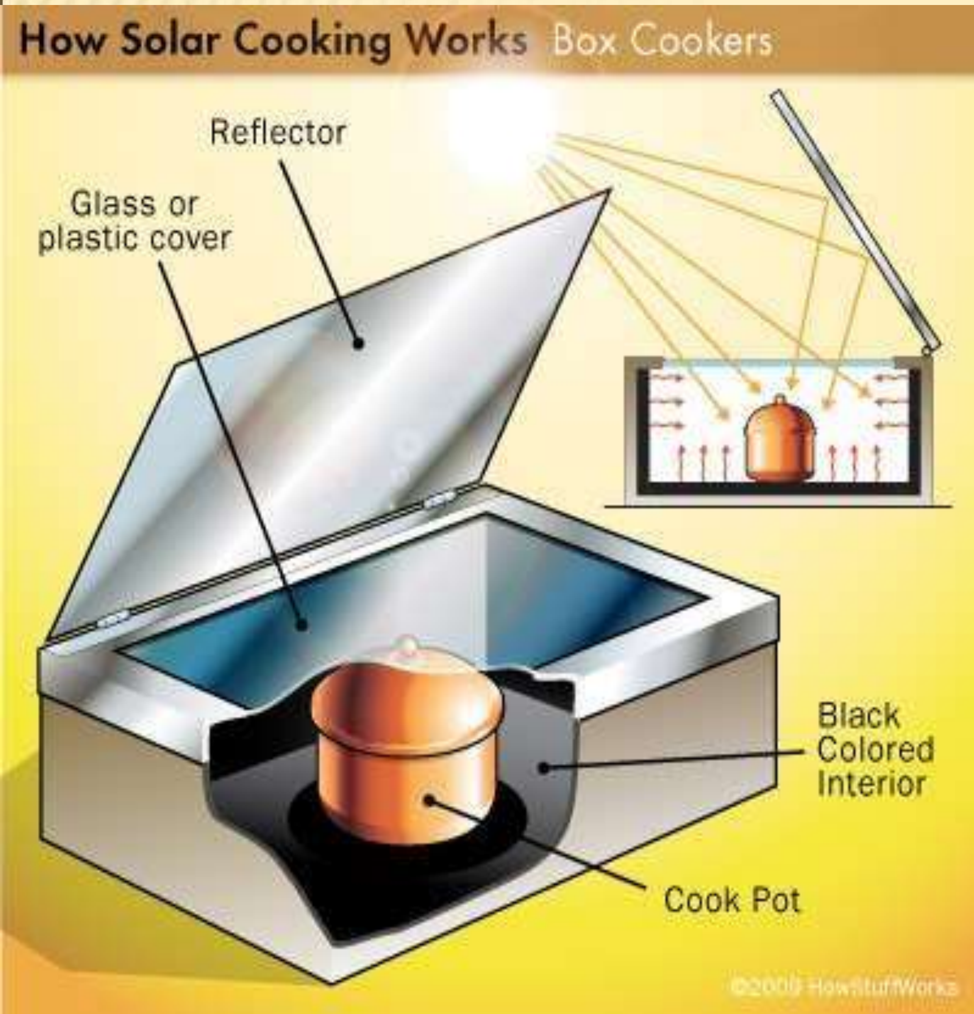




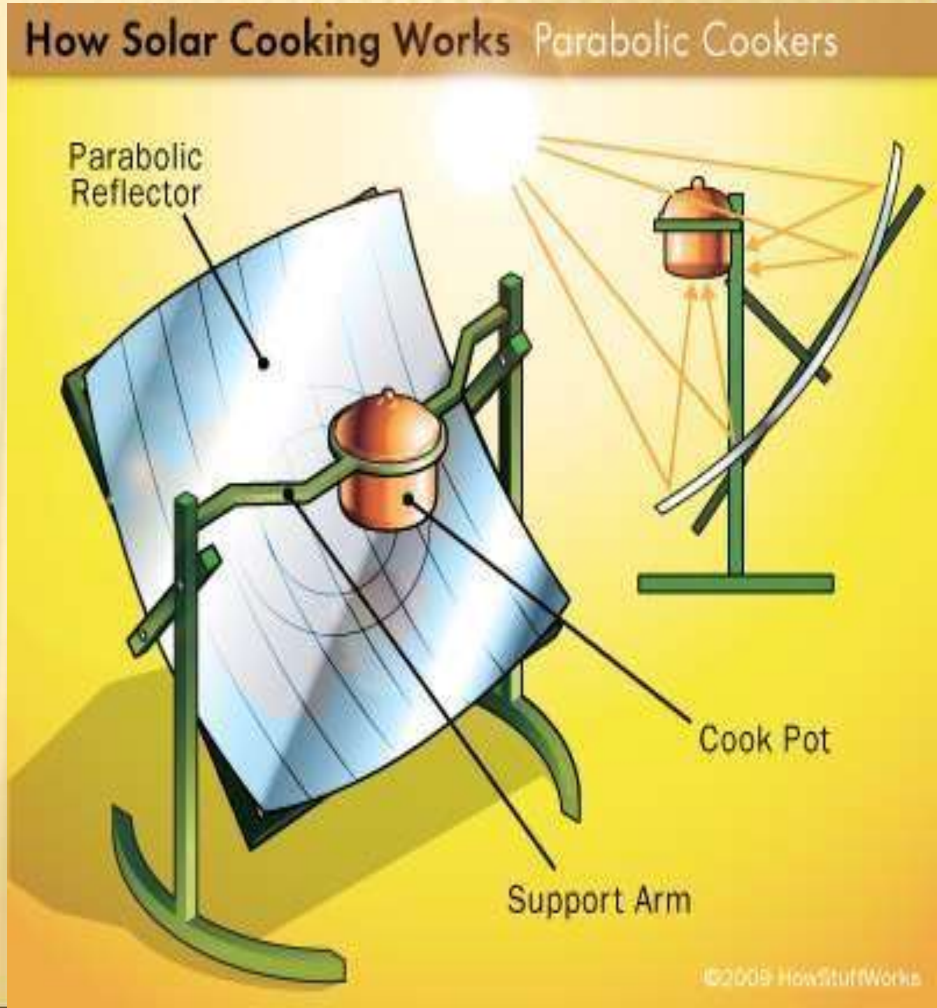
APPLICATIONS

- **Solar Cookers:**

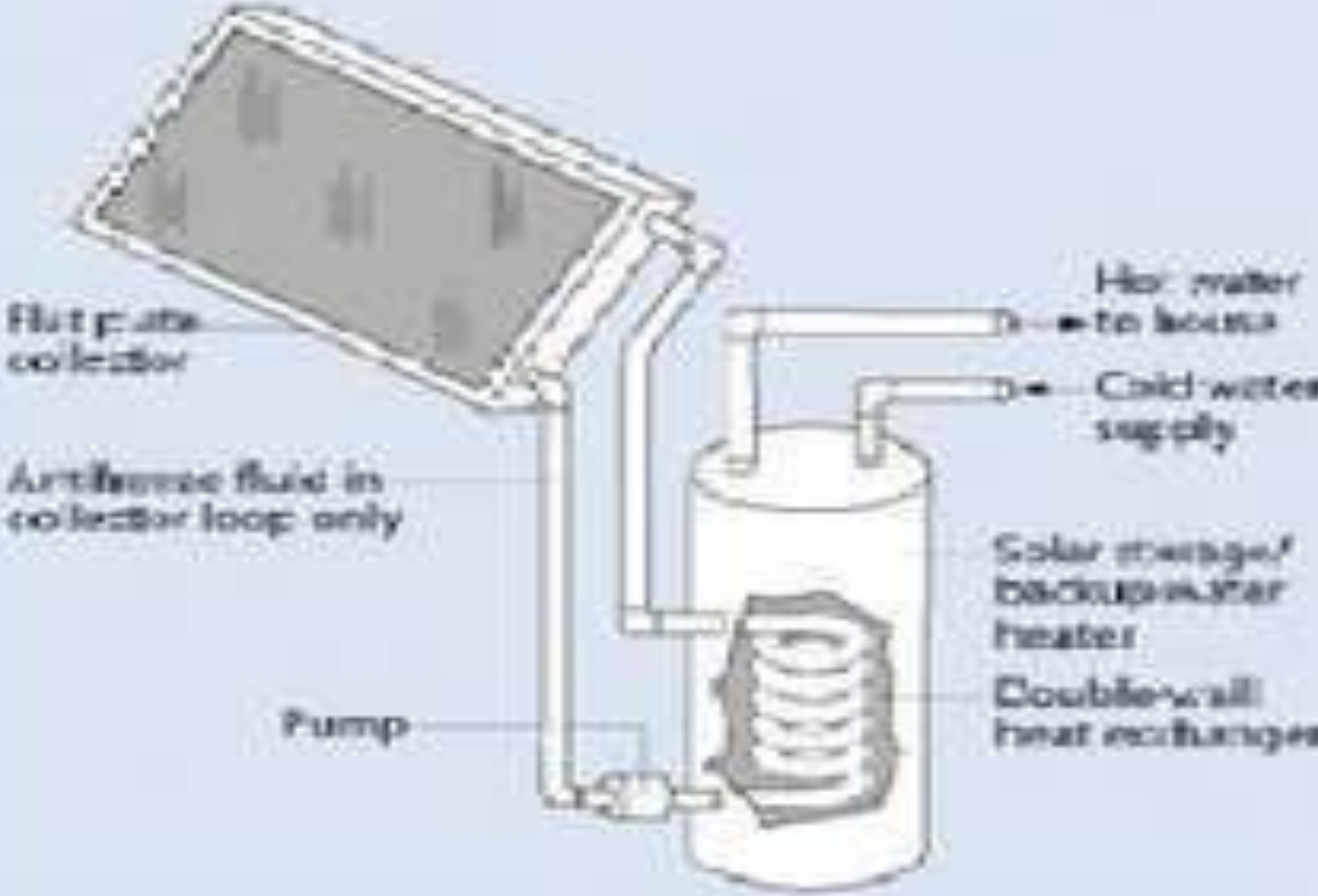
Box type solar cookers:



Parabolic concentrating solar cookers:



➢ **Solar Water Heaters:**



➢Solar Photovoltaic Cells In Transport:

ADVANTAGES :

1.Solar energy is free although there is a cost in the building of 'collectors' and other equipment required to convert solar energy into electricity or hot water.

2.Solar energy does not cause pollution. However, solar collectors and other associated equipment / machines are manufactured in factories that in turn cause some pollution.

3. Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid.

4.Many everyday items such as calculators and other low power consuming devices can be powered by solar energy effectively.

5.It is estimated that the world's oil reserves will last for 30 to 40 years. On the other hand, solar energy is infinite (forever).

DIS-ADVANTAGES:

1. Solar energy can only be harnessed when it is daytime and sunny.

2. Solar collectors, panels and cells are relatively expensive to manufacture although prices are falling rapidly.

3.In countries such as the UK, the unreliable climate means that solar energy is also unreliable as a source of energy. Cloudy skies reduce its effectiveness.

4.Large areas of land are required to capture the suns energy. Collectors are usually arranged together especially when electricity is to be produced and used in the same location.

5.To Built Solar Power plant the cost expenses are too high.

FUTURE SCOPE:

As the technology has advanced, we now have started making use of electric vehicles too. Such vehicles have started becoming readily available and are operated using battery technology as well as solar energy. Their costs are now dropping and such vehicles are becoming readily available to the masses. Electric vehicles have a wonderful future for sure as they do not pollute the environment. They are also cheap in their usage.

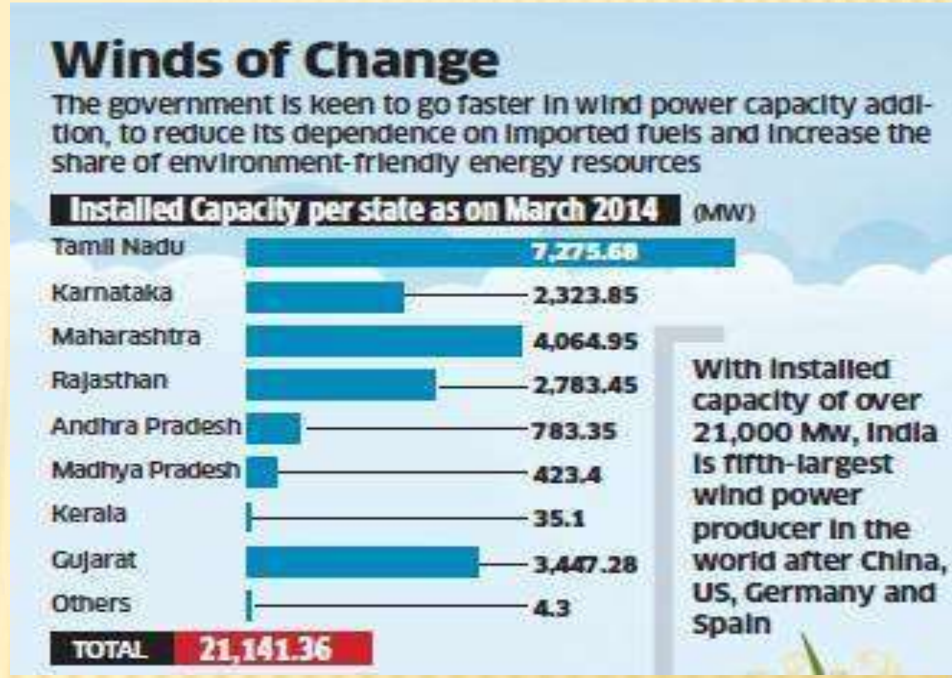
CONCLUSION:

Use of solar energy is efficient in nature as it is a renewable energy source. By using such type of energies to generate and environment can be protected from global warming. Solar energy right now is minimal and does not make enough difference to justify the costs, in the future it probably has the greatest amount of potential because it does not have to be manually produced, extracted or burned. And it can also be used in outer space.

Wind Energy

- Merits of Wind energy
- Basics of Wind energy
- Generation of wind
- Component of Wind turbine

Merits of Wind Energy



- Wind energy is clean
- Wind energy means jobs
- Wind energy is abundant
- Wind energy is affordable
- Wind energy is inexhaustible
- Wind energy is elegant
- Wind energy is environmentally preferable

Wind Energy Basics

- Wind is a form of **solar energy**.
- Winds are caused by
  - **Uneven heating of the atmosphere by the sun,**
  - **Irregularities of the earth's surface, and**
  - **Rotation of the earth.**
- **Wind flow patterns** are modified by the **earth's terrain, bodies of water, and vegetative cover**.
- This wind flow, or motion energy, "harvested" by modern **wind turbines**, can be used to generate **electricity**.

How Wind Power is Generated ?

- Wind is used to generate **mechanical power or electricity**.

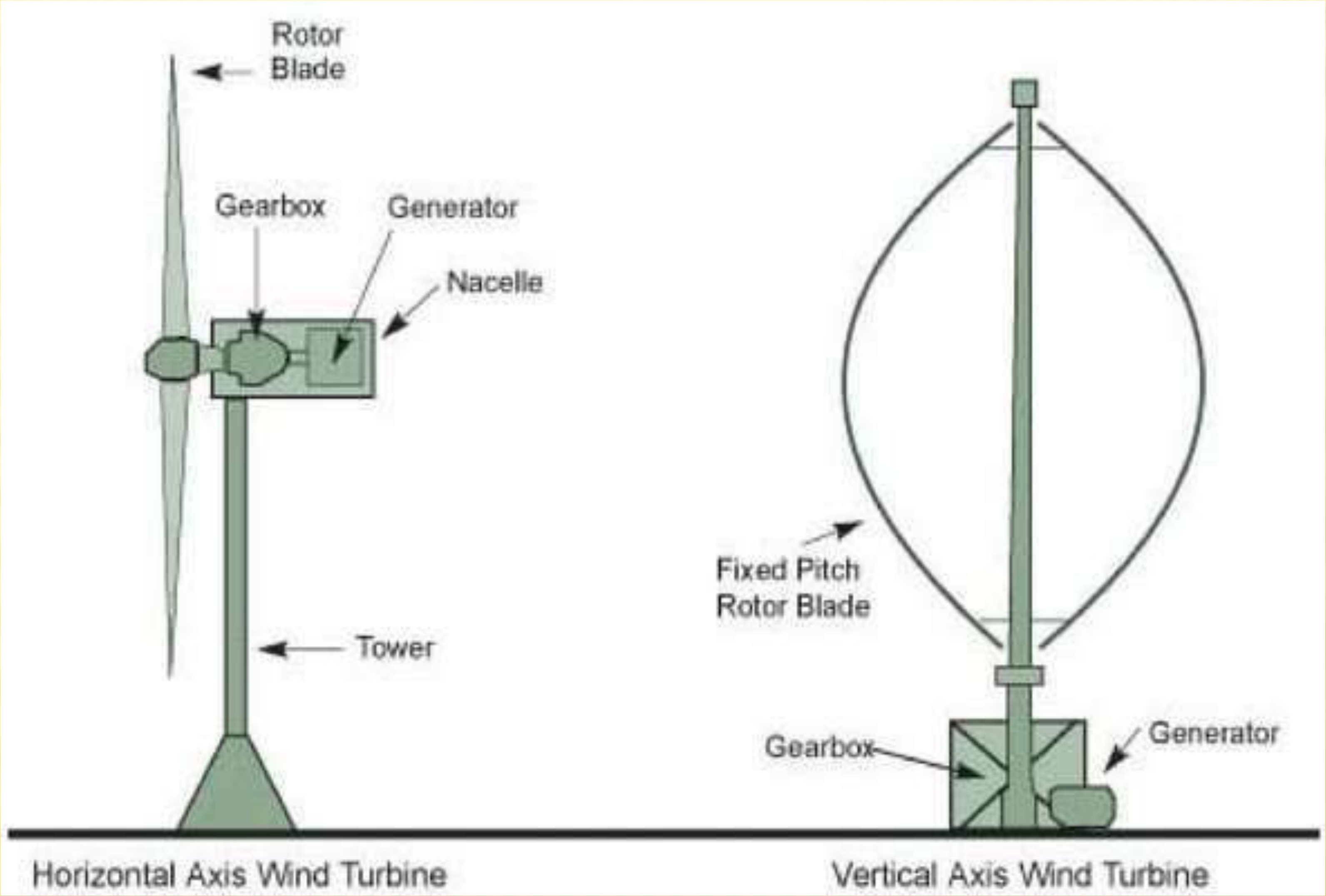
- Wind turbines convert the **kinetic energy of wind into mechanical power.**
- This mechanical power can be used for a **generator** and convert this **mechanical power into electricity**.

Kinetic energy → Mechanical power → Electricity

Wind Turbines

- Wind turbines, like aircraft propeller blades,
- Rotate by the influence of moving air and electric generator that supplies an electric current.
- Wind turbine is the opposite of a fan.
- *Fan (Mechanical Energy to Mechanical Energy)*
- *Wind (Mechanical Energy to Mechanical Energy)*

Wind Turbine Types



Wind Turbine Types

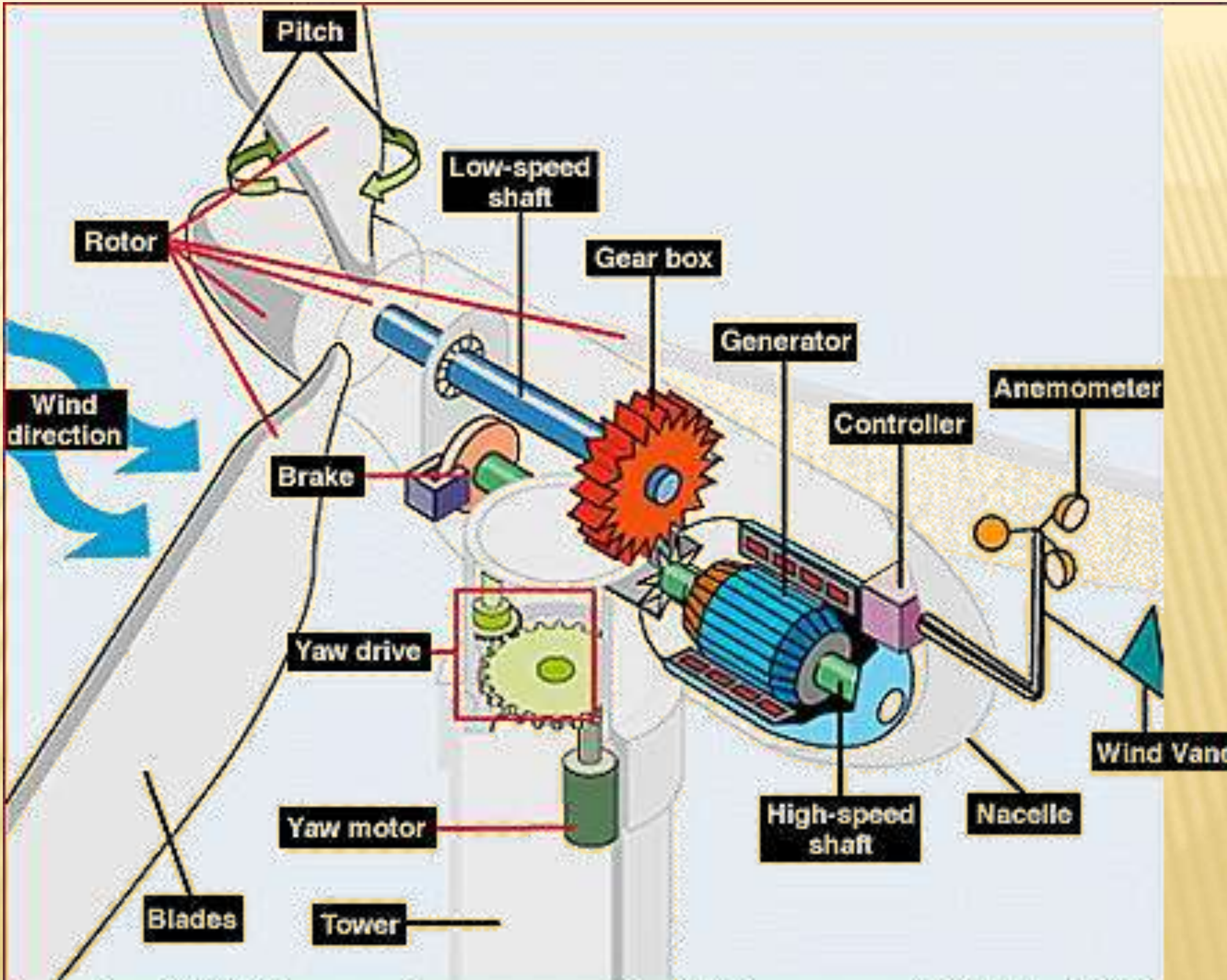
- two basic groups;
- **Horizontal-axis** variety, like the **traditional farm** windmills used for **pumping water**,
- **Vertical-axis** design, like the **eggbeater**-style.
  - Most of the large modern wind turbines are horizontal-axis turbines.

Turbine Components

- Horizontal wind turbine, components include:

1. **blade** or **rotor**,
   - which converts the energy in the wind to rotational shaft energy;
2. **Drive train**,
   - usually including a gearbox and a generator;
3. **Tower**
   - supports the rotor and drive train;
4. other equipment,

   controls, electrical cables, ground support equipment, and interconnection equipment.


Pitch
Low-speed shaft
Rotor
Gear box
Generator
Anemometer
Controller
Wind direction
Brake
Yaw drive
Wind Vane
High-speed shaft
Nacelle
Yaw motor
Blades
Tower

Tower 26.3%

Range in height from 40 metres up to more than 100 m. Usually manufactured in sections from rolled steel; a lattice structure or concrete are cheaper options.

Rotor blades 22.2%

Varying in length up to more than 60 metres, blades are manufactured in specially designed moulds from composite materials, usually a combination of glabse fi and epoxy resin. Options include polyester instead of epoxy and the addition of carbon fibre to add strength and stiffness.

Rotor hub 1.37%

Made from cast iron, the hub holds the blades in position as they turn.

Rotor bearings 1.22%

Some of the many different bearings in a turbine, these have to withstand the varying forces and loads generated by the wind.

Main shaft 1.91%

Transfers the rotational force of the rotor to the gearbox.

Main frame 2.80%

Made from steel, must be strong enough to support the entire turbine drive train, but not too heavy.

Cables 0.96%

Link individual turbines in a wind farm to an electricity sub-station.

Gearbox 12.91%

Gears increase the low rotational speed of the rotor shaft in several stages to the high speed needed to drive the generator

Generator 3.44%

Converts mechanical energy into electrical energy. Both synchronous and asynchronous generators are used.

Yaw system 1.25%

Mechanism that rotates the nacelle to face the changing wind direction.

Pitch system 2.66%

Adjusts the angle of the blades to make best use of the prevailing wind.

Power converter 5.01%

Converts direct current from the generator into alternating current to be exported to the grid network.

Transformer 3.59%

Converts the electricity from the turbine to higher voltage required by the grid.

Brake system 1.32%

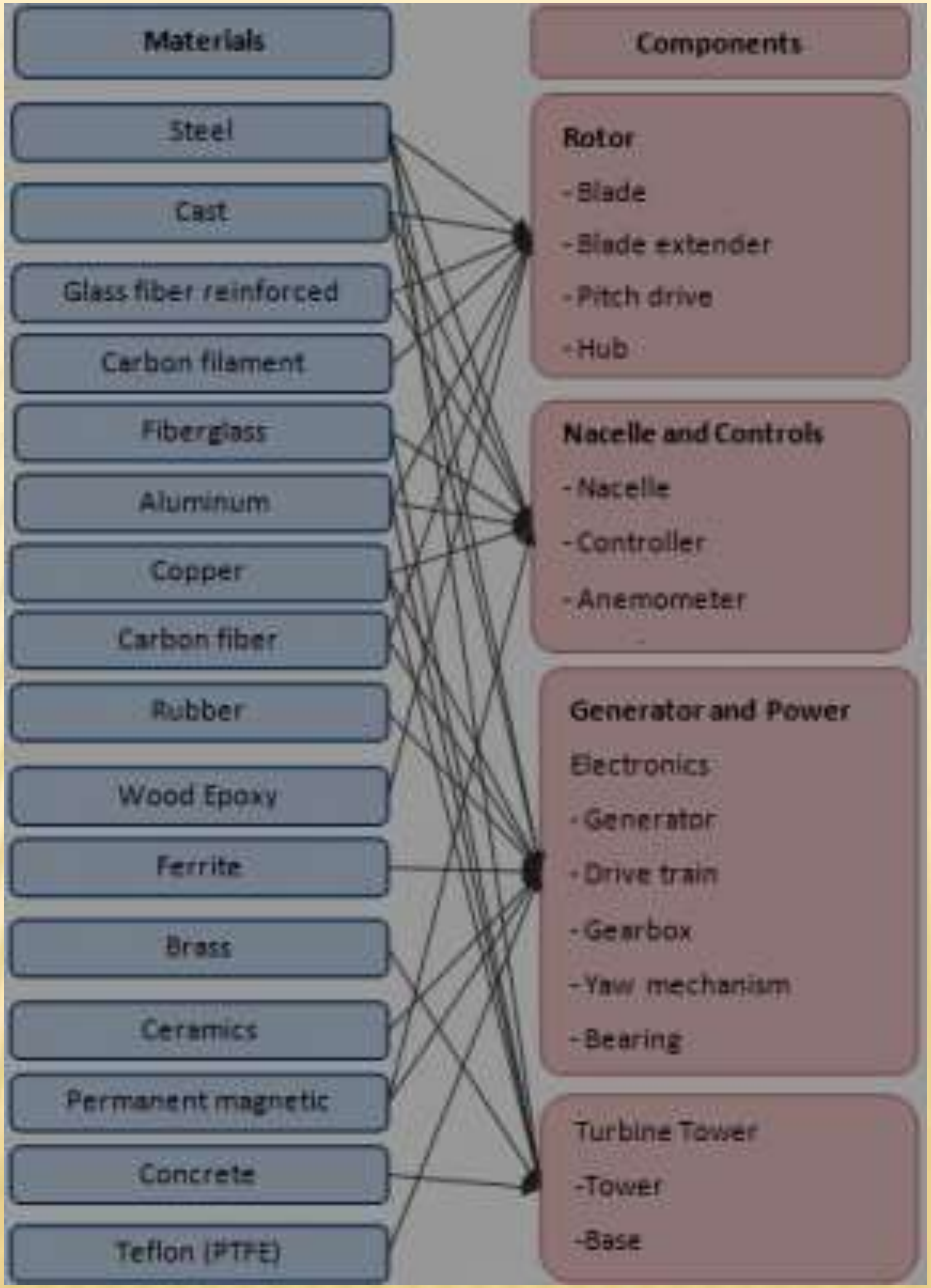
Disc brakes bring the turbine to a halt when required.

Nacelle housing 1.35%

Lightweight glass fire box covers the tur-bine's drive train.

Screws 1.04%

Hold the main components in place, must be designed for extreme loads.


Materials
Steel
Cast
Glass fiber reinforced
Carbon filament
Fiberglass
Aluminum
Copper
Carbon fiber
Rubber
Wood Epoxy
Ferrite
Brass
Ceramics
Permanent magnetic
Concrete
Teflon (PTFE)
Components
Rotor
- Blade
- Blade extender
- Pitch drive
- Hub
Nacelle and Controls
- Nacelle
- Controller
- Anemometer
Generator and Power
Electronics
- Generator
- Drive train
- Gearbox
- Yaw mechanism
- Bearing
Turbine Tower
-Tower
-Base

Nacelle

- The nacelle contains the key components of the wind turbine, including the **gearbox, and the electrical generator.**
- Service personnel may enter the nacelle from the tower of the turbine.
- To the **left of the nacelle** we have the **wind turbine rotor**, i.e. the rotor blades and the hub.

Rotor blades

- The rotor blades capture the wind and transfer its power to the rotor hub.

- On a modern **1000 kW** wind turbine each rotor blade about **27 metres (80 ft.)** in **length** and is designed much like a **wing of an aeroplane.**

Hub

- It is attached to the low speed shaft of the wind turbine.

Low speed shaft

- ➢It connects the rotor hub to the gearbox.
- ➢On a modern 1000 kW wind turbine the rotor rotates relatively slowly, about 19 to 30 revolutions per minute (RPM).
- ➢The shaft contains pipes for the hydraulics system to enable the aerodynamic brakes to operate.

Gearbox

- The gearbox has the low speed shaft to the left.
- It makes the high speed shaft to the right turn approximately 50 times faster than the low speed shaft.

High speed shaft

- The high speed shaft rotates with approximately 1,500 revolutions per minute (RPM) and drives the electrical generator.
- It is equipped with an emergency mechanical disc brake.
- The mechanical brake is used in case of failure of the aerodynamic brake, or when the turbine is being serviced.

Electrical Generator

- The electrical generator is usually called induction generator.
- On a modern wind turbine the maximum electric power is usually between 600 and 3000 kilowatts (kW).

Electronic controller

- The electronic controller contains a computer which continuously monitors the condition of the wind turbine and controls the yaw mechanism.

- In case of any malfunction, (e.g. overheating of the gearbox or the generator), it automatically stops the wind turbine and calls the turbine operator's computer via a telephone modem link.

Hydraulics system

- It is used to reset the aerodynamic brakes of the wind turbine.

Cooling unit

It contains an electric fan which is used to cool the electrical generator.

In addition, it contains an oil cooling unit which is used to cool the oil in the gearbox.

Some turbines have water-cooled generators.

Tower

- The tower of the wind turbine carries the nacelle and the rotor.
- A typical modern 1000 kW turbine will have a tower of 50 to 80 metres (150 to 240 ft.) (the height of a 17-27 story building).
- Towers may be either tubular towers or lattice towers.
- Tubular towers are safer for the personnel
- The advantage of lattice towers is they are cheaper.

Anemometer wind wane

- It is used to measure the speed and the direction of the wind.
- The computers stops the wind turbine automatically if the wind speed exceeds 25 metres per second (50 knots) in order to protect the turbine and its surroundings.
- The wind vane signals are electronic controller to turn the wind turbine against the wind, using the yaw mechanism.

Thank You