



Commercial Use of Anaerobic Digestion Technology in the U.S. Livestock Industry

Kurt Roos

Methane to Markets – United States
U.S. Environmental Protection Agency



Overview: U.S. Livestock Waste Management

- Regulated under Clean Water Act
 - No discharge to surface waters
- Typical conventional systems
 - Manure Storage (ponds, tanks, stacks)
 - Combined treatment/storage lagoons common for pig and some dairy farms
- For larger farms Land application according to nutrient management plan (NMP) required
 - NMP based on nitrogen and phosphorus relative to land acreage and crop uptake



Conventional Waste System Issues

Water

- Limited reduction of:
 - Biological oxygen demand (BOD)
 - Chemical Oxygen Demand (COD)
 - Pathogen and health indicator organisms

Air

- Create nuisance odors often resulting in complaints and legal action
- Other air emissions such as ammonia and hydrogen sulfide
- Greenhouse gas emissions as methane (GWP of 21)
 - 7% of U.S. emissions

Financial

- Sunk cost to business operation

Industry Interest in Anaerobic Digestion Technologies

1) Offer Air Quality benefits

- Control odors from storage and field application
- Reduces Greenhouse gases (methane)
- Controls other emissions (H₂S, ammonia)

2) Offer Water Quality benefits

- Stabilize manure organics (BOD)
- Significantly reduce pathogens
- Provide nutrient management predictability and flexibility



3) Offer return on Investment

- Energy revenues
- Carbon Markets
- Greenhouse Production
- Peat market (dairy only)
- Bedding offsets (dairy only)



Environmental Retrofit

Retrofit Plan



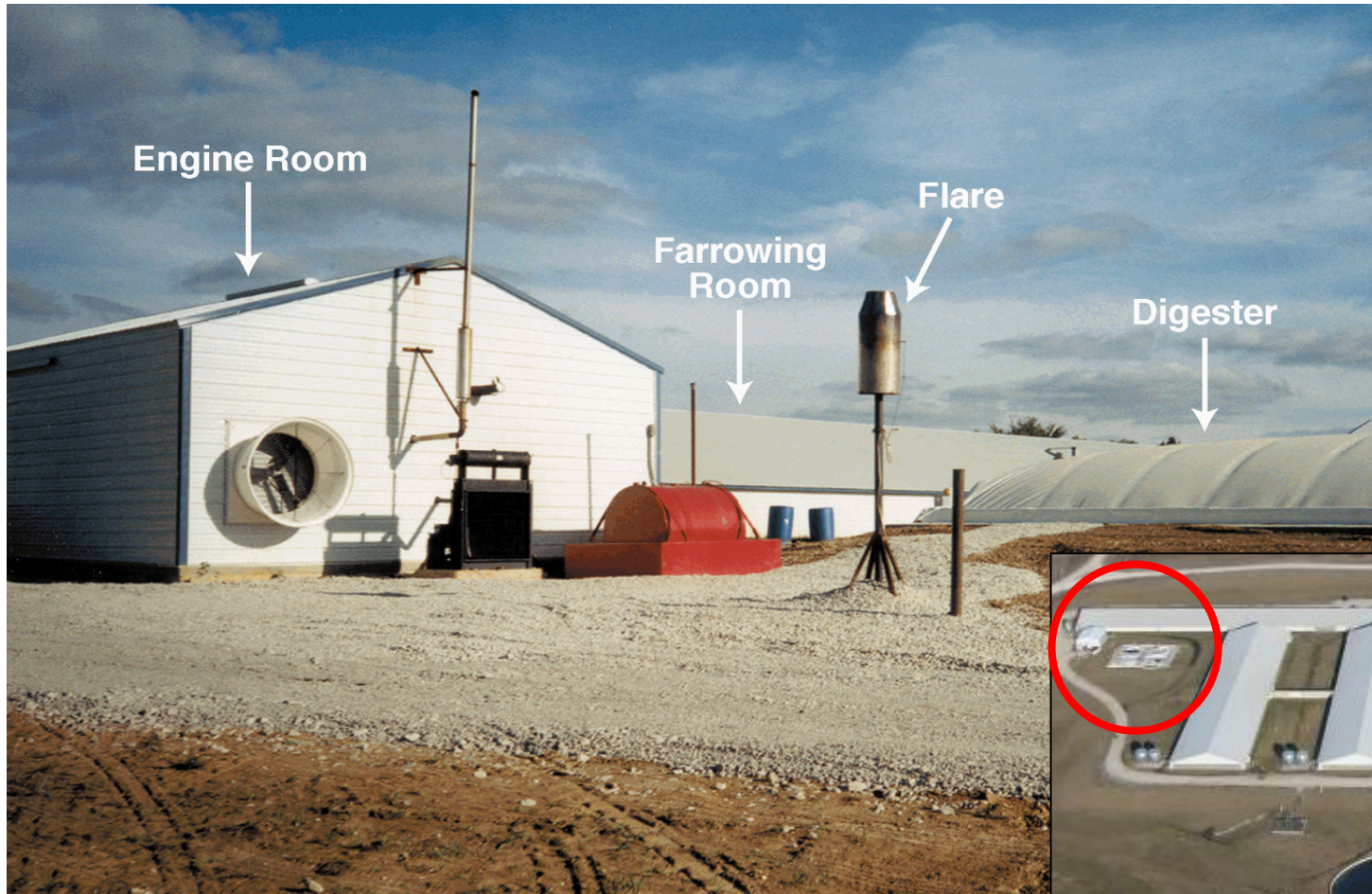
Before



After



Typical Digester Configuration



Project Types: On-farm

- On-Farm or Farm Scale: System is owned and operated by farm owner/manager
 - Currently the predominant project type in the U.S.
 - Some co-digest higher value organics
 - Cheese whey
 - Ice cream
 - Greases/oils



Project Types: Centralized

- 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)
 - Currently two operating on Dairy waste on west coast
 - Chino, CA
 - Tillamook, OR
 - Can also include co-digestion



Unheated Digesters

Covered Lagoons



Attached Media



Heated Mixed Digesters



Heated (Mesophilic) Plug Flow Digesters

Used for Dairy only w/ Separation



Gas Use: Electrical Generation

Recip. Engines 40-250kW



Gas Handling



C
O
M
P
O
N
E
N
T
S

Engine Controller



Electric Metering



Gas Use: Heat

Boilers



Forced Air



Hot Water Storage



Hot Water Use



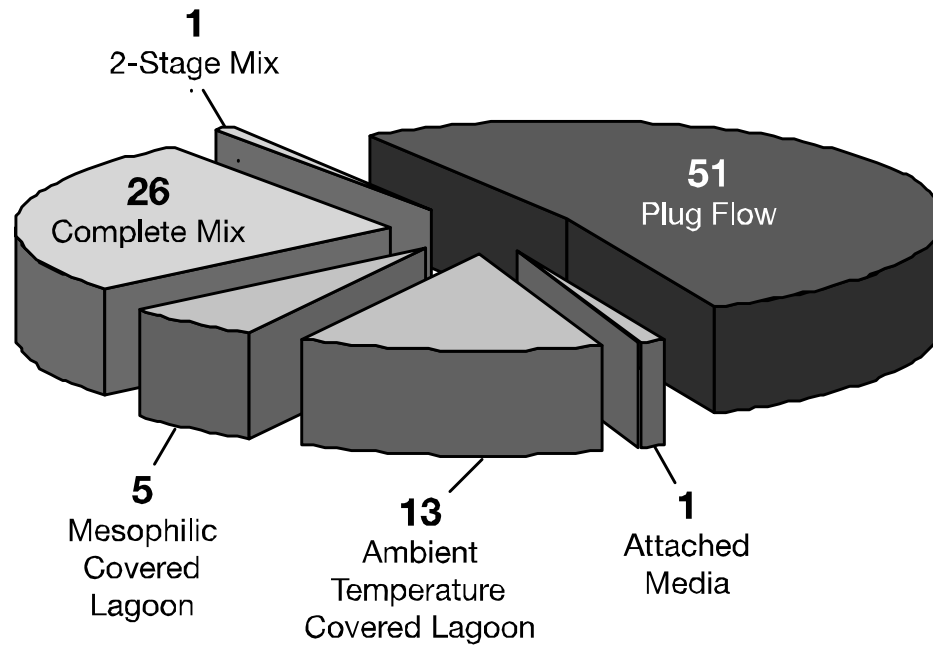
Gas Use: Flares

Odor Control and Greenhouse Gas Mitigation



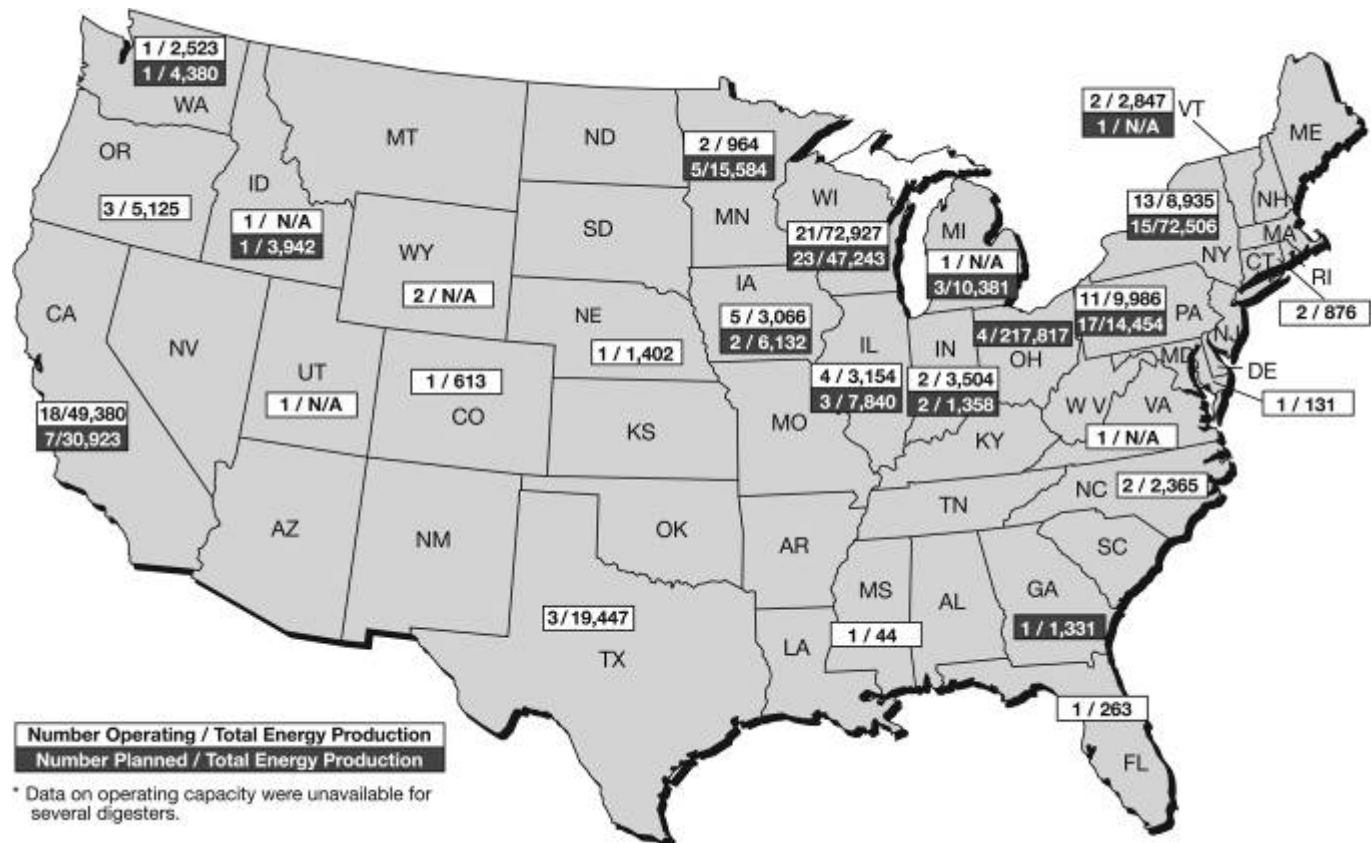
U.S. Status 2005

Figure 2. Operating anaerobic digesters by technology*.

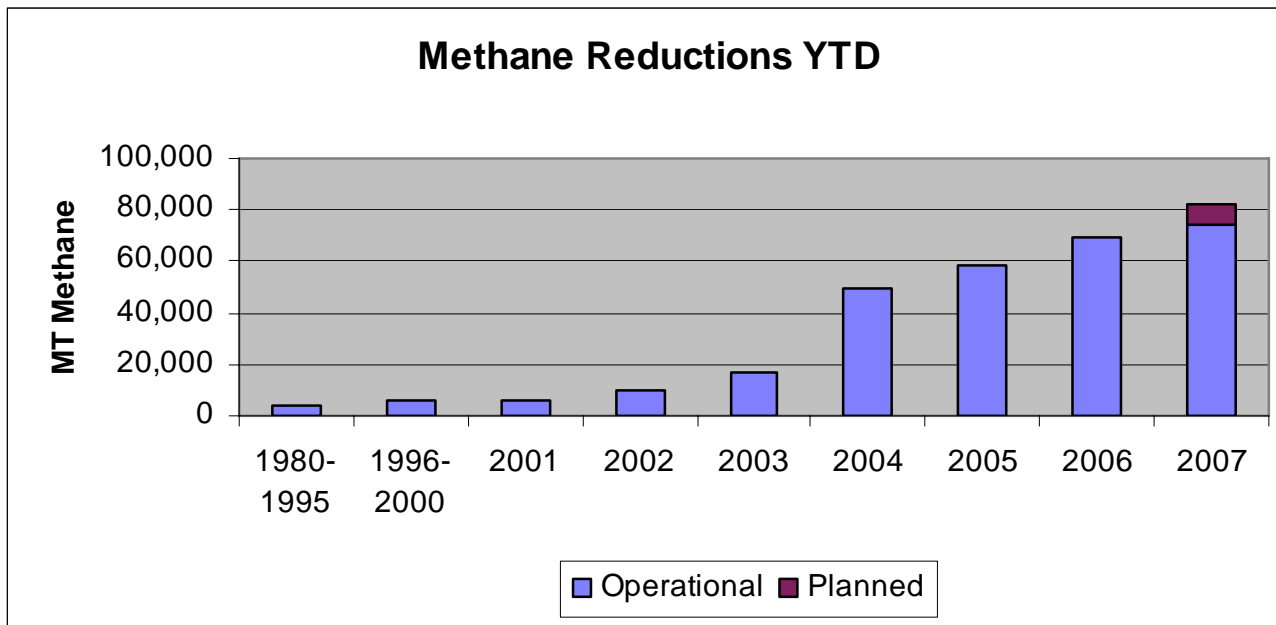


*Includes digesters in start-up and construction stage.

National Perspective



GHG Reductions



In 2006

All 'operating' projects ~275 million kWh equivalent.

~200 total projects: ~135 operating or in start-up and ~65 planned or in construction.

Digesters are Cost Effective when Environment Considered

Environmental Effectiveness of Manure Management Options

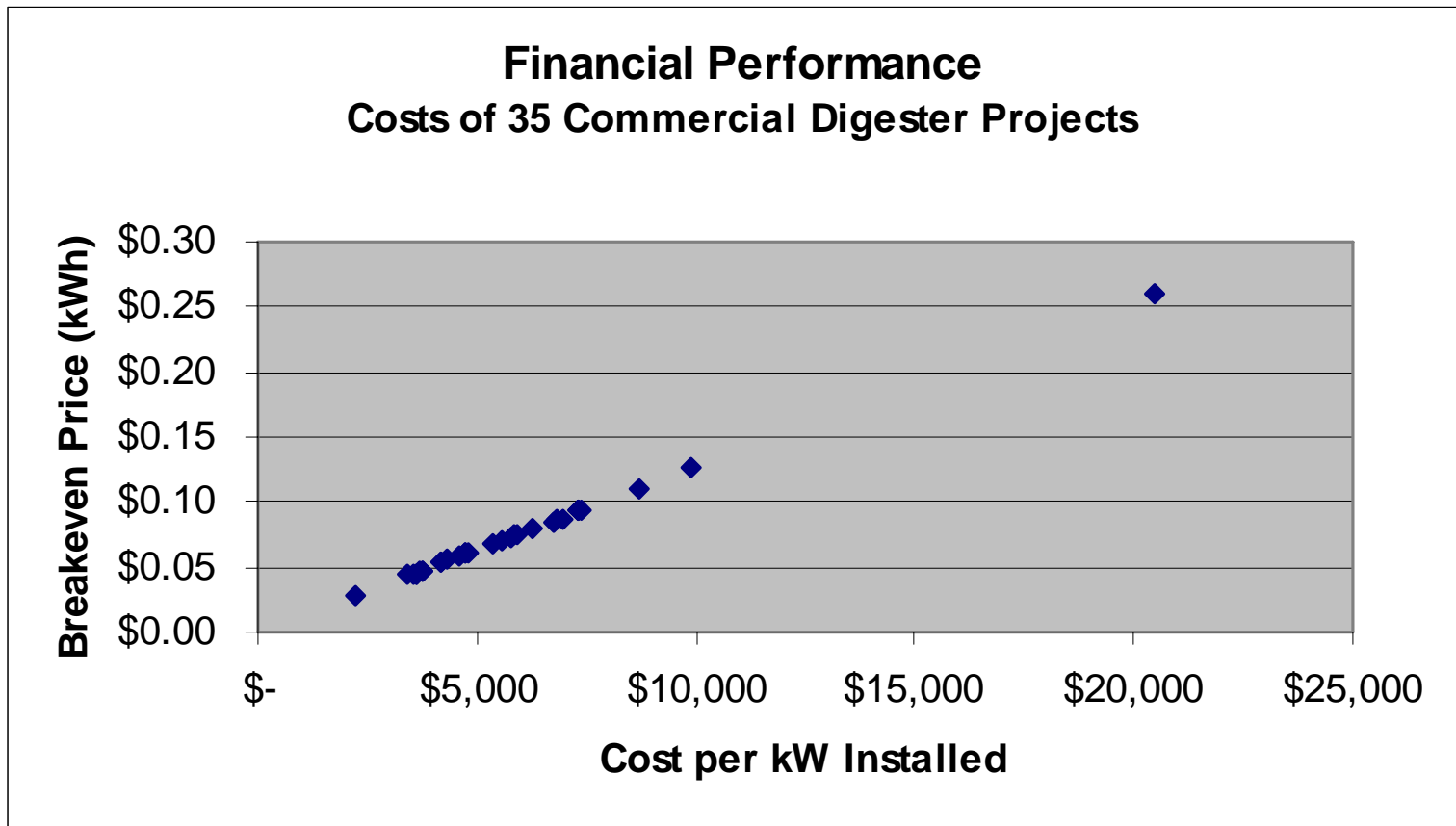
Options	Odor Control	Greenhouse Gas Reduction	Water Quality Protection	Cost Range ^{††} (per 1,000 lbs/ live weight)
Covered lagoon digesters with open storage ponds	E	H	G	\$150-400
Heated digesters (i.e., complete mix and plug flow) with open storage tanks	E	H	G	\$200-400
Aerated lagoons with open storage ponds [†]	G-E	H	F-G	\$200-450
Separate treatment lagoons and storage ponds (2-cell systems)	F-G	L	G	\$200-400
Combined treatment lagoons and storage ponds	P-G	L	F-G	\$200-400
Storage ponds and tanks	P-F	M-H	P-F	\$50-500

Key: P=poor, F=fair, G=good, E=excellent, L=low, M=medium, H=high

[†]Aerated lagoon energy requirements add an additional \$35-50 per 1,000 lbs/year.

^{††}Cost ranges do not include annual operation and maintenance (O&M) costs.

Cost Ranges can be Larger



Key A.D. Drivers

- **USDA, AgSTAR Program, and Farm Bill**
 - AgSTAR program initiated in 1992 – coordinated with USDA
 - Energy Title; Section 9006; “Renewable Energy and Energy Efficiency”
 - Primary funding source for “proven technologies”
- **Carbon Markets**
 - Array of carbon brokers emerging
 - Two farms receiving payments for reductions
 - California Climate Registry
 - Markets have varied carbon accounting methods
 - Some over estimate
- **Energy**
 - Net Metering Legislation – state by state
 - Green Pricing Programs
- **Regulatory**
 - Water and air concerns are increasing at local, state, and federal levels

U.S Digester Protocol and Carbon Accounting

A Protocol for Quantifying and Reporting the Performance of Anaerobic Digestion Systems for Livestock Manures

January 2007 release

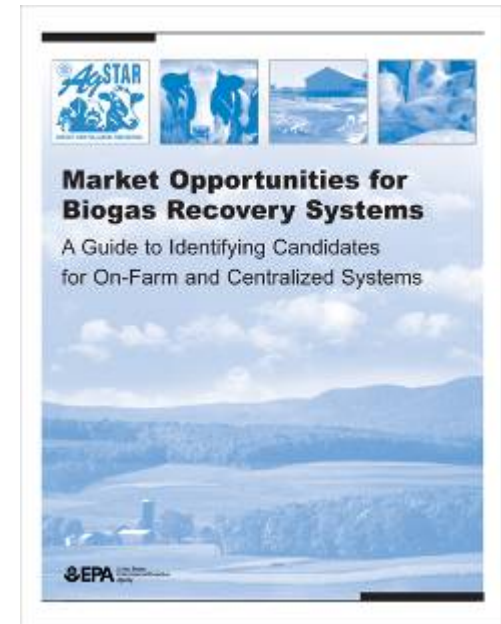


Carbon Reduction

(Emission offset from baseline WMS + Fossil fuel emission offset) - digester leakage

Top States and Opportunities

State	Number of Candidate Farms	Potential Methane Emissions Reduction (000 Tons)	Methane Production Potential (million ft ³ /year)	Electricity Generation Potential (000 MWh/year)
SWINE FARMS				
NORTH CAROLINA	1,179	247	11.5	766
IOWA	1,022	126	10.2	677
MINNESOTA	429	40	3.5	234
OKLAHOMA	52	54	2.9	196
ILLINOIS	267	36	2.8	184
MISSOURI	200	53	2.7	177
INDIANA	234	28	2.2	145
NEBRASKA	148	25	2.0	134
KANSAS	91	29	1.6	109
TEXAS	13	21	1.1	75
Remaining 40 States	646	113	7.3	487
Subtotal	4,281	773	48	3,184
DAIRY FARMS				
CALIFORNIA	963	263	18.1	1203
IDAHO	185	61	4.0	267
NEW MEXICO	123	62	3.9	259
TEXAS	149	32	2.3	154
WISCONSIN	175	8	2.1	138
NEW YORK	157	6	2.0	132
ARIZONA	73	35	1.9	126
WASHINGTON	122	22	1.9	126
MICHIGAN	72	6	1.9	73
MINNESOTA	60	3	0.7	46
Remaining 40 States	544	75	9.4	624
Subtotal	2,623	573	48	3,148
U.S. Total	6,904	1,346	96	6,332



Remember.....

- Solar energy when the sun shines
- Wind energy when the wind blows
- Hydro energy when it rains

BUT, MANURE DOESN'T STOP.....

Biogas energy all the time!

Gracias!