Western Forest Economists
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Biomass Energy Economics

Presented by
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John Martin
Background & Experience

- B.S. and M.S. Mechanical Engineering
- 42 Years in Thermal Power Systems
  - Gas Turbine Design
  - Electric Power Plant Design & Construction
  - Cogeneration
  - 15+ Biomass Power Projects - past 19 years
- At Pacific Energy Systems – 19 years

Pacific Energy Systems, Inc.

- Energy Consulting Firm
  - Industries
  - Utilities/Independent Power Producers
  - Colleges and Universities
  - Banks and Financial Institutions
- Focus on Electric Power and Steam Generation
- Extensive Experience with Biomass Energy

Biomass Energy Economics
Scope of Discussion

Large Industrial and Utility Energy Facilities

- Industrial Steam Systems (100,000 lb/hr & greater)
- Thermal Electric Power (10 to 50 MW)
- Combined Heat & Power (5 to 50 MW)

Brief Biomass Energy History

Large Industrial/Utility Systems

- Early 1900's - District Heating and Power
- 1900's to Present-Numerous applications - forest products
- 1950's through 1980 - Fewer applications for power production (cheap electricity and fossil fuels)
- Late 1980's - Resurgence based on mandated contracts
- After 1994 - few if any new plants
- 2000's - Resurgence based on:
  - Increasing cost of fossil fuels - oil and natural gas
  - Global warming/greenhouse emissions
  - Government mandate for renewable energy resources

Characteristics of Biomass Steam Systems

Capital - $5 to $15 Million

Fuel for 50,000lb/hr avg. - 65,000 green tons/yr

Efficiency - 70%+

Jobs - Fuel supply

Economic Development - local industry

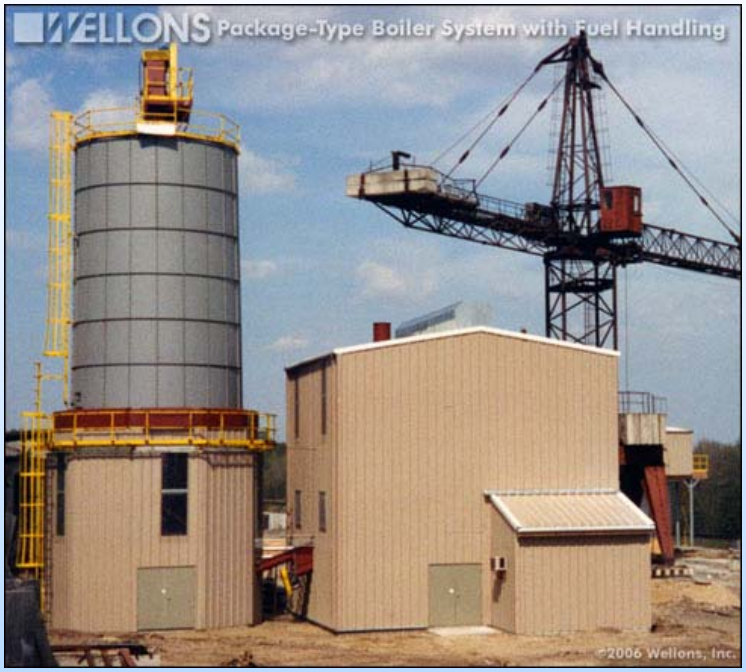
Incentives(Oregon) - BETC's, SELP, HB2210

Global Warming - Positive impact, if sustainable

Significant space for fuel storage and equipment

Additional operating staff compared to gas/oil

Non-fuel O&M Costs greater than gas/oil fuels

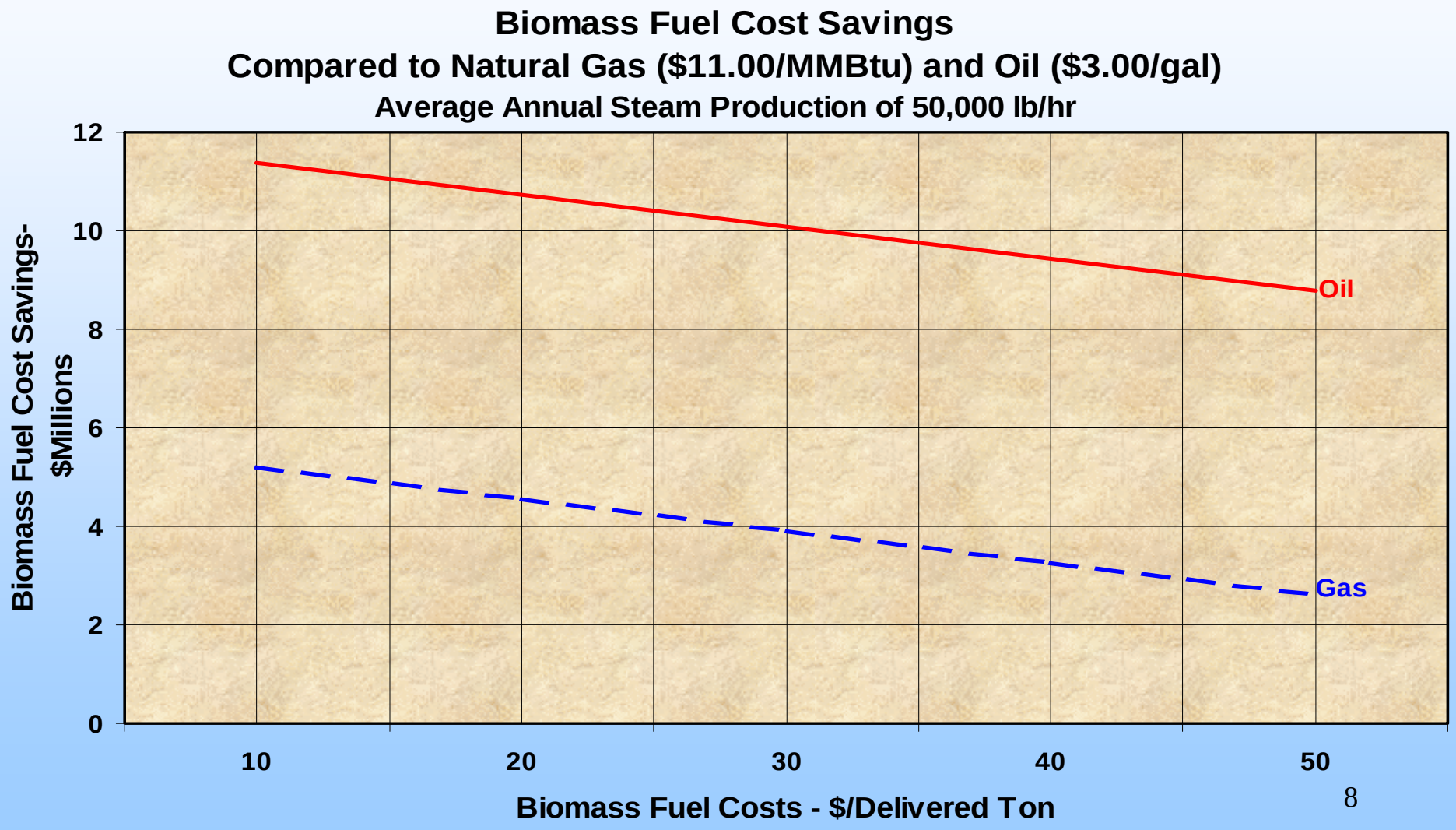


Comparison of Steam Fuel Cost [a]

Factor	Natural Gas	Biomass [b]	Oil
Assumed Fuel Cost	$11.00 per MMBtu	$20.00 per Ton [c]	$3.00 per Gallon
Fuel Cost per MMBtu	$11.00	$2.14 [b]	$19.23
Assumed Boiler Efficiency	82.0%	72.0%	84.0%
Fuel Cost per 1,000 lb of steam	$13.41	$2.98	$22.89
Annual Cost - 50,000 lb/hr	$5,875,610	$1,303,200	$12,032,967
Annual Biomass Fuel Savings – 50,000 lb/hr Average	$4,572,410	Base	$10,729,768

a. Assumed steam condition 150 psia, saturated, and 1,000 Btu/lb of steam produced.
b. Based on 45% moisture and higher heating value of 4,688 Btu/lb wet.
c. Wood cost delivered at 45-percent moisture.

Biomass Fuel Cost Savings



Thermal-Electric Power Production

Fuel required for 40 MW – about 527,000 green tons/yr

Capital cost $90 to $110 million

Efficiency – 23%

Construction jobs – 40 to 80

Construct duration – 18 mo.

Jobs for plant operation – 21

Jobs for fuel production - numerous

Incentives– (Oregon) BETC's, SELP and RPS, and Federal Production Tax Credits?

Global Warming- Positive, if sustainable

Requires about 20 acres minimum

Biomass Power Plant Characteristics

- Minimum Plant Size – 10 MW
- Maximum Plant Size – 50 MW
- Strong Economy of Scale Favors Larger Plants
  - Capital Cost
  - Operation & Maintenance Staffing Cost
  - Performance (More Efficient)

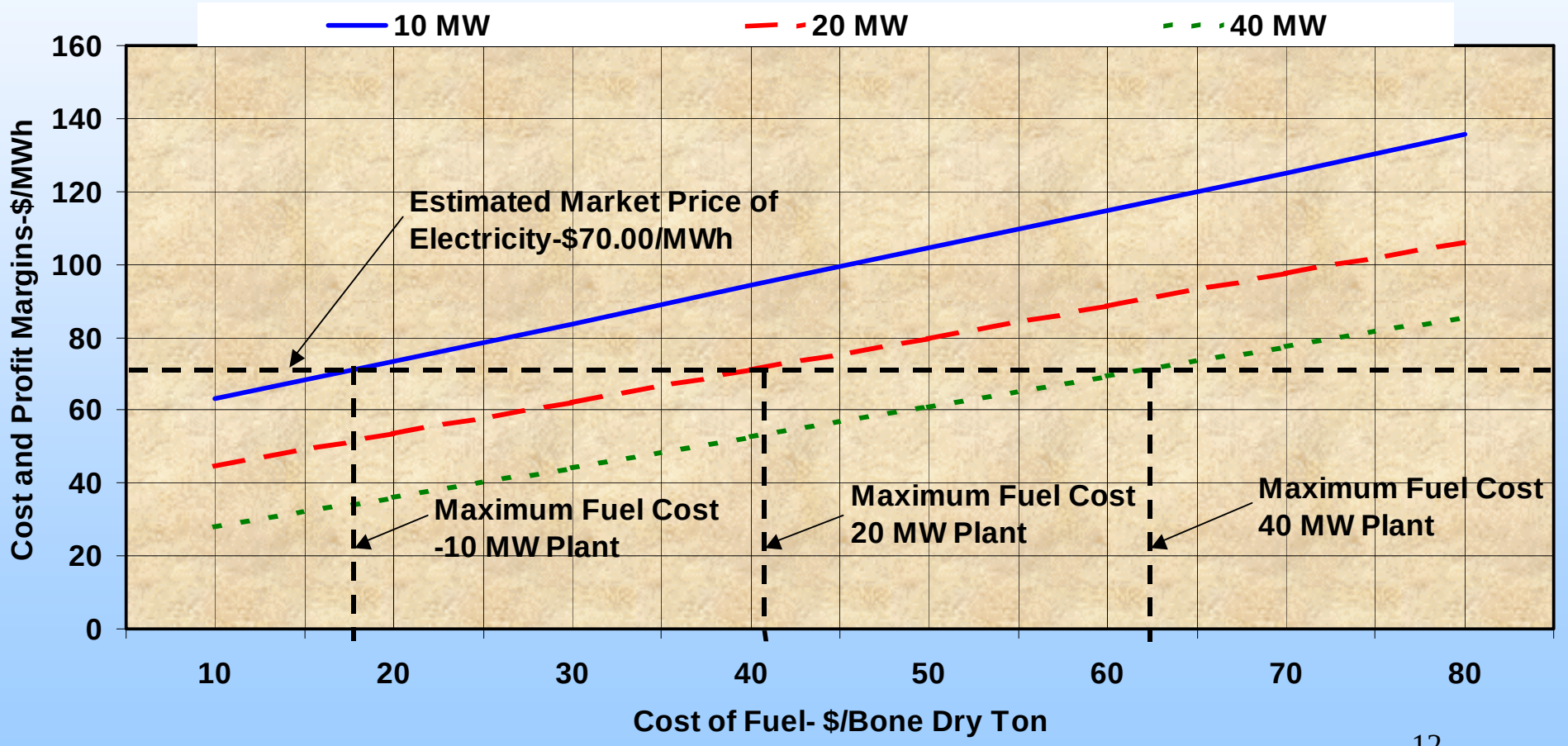
Biomass Power Plant Fuel Requirement

Plant Capacity MW	Heat Rate Tons/MWh [a]	Annual Fuel Tons [b]
10	2.0	165,000
20	1.70	280,000
40	1.60	527,000

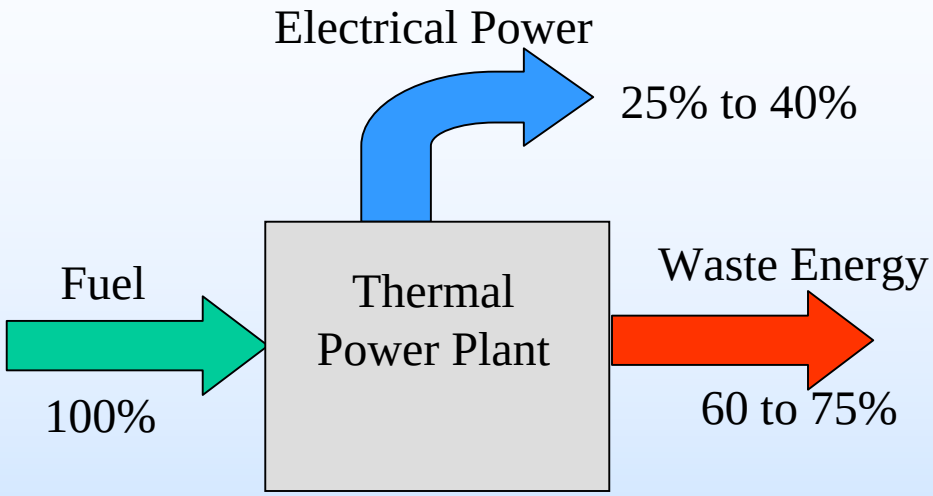
[a] Based on a fuel moisture of 45% and a higher heating value of 8,400 Btu/lb dry.

[b] Based on the design output, heat rate, and an annual capacity factor of 94%.

Fuel Cost, O&M Cost, and Profit Margins
Biomass Power Generation-$/MWh



Typical Thermal Power Plant Efficiencies



	Heat Rate	Electrical Efficiency
Natural gas combined-cycle	7,500 Btu/kWh	45.5%
Coal-fired steam-electric	10,000 Btu/kWh	34.1%
Biomass-fired steam-electric	15,000 Btu/kWh	22.7%

Combined Heat & Power Production

Fuel for 200,000 lb/hr steam & 5 MW? About 280,000 ton/yr @ 45% Moisture.

Capital cost $20 to $40 million

Efficiency – 70%

Construction jobs – 40 to 80

Construct duration – 18 mo.

Jobs for plant operation – 10

Jobs for fuel production - numerous

Incentives – (Oregon) BETC's, SELP and RPS. Federal Production Tax Credits?

Global Warming- Positive-if sustainable

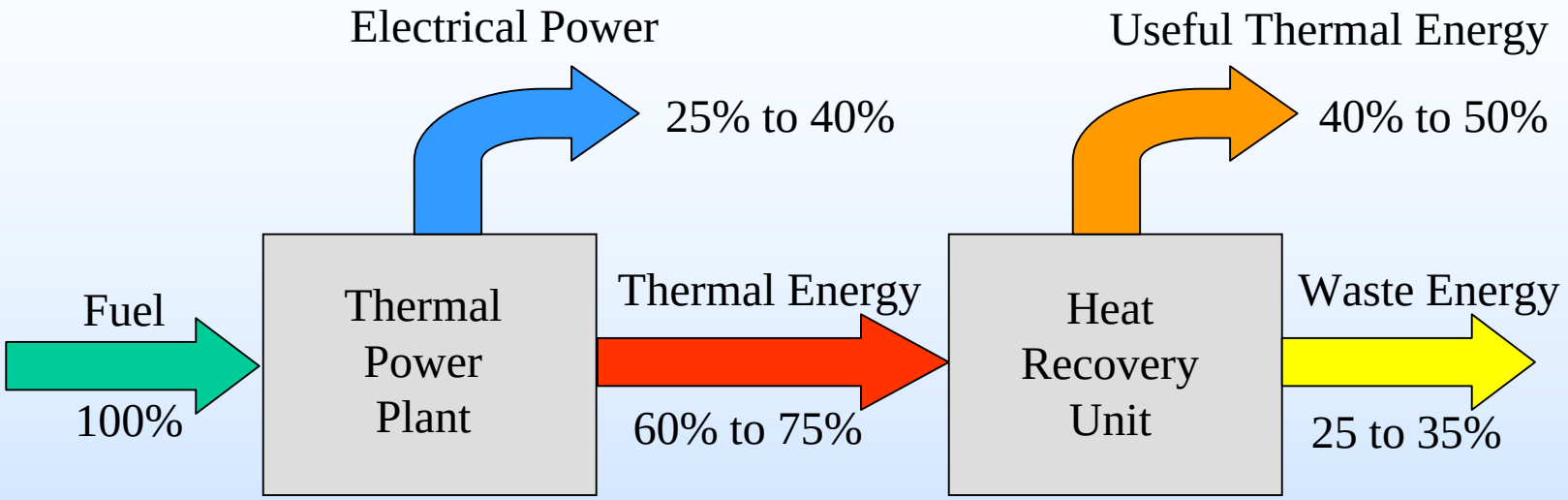
Requires between 10 and 15 acres

Biomass High Efficiency CHP Advantages

- Lower Capital Cost
- Lower Operation & Maintenance Costs
- Higher Efficiency for Power Generation

Annual Fuel-Tons	Steam Produced	Estimated Power
165,000	100,000 lb/hr	2,450 kW
280,000	200,000 lb/hr	5,700 kW
527,000	392,500 lb/hr	11,200 kW

Typical Power Plant Efficiencies



	Heat Rate	Electrical Efficiency	Overall Efficiency
Natural gas combined-cycle	7,500 Btu/kWh	45.5%	45.5%
Coal-fired steam-electric	10,000 Btu/kWh	34.1%	34.1%
Biomass-fired steam-electric	15,000 Btu/kWh	22.7%	22.7%
Biomass-fired CHP	8,500 Btu/kWh	40.1%	70.0% max

Funding and Incentives

- Oregon Business Energy Tax Credit (BETC's)- Tax credit of 50% of qualified costs.
- Oregon Bio-fuels Act of 2007 (HB 2210)-$10.00 per green ton transferable tax credit for "collectors" of waste biomass used for fuel.
- Oregon State Energy Loan Program (SELP)
- Oregon Renewable Portfolio Standard (RPS)
- Energy Trust (Oregon)
- Climate Trust
- Federal Energy Production Tax Credits ?

Important Conclusions

- Biomass energy is an important economic resource.
- High efficiency biomass CHP is very attractive from an economic and energy efficiency prospective.
- Neutral greenhouse gas if done sustainably.
- Development of biomass energy systems will depend on the a robust and reliable biomass fuel supply- target price between $20.00/BDT and $40.00/BDT.
- Biomass energy systems are very capital intensive.
- Biomass O&M is higher than other fuels.
- Large incentives for collectors of fuels/feedstock.

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Thank You!

John R. Martin