

Panel Primer

Animal Waste to Biogas Can This Be a Significant Energy Resource

Jim Bodensteiner – Iowa DNR

John Cuttica – Midwest CHP Application Center

Mark Hall – Environmental Power

Ricardo Amon – California Energy Commission

ACEEE Forum on Energy Efficiency in Agriculture

Des Moines, Iowa

Thursday, February 21, 2008

What is Anaerobic Digestion?

AD is a process where ***organic waste*** is ***broken down*** in a ***controlled, oxygen free*** environment by naturally occurring ***bacteria*** in the waste material

Benefits of Anaerobic Digestion

- **Odor reduction (digestion stabilizes degradable organic matter)**
- **Digested manure retains most of its nutrient/fertilizer value**
- **Digestion minimizes release of methane to atmosphere during later storage**
- **Produces a useable fuel (biogas)**

Climate Change is the Newest Environmental Driver

Principal Sources of U.S. Anthropogenic Methane Emissions, 1990-2005

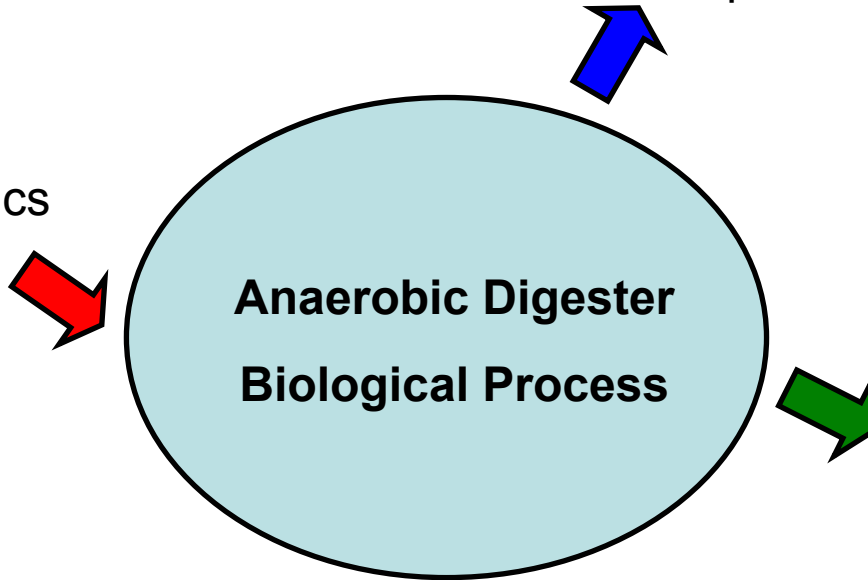
| Source | Million Metric Tons CO ₂ e | | Percent Change | |
|----------------------|---------------------------------------|-------|----------------|-----------|
| | 1990 | 2005 | 1990-2005 | 2004-2005 |
| Energy | 275.0 | 254.9 | -7.3% | -1.3% |
| Waste Management | 250.6 | 171.5 | -31.6% | 4.3% |
| Agriculture | 173.4 | 183.0 | 5.5% | 1.0% |
| Industrial Processes | 2.7 | 2.5 | -8.4% | -7.7% |

26% of the agriculture sectors methane emissions are from manure management. In 2005, this was equal to 42.6 million metric tons CO₂e. From 1990 to 2005, emissions from manure management increased by 34%.

Anaerobic Digestion Process Overview

Manure / Food Processing Wastes

- Pathogens
- Macronutrients
- Unstable organics



Biogas – Methane (CH₄)

- 50 – 70 % CH₄/vol
- 20-50% CO₂/vol
- Trace gases (H₂S)
- ~ 600 BTU per ft³

Treated Effluent

- Pathogen reduction
- Nutrient rich
- Stable (low odor)

Products from Anaerobic Digestion



Products from Anaerobic Digestion

- Liquids (filtrate)
 - Liquid fertilizer
- Solids (fiber)
 - Compost
 - Animal bedding
 - Pellet/Granule fertilizer
 - Medium density fiberboard and decking
- Biogas
 - 60% fuel value of natural gas
 - Flare It ~~Ø~~
 - Use It for Heating
 - Use It for CHP
 - Clean It Up for Pipeline Use

Approximate Feedstock Yields (Manure Only)

| Animal Type | Daily Biogas Production | Btu Content (600 Btu/cuft) | kWh/day/head | Population for 40kW Gen. |
|-------------|-------------------------|----------------------------|--------------|--------------------------|
| Dairy Cow | 50 – 80 cuft | 30,000 – 48,000 | 2.6 – 4.2 | 230 - 370 |
| | | | | |
| SOW | 4 – 6 cuft | 2,400 – 3,600 | 0.21 – 0.32 | 3,000 – 4,500 |

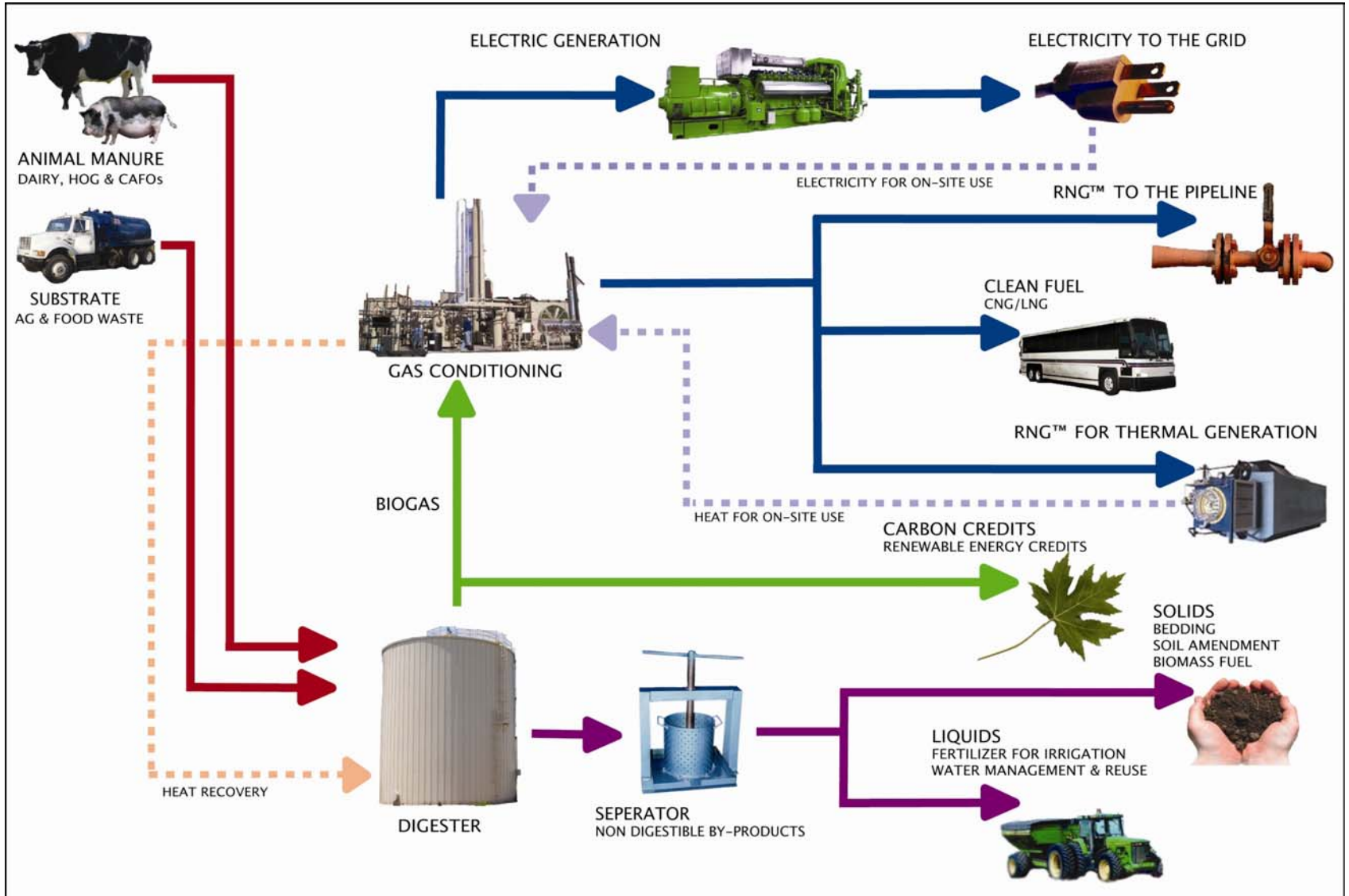
Note: Seen claims of 5 to 6 kWh/day/head (Dairy) -- < 200 head for 40kW

Ag Anaerobic Digestion Types

- Plug flow digesters
- Mixed plug flow digesters
- Complete mixed digesters
- Covered lagoons
- Temperature-Phased Anaerobic Digesters
- Anaerobic sequencing batch reactor (ASBR)
- Fixed film digesters
- Upflow anaerobic sludge bed (UASB)



Livestock Based Green Energy Production



Energy Recovery – Biogas

(60% to 65% Methane)

- Flare It ~~Ø~~
- Use It for Heating
 - Displace Natural Gas / Propane
- Use It for CHP
 - Displace Purchased Electricity
 - Displace Natural Gas / Propane
- Clean It Up for Pipeline Use

CHP Technologies (Biogas Applications)

- Prime Movers:
 - Reciprocating Engines
 - Micro-turbines
- Gas Clean up (H_2S) – certainly for micro-turbines
- Gas Compression (micro-turbines)
- Generator / Heat Recovery
- Grid Interconnect Hardware – can be the biggest issue

Pipeline Quality Gas

- Must Remove H₂O, H₂S, and CO₂
- Experience to Date:
 - Stage 1: 86% Methane required for injection in transmission pipeline – high dilution rates
 - Stage 2: 94+% Methane most probably required for distribution line injection

Questions on Gas Injection Option

- Cost of cleanup – the larger the gas volume, the more cost competitive
- Gas company cooperation – experimental today, injection into pipeline (large dilution)
- Biogas injection specs being developed, a somewhat unknown? (Level of cleanup, cost to meet specs, etc)

Co-Digesting & Community Digesters

- Adding Food Processing Waste to a Manure System Can Increase Biogas Production with Higher Methane Content – Co-digesting
 - Tipping Fees Normal for Handling Food Wastes
 - On / Off Farm Location???

Current US Deployment of AD

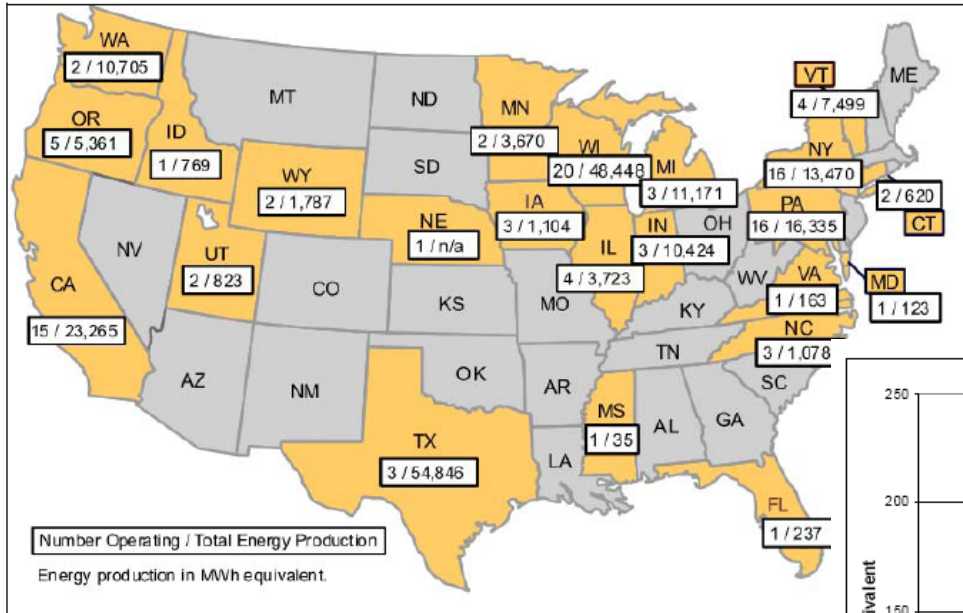


Figure 3. 2007 Operating Manure Digesters

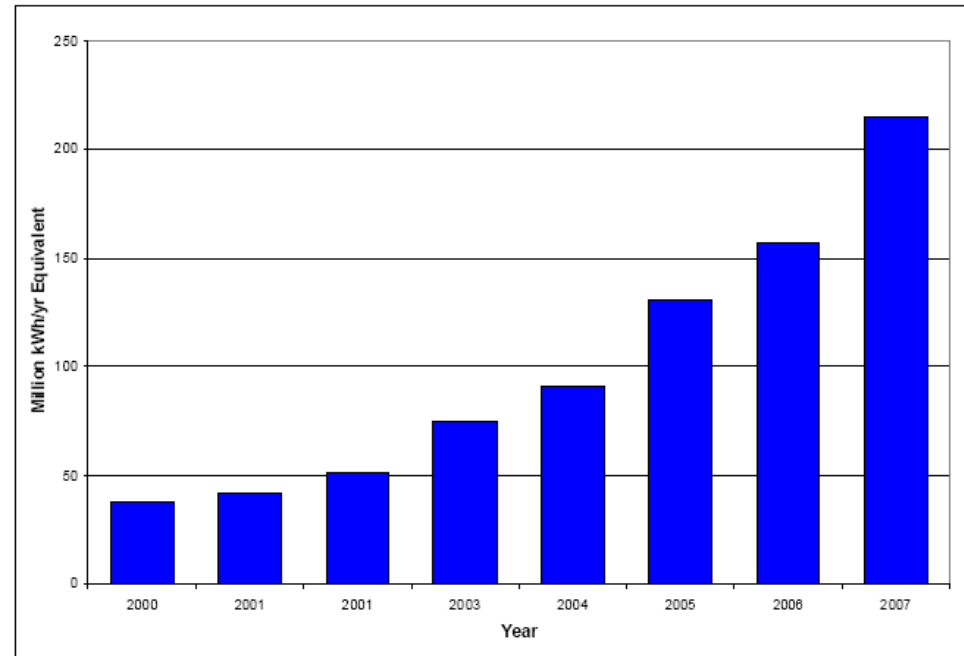


Figure 1. Trends in Energy Production by Anaerobic Digesters - 2000 through 2007

Source: USEPA November 2007

Potential U.S. Market Anaerobic Digester Gas

- Over 3 GW of Potential Capacity
 - 7,000 Dairy Farms
 - 11,000 Hog Farms
 - 6,800 WWTPs

**Source: Resource Dynamics Corp.
“Opportunity Fuels for CHP” www.rdcnet.com**

Panel Discussion

Please Ask Questions

