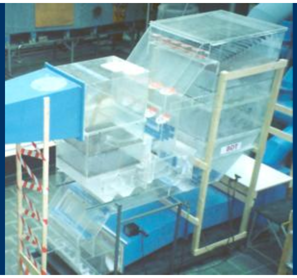
Riley Power Inc.
Biomass Conversion of Existing Power Plants


One Source *Many Solutions* *One Purpose*

McIlvaine Company, Hot Topic Hour
March 17, 2011

Kevin Toupin, Director Boiler Equipment
Riley Power Inc.
Worcester, Massachusetts

Utility Biopower

Biomass Power Plant

Typical Options

Today's Discussion

1) **New Biomass Power Plant**
   10 – 60 MWe

2) **Biomass Conversion of Existing Power Plants**
   (Original Coal Firing to 100% Biomass)
   10 – 60 MWe

3) **Biomass Co-firing with Coal** (Coal primary fuel)
   3 – 15% Biomass fuel (by heat input)

Conversions
Coal to Biomass Firing
Advantages

- **Alternative to building a new power plants**
  - Easier public acceptability since there is an existing power plant is in-place
  - Positive Public Perception of going from a dirty fuel to a Clean environmentally friendly Green fuel
- **Reuses existing equipment / Offers a second life to older Power Plants**
  - Saves development costs
  - Maintains trained plant employment
- **Adds desirable renewable energy to a Utilities portfolio**

Key Steps for a Biomass Conversion

Study 1	**Biomass Fuel Study**
Study 2	**Boiler & Combustion System Study**
Study 3	**Emissions Study**
Study 4	**Plant Arrangement & Site Space**

Study 1

Biomass Fuels Study

"It All Starts with the Fuel"

- ***Combustion System Design***
- ***Boiler Design***
- ***Emissions Equipment Design***

Wood Fuels

Energy Crops

Biomass Energy Sources

Bio-Diesel

Landfill Gas

Agricultural Residues

Waste Materials

Biomass Fuels

Fuel Availability *"Rules of Thumb"*

A) **Raw Fuels** *(Examples: Wood Chips, Tree Tops, agricultural waste, etc.)*

Typically with-in 50 mile radius of plant

B) **Processed / Pelletized Fuels** *(Example: Wood Pellets)*

Typically exceeds 50 mile radius of plant

- *Low Moisture Content*
- *Pulverized*
- *High Density*
- *Higher Heating Value*

Being evaluated in USA & Europe

Co-firing with Pulv. Coal Units

Biomass Fuels
Factors to Consider

- Fuel Characteristics
  - Heating Value
  - Moisture
  - Size
  - Fouling and Slagging
  - Corrosion
  - Erosion
  - Emissions

All must be taken into consideration in the final project design

Important Note

Biomass
Fuel Flexibility

Being able to burn various biomass fuels is a big advantage to the plant economics.

Study 2
Boiler & Combustion System Study

Boiler Engineering Study
Coal to Biomass Conversion

Recommend ***"phased "*** approach.

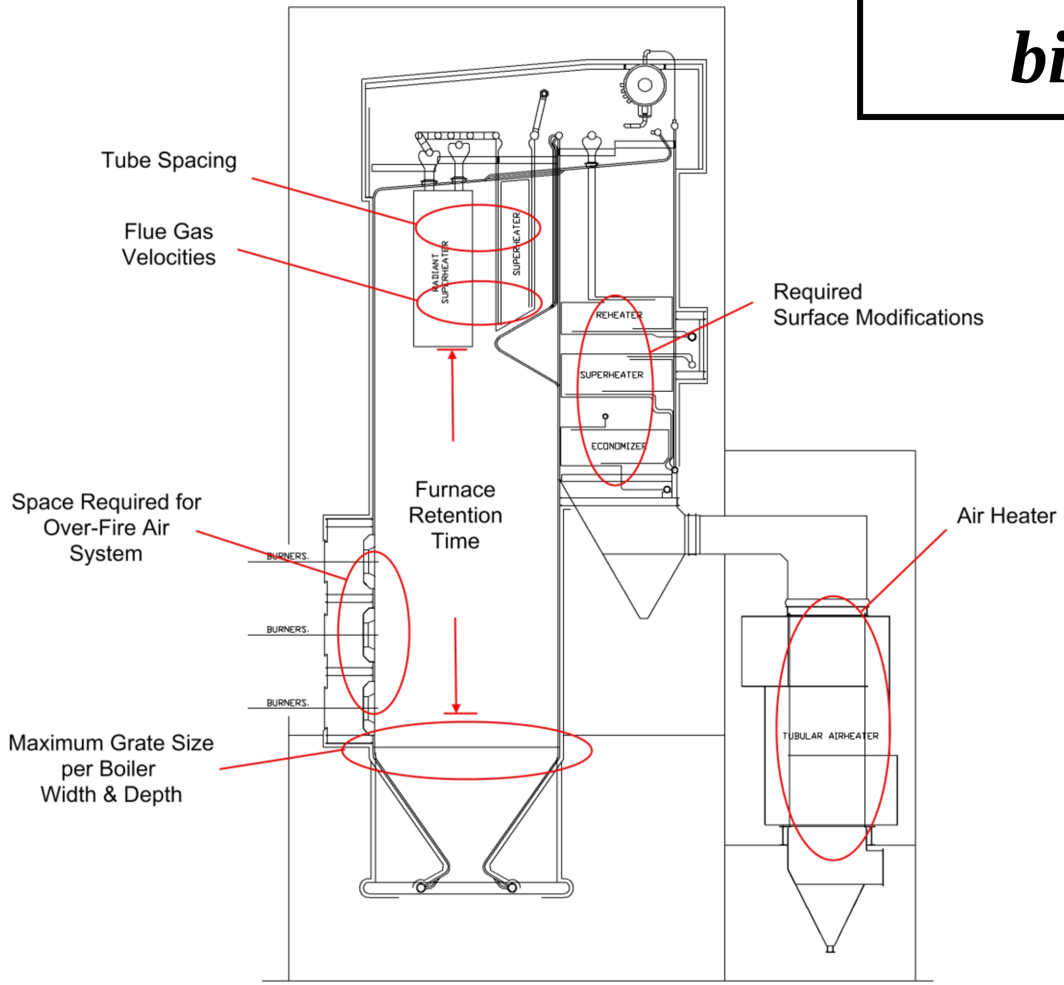
Allows study to be stopped at any time if a "fatal flaw" is discovered.

Saves $ and time!

- Phase 1: Initial Screening (Is the plant a good candidate?)
- Phase 2: Feasibility Engineering Study
- Phase 3: Detail Engineering Design & Material Acquisition
- Phase 4: Constructability

Phase 1: Initial Screening "Quick Study"

Is the boiler a candidate for biomass conversion?



- Preferably 5-80 MW units (50-800 KPPH)
- Pulverized coal units more favorable
- Oil/gas units have smaller furnaces, tighter tube spacing. Typically not good for converting to Biomass
- Is there site space for biomass storage, fuel systems, and emissions equipment?

Step 3
Emissions Study

Biomass Environmental Considerations

Pollutants

PM

SO_2

NOx

CO

VOC

Particulate Control

- Electrostatic Precipitators (ESP's):
  - Different chemical composition and smaller particle size
  - Resistivity typically within the range for an ESP
  - Major retrofits typically require lower PM emissions
    - Required emissions are typically 0.015/lbm/MBtu
    - May require modifications
- Fabric Filters:
  - Higher gas flows associated with biomass firing
  - May exceed the design air to cloth ratio

SOx Emissions Control

- Biomass typically has lower sulfur content than coal
- Alkalinity of biomass flyash can provide sufficient reduction in SO_2 and HCl without the need for further acid gas removal
- In most applications, no SO_2 control equipment is required
- Control Methods:
  - Sorbent Injection w/ Baghouse
  - Scrubber (Worst Case)

NOx Control for Biomass Applications

- Fuel bound N_2 lower
- Required NOx Reduction Not achievable with SNCR, OFA/FGR, ROFA with NH_3
- Conventional SCR
  - Temperature requirements dictate location
  - High dust environment
  - Susceptible to poisons:
    - Sodium (Na), Potassium (K), Lead (Pb), Arsenic (As)
- Requires use of a tail end SCR

Biomass
Tail-end SCR system

- After the particulate removal device
- Clean low temperature gas
- Mitigates poisoning issue
- Need high thermal efficiency for low operating cost

CO & VOC Control for Biomass Applications

- High moisture fuels produce more CO
- Proper OFA and furnace sizing will reduce CO emissions
- Tail-end SCR catalyst can make stringent CO emission guarantees

Emissions from a 100% Biomass Conversion

- Should not be viewed as an impediment to pursuing a biomass conversion project
- Controlled to low levels using proven and efficient technologies

4 commercial units in operation

2 with CO catalyst

<u>5+ years of successful operation and REC qualification</u>

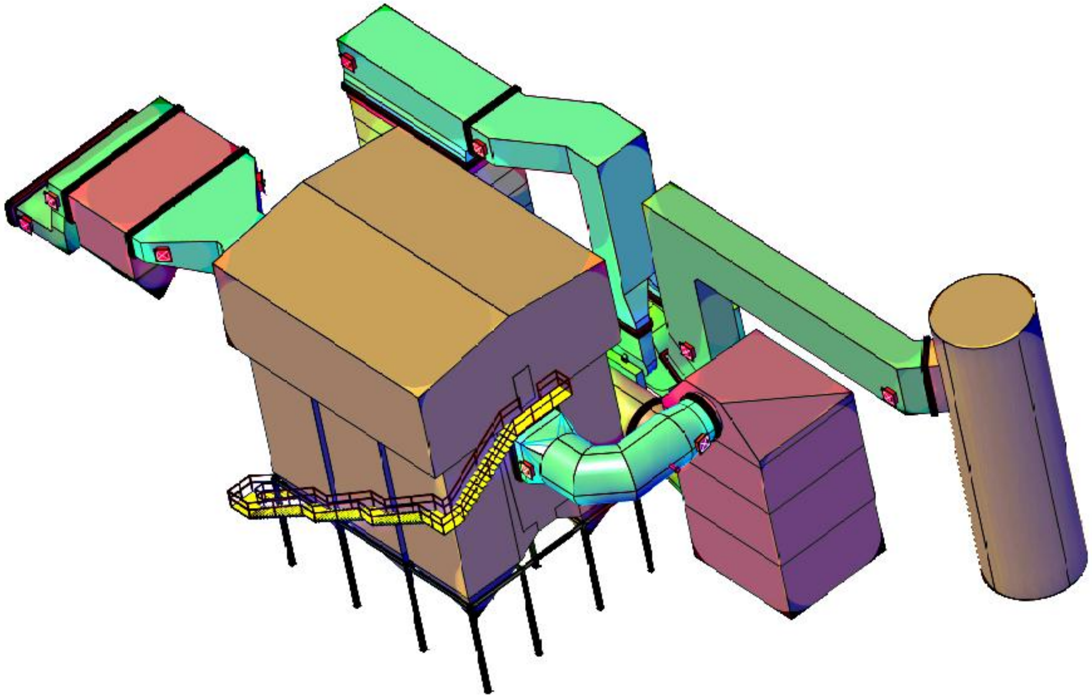
Step 4

Plant Arrangement

Plant Arrangement

Challenging Tasks

- Existing Plant
  - Space restrictions
  - Equipment interferences
- Equipment arrangement must be flexible
- Designer must be experienced, open minded and "think out of the box"
- 3-D Models for interference checks



Thank You