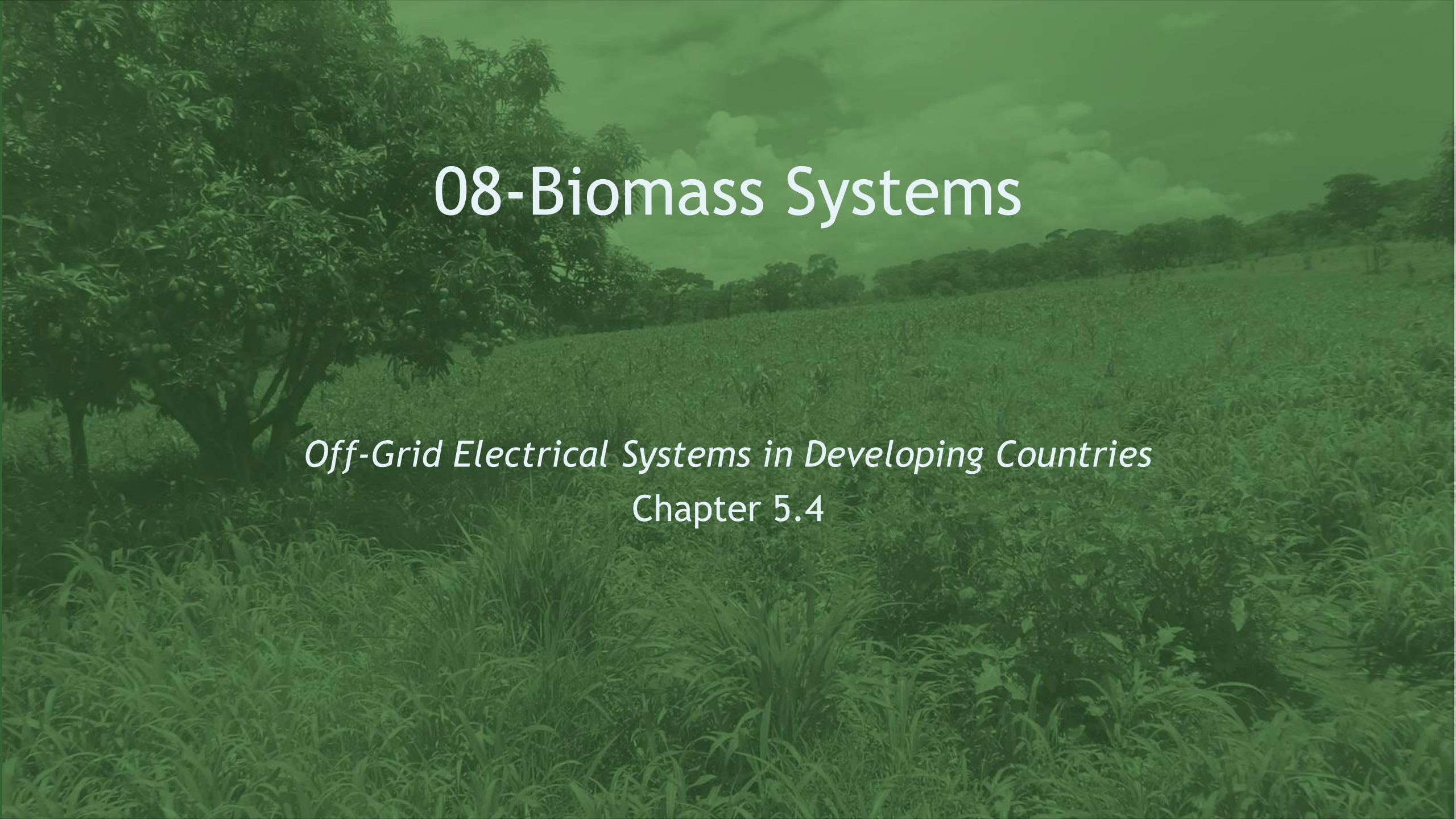


08-Biomass Systems

Off-Grid Electrical Systems in Developing Countries

Chapter 5.4

Learning Outcomes

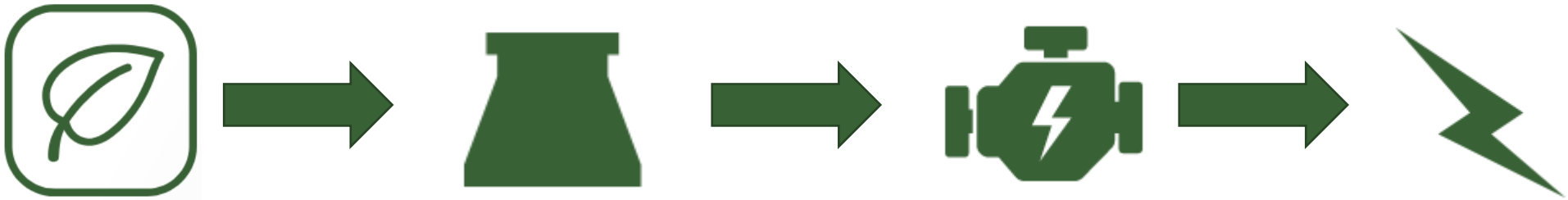
At the end of this lecture, you will be able to:

- ✓understand the role of biomass systems in off-grid electricity access
- ✓distinguish between syngas and biomass in their chemical composition and how they are produced

Read Chapter 5.4

Biomass

- Organic material from recently alive organisms
- Feedstock biomass is processed into a more convenient form before use in a gen set or steam turbine



Biomass Feedstock | Processing | Combustion | Electricity production

Biomass Feedstocks

Forest waste

Crop residue

Animal waste

Food waste

Biomass Processing

Feedstock

Output

bagasse, bamboo, nut shells, cotton stalks, forest pruning, rice husk, wood pulp, etc.

thermo-chemical reactions

Syngas
(hydrogen, carbon monoxide)

pig/cattle manure, chicken litter, food waste, slaughterhouse waste, stalks, straw, etc.

biological processes

Biogas
(methane, carbon dioxide)

forest waste, manufacturing waste, etc.

cutting, drying

Dried Biomass

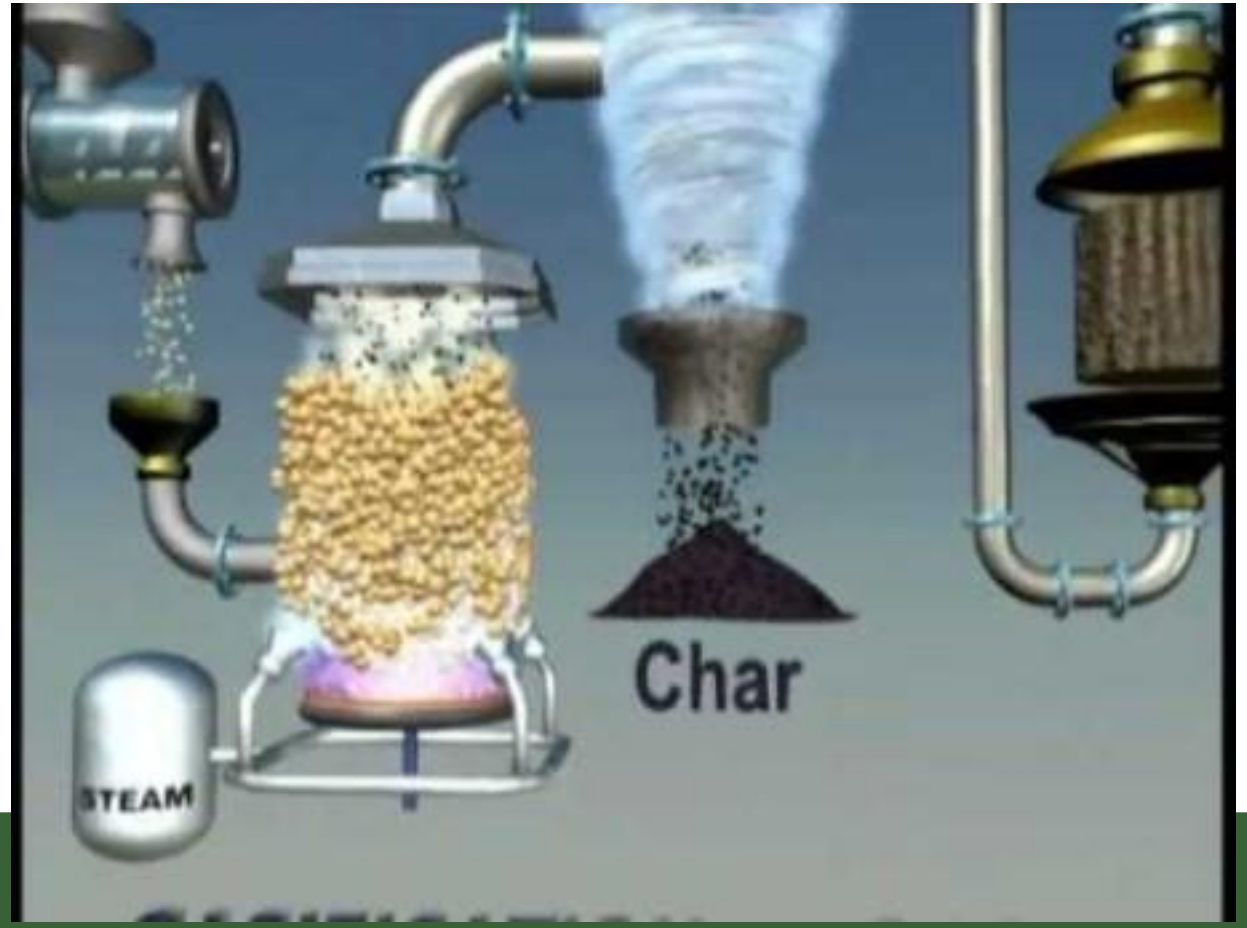
Syngas

- Thermo-chemical reactions convert dry biomass to syngas (gasification) inside a reactor vessel
- Dried woody biomass or crop residue often used
- High-temperature process, gas must be cooled and filtered before use
- Gas used in modified ICE gen set to produce electricity

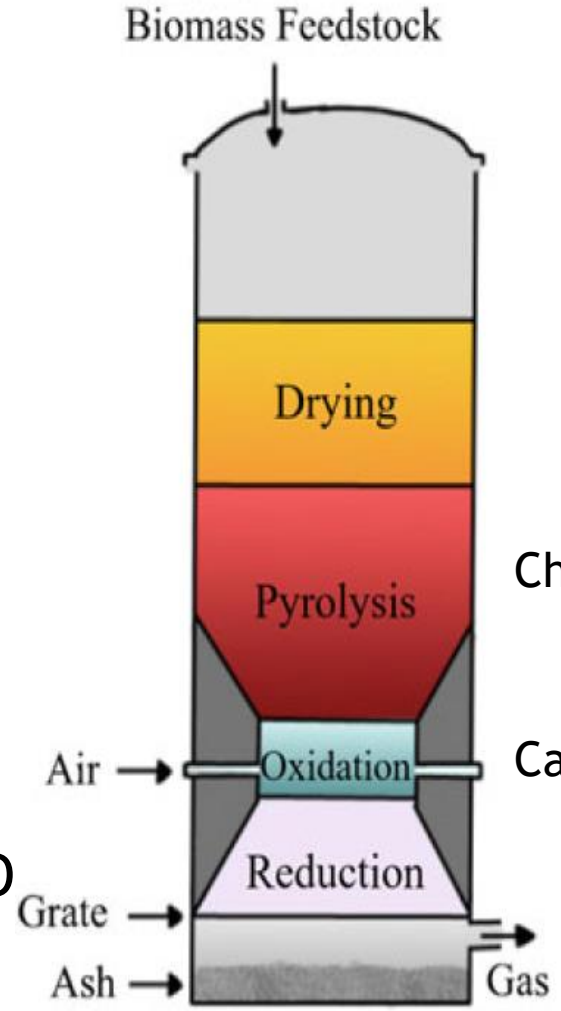
Example for Glucose

$$C_6H_{12}O_6 + O_2 + H_2O \longrightarrow xCO + yCO_2 + zH_2 + \text{other species}$$

Syngas Production



Syngas Reactor



C

Char produced

$C + O_2 \longrightarrow CO_2$

Carbon dioxide, heat

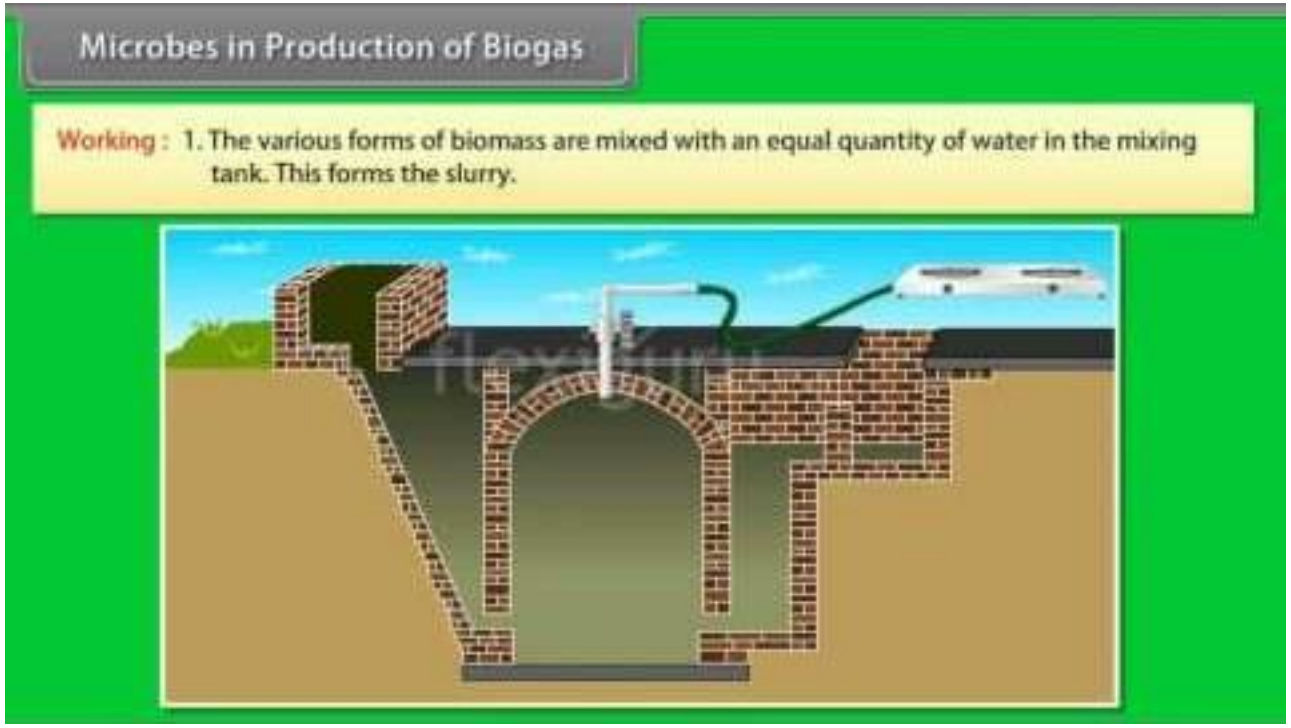
$C + H_2O \longrightarrow H_2 + CO$

Syngas (hydrogen, carbon monoxide)
1.5 m^3 (3 to 6 MJ) per kilogram of dry input

Syngas Reactor

Source: https://www.fastcompany.com/1714395/husk-power-systems-wants-lead-revolution-electricity

Biogas Production



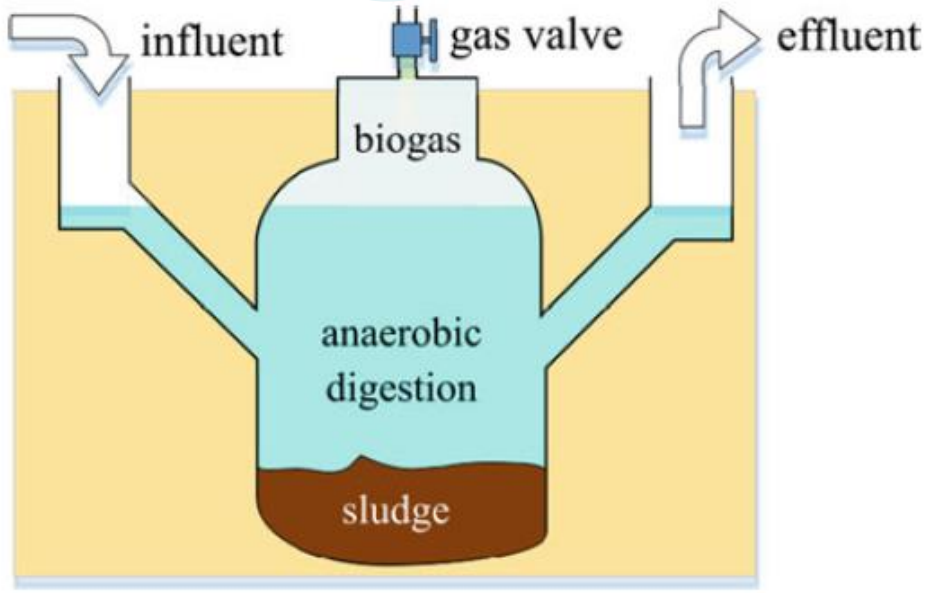
Biogas

- Microorganisms convert biomass to biogas
- Requires biomass and water (or wet biomass such as manure)
- Process takes 10-30 days
- High efficiency (up to 85%)
- Digestor is simple to construct
- Millions of digestors implemented, very few used for electricity generation
- Gas used in modified ICE gen set to produce electricity

Biogas
(methane, carbon dioxide)

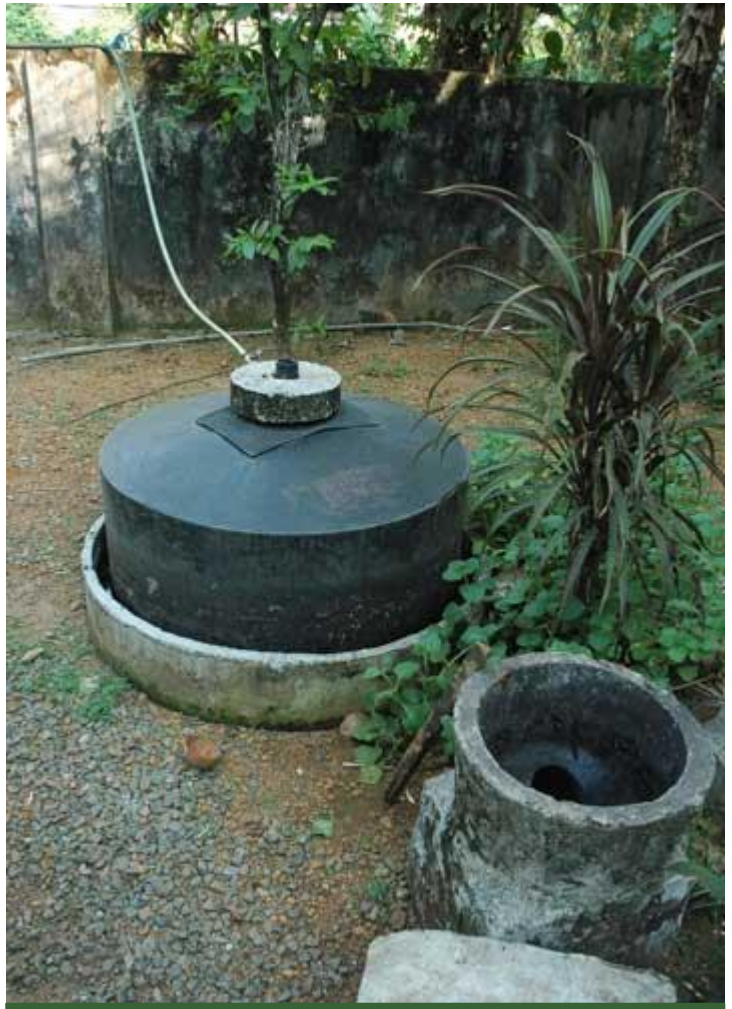
0.3 m^3
(~6 to 7 MJ) per
kilogram of dry input

1 kg biomass
(dry weight)



Biogas Digestor

Biogas digestor under construction in Malawi
(courtesy P. Dauenhauer)



Biomass Systems

- Can be considered a renewable resource, depending on feedstock and rate of use
- By-product can be used as fertilizer
- Makes use of waste products
- Biomass fuels can be stored and used on-demand
- Potential for Combined Heat and Power (CHP) systems
- Creates employment and cash flow in rural areas (collecting, transporting and processing biomass)

- Requires gen set or turbine to produce electricity
- Feedstock supply chain management
- Seasonal availability of feedstock
- Might compete with crops used for food
- Might require full-time staff to manage systems
- Might require waste to be removed
- Might require reliable water supply

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