Combustion Technologies: Scale and End Products

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For: Innovative Environmental Technologies Symposium

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Drivers

- Regional P surpluses—need for practical alternatives to local land application of poultry litter
- High fossil fuel prices
- Increasing pressure to reduce greenhouse gas emissions

Fuel Property Challenges: Operational

	Green Sawdust	Poultry Litter
Moisture, %	52.6	27.4
Ash, %	2.0	15.7
HHV, Btu/lb	4,150	4,637
HHV (dry), Btu/lb	8,760	6,394
K_2O in ash, %	**5.8**	**16.3**
Na_2O in ash, %	**1.7**	**9.2**
lb alkali/MBtu (slagging and fouling)	**0.35**	**9.3**
Chloride, % (corrosion)	**--**	**0.7**

Fuel Property Challenges: Environmental

	Green Sawdust	Poultry Litter
	%	
Nitrogen	0.22	2.7
Sulfur	0.02	0.3
Chloride	---	0.7
Ash	2.0	15.7

Minimal Products of Incomplete Combustion Also Required

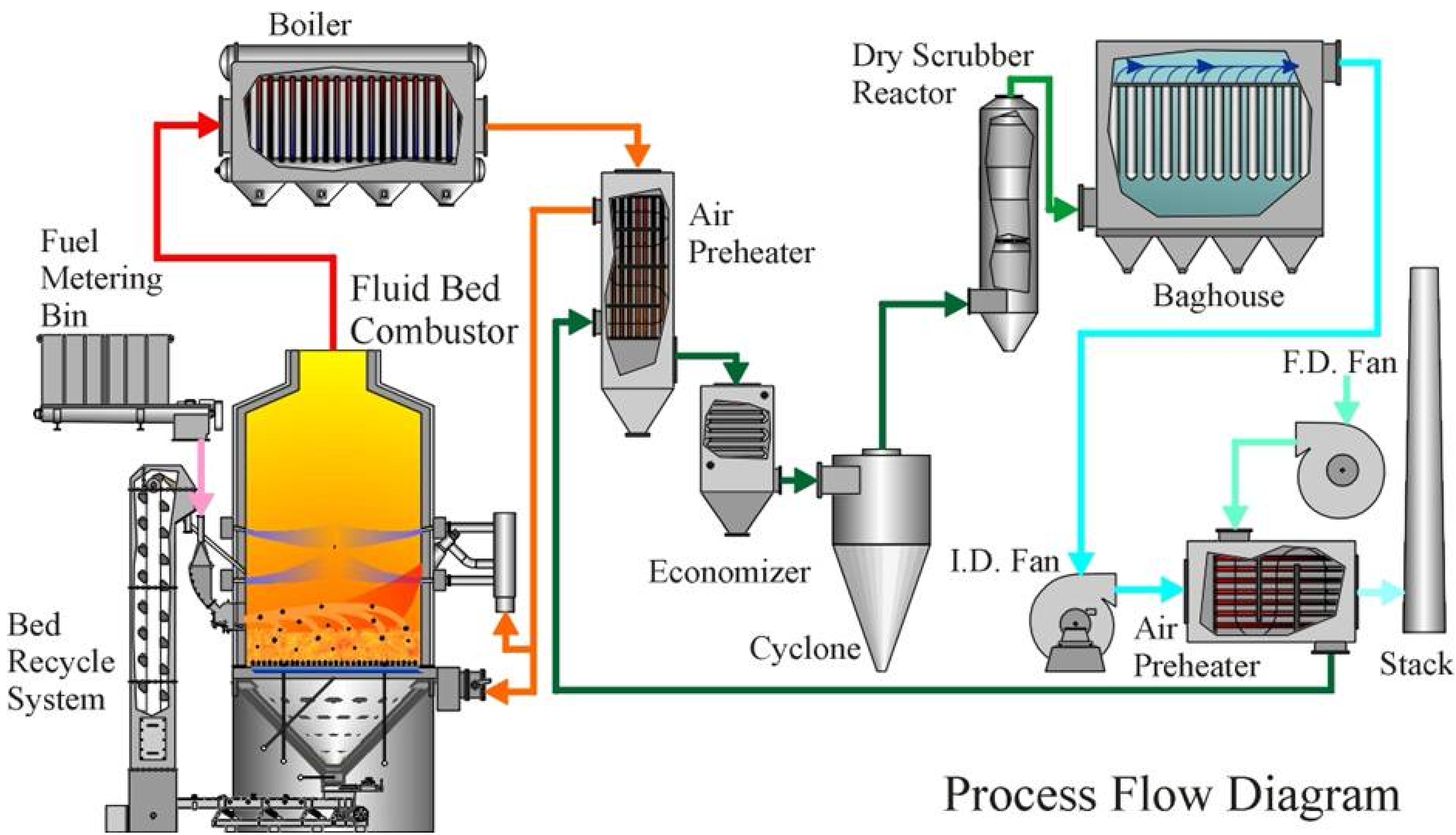
- Carbon monoxide
- Volatile organic compounds
- PCB’s, dioxins, furans, etc.

15 Day 24/7 Pilot Scale Test: Summary Energy Products of Idaho (EPI)

- No material handling problems
- Slagging and fouling controlled by maintaining combustion temperatures within narrow limits
- Atmospheric emissions controlled below permitable limits via ameliorating fuel properties and operational procedures
- Summary of results at: http://www.fppcinc.org/pdf/capefear.pdf
- Earlier EPI test results: http://www.brbock.com/FluidBedSolutions.pdf

EPI Pilot Plant

Poultry Litter Feeder



Courtesy of Energy Products of Idaho

SO_X Emission Control

--Fuel Ca forms $CaSO_4$ deposited with ash

--Added lime ($CaCO_3$), if required

Prevention of Ash Fusion due to K, Na, Cl

--Uniform air & fuel dist.

--Low temperatures

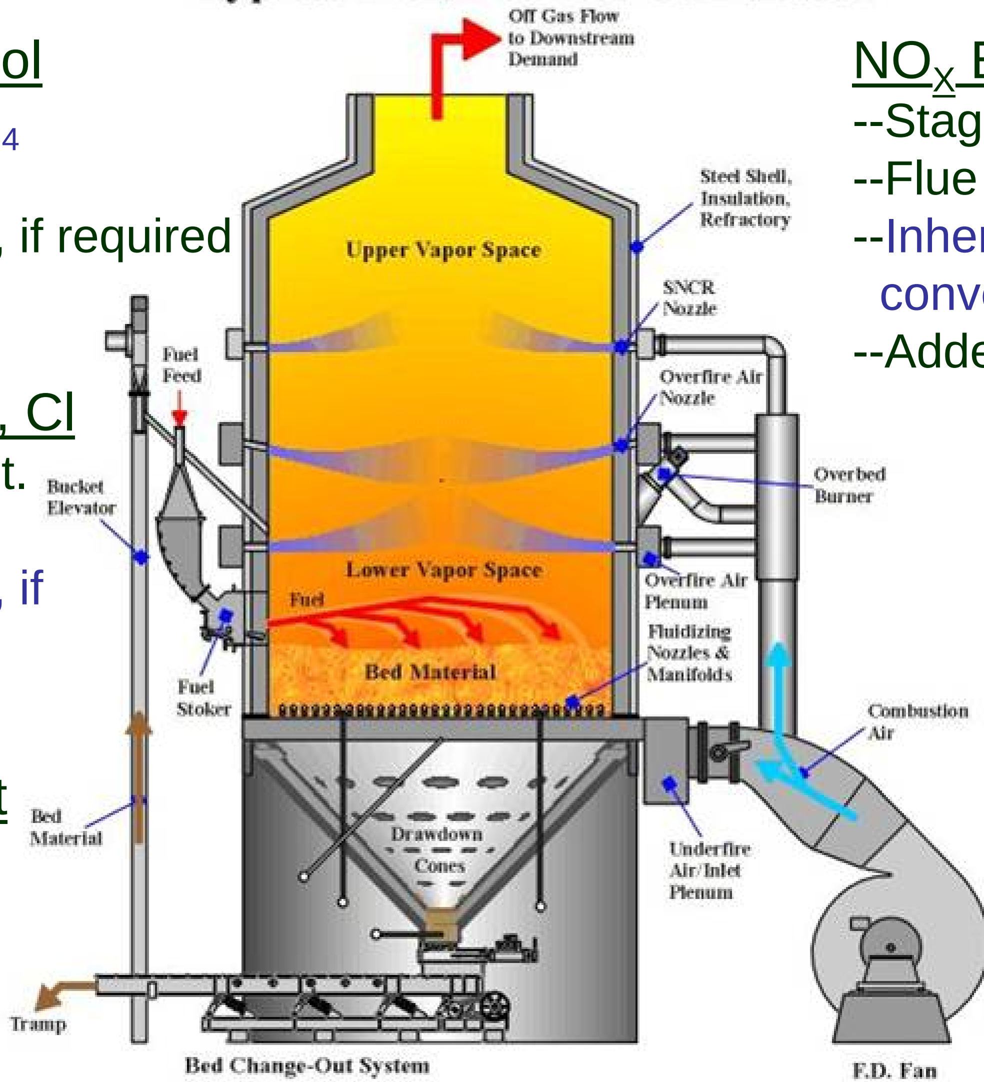
--Added lime ($CaCO_3$), if required

Complete C Burnout

--Bed mixing and fuel/ash abrasion

--Excess air vs. starved air for gasification

Typical Fluidized Bed Combustor



NO_X Emission Control

--Staged combustion

--Flue gas recirculation

--Inherent fuel NH_3 converts NO_X to N_2

--Added NH_3, if required

Courtesy of Energy Products of Idaho

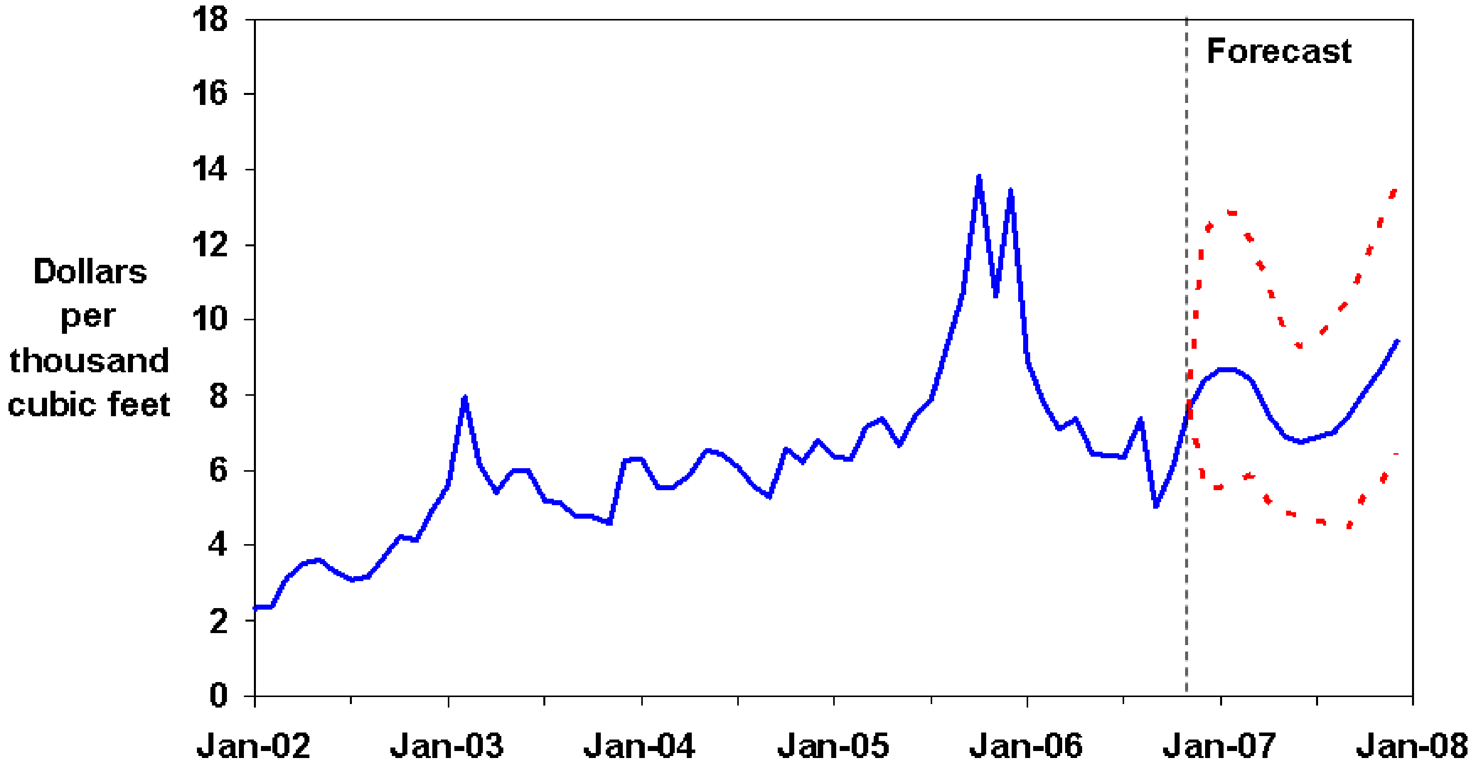
Industrial Scale

- Advantages
  - Large economies of scale
  - Practical for continuous operator involvement
  - High utilization of equipment
  - Process heat--displacing high-priced natural gas (but need process energy host)
- Disadvantages
  - Significant poultry litter transportation costs
  - Intermediate poultry litter storage costs in some cases
  - High construction costs if not modular design
  - More stringent limits on atmospheric emissions
  - Generally low price for electricity sold to grid (utilities)

Fibrominn Poultry Litter Plant

- Based on UK experience (3 similar plants)
- 55 MW
- 500,000 tons poultry litter/year +200,000 tons supplemental wood
- 21 year contract at 8.6¢/kWh
- High contract price from Xcel Energy as part deal allowing burial of nuclear waste in western part of state

Natural Gas Henry Hub Spot Prices
(Base Case and 95% Confidence Interval*)



*The confidence intervals show +/- 2 standard errors based on the properties of the model.

Short-Term Energy Outlook, December 2006

www.eia.doe.gov

Comparison of Electric Power and Steam Revenues in Units of $/ton Poultry Litter Feedstock

Electric Power		Process Steam		
Electric Revenue Equivalents		Steam Revenue Equivalents		Equivalent Natural Gas Price
$/MWh	$/ton Poultry Litter[1]	$/1,000 lb Steam	$/ton Poultry Litter[2]	$/MBtu[3]
20.00	12.00	4.00	27.00	3.40
30.00	18.00	5.00	33.75	4.25
40.00	24.00	6.00	40.50	5.10
50.00	30.00	7.00	47.25	5.95
60.00	36.00	8.00	54.00	6.80
70.00	42.00	9.00	60.75	7.65
80.00	48.00	10.00	67.50	8.50

[1]Assumes 9 MBtu/ton poultry litter and 15 MBtu poultry litter/MWh

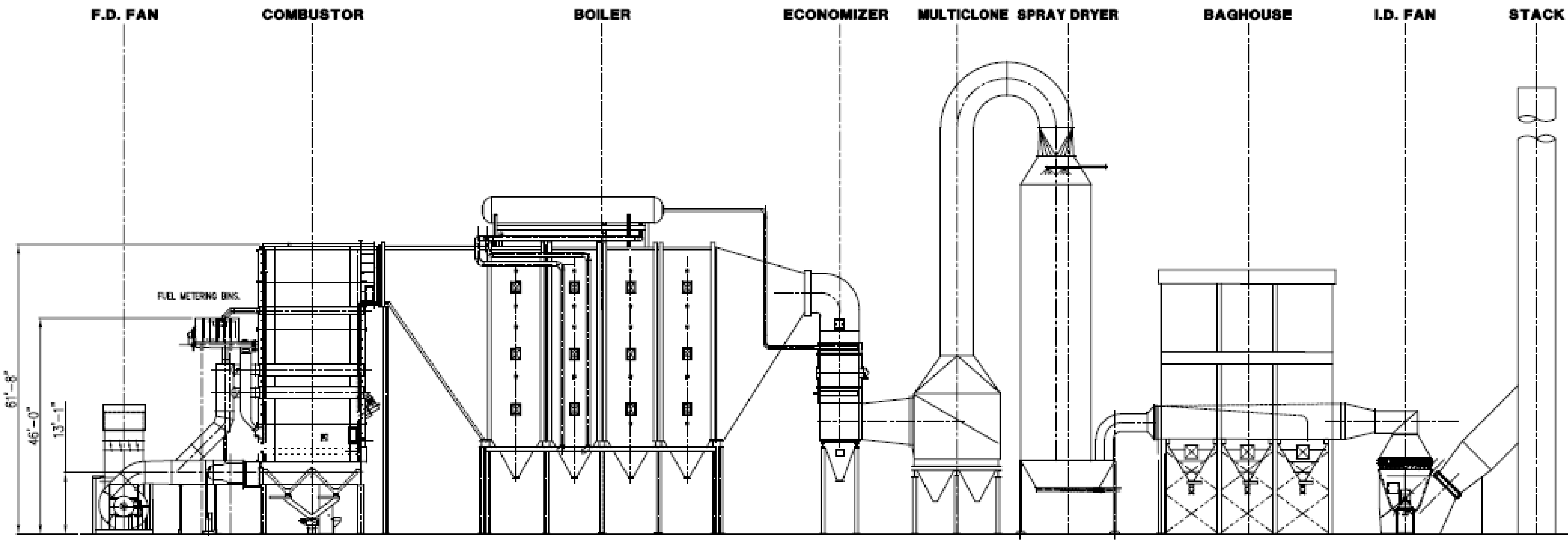
[2]Assumes 1 lb steam/1,000 Btu, 0.75 Btu steam/Btu poultry litter, and 9 MBtu/ton poultry litter

[3]Assumes 1 lb steam/1,000 Btu and 0.85 Btu steam/Btu natural gas

Poultry Litter Process Heat for an Ethanol Plant—North Alabama

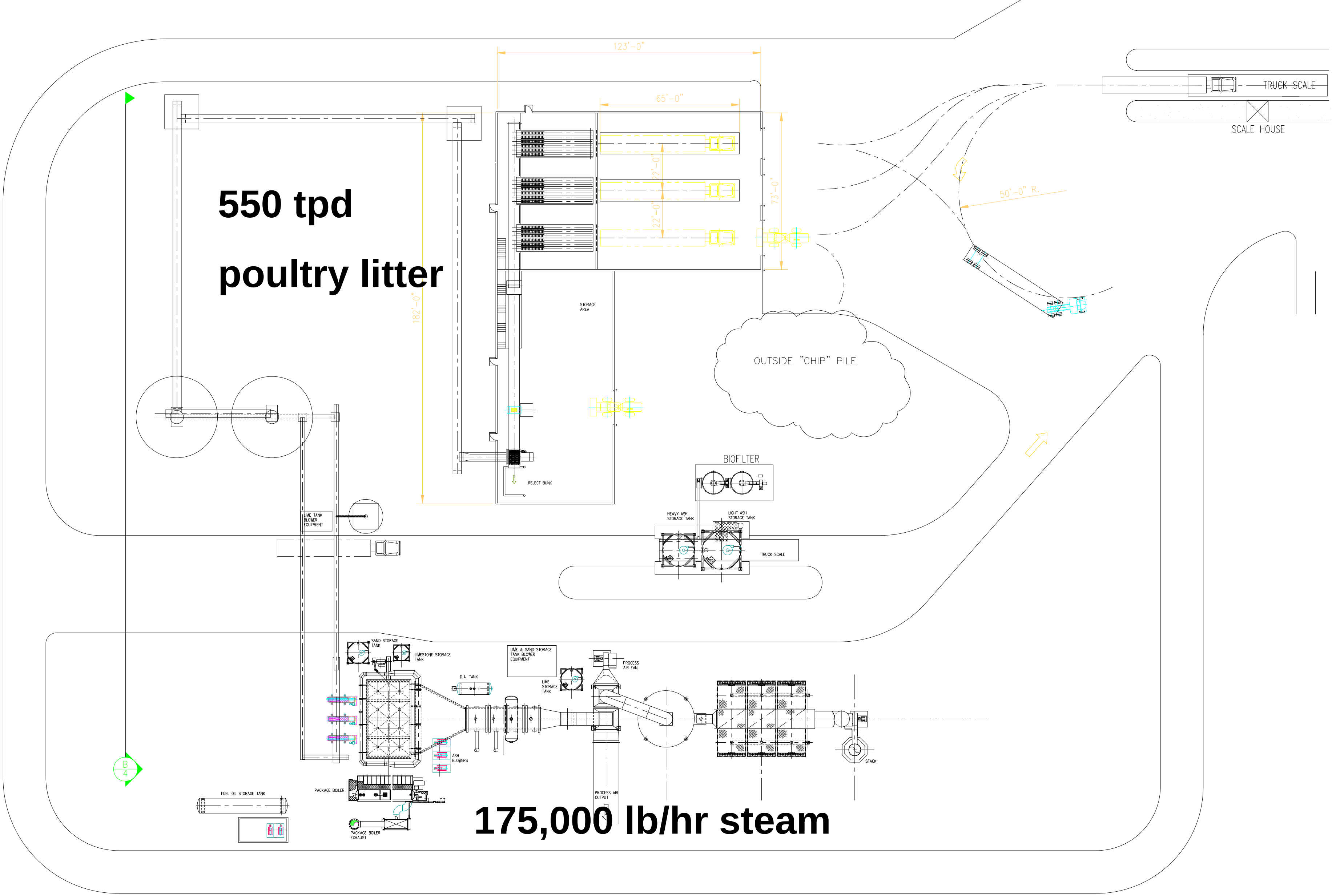
- Nominal 50 million gallons/year ethanol plant
- Displace natural gas—170,000 lb steam/hour
- 195,000 tons poultry litter/year
- 24/7 operation
- Integration synergies
- Litter in exchange for cleanout and transportation
- Feasibility Study—very favorable economics based on projected avoided natural gas costs: http://www.brbock.com/RefFiles/IPEP_68_3A75_3_144s.pdf

Poultry litter combustor for 50 mgy Dry Mill—175,000 lb process steam/hr



Miles and Bock (2006)

EPI System at Goldfield, IA



Miles and Bock (2006)

Integration Synergies

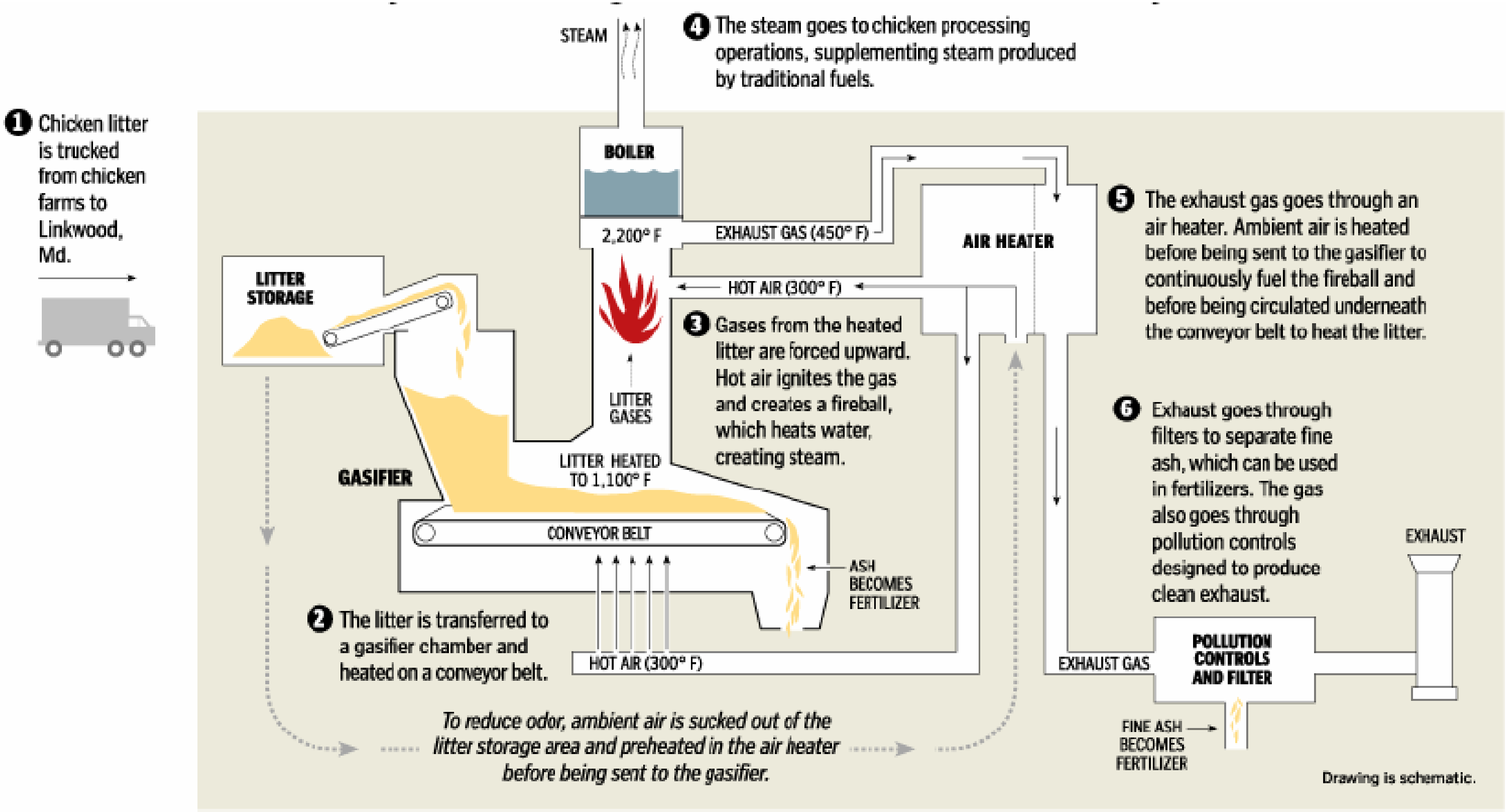
Process Heat from Beef Feedlot Manure

- Panda Ethanol at Hereford, TX
- 100 million gallons ethanol/year
- EPI fluidized bed combustion technology
- Design based on pilot tests at EPI facility
- 500,000 tons/year beef feedlot manure
- Fuel property challenges greater than for poultry litter
  - High alkali and chloride
  - Higher ash
  - Lower heating value

REM Engineering/Allen Family Foods/ JCR Enterprises Rendering Plant Project

- Demonstration project
- Supplying 15% of steam requirement for rendering plant
- 10,000 lb steam/hour
- 14,000 tons poultry litter per year
- 24/7 (whole plant 5 1/2 days/week)
- Modular design
- State approval to construct
- Technicality with local permit
- Future projects: (10 to 60 MBtu/hour modules)

REM Engineering System Schematic



Coaltec Modular Approach

BR Bock Consulting, Inc.

Waste, Energy and Nutrient Solutions for a Better Tomorrow

Coaltec Modular Approach

Coaltec Test Results with Turkey Litter

- Good operational and emission results
- Feasibility and design study for feed mill: http://www.xcelenergy.com/docs/corpcomm/RDFCyc2RptCoaltecWMITurkeyRpt3.pdf

Poultry Litter Ash

Nutrients of Primary Value

Nutrient	PL Ash	DCP
Fertilizers		
Total P_2O_5, %	24.4	
Total K_2O, %	16.3	
Mineral Feed Supplements		
Total P, %	10.7	18.5
Total Ca, %	12.4	24.1

Ash Value and Cost Factors

Value Factors	**Fertilizers**	**P Feed Supp.**
% of P credited		
w/o further processing	50-70	100
w/ further processing	90-100	N/A
% of K credited	95-100	0
Value-add for low F	no	yes
Cost Factors		
Granulation required	yes	no
Transportation	Med to High	Low

Fertilizer Granules Containing PL Ash

Poultry Litter Ash Performed the Same as Dicalcium Phosphate as a P and Ca Supplement for Broilers

Two Auburn University Studies

http://www.brbock.com/RefFiles/Blake_AshreviewUSDA.pdf

Logistics of Year-Round Poultry Litter Supplies

- Biosecurity
- Staggered year-round cleanout

  vs.
- Spring and fall cleanout with intermediate storage
- Cake vs. cleanout from whole house
- Cleanout frequency
- Litter amendments
- Type of operation: broiler, pullet, breeder, layer

Poultry Litter Supply Business Models

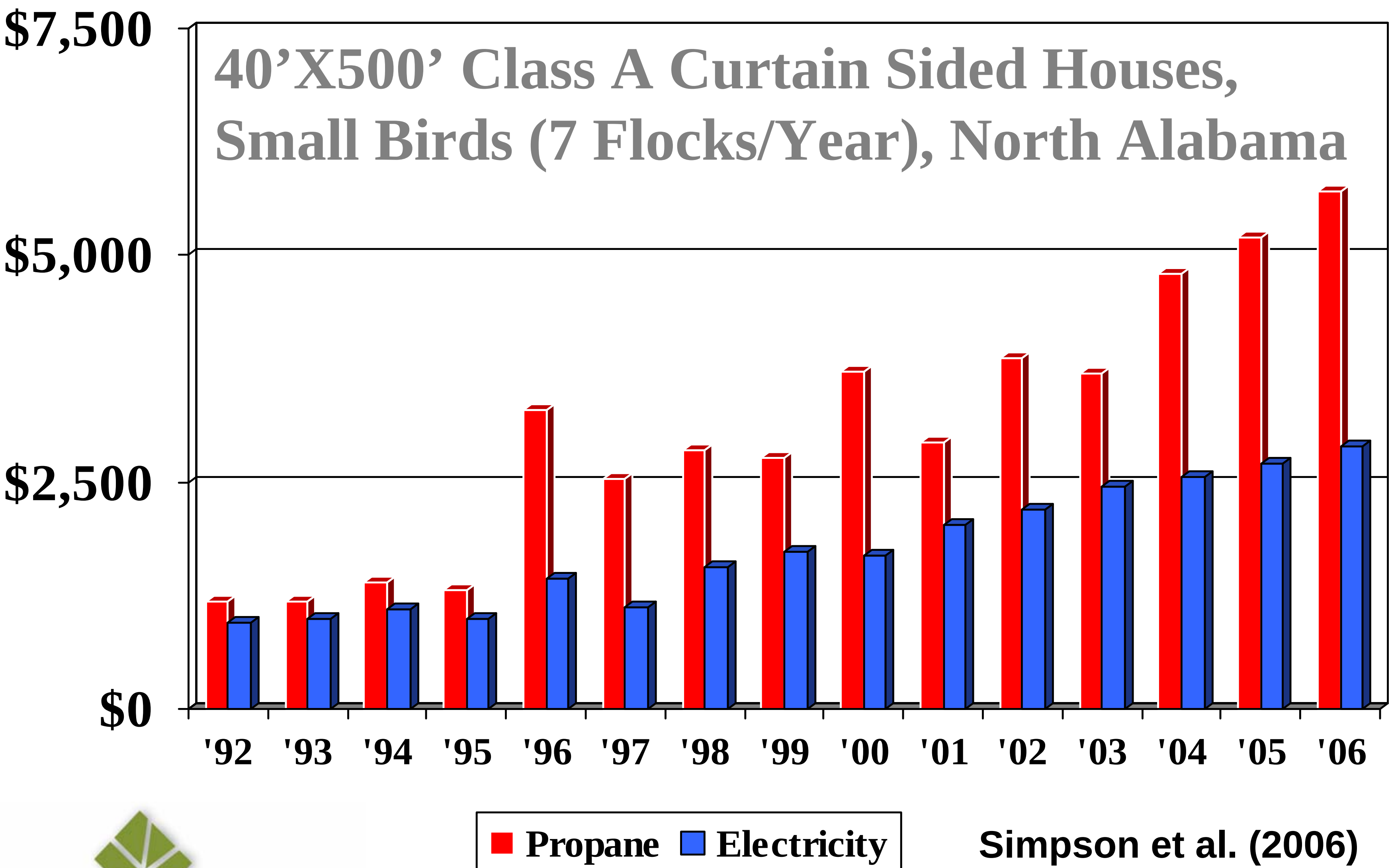
- Contract vendors
  - Larger trucks
  - Year-round operation, possibly 24/7
  - No land-spreading time
  - Simpler nutrient management compliance: records, etc.

    vs.
  - Longer haul
- Supply Coop
  - Separate ownership from energy facility
  - Co-owner of energy facility

Farm Scale

- Advantages
  - No poultry litter transportation costs
  - Ample litter/house for heating
  - Modular design: shop fabrication vs. on-site construction
  - Displacing propane (higher price) vs. natural gas
  - “Dry heat” for poultry house heating
  - Better heat distribution via distribution tube
- Disadvantages
  - Requires on-farm litter storage
  - Small economies of scale
  - Low utilization of equipment
  - May require more operator involvement than practical

Per House Energy Costs -15 Years



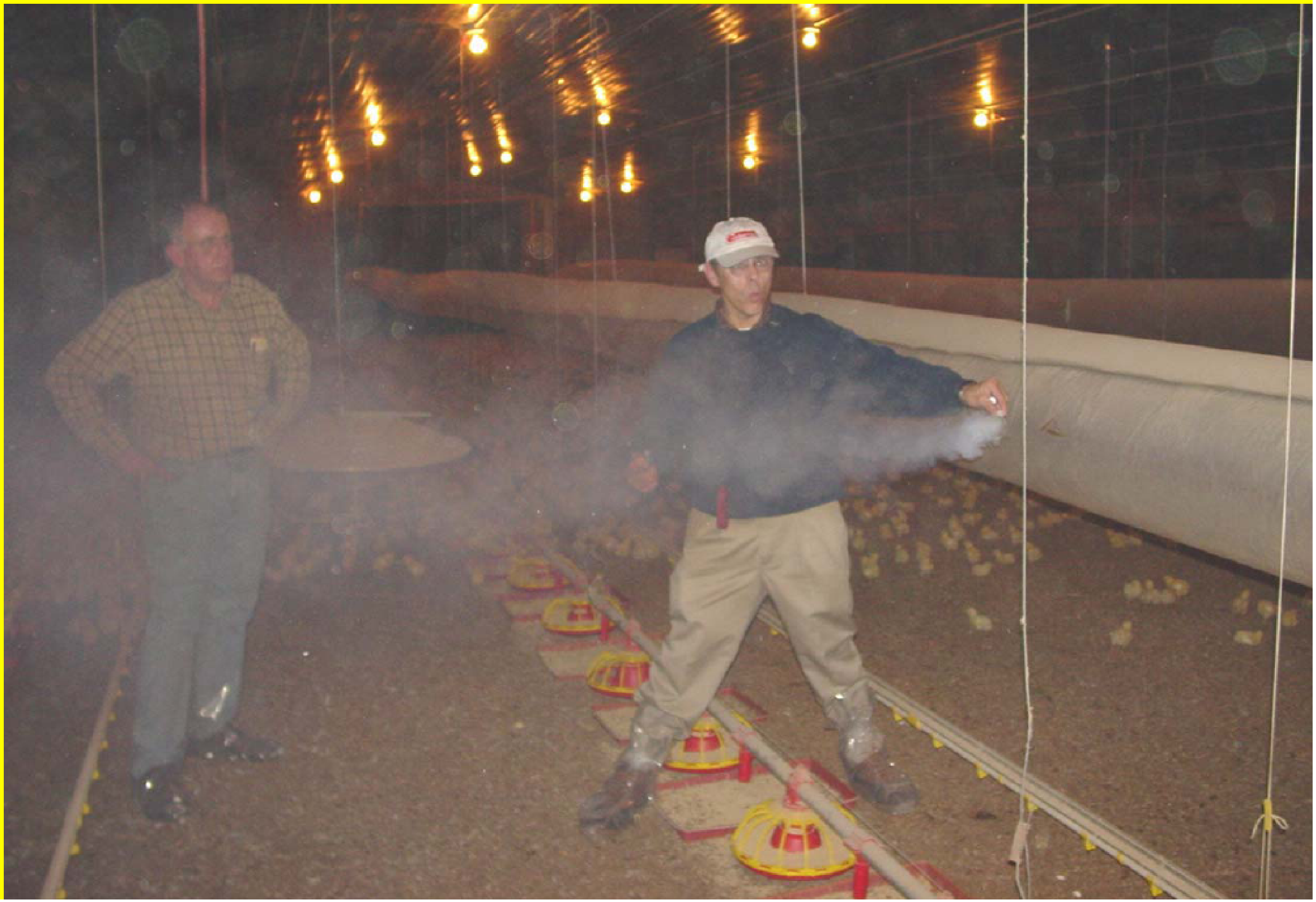
Simpson et al. (2006)

Farm-Scale Module for Josh Frye Demo.

Lynndale Farm-Scale Combustor: U of Arkansas

Loading Automated Lynndale Feeder

Heat Distribution Tube



Conclusions

- Poultry litter has challenging fuel combustion properties that can be managed with careful system design and operating procedures for
  - Efficient and economical operation
  - Low emissions within permitted limits
- Industrial-scale poultry litter combustion projects are being built
- Generally is more economical to provide process heat than electricity
- Ash value is an important economic component
- Farm-scale systems are under development and hold promise for heating poultry houses

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