

Biomass Characteristics

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“Quiz”

- Biomass does not produce CO₂.
- Biomass does produce CO₂.
- Biomass does not make net addition to CO₂.

Outline

- **Definition of Biomass**
- **Biomass Classification**
- **Classification of Biomass Fuels**
- **Properties of Biomass**
 - **Physical**
 - **Thermodynamic**
 - **Other**

What is Biomass?

- Any organic material derived from plants (botanical) or animals (biological)
- A non-fossilized fuel source that is biodegradable
- Excludes materials normally used as foods

A Renewable Energy Source

- When biomass dies it is naturally broken down and releases H₂O, CO₂, and energy
- The same change happens when used for chemical or energy purposes
- Net pollution contribution is zero!

How is Biomass Formed?

- Botanical (plant) biomass converts CO_2 and H_2O to carbohydrate and oxygen with energy from the sun through photosynthesis
- Biological (animal) species grow by consuming botanical species or other biological species



Biomass Classification

A. Virgin Biomass

1. Terrestrial

- Forest
- Grasses
- Energy crops
- Cultivated crops

2. Aquatic

- Algae
- Water plants

Biomass Classification

B. Waste Biomass

1. Municipal waste

- Municipal solid waste
- Bio-solids, sewage
- Landfill gas

2. Agricultural solid waste

- Livestock and manures
- Agricultural crop residues

3. Forestry residues

- Bark, leaves, floor residues

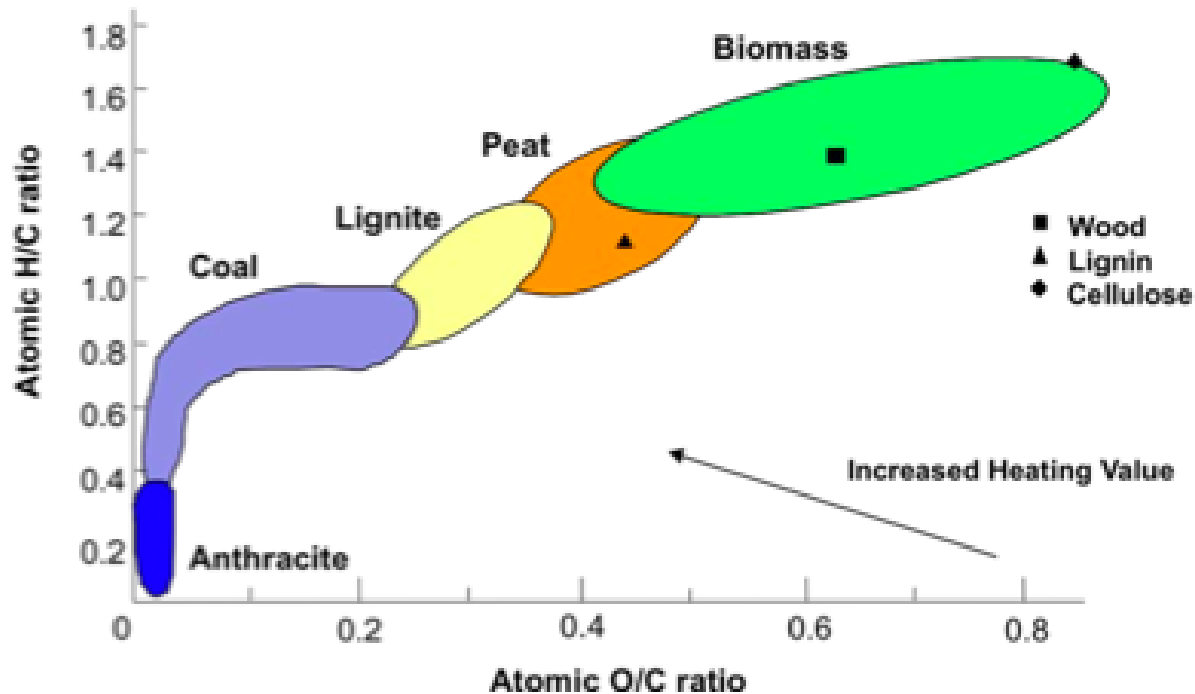
4. Industrial wastes

- Demolition wood, sawdust
- Waste oil, fat

Classification of Biomass Fuels

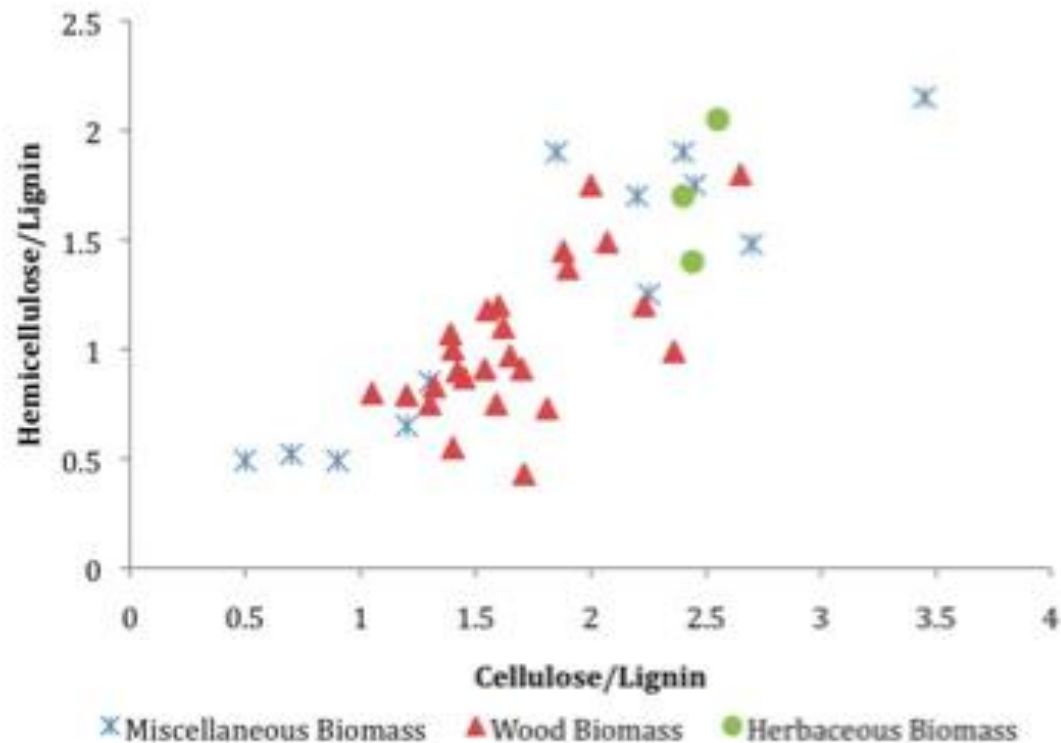
1. Atomic ratios

- H:C:O content
- van Krevelen diagram (H/C versus O/C)



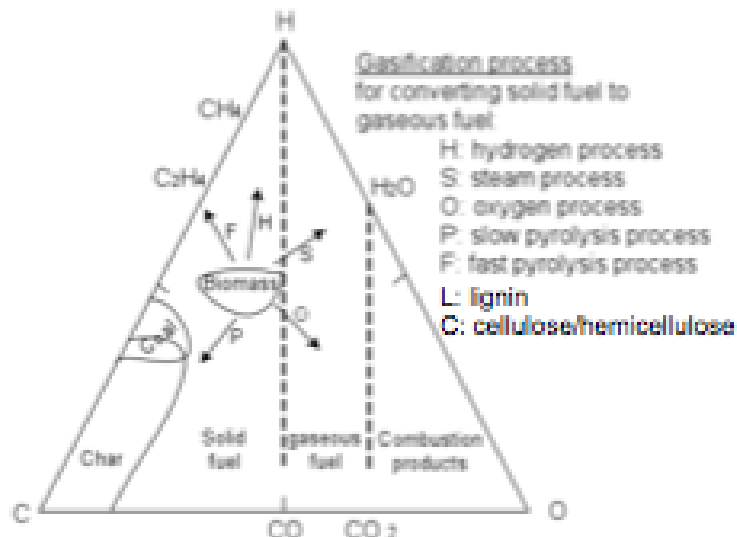
Classification of Biomass Fuels

1. Atomic ratios
2. Ratio of biomass components
 - Cellulose, hemicellulose, and lignin



Classification of Biomass Fuels

1. Atomic ratios
2. Ratio of biomass components
3. Ternary diagram
 - Shows biomass conversion processes in terms of H:C:O ratio



Physical Properties of Biomass

- True density

$$\rho_{\text{true}} = \frac{\text{total mass of biomass}}{\text{solid volume in biomass}}$$

Physical Properties of Biomass

- True density
- **Apparent density**

$$\rho_{\text{apparent}} = \frac{\text{total mass of biomass}}{\text{volume of solids and internal pores}}$$

Physical Properties of Biomass

- True density
- Apparent density
- **Bulk density**

$$\rho_{\text{bulk}} = \frac{\text{total mass of biomass particles or stack}}{\text{bulk volume occupied by particles or stack}}$$

Physical Properties of Biomass

- True density
- Apparent density
- Bulk density
- **Biomass density**
 - **Biomass available per unit area land**
 - Kg/hectare of a harvested crop
 - Oven dry tons/hectare of trees

Thermodynamic Properties of Biomass

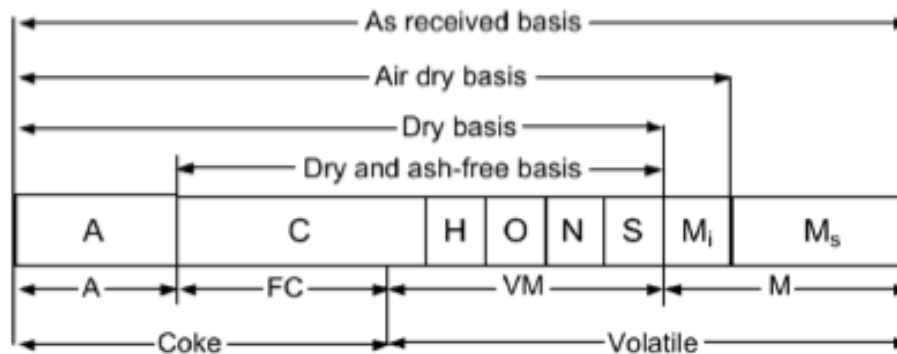
- **Thermal conductivity**
 - The ability of the biomass to conduct heat
- **Specific heat**
 - The amount of heat required to raise a unit mass of biomass by one unit of a specified temperature
- **Heat of formation**
 - Energy to form the biomass from its constituent elements

Thermodynamic Properties of Biomass

- **Heat of combustion**
 - Heat released/absorbed in a chemical reaction without a change in temperature
- **Ignition temperature**
 - The temperature of the biomass at which the combustion reaction becomes self sustaining
- **Heating value**
 - HHV – heat released by combustion of a fuel at 25°C and returned to 25°C
 - LHV – heat released by combustion of a fuel at 25°C and returned to 150°C
 - $LHV = HHV - \text{latent heat of vaporization}$

Other Properties of Biomass

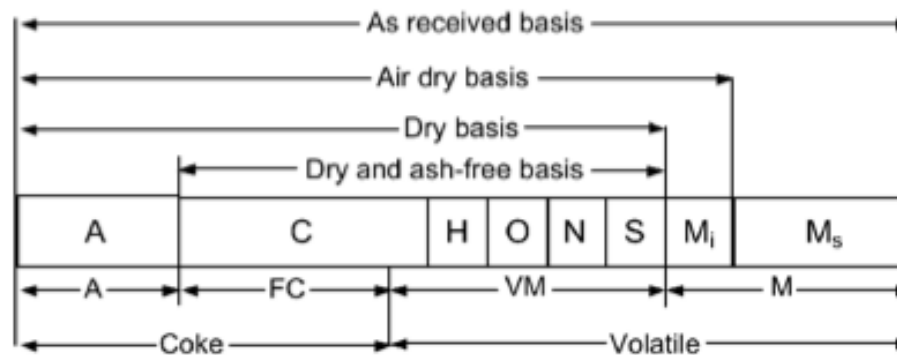
- Bases of expressing biomass composition
 - “As received” basis
 - Ultimate analysis
 - Determines the composition of the biomass fuel in terms of basic elements
 - $C + H + O + N + S + A + M = 100\%$



A – Ash	H – Hydrogen	C – Carbon
O – Oxygen	N – Nitrogen	S – Sulfur
M _i – Inherent Moisture	M _s – Surface Moisture	

Other Properties of Biomass

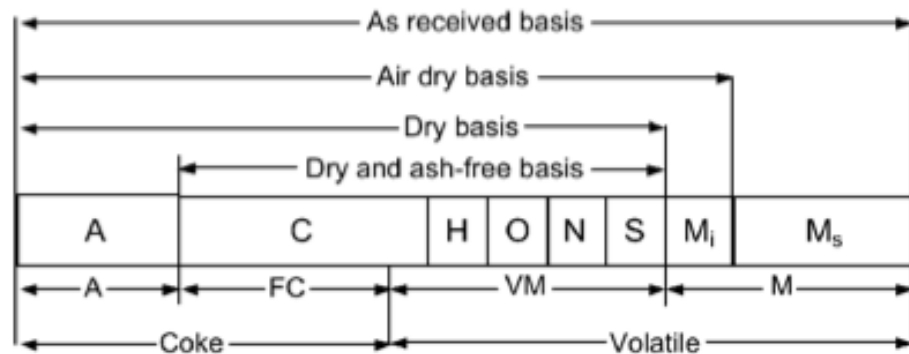
- Bases of expressing biomass composition
 - “As received” basis
 - Proximate analysis
 - Determines the composition of the biomass fuel in terms of gross components
 - $VM + FC + A + M = 100\%$



A – Ash	H – Hydrogen	C – Carbon
O – Oxygen	N – Nitrogen	S – Sulfur
M_i – Inherent Moisture	M_s – Surface Moisture	

Other Properties of Biomass

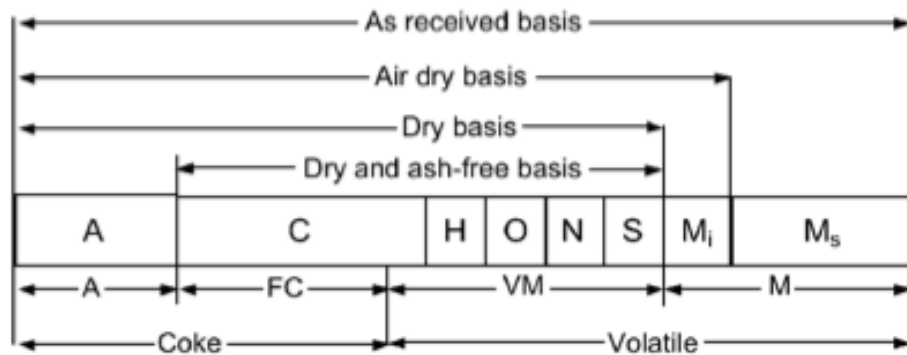
- Bases of expressing biomass composition
 - “As received” basis
 - “Air dry” basis
 - The biomass is dried in air, removing surface moisture



A – Ash	H – Hydrogen	C – Carbon
O – Oxygen	N – Nitrogen	S – Sulfur
M _i – Inherent Moisture	M _s – Surface Moisture	

Other Properties of Biomass

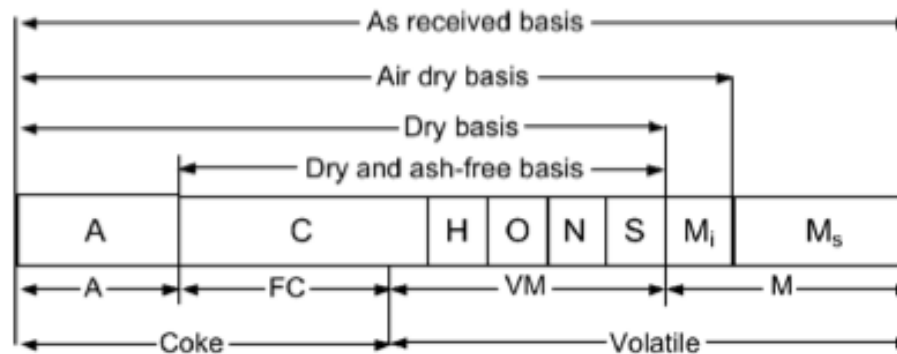
- Bases of expressing biomass composition
 - “As received” basis
 - “Air dry” basis
 - “Dry” basis
 - The biomass completely dried, removing both surface and inherent moisture



A – Ash	H – Hydrogen	C – Carbon
O – Oxygen	N – Nitrogen	S – Sulfur
M _i – Inherent Moisture	M _s – Surface Moisture	

Other Properties of Biomass

- Bases of expressing biomass composition
 - “As received” basis
 - “Air dry” basis
 - “Dry” basis
 - “Dry and ash free” basis
 - Components are reported with ash and water removed



A – Ash	H – Hydrogen	C – Carbon
O – Oxygen	N – Nitrogen	S – Sulfur
M _i – Inherent Moisture	M _s – Surface Moisture	

Conclusions

- **Biomass is a renewable and sustainable alternative to fossil fuels**
- **There is no net pollution to the environment**
- **Classification of Biomass**
- **Properties of Biomass**
 - **Physical**
 - **Thermodynamic**
 - **Other**