COLBY COLLEGE: New Biomass Facility
In FY 2011, approximately how many gallons of heating fuel did we use annually?

a) 105,000 gallons  
b) 501,000 gallons  
c) 1.05 million gallons  
d) 10.5 million gallons

We used No.6-low sulfur fuel in the steam plant and No. 2 fuel in outlying buildings.

Based on Colby’s Climate Action Plan, the College has a goal to be carbon neutral by what date?

a) 2015  
b) 2020  
c) 2025  
d) 2030

We achieved in April 2013, two years ahead of schedule. Reduction in fuel oil a key component.
AGENDA

Project Overview
Early Analysis
Design
Lessons-Learned
Project Summary
Existing High Pressure Steam Plant, 1992

Thermal Energy for Approximately 1,400,000 sq.ft.

Energy Source 100% No. 6 Fuel Oil

Three Water-Tube Boilers, 800 BHP Output Each @ 300 psig

One 600 kW Back-Pressure Turbine, 1M kWh/Year (10% Total)

1,100,000 Gallons No. 6/Year

4 CHP FTEs
PROJECT OVERVIEW: Post-Project Conditions

- Wood Chip Biomass Integrated with Existing Plant
- Energy Source 90%+ Biomass
- Fuel Oil for Peak-Shaving and Back-up Only
- Two Biomass Gasifiers Coupled Two Fire-Tube Boilers, 400 BHP Output Each @ 300 psig
- Full Integration w/ Back-Pressure Turbine
- 100,000 Gallons No. 6/Year + 22,000 Tons Wood Chips/Year
- Reduce Carbon Dioxide Emissions by 9,500 to 13,700 tons/Year
- 5 CHP FTEs
EARLY ANALYSIS
PROJECT OVERVIEW: Colby’s Interest

- **Initial Interest**
  - Secondary Source of Fuel
  - NOT Economics
  - NOT Sustainability

- **Deciding Interest**
  - Secondary source of fuel AND Economics AND Sustainability
EARLY ANALYSIS: Biomass Fuel Source

CHIPS
- Quality Control Challenges
- High Storage Volume Required
- Complex Material Handling
- Large Footprint for Boilers, etc.
- Locally Sourced Forest Waste
- $40/ton = $7/MMBtu Output

PELLETS
- Extremely Uniform
- 3x More Energy Per Volumetric Unit
- Fuel Delivery Most Like Traditional
- Modular Boilers Possible
- Manufactured Product
- $200/ton = $15/MMBtu Output
**EARLY ANALYSIS: Biomass Fuel Source**

**CHIPS**
- Quality Control Challenges
- High Storage Volume Required
- Complex Material Handling
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**PELLETS**
- Extremely Uniform
- 3x More Energy Per Volumetric Unit
- Fuel Delivery Most Like Traditional
- Modular Boilers Possible
- Manufactured Product
- $200/ton = $15/MMBtu Output
Identify Suppliers
  • Selected a “Broker”

Specify Fuel Quality
  • Whole Tree and Bole Chips (Low Value Wood)
  • Moisture Content: 45%
  • Size: 1/8” x 1/8” to 2½” x 2½”
  • Non-standard: Sticks and Branches <5% (Never Over 12”)

Specify Delivery Parameters
  • Year-round Stockpile
  • 50-mile Radius
  • Sustainable Foresting Practices (4 Options)
EARLY ANALYSIS: Biomass Equipment and Procurement

Consider Combustion Technology

GASIFIER
- Higher Initial Cost
- Dual-stage Burn
- More Fuel Efficient Technology
- Fewer Emissions
- ± 10:1 Turn Down Ratios
- Less Ash Produced

STOKER
- Lower Initial Cost
- Single-stage Burn
- Less Fuel Efficient Technology
- Higher Emissions
- ± 5:1 Turn Down Ratios
- More Ash Produced
**BIOMASS SYSTEM GOALS:**
- Enable Year-Round Operation
- Provide System/Equipment Redundancy

**OVERVIEW SYSTEM APPROACH:**
- 800 BHP Total; Two 50% Capacity Systems

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**Colby College Historical Hourly Average Steam Flow Rate (lbs/hr) with 800 BHP Biomass Boiler**

- **800 BHP Biomass Boiler Capacity**
- **7-year Average Steam Profile**
- **Maximum Biomass Boiler Turndown**
- **10% Additional Capacity**

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*Date:* 1/1, 1/31, 3/1, 3/31, 5/30, 6/29, 7/29, 8/28, 9/27, 10/27, 11/26, 12/26
EARLY ANALYSIS: Biomass Equipment and Procurement

- Consider Combustion Technology (Gasifier vs. Stoker)
- Package Total Biomass System
- Review Vendors and Select One
- Partner with Selected Vendor Throughout
EARLY ANALYSIS: Biomass Equipment and Procurement

- Consider Combustion Technology (Gasifier vs. Stoker)
- Package Total Biomass System
- Review Vendors and Select One
- Partner w/ Selected Vendor Throughout

- Design Building to Fit Biomass
DESIGN: Integrating New and Existing

- Separate Dirty/Clean
- Use Existing CHP Support Systems
- Integrate with Existing Backpressure Turbine
DESIGN: Overall Biomass System – Five Subsystems

- Fuel Storage and Handling
- Combustion Air and Fuel Drying
- Fuel Combustion
- Breeching and Pollution Control
- Ash Handling and Disposal
DESIGN: Fuel Storage and Handling

- Storage Bin
DESIGN: Fuel Storage and Handling

- Storage Bin
- Leveling Screws
DESIGN: Fuel Storage and Handling

- Storage Bin
- Leveling Screws
- Sliding Wedge Floor
- Hydraulic Rams
DESIGN: Fuel Storage and Handling

- Storage Bin
- Leveling Screws
- Sliding Wedge Floor
- Hydraulic Rams

Conveyors

Lower Receiving Conveyor

Upper Receiving Conveyor
DESIGN: Fuel Storage and Handling

- Storage Bin
- Leveling Screws
- Sliding Wedge Floor
- Hydraulic Rams

- Conveyors
- Resizers
Design: Fuel Storage and Handling

- Storage Bin
- Leveling Screws
- Sliding Wedge Floor
- Hydraulic Rams
- Conveyors
- Resizers
- Metering Bin and Feed Auger
DESIGN: Combustion Air and Fuel Drying

- Combustion Air and Plant Ventilation
DESIGN: Combustion Air and Fuel Drying

- Combustion Air and Plant Ventilation
- Chip Drying

Chip Drying Supply Air
Perforated Plates
Gasifiers
DESIGN: Fuel Combustion

- Gasifiers
- Boilers
DESIGN: Breaching and Pollution Control

- Cyclonic Dust Collectors
DESIGN: Breeching and Pollution Control

- Cyclone Separators
- Economizers and Induced Draft Fans
DESIGN: Breeching and Pollution Control

- Cyclone Separators
- Economizers and Induced Draft Fans
- Electrostatic Precipitator
DESIGN: Ash Handling and Disposal

- Gasifier Ash Auger
- Cyclonic Dust Collector Ash Drop
DESIGN: Ash Handling and Disposal

- Gasifier Ash Auger
- Cyclonic Dust Collector Ash Drop
- Ash Outlet and Roll-off Dumpster
DESIGN: Ash Handling and Disposal

- Gasifier Ash Auger
- Cyclonic Dust Collector
  Ash Drop
- Ash Outlet and Roll-off
  Dumpster
- Disposal
- Consider Plant an Educational Tool
- Improve CHP Presence on Campus
DESIGN: Site and Architecture

Before

After
LESSONS-LEARNED: Leveling Screws Blockage
LESSONS-LEARNED: Fuel Conveyor Issues

Spillage at Base of Elevating Conveyor

Retrofit to Prevent Spillage
LESSONS-LEARNED: Boiler Refractory Failure

Worn Original Refractory

Retrofitted Refractory
LESSONS-LEARNED: Dust Generation

Shredder Feed Funnel

Retrofit for Dust Control
LESSONS-LEARNED: Internal Ash Auger Failure

Auger Locations

Internal Ash Auger

Failed Auger
LESSONS-LEARNED: Potential for Microbial Growth

Chip Bin Material Handling

Chip Bin Divider Wall Retrofit
PROJECT ECONOMICS/SUMMARY
Total project cost $11.25M

$750,000 Efficiency Maine Grant

Higher efficiency resulting in less wood use

During 2012, reduced oil use by close to 700,000 gallons

Total anticipated savings once plant is fully operational is over $1.5 million annually
Provided secondary source of fuel

Reduced carbon emissions by 9,500 - 13,700 tons/year

Key component of Colby reaching carbon neutrality

Provided long-term regional economic benefits

USGBC LEED Gold Certification