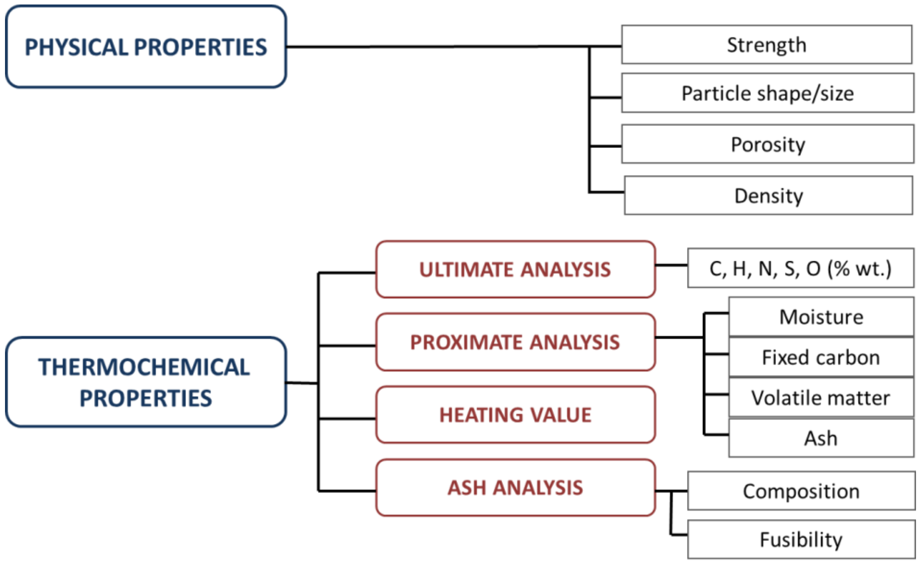
IEA Bioenergy

BIOMASS AS GASIFICATION FEEDSTOCK

The physical and thermochemical properties of the feedstock influence the quality of the producer gas, and therefore, play a decisive role on the selection of the gasification technology. Biomass has special characteristics that affect the whole conversion process (pre-treatment, gasification, and gas cleaning system).



Feedstock properties influencing the gasification process.

Woody biomass	Herbaceous biomass
• Higher density. • Lower ash content. (dependent on bark content). • Higher ash melting point (> 1000°C).	Examples: straw, miscanthus, rice husk. • Lower density. • Fibrous (lower friability). • Higher content of Cl and S. • Higher ash content. • Lower ash melting point (< 700°C).

More info: www.phyllis.nl

Main properties of biomass

- High moisture content (hydrophilic).
- Low bulk density, high porosity.
- Fibrous nature (low friability).
- Chemical composition: high volatile content, low fixed carbon.
- Lower C and higher O content than coal → lower heating value.
- Low N, S, and Cl content.
- Lower ash content than coal, with lower melting point and very aggressive in molten state.
- Higher content in alkaline metals (Na, K) than coal.

BIOMASS PRE-TREATMENT OPTIONS FOR ENTRAINED-FLOW GASIFICATION.

- Torrefaction: mild pyrolysis at 200-300°C. Biomass is transformed in a hydrophobic solid material easier to grind, pelletize and transport. Thermal efficiency > 90%.
- Flash pyrolysis: solid biomass is transformed into a liquid bio-oil (efficiency < 70%), which can be further pumped and fed into the gasifier. Bio-oil can be also mixed with char to form slurry (efficiency ~ 90%).

Requirements for different gasification technologies

Type of gasifier	Fuel specifications
Fixed/moving bed	• Fuel particle size: 1 – 10 cm. • Mechanically stable fuel particles (unblocked passage of gas through the bed). Pellets or briquettes as preferred option. • Updraft configuration more tolerant to biomass moisture content (up to 40-50%) because drying occurs as biomass moves down the gasifier.
Fluidised bed	• Ash melting temperature of fuel: higher limit for operating temperature. • Fuel particle size relatively small to ensure good contact with bed material. Generally < 80 mm for BFB and < 40 mm for CFB gasifiers. • Good fuel flexibility due to high thermal inertia of the bed.
Entrained-flow	• Fuel particle size: ~ 50 μm (pulverized for high fuel conversion in short residence times). • Low moisture content required. • Attention to ash melting behaviour for reactor/process design.

OVERVIEW OF INFLUENCE OF BIOMASS PROPERTIES ON THE GASIFICATION SYSTEM

	Biomass properties	Impact on gasification system
Physical	High moisture content (hygroscopic)	• Decrease in heating value of fuel. • Storage durability. • Fuel transportation costs. • Lower process temperature. • Reduction in producer gas quality, gasification efficiency and fuel conversion. • Optimal moisture content for gasification: 10-15% wt.
	Low apparent density	• Energy density (→ transportation, storage and handling costs). • Feeding system.
	Shape and distribution of particle size	• Transport and feeding system. • Gasification technology. • Reactivity of fuel.
	Low friability	• Fuel pre-treatment and feeding (entrained-flow gasifiers).
	Porosity / specific surface area / distribution of pore size	• Reactivity of fuel.
Thermochemical	Cellulose, hemicellulose and lignin content	• Reactivity of fuel.
	Ultimate analysis - C, H, O content	• Heating value of fuel.
	- N content	• Fate of fuel-bound N during gasification: mainly transformed into NH_3 and HCN → design of gas cleaning section. • Emissions.
	- S content	• Fate of fuel-bound S during gasification: mainly transformed into H_2S and COS. → design of gas cleaning section. • Interaction with alkali metals: emissions, deposits, corrosion. • Deactivation of downstream catalysts.
	- Cl content	• Decrease of softening temperature of ash. • Enhancement mobility of K (→deposition and agglomeration). • Emissions, corrosion and ash sintering.
	High volatile content, low fixed carbon content	• Reactivity of fuel.
	Ash content	• Decrease of fuel heating value. • Energy density: transportation costs. • Emissions. • Ash disposal costs. • Design of equipment (grates, heat exchangers, gas cleaning).
	Ash composition	• Ash-melting behaviour (softening and melting temperatures) → deposition, agglomeration, fouling.
	- Na and K content	• Involved in ash deposition and formation of deposits. • Lowering of ash melting temperatures. Formation of eutectics. • Reaction with Si and S: deposition, agglomeration, fouling, corrosion. • Ash valorisation.
	- Mg, P, Ca content	• Increase of ash melting temperature. • Ash disposal applications.
	- Heavy metals	• Emissions. • Ash disposal costs, ash applications.