Northwest **Power** and **Conservation** Council

October 4, 2016

MEMORANDUM

TO: **Council Members**

FROM: **Gillian Charles**

SUBJECT: **The potential conversion of Boardman to biomass**

BACKGROUND:

Presenter: Wayne Lei, Project Manager – Strategic Support, Portland General Electric

Summary: In 2010, Portland General Electric (PGE) announced its plans to cease coal-fired operation at its Boardman plant by December 31, 2020. Since then, PGE has been researching and testing alternative ways to utilize the existing infrastructure and transmission lines at the Boardman site, once it is no longer operated as a coal plant. The idea of converting Boardman to a biomass plant has been extensively studied by PGE over the past several years.

Wayne Lei will discuss PGE's work, past and present, on the potential conversion of Boardman from a coal-fired plant to a biomass plant, including plans for a 100% biomass test burn for 24 hours scheduled for some time later this year.

Relevance: As part of the Seventh Power Plan's action item ANLYS-14, the Council is to monitor and track emerging technologies and innovations that hold potential for the future regional power system.

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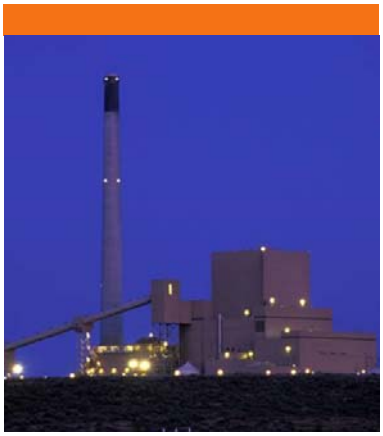
Workplan: Power division work plan, Action A. Implement Seventh Power Plan and related Council priorities

Background: Boardman is a 600 megawatt coal-fired generating plant operated and majority-owned (90%) by PGE. It is the only coal plant operating in the state of Oregon. By ceasing coal-fired operations in 2020, PGE is avoiding having to make substantial long-term investments to the plant in order to comply with several environmental regulations.

The term “biomass” covers a variety of fuels derived from organic materials, although the most common fuel is wood. Other fuels include waste from food crops and animals, forestry and agricultural residues, and landfill gas.

The Potential Conversion of Boardman to Biomass



October 12, 2016

Wayne Lei
Randy Curtis
Mark LaPlante
Tom Nilan
Dave Rodgers
Brad Jenkins

With Gratitude to Oregon Torrefaction

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Presentation

- Status of Boardman 100% torrefied biomass test burn
- Quick roadmap history: Bumps, dead ends and all
- Regulatory & environmental side boards
- Obtaining 8,000 tons of torrefied fuel
- Combustion pre-testing at Western Research Institute
- Production and transportation logistics
- Project status as of late September 2016

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Integrated Resource Plan Context

Biomass is being explored as one component of a balanced resource strategy in which PGE is accelerating the renewable energy future

It starts with energy management , e.g.

- Energy Efficiency;
- Demand Response
- Conservation Voltage Reduction, etc.

Then seeks to expand use of renewable resources (including hydro) and leverages integration technology to reduce emissions

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Boardman Power Plant

Baseload workhorse

- 600 MW capacity; PGE owns 90%
- Plant to cease coal operations by Dec. 31, 2020
- 100% operation on biomass may be an option with regulatory approval

Using Biomass at this scale Breaks New Ground

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Basic Tenets

Boardman is a 600 MW pulverized coal-fired power plant

Biomass in Oregon

- Counts as a source of renewable power
- Helps PGE fulfill its RPS need

Can use biomass in the Boardman Power Plant BUT….

- The biomass must be made crispy so that it will pulverize
- Pulverized fuel is then fed into the boiler

Key things the fuel has to do:

- Grind well
- Burn well
- Adequate ash collection

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Torrefaction process flow – Typical Example

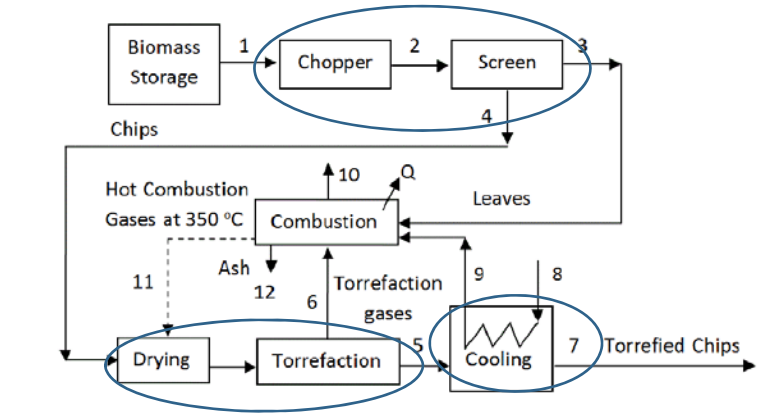

Figure 3 Conceptual design of a proposed torrefaction process proposed (Bergman et al. 2005).

= Principal Components

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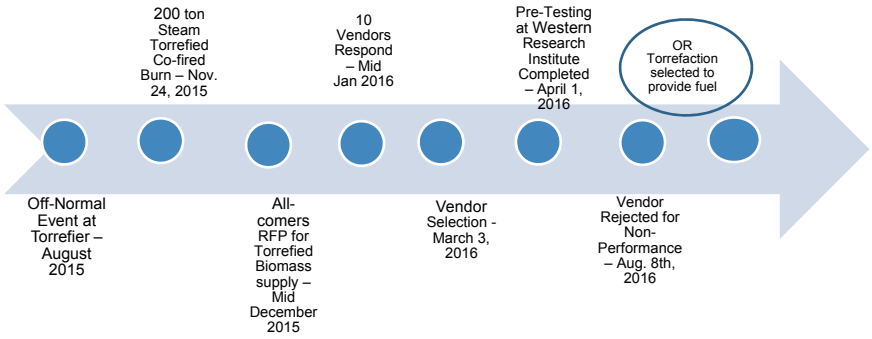
Timeline of Activity



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Regulatory Side Boards – 2016 Decision

Phase 1: Co-fire test burn [2015]

Phase 2 [2016]

- 100% Torrefied test burn
- One full power day equivalent
- 6 pulverizers for 24 hours
- 3 pulverizers for 48 hours

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Environmental: Longer-term Permitting Issues

Multi-year permitting process for site certificate and air permit

- Start ASAP after successful test burn and "go" decision on torrefaction
- Ambient air quality background monitoring network may be needed

Uncertainty of obtaining air permit

- Challenges with meeting new ambient air quality standards (1-hr NO_2 and 24-hr $PM_{2.5}$) without additional controls
- Class I visibility (regional haze)

Additional emission controls likely required

- Selective catalytic reduction (SCR) (NOx)
- Catalytic oxidation (CO and VOCs)
- Additional baghouse (PM, driven by regional haze issues)

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Request for Proposal
8,000 tons Torrefied Biomass

16 Sources Worldwide – All comers

- Steam Torrefied
- Kiln Torrefied

10 Responses

One Response at close to levelized cost

Located in the Commonwealth of Virginia

- Heart of "Coal Country"
- Excess capacity in transportation, labor due to coal downturn

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Oregon Torrefaction, LLC

Benefit corporation

- 70% US Endowment for Forestry and Communities (Greenville, SC)
- 15% Ochoco Lumber (Prineville, OR)
- 15% Bonneville Environmental Foundation (Portland, OR)

Well capitalized

Mission driven

Planning a stationary torrefier in John Day, OR

Collaboration with PGE as torrefied fuel off-taker

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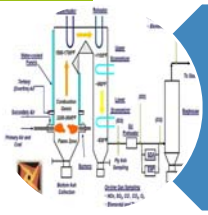
Western Research Institute – Combustion Tests

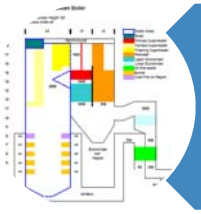
WRI



Upsides

- Can compare PRB Coal with "similar" solid fuels under same combustion conditions
- Has most of the Boardman components but smaller scale
- Offers an initial read on potential for success

Boardman



Downsides

- Cannot fully predict what will happen in Boardman's boiler
- Boardman's burners are more sophisticated
- Introduction of combustion air is different
- Flue gas at WRI is 500 ˚F cooler

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Torrefied Fuel Combustion Performance

Torrefied fuel milling was identical to PRB Coal

Vendor 300°C combusted well

- Almost identical to PRB coal
- Duplicate runs were similar – No fluke

Vendor 450°C did NOT yield a good, stable burn

Ash deposition for Vendor 300°C

- Coloration is a little different
- Tends to deposit in "back pass" of the boiler which is later in the system
- Needs further study on Boardman ESP for ash capture

Conclusion: Go with Vendor 300; Decline use of Vendor 450

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Flame Quality: Flame Image

PRB Coal

Vendor 300

Vendor 300 fire ball

- Very uniform and stable flame
- Spreads out well in the furnace
- Bright orange indicates good combustion turbulence

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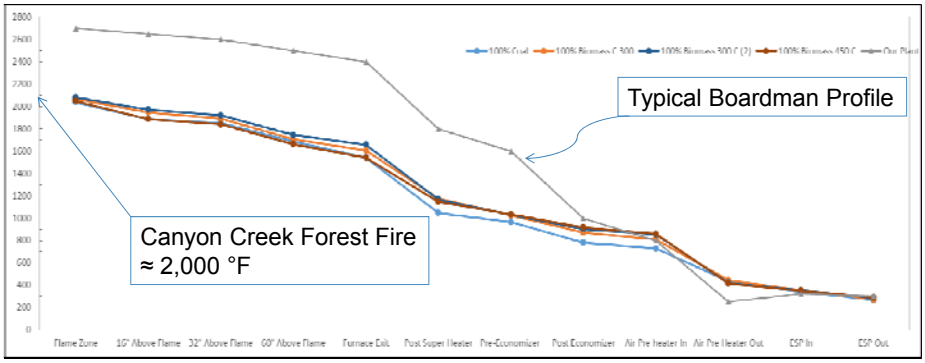
Temperature Profiles PRB Coal & Vendor Samples

Temperature profile



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Oregon Torrefaction Support

Concurrent milling and combustion testing at WRI

Testing – 1st Phase: $150,000 in value

- Torrefied Pacific NW fir, Doug Fir, pines
- Torrefied woody biomass from vendors
- Local torrefaction capability from ReKlaim, INL, TSI

Phase 2: Energy Grasses

- Arundo
- Sorghum for biomass

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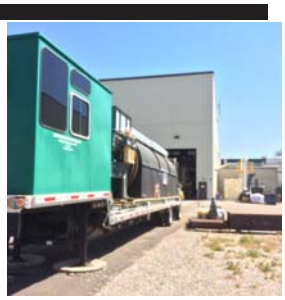
Locally Constructed or Operated Torrefiers

TSI 100 lb/hr, mobile unit
Everett, WA

INL 3-4 ton/hr mobile unit Boardman, OR

ReKlaim Stationary Unit
Boardman, OR



TSI 1 ton/hr stationary unit
White Castle, LA

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Chipping Fuel for the Boardman 2016 Test Burn

Blue Mountain Lumber Co.
Boardman Industrial Park

- Log deck
- Chip pile
- Pulp sized chips

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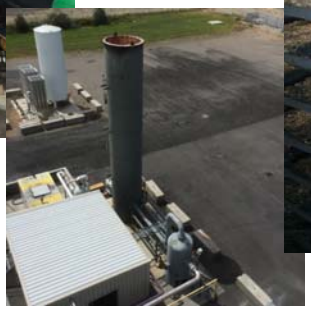
ReKlaim – Vertical Torrefier



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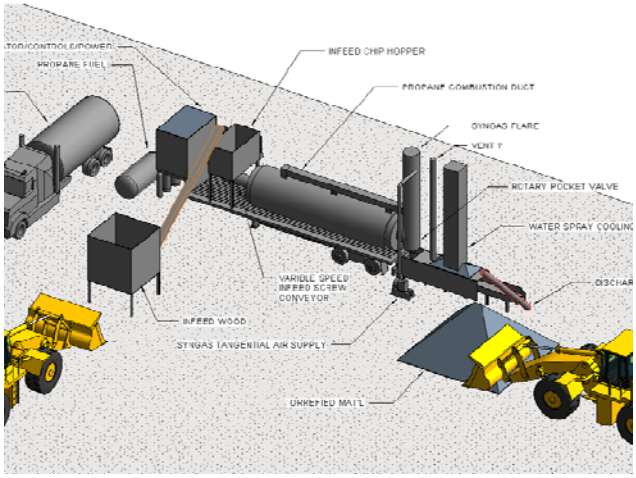
INL Torrefier – Horizontal Rotary Kiln



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Assembling INL Torrefier 8-23-16

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INL Torrefier: 3 to 4 tons/hour; Boardman Chip Plant

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Biomass Types - Test Torrefied by PGE

1. Corn Stover
2. Annual Rye Straw Pellet
3. Wheat Straw
4. Perennial Rye Straw
5. Pea Hay
6. Sorghum for Biomass
7. Poplar Planer Saw Dust (shavings)
8. Poplar Wood Chips
9. Digester Fiber - Cow manure biosolids (Sunnyside, WA)
10. *Arundo donax* harvested September, 2011 (Boardman)
11. Poplar Coppice Compost from summer 2011 (Boardman)
12. Arundo + Coppice (January, 2012; Boardman)
13. Red Fir Wood Chips (Red fir wood chips - suitable for pulping)
14. Red Fir Bark Chips (Red fir hog fuel - principally bark)
15. White Fir Wood Pellet Fuel (*Abies*) pellets – includes zeolite (Pendleton)
16. Red Fir (*Pseudotsuga* Doug Fir) Wood Pellet Fuel (Pendleton)
17. Mint slugs (Boardman)
18. Poplar Planer Dust (Poplar sander dust)

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Also Torrefied – Invasive Species

1. English Ivy
2. Himalayan Blackberry
3. Western Juniper
4. Russian Olive
5. Phragmites
6. Canary Reed Grass
7. Scot's Broom

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Torrefied biomass: high energy density

Torrefaction effects:

- Decreases mass (de-water)
- Becomes hydrophobic
- Resists bacterial & fungal attack
- Increases energy density
- Decomposes volatile organics
- Makes the biomass “crispy”
- Yields good grindability
- Compatible combustion chemistry
- Sulfur content remains low

Undensified Material	BTU / lb
Canary Reed Grass	9,400
Wheat Straw	9,700
Corn Stover	8,200 - 9,700
Willow	9,400
Bamboo	8,100 - 9,500
Giant Cane (*Arundo*)	10,000
Boardman Coal	8,500

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Recent versus Very Old Stored Sunlight

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And… a Little Success: Sept. 21, 2016

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Boardman Power Plant – Breaking New Ground

Baseload workhorse

- 600 MW capacity; PGE owns 90%
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Some Notable Facts:
- Largest Conversion in US
- Largest Torrefied Fuel Order
- Sets 1st Market Price
- Largest Amount Moved
- Largest Test Burn

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