



Zilkha Black® Pellets Handling, Storage and Grinding in Existing Coal Plants

World Biomass Power Markets – Amsterdam, Netherlands

05 February 2014





Company Overview



Zilkha Biomass Fuels I LLC builds, owns and operates manufacturing facilities which produce a proprietary, waterproof “black” wood pellet.

The proprietary Zilkha Black[®] pellet seamlessly replaces coal in existing coal-fired power plants with minimal additional CapEx required.

Zilkha Track Record in Energy

	Name	Position	Summary Biography
	Selim K. Zilkha	Co-Owner	Director and 50% owner of Zilkha Renewable Energy (Horizon Wind Energy) from 1998 to 2005 Director of El Paso Corporation from 1999 until 2002 CEO and sole director of Zilkha Energy Company from 1983 until 1998
	Michael Zilkha	Co-Owner	President and co-owner of Zilkha Renewable Energy (Horizon Wind Energy) from 1998 to 2005 Executive VP and co-owner of Zilkha Energy Company from 1986 until 1998

E & P

WIND

BIOMASS

**Zilkha Energy Co.
(1983-1998)**

- Independent Oil and Gas Company; Largest Acreage Holder on the shelf in the Gulf of Mexico in 1997
- Sold to Sonat for \$1.2 Billion

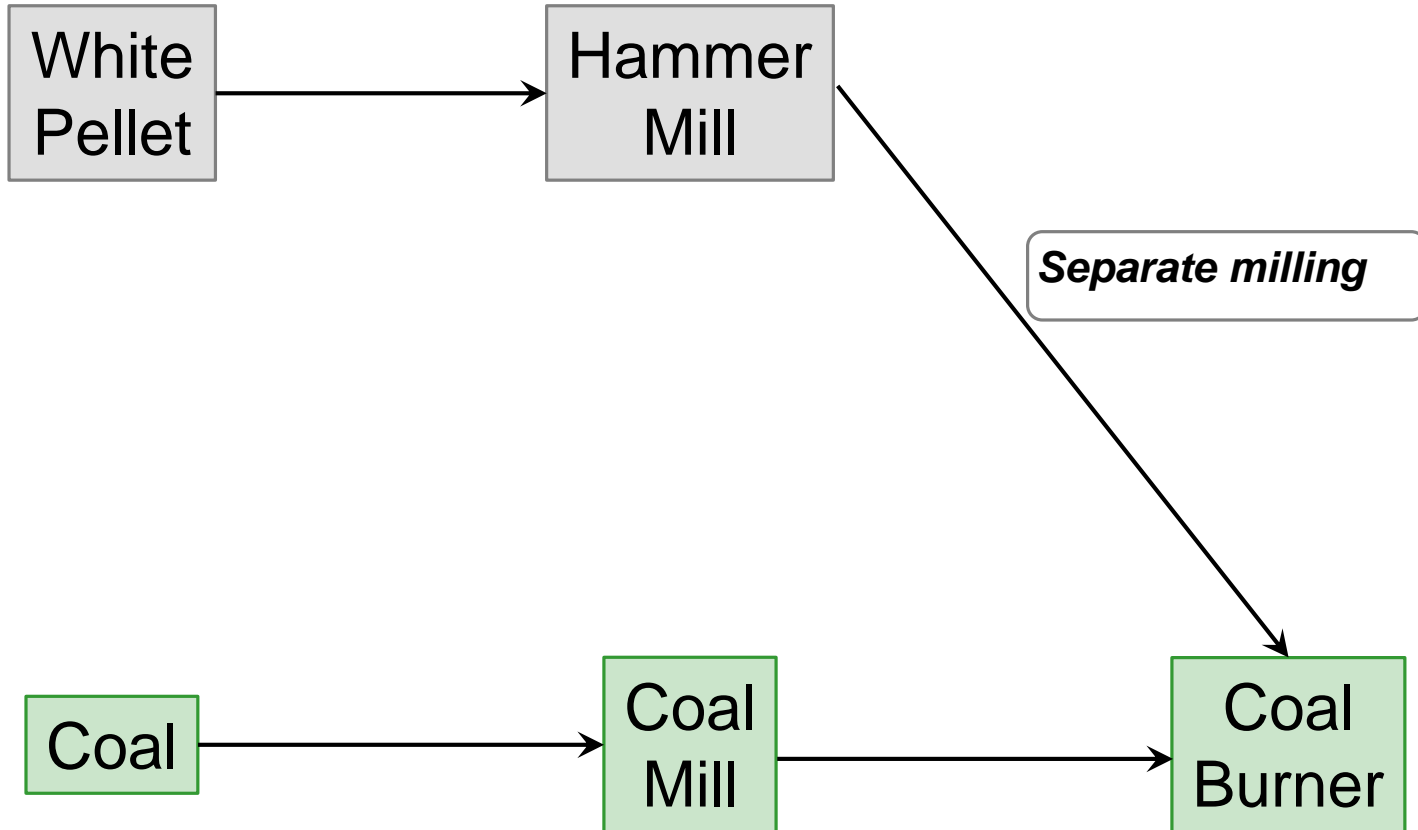
**Zilkha Renewable
Energy Co.
(1998-2005)**

- Largest Independent Wind Power Developer in U.S.
- Sold to Goldman Sachs in 2005; Sold to EDP in 2007 for \$2.7 Billion

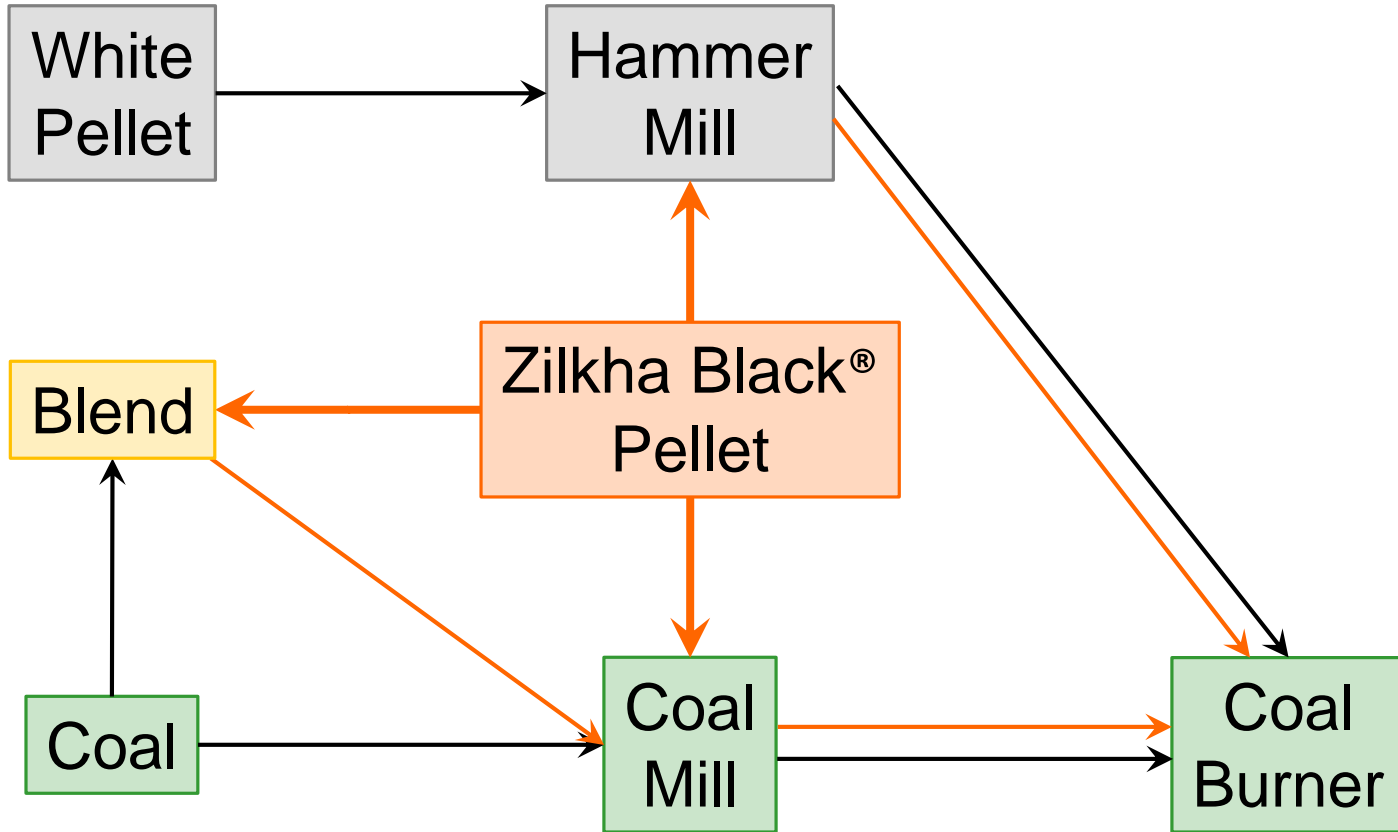
**Zilkha Biomass Energy
(2006)**

- Manufacture and Marketing of Waterproof "Black" Wood Pellets
- Patented Efficient Biomass Steam Explosion Technology
- Have invested \$120 million

Cofiring Options: White Pellets



Cofiring Options: Zilkha Black[®] Pellets





Zilkha Black® Pellets: Superior Energy and Handling Qualities

Key Criteria	White Pellets	Zilkha Black® Pellets
ENERGY	17.0 GJ per bdmt	19.4 GJ per bdmt
DENSITY	640 kg/m ³	750 kg/m ³
DURABILITY	96.5% PDI	98% PDI
SAFETY	Self-heating common Off-gassing significant	No self-heating Minimal off-gassing
GRINDING	15-20 HGI 26 hp/ton hammer mill	25-35 HGI 15 hp/ton hammer mill

Key Points:

- 1) **COST:** Zilkha Black® pellets contain more energy than white
- 2) **GRIND:** Zilkha Black® pellets grind more like coal than white
- 3) **BURN:** Zilkha Black® pellets burn more like coal than white
- 4) **SAFETY:** Zilkha Black® pellets are less dangerous than white



Zilkha Black[®] Pellet Spec

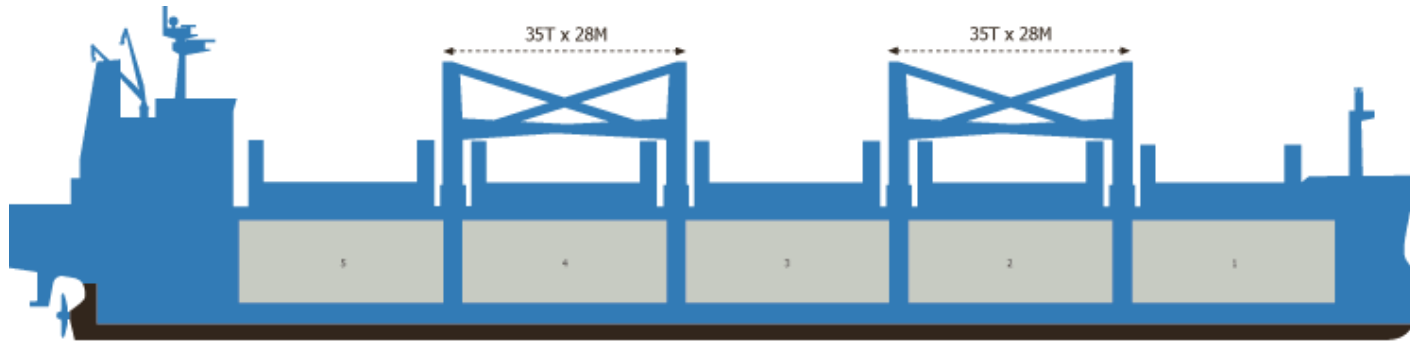
ZILKHA BLACK[®] PELLET SPECIFICATION
Assumption: 100% Pine Pellets



Proximate Analysis		Min	Max	
Total Moisture	As received	1	5	%
Ash	ADB		<1.00	%
Volatile Matter	ADB	77	82.5	%
Fixed Carbon	ADB	17	22.5	%
Total Sulphur	ADB	0.01	0.04	%
Gross Calorific Value	dry basis	21,100	22,000	kJ/kg
Gross Calorific Value	gross AR	20,000	21,100	kJ/kg
Net Calorific Value	net AR	18,900	19,700	kJ/kg
HGI		24	30	



Black pellets will always be cheaper to ship



BLACK PELLETS		WHITE PELLETS	
Bulk Density	750 kg/m ³	Bulk Density	640 kg/m ³
CV	19,400 kJ/kg	CV	17,000 kJ/kg
Energy Density	14,550 MJ/m ³	Energy Density	10,880 MJ/m ³
Cubic space on vessel	58,500 m ³	Cubic space on vessel	58,500 m ³
Tonnes aboard	43,875 mt	Tonnes aboard	37,440 mt
CV aboard	851,175 MJ	CV aboard	636,480 MJ

**34% savings
with Zilkha
Black® pellets**



LOGISTICS: No Problems Loading in Rain



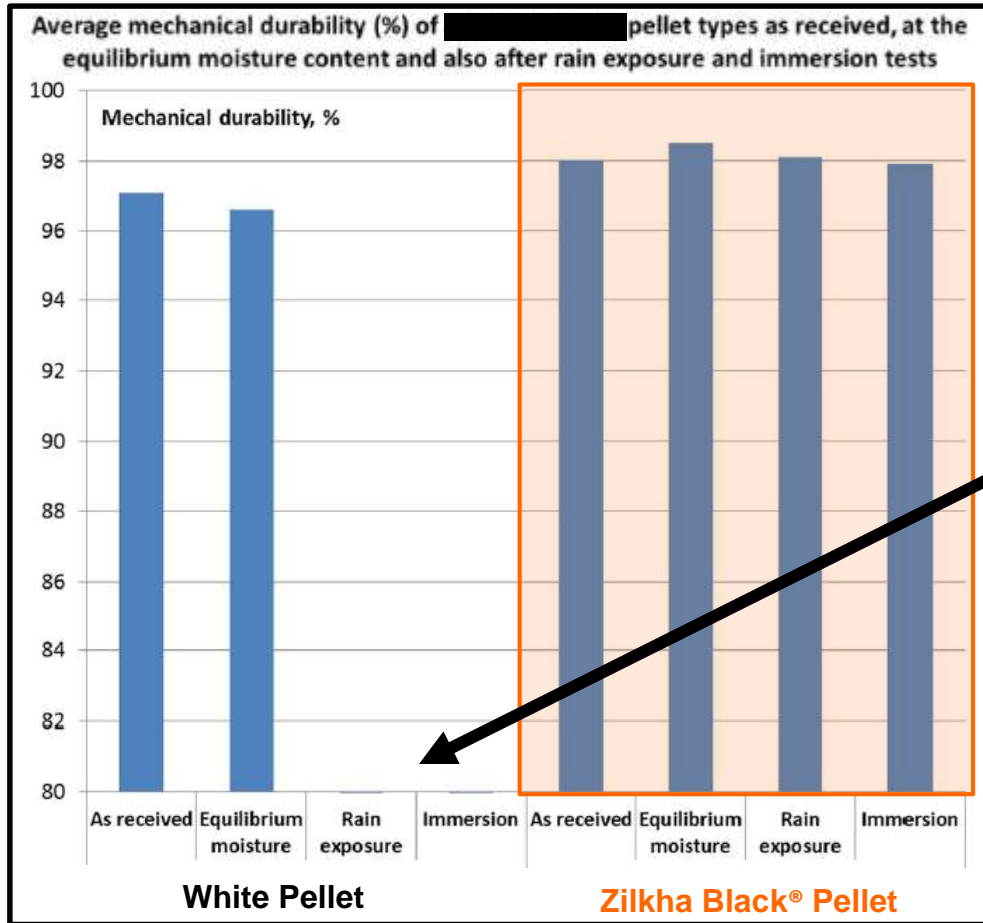


LOGISTICS: Unloading Black Pellets

- Pellets handled with dozers, front-end loaders, and conveyors with no deterioration
- Minimal dusting at loading and unloading locations
- Unloaded via mobile quay crane – half of cargo into trucks and half onto dock for further shipment via barge
- Full-scale burns taking place in five power plants



Black Pellet Maintains Durability After Rain



White pellets
have no
durability after
rain.



LOGISTICS: Successful Long-term Durability Tests

- One of four long-term outdoor storage piles
- Pile in Northern Europe pictured below
- Successfully burned after a year outdoors



First laid outside Mar-2012



Seven months later, in Oct-2012



LOGISTICS: Zilkha Shipment Test Results

- Stored outdoors in a seaside area of Western Europe, partially covered with a tarp
- Experienced nine (9) 'touches' through the period (from front-end loaders, etc)
- Rained during loading; rained, snowed, etc. rest of the period
- **Little change in Black pellet characteristics over time**

—————→ 2 years

Date	May-11	December-11	January-12	April-13
Activity	Production & Inventory	Loaded on vessel during heavy rain and much mechanical handling	Unloaded to warehouse storage	Sample retained to test for moisture over time
Moisture Content	4.00%	4.59%	5.54%	6.30%
Net CV (AR)	19,500	19,568	19,463	18,884
Pellet Durability Index	98.00%	Not taken	97.70%	98.23%



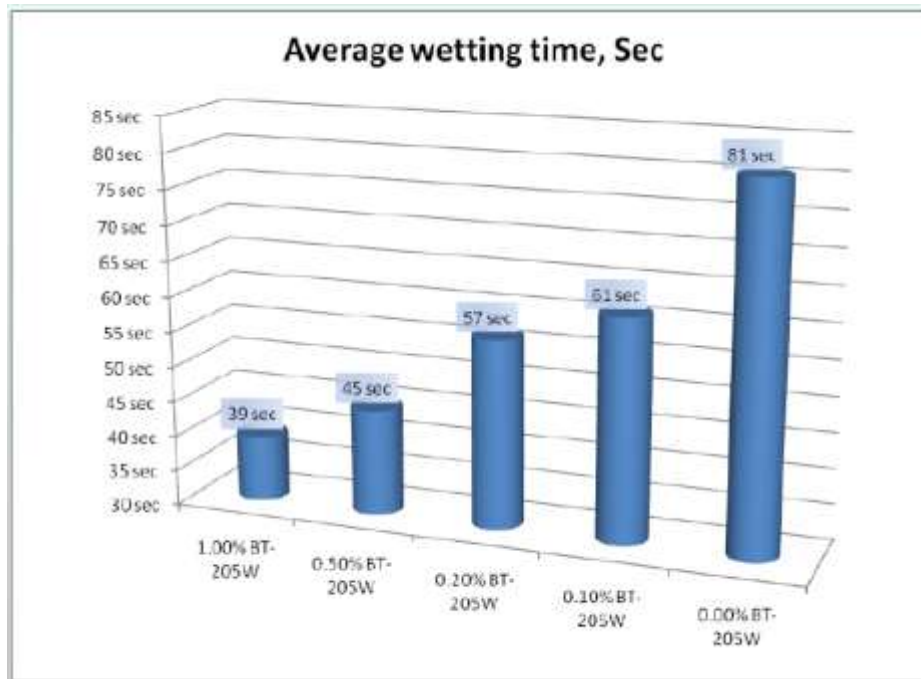
DUST: Pellets

- All pellets have some dust
- White pellets generate much more dust than Black
- White pellets generating dust along every step in the supply chain
- Dust generated during manufacture of Zilkha Black® pellet is removed and recycled before shipment.
- Black pellet tests:
 - *European Utility Test: less dust = smoother and faster operations*
 - *North American Utility Test: no dust <74 um, can be wetted then milled*



DUST: Surfactants – An Option for Black Pellets

A simple, low-cost and readily-available coal dust solution only possible with Black pellets.



- Testing confirmed that industrial surfactants (**exactly the same as those used for coal**) are effective wetting agents for Black pellets
- Required concentrations can only be confirmed in the field but expected to be between 0.20% and 0.50%
- This testing employed BT-205W
- Residual agents such as BT-425 would offer superior control

SAFETY: Necessary Controls for White Pellets

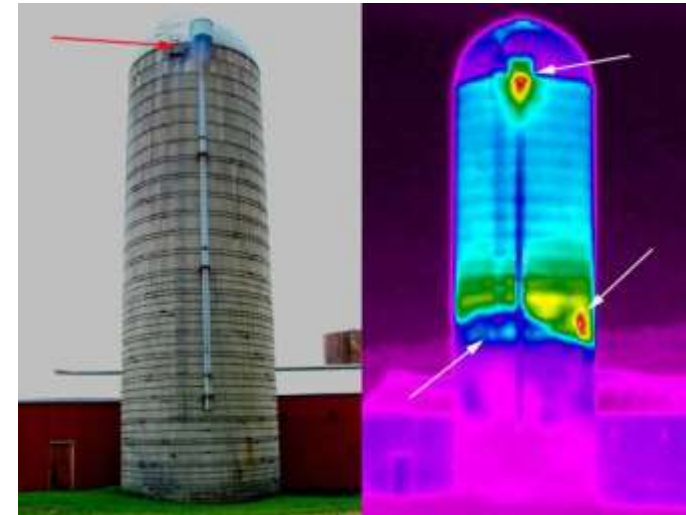
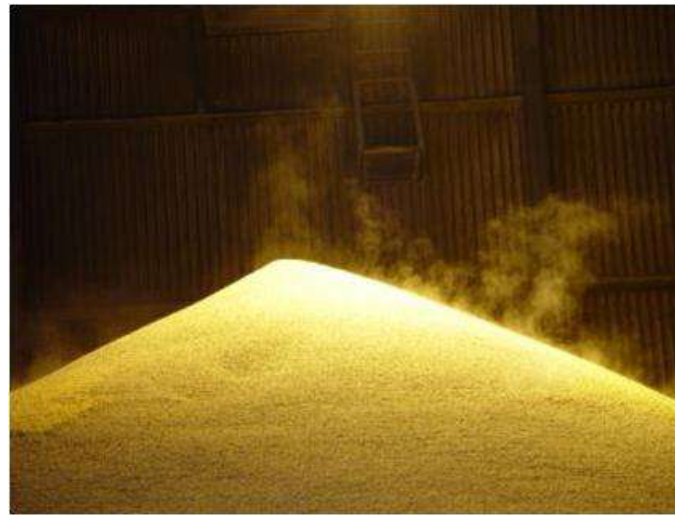
- Fire detection
- Atmospheric monitoring systems
- Fire suppression systems
- Moisture detection systems
- Ventilation systems to control moisture
- Temperature monitoring
- Adequate space requirements for emergency vehicles
- Personal worker safety precautions





...to monitor and control:

- 1) Dust explosion
- 2) Off-gassing
- 3) Self-heating





SAFETY: Black pellet dust harder to ignite

Black pellet dust MIE 5-20x higher than set standards.

DUST EXPLOSION ANALYSIS	WPAC Standards	Zilkha Black	Coal
Minimum Ignition Temperature (5mm layer) °C	300	330-340	
Dust cloud auto-ignition temperature °C	450	460-470	585
Dust cloud minimum ignition energy (mJ)	17	100-300	110 mJ
Dust cloud max. explosion pressure (bar)	8.1	7.2	7.3
Kst (bar.m/s)	146	157	

- Zilkha Black® pellet far less ignitable pellets that meet Wood Pellet Association of Canada (WPAC) standards
- No difference in explosion class (both 'weak')



SAFETY: Positive UBC Off-gassing Test

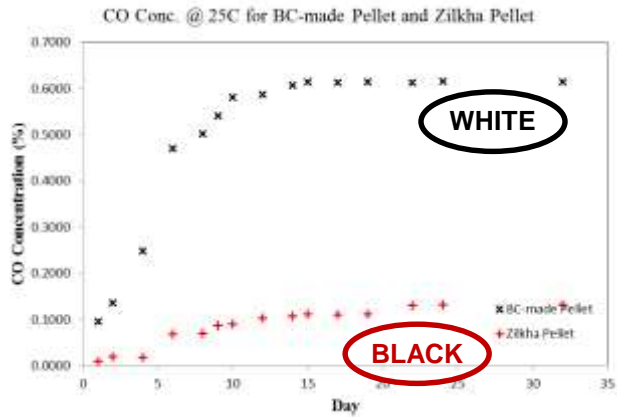


- Pellets were sealed in jars and kept at temps of 25C, 35C and 45C.
- Off gasses were collected and analyzed after 30 days of storage.
- Results from Zilkha Black® pellets were compared to white pellets from BC
- Test conducted by University of British Columbia under contract with Zilkha Biomass

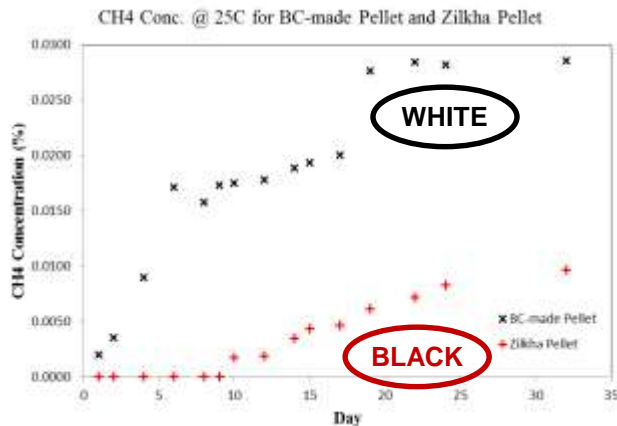


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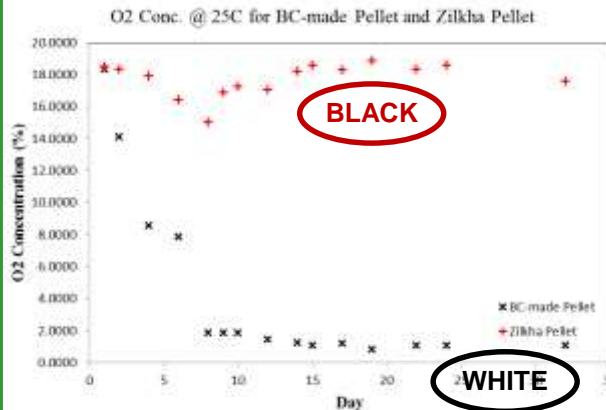
Less carbon monoxide:



Less methane:



More oxygen:



- Black pellets tested as far less reactive than white
- Black pellets also showed reduced oxygen depletion
- Oxygen depletion is a very real operational barrier (buddy systems, etc.)
- Similar results @ 45 deg. C – superior even when forced to higher temperature
- Virtually no H2



SAFETY: No Indications of Self-Heating

ZILKHA TESTING:

August 8, 2011	92°F	32.8°C			
Pellet Description	Shed	Bay	Production Date	Pellet Pile Temp	Pellet Pile Temp
Hardwood - 6mm	4	7	Jan 2011 - May 2011	81 °F	27.2 °C
Hardwood - 6mm	4	9	Jan 2011 - May 2011	83 °F	28.3 °C
Hardwood - 6mm	4	19	Jan 2011 - May 2011	87 °F	30.6 °C
Pine - 6mm	4	3	May 2011 - June 2011	84 °F	28.9 °C
Pine - 6mm	4	5	May 2011 - June 2011	85 °F	29.4 °C
Pine - 6mm	4	8	May 2011 - June 2011	84 °F	28.9 °C
Pine - 8mm	5	25a	July 2011	89 °F	31.7 °C
Pine - 8mm	5	27a	August 2011	87 °F	30.6 °C

QUOTES FROM UTILITY TEST:

- Regular temperature monitoring via surface measurements and thermocouples imbedded within the pile
- All measurements tend to track with the ambient temperature
- No indications of self-heating

GRINDING: White Pellet Issues

2006 University of Newcastle study revealed issues with milling white pellets

white pellets

3. Flow properties of the biomass are a potential problem in transferring biomass through a silo hopper. The 10 wt% UGW blend with Lithgow coal completely block the opening of the transfer hopper for the pilot-scale mill. The materials need to be continuously stirred to overcome the problem.

white pellets

6. The mill power profiles corresponding to 10 wt% blending ratio of woody biomass did not show any sign of steady-state operation, suggesting that introducing 10 wt% biomass in a vertical spindle mill is not practical. Previous research also confirms this finding (IHI 2003). If one would attempt blending ratios greater than 10 wt%, then a separate size reduction and injection unit for biomass is required to avoid technical difficulties.

7. Grinding pressure of the rollers has a great impact on mill power requirement. This study shows that the impact of biomass addition on mill power is greater for mill operation with high grinding pressure.

white pellets



GRINDING & COMBUSTION: Hammer Mills

Black pellets get more energy through hammer mills at less opex cost.

Test Report: CPM Grinding Report

- Black pellets grind approximately **25% finer** than white wood pellets with each screen size tested
- Black pellets require approximately **42% less horsepower** to grind one ton of pellets to a specified size than grinding one ton of white wood pellets to the same size.
- Black pellets have approximately **20% less loss in bulk density** than white pellets when grinding with 3 tested screen sizes.

Test Report: WTS AB re: Jaffrey Hammermill

- At the same parameters, black pellets have **87% passing** the 0.5mm screen (500 microns) versus 55% passing for white

California Pellet Mill (CPM) Test

#7 Screens	Black Pellets	White Pellets
Pellet Moisture	4.11%	4.95%
Pellet Bulk Density	45 lbs/ft ³	41 lbs/ft ³
Ambient Temp	69° F	69° F
Capacity	15 hp/ton	25.9 hp/ton
Exit Temperature	78° F	79° F
Exit Bulk Density	36 lbs/ft ³	23 lbs/ft ³
Exit Moisture	3.95%	4.95%
Sieve (2000 um) 10	99.99%	99.97%
%< (1190 um) 16	99.26%	99.48%
(707 um) 25	94.75%	93.22%
(297 um) 50	61.32%	47.97%
(149 um) 100	35.04%	23.31%
(74 um) 200	16.63%	9.32%
(44 um) 325	7.42%	3.08%
Pan	0.00%	0.00%

Zilkha Black® pellet will relieve the fuel delivery bottleneck by delivering more energy to burner.

GRINDING & COMBUSTION: Coal Mills

Test: Alstom Abrasion & Grindability on Raymond tabletop test mill (no airflow)

- Testing resulted in similar abrasion index for Black pellets (1.19%) and Midwestern bituminous coal (1.31%). Max threshold for normal mill wear is 25%.
- Grinding Black pellets to similar particle size to coal required increased energy.

Test: TU Clausthal (2011) on laboratory roller mill (with airflow)

- The energy consumption in order to reach a particular particle size is at the range in energy consumption required to reach the same particle size for Sub-bituminous, Bituminous, and Anthracite.

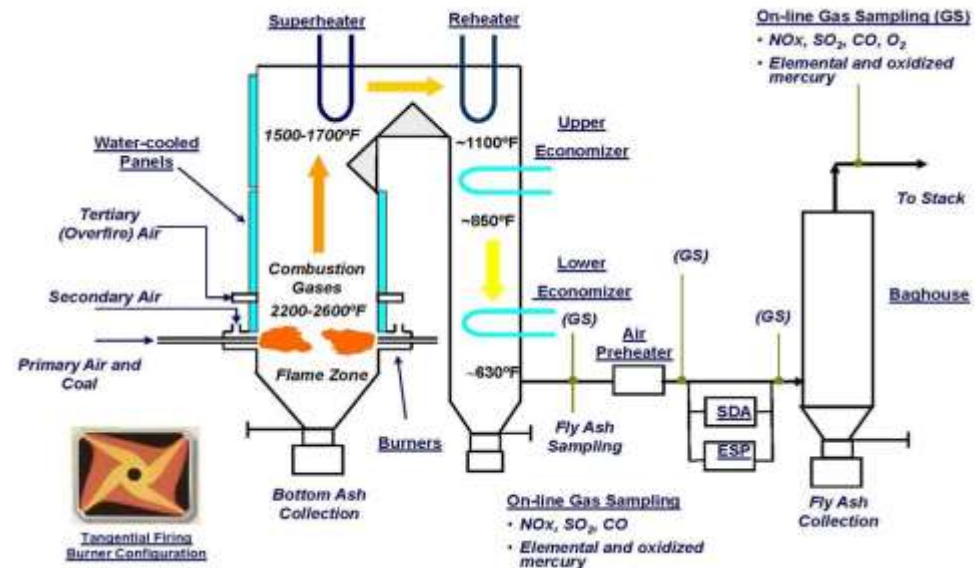
Test: Loesche Laboratory Report 45/2011 (with airflow)

- Per EU Utility, similar throughput to hard coal was achieved by increasing airflow speed through the classifier to allow coarser Black pellet particles through the mill.

“Remaining question is how fine does the product have to be to burn out satisfactorily, and what modifications would be necessary in the mills to allow coarser product into the burners.”

GRINDING & COMBUSTION – WRI Test

- Combustion Test Facility in Laramie, WY (May, 2011)
- 250,000 BTU/hr corner fired boiler. 4 total burners. Coal fired replication.
- Focus on emissions data when cofiring with coal at two sieve sizes
- Burned blends of coal and Black pellets milled to 50 and 200 mesh
- The carbon in ash stayed the same when comparing the 2 different milled sizes.



Black pellets can be milled to a larger size and achieve the same carbon burnout as that of a more finely milled fuel.

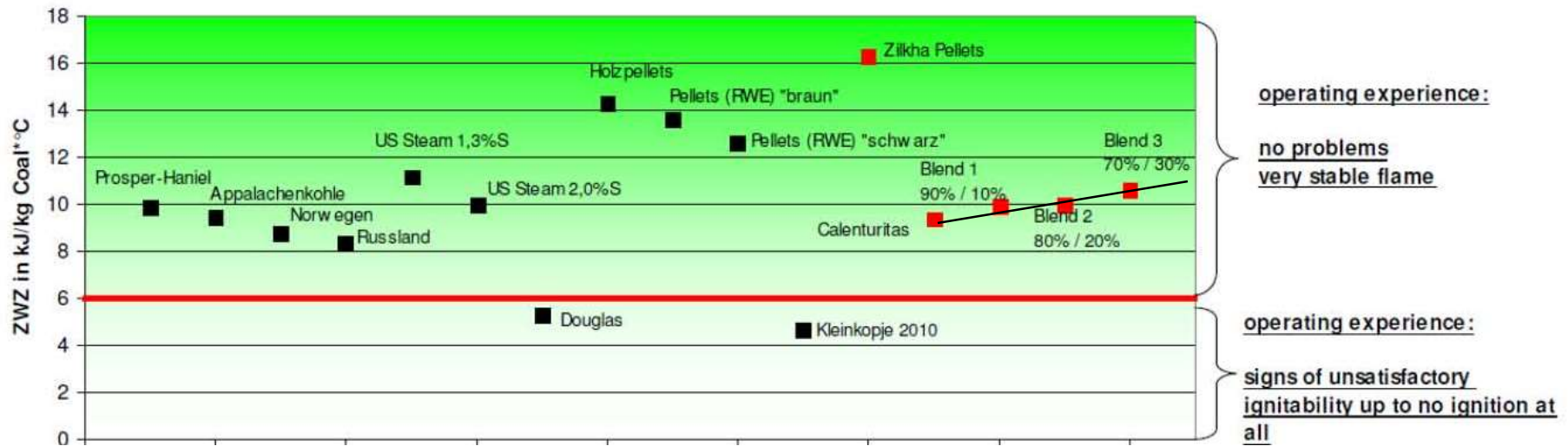


GRINDING & COMBUSTION: Europe Test Burns

- Five (5) full-scale test burns conducted in European coal plants within past 18 months
- Units range between 75 MW and 300 MW
- Co-milling and dedicated milling have both exhibited positive results in coal regimes
- Co-burning and dedicated burning have both exhibited stable flames in coal burners



COMBUSTION: Black Pellets' Superior Ignition Potential



- A ZWZ value (ignition potential) above 6 [kJ/kg fuel/°C] is seen as satisfactory for producing a stable flame.
- Zilkha Black[®] pellets were found to do considerably better than all the reference fuels, including white wood pellets and a number of commercial coals, with a ZWZ value of 16.28 [kJ/kg fuel/°C].



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