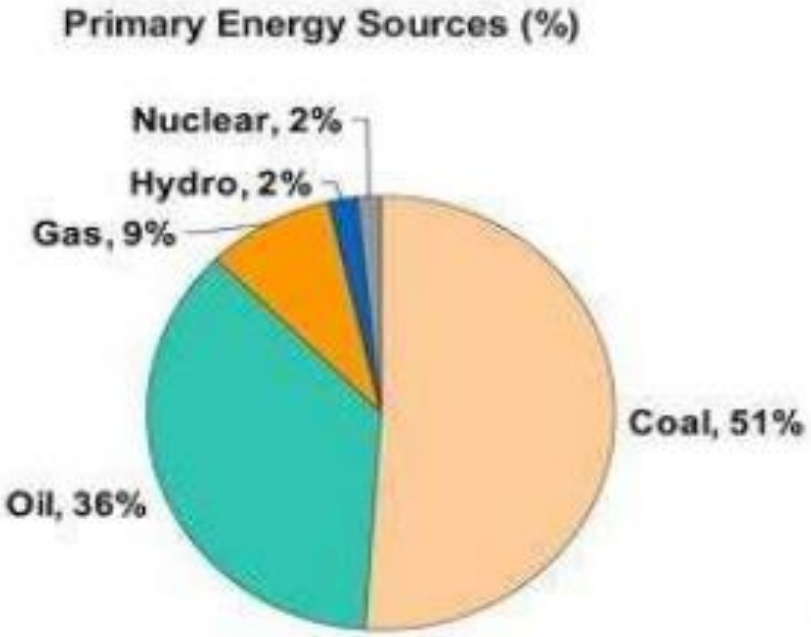
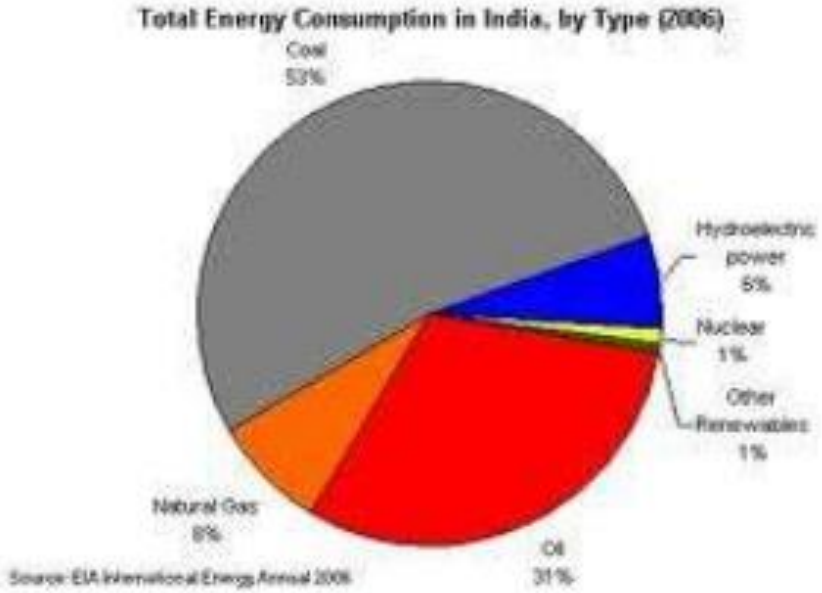
ALTERNATE ENERGY SOURCES

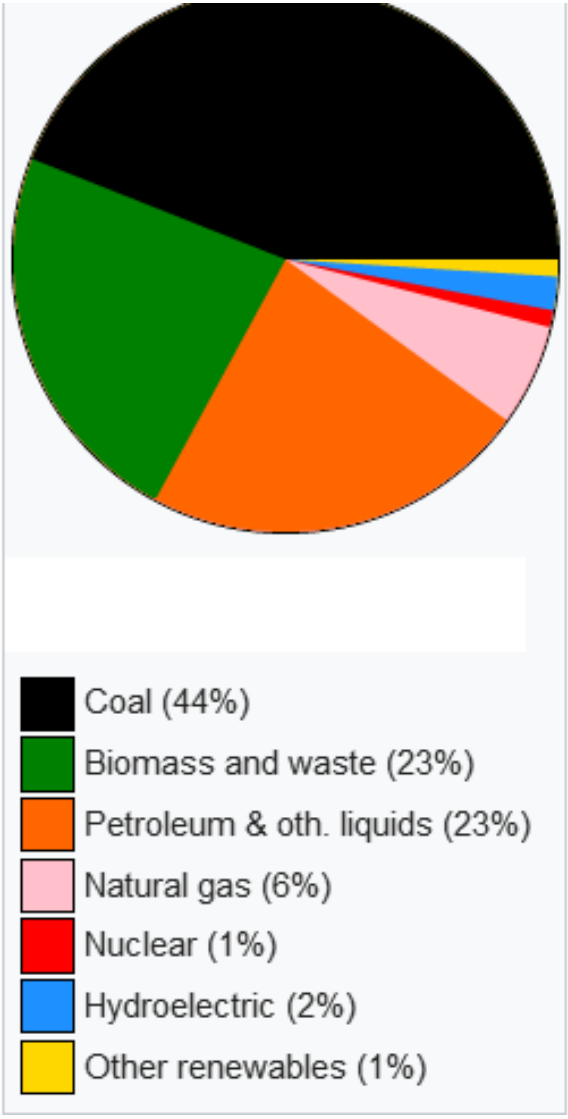
INTRODUCTION

Main energy sources

- Coal
- Oil
- Natural gas
- Nuclear power
- Hydro power
- Other renewable sources(like wind, biomass, solar power, geothermal power, tidal etc.)


Primary Energy Sources (%)
Nuclear, 2%
Hydro, 2%
Gas, 9%
Coal, 51%
Oil, 36%


Total Energy Consumption in India, by Type (2006)
Coal
53%
Hydroelectric
power
5%
Nuclear
1%
Other
Renewables
1%
Natural Gas
9%
Oil
31%
Source: EIA International Energy Annual 2006


Coal (44%)
Biomass and waste (23%)
Petroleum & oth. liquids (23%)
Natural gas (6%)
Nuclear (1%)
Hydroelectric (2%)
Other renewables (1%)

ENERGY SCENARIO

- **Coal:**
  - Dominates the energy mix.
  - Contributes to 55% of primary energy production & 53% of energy consumption.
  - India fourth largest producer.
  - 70% total domestic electricity & 50% commercial energy demand is met.
  - 8.6% of world reserves ie. about 84396 million tonne & last for next 235 years
  - Lignite is also used
  - Dominant fuel when energy demand increases in future

- **Oil:**
  - Accounts for 36% of total energy consumption and 34% total energy production.
  - India is one among top ten consumer in the world
  - 0.3% world's reserves
  - 70% of demand is met by imports i.e 1.2 million barrel per day.
  - Consumption of petrol in transport sector-53%, domestic-18%, industries-17% .
  - Total installed capacity of Diesel based power plants in India is 1,199.75 MW.
  - 20-17% decline in share in primary energy production

- **Natural gas:**
  - Accounts for 8% of energy consumption & 9% of energy production.
  - The total installed capacity of gas based power plants in India is 17,353.85 MW about 10% of total installed capacity.

- **Electrical energy**
  - Out of total production
    - 65.8% comes from thermal power plant,
    - 26.3% from hydro electricity,
    - 3.1% from nuclear power & rest renewable sources
  - Gross generation of energy is 531 billion units. Overall electrification rate is 64.5%.
  - Power generation assets are not evenly spread.
  - 52.5% of rural households have access to electricity while in urban areas it is 93.1% .
  - Electricity demand outstripped supply by 7-11%. Plans 8-10% growth ie. 215,804MW capacity

- **Nuclear power**
  - Fourth largest source of electricity.
  - Contributes to 2.5% in total energy production, and 3.1% in electricity generation.
  - Nineteen nuclear power reactors and six nuclear power plants produce **4,560 MW**(2.9% of total installed base).
  - To achieve 20000 MW generation capacity

- **Hydro power**
  - Only 15% utilized
  - 25% share in total generation unit with installed capacity of 36877 MW
  - It share in power generation has decreased

NUCLEAR POWER PLANTS

Power station	State	Installed capacity(MW)
Narora Atomic Power Station	Uttar Pradesh	440
Rajasthan Atomic Power Station	Rajasthan	1180
Tarapur Atomic Power Station	Maharashtra	1400
Kakrapar Atomic Power Station	Gujarat	440
Kudankulam Nuclear Power plant	Tamil Nadu	2000
Madras Atomic Power Station	Tamil Nadu	500
Kaiga Nuclear Power Plant	Karnataka	880
Madras Atomic Power Station	Tamil Nadu	440

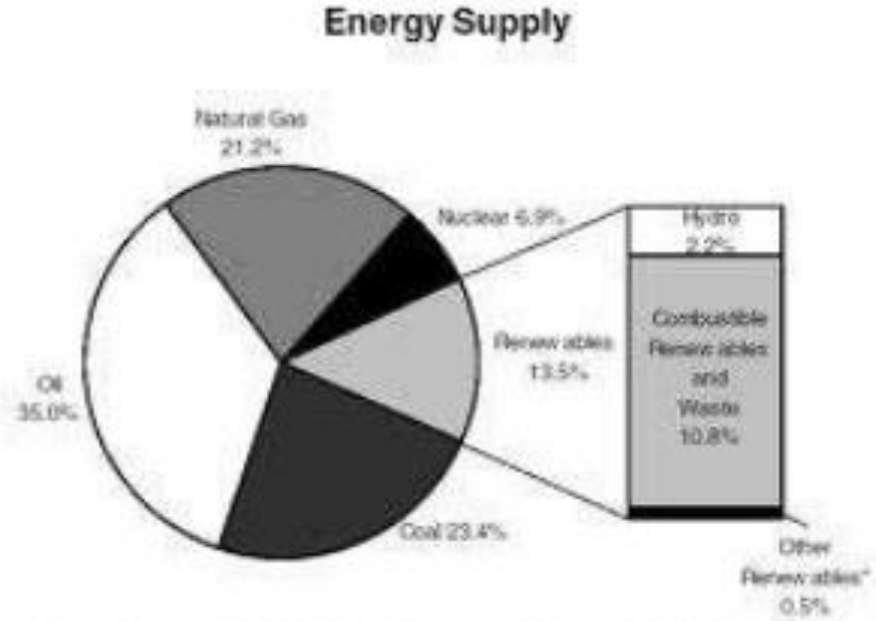
- **Thermal power**
  - Accounts for 64.6% in total energy production.
  - Installed capacity of Thermal Power is 1,04,424 MW which is 63.7% of total installed capacity.
  - Thermal power produced from

Thermal power based on	Installed capacity (MW)	Total %
Coal	86003	53
Gas	17221	10.61
Oil	1199	74

- **Renewable resources**
  - Immense potential
  - Current installed base of is **16,492.42 MW** which is 10.12% of total installed base.
  - Second largest exploiter of wind energy(1000 MW) & fifth largest wind power industry, with installed capacity of 9587MW.
  - Tamil Nadu contributing nearly a third of it (5008.26 MW) largely through wind power.
  - Utilizes 33lakh bio-gas plant, 2 lakh solar cooker & street lighting system using photo voltaic technology.
  - Targets 14000MW generation capacity in future.

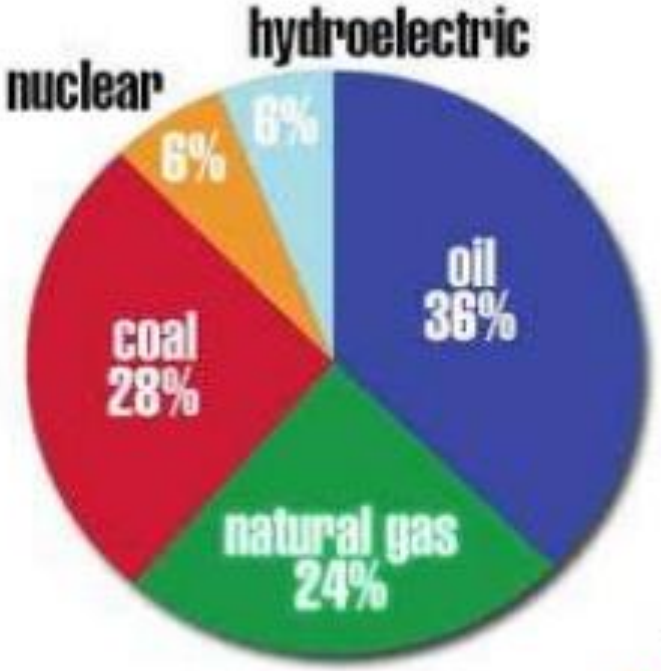
World energy scenario

Energy production



*Other Renewables: Geothermal, Wind, Solar, Tide.

Energy consumption



OVERVIEW

(in thousand of metric tone of oil equivalent)	**INDIA**	**WORLD**
Total energy production	421565	10077984
% change since 1980	90	37
Energy imports	59162	9521506
Energy exports	2376	3419104
Total energy consumption	480418	9702786
Electricity consumption	32529	1040770
Energy consumption by sector		
Industry	97859	2140474
Transportation	44475	1755505
Agriculture	9741	166287
Commercial & public service	2737	511555
Residential	200781	1845475

CONT….

Energy consumption by source		
Coal & coal product	157169	2278524
Oil	79557	3563084
Natural gas	20754	2012559
Nuclear	3409	661901
Hydro electric	7004	222223
Solid biomass	198018	1035139
Bio gas & liquid biomass		14931
Geo thermal		43802
Solar		2217
Wind	89.2	1748
Tide		53

Energy strategies for a sustainable world

- Necessary condition for socio-economic change to lead to a sustainable world must include
  - Satisfaction of basic needs of the peoples
  - Economic viability
  - Self reliant interdependence of nations
  - Harmony with the environment
- Energy strategies for future can be classified as
  - 1.Immediate
  - 2.Mid-term
  - 3.Long term

- **Immediate term strategy:**
- Optimum utilization of existing assets.
- Efficiency in production system & reduction in distribution losses.
- Promoting R&D, transfer and use of technologies for environmentally sound energy systems.
- Rationalizing the tariff structure of various energy products.

- **Medium-term strategy:**
- Demand management through conservation of energy, structural changes in economy, model mix in transportation sector, recycling
- A shift to less energy-intensive modes of transport
- Shift to renewable sources of energy.

- **Long – term strategy:**

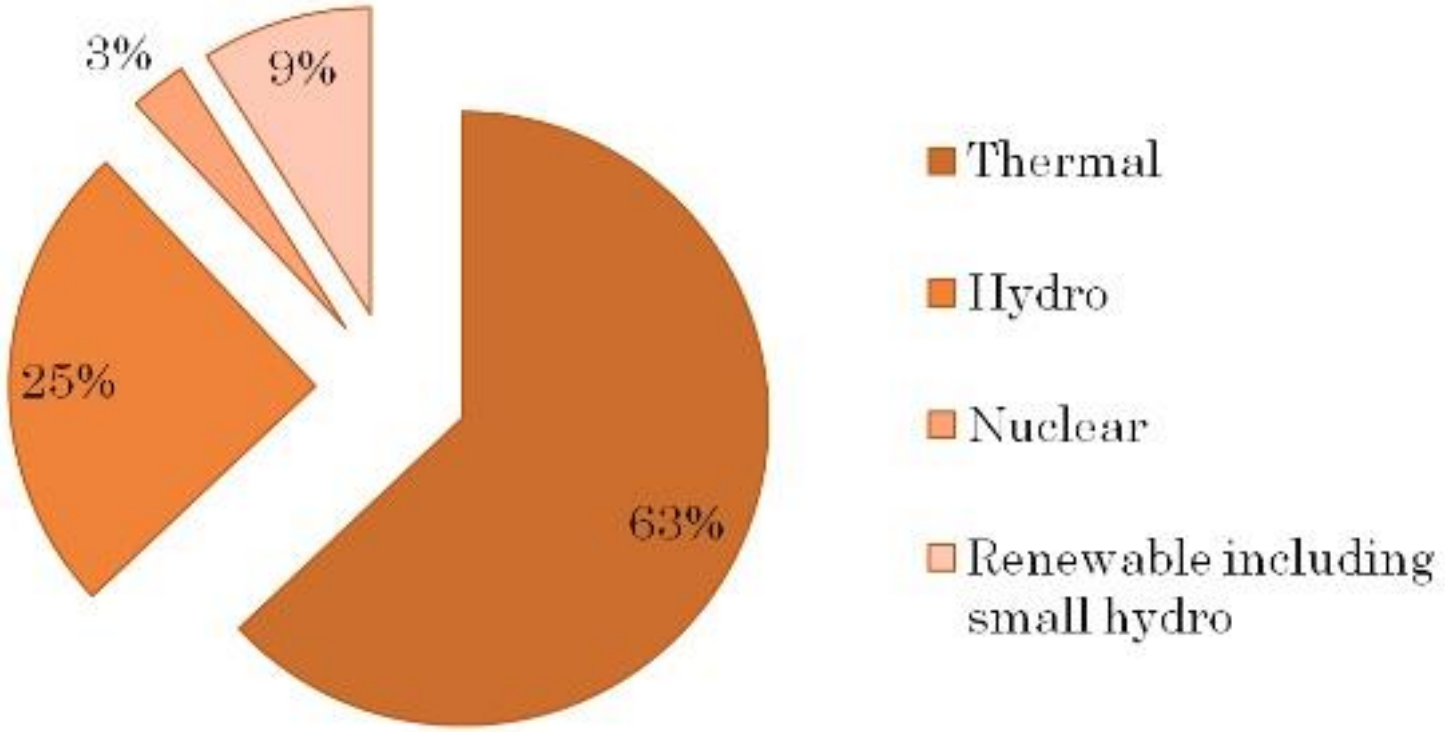
- Efficient generation of energy resources.
- Efficient production of coal.oil & natural gas.
- Reduction of natural gas flaring
- Improving energy infrastructure
- Creation of urban gas transmission and distribution network.
- Improving energy efficiency in accordance with national, socio-economic & environmental priorities.
- Promoting of energy efficiency & emission standards.
- Programs for adopting energy efficient technologies in large industries.
- Deregulation and privatization of energy sector

ENERGY IN INDIA: AN OVERVIEW

- India consumes 3.7% of the world's commercial energy making it the 5th largest consumer of energy globally.
- Total installed capacity of 1,44,912 MW.
- 350 kgoe per capita primary commercial energy consumption. 22% of world average.
- Per capita electricity consumption: 600 kWhr per year.
- About 80% of total rural energy consumption comes from non-commercial energy.
- 84% villages electrified. 44% of rural households electrified.

INDIAN POWER SECTOR

Total Installed Capacity: 1,44,912 MW



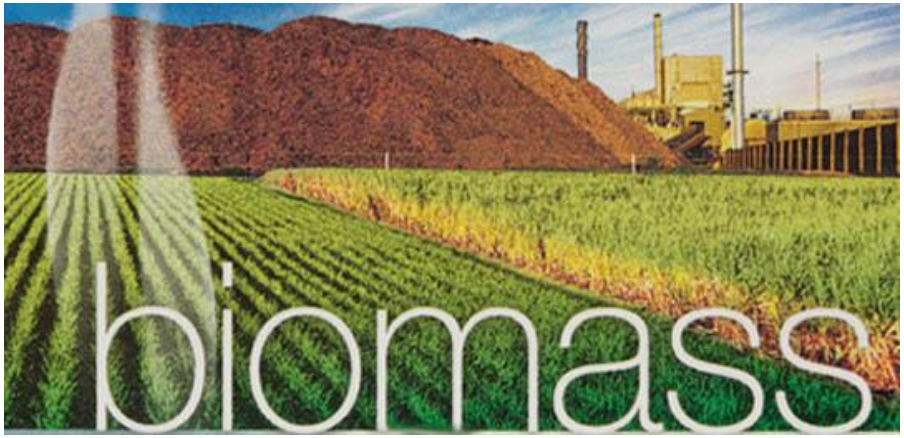
Source: Ministry of New and Renewable Energy

WHY RENEWABLE ENERGY FOR INDIA?

- Power shortage
- Rising Prices of Oils & Gases
- Ecological Hazards
- Ample resources and sites available
- Abundant sunshine
- Government incentive
- Increased financing options

BENEFITS OF RENEWABLE ENERGY

- Avoid the high costs involved in transmission capex.
- Avoid distribution losses – Technical & otherwise
- Avoid recurring fuel cost
- Boost the rural economy
- Encourage self help groups & self dependence
- Enable village co-operatives to supply and / or monitor distribution
- Make available much needed energy for basic needs at the doorstep at affordable prices.



Biomass/Biofuel/Biogas

What is biomass?

- Biomass is a renewable energy source that is derived from living or recently living organisms.
- Biomass includes biological material, not organic material like coal.
- Energy derived from biomass is mostly used to generate electricity or to produce heat.
- Thermal energy is extracted by means of combustion,
- Biomass can be chemically and biochemically treated to convert it to a energy-rich fuel.

Types of Biomass

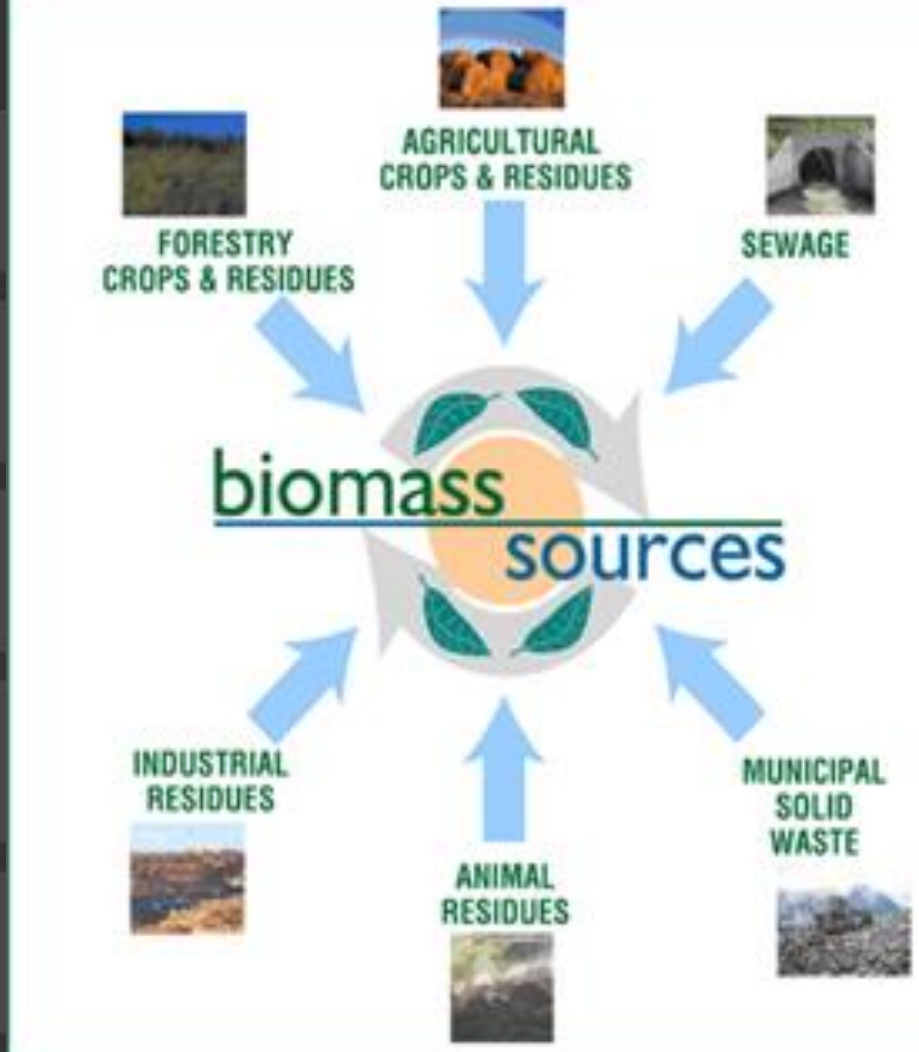
Wood fuel

Rubbish

Alcohol fuels

Crops

Landfill gas



Using biomass as a primary fuel source

Biomass is used as a primary fuel source in developing countries specifically in rural areas.

Something to know…

- Biomass has a smaller energy content for its bulk than fossil fuels
- Costs of labor, transportation, and storage would then be higher

Biofuels and biodiesels

Biofuels are created from vegetable or animal based oils (Ex: canola or soybean oil, palm oil, grease, sewage or leftover trash) It is used and fuels for vehicles.

Biodiesel is also a type of fuel created by vegetable or animal oils but it is often blended with regular diesel. Biodiesel is a cleaner alternative to diesel. But not all vehicles can use diesel.

Advantages for Biomass, Biogas, and Biofuel

1. It's renewable - You will always have a source for biomass (Crops and garbage)
2. Abundant - Biomass is available all over the world
3. Cheaper than other fuels - It cost ⅓ less than fossil fuel which can save you a lot of money
4. Carbon neutral - Biomass is a part of the carbon cycle. It is a clean source and do not contribute to global warming

ENVIRONMENTAL ADVANTAGES

- Renewable resource
- Reduces landfills
- Protects clean water supplies
- Reduces acid rain and smog
- Reduces greenhouse gases
- Carbon dioxide
- Methane

BIOMASS AND CARBON EMMISIONS

- Biomass emits carbon dioxide when it naturally decays and when it is used as an energy source
- Living biomass in plants and trees absorbs carbon dioxide from the atmosphere through photosynthesis
- Biomass causes a closed cycle with no net emissions of greenhouse gases

Disadvantages for Biomass, Biogas, and Biofuel

1. Expensive - Biomass is expensive to set up and store

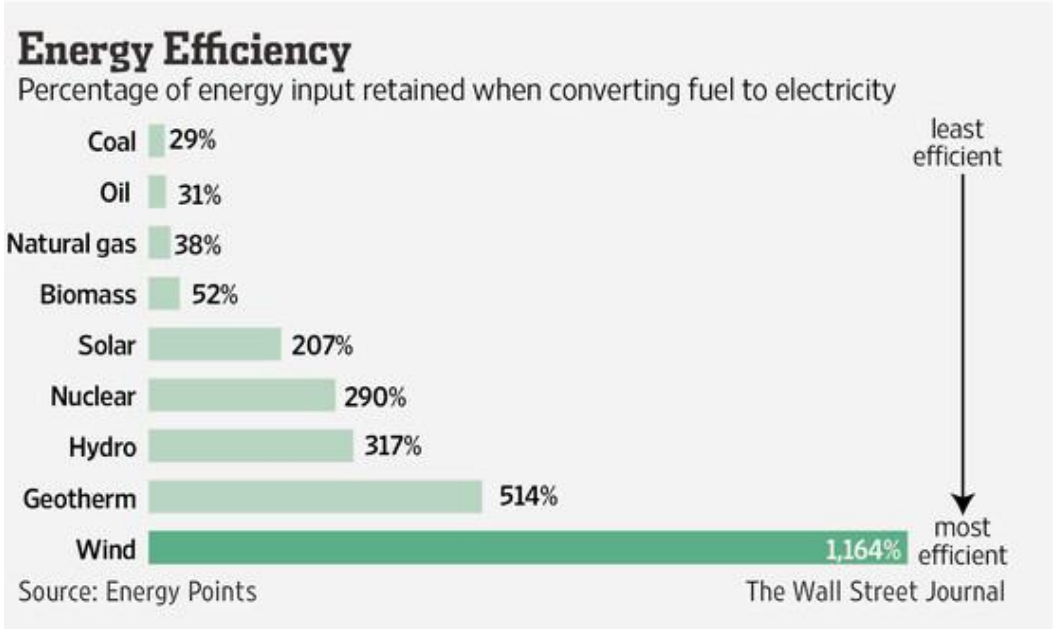
- 2. Requires a lot of space - We need a lot of space to store all the energy

ENVIRONMENTAL DISADVANTAGES

- Crop and forest residues often contain high concentrations of important nutrients
- If the residue is harvested as energy, the nutrients can be lost to the surrounding environment.
- Other synthetic chemical nutrients or fertilizers can later be added
- More plants and trees must be planted, because they will be used in a higher quantity

Energy Efficiency

- Biomass is 52% efficient, so using it is less efficient because it only gives off half of its energy.



Sources of Biofuels

- Algae
- Ethanol
- Vegetable oil
- Biogas
- Syngas
- Blended Biodiesel

Biogas

- Biogas is defined as a mixture of different gases produced by the breakdown of once living organisms in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material,sewage, green waste, or food waste.

Biogas

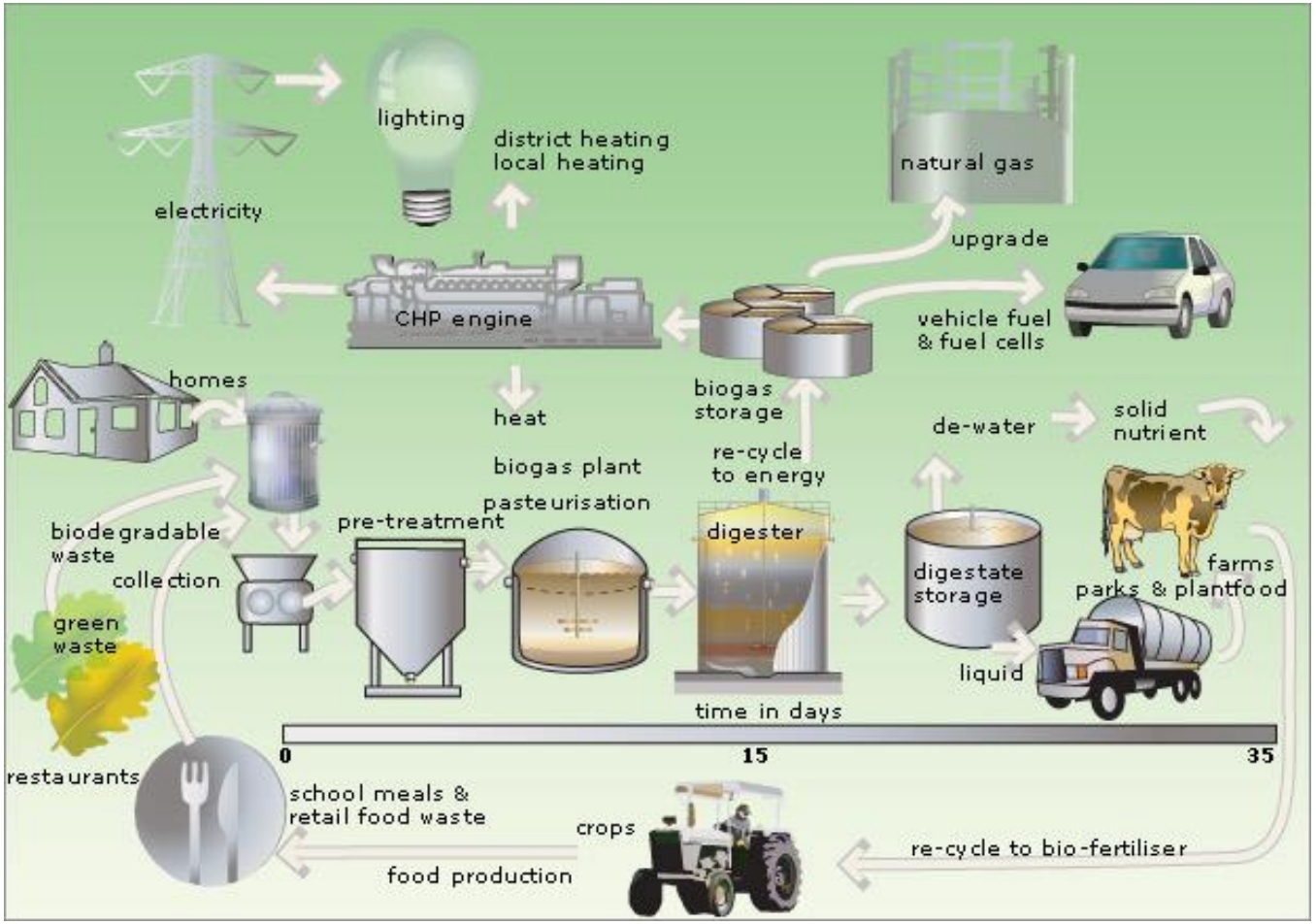
Pros of Biogas

- Provides non-polluting and renewable source
- efficient way of energy conversion(saves fuelwood)
- saves women and children from carrying firewood and exposure to kitchen smoke

Cons of Biogas

- Difficult to enhance efficiency of biogas systems
- contains some impurities and gas that are harmful
- it is somewhat unstable make it prone to combustion if methane comes in contact with oxygen

Biogas Digester



Biogas Digester Construction

BIO – GAS & BIO GAS PLANTS

BIOGAS

Mixture of gases.

Produced by anaerobic digestion of organic matter.

Consist of CH_4,CO_2,traces of H_2& other gases.

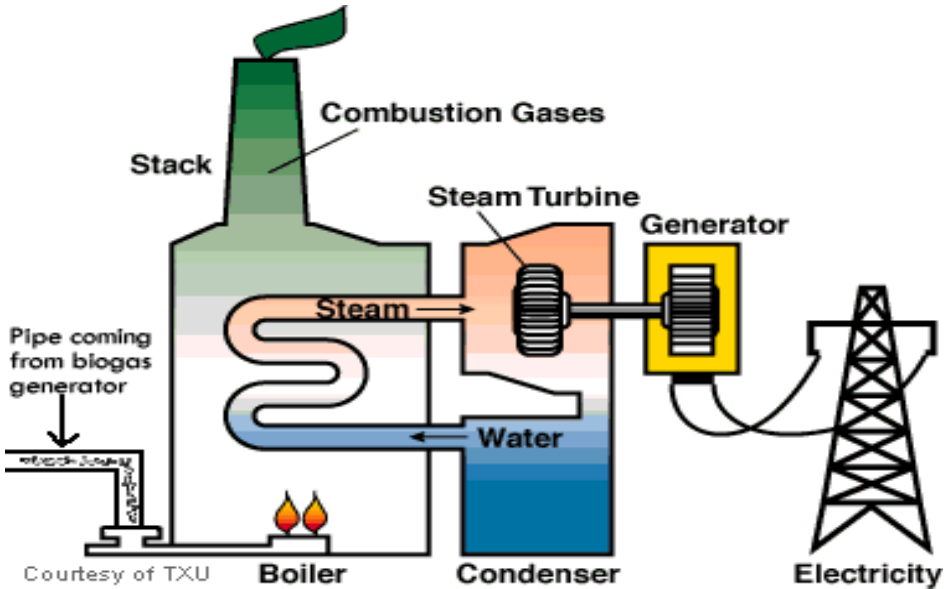
Composition of Biogas

Type of gas	% in the mixture by volume
Methane	50–80
Carbon dioxide	15–45
Water	5
Other gases including hydrogen	0–1
Hydrogen sulphide	0–3

BENEFITS FROM BIOGAS PLANTS

Used mainly for cooking & lighting purposes.

Used in internal combustion engines to power water pumps & electric generators.



Used as fuel in fuel type refridgerators.

Sludge - fertilizer.

↓ envt. pollution

SUBSTRATE

Plant & animal biomass.

Plant biomass –

Animal biomass – cattle dung,manure from poultry,goats & sheep slaughter house & fishery wastes.

Agricultural wastes also used

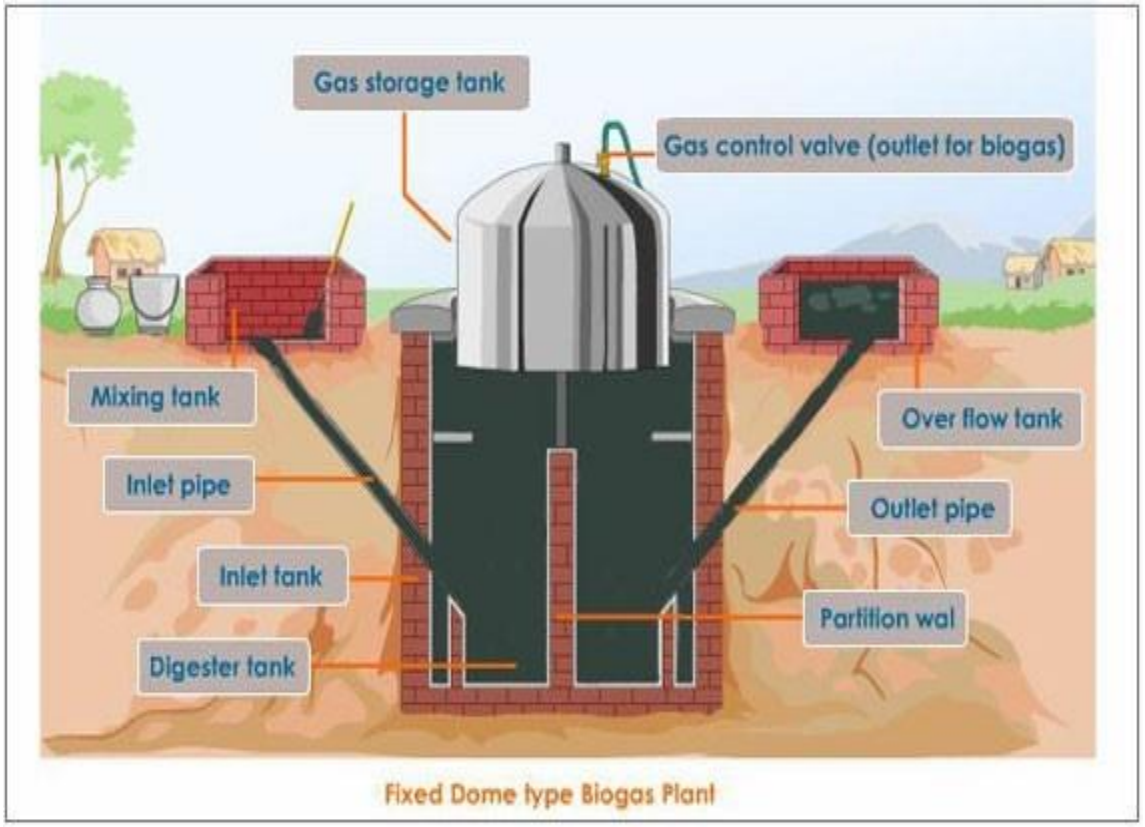
Parts of biogas plant

Digester

Gas holder

Inlet

Outlet



Inlet chamber

To supply cow dung to the digester

It is made at the ground level so that the cow dung can be poured easily.

made up of bricks, cement and sand.

The outlet wall of the inlet chamber is made inclined so that the cow dung easily flows to the digester.

Digester

Most important part of biogas plant

Fermentation takes place - fermentation tank.

Built underground – insulated,airtight

Made up of bricks, sand and cement.

Almost at the middle of the height of digester, two openings are provided on the opposite sides for inflow of fresh cow dung and outflow of used cow dung.

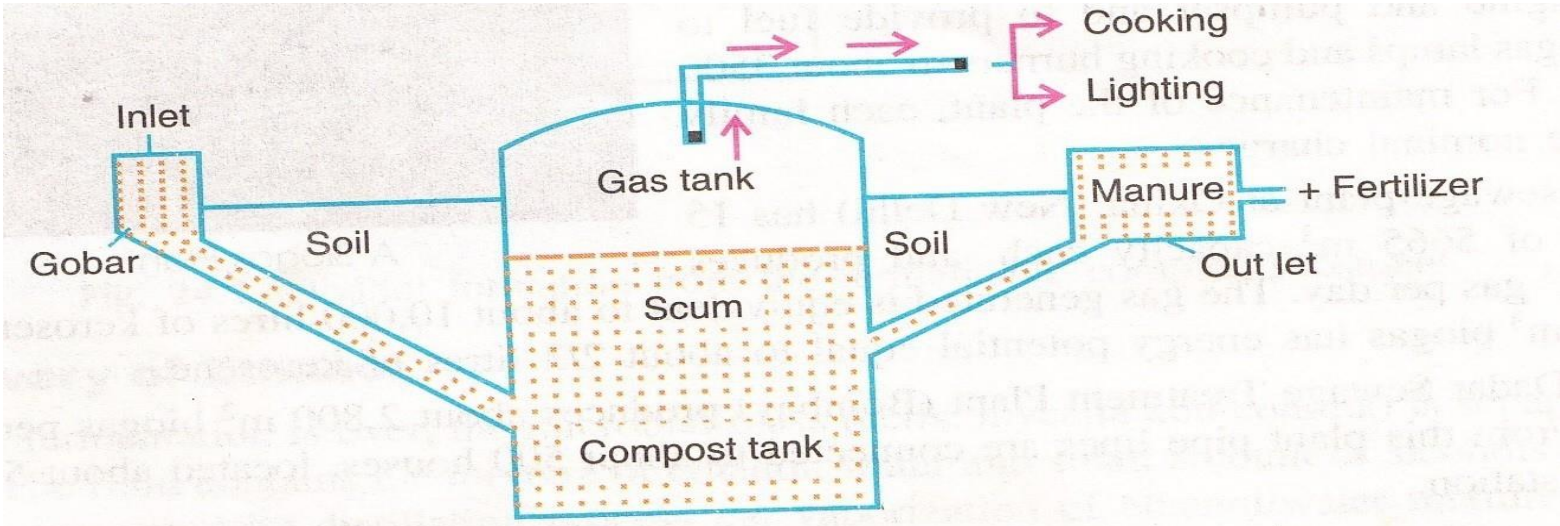


Fig. 24.2. Diagram of a Janata Vayu Gas (gobar gas) Plant.

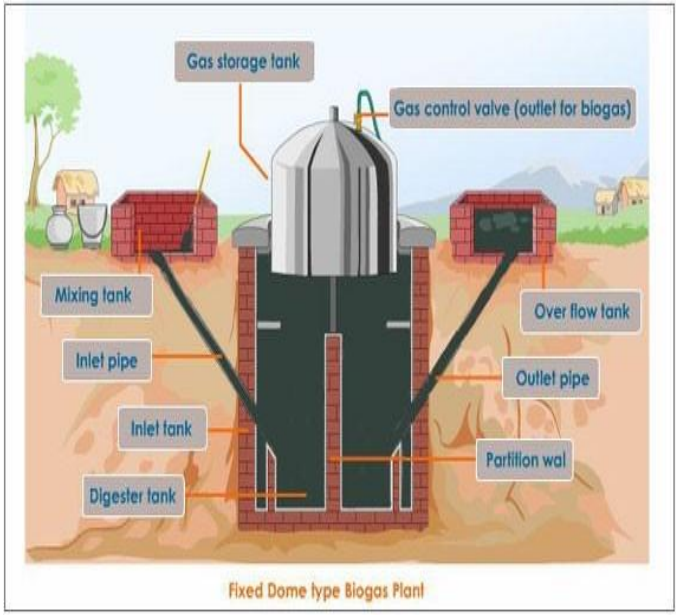
Gas holder

Cylindrical container

Above digester

Collect gas

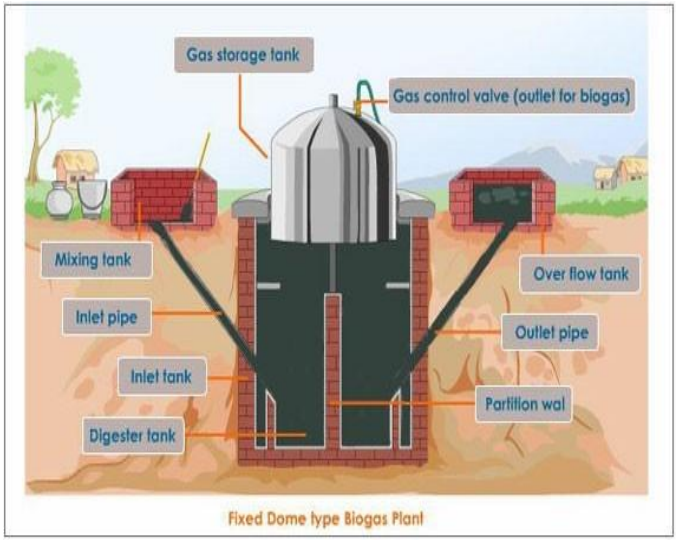
The gas pipe carries the biogas to the place where it is consumed.



Outlet Chamber

- Digested slurry from which the biogas has been generated is removed from the biogas plant.

The outlet chamber is also at the ground level.



Fixed dome type

A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester.

Floating-drum type

Consist of an underground digester and a moving gas-holder.

- Gas-holder floats either directly on the fermentation slurry or in a separate water jacket.

The gas is collected in the gas drum, which rises or moves down, according to the amount of gas stored

Floating-drum type

Batch type

Filled once,sealed.

Emptied when raw materials stop producing gas.

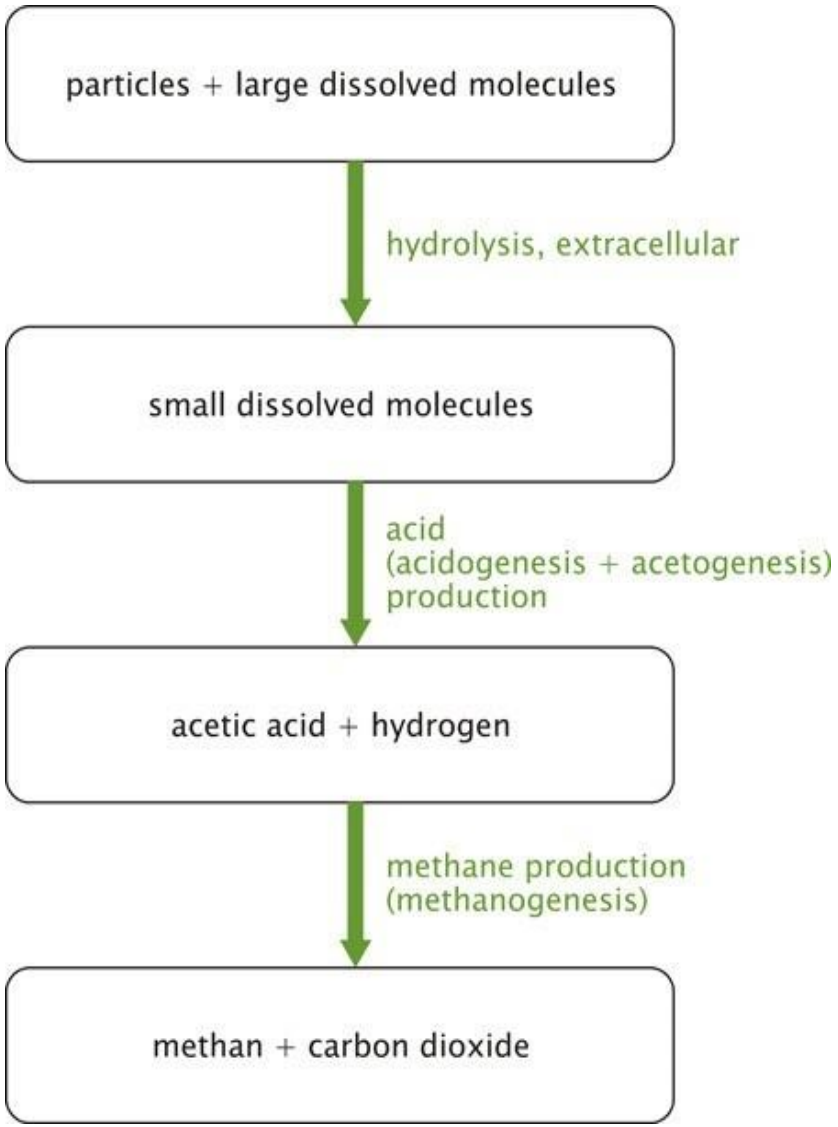
Continuous type

Fed with a definite quantity of wastes at regular intervals

Gas production continuous & regular

MICROBIOLOGY OF BIOGAS

- **4 steps**
- **Hydrolysis**
- **Acidogenesis**
- **Acetogenesis**
- **Methanogenesis**



Hydrolysis

Biomass is made up of large organic polymers

Complex polymers hydrolysed to monomers

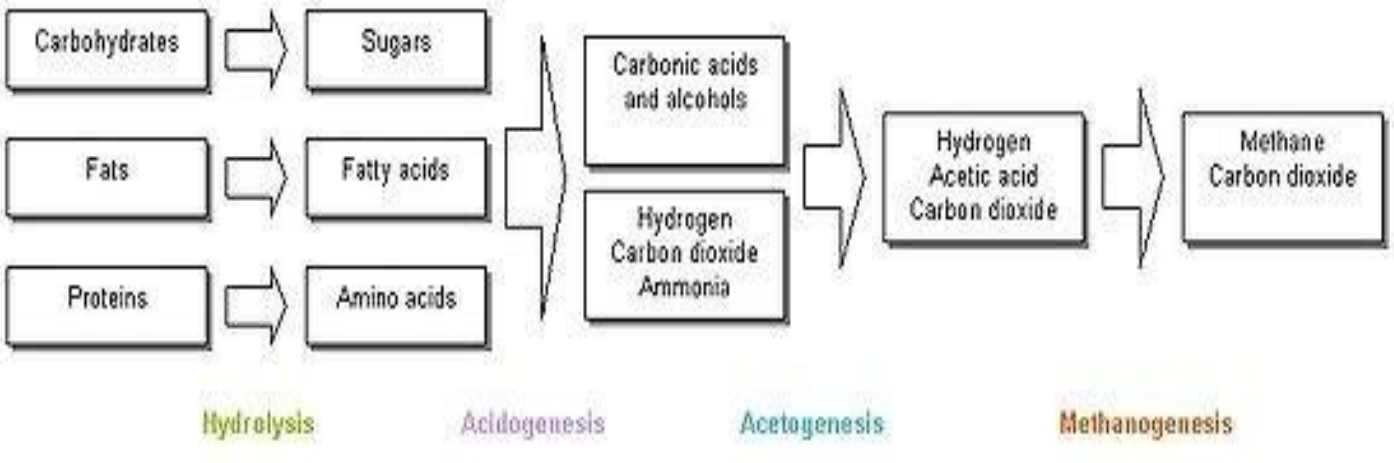
complex organic molecules → simple sugars, amino acids, and fatty acids.

Done by hydrolytic fermentative bacteria

Acidogenesis

Results in further breakdown of the remaining components by acidogenic bacteria.

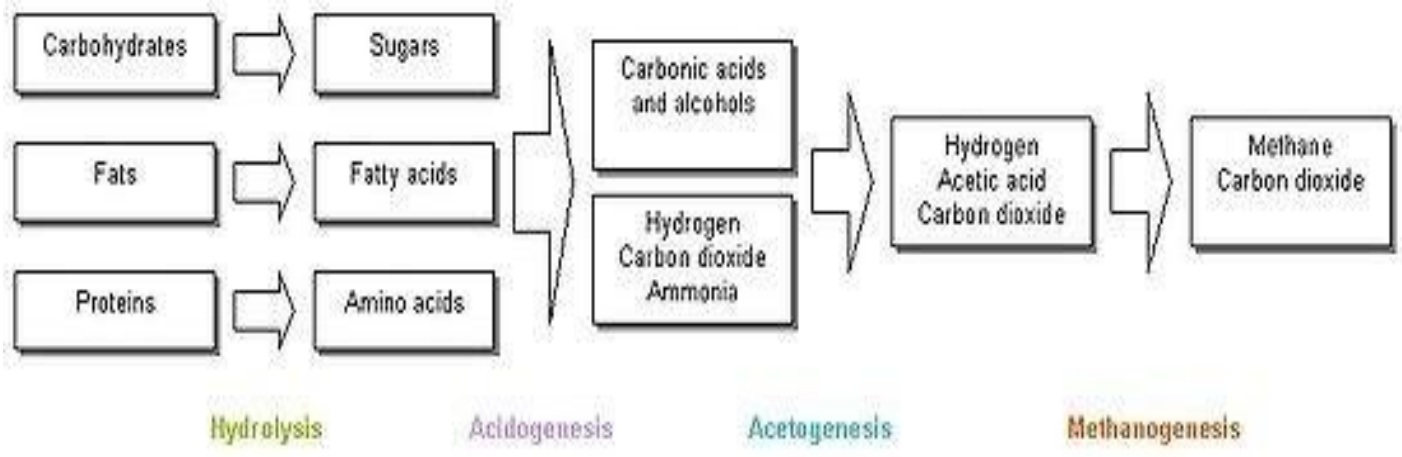
Ammonia, H_2, CO_2, H_2S, shorter volatile fatty acids, carbonic acids, alcohols, as well as trace amounts of other byproducts produced



Acetogenesis

Simple molecules created through the acidogenesis phase further digested to acetic acid, carbon dioxide and hydrogen.

Acetogenic bacteria



Methanogenesis

The terminal stage

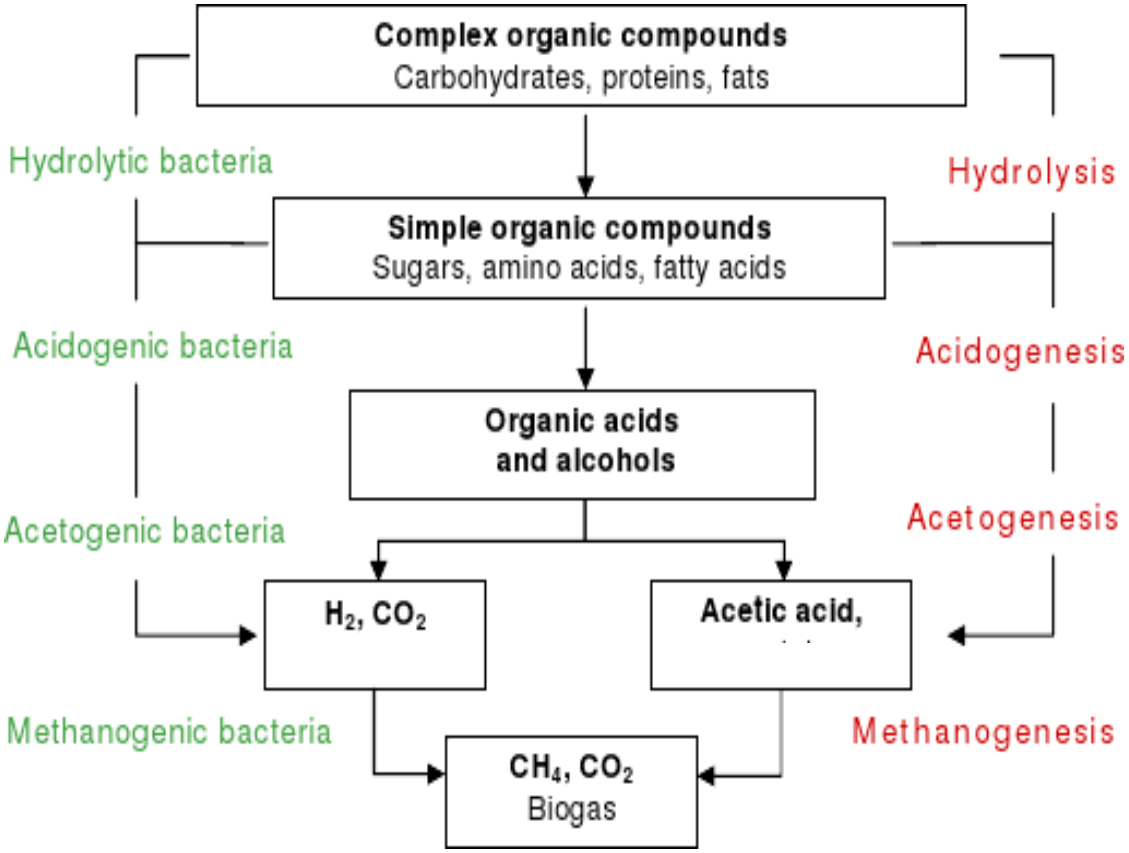
Intermediate products of the preceding stages converted to methane, carbon dioxide, and water.

These components make up the majority of the biogas emitted from the system.

Methanogenic bacteria

MICRO ORGANISMS

- Hydrolytic & fermentative bacteria. Acidogenic bacteria.
- Acetogenic bacteria. Methanogenic bacteria.


Complex organic compounds
Carbohydrates, proteins, fats
Hydrolytic bacteria
Hydrolysis
Simple organic compounds
Sugars, amino acids, fatty acids
Acidogenic bacteria
Acidogenesis
Organic acids
and alcohols
Acetogenic bacteria
Acetogenesis
H2, CO2
Acetic acid,
Methanogenic bacteria
Methanogenesis
CH4, CO2
Biogas

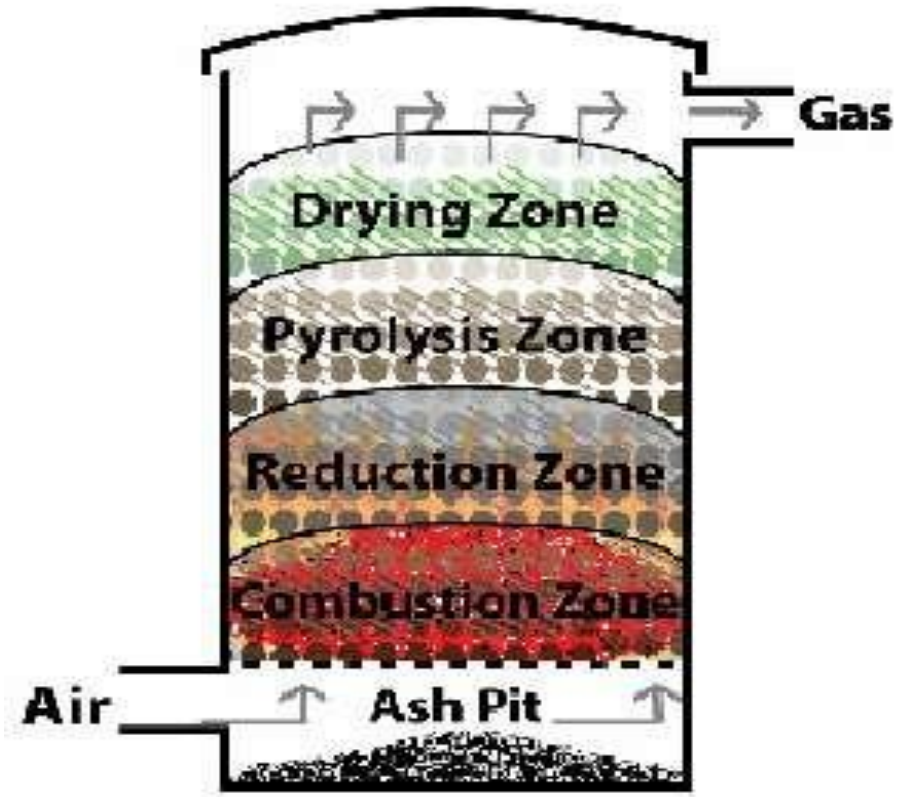
GASIFICATION

- Gasification is a process that converts organic or fossil fuel based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen and/or steam. The resulting gas mixture is called syngas (from synthesis gas or synthetic gas) or producer gas and is itself a fuel.
- The advantage of gasification is that using the syngas is potentially more efficient than direct combustion of the original fuel because it can be combusted at higher temperatures or even in fuel cells, so that the thermodynamic upper limit to the efficiency defined by Carnot's rule is higher or (in case of fuel cells) not applicable. Syngas may be burned directly in gas engines, used to produce methanol and hydrogen, or converted via the Fischer–Tropsch process into synthetic fuel. Gasification of fossil fuels is currently widely used on industrial scales to generate electricity.

TYPES OF GASIFIERS

- Gasifier equipments are generally classified as upward draft, downward draft and cross draft gasifiers, based on the direction of air/oxygen flow in the equipment. It should be noted that there are types of gasifier equipment which are different from types of gasification processes. Gasification processes can be categorized into three groups: entrained flow, fluidized bed and moving bed (sometimes called, somewhat erroneously, fixed bed).
- In gasifier Fuel Interacts with air or Oxygen and steam. So the gasifier are classified according to the way air or oxygen is introduced in it. On a bigger scale there are following four type of gasifiers.
- The choice of the one type of gasifier over there is mostly determined by the fuel, its final available form, its size , moisture content and ash content. First three type of gasifiers are mostly used
  in entrained bed gasification process and moving bed gasification process. While the last one
  is fluidized bed gasification process.

Updraft Gasifier



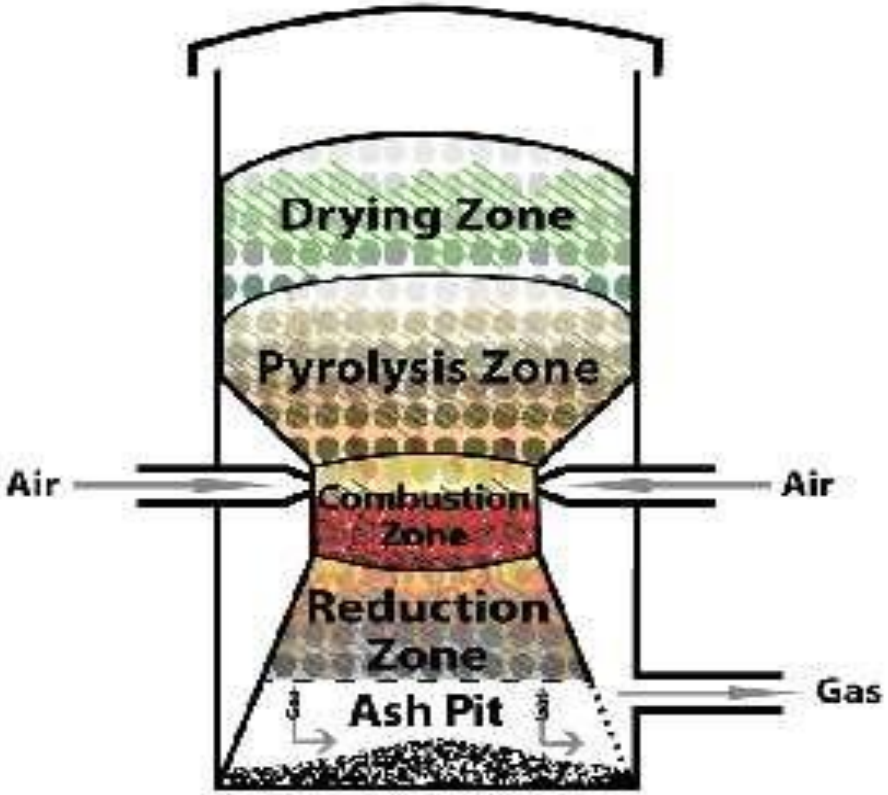
DOWNDRAFT OR CO-CURRENT GASIFIER

DOWNDRAFT OR CO-CURRENT GASIFIER

- In updraft gasifier there is a problem of tar entrainment in the product gas leaving stream. A solution is to have primary gasification air introduced at or above the oxidation zone in the gasifier. The produced gas is taken out from the bottom.
- On their way down, the acid and tarry distillation products from the fuel must pass through a glowing bed of charcoal and therefore are converted into permanent gases hydrogen, carbon dioxide, carbon monoxide and methane.
- Main advantage of downdraft gasifier lies in the possibility of producing tar free gas for engine operation. However in practice very rarely tar free gas is produced but the % of tar leaving in product stream is considerably lower than leaving through the updraft gasifier.
- Main disadvantage is that downdraft gasifier cannot be operated with range of different feedstocks. Low density feedstock gives rise to flow problems and excessive pressure drop. High ash content coal also gives more problem with this kind of gasifier than updraft gasifier.
- Other disadvantage is it gives lower efficiency, since there is no provision internal heat exchange compare to updraft gasifier. The product stream also has low calorific value.

Downdraft Gasifier

Nozzle and constriction (Imbert)

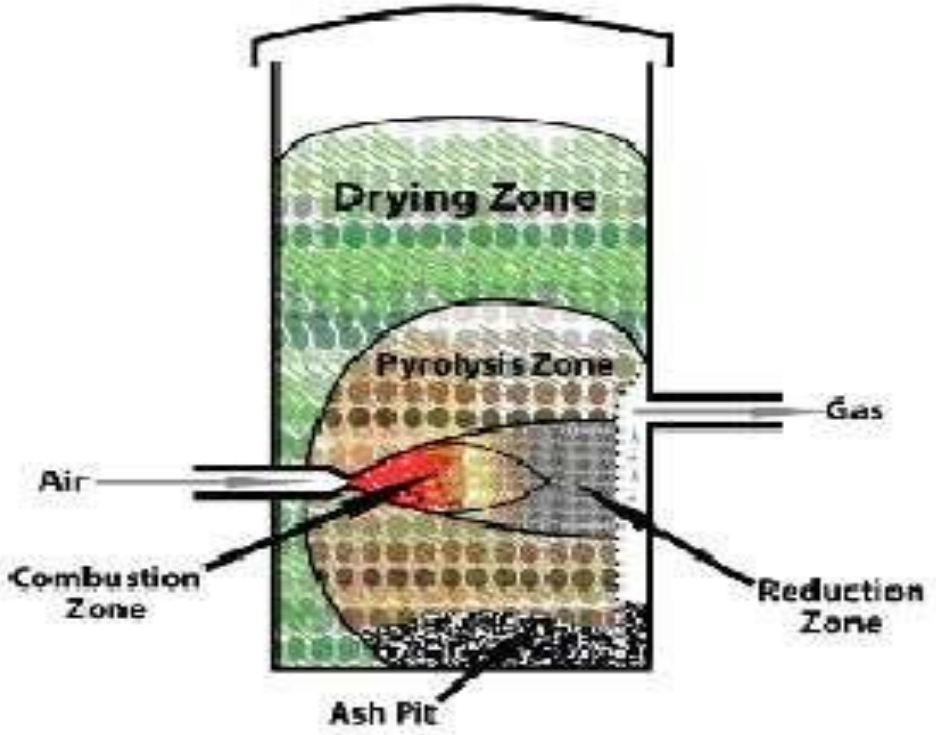


CROSS DRAFT GASIFIER

CROSS DRAFT GASIFIER

- Although cross draft gasifiers have certain advantages over updraft and downdraft gasifiers, they are not ideal. The disadvantages such as high exit gas temperature, poor CO_2 reduction and high gas velocity are the consequences of the design. Unlike downdraft and updraft gasifiers, the ash bin, fire and reduction zones in cross draft gasifiers are separate. These design characteristics limit the type of fuel usage restricted to only low ash fuels such as wood, charcoal and coke. The load following ability of cross draft gasifier is quite good due to concentrated zones which operate at temperatures up to 1200^0C. Start up time (5-10 minutes) is much faster than that of downdraft and updraft units. The relatively higher temperature in cross draft gas producer has an obvious effect on exit gas composition such as high carbon monoxide and low hydrogen and methane content when dry fuel such as charcoal is used. Cross draft gasifier operates well on dry air blast and dry fuel.

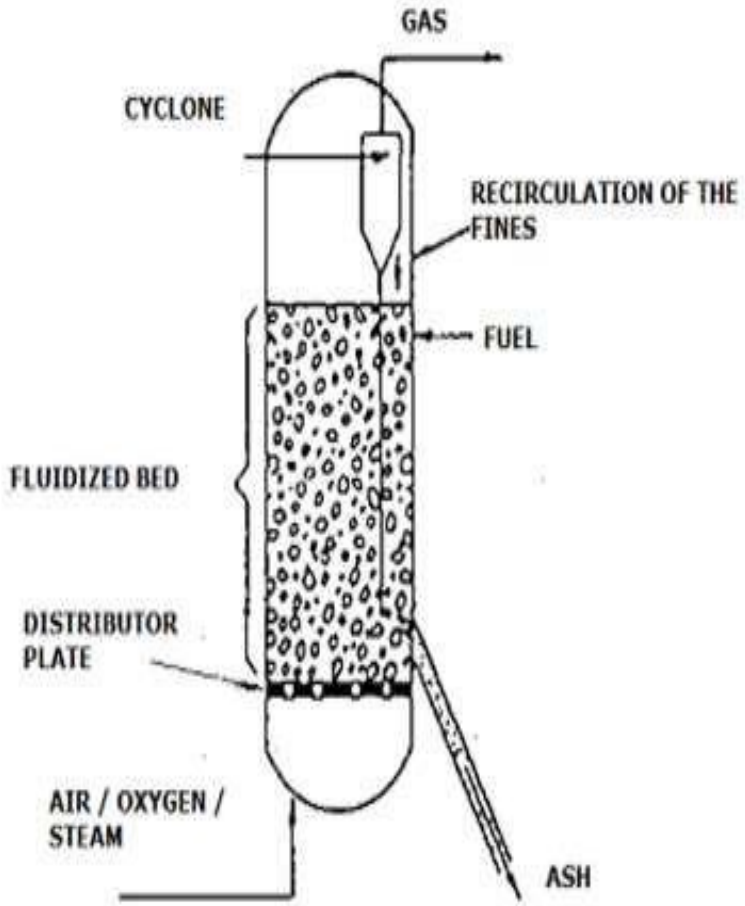
Crossdraft Gasifier



FLUIDIZED BED GASIFIER

FLUIDIZED BED GASIFIER

- The operation of both up and downward draft gasifiers is influenced by the morphological, physical and chemical properties of the fuel. Problems commonly encountered are: lack of bunker flow, slagging and extreme pressure drop over the gasifier.
- A new design to address all this difficulties is fluidized bed gasifier.
- Air is blown through a bed of solid particles at a sufficient velocity to keep these in a state of suspension. The bed is originally externally heated and the feedstock is introduced as soon as a sufficiently high temperature is reached. The fuel particles are introduced at the bottom of the reactor and almost instantaneously heated up to the bed temperature. As a result of this treatment the fuel is pyrolysed very fast, resulting in a component mix with a relatively large amount of gaseous material. Ash particles are also carried over the top of the reactor and have to be removed from the gas stream if the gas is used in engine applications. To remove ash particles cyclone and candle filter are used.
- The major advantage of fluidized bed is processing of feedstock. This type of gasifier are mostly used for high ash coal and biomass. Since temperature is below the ash softening temperature so handling of ash is relatively simple.
- Drawback of fluidized bed gasifiers is - high tar content in the produced syn gas.

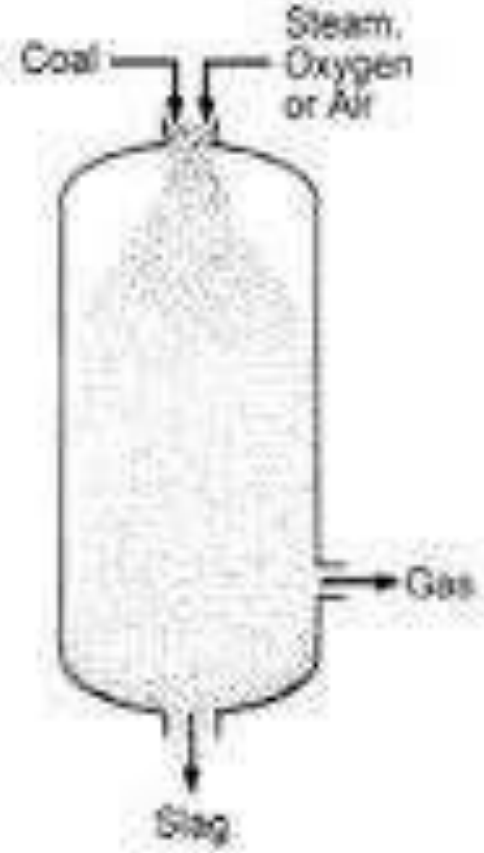

GAS
CYCLONE
RECIRCULATION OF THE FINES
FUEL
FLUIDIZED BED
DISTRIBUTOR PLATE
AIR / OXYGEN / STEAM
ASH

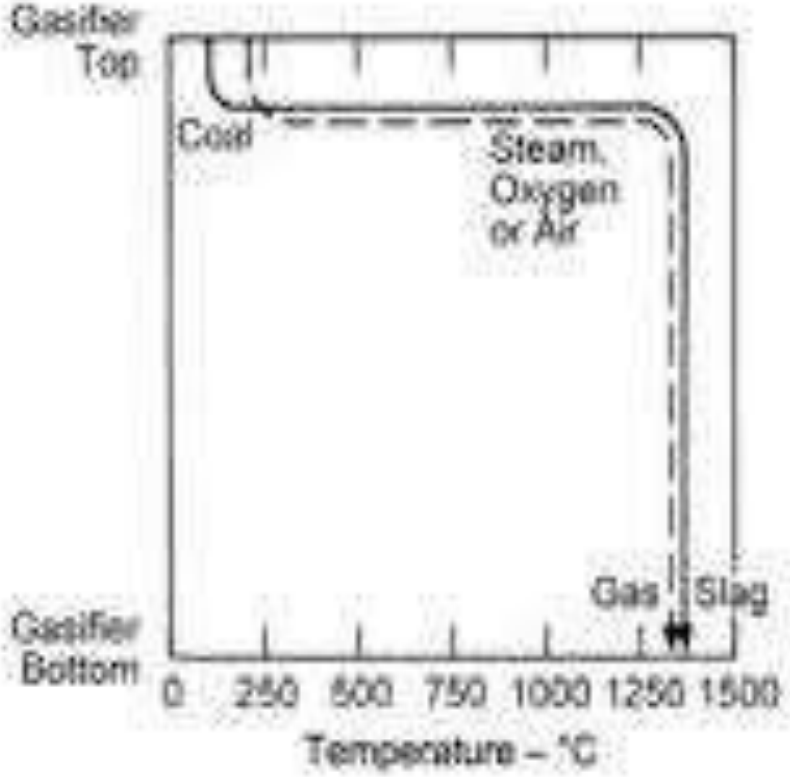
ENTRAINED FLOW GASIFIER

ENTRAINED FLOW GASIFIER

- A dry pulverized solid, an atomized liquid fuel or a fuel slurry is gasified with oxygen in co-current flow. The gasification reactions take place in a dense cloud of very fine particles.
- The high temperatures and pressures also mean that a higher throughput can be achieved, however thermal efficiency is somewhat lower as the gas must be cooled before it can be cleaned with existing technology.
- A smaller fraction of the ash is produced either as a very fine dry fly ash or as a black colored fly ash slurry. Some fuels, in particular certain types of biomasses, can form slag that is corrosive for ceramic inner walls that serve to protect the gasifier outer wall.

Entrained-Flow Gasifier





PLASMA
PLASMA GASIFIER
GASIFIER

In a plasma gasifier a high-voltage current is fed to a torch, creating a high-temperature arc. The inorganic residue is retrieved as a glass-like substance