The Evolution of Clean Wood Thermal Technologies

MD Wood Energy Coalition

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Overview

- Wood composition
- Stages of thermochemical conversion (combustion)
- Advanced combustion technologies / design approaches

What is wood?

Constituent	% by Weight (dry basis)
Carbon (C)	47.1 – 51.6
Hydrogen (H)	6.1 – 6.3
Oxygen (O)	38.0 – 45.2
Nitrogen, Potassium, Calcium, Phosphorous, Sulfur, Magnesium, etc.	~1.0

Approximately 76-86% is volatiles (e.g. methane, other hydrocarbons)

Thermochemical conversion? (combustion)

- Goal is to convert stored energy to heat as efficiently as possible

- Stages of wood combustion
  - Evaporate water (drying)
  - Drive off volatiles (pyrolysis/gasification)
  - Combustion (oxidation)

Drying

- Water stored in the fuel
  - Wood moisture content
- Water generated through the combustion process
  - Complete oxidation creates CO_2 & H_2O

Pyrolysis / Gasification

- High percentage (~80%) of wood by dry weight is volatiles (hydrocarbons)
- Pyrolysis = absence of O2
- Gasification = O2 present

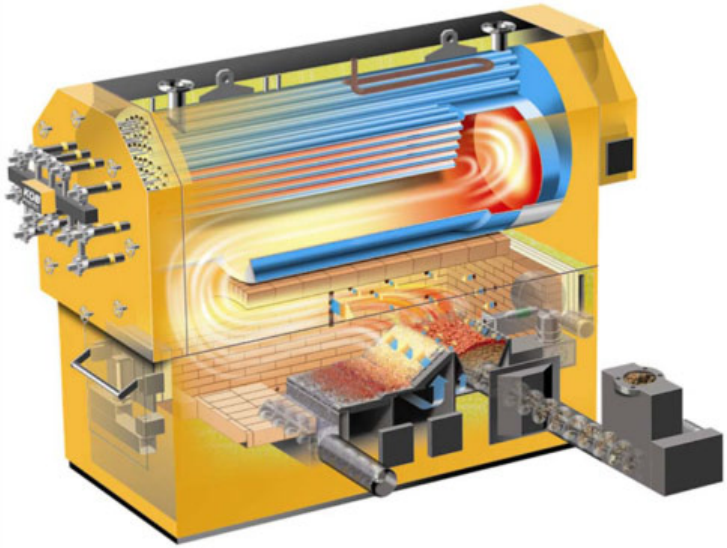


Image courtesy Viessmann USA

Combustion

- Burn (oxidize) carbon
  - $C + O_2 = CO_2$ & CO

- Burn (oxidize) gases
  - $HC + O_2 = CO_2$ & CO & H_2O
  - $CO + O_2 = CO_2$
  - $H_2 + O_2 = H_2O$

Technology – Two-Stage Combustion

- Gasification Stage = low O2/temp
  - Flue gas recirculation
  - Control of air / temp
- Combustion Stage = high O2/temp
  - Time / Temp / Turbulence
  - Control of air / temp

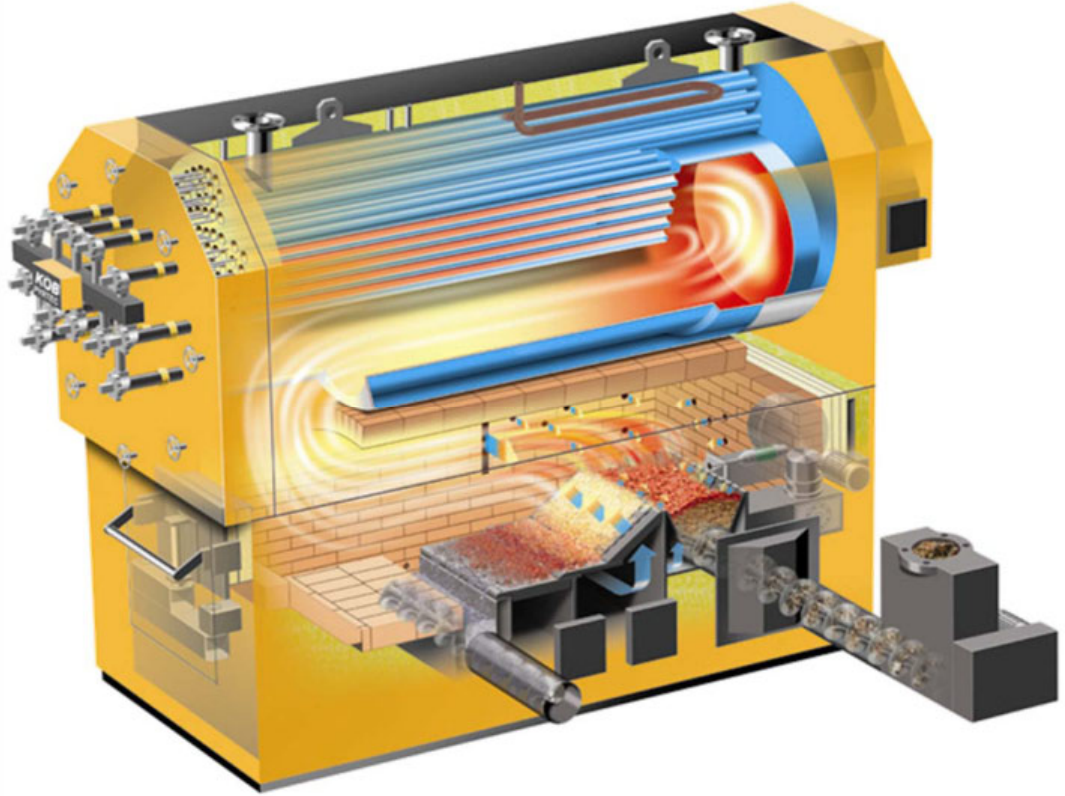
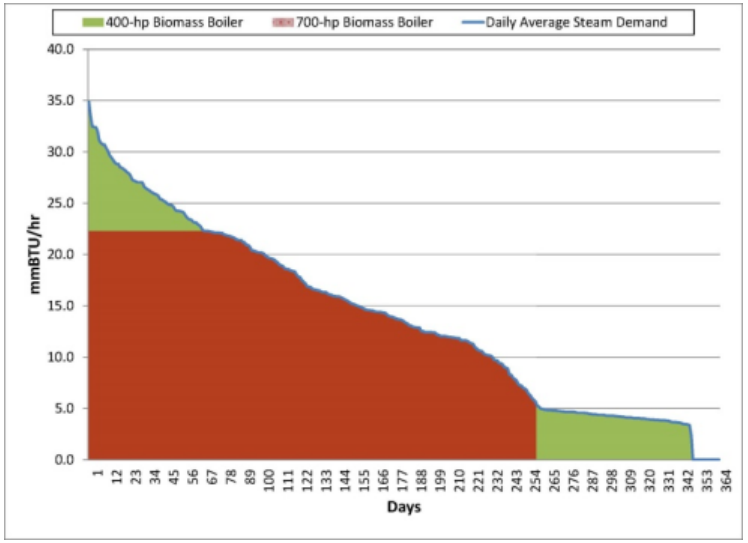


Image courtesy Viessmann USA

Design to maximize efficiency / minimize emissions

- Sizing
  - Operate system within constant 30-100% of capacity
- Integration with demand
  - Thermal storage
  - System and load controls
  - Reduce boiler cycling between firing rates



Summary

- Wood stores energy from the sun
  - Carbon, Hydrogen, Oxygen
- Maximizing efficiency reduces emissions
  - Two-stage combustion technologies
  - System design – sizing & integration with demand