CMR INSTITUTE OFTECHNOLOGY USN

Internal Assessment Test - II

Sub:	Renewable Energy Systems							Code:	18EE653
Date:	25/05/2023	Duration:	90 mins	Max Marks:	50	Sem:	6th	Branch:	CSE/ISE/ECE /MECH/CV

Answer Any **FIVE FULL** Questions.

		Marks	OBE	
			CO	RBT
1	Explain the principle of conversion of solar energy into heat. Explain with a neat diagram, how this is employed in the flat plate collectors.	10	CO2	L1
2	How is the heat from sunlight converted into mechanical power? Explain Stirling and Brayton heat engines with a neat sketch.	10	CO2	L1
3.a	With neat sketch, explain (i) box-type solar cooker; (ii) reflector-type (parabolic type) solar cooker; (iii) solar steam and convection cookers	6	CO2	L1
3.b	Explain,how is solar heated air used for drying? Mention the main applications of a solar dryer.	4	CO2	L1
4	With a neat sketch, explain the following fixed bed gasifiers (i) Updraft; (ii) downdraft; and (iii) Cross draft. Mention their applications.	10	CO2	L1
5	With the help of chemical reaction at every stage, explain the process of biomass gasification. What is the general composition of the producer gas and what is its heating value?	10	CO4	L1
6.a	What is a gasifier? Summarize the different types of gasifiers used in the biomass gasification process.	6	CO4	L2
6.b	Define biomass. Give a descriptive classification of biomass resources	4	CO4	L1

CCI **CI** **HOD**

1. Explain the principle of conversion of solar energy into heat. Explain with a neat diagram, how this is employed in the flat plate collectors.

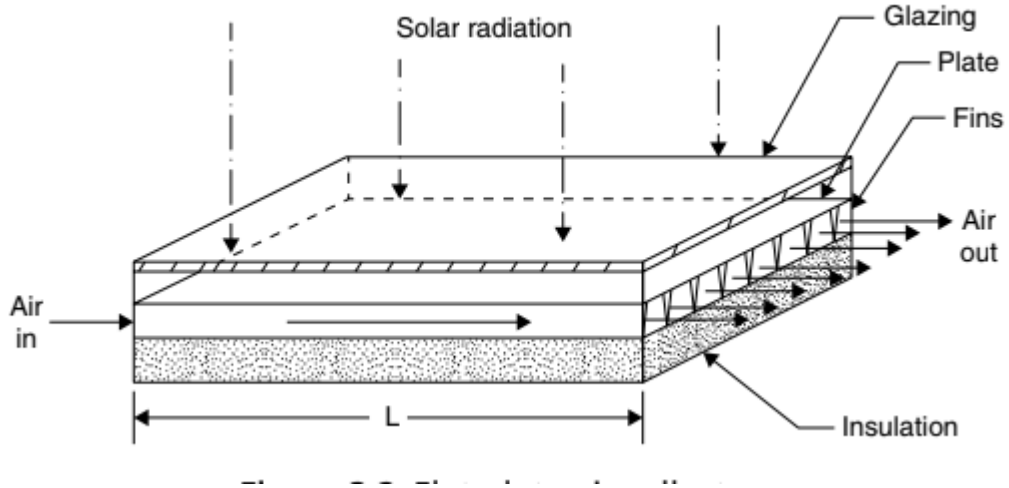
Sun's heat energy is a diffuse energy. It is always first collected and then concentrated. In residential systems, simple and cheap solar panels are used to collect the solar heat energy below 60°C. Residential panels for heat collection are referred to as flat plate collectors.

In utility scale systems, solar heat energy is required to be concentrated at high temperature level in the range 70°C—80°C at the collectors. The utility panels are, therefore, called concentrators.

Solar energy collectors are special kind of heat exchangers that transform solar radiation energy into internal energy of the transport medium. The major component of any solar system is the solar collector.

The solar collector absorbs the incoming solar radiation, converts it into heat, and then transfers this heat to a fluid (usually air, water, or oil) flowing through the collector. The solar energy, thus, collected is carried from the circulating fluid either directly to the hot water or space conditioning equipment or to a thermal energy storage tank, from which it can be drawn for use at night and/or cloudy days.

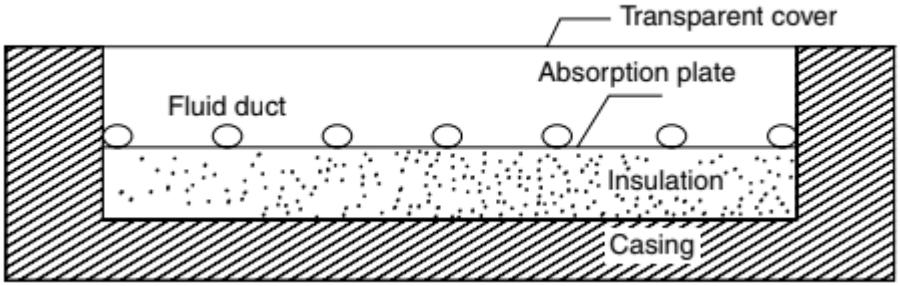
Flat Plate Air Collectors



Air flat plate collectors are used mainly for solar space heating. The absorber plates can be made of metal sheets, layers of screen, or non-metallic materials. The air flows past the absorber by using natural convection or a fan. Since air does not conduct heat as easily as liquid, air collectors are typically less efficient than liquid collectors.

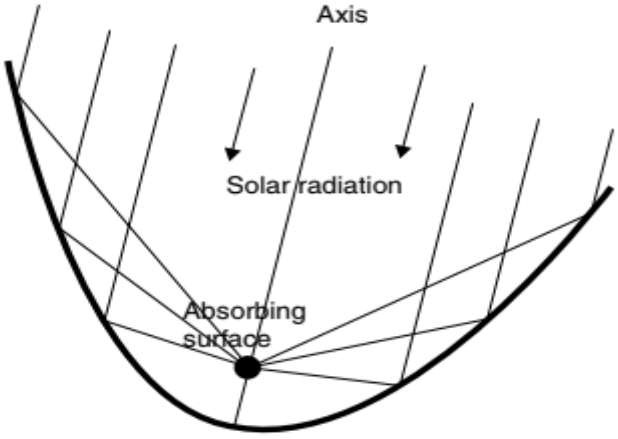
Flat Plate Liquid Collectors

The simplest liq-uid systems use household water that is heated as it passes directly through the solar collector and then flows to the house. Solar pool heating uses liquid flat plate technology, but the collectors are typically unglazed. The liquid tubes can be welded to the absorbing plate, or they can be an inte- gral part of the plate. The liquid tubes are connected at both ends by large diameter header tubes.



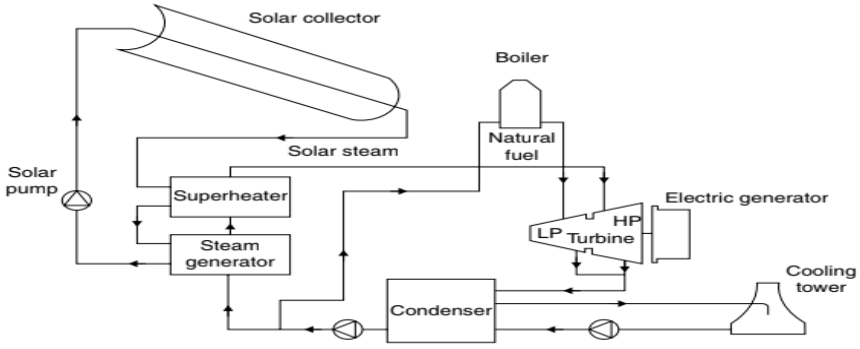
Concentrating Collectors

By using reflectors to concentrate sunlight on the absorber of a solar collector, the size of the absorber can be dramatically reduced, which reduces heat losses and increases efficiency at high temperatures. Another advantage is that reflectors can cost substantially less per unit area than collectors.



2. How is the heat from sunlight converted into mechanical power? Explain Stirling and Brayton heat engines with a neat sketch.

After the array of mirrors focuses the sunlight, the concentrated sunlight then heats up the working fluid to temperatures of around 750°C within the receiver. The heated high temperature working fluid is then used in either a Stirling or Brayton heat engine cycle to produce mechanical power via rotational kinetic energy and then electricity for utility use with an electric generator. An example of a Brayton cycle used to produce electricity for a parabolic dish power plant.

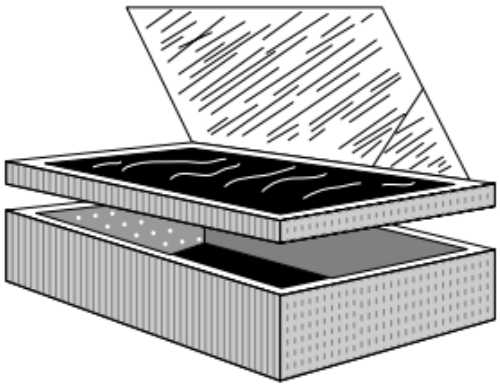


In the cycle, the concentrated sunlight focused on the solar fluid heats up the compressed working fluid of the cycle, i.e., air, replacing altogether or lowering the amount of fuel needed to heat up the air in the combustion chamber for power generation. As with all Brayton cycles, the hot compressed air is then expanded through a turbine to produce rotational kinetic energy, which is converted to electricity using the alternator. A recuperate is also utilized to capture waste heat from the turbine to preheat the compressed air and make the cycle more efficient.

3. A) With neat sketch, explain (i) box-type solar cooker; (ii) reflector-type (parabolic type) solar cooker; (iii) solar steam and convection cookers

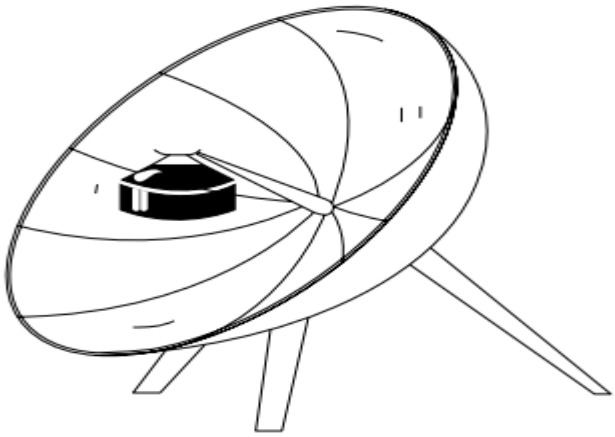
(i) box-type solar cooker

Solar cooking is a technology that has been given a lot of attention in recent years in developing countries. The basic design is that of a box with a glass cover. The box is lined with insulation and a reflective surface is applied to concentrate the heat onto the pots. The pots can be painted black to help with the heat absorption.



(ii) reflector-type (parabolic type) solar cooker

Reflector cookers concentrate the sun's radiation by a more or less parabolic reflector into a focal region, where the cooking vessel is fixed. Success in disseminating solar reflector cookers has only been reported from China, as shown. Reflective materials are used to concentrate light and heat from the sun into a small cooking area, making the sun's energy more concentrated and, therefore, more powerful, resulting in the fastest cooking times of all cooker designs. Parabolic cookers require more precision to focus the sunlight on the cooking vessel and are, therefore, the most complex design to build. If the sunlight is not focused exactly on the cooking vessel, the food will not cook efficiently.

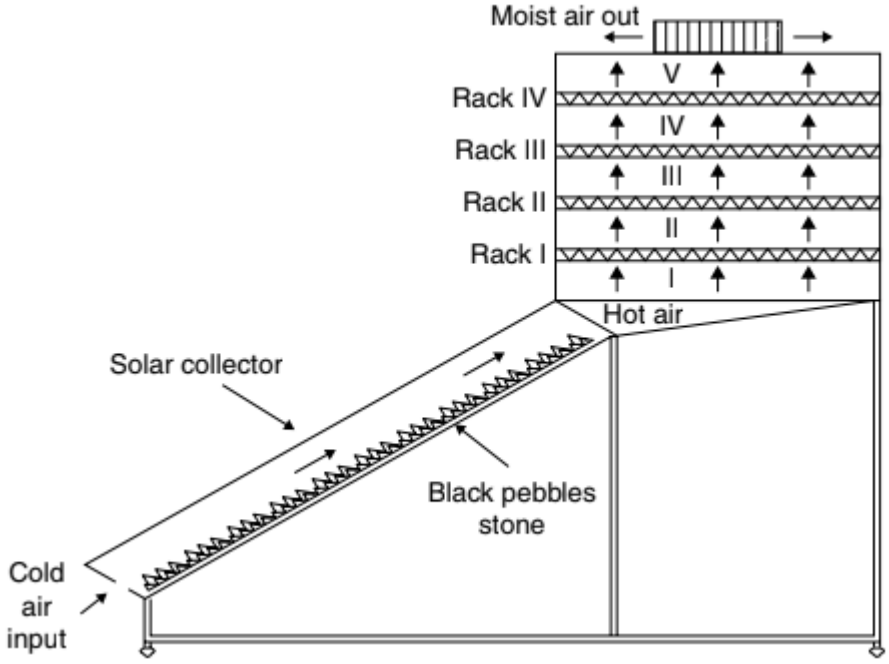


(iii) solar steam and convection cookers

Solar steam and convection cookers use vapour or hot air as heat transfer medium. Water is evaporated or air is heated up mostly in flat plate or vacuum collectors and then led in a piping system to the cooking vessel. Collector and cooking place can be separated and thus cooking in the shadow is possible. Most steam and convection cookers have a low efficiency and a high price, and further, they require relatively much effort in manufacturing.

3.B) Explain, how is solar heated air used for drying? Mention the main applications of a solar dryer.

Solar dryers can be utilized for various domestic purposes. They also find numerous applications in industries such as textiles, wood, fruit and food processing, paper, pharmaceutical, and agro-industries. A rice solar dryer is the main applications.

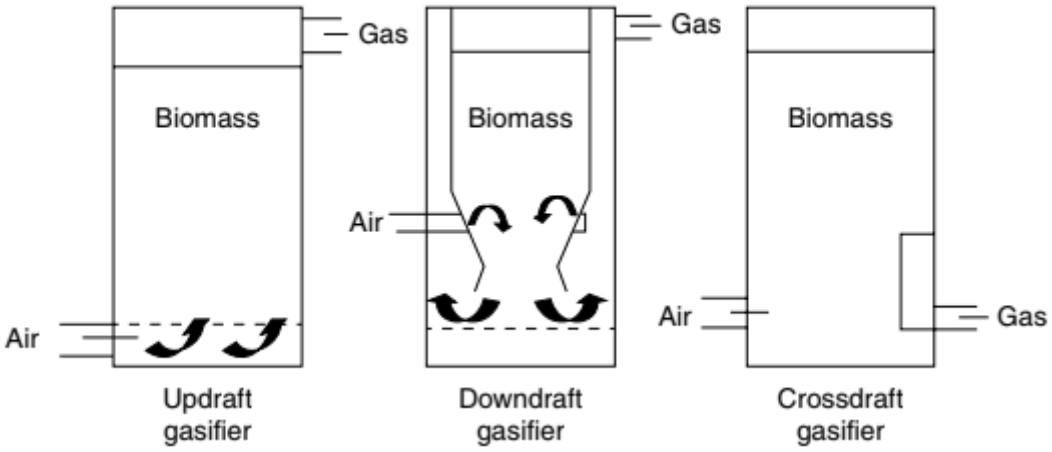


It was designed for the particular requirements of rice but the principles hold for other products and design types, since the basic need to remove water is the same. Air is drawn through the dryer by natural convection. It is heated as it passes through the collector and then partially cooled as it picks up moisture from the rice. The rice is heated both by the air

and directly by the sun. Warm air can hold more moisture than cold air so the amount required depends on the temperature to which it is heated in the collector as well as the amount held (absolute humidity) when it entered the collector.

4. With a neat sketch, explain the following fixed bed gasifiers (i) Updraft; (ii) downdraft; and (iii) Cross draft. Mention their applications.

(a) *Downdraft gasifiers*: In the downdraft gasifier, the air is passed from the layers in the downdraft direction. Single throat gasifiers are mainly used for stationary applications, whereas double throat gasifier is used for varying loads as well as automotive purposes.
(b) *Updraft gasifiers*: Updraft gasifier has air passing through the biomass from bottom and the combustible gases come out from the top of the gasifier.
(c) *Cross draft gasifiers*: It is a very simple gasifier and is highly suitable for small outputs. With slight variation, almost all the gasifiers fall in the abovementioned categories.



	Updraft Gasifier	Downdraft Gasifier	Cross-draft Gasifier
Comparative features	1. It works on coal, briquettes, and other fuels (fuel flexibility).	1. It works on woody biomass and charcoal (fuel specific).	1. Type of fuel usage restricted to only low ash fuels such as wood, charcoal, and coke.
	2. Comparatively low quality gas having tar and particulate matter.	2. High quality gas.	2. Good quality gas.
	3. Suitable for thermal applications.	3. Suitable for power (IC engines) and thermal applications.	3. Suitable for heat and power applications.
	4. Gas is drawn out of the gasifier from the top of the fuel bed, while the gasification reactions take place near the bottom. The air comes in at the bottom and produced syngas leaves from the top of the gasifier.	4. Air is introduced into downward flowing packed bed or solid fuels and gas is drawn off at the bottom. Hence, fuel and gas move in the same direction.	4. Air enters from one side of the gasifier, and fuel is released from the opposite side.
	5. It tolerates higher ash content, higher moisture content, and greater size variation in fuel.	5. It is sensitive to ash content, moisture content, and size variation in fuel.	5. Flexible gas production.

5. With the help of chemical reaction at every stage, explain the process of biomass gasification. What is the general composition of the producer gas and what is its heating value

Four distinct processes take place in a gasifier when fuel makes its way to gasification:

1. *Drying zone of fuel*: In this zone, the moisture content of biomass is removed to obtain the dry biomass. Some organic acids also come out during the drying process. These acids give rise to corrosion of gasifiers.
2. *Pyrolysis zone*: In this zone, the tar and other volatiles are driven off. The products depend upon temperature, pressure, residence time, and heat losses. However, following general remarks can be made about them.

(a) Up to the temperature of 200°C, only water is driven off.
(b) Between 200°C and 280°C carbon dioxide, acetic acid, and water are given off.
(c) The real pyrolysis, which takes place between 280°C and 500°C, produces large quantities of tar and gases containing carbon dioxide. Besides light tars, some methyl alcohol is also formed.
(d) Between 500°C and 700°C, the gas production is small and contains hydrogen.

3. *Combustion(oxidation) zone*: In this zone, carbon from the fuel combust and forms carbon dioxide with the oxygen in the air by the reaction:

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

Because of the heat emitted during the reaction, the temperature rises until a balance between heat supply and heat loss occurs.

4. *Reduction zone*: The hot gas passes through the reduction zone after the combustion zone. As there is no free oxygen in this zone that causes inflammable carbon dioxide gas to react with the carbon in the fuel and forms flammable carbon monoxide gas. This reaction is endothermic (demands heat) and occurs at temperature exceeding about 1,000°C. Carbon monoxide is the most important flammable elements in the produced gas obtained from the reduction reaction as

$$C + CO_2 + \text{heat} \rightarrow 2CO \qquad (9.3)$$

Another important endothermic reaction in the reduction zone is the water–gas shift reaction. It is the reaction of water vapour and carbon to give carbon monoxide and hydrogen

$$C + H_2O + \text{Heat} \rightarrow CO + H_2 \qquad (9.4)$$

Both gasses are flammable, and the heating value of the gas is increased. If there is still surplus of water in the reduction zone, then carbon monoxide may react with water vapour and form carbon dioxide and hydrogen. This reaction is exothermic (emits heat) and decreases the heating value of the produced gas. The reaction is

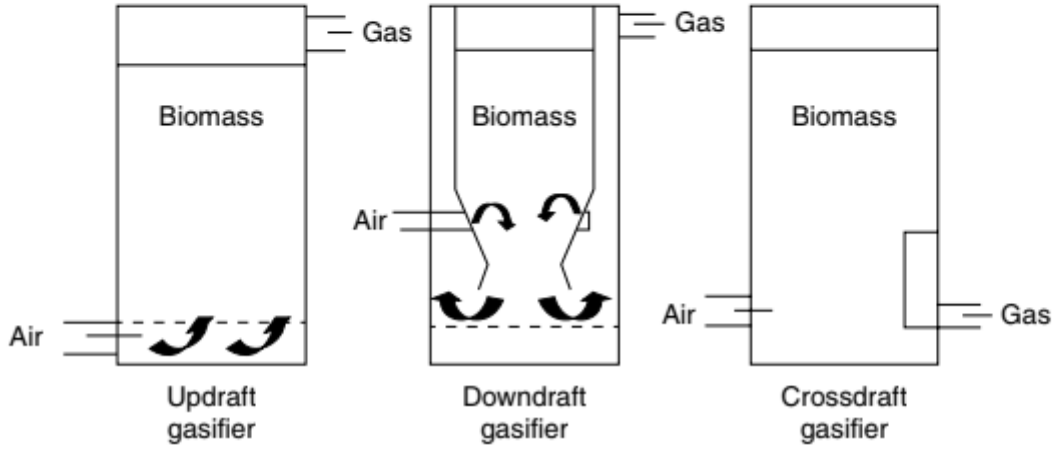
$$CO + H_2O - \text{Heat} \rightarrow CO_2 + H_2 \qquad (9.5)$$

6. A) What is a gasifier? Summarize the different types of gasifiers used in the biomass gasification process.

Biomass gasifier may be considered as a chemical reactor in which biomass goes through several complex physical and chemical processes and producer or syngas is produced and recovered.

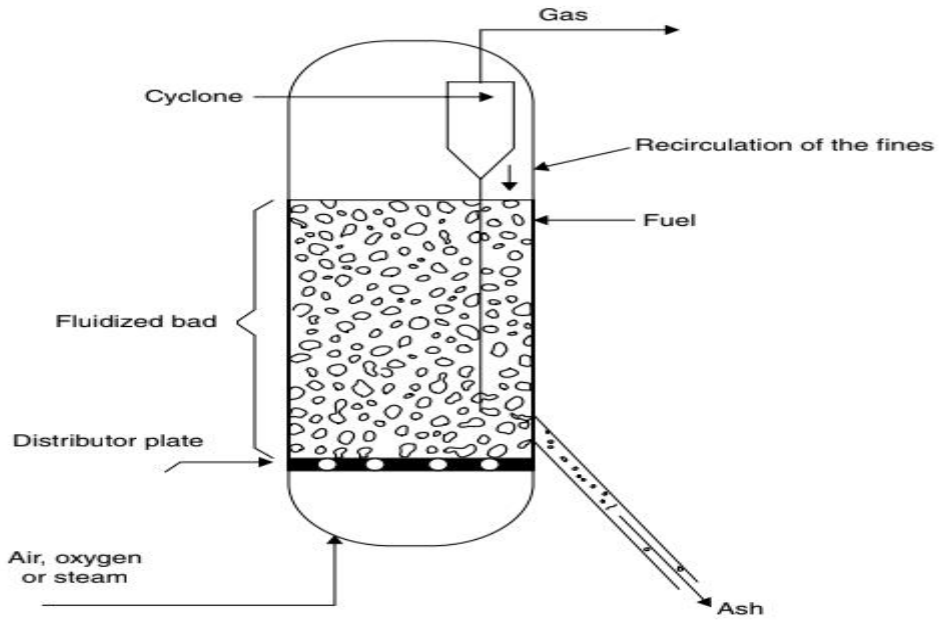
Fixed bed gasifier: In this gasifier, biomass fuels move either countercurrent or concurrent to the flow of gasification medium (steam, air, or oxygen) as the fuel is converted to fuel gas. They are relatively simple to operate and have reduced erosion.

Since there is an interaction of air or oxygen and biomass in the gasifier, they are classified according to the way air or oxygen is introduced in it. There are three types of gasifier as shown in Figure 9.2.



Fluidized bed gasifier: In fluidized bed gasifier, an inert material (such as sand, ash, or char) is utilized to make bed and that acts as a heat transfer medium

Fluidized bed gasification has been successfully used to convert prepared wastes (i.e., wood wastes, bark, agricultural wastes, and RDF (Refused Derived Fuel) into a clean fuel gas that can be used to fire various types of industrial equipment. Past applications have included gasification of wastes to provide gas for dryers previously fired on natural gas.



6 b) Define biomass. Give a descriptive classification of biomass resources.

Sun is the primary source of all kinds of available raw energy resources including biomass. The sunlight energy is transferred to biosphere by the photosynthesis process that occurs in plants, algae, and some types of bacteria.

Plant matter created by the process of photosynthesis is called biomass. Photosynthesis is a natural radiation. In its simplest form, the final reaction of this process can be represented as follows:

$$6H_2O + 6CO_2 + \text{solar light energy} \rightarrow C_6H_{12}O_6 + 6CO_2$$

It is seen that in the process, water and carbon dioxide are converted into organic material.

The term biomass refers to those organic matters that are stored in plant and trees in the form of carbohydrate (sugar). It is then transferred through food chains in humans, animals, and other living creatures and their wastes.

The term biomass includes all plant life: trees, agricultural plants, bush, grass and algae, and their residues after processing. Biomass may be obtained from forests woods, agricultural lands, arid lands, and even waste lands. It may be obtained in a planned or unplanned manner. The term is also generally understood to include animal and human waste.

Biomass has the advantage of controllability and availability when compared to many other renewable energy options. There are a variety of ways of obtaining energy from biomass. These may be broadly classified as direct methods and indirect methods.

Raw materials that can be used to produce biomass energy are available throughout the world in the following forms:

1. Forest wood and wastes
2. Agricultural crops and residues
3. Residential food wastes
4. Industrial wastes
5. Human and animal wastes
6. Energy crops

Properly managed forests will always have more trees, and agricultural and energy crops management will always have crops; further, the residual biological matter are taken from those crops.

Raw biomass has a low energy density based on their physical forms and moisture contents and their direct use are burning them to produce heat for cooking. The twin problems of traditional biomass use for cooking and heating are the energy inefficiency and excessive pollution.

Inefficient way of direct cooking applications, inconvenient and inefficient methods of raw biomass transportation and storage and high environmental pollution problems made them unsuitable for efficient and effective use. This necessitated some kind of pre-processing and conversion technology for enhancing the usefulness of biomass.