Measures of Manure Quality as Fuel

- Brent Auvermann, Texas Cooperative Extension-Amarillo

Measures of Fuel Quality

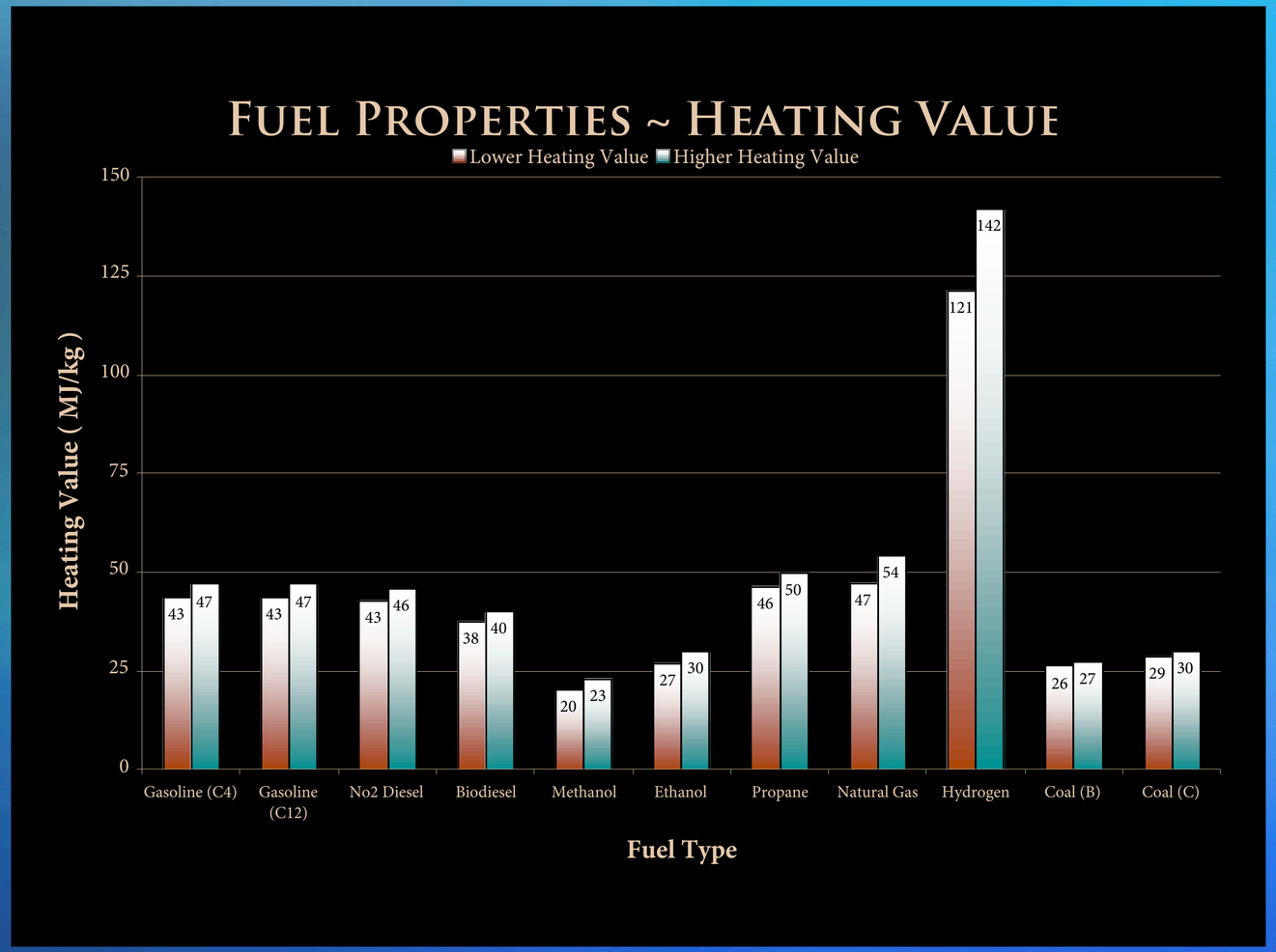
- Heating value - lower vs. higher (LHV vs. HHV)
- Reporting basis - dry, ash-free, dry ash-free, moisture and ash free
- Comparisons to traditional fuels
- Interpreting a fuel-analysis laboratory sheet
- Laboratories available

Heating Values: Low vs. High

- Low heating value (LHV)
  - Reflects combustion heat used to evaporate water (“latent heat of vaporization”)
  - Assumes no post-combustion condenser to recover the LHOV
  - Related to hydrogen content of fuel ($2H_2 + O_2 <=> 2H_2O$)
  - Use LHV when fuel is used in (for example) automotive engines

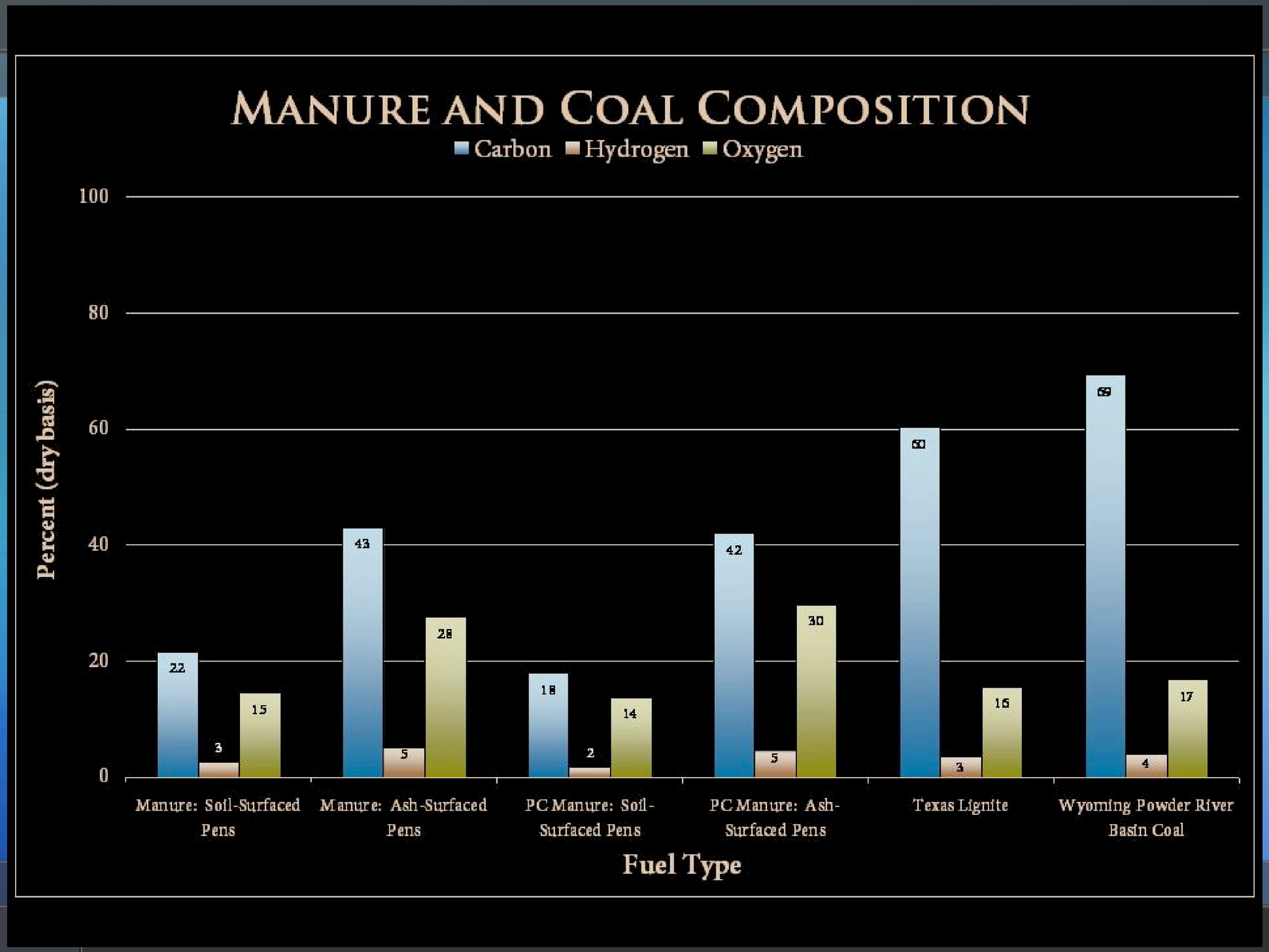
Heating Values: Low vs. High

- High heating value (HHV)
  - Assumes all combustion heat is recovered
  - Assumes a post-combustion condenser to recover the latent heat of vaporization
  - Advanced boiler technologies can realize a fuel's HHV
  - *We will be considering only HHV today*



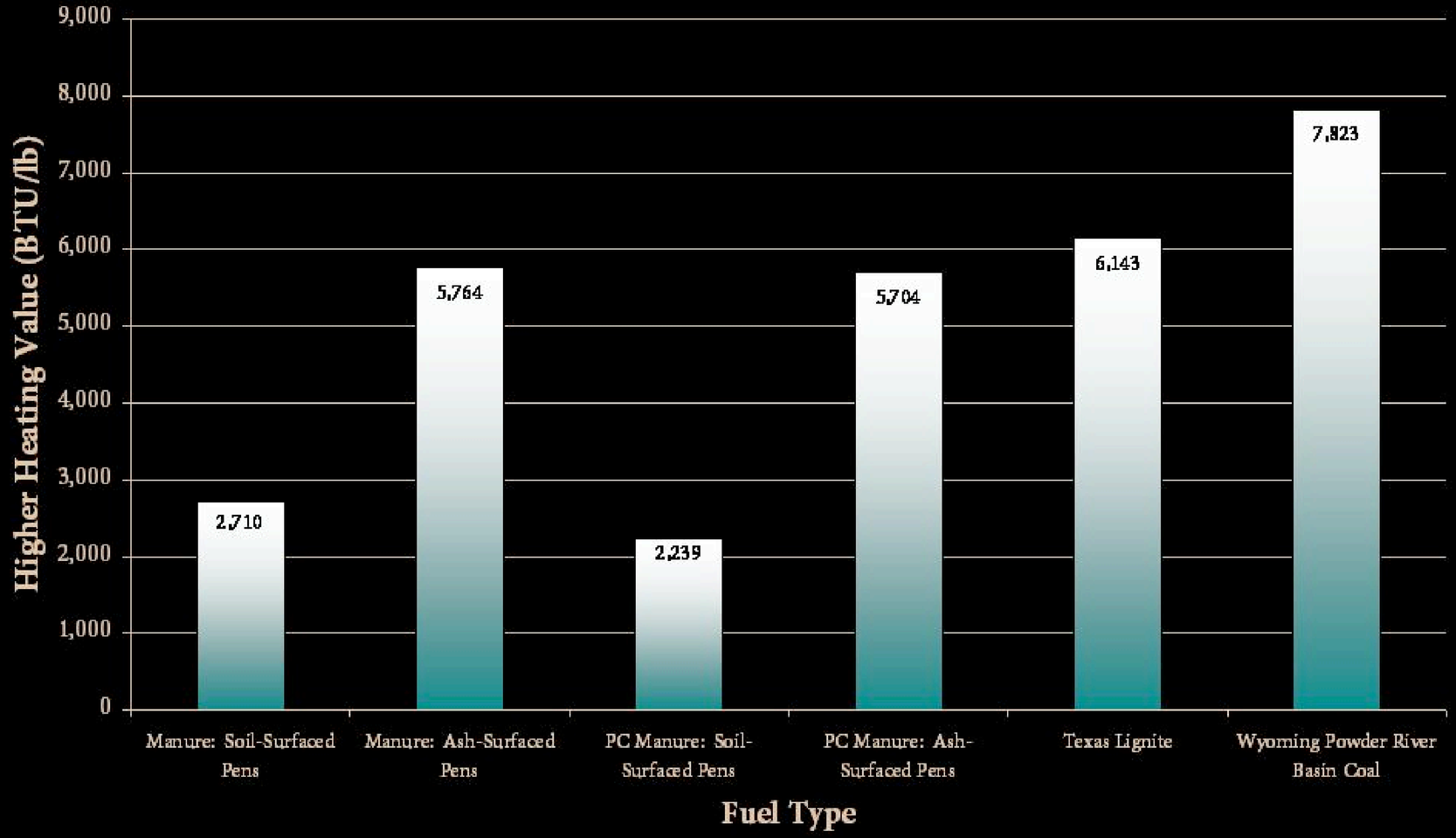
LHV vs. HHV

- The greater the % hydrogen in the fuel, the greater the % discount in heating value if steam is not condensed from combustion exhaust
- For hydrogen, the discount approaches 15% of HHV
- For coal, the discount is around 3-5% of HHV
- Advanced boiler designs recover steam heat, so HHV is the appropriate fuel value to use here

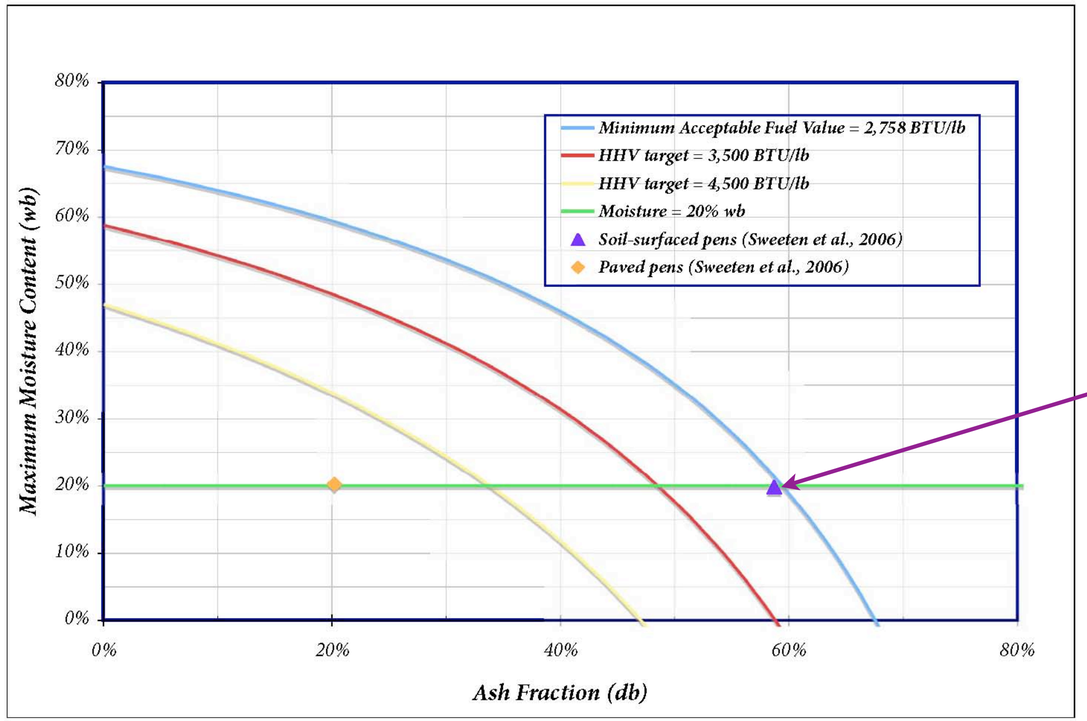

Manure and Coal Composition
Carbon
Hydrogen
Oxygen
Percent (dry basis)
100
80
60
40
20
0
22
3
15
43
5
28
18
2
14
42
5
30
60
3
16
69
4
17
Manure: Soil-Surfaced Pens
Manure: Ash-Surfaced Pens
PC Manure: Soil-Surfaced Pens
PC Manure: Ash-Surfaced Pens
Texas Lignite
Wyoming Powder River Basin Coal
Fuel Type

Fuel Properties ~ Heating Value

(As Received; Sweeten et al., 2006)



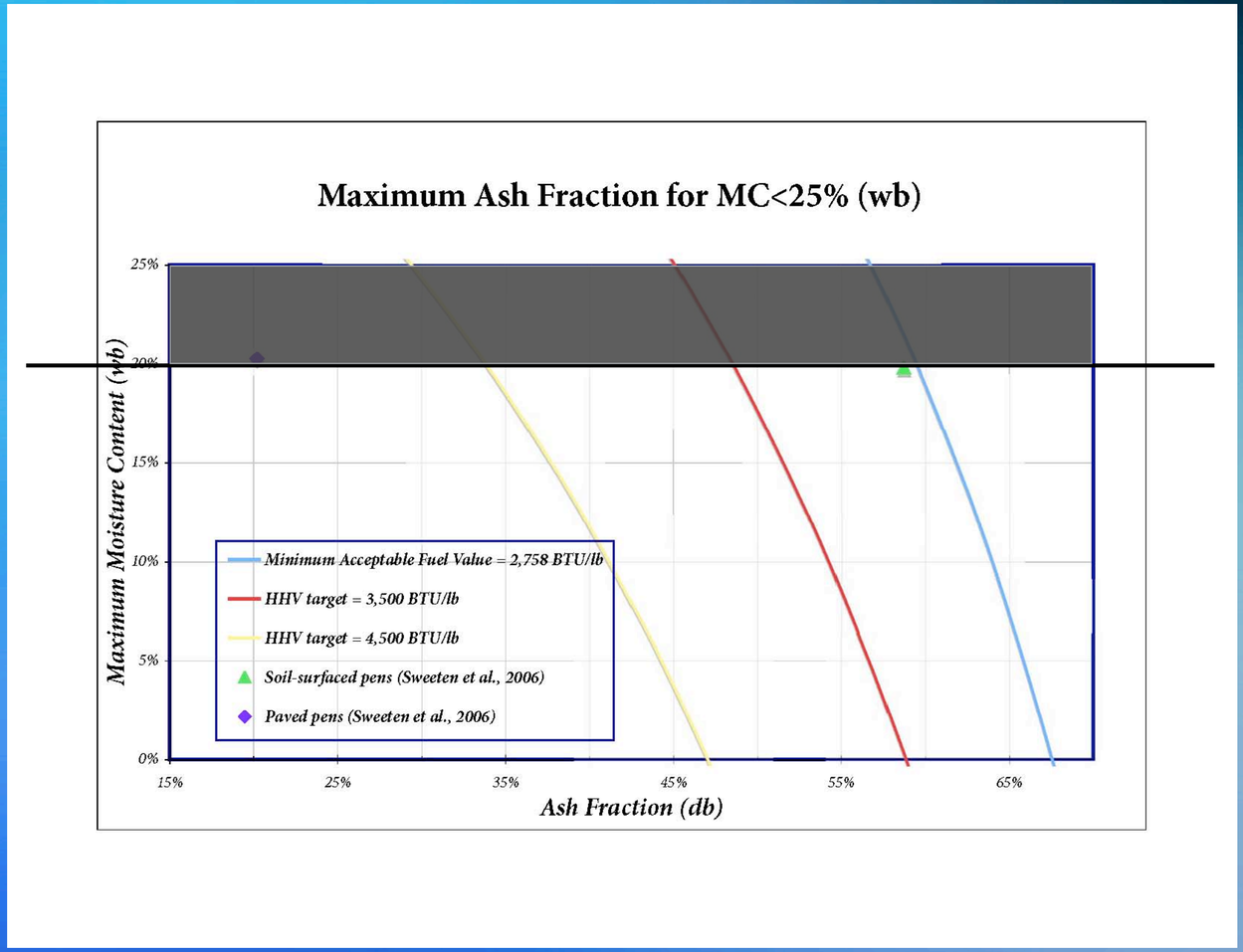
Minimum Acceptable Fuel Value (MAFV)



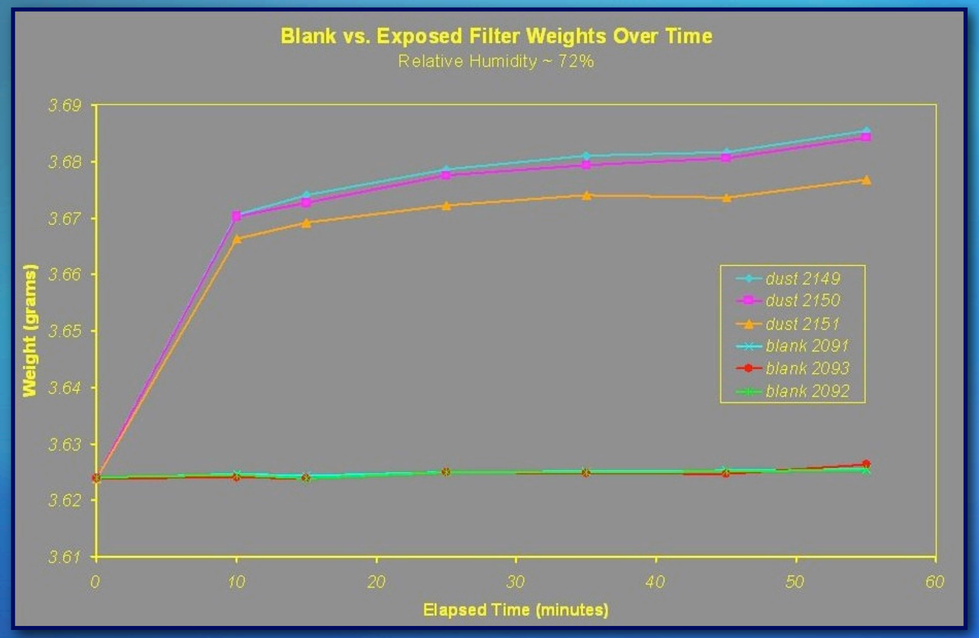
- Panda Ethanol's MAFV is 2,758 BTU/lb
- Only manure with HHV>MAFV will be accepted
- Maximum moisture content is 20% (wb)
- At MC=20%, maximum ash content is 60% (db)

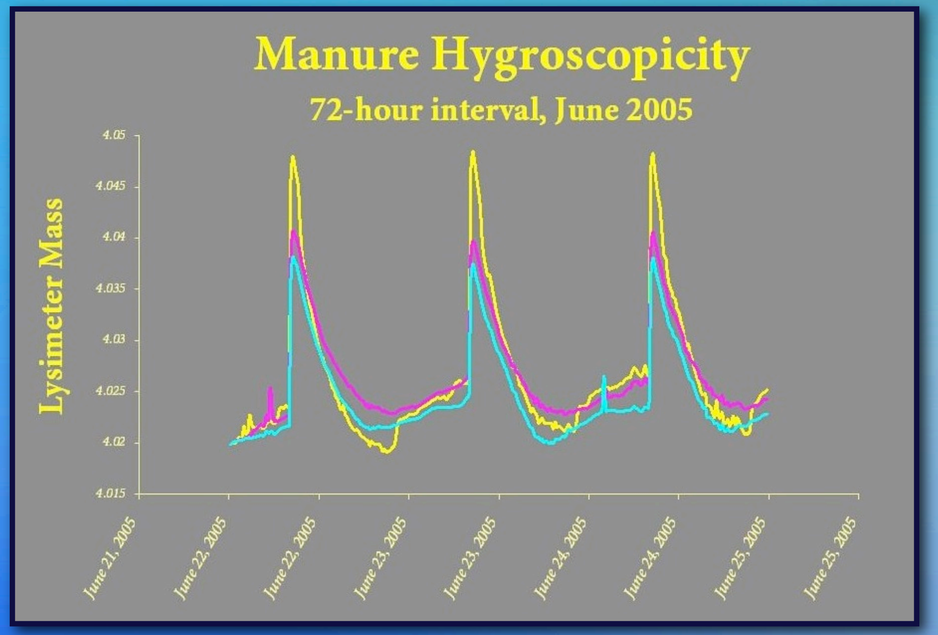
A Closer Look

- Panda Ethanol's MAFV is 2,758 BTU/lb
- The drier the manure, the more ash is permissible
- *Absolute* maximum ash content is 67% (0% moisture)
- *Practical* maximum ash content is 65% (7% moisture)



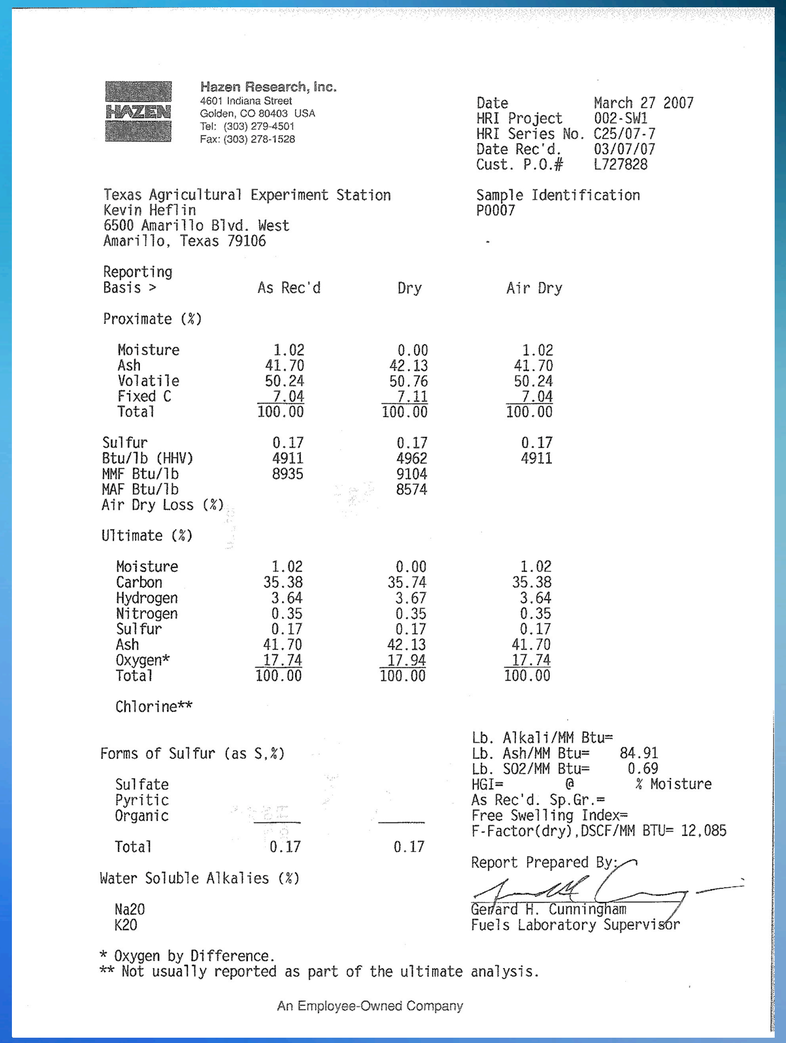
Note: Manure is *Hygroscopic*





Interpreting a Lab Report

- Major Components
  - Proximate analysis (Moisture, ash, volatiles, fixed C)
  - Ultimate analysis (Moisture, ash, C, H, N, S, O)
  - Heating values (HHV, MMF/DAF etc.)
  - Other useful information



HAZEN

Hazen Research, Inc.
4601 Indiana Street
Golden, CO 80403 USA
Tel: (303) 279-4501
Fax: (303) 278-1528

Date March 27 2007
HRI Project 002-SWI
HRI Series No. C25/07-7
Date Rec'd. 03/07/07
Cust. P.O.# L727828

Texas Agricultural Experiment Station
Kevin Heflin
6500 Amarillo Blvd. West
Amarillo, Texas 79106

Sample Identification
P0007

Reporting Basis >	As Rec'd	Dry	Air Dry
Proximate (%)			
Moisture	1.02	0.00	1.02
Ash	41.70	42.13	41.70
Volatile	50.24	50.76	50.24
Fixed C	7.04	7.11	7.04
Total	100.00	100.00	100.00
Sulfur	0.17	0.17	0.17
Btu/lb (HHV)	4911	4962	4911
MMF Btu/lb	8935	9104	
MAF Btu/lb		8574	
Air Dry Loss (%)			
Ultimate (%)			
Moisture	1.02	0.00	1.02
Carbon	35.38	35.74	35.38
Hydrogen	3.64	3.67	3.64
Nitrogen	0.35	0.35	0.35
Sulfur	0.17	0.17	0.17
Ash	41.70	42.13	41.70
Oxygen*	17.74	17.94	17.74
Total	100.00	100.00	100.00
Chlorine**			
Forms of Sulfur (as S,%)			
Sulfate			
Pyritic			
Organic			
Total	0.17	0.17	
Water Soluble Alkalies (%)			
Na2O			
K2O			

Lb. Alkali/MM Btu=
Lb. Ash/MM Btu= 84.91
Lb. SO2/MM Btu= 0.69
HGI= @ % Moisture
As Rec'd. Sp.Gr.=
Free Swelling Index=
F-Factor(dry),DSCF/MM BTU= 12,085

Report Prepared By:

Gerard H. Cunningham
Fuels Laboratory Supervisor

* Oxygen by Difference.
** Not usually reported as part of the ultimate analysis.

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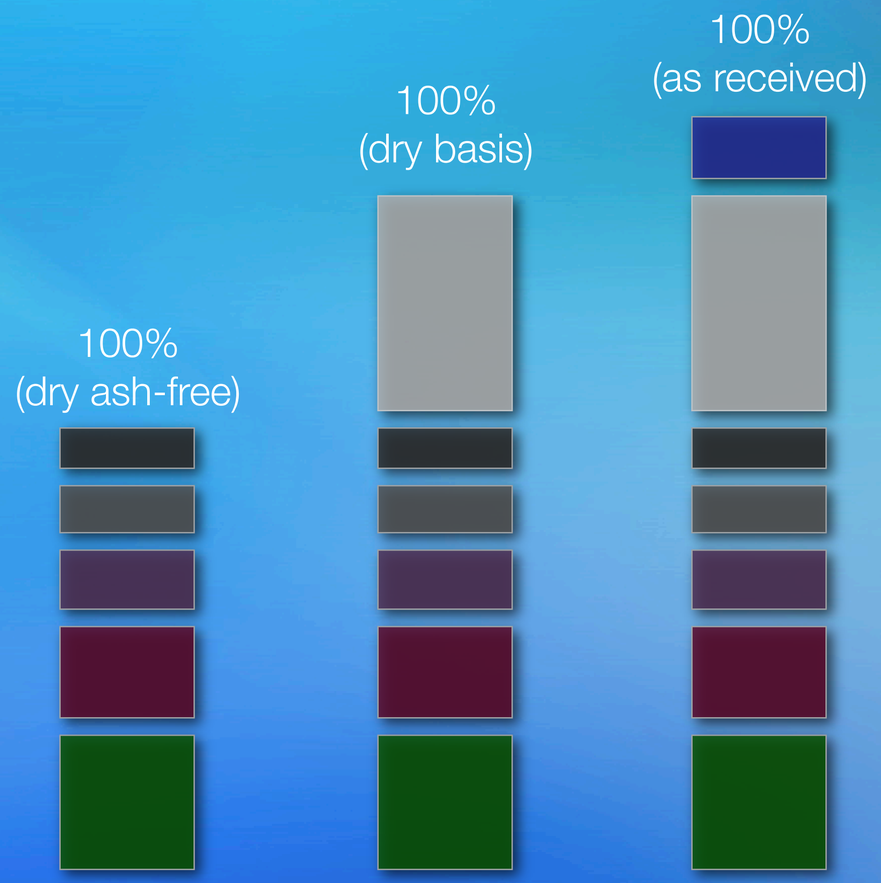
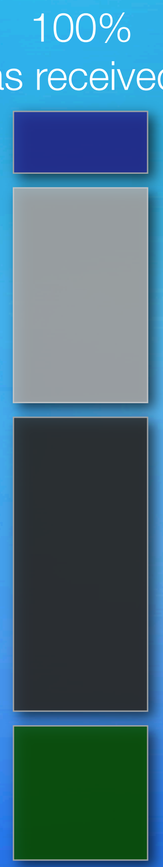
Reporting Basis

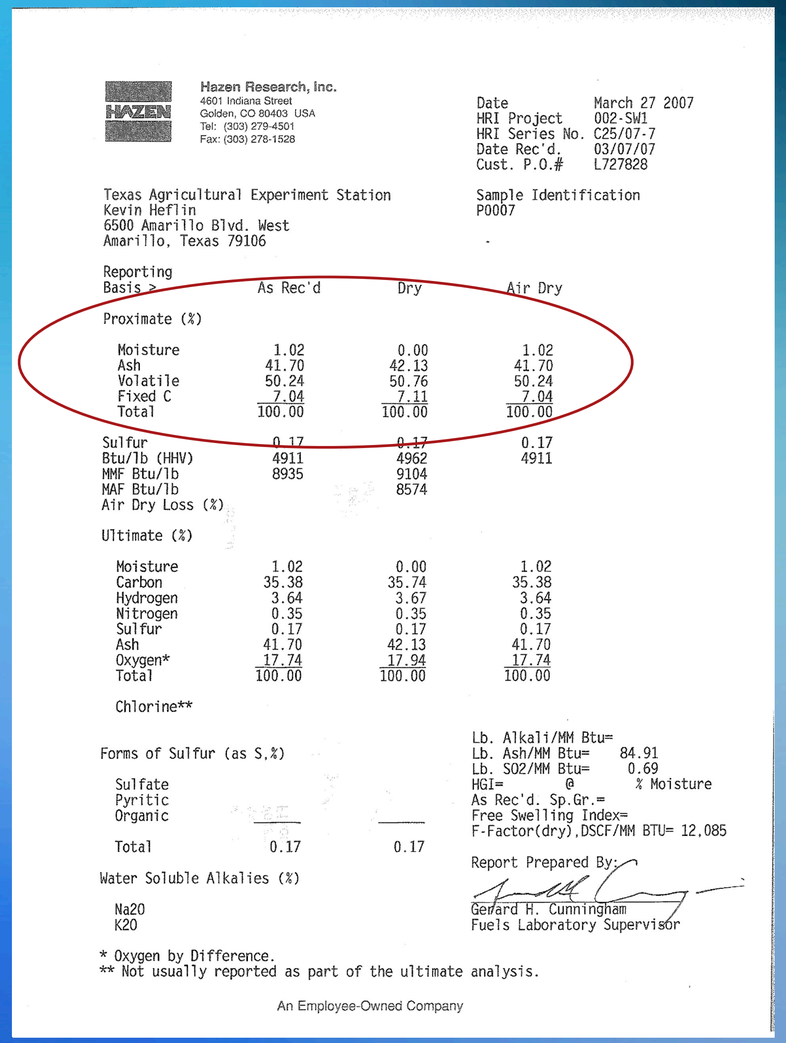
- “As received” = “wet basis”
- “Dry basis” = “moisture free”
- “Dry, ash-free” (DAF) = MMF



Proximate Analysis

- Moisture
  - Oven drying
- Ash
  - Ashing furnace (600° C)
- Volatile Matter
  - 100% - (Ash + Fixed C)
- Fixed Carbon





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Ultimate Analysis

- Moisture
- Ash
- Carbon
- Hydrogen
- Nitrogen
- Sulfur
- Oxygen

100%
(as received)

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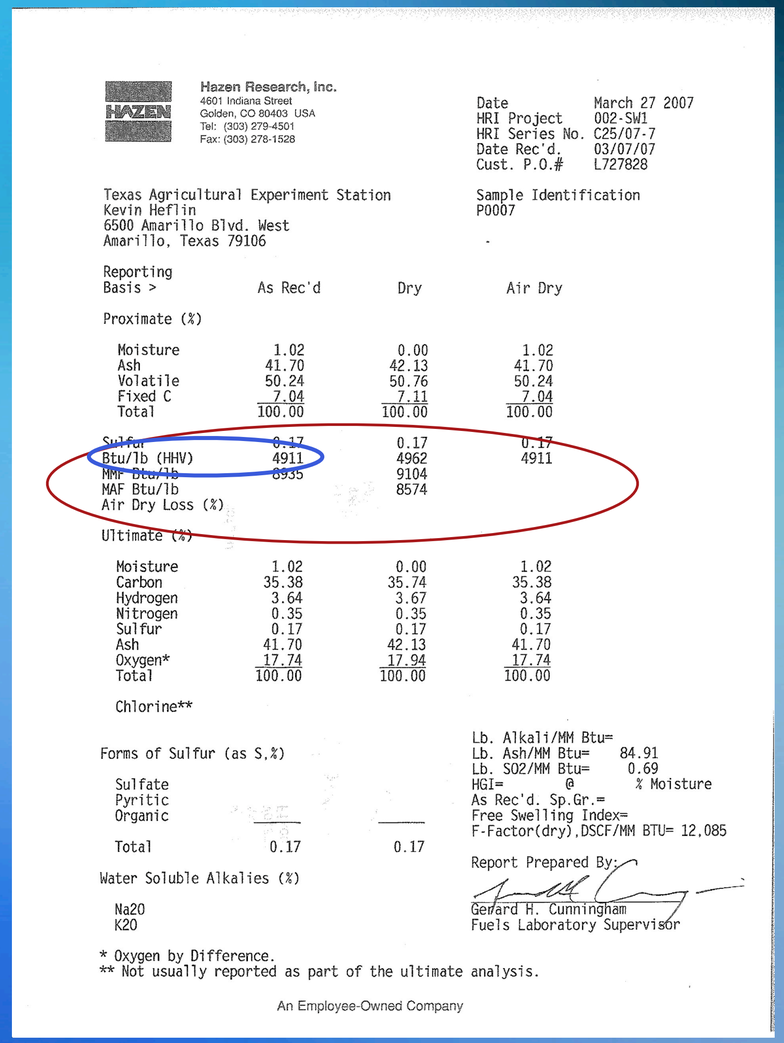
Heating Values

- Bomb calorimetry
  - HHV = *gross* calorimetric value (w/condenser recovery)
  - LHV = *net* calorimetric value (no condenser recovery)
  - “As Rec’d” column gives heating value for comparison with Minimum Acceptable Heating Value (MAHV) of 2,758 BTU/lb



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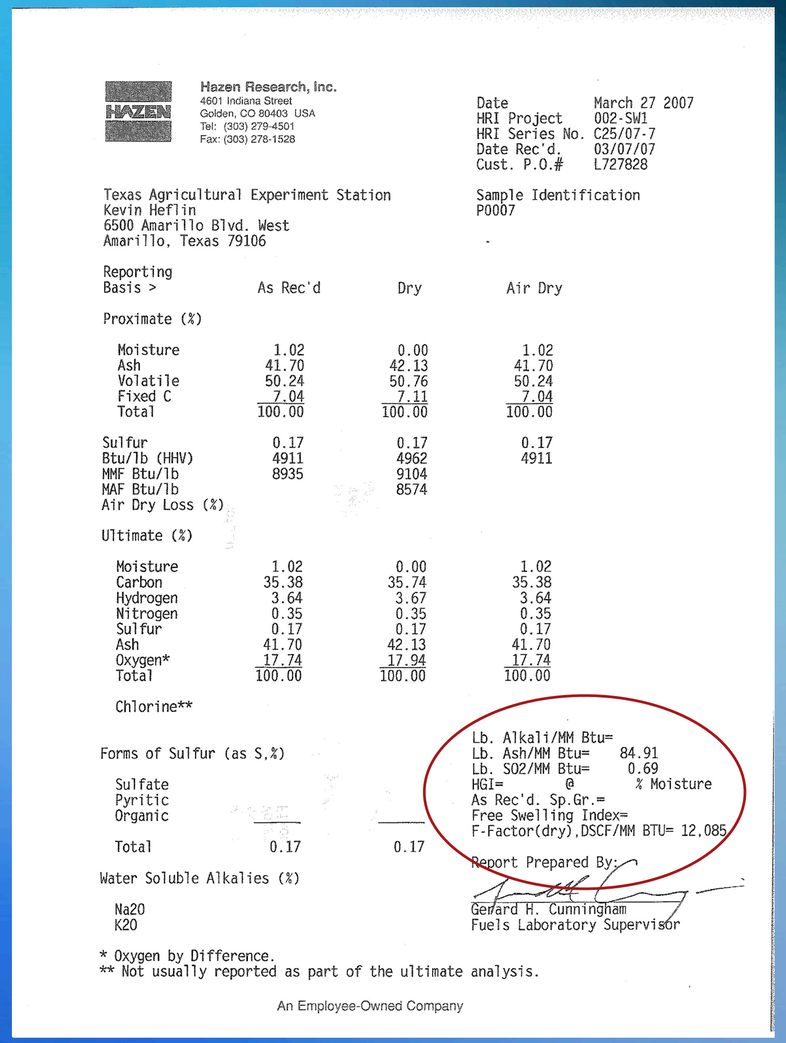
Other Useful Information

- Waste yield per unit energy yield
- Slagging, corrosivity, ash, air pollutants
- Helpful in projecting pollution-control requirements for a given power output



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