1.6 BIOMASS POWER PLANT

Biomass refers to the organic material that is used for the production of energy referred to as Bioenergy. Biomass is primarily found in the form of living or recently living plants and biological wastes from industrial and domestic use. The process of energy conversion from biomass includes thermal conversion, chemical conversion, biochemical conversion and electrochemical conversion.

Bio mass resources: Solid Biomass Resources include

a. Agricultural Residues
   - Plant leaves, husks, some roots and stems

b. Food Processing Waste
   - Breakfast, cereal bar, fresh and frozen vegetable, alcohol, breweries

c. Municipal Solid Waste
   - Paper, cardboard, discarded food products

d. Animal Waste

e. Dedicated Biomass Energy Crops

Energy crops are defined as plants and crops grown specifically as an energy resource. The current production of biomass resources includes primarily agricultural byproducts, (Herbaceous crops) and forestry byproducts, (woody biomass crops).

f. Herbaceous Energy Crops

They have little or no woody tissue such as grasses and legumes grown on grasslands. Generally, food crops, such as maize, wheat, rice and sugarcane represent good sources of herbaceous biomass.

g. Woody Energy Crops
   - Timber waste, Industrial wood, Sawdust, Wood shavings, plantations

h. Lipids

Water insoluble oils and fats
   - Soya bean oil, palm oil, rapeseed oil, waxes, animal fats, greases

Biomass can be converted into useful forms of energy using a number of different processes. Factors that influence the choice of conversion process are:

- the type and quantity of biomass feedstock,

- the desired form of the energy, i.e. end-use requirements,
- environmental standards,
- economic conditions

In many situations the form in which the energy is required determines the process route followed by the available types and quantities of biomass.

Biomass Conversion Technologies:

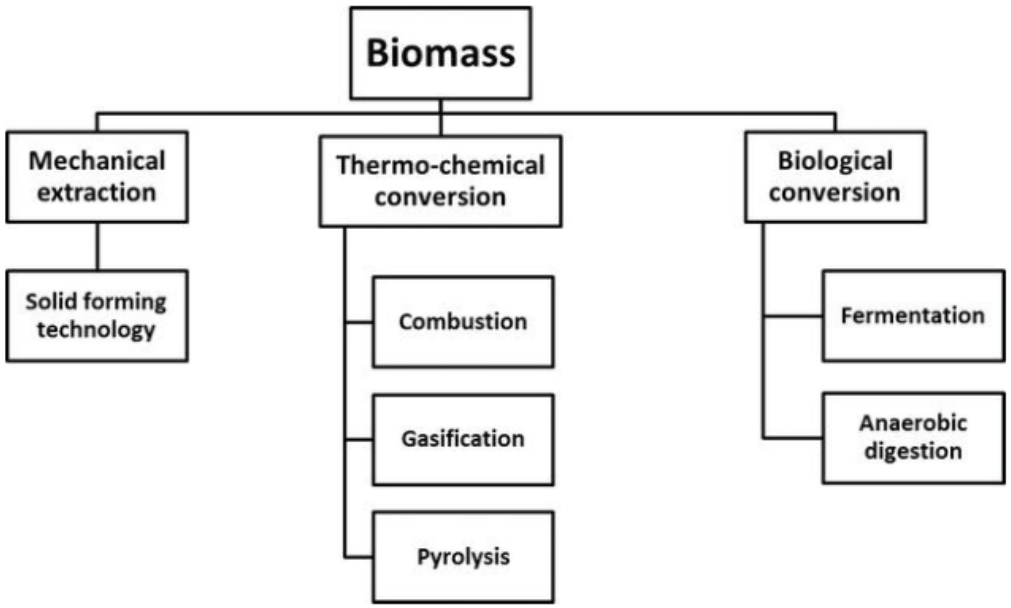


Fig.1.18 Biomass conversion technologies

[Source: https://www.intechopen.com/chapters/59423]

i. DIRECT COMBUSTION PROCESS

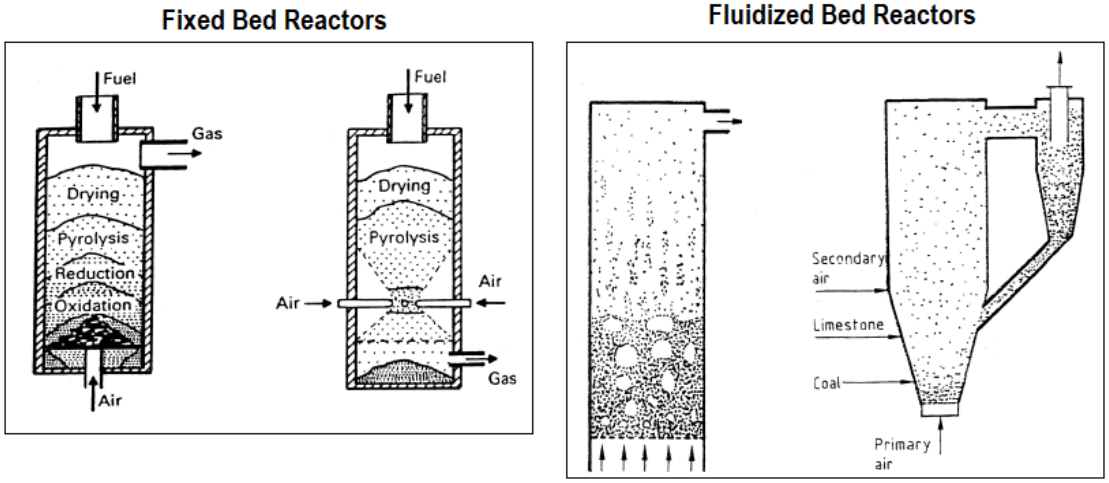


Fig.1.19 Direct Combustion Process

[Source: https://doi.org/10.1016/S0961-9534(00)00009-X]

ii. THERMOCHEMICAL PROCESS

a. PYROLYSIS

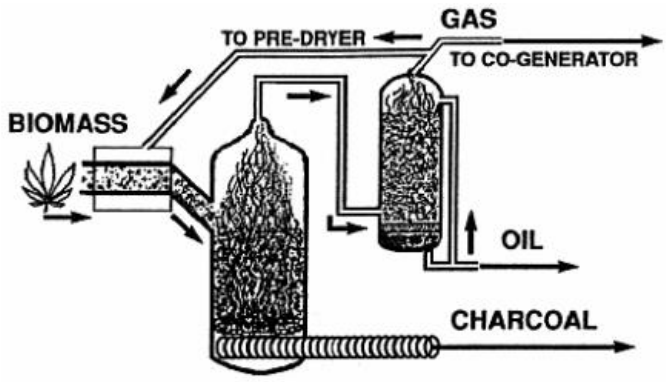
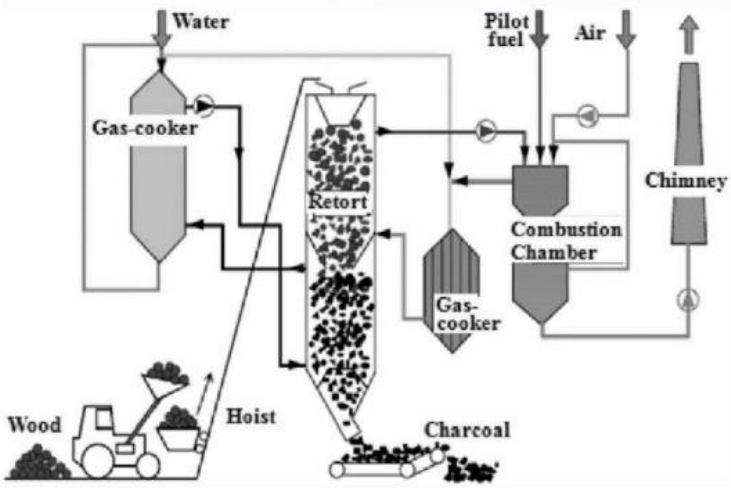


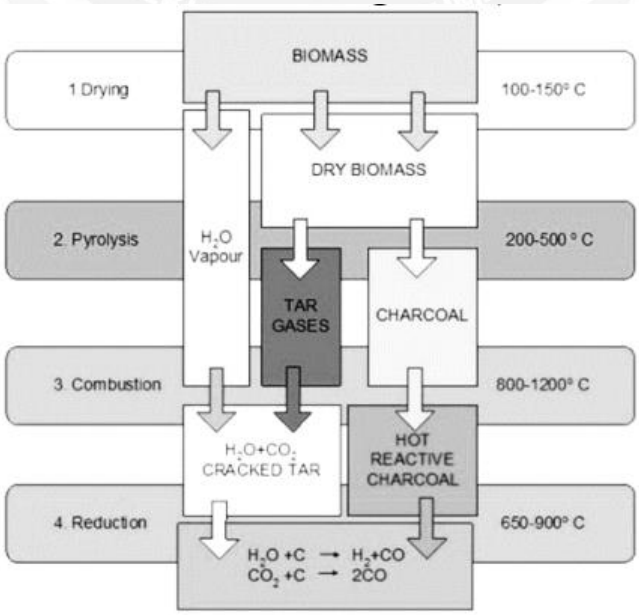
Fig.1.20 Pyrolysis

[Source: https://ratical.org/renewables/biomass.html]

b. CARBONIZATION



c. GASIFICATION



d. CATALYTIC LIQUEFACTION

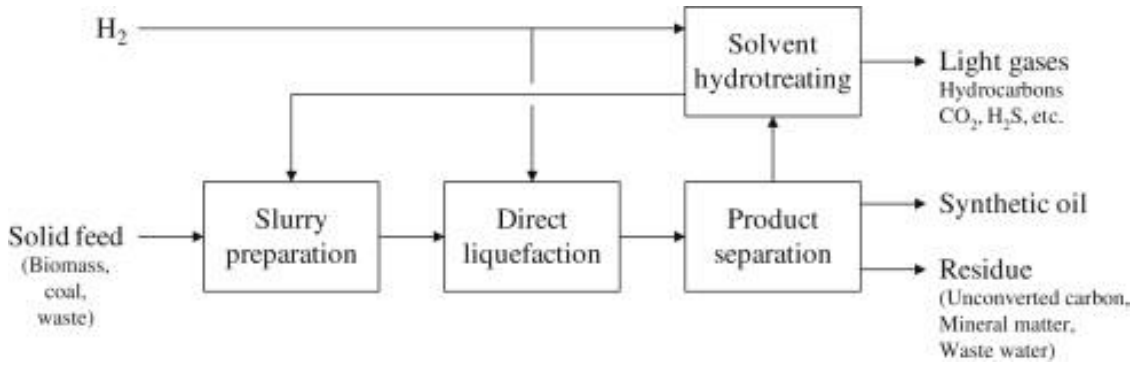


Fig.1.21 Catalytic Liquefaction

[Source: https://www.sciencedirect.com/topics/engineering/catalytic-liquefaction]

iii. BIOCHEMICAL PROCESS

a. ANAEROBIC FERMENTATION

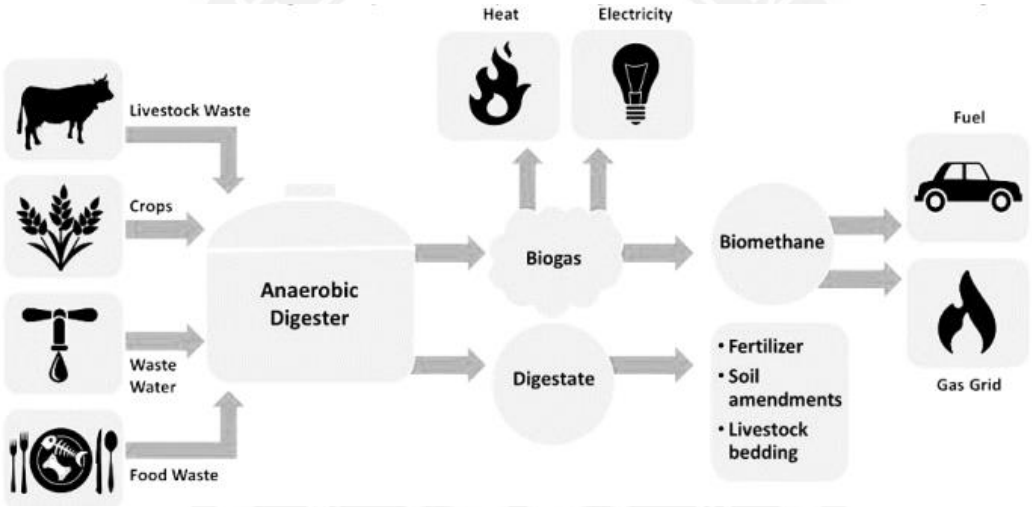
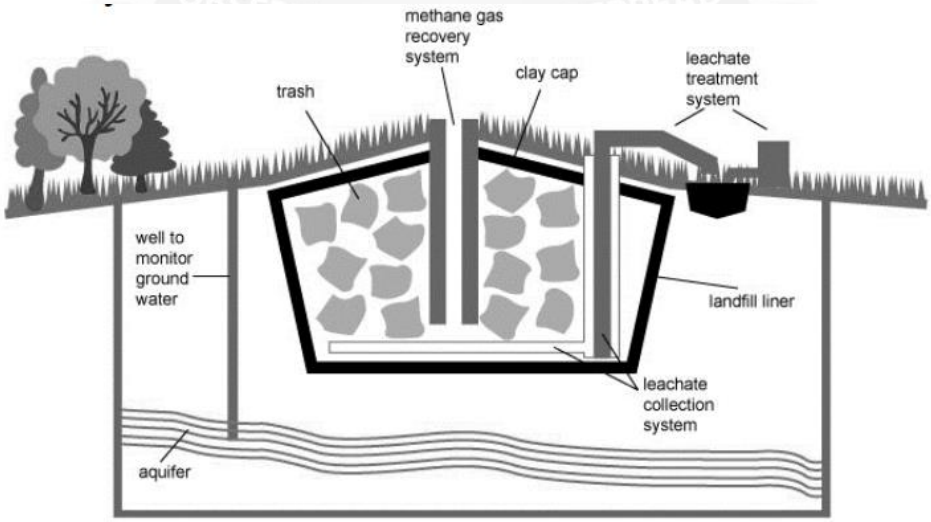


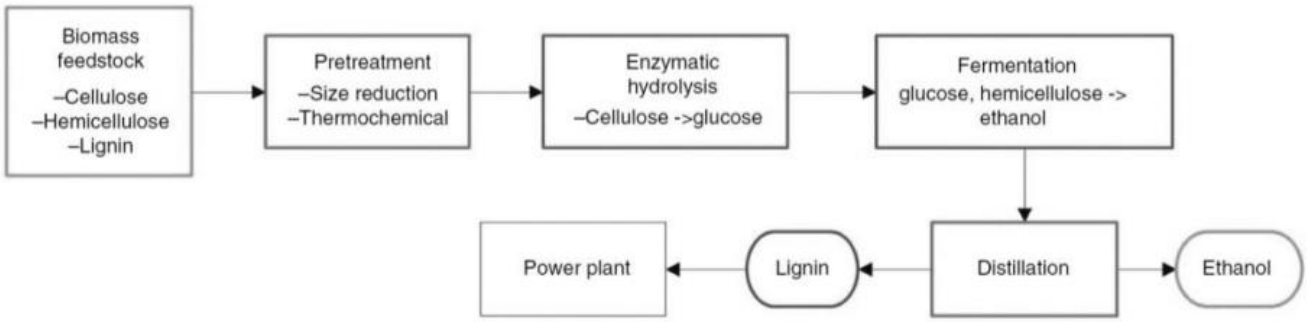
Fig.1.22 Anaerobic Fermentation

[Source: https://www.eesi.org/papers/view/fact-sheet-biogasconverting-waste-to-energy]

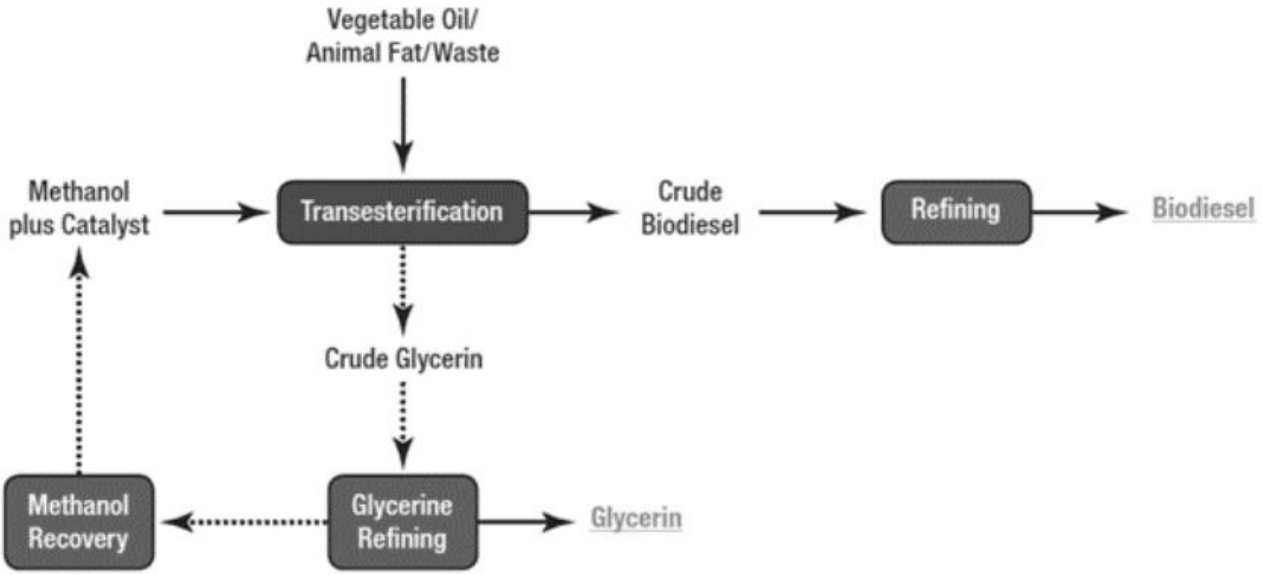
b. METHANE PRODUCTION IN LANDFILLS



c. ETHANOL FERMENTATION



d. BIODIESEL



BIOMASS COGENERATION PLANT:

The process of producing electricity and heat from steam includes the following components: a biomass combustion system (combustion chamber), a steam system (boiler plus distribution systems), a steam turbine, an electricity generator and the heat distribution system for heating from the condenser

The operating principle is in line with the classic Clausius-Rankin process. High temperature, high pressure steam is generated in the boiler and then enters the steam turbine. In the steam turbine, the thermal energy of the steam is converted into mechanical work. The low-pressure steam leaving the turbine enters the condenser housing and condenses on the condenser tubes. The condensate is transported by the water supply system to the boiler, where it is reused in a new cycle. Biomass cogeneration plants generally use grid combustion systems with a thermal combustion capacity of 20 to 30 MW. In the case where chemically untreated wood biomass is used, the steam temperature reaches 540˚C. The achievable annual electrical efficiency

depends on the steam parameters (temperature & pressure) and temperature level required for the heating process. Annual electricity efficiencies generally range from 18% to 30% for biomass cogeneration plants between 2 & 25 MW.

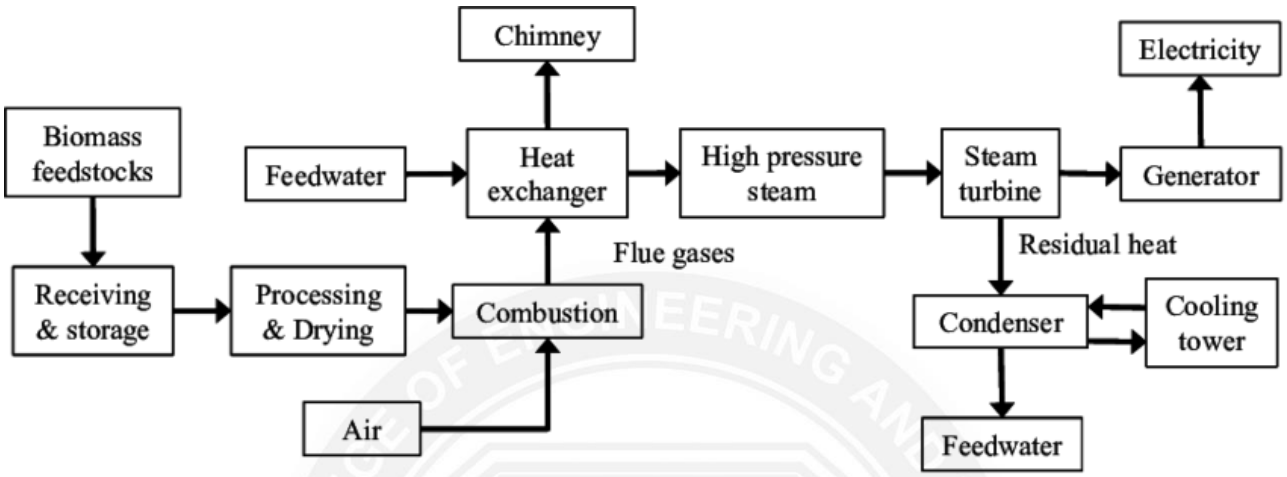


Fig.1.18 Biomass power process flow diagram

[Source: https://www.researchgate.net/figure/ Biomass-power-process-flow-diagram_fig1_282348769]

Site Selection of Biomass Power Plant:

1. Biomass Availability and Logistics:
   a. Quantity and Type: Ensuring a consistent and sufficient supply of biomass feedstock (agricultural residues, forestry residues, energy crops, etc.) is crucial.
   b. Accessibility: Proximity to biomass sources and efficient transportation infrastructure (roads, railways) are vital for minimizing fuel costs.
   c. Storage: Adequate space and facilities for storing biomass feedstock are necessary.
2. Proximity to Load Centers:
   a. Transmission Costs: Locating the plant close to major electricity load centers reduces transmission costs and energy losses.
3. Environmental Considerations:
   a. Land Use: Selecting a site with minimal impact on existing land uses (agriculture, forestry, protected areas) is important.
   b. Emissions: Minimizing air and water pollution through proper plant design and operational procedures.
   c. Water Availability: Ensuring a reliable water source for the plant's operation.
4. Social and Economic Factors:

a. Community Impact: Minimizing negative impacts on local communities (noise, traffic, visual impact) and maximizing positive impacts (job creation, economic development).
b. Regulations and Permitting: Complying with local, state, and federal environmental regulations and obtaining necessary permits.
c. Land Costs: Minimizing land acquisition costs while ensuring sufficient space for the plant and related facilities.

5. Technical and Operational Factors:
   a. Topography and Geology: Selecting a site with suitable topography and geological conditions for plant construction and operation.
   b. Infrastructure: Availability of necessary infrastructure like roads, electricity, water, and gas pipelines.
   c. Plant Design: Choosing a plant design that is compatible with the available biomass feedstock and local conditions.

Advantages:

a) Renewable energy source
b) Reduce GHG
c) Cleaner environment
d) Availability of resources
e) Carbon neutral
f) Reduces amount of waste in landfills

Disadvantages:

1. Deforestation and Habitat Loss
2. Air pollution, Greenhouse gas emission
3. Water consumption
4. Ash generation
5. Lower efficiency
6. High costs
7. Logistical challenges
8. Limited availability