

Energy and Environment Sceince

L-T-P-C: 2-0-0-2

Syllabus:

Unit – 1 [4 Hours]: Present Energy resources in India and its sustainability:

Energy Demand Scenario in India, Different type of **conventional Power Plant**, Advantage and Disadvantage of conventional Power Plants, **Conventional vs Non- conventional power generation.**

Unit – 2 [4 Hours]: Basics of Solar Energy: Solar Thermal Energy; Solar Photovoltaic: Advantages and Disadvantages, Environmental impacts and safety.

Unit – 3 [4 Hours]: Wind Energy: Power and energy from wind turbines, India's wind energy potential, **Types of wind turbines, Offshore Wind energy**, Environmental benefits and impacts.

Unit – 4 [4 Hours]: Biomass Resources: **Biomass conversion Technologies**, Feedstock pre-processing and treatment methods, Bioenergy program in India, Environmental benefits and impacts; **Other energy sources: Geothermal Energy resources, Ocean Thermal Energy Conversion, Tidal Energy.**

Unit – 5 [4 Hours]: Air pollution: Sources, effects, control, air quality standards, air pollution act, air pollution measurement; **Water Pollution:** Sources and impacts; **Soil Pollution:** Sources and impacts, disposal of solid waste. **Noise pollution**

Unit – 6 [4 Hours]: Greenhouse gases effect, acid rain; Pollution aspects of various power plants; **Fossil fuels and impacts, Industrial and transport emissions impacts.**

Unit – 4 : Bio Energy

Bio Energy

- **Introduction**
- **Biomass Types and Sources**
- **Biomass conversion Technologies p**
- **Feedstock pre-processing and treatment methods,**
- **Bioenergy program in India,**
- **Environmental benefits and impacts;**

Other energy sources:

- **Geothermal Energy resources,**
- **Ocean Thermal Energy Conversion,**
- **Tidal Energy.**

BIO ENERGY

Session 1

Learning Objectives

In this Session you will be able to:

- ✓ **Know about the origin of biomass energy**
- ✓ **Recognize the importance of biomass as a useful source of renewable energy**

The Ex-President's Message: Independence

- Cut down energy losses
- Utilize technologies to provide a diverse supply of environmentally friendly energy
- “We must achieve Energy Independence by 2030”, including a cut down in ALL sectors
- Increase the power generated **through renewable energy** sources from 5% to 25%
- *This is the nation’s “first and highest priority”*

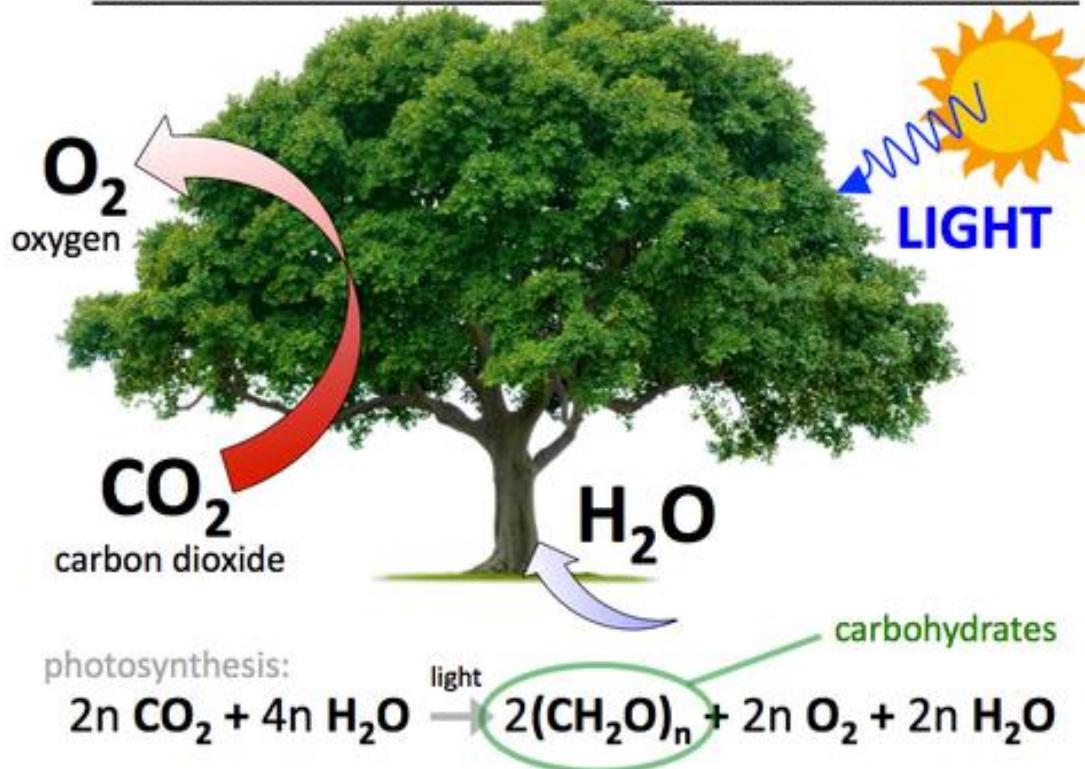


Ex-President A.P.J. Abdul Kalam
(Rocket Scientist)

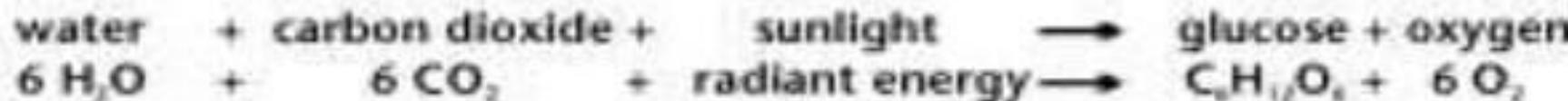
What is a Biomass?
How it is Generated?

A Lesson Learned from Nature

Carbon Dioxide & Carbon Fixation

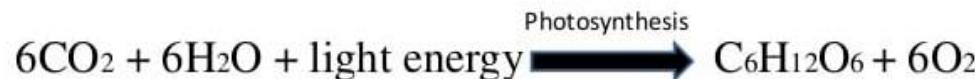
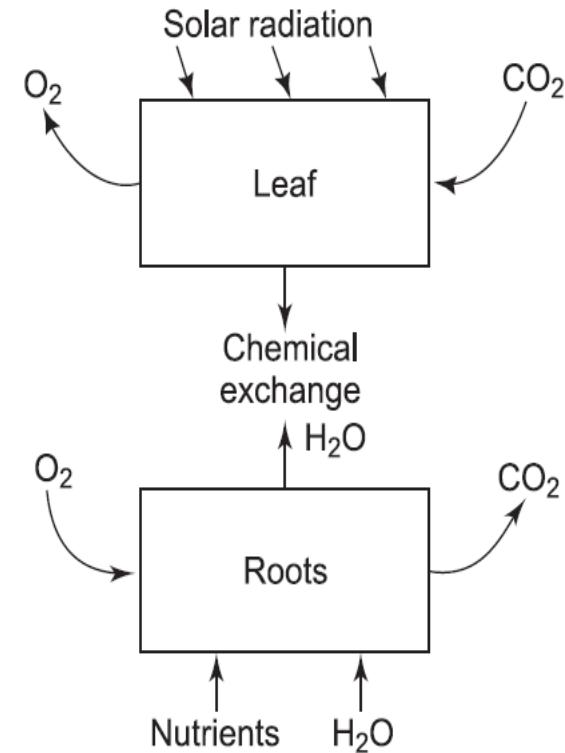


In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose - or sugar.



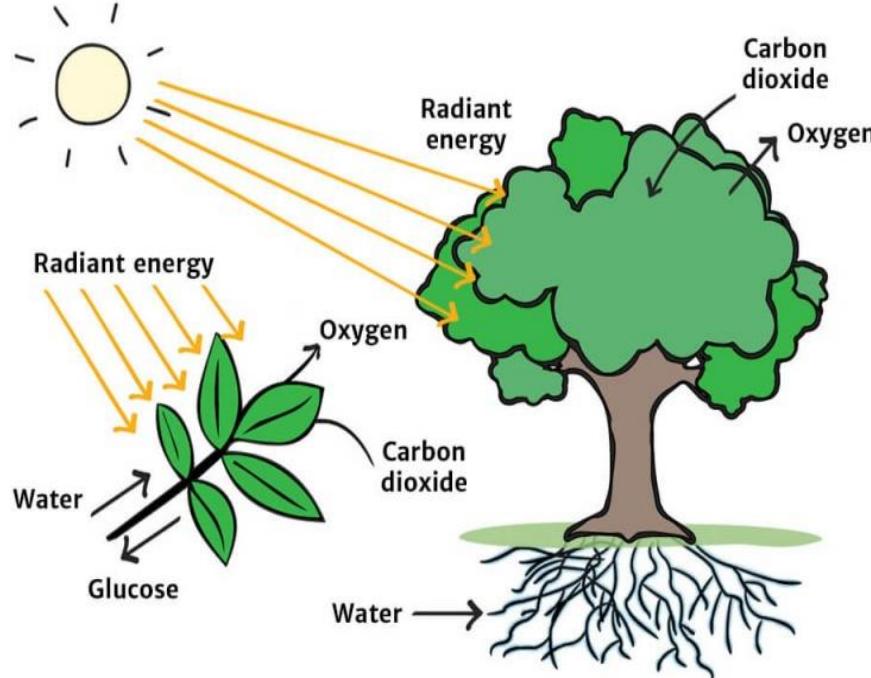
PHOTOSYNTHESIS PROCESS

- Solar radiation incident on green plants and other photosynthetic organisms performs **two basic functions:**
 - temperature control** for chemical reactions to proceed and
 - photosynthesis process.**
- The fundamental conversion process in green plants is photosynthesis, which is the process of **combining CO₂ from the atmosphere with water plus light energy to produce oxygen and carbohydrates** (sugars, starches, celluloses and hemicelluloses).



Introduction to Biomass Energy

Bioenergy Photosynthesis



Biomass is a collective term used for all materials that are biogenic in origin, that is, derived from the product of photosynthesis

Biomass is **organic matter – anything that is alive or was a short time ago** - that can be used as an energy source.

1. Biomass is a form of **stored solar energy**.
2. Biomass is considered as **a carbon neutral**.

Introduction to Biomass Energy

- Biomass is a general term **for living material plants, animals, fungi, bacteria.**
 - Biomass is basically organic matter such **as wood, straw, crops, algae, sewage sludge, animal waste and/or other biological waste**
 - The energy obtained from biomass is known as biomass energy.
1. since biomass can be re-grown, it is potentially a **renewable resource**.
 2. Animals feed on plants and plants grow through photosynthesis process using solar energy.
 3. **photosynthesis process** is primarily responsible for generation of biomass energy.



Pelleted Fuel

Who are (*the persons*) spending most of their life to gather fuel(energy) in rural areas.?



BIOMASS ENERGY IN INDIA:

STATUS

- Biomass **contributes over a third of primary energy in India.**
- Biomass fuels are predominantly used in **rural households for cooking and water heating, as well as by traditional and artisan industries.**
- Biomass delivers most energy for the domestic use (**rural - 90% and urban - 40%**) in India (NCAER, 1992).
- Wood fuels contribute 56 percent of total biomass energy (Sinha et. al, 1994).
- Consumption of wood has grown annually at 2 percent rate over past two decades
- the biomass sources contribute **14% of global energy and 38% of energy in developing countries** (Woods and Hall, 1994)

**What are the different types of
Biomass?**

**What are usable forms of BIOMASS
and its composition properties**

What is Biomass?

Biomass is dead organic matter

- Examples: corn, algae, sugar cane

Types of biomass

– Woody

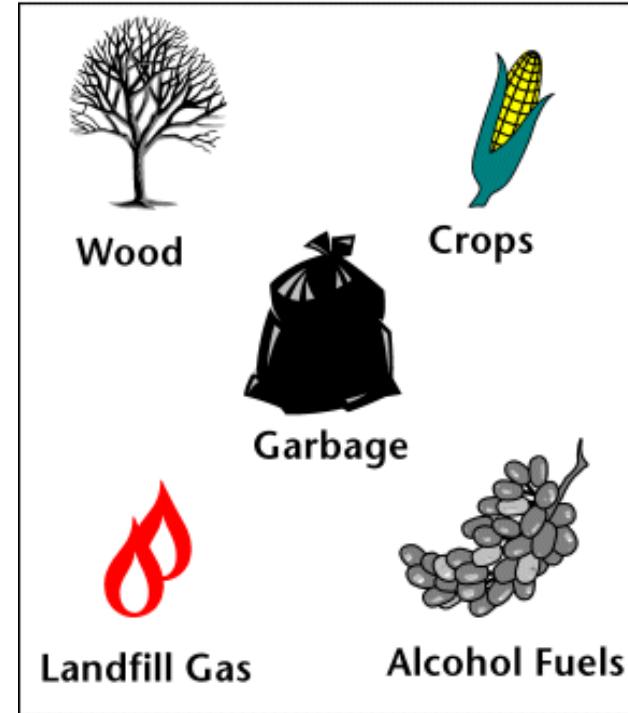
- Examples: coconut, oil palm, poplar, pine
- Generally burned to heat space or heat water to produce steam to generate electricity via a turbine generator
 - When utilized directly: direct biomass

– Non-Woody

- Examples: corn, sugar cane, soybeans, algae
- Generally processed to produce different liquid biofuels

– Indirect biomass

Types of Biomass



USABLE FORMS OF BIOMASS, THEIR COMPOSITION & FUEL PROPERTIES

1 Fuel Wood (Virgin Wood)

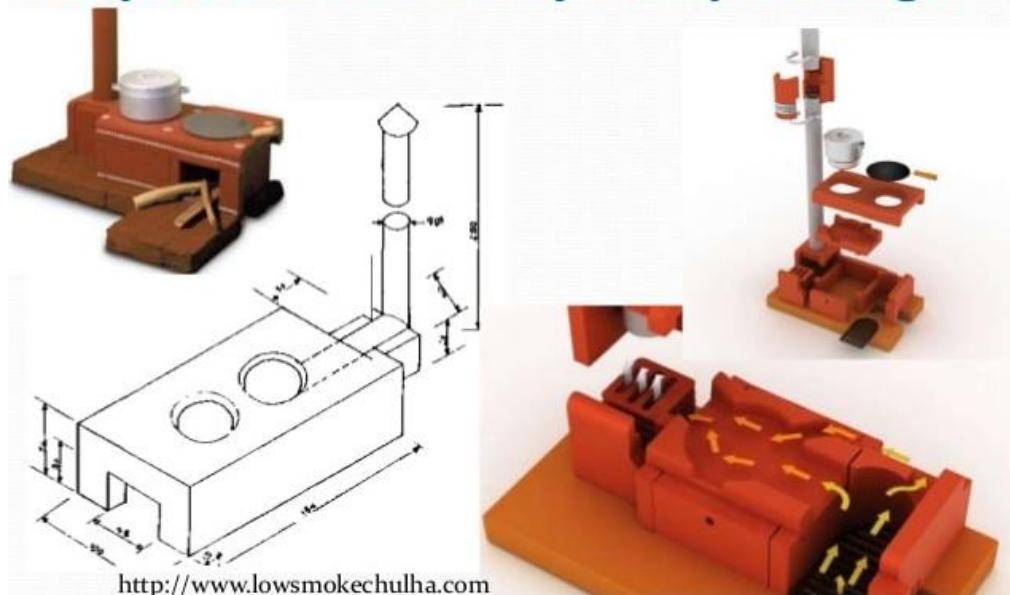
- Wood is the oldest source of biomass energy and main source of energy used by mankind for centuries.
- **Direct combustion** is the simplest way to obtain heat energy. Its energy density is 16–20 MJ/kg. It can also be converted to more useful forms such as **charcoal or producer gas**.



- Conventional household stove (Chulhas), only 5 % efficiency.
- Improved stoves (Chulhas) and use of pressure cooker is being encouraged for better fuel utilization.



Improved Chulha by Philips Design



USABLE FORMS OF BIOMASS, THEIR COMPOSITION AND FUEL PROPERTIES

2 Charcoal :

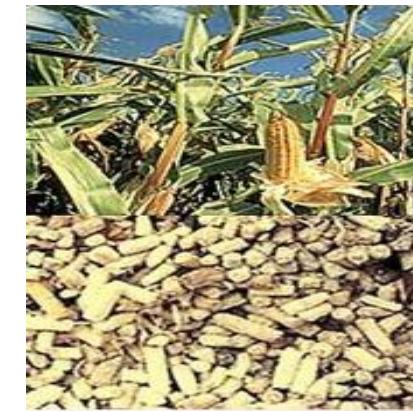
- Charcoal is a clean (smokeless), dry, solid fuel of black color.
- It has 75–80 per cent carbon content and has energy density of about 30 MJ/kg.
- Obtained by carbonization process of woody biomass to get higher energy density .
- Chemical grade charcoal has many uses in laboratory and industrial chemical processes. It is also used for making high quality **steel**



USABLE FORMS OF BIOMASS, THEIR COMPOSITION AND FUEL PROPERTIES

3. Fuel Pellets and Briquettes

- Crop residues such as **straw, rice husk etc.** and **waste wood** are **pressed to form lumps**, known as fuel **pellets or briquettes** and used as solid fuel.
- The purpose is to reduce moisture content and increase the energy density of biomass making it more feasible for long distance transportation.

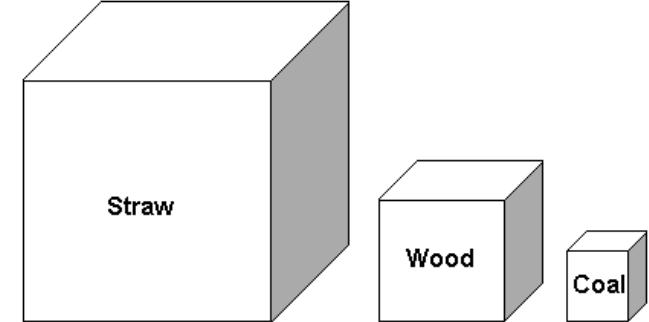


Pelleted Fuel



Huge volume of Bio mass transportation

Transport cost is high



Equivalent energy content by volume of unprocessed materials.

Why Densify?

The low density of biomass materials poses a challenge for the handling, transportation, storage and combustion processes. These problems may be addressed through densification, a process that produces either liquid or solid fuel with denser and more uniform properties than the raw biomass.

BRIQUETTED BIOMASS



Bulk Density : 600 – 800 kg / m³

USABLE FORMS OF BIOMASS, THEIR COMPOSITION AND FUEL PROPERTIES

4. Bio-diesel –

- Vegetable oils, edible as well as non-edible can be used (*after some chemical processing*) in pure form or its blend with petroleum diesel as fuel in a compression–ignition (diesel) engine.
- Bio-diesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics

Jatropha Tree

- Biodiesel from Jatropha.
- Seeds of the Jatropha nut is crushed and oil is extracted
- The oil is processed and refined to form bio-diesel.



USABLE FORMS OF BIOMASS, THEIR COMPOSITION AND FUEL PROPERTIES

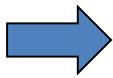
5. Bio-ethanol

1. Ethanol (C_2H_5OH) is a colorless liquid biofuel.
2. Its boiling point is 78 °C and energy density is 26.9 MJ/kg.
3. It can be derived from wet biomass containing **sugars** (e.g. sugarcane, sugarbeet, sweet sorghum, etc.), **starches** (grains, tubers such as potato, cassava, etc.) or **cellulose** (woody matter).

Replace Conventional Oil

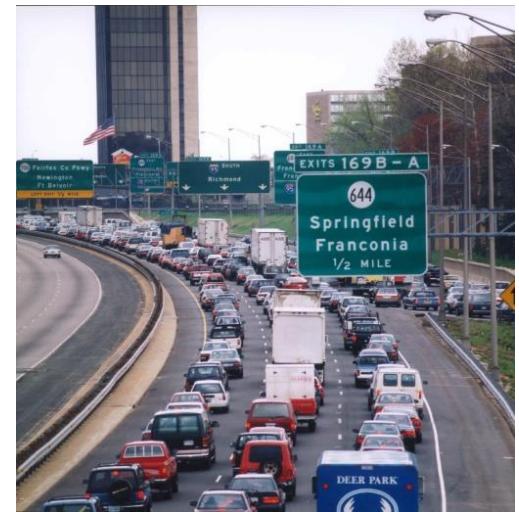
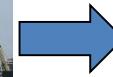


corn/sugar cane



ethanol plant

cellulosic breakdown to
sugar or fuel



cellulosic biofuel

lasts a long time
does no harm



Methanol and ethanol blending in petrol



Advances

- ✓ Euro 6/VI- 20km/lit
- ✓ Electric Car/Hybrid
- ✓ Ethanol Blending 20%

- India has adopted Euro 6/VI equivalent standards that will go into effect in 2020.
- The government is promoting use of electric and hybrid vehicles.
- Government of India has also proposed **methanol and ethanol** blending in petrol.

USABLE FORMS OF BIOMASS, THEIR COMPOSITION AND FUEL PROPERTIES

6. Biogas - Organic wastes from plants, animals and humans contain enough energy to contribute significantly to energy supply in many areas, particularly the rural regions of developing countries. Aquatic biomass can also be used. Biogas is produced in a biogas fermenter or digester. Nitrogen rich sludge (fertilizer) is also produced as a byproduct with improved sanitation as an added bonus

7. Producer Gas - Woody matter such as crop residue, wood chips, bagasse (fibrous residue of sugarcane after juice extraction), rice husk, coconut shell, etc., can be transformed to producer gas (also known as synthesis gas, syn gas, wood gas, and water gas or blue gas) by a method known as thermal gasification of solid fuel. The composition of gas produced depends upon the type of biomass and the design of gasifier.

Bio mass Energy

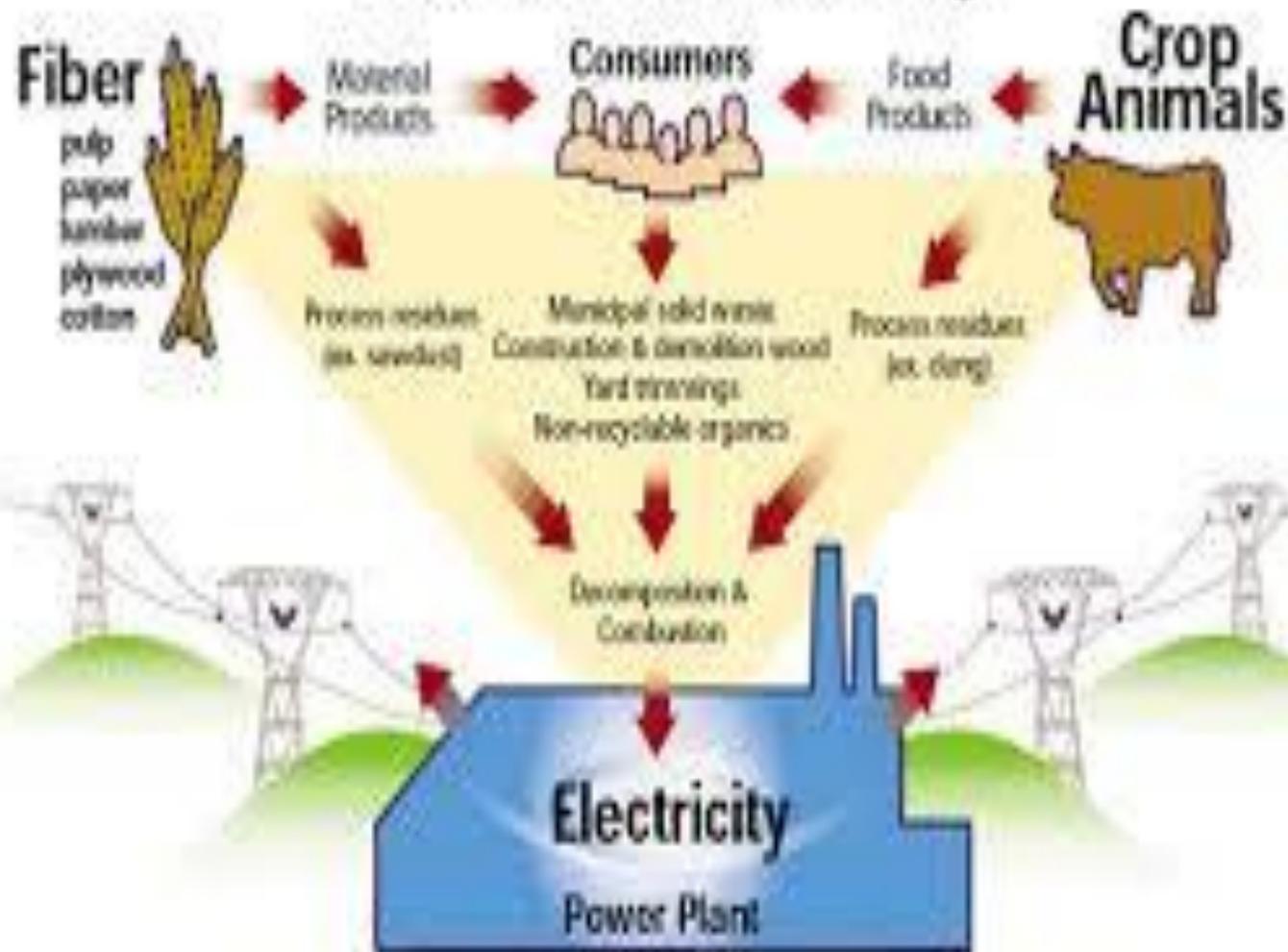


Community Biogas plant at Methan, Distt. Mehsana, Gujarat



Biomass gasifier based village electrification project commissioned at Gosaba village in Sunderbans, West Bengal.

Biomass to Electricity



Direct Combustion of Biomass and Electricity Generation

Direct combustion is the combustion of biomass in a grate, stoker or fluidized bed with excess air followed by capturing the release of energy, which can then be used to provide steam or hot water for process heating and/or for providing **electricity**



Agro Residues



Table 1.15 Ultimate Analysis of Typical Agro Residues

	Deoiled Bran	Paddy Husk	Saw Dust	Coconut Shell
Moisture	7.11	10.79	37.98	13.95
Mineral Matter	19.77	16.73	1.63	3.52
Carbon	36.59	33.95	48.55	44.95
Hydrogen	4.15	5.01	6.99	4.99
Nitrogen	0.82	0.91	0.80	0.56
Sulphur	0.54	0.09	0.10	0.08
Oxygen	31.02	32.52	41.93	31.94
GCV (Kcal/kg)	3151	3568	4801	4565



Rice Husk



Rice Straw



Saw dust



Coconut shell



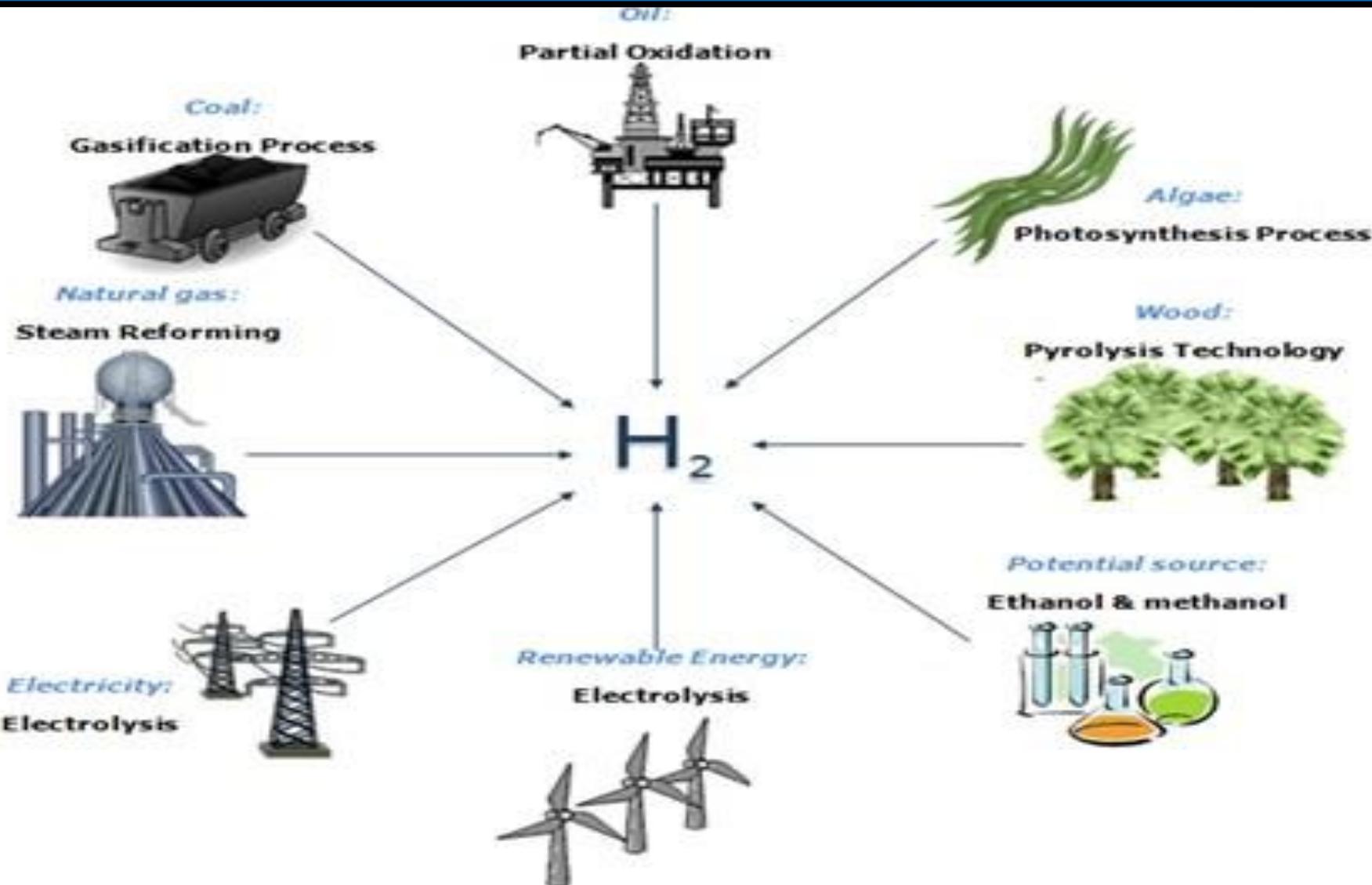
Palm Shells

NEW ENERGY SOURCES

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Hydrogen

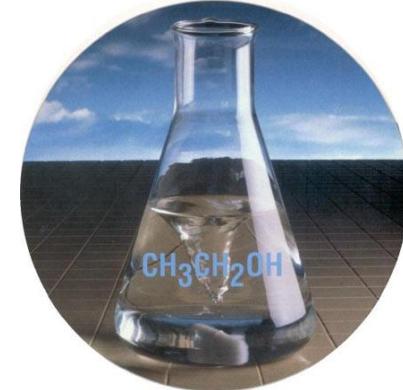
HYDROGEN SOURCES & PRODUCTION PROCESSES



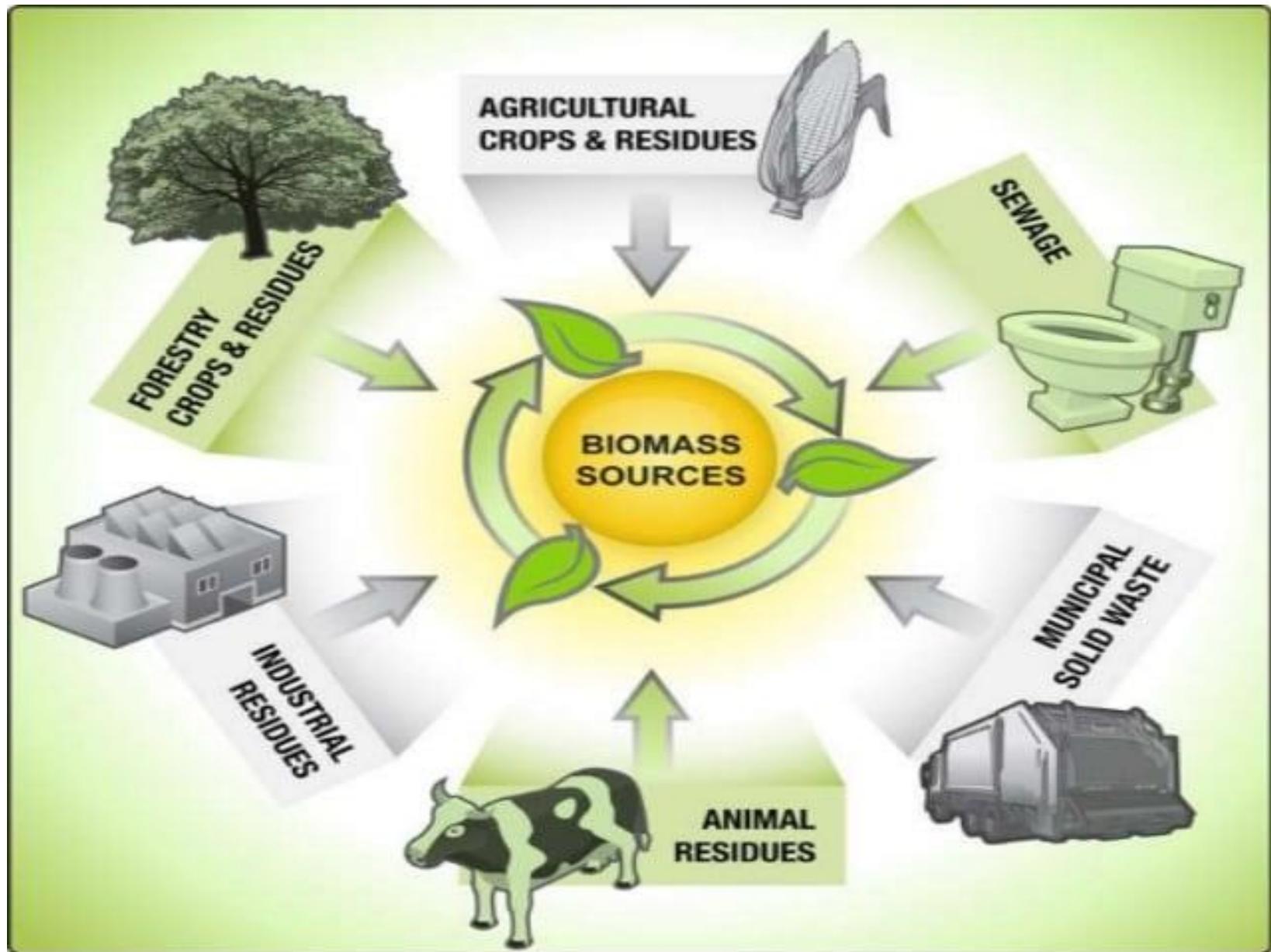


Bioenergy Types

- **Biofuels**
 - Liquids
 - Methanol, Ethanol, Butanol, Biodiesel
 - Gases
 - Methane, Hydrogen
- **Bioheat**
 - Wood burning
- **Bioelectricity**
 - Combustion in Boiler to Turbine
 - Microbial Fuel Cells (MFCs)



What are the different Sources of Biomass?



Different Sources of Biomass

Biomass resources for energy production encompass a wide spectrum of materials ranging from

1. **silviculture (forest),**
2. **agriculture (field),**
3. **aquaculture (fresh and sea water)**
4. **industrial and social activities that produce organic wastes residues (food processing, urban refuse, etc.).**

Agricultural and Forestry Wastes

1. Crop and forestry residues
2. Animal manures
3. Food / feed processing residues
4. Logging residues (harvesting and clearing)
5. Wood processing mill residues
6. Paper & pulping waste slurries
7. municipal solid wastes, sewage, industrial waste



BIOMASS RESOURCES

1. Forests

- Forests; natural as well as cultivated, serve as a source of fuel wood, charcoal and producer gas.
- Forest waste and residues from forest processing industries can be utilized at the mill itself.
- Forest resource is consumed, not just for firewood but also for sawn timber, papermaking and other industrial purposes.
- Some fast growing energy intensive trees such as eucalyptus, poplar, pine are specially cultivated for the purpose of energy.



BIOMASS RESOURCES

Forests - Some fast growing energy intensive trees such as eucalyptus, poplar, pine are specially cultivated for the purpose of energy.



$$800 \text{ no} \times 25 \text{ kg} = 20000 \text{ kg}$$

20 Tons / clump or plant

Super Bamboo Plant found in nature yields as much as 100 tons bamboo from one acre

BIOMASS RESOURCES

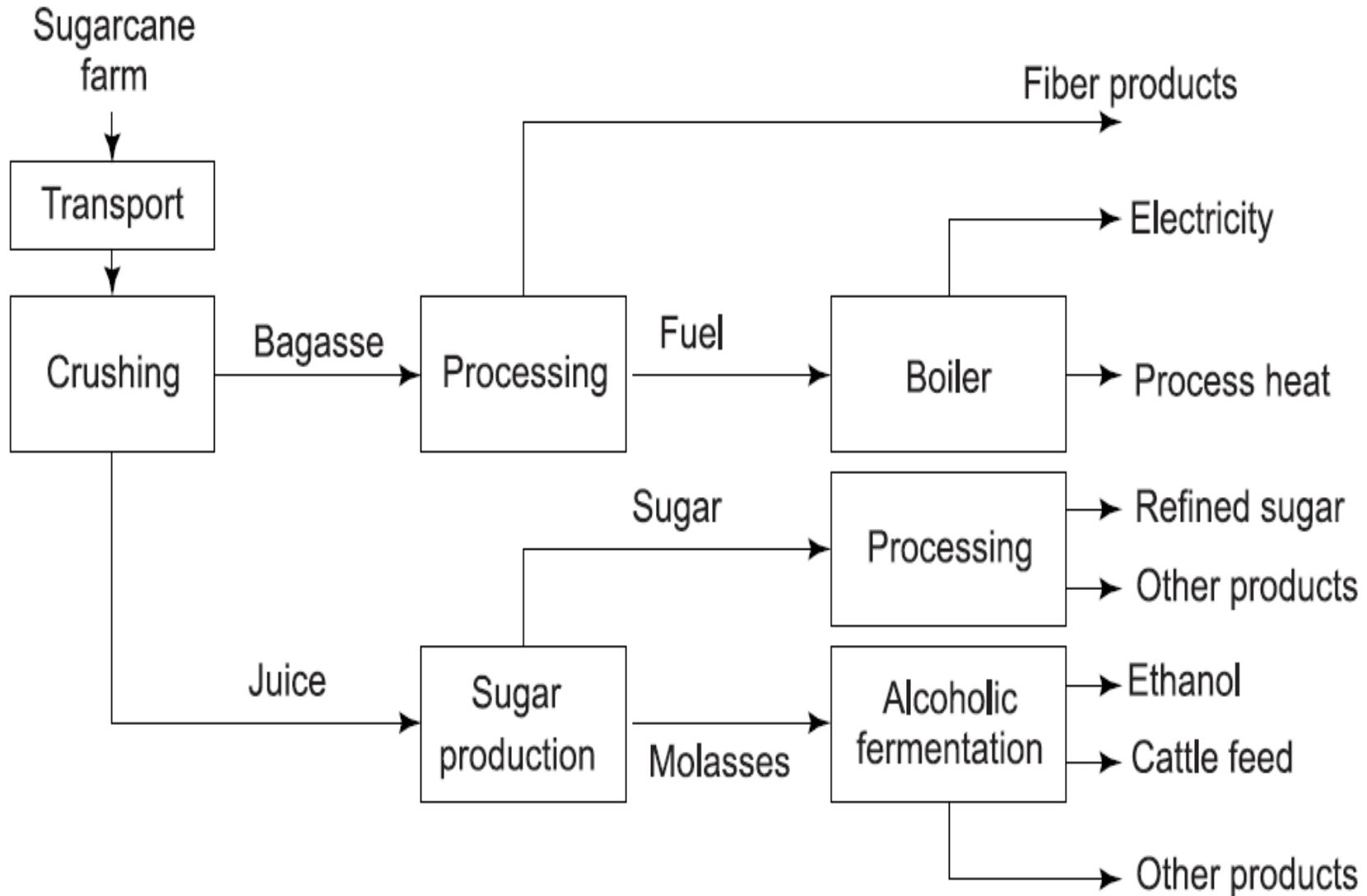
2. Energy Crops

Certain cultivated plants produce raw material for bio-fuels. The greatest potential for energy farming occurs in tropical countries, especially those with adequate rainfall and soil condition.

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- (a) Sugar Plants** - Sugarcane is a major raw material source for bio-ethanol
- (b) Starch Plants** - Jerusalem artichoke provides raw material for bio-ethanol.
Grains, such as maize, barley, rice and wheat provide starch, which can be converted to ethanol.
- (c) Oil Producing Plants** In a short-term diesel engine test, over 40 different plant derived oils have been evaluated including sunflower, rapeseed, palm oil, castor oil, soybean, groundnut and cottonseed.

BIOMASS RESOURCES



Sugarcane industry products

BIOMASS RESOURCES

3. Agricultural Residues

Crop residues such as straw, rice husk, coconut shell, groundnut shell, sugarcane bagasse etc., are gasified to obtain producer gas. Alternatively, these are converted to fuel pellets or briquettes and used as solid fuel.



4. Aquatic Plants

Some water plants grow faster than land based plants and provide raw materials for producing biogas or ethanol. These are water hyacinth, kelp, seaweed and algae, etc.

5. Urban Waste

Urban waste is of two types: (a) Municipal Solid Waste (MSW or garbage) and (b) sewage (liquid waste). Energy from MSW can be obtained from direct combustion (incineration) or as landfill gas. Sewage can be used to produce biogas after some processing.

Benefits of biomass energy

Energy security: Decentralized biomass energy could help nation to substantially reduce dependence on fossil fuels.

Rural economic growth: Biomass energy could stimulate growth in farming,

forestry and rural industry leading to overall rural development.

Biomass energy could also provide a productive avenue for using agricultural and forestry wastes, besides plantations.

Environmental protection: By offsetting fossil fuel use and related emissions of nitrogen oxides, sulfur dioxides, and other pollutants, biomass energy will

contribute to cleaner air and water. Furthermore, increased cultivation of carbonfixing plants will help mitigate greenhouse gas emissions that contribute to global

Main advantages of biomass energy are:

1. it is a **renewable source**; the **energy storage** is its in-built feature;
2. it is **indigenous source** requiring little or no foreign exchange;
3. forestry and agricultural industries that supply feed stocks also provide **substantial economic development** opportunities in rural areas;
4. **pollutant emissions from combustion of biomass are usually lower than those from fossil fuels**;
5. commercial use of biomass may avoid the problems of waste disposal in other industries
6. use of biogas plants supply clean gas, leads to improved sanitation, better hygienic conditions in rural areas
7. the nitrogen-rich bio-digested slurry and sludge from biogas plant serves as a very good soil conditioner and improves the fertility of the soil

Its main disadvantages are:

it is a **dispersed and land intensive** source,

it is often of **low energy density** and

it is also **labor intensive** and the cost of collecting large quantities for commercial application is significant.

- Most current commercial applications of biomass energy use material that has been collected for other reasons, such as timber and food processing residues and urban waste.

capacity is determined by availability of biomass and not suitable for varying loads not feasible to set up at all locations

Quiz Session

Thank You

Save energy and water for Sustainable Life

