



RESOR - Renewable Energy Sources as a Chance for Development for the Rural Areas



Module 1: Biomass Energy

by Gürsu Municipality

Biomass: Definition and Types

- Biomass is the total weight of an organism in a designated area unit; refers to the total volume of organisms as a specified volume unit. Biomass is a source of organic matter that occurs as a result of the storage of green plants by converting solar energy into chemical energy by means of photosynthesis. Biomass, which is synonymous with live mass and sewn product, is often divided into phytoplankton and zooplankton.
- Biomass energy is energy produced from organic materials, a renewable and sustainable energy source used to generate electricity or other forms of power. For example, wood products, dried vegetation, crop residues, aquatic plants and even garbage known as household waste can be used in biomass energy.

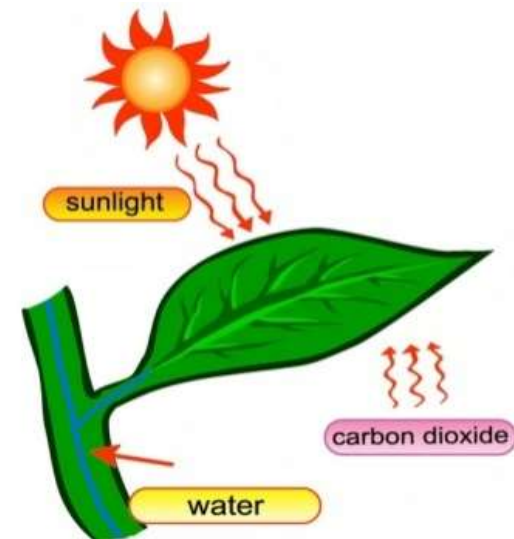
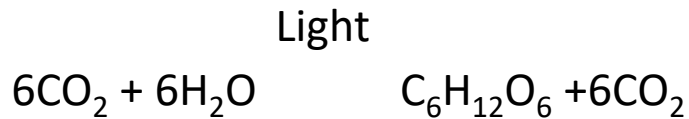
Biomass: Definition and Types

The following products are mostly used in bioenergy production.

- Wood and wood waste;
- Organic part of urban solid wastes;
- The organic part of industrial wastes;
- Sewer;
- Manure;
- Crops, food production by-products.

Photosynthesis

- Photosynthesis is an assimilation activity and therefore also called assimilation or assimilation. Photosynthesis is the production of organic compounds by using light energy in living organisms carrying chlorophyll. In this way, all living organisms that produce food are called photosynthetic organisms. Most of them are plants. Photosynthetic organisms use energy to store energy and produce organic compounds.



- Approximately 200-500 billion tons of CO₂ are transformed each year through photosynthesis.

Utilization of Biomass

- Biomass energy can be used in different fields.
- This energy is mainly used in the production of heat and electricity.
- The heat generated during the conversion of biomass to energy can be recovered and used for heating or heating instead of the heat required for the plant.
- The energy produced is converted to electricity and used for power and surplus is supplied to the transformer to meet the electricity needs of the residences in the vicinity. When not used as electricity, it is possible to purify the gas produced and use it as biofuel.



Utilization of Biomass

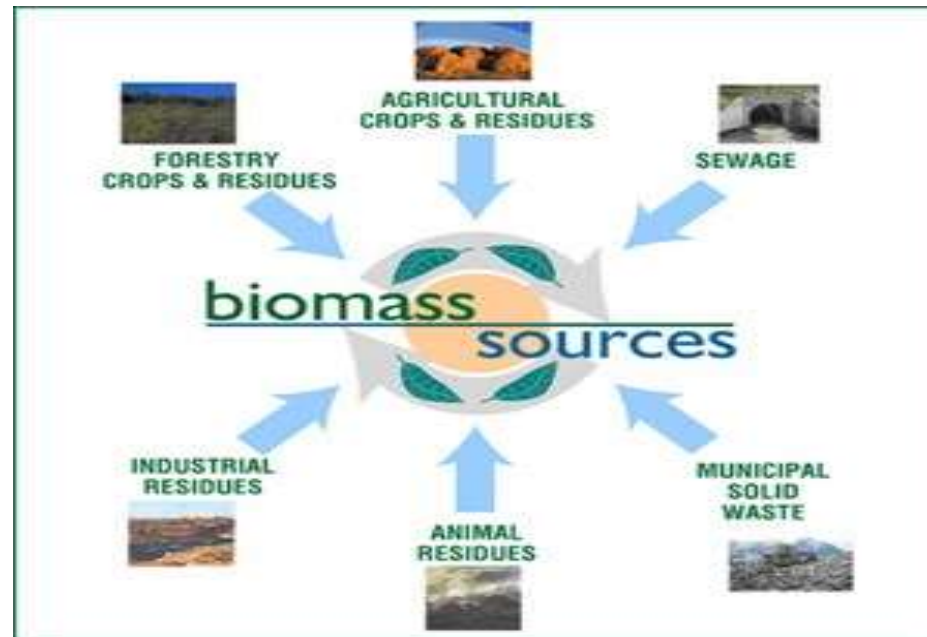
The main uses of biomass energy are:

- **Traditional home use:** Can be used for home cooking, lighting and underfloor heating in developing countries. In this way, the energy conversion efficiency of the biomass is generally between 5% and 15%.
- **Traditional industrial use:** Biomass tobacco, tea and so on. can be used for drying the products in processing. In such use, the efficiency is less than 15%.
- **Use in modern industry:** Industries use technologically advanced thermal conversion technologies. Expected conversion yields in this area range from 30% to 55%.

Biomass Resources

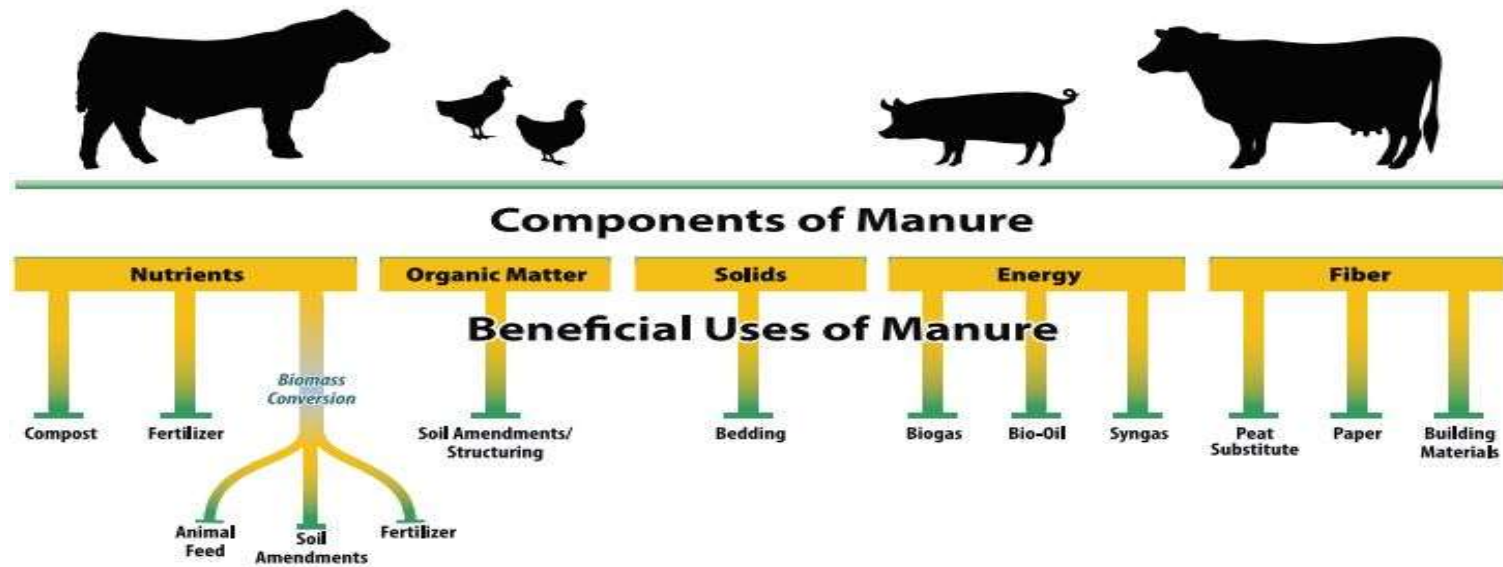
The main sources of biomass are:

- *Biomass sources from forest and forest products:* These are wood and forest waste (energy forests and energy plants, various trees).



Biomass Resources

- *Animal biomass sources:* Cattle, horses, sheep, feces of animals such as chickens, slaughterhouse wastes and waste produced during processing of animal products.



Biomass Resources

- *Agricultural wastes*: It consists of vegetable and agricultural wastes (branches, stalks, straw, roots, bark, etc.).
- *Organic waste, biomass sources from urban and industrial wastes*: It consists of sewage and bottom sludges, paper, industrial and food industry wastes, industrial and domestic wastewater, municipal and large industrial wastes.
- *Energy plants*: In this group, the plants listed below are used for biomass production.
- Oilseed plants (canola, sunflower, soy etc.)
- Sugar and starch plants (potatoes, wheat, corn, sugar beet etc.)
- Fiber plants (flax, hemp, sorghum, miscanthus, etc.)
- Protein plants (peas, beans, etc.)



Feedstock Supply, Harvesting and Handling

Biomass raw materials; special energy crops, agricultural product residues, woodland residues, algae, woodworking residues, municipal wastes and irrigated wastes (product wastes, forest residues, purpose-grown herbs, woody energy plants, algae, industrial wastes, classified municipal solids).

- *Energy crops* are non-food crops that can be grown, particularly on marginal land (soils unsuitable for conventional crops such as corn and soybeans) to provide biomass.
- *Short-rotation woody products* are fast-growing hardwoods collected in 5 to 8 years. These include hybrid poplar, hybrid willow, silver maple, eastern cotton tree, green ash, black walnut, sweetgum and plane tree.



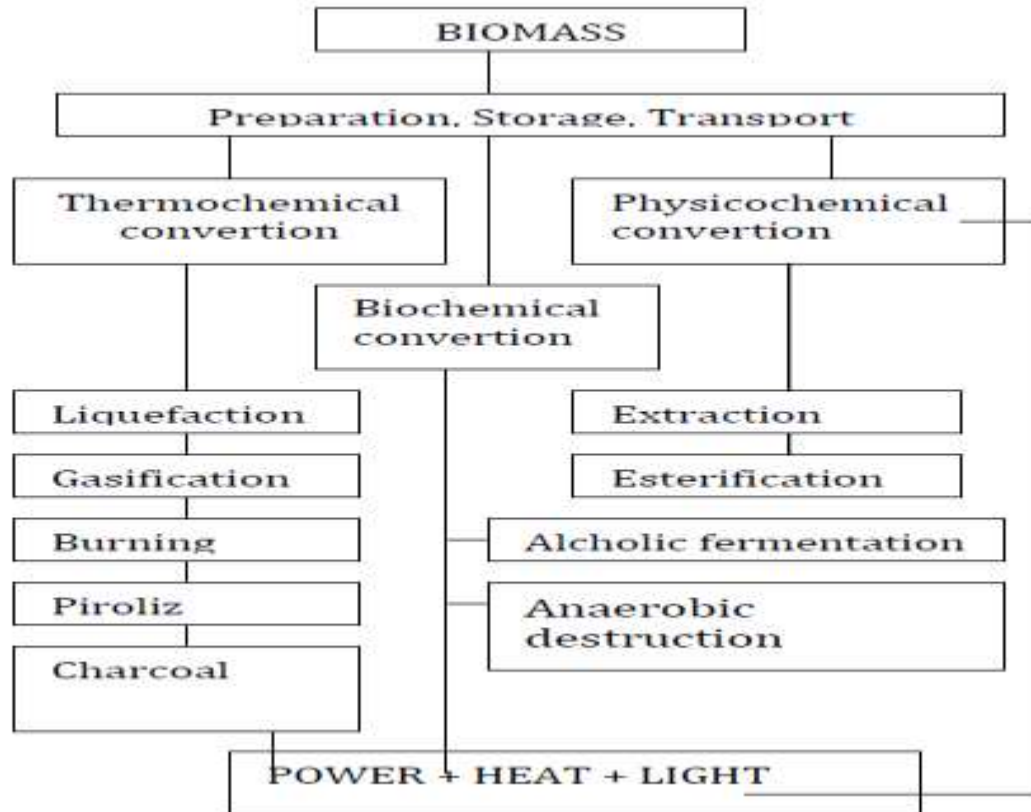
Feedstock Supply, Harvesting and Handling

- *Forest* biomass raw materials fall into one of two categories: forest residues (branches, bark) left after timber logs or whole tree biomass collected for biomass.
- *Algae* as a raw material for bioenergy refers to a variety of high-yielding organisms, including microalgae, macroalgae (seaweed) and cyanobacteria (previously called “blue-green algae”).
- *Urban solid wastes* include garden ornaments, mixed commercial and household waste such as paper and cardboard, plastic, rubber, leather, textiles and food waste.

Biomass Conversion Technologies

There are several methods of converting biomass into electricity.

- The first is to burn biomass directly, heat water to steam, and then send it through a steam turbine that generates electricity.



Biomass Conversion Technologies

- The second way requires the gasification of the biomass. A biomass gasifier receives dry biomass, such as agricultural waste, and in the absence of oxygen and at elevated temperatures, synthesis gas ($\text{CO} + \text{H}_2$), also known as pyrolysis of the biomass, is produced.

Biomass	Conversion method	Fuels	Using
Forest Waste	Anaerobic Digestion	Biogas	Electricity Generation
Agricultural wastes	Pyrolysis	Ethanol	Heating
Energy crops	Direct burning	Hydrogen	Water heating
Animal wastes	Fermentation	Methane	Automobiles
Organic Garbage	Gasification	Methanol	Airplanes
Algae	Hydrolysis	Synthetic Oil	Rockets
Energy forests	Photolysis	Diesel	Product Drying



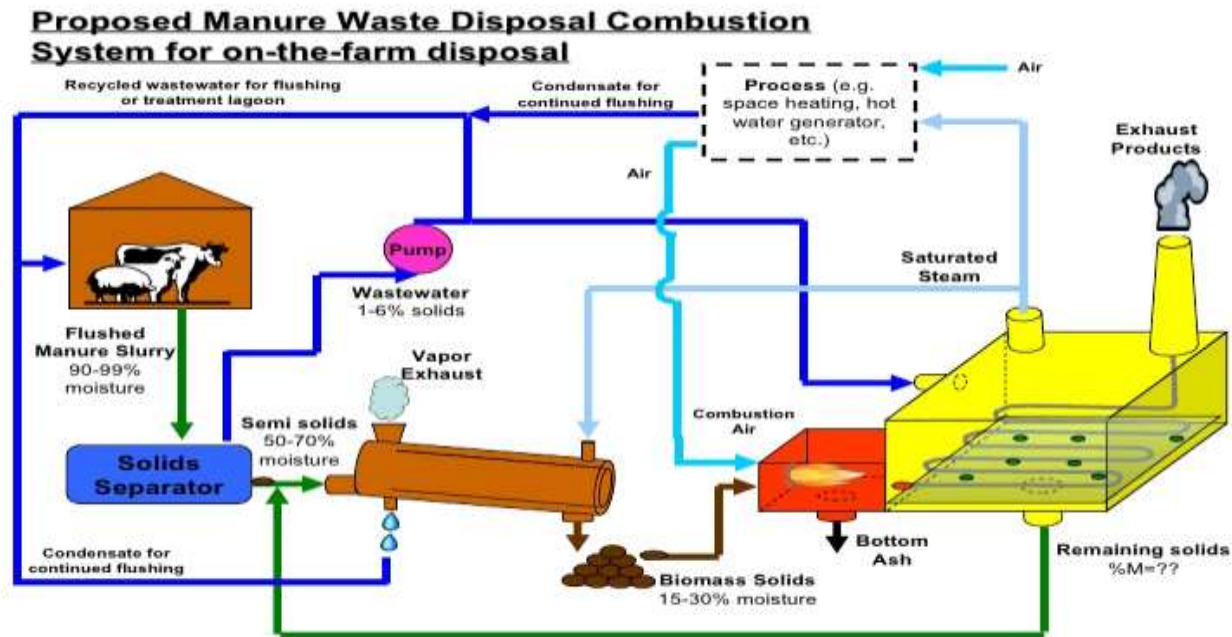
Biomass Conversion Technologies

- Gasification processes wet biomass such as food waste and fertilizer into methane (CH_4) in a digestive tank. Both methane and syngas can be used in a gas engine or in a gas turbine for electricity generation. A third way to generate electricity from gasified biomass is by using fuel cells.

Biomass Conversion Technologies

The conversion technologies of biomass can be listed as follows:

- **Direct burning:** Incineration is defined as the process of rapid chemical reaction of flammable materials in biomass with oxygen. Direct combustion is the most common technique for generating both heat and electrical energy from biomass waste. Thermal efficiencies of up to 80-90% can be achieved with advanced gasification technology with greatly reduced atmospheric emissions.



Biomass Conversion Technologies

- **Co-ignition system:** Co-ignition is considered an inefficient combustion method. In this process, biomass replaces 15 to 20% of the coal used in a power plant.
- **Pyrolysis:**Pyrolysis is the process of extracting gas from biomass by decomposing organic molecules in an oxygen-free environment. With this method, liquid and gaseous fuels are produced from solid fuel.
- **Carbonization:** Carbonization is the chemical decomposition of organic materials such as wood and coal in an airless environment. Gas components released as a result of carbonization process; approximately 50% CO₂, 35% CO, 10% CH₄ and 5% other hydrocarbon and H₂.



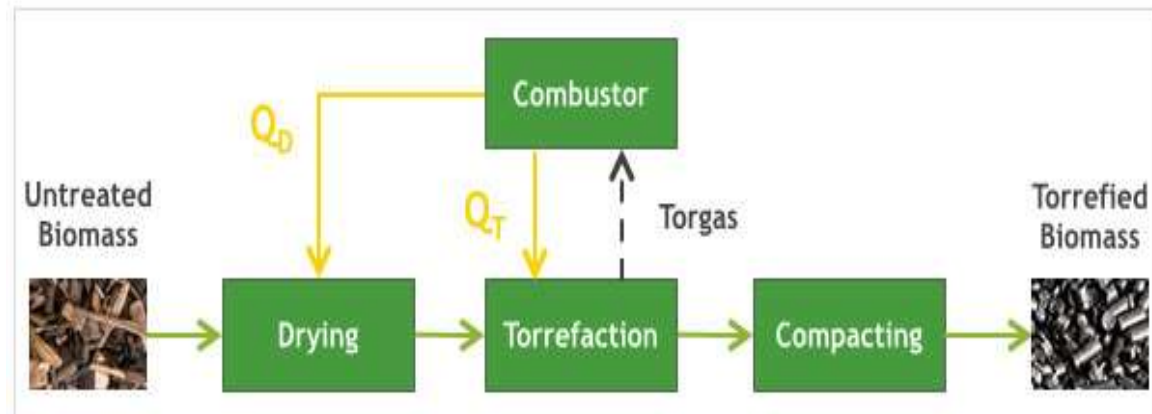
Biomass Conversion Technologies

- **Anaerobic digestion:** Airless digestion is the fermentation of biomass in an oxygen-free environment with the help of microorganisms, and it is transformed into a valuable fuel and fertilizer to be used almost everywhere. The gas produced from biomass by this method is the best known and widely used biogas among fuels.
- **Fermentation:** Fermentation; It is the process of decomposing carbon hydrates, proteins and fats, which are the three basic elements of organic matter, into CO₂, acetic acid and soluble volatile organic substances under the influence of enzymes produced by some microorganisms.

Biomass Conversion Technologies

- **Torrefaction:** For biomass production, torrefaction is a thermo-chemical process using heat. The temperature required for this process is between 200 and 320 ° C. Oxygen is removed during the process, the moisture in the biomass is removed and called volatile matter. Unnecessary volatiles are also removed for a more convenient form of biomass. The result of this process is a dry black solid biomass known as bio-coal. Bio-charcoal is typically made into pellets or briquettes and used for heating in homes or for fuel in industry. Bio-coal has less smoke than other combustibles.

BASIC TORREFACTION PRINCIPLE



Advantages and Disadvantages

Advantages

- Using biomass can help reduce the amount of organic waste
- Biomass is always available and can be produced as a renewable resource.
- Biomass, fuel from agriculture, is perhaps a secondary product that adds value to the agricultural product.
- Growing biomass plants produce oxygen and consume carbon dioxide.
- Reduces carbon release.
- It is cheaper than fossil fuels.
- Reduces the amount of waste in the environment.
- Does not cause acid rain.
- Transport can be done safely.
- Improves the socio-economic structure of rural areas.
- Suitable for energy efficiency at any scale.
- Does not create environmental pollution.

Advantages and Disadvantages

Disadvantages

- To produce biomass, the crops require bread. Can compete with the food.
- IFurther studies are needed in areas such as harvesting methods.
- Land used for energy crops may also be claimed for other purposes, such as conservation, housing, holiday village or agricultural use.
- The use of biomass as fuel produces higher levels of air pollution than conventional fuel sources, such as coal or natural gas, in the form of carbon monoxide, NOx (nitrogen oxides), particles and other pollutants.
- Since the use of biomass from forests takes a long time to regenerate trees, CO2 consumption is not continuous.
- Has low cycle efficiency.
- Not completely clean.
- Requires a lot of water,
- Inefficient compared to fossil fuels.



Biomass and the Environment

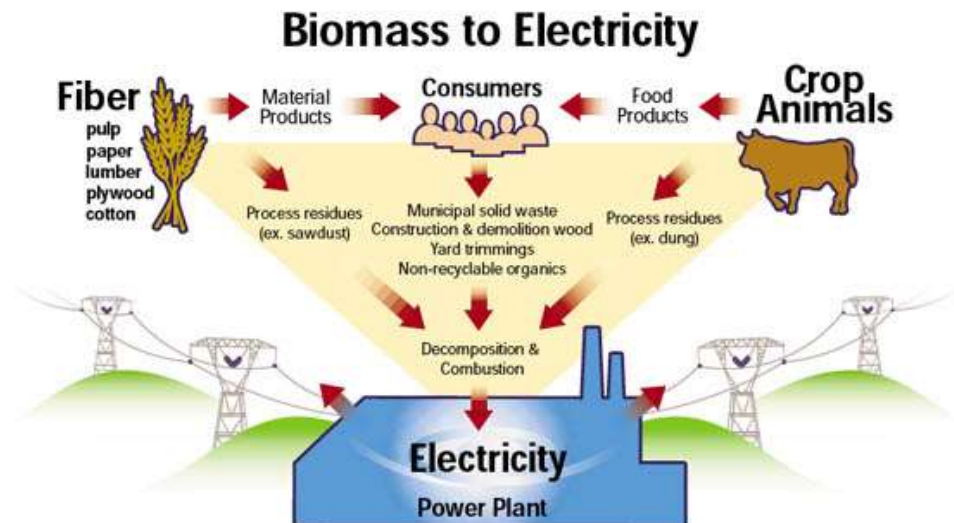
- Biomass is known as a carbon-neutral energy source and is considered an important alternative to fossil-fueled basic energy production.
- Using a highly efficient conversion turbine can also provide additional environmental benefits in the long run for industries and electricity producers who want to further reduce their carbon and emission footprints.
- Because, thanks to the increased efficiency of the power plant, it consumes less fuel during its life and saves significant cost while reducing the emission effects. These advantages are even more pronounced, especially if the biomass system includes a reheated steam turbine or a Combined Heat and Energy (CHP) application



Using biomass to produce electricity

Most biomass conversion plants use direct ignition combustion systems. Biomass is burned directly to produce high pressure steam which drives the electric turbine generator.

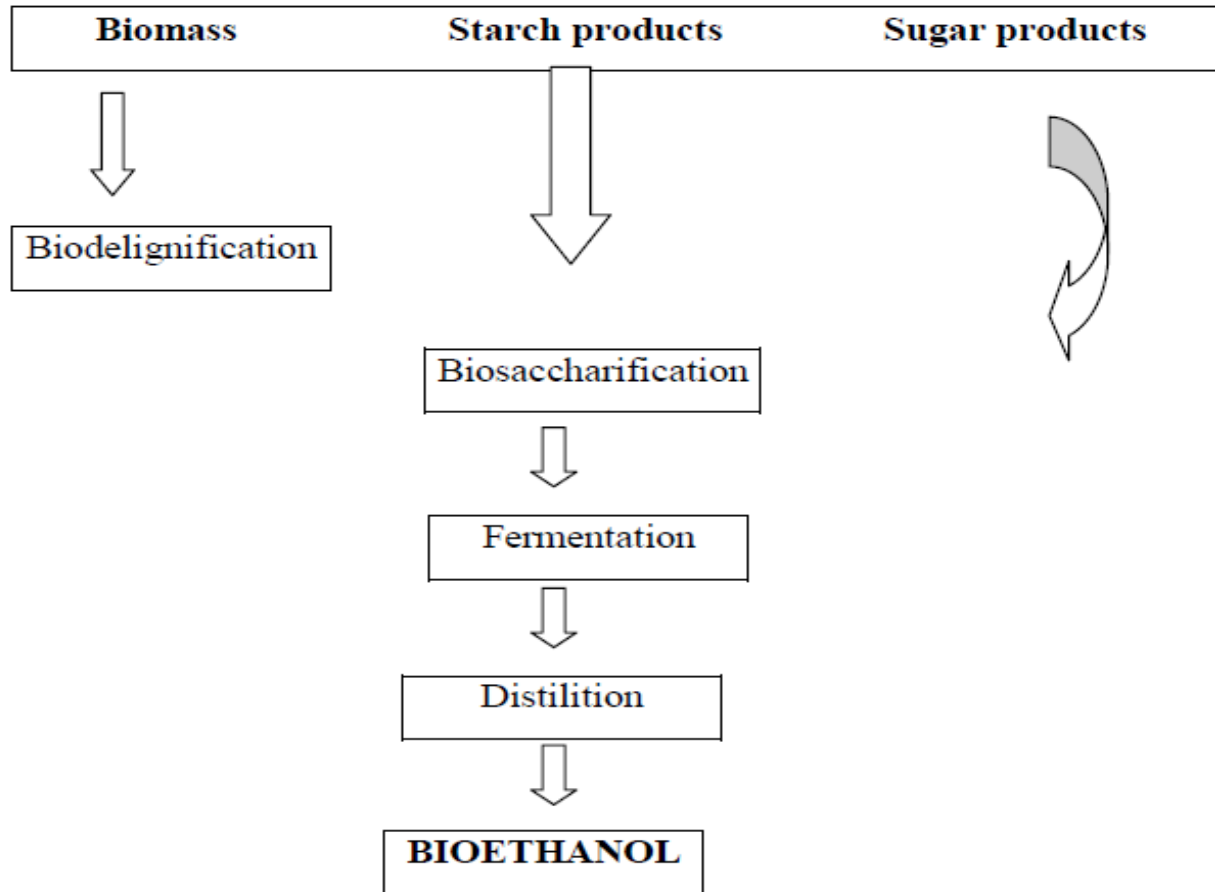
- A simple biomass power generation system consists of several important components. For a steam cycle, this system consists of a combination of the following elements:
- Fuel storage and transportation equipment,
- Burner / furnace,
- Boiler pumps,
- Fans,
- Steam turbine,
- Generator,
- Condensers,
- Cooling tower,
- Exhaust / emission controls,
- System controls (automatic).



Using biomass to produce biofuels (ethanol, biodiesel, etc.)

- *Biofuels* are vehicle fuels such as ethanol and biodiesel produced from biomass materials. These fuels are often mixed with petroleum fuels (gasoline and diesel fuel) or used directly. The use of ethanol or biodiesel reduces the amount of crude oil used. Ethanol and biodiesel are also burning fuels cleaner than pure gasoline and diesel fuel.
- *Bioethanol* is an alcohol derived from sugars found in cereals such as corn, sorghum and barley.

Using biomass to produce biofuels (ethanol, biodiesel, etc.)



Using biomass to produce biofuels (ethanol, biodiesel, etc.)

Today, the widespread use of bioethanol as a fuel is alternative to petrol and diesel fuel in four forms.

- Gasohol: 10% alcohol + 90% gasoline mixture
- E25: 25% alcohol + 75% gasoline mixture
- E85: 85% alcohol + 15% gasoline mixture
- E-Diesel: Diesel containing up to + 15% alcohol (Oxy-Diesel, Diesohol)

Biodiesel is a fuel made from vegetable oils, oils or greases, such as recycled restaurant oil. Biodiesel fuel can be used in diesel engines without changing the engine. Pure biodiesel is non-toxic and biodegradable. Burning biodiesel produces more air pollutants than petroleum-based diesel fuel.



Technical Impediments

Nowadays, the main barriers to the utilization of agricultural wastes are:

- Obstacles in the institutional, legal and administrative framework,
- Perceptions about biomass energy,
- Time-consuming administrative barriers for foreign investors,
- Need for infrastructure and management technology transfer support at local level,
- YInsufficient private sector participation,
- Personnel with sufficient technical knowledge,
- Planning, project feasibility,
- Other barriers to environment and agriculture.



Case Study



Case study 1: Mutlular Energy: Turkey's First Biomass Energy Plant, Gonen, Balıkesir, Turkey . (<https://www.yesilodak.com/turkiye-nin-ilk-biyokutle-enerji-tesisi->)

- The “Biomass Power Plant was established in Gönen, Balıkesir to generate electricity by burning plant waste such as paddy stalk, tree stump, stubble and canola stalk.
- Turkey's first "Biomass Power Plant" Gonen district of Balıkesir, Mutlular was founded in the energy body. Referring to Gönen as a district with 75 thousand inhabitants, İbrahim Mutlu said, we will have enough production for 300 thousand inhabitants. In order to produce this electricity, 210 thousand tons of vegetable waste is required annually. We burn 700 tons of vegetable waste a day. Mutlu says that besides manure, animal manure is also burned, and when the investment is fully operational, we will start to provide electricity to the national distribution network.
- Hourly 30 MW of installed power, Turkey's largest licensed "Biomass Energy" facility, aimed at meeting of Balıkesir electric with energy derived from vegetable waste. In the Biomass Power Plant, paddy stalk, canal, corn stalk, forest base and bovine manure will be transformed into energy by recycling. 720 MW of energy will be generated by recycling 700 tons of waste per day.

Case Study

Case study 2: *Roves Farm Biomass Central Heating*

- Roves Farm is a family business in the UK (www.rovesfarm.co.uk). This farm has 166 hectares of land and livestock and crop production. It is also suitable for ecotourism activities. Entertainment and adventure activities are held at this farm, where people of all ages come.

Resources & Links

Videos

- https://www.youtube.com/watch?v=nVl17JLn_u0
- <https://www.youtube.com/watch?v=iJ587pg66Ss>

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- http://yambiz.com/ecoenergy/index.php?option=com_content&view=article&id=56:how-biomass-energy-works&catid=35:publications&Itemid=55&lang=tr
- <https://www.elektrikport.com/haber-roportaj/yldz-yukselen-bir-elektrik-uretim-sekli-biyokutle-elektrik-uretimi/2808#ad-image-0>
- <https://www.eia.gov/energyexplained/biofuels/>
- <https://energyinformative.org/how-electricity-is-generated-from-biomass/>
- <https://www.wbdg.org/resources/biomass-electricity-generation>
- <https://bilim.beyan.org/bilgi/fotosentez-nedir.html>
- <https://www.tech-worm.com/fotosentez-nedir-fotosentez-nasil-gerceklesir/>
- <https://www.energy.gov/eere/bioenergy/biomass-resources>
- <https://enerji.gov.tr/en-US/Pages/Bio-Fuels>

Resources & Links

- <http://bepa.yegm.gov.tr/>
- <https://www.cevreportal.com/biyomass-nedir/>
- <http://kojenturk.org/tr/biyokutle-nedir-8>
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