



Making Digesters Work:

The economics of bedding and co-feeding

2011 Midwest Manure Summit

Green Bay, WI

February 16, 2011

Dana M Kirk

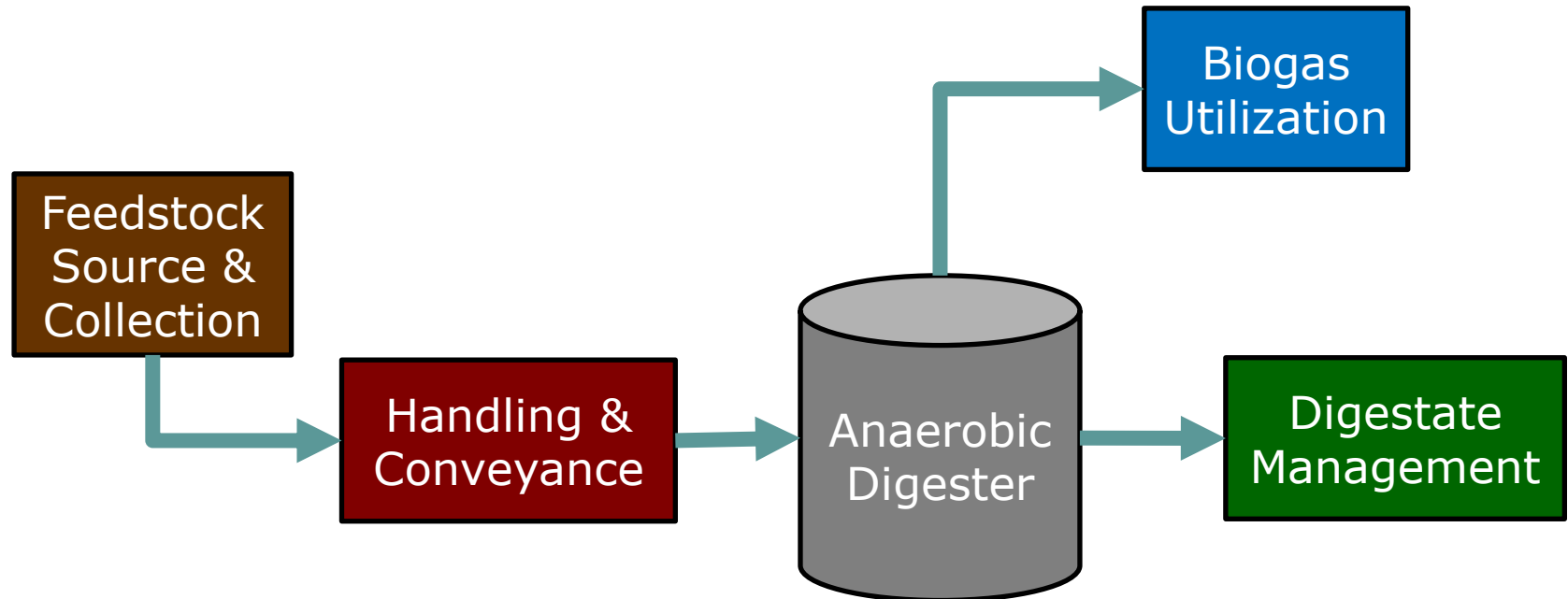
Michigan State University

Biosystems and Agricultural Engineering

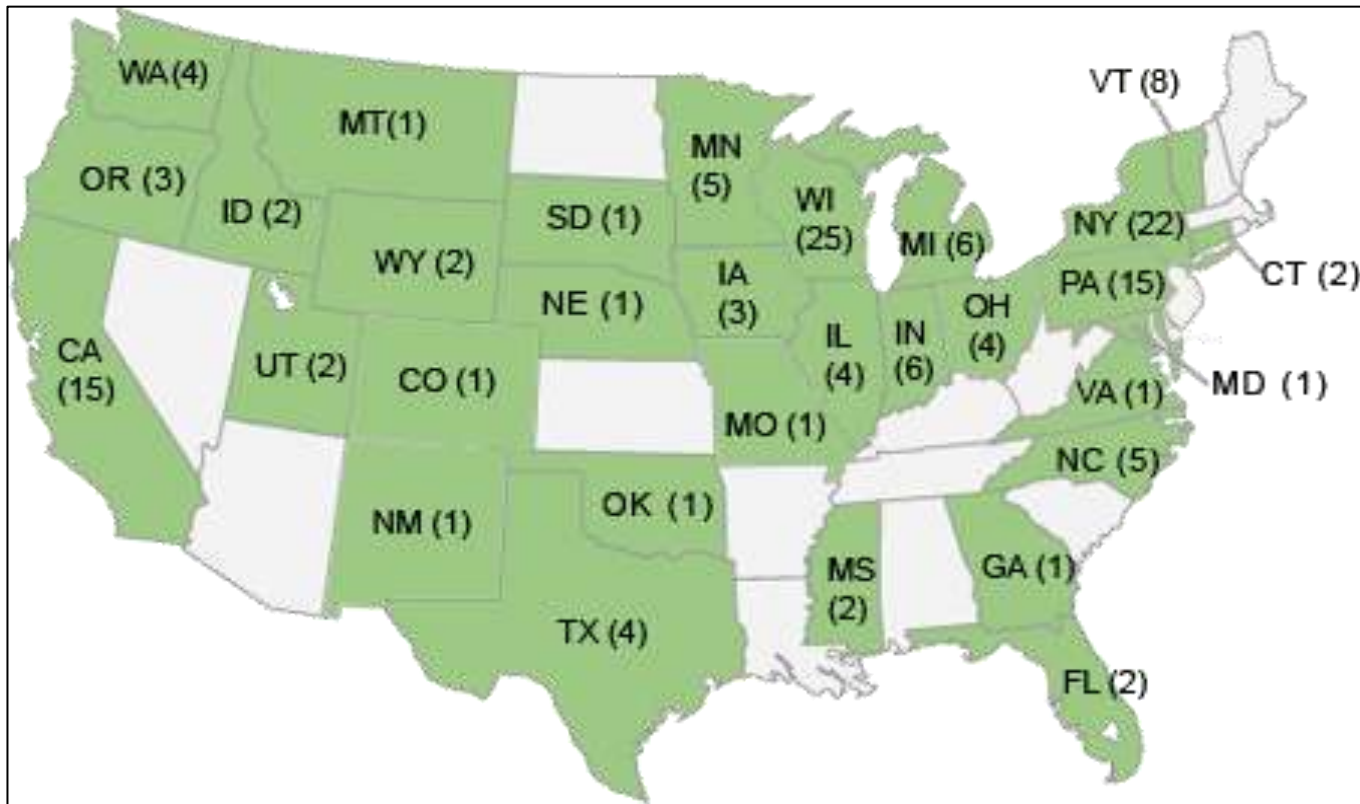
Anaerobic Digestion Research and Education Center

Making digesters work...

- Technology
- Operational
- AD system profitability

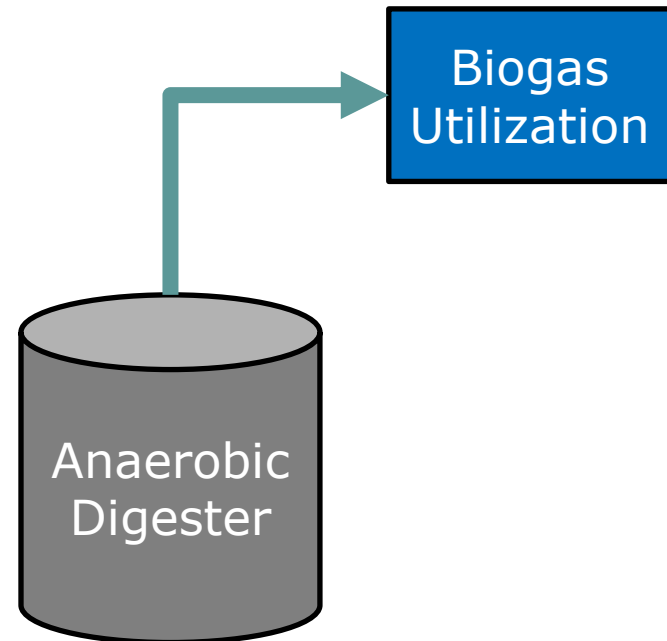


U.S. on-farm AD's



151 Total Systems, 450,000 MWh/yr

Profitability – traditional view



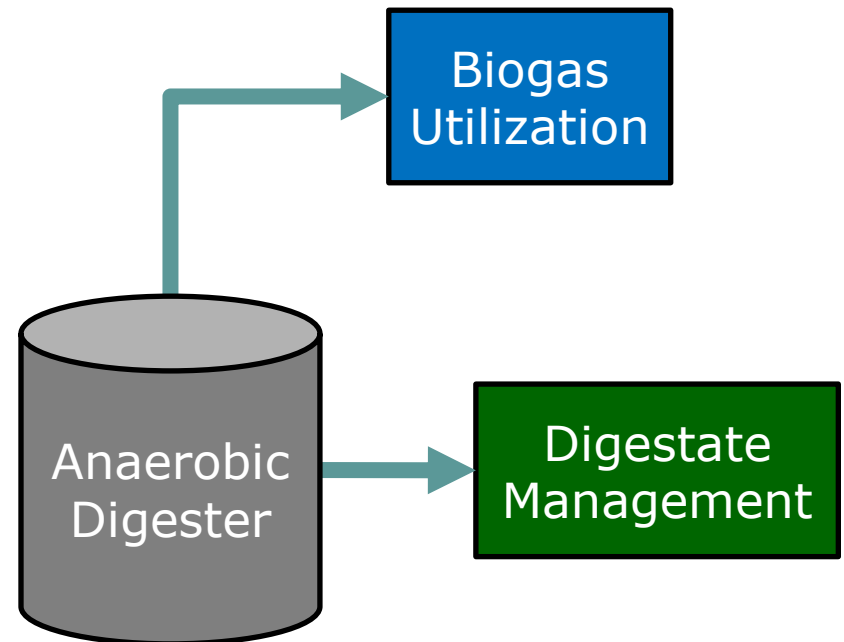


Profitability – traditional view

- Energy production (electrical)
- Manure treatment
 - Odor control
 - Stabilization
 - Pathogen reduction

Profitability – modern view

Feedstock
Source &
Collection





Profitability – modern view

- Energy production
 - Electrical
 - Natural gas (CNG)
- Environmental attributes
 - Renewable energy certificates
 - Carbon credits
- Digester fiber (pathogen reduction)
- Manure treatment
 - Odor control
 - Stabilization
 - Pathogen reduction



Challenges with AD systems

- Operations
- Safety
- Capital cost
- Access to markets
 - Location
 - Utilities
- Revenue generation
 - Low value of products
 - Assessing value of environmental benefits
- Technological gaps
 - Nutrient separation/utilization
 - Liquid reduction
 - CNG vehicle conversion

Operational - bedding





Bedding and anaerobic digestion

- Increased volume
- Addition of inorganic material
 - Sludge/grit accumulation
 - Crusting
- Equipment wear
- Heating requirements
- Biogas production per unit volume

Bedding material costs

- Sand – \$0.18 to \$0.30/cow/d
(\$7-\$12 per ton, 50 lb/cow/d)
- Wood shavings – \$0.30/cow/d
(\$50 per ton, 12.1 lb/cow/d)¹
- Digester fiber – \$0.08 to \$0.19/cow/d
(\$15-\$20 per ton, 19 lb/cow/d)²
- Compost – \$0.35 to \$0.85/cow/d³

MWPS-18. 2000. Manure Characteristics.

¹MSU Dairy Farm. 2010. Sawdust purchase price.

²Quantum Dairy and Willow Point Dairy data. 2010.

³Endres & Janni. 2010. Compost Bedded Pack Barns for Dairy Cows. eXtension.

Bedding & dairy performance

Table 3. Sand-bedding benefits compared with mattress herds for 62 freestall herds investigated by our Food Animal Production Medicine group since 2001.

| Factor | Mattress Herds | Sand Herds | Sand Benefit |
|----------------------------------|----------------|------------|--------------|
| RHA milk production per cow (lb) | 24,260 | 25,926 | +1,666 |
| Somatic Cell Count ('000/ml) | 373 | 298 | -75 |
| Cow Case Mastitis Rate (%) | 62 | 45 | -17 |



Sand bedding & digestion

- Sand bedding can be used successfully on farms digesting manure
 - Green Meadows Farms, Inc
 - Fair Oaks Farms
 - Central Sands Dairy
 - Lake Breeze Dairy
 - Qualco Energy

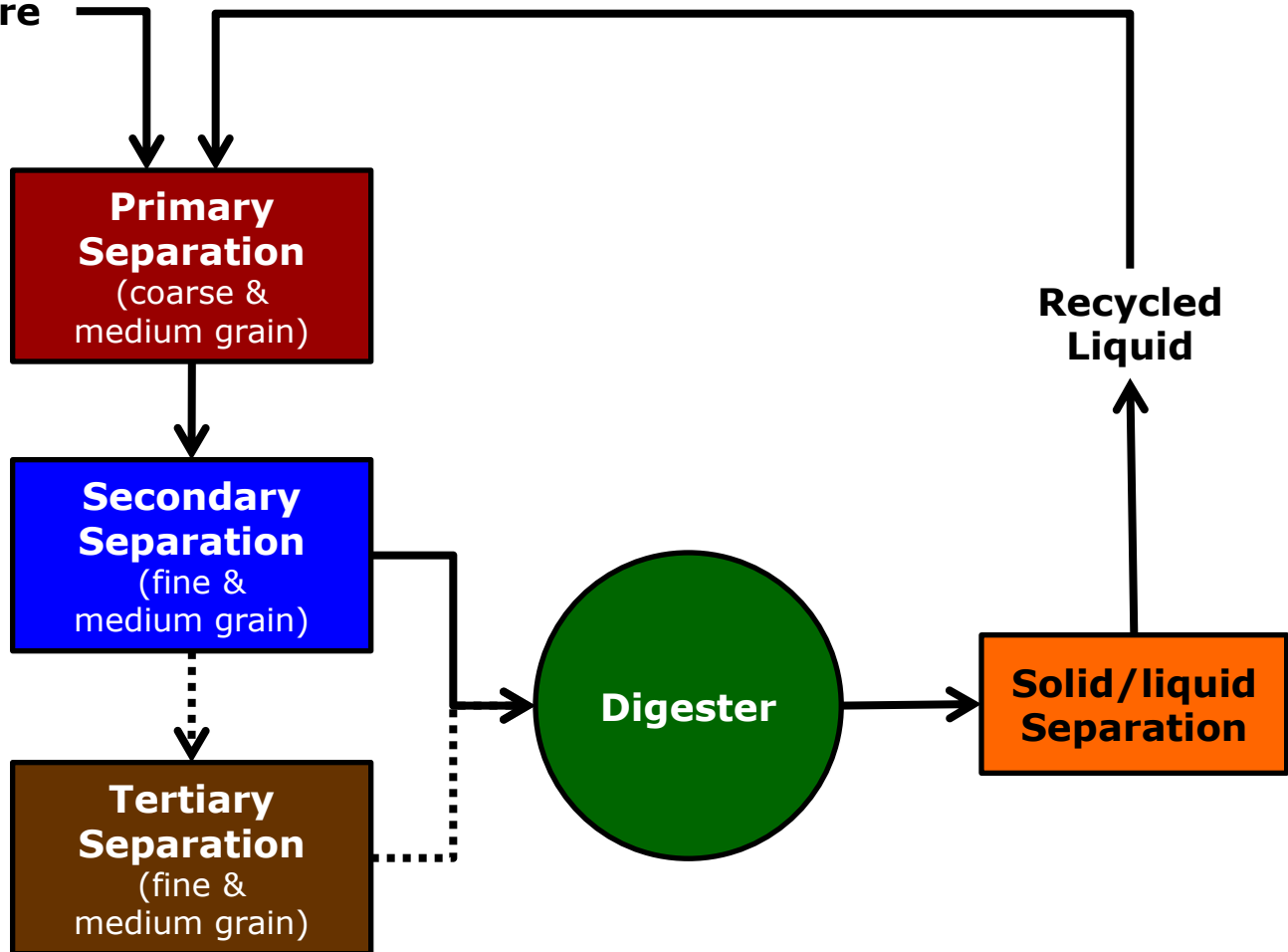


Sand bedding & digestion

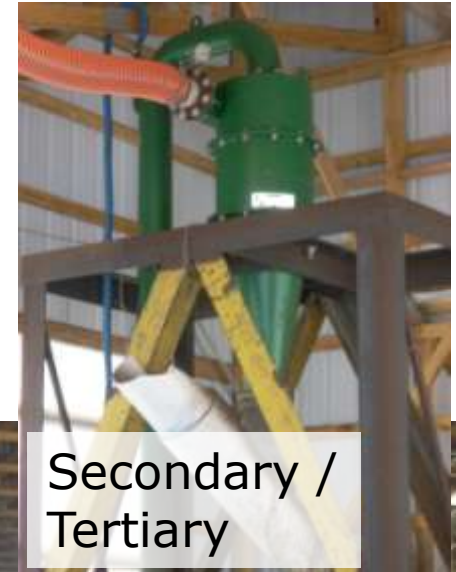
- Separation is essential
- Separation system characteristics:
 - Sand removal >90%
 - Mean particle size reduction
 - Minimal dilution water
 - Retention of organic material

Conceptual sand separation system for digestion

Sand Laden Dairy Manure (SLDM)



Sand separation components





Observations from Green Meadow Farms

- Sand separation operating for 12 years
- Digester operation since 2007
- Sand separation >90%
- Residual sand particle size reduced
- Volatile solids loss
- Volume increase
- No significant sand/sludge accumulation observed as of the fall of 2009

System profitability

Increasing revenue!



AD system cost

- Capital costs are highly variable
 - System type
 - Biogas utilization
 - Interconnection
 - Digester capital costs
 - \$280 to \$630 per cow¹
 - \$452 to \$1,173 per cow²
 - \$1,150 to \$5,300 per cow³
- O&M cost vary with technology⁴
 - Digester - 2% of capital/yr
 - Generator - \$0.01 to 0.02 kWh

¹ Managing Manure with Biogas Recovery Systems. 2002. USEPA AgStar.

² Economic Feasibility of Anaerobic Digestion To Produce Electricity on Florida Dairy Farms. 2005. Giesy, R., et al.

³ MSU Next Generation Energy Strategy. 2010. Black Veatch

⁴ Lazarus, 2010

Conventional sources of revenue

Electricity

- Electrical potential: 3 to 7 kWh/cow/d
- Electrical value: \$0.04 to \$0.09 kWh
- Revenue (offset): \$44 to \$230/cow/yr

Carbon credits

- Carbon credit potential: 2 to 5 Mton/cow/yr
- Carbon credit value: ?? \$0.05 to \$1 Mton ??
- Revenue: \$0.1 to \$5/cow/yr

Conventional sources of revenue

Renewable energy certificate (REC)

- REC value: \$10 to \$40/MWh
- Revenue: \$11 to \$100/cow/yr

Thermal energy*

- Thermal potential: 3 to 7 kWh/cow/d
- Thermal value: \$0.025 kWh
- Revenue: \$28 to \$64/cow/yr

Increasing revenue - bedding



Additional sources of revenue (cost offset)

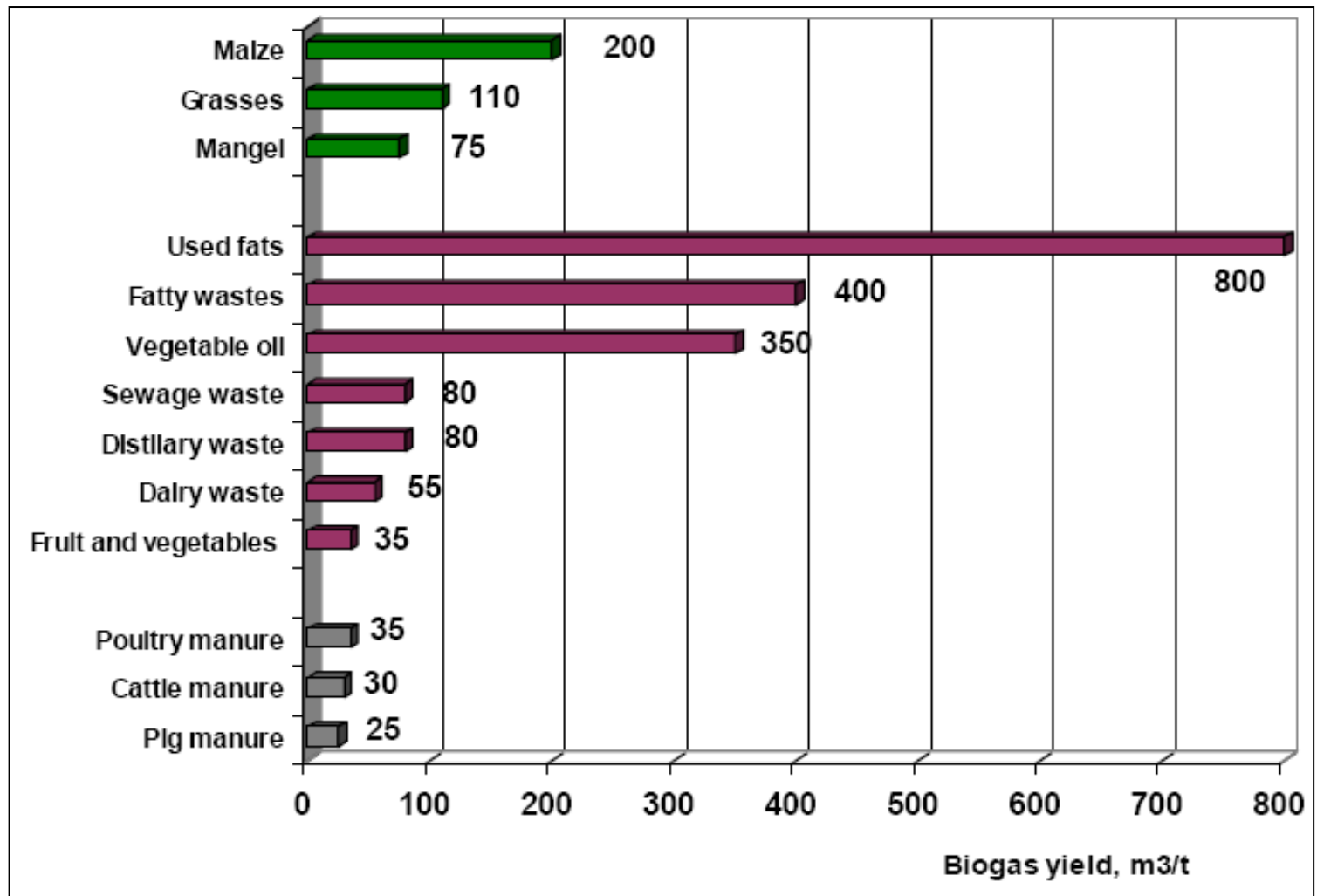
Digester fiber bedding

- Fiber value: \$15-\$20 per ton
- Bedding usage: 10 to 23 lb/d/cow
- Cost offset: \$0.08 - \$0.23/cow/d
\$29 to \$84/cow/yr

Increasing revenue - co-feeding



Feedstock biogas potential



Additional sources of revenue

Co-feeding

- Fatty wastes = 400 m³/mton (15,500 ft³/t)
 - Methane = 8,500 ft³/t
 - = 745 kWh /t
 - = \$45/t @ \$0.06 kWh
 - Tipping fee = 254 gal/t
 - = \$15/t @ \$0.06/gal

Tipping fees are variable & market driven

Additional sources of revenue

Co-feeding, cont.

- Fatty wastes = $400 \text{ m}^3/\text{mton}$ ($15,500 \text{ ft}^3/\text{t}$)
 - Revenue = \$60/t
 - = $5.4 \text{ t}/\text{cow}/\text{yr}$ (@20%)
 - = \$320/cow/yr
 - Disposal = \$7.6/ton @ \$0.03/gal
 - = \$40/cow/yr

Digester revenue summary

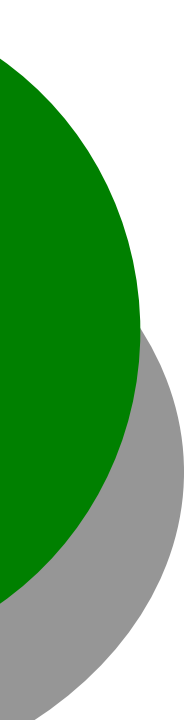
Conventional

| | | |
|------------------|-------|-----------------------------|
| ○ Electricity | \$44 | \$500 to \$1,200/cow |
| ○ REC's | \$11 | \$100/cow/yr |
| ○ Carbon credits | \$0.1 | \$5/cow/yr |
| Total | | \$55 to \$335/cow/yr |

Capital Cost

Modern/additional

| | | |
|--------------|------|-----------------------------|
| ○ Heat | \$28 | \$64/cow/yr |
| ○ Bedding | \$29 | \$84/cow/yr |
| ○ Co-feeding | \$25 | \$200/cow/yr |
| Total | | \$82 to \$335/cow/yr |



Other opportunities for added value products (revenue)

- Organic amendment
- Nutrient separation
- Finished compost
- Composite material
- Integrated energy production system
 - Ethanol
 - Combustion/gasification
 - Algae

Increasing revenue comes with costs

- Additional management/labor
- Permits
- Digester fiber bedding
 - Storage
 - Freestall management
 - Animal health / milk production
- Co-feeding
 - Consistency (quality & supply)
 - Market forces
 - Record keeping
 - Digestate management
 - Nutrient management

Others opportunities for improving profitability

- Feedstock blending
- Biogas utilization
 - Hydrogen sulfide
 - Conversion efficiency (CHP/IC)
 - Upgrading to CNG
- Value added use of digestate
 - Nutrient recovery
 - Biofiber
- System optimization
 - Configuration
 - Enzyme and nutrient additives
 - Microbial/algal community
- Integration of systems

Dana M Kirk
Biosystems and Agricultural Engineering
Anaerobic Digestion Research and Education Center
E: kirkdana@msu.edu
P: 517.432.6530



IMPORTED FROM DETROIT

