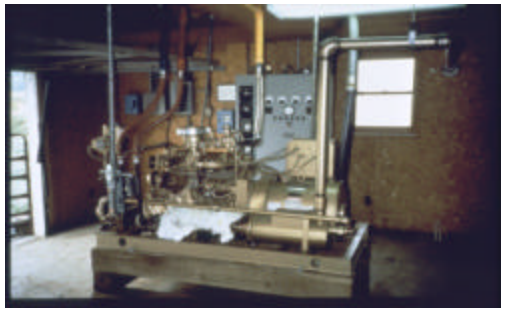

Status of Existing and Emerging Biogas Production and Utilization Systems

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AgSTAR Program
U.S. Environmental Protection Agency

Background

- 1996 - first set of interim USDA digester standards developed based on record of commercially operating animal waste digesters at U.S. Farms.
  - Criteria included:
    - Operational on animal waste for >1 year at design load and steady state
      - Specific to animal type and waste handling methods
    - Replication preferred
- Resulted in three interim standards
  - Ambient temperature covered lagoons
  - Mesophilic Complete Mix Digesters
  - Mesophilic Plug Flow Digesters
- By 2003 U.S. doubles number of operating systems

In 2004

- USDA issues National Anaerobic Digestion Practice Standards
- Currently 50 digesters in operation
  - On-farm - owned and operated by farm owner or manager
    - Typically require farm friendly simpler digester technologies
  - Centralized - where multiple farms provide waste to a facility owned and operated by a third party.
    - Can use an array of simpler to more complex digestion technologies
- Majority have been successful
    - Some have had difficulties – very few failures
      - Equipment, construction quality, design
- Demand is growing
  - Additional 60 systems in either construction, start-up or planning phases
- Reliability and cost effectiveness will be key to sustain demand

Current On-farm Digester Technologies

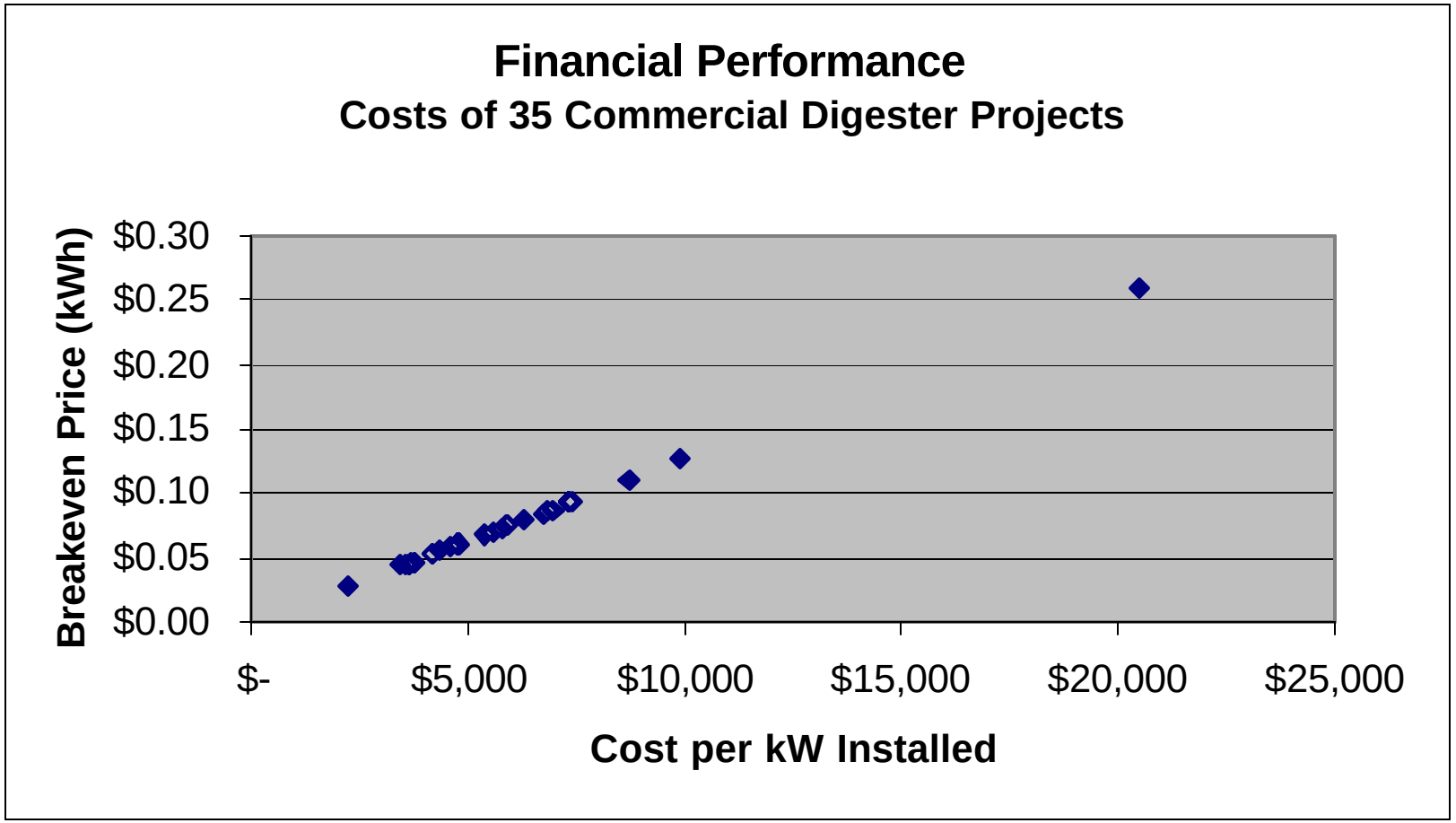
- Mesophilic Complete Mix Systems
  - Concrete Tank w /Flexible top
  - Concrete Tank w /Hardtop
  - Above ground tank w/Hardtop
  - Mixed Covered Lagoons
- Mesophilic Plug Flow Systems (Dairy only)
  - Vertically mixed concrete tank w/ hardtop
  - Concrete tank w/flexible top
  - Concrete tank w/ hardtop
- Unheated Attached Media
  - Above Ground Tank w/ Hardtop
- Unheated Covered Lagoons
  - Bank-to-bank
  - Modular

Current Centralized Digester Technologies

- Mesophilic Plug Flow
  - Concrete tank w/ flexible top
  - Vertically mixed concrete tank w/ hardtop
  - Concrete tank w/ hardtop
- Thermophilic - Mesophilic Complete Mix
  - Above ground tank w/ hardtop

- Other On-farm and centralized technologies being applied
  - Mesophilic attached media
  - Thermophilic processes
  - Two phase processes

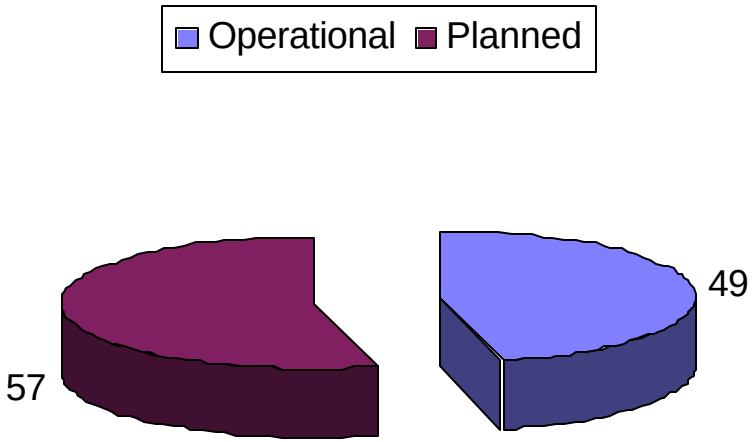
Technologies Have Large Cost Ranges!



Summary of Operating and Planned Digester Technologies

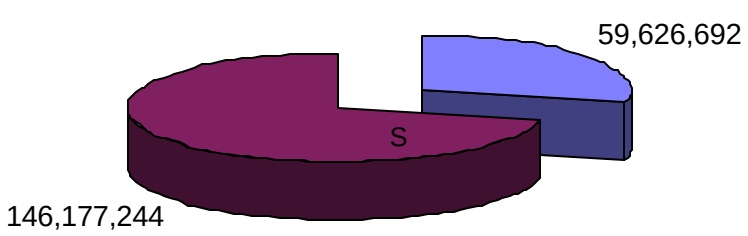
- How many?
  - Of what project type
  - Of what technology type
- How much energy
  - Of what project type?
  - Of what kind of technology?
- Historical trends and greenhouse gas reductions?
- Important considerations as technology market diversifies.

U.S. Animal Waste Digesters

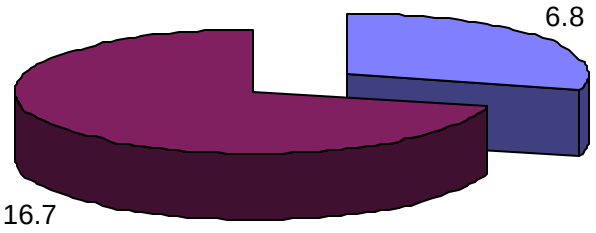


106 Total Systems

Energy Production (KWh/year)



Power Production (MW)



Notes:

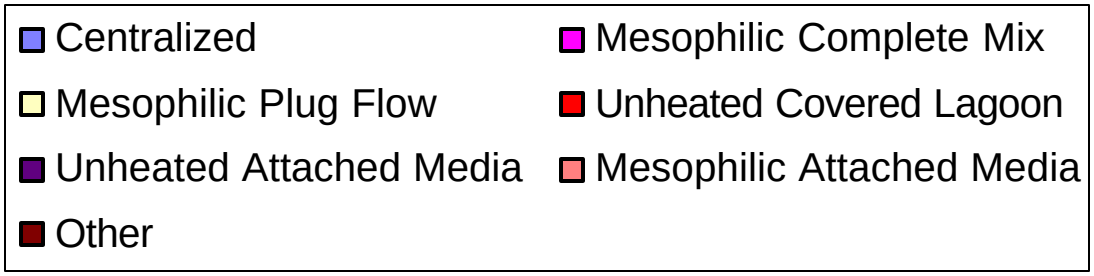
Analysis assumes 90% operational efficiency.

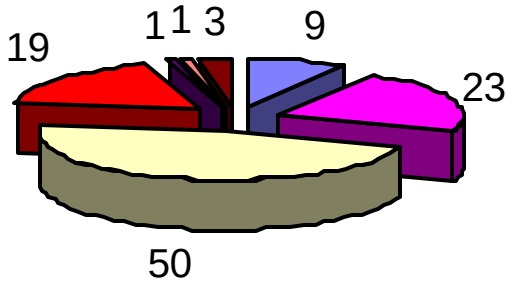
Analysis is energy equivalent as some projects are for heat, odor control and greenhouse gas reduction.

Some operational projects have not bee verified,

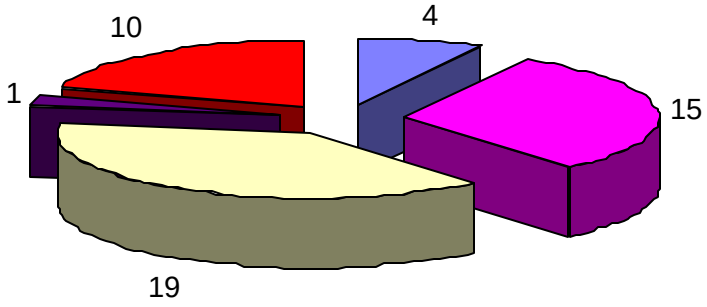
All planned project performance has not been verified and are assumed to be successful

Total Digesters by Type

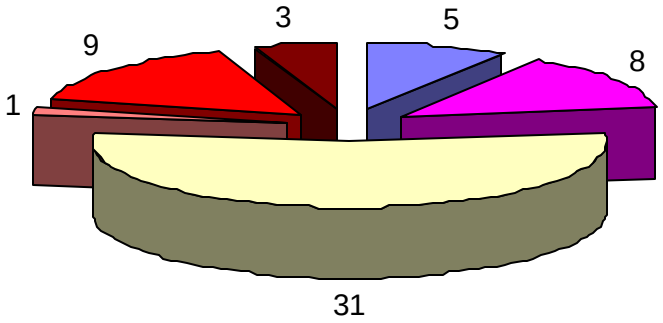




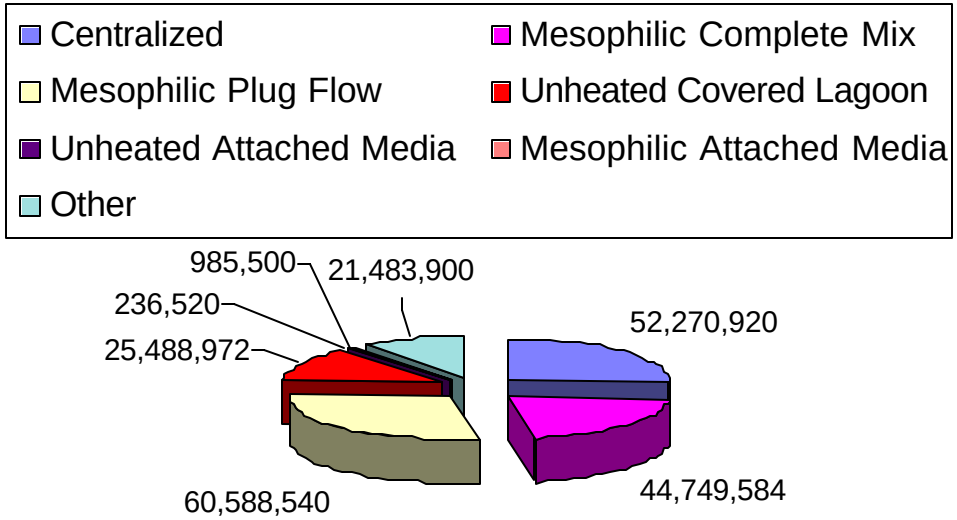
Operating Digesters by Type



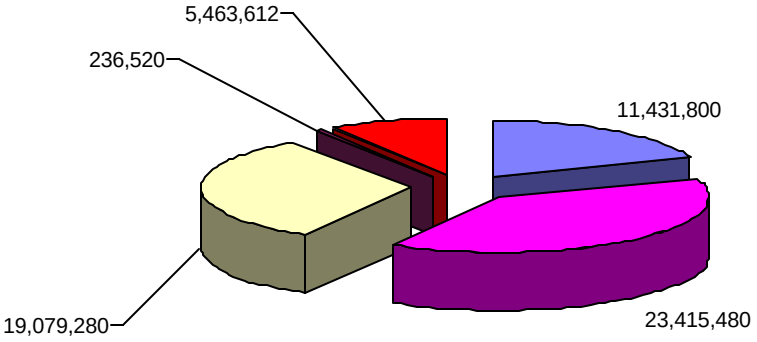
Planned Digesters by Type



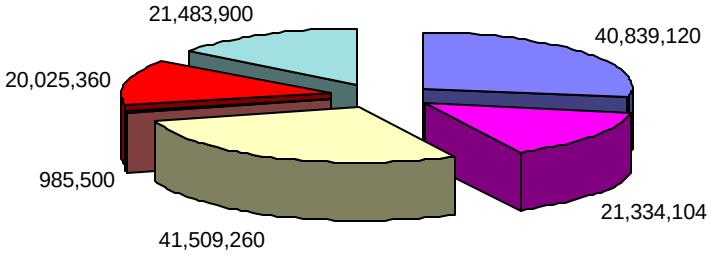
Energy Production All Digesters



Energy Production Operating Digesters



Energy Production Planned Digesters



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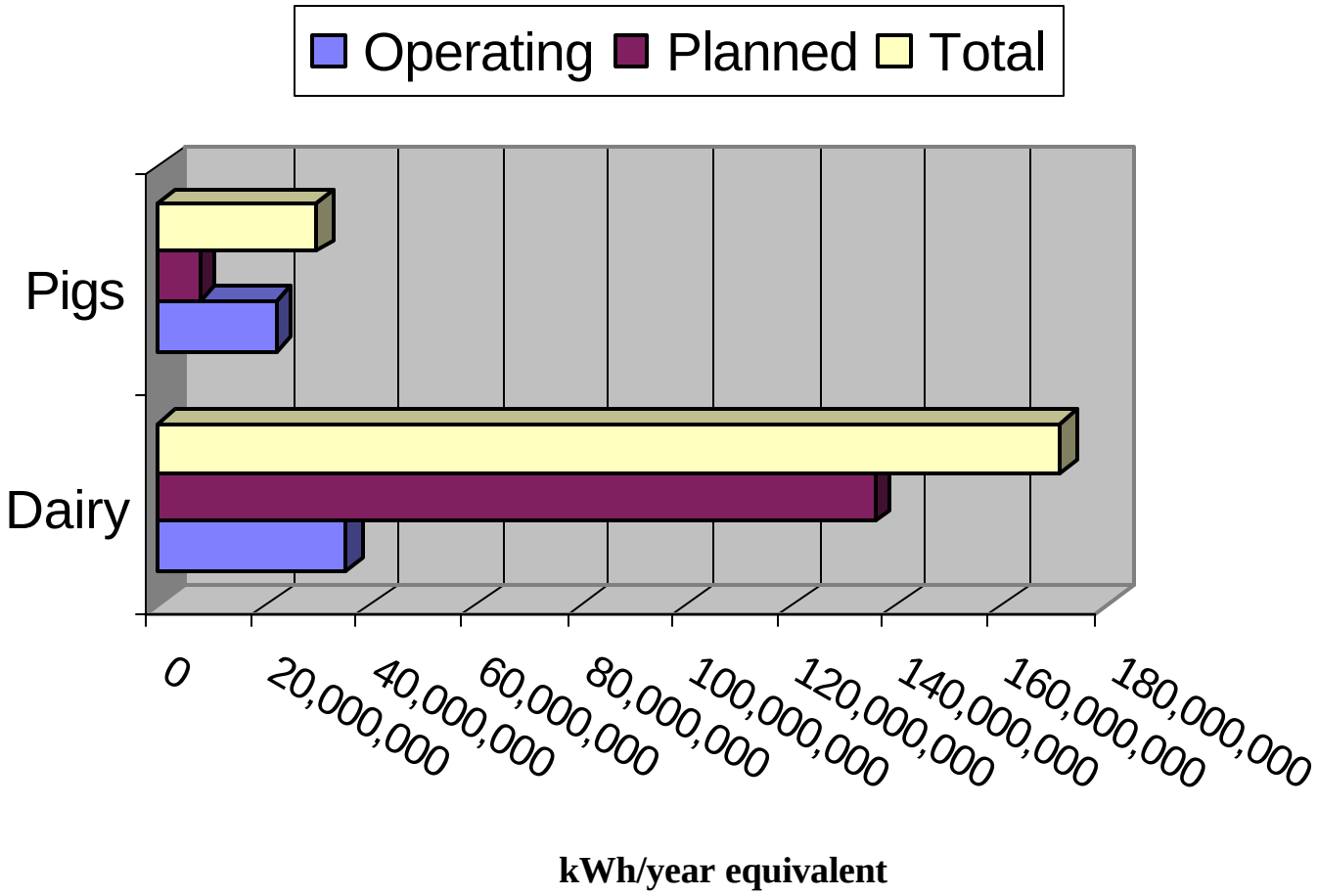
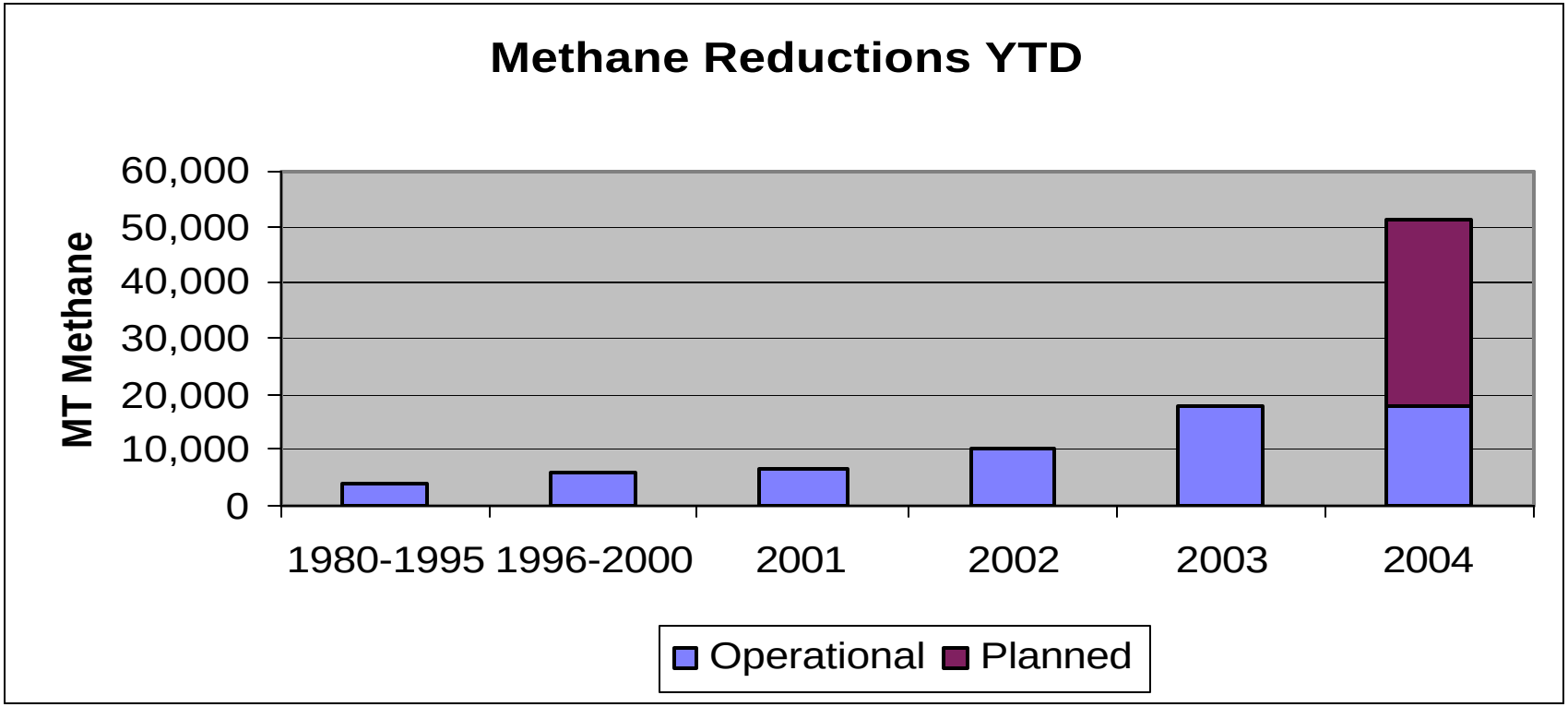
Current Renewable Contribution by Industry



Greenhouse Gas Reductions



GHG Reductions Will Not Equal Energy Production

Example: Comparative 600 Cow dairy with varying baseline waste management systems

	Waste System Types		
	Pasture Graze	Storage	Lagoon
(A) Baseline Farm - MCF	1%	30%	80%
Baseline Methane Emission - MT/yr	2.2	66.6	177.7
(B) MT Combusted CH_4/Year[1]	222	222	222
(C) MT CO_2 Utility Emission Offset (as CH_4)	39	39	39
(D) Refractory Emission[2] @3% biodegradable VS	6.7	6.7	6.7
MT Methane Reduction/Year[3]	4.4	-60.0	-171.0
as CO_2	93	-1,260	-3,592
as C_{arbon} $E_{quivalent}$	25	-344	-980
Notes:			
[1] For this farm energy capacity is about 90 kW. Energy output is about 80 kWh/hr.			
[2] Remaining biodegradale VS results in refractory emissions.			
[3] Positive value indicates increase in emission			

Lets Not Do this Again!

Need for Standard Evaluation Protocol