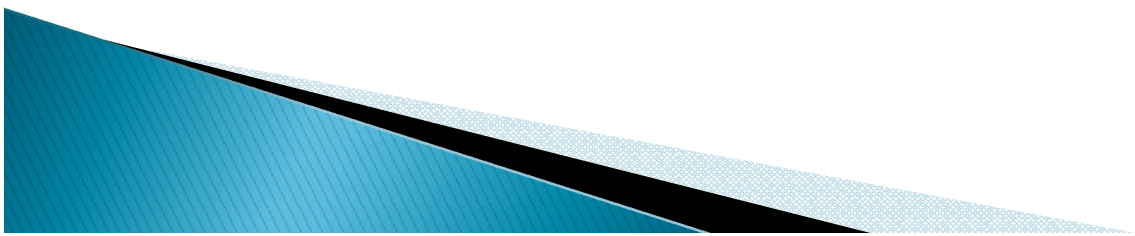
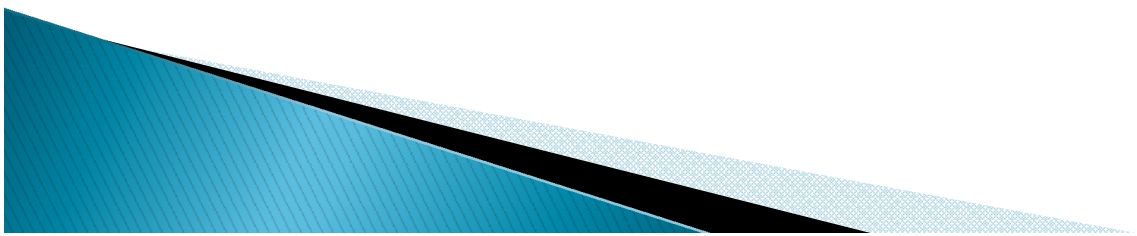
BIOMASS ENERGY



STORAGE OF RENEWABLE ENERGY BY PHOTOSYNTHESIS IN GREEN PLANTS (ORIGIN OF BIOMASS)

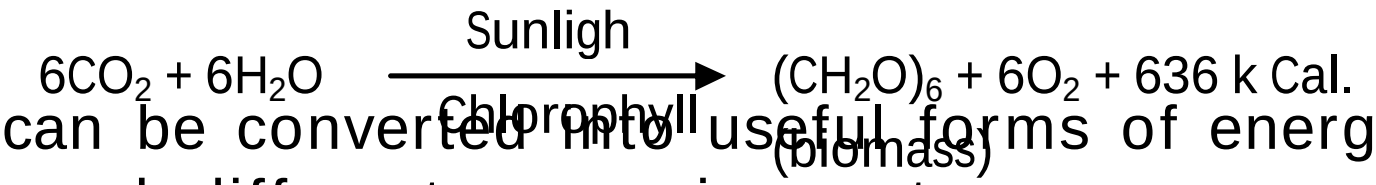
- The origin of biomass energy resources is through the Photosynthesis in green plants under sunlight. Photosynthesis means synthesis of chemicals using light. Green plants consume atmospheric carbon-dioxide gas, moisture, minerals and water from earth/water and photo energy from the sunlight and produce biomass containing energy.



Biomass Energy

Biomass:

- renewable organic matter
- produced by plants through photosynthesis.



$$6CO_2 + 6H_2O \xrightarrow{\text{Sunligh}} (CH_2O)_6 + 6O_2 + 636 \text{ k Cal.}$$

- It can be converted into useful forms of energy through different conversion routes.
- It is a source of '5F'

  Food, Fodder, Fuel, Fiber and Fertilizer.

BIOMASS TERMINOLOGY

- **Biomass**

Biomass is **biological material** derived from living, or recently living organisms.

The term equally apply to both animal and vegetable derived material, but in the context of energy, it refers to plant based material.

- **Biomass Energy**

Energy obtained from biomass is called biomass energy.

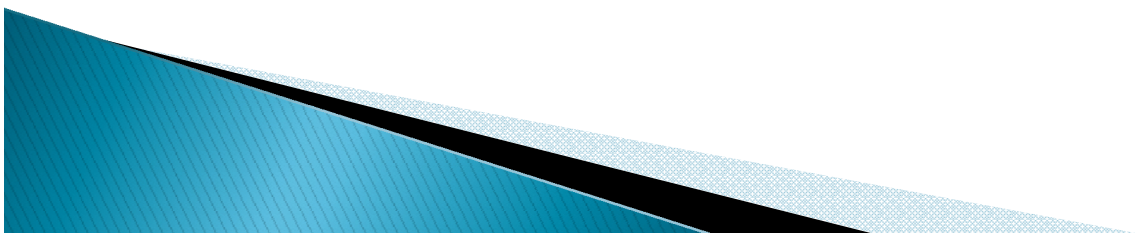
- **Bio-fuel**

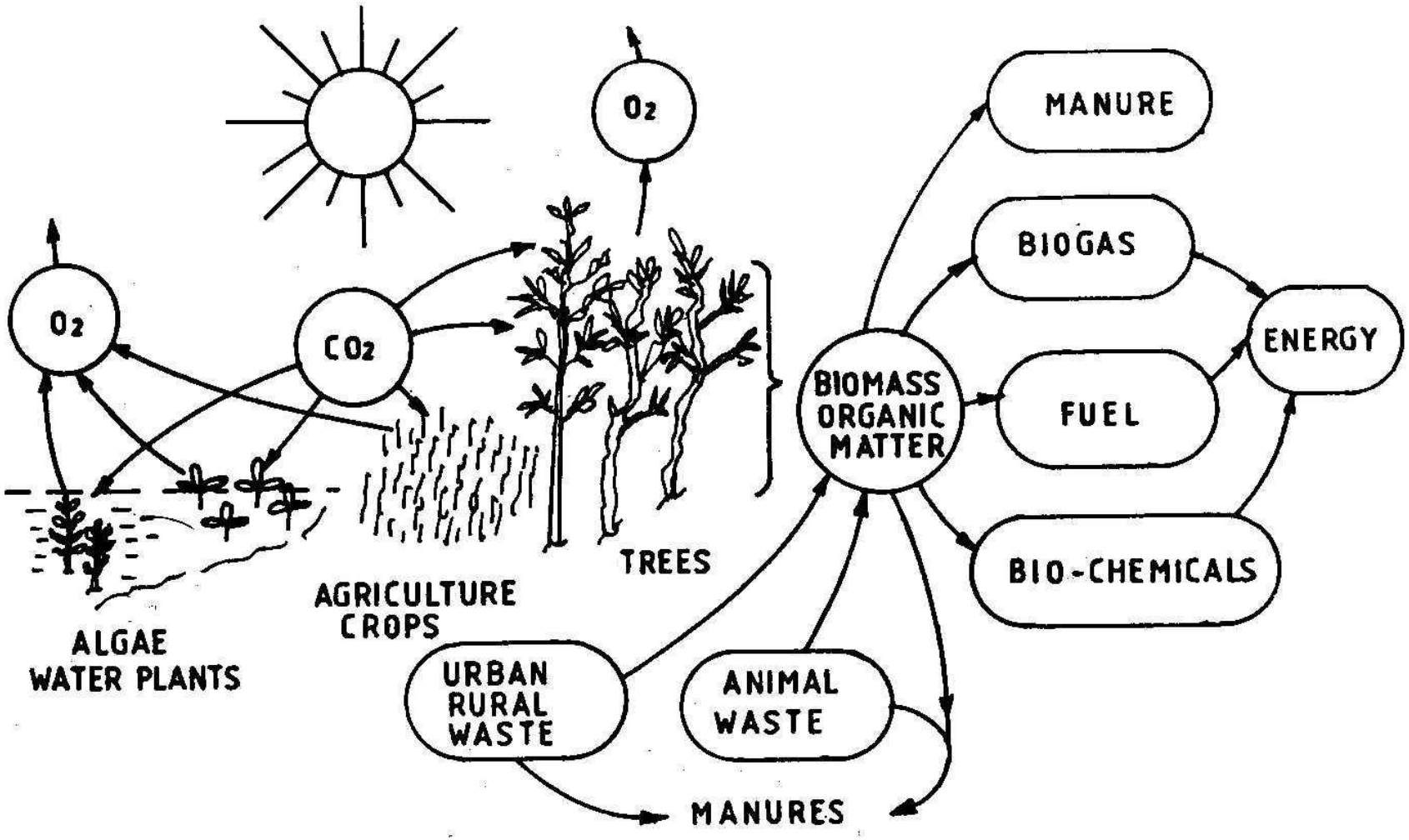
Fuels produced from Biomass (bio-gas, bio-diesel).

- **Biomass Energy Resource**
  - The raw ***Biomass*** for extracting secondary energy (fuel, organic chemicals, etc.) is called biomass energy resources.

  Biomass energy resources are:

  - Botanical plants
  - Vegetation
  - Algae
  - Animals
  - Organisms living on land or in water

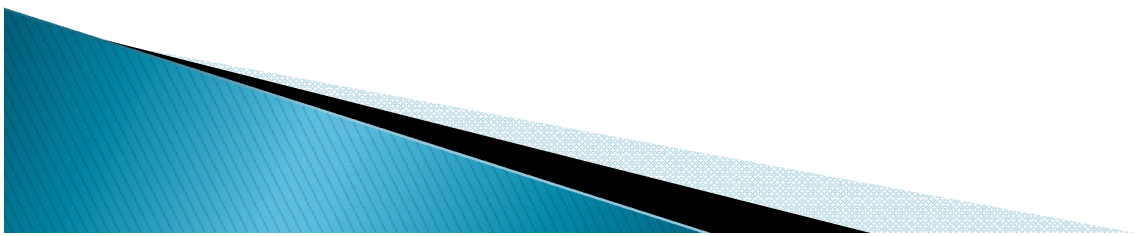




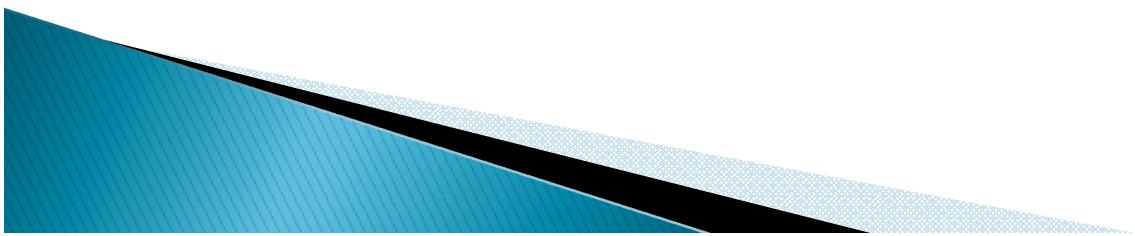
Origin of Biomass Energy Resources

Sources of Biomass

- Land
  - Agriculture waste
  - Energy plantation
  - Forest
- Aquatic
  - Plants (e.g. hyacinth)
  - Algae

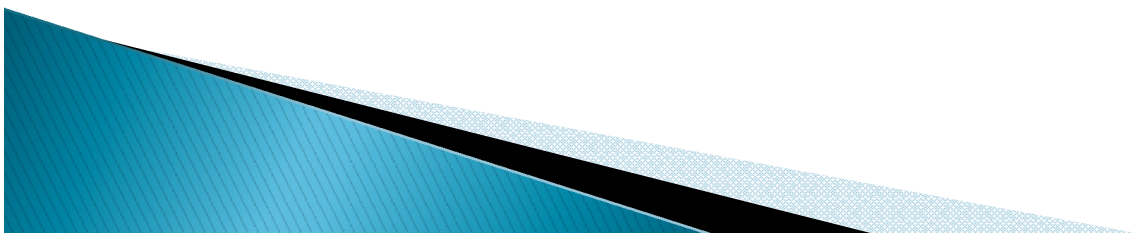


- In all these biomass Energy is stored in the form of complex organic compounds of carbon, hydrogen, nitrogen, etc.
- The biomass can be converted to useful energy forms such as:
  - Heat
  - Gaseous fuel
  - Solid fuels
  - Organic chemical
  - Liquid fuels



Two type of biomass resources

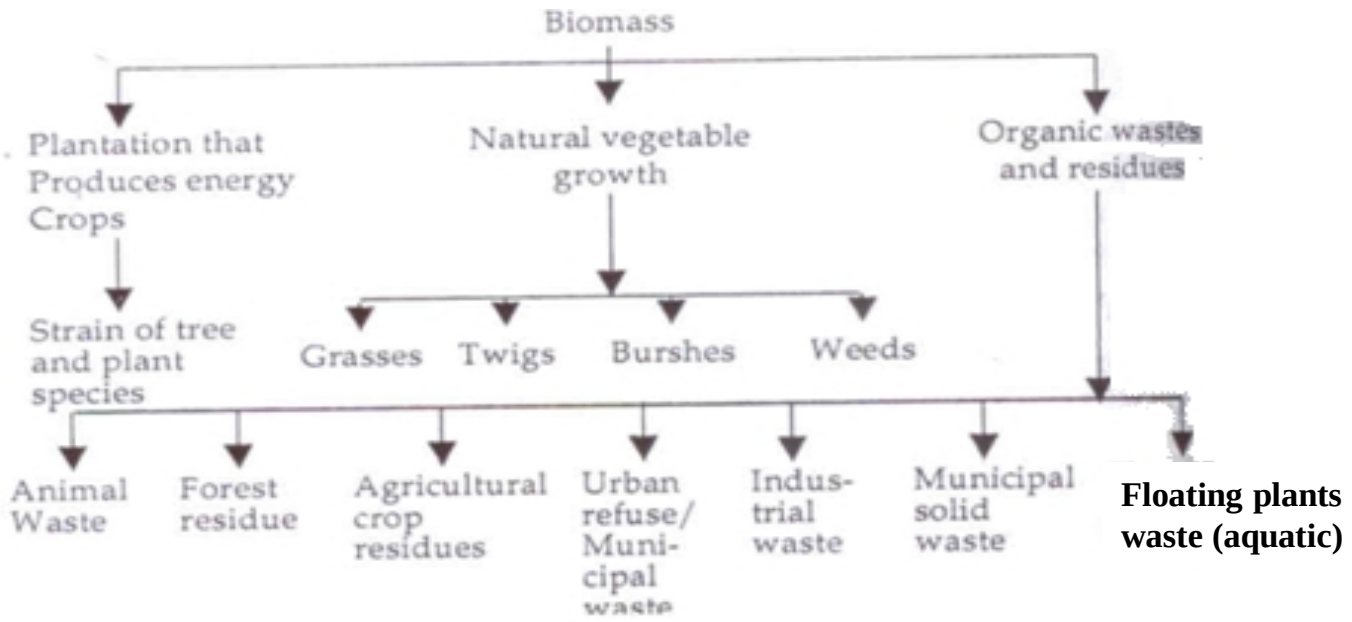
- **Nurtured**: Biomass from cultivated fields, crops, forests and harvested periodically, Aquatic and marina plants.
- **Waste Material**: Biomass from waste e.g. municipal waste, animal excreta/dung, forest waste, agricultural waste, bioprocess waste, Industrial waste, butchery waste, fishery wastes, processing waste etc.



State	Area (kha)	Crop Production (kT/Yr)	Biomass Generation kT/Yr	Biomass Surplus (kT/Yr)	Power Potential (MWe)
Andhra pradesh	2540.2	3232.0	8301.7	1172.8	150.2
Assam	2633.1	6075.7	6896.3	1398.4	165.5
Bihar	5833.1	13817.8	20441.8	4286.2	530.3
Chattisgarh	3815.5	6142.8	10123.7	1907.8	220.9
Goa	156.3	554.7	827.2	129.9	15.6
Gujarat	6512.9	20627.0	24164.4	7505.5	1014.1
Haryana	4890.2	13520.0	26160.9	9796.1	1261.0
Himachal pradesh	710.3	1329.2	2668.2	988.3	128.0
Jammu & kashmir	368.7	648.7	1198.7	237.7	31.8
Jharkhand	1299.8	1509.0	2191.2	567.7	66.8
Karnataka	7277.3	38638.5	23766.8	6400.6	843.4
Kerala	2041.7	9749.7	9420.5	5702.6	762.3
Madhya pradesh	9937.0	14166.9	26499.6	8033.3	1065.4
Maharashtra	15278.3	51343.3	36804.4	11803.9	1585.0
Manipur	72.6	159.4	318.8	31.9	4.1
Meghalaya	0.8	14.0	42.0	8.4	1.1
Nagaland	27.1	87.6	149.2	27.2	3.1
Orissa	2436.6	3633.3	5350.4	1163.4	147.3
Punjab	6693.5	27813.7	46339.8	21267.0	2674.6
Rajasthan	12537.5	93654.8	204887.6	35531.1	4595.0
Tamil nadu	2454.0	24544.6	15976.6	6658.7	863.7
Uttar pradesh	12628.2	46800.8	50416.7	11725.9	1477.9
Uttaranchal	66.4	135.8	159.9	51.6	6.6
West bengal	5575.6	21062.8	23316.0	2959.7	368.3
Total	**105786**	**399262**	**546422**	**139355**	**17981**

Potential of biomass resources

- 546 MT of agricultural residues / annum
- 433 MT of cattle dung /annum from 273 million cattle population
- Fuel wood consumption – 227 MT/year.



Types of Biomass resources

Energy Plantations

- Growing of selected species of tree and plants on a short rotation basis on waste or arable land for energy generation point of view e.g.
  - Acacia nilotica (Babul, grows even in wasteland)
  - Dalbergia Sissoo (Sheesham, high calorific value, up to 4900 kcal/kg)
  - Prosopis Juliflora (Vilayati Babul, Root up to 50m)
  - Albizzia Lebbeck (Siris)

Acacia Nilotica

Dalbergi Sissoo

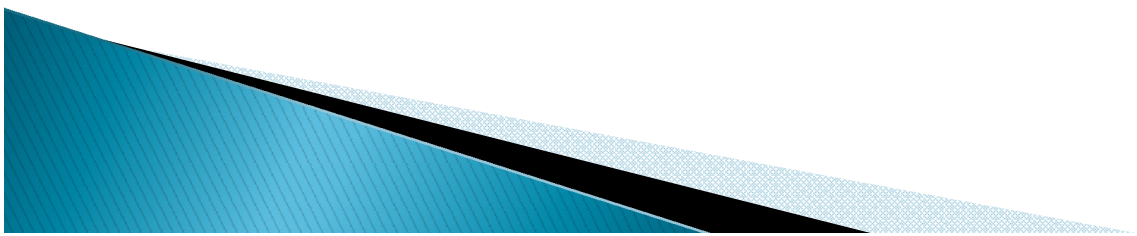
Prosopis Juliflora

Albizza Lebbeck

Energy Plantations (aquatic)

- Growing of floating water plants e.g., water hyacinth in rivers, lakes, ponds etc in tropical / sub-tropical area (yield 25 T(dry)/ha/yr)

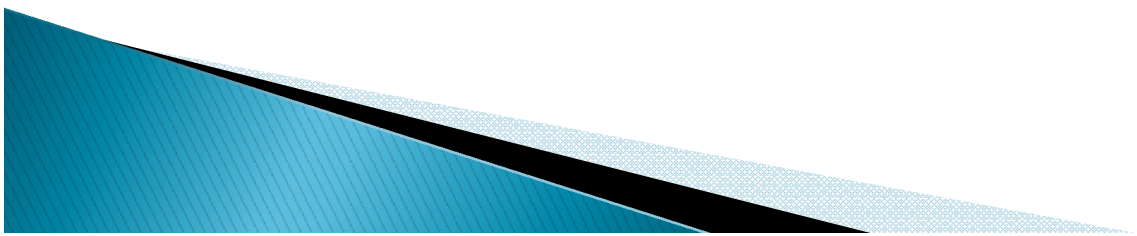
- Biomass energy is **well known since dawn of agricultural age**.
  - Wood, cow dung etc. are used as fuels particularly in rural and tribal areas.
- Biomass energy is produced in green plants by photosynthesis in presence of sun light.
- Other living organisms consume green plants or their products and generate biomass.



- Biomass cycle maintains the environmental balance of oxygen,
  carbon- dioxide, rain etc.

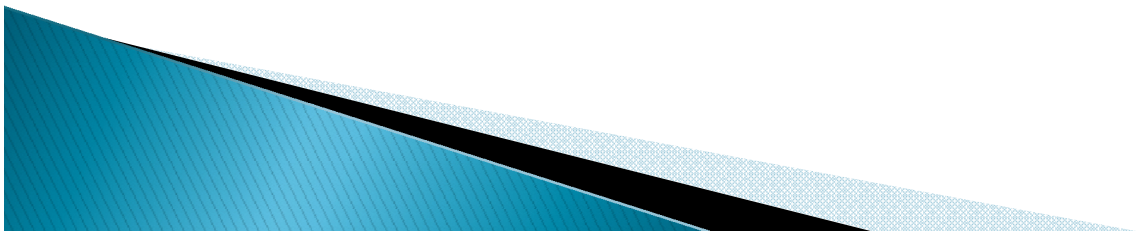
- Biomass energy technology is an environment friendly technology.

- Biomass is being used for production at process heat, electricity, gaseous, liquid and solid fuels etc.

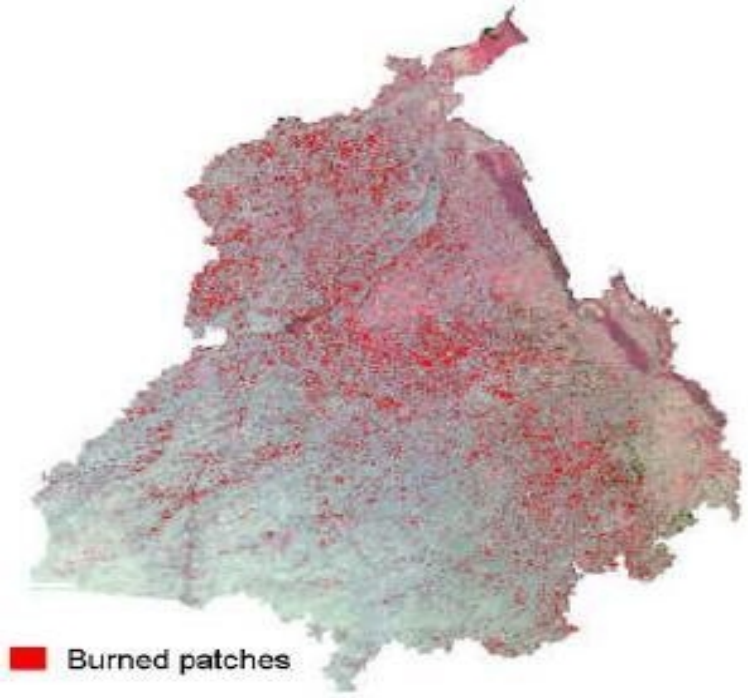


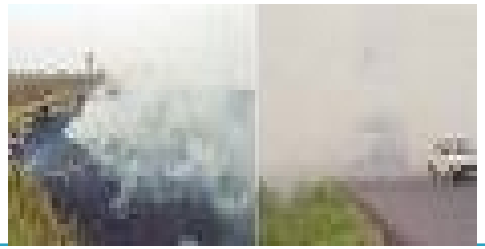
SCOPE OF BIOMASS

- Rural applications of biomass energy.
- Urban and industrial applications of biomass energy.
- Biomass as a primary source for large scale electrical power generation.
- Present contribution of biomass energy is between 4% to 18% of total energy consumption of various countries.
- It is expected by 2015 it will become 25% - 40% as disposal of agriculture byproduct is becoming a serious threat to environment.

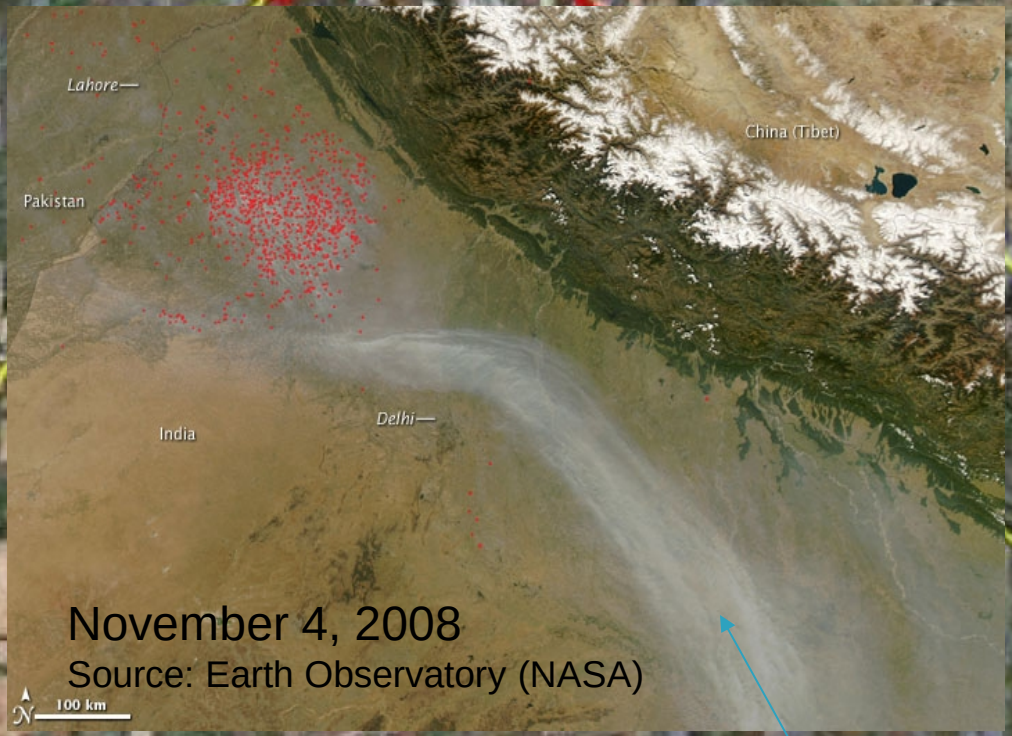


Disposal of Paddy Straw





Superposition of satellite photograph on Google Earth Snapshot of Northern India



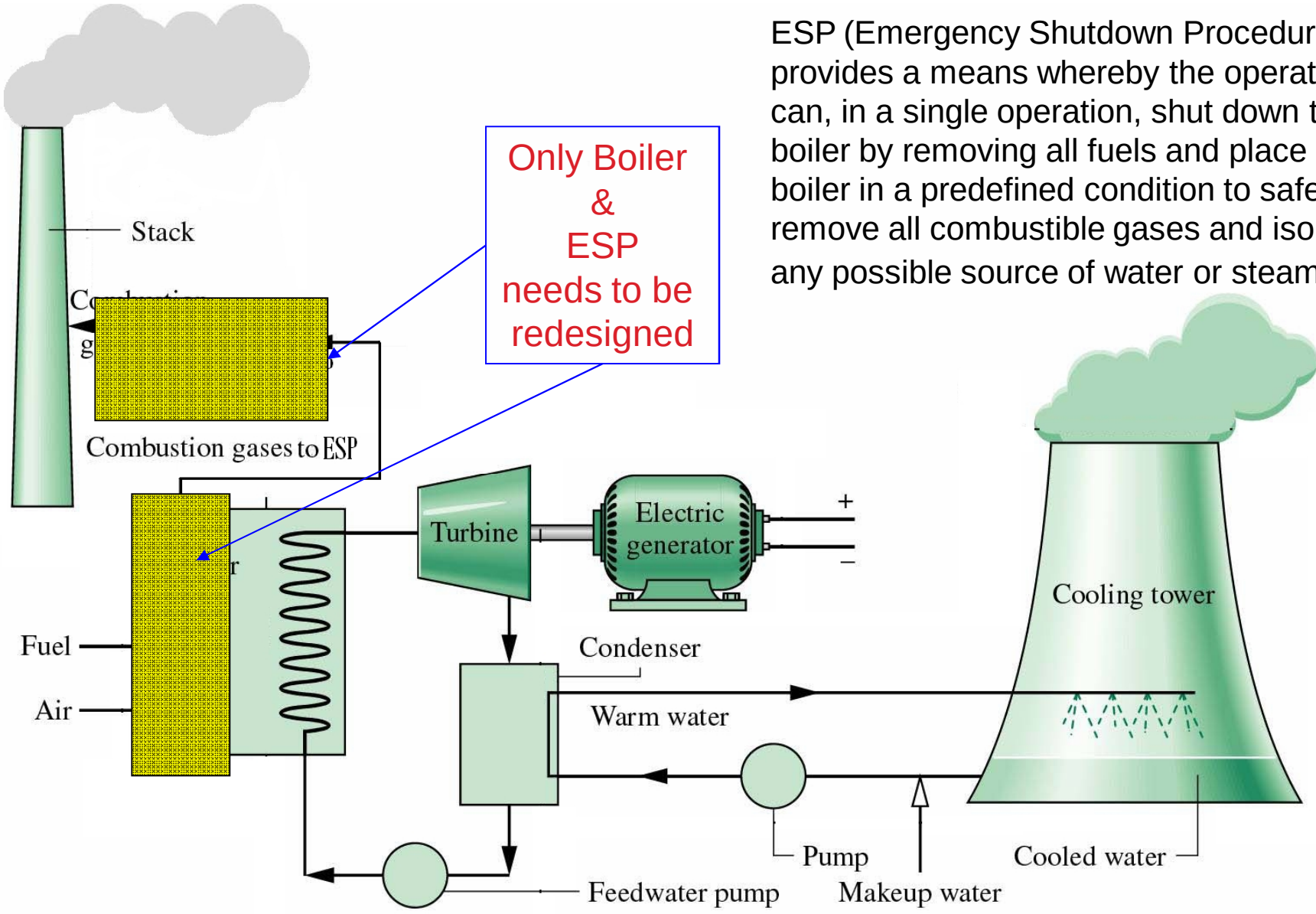
November 4, 2008

Source: Earth Observatory (NASA)

Smoke due to improper combustion (Damage to environment and Loss of huge source of energy)

A Typical Power-plant

ESP (Emergency Shutdown Procedure) provides a means whereby the operator can, in a single operation, shut down the boiler by removing all fuels and place the boiler in a predefined condition to safely remove all combustible gases and isolate any possible source of water or steam.



BIO-MASS STORAGE METHODS

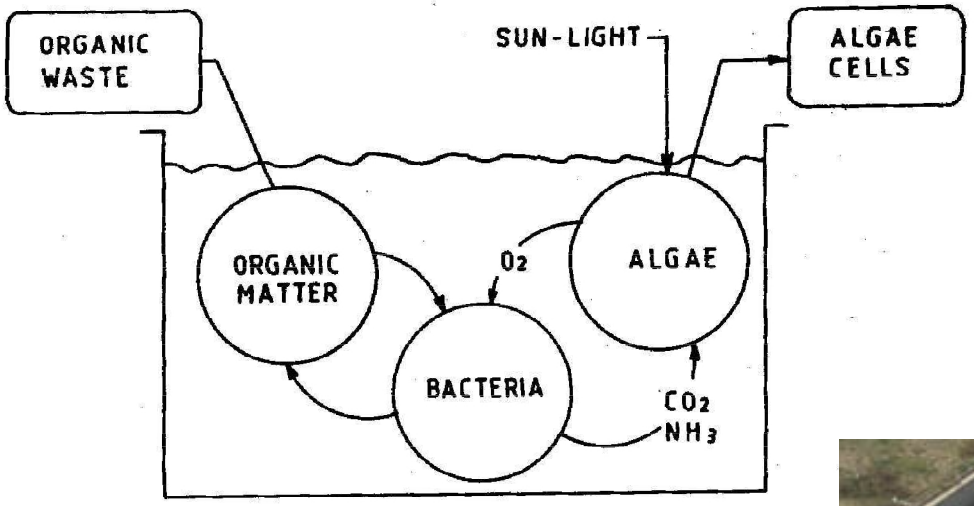
SILAGE PILING

BIO-MASS STORAGE METHODS

EURO BAGGING

Biomass from Water bodies

Algae biomass is an important renewable source of energy produced by photosynthesis.



Algae ponds at Ashkelon, Israel

- The algae is produced in algae farms. Algae **contains organic matter which can be converted into methane gas** (a useful fuel) in a simple biogas plant by the process called **anaerobic digestion**. Algae crops are likely to be cultivated on large scale to obtain renewable energy.

- **The process of algae production**. After extracting the biogas, the organic residue from the biogas-plant is added to the algae pond. This acts as a food to the bacteria in algae pond. Special fast growing and energy packed algae species are developed by genetic research. The algae-bacterial combination consumes the waste organic water in the pond, absorbs solar energy and results in rapid growth of algae.

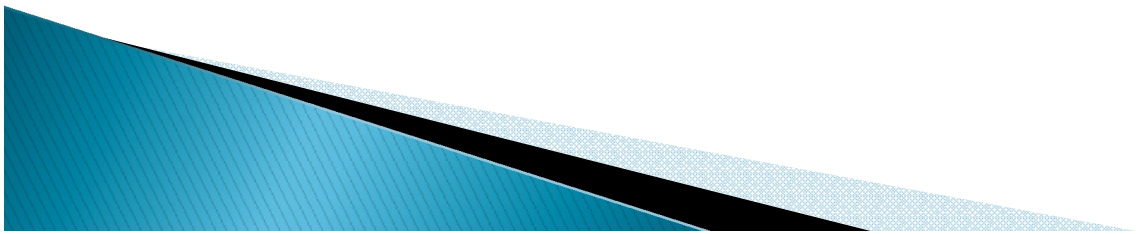
- There are several alternative routes for producing useful secondary energies from biomass.

  Biomass Technologies deal with the entire processes of producing biomass, processing the biomass and delivering the useful secondary energies.

- Biomass energy obtained from the plant photosynthesis is likely to solve the energy problem in the coming years in a significant way. Energy strategies of various countries are focusing their attention on biomass resources.

PRINCIPAL BIOMASS ENERGY RESOURCES AND CONVERSION PROCESS

Category	Name of the Biomass Source	Conversion Process
Cultivated Energy Resource	Trees, (Wood chips, saw dusts)	Burning to produce heat and electricity
	Aquatic crops, algae, green plants	Producing biogas and biochemical
	Agricultural crops	Production of gas and manure -Wood gasification
	Fruit farms	Production of wood oil and charcoal. Wood to oil process



Category	Name of the Biomass Source	Conversion Process
Waste – Biomass resources from farms and bio-industry	Rice and wheat husk	Production of ethyle alcohol by fermentation molasses, beet root, fuits, potatoes, cereals
	Baggase of sugar cane	
	Coconut husk, groundnut shell, straw of rice, wheat etc.	
	Waste of furniture industry, wood industry	
	Waste of poultry industry, fishery industry, food industry, brewery, tannery, butchery etc.	
	Carbohydrates, glucose, fructose etc.	

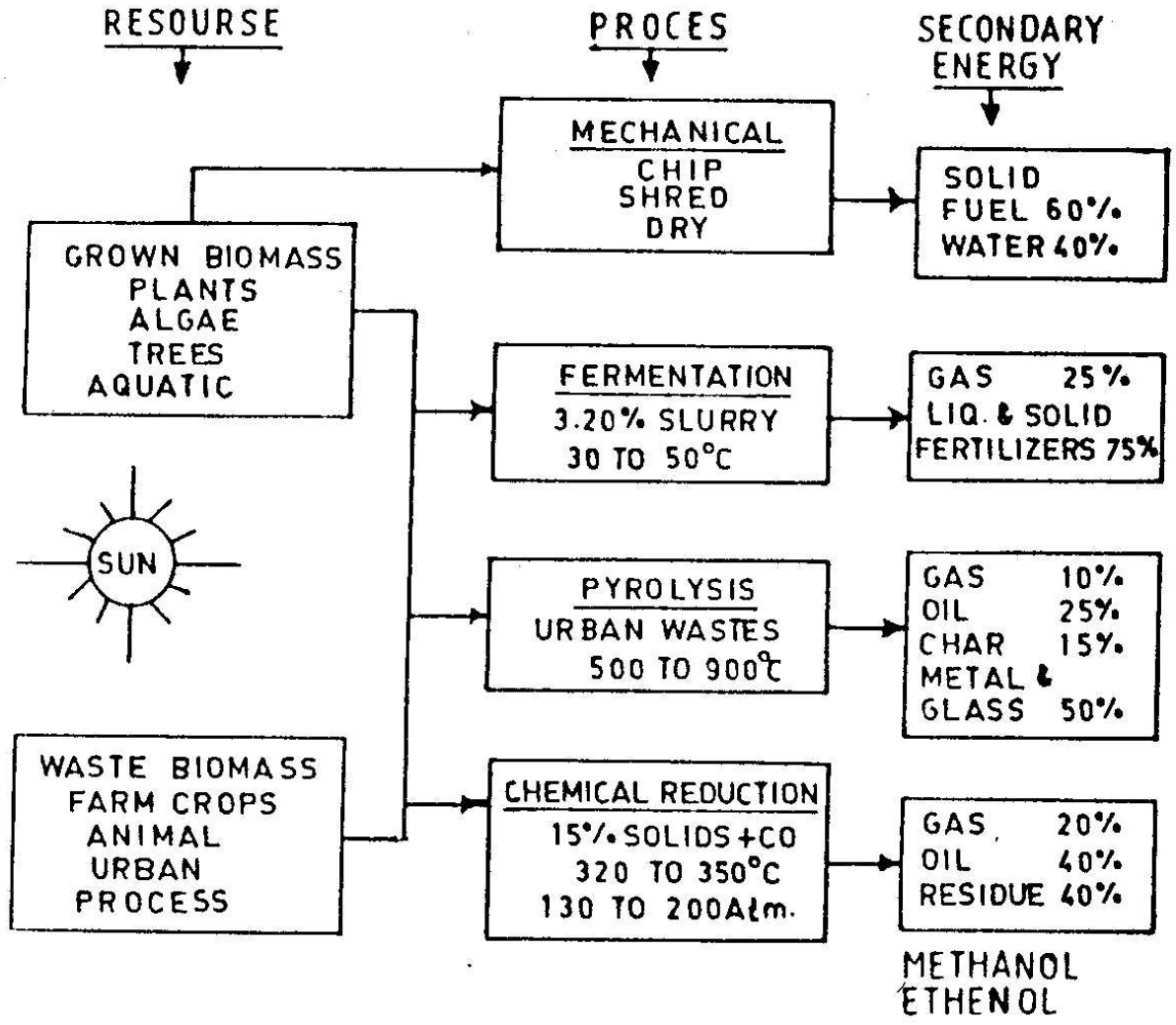
The world's biomass through municipal solid waste in about 60,00,000 tones per day. About 3% of it can be converted into electricity and heat contributing about 2[illegible],000 MW

- In developing countries fuel-wood constitutes about 75% of energy needs of rural areas. It is covered in the category '*non-commercial energy resource*'. Deforestation is a serious problem created by the use of wood as a fuel. However, by planned forestation of fast growing trees as a source of energy, wood is likely to be an important renewable source of energy.
- Waste biomass serves double purpose:
  - Disposal of waste in a safe, economical and environmentally healthy manner.
  - Generating useful energy from the waste.

BIOMASS CONVERSION PROCESSES

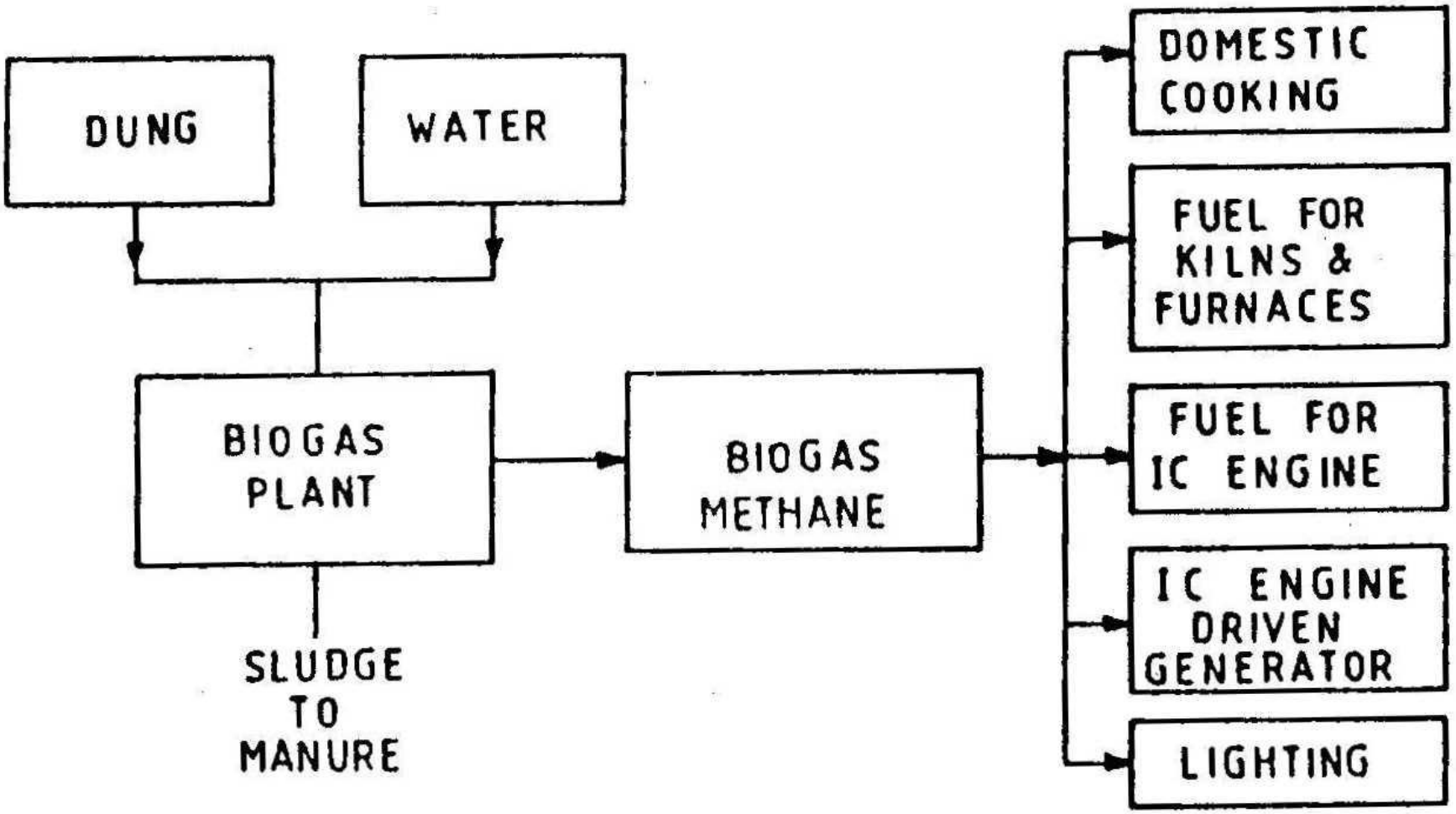
- The energy technology is concerned in conversion of biomass into useful secondary energy. A few energy conversion processes suitable for commercial applications have been developed whereas several other conversion processes are under research and development stage.
- The biomass conversion process (Bio conversion process) has several routes depending upon temperature, pressure, micro-organisms, and process conditions. These routes are classified in following three broad categories.

- Direct combustion (Incineration)
- Thermo-chemical conversion
- Biochemical conversion



Biomass energy Conversion Routes

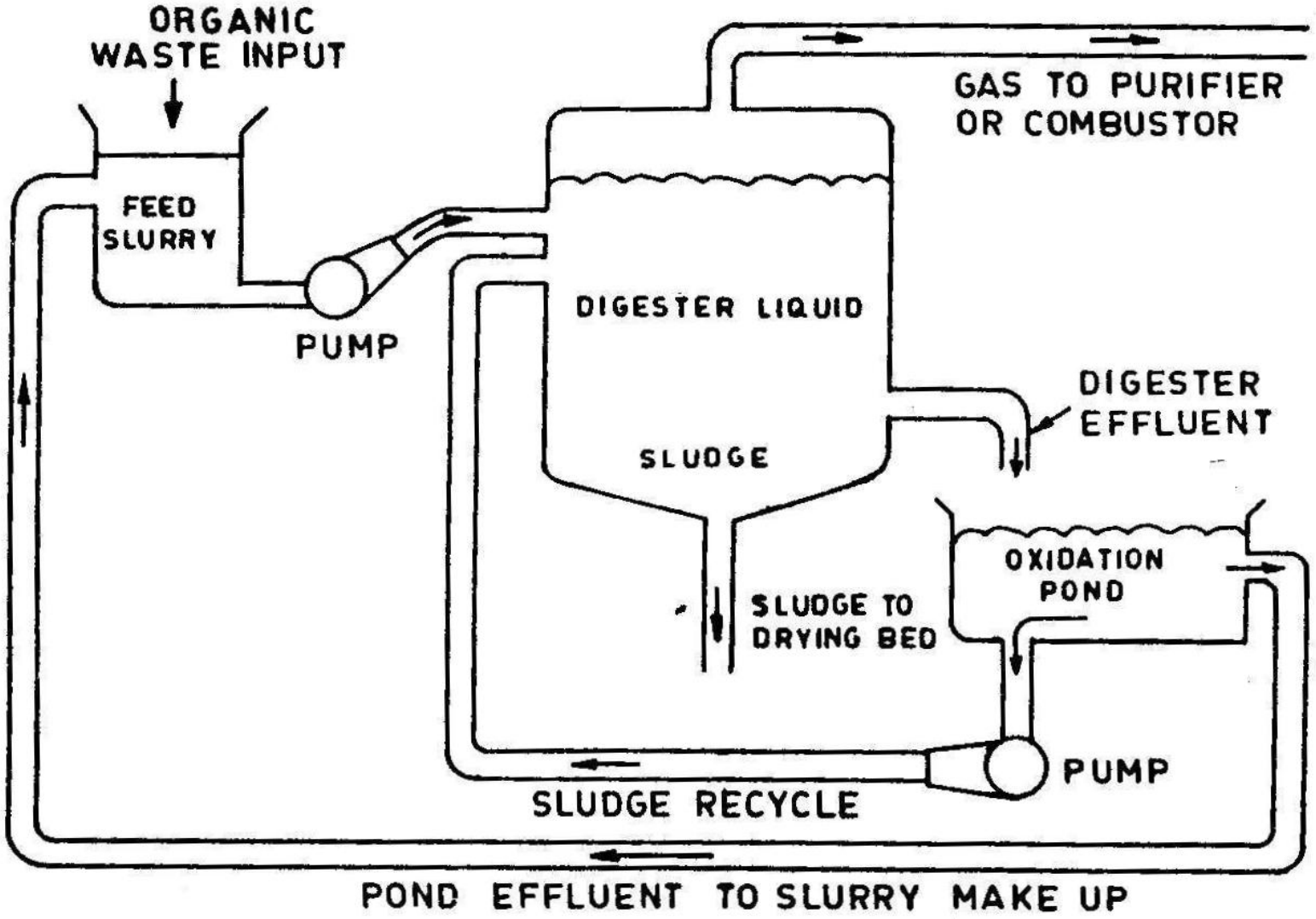
- Chemical and biological treatment of biomass is known as Digestion.
- Biological treatment can be done either in presence of oxygen (aerobic) or in absence of oxygen (anaerobic).
- In India Anaerobic Digestion Plants are commonly known as Biogas Plants or Gobar Gas Plants. In such plants slurry of cow dung and water is fed to the digester and is allowed to ferment for a few weeks. The biogas is released. The biogas contains about 55% of methane (CH_4). This gas is used as a fuel.



Energy Route of Biogas

Typical Biogas composition

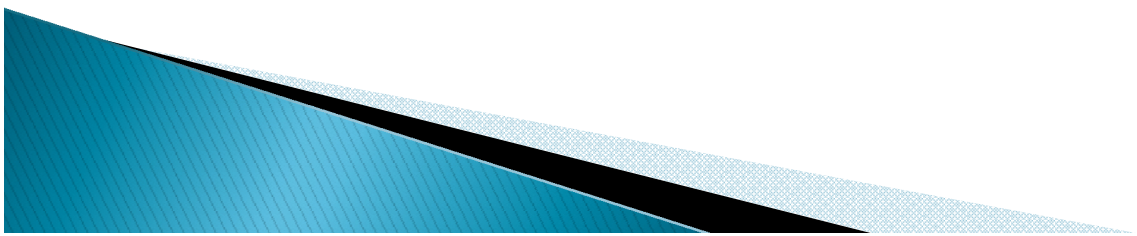
Sl. No.	Constituents	% (V/V)
1	CH_4	60
2	CO_2	38
3	H_2S	< 1
4	H_2O vapors	~ 1
5	Heating value	4500 – 4700 k cal/m^3

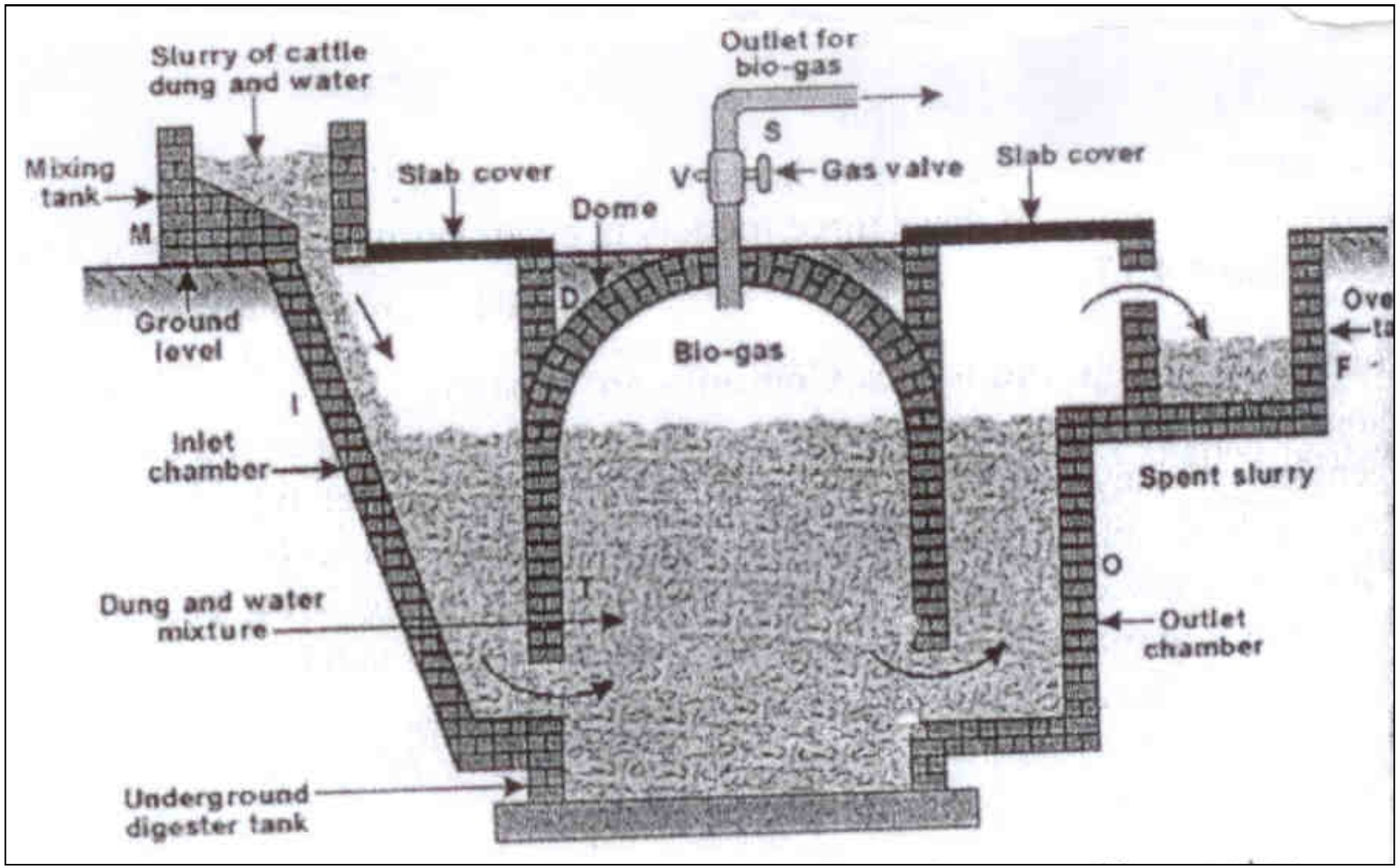


Schematic of a biogas plant for producing biogas (methane) by Anaerobic Fermentation

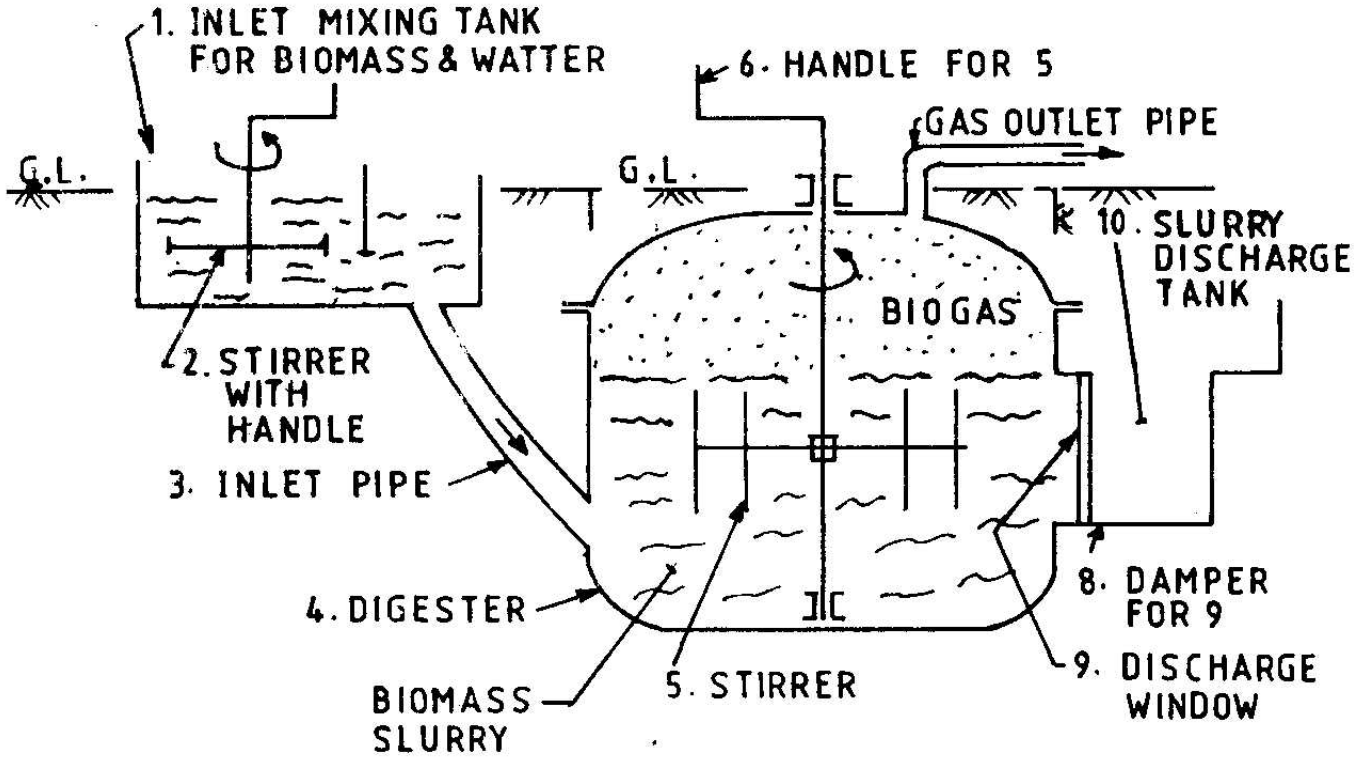
There are two types of Biogas Plants

- Fixed head
- Floating head

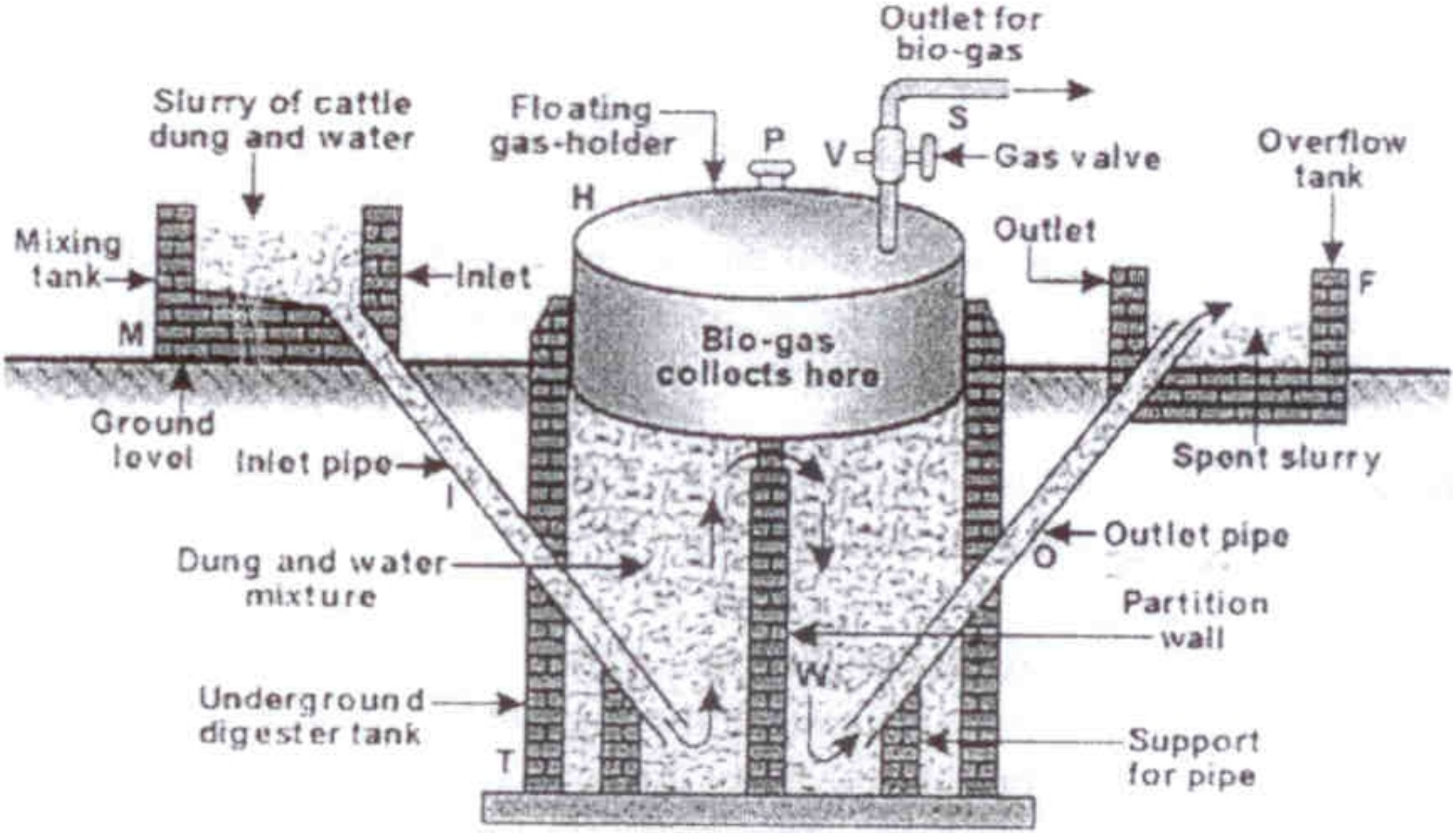




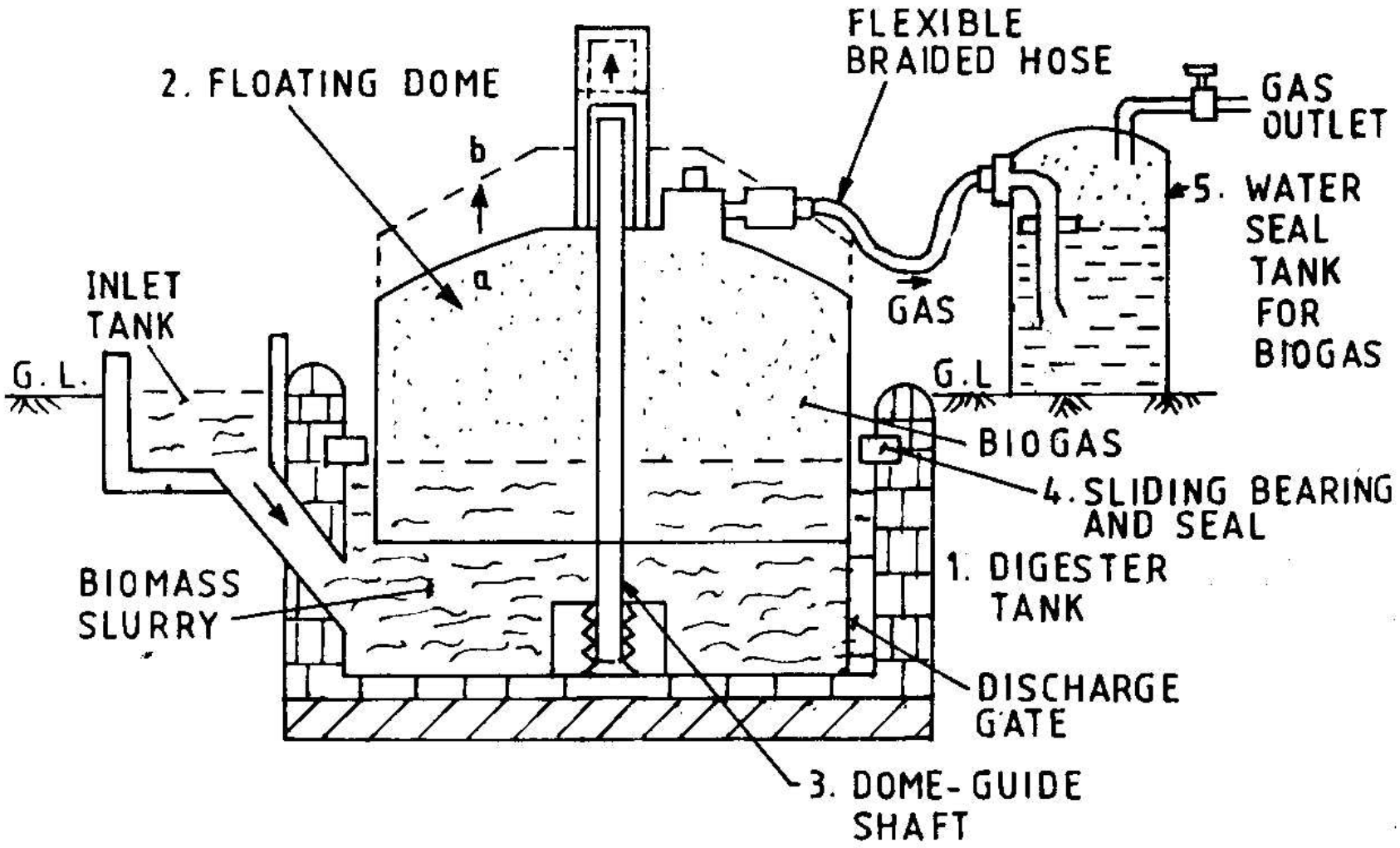
Schematic diagram of fixed-dome type biogas plant



Schematic of fixed dome type biogas plant



Schematic diagram of floating gas-holder type bio-gas plant



Floating Dome Type Biogas Plant
(a) Position of dome with less gas in the dome.
(b) Position of dome with more gas in the dome.

Comparison of Fixed and Floating head Biogas plant

	Janta / Fixed dome type	Floating Dome type Biogas Plant
1	Gas is released at variable pressure	Gas is released at constant pressure
2	Identifying defects is difficult	Identifying the defects in gas holder easy
3	Cost of maintenance is low	Cost of maintenance is high
4	Capital cost is low (for some capacity)	Capital cost is high
5	Space above the drum can be used	Floating drum does not allow the use of space for other purpose
6	Temperature is high during winter	Temperature is low during winter
7	Life span is comparatively longer	Life is short
8	Requires more excavation work	Requires relatively less excavation

Sizes of Biogas Plants

Category	Biogas Delivery	Size of Digester	Application
Very small Biogas plant	0.65 m^3/day	-	For small family of 3 members, having 2 cattle.
Small biogas plant	2 m^3/day	-	For family of 6 members, having 8 cattle.
Medium (family size) biogas plant	3 m^3/day	1.6 m dia, 4.2 m height, 8.34 m^3	For family of 12 persons having 12 heads of cattle.
Large (farm size) biogas plant	6 m^3/day	3.3 m dia, 4.65 m height	For a farm having poultry diary etc., 20 cattle.
Very Large (community size)	2600 m^3/day (CO_2 free)	1000 m^3	Cattle 1000
Extra Large (community size)	20,000 m^3/day (CO_2 free)	4 Digesters Total 60,000 m^3/day	Cattle 50,000

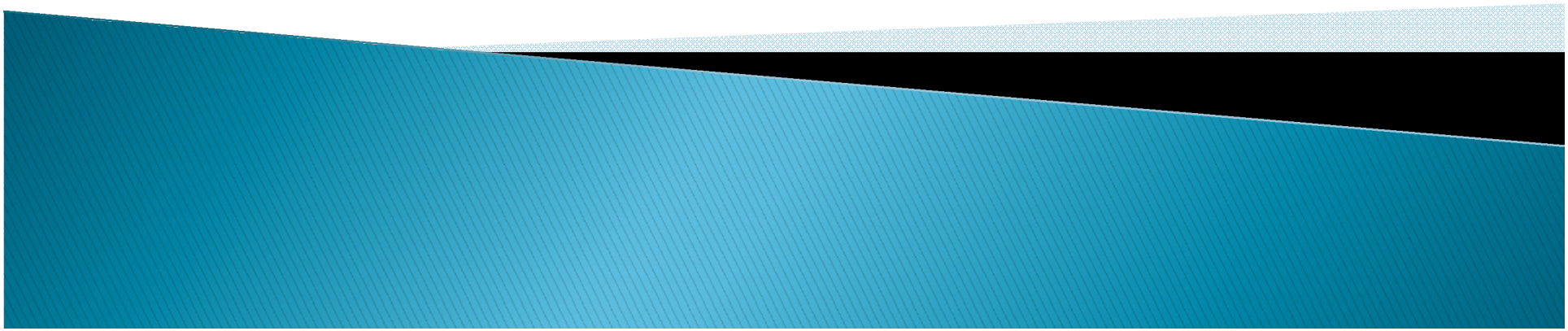
Advantages of Floating Dome Design	Disadvantages of Floating Dome Design
The slurry is constantly submerged below the dome.	Higher cost due to fabricated dome construction.
The pressure is naturally equalised.	Dome upper surface is exposed to sunlight and external atmosphere. The heat is lost during winters.
No danger of excessive pressure.	The outlet pipe between the floating dome and fixed external connection should be of flexible hose type. It is subjected to sun rays, rain and movement. It needs regular attention and maintenance.
No danger of mixing between biogas and external air. Hence no danger of explosion.	
Gas is obtained at uniform and constant pressure.	
Gas does not leak through the dome as the slurry provides natural seen.	

Typical Gas Production from Different Feedstock

Sl.No.	Feedstock	Typical Gas Yield (liters/kg)	Typical Methane Content (%)
1.	Paper Waste	480	53
2.	Bagass	330	57
3.	Spent Tea Waste	235	57
4.	Food Waste	160	62
5.	Bamboo Pulp	145	54
6.	Dry Leaves	118	60
7.	Green leaves & twigs	100	65
8.	Fruit waste	91	50
9.	Bamboo dust	53	72
10.	Distillery effluent	31	75
11.	Black liquor (Paper Mill)	22	69
12.	Animal Excreta - Cow/Bullock - Buffalo - Pig - Chicken	 36 36 78 62	 60-65% “ “ “
13.	Human Excreta	70	“

Fermentation

(for Fuel grade alcohol production)



Fermentation

- Process of production of ethyl alcohol from any feedstock containing sugar or starch or also from cellulose materials.
- Feedstock:
  - Sugar: Sugar beets, sugar cane, sweet sorghum, Fruits etc
  - Starches: Grains like corn, wheat, potatoes etc.
  - Cellulose: Wood, solid waste, agricultural wastes etc.
- Process of production:
  - Fermentation of fermentable sugar solution
  - Fermentation of sugar solution to Ethyl alcohol

(Sugar beet)

(Sorghum)

Process of Production

Feedstock

↓

Milling

↓

Sterilization

↓

Cooking (enzymes & water added to form mess)

↓

Cooling

↓

Fermentation (yeasts addition)

↓ (2 days)

Bear (10% ethyl alcohol)

↓

Distillation

↓

Dehydration

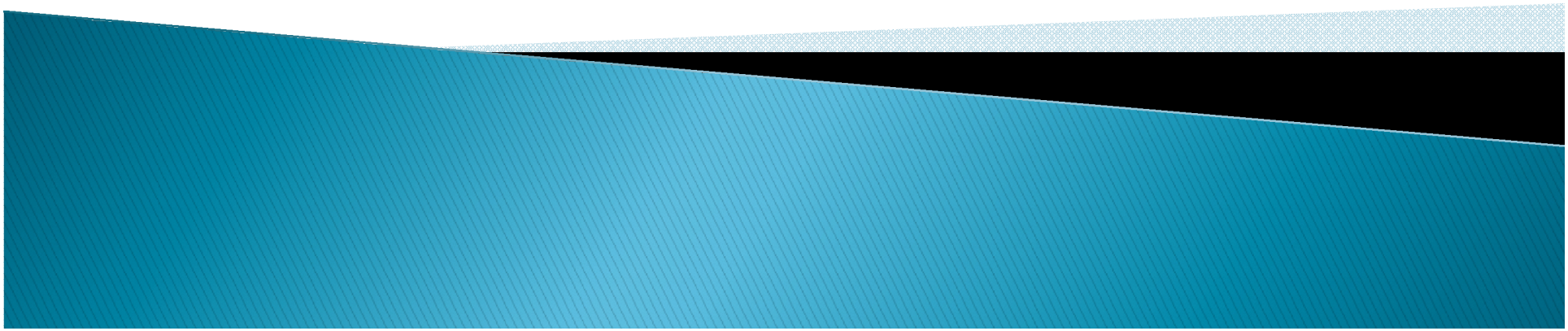
↓

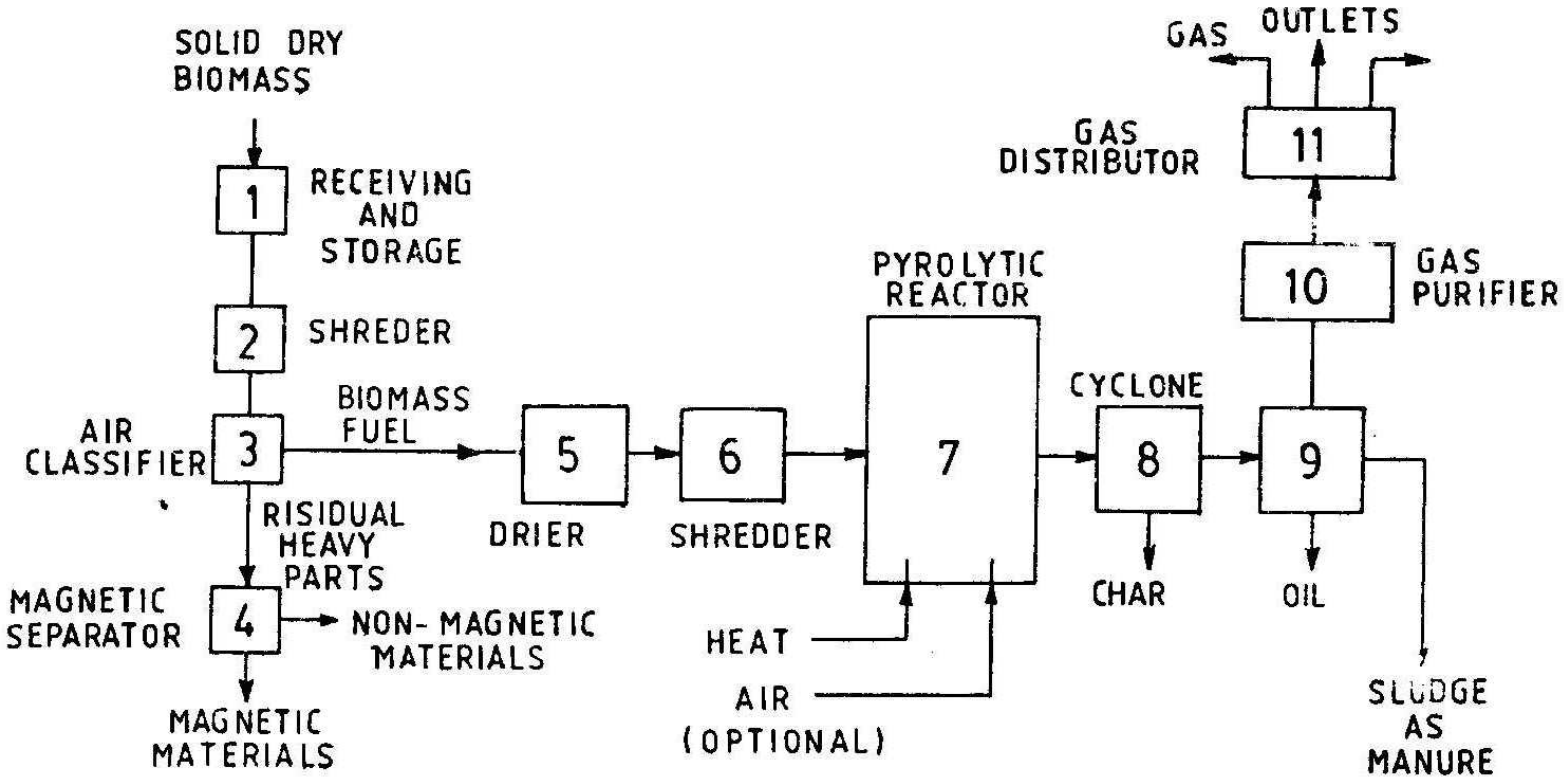
Denaturation

↓

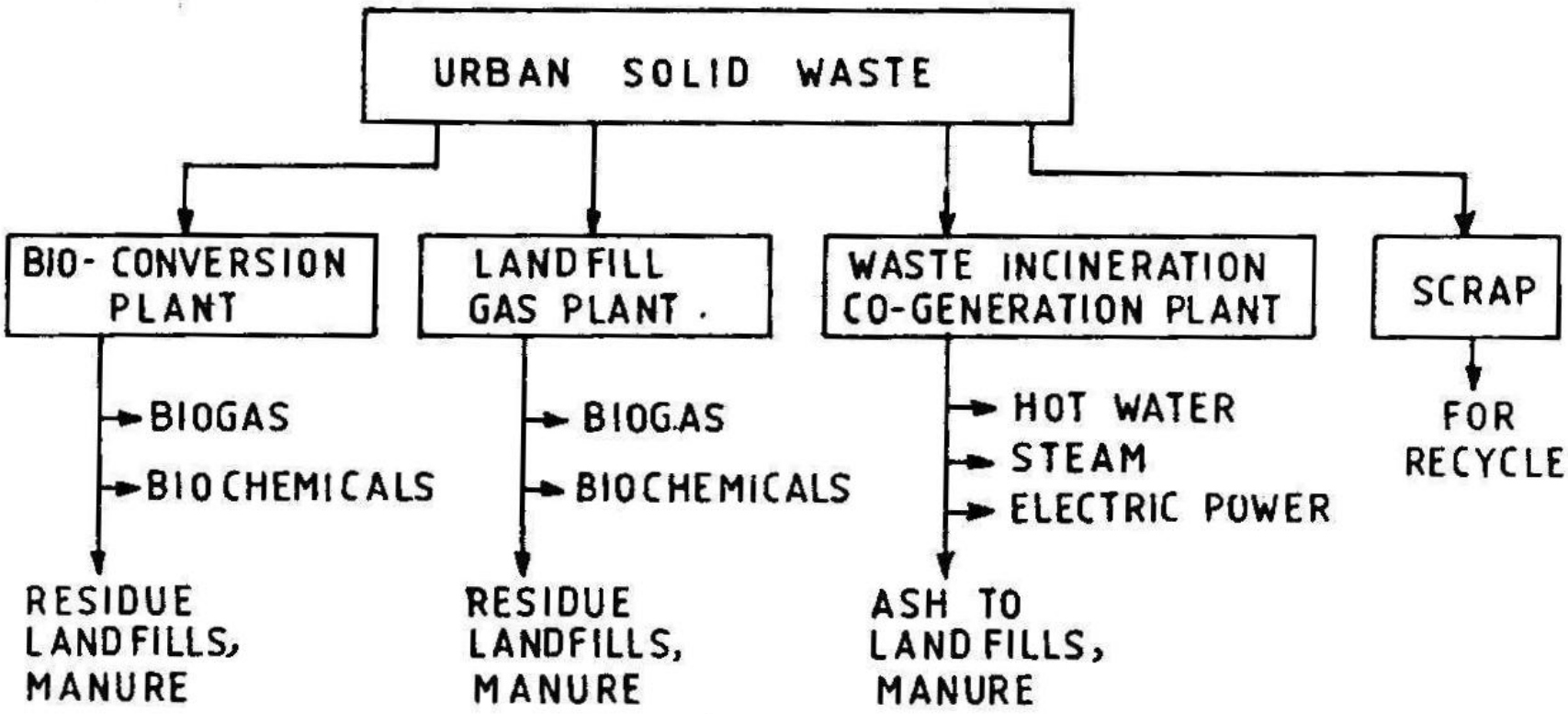
Fuel alcohol

Energy from Waste Material





Pyrolysis of Urban Waste



Energy Routes of Urban Waste to Energy

BIOMASS ENERGY CONVERSION PROCESSES AND END PRODUCTS

Biomass Resource	**Conversion Process**	**Energy Products**	**Users**
1. Dry biomass -Wood -Residue	Combustion	Heat Steam Electricity	-Industry -Domestic
	Pyrolysis	Oil Char Gas	-Industry -Transport
	Hydrolysis and Distillation	Ethenol (Ethylalcohol)	-Transport -Industry
2. Wet biomass -Sewage Sugars from fruits, beet, molasses	Anerobic digestion	Methane	-Industry -Domestic
	Fermentation and Distillation	Ethenol (Ethylalcohol)	-Transport -Chemical
3. Water	-Photochemical -Photobiological -Catalystic	Hydrogen	-Industry -Chemicals