Reinhold Environmental Ltd.

2009 APC Round Table & Expo Presentation

July 12-14, 2009, in The Woodlands, TX

Biomass Co-Firing
Combustion and Boiler Impacts

Panel Discussion

Led by

Steve Johnson

Quinapoxet Solutions

13 July 2009

Panel Overview

- **Today's Agenda**
  - **Co-firing Methods**
  - **Co-firing Experience**
  - **Advantages and Technical Concerns of Co-firing**
  - **Impacts of Co-firing on Emissions**
  - **Economics of Co-firing**

QUINAPOXET SOLUTIONS

Renewable Drivers (SCS)

- **Current renewable power drivers:**
  - **The political and societal movements toward capping CO2 emissions from power plants to curtail global warming**
  - **State and Federal Renewable Portfolio Standards**
  - **Cost and dependence on imported fuels**
  - **Current Administration's Agenda**

Renewable Portfolio Standards (RPS) or Renewable Electricity Standard (RES)

- **Currently 28 of the 50 US states and the District of Columbia have adopted a RPS.**
  - **RPSs range from 105 MW in Iowa to 25% by 2025 in Oregon.**

- **Nationally there are multiple proposed bills:**
  - **Binghaman – 20% by 2020, Efficiency up to 5%, 5M MWh and up.**
  - **Markey – 25% by 2025, no EE, 1M MWh and up.**

QUINAPOXET SOLUTIONS

Potential Co-Firing Advantages

- **Simpler than 100 percent biomass**
  - **Quicker to implement**
  - **Lower capital investment**
- **Lower-cost fuel**
- **Reduced emissions**
- **Tax credits**

QUINAPOXET SOLUTIONS

Co-Firing Issues

- **Lower energy density of biomass**
- **Compatibility with coal handling and feeding equipment**
- **Reliability and consistency of biomass sources**

QUINAPOXET SOLUTIONS

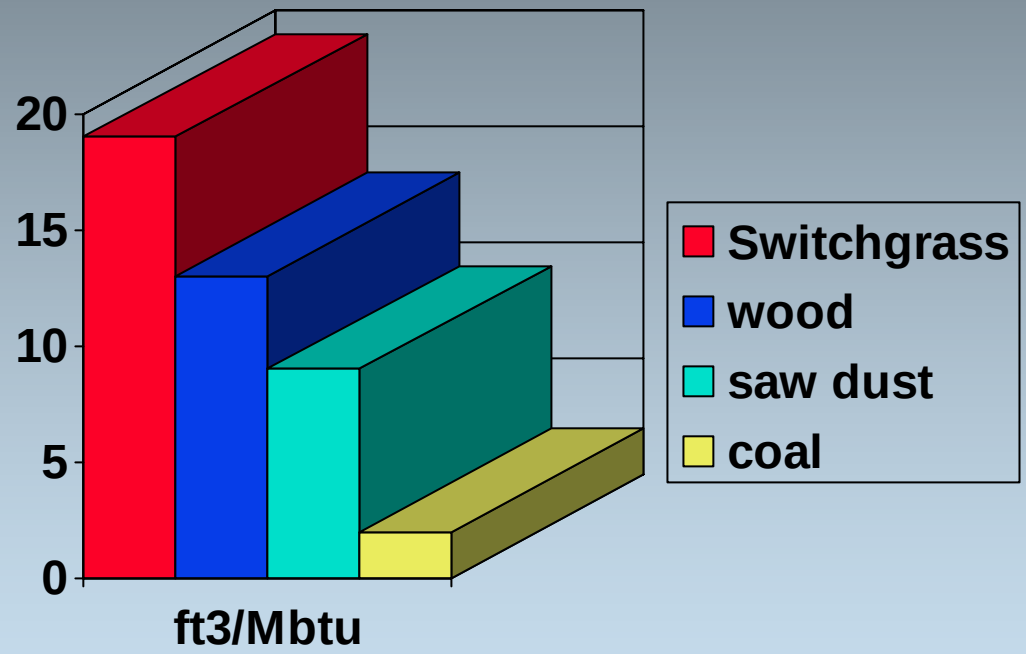
Biomass Compared to Coal

	Saw Dust	Switch Grass	Coal
Btu/Lb as-received	5,400	7,400	12,000
Moisture (%)	35	12	6
Ash (%)	0.7	5.3	10
Sulfur (%)	0.01	0.1	1.0
Nitrogen (%)	0.1	1.2	1.4

QUINAPOXET SOLUTIONS

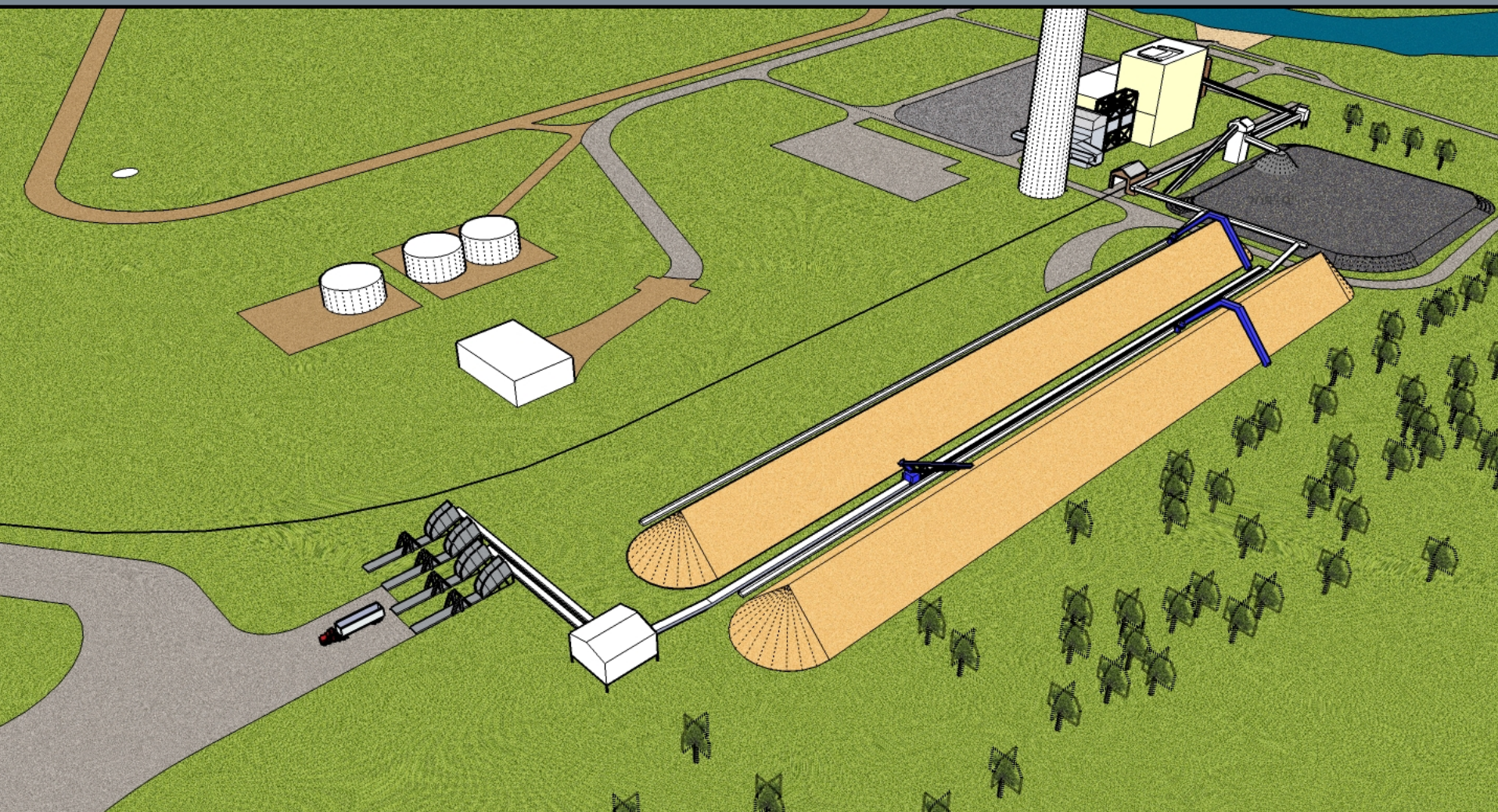
Energy Density

- Coal may contain 5 to 10 times more energy per cubic foot than biomass.
- Firing 10% (Btu basis) of biomass may double the fuel volume.
- Issues with storage as well as feeder capacities.



QUINAPOXET SOLUTIONS

Mitchell Wood Yard Concept #1 – Linear Piles (SCS)



Co-Firing Options

- **Co-milling**
  - Coal is hard and brittle
  - Biomass is soft and fibrous
  - Therefore, coal mills may not work well
- **Injection into the coal pipes (control nightmare)**
- **Biomass injectors**
  - Biomass is more volatile
  - May rob air from coal burners
- **Biomass burners ($$$$)**

QUINAPOXET SOLUTIONS

Economics at Southern Company

- **Co-milling sawdust saved money ($0.009/kwh) at 1-4 % heat input**
- **Co-injecting switch grass at 10 % of heat input cost money ($0.019/kwh) including the tax credit.**
- **Based on testing at Plant Gadsden**

QUINAPOXET SOLUTIONS

Oxygen Enhanced Biomass Co-firing Example: 10% wet wood co-firing

- About 4% of combustion air is replaced with oxygen to maintain the total flue gas volume and boiler heat transfer balance.
- Oxygen is directly injected to coal stream to reduce NOx (proven commercial technology).

QUINAPOXET SOLUTIONS

Comparison of projected performance for a 165 MW boiler (Praxair)

	AIR	AIR	OEC
BITUMINOUS COAL (% OF TOTAL BTU)	100	90	90
WOOD WITH 45% MOISTURE (% OF TOTAL BTU)	0	10	10
GROSS POWER OUTPUT(MW)	165	159	165
AUX. POWER REQUIRED (MW)	9	9	9
OXYGEN REQUIRED (TPD)	0	0	151
OXYGEN PLANT (MW)	0	0	1.5
NET POWER OUTPUT(MW)	156	150	154.5
NET HEAT RATE (BTU/KWH)	9,625	9,803	9,845
NO_x EMISSION (LB/MBTU)	0.3	0.3	0.2

QUINAPOXET SOLUTIONS

Economics of Co-firing – Costs of Aux Power (source: B&V)

- **Co-firing systems require some auxiliary power**
  - Primarily biomass sizing and pneumatic convey equipment
  - For 20 to 40 MW of co-firing capacity, equipment may require 2 to 3 MW of aux power
  - Smaller systems require greater percentage of aux power

- **Replacement power cost**
  - Utilities must operate at increased load on other units or purchase replacement power to offset aux load
  - Replacement power cost: $80/MWh to $120/MWh
  - Other renewables require additional spinning reserve

QUINAPOXET SOLUTIONS

Is CO_2 Really Reduced?

- Emissions during co-firing of biomass and coal depend on fuel properties and the unit-specific combustion dynamics
- Co-firing test burns required to determine actual impacts
  - » In general, CO_2 emissions at the stack increase slightly due to slight decrease in unit efficiency
  - » CO_2 emissions from biomass fuels are considered carbon neutral
  - » Adjusted CO_2 emissions are reduced by slightly less than the proportion of heat input provided by biomass

QUINAPOXET SOLUTIONS