Growth in the Industrial Pellet Sector:

The potential for power plant conversions in North America

William Strauss, PhD

President, FutureMetrics
Director, Maine Energy Systems
Chief Economist, Biomass Thermal Energy Council
FutureMetrics

Globally Respected and Award Winning Consultants
in the Wood Pellet Sector

8 Airport Road
Bethel, ME 04217, USA
www.FutureMetrics.com
Expert advice, analysis, and strategic guidance for the wood pellet sector.

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Financial modeling
Risk and decision analysis
Economic impact analysis

Global Oil Supply - Source and Total
Change on a Year Earlier in Millions of Barrels per Day

Heating Oil Prices and Wood Pellet Demand
wood pellet demand as change in NE tonnage volumes from a year earlier

source: EIA, 2014; Demand estimates by FutureMetrics; 2015 forecast based on various crude oil forecasts; Analysis by FutureMetrics
Award Winning Team Members

Dr. William Strauss, President, FutureMetrics

Recipient of the 2012 International Excellence in Bioenergy Award

John Swaan, Senior Associate, FutureMetrics

Recipient of the 2014 International Founders Award
## North America

Capacity to produce over 12 million metric tonnes per year for export

<table>
<thead>
<tr>
<th>Metric Tonnes per Year</th>
<th>Current Export Production</th>
<th>Current Domestic Heating Market Production</th>
<th>North America Capacity Under Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>18,000,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16,000,000</td>
<td></td>
<td></td>
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<tr>
<td>14,000,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12,000,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10,000,000</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>8,000,000</td>
<td></td>
<td></td>
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<tr>
<td>6,000,000</td>
<td></td>
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<td>4,000,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,000,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8,869,364
4,539,909
3,250,000

12,041,000
4,618,000

Modest growth in the domestic heating markets

Source: BBI pellet mill database, analysis by FutureMetrics

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How does that compare to actual exports?

Canada and US adds up to about 5.1 million metric tonnes in 2013 (adjusted for 11 months in the data)


GTIS = Global Trade Information Services
US

FutureMetrics - Globally Respected Consultants in the Wood Pellet Sector

Source: BBI pellet mill database, analysis by FutureMetrics
Canada

Source: BBI pellet mill database, analysis by FutureMetrics

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What is the Future of the Pellet Markets?

Almost 30 million tonnes!

Source: RISI, “Global Pellet Demand,” 2014
Downside risk is due to lower heating oil prices. That scenario is very possible. See chart on the next slide...

Annual North American Pellet Demand for Domestic Heating (tons)

- **Annual Pellet Demand (tons)**
- **Expected Demand**
- **Upper 95% Confidence Band**
- **Lower 95% Confidence Band**

2.2 million short tons

Source: for pellet stoves, HPBA, 2014; for pellet boilers, FutureMetrics data; Forecast and Analysis by FutureMetrics
Where will demand for domestic heating pellets go in 2015?
Uncertainty in the export markets for future growth and potential excess capacity!

Fluctuations in demand for heating pellets...

There is an untapped market for industrial wood pellets (white and black) right in our backyard!
The potential for significant growth in the industrial pellet market is in the conversion of North American pulverized coal power plants.

There are three large “proof of concept” operations:

• Drax in the UK (650 MWs per unit)

• Ontario Power Generations' 240 MW Atikokan and Thunder Bay plants in Ontario

There are hundreds of others that can be converted economically and can produce low cost, dispatchable, and job creating electricity.
27 US states do have **renewable portfolio standards (RPS)**. 11 other states have variants on RPS.

**2012-2030 RPS gap = 155,824 GWh**

Closing all RPS gaps increases total RPS-supported demand to 9.3% of total generation by 2030.

New U.S. EPA ruling (111D)

• July 2, 2014 U.S. EPA released the Clean Power Plan proposal, to cut carbon emission from the power sector by 30 percent below 2005 levels.

• Program to be implemented at State level based on Federal EPA Regulation Guidelines

• States developing Section 111D plans over next year, to be approved by EPA, and implemented starting in 2016
The pathway to that lowest cost renewable power for RPS and EPA compliance that also has the benefits of being available on demand (dispatchable) or continuously (baseload) is via the conversion of older pulverized coal power plants to use advanced solid biofuels.
Every MW of wind or solar power needs a MW of thermal generation (or hydro where available) to keep the grid balanced when the wind is not blowing and the sun is not shining.

MW’s of power from plants running on pelletized refined biofuel are cheaper than wind or solar.

And those plants also **solve the intermittency problem** with renewable power (rather than relying on coal peaking plants).
How is coal burned in a power plant boiler?

The coal is ground in to dust, pneumatically transferred to a burner in the sidewall of the boiler, and the dust blown into the burner. Combustion takes place rapidly.

Replacing coal with pellets is very straight forward with minor modifications.
Pulverized Pellet Burner in the Atikokan Power Plant
OPG’s Atikokan Plant Running on 100% Pellets

The $170 million conversion works out to about $700 per kW of capacity.

About $350/kW of that was for new dry storage and handling.

New wind is about $2000/kW. New solar PV is about $4000/kW.

Neither wind or solar is dispatchable!
The economics of the cost of power generation

There are four broad components that add up to the total cost per MWhₐ of generation:

• The capital cost to build the plant,

• The fixed and variable operations and maintenance (O&M) costs,

• The fuel cost,

• Capacity factor.
Capacity factor matters. Capacity factor is the ratio of actual power production to the theoretical maximum if the plant were to run at 100% of its nameplate 365 days a year.

Wind and solar PV have low capacity factors so the amortized capital cost burden on each MWh produced is much higher.
The fuel cost is not the only component of the total cost of generation.

If it were, then wind and solar with free fuel would provide free electricity.

A **significant component** of the total cost of generation is the amortized capital costs of building the generating facility (especially for low capacity factor generators such as wind and solar).
Why are Older Pulverized Coal Power Stations a Pathway to Lowest Cost RPS Compliance?
There are 428 operating pulverized coal plants in the US (greater than 50 MW). The median age is 48 years. 77.3% of the plants are older than 35 years.

Data is from the EPA Emissions & Generation Resource Integrated Database (eGRID), February, 2014. Distribution modeling is done with Palisade @RISK software.
There are about 20 coal fired power plants in Canada

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>State/Province</th>
<th>Plant Generation Capacity (MW)</th>
<th>SO2 (t)</th>
<th>Hg (kg)</th>
<th>CO2 (t)</th>
<th>CO2 Emission Rate (kg/MWh)</th>
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</thead>
<tbody>
<tr>
<td>EPCOR GENERATION - Genesee</td>
<td>Alberta</td>
<td>1,315</td>
<td>16,680</td>
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<td>TransAlta Utilities Corporation - Keephills</td>
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<td>Milner Power Inc. - H.R.Milner Generating</td>
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<td>23,236</td>
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<td>NOVA SCOTIA POWER - Lingan</td>
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<td>55</td>
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<td>37,809</td>
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<td>40</td>
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TOTALS: 18,065 453,473 2,047 97,772,909

TOTALS Minus ONTARIO: 9,580 342,333 1,727 68,517,797
Assume that any conversion from coal to wood pellet fuel will be plants that are older than 35 years.

In that case, the primary new major capital cost for a conversion from pulverized coal to wood pellet fuel would be the fuel storage and handling systems.
Converted plants older than 35 years have zeroed out original capital cost. Conversion cost is capitalized.

<table>
<thead>
<tr>
<th>Green shading for renewable solutions</th>
<th>Fixed Capital Cost per MWhₑ</th>
<th>Fixed and Variable O&amp;M per MWhₑ</th>
<th>Fuel Cost per MWhₑ</th>
<th>Total Cost per MWhₑ (at the power station bus bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>$46.03</td>
<td>$4.10</td>
<td>$</td>
<td>$50.13</td>
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<tr>
<td>Natural Gas Combined Cycle</td>
<td>$16.18</td>
<td>$1.70</td>
<td>$37.53</td>
<td>$55.41</td>
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<tr>
<td>Pulverized Coal (less that 35 years old)</td>
<td>$40.77</td>
<td>$5.60</td>
<td>$25.75</td>
<td>$72.12</td>
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<tr>
<td>Conversion: Old Pulverized Coal to White Pellets*</td>
<td>$8.55</td>
<td>$5.50</td>
<td>$78.92</td>
<td>$92.97</td>
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<tr>
<td>Nuclear</td>
<td>$84.17</td>
<td>$11.80</td>
<td>$12.50</td>
<td>$108.47</td>
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<tr>
<td>Landbased Wind</td>
<td>$111.27</td>
<td>$13.00</td>
<td>$</td>
<td>$124.27</td>
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<tr>
<td>Offshore Wind</td>
<td>$109.24</td>
<td>$22.80</td>
<td>$</td>
<td>$132.04</td>
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<tr>
<td>Solar PV</td>
<td>$171.24</td>
<td>$11.40</td>
<td>$</td>
<td>$182.64</td>
</tr>
</tbody>
</table>

*Assumes CAPEX is only for the conversion since the plants are over 35 years old and all installed CAPEX costs have been recouped.

Fixed Capital Cost per MWhₑ is greater than any fuel costs for thermal generation!

$0.02/kWh difference
Total Cost per $kWh_e$
(at the power station bus bar)

Lowest Cost Renewable Generation other than Hydro: About $0.02 per kWh more than coal

Wind is about $0.03 per kWh more expensive AND CREATES NO JOBS

source: see table above; Analysis by FutureMetrics
Job creating!

Total Jobs Created to Supply Fuel to a 500 MW Power Plant

- Wood pellets: 3481
- Coal: 2538
- Wind: 0
- Solar: 0

Analysis on pellet and chip jobs by FutureMetrics using IMPLAN. Data on coal employment from “U.S. Coal Exports: National and State Economic Contributions”, Ernst & Young, May, 2013. Both include direct, indirect, and induced jobs. Analysis by FutureMetrics.
<table>
<thead>
<tr>
<th>Green shading for renewable solutions</th>
<th>Construction or Conversions for Coal Plant per kW</th>
<th>Size (MW)</th>
<th>Capacity Factor</th>
<th>Install Cost</th>
<th>Annual Capital Cost Amortization</th>
<th>Annual Output (MWh_e)</th>
<th>Fixed Capital Cost per MWh_e</th>
<th>Fixed and Variable O&amp;M per MWh_e</th>
<th>Fuel Cost per MWh_e</th>
<th>Total Cost per MWh_e (at the power station bus bar) (Assumed Power Plant Efficiency)</th>
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</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>$ 3,500</td>
<td>1000</td>
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<td>$ 3,500,000,000</td>
<td>$ 362,913,968</td>
<td>7,884,000</td>
<td>$ 46.03</td>
<td>$ 4.10</td>
<td>$ -</td>
<td>$ 50.13</td>
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<tr>
<td>Natural Gas Combined Cycle</td>
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<td>580</td>
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<td>$ 713,400,000</td>
<td>$ 73,972,236</td>
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<td>$ 1.70</td>
<td>$ 37.53</td>
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<tr>
<td>Pulverized Coal (less that 35 years old)</td>
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<td>500</td>
<td>90.0%</td>
<td>$ 1,550,000,000</td>
<td>$ 160,719,043</td>
<td>3,942,000</td>
<td>$ 40.77</td>
<td>$ 5.60</td>
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<td>Conversion: Old Pulverized Coal to White Pellets*</td>
<td>$ 650</td>
<td>500</td>
<td>90.0%</td>
<td>$ 325,000,000</td>
<td>$ 33,699,154</td>
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<td>$ 8.55</td>
<td>$ 5.50</td>
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<td>$ 92.97</td>
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<tr>
<td>Nuclear</td>
<td>$ 6,400</td>
<td>1125</td>
<td>90.0%</td>
<td>$ 7,200,000,000</td>
<td>$ 746,565,877</td>
<td>8,869,500</td>
<td>$ 84.17</td>
<td>$ 11.80</td>
<td>$ 12.50</td>
<td>$ 108.47</td>
</tr>
<tr>
<td>Landbased Wind</td>
<td>$ 2,350</td>
<td>50</td>
<td>25.0%</td>
<td>$ 117,500,000</td>
<td>$ 12,183,540</td>
<td>109,500</td>
<td>$ 111.27</td>
<td>$ 13.00</td>
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<tr>
<td>Offshore Wind</td>
<td>$ 3,230</td>
<td>50</td>
<td>35.0%</td>
<td>$ 161,500,000</td>
<td>$ 16,745,887</td>
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<td>$ 109.24</td>
<td>$ 22.80</td>
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<td>$ 132.04</td>
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<tr>
<td>Solar PV</td>
<td>$ 4,340</td>
<td>100</td>
<td>30.0%</td>
<td>$ 434,000,000</td>
<td>$ 45,001,332</td>
<td>262,800</td>
<td>$ 171.24</td>
<td>$ 11.40</td>
<td>$ -</td>
<td>$ 182.64</td>
</tr>
</tbody>
</table>

*Assumes CAPEX is only for the conversion since the plants are over 35 years old and all installed CAPEX costs have been recouped.

Hydro is Green and Baseload but US Hydro is fully exploited. No new large hydro opportunities are left. Peak was in 1973.
27 States have Renewable Portfolio Standards. This is a solution that provides a pathway to compliance with HUGE benefits.
Although the potential US market is much larger and Canada should supply fuel, Canada has conversion opportunities also.

**Policies based on carbon reduction.**

Each kWh of electricity from coal has a by-product of about 2.15 pounds of CO₂

That is about 1.1 short tons of CO₂ per MWh

The incremental reduction in CO₂ from using sustainable wood pellets is about 70% to 85% depending on supply chain factors

**A 200 MW pulverized coal plant that converts to pulverized wood pellets will reduce CO₂ emissions by more than 1,200,000 tons per year**
We have not talked about co-firing

**Example**: Korea Southeast Power (KOSEP) is co-firing 3% wood pellets with coal with **no modification** to the power plant and no dry storage solution at the power plant.

Pellets are simply metered into the coal before the pulverizers.

The power station consumes about 9.7 million tonnes per year of coal. Co-firing a “modest” amount of pellets in terms of percentage is still **300,000 tonnes per year of pellets**.
Dong Energy’s Inbicon Kalundborg Demonstration Plant
Steam, Power, and pellet fuel Integration with Asnæs Power Station:
The 780 MW station is co-firing black lignin pellets.

Leifmark, LLC is an independent U.S. company founded in 2011 to market Dong’s Inbicon Biomass Refinery technology in North America. www.leifmark.com
Dong’s Inbicon Biomass Refinery

- Steam and Power Lines from Powerplant
- Lignin Outlet
- Ethanol Outlet
- Biomass Receiving
- Pre-treatment
- Liquefaction
- Fermentation
- Distillation
Lignin Pellet Properties

- High energy value, clean combustion, low sulfur content – 21 GJ/mt
- Low in corrosive elements, by design
- High resistance to moisture
- Easy to handle, excellent durability for transportation and storage
- Competitive capital and operating cost to implement (all in cost per GJ similar to wood pellets)
- **DONG Energy has proven Inbicon lignin use in coal power plants**
A significant proportion of domestic power plants can convert to dispatchable pellet fuel and provide low-cost grid-balancing renewable power.

The constraint on wood pellet volumes is the quantity of sustainable wood.

But that limit is many times current Canadian and US production levels.
If we consider lignin pellets:

For example, there is enough corn stover (currently a waste or low value fuel for purpose built power plants) from the 24 corn ethanol producers in Nebraska to produce 3.1 million mtons per year of lignin pellets.

That would replace 20% of the coal consumed in Nebraska.
The forest products industry needs wood pellet manufacturers.

The world is changing.

(can you believe that PPI is telling its readers to move away from print!)
“Verso mill in Bucksport to close by year’s end, 570 employees to lose jobs”
[Bangor, Maine Daily News, October 2, 2014]
We need to **engage** with our policymakers and regulators at the provincial/state and federal levels to **educate** them on the significant positive characteristics of this strategy:

A dedicated, consistent, and unified voice is needed.
• The **lowest cost renewable** power generation solution;

• Dispatchable and baseload **power that is available when needed**;

• **More jobs** per megawatt-hour of energy than any other generation technology;

• **Very low carbon** footprint;
Thank you
William Strauss

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