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Ordway Feedyard

Manure to Energy Project

Status Report

for

Colorado Department of Agriculture

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Project Background

Ordway feedlot is a beef feedlot located in Crowley County, Colorado. The feedlot hosts between 40,000 to 50,000 beef cattle at any time, resulting in the production of approximately 250 million pounds of wet manure per year. The cost to dispose of this large amount is about 250,000 USD per year. The aim of this project is to evaluate various manure-to-energy technologies, and implement the one that would most efficiently help the feedlot to use the manure as an energy source, instead of a waste, with minimal environmental impacts.

Current Status/Accomplishments

FEASIBILITY STUDY

The first deliverable of this project was finished and presented to Luke Larson, manager of Ordway Feedyard, LCC. This consisted of a feasibility study, showing the current necessities of Ordway Feedyard, and a detailed description of the main technologies applicable to this case. This is a brief summary of such technologies:

- Anaerobic digesters. Manure is mixed with water and placed in a closed space where the resultant methane is captured.
    - Advantages: Low cost, very simple technology.
    - Disadvantages: Water usage. Reliability: there is a history of 50 % success with this process.
- Briquettes. Manure is dried and mixed with other forms of biomass and compressed into compact solid blocks that can be used as a fuel alternative to coal or wood.
    - Advantages: Easy and clean handling and storage, high energy content.
    - Disadvantages: Several different pieces of equipment needed. The process would not be automatic.
- Pyrolysis. This is a thermo-chemical process at a very high temperature in absence of oxygen used to convert manure to a liquid fuel such as ethanol.
    - Advantages: The final product is easy to handle. There is a more consistent quality compared to any solid biomass.
    - Disadvantages: This process requires a rather complicated plant.

- Gasifiers. Gasifiers convert materials with high organic content, such as manure, at high temperature in an oxygen limited environment to produce a high energy value gaseous mix known as synthetic gas or syngas.
    - Advantages: This is technology is being developed by several companies and universities in this country, there are commercial products available now
    - Disadvantages: There are no antecedents of use of this technology in feedlots, or similar environments.
- Biofuel conversion to ethanol. This is a very similar process to gasifiers, with an additional conversion from syngas to ethanol.
    - Advantages: Ethanol can be widely used by several different vehicles and equipment, which opens the possibility of commercialization.
    - Disadvantages: This technology requires a plant with a high degree of complexity. So far there are no developments towards a plant simple enough to be used in a feedlot.
- Incineration. Incineration of dried manure directly is one of the oldest manure-to-energy practices that have been widely practiced across the globe.
    - Advantages: Modern developments make this a clean, simple and safe option. It might offer a relatively short return of investment period. There are commercial plants available.
    - Disadvantages: High initial investment when compared to digesters.

After this initial feasibility study, the technologies that showed the most promising possibilities according to iCast are: digesters, incineration and gasification.

Mike Biggs and Rajat Srivastav met with Luke to review the options shown in the feasibility report, and to find a technology that would address Ordway's needs in the most efficient way. From this meeting, two technologies emerged as the most feasible: incineration and gasification. Digesters' 50% reliability, and the water needed to run them make this type of technology unfeasible for Ordway.

RESOURCE GUIDE

Currently, Rajat Srivastav is working on the *Resource Guide*. The main objective of this document is to provide a comprehensive and easy to understand guide that will help other businesses of the same nature in Colorado to develop their own solution to manure management problems.

Next Steps

Test

To ensure Ordway chooses the technology that best suits its needs and adjusts to the amount of manure they'll be processing, a test should be performed.

Incineration

Regarding incineration, Elimanure is a commercially available system that is customized to cater the needs of their customers. It consists of a bio-dryer, which in this case might not be needed because of both the dry climate in Colorado, and the qualities of the manure produced by cows in a feedyard. This would mean an advantage for Ordway, since the project would cost less and time would be saved during the conversion process. We have contacted Skill Associates, the company that designed the system. They have a sample of the manure, which will be tested to assess the amount of energy that can be produced by its incineration. They will also investigate the nutritious contents of the remaining ashes, which will be possibly used as fertilizer.

After these tests are done, we have to work with both Ordway and Skills Associates to design a system of a suitable scale.

Gasification

Agricultural Waste Solutions (AWS) developed a gasification system that might be applicable to this case. We've contacted Kingston Energy, a supplier of AWS systems, and a test will be performed by them.

Customization

Careful analysis regarding the design of the final system to be deployed should be completed to ensure it converts the biomass at an appropriate rate, i.e. it doesn't produce more energy than what can be consumed by the feedyard.

Finish and present Resource Guide

A completed guide will be submitted by the end of October for review.

Energy Production from Manure at the Ordway Feedyard

Rajat Srivastav and Prof. Angela R. Bielefeldt,
University of Colorado at Boulder
September 4, 2008

Ordway Feedyard Information

- About 40,000 – 50,000 head of cattle/yr
  - Beef cattle ranging from 750 to 1300 lb
  - Each head on-site for ~120-200 d
  - Fed ~80% corn, 8% alfalfa hay, etc.
- ~250M pounds manure/yr [wet]
  - Scraped from the dirt pens to a pile
- $400,000/yr for electricity and gas

for feedmills

Manure Composition

- Reported at ~20% moisture
  - Ordway Feedlot in a dry environment

- Est. 3 tons manure/head/yr (ISU) = 240M lb/yr (close to Ordway value) [wet]
- Gross energy ~3.75-4.38 Mcal/dry kg (North&Garrett1986) ~4.6 kWh/dry kg

Technology Overview

- Anaerobic digesters
- Briquettes
- Gasifiers
- Pyrolysis
- Incineration
- Methane syngas conversion

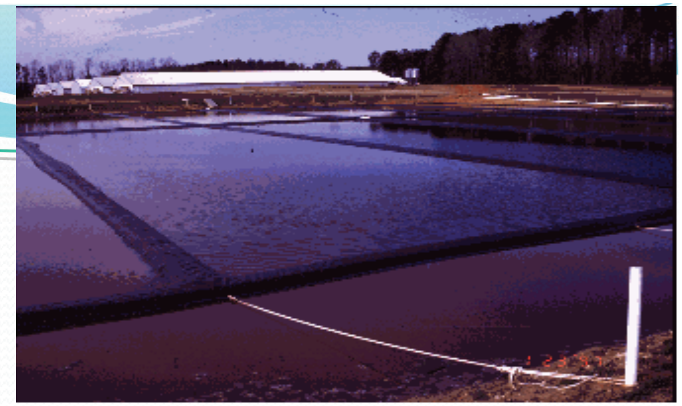
Anaerobic Digesters

- In the absence of oxygen, bacteria break down organics and produce methane
- Need "digester" reactor and heat engine/generator or microturbine/generator
- Ave 4.8 kWh/dairy cow/day (Mehta 2002)
- Typical "liquid" digesters have <15% dry matter (>85% water)
- Effluent material – use as fertilizer; feed to cattle, etc.
- Potential: vertical and horizontal "solid" digesters that are typically used for food waste (~70% moisture content)

Anaerobic Digesters

- USDA 2007 report:
  - ~40 manure AD in US
  - Failure rates (O&M demands OR technical failure):12% for covered lagoons, ~50% PF, 67% complete mix; 30% biomass burning power plants)
  - Failure rates were determined based on the number of facility that continued operating after AgStar 3 year funding was cut off
  - Covered lagoons and PF seem most viable
- AGSTAR report also very good resource

Covered Lagoon



- Pool is created by digging down into the ground
- The pool of liquid manure is covered by a pontoon or other floating cover
- Typical 60-360 d HRT, but low Organic Loading rate <0.20 kg COD/m^3/d so large area needed
- Lowest capital cost and O&M of AD types
- USDA2007 2 at dairies (1100-1600 head) and 6 with swine
- Requires influent solids content to be < 2% for which high volumes of water is required

Conventional Plug Flow Anaerobic Digester

- 19 PF in US, all at dairies w/ 120-15,000 head (USDA07; 15000 at AZ)
- Cylindrical tank new manure being fed into the one end and gas and other by-products are released
- Loading Rate 1-6 COD/ m^3/day
- HRT range from 15 to 30 days
- Influent solids content 11 to 13 %
- Hot water supply to maintain the tank temperature

Mixed flow anaerobic digester

- Reactor consists a cylindrical tank in which the manure is generally heated and mixed
- Most expensive system to install and operate,
- HRT range 18 to 20 days
- Influent solids content is usually between 2 to 10 percent
- Highest biogas yield is observed

Incineration

- HHV of manure 8500 BTU/lb (dry ash-free (Sweeten et al)
- Used for poultry manure (HV ~6000 BTU/lb); FibroWatt in Europe and planned in MD and MN;
- Can co-fire manure with coal (10 and 20% manure tested)
- US EPA 1977 beef slaughter paunch manure incinerator (lab study +design)
  - Dewatered to fluidized bed incinerator
- Wastewater sludge
- Biodrying + Gasifier + Generator (Elimanure Incineration prototype) tested in a Wisconsin Farm high capital cost
- Fibrowatt a UK based power company proposed a 40 MW power plant in Minnesota

Pyrolysis

- Lab and pilot tests by Sanchez 2007; reactor 500-600C and 20 min residence time, combustion chamber 850C 2s; ash used in cement
  - Report manure HHV 17.81 MJ/kg, LHV 16.62 MJ/kg (slightly higher than sludge)
  - Pyrolysis classified as conventional and flash pyrolysis
  - For high energy yield flash pyrolysis recommended
  - Experimental study was conducted at University of Illinois at Urbana Champaign to evaluate the thermal conversion potential of swine manure using pyrolysis
  - Omnifuel a Canadian firm developed an commercial rapid pyrolysis sytem.

Gasification

- Gasifiers convert materials with high organic content, such as manure, at high temperature (> 700 °C) in an oxygen limited environment to produce a high energy value gaseous mix commonly known as synthetic gas or syngas
- Char and tar are the primary end products of the process
- Syngas has high calorific value of 125 to 200 BTU/SCF
- Agricultural Waste Solution implemented a gasification system for a 500 milking cow dairy in California used to generate 200 KW electricity

Briquetting

- Biomass Briquetting can be defined as a process to densify loose biomass under high pressure and temperature conditions
- Briquettes easy to handle transport and store
- Usually manure is combined with other agricultural waste such as crop residues for briquettes
- Common briquetting techniques
  - Screw Extruder briquetting
  - Die and Punch technology

Manure to Ethanol

- Manure to synthesis gas, or "syngas", composed primarily of carbon monoxide, hydrogen, and methane, which is then cleaned and cooled and converted to ethanol
- Advanced Concept Technology supplies a system which converts manure to ethanol via gasification
- System designed for influent manure moisture content of 25 %
- Estimated yeild of 17000 gal/day of ethanol for feed manure amount of 400 tons/day with 40 % moisture content

Technology Review Criteria

- Each technology reviewed on the following criteria
  - Payback
  - Technical Feasibility
  - Reliability
  - Water Requirement
  - Net Energy
  - Environmental Impacts
  - Safety and Health
  - Land Requirement (weight = 0)

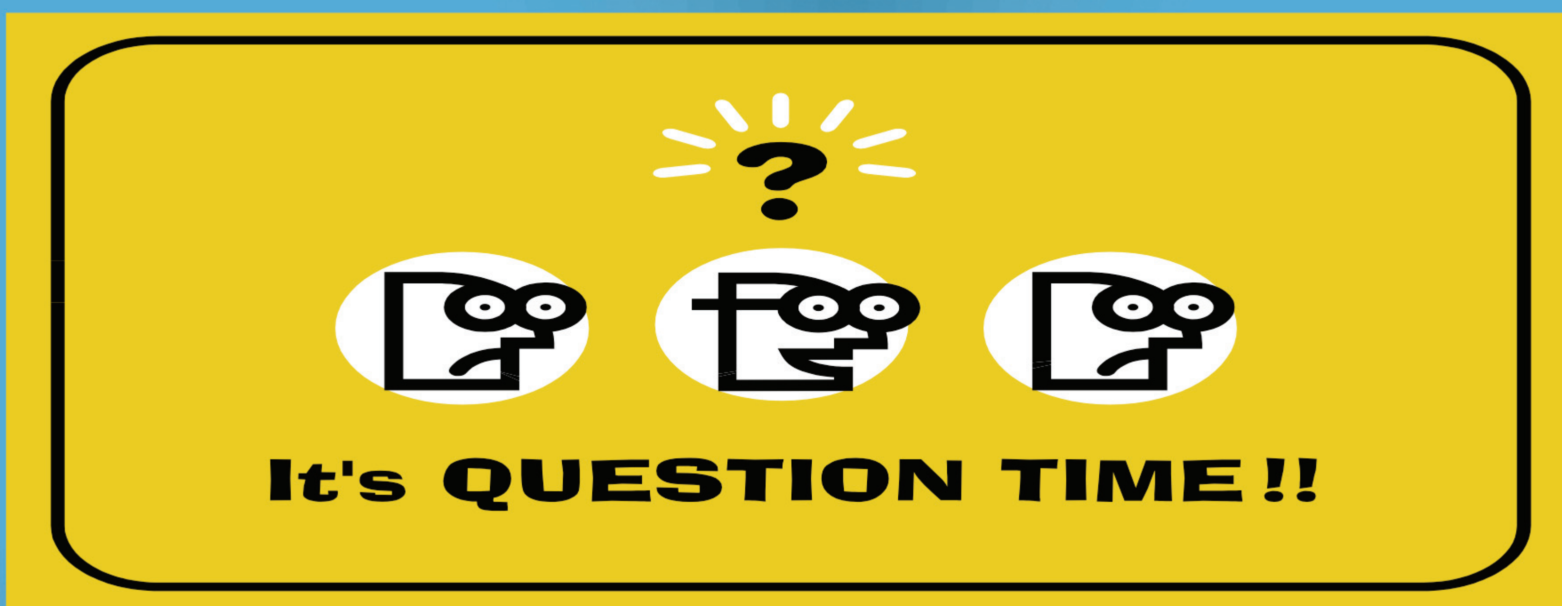
Final Decision matrix

Criteria	Wt	Lagoon AD	PF AD	MF AD	Incin	Gasification
PayBack* (Inflow/Year)	25	6 (+0.17)	7 (+0.525)	0 (-0.41)	9 (+5.86)	0 (-3.25)
Technical Feasibility	25	8	6	4	2 ± 1	4 ± 2
Reliability	15	8	5	3	4 ± 3	4 ± 3
Net Energy	5	4	6	8	8	5
Environmental Impacts	10	8	10	10	10	6
Safety&Health	10	7	8	4	10	7 ± 3
Water req'd	10	3	6	3	9	3
TOTAL	*100*	*44*	*48*	*32*	*52*	*29*
Wt'd TOTAL		670	660	355	665	560

Conclusions

- Elimanure Incineration system appears to be a promising solution for the Ordway Feedlot
- Calculations based on information provided by manufacturer
- The plug flow (PF) and Covered Lagoon anaerobic digester (AD) currently appears the best in terms of farm scale applicability and technical feasibility


THANK YOU


It's QUESTION TIME !!