



Methane to Markets



Anaerobic Digestion Technology in the U.S. Livestock Industry



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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
- Required to land apply according to nutrient management plan (NMP)
 - NMP based on nitrogen and phosphorus relative to land acreage and crop uptake
- Typical waste management systems
 - Manure Storage (ponds, tanks, stacks)
 - Combined treatment/storage lagoons common for pig and some dairy farms



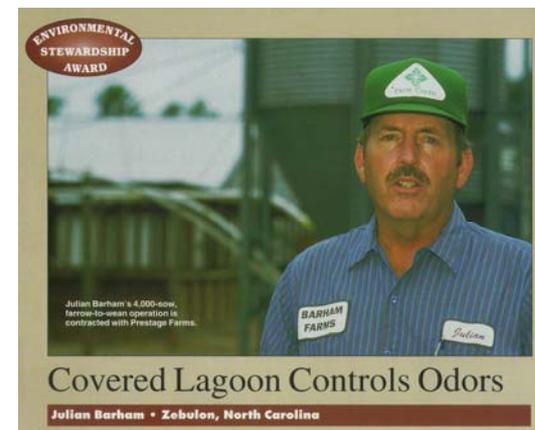
Industry Interest in Anaerobic Digestion Technologies

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



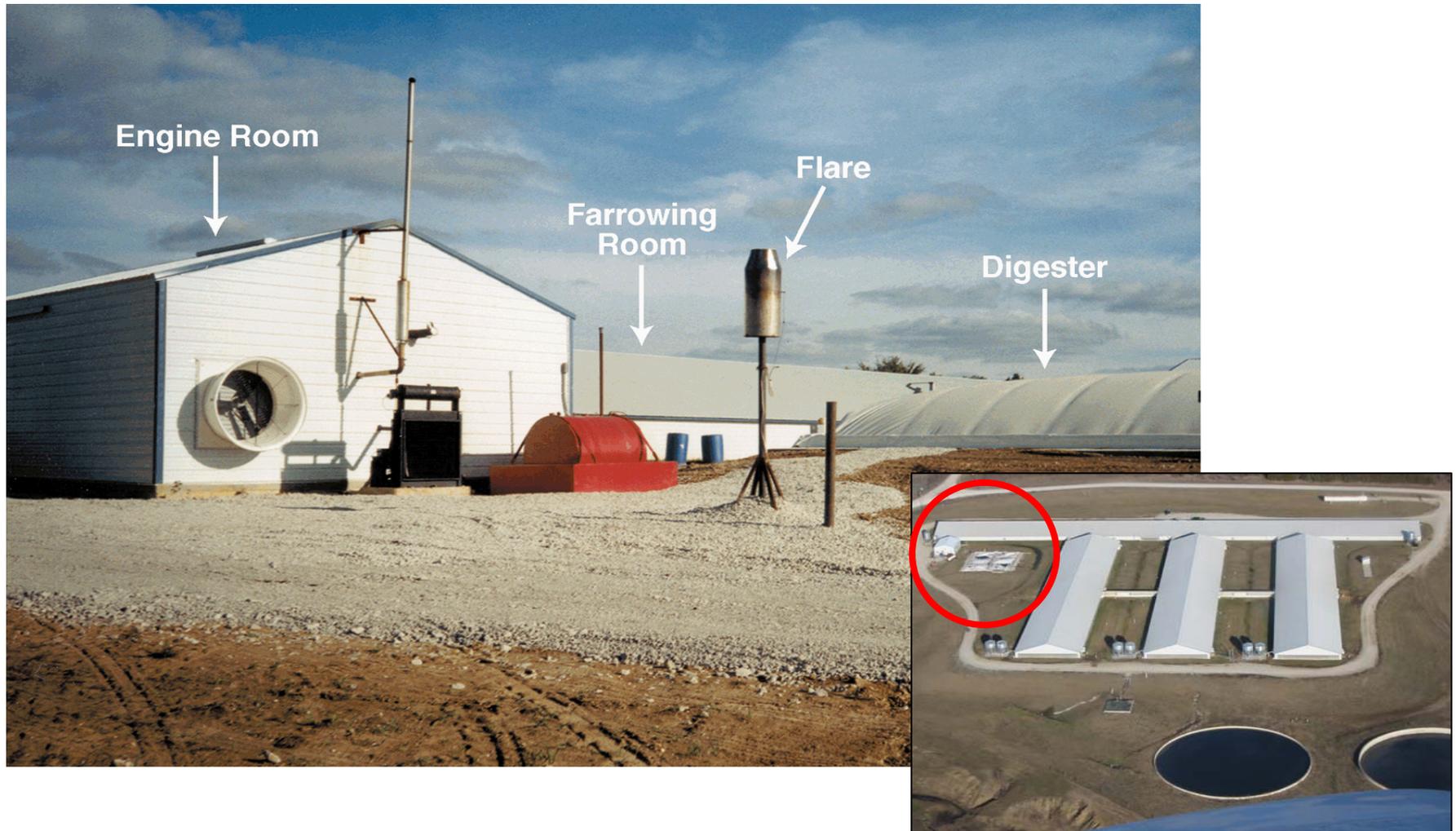
Before



After

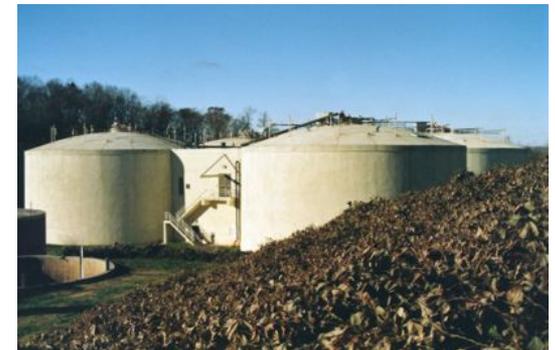


Typical Digester Configuration



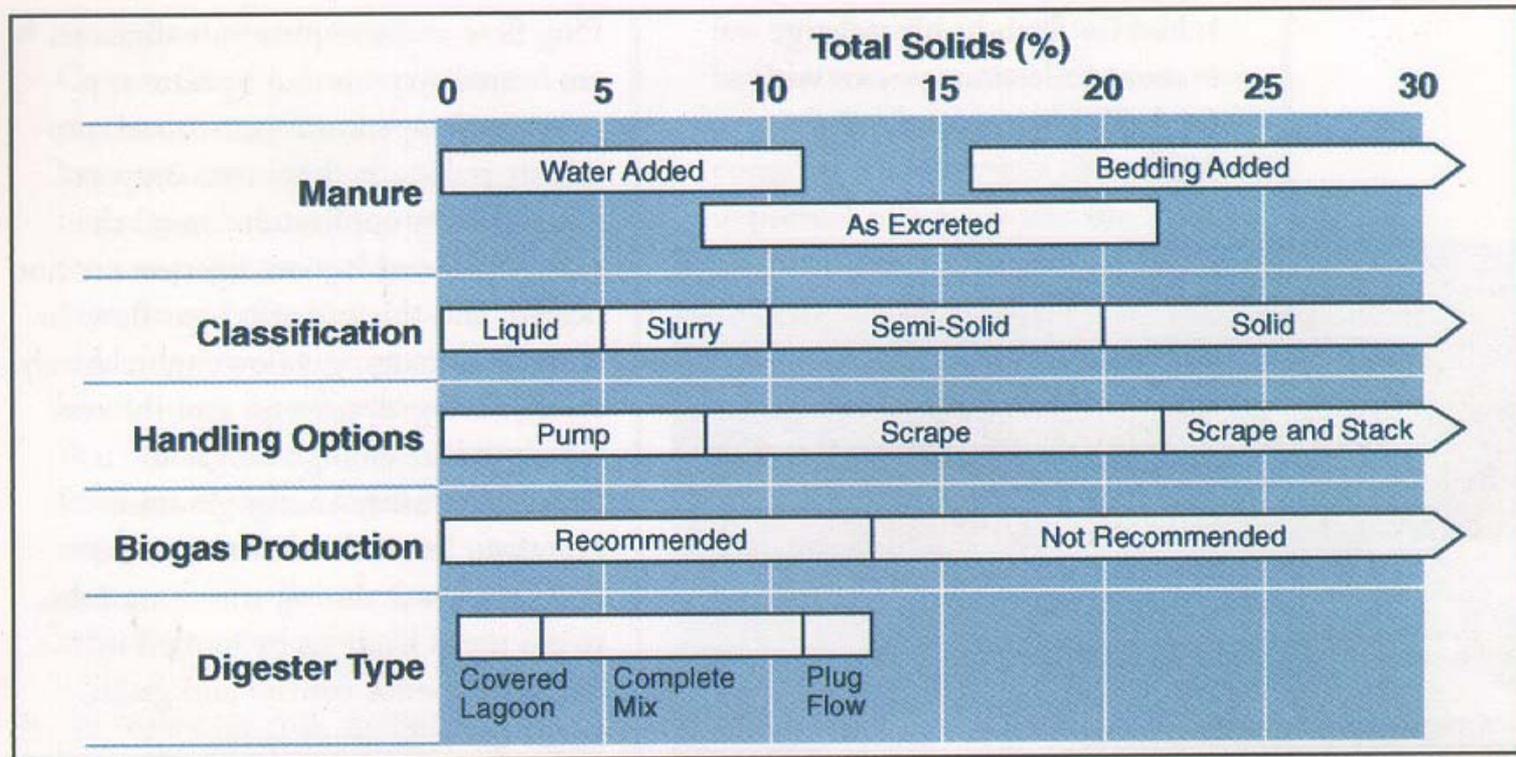
Project Types

- On-Farm 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)



Selecting a Digester

- Hog and Dairy industry constitute >90% of market potential



Covered Anaerobic Lagoons

USDA Practice Standard 365, Ambient Temperature



Lagoon Sizing Criteria

- Sized to maintain bacterial populations to ensure year round manure treatment and gas production
 - Loading Rate and Hydraulic Retention Time are key
 - Dairy requires separation

Figure 1: Covered Anaerobic Lagoon Maximum Loading Rate (lb VS/1000ft³/day)

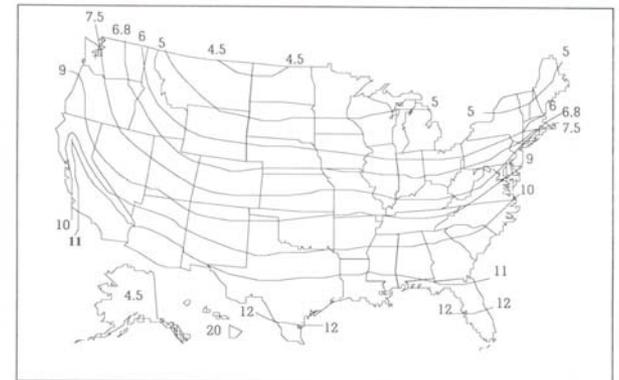
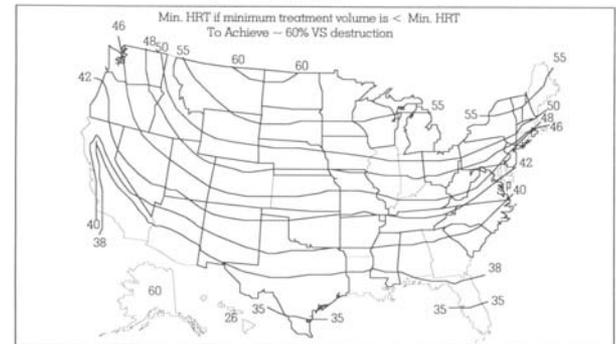


Figure 2: Covered Anaerobic Lagoon Minimum Hydraulic Retention Times (MINHRT in days)



Complete Mix Digester

USDA Practice Standard 366, Controlled Temp



Plug Flow Digester

USDA Practice Standard 366, Controlled Temp.

Used for Dairy only w/ Separation



Gas Use: Electrical Generation

Recip. Engines 40-250kW



Gas Handling



C
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Engine Controller



Electric Metering

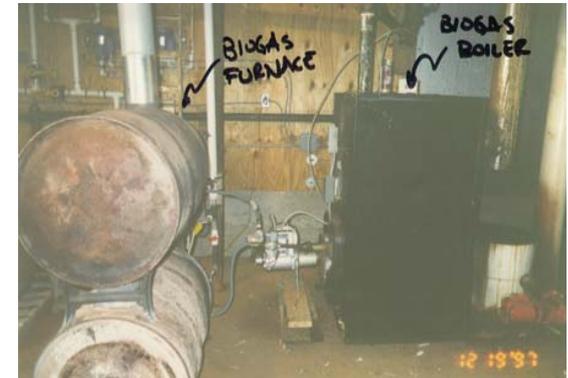


Gas Use: Heat

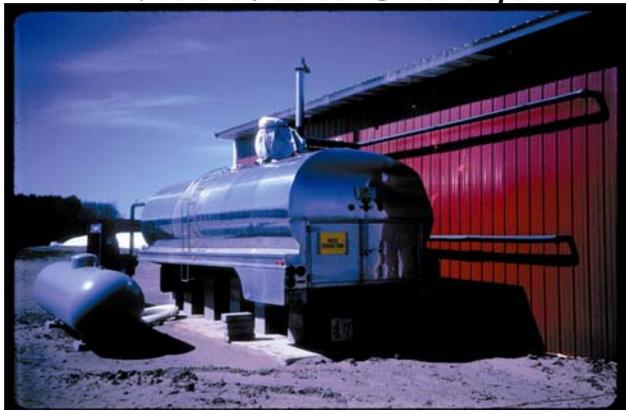
Boilers



Forced Air



Hot Water Storage

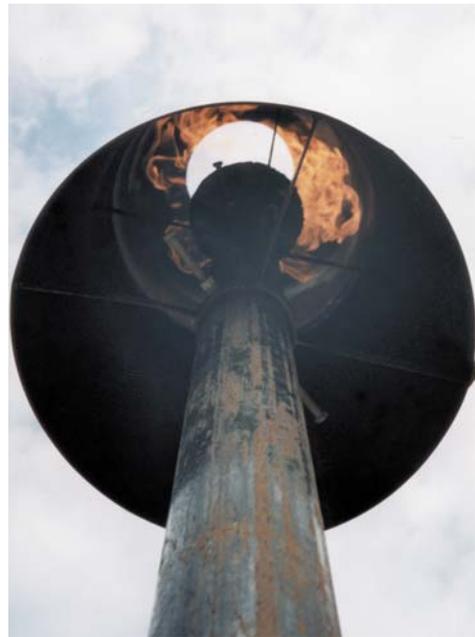


Hot Water Use



Gas Use: Flares

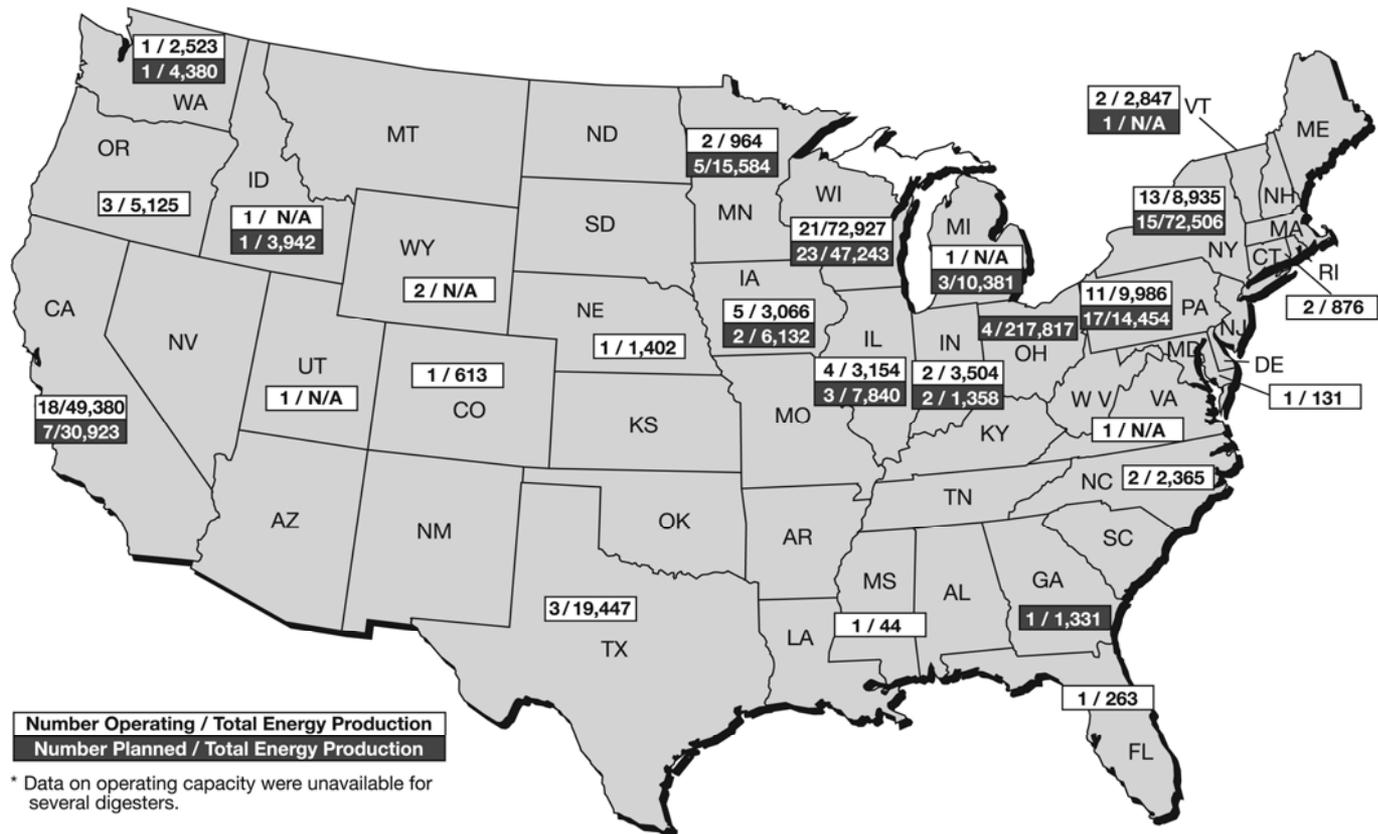
Odor Control and Greenhouse Gas Mitigation



Gas Use: Gas Purification

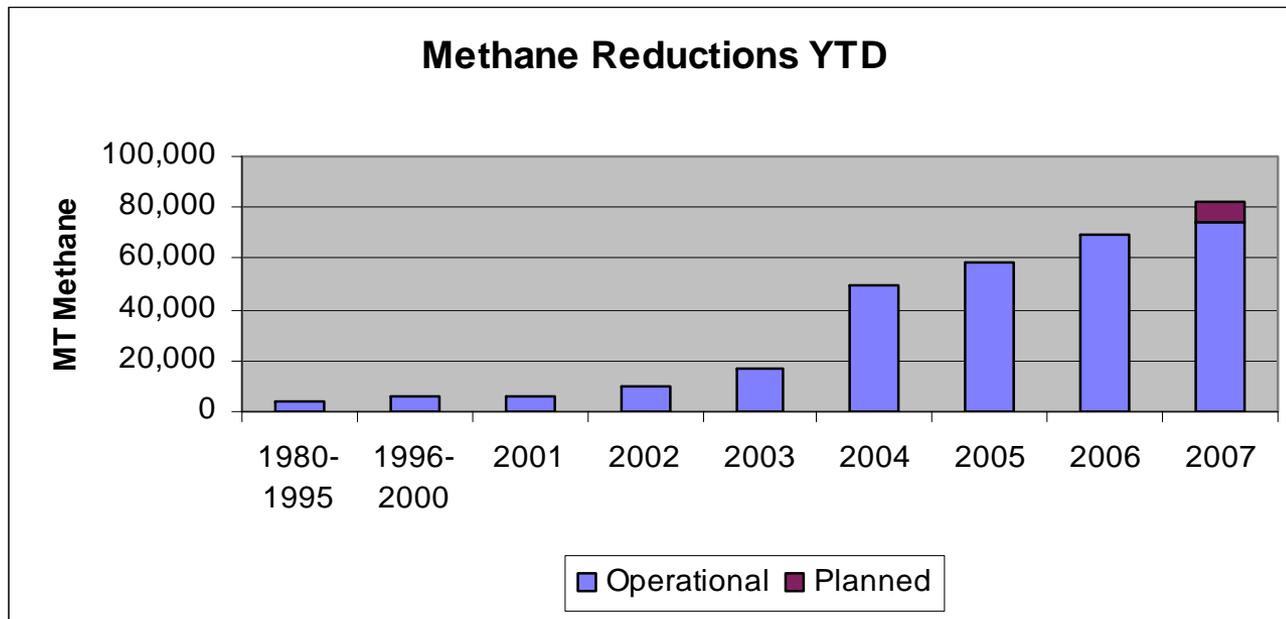


National Perspective



* Data on operating capacity were unavailable for several digesters.

GHG Reductions

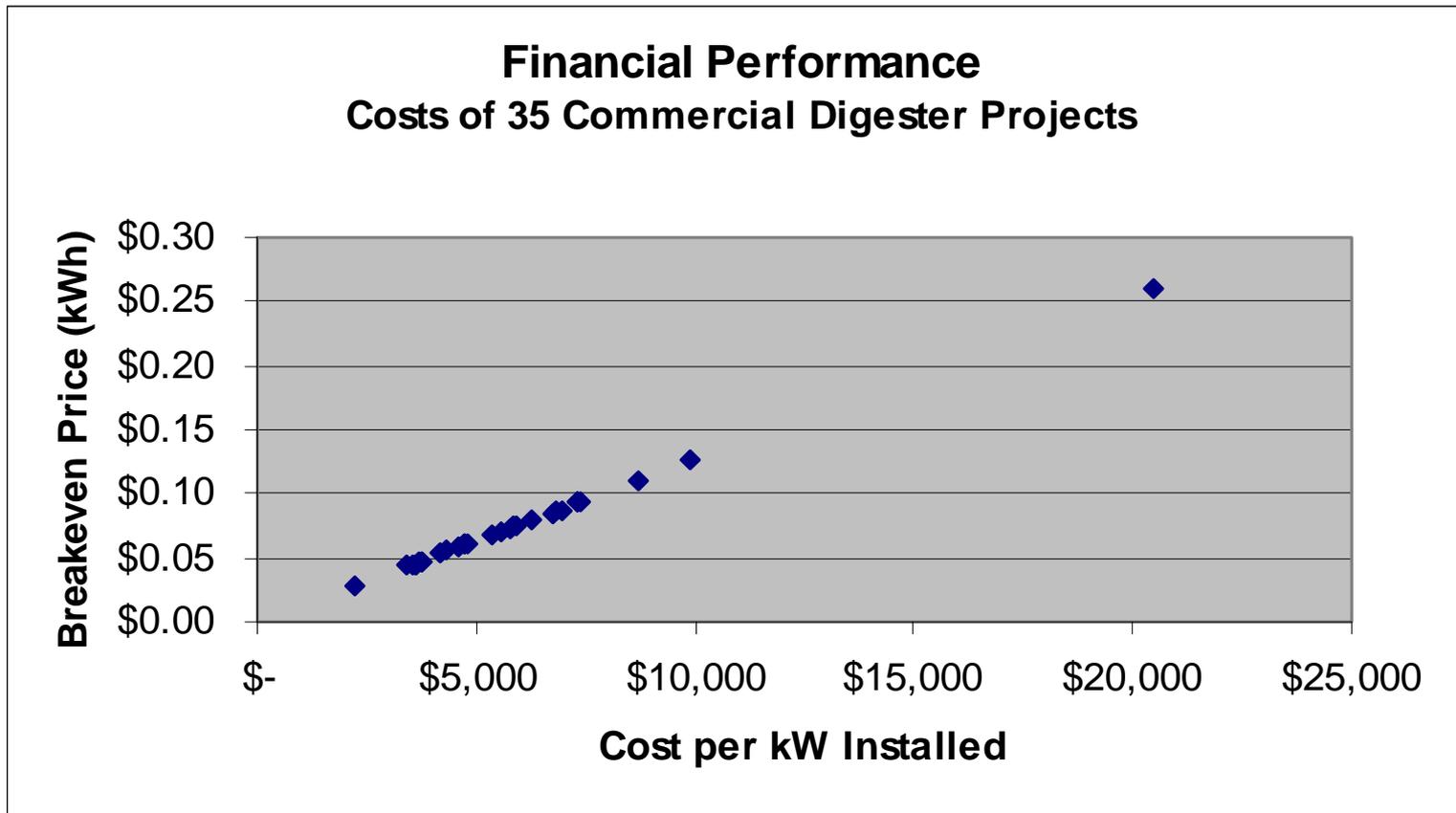


In 2006

All 'operating' projects ~275 million kWh equivalent.

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

Cost Ranges

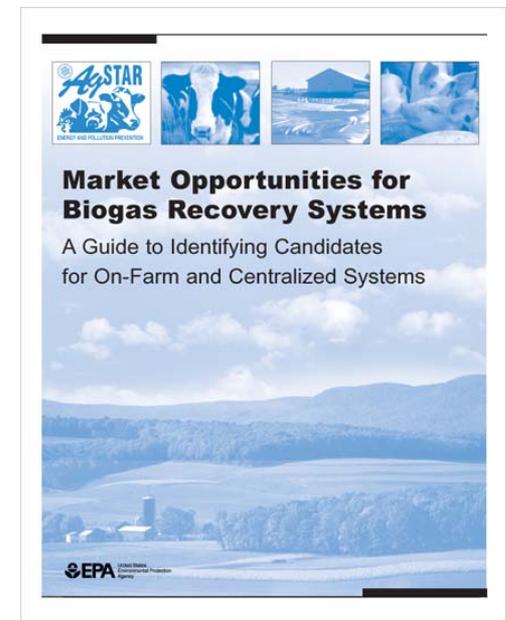


Key A.D. Drivers

- **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
- **Carbon Markets**
 - Carbon industry growing in US
 - Numerous transactions have occurred
- **Energy**
 - Net Metering Legislation – state by state
 - Green Pricing Programs
- **Regulatory**
 - Water and air concerns are increasing at local, state, and federal levels

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!

Xie xie!