Chariton Valley Biomass Project
Iowa Switchgrass Cofiring Update

2nd World Conference and Technology Exhibition on Biomass for Energy and Industry and Climate Protection
Rome, Italy

A G E N D A

- **Focus of December 2003 Test Burn**
- **Test Burn Statistics & Activities Update**
- **Emissions Results to Date**
- **Status of Reporting**
- **What's Next ???**

- **Questions / Discussions**

Focus of December Test Burn

- Optimize Processing Equipment Performance
- Obtain Clearer Understanding of Air Emissions
- Determine SWG effect on Fly Ash Marketability
- Obtain OGS Performance Data

Test Burn Statistics

- Co-fired 1,673 bales of SWG (753 tons).
  - Average Weight of 900 #
  - Average Moisture 12.8 %
- Gathered nearly 300 samples for lab analysis
  - Raw Coal Samples
  - SWG Samples (raw, debaled, ground)
  - Ash Samples (Bottom ash, Fly ash, Economizer)
  - Liquids (bottom ash)
- Collected 2,760# of Fly Ash for analysis & Testing
  - 160# from auto sampler (5 gallon buckets)
  - 2,600 # bulk samples (55 gallon drums)
- Generated Approx 1100 Mwh (from SWG)
- Aux Pwr Load Approx 25 kwh/ton SWG

Testing Activities Update

- Coal Samples Tested for:
  - Ultimate Analysis; Ash Mineral & fusion temp; LOI; Water Soluable Alkalis; RCRA Trace Elements
- SWG Samples Tested for:
  - Ultimate Analysis; Ash Mineral & Fusion Temps; LOI; Sieve Particle Distribution; Water Soluable Alkalis; RCRA trace Elements; Ash Resistivity
  - Petrography (Carbon Characterization)
  - Ash Resistivity – Clean Air Engineering

Testing Activities Update

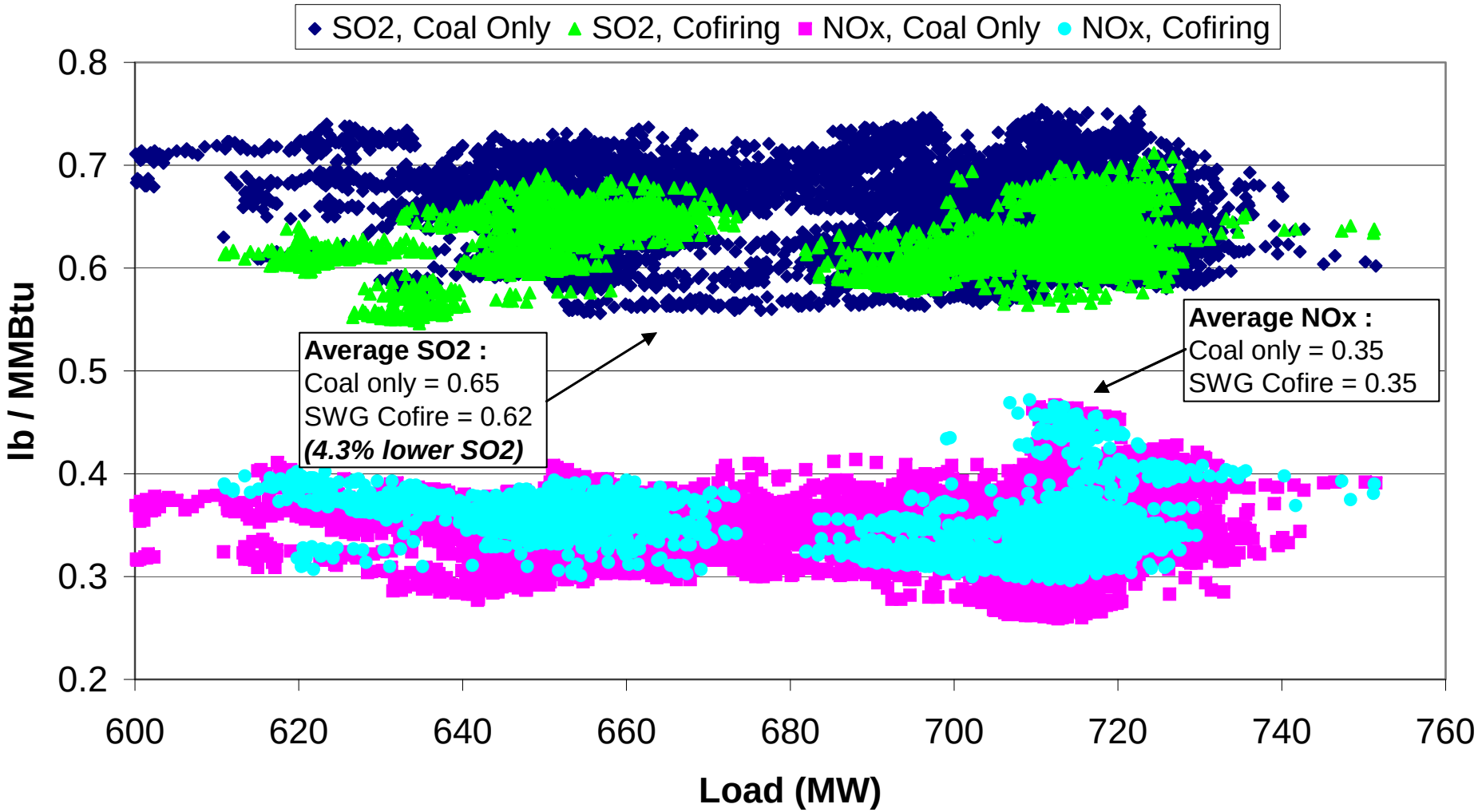
- Fly Ash Samples:
  - Sent to Iowa State Univ. for testing (03/2004)
    - Project provided a detailed description of sample collection methodology, etc
    - Uniformity & Comparative analysis
    - Compression cylinder testing (results w/in 60 days)
    - ISU pleased with volume of material provided
  - Samples Provided to IDOT from bulk samples for their analysis and testing

Summary: Emissions Results to Date

- From Continuous Emissions Monitoring System:
  - 6000 minutes of emissions data collected and analyzed
  - 8 am – 6 pm on all test days
  - 53 hours cofiring, 47 hours coal-only
  - Average heat input from switchgrass was 2.5% of boiler total
  - Results when cofiring:
    - Average Sulfur Dioxide (SO2) emissions decreased by over 4%
    - Average Nitrogen Oxides (NOx) emissions did not change
    - Average Stack Opacity increased by a percentage point
- From Stack Emissions Testing:
  - Particulates decreased by 4% (PM), and 14% (PM10)
  - Carbon Monoxide (CO) emissions did not change
  - Mercury emissions decreased by 7%

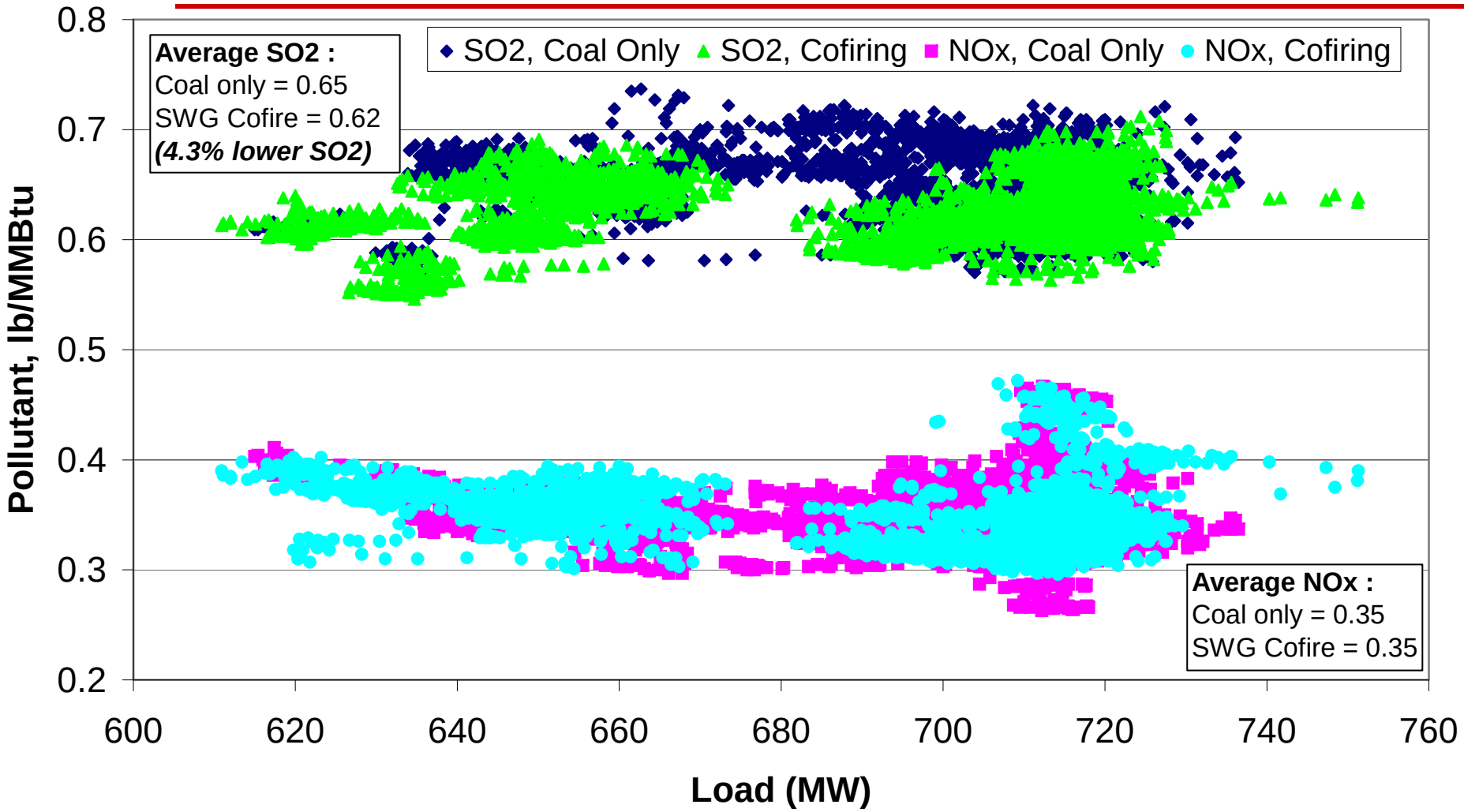
Chariton Valley Biomass Project--Interim Test Burn
NOx & SO2 vs. Load, Ottumwa Generating Station

Continuous Emissions Monitoring System Data for: December 1 to 12, 24 hours per day



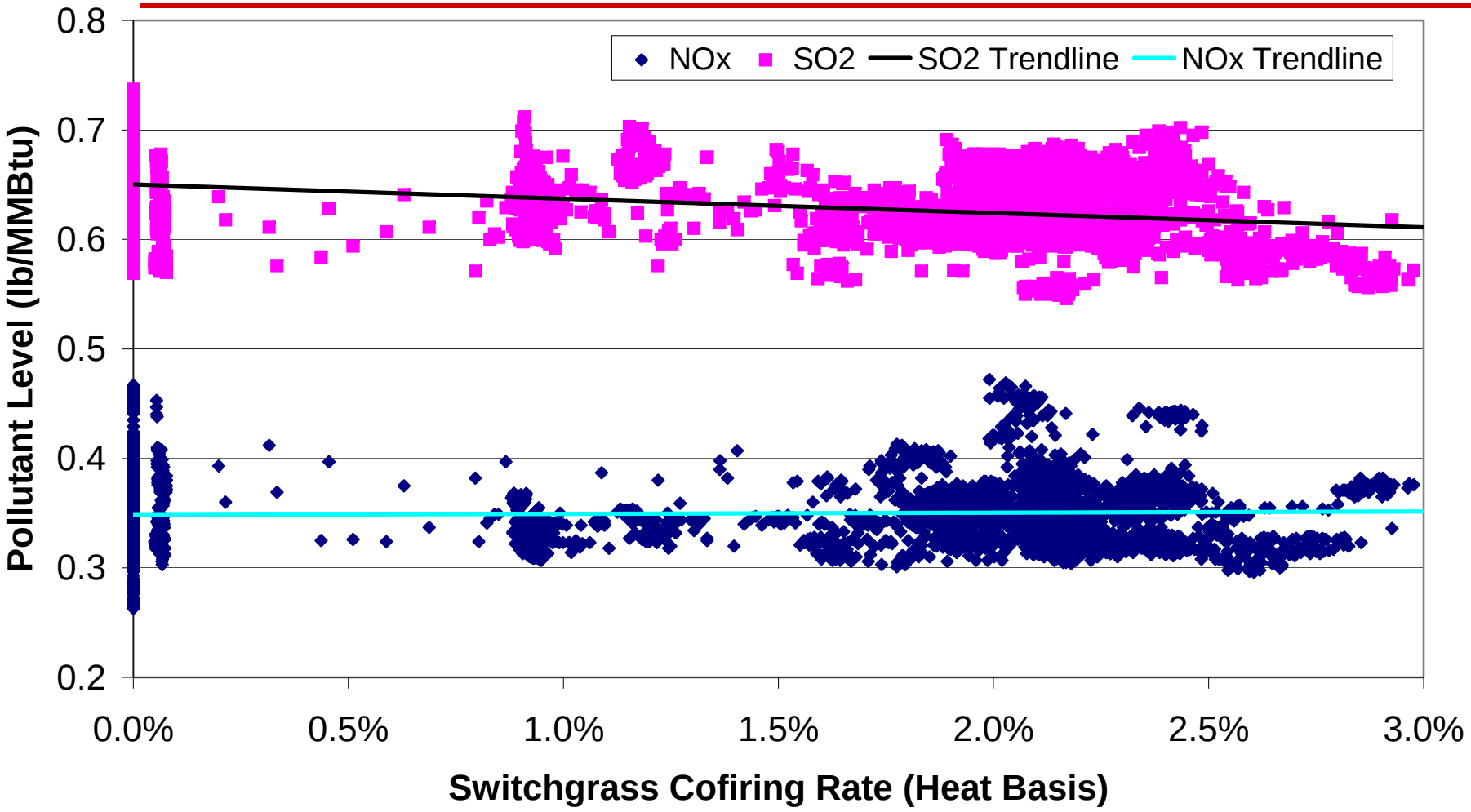
Chariton Valley Biomass Project--Interim Test Burn
NOx & SO2 vs. Load, Ottumwa Generating Station

Continuous Emissions Monitoring System Data for: December 1 to 5, December 8 to 12, 8 am to 6 pm



Chariton Valley Biomass Project--Interim Test Burn
NOx & SO2 vs. Cofire Rate, Ottumwa Generating Station

Continuous Emissions Monitoring System Data for: December 1 to 5, December 8 to 12, 8 am to 6 pm



Fuel Properties

Sample Type =>	COAL				DEBALED SWITCHGRASS			
Statistic	*Average*	*Min.*	*Max.*	*Count*	*Average*	*Min.*	*Max.*	*Count*
	Proximate + Btu Analysis (As-received basis)							
Moisture, %	24.80	23.13	25.88	12	5.99	5.44	8.29	8
Vol. Matter, %	33.33	32.18	33.86	12	72.24	70.64	74.02	8
Fixed Carbon, %	36.10	35.25	37.07	12	16.99	15.88	17.52	8
Ash, %	5.45	4.11	7.95	12	4.63	4.08	5.27	8
Sulfur, %	0.31	0.29	0.33	12	0.09	0.07	0.12	8
Chlorine, %	0.00	0.00	0.00	12	0.06	0.03	0.08	8
Btu/lb (HHV)	8,942	8,680	9,114	12	7,479	7,410	7,579	8
	Proximate + Btu Analysis (dry basis)							
Vol. Matter, %	44.34	41.86	45.52	12	76.85	75.82	78.64	8
Fixed Carbon, %	48.43	47.80	49.88	12	18.23	17.03	18.71	8
Ash, %	7.24	5.49	10.34	12	4.92	4.33	5.60	8
Btu/lb (HHV)	11,893	11,292	12,107	12	7,956	7,836	8,115	8
MAF Btu/lb.	12,821	12,594	12,951	12	8,368	8,248	8,501	8
	Ultimate Analysis (dry basis)							
Ash, %	7.24	5.49	10.34	12	4.92	4.33	5.60	8
Carbon, %	69.15	65.98	70.20	12	47.99	47.58	48.51	8
Organic C, %	68.98	65.97	70.19	10	47.98	47.58	48.51	8
Inorganic C, %	0.01	0.01	0.01	10	0.01	<0.01	0.02	8
Hydrogen, %	4.70	4.37	5.04	12	5.70	5.63	5.78	8
Nitrogen, %	1.02	0.92	1.08	12	0.32	0.17	0.50	8
Oxygen, %	17.48	16.90	18.66	12	40.91	40.39	41.77	8
Sulfur, %	0.41	0.39	0.45	12	0.09	0.07	0.13	8
Chlorine, %	0.00	0.00	0.00	12	0.06	0.04	0.08	8
ppm Chlorine	27	13	45	12	627	361	850	8

Fuel Properties

Sample Type =>	COAL				DEBALED SWITCHGRASS			
Statistic	*Average*	*Min.*	*Max.*	*Count*	*Average*	*Min.*	*Max.*	*Count*
	Water Soluable Alkali (ppm dry basis, except where noted)							
Soluble Na	490	440	520	10	55	46	60	8
Soluble K	34.3	25.2	42.6	10	3,533.4	2,365.0	4,948.0	8
	Major Ash Elements, Wt % Ash (Ignited to 750 Deg. C)							
SiO2	34.45	30.53	44.76	10	60.81	57.62	62.75	8
Al2O3	16.75	13.98	19.84	10	1.53	1.23	2.04	8
TiO2	1.37	1.17	1.91	10	0.09	0.07	0.11	8
Fe2O3	4.73	3.96	5.42	10	6.12	3.74	10.11	8
CaO	22.37	15.72	24.83	10	9.81	9.15	10.36	8
MgO	3.85	3.02	4.12	10	3.85	3.28	4.55	8
Na2O	1.25	0.98	1.41	10	0.31	0.20	0.39	8
K2O	0.37	0.15	0.77	10	8.03	6.01	9.64	8
P2O5	1.25	0.74	1.63	10	5.17	4.12	5.96	8
SO3	12.06	8.50	14.08	10	3.25	2.85	3.76	8
Oxide Total	98.45	97.65	99.73	10	98.95	97.56	100.45	8

Fuel Properties

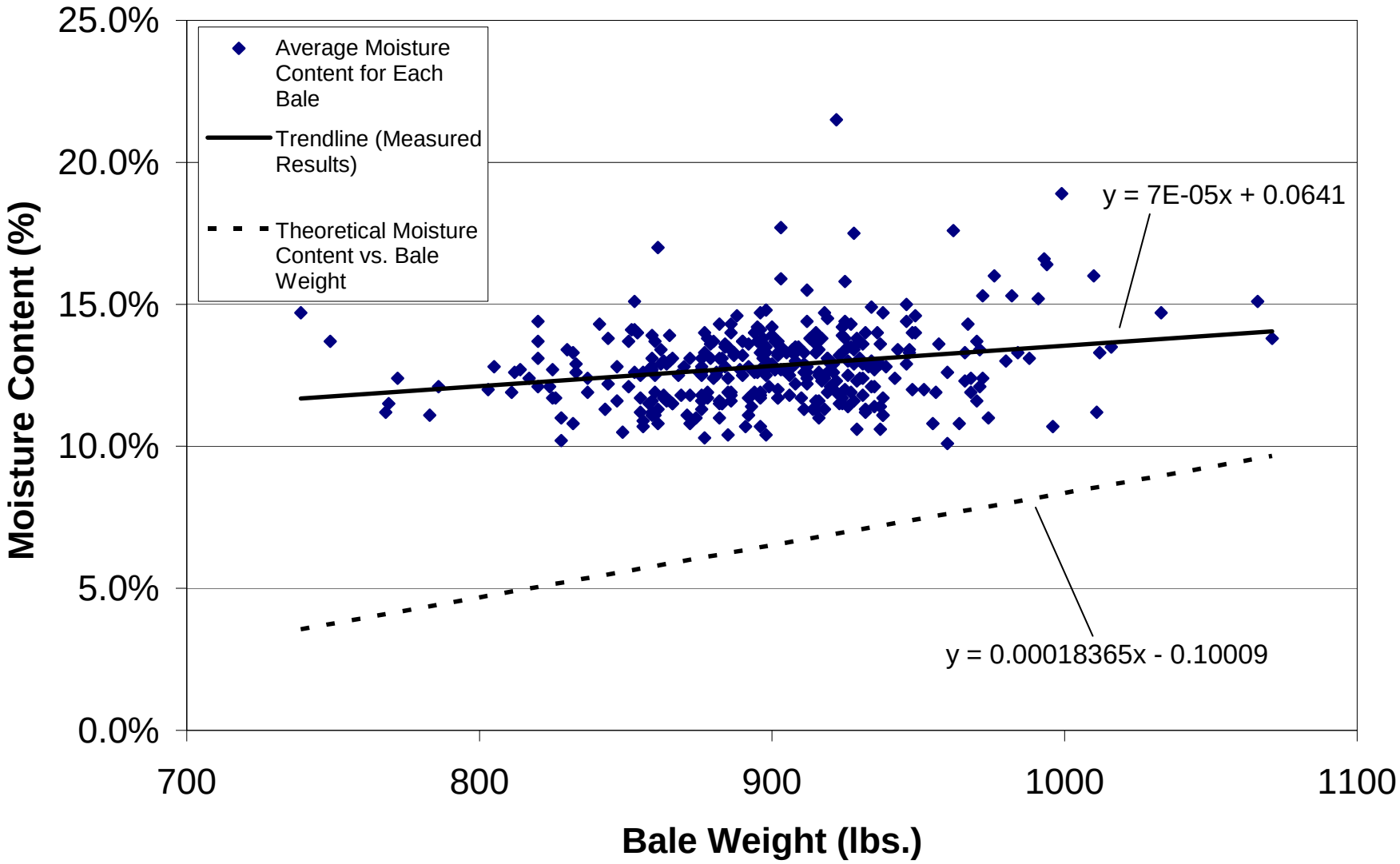
Sample Type =>	COAL				DEBALED SWITCHGRASS			
Statistic	*Average*	*Min.*	*Max.*	*Count*	*Average*	*Min.*	*Max.*	*Count*
	RCRA Trace Metals, ppm Dry Weight Basis (except where noted)							
Ag	0.05	0.04	0.06	10	0.01	0.01	0.01	8
As	1.10	0.76	1.40	10	0.24	0.09	0.54	8
Ba	294.00	261.40	325.65	10	35.32	24.35	65.86	8
Cd	0.08	0.05	0.11	10	0.05	0.02	0.10	8
Cr	3.72	2.55	6.31	10	6.05	3.29	8.81	8
Hg	0.09	0.07	0.12	12	0.02	0.02	0.03	8
Pb	2.44	2.01	2.88	10	0.73	0.38	1.11	8
Se	0.77	0.54	1.22	10	0.79	0.53	1.22	8

Bale Weights and Moisture Content

Bales Weighed:	347	
Average Bale Weight:	899.8	lbs.
Weighted Average Moisture Content:	12.8%	weighted average
Average Moisture Content:	12.8%	standard average
Minimum Ave. Bale Moisture Content:	10.1%	
Maximum Ave. Bale Moisture Content:	21.5%	
Maximum Moisture Probe Reading:	38.0%	single probe sample
Ave Max. Moisture Probe Reading (per bale):	14.7%	single probe sample

Bale Weight vs. Moisture Content

(Chariton Valley Biomass Project Interim Test Burn, measurements made on Dec. 10 & 11, 2003, Bales stored indoors)



Bale Weight vs. Moisture Content

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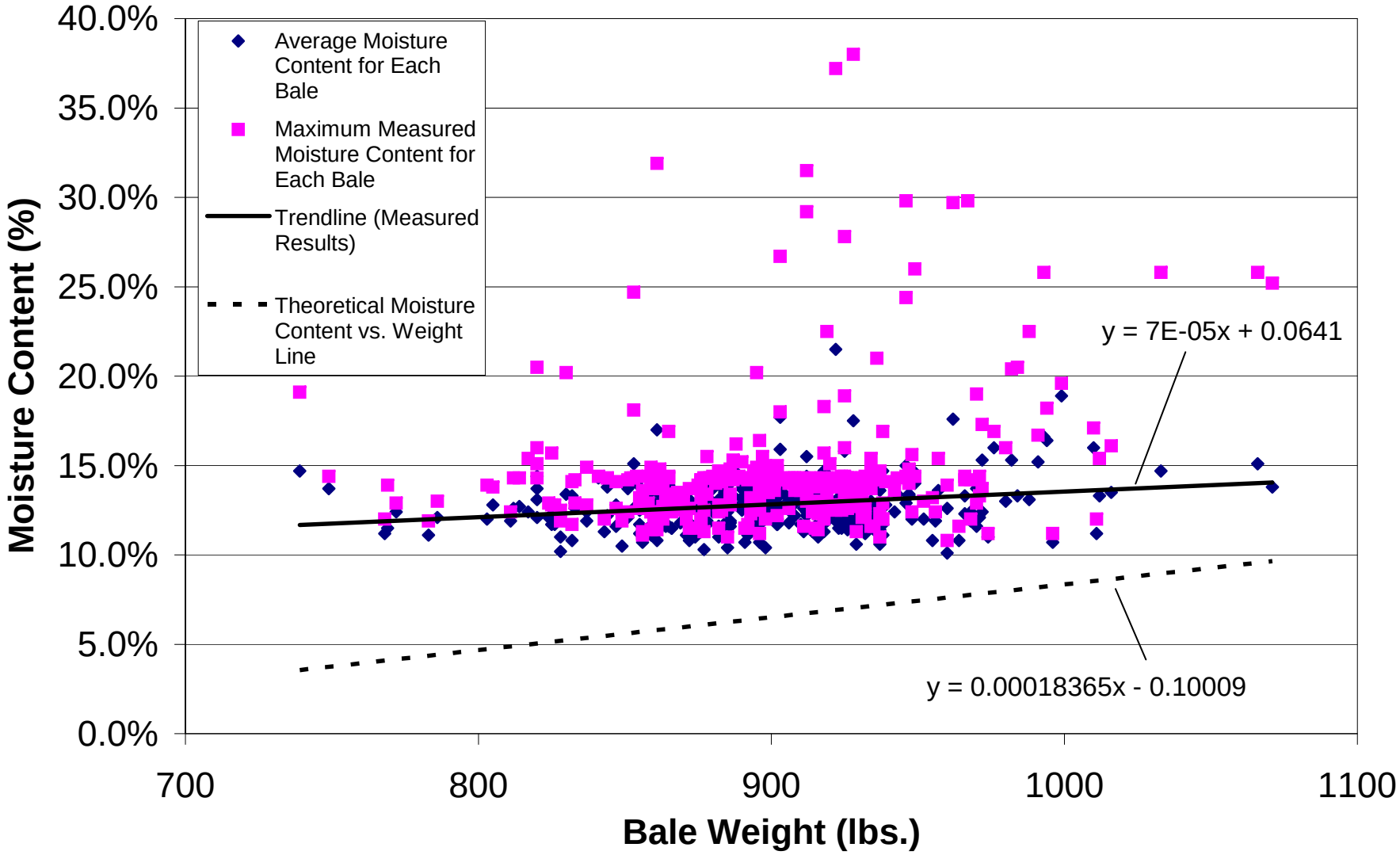
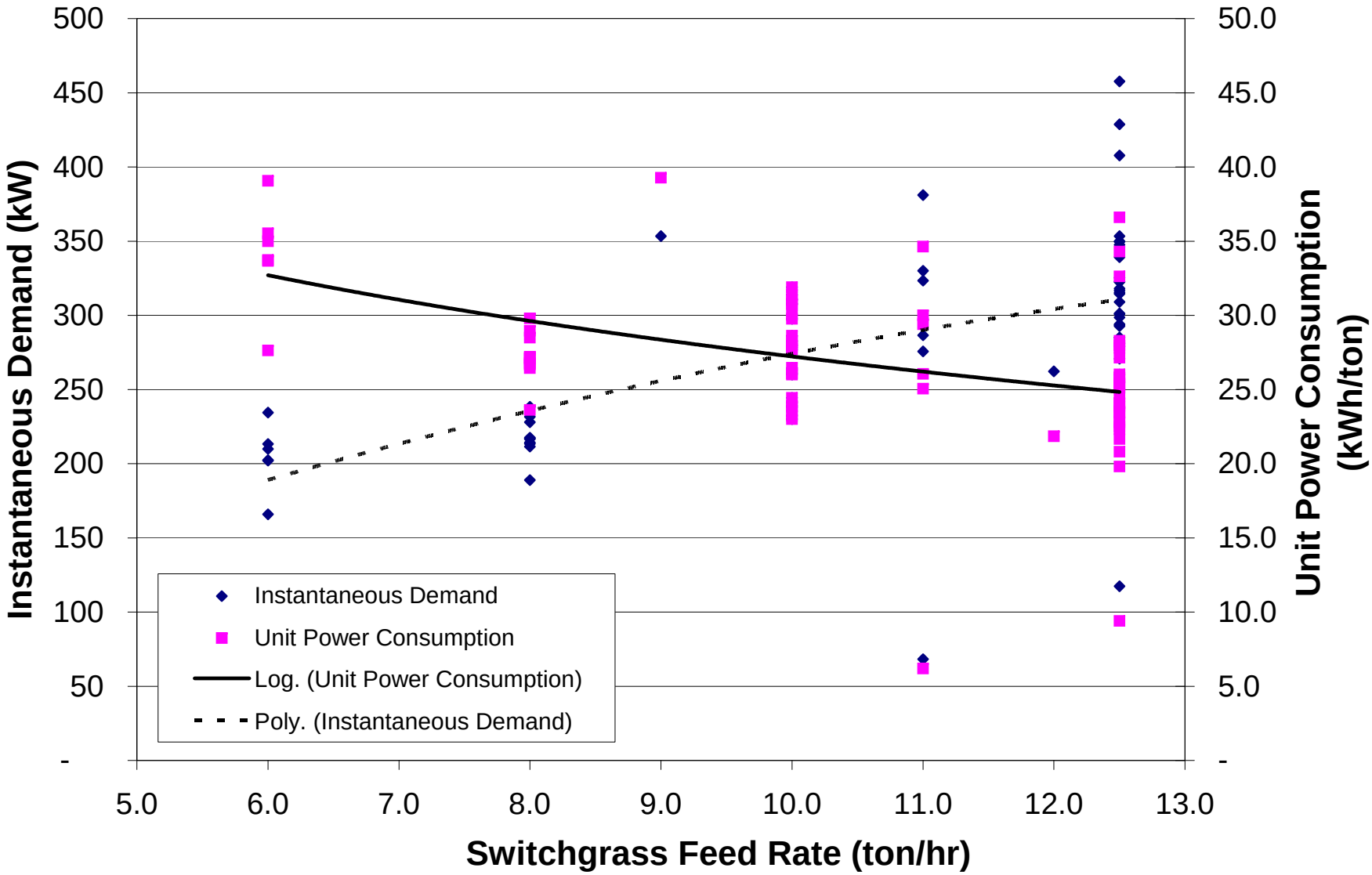


Power Consumption Data--Biomass Processing



Boiler Efficiency Results

- Calculated Boiler Efficiency
  - Data used for calculations:
    - Hourly average air and gas temperatures, fuel and air flow rates, air conditions, and O2 measurements
    - Daily fuel analyses and LOI results
  - Average calculated boiler efficiency during cofire periods was 0.01% lower than coal-only periods
  - Average plant loads during for efficiency calculations were:
    - Cofire periods: 684.5 MW
    - Baseline periods: 699.5 MW
  - Average switchgrass feed rate during the cofire periods was 8.9 tons per hour

Loss-On-Ignition Results

CVBP Interim Test Burn Loss-on-Ignition Test Results

Firing Mode	Minimum LOI, %	Average LOI, %	Maximum LOI, %	No. of Samples
Bottom Ash Samples				
Coal-only	0.31	7.44	22.97	4
Cofire	0.17	1.63	5.01	7
Economizer Ash Samples				
Coal-only	0.01	0.03	0.07	3
Cofire	0.02	0.26	0.76	7
Fly Ash Samples				
Coal-only	0.22	0.27	0.31	3
Cofire	0.18	0.31	0.35	7

Bottom Ash Observations & Tests

- Large unburned biomass particles were observed at times in bottom ash
  - Most of unburned biomass was *not* switchgrass
  - Most of unburned switchgrass was “nodes”
  - Suspected causes for unburned biomass in bottom ash
    - Foreign biomass (not switchgrass) in some bales
    - “Nodes” do not burn out as well as stems
    - Possibly also:
      - Higher moisture bales
      - Larger than desired switchgrass particle sizes

Bottom Ash Observations & Tests

Bottom Ash Sample Collected on a Cofire Day (not necessarily a typical sample for a cofire day)

Same Bottom Ash Sample, with Unburned Biomass Separated

Bottom Ash Observations & Tests

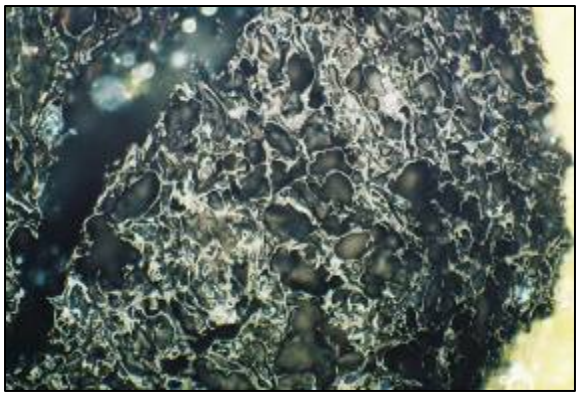
Unburned Switchgrass "Nodes"

Large Unburned Biomass (Non-Switchgrass)

Petrography Results

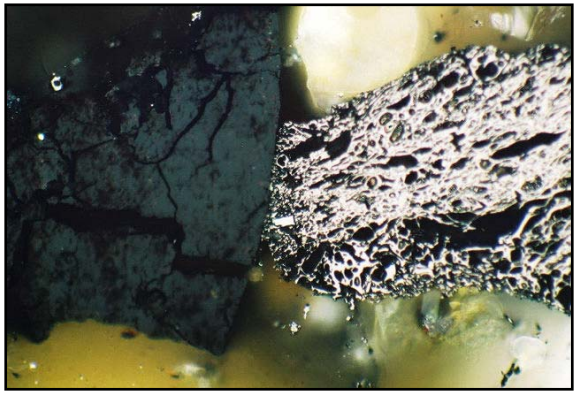
- Consol Energy used petrography tests/methods to determine the origin of carbon forms in ash samples
- Yielded estimates of % volume of total unburned carbon in ash, and fractions from coal and biomass
- Origin (coal or grass) and nature (unburned or char) of carbon forms are recognizable by trained petrographer under microscope (500x)
- Grass forms are more cellular

Petrography Image Samples

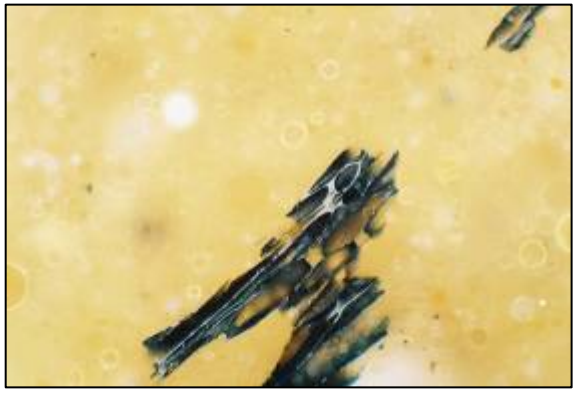


Coal Char, Fly Ash 12/11/03

Unburned Coal, Econ. Ash 12/11/03

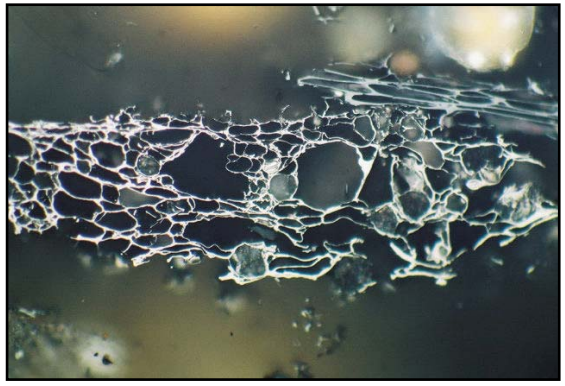


Unburned Coal & Char, Bottom Ash 12/7/03



Grass Char, Fly Ash 12/11/03

Grass Char, Econ. Ash 12/11/03



Grass Char, Bottom Ash 12/11/03

Petrography Results

- Highest carbon in bottom ash occurred on a coal-only day
- Little or no detectable unburned switchgrass in fly ash and economizer ash

Sample Date	Test Activity	Sample Description	Total Petrographic Carbon Forms, Vol %	% Carbon Forms from Grass	% Carbon Forms from Coal
12-05-03	Cofire, wet switchgrass from outdoor storage	BOTTOM ASH	1.6	31	69
12-07-03	Coal only	BOTTOM ASH	15.6	--	100
12-10-03	Cofire, "dry" switchgrass from indoor storage	BOTTOM ASH	0.6	--	100
12-11-03		BOTTOM ASH	9.2	93	7
12-10-03		ECONOMIZER ASH	2.6	8	92
12-11-03		ECONOMIZER ASH	0.2	--	100
12-11-03		FLY ASH	0.3	--	100
12-11-03		FLY ASH	0.1	--	100

Status of Reporting

- Report Submittal to IDNR – Mid February, 2004
  - Draft Report Submitted – February 13, 2004
  - Final Report to be submitted upon receipt of laboratory analysis and report (May)
- Report to USDOE – June, 2004
- Ash Report (from ISU) – September 2004

So….What's Next ???

- Focus on completion of Fly ash testing and acceptability by IDOT
- Completion of Emissions reporting to IDNR
- Completion of fly ash resistivity testing / determination of effect on ESP performance
- Continue efforts to optimize processing equipment performance and "layout".
- Perform additional "testing" to better understand SWG/Opacity relationship (cold air testing)
- USDOE Has approved funding for relocation of SWG processing facility to top of hill
- Long Term Test Burn now targeted for late 2005


Straw Palace
(Straw Storage)
Hoop Building
(Straw Storage)
OGS Main
Plant Building
“Biosilo”
(Straw Storage &
Processing)

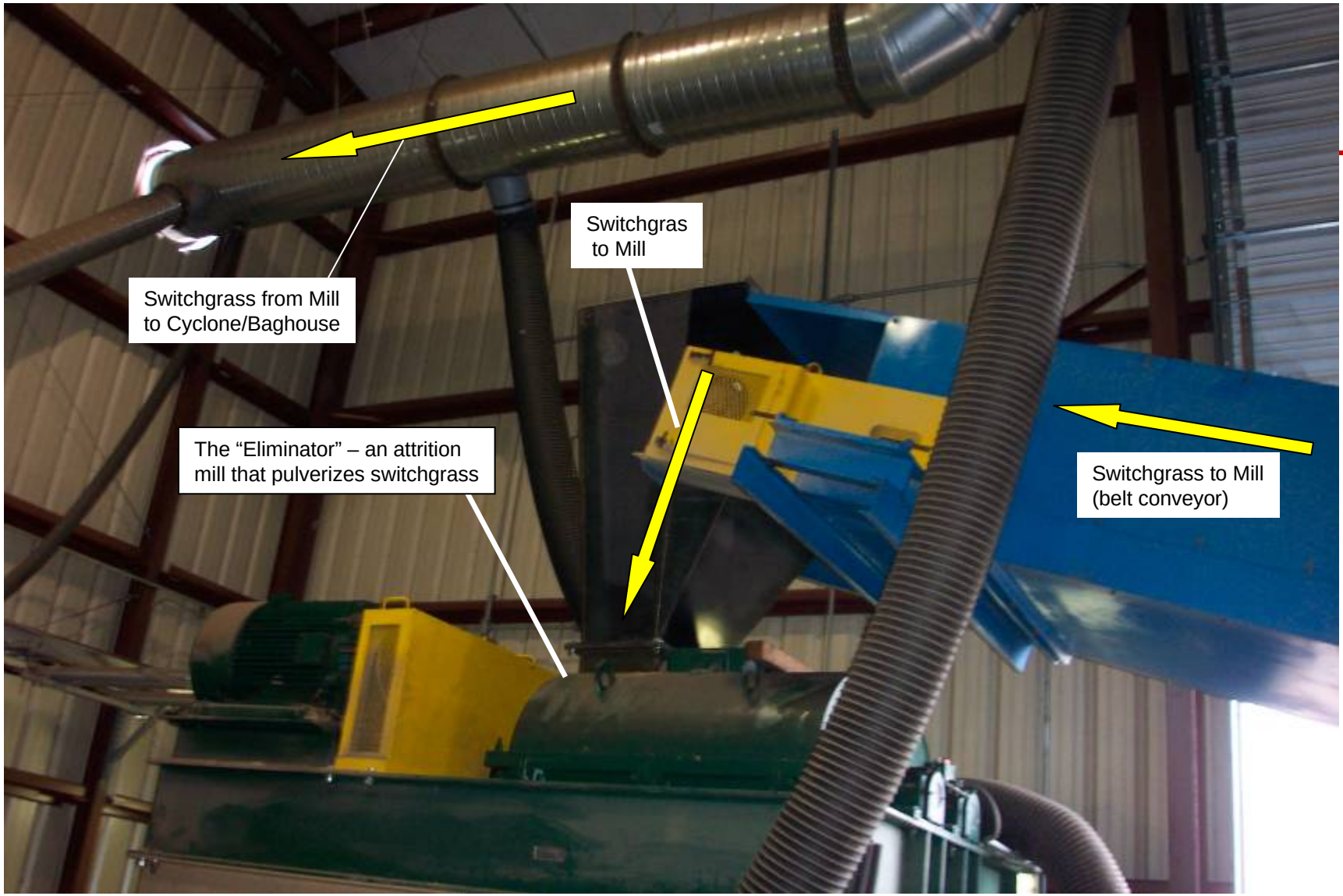

Cyclone / Baghouse
(filters dust from
processing equipment)
“Biosilo”
(Straw Storage &
Processing)

Bale Infeed Conveyor

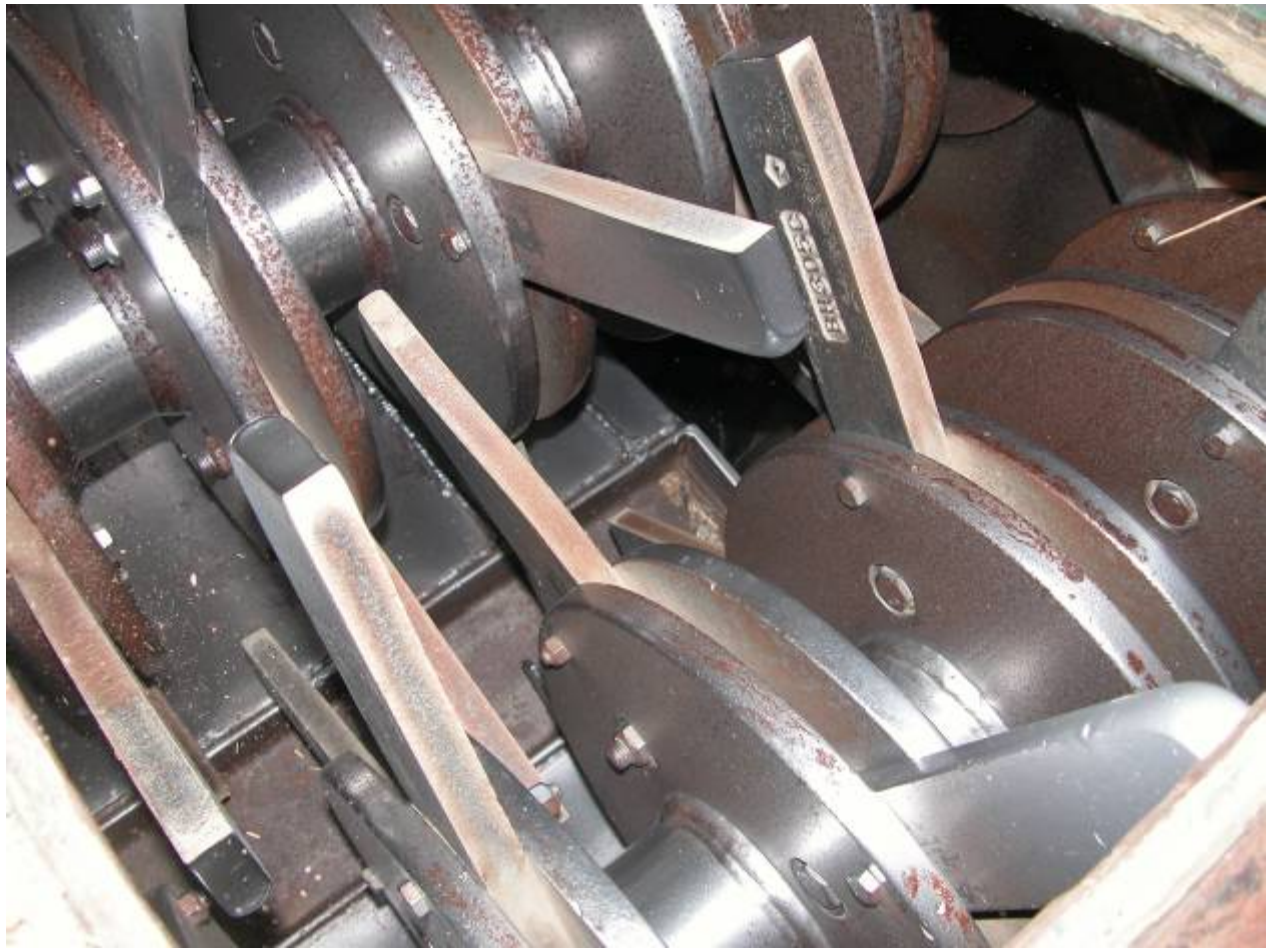
Loading 1000 lb. Bale

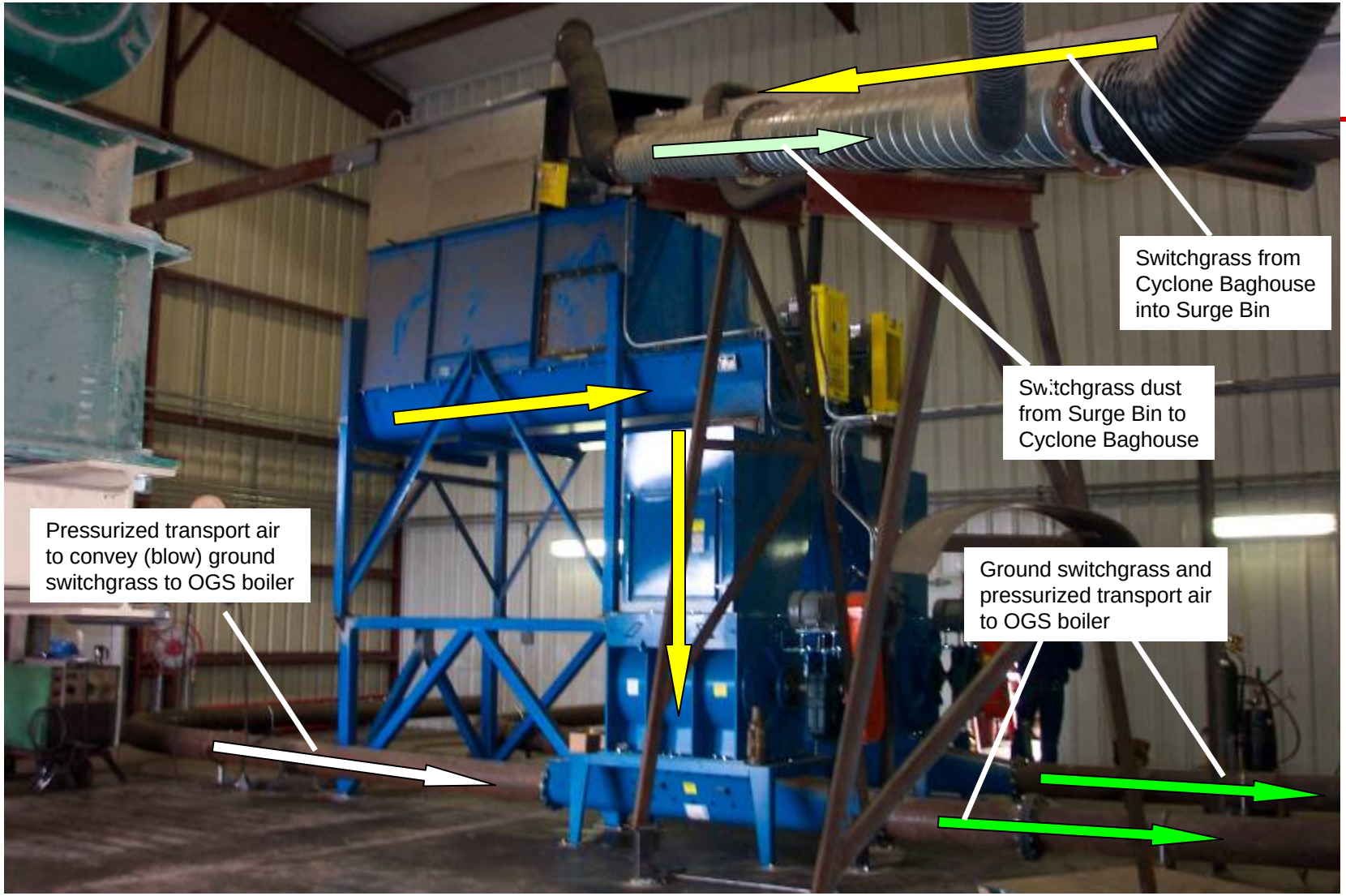
400 Hp De-baler

Cutter blade on the D-Stringer.

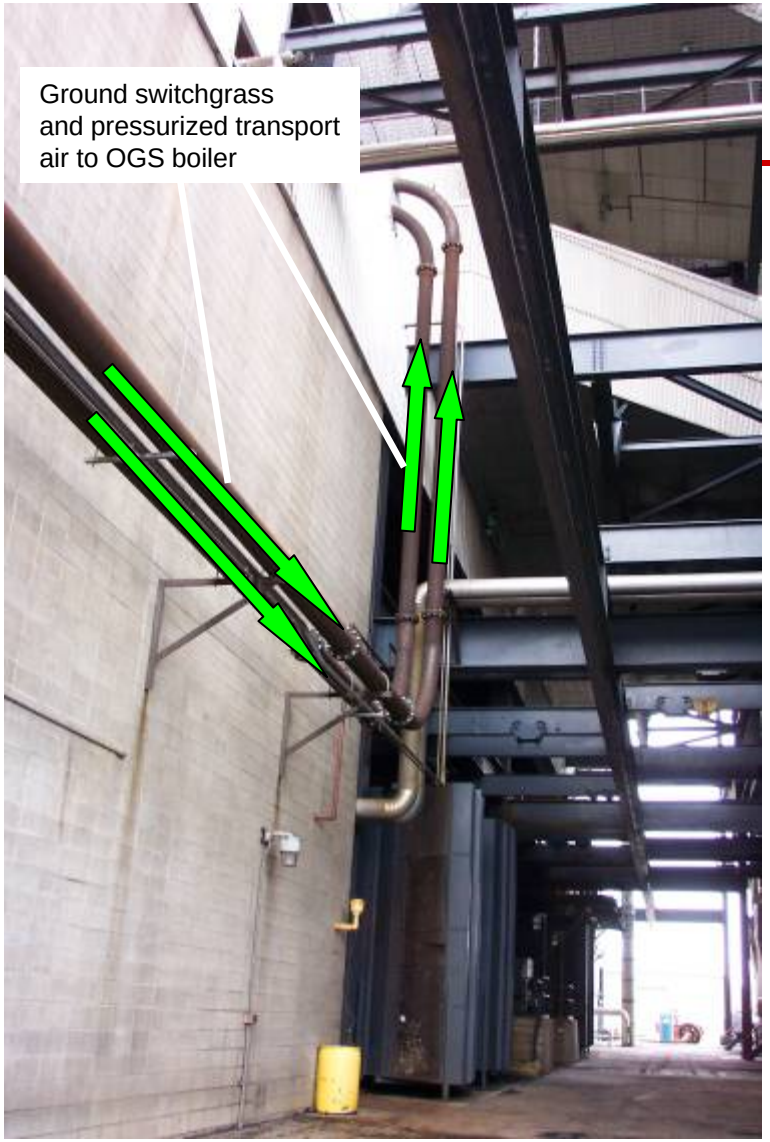

Switchgrass from Mill to Cyclone/Baghouse
Switchgras to Mill
The “Eliminator” – an attrition mill that pulverizes switchgrass
Switchgrass to Mill (belt conveyor)

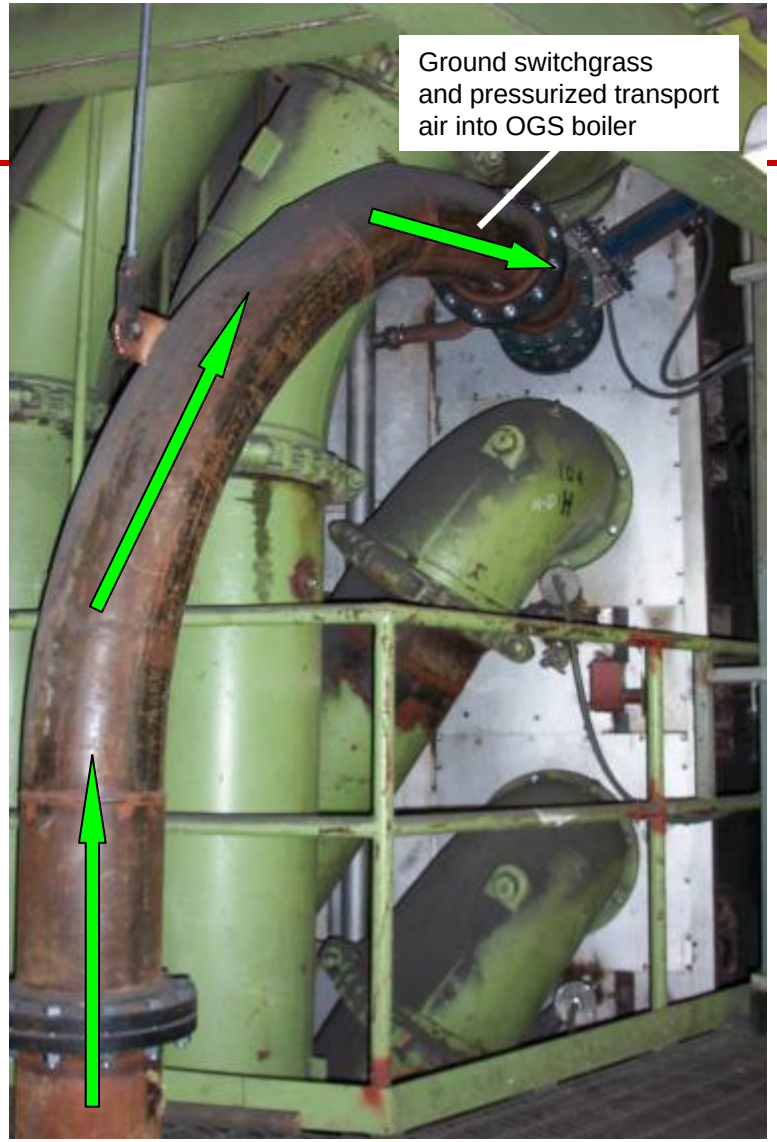
Secondary Grinder Internals





Surge Bin, Rotary Airlocks, and Switchgrass Blow Lines to Boiler.





Switchgrass Blow Lines Transporting Ground Switchgrass into Boiler House (left) and Boiler (right).

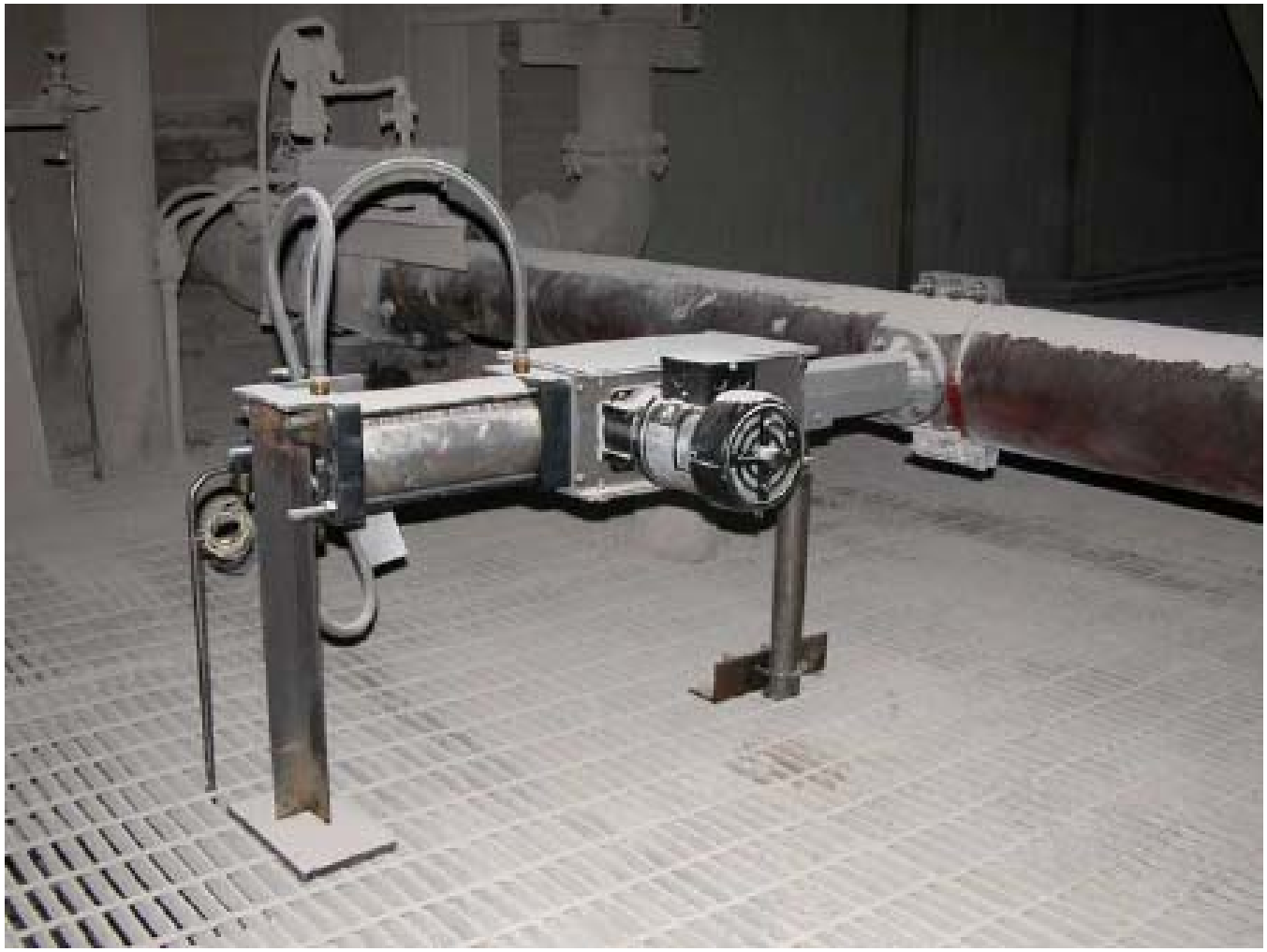
Debaled and Ground Switchgrass

Debaled Switchgrass

Ground Switchgrass

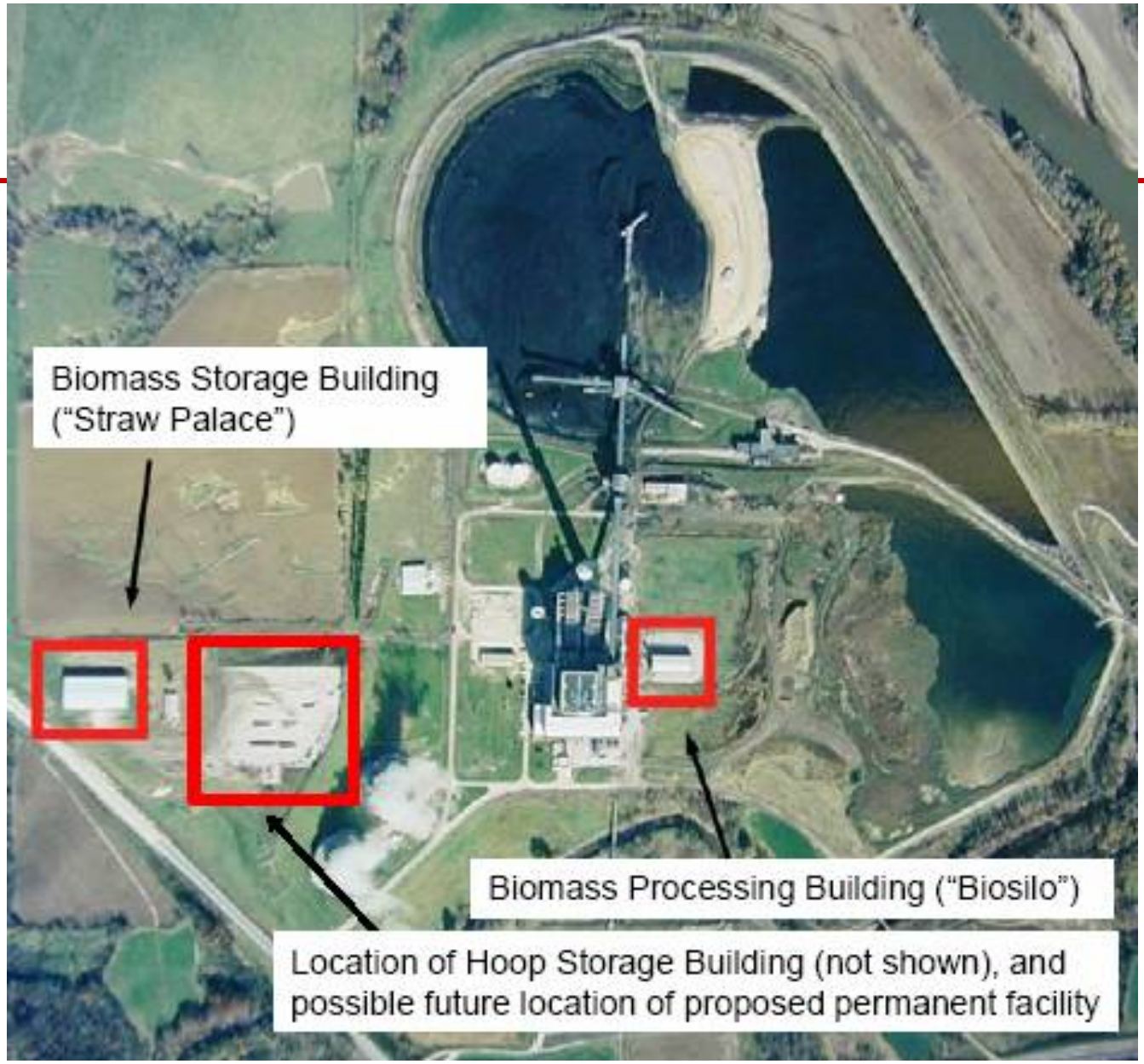
Switchgrass System Control Room.

Automated Flyash Sampler

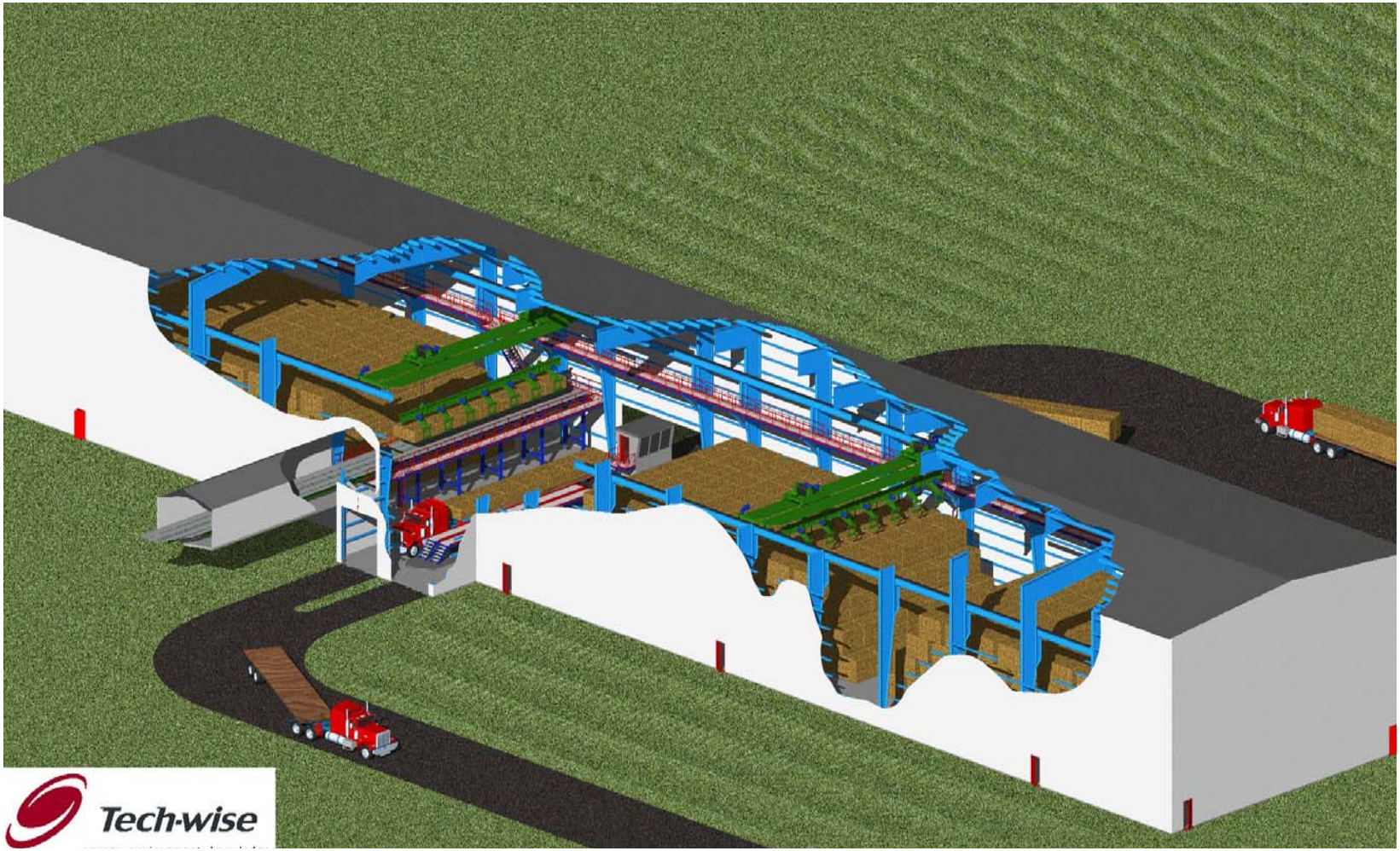


Future Plans and Possibilities

- Long Term Co-fire Testing – 2005/2006
  - 2000+ hours (90 days) testing
  - Co-fire up to 25,000 Tons of SWG @ 12.5 TPH
  - Boiler performance / Operational Data
  - Combustion Optimization (RMT/CI)
  - Corrosion, Erosion, Slagging, Fouling data
- Commercial Operation
  - Depending upon economics
  - SWG Storage / Processing Facility Located off site
  - Alliant & Prairielands Fuel Supply Agreement
  - 100,000 – 200,000 TPY SWG co-fired @ OGS
  - SWG delivered to OGS boiler via pneumatic blow line


Biomass Storage Building
("Straw Palace")
Biomass Processing Building ("Biosilo")
Location of Hoop Storage Building (not shown), and
possible future location of proposed permanent facility

CVBP Process Facility
(Bale Storage and Reclaim Section)



Emissions Monitoring (GE)

Emissions Probe In Outlet Duct

GE's Mobile Emissions Lab

GE's Emissions Vans at Stack

Emissions Equipment at OGS

CEMS Probes In Outlet Duct

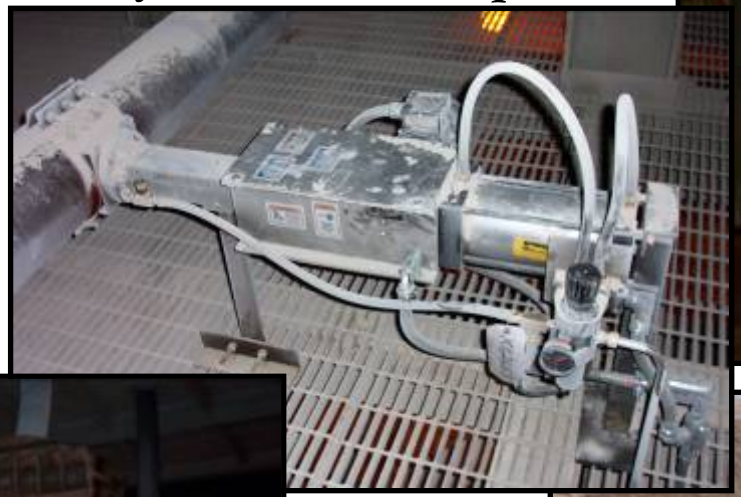
Portable Emissions Monitor

Other Sampling

Bottom Ash Liquids

Economizer Ash

Fly Ash Auto Sampler



Bottom Ash

Bulk Fly Ash


THANK YOU