Making an Agricultural Waste-to-Energy Facility Work on a South Carolina Swine Farm

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Burrows Hall Bioenergy Project

Agenda

- The Project
- The Challenges
- Waste-to-Energy: Basics, Anaerobic Digestion, & Biogas
- Practical Considerations
- Our System
- Lessons Learned

Burrows Hall Bioenergy Project

Funded by a grant from the South Carolina Department of Agriculture and administered by the South Carolina Energy Office.

The Partners:

- Farmer
- Santee Cooper (South Carolina's state-owned electric and water utility)
- SCIES (South Carolina Institute for Energy Studies)
- System Builder

The Challenges

- Over 2,000 anaerobic digester (AD) systems on farms in Europe[1]
- 1500 in Germany[2]
- Advanced technologies in Europe
- 151 digester systems at commercial livestock facilities in US[3]
- None in SC
- None successful in NC & GA (despite a NC mandate that 0.07 percent of electric sales come from swine waste by 2012.)
- Relatively Small generation potential (100s of kW vs. MWs)
- Low cost of electricity in the Southeast

[1]Preusser, Steffen. 2006. Biogas Polities and Technologies in Germany. Agricultural Waste to Energy Workshop. Abbotsford, British Columbia, July 19.
[2]BBI International, Lakewood, Colorado
[3]AgStar, 2010

Waste-to-Energy

- Agricultural Waste – manure
- Agricultural Waste – crop residue
- Food Processing – rendering, preparation, fruit & vegetable
- Municipal Wastewater
- Industrial Waste
- Municipal Solid Waste (Landfill gas)
- Biomass – other
- ❖ Energy Crops

Energy Conversion Options

- Direct Combustion
- Gasification
- Anaerobic Digestion

Anaerobic Digestion

anaerobic decomposition: decomposition of organic matter by bacteria in the absence of oxygen

organic molecules:

- carbohydrates
- proteins
- amino acids
- lipids

$$C, H, N, O, S, P \xrightarrow[\text{no } O_2]{\text{anaerobic bacteria}} CH_4, CO_2\ NH_3, NH_4^+, H_2S, HPO_4^{2-}, H_2PO_4^-$$

- multi-step process

Biogas

- 60 – 65% CH_4 (methane)
- 35 – 40% CO_2
- H_2S
- other
- flammable as-is

- Burn biogas as source of heat.
- Clean biogas for sale as natural gas.
- Burn in an engine for mechanical/electrical energy.
  - internal combustion engine or turbine [1]
- CHP = Combined Heat & Power
- Burn ("flare") to convert CH_4 to CO_2 [2]

[1] or Fuel Cell

[2] CH_4 21x more potent than CO_2 as GHG

Anaerobic Digestion

- Total Solids (T.S.)
- Volatile Solids (V.S.)
- COD
- "organic load"
- Hydraulic Retention Time (HRT)

assumptions:

- 50% conversion of C to CH_4
- gas turbine: 25% efficiency
- gas engine: 30 – 40% efficiency
- AD-turbine: 1,285 BTU/lb VS
- AD-engine: 2,056 BTU/lb VS

Example Energy Estimate

example: Swine

- TS = 6.34 lb/d/1000# (1000# = 1 A.U.)
- VS = 5.40 lb/d/1000#
- 10,000 animals
- average animal wt = 150 lb

- 5.40 lb/d/1000# x 10,000 animals x 150 lb/animal x 1 A.U./1000# = **8,100 lb VS/day**
- 8,100 lb VS/day x 0.6020 kW·h/lb VS → **203 kW**

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Agricultural Waste: Practical Considerations

- CAFO = Concentrated Animal Feeding Operation
- Free-range
- Type of animal
- Manure handling, management, water management
- % solids
- Bedding materials


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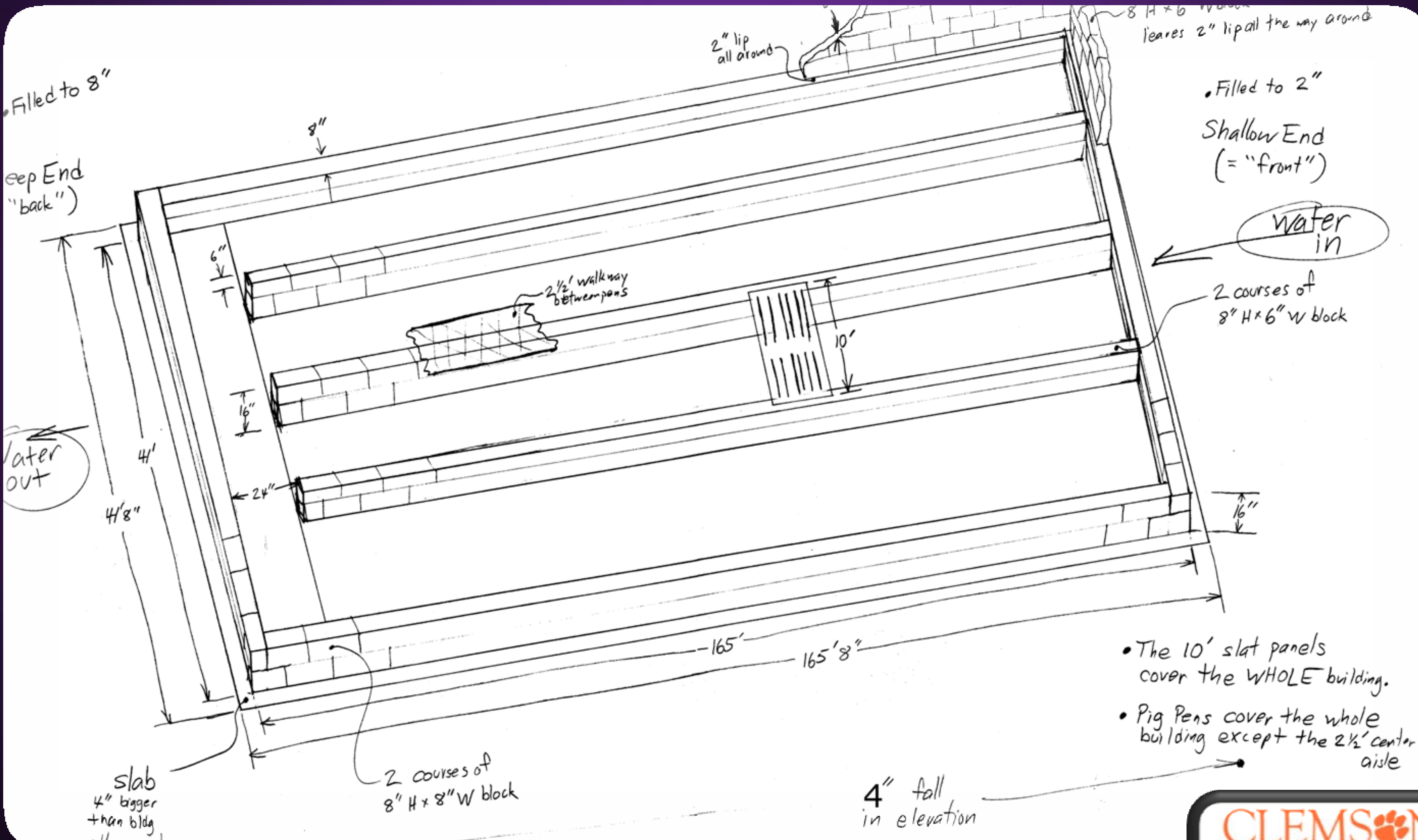


2" lip all around
leaves 2" lip all the way around
Filled to 8"
eep End ("back")
8"
Filled to 2"
Shallow End (= "front")
water in
6"
2½' walkway between pens
10'
2 courses of 8" H x 6" W block
16"
Water out
4'
4'8"
24"
16"
165'
165'8"
The 10' slat panels cover the WHOLE building.
Pig Pens cover the whole building except the 2½' center aisle
slab 4" bigger than bldg all around
2 courses of 8" H x 8" W block
4" fall in elevation

AD Systems: Practical Considerations

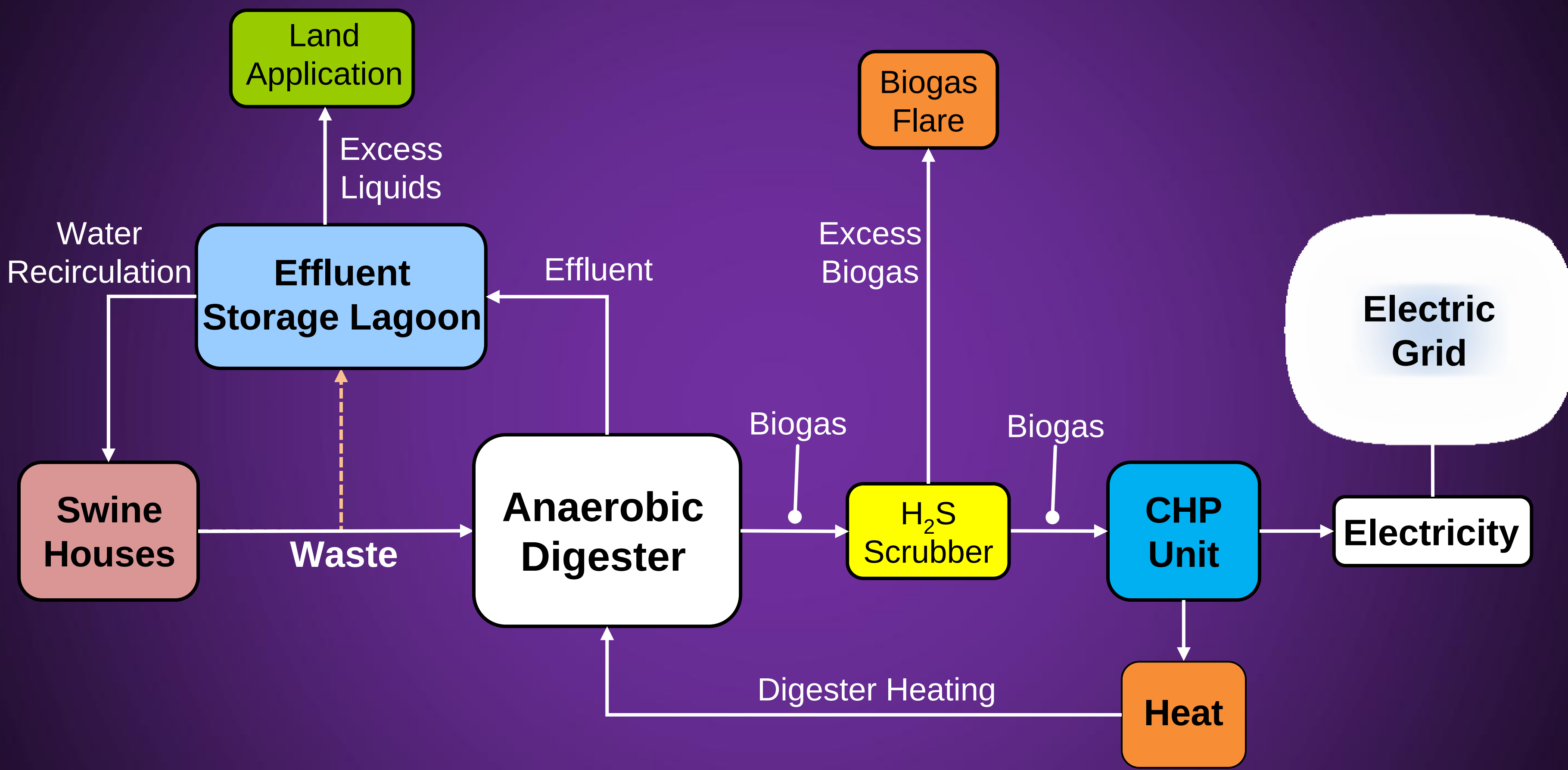
- Batch
- Continuous
- Complete Mix
- Plug Flow
- Fixed Film

- Tanks
- Lagoons

- Temperatures:
  - < 30ºC (psychrophilic) (<86ºF)
  - 30 – 40ºC (mesophilic) (86-104ºF)
  - 40 – 55ºC (thermophilic) (104-131ºF)

Anaerobic Digester

- New lagoon
- Lined, covered, insulated
- Mixed
- Heated to 95^{o}F (mesophilic)
- Gas collection
- Rain water collection
- > 20 year life



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System Site
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Digester Construction

Photo: Environmental Fabrics, Inc.

Digester Construction

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Digester Construction

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Example Digester Construction

Power Generation – Piston Engine

- 4-stroke industrial engine
- Complete generation and CHP system
- 38% efficiency
- Optimized for biogas

Economics

- Sale of Electricity
- Carbon Credits
- Renewable Energy Certificates
- Renewable Energy Production Incentives
- Renewable Energy Production Tax Credits
- Sale of Byproducts?
- Also consider “behind the meter” options.

Lessons Learned

- Chose simple, proven technologies
- Reciprocating engine vs. turbine (+ gas conditioning) vs. fuel cell
- Sale of power
- Agreements
- Permits
- Co-digestion could increase production.

Sale of Power

- **Good PPA a necessity!**
- Example: AD system in another state
- Example: a co-op's position on small renewables
- Example: a large utility's position on small renewables
- No net metering, no RPS in South Carolina.

Business Agreements

- Power Purchase Agreement (PPA)
- Waste Stream/Lease Agreement
- Interconnection Agreement

Permits

- SC DHEC Agricultural Permit
- SC DHEC Air Quality Permit
- County Building Permits

➢ No increase in hog operation
➢ No change in water discharge

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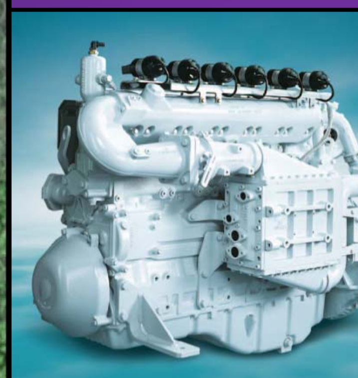
South Carolina's first Agricultural Waste-to-Energy Project

- on-line June 2011



- 180 kW

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