Co-firing Black Pellets with Coal in Japan

Japan Biomass Power Conference

Tokyo

May 19-21, 2015

www.zilkhabiomass.com
Zilkha Black® Pellets—A Real Option for Japan Genco’s and IPP’s

Advanced wood pellet that is:
- Grindable
- Low-dust
- Water-resistant
- Can be burned in existing steam turbine power plants
- Co-fired up to 100%
- Reduced capital required

Certified sustainably harvested

Carbon neutral compared to traditional fossil fuels
• How Black pellets are made
• Selma in Commercial Operation: Summary of project to convert plant to Zilkha Black, manufacturing, and pellet transport & storage at port
• Safety in Operations: Advantages of Black vs. white

Because Black pellets handle, store, and can be managed just like coal, Japanese Genco’s, IPP’s, and industrial companies can participate in FIT with:

• lower capital investment and in-country logistics,
• higher investment returns, and
• safer operations
Zilkha Black® Pellet Technology
What Is a Black Pellet?

- Zilkha Black® pellets are thermally conditioned biomass pellets. 100% wood with no natural or artificial additives. NONE.
- The thermal conditioning process is well known. NOT TORREFACTION
- Black pellets have highly desirable mechanical & physical properties for use in coal power plants to replace coal
- Specifically, Black pellets are harder than white pellets because when pelletized, the abundant free lignin melts and acts as a water resistant glue
- Because Black pellets are naturally “glued”, fines are reduced and dust is very low compared to conventional white pellets. Not zero. But greatly reduced.
- Black pellets can be shipped, received, stored, conveyed, and milled just like coal
Manufacturing of Zilkha Black® Pellets is similar to the production of standard white pellets, with the addition of our patented thermal conditioning step.

**Intake**
Sawdust, wood chips, and first thinnings

**Drying**
Reduce moisture content from ambient (~50%) to 6-10%

**Proprietary Patented Zilkha Thermal Conditioning**

**Milling & Pelletizing**
Feedstock is resized then passed through dies to create Zilkha Black® pellets
Making Black Pellets

HOW:
- Wood is chipped, sealed in a pressure vessel, and pressured with steam
- After “cooking” briefly (5-15 min) the pressure is quickly released and the steam pressure “blows” the material into a receiving tank
- The conditioned material moves by conveyor to a standard pellet mill

KEY:
- Wood is composed of cellulose, hemicellulose, and lignin (~1/3-1/3-1/3)
- The thermal conditioning frees the lignin
- Lignin is a natural waterproof glue which melts at ~125+ °C, a temperature which is reached inside the pellet die
- Results in a tight, hard pellet bonded together with a natural, waterproof glue
- No additives are used. Of any kind.
Thermal Conditioning Before and After

Hammer-milled wood particles before thermal conditioning

The result AFTER thermal conditioning: the wood is more easily pelletized and is “glued” using abundant lignin
Feedstock, Conditioned, and Pelletized
End Result: A Direct Replacement for Coal

How do Black pellets stack up vs. white pellets?

- Harder and more brittle
- Fewer fines (<3.15 mm)
- Less dust (<500 μm)
- Water resistant

Just Like Coal
Selma Plant Began Commercial Operation in April, 2015

Trucking of Finished Black Pellets is Now In-Progress
Selma Plant Started Commercial Operation in April

Zilkha Thermal Conditioning Island
First Black Pellets from Selma
Selma Rebuild = General Improvements + Black Conversion

Investment in General improvements to existing plant:
- New chip yard (scale, truck dump, radial stacker, chip reclaim, scalper, green chip resizing, new green feed delivery conveyors)
- Dryer island (dryers reconditioned, new fuel system)
- Pelleting (reconditioned pellet machines, aspiration, pellet conveyors)
- Outloading (more storage, de-dusting, truck loading station)

Investment in the “White to Black” conversion to make Black pellets:
- Black pellet island (thermal conditioning and blow tank)
- Post conditioning (dry grinding, delivery conveyors)
Conversion—Flow Rerouted Through Thermal Island

Outloading
Coolers
Pelleting
Dryers
Resizing
Chipyard

www.zilkhabiomass.com
Adding Black Unit Achieves Conversion from White
New Thermal Conditioning Island

CAD 3-D Design

As-Built
Selma Operations—Inbound Chip Delivery

Pulp chips & Whole Tree Chips

www.zilkhabiomass.com
Resizing, Drying, and Thermal Conditioning
Pelletizing
Pellet Trucking from Selma to Mobile, Alabama

- 25 Metric Tonnes per Truck
- 173 miles from Selma to Mobile
- 36 Trucks per Day
- 216 Trucks per Week
- 936 Trucks per Month
- 11 Hours of Unloading per Day / 6 Days per Week

Truck Loading System

End-Dump Wood Chip Trailer
Selma Truck Loading for Transfer to Mobile

Note lack of dust
Terminal Operations in Mobile

Pellets stored in hopper barges

Pellets unloaded using truck dump dedicated to Black pellets
Barges Fleeted Prior to Mid-Streaming Onto Ships

www.zilkhabiomass.com
Black Pellets Reduce the Safety Risks of White Pellets

Plus Operational Benefits from Use of Coal Handling Methods
White Pellet Risk Factors Are Black Pellet Advantages

Key areas where Black pellets have a storage and handling advantage:

- Self Heating: None detected
- Off-Gassing: Significantly reduced
- Fines & Dust: Significantly reduced

These advantages reduce the risk of explosions, fire, and worker injury at the plant and to neighbors
Safety Lessons Learned from White Pellets

- Fines (<3.15 mm) = real fire risk
- Dust (<500 μm) = serious explosion risk
- Explosion mitigation takes capital beyond that required to handle coal
- Off-gassing of CO, CO$_2$, and CH$_4$ require venting during storage and transport
- Pellet pile self heating can lead to fires

Univ of Nottingham: Self Heating Not Present in Black

- University of Nottingham
- 2 thermally conditioned piles and 2 wood chip piles
- 6 month storage test
- Conclusion:
  - Thermally conditioned Black pellets, both indoor and outdoor, saw no distinct increase in temperature. No evidence of self-heating.

Self Heating Testing
- Outdoor testing with Univ Nottingham
  - Big willow chip pile - middle
  - No Self Heating

- Lab Testing with Technical Research Institute of Sweden (SP)
  - Lab testing heated pellet to encourage self-heating

<table>
<thead>
<tr>
<th>Product</th>
<th>White Pine Pellets</th>
<th>Sunflower Husk Pellets</th>
<th>Torrefied Pellets</th>
<th>Zilkha Steam Treated Pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Heat Rate (mW/g)</td>
<td>0.92 - 0.56</td>
<td>0.17</td>
<td>0.18</td>
<td>0.16</td>
</tr>
</tbody>
</table>

www.zilkhabiomass.com
UBC: Dangerous Gas Emissions Greatly Reduced

- Zilkha Black® pellets tested at UBC were far less reactive than white pellets. Black pellets were found to have significantly reduced oxygen depletion.

- Oxygen depletion is a significant operational issue. Extra workers and other special safety restrictions are required for workers entering white pellet storage areas.

- These results @ 25 C. but similar results @ 45 C.
Minimal Dust from Conveyor Drop

- Pellets drop several feet from final conveyor discharge at Zilkha’s Crockett plant
- No visible dust
Parking Lot Drop Test Shows Minimal Dust

- Pellets stored outside in Europe
- Urban location sensitive to dust
- Pellets were exposed to a few days of rain
- Operator test was looking for dust
- Very little dust is observed

www.zilkhabiomass.com
Black Pellets are Water-Resistant which Means ...

Zilkha Black® Pellets compared to conventional white pellets after brief exposure to water.
Black Pellets Load Like Coal and No Problem with Rain
In Fact Black Pellets Can Use Coal Dust Suppression Technology

Water is a very effective, widely used method of dust suppression for coal. The same methods can be used for Black pellets. Just like coal. Zilkha is currently recommending this “coal” solution to power plants for dust suppression.
Water Spray on Coal at Transfer Points & Hoppers

Transfer Points

Without Suppression  With Suppression

Hoppers

Without Suppression  With Suppression

www.zilkhabiomass.com
Zilkha Black Pellet Outdoor Storage Experience

Canada

In both cases one year storage trials followed by successful burns

Sweden

Black pellets stored outdoors in Sweden since Mar 2012
Zilkha Black Pellet Outdoor Storage Experience

Denmark
On the Coal Pile

France
Outdoors in the Rain

Coal
Black Pellets
Licensing Overview

- In addition to building new Black plants, adding a Black step to existing white pellet plants allows those plants to make Black pellets.

- Zilkha provides the technology under a license which includes continuous improvement of the technology, including Zilkha’s relationship with Valmet.

- Black pellets have transportation cost savings that support making Black pellets.

- Black pellet buyers benefit through improved investment returns from significant capital savings and operating cost savings at the power plant due to storage, reduced dust, and improved safety.

- Black pellet producers can expect a return on their capital investment to make Black pellets at existing or new white pellet plants.
Summary

- Zilkha’s 275,000 tpy Selma plant is now in commercial operation with output sold under a long term contract to Europe
- Selma proves Black pellet manufacturing, proves conversion from white pellets is straightforward, and supports greenfield construction of new Black pellet plants
- Zilkha and its licensees will provide ownership, load port, and geographic diversity
- Cooperative supply relationships and mutual marketing agreements among producers will form a secure supply system from new plants and white conversions

Because Black pellets handle, store, and can be managed just like coal, Japanese Genco’s, IPP’s, and industrial companies can participate in FIT with:
- lower capital investment and in-country logistics,
- higher investment returns, and
- safer operations