




CENTRE FOR RENEWABLE &
SUSTAINABLE ENERGY STUDIES



• Biomass Energy



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science
& technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA



National
Research
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What is Biomass Energy?

- **Biomass** energy is energy derived from **plants** and **animal waste** which are, or were recently, living material.
- Through **photosynthesis**, **light energy** from the sun is converted to **chemical energy** which is stored in plants.
- **Animals** eat plants and **store** the **chemical energy**.
- This stored **chemical energy** in the biomass can be **converted into electricity, fuel and heat**.
- **Evasive species** like seaweed are used as a **source of bioenergy** in recent research.
- Bioenergy plant sources can be divided into **woody, cellulosic and oil rich plants**.



Types of Biomass

Primary Source



Crops



Wood fuel



Sugar cane

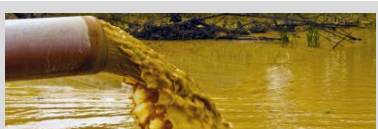
Secondary Source



Paper mill sludge



Plant residue



Sewage

Sources

- **Biomass** is **available** almost **everywhere** in the world.
- **Biomass** is divided into **primary** and **secondary** sources.
- **Primary biomass** energy sources are plant materials grown for energy production, such as wood, crops, fruits, maize, sugar cane, and sunflower seeds which get converted to sunflower oil.
- **Secondary biomass** energy sources are **'waste' materials** which can be used for energy production. These include
 - Plant residues: agricultural and forestry residues
 - Fish and animal waste: manure, fish heads and abattoir waste
 - Waste yeast from the beer-brewing industry
 - Paper mill sludge
 - Sewage

Types of Biomass

Primary Source



Crops



Wood fuel



Sugar cane

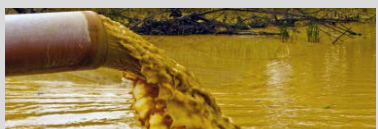
Secondary Source



Paper mill sludge



Plant residue



Sewage

Sources

- Good primary biomass energy sources have a high yield of **dry material** and **use minimal land**.
- Crops should **generate more energy** than their production consumes.
- Biological power sources are **renewable** and, if harvested sustainably, **CO₂ neutral**.
- This is because the gas emitted during the transfer into useful energy is balanced by the CO₂ absorbed whilst the plants were still growing.
- Unfortunately biomass is **not easily stored** and transport is expensive.

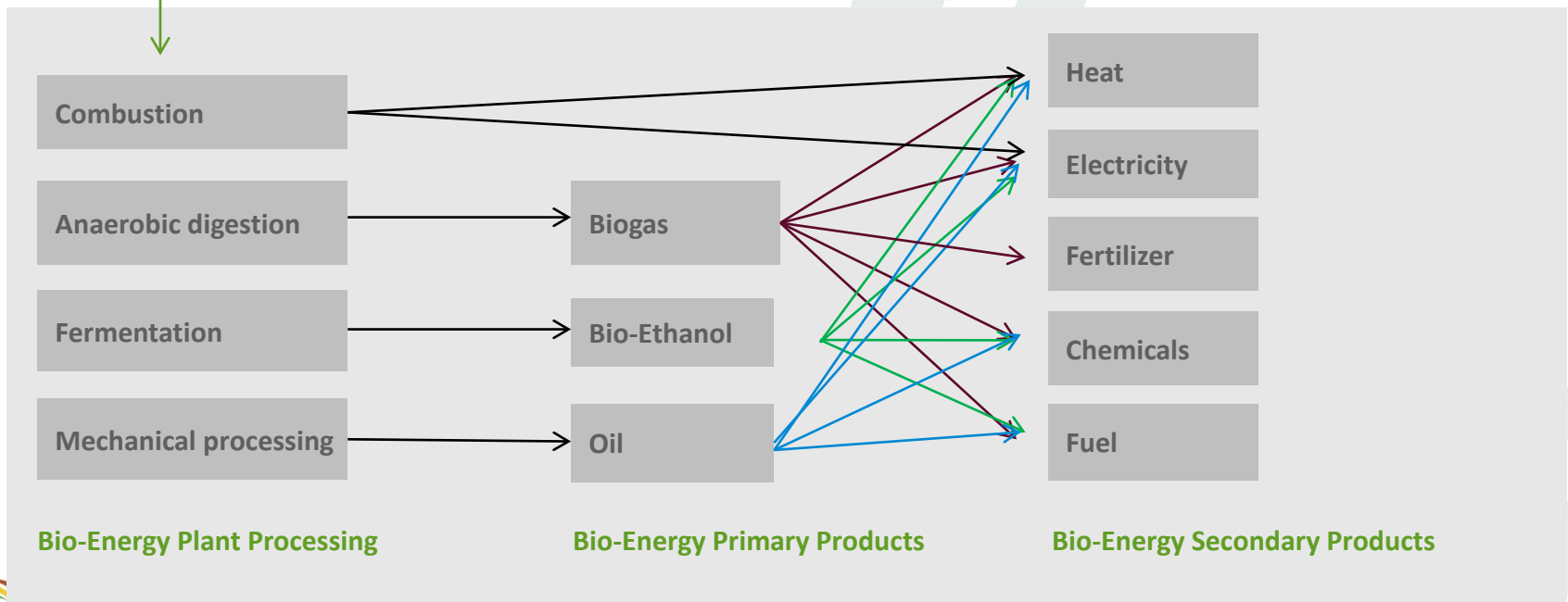


Biomass Conversion Technologies and Products

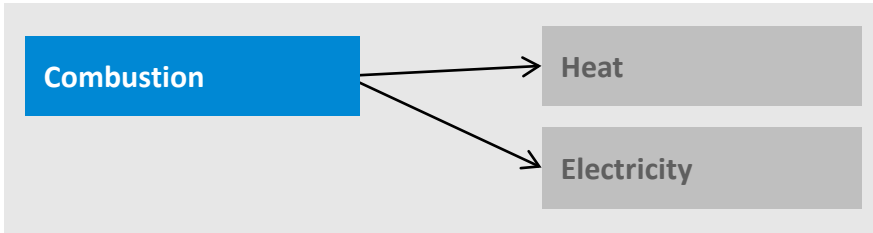
Harvesting;
Pre-Processing

Transport to Bioenergy Plant

- **Combustion** is the process of **burning of material to produce heat**. The heat produced can be used to produce steam to generate electricity.
- **Anaerobic digestion** is a series of biological processes where microorganisms **break down biodegradable material in the absence of oxygen**. The product is biogas (CO₂ and CH₄) and liquid fertilizer. Biogas can be burnt directly for cooking or to produce electricity.
- **Fermentation** is the **conversion of sugar** into acids or alcohol **with the help of bacteria or yeast**.
- **Mechanical processing** can be, for example, **grinding** seeds to extract the oils they contain to produce biofuels.



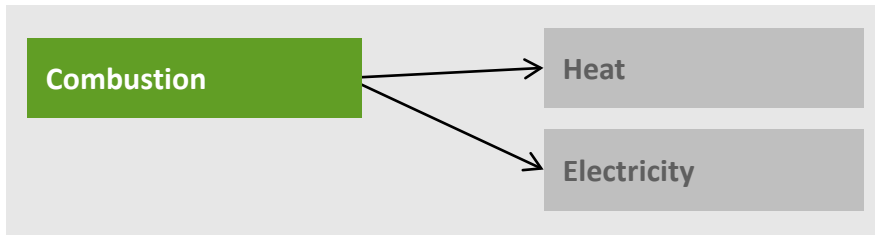
Uses of Biomass: Combustion (Heating & Cooking)



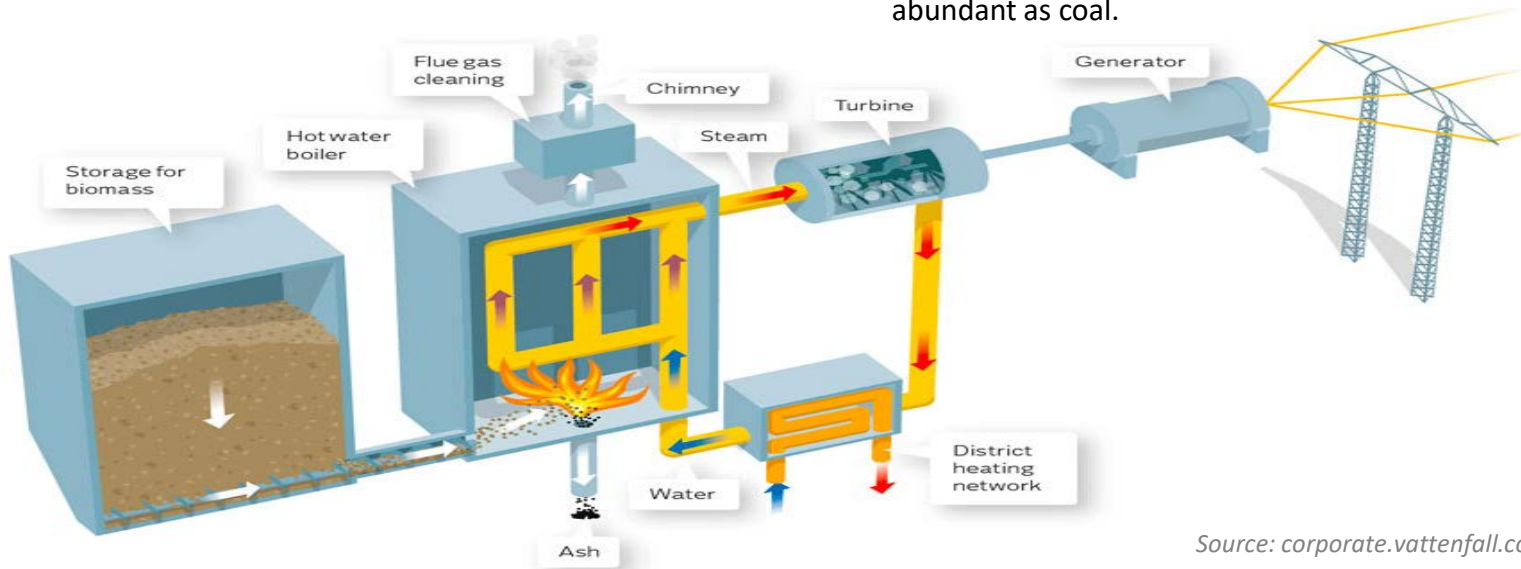
Wood can be burned for heating living spaces or to prepare food.



Uses of Biomass: Combustion (Generating Electricity)



- When wood is burned, the **chemical energy** in biomass is released as **heat and light energy**.
- Biomass power plants work on a **similar principle to natural gas or coal power plants**.
- The heat energy being released **boils water to form steam**, which then turns a generator.
- In combined heat and power systems, the **surplus heat energy** can also be utilized, for example for heating water or nearby homes.
- These power plants are usually **not as large as coal power stations** because their fuel supply has a lower energy content and is not as abundant as coal.



Source: corporate.vattenfall.com



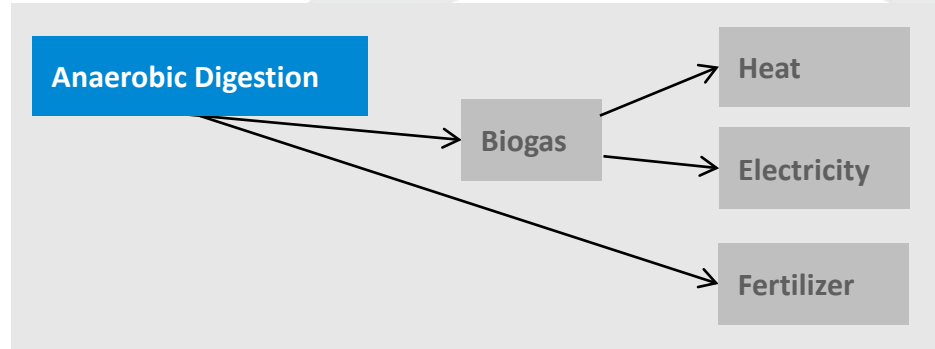
Uses of Biomass: Anaerobic Digestion (Biogas digester)



10m³ Balloon-type digesters installed at Krwakrwa and Melani villages in the Eastern Cape

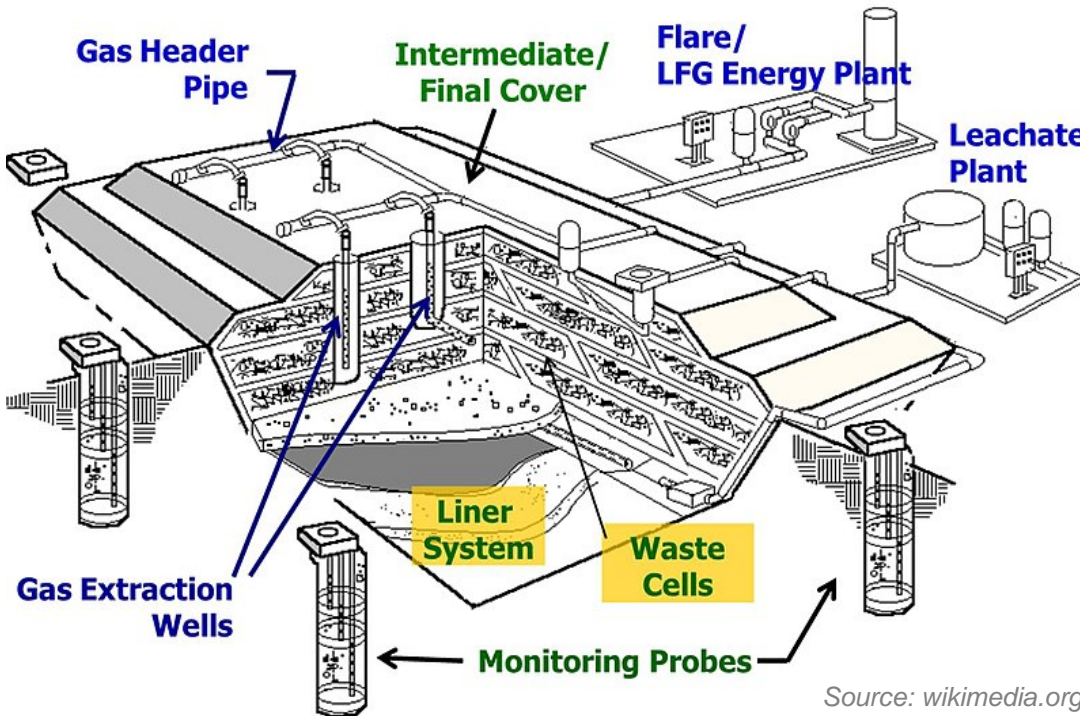
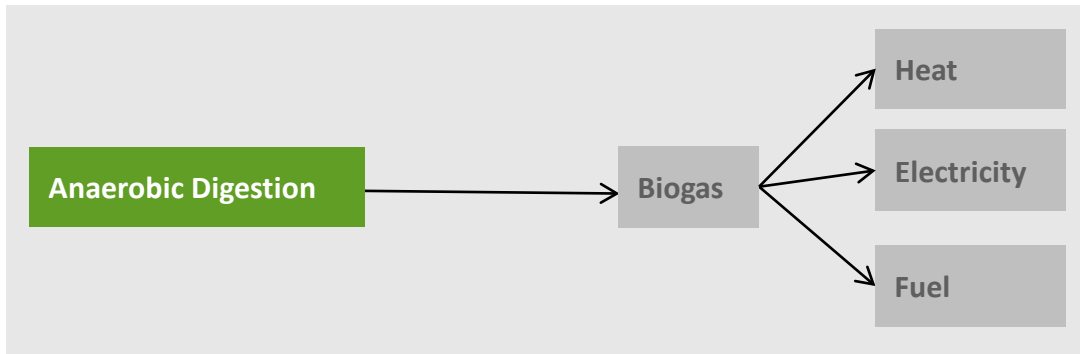


6m³ Fibreglass fixed-dome digesters installed at Melani, Sompondo, Francis, and Krwakrwa villages



- **Anaerobic digestion** is the process where microorganisms break down organic materials into sugars and then into various acids which are further broken down to produce bio-gas. **Biogas** is a mixture of CO₂ and CH₄. CH₄ (**Methane**) is a combustible gas that can be used directly in biogas stoves for cooking, or in gas engines to produce electricity.
- A **biogas digester** consists of one or more airtight reservoirs into which a suitable feedstock (cow dung, human waste, and abattoir waste or plant material) is placed. The waste should have a high moisture content.
- **Small-scale digesters** for household use are commonly made of concrete, bricks, metal, fibreglass, or plastic.
- **Larger commercial biogas digesters** are made mainly of bricks, mortar, and steel.
- An odourless phosphorus- and nitrogen-laden slurry is produced as waste – an excellent **fertilizer**!
- Depending on the temperature and moisture content, it takes about **6–25 days to fully process a batch**; simpler digesters may take longer.

Uses of Biomass: Anaerobic Digestion (Landfill power plant)



- **Landfill power plants** work on the same principle as a bio-digester.
- **Decomposition** is taking place in the absence of oxygen, hence an **anaerobic process** done by micro-organisms.
- A variety of gases are formed of which the most are **methane and carbon dioxide**.
- **Landfill gas utilization** is a process of gathering, processing, and treating the **methane** gas emitted from decomposing garbage to produce **electricity, heat, fuels**, and various **chemical compounds**

Small-scale Biomass Power Plants in South Africa

- The first bidding round of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) started in 2011. To date, four bidding rounds have been completed.
- The website: www.eskom.co.za/Whatweredoing/Pages/RE_IPP_Procurement_Programme.aspx
- contains a map which provides details of each REIPPPP project in South Africa

The following details can be viewed on the website:

- Name of the project
- Type of technology being built
- Capacity of the power plant, and the
- Current status of the project



Bidding round	Number of Projects		Capacity allocated (MW)
	Biomass	Landfill	
Window 1	-	-	-
Window 2	-	-	-
Window 3	1 (16 MW)	1 (18 MW)	34
Window 4	1		62
Total	2	1	96 MW

Uses of Biomass: Biofuels



First Generation: Corn



Second Generation:
Sugarcane Bagasse

- **Biomass fuel, or biofuel**, is a broad term to describe **material of biological origin that can be used as a source of energy**.
- Biomass can be converted into **liquid biofuels**.
- **First-, second- and third-generation biofuels** can be used in these processes.
- **First-generation biofuels** are made from maize, sugar cane, sunflower oil, soybeans, etc., which are traditionally seen as food crops.
- **Second-generation biofuels** are produced from plant residue, for example maize cobs, sugarcane and sweet sorghum bagasse. The food products are harvested, as well as the residue but the yield in terms of energy is lower.
- **Third-generation biofuels** are cultivated from algae to produce biodiesel from the oil.
- There is **controversy** around first-generation biofuels regarding the ethical question of whether food should be used for fuel.
- Therefore the tendency is that more and more **research is focused on second-generation biofuels**, where one will have the benefit of the food as well as the usefulness of the residue.
- With biofuels we need to ask the following questions:
 1. Can we use food for fuel?
 2. What is the effect of mono crops on nature?

Uses of Biomass: Biofuels

**First Generation:
Food**



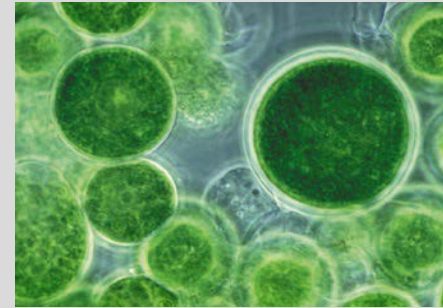
Maize

**Second Generation:
Plant and Animal Waste**



Sugar Cane Bagasse

**Third Generation:
Algae**



Algae



Sugar Cane

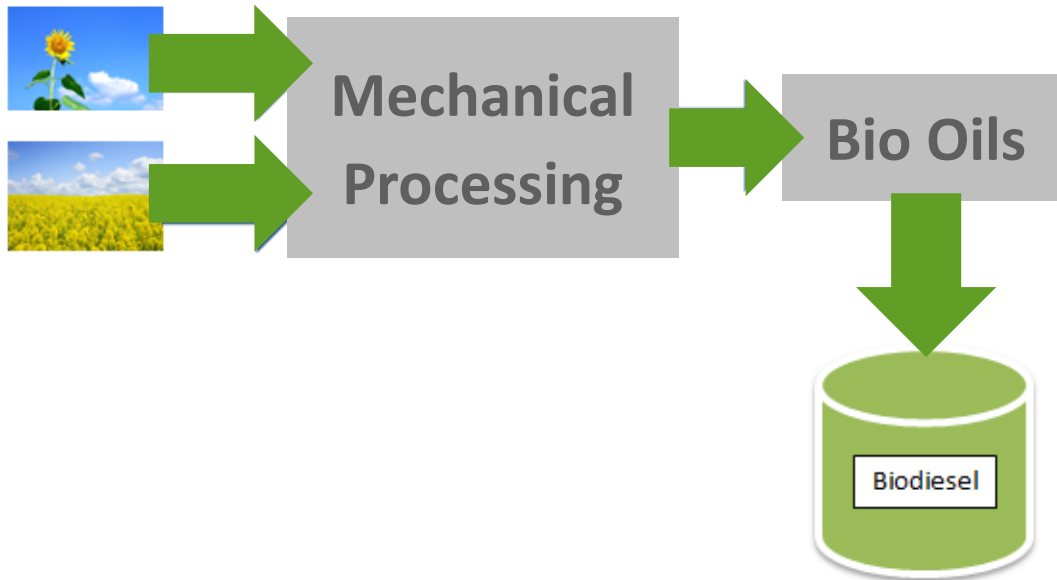
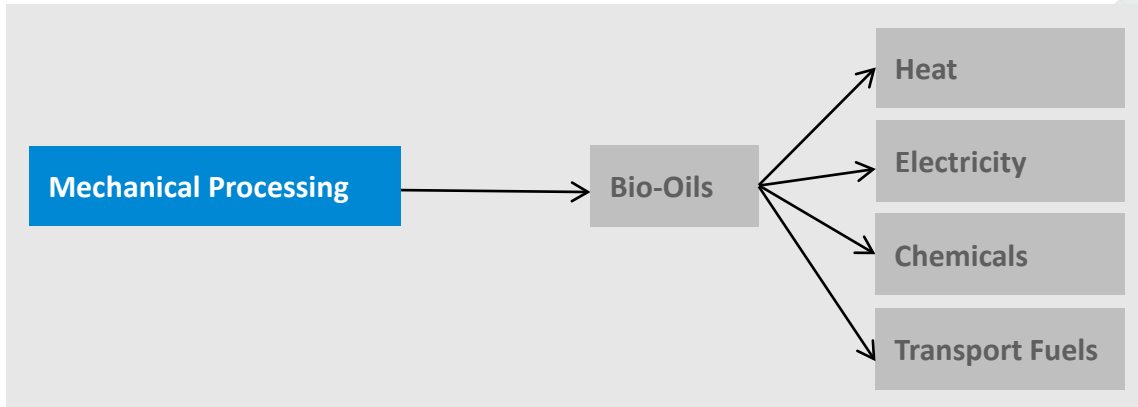


Sewage



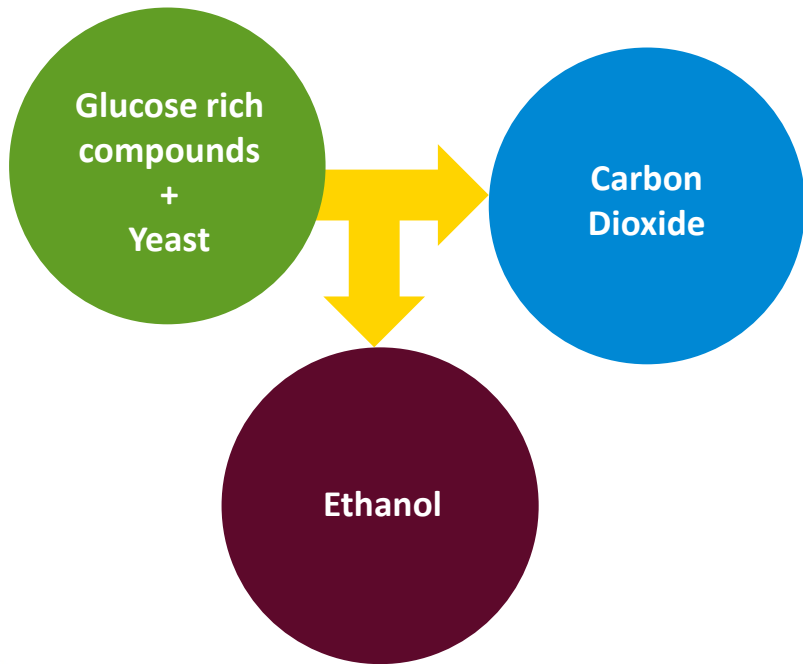
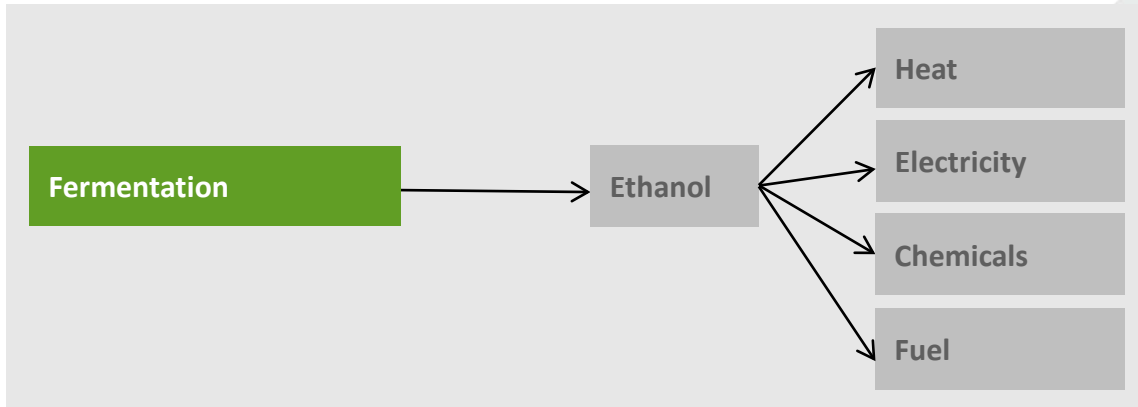
Algae Photo Bioreactor

Uses of Biomass: Mechanical Processing (Biodiesel)



- Biomass fuel, or biofuel, is a broad term to describe material of biological origin that can be used as a source of energy.
- **Biomass can be converted into liquid biofuels through mechanical processing and fermentation.**
- **First-generation food crops** like sunflower seed oil, soybeans and other crops can be converted into biodiesel through mechanical processing.
- **Oil from these fuels are often more effective than wood**, since they represent a more **concentrated energy source**.

Uses of Biomass: Fermentation (Biofuel)



- **First- and second-generation crops** like maize, sugar cane and sweet sorghum bagasse **can be converted into fuel or gas** through a fermentation process.
- Through **fermentation**, maize and sugar cane are converted into:
 - 1. Ethanol – a liquid biomass fuel.
 - 2. Methane – a gas.
- In Brazil, ethanol from sugar cane crops is a major contributor to fuel resources, and is called **gasohol**.
- This **reduces the amount of fossil fuels** needed to power cars.

Uses of Biomass: Algae



Third-generation biomass (**algae**) is used to produce biofuels. The technology is still in the **research phase**.

Benefits

- **Fast growing**
- contains oil; contains no sulphur; non-toxic
- Algae fuel is also known as algal
- **Not** in competition with crops
- **Can be grown** with seawater in the desert and it won't use agricultural space

Concerns

- **Expensive** to develop
- **Cannot** provide **enough oil** to satisfy the **total transport demand**, although it can meet the **aviation demand** which is smaller.

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