Biomass Design & Potential

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Biomass Design & Potential

This course covers:
The considerations one should make when designing and planning an automated biomass heating system
A Self-Performing Contractor

**What We Do:**

- Biomass Boiler System Installations
  *with Integration into Existing Boiler Systems*
- Complete Project Management
- Biomass Boiler Servicing & Maintenance
- Manufacture & Delivery of PDCs
Our Experience:

145 Biomass Boilers Installed

Fuel: Mostly wood pellet & dry wood chip

at over 100 Customer Sites

Plus Cleaning, Maintenance & Repairs
PART 1:

Biomass Fuel Choices:

- Wood Pellets
- PDCs
- Green Wood Chips
3 BIOMASS FUELS TO CONSIDER DEPENDING ON FUEL CONSUMPTION AT YOUR BUILDING!

**PELLETS**
3000 to 30,000 gallons of oil

**PDCs**
20,000 to 70,000 gallons of oil
(Precision Dry Wood Chips)

**GREEN CHIPS**
40,000 gallons of oil to Huge
Wood Pellets

7% moisture content
Precisely controlled small size
Flows like water—easy to store & move
Compact BTU storage (by weight & volume)
PDCs
“Precision Dry Wood Chips”

25% moisture content
Screened: Nothing bigger than a matchbook
Stacks—does not flow. 90% hardwood
PDCs: A Value Added Product

- 25% Moisture Content
- Made from bole wood (the main trunk of a tree)
- Wood quality is similar to wood pellets (Bole wood)
- Screened to eliminate sticks, oversized chunks, rocks and “Tramp metal”
- Able to be blown into a bin through a 5” pipe as long as 150 feet
- Produced with quality control standards
- Does not require a large pit-type bin with roof, garage doors, live floor, etc…
Green Wood Chips

35% to 50% moisture content (varies by season)
Many Variables: Size, hard/soft wood, % bark
Price is determined by Quality
Wood Chips—In General
The more selectively produced = More expensive

- Whole Tree Chips
- Hardwood / Softwood
- Bole Wood—Main tree trunk with bark
Comparing PDCs and Green Chips

- Green Chips are more readily available
- Green Chips cost less
- Green chips require larger initial investments due to larger infrastructure requirements:
  - Chip delivery & storage systems are bigger and more costly
  - Fuel material handling systems are more robust/costly
  - Green Chip systems usually employ single large boilers
  - The Larger the Load: the more Green Chips make sense!

- Boilers over 2 million BTU/hr output are regulated in NH and must prove compliance with technical standards
  - PDC boilers are usually less than 2 Million BTU/hr

- Green Chips can compost, generating heat or get moldy
  - Must be managed—bins emptied in summer
3 BIOMASS FUELS TO CONSIDER

**Volume per Ton**

- **PELLETS**
  - 50 cubic feet per Ton
  - (Delivery: Blown into silo)

- **PDCs**
  - 133 cubic feet per Ton
  - (Delivery: Blown into bin)

- **GREEN CHIPS**
  - 83 cubic feet per Ton
  - (Delivery: Dumped into bin)

Calculations use HHV energy content of hardwood burned at 84% Efficiency
### 3 BIOMASS FUELS TO CONSIDER

**Net (burned) Heat Content of Fuel**

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Gal Oil per Ton</th>
<th>Million BTU per Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>PELLETS</td>
<td>120.5</td>
<td>13.370</td>
</tr>
<tr>
<td>PDCs</td>
<td>93.5</td>
<td>10.392</td>
</tr>
<tr>
<td>GREEN CHIPS</td>
<td>66</td>
<td>7.335</td>
</tr>
</tbody>
</table>

Calculations use HHV energy content of hardwood burned at 84% Efficiency
EXAMPLE:

*To Offset 30,000 Gallons of Oil…*

**PELLETS**

Need 249 Tons  
Total Biomass Boiler Output: 1.3 Million BTU  
Storage: 28 ton steel silo 9 fillings

**PDCs**

Need 321 Tons  
Total Biomass Boiler Output: 1.3 Million BTU  
Storage: 23 ton bin (Min) w/3100 cu ft  
14 fillings using 15 ton truck

**GREEN CHIPS**

Need 486 Tons  
Total Biomass Boiler Output: 1.75 Million BTU  
Storage: 41 ton bin (Min) w/4000 cu ft  
20 fillings using 25 ton truck

Calculations use HHV energy content of hardwood burned at 84% Efficiency
# 3 Biomass Fuels to Consider

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Delivery Price</th>
<th>Cost per Million BTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>$2.75/gal</td>
<td>$35.95</td>
</tr>
<tr>
<td>Oil</td>
<td>$3.00/gal</td>
<td>$27.02</td>
</tr>
<tr>
<td>Propane</td>
<td>$2.00/gal</td>
<td>26.14</td>
</tr>
<tr>
<td>Oil</td>
<td>$2.50/gal</td>
<td>$22.52</td>
</tr>
<tr>
<td>Propane</td>
<td>$1.50/gal</td>
<td>$19.61</td>
</tr>
<tr>
<td>Oil</td>
<td>$2.00/gal</td>
<td>$18.02</td>
</tr>
<tr>
<td>Propane</td>
<td>$1.50/gal</td>
<td>$13.59</td>
</tr>
<tr>
<td>Oil</td>
<td>$1.00/gal</td>
<td>$13.07</td>
</tr>
<tr>
<td>Pellets</td>
<td>$240/ton</td>
<td>$17.95</td>
</tr>
<tr>
<td>Oil</td>
<td>$1.50/gal</td>
<td>$11.55</td>
</tr>
<tr>
<td>Propane</td>
<td>$1.00/gal</td>
<td>$10.22</td>
</tr>
<tr>
<td>Green Chips</td>
<td>$60/ton</td>
<td>$8.18</td>
</tr>
<tr>
<td>Oil</td>
<td>$1.00/gal</td>
<td>$9.06</td>
</tr>
<tr>
<td>Pellets</td>
<td>$120/ton</td>
<td>$11.55</td>
</tr>
<tr>
<td>Oil</td>
<td>$75/ton</td>
<td>$10.22</td>
</tr>
</tbody>
</table>

**Net Cost of Delivered Fuels……$ per Million BTU**
HISTORICAL FUEL PRICES FOR OIL, Propane, or BIOMASS:

15 Years of Equalized Prices for Fuel Oil, Propane and Wood Pellets
(The net heat values of Propane & Pellets have been equalized to have the same net heat value as a gallon of fuel oil)

Propane
#2 Fuel Oil
Wood Pellets
PDCs $1.28
Green Chips $1.19-$ .91

All prices noted in Net Oil Price Per Gallon Equivalents
3 BIOMASS FUELS TO CONSIDER

*Fuel Cost in Oil Equivalent with THERMAL RECs*

- **PELLETS**: Costs the same as $1.51/Gal Oil
- **PDCs**: Costs the same as $0.80/Gal Oil
- **GREEN CHIPS**: Costs the same as $0.42 to $0.65/Gal
FUEL PRICES:  BIOMASS With Thermal RECs!!

15 Years of Equalized Prices for Fuel Oil, Propane and Wood Pellets
(The net heat values of Propane & Pellets have been equalized to have the same net heat value as a gallon of fuel oil)

All prices noted in Net Oil Price Per Gallon Equivalents
PART 2:

Biomass Heating Systems
A Few Basic Biomass Boiler System Designs
Interior Pellet Storage Bag(s) with Pneumatic Feed to Boiler
Pneumatic Pellet delivery trucks—Quick & Easy

15 ton tanker

30 Ton Trailer
Interior Pellet Storage Bin with Augur and Pneumatic Feed to Boiler
Exterior Pellet Storage Silo with Pneumatic Feed to Boiler
Exterior Pellet Storage Silo with Auger Feed to Boiler
Horizontal Auger Extraction System

Interior Pellet Storage Bin with Auger Feed to Boiler
Our New Biomass Fuel:

Made at our facility in Peterborough

Delivered in our Box Truck and *BLOWN* into customer storage bins
DESIGN PARAMETERS for PDCs

For 20,000 to 70,000 Gallons per year Consumption

Storage Bin: Interior Sweeper Arm Type:
15, 23 or 34 tons each (Min/Max) 144/225/324 sq ft

- Each Bin supplies one or two Boilers
- Boilers are direct fed with rigid auger from Bin
- Bin must be close to Boiler (back to back)
- Boiler and Bin also able to handle pellets (Dual Fuel)
- New building often needed due to larger footprint
PDCs are blown into the silos from our blower truck.
HIGH MOWING SCHOOL
Wilton, NH

2 Froling TX-150 Boilers = 1 Million BTU/hr
Propane Back up = 1.5 million BTU/hr

9 Building District Heating System
with Central Biomass Boiler Building
Prior fuel use: 30,000 Gal Oil
Shown: A Typical Messersmith System
GREEN CHIPS

VHF VERTICAL HYBRID FIREBOX SERIES

Available in
50 BHP 100 BHP
150 BHP 200 BHP 250 BHP
Pressures to 300 PSI
Steam and Hot Water Models

CAT # W-19
Figure 3.1
A Typical Biomass System

- chimney
- cyclone flue gas cleaner
- induced draft fan
- boiler
- inclined fuel conveyor
- combustor
- receiving auger
- fuel storage bin (walls not shown)
- bin unloading system (hydraulic scraper type shown)

Courtesy KMW Energy Systems
Photo of Green Chip Delivery Truck (Live Chips)
Example: Hanover High School
Green Wood Chip Boiler System
5 Million BTU Max Output
A Cyclone is often required to remove particulates from the exhaust.

Example: Hanover High School
Green Wood Chip Boiler System

In some cases an ESP is required in the exhaust stream (Electrostatic Precipitator)
DESIGN PARAMETERS for Green Chips

For over 40,000 Gallons per year Consumption

Interior Bin: 37 tons minimum (400 sq ft)

Design: Live Floor or Rake / Auger & conveyors

- Bin must be fairly close Boiler so conveyor system can get the chips up to the boiler
- Typically installed in new boiler room/house due to large footprint
- Usually employs one large boiler (100% Design Load)
- Boilers are fed by conveyors, pushers & augers
PART 3:

Sizing for Financial Viability
When to switch to Biomass?

- Oil Boilers need to be replaced
- Oil Tank Inspection Results need repairs or replacement
- Green Initiative (Sets Green Example for Students and the Community)
- New Addition / New Building
- Performance Contract
Design Criteria

- How much fuel is consumed each year? (3-5 yr avg)
- What conservation steps reduce the heat load?
- Are other buildings close that could be in a District system?
- What physical constraints do the property present?
- Are other issues forcing a need to replace current equipment?
Issues & Challenges of Conversion

- Boiler room too small
- New Boiler House is necessary
- Difficulty locating fuel storage silo/bin near boiler
- Difficult access to silo/bin for Fuel Delivery Truck
- Steam Heat (Convert to FHW?)
- Availability of Natural Gas!

PELLETS

PDCs

GREEN CHIPS
Don’t Oversize the System

Size the Biomass System to be 65% to 75% of Design Load...

And cover 90% to 95% of annual heat needs.
Don’t Oversize the System!

Smaller Boiler Systems Cost Less.

An average of only 7 days per year get close to Design Load.
For BIG Fuel Users

Size the Biomass System to be 100% of Design Load…

GREEN CHIPS

BUILDING DESIGN LOAD

BIOMASS SYSTEM SIZE

BACK-UP SYSTEM SIZE
And cover 80% of annual heating needs.

**WHY?**
When loads are too small these systems are turned off:
Start Up in October & Turn Off in March
The 95% vs 80% Coverage Dilemma

If you are burning 50,000 gallons of oil per year…

<table>
<thead>
<tr>
<th></th>
<th>PDCs</th>
<th>GREEN CHIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Cost Estimate:</td>
<td>$350,000</td>
<td>$500,000</td>
</tr>
<tr>
<td>Net Average Oil offset:</td>
<td>95% or 47,500 Gal</td>
<td>80% or 40,000 Gal</td>
</tr>
<tr>
<td>Average Biomass use:</td>
<td>507 tons per year</td>
<td>605 tons per year</td>
</tr>
<tr>
<td>Biomass Cost:</td>
<td>at $120/Ton = $60,840</td>
<td>at $60/Ton = $36,300</td>
</tr>
<tr>
<td>Average Thermal RECs:</td>
<td>1542 @ $15 = $23,130</td>
<td>1542 @ $15 = $23,130</td>
</tr>
<tr>
<td>Net Average Oil Use:</td>
<td>2,500 gallons</td>
<td>10,000 gallons</td>
</tr>
<tr>
<td>Net Average Oil Cost:</td>
<td>@ $3.00 = $7,500</td>
<td>@ $3.00 = $30,000</td>
</tr>
<tr>
<td>TOTAL Average Annual Fuel Cost:</td>
<td>$45,210</td>
<td>$43,170</td>
</tr>
</tbody>
</table>

At $40 a ton for Green Chips…
Fuel costs cut by $12,100
Economics of a Biomass Conversion

A simple economic analysis is tempting:
Total System Cost
Divided by
Projected Average Annual Savings

HOWEVER: Other important factors may be pivotal.

- Buried Oil Tank is failing
- Existing Oil Boilers need replacement
- Energy Conservation Measures planned
- New Addition is being planned
- Switching from Steam to FHW
Making the Case for a Biomass System

ROI and “Payback” models don’t tell the Whole Story!

- A more realistic method is costing out “Alternate Futures”
  - PLAN A: Stick with Oil—Replace oil boiler in year X. Replace buried oil tank. Upgrade other components. + 10 Yrs Fuel Costs
  - PLAN B: Convert to wood pellet boiler system. Remove buried oil tank. Back up with Propane boilers. + 10 Yrs Fuel Costs
  - PLAN C: Convert to PDC boiler system + 10 Yrs Fuel Costs
  - PLAN D: Convert to Green Chip boiler system + 10 Yrs Fuel Costs
- Include Rebates, RECs, Grants, etc… in Each PLAN
- Include 10 to 20 years of projected future fuel costs in each PLAN
  - Agree upon reasonable future fuel prices in projections ($3 Oil?)
  - Keep fuel costs flat over the 10 to 20 year period
NH Pellet Boiler 30% Rebate

- Rebate comes from NHPUC
- Wood Pellet systems ONLY
- Cap of $50,000 (+ $5,000 max for Buffer Tank)
- Apply in advance > Funds earmarked for you.
  - Funds paid out when project is complete
- Best to apply before a public vote
- Must use recognized equipment and trained installers
**NH Thermal RECs**

(Renewable Energy Credits)

- T-RECs available for any Biomass boiler system installed after January 1, 2013
- Must have site approved by NHPUC
- **Pellets get approximately 4 T-RECs per ton**
  - PDCs: 3/ton   Green Chips 2/ton
  - Generally: .0325 RECs per Offset gallon of Oil
- Requires Monitoring Equipment
  - BTU Meter & Data Accumulator
- Requires Qualified Verification
- Sell T-RECs in NEPOOL System Directly or by Agent.
  - Value varies approx $10-$25 each
PART 5:
The Near Future and Cogeneration Options
Spanner CHP
45KW Electrical Power
108KW Thermal Power
81% overall efficiency
Cost installed app. $300K
Froeling CHP 50

50KW Electrical Power
107KW Thermal Power
83% Overall Efficiency
Installed Cost $350K
PART 6:

Three Biomass Heating Projects
LYME ELEMENTARY SCHOOL
Lyme, NH
LYME ELEMENTARY SCHOOL
Lyme, NH

Prior Oil Use: 10,000 Gallons/yr
2 - 340,000 BTU boilers do 95% coverage
28 ton Silo
Propane back up can cover 100%
CORNISH ELEMENTARY SCHOOL
Cornish, NH
Projects

CORNISH ELEMENTARY SCHOOL
Cornish, NH
Containerized Boiler Rooms

Built at our shop—dropped into place by crane
CORNISH ELEMENTARY SCHOOL
Cornish, NH
CORNISH ELEMENTARY SCHOOL
Cornish, NH
Projects

STEVENS HIGH SCHOOL
Claremont, NH

PELLETS

PDCs
Projects

STEVEN'S HIGH SCHOOL
Claremont, NH

Before

After

A large scale renovation was done in 2014
Projects

STEVENS HIGH SCHOOL
Claremont, NH

Three 1970s Oil boilers were HUGE!

PELLETS
PDCs
2 Froling TX-150 Pellet/PDC Boilers
500,000 BTU/Hr Each

Steel Interior Silo can hold
70 tons of Pellets
Or 35 tons of PDCs
STEVENS HIGH SCHOOL
Claremont, NH
“Constant Monitoring”
Thank You!

HEAT LOCAL

Jim@FrolingEnergy.com  603-924-1001  www.FrolingEnergy.com
A 30% Rebate is available now from the NHPUC for Commercial Bulk-Fed Wood Pellet Central Heating Systems
(Schools & Municipal Buildings Included)

For installation of bulk-fuel fed wood pellet boilers and furnaces of 2.5 million BTU Output or less

Provides 30% of the cost of the boilers with installation, up to a maximum of $50,000.

Must be operational before December 18, 2013.
RENEWABLE ENERGY CREDITS FROM THE NHPUC

FOR CLASS I THERMAL SOURCES WITH RENEWABLE THERMAL ENERGY CAPACITY GREATER THAN 150,000 BTU/HR

- The Biomass boiler system installation must be completed with an approved energy production metering system in place

- A Registered Engineer must affirm that the installation meets the standards

- The official Application is completed, submitted and accepted by the NHPUC
RENEWABLE ENERGY CREDITS FROM THE NHPUC

Current Values

- For each ton of biomass (wood pellets) burned you get about 4 Thermal RECs
- Thermal RECs can be sold each year at a set rate
- We expect them to trade for between $12 and $25 each year
- RECS were sold for $22 in the most recent sale
PART 7: More Biomass Heating Projects
NORTHWEST ELEMENTARY SCHOOL
Rutland, VT
CANAAN ELEMENTARY  Canaan, NH  PELLETS
RUTLAND HIGH SCHOOL
& STAFFORD TECHNICAL CENTER
Rutland, VT
PART 4:

Emissions Implications of Biomass Fuels
Proven Emissions Control Equipment

- Electro Static Precipitator (ESP)
- Metal Mesh Filter
- Bag House
- Ceramic filter Baghouse
- Cyclone
Massachusetts Emissions Limits so you can get Grants (200,000-3,000,000BTU)

- Sensitive Receptor Sites (Hospitals, Schools, Nursing Homes, Daycare Centers)
  - PM 2.5 < .03 lbs/MMBTU/hr
  - Nox < .22 lbs/MMBTU/hr
  - CO < .18 lbs/MMBTU/hr

- General Sites
  - PM 2.5 < .08 lbs/MMBTU/hr
  - Nox < .22 lbs/MMBTU/hr
  - CO < .18 lbs/MMBTU/hr
Equipment that will comply with regulations
Complies in MA and NH with Pellets

Fröling P4
Fröling T4
Fröling TX
Fröling TM

Needs ESP with Chips
Viessmann KRT and KPT Boilers
Complies in MA and NH with Pellets

350MBH to 4300MBH

Needs ESP with Chips