



University of Asia Pacific

Department of Electrical & Electronic Engineering

EEE 401: Energy Conversion and Special Machines

Module 3: Biomass Energy



INTRODUCTION

- Biomass refers to all materials constituting and originating from plants and animals.
- Biomass accounts for 14-15% of global energy use at present.
- In developing countries biomass:
 - provides basic energy requirements for cooking and heating of rural house holds.
 - accounts for 20-90% of the total energy consumption.



Advantages of Biomass

- Biomass is a renewable resource and is readily available.
- Used as a fuel biomass reduces the need for fossil fuels.
- Adds secondary value to agricultural crops.
- Biomass can be converted to several forms of energy.
- Growing biomass crops produce oxygen and use carbon dioxide.
- The use of waste Materials reduces waste in landfills.



Disadvantages of Biomass

- Low bulk density, high moisture content, Low calorific value.
- Energy comes mainly from plants which must be harvested.
- Land used to grow biomass materials is needed for other uses.
- Biomass crops can deplete soil of nutrients.
- Burning plants releases carbon dioxide.
- Bi-products of biomass contain less energy per litre than gasoline.
- Research needed to make more cost efficient.



Biomass Resources

➤ Rural Resources:

- *Forest residues and wood wastes*
- *Crop residues*
- *Energy crops*
- *Animal manure (biogas)*

➤ Urban Resources:

- *Urban wood wastes*
- *Wastewater (biogas)*
- *Municipal Solid Waste (MSW) and Landfill Gas (LFG)*
- *Food processing residues*

Types of Biomass





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Biomass Examples



wood chips



bagasse



rice straw



rice husk

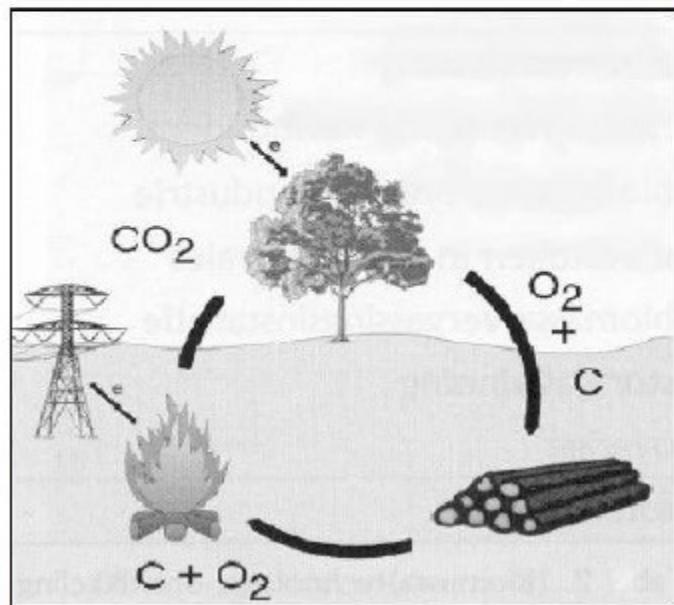
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Wood

► One form of biomass is wood. Wood waste from sawmills or trees from a forest fire area can be burned to create heat or generate electricity.

► If the same amount of wood we use for energy is allowed to grow again in our lifetime, it is a renewable form of energy.



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Crops

- Agricultural residues provide a significant fraction of total national energy requirement in many developing countries.
- Many crop residues often remain partly or wholly unutilized and cause environmental problems.
- The residues could therefore meet higher energy demands in the future through more extensive and efficient use.



Municipal Waste/Garbage

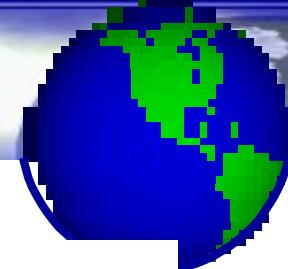
- Solid waste generation
 - based on the economic development,
 - density of population,
 - size of the urban habitation and
 - consumption rate of commercial goods.
 - The per capita generation of solid waste in Asian cities indicates a range of 0.2 to 1.7 kg / day.



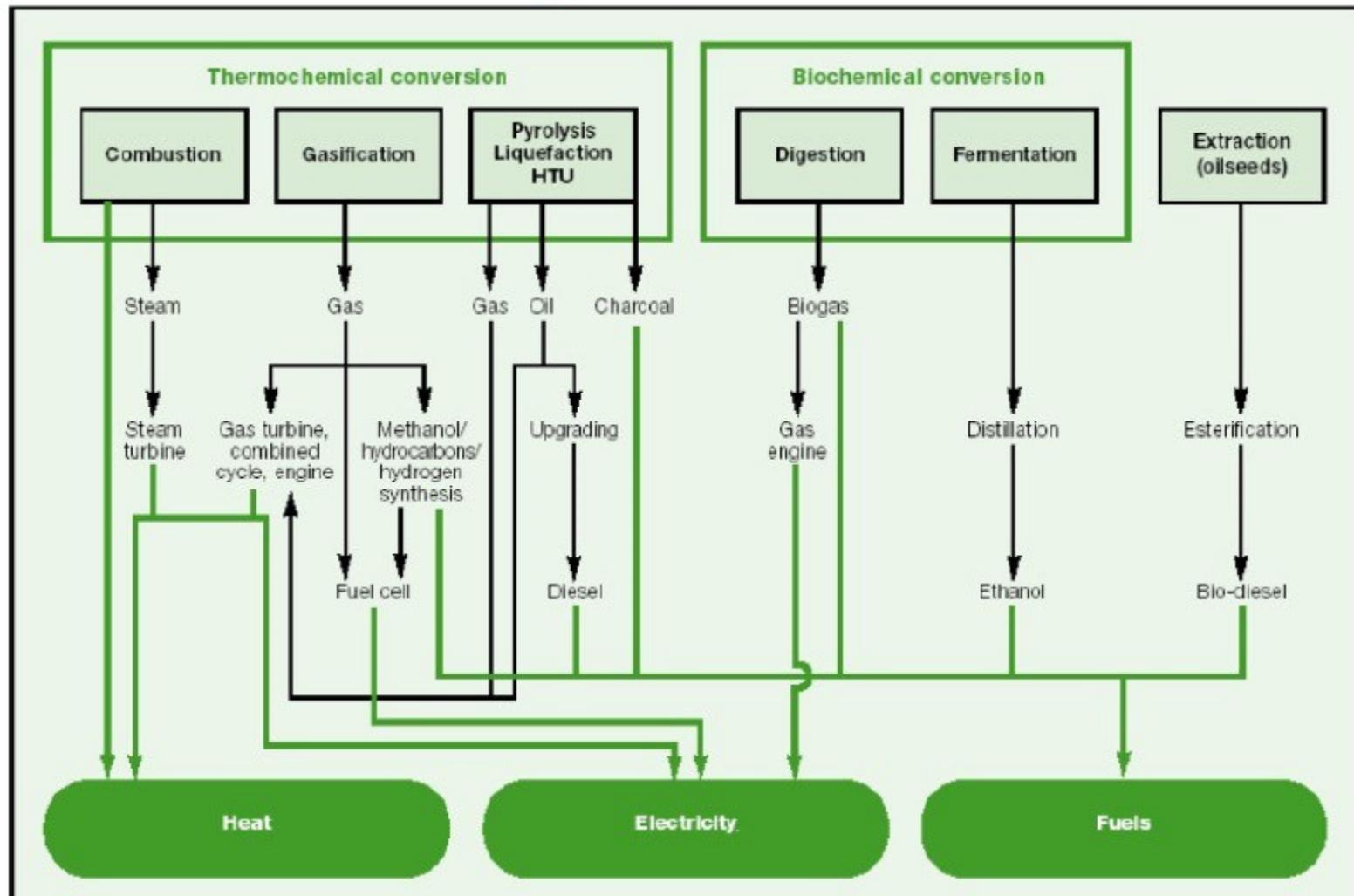
Landfill Gas

- Landfills can collect the methane gas, purify it, and then use it as an energy source.
- Methane, which is the same thing as natural gas, is a good energy source.
- Most gas furnaces and gas stoves use methane supplied by natural gas utility companies.

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Biomass Energy Conversion Routes





Biomass Conversion and Utilization

- ❖ Cook stoves
- ❖ Generating electricity from biomass
 - a) Direct combustion
 - b) Gasification
- ❖ Pyrolysis –charcoal making
- ❖ Densification
- ❖ Biogas
- ❖ Biofuel



Generating Electricity from Biomass

a) Direct Combustion

- Burned to produce steam, the steam turns a turbine and the turbine drives a generator, producing electricity.

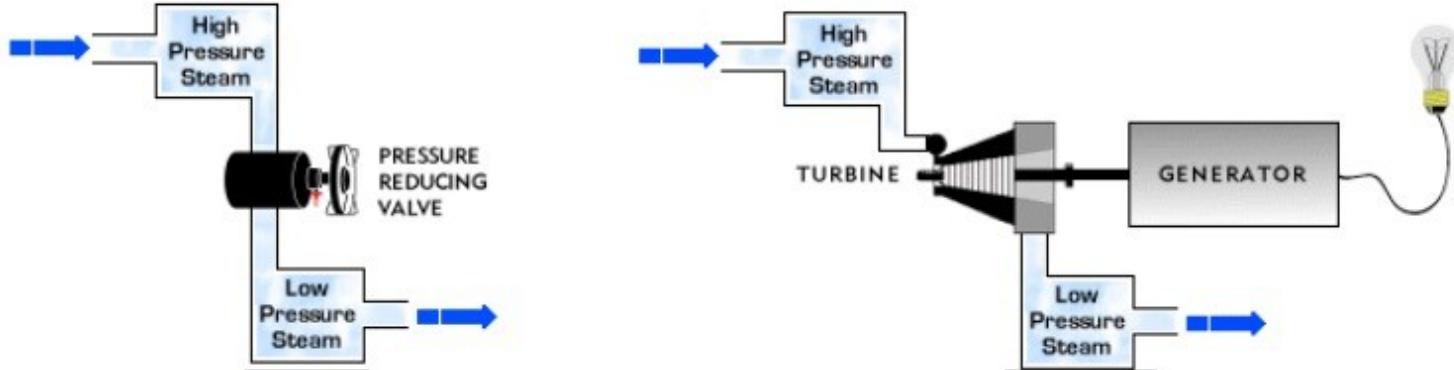
b) Gasification

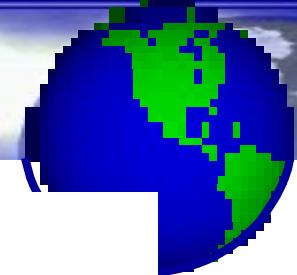
- Gasifiers are used to convert biomass into a combustible gas (producer gas or biogas). The producer gas is then used to drive a high-efficiency, combined-cycle gas turbine.



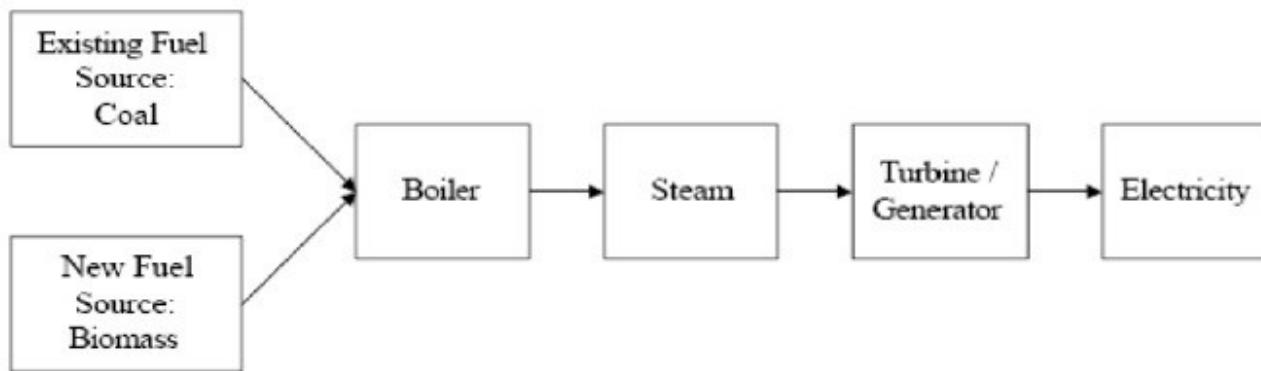
Cogeneration

- It is the process of producing two useful forms of energy, normally electricity and heat, utilizing the same fuel source. Often, there is substantial scope for efficiency improvements in such cases.





COFIRING



Biomass cofiring in a coal power plant

- *Co-firing is simultaneous combustion of different fuels in the same combustion system.*
- *Co-firing biomass with coal in existing coal fired plants is one of the most cost effective and easily implementable with minor modifications to the boiler with no major changes in boiler efficiency.*
- *In biomass Co-firing, biomass can substitute for up to 20% of the coal used in the boiler.*



GASIFICATION TECHNOLOGIES

- A process of converting a solid fuel to a combustible gas by supplying a restricted amount of oxygen.
- The exit gas stream (i.e. producer gas or syngas) from the gasifier is a mixture of combustible gases, e.g. CO, H₂ and CH₄, N, and liquid vapours, e.g. water and tar.
- Air gasification of biomass produces a low calorific syngas, which contains about 50% nitrogen.
- The syngas can be burned directly for heating applications or used as fuel for internal combustion engines after cooling and removing the tar.



Gasification Technologies

- Compared with direct combustion system, gasification is not yet an established commercial technology.
- There is great interest in the biomass gasification because of:
 - A gaseous fuel is more versatile than a solid fuel. It can be used in boilers, process heaters, turbines, engines and fuel cell.
 - Wide range of biomass feedstocks can be used without major changes in the basic process.
 - It can be used to process waste fuels, providing safe removal of biohazards and entrainment of heavy metals.



Pyrolysis

- Pyrolysis is the process of changing solid fuels irreversibly by heating in the absence of oxygen and yields a mixture of gases, liquids and a solid.
- The solid produced from pyrolysis of lignocellulosic is called charcoal.
- Production of charcoal, which is widely used as a cooking fuel in many developing countries as well as in a number of industrial applications, is the most important pyrolysis process at present.



Biomass Densification

- Densified biomass is mostly in the form of briquettes in developing countries and in the form of pellets in developed countries.
- Heated-die screw press and piston press are the two common types of briquetting presses employed in developing countries.
- Heated-die screw press technology is most common in Asian countries.
- The piston press technology is the dominant briquetting technology in India, Brazil and Africa.



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➤ Use of heated-die screw press machines is well established. Saw dust briquettes are mostly carbonized to get briquetted charcoal for domestic and export markets.



Sawdust briquettes



Carbonized briquettes

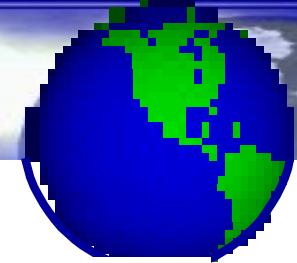


Metal charcoal kiln



Smokeless charcoal kiln

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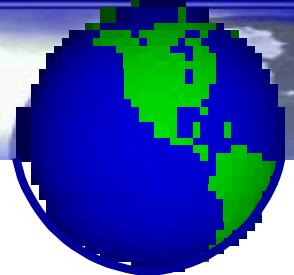
Densified Products





Biogas Production

- Biogas is produced during anaerobic digestion – a process in which certain micro-organisms act upon organic matter in the absence of oxygen.
- The most suitable materials for biogas production are animal manures. Municipal sewage as well as solid wastes and certain organic plants (algae) have also been used for biogas production.



Biogas Production

- Biogas consists of about
 - 60 to 80 percent methane,
 - 20 to 40 percent carbon dioxide, and
 - trace amounts (1 to 2 percent) of other compounds such as hydrogen sulfide, ammonia, and water vapour.

The gas is similar to natural gas and is produced as a byproduct from the biological breakdown of organic material



Liquid Biofuels

- First Generation (from Sugars, grains or seeds)
 - Biodiesel
 - Rapeseed, soybeans, sunflowers, jatropha, coconut, palm, recycled cooking oil.
 - Pure plant oils (Vegetable oil)
 - Alcohols (ethanol, butanol)
 - From grains or seeds, corn, wheat.
 - From sugar crops: sugar cane, sugar beets.
- Second Generation (from lignocellulose, crop residues, grasses, woody crops)
 - Biological
 - Ethanol (or butanol) via enzymatic hydrolysis
 - Thermochemical fuels (most made via gasification)