Upgrading Biomass Fuels:
Sizing, Drying, Torrefaction, Densification

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Thomas F. McGowan, PE
TMTS Associates, Inc.
tfmcgowan@mindspring.com
404 627 4722

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Task: Make the fuel fit the equipment while minimizing all costs, including transportation

- Sizing
- Drying
- Torrefaction
- Densification

How much is too much feed prep?

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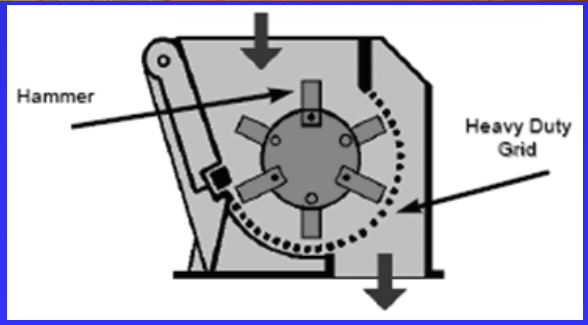
In-forest chipping, or landfills

Courtesy Peterson/ASTEC

At plant -- front end loader, drag chain, hammermill

Courtesy Earth Care Inc.

Standard 2 x2 x ¼ chips



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Chips vs. micro chips – easier drying, conveying

~1/4” top size, x 1/8” thick

Bonus: Power cut in half!!!

Courtesy Peterson/ASTEC

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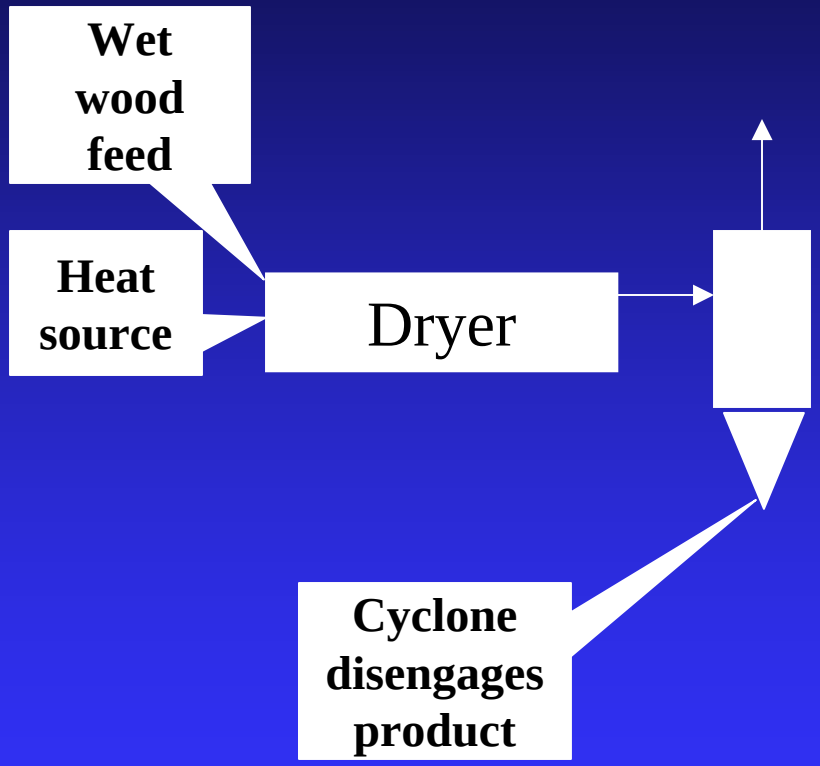
Drying wood prior to combustion via waste heat or wood fuel



Flighted dryer

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Suspension burners for dryers

ASTEC prototype, @ 42 MM Btu/hr

ONIX suspension burner

Earth Care cyclonic suspension burner

COEN DAZ, wood, some gas

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Dryer Costs

- **About $1MM for 100 MM Btu/hr dry fuel output system, including size reduction and burner**
- **Multi-pass dryers cut capital cost**
- **Smaller feed means smaller dryer**
- **Burning wood, need to blend inlet temperature down to reduce chance of burning in dryer drum**
- **Using flue gas at 450F as heat source saves fuel, but increases dryer size and dryer cost**
- **Cost to dry, ~ $4/wet ton**

What does it cost to dry wood?

(Costs: Capital, maintenance, power, labor, etc.)

- **Fuels savings: Difference in LHV (lower heating value), plus sensible heat in water vapor -- from 50% to 10% MC, gain in heating value = 13%**

- **Boiler example: Fuel saved in not having to vaporize water from 60F to 450F, 1176 Btu/lb water**

Feed rate, wet	Hot gas	$10/ton wood	$30/ton wood
7 tph	**$4/MM Btu gained**	**$5/MM Btu gained**	**$8/MM Btu gained**
30 tph	**$2.5/MM Btu gained**	**$4/MM Btu gained**	**$7/MM Btu gained**

Next step up -- torrefaction – removes water, some volatiles, makes it friable, grindable, hydrophobic

Raw wood

Torrefied -- After pilot plant processing, typically at ~200-300C

Used with permission: Feeco International

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MO Utility Test Coal/Torrefied Wood

Laboratory Analysis for Wood, Coal, Torrefied Wood, 20/80 Blend

	Moisture %	Ash %	Sulfur %	Nitrogen %	Carbon %	Volatile %	BTU Lb
100% Wood Chips	27.25	1.22	0.12	0.12	35.3	59.1	6083
100% Coal	26.6	4.86	0.23	1.06	51.24	32.86	8825
8/11 Torrefied Biomass	18.78	1.74	0.01	0.25	70.52	15.14	11604
8/13 Torrefied Biomass	5.63	3.14	0.01	0.26	61.93	47.63	10380
20/80 Coal Belt Blend	22.83	4.26	0.18	0.89	52.22	36.59	8911
Calculated Blend	22.41	4.52	0.19	0.90	53.38	35.81	9136
20/80 Standpipe Blend	23.63	4.26	0.18	0.97	51.98	36.16	9210
20/80 Coal Pipes Blend	17.27	4.96	0.23	1.06	57.03	39.64	9821
100% Coal from Coal Pipes	20.32	5.16	0.24	1.12	55.63	36.59	9601

Note: The high moisture content in 8/11 Torrefied biomass is surface moisture caused by spraying water used for cooling.

Courtesy Earth Care Products, Inc.

Major markets?

- **Utility power production**
- **Industrial facilities to provide steam and power**
- **100% biomass -- or co-firing with coal**
- **Foreign export for CO2 compliance**

Densification

- Improves shipping; lowers shipping cost
- Material is also dried as part of process
- Big issue is cost -- @ $150 ton = $10/ MM Btu

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

Courtesy ASTEC/Breaker Technologies

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Other Engineered/Manufactured Fuels

- **Plyfuel©**
- **Flakefuel© in bulk**
- **DMC Fuel© in bulk**
- **Briquettes**
- **Bioenergy bales**
- **Torrefied wood**

Briquettes

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BioPellet

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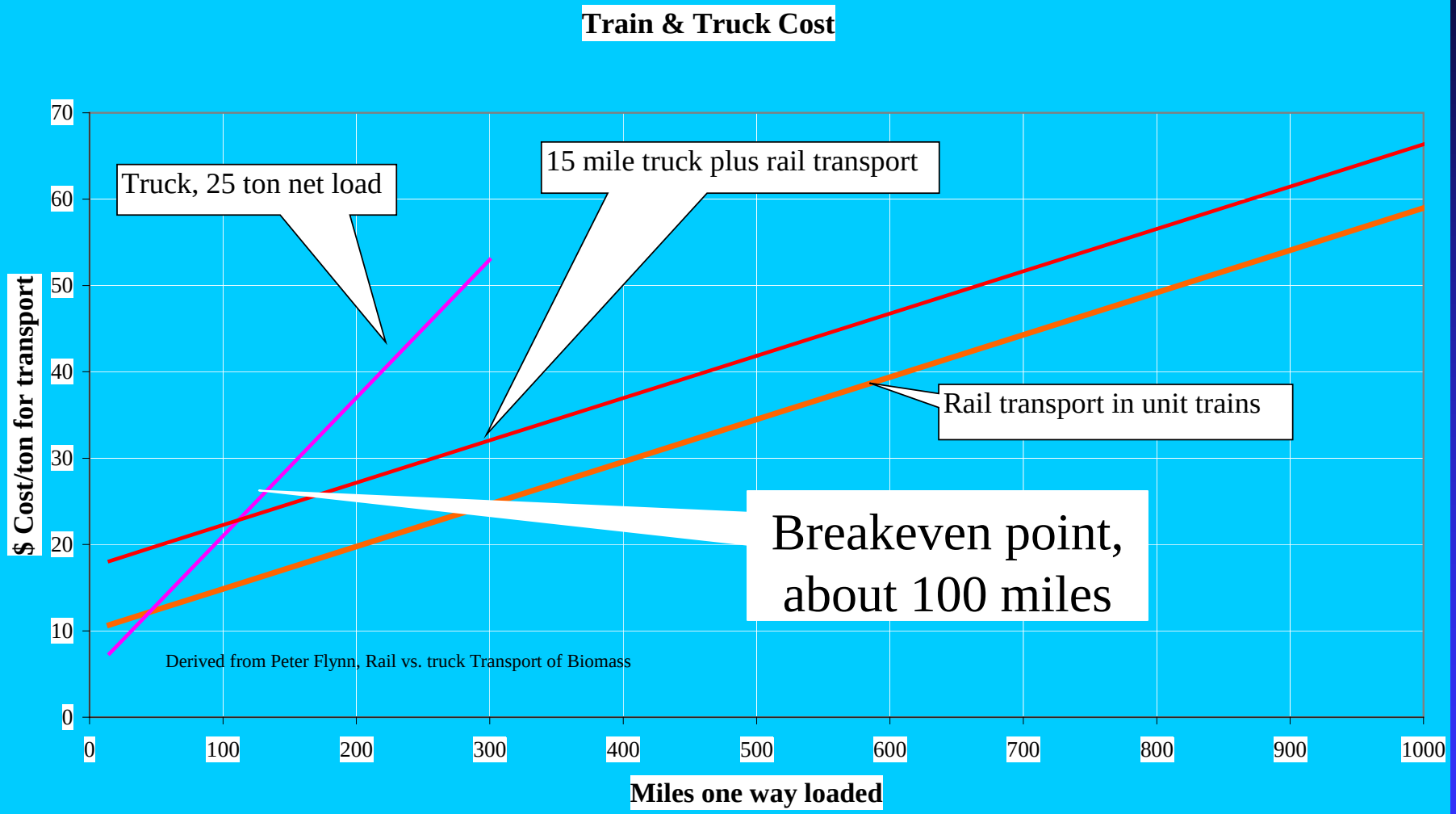
Transportation options and costs



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Standard Chip Van – 25 ton net load

Top or end loading ~$4 per loaded mile

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Other Transportation Options

- High volume vans for low density material (150 yds)
- Barge/ship transport
- Train transport/unit trains

Rotary car dumper, stacking conveyor

Bottom dumper

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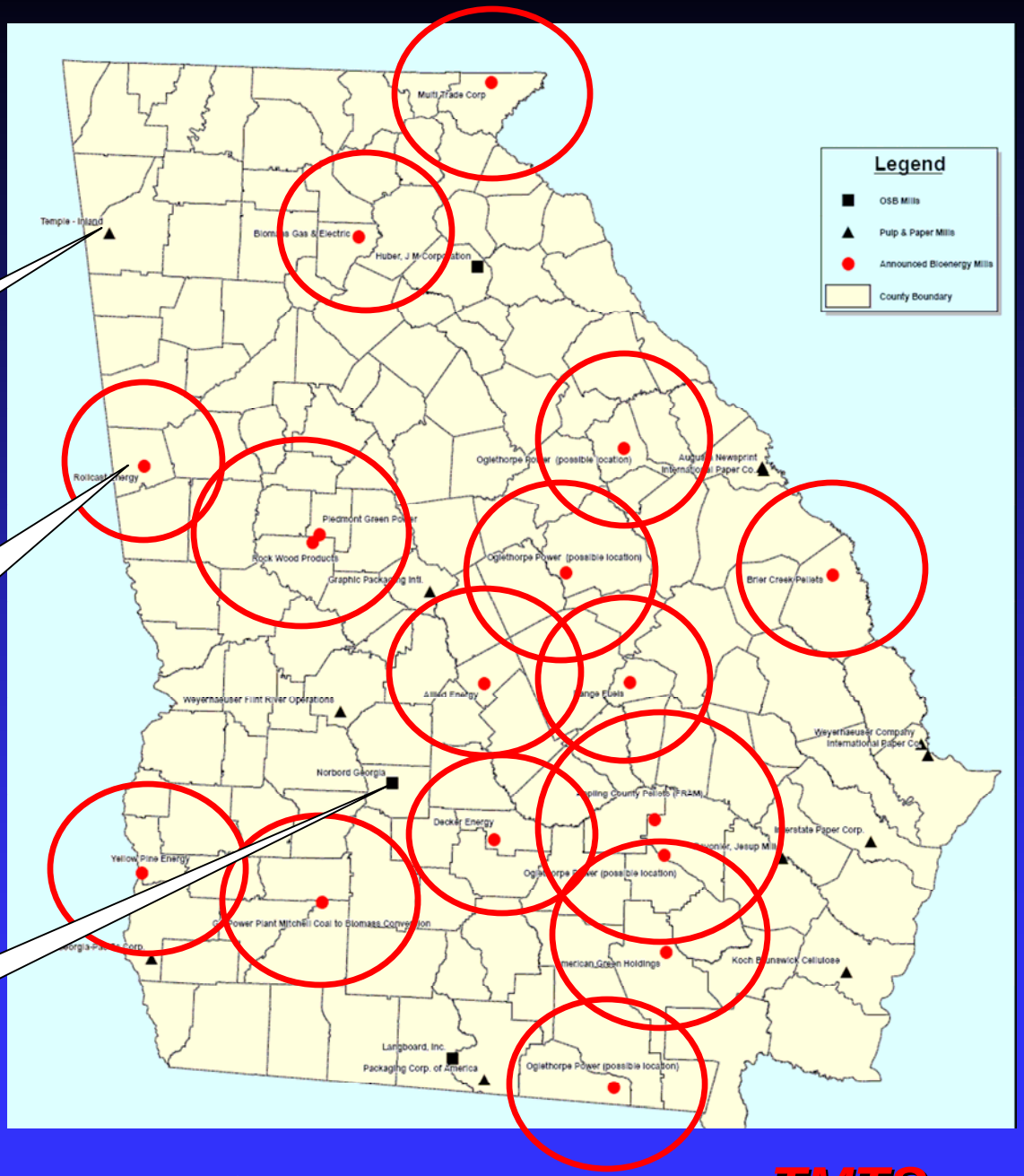
Current, Planned and Potential Wood Users – Its All About Shipping Distance

Pulp and Paper

Announced bio power plants

OSB Plants



Source: Georgia Forestry Commission

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Fuel Value and Cost - Industrial

Fuel	Approximate Cost, $/MM Btu
Natural gas	$4.58 *
Propane (winter cost higher!)	$14.03 (industrial wholesale) **
No. 2 fuel oil	$9.31 *
No. 6 fuel oil	$5.14 *

Fuel	Approximate Cost, $/MM Btu
Coal	$2.15 (Utility)
Pet coke/TDF	$1.49/$1.61
Wood waste	$1.20
Whole tree Chips	$3.20
Tub grind waste	$2.60
Pellets	$10@ $150/tn
Chicken litter	$1.20

* Data collected December 2009

** Data collected 12/09

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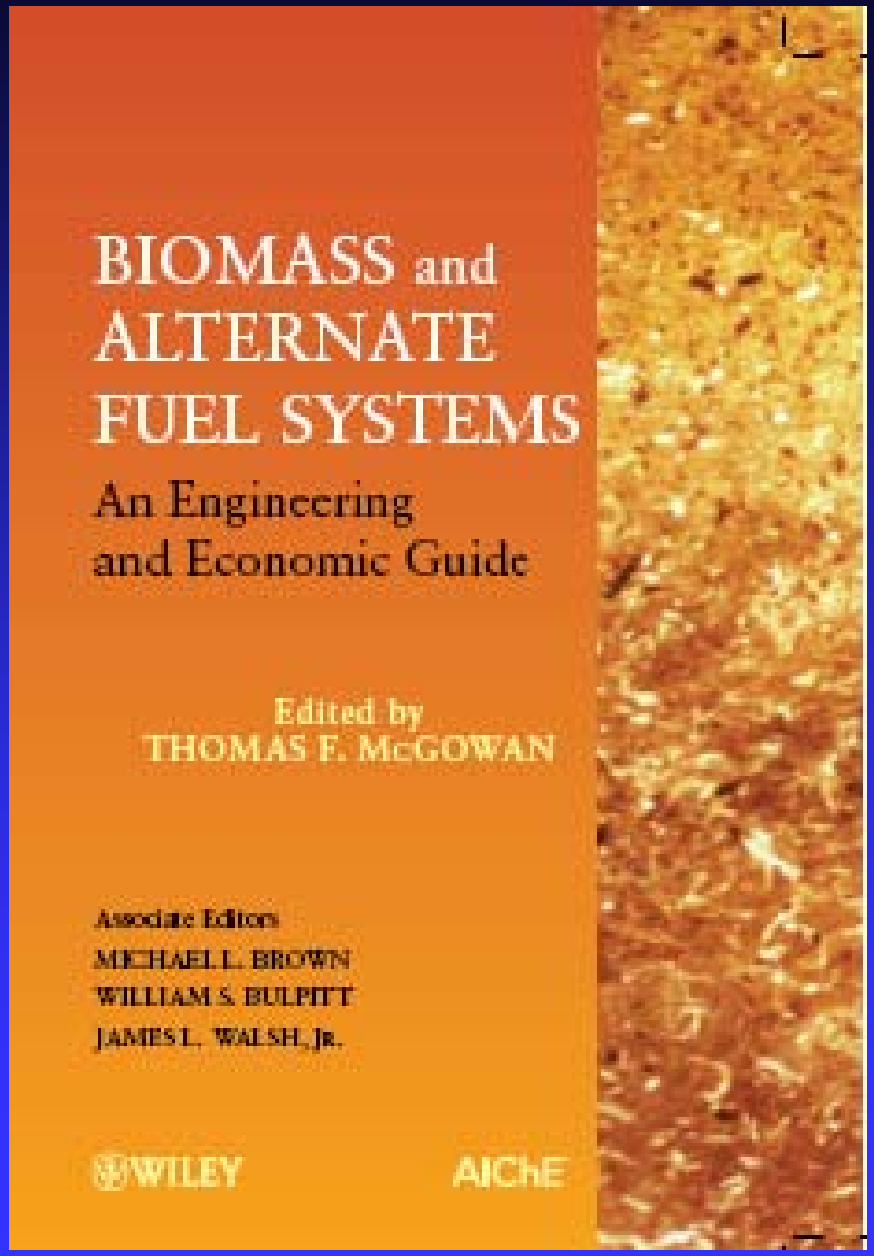
The Book for Those Who Want The Details



Available from John Wiley & Sons and Amazon.com

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

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SUMMARY

- **Size reduction is a must for transportation, handling and combustion**
- **Drying may be advantageous to allow higher burning rates and lower shipping costs**
- **Densification (pellets, briquettes) aids in shipping and storage, but is costly**
- **Always do the least preparation required for the equipment, and as dictated by economics**