ANAEROBIC DIGESTION OF ANIMAL MANURE

The History and Current Needs

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History of Anaerobic Digestion

- Early civilization method to obtain energy from manure
- Late 1800's -Louis Mouras (France) - Patent on sealed cesspool
- 1895- England - Developed a septic tank for Exeter to utilize gas for lighting
- 1904- England - First dual-purpose tank (sedimentation and sludge treatment) installed in Hampton
- 1907- Imhoff (Germany) - Patent issued for Imhoff tank
- 1906- England - Digest sludge in an anaerobic lagoon successful in 1911
- 1930's- Anaerobic digestion of manure/ agriculture waste for methane gas
- 1940's- Increased digestion of manure for methane in France and Germany around World War II

History of Anaerobic Digestion

- 1960's - Animal manure concerns increased digestion, little interest in methane so lagoons focus
- 1970's- Energy crisis encouraged funding:

  plug-flow digester for dairy manure was developed
- 1979- Humenik et. al., Methane Production from Swine Waste with a Mesophillic Solar-Heated Reactor. Environmental Protection Engineering, Warsaw Technical University, Warsaw, Poland. vol. 5, No. 3.
- 1980- Many digester papers at 4th International Symposium on Livestock Waste
- 1980's- Anaerobic digester interest declined because of low-cost fuels and digester problems

History of Anaerobic Digestion

- 1990's- Renewed interest for energy and waste stabilization. EPA AgSTAR Program resulted in about 75 dairy and swine digesters. Majority plug flow digesters for dairy and remainder a mixture of covered lagoon and complete mix systems for dairy and swine
- 2001- Ambient temperature anaerobic digester and greenhouse for swine waste treatment and bio resource recovery at Barham Farm-NCSU Smithfield project
- 2003- Humenik et. al. Evaluation of a Permeable, 5 cm Thick, Polyethylene Foam Lagoon Cover. Transactions ASAE 46 (5): 1421-1426
- 2004- Humenik et. al. Smithfield Belt System – High Solids, High Temperature Digester

First Generation: 1970-1990

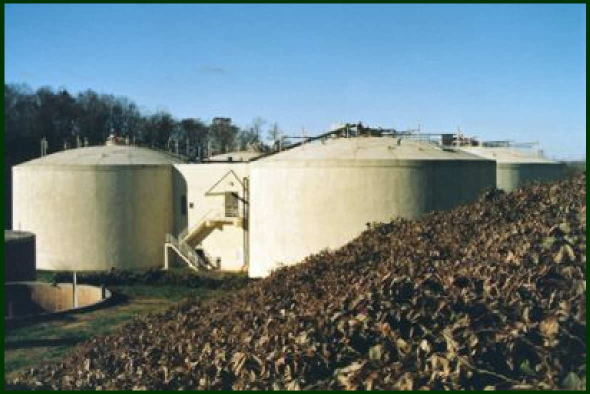
- Mid 1970's rising oil prices triggered interest in farm scale digestion for energy production
- 140 systems installed
  - 69 as university research
    - None in operation today
  - 71 at commercial swine, dairy, and layer farms
    - >60% failure rate

	Complete Mix	Plug Flow	Covered Lagoon	TOTAL
Operating	9	9	7	25
Not operating	13	30	3	46
TOTAL	22	39	10	71

Source: DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook", 1995

Project Types

- On-Farm or Farm Scale: System is owned and operated by farm owner/manager
  - Currently the predominant project type in the U.S.
- Regional or Centralized Digesters: Off farm management and operation with a third party
  - Ideally located at a large energy (electric or heat) consuming source or interconnection point (feed mills or utility substation)



Main Reasons for Failures

- Design and engineering deficiencies
  - 19 failures occurred by one vendor
- Complex digestion processes transferred from other industries.
  - Farm did not upgrade labor skills, receive adequate training and technical support.
  - Systems became to expensive to maintain and repair because of complexity.
  - No service industry available for repair
- Inappropriate equipment installed
  - over sizing, under sizing, reliability

Examples of Failures

Current Needs

- Modification to maximize net income of well known technology for maximum waste stabilization to minimize subsequent treatment and disposal costs
- Maximizing economics will justify use and conservation/utilization of manure energy
- Design/operation must avoid marginal cost of producing additional energy that reduces economic attractiveness
- Green energy policies and fair pricing needed to make technology cost justified.

System Evaluation

- Standard protocol for evaluating current and proposed alternative systems is required
- Study state operation is required before evaluation and covered lagoons must be evaluated on an annual basis.
- Alternatives for sampling flow must be utilized to accurately determine system performance by mass balances.
- Actual total cost and income from utilization/sale of energy produced are essentials

Standards

- Standards for design/performance that are consistent and attainable are required to:
  - Provide producers with an unbiased basis for evaluating alternatives
  - Produce informed consumers for retaining consultants and contractors
  - Document regional performance expectations for operators and regulatory agencies
- Standards are required for structural design and different performance objectives

Anaerobic Digester Limitations

- Anaerobic digesters are not the complete answer or "silver bullet" for all manure management requirements because:
  - N is not reduced
  - P is not reduced
  - liquid effluent must be managed
  - solids accumulation or effluent must be managed
  - N/P build-up in covered lagoons may exceed land receiver capabilities requiring harvesting for production of by-products for off farm use
  - just one unit process in total animal production/manure management system

Barham Farm

- AgSTAR funded
- First cover early 1997
- Second cover mid 1997
- Third cover 1998 -

Ambient temperature anaerobic digester and greenhouse for swine waste treatment and bioresource recovery and Barham farms

- The ambient digester consists of an impermeable cover over an in-ground digester.
- Methane gas is delivered to a generator, where electricity is produced. Heat from the generator is used to produce hot water.
- Effluent form the digester flows into a lagoon that was the primary lagoon before the digester was built.
- Nutrients in the effluent from the lagoon/nitrification unit are used to fertilize plant and vegetable species in a greenhouse.

In-ground ambient temperature anaerobic digester/energy recovery /greenhouse vegetable production system

4,000 Head farrow to wean

Nitrification Tanks – Barham Farm Project


HYDROPONIC TOMATOES
U.S. No. 1

Results reported (July 2003): In-ground ambient temperature digester / energy recovery / greenhouse vegetable production system

- **Carbon loading reduced by 90%**
- **560 – 990 kWh electricity/d**
- **Tomato yield of 711 kg/d**

North Carolina Lagoon with Permeable, Floating Cover

- Designed by the County Soil and Water Conservation Commission staff
- Depth: 12 feet
- Surface area: 0.5 acres
- Excess liquid applied to nearby Bermuda hay or corn land

The cover was assembled on land then pulled onto the lagoon

Cover was buried into the dikes to hold it in place

There was a small amount of water on the surface after a rain

Four year old permeable cover

Algae tended to grow on the surface without adverse impacts.

Vegetation growing on permeable cover

Lagoon Covers Summary

- Impermeable covers required for methane collection
- Permeable covers reduce odor and ammonia/methane volatilization
- Different water management required for both covers
- Both covers result in increased nitrogen in lagoon
- Cover material, installation and maintenance important
- Covers may be used to upgrade existing lagoons

Digester Summary

Well known technology for maximum waste stabilization to minimize subsequent treatment and disposal costs.

- Option to reduce odor, ammonia volatilization, methane emissions/greenhouse gasses and conserve/utilize energy/nitrogen source

- Policies, agreements and operational strategies are critically required to make cost justified

- Just one unit process in the total animal production/manure management system

Conference Importance

- Exchanging ideas and successes/failures
- Discuss important issues
  - Energy policies so production of biogas/electricity is cost effective
  - Role of covered lagoons
  - Development of uniform protocol for evaluation
  - Develop standards for design, operation and alternative performance goals - especially cost justification

National Center for
Manure & Animal
Waste Management
USDA-Fund for Rural America Grant

Livestock and Poultry
Environmental Stewardship

Summary Descriptions:
Environmentally Superior
Technologies Being Evaluated
per Agreements Between
North Carolina Attorney General,
Smithfield Foods,
Premium Standard Farms
and Frontline Farmers

Thank-you!

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