Wood Pellets: Production, Applications, and Co-firing Potential

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Presentation Overview

• Introduction to Indeck Energy
• Introduction to Wood Pellets
  • Pellets for Co-firing with Coal
    • Co-firing Pellets in Wisconsin
  • Pellets for Institutional and Industrial-Sized Boilers
  • Technical Overview of Wood Pellet Production
Indeck Energy Services, Inc.

- Formed in 1985
- Part of the Indeck Group of Companies
  - Indeck Energy Services, Inc.
  - Indeck Operations, Inc.
  - Indeck Power Equipment Company
  - Indeck Boiler Company
  - Indeck Keystone Energy, LLC
Indeck Energy Services, Inc.

• Developer, owner and operator of power and biofuels projects
  • Power generation projects consisting of 3,000 MW internationally
  • Ethanol and biodiesel facilities representing 755 million gallons per year production
  • Wood pellet production facilities
    • 90,000 TPY in production
    • 90,000 TPY in development
## Indeck’s Alternative Energy Projects

<table>
<thead>
<tr>
<th>Facility</th>
<th>Location</th>
<th>Technology</th>
<th>Capacity</th>
<th>Commercial Operation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Enfield</td>
<td>West Enfield, ME</td>
<td>Biomass C.F.B.</td>
<td>25 MW</td>
<td>1987</td>
<td>Sold</td>
</tr>
<tr>
<td>Jonesboro</td>
<td>Jonesboro, ME</td>
<td>Biomass C.F.B.</td>
<td>25 MW</td>
<td>1987</td>
<td>Sold</td>
</tr>
<tr>
<td>Alexandria</td>
<td>Alexandria, NH</td>
<td>Biomass Stoker</td>
<td>16 MW</td>
<td>1988</td>
<td>Operating</td>
</tr>
<tr>
<td>Senneterre</td>
<td>Quebec, Canada</td>
<td>Biomass Stoker</td>
<td>25 MW</td>
<td>Development</td>
<td>Sold</td>
</tr>
<tr>
<td>Hydro West Enfield</td>
<td>West Enfield, ME</td>
<td>Run of River</td>
<td>13 MW</td>
<td>1988</td>
<td>Sold</td>
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</tbody>
</table>

## Indeck’s Wood Pellet Project

<table>
<thead>
<tr>
<th>Facility</th>
<th>Location</th>
<th>Capacity (Tons/Year)</th>
<th>Commercial Operation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indeck Ladysmith BioFuel Center</td>
<td>Ladysmith, WI</td>
<td>90 Thousand</td>
<td>2009</td>
<td>Operating</td>
</tr>
<tr>
<td>Indeck Magnolia BioFuel Center</td>
<td>Magnolia, MS</td>
<td>90 Thousand</td>
<td>2011</td>
<td>In Development</td>
</tr>
<tr>
<td>Facility</td>
<td>Location</td>
<td>Capacity (Gallons/Year)</td>
<td>Commercial Operation</td>
<td>Status</td>
</tr>
<tr>
<td>----------------------------------</td>
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<td>----------</td>
</tr>
<tr>
<td>Little Sioux Corn Processors</td>
<td>Marcus, IA</td>
<td>50 Million</td>
<td>2003</td>
<td>Operating</td>
</tr>
<tr>
<td>KAAPA Ethanol</td>
<td>Kearney, NE</td>
<td>60 Million</td>
<td>2003</td>
<td>Operating</td>
</tr>
<tr>
<td>Lincolnland Agri-Energy, LLC</td>
<td>Robinson, IL</td>
<td>45 Million</td>
<td>2004</td>
<td>Operating</td>
</tr>
<tr>
<td>Big River Ethanol</td>
<td>West Burlington, IA</td>
<td>100 Million</td>
<td>2004</td>
<td>Operating</td>
</tr>
<tr>
<td>Platte Valley Ethanol</td>
<td>Central City, NE</td>
<td>40 Million</td>
<td>2004</td>
<td>Sold</td>
</tr>
<tr>
<td>United Wisconsin Grain Producers</td>
<td>Friesland, WI</td>
<td>45 Million</td>
<td>2005</td>
<td>Operating</td>
</tr>
<tr>
<td>Granite Falls Ethanol</td>
<td>Granite Falls, MN</td>
<td>40 Million</td>
<td>2006</td>
<td>Operating</td>
</tr>
<tr>
<td>Iroquois Bioenergy</td>
<td>Rensselaer, IN</td>
<td>40 Million</td>
<td>2006</td>
<td>Sold</td>
</tr>
<tr>
<td>Western Wisconsin Energy</td>
<td>Boyceville, WI</td>
<td>40 Million</td>
<td>2006</td>
<td>Operating</td>
</tr>
<tr>
<td>Cardinal Ethanol</td>
<td>Winchester, IN</td>
<td>100 Million</td>
<td>2008</td>
<td>Operating</td>
</tr>
<tr>
<td>Blackhawk Biofuels, LLC</td>
<td>Danville, IL</td>
<td>45 Million</td>
<td>2009</td>
<td>Operating</td>
</tr>
<tr>
<td>Big River Development</td>
<td>Various, IA</td>
<td>100 Million</td>
<td>Various</td>
<td>Operating</td>
</tr>
<tr>
<td>Highwater Ethanol</td>
<td>Lamberton, MN</td>
<td>50 Million</td>
<td>2009</td>
<td>Operating</td>
</tr>
<tr>
<td><strong>Total Annual Production</strong></td>
<td></td>
<td><strong>755 Million</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Coal Use in the U.S.

• U.S. is 2nd largest user of coal in the world, after China
• U.S. consumed approx. 1 billion tons of coal in 2009
• Coal accounts for 46% of U.S. electricity generation
• U.S. has nearly half of a billion tons of biomass available for energy production
Co-firing Wood Pellets

- Most U.S. experience of co-firing pellets with coal in utility boilers is in the testing stage
- Europe has been co-firing pellets successfully with coal since the 1990s
  - Sweden, Denmark, Germany, and Austria are biggest users
  - Europe used about 6.6 million tons of pellets in 2009 and imported about 30% of that. Imports are increasing from large U.S. pellet plants, mainly in southeastern U.S.
- Co-firing is successful financially in Europe because of carbon legislation and utility cooperation
Co-firing

- Wood pellets are well-suited for co-firing with coal
  - Densified, low-moisture, uniform biomass
  - Avoid many challenges of co-firing raw biomass
  - Many characteristics similar to coal
  - Cause fewer harmful emissions than coal, such as mercury and nitrous oxides
  - Lower in ash and result in less boiler corrosion and slagging
  - Carbon neutral
## Wood Pellet Characteristics

<table>
<thead>
<tr>
<th>Property</th>
<th>Wood Pellets (Industrial)</th>
<th>Bituminous Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Content (MMBTU/ton)</td>
<td>15.8 – 17.0</td>
<td>16.7 – 26.9</td>
</tr>
<tr>
<td>Ash Content (% wt.)</td>
<td>2.0</td>
<td>3.3 – 11.7</td>
</tr>
<tr>
<td>Moisture Content (% wt.)</td>
<td>&lt;8.0 (TYP 4.0-6.0)</td>
<td>2.2 – 15.9</td>
</tr>
<tr>
<td>Sulfur (% wt.)</td>
<td>0.010 – 0.015</td>
<td>0.7 – 4.0</td>
</tr>
<tr>
<td>Nitrogen (% wt.)</td>
<td>0.03</td>
<td>1.5</td>
</tr>
<tr>
<td>Mercury (% wt.)</td>
<td>0.16 E-8</td>
<td>2.21 E-8 – 6.91 E-7</td>
</tr>
<tr>
<td>Bulk Density (lb/ft³)</td>
<td>45</td>
<td>43 – 50</td>
</tr>
</tbody>
</table>

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[3] 2008 EIA Monthly Time Series File, EIA-923. Range of coal heat content in WI power plants only was used.
[6] EIA Coal Transportation Sensitivity Analysis, April 2005
Why Use Wood Pellets for Co-firing? Environmental Benefits

- Reduction of greenhouse gas emissions, CO$_2$
- Reduction of SO$_x$
- Reduction of NO$_x$
- Reduction of harmful heavy metals such as mercury and cadmium
Technical Benefits

• Co-firing Fuel – Wood Pellets vs. Wood Chips or Ag-Residue
  • Consistent fuel specification – provides for high reliability
  • Low moisture content – provides for minimal degradation of boiler performance
  • High heat content – closely matches heat content of coal
  • Low ash content – less ash than coal
  • No agricultural biomass fertilizer residuals – avoid impact on boiler tubes
  • Ease of transport and handling
  • Extensive test runs already performed
    • UWEC, Alliant, FirstEnergy, AEP, EKPC
Focus on Wisconsin: An Energy Importer

• Over $16 billion/year spent on energy imports
• Almost $900 million/year spent on coal imports alone
• 5% co-firing keeps more than $45 million spent on coal imports in the state
Co-firing

• Wood pellets in utility coal boilers
• Sustainability - Wisconsin has the biomass resource to co-fire every coal boiler in the state with wood pellets at a 15% co-firing rate utilizing less than one-third of the available resource annually
• Co-firing is a least cost solution compared to wood chip biomass power plants and is on par with wind energy, typically the most economic of the renewable technologies
Co-firing

• WI has 30+ utility, industrial, and institutional coal boilers totaling 7,800 MW
• Consumes 26 million tons of coal annually
  • All sourced from out of state
Co-firing

• Wisconsin utilities could set an example for other states and become a leader in this field
• Likely that Wisconsin will be required to implement renewable legislation in near future
• Use clean, renewable, dependable in-state resources
# The True Cost of Coal

## Assumptions and Sources

- **Coal Cost**: EIA 2009 WI average electric utility coal cost, delivered.
- **Carbon (CO₂) Cost**: Spot settled CO₂ price from European Climate Exchange as of 8/24/2010.
- **Total WI Coal Usage**: 26,224,036 tons/year, per EIA-923 and EIA-860 data series.
- **Emissions Factors**: EIA, EPA.
  - Coal CO₂: 2.34 ton CO₂/ton coal.
  - Coal NOₓ: 1.15E-05 ton NOₓ/MWh.
  - Coal SO₂: 4.00E-03 ton SO₂/MWh.
  - Coal Mercury: 3.57E-07 % wt.

### All Coal-Fired Boilers in Wisconsin (7800 MW)

<table>
<thead>
<tr>
<th></th>
<th>Tons</th>
<th>Unit Cost</th>
<th>TOTAL ANNUAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Delivered Cost</strong></td>
<td>26,224,036</td>
<td>$35.68/ton</td>
<td>$935,673,604.48</td>
</tr>
<tr>
<td><strong>Carbon (CO₂) Cost</strong></td>
<td>61,460,733</td>
<td>$18.90/ton</td>
<td>$1,161,607,853</td>
</tr>
<tr>
<td><strong>NOₓ Cost</strong></td>
<td>480</td>
<td>$450/ton</td>
<td>$215,827</td>
</tr>
<tr>
<td><strong>SO₂ Cost</strong></td>
<td>166,614</td>
<td>$10/ton</td>
<td>$1,666,144</td>
</tr>
<tr>
<td><strong>Mercury Cost</strong></td>
<td>9.35</td>
<td>$1450/oz</td>
<td>$433,848,354</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td></td>
<td></td>
<td>$2,553,011,782</td>
</tr>
</tbody>
</table>
# The True Cost of Co-firing

## All Coal-Fired Boilers in Wisconsin: 5% Co-firing Case (7800 MW)

<table>
<thead>
<tr>
<th></th>
<th>Tons</th>
<th>Unit Cost</th>
<th>TOTAL ANNUAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Delivered Cost:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>24,912,834</td>
<td>$35.68/ton</td>
<td>$888,889,924</td>
</tr>
<tr>
<td>Pellets</td>
<td>1,402,870</td>
<td>$150/ton</td>
<td>$210,430,536</td>
</tr>
<tr>
<td><strong>Carbon (CO₂) Cost</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58,387,696</td>
<td>$18.90/ton</td>
<td>$1,103,527,460</td>
<td></td>
</tr>
<tr>
<td><strong>NOₓ Cost</strong></td>
<td>462</td>
<td>$450/ton</td>
<td>$208,045</td>
</tr>
<tr>
<td><strong>SO₂ Cost</strong></td>
<td>158,373</td>
<td>$10/ton</td>
<td>$1,583,726</td>
</tr>
<tr>
<td><strong>Mercury Cost</strong></td>
<td>8.91</td>
<td>$1450/oz</td>
<td>$413,197,427</td>
</tr>
<tr>
<td><strong>Pellet Mill Job Creation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Annual Salaries)</td>
<td></td>
<td></td>
<td>$14,700,000</td>
</tr>
<tr>
<td><strong>Related Job Creation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Annual Salaries)</td>
<td></td>
<td></td>
<td>$58,800,000</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td></td>
<td></td>
<td>$2,544,337,119</td>
</tr>
</tbody>
</table>

### Assumptions and Sources

- **Pellet Cost:** $135/ton, bulk, industrial grade pellets. FOB production facility. $15/ton delivery via rail from Ladysmith, WI to Madison, WI.
- **Pellets Required:** 1,402,870 tons based on 5% by energy co-firing.
- **Job Creation (Pellet Mills):** Based on 21 pellet mills (Production: 70,000 tons annually each) required to produce 1.4 million tons of pellets annually. Each mill has 20 employees.
- **Job Creation (Related):** Encompasses logging, aggregation, transportation, construction and other indirect jobs. Approximately 80 indirect jobs created per pellet mill.
- **CO₂ Cost:** Assumes carbon neutrality of pellets.
- **Emissions Factors:** EIA, EPA.
  - Pellets NOₓ: 3.21E-06 ton NOₓ/MWh.
  - Pellets SO₂: 4.27E-05 ton SO₂/MWh.
  - Pellets Mercury: 1.60E-08 % wt.
- See previous slide for remaining assumptions.
Clean Renewable Energy Jobs
5% Co-firing Case: 21 Wood Pellet Plants

Construction Jobs: 1,300

Permanent Jobs: 1,300

350 Wood pellet plant operators
800 Loggers
150 Truckers
Clean Renewable Energy Benefits
5% Co-firing Case: 21 Wood Pellet Plants

Annual Benefits
• $45 million would not be spent on out of state coal
• $15 million wood pellet plant salaries
• $59 million logger and trucker wages

Additional Annual Benefits
• Real estate taxes
• Plants buy or lease products
• Things break or need to be serviced: repair bills
• Water, sewage, electricity & telephone bills

Capital Investment for Wood Pellet Plants
• $400 million
• Additional costs for road and infrastructure upgrades
Wisconsin Wood Resource

- About 16.2 million acres of timberland
- Over 70% of timberland in WI is privately owned
- Annual growth is about 1.7 x annual harvest (16 million tons grown vs. 9.5 million tons harvested)
- On average, growth rate is increasing, while mortality and removals have remained static for past decade
- Aspen and basswood make up approximately 50% of Wisconsin forests
Wisconsin Wood Pellet Market

• Utility co-firing / coal replacement
  • Co-firing is ideal for meeting state RPS
    – No energy imports required
    – No major technological advances required
    – Creates in-state jobs
    – Feedstock available for pellets can supply 100% of renewable generation required

• Institutional and industrial pellet boilers
Wood Pelletization Process

- Sawdust Pile
- Feed Hopper & Conveyor
- Wet Hammermill
- Dryer
- Pellet Cooler
- Cyclones
- Pellet Mills
- Pellet Storage
- Bagged Product
- Fine Separation
- Pellets to Burner for Fuel
Wood Pelletization: Technical Overview

- Feedstock can be de-barked
- Feedstock chipped
Wood Pelletization: Technical Overview

- Chips conveyed, ground, dried, and re-ground
Wood Pelletization: Technical Overview

- Sawdust pelletized
- Pellets cooled
- Pellets filtered via shaker and screener
- Transported to Bulk Bins

Wood Pelletization: Technical Overview

- Bulk Storage
Institutional/Industrial Pellet Boilers

- Current coal boilers:
  - State/government facilities
  - Manufacturing companies, especially paper and pulp mills
  - More than 20 total in state
- Incentives should exist for converting industrial coal users to biomass
- Utilities must meet RPS but institutional and industrial facilities are not required to meet RPS
  - Industrial coal users in WI consume over 1.3 million tons and emit over 5% of total CO₂ emissions in state
  - Could be using in-state resources and emitting far less
Indeck in Wisconsin:
Indeck Ladysmith BioFuel Center

- Wood pellet plant with 90,000 TPY capacity, enough to heat up to 30,000 homes
- Located in Ladysmith, Rusk County
- Began operation in August 2009
- First BCAP-approved facility in Wisconsin
- Feedstock mainly hardwood from sustainable forestry practices, forest residue, and local mill residue
Indeck Ladysmith BioFuel Center

- Located in northwest Wisconsin 50 miles from Eau Claire, WI
- Supported off CN railroad main line
- Feedstock requires over 200,000 TPY forest and mill residue
- Industrial, commercial, and residential pellets available
- Bulk rail and truck loading available
- Employs 25+ Wisconsin residents when fully operational and supports 45-75 logging and transportation jobs
Wisconsin Partner: Midwest Forest Products Co.

- Feedstock aggregator and partial owner of Indeck Ladysmith BioFuel Center
- Formed in 1977 for the production of high quality debarked pulpwood to paper mills
- Pioneered portable ring debarking and chipping services
- Actively involved with
  - Wood processing and procurement
  - Chipping
  - Trucking
  - Harvest
  - Timberland management
Summary

• Wisconsin has an abundant biomass supply and wood pellets are ideal way to utilize this biomass for energy
  • Technical Benefits
  • Economic Benefits
  • Environmental Benefits

• Wood pellets create clean renewable energy jobs
• Wisconsin energy independence: offset out of state/country fossil fuels – keeps money flowing within the state
• Going forward
Indeck Energy Services, Inc.

Energy for Generations®

For more information please visit us at:
www.indeckenergy.com
- and -
www.indeckpellets.com