Carbon Management Workshop: Digester Economics for a Complete Mix Digester

3/27/12

AgStar 2012: Got Manure?

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UTS Residual Processing, an Anaergia Company

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Economics of Total Mixed Digestion

1. Introduction
   a. Who is Anaergia
   b. The UTS Advantage
2. The Total Mixed Digester
3. What impacts the Design and Cost of a Digester:
   1. Manure Management and Bedding
   2. Ambient Conditions
4. Impact of Substrates on a Mixed Substrate Design
5. Digester Economics based on Dairy Herd Size
6. Summary

Anaergia Group of Companies

UTS Biogastechnik, GmbH

UTS Products, GmbH

UTS Residual Processing, LLC

UTS Bioenergy, LLC

Pharmer Engineering Inc.

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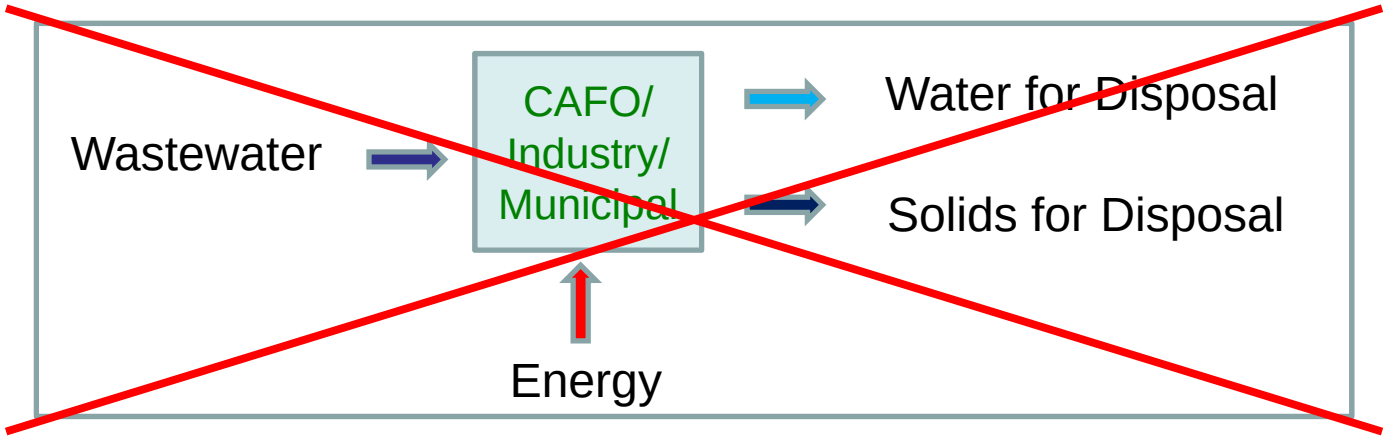
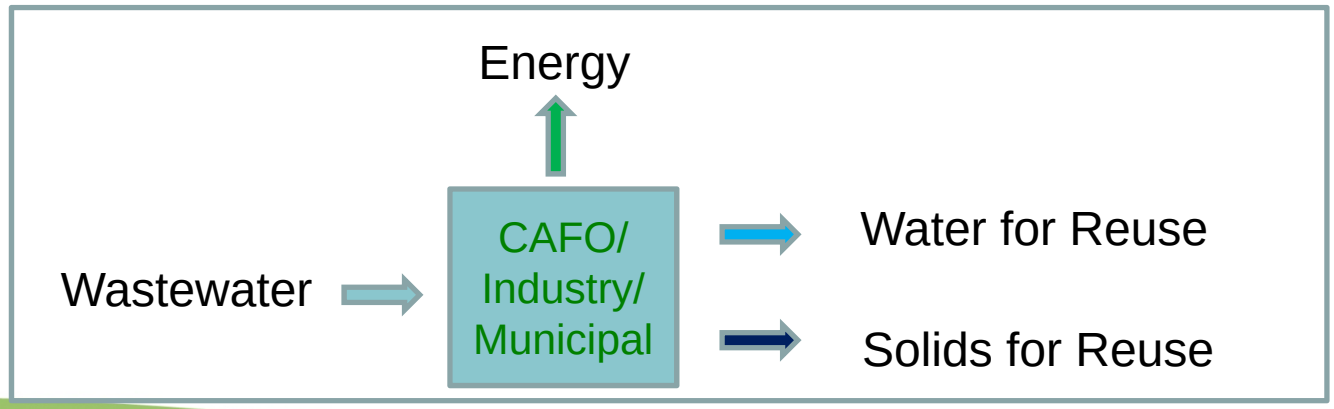
Anaergia / UTS in North America

- Anaergia Inc. Headquarters – Toronto, Canada
- 4 offices and 50 employees across US and Canada
- UTS Bioenergy - Encinitas, California
  - Energy project financeer/developer
  - Fuel cell and CHP PPAs
  - Biomethane upgrading for vehicle fueling and pipeline injection
- UTS Residuals – Eaton Rapids, Michigan
  - Develop biogas projects for Agricultural applications and UTS equipment

Waste and Wastewater Treatment



Today



Tomorrow

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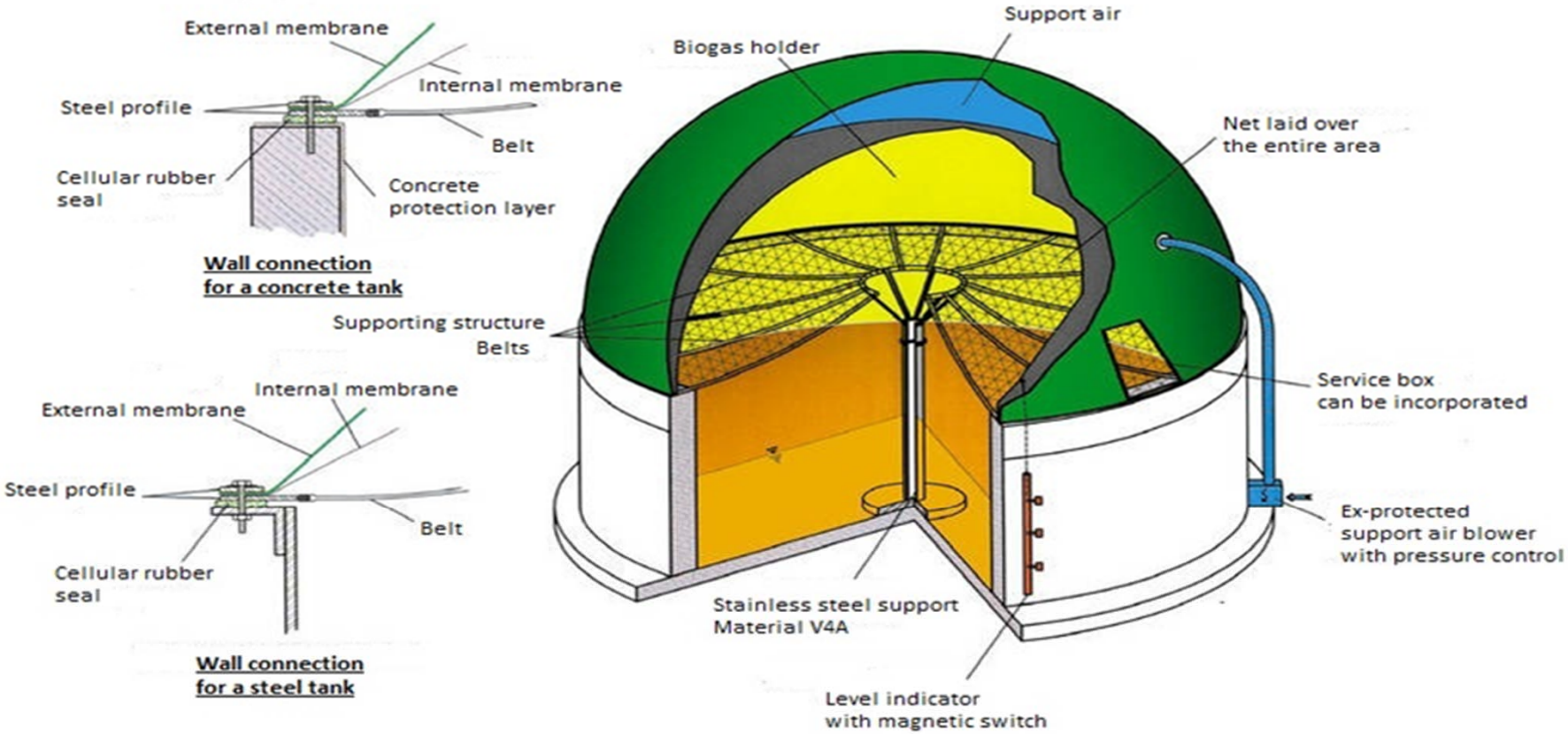
2.0 Typical Total Mixed Digester

Double-layer membrane biogas holder roof



3.0 Design Factors... Implied Cost

- Manure Management Technique will have significant impact on the design of the digester; both conveyance, sizing, hydraulic and solid detention times and organic loading rate.
- Ambient temps and environmental conditions will impact parasitic loads and heating requirements
- Available substrates, haul distances, stability of substrates.
- When and how to mix
- Pasteurization: Class A digestion residuals

Why are Manure Management and Bedding Significant Factors?

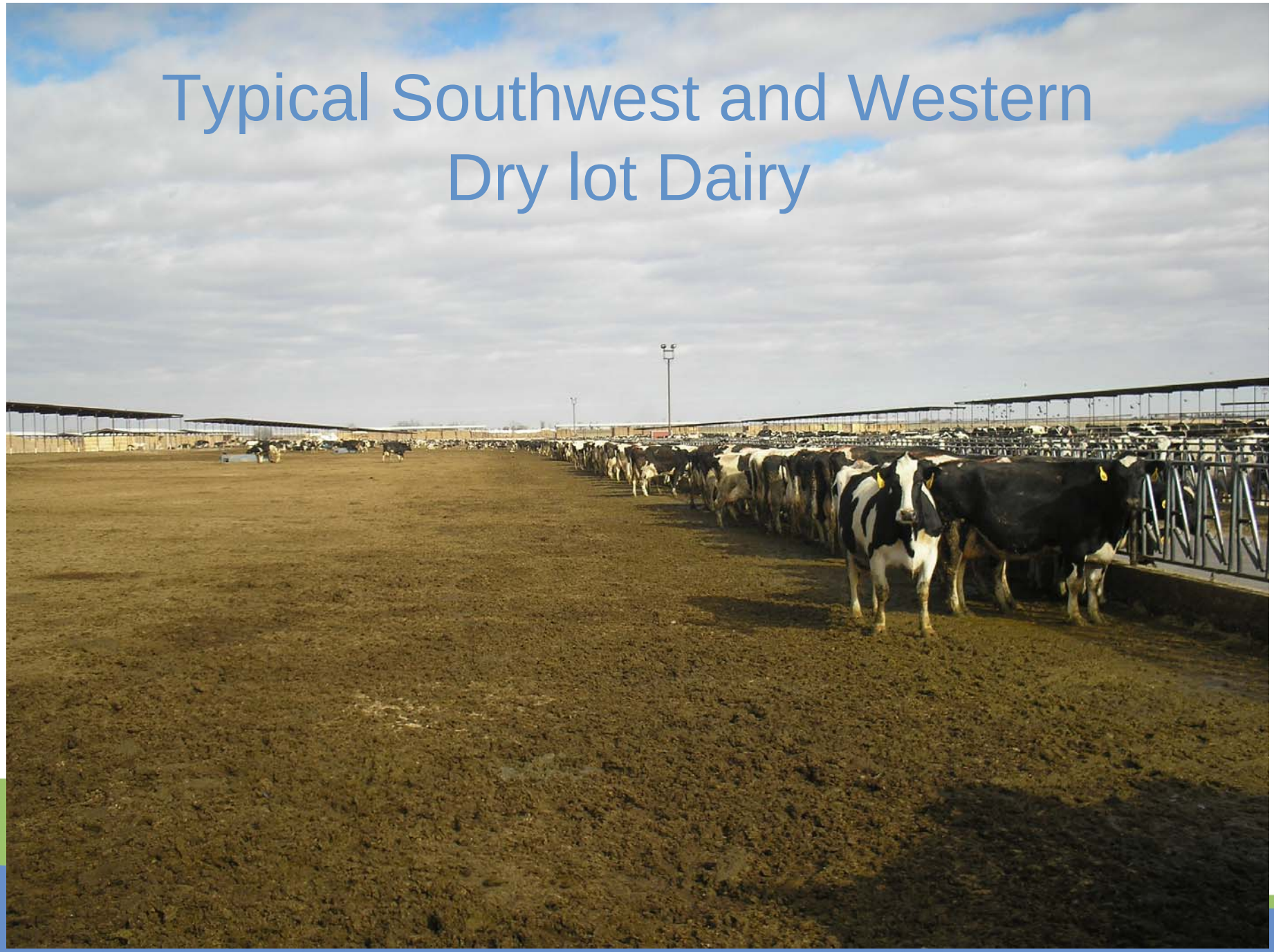
- Manure Management
  - Scrape; Free stall is the most suitable for whole effluent, high solids digestion,
  - Flush Flume; alternative. Thickening is possible but key is to digest both solids and liquid fractions.
  - Flush; Problematic. Higher volumes; high loading or recycle important to prevent washout.
  - Dry Lot; environment critical. May be so may cows but so little USEABLE manure; Open lot Flushed, worst of both worlds
- Bedding:
  - Organic including Rice Hulls, Compost, Digested Solids(the economics of a number of Dairy Digesters has been based on Bedding);
  - Sand;
  - Other.

Some other Issued with Dry Lots and Flushing

- Dry Lots
  - Collection of manure on a dry lot is problematic:
  - Collection contamination;
  - The longer the manure is left on the lot more the volatile solids are lost;
  - One day on the feed lane yields manure that begins digestion more quickly with minimal loss of biogas potential.

Feed aprons – for daily scraping to digester

Typical Southwest and Western Dry lot Dairy



Typical Dry Lot Loading Corral Scrape

Dry Lot Manure Staging

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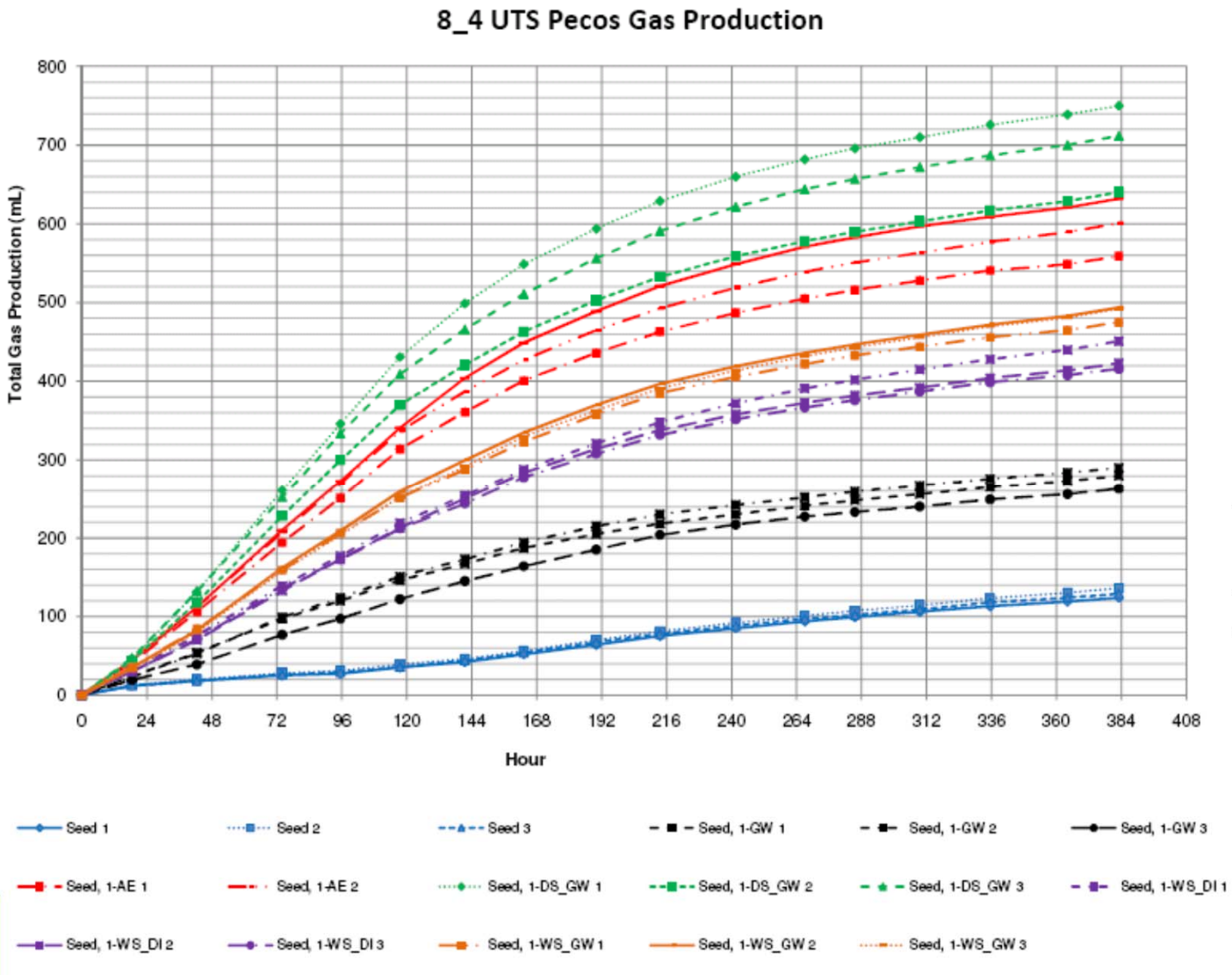
BioMethane Potential Testing Results



- Daily Scrape
- As-Excreted
- Weekly Scrape
- Green water
- Seed Stock

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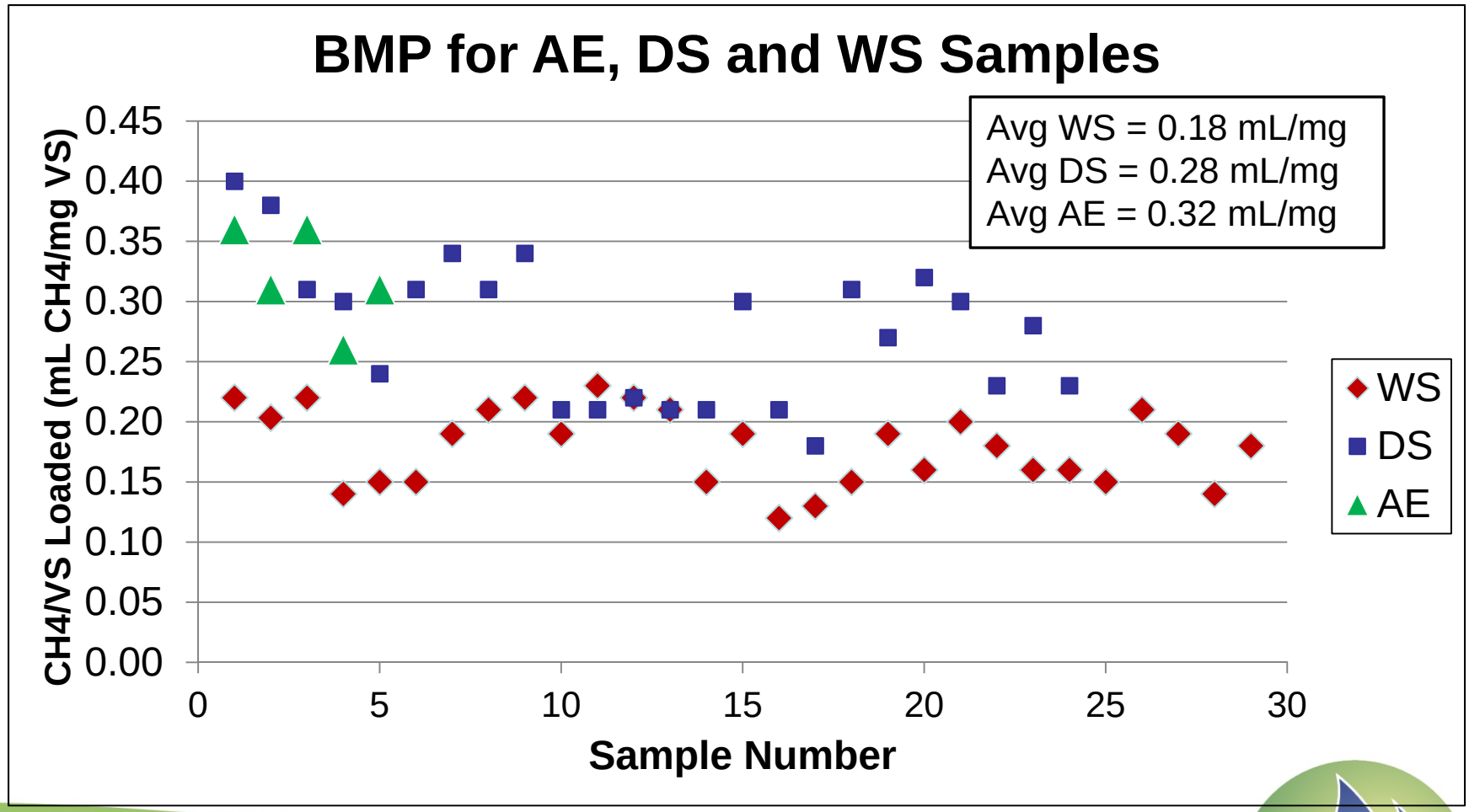

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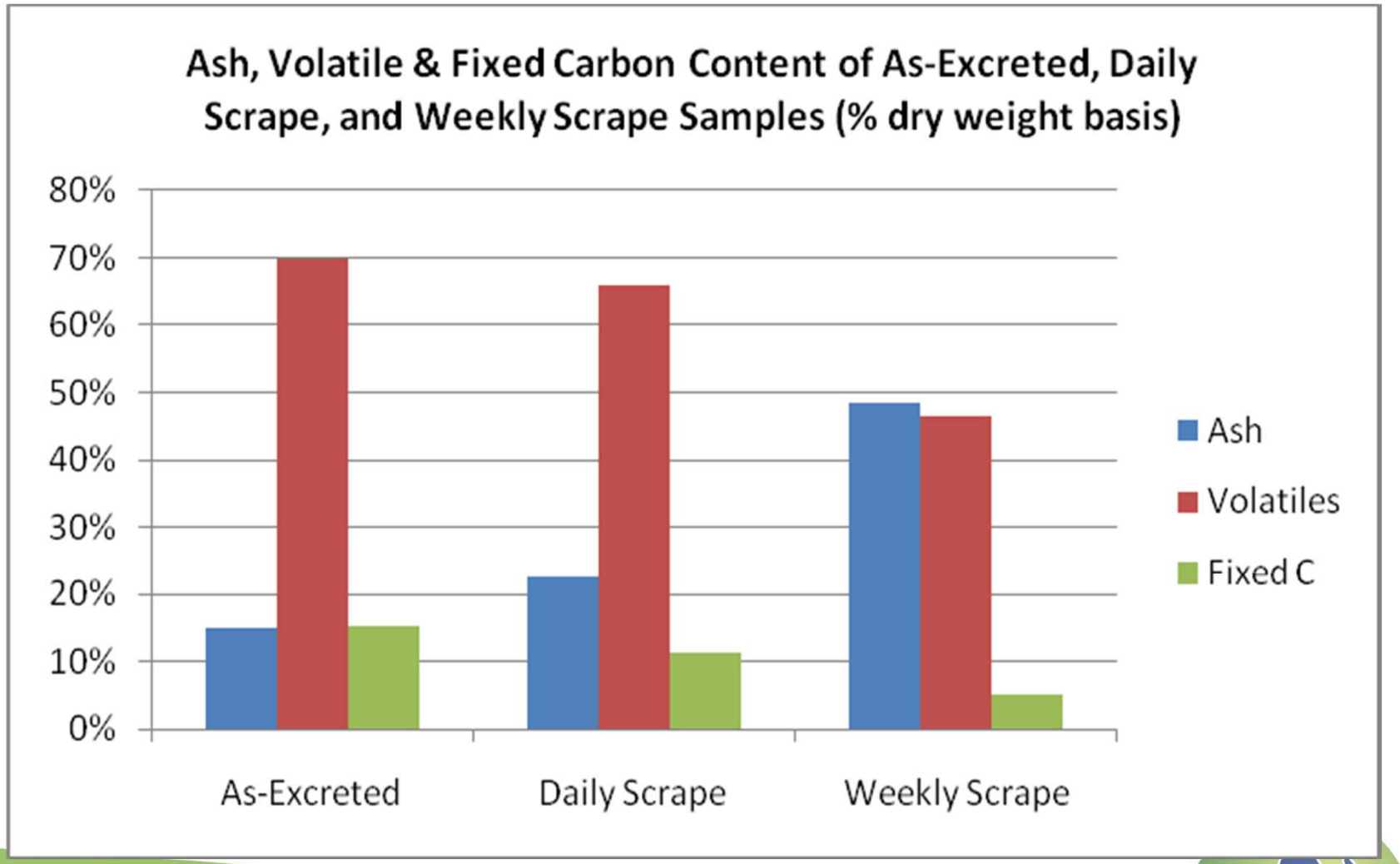

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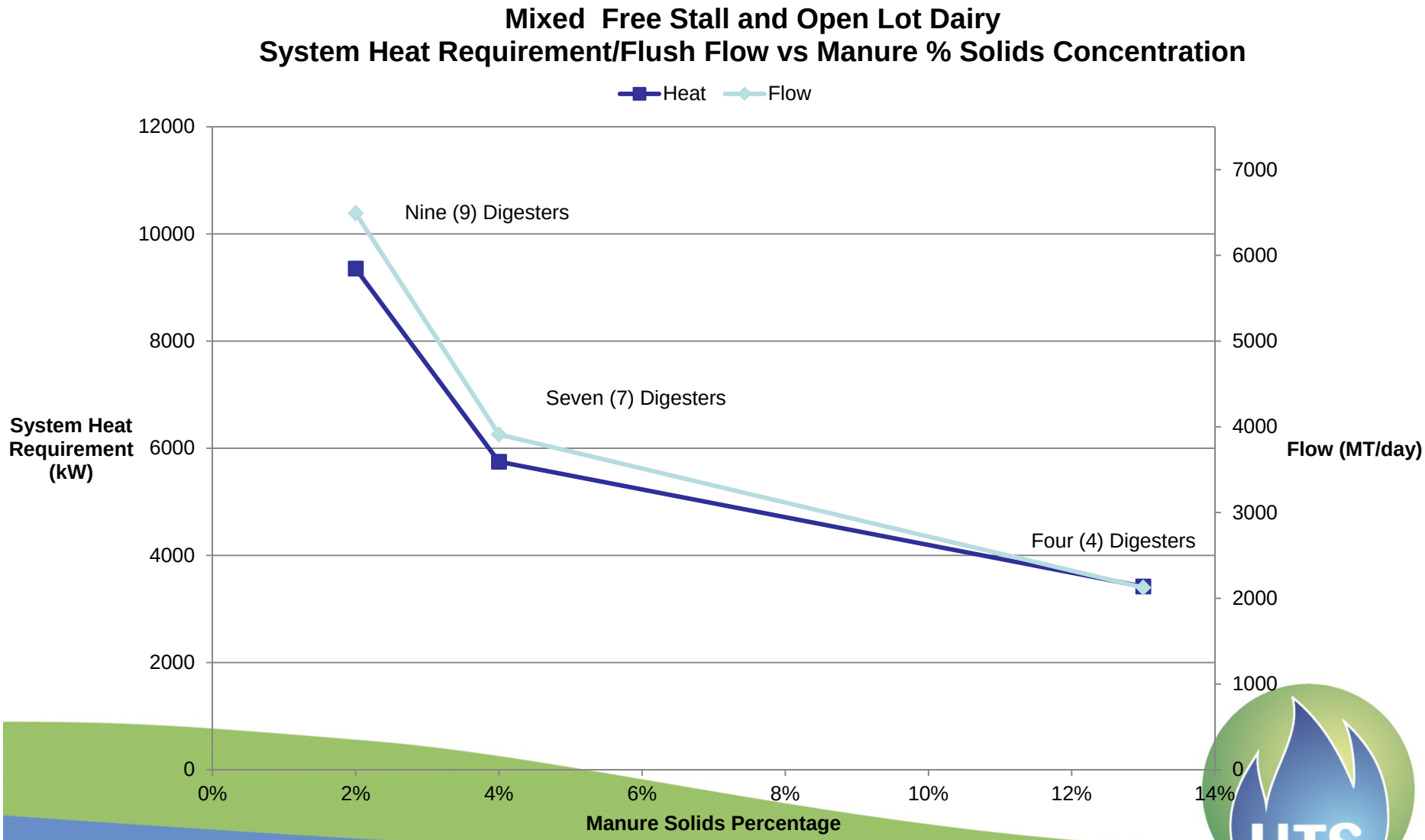
Flush Issues

- Flushing
  - Thickening of manure using screens is a way to recover manure solids for bedding or composting and not digestion,
  - The washed fibers will generate some biogas; solids from two stage separation will generate less than 25% of the biogas that whole manure will generate
  - Why?
  - Most of the gas generating compounds are soluble, dissolved and suspended solids which are not captured on a separator or via chemical recovery

How does flushing impact digester Economics?



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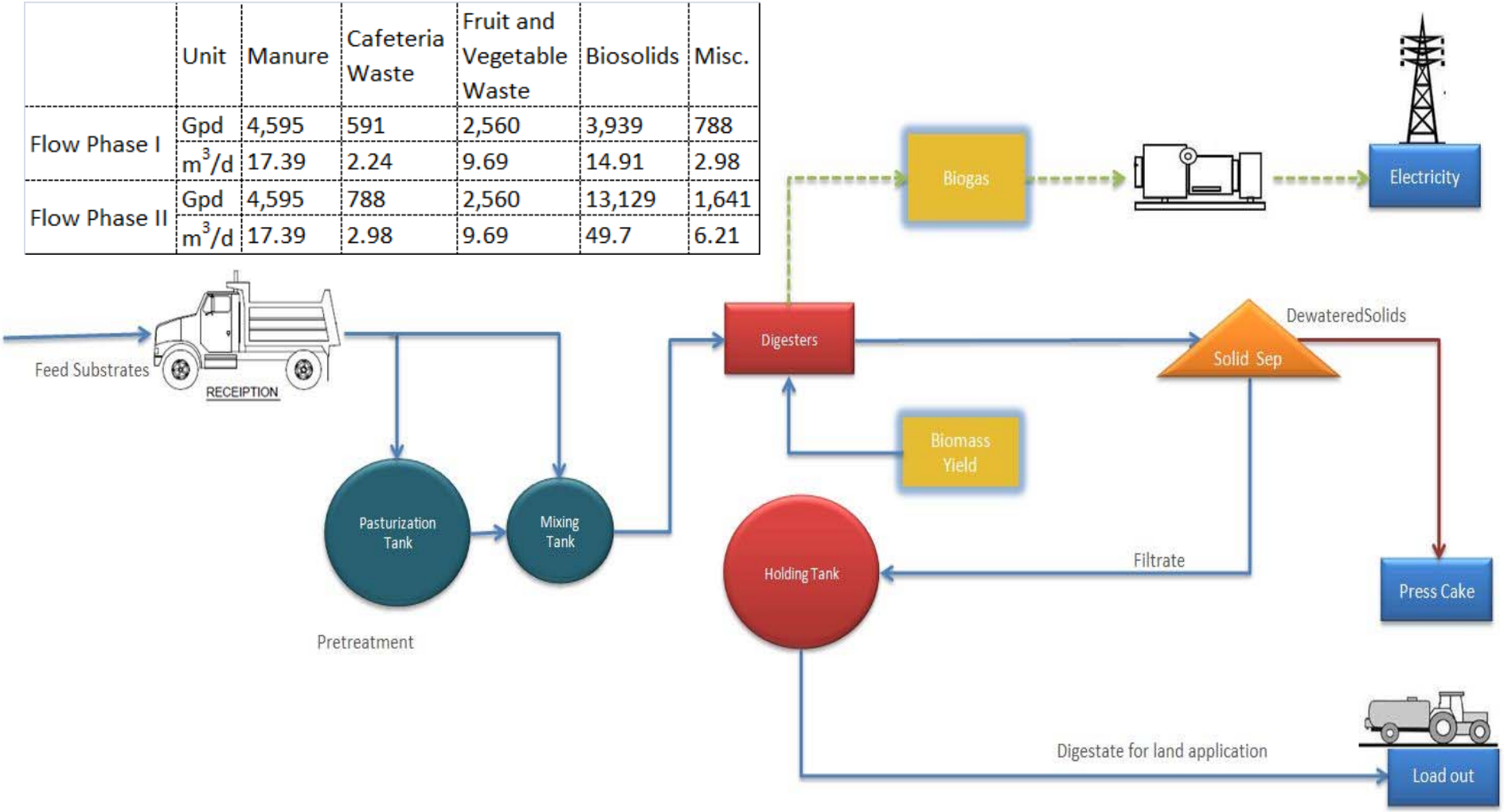
4.0 Mixed Substrate Case Study

- AD Project for mixed substrate
- Substrates included dairy and swine manures, food processing residuals, municipal waste activated sludge, cafeteria waste.
  - Develop project team, contractors, tank supplier, engines, etc.
  - P&ID, Pipe schedules, motor location diagrams, wiring schedules and layout drawings.
- UTS provided contractors with specifications and drawings to refine bids and reduce contingency.
- Goal to bring Contingency to minimum by having accurate tight bidding.
- In the end, the cost was within $100,000 of first cut estimate but contingency was cut significantly.

Design Basis & System Configuration

	Unit	Manure	Cafeteria Waste	Fruit and Vegetable Waste	Biosolids	Misc.
Flow Phase I	Gpd	4,595	591	2,560	3,939	788
	m^3/d	17.39	2.24	9.69	14.91	2.98
Flow Phase II	Gpd	4,595	788	2,560	13,129	1,641
	m^3/d	17.39	2.98	9.69	49.7	6.21



Project Summary

	Unit	Phase I Summary	Phase I (potential)*
Digester Volume	M^3	1,882	1,882
	US gal	497,327	497,327
Dilution Water Requirement	M^3/d	19.7	31.9
	Us gal/d	5,219	8,421
Hydraulic Retention Time	Day (assuming fresh water dilution)	28	21
Hydraulic Retention Time (assuming 50% recycle)	Day	33	25.6
Volatile Solids Fed	Kg/d	5,483.5	8,000
	Lb/d	12,089	17,637
Organic Loading Rate	KgVS/m3/d	2.91	4.25
	Lb/ft3/d	0.18	0.27
Biogas Production.	Scfm	68	138.6
	NM^3/d	2,759	5,653
CH_4 ,as % of Biogas	%	56	62
CH_4 Production	scfm	38	86.2
	NM^3/d	1,547	3,515

*Potential is calculated assuming the availability of 14 tanker loads of FOG per month
The system is designed to handle the above organic load with the exception of CHP

Project Summary, cont.

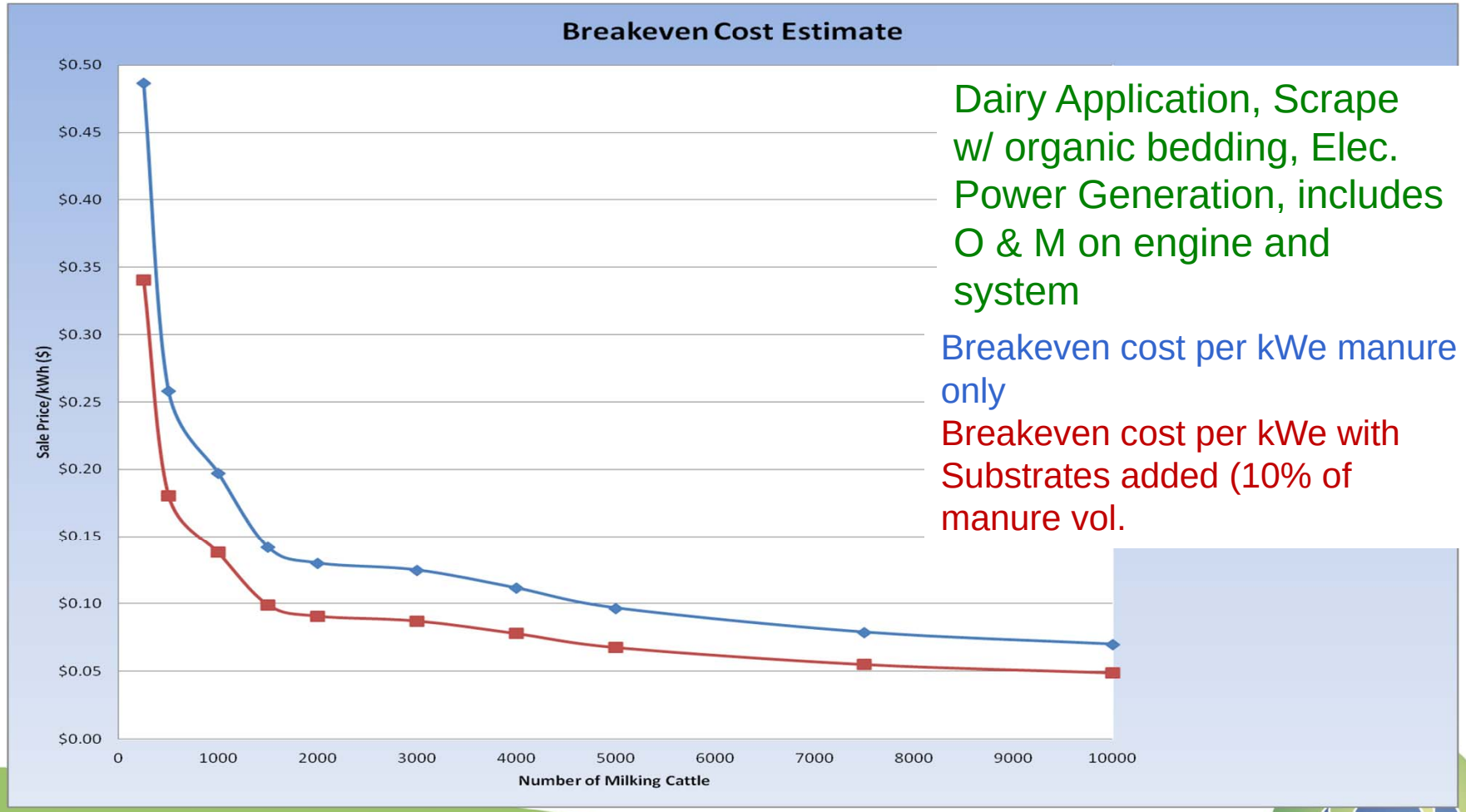
	Unit	Phase I	Phase I (potential)*
CH_4 Production	scfm	38	86.2
	NM^3/d	1,547	3,515
Energy Production	Electrical kW	250	571
	Thermal kW	297	675
Engine Efficiency	%	86.8%	86.8%
Engine Availability	%	95%	95%
Overall Efficiency	%	82.46%	82.46%
Annual Electrical Output	Electrical kWh/yr	2,080,500	4,752,000
	Thermal kWh/yr	2,464,000	5,617,000
Project Cost	USD	4,095,111	5,00,000 (projected incremental cost)
Capital Cost per Annual kWh Produced	USD/kWh/yr	$1.97	$0.97

*Potential is calculated assuming the availability of 14 tanker loads of FOG per month
The system is designed to handle the above organic load with the exception of CHP

Bid Summary and Analysis – Public Record

Firm	Base Bid Cost	Annual KW Power	O and M Cost	Estimated KWe 95% uptime	Cost per installed KWe	O & M Cost per Kwe	Corrected O&M Cost per Kwe no labor	Diff in CapX Cost Versus Firm 1	Corrected O&M for Labor vs. Firm 1
Firm 1	$ 4,095,111.00	2080500	$ 107,599.00	250	$ 16,380	$ 0.052	$ 0.016	$ -	$ -
Firm 2	$ 4,700,000.00	986800	$ 119,000.00	119	$ 39,637	$ 0.121	$ 0.060	$ 604,889.00	$ 11,401.00
Firm 3	$ 4,791,087.00	1905826	$ 34,660.00	229	$ 20,921	$ 0.018		$ 695,976.00	$ 2,061.00
Firm 4	$ 4,203,889.00	2483460	$ 40,010.00	298	$ 14,087	$ 0.016		$ 108,778.00	$ 7,411.00
Firm 5	$ 5,250,000.00	3593000	$ 61,250.00	432	$ 12,160	$ 0.017		$ 1,154,889.00	$ 28,651.00
Firm 6	$ 11,300,000.00	2049840	$ 40,000.00	246	$ 45,876	$ 0.020		$ 7,204,889.00	$ 7,401.00
Firm 7	$ 4,700,000.00	2000000	$ 45,000.00	240	$ 19,557	$ 0.023		$ 604,889.00	$ 12,401.00
Firm 8	$ 4,649,829.00	1975000	$ 36,800.00	237	$ 19,593	$ 0.019		$ 554,718.00	$ 4,201.00

5.0 Economics of Anaerobic Digestion based on Dairy Herd Size



Dairy Application, Scrape w/ organic bedding, Elec. Power Generation, includes O & M on engine and system

Breakeven cost per kWe manure only

Breakeven cost per kWe with Substrates added (10% of manure vol.

6.0 Summary: Economics of Digesters

- Best case is for a 3500 to 4000 head, fiber bedded, scrape management dairy 1 MWe could be realized from digestion of manure only.
- Flush systems become very problematic both in size and heating requirements;
- In general a scrape/organic bedded site will use 25% of total heat generated by engines;
- Dry lots provide only 40% of the actual manure generated due open lot recovery issues;
- Arid lands can have significant impact on manure quality;
- Digestion at sand bedded is feasible but also challenging; easiest with mechanical separation and require recycle.

6.0 Summary, continued

- The 1 MWe scrape facility would need a payback on electric energy only in the range of $0.11 per kW-hr to simply break even. This is based on Cap-X costs, total of $0.03 total maintenance on engine and system, 10 year financing.
- Substrates can greatly impact this model, but have the potential to affect may other issues; material handling, nutrient management, permitting, off-take agreement.
- Significant issue is how long is contract for substrate supply? Numerous digesters have been partially completed only to not fund due to length of contract on the substrates.
- As expected as the number animal units increases the Cap-X per KWe drops but manure management becomes more of concern. More animals means more advanced handling and probably more WATER.

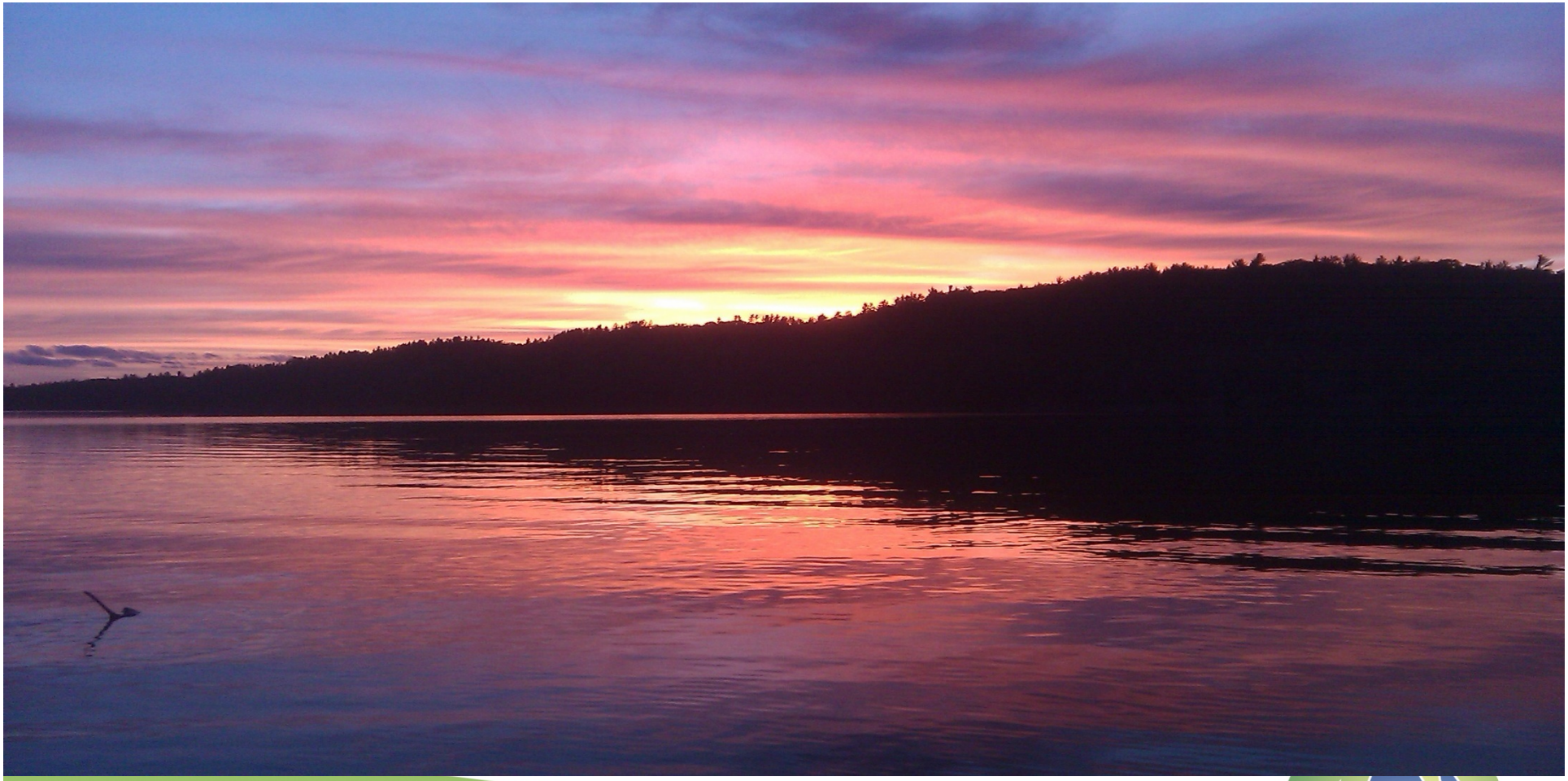
6.1 Questions to Ask: Time = Money

- Questions to ask:
- Do you have funding in place?
- Number of cows, chickens, feeders, etc.? Manure management system? Bedding? Substrates to be utilized?
- Dairy: Solids Content of Manure, interest in conversion of bedding?
- Do you have an off take agreement, i.e., is there an entity in place to purchase what you are selling (high BTU bio-methane or electricity)?
- Is project viability based on sale of bi-products? Be very wary of projects where selling processed substrates is a large portion of the income stream.
- Do you have funding in place?

Thanks to:

- Pecos Valley Biomass Cooperative
- New Mexico Dairy Producers Association
- Senator Jeff Bingaman
- US Department of Energy
- Fair Oaks Dairy
- Michigan State University

Questions



In the end there must be a reason, just beyond money, to do this,. It is a simple fact that we must have clean water and energy to subsist.

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