CIBO'S 33RD ANNUAL MEETING

Acquiring Biofuels for Existing Solid Fuel Boilers

OCTOBER 12-14, 2011

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T.B. SIMON POWER PLANT

Overview

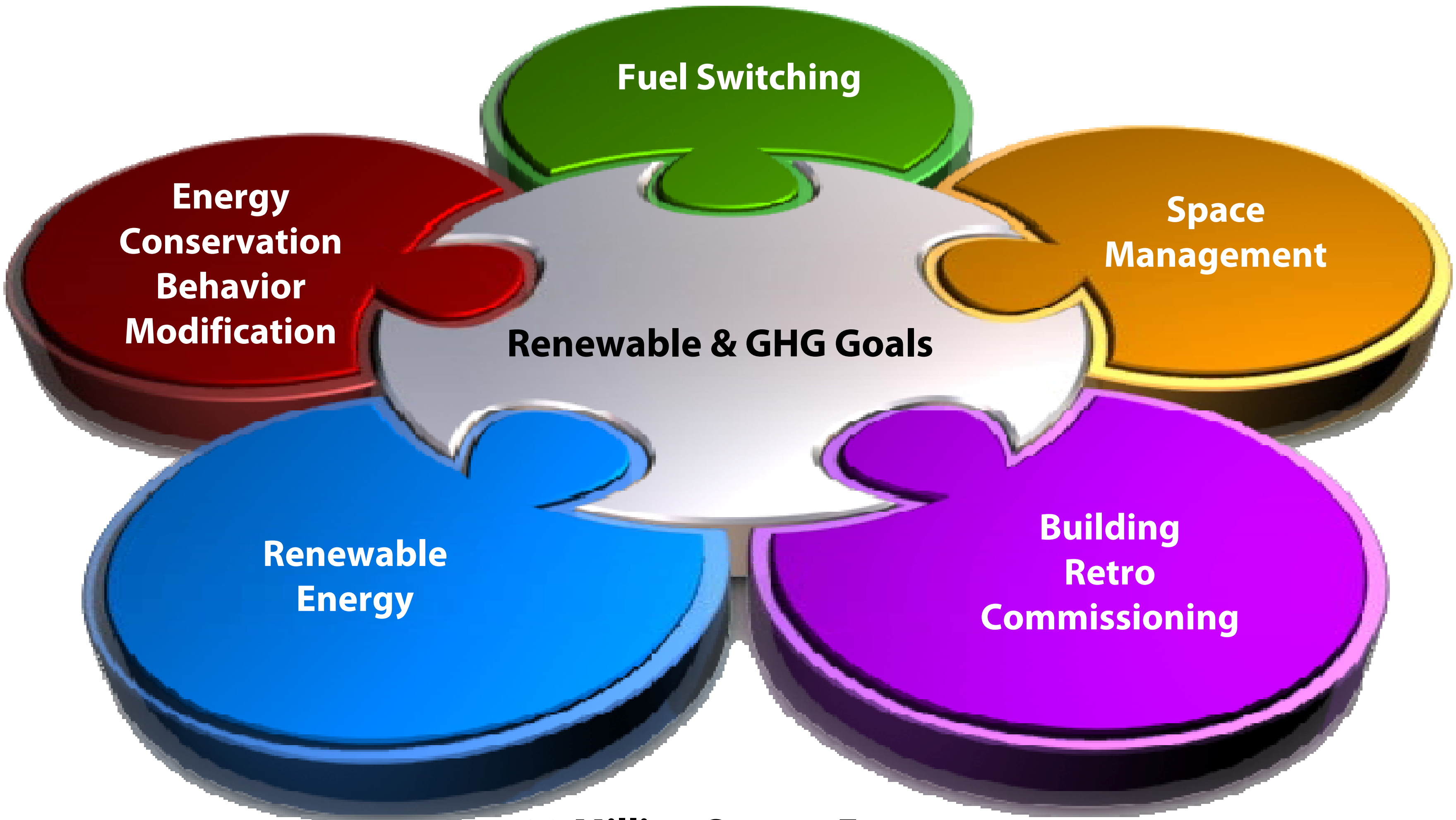
- Background
- Regulatory Approvals
- Market Access
- Capital Projects
- Acknowledgements

MSU Draft Goals

	% Greenhouse Gas Emission Reduction	% Campus Renewable Energy
FY 2009	Baseline	Baseline
FY 2015	30	15
FY 2020	45	20
FY 2025	55	25
FY 2030	65	40

http://energytransition.msu.edu/

Potential Solutions



20 Million Square Feet

Simon Plant Boiler List

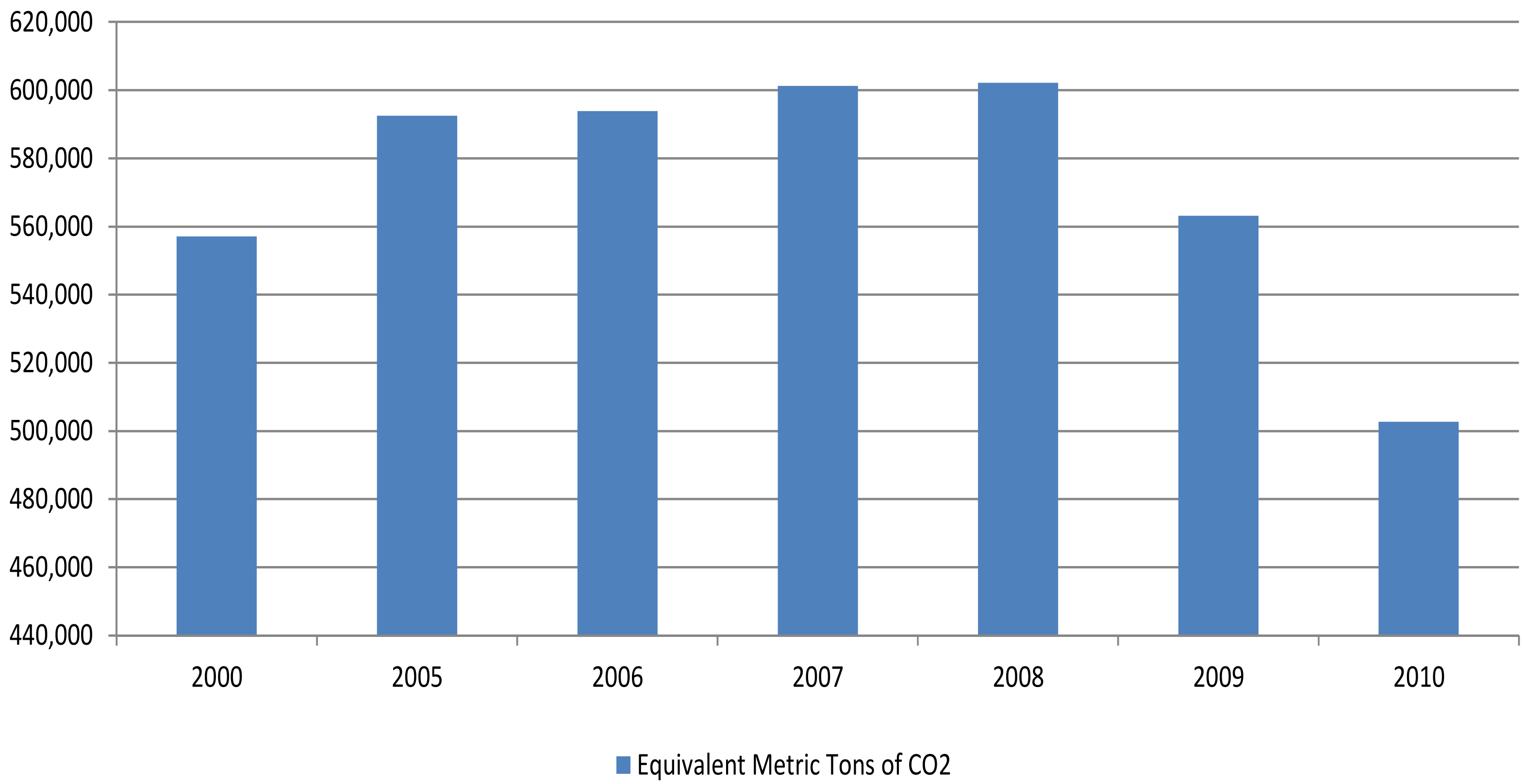
MANUFACTURER	UNIT	CAPACITY (LBS/HR)	TYPE
WICKES	1	250,000	PC
WICKES	2	250,000	PC
ERIE CITY	3	350,000	PC
METSO (TAMPELLA)	4	350,000	CFB
NEBRASKA BOILER	6	115,000	HRSG

Facts and Statistics

	Power & Water Department	2005	2006	2007	2008	2009	2010
Amount Burned: *T.B. Simon Power Plant began burning biofuel in 2008*	Coal (tons)	247,893	251,488	230,406	248,310	222,819	178,550
	Natural Gas (mcf)	292,531	321,318	435,573	465,966	887,742	1,835,513
	*Biofuel (tons)	N/A	N/A	*59	10	76	1464
Emissions (tons):	CO_2	571,015	578,175	579,767	576,708	542,606	480,593
	SO_X	3,421	3,856	3,594	3,390	2,812	2,715
	NO_X	1,031	1,057	1,037	1,063	794	755
	PM_{10}	10	10	12	11	11	14
Water (1000 gallons):	Produced	2,206,276	2,004,956	1,834,301	1,758,654	1,542,474	1,436,266
	Distributed	1,592,565	1,562,696	1,544,407	1,490,780	1,344,167	1,220,456
	Purchased	2,286	3,002	5,884	6,603	8,932	47,176
Annual BTU's:		6,379,876	6,552,234	6,151,312	6,511,794	6,445,845	6,189,904
		FY 05-06	FY 06-07	FY 07-08	FY 08-09	FY 09-10	FY 10-11
Fuel Expenses:	Coal	$22,332,263	$25,323,350	$20,652,312	$27,700,813	$29,852,555	$23,110,936
	Gas	$2,878,360	$3,466,595	$5,183,295	$5,805,091	$3,202,284	$9,747,767
Commodity Rates:	Electricity (kWhr)	$0.071	$0.076	$0.074	$0.084	$ 0.092	$ 0.091
	Steam (1000 pounds)	$10.132	$11.083	$11.869	$13.921	$ 18.359	$ 18.293
	Water/Sewage (1000 gallons)	$2.355	$2.199	$2.475	$3.032	$ 3.818	$ 4.444

Environment

Michigan State University Greenhouse Gas Emissions



Regulatory Approvals

MSU Renewable Operating Permit History

- 12/21/06: Biofuel test burn approval
- 02/06/09: Biofuel Permit to Install application
- 08/20/09: Biofuel Permit to Install approval
- 02/11/11: Biofuel Permit to Install application
- 10/12/11: Biofuel Permit to Install application public comments

2011 Permit to Install Application

Unit	Biofuel Application
1	5%
2	5%
3	5%
4	30%

As part of an air permitting process, determine if the use of alternative fuels triggers PSD.

- Can use "Actual to Projected Actual" or "A2A"
  - Estimate future actual emissions ("projected actuals") after fuel switch and compare to what was done in the past (baseline)
    - » Projected actual emissions based on EPA data (AP42), trial burn data (site specific or similar source), and/or supplier analytical data
  - Can reduce "projected actuals" by excluding those emissions that would have occurred regardless of the fuel project ("excludables").
    - » Demonstrate that those emissions could have been legally and physically accommodated during the baseline time period and consider any operational restrictions during the projection period.
    - » Use project future heat input or capacity factor data based upon historical operations
- – Biogenic GHG emissions not included at this time (deferred for 3-years)
- – Evaluate compliance with applicable state air toxics rules

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Solid Waste Considerations

- Combustion of any amount of non-hazardous secondary materials defined as "solid waste" will classify the unit as Commercial and Industrial Solid Waste Incineration (CISWI) unit and subject it to the CISWI Rules (40 CFR 60, Subpart CCCC (new sources) or DDDD (existing sources)
- 40 CFR Part 241 defines non-hazardous secondary materials that may be considered solid waste when used as fuel
  - Traditional and some "alternative" traditional fuels are not solid waste
  - Determination of whether alternative fuels are solid waste:
    - Depends on whether fuel is considered processed
    - Depends on whether fuel meets legitimacy criteria
      - Storage must not exceed reasonable time frames;
      - Must be managed in a manner consistent with an analogous fuel or if no analogous fuel, must be adequately contained to prevent releases;
      - Must have a meaningful heating value (typically >5000 Btu/lb.); and
      - Must contain contaminants at levels comparable in concentration to or lower than those in traditional fuels
  - State specific requirements may be more stringent than 40 CFR Part 241.

- MSU withdraws processed digestate (potential fuel) from permit application

- Need legitimacy test, a lengthy process

Market Access

- Bio Material on MSU Property
  - Switchgrass
    Chips
- Purchased Bio Fuel
  - Pellets
  - Chips

Fuel Data

Unit Number	Sample Date	Identification	As Received Moisture	As Received % Ash	As Received BTU/lb	As Received % Sulfur
4	10/8/10	Switch Grass	16.22	3.83	6778	0.09
4	4/18/11	Switch Grass	9.12	1.85	7483	0.05
4	4/5/10	Wood Chips	10.54	3.64	7377	0.02
4	5/14/10	Wood Chips	39.96	2.93	4999	0.02
4	7/19/10	Wood Chips	19.03	6.90	6301	0.05
4	9/28/10	Wood Chips	46.65	1.68	4350	0.03
4	9/24/10	Wood Chips	36.09	0.45	5326	0.04
4	11/30/10	Wood Chips	34.84	0.93	5502	0.03
4	3/2/11	Wood Chips	37.39	1.02	5264	0.02
4	3/30/11	Wood Chips	21.97	0.66	6072	0.04
4	5/17/11	Wood Chips	49.72	5.77	3941	0.03
4	6/9/11	Wood Chips	32.94	6.51	5037	0.05
4	7/12/11	Wood Chips	41.58	0.93	4782	0.02
4	8/11/11	Wood Chips	30.87	4.45	5696	0.05
4	4/5/2010	Wood Pellets	7.84	1.39	7918	0.01

MSU Fuel Procurement 5/10/11

Wood Fuel Bids Summary								
Wood Chips			BASE BID	BASE BID with	MS Hickory Corners	MSU Hickory Corners	Ability to supply full contract	Fuel Surcharge
Vendor Name	Price/Ton	typical BTU's/lb	$/mmbtu	HC Discount		discount/ton		
Great Lakes Energy	$36.50	5000	$3.65	$3.65				
Maeder with Rush	$33.00	5000	$3.30	$3.00	Yes	$3	yes	yes above $4.25 gal
Rush Farms	$32.95	5000	$3.30	$3.00	Yes	$3	yes	yes above $4.25 gal
Quality Hard Wood	$32.00	5000	$3.20	$3.20	No		no	no
Integrity Tree	$34.00	5000	$3.40	$3.30	Yes	$1	no	yes

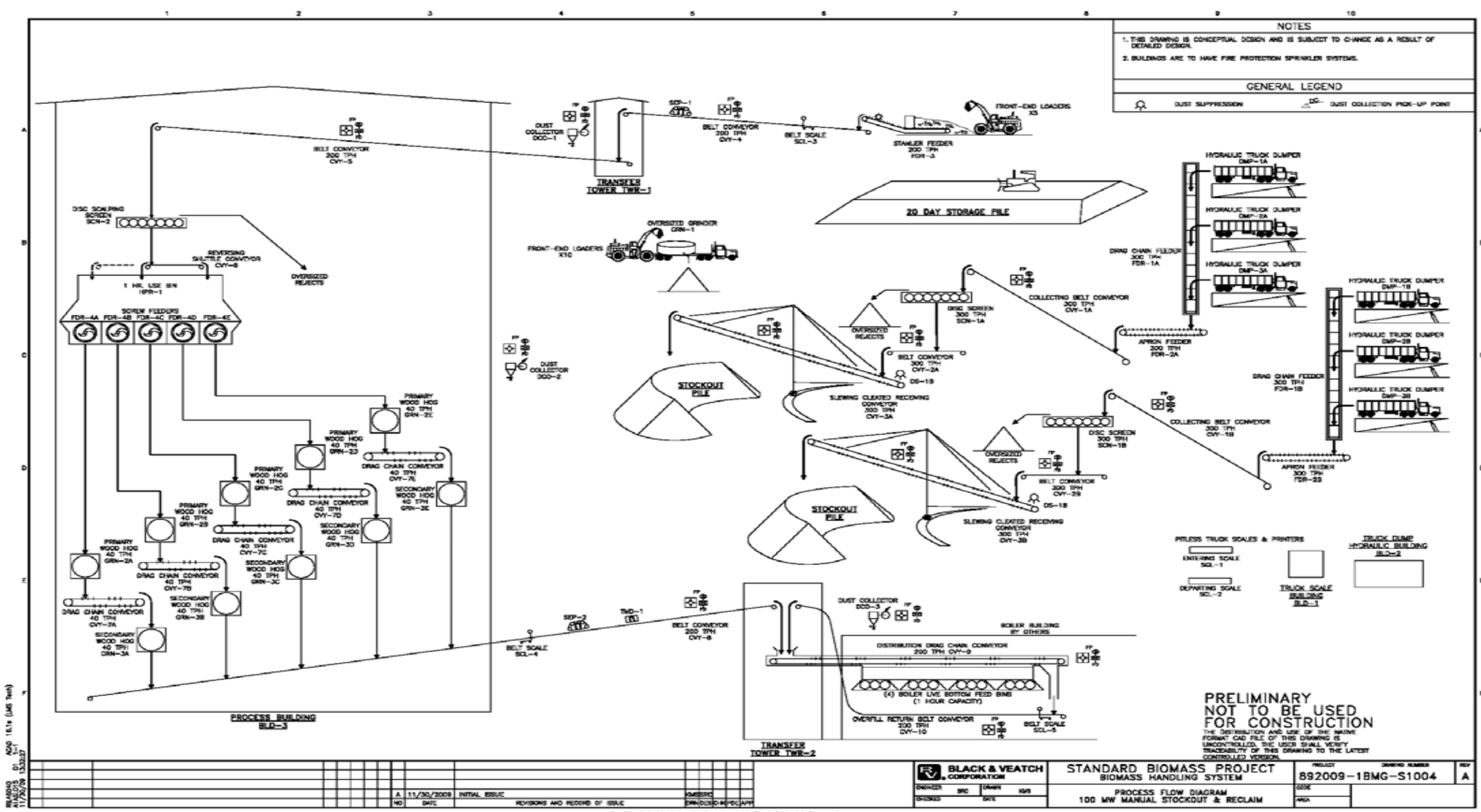
Wood Pellets								
Vendor Name	Price/Ton	typical BTU's/lb						
Renewafuel	$145.50	7800	$9.33	$9.33	No		Yes	Yes above $4.50 ga
Maeders	$150.00	8000	$9.38	$9.38	Yes		yes	yes above $4.25 gal
Fiber By-Products	$150.00	8300	$9.04	$9.04	No		yes	

Marketing Questions

- Can we find torrefied fuel for pulverized coal boilers

- Will Bio Sludge be approved as fuel?

Capital Projects



Material Handling

- Just In Time delivery
- Storage
- Conveying

Just In Time Delivery

- Portable grinding equipment

- Weighing issues
  - Truck scales
  - Loader with scales

Bulk Material Handling System (BMHS) Basics

Biomass handling systems are typically designed to handle a specific type of fuel. There is an increasing trend to design systems for multiple types of fuel so plants can diversify their fuel sources. The areas listed below comprise a biomass fuel handling system:

Plants with existing biomass handling systems stress the need to take extra care at the beginning of the project with design of the fuel feed system.

- Transportation
- Unloading
- Stockout/Storage
- Reclaim
- Process (Sizing)
- Delivery to boiler
- Fire Protection / Dust Collection

Fire Protection and Dust Control

- Handling wood creates dust that is explosive
    - Enclosed areas should have explosion venting
    - Dry dust collection systems should be provided at all transfer points where dust is generated.
    - CO detection and full extinguishing system should be provided in areas handling fine particle sizes.

RULES-OF-THUMB FOR WOOD FUEL SUPPLIES

- **8,500 Btu/lb of bone dry wood = 17 million Btu/dry ton**
- **40 to 50% moisture content is typical for forest residues and urban wood waste (tree trimmings)**
- **5,100 Btu/lb of wood at 40% moisture content**
- **~1 ton/hr/MW at 40% moisture for 10,000 Btu/kWh heat rate**
  ~1.3 ton/hr/MW at 40% moisture for 13,000 Btu/kWh heat rate
- **A typical truck load of wood provides ~24 tons of wood**
- **One truck-load per hour (i.e., 24 trucks per day) of wood fuel provides sufficient fuel for:**
  - **~18 MW of stand-alone generation capacity**
  - **~24 MW of co-firing generation capacity**
- **Truck-loads of biomass fuel are not typically delivered 24-7**

MSU Control Strategy

- When implementing fuel changes to 10% bio we found that Air to Fuel ratio auto control needs to be biased and the percentage of primary to secondary air has to be adjusted
- Working with Metso on automated fuel feed control loops for higher percentage of bio

Operational challenges when co-firing bio fuels:

Combustion control:

- Inconsistent fuel quality, flow and/or asymmetrical feed
  - 90% of disturbances are from the fuel
  - If control loops are not designed to handle inconsistent fuel, oscillations will propagate

- How to balance energy in vs. energy out?
  - Varying btu, density & moisture content make it hard to maintain steam output
  - Boiler controls need to be adapted to reach maximum and minimum load
  - Bio-fuels have a higher volatile matter (VM) content compared to coals. Higher VM fuels require different air distribution

- Emissions
  - Optimizing between emissions and efficiency requires constant monitoring and adjustments from the operators
  - This is time consuming and unnecessary with modern DCS's. With proper planning, a lot of the challenges with burning bio-fuels can be overcome.

Is your DCS prepared for the change?

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Phase 1: Building the foundation

Metso recommends a two phased approach to adapting your DCS:

Phase 1: Review, tune, and if required, modify existing control loops

Two areas you must focus on:

- Fuel feed control loops
  - Fuel feed symmetry is important to stabilize the bed
  - Excess O2 levels and furnace temperature feedbacks should be factored into the fuel feed control loops
  - At least two O2 transmitters are required on either side in the back pass to monitor symmetry

- Air distribution control loops
  - Total air calculation must be based on total fuel power and not total fuel flow
  - Fuel power to air ratio is more stable than fuel to air ratio
  - Air distribution across different elevations must be based on fuel composition. For example, more SA air is required to burn volatiles in bio-fuels vs. coal

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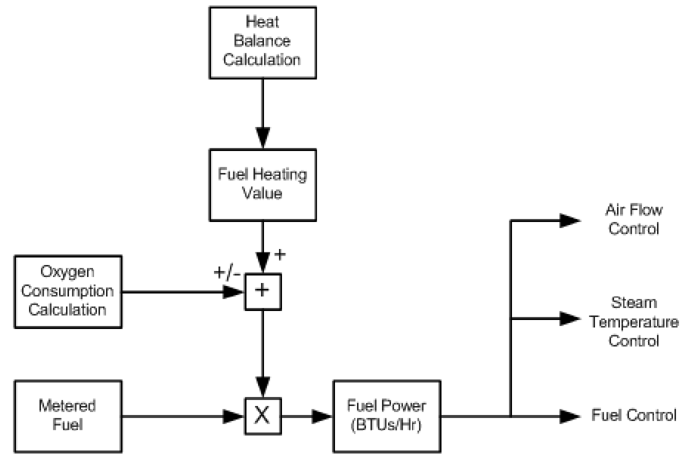
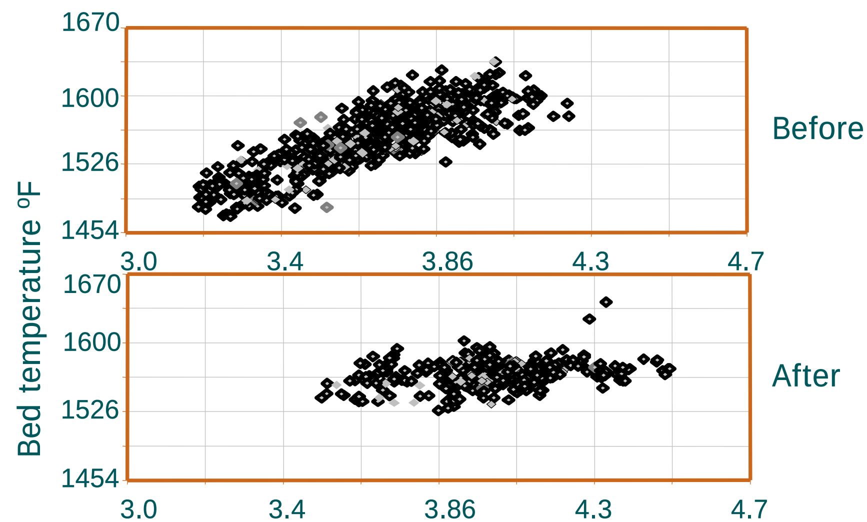
Phase 2: Advanced process control solutions

- Advance process control solutions continuously monitor and compensate for process fluctuations

- Real time fuel btu compensation
  - Essential to compensate for fluctuations in fuel quality
  - Boiler balance and O2 consumption algorithms calculate fuel btu in real time
  - The O2 consumption calculation is fast and correlates well with the firing rate
  - Calculated fuel power is input into the boiler combustion controls
  - Fuel power to air ratio is maintained at the optimum
  - Helps decouple fluctuations in fuel quality and steam flow output





Btu value of the fuel * (1000 Btu/lb)
(Decoupled bed temp from fluctuating btu)

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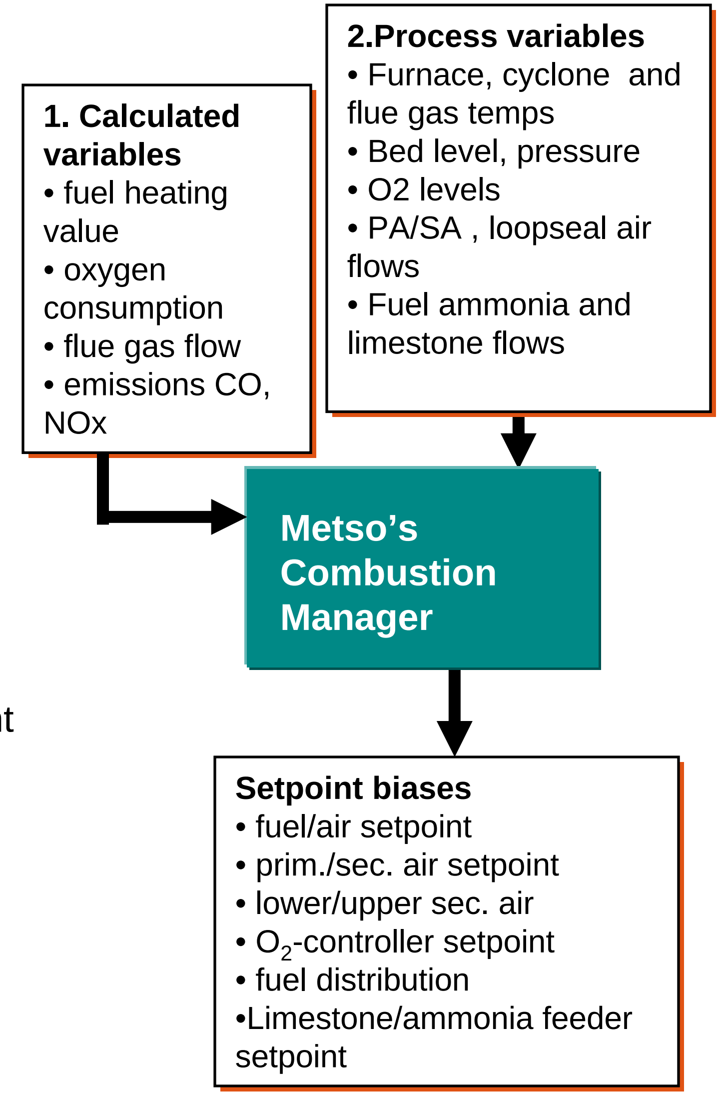
Phase 2: Advanced process control solutions

Combustion management:

- With Phase 1, the base controls are tuned and the process stabilized.
- Phase 2 optimizes the process
- The application sits above the DCS level and continuously monitors and biases the process
- Let the combustion management application:
  - Optimize your furnace temperature profile. Prevent any hot spots from forming
  - Optimize between O2, CO, SO2, NOx, and minimize ammonia and limestone use
  - Always keep you within emission limits while maximizing load



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