AD in Agriculture - a Global Perspective

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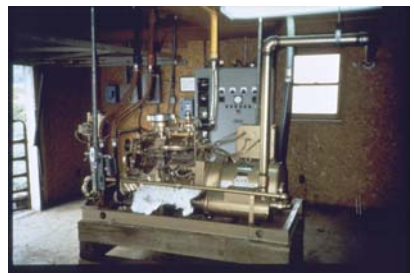


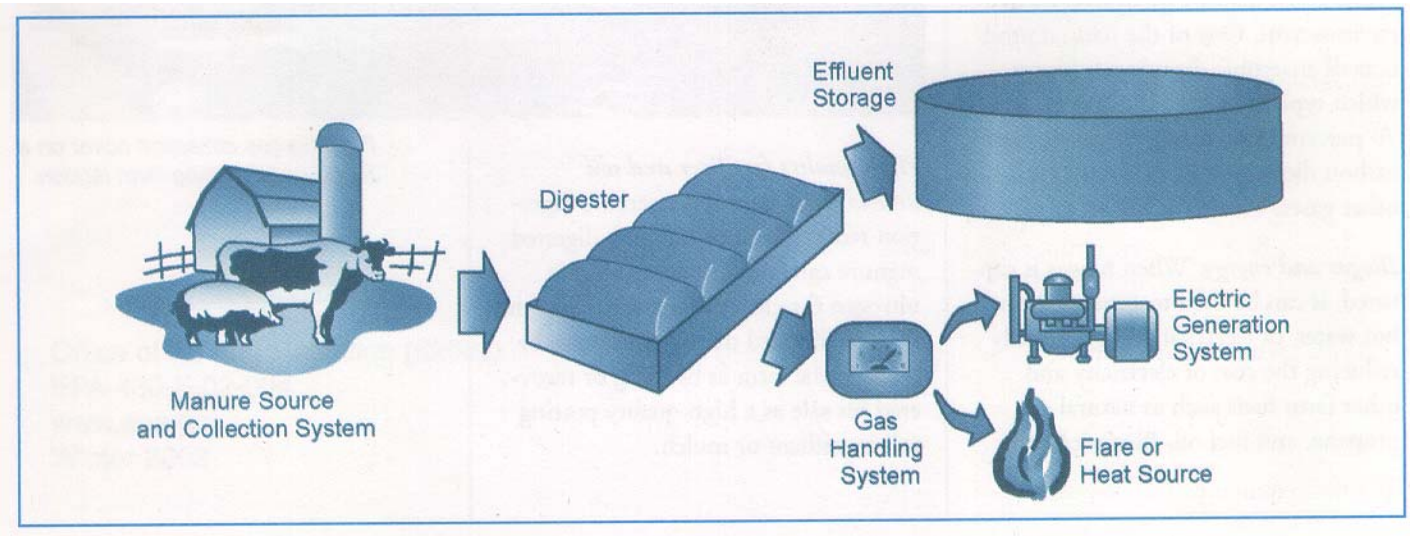
Presentation Overview

- What are anaerobic digesters?
- What makes them work?
- What kinds of wastes can be used?
- What kinds of systems are there?
- Where do they make sense?
- What benefits do they offer?
- What types of project approaches are there?
- What do they cost?
- Why we don’t see more of this in some parts of the world?

What are Anaerobic Digesters?

Biological treatment/stabilization systems applicable to liquid, slurry, and semi-solid waste that collect and combust off-gases.

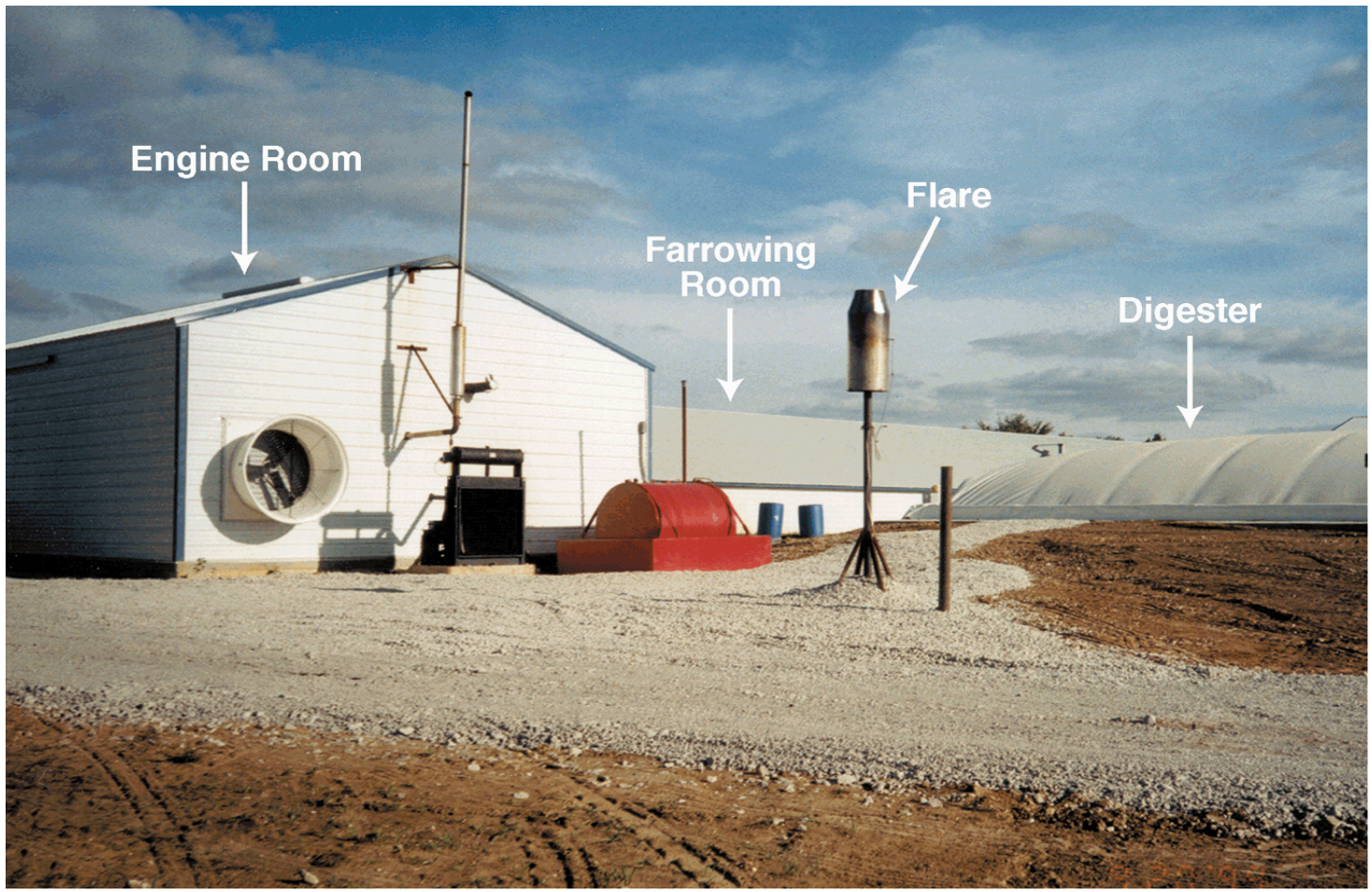
Digesters separate manure treatment from storage functions which can result in lower initial installation costs for new or expanding farms



Why Anaerobic Digesters?

1) Offer Air Quality benefits
   - -Control odors from storage and field application
   - -Reduces Greenhouse gases (methane)
   - -Controls other emissions (H_2S, 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

Typical Digester Configuration



Environmental Retrofit

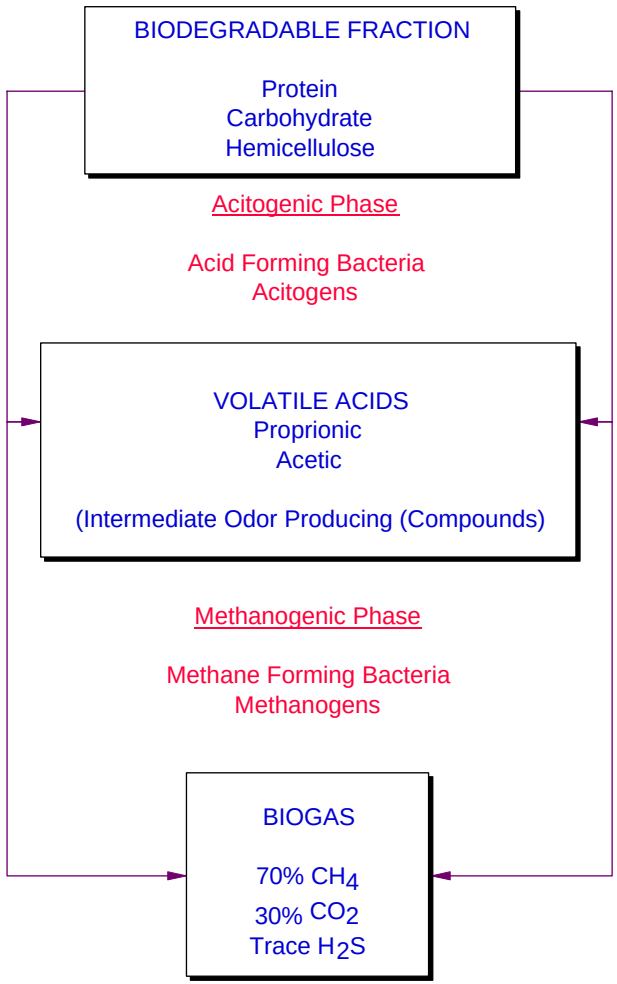
Retrofit Plan

Before

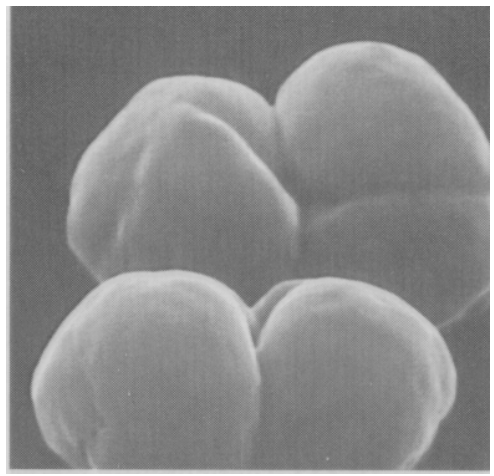
After

What Makes Digesters work?

Anaerobic digestion is a biological process. It occurs in an oxygen free environment.



Methanogens



Suitability of Waste Materials

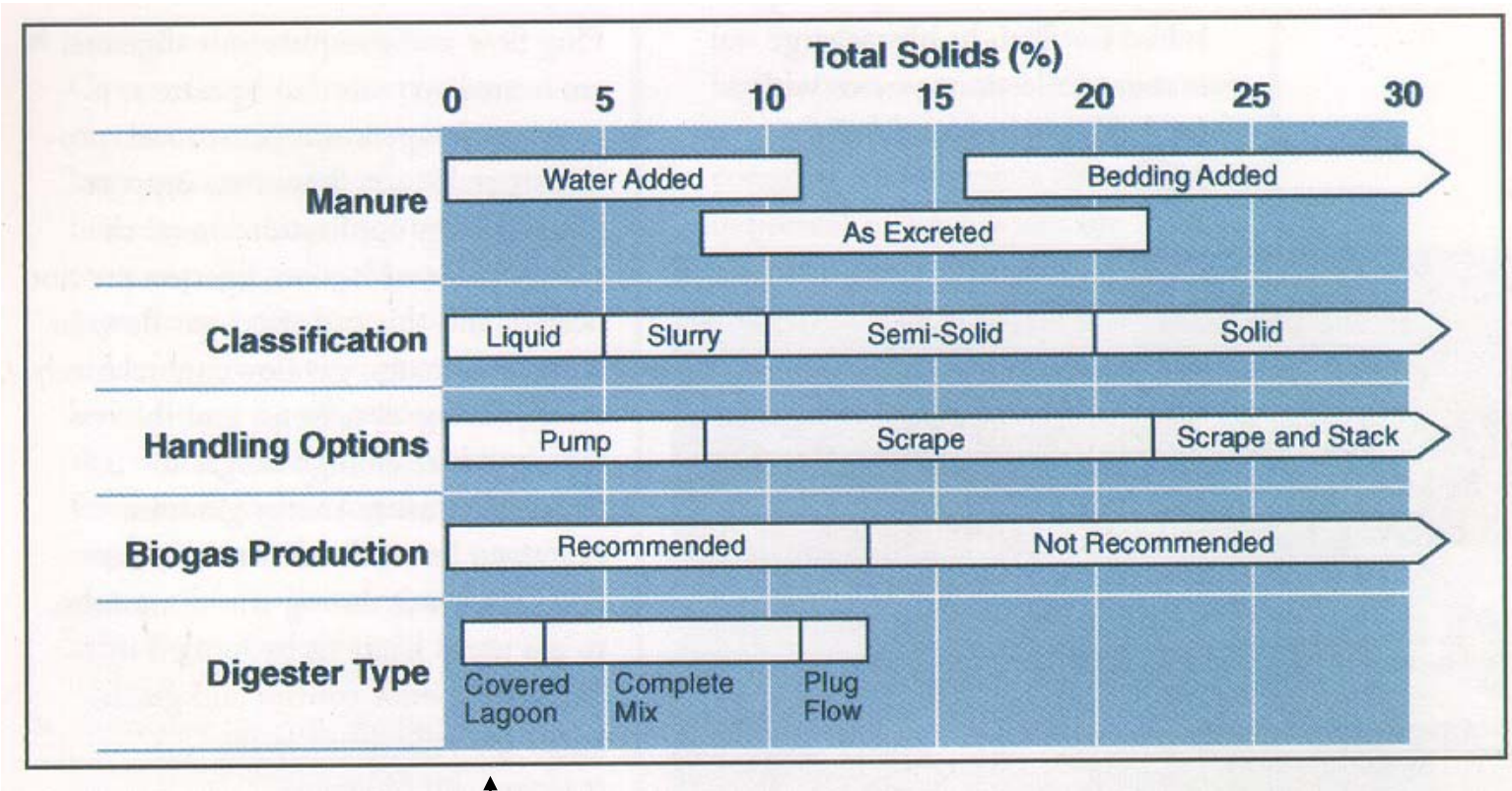
Type	Biodegradability	Fraction Digested
Blood, slaughter house wastes, greases, whey	Very high	>90%
Pig waste	Moderate	@55-65%
Dairy waste	Moderate	@30-40%
Broiler waste	Low	@10-15%
Straw	Very low	<5%

All values are approximate

Some substrates can increase methane emissions depending on baseline

Digester Selection

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



Attached Film

Unheated Digesters

Covered Lagoon Digester and Attached Media <2% TS

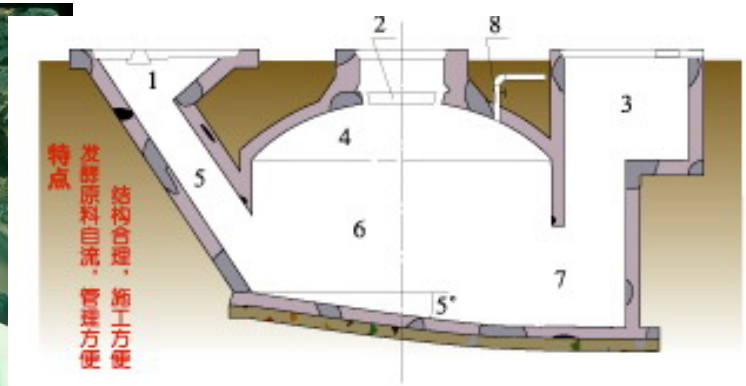
Bank-to-Bank Cover

Modular Cover

Attached Media

More Unheated Digesters

Small - Intermediate Scale Digesters



Heated Digesters

Plug Flow Digesters 11-14% TS - Dairy Manure Only

Heated Digesters

Mixed Digesters (5-10% TS)

Heated Digesters

Insulated Covered Mixed Lagoon Digester (5-10% TS)

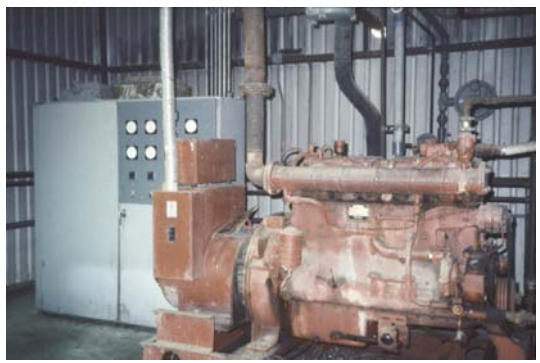
Gas Use: *Electric*

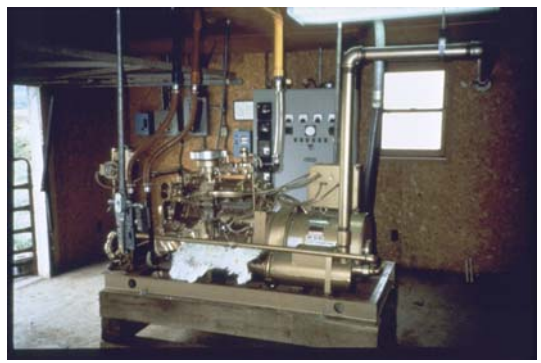
Recip. Engines 40-150kW

Engine Controller

Net Metering

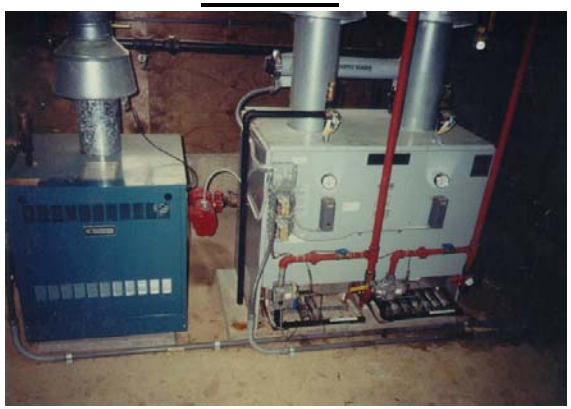
More Engines



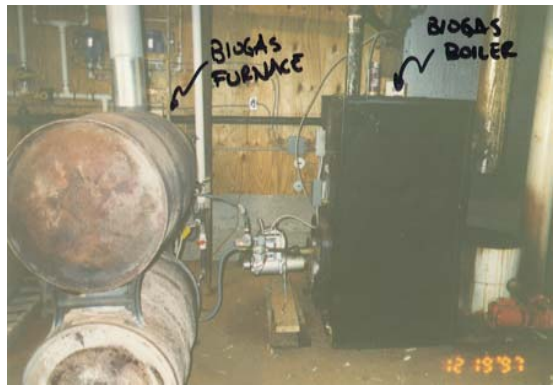


Gas Use: *Heat*

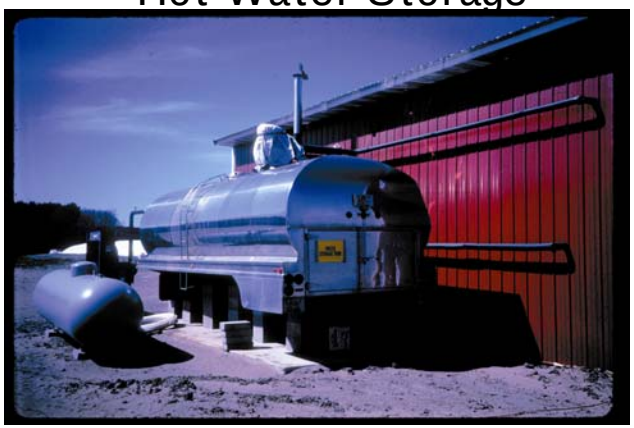
Boilers



Forced Air



Hot Water Storage

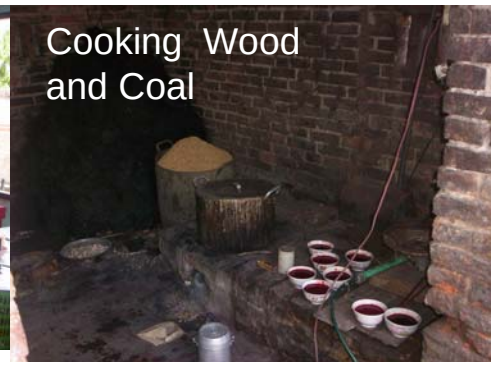


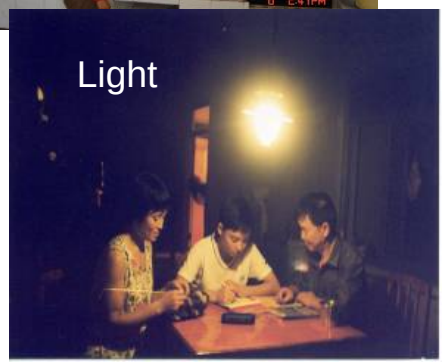
Hot Water Use

Gas Use: *Flares*

Odor Control and Greenhouse Gas Mitigation

Other Gas Use Options

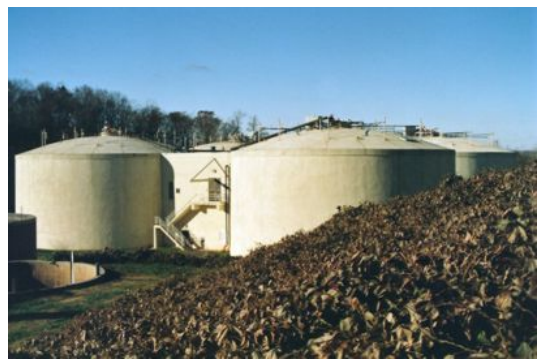




Project Types

- On-Farm or Farm Scale: System is owned and operated by farm owner/manager

- 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)



Methane Emission Baselines

Factors effecting methane emissions:

1) Manure type
2) Manure handling (liquid, slurry, semi-solid, solid)
3) Temperature and time

AMWS Systems and Methane Emission Factor by Climate Type									
	Manure Management System								
Climate	*Lagoon*	*Liquid and Slurry*	*Solid Storage*	*Dry lot*	*Pit <1 month*	*Pit >1 month*	*Daily Spread*	*Digester*	*Other*
Cool	90%	10%	1%	1%	5%	10%	0.10%	10%	1%
Temperate	90%	35%	1.50%	1.50%	18%	35%	0.50%	10%	1%
Warm	90%	65%	2%	5%	33%	65%	1%	10%	1%

Calculating Methane Reductions

Example: 500 cow dairy with varying baseline waste management systems in a warm climate

	Waste System Types		
	Daily Spread	Liquid/Slurry Storage	Lagoon
(A) Baseline Farm - MCF	1%	65%	90%
Baseline Methane Emission - MT/yr	1.9	120.3	166.6
(B) MT Combusted CH_4/Year[1]	185	185	185
(C) MT CO_2 Utility Emission Offset (as CH_4)	32	32	32
(D) Refractory Emission[2] @1% biodegradable VS	1.9	1.9	1.9
MT Methane Reduction/Year[3]	0.0	-118.5	-164.8
as CO_2	0	-2,488	-3,460
as C_{arbon} $E_{quivalent}$	0	-679	-944

Notes:

[1] For this farm energy capacity is about 80 kW. Energy output is about 69 kWh/hr.

[2] Remaining biodegradale VS results in refractory emissions, assumed

[3] Positive value indicates increase in emission

General Costs: *Livestock Basis*

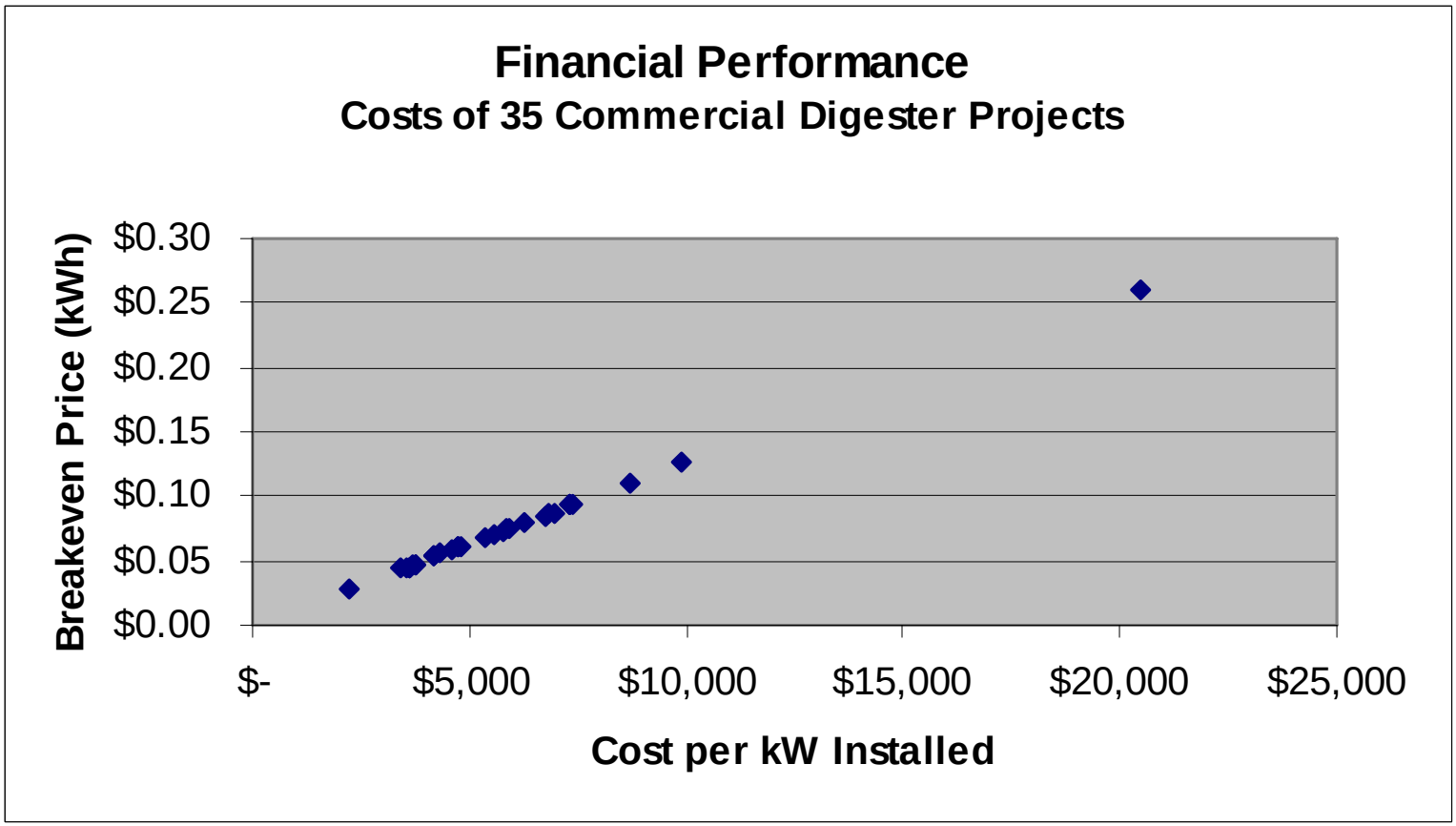
Digester Type	Cost per Cow (1,400 lbs.)
Attached Media	$500-800
Complete Mix	$400-700
Covered Lagoon	$300-1,000
Plug Flow	$400-700

Swine equivalents: 4 sows = cow;10 feeder pigs = cow

Note: Cost assumes all manure is collected

Costs include engine gensets and separator (dairy systems)

Cost Ranges can be Larger

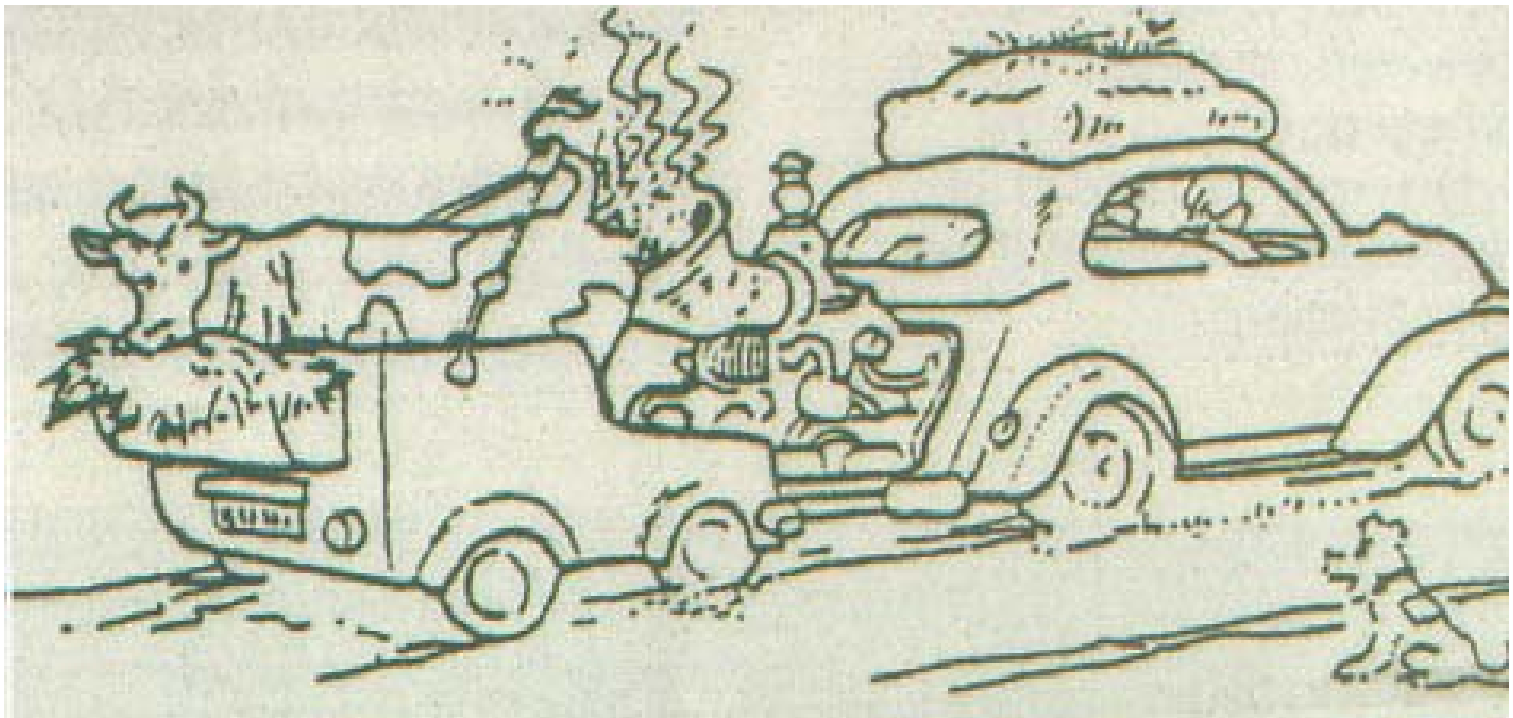


Market Barriers

- **Technical**
  - Reliability
  - Available service, parts, and technical support
  - Operational complexity
- **Policy**
  - Lack of environmental requirements or enforcement
    - Air and water quality
  - Energy policy – is renewable energy really desirable or only political?
    - Energy rates and interconnection

- Economic
  - Systems can be expensive but need to be affordable
    - Favorable energy rates
    - Financial assistance
    - Industry *Codes of Practice* - labeling

And that's all for now...



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