Anaerobic Digester Workshop

Colorado Governor's Office of Energy Management and Conservation (OEMC)

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Anaerobic Digesters (AD), In General

- Have been around for at least a thousand years – millions currently in existence around the world
- Exist in large numbers at US municipal wastewater plants, some food waste plants and on a small number of US farms and agricultural operations
- Come in many shapes, sizes and level of technology
- Must be correctly sized for operation, or built to be modular
- BTU values, on average, vary from 500 to 750 (50% to 75% of gas), depending on design, efficiencies, amount of water in mixture, temperature of mixture, hydraulic retention time (HRT), operator and maintenance attention
- Can utilize “super bugs” to increase gas production and reduce odors and some animal illnesses
- Extract differing percentages of gas (methane) depending on HRT and AD type

Anaerobic Digesters (AD), In General (cont'd)

- Produce reliable electricity; capable of offsetting one-third to all of a farm's electricity – depending on farm's general energy efficiency and design of digester
- Can utilize other waste streams in combo with manure for greater gas production
- Require relatively little time to operate and maintain; so long as all equipment and processes are understood and judiciously attended to on a scheduled or as-needed basis
- Must take a backseat to primary purpose of farm or have a power producer contract with an independent party
- Reduce solids by 65% and up
- Reduce volatile acids by 90%
- Destroy 99+% of pathogens

Anaerobic Digesters (AD), In General (cont'd)

- Destroy H2S as it passes through combustion chamber
- Provide an approved method to meet Colorado Amendment 14
- Can, depending on methods of design, fully eliminate air and water concerns, as well as all off-site discharges
- Can be coupled with dryers or other moisture extractors to provide recycled water for flushings or to minimize or eliminate site discharge
- Require much smaller lagoons, or no lagoon, and therefore reduce initial farm costs
- Provide digested sludge for making compost or using as a safer material for field application - compost can lock up heavy metals, provide improved plant uptake of nutrients and greatly reduce runoff of nutrients

Anaerobic Digesters (AD), In General (Cont'd)

- Can provide heat, beyond that needed for heating digester, for space or process heating
- Incorporate scrubbers for greatly reducing or eliminating compounds, particularly sulfur at hog farms, to reduce odors and mitigate animal digestion problems and corrosion within the digester engines and plumbing
- Cost to build AD varies greatly across operations, depends on number and type of animals - ~$1.40 to $8/Watt - and on how much technology is involved

AD engines for power production

- <u>Micro Turbines, in general:</u>
  - Have lower emissions than most generation devices
  - Are very reliable
  - Have very few moving parts
  - Are easy to operate and maintain
  - Have only three major manufacturers; only two produce biogas models
  - Are very close in cost to internal combustion, reciprocating engines
  - Are easily damaged if water or corrosive material reaches combustion area
  - Require necessary, add-on equipment that can be costly, depending on application
  - Are not yet very widespread, about 3,000 in field, so quick turnaround repairs can be a problem – remote locations can be a particular problem

AD engines for power production (Cont'd)

- <u>Single MT application drawbacks (applies to 30 kW Capstone)</u>
  - Add-on equipment costs are too high
  - Engineering costs can be too high
  - By itself, a single unit yields too little output for most uses
  - Increases in altitude and heat decreases power output

AD engines for power production (Cont'd)

- <u>Multiple MT application attributes</u>
  - Add-on equipment for one MT can actually suffice for two or more MTs
  - Engineering costs are much cheaper, per unit, for multi unit applications
  - Can be ganged to size for any application
  - Custom scrubbers can be very cost effective

AD engines for power production (Cont'd)

- <u>Caterpillar, internal combustion reciprocating engines</u>
  - Emissions are not as good as MTs
  - Appears they are less reliable
  - Many years of excellent track record
  - Myriad manufacturers
  - Extremely wide array of output sizes
  - Much less susceptible to corrosive materials in gas
  - Far more numbers of experienced technicians available in any area
  - Many internal parts
  - Generally easy to operate and maintain
  - Easy to engineer hookups
  - Few add-on parts
  - Can run on dual fuels
  - Very widespread, millions are in use around the world

Electrical value of manure (feces and urine)

- A chicken produces about 9/10th pound of manure per day, a human produces about 2.5 pounds; a hog produces about 9 pounds; a feedlot cow produces about 90 pounds; and a dairy cow produces about 140 pounds
- Approximately 9/10th pound of manure yields one watt of power for a day - therefore, 900 pounds from any source yields one kilowatt (kW) of power for a day or 24 kWh. As such, one chicken yields 9/10th watt; one human yields about 3 watts; one hog yields 10 watts; one feedlot cow yields 102 watts; and one dairy cow yields 155 watts
- For comparison, one kW, averaged across time, can power an average size home
- From manure alone, a 5000 head: chicken farm could produce 5 kW; hog farm could produce 50 kW; feedlot operation could produce 512 kW; and dairy farm could produce 775 kW and 5,000 people could product 150 kW.

Electrical value of manure (feces and urine)

- Estimates of total manure produced in the US, per year, on animal farms range from 750 million to one billion tons
- Theoretically, at that number, 4.6 to 6.1 gigawatts could be produced from US CAFOs
- These estimates do not include animal mortalities and slaughter byproducts which, pound for pound, can produce up to four times as many watts
- Further, the current US human population could theoretically produce 835 MW and the world population could produce 18.0 gigawatts

Colorado Pork/Custom Swine Partners

- Is the first farm in Colorado to have incorporated an anaerobic digester – it was among only 30 at the time
- Was the first farm in Colorado to show that anaerobic digestion could meet Amendment 14 odor requirements
- Was the first farm in North America, and the second active farm in the world, to have incorporated a micro turbine to produce power
- Is believed it will be the first farm to blend wind power with biogas and one of the first two to use its biogas in a Stirling engine
- Was designed to use twice as much manure as it had available when it started up – expected to truck in more from another farm
- Serves as a laboratory and, sometimes, an informal place to try new inputs or processes to the digester

Colorado Pork/Custom Swine Partners, (Cont'd)

- Strongly demonstrates the importance of:

  - adequately hiring and training staff to operate and maintain the digester, or contracting to have it done;

  - preparing for such contingencies as animal disease outbreaks or rapid turnover of personnel;

  - properly designing a digester;

  - designing in or retrofitting for energy efficiency;

  - incorporating known improvements to the efficiency of a digester or eliminating or improving air and water issues

Anaerobic Digestion: Cost To Build (Comparative Cost Analysis To Meet Colorado‘s Amend. 14 For A 8,000 Sow Farm; i.e., Lamar_Site)

SYSTEM TYPE	ACTUAL CONSTRUCTION COSTS TO NEAREST $500	NET ELECTRICITY COSTS SAVED PER YEAR
Single Cell Lagoon	$301,500	Zero
Two Cell Lagoon	$357,500	Zero
Covered Single Cell Lagoon	$476,500	Zero
Covered Two Cell Lagoon	$473,500	Zero
Anaerobic Digester (w/ small scale single cell lagoon and 75kW genset)	$375,000	$40,000 (if $.0675/kWh)
Retrofit To Add AD and Genset For Any Of First Four Above	Additional $250,000, approximately	$40,000 (if $.0675/kWh)

For More Information, Please Contact:

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