The Biomass Energy Advantage: Cost Competitive Carbon-Neutral Energy and Fuels

Thomas F. McGowan, PE
President
TMTS Associates, Inc.
399 Pavillion St.
Atlanta, GA 30315
404 627 4722
http://tmtsassociates.home.mindspring.com

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What is Biomass?

Biomass is a renewable energy source made of biological material that is alive, or was recently alive

Examples in decreasing order of importance:

- **Wood**
- **Agricultural (ag) waste and crop residue**
- **Landfill gas**
- **Anaerobic digester gas**
- **Pulp mill black liquor**
- **Energy crops**

Why Biomass?

- **Fuel costs**
- **Concern about oil imports vs. homegrown energy**
- **Concern about global warming due to Greenhouse gases**
- **Concern about supplies and fuel flexibility in case of curtailment (e.g., Hurricane damage)**

Biomass is a solution to all the above!

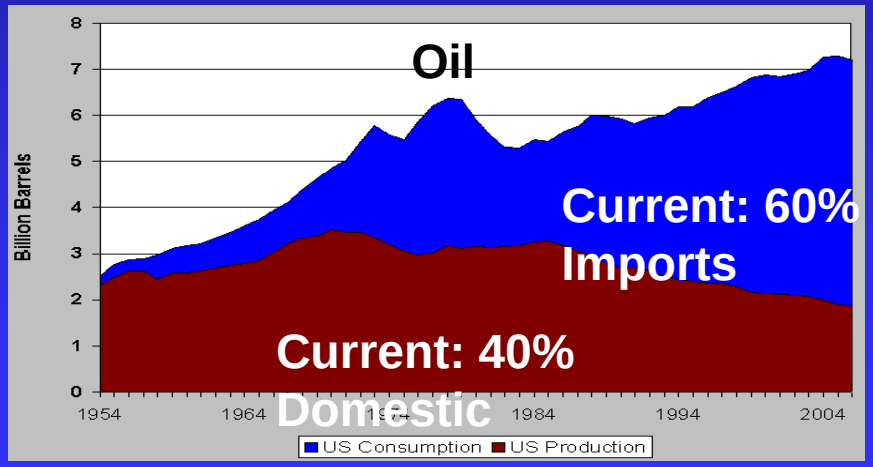
U.S. Energy Use

- 99 quads (quadrillion Btu) in 2008
- ~24% of global energy; 88% is fossil fuel
- Industry 33% of U.S. total
- CPI 25% = 8% of all U.S. energy = 8 quads
- CPI biomass for power/fuel = 2 quads
- CPI Non-forest products consumes only 0.003 quads biomass – plenty of room for expansion there!

Global Reserves

Fuel	Reserve life at current consumption rate (years)	Reserve life at projected GDP growth (years)
Oil	35	25
Natural Gas	60	45
Coal	400	100

Growth difference



Sustainability in the Chemical Industry: Grand Challenges and Research Needs - A Workshop Report (2005) pg 56

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CPI Biomass Projects

Traditional applications

- **Hog fuel (sawdust, bark and chips) for power and steam at pulp and paper mills**
- **Planer shavings, sander dust and dried wood burned in suspension burners for dryers and boilers**

Newer technology

- **Old pulp and paper grate fired boilers being upgraded with fluidized beds for lower emissions (B&W, for Bowater, Inland Rome and Rayonier)**

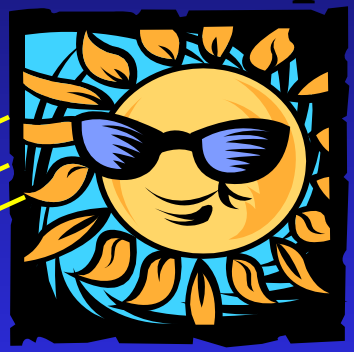
The Basics of Greenhouse Gases

- The goal for international, and now national programs, is to reduce CO2 emissions to 1990 base year levels
- CO2 is the primary combustion-related greenhouse gas; another major greenhouse gas is CH4, with a 21 multiplier vs. CO2
- Each lb of C burned yields 3.7 lb CO2

Ref: http://ec.europa.eu/environment/climat/kyoto.htm

Biomass is Greenhouse Gas Neutral!

Burning biomass releases CO2, which in turn, goes into the atmosphere, to grow more biomass in a endless loop



Photosynthesis

CHO

CO2

Combustion

With fossil fuels - one way ticket!

CO2

CH

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Fuel Value and Cost - Industrial

Fuel	Gross Heating Value Btu/lb	Approximate Cost, $/MM Btu
Natural gas	23,896	$4.58
Propane (winter cost higher!)	21,523	$7.86 (industrial) $19.12 (res/commercial)
No. 2 fuel oil	19,567	$9.31
No. 6 fuel oil	18,266	$5.14

Data collected October 2009

Fuel Value and Cost

Fuel	Gross Heating Value Btu/lb	Approximate Cost, $/MM Btu
Coal	9000 – 15000	$2.15 (Utility)
Pet coke/TDF	~15,500	$1.49/$1.61
Wood waste	4250 at 50% mc	$1.20
Whole tree Chips	4250 at 50% mc	$3.20
Tub grind waste	4250 at 50% mc	$2.60
Planer shavings	7650 at 10% mc	Local/internal use
Wood Pellets	7650 at 10% mc	$9.80 Ind/$16.80 Res
Chicken litter	~6130 at 11% mc	$1.20

Data collected October 2009

Cost Summary…

- **Premium liquid/gas fuels ~ $5-9/MM Btu; long term, non recession, perhaps $8-12?**
- **Some waste fuels are 20 – 50% of price premium fuels**
- **Some wastes have negative value, that is, the cost of current disposal**
- **But, the cheaper the fuel, the more it will cost to handle and burn it**
- **Supply and demand control prices of standard and alternate fuels**

Where is the Money Going?

- **Big interest now by power companies and independent power producers in forested areas to make Green power via boiler/steam turbine/generator**
- **Same could be done at CPI facilities to provide steam and power**
- **CPI can also make bio based fuels and chemicals**

Converting from Coal to Wood

Public Service of New Hampshire, 1 unit at Schiller Station

- $75 million (fluidized bed, emission controls, wood handling)
- 50 MW, 300k – 400k RECs per year
- Emissions
  - NOx down 70 percent
  - Hg down 90 percent
  - SO2 down 95 percent
- Less expensive than building and staffing new plant

Also: GPC, Plant Mitchell 100 MW Conversion

Source: Kryzanowski, Tony, "Wood Chip Power", *enerG Alternative Sources Magazine*, MerCo Publishing, Vancouver, BC, Nov/Dec 2007.

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Industrial Steam and Cogen

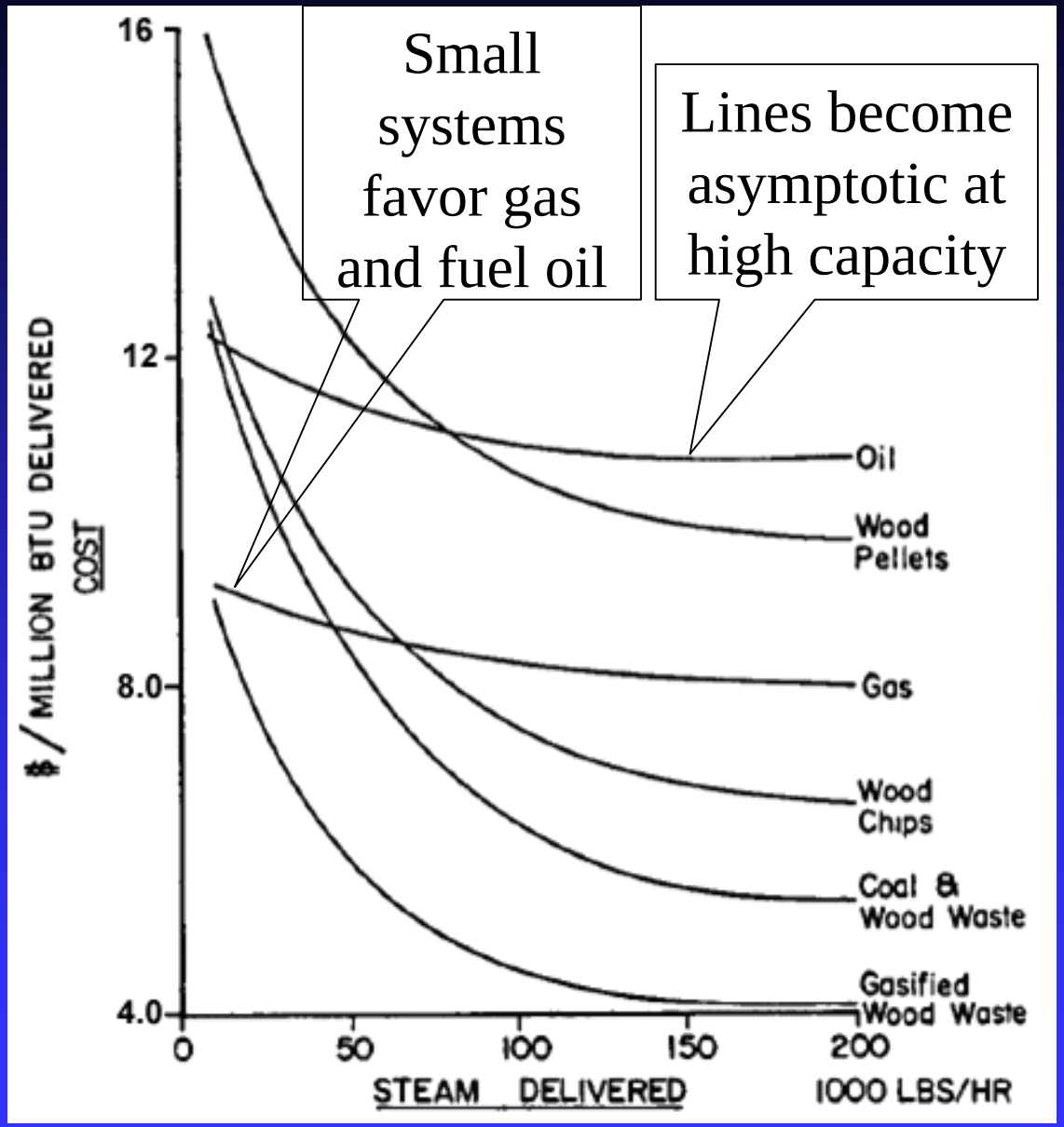
Examples of firms making and installing industrial scale biomass systems for hot oil, steam and cogen:

- **Hurst boilers (GA)**
- **The Teaford Co. (GA)**
- **McBurney (GA)**

Utility scale vendors

- **Babcock & Wilcox**
- **Foster Wheeler**
- **Indeck Keystone**

Cost of Delivered Energy



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Wood for Fuel

At the Resource…

Mixed pine and hardwood forest

Sources: Forest harvest, windfalls, beetle damaged, road clearing, thinning, urban trimming

And at the combustor…

Wood chips and sawmill residue

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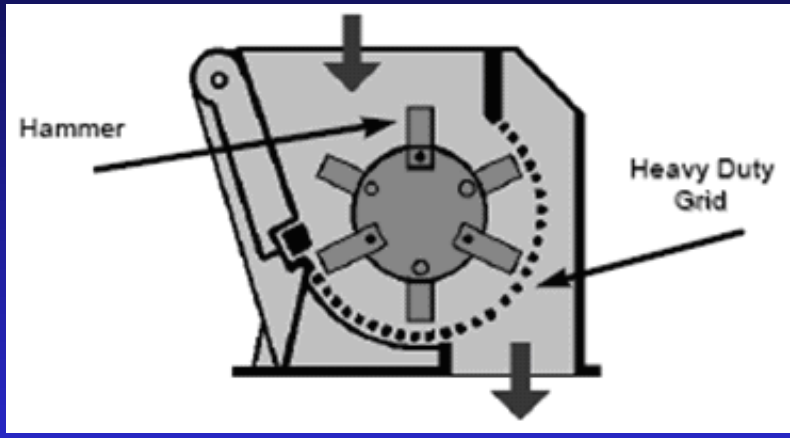
Future Ag Energy Crops???

Potential for Switchgrass or other fast growing species to supply cellulosic feedstocks -- but there are competing uses for agricultural land, and cost/ton likely higher than silvaculture/forest resource

Getting wood into chipped form

In-forest whole tree chipper, fed by feller-buncher and skid grapple



In-plant hammermill for size reduction, also disk screens, shaker screens

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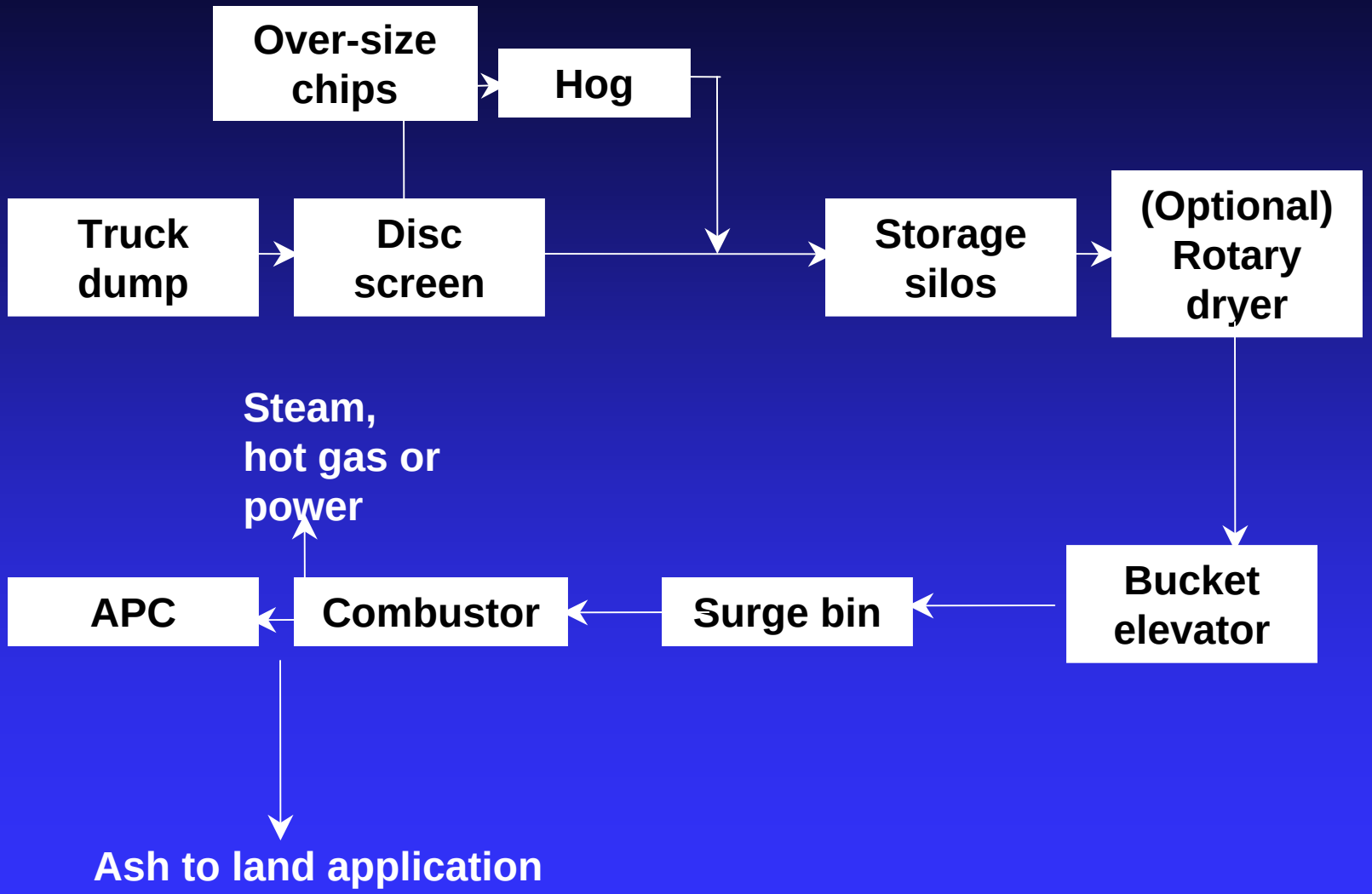
Typical Material Flow



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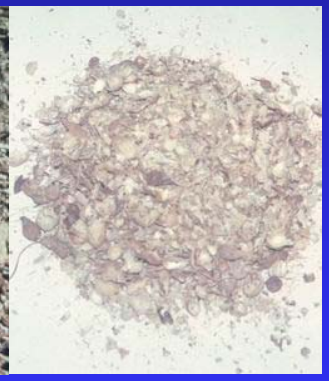
Transportation and Receiving

Tools: Truck dump, front end loaders, storage yard, retrieval, chipping to less than 2” top size, iron removal

Bin/silo for short term feed, under cover, to combustor

Bark and chips

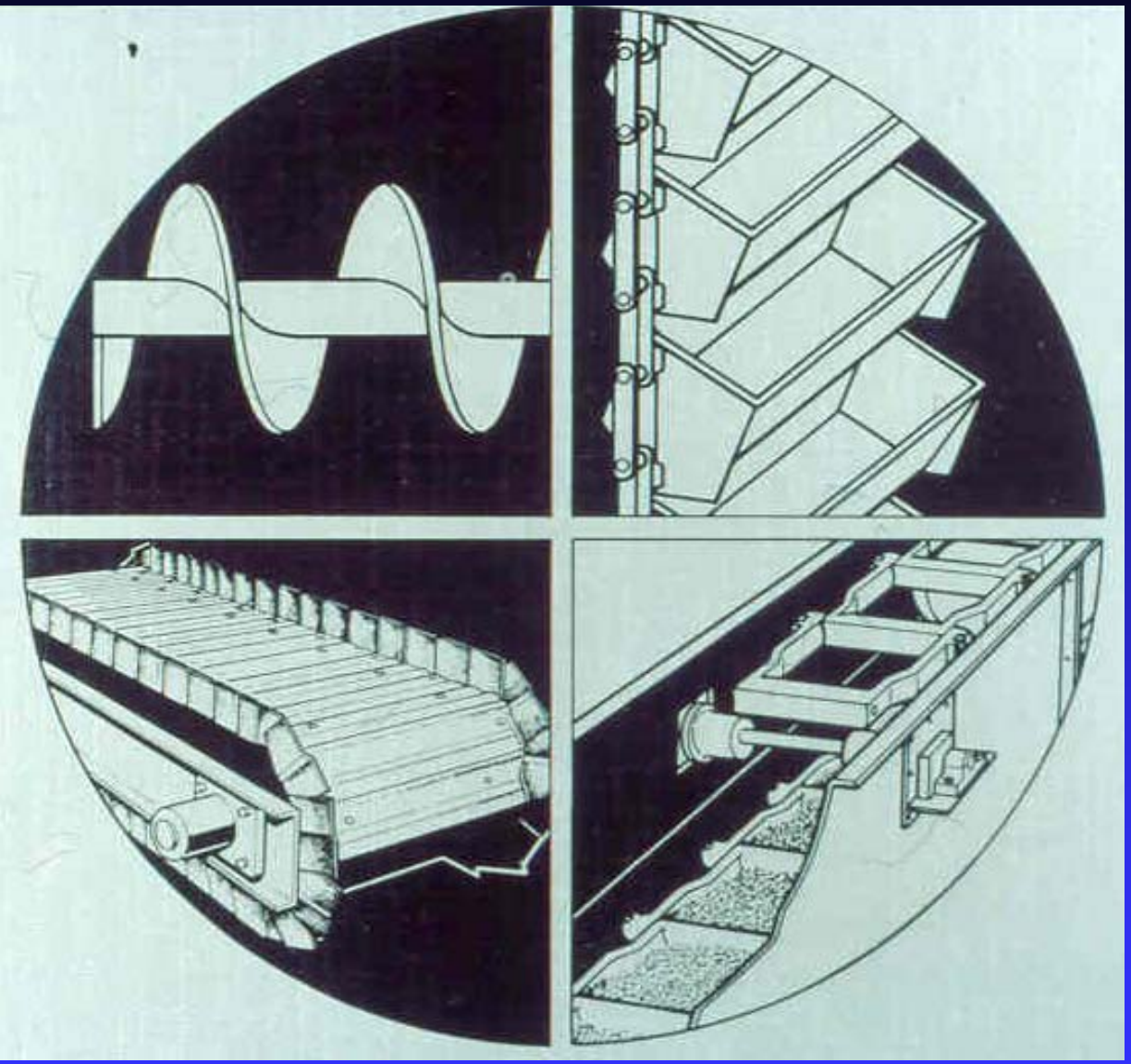


Peanut Hulls

Tractor/trailer dump

Requires supply contracts for sawmill waste, windfalls, C&D waste or whole tree chips

Conveying Auger, Bucket Elevator, Apron Conveyor & Drag Chain



Belt conveyor

Belts and augers most common conveyors

5 Cubic Yard Articulated Front End Loader

Matching the Fuel and the Equipment

Need combustion data before burning biomass:

- **Heating value, Btu/lb (kcal/kg)**
- **Moisture content**
- **Sulfur**
- **Chlorine**
- **Nitrogen**
- **Ash content, ash fusion temperature**
- **Density**

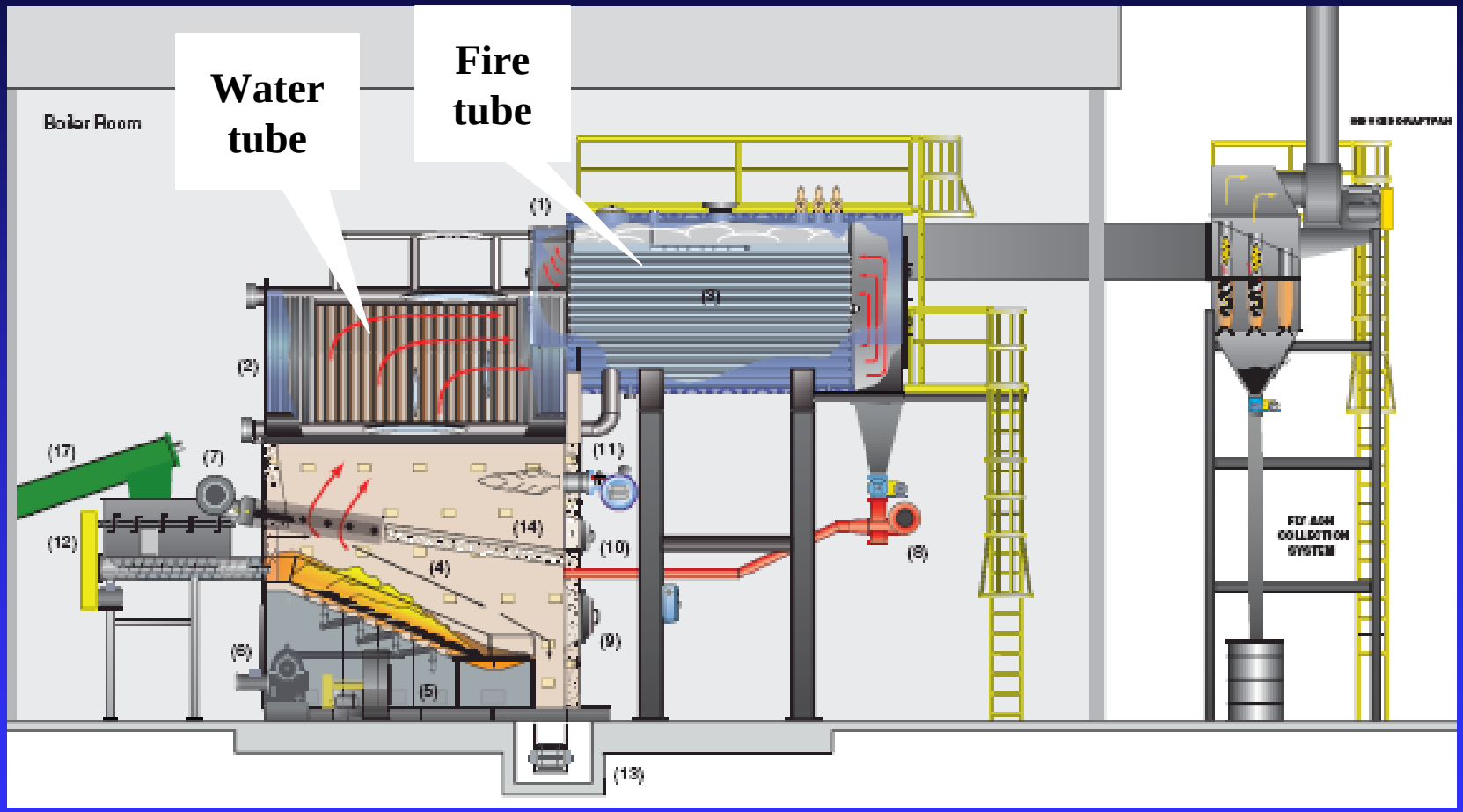
Wood Fired Boilers

- **Small units, HRT (horizontal return tubular) boilers (5-60K lb/hr steam)**
- **Larger units are water tube (50-500K+ lb/hr stream)**
- **Usually use pneumatic spreader stokers for suspension/grate burning; some sloped grates**
- **Larger sizes (e.g., 500K lb/hr steam) now use fluid bed combustors**
- **Many burn oil, gas, coal as aux fuel for load control, startup, and to maintain furnace temp**

Mid Sized Industrial Wood Fired Boiler System

Used with permission Hurst Boiler

Biomass Boilers – Hybrid HRT



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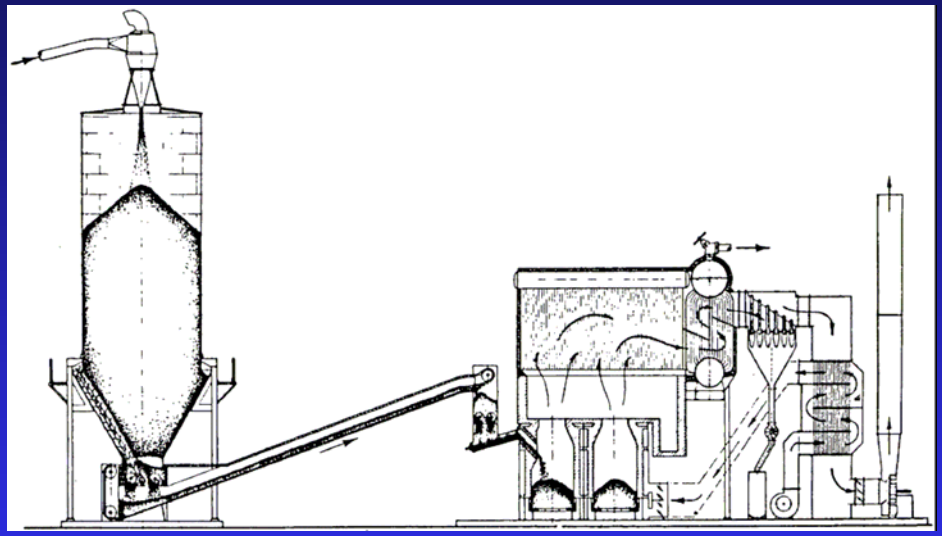
Biomass Boilers

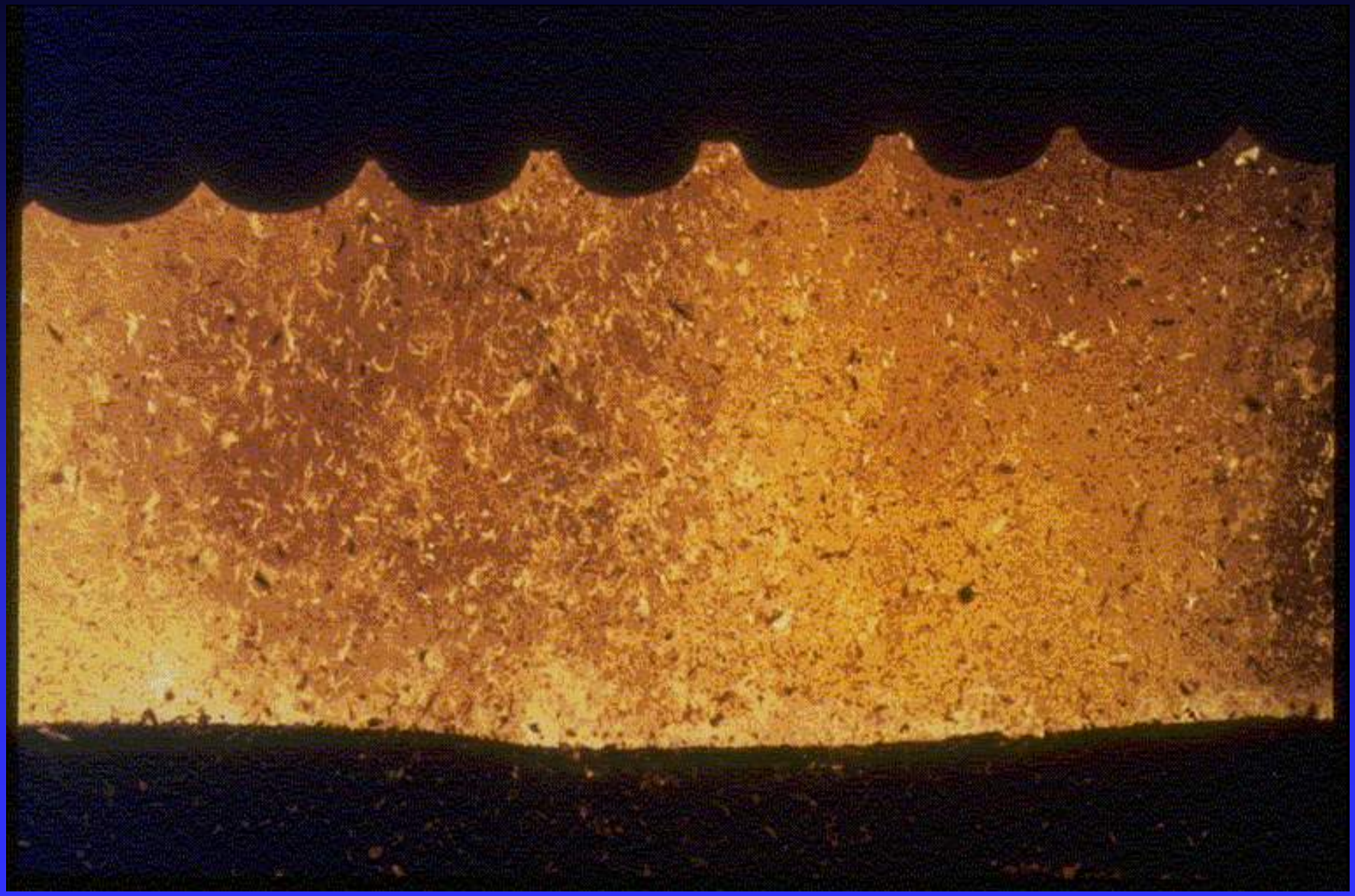
Hybrid water/fire tube

Used with Permission Hurst Boiler



Wellons dual cell type furnace with water tube boiler

Burning wood big time – 550 MM Btu/hr



48 MW Wood fired Power Plant – Craven County, NC

Built 1990; 540,000 tpy waste wood; two drum boiler/stoker system, 423,000 pph/1,500 psig/955F superheat

Used with permission: Indeck Keystone Energy

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Biomass Hot Gas Generator for Dryer

Used with permission WEI

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75 MM Btuh Hot Oil System

Used with permission The Teaford Company

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Suspension burners for dryers, wall firing for boilers

ASTEC prototype, @ 42 MM Btu/hr

ONIX suspension burner

Earth Care cyclonic suspension burner

COEN DAZ, wood, some gas

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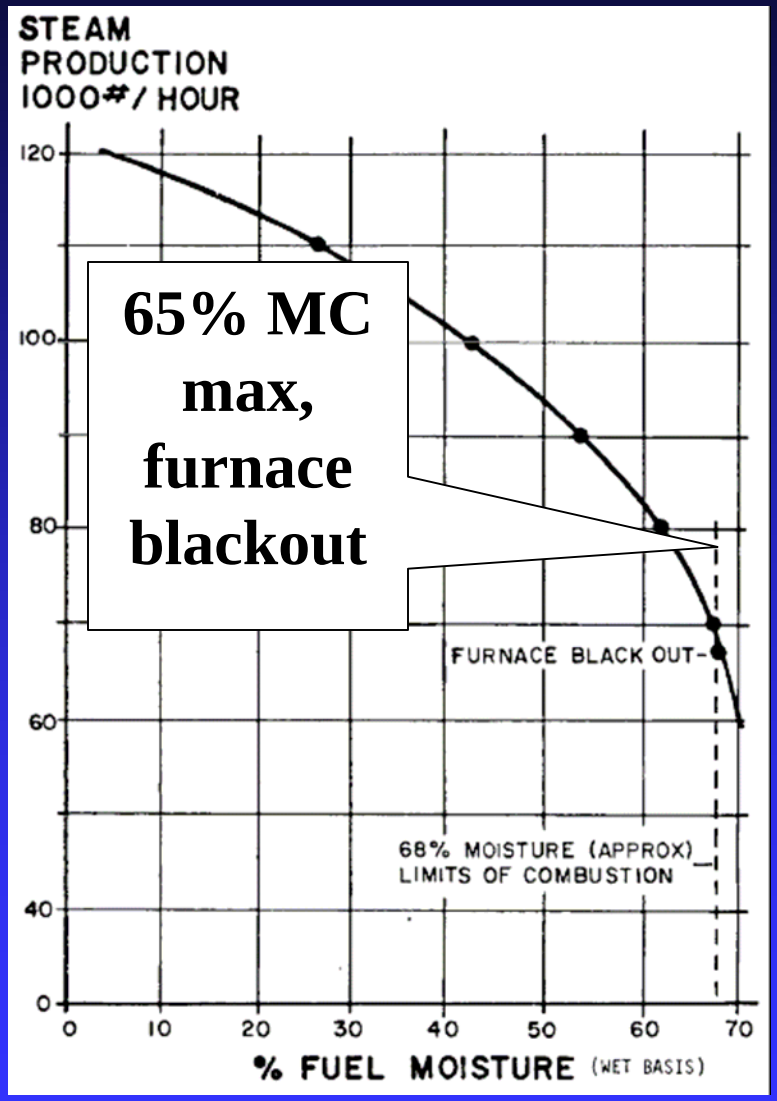
Moisture Content Counts - Drying a Plus



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Air Pollution Control

- **Smaller systems: Dual multiclones for PM**
- **Larger systems**
  - **Dry electrostatic precipitators and baghouses (sparklers and pinholes in the bags can be a problem); both yield dry ash suitable for use as soil amendment**
  - **Wet scrubbers (conventional venturis, Enviro Care's multi venturi system), yield a sludge product**
- **No SO2 or other HCl acid gas scrubbers required; trace amounts in fuel neutralized by alkalis in ash**

Cellulose Can Be Used to Produce Liquid Fuels

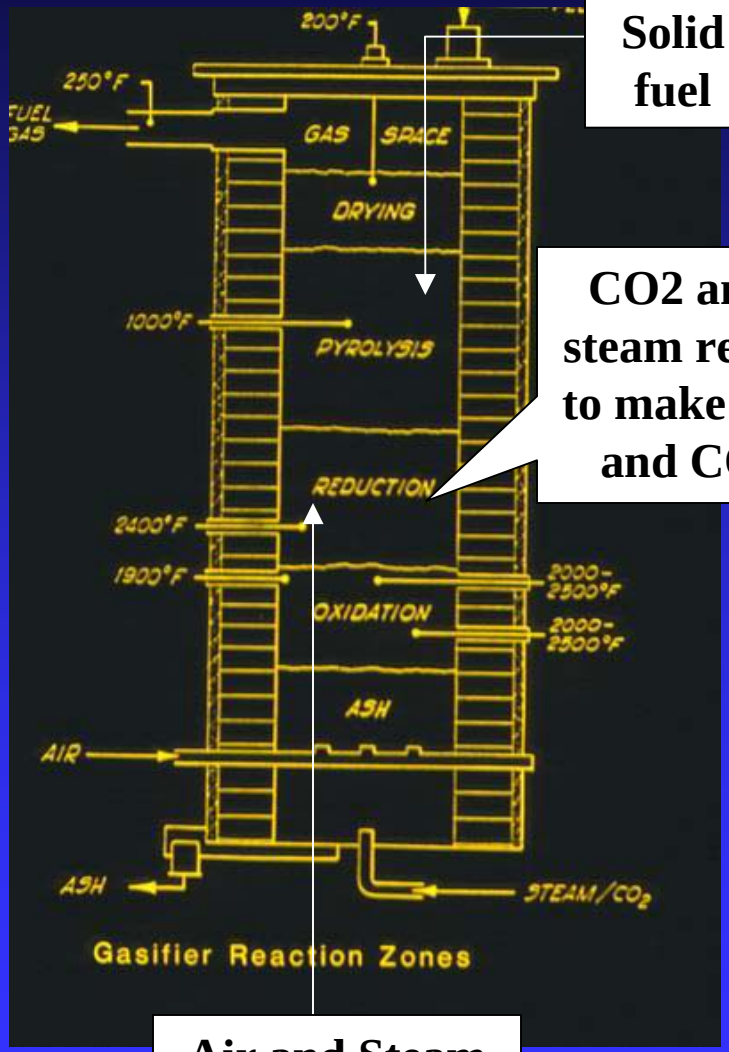
- **Rather than ethanol from corn -- alternate route that may be more promising in the long run is ethanol from wood**
- **Wood is converted into sugars for fermentation to ethanol, or gasified and reacted**
- **Not as CO2 neutral as direct firing**
- **Can also be used to create many more chemical feedstocks**

Explosion of activity in the Southeast!

- **15 ethanol from cellulose projects**
- **2 cogen -- 20 and 50 MW plants**
- **40 biomass power plants, 10-100 MW**
- **1 585 MW plant -- 20% biomass fired**
- **15 wood pellet plants**

Gasifiers convert solid fuels to fuel gas

Updraft Gasifier



Solid fuel

CO2 and steam react to make H2 and CO

Air and Steam

Downdraft Gasifier

Air & fuel

Gas out

Fluid bed Gasifier

Gas out

For close coupled, inject air into upper, dilute bed

Fuel goes into rich dense lower bed

Air & Steam

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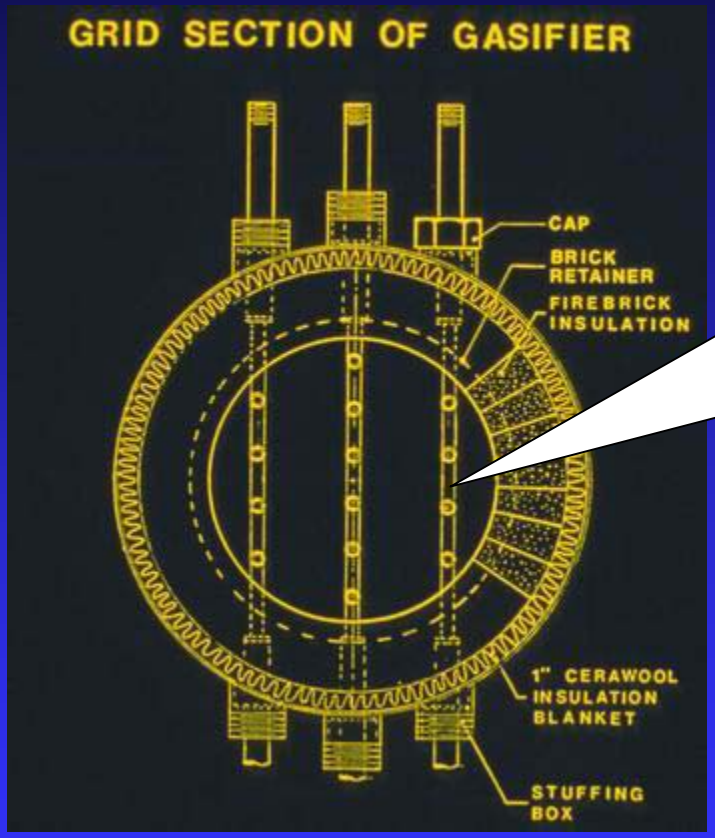
Gasifier Converting Wood to Low Btu Gas

GTRI R&D Updraft Gasifier

Gasifiers Internals -- a Critical Element



Grates can be inspected in place, and slide out for removal/ service

GTRI R&D Patented Grates for Fixed or Fluid Bed Use

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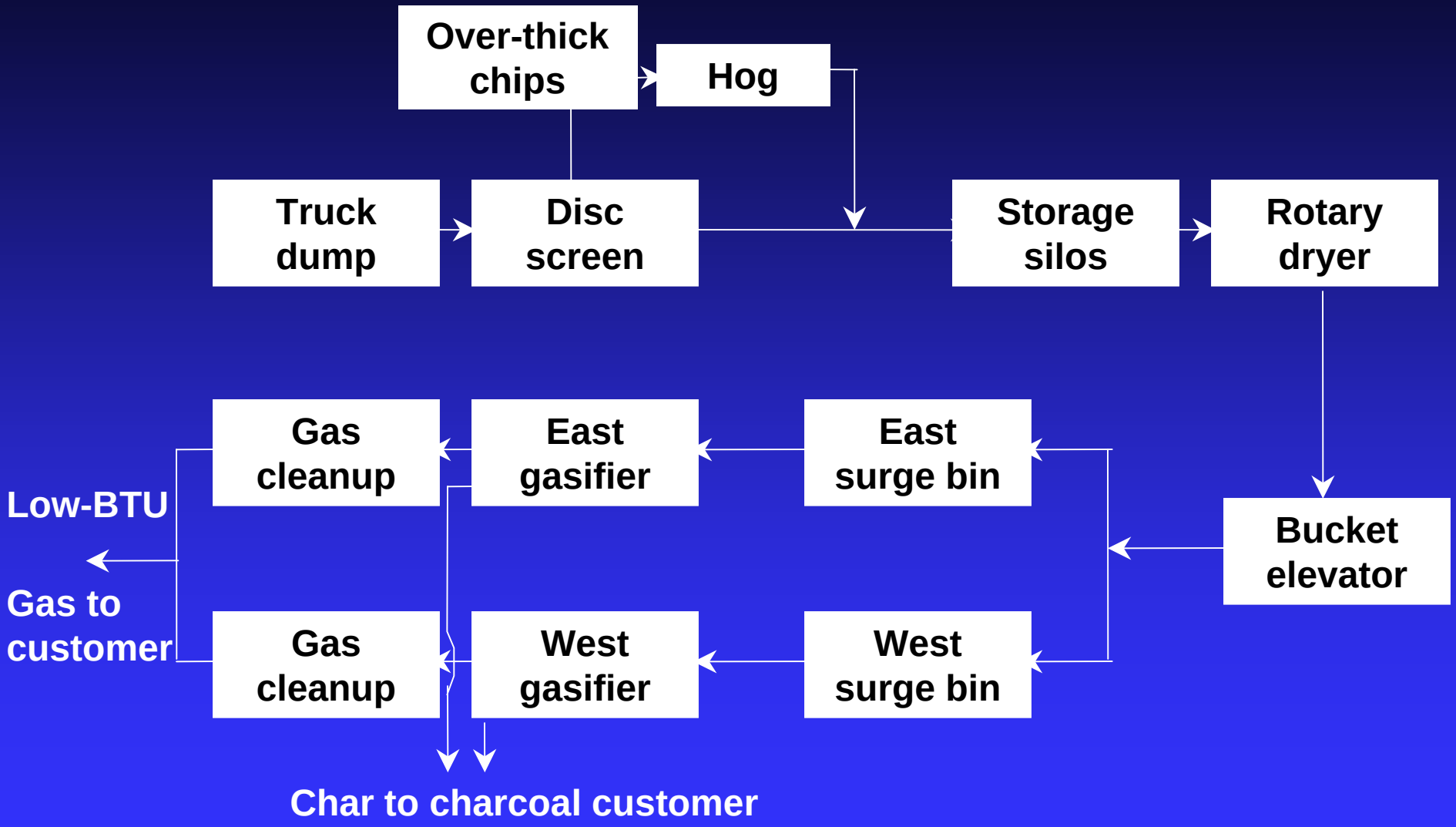
Gas Production

- **Amount: Up to 300 MMBtu/hr**
- **Heating Value: Up to 200 Btu/SCF**
- **Constituents**
  - **Hydrogen (H2) 13%**
  - **Carbon Dioxide (CO2) 16**
  - **Methane (CH4) 6**
  - **Ethylene (C2H4) 2**
  - **Ethane (C2H6) 0.3**
  - **Carbon Monoxide (CO) 16**
  - **Nitrogen (N2) 48**

Material Flow in the SEI Gasification Plant



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Gasification for Fuel Synthesis

- **The backbone of fuel synthesis (since ~1924) is the use of CO and H2**
- **CO + 2H2 → (-CH2-) + H2O (FT Diesel)**
- **CO + 2H2 → CH3OH (methanol)**
- **2 CH3OH → C2H6O + H2O (dimethyl ether, a new diesel substitute)**

Pellets and Other Engineered/Manufactured Fuels

- Pellets require a lot of power for size reduction and extrusion
- Used for residential systems here, and export to Scandinavia

- Alternates:
- Plyfuel© process; Flakefuel© in bulk; Briquettes; Torrefied wood; Biochar
- For developing countries, natural binders for charcoal fines

Used with permission
BioPellet

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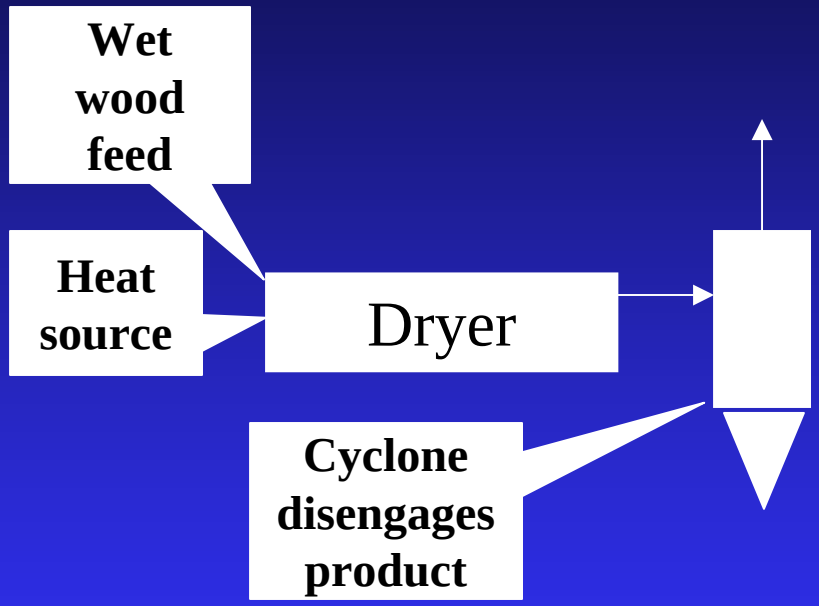
Torrefaction – removes water, some volatiles, makes it friable, grindable, hydrophobic

Raw wood

Torrefied -- After pilot plant processing, typically at ~200C

Used with permission: Feeco International

Drying wood prior to combustion via waste heat or wood fuel



Flighted dryer

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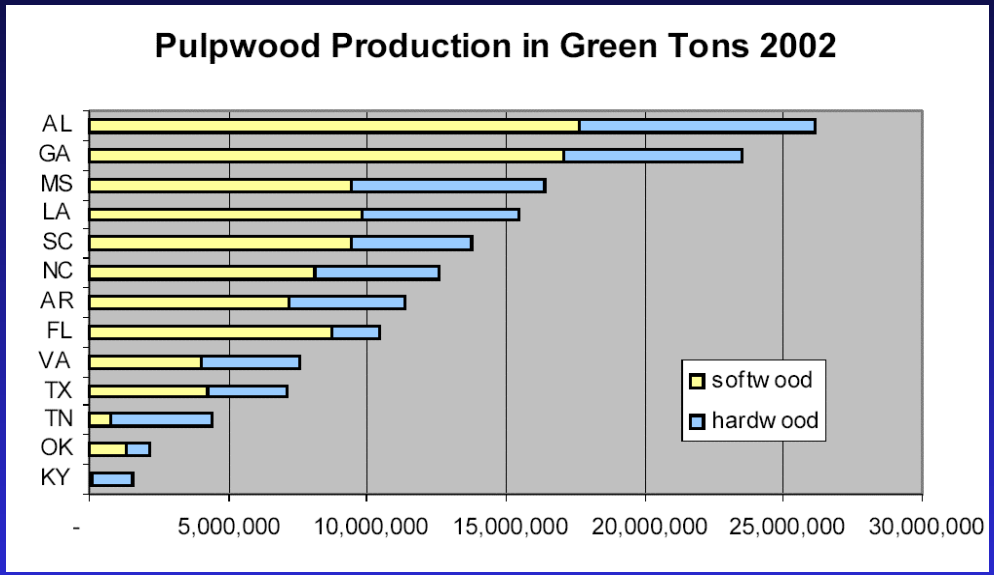
Southern Pine Resource:
Go where the wood is…

- Agricultural wood resource underutilized
- 18+ million green tons unused southern pine available per year in GA (sustainable)
  - ~730 million gallons ethanol equivalent
  - ~20% of GA's gasoline use
  - 30 year crop: 10 yr thin, 20 yr pulpwood, 30 yr saw timber, then replant



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National Wood Resource

Oak Ridge study:

Sustainable harvest 350 million dry tpy wood residue

Add to that ag burn or bury of 900 million tpy = 1.25 billion tpy

In comparison, annual coal production 1.17 billion tons, equivalent to 1.4 billion tons of biomass

Landfill Gas

- Renewable fuel (as long as we make trash)
- Three levels: Local use with minimum cleanup

  Engine gen sets for power production

  Upgrade to pipeline quality gas
- Not unusual to pipe gas up to 5 miles to end user
- Gas is ~50% methane; rest is CO2, N2, O2, water, H2S
- Generates big Greenhouse Gas credits, as CH4 is 21 X Greenhouse gas compared to CO2

Landfill Gas for Power Generation – Two CAT 1.6 MW Spark Ignited Engines

Landfill gas ~500 Btu/ft3, from bio decom-position

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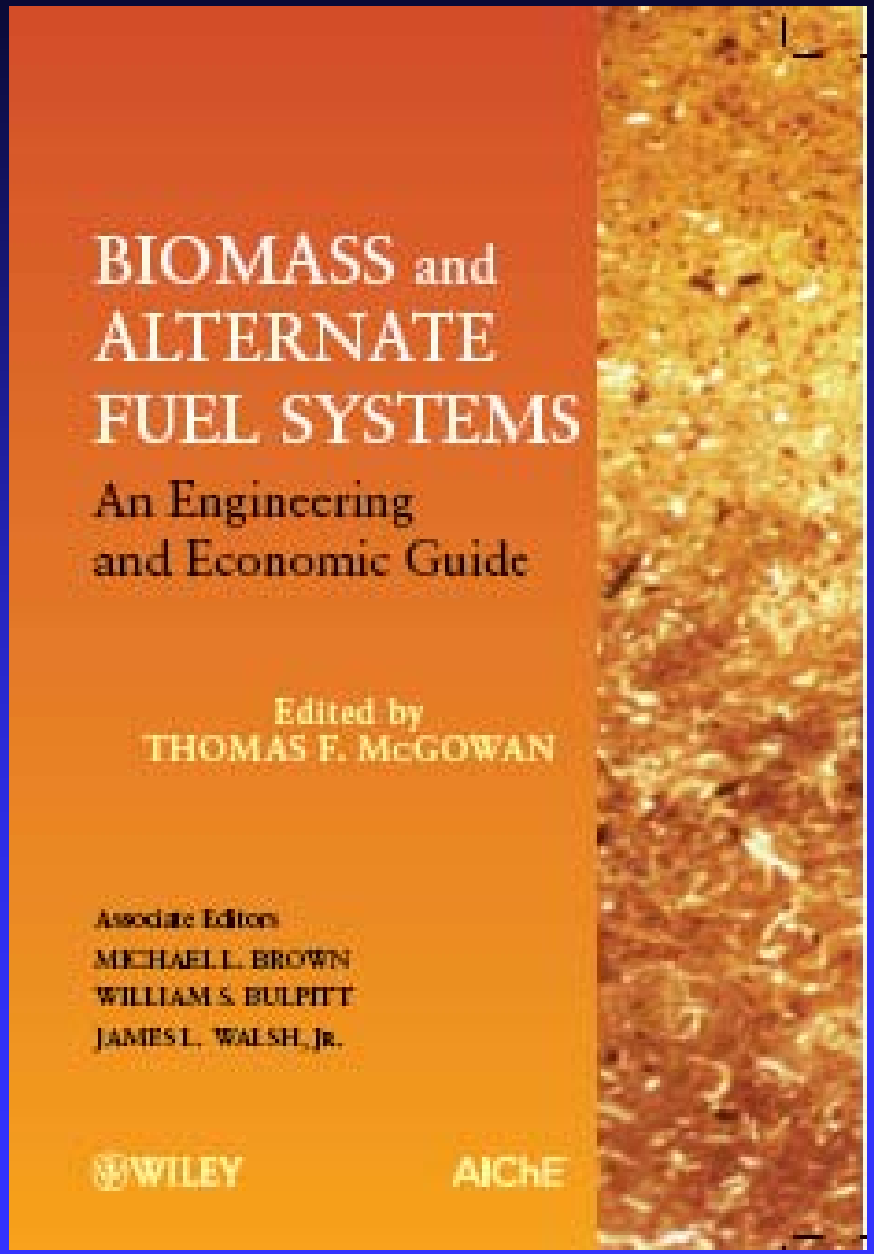
SUMMARY

Switching to biomass can save $$$, and is CO2 neutral

However:

- **Properties of the fuel and end use application must be known**
- **Need assurance on fuel supply**
- **Must assess potential changes in emissions and**
- **Need to run the economics!**

The Book for Those Who Want More Details…



Available from John Wiley & Sons and Amazon.com

http://tinyurl.com/Amazon-biomass-book

For further information, contact

Tom McGowan

TMTS Associates, Inc.

404 627 4722

tfmcgowan@mindspring.com

http://tmtsassociates.home.mindspring.com