Overview of Biomass Thermal Energy & CHP
California State Wood Energy Team Meeting
June 17, 2014
Adam Sherman
Biomass Energy Resource Center (BERC)
Advancing Community-scale Biomass Energy in North America

Technical Consulting
• Project feasibility studies
• Fuel supply assessments and procurement
• Third-party expert review
• Develop and review of standards
• Market Assessments

Program Design & Implementation
• Expansion potential assessments
• Program management
• Training, and advisory support services

Advocacy
• Showcasing “best practices” and case studies of successful projects
• Tracking market growth and impacts

BERC is a program of the Vermont Energy Investment Corporation
A mission-driven non-for-profit whose mission is to reduce the economic and environmental impacts of energy production and consumption
US Energy Consumption by Energy Sector

- Thermal
- Electric
- Transport
# Renewable Energy Matrix

<table>
<thead>
<tr>
<th></th>
<th>Heat</th>
<th>Electricity</th>
<th>Fuel Gas</th>
<th>Fuel Liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Wind</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

![BERC Biomass Energy Resource Center](https://example.com/berc-logo.png)
Bioenergy Technology Pathways

Thermal
- No Air
  - Pyrolysis
- Partial Air
  - Gasification
- Excess Air
  - Combustion

Biological
- Partial Air
  - Anaerobic Digestion
- No Air
  - Fermentation

Chemical
- Hydrolysis
  - Steam Reforming
  - Transesterification
Efficiency of “Off the Shelf” Conversion Technologies

- Industrial Process Heat
- Building Heat
- CHP Thermal
- District Heat
- Wood Stove
- CHP Power
- 200 MW Co-Firing
- 50 MW Power Plant
- 20 MW Power Plant

Efficiency (%)

- Electric
- Thermal

BERC
Biomass Energy Resource Center
Traditional Wood Heating Fuels

**Chunkwood**

**PROS:** Simple, cost effective, easy to self-supply

**CONS:** Manual feed, less efficient combustion, less convenient

**Woodchips**

**PROS:** Cost effective fuel, by-product supply, great for heating large facilities

**CONS:** High capital costs, not effective for residential heating

**Wood Pellets**

**PROS:** Energy dense fuel, clean burning, efficient, and convenient

**CONS:** Slightly higher cost per MMBtu
Perceptions of “Biomass Heating”
Modern Wood Boiler Technology

Cordwood system

Pellet system

Woodchip system
Advancements in Modern Combustion

Source: Dr. Christian Rakos, ProPellet, Austria
<table>
<thead>
<tr>
<th>Technology</th>
<th>Cordwood Boilers</th>
<th>Pellet Boilers</th>
<th>Single Facility Woodchip Heating</th>
<th>District Heating w/Woodchip Boilers</th>
<th>Industrial CHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical heat output capacity</td>
<td>20kW – 100kW</td>
<td>20kW - 1MW</td>
<td>500kW – 9MW</td>
<td>1.5MW – 15MW</td>
<td>8MW - 150MW</td>
</tr>
<tr>
<td>Applications</td>
<td>Home heating and farm buildings</td>
<td>Home heating &amp; small commercial buildings</td>
<td>Schools, hospitals, office buildings, etc.</td>
<td>College campuses and downtown communities</td>
<td>Merchant Power Plants</td>
</tr>
<tr>
<td>Fuel Type</td>
<td>Locally harvested firewood</td>
<td>Premium pellets</td>
<td>Paper grade and screened bole chips</td>
<td>Bole chips and whole-tree chips</td>
<td>Whole-tree chips and hog fuel</td>
</tr>
<tr>
<td>Annual Fuel Use</td>
<td>2-15 cords</td>
<td>2-20 tons</td>
<td>100 – 10,000 tons</td>
<td>500- 50,000 tons</td>
<td>1,000 – 500,000 tons</td>
</tr>
<tr>
<td>Fuel Sourcing</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Average Efficiency</td>
<td>65%</td>
<td>80%</td>
<td>75%</td>
<td>75%</td>
<td>28% - 40%</td>
</tr>
</tbody>
</table>
Biomass CHP Technology Pathways

Combustion

- Steam
- Thermal Oil

- ORC Turbine
- Steam Turbine (>1 MW)
- Gas Turbine (>0.5 MW)
- Sterling Engine

Gasification

- Hot Gas
- Synthesis Gas

- Internal Combustion Engine (Up to 0.5 MW)
- Gas Turbine (>5 MW)
Steam Turbine CHP Technology
Organic Rankine Cycle (ORC) CHP Technology
Gasification to IC Engine CHP Technology
Matching Loads for CHP

Heat demand

Electricity demand
Community-scale Modern Wood Heating Projects in the US
CAMPUS WOODCHIP HEATING SYSTEM

Middlebury College
MIDDLEBURY, VERMONT, UNITED STATES

- **Heating Capacity (output):** 8.8 MW (30 MMBtu/hr) Electric output 0.5 MW
- **Year Installed:** 2008
- **Fuel Use:** 20,000 GT/yr
- **Thermal Output:** Steam for heating, cooling, and power generation
WOODCHIP DISTRICT CHP SYSTEM

Towns of Toblach and Olang
SOUTH TYROL, ITALY

- **Heating Capacity (output):** One 10 MW (34 MMBtu/hr) boiler and two 4 MW (14 MMBtu/hr) boilers
- **Electrical Capacity:** 1.5 MW
- **Emissions Reduction and Combustion Control Equipment:** Multi-cyclone, electrostatic precipitator, condensation plant, moving grates, O$_2$ sensor control
- **Year Installed:** 1995
- **Thermal Output:** Hot water
- **District Heating Network Length:** 44 km (27 miles)
- **District Heating Customers:** 900
WOODCHIP DISTRICT CHP SYSTEM

Vølund Gasifier Plant and Town of Harboøre
JUTLAND, DENMARK

- Heating Capacity (output): 4 MW (14 MMBtu/hr)
- Electrical Capacity: 1.6 MW
- Emissions Reduction and Combustion Control Equipment: Electrostatic precipitator
- Year Installed: 2000
- Thermal Output: Hot water
- District Heating Network Length: 10 km (6 miles)
- District Heating Customers: 900
Cost of Heating Fuels in the US

Heating Fuels - $ per MMBtu

Data sources: EIA and BERC
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Wood pellet heating system
Space heating and domestic hot water supply with pellets

Wood pellets
2-5 cm (0.8-2 in.) in length, diameter 0.6 cm (0.24 in.)

Storage room

Domestic hot water

Space heating

Pellet boiler

Buffer storage

1. Once or twice a year the pellets are delivered by a silo tanker. A loaded storage room of 4.5 m² is enough to keep a single-family house warm for one year.

2. The pellets are carried from the storage room to the boiler by a fully automatic pellet feed.

3. After the burning process all that’s left is ash – with a weight of only 0.5 per cent of the original pellet. The ash can be disposed of with the domestic waste.

4. If the pellet boiler is interconnected with a buffer storage, emissions can be reduced and efficiency increased.

www.unendlich-viel-energie.de
The Carbon Cycle
Biomass Heated Buildings vs. Fossil Fuel Heated Buildings
Approach to Sector Focused Market Transformation

Categories of Innovativeness*

- Early Adopters 13.5%
- Early Majority 34%
- Late Majority 34%
- Laggards 16%
- Innovators 2.5%

Opportunity for Expanded Biomass Heating in VT

Heating Fuel 2011
- Heating Oil: 49%
- Natural Gas: 18%
- LPG: 15%
- Electricity and Other: 3%

Expanded Use of Wood
- Heating Oil: 36%
- Natural Gas: 18%
- LPG: 15%
- Wood: 28%
- Electricity and Other: 3%

Source: VPIRG Clean Heat Report & EIA consumption data
### Spectrum of Policies and Incentives Offered in VT

<table>
<thead>
<tr>
<th>Policy Description</th>
<th>NY</th>
<th>VT</th>
<th>NH</th>
<th>ME</th>
<th>MA</th>
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<tbody>
<tr>
<td>Flexible Boiler Regulations</td>
<td></td>
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<tr>
<td>Sales Tax Exemption on Biomass Appliances</td>
<td></td>
<td>√</td>
<td></td>
<td>Partial</td>
<td>Partial</td>
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<tr>
<td>Sales Tax Exemption on Biomass Fuel</td>
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<td>√</td>
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<td>Residential only</td>
<td>Residential only</td>
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<td>State Income Tax Credit</td>
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<td>N/A</td>
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<tr>
<td>Pellet Boiler Incentives</td>
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<tr>
<td>PACE Financing</td>
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<td>Thermal RPS</td>
<td></td>
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<td>√</td>
<td>Almost</td>
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<tr>
<td>State Grants for Biomass Thermal Projects</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
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</tr>
<tr>
<td>Government “Lead by Example” for Biomass Thermal</td>
<td></td>
<td>√</td>
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<tr>
<td>System Benefits Charge</td>
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<td>Weatherization only</td>
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<tr>
<td>Mandatory Renewable Energy Targets Applied to Building Codes</td>
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## Policy Options for Overcoming Market Barriers for Biomass Thermal Sector

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Potential Policy Solution</th>
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<tbody>
<tr>
<td>High capital costs</td>
<td>• Federal 30% tax credit</td>
</tr>
<tr>
<td></td>
<td>• State income tax credits</td>
</tr>
<tr>
<td></td>
<td>• State funded rebate programs</td>
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<tr>
<td></td>
<td>• Thermal inclusion in RPS in a way that creates “credit worthy” thermal RECs used toward capital costs</td>
</tr>
<tr>
<td>Public awareness</td>
<td>• Adopt policies such as “lead by example” programs by state and local government</td>
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<td></td>
<td>• Provide program support services to show case “best in class” projects using modern, efficient biomass thermal technologies</td>
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<tr>
<td></td>
<td>• Support education, outreach, and training for architectural, building construction, insurance, real estate, and engineering professions</td>
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<tr>
<td>Lack of regulatory framework for thermal sector</td>
<td>• Develop comprehensive “total energy” approach including electrical, thermal, and transportation energy</td>
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<tr>
<td></td>
<td>• Expand RPS to include thermal energy</td>
</tr>
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<td></td>
<td>• Apply SBC to heating fuels</td>
</tr>
<tr>
<td>Expanded natural gas service into new jurisdictions</td>
<td>• Apply a SBC to natural gas to further fund thermal efficiency and renewables such as biomass</td>
</tr>
<tr>
<td>Expanded use of electric powered air source heat pumps</td>
<td>• Create policies to encourage the combined use of biomass boilers and heat pumps as back-up systems</td>
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