Chapter 6
Other Non-conventional source of energy

Biomass

- ❑ It is the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste.
- ❑ Biomass resources include primary, secondary, and tertiary sources of biomass.
- ❖ Primary biomass resources are produced directly by photosynthesis and are taken directly from the land.
- ❖ They include perennial short-rotation woody crops and herbaceous crops, the seeds of oil crops, and residues resulting from the harvesting of agricultural crops and forest trees.
- ➢ Secondary biomass resources result from the processing of primary biomass resources either physically, chemically, or biologically.
- ✓ Tertiary biomass resources are post-consumer residue streams including animal fats and greases, used vegetable oils, packaging wastes, and construction and demolition debris.

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

Biomass Energy

- ❑ Bioenergy consists of solid, liquid, or gaseous fuels.
- ❑ Liquid fuels can be used directly in the existing road, railroad, and aviation transportation network stock, as well as in engine and turbine electrical power generators.
- ❑ Solid and gaseous fuels can be used for the production of electrical power from purpose designed direct or indirect turbine-equipped power plants.
- ❑ Chemical products can also be obtained from all organic matter produced.
- ❑ Additionally power and chemicals can come from the use of plant-derived industrial, commercial, or urban wastes, or agricultural or forestry residues.

Biomass conversion process

- ❑ There are various conversion technologies that can convert biomass resources into power, heat, and fuels for potential use in various countries.

➢ **Pyrolysis:**

- ❖ Pyrolysis is the application of heat to a feedstock in the absence of oxygen to break down the long chain molecules into short chain molecules.
- ❖ Typically the feedstock is biomass or waste, and the process is used to produce a syngas (a mixture of hydrogen, volatile organic compounds, and carbon monoxide).
- ❖ Varying the process conditions allows the production of fluids similar to diesel, and a variety of other products.
- ❖ Further work is now concentrating on the use of high pressure reactor conditions to produce hydrogen.
- ✓ They convert solid material into gases and vapours which are less costly to handle, transport and store.

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

Biomass conversion process

- ✓ The gases will burn in boilers, gas turbines and reciprocating engines increasing fuel flexibility and security.
- ✓ Capturing and combusting the methane and carbon monoxide and produces carbon dioxide which is a less potent greenhouse gas than methane.

➢ **Carbonisation**

- ✓ This is an age old pyrolytic process optimised for the production of charcoal.
- ✓ Traditional methods of charcoal production have centered on the use of Earth mounds or covered pits into which the wood is piled.
- ✓ Control of the reaction conditions is often crude and relies heavily on experience.
- ✓ During carbonisation most of the volatile components of the wood are eliminated; this process is also called 'dry wood distillation.
- ✓ Recirculating heated gas systems offer the potential to generate large quantities of charcoal and associated by-products, but are presently limited by large scale plant.

Biomass conversion process

➢ **Biomass gasification**

- ✓ Biomass gasification, or producing gas from biomass, involves burning biomass under restricted air supply for the generation of producer gas.
- ✓ Producer gas is a mixture of gases: 18–22% carbon monoxide (CO), 8–12% hydrogen (H_2), 8–12% carbon dioxide (CO_2), 2–4% methane (CH_4) and 45–50% nitrogen (N_2) making up the rest.
- ✓ Producing gas from biomass consists of the following main reactions, which occur inside a biomass gasifier:

i. **Drying:** Biomass fuels usually contain 10–35% moisture. When biomass is heated to about 100°C, the moisture is converted into steam.

ii. **Pyrolysis:** After drying, as heating continues, the biomass undergoes pyrolysis. Pyrolysis involves burning biomass completely without supplying any oxygen. As a result, the biomass is decomposed or separated into solids, liquids, and gases. Charcoal is the solid part, tar is the liquid part, and flue gases make up the gaseous part.

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

Biomass conversion process

iii. **Oxidation:** Air is introduced into the gasifier after the decomposition process. During oxidation, which takes place at about 700–1400°C, charcoal, or the solid carbonised fuel, reacts with the oxygen in the air to produce carbon dioxide and heat.

$$C + O_2 \rightarrow CO_2 + \text{heat}$$

iii. **Reduction:** At higher temperatures and under reducing conditions, that is when not enough oxygen is available, the following reactions take place forming carbon dioxide, hydrogen, and methane.

$$C + CO_2 \rightarrow 2\,CO$$
$$C + H_2O \rightarrow CO + H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$
$$C + 2H_2 \rightarrow CH_4$$

Biomass conversion process

❖ **Advantages:**

✓ Biomass gasifiers are available in several designs and capacities to suit different requirements.

✓ The technology is suitable and economical for small, decentralized applications, typically with capacities smaller than a megawatt.

✓ A gasifier based power system can generate electricity when required and also wherever required.

✓ Whereas large thermal power plants and solar and wind based units are very location specific, biomass gasifier based systems can be set up at almost any place where biomass feedstock is available.

✓ For small-scale systems, the cost of power generation by biomass gasification technology is far more reasonable than that of conventional diesel based power generation.

✓ Biomass is a CO_2 neutral fuel, unlike fossil fuels such as diesel does not contribute to net CO_2 emissions.

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

Biomass conversion process

➢ **Catalytic liquefaction**

- ✓ Catalytic liquefaction is a low temperature, high pressure thermochemical conversion process carried out in the liquid phase.
- ✓ It requires either a catalyst or a high hydrogen partial pressure.
- ✓ This technology has the potential to produce higher quality products of greater energy density.
- ✓ These products should also require less processing to produce marketable products.
- ✓ Technical problems have so far limited the opportunities of this technology.

Wind power

- ❑ **Wind energy** or **wind power** describe the process by which the wind is used to generate mechanical power or electricity.
- ❑ Winds are caused by
- ✓ The uneven heating of the atmosphere by the Sun,
- ✓ The irregularities of the Earth surface, and
- ✓ Rotation of the Earth.
- ✓ Wind flow patterns are modified by the Earth terrain, bodies of water and vegetative cover.

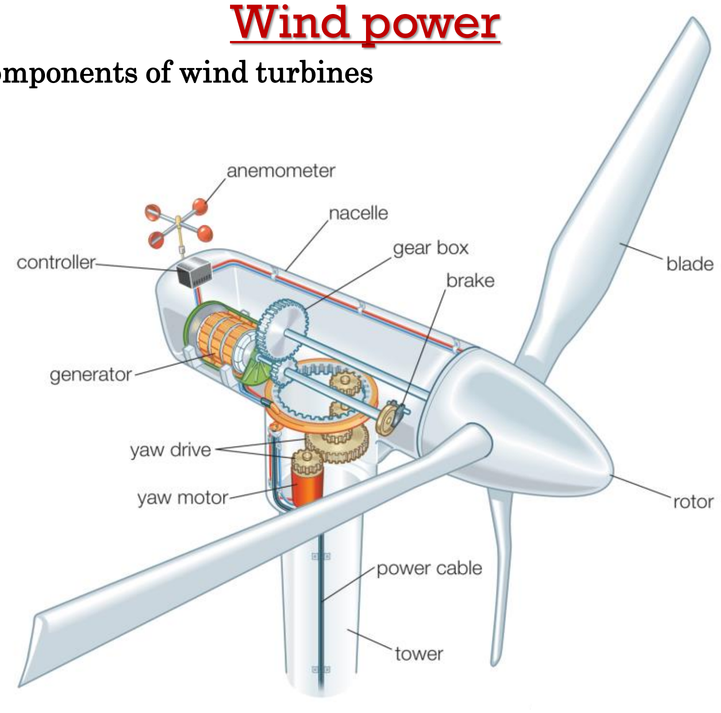
- ❖ The power in the wind is extracted by allowing it to blow past moving blades that exert torque on a rotor.
- ❖ The amount of power transferred is dependent on the rotor size and the wind speed.
- ❖ Wind turbines range from small four hundred watt generators for residential use to several megawatt machines for wind farms and offshore.

Wind power

- The amount of electricity produced from a wind turbine depends on three factors:
- ✓ **Wind speed:** The power available from the wind is a function of the cube of the wind speed. Therefore if the wind blows at twice the speed, its energy content will increase eight-fold. Turbines at a site where the wind speed averages 8 m/s produce around 75–100% more electricity than those where the average wind speed is 6 m/s.
- ✓ **Wind turbine availability:** This is the capability to operate when the wind is blowing, i.e., when the wind turbine is not undergoing maintenance. This is typically 98% or above for modern European machines.
- ✓ **The way wind turbines are arranged:** Wind farms are laid out so that one turbine does not take the wind away from another. However other factors such as environmental considerations, visibility and grid connection requirements often take precedence over the optimum wind capture layout.

Wind power

- **Components of wind turbines**



Wind power

- **Components of wind turbines**
- ***Anemometer:*** Measures the wind speed and transmits this data to the controller.
- ***Blades:*** Most turbines have either two or three blades. Wind blowing over the blades causes the blades to 'lift' and rotate.
- ***Brake:*** A disc brake, which can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.
- ***Controller:*** Starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Do not operate at wind speeds above about 55 mph because they might be damaged by the high winds.
- **Gear box:** Wind turbines rotate typically between 40 rpm and 400 rpm. Generators typically rotate at 1200 to 1800 rpm. Most wind turbines require a step-up gear-box for efficient generator operation. Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 40 to 60 rpm to about 1000 to 1800 rpm. The gear box is a costly (and heavy) part of the wind turbine.

Wind power

- ***Generator:*** Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.
- ***High-speed shaft:*** Drives the generator.
- ***Low-speed shaft:*** The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.
- ***Nacelle:*** The nacelle sits a top the tower and contains the gear box, low and high-speed shafts, generator, controller and brake.
- ***Pitch:*** Blades are turned, or pitched, out of the wind to control the rotor speed and keep the rotor from turning in winds that are too high or too low to produce electricity.
- ***Rotor:*** The blades and the hub together are called the rotor.
- ***Tower:*** Towers are made from tubular steel, concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.
- ***Yaw drive:*** Upwind turbines face into the wind, the yaw drive is used to keep the rotor facing into the wind as the wind direction changes.

Wind power

- **Working principle of wind turbine**

✓ When the wind flows across the blade, the air pressure on one side of the blade decreases.
✓ The difference in air pressure across the two sides of the blade creates both lift and drag.
✓ The force of the lift is stronger than the drag and this causes the rotor to spin.
✓ The rotor is connected to the generator, either directly or through a shaft and a series of gears that speed up the rotation and allow for a physically smaller generator.
✓ This translation process generate electricity.

Wind power

- **Advantages:**

✓ Clean & Environment friendly Fuel source
✓ Renewable & Sustainable
✓ Wind energy is cost effective, and prices are dropping still
✓ Industrial and Domestic Installation
✓ Job Creation

- **Disadvantages:**

✓ Fluctuation of Wind and Selecting good wind sites
✓ Noise and aesthetic pollution: A single wind turbine can be heard from hundreds of meters away.
✓ Not a profitable use of land: Alternative uses for the land might be more highly valued than electricity generation.
✓ Threat to wildlife: Birds have been killed by flying into spinning turbine blades.

Wind power

- **Efficiency:**

$$\text{Power (W)} = 0.6 \times Cp \times N \times A \times V^3$$

$$\text{Revolutions (rpm)} = V \times TSR \times 60 / (6.28 \times R)$$

Cp = Rotor efficiency, N = Efficiency of driven machinery, A = Swept rotor area (m^2), V = Wind speed (m/s) TSR = Tip Speed Ratio , R = Radius of rotor

- Rotor efficiency can go as high as Cp = 0.48, but Cp = 0.4 is often used in this type of calculations.

- **Example:**

✓ If tip speed ratio = 7, Wind speed = 8.6 m/s, Rotor efficiency = 0.4, Generator efficiency = 0.7, Swept rotor area = 2.11 M^2, Radius of rotor = 0.82 m,

✓ Then **Revolutions** = 701 rpm & **Power output** = 226 W.

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU