What the Future Looks Like in Farm-Scale Digestion

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&

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Acknowledgements:

Joseph Gallo Farms
Atwater, California

Straus Family Creamery
Marshall, California

Western United Resource Development
Modesto, California

California Institute for Specialty Crops
Cal Poly, San Luis Obispo
Assessment of Biofuels in California and Potential for Future Utilization

By

D.W. Williams, BRAE Department
J. Ahern and K. Ochwat, Agribusiness Department
October, 2004

California Institute for the Study of Specialty Crops, Cal Poly

Complete Paper:
http://www.cissc.calpoly.edu/
Executive Summary

1. Analysis of total potential energy resources from agricultural biomass residues in California

2. Residues included crop straw and stalks, vegetable culls and waste, tree prunings and livestock manure

3. Total residues amounted to the equivalent of almost 13 million dry tons per year

4. Energy equivalent of almost 190,000 billion Btu’s
5. “Wet Residues” produced at over 50% moisture:
   • Cattle and poultry manure, vegetable cull and residues

6. Wet residues amounted to the equivalent of almost 5 million dry tons per year

7. Using anaerobic digestion and cogeneration, explained in more detail in this presentation:
   • 3 billion kwhrs electricity worth $328 million/year
   • Steam worth $118 million
8. “Dry Residues” produced at under 50% moisture:
   • Grain straw, cotton and corn stalks, tree crop residues

9. Dry residues amounted to the equivalent of almost 8 million dry tons per year

10. Using combustion, steam production and cogeneration, as shown in the next slide:
    • 6 billion kwhrs electricity worth $660 million/year
    • Steam worth $70 million
California Walnut Processor
34,000 Tons of Walnut Shells, 4.5 MW
26 Million KWhrs and $300,000 of Steam
Total of wet and dry residues in California
9 billion KW-hrs electricity worth $1,000 million/year
Steam worth $188 million/year

CALIFORNIA BIOMASS ENERGY
POTENTIALLY OVER A
ONE-BILLION DOLLAR-A-YEAR BUSINESS
Case studies for digesters on two dairies in California, small and large

Both utilize covered lagoons ranging from 0.8 to 40 million gallons

Both utilize internal combustion (IC) engines to produce electricity and heat 1st @ 75 KW, and 2nd @ 300 KW, with interconnection agreements with PG&E
Covered Lagoon Digester
Straus Family Creamery
Marshall, California
Straus Family Creamery
Blakes Landing Dairy

Albert Straus and Doug Williams
at 250-Cow Freestall Dairy
Manure is flushed from freestalls and flows by gravity through pipe to covered lagoon.
Flushwater Mixed with Creamery Wastewater

Flushwater then goes to solids separator, with liquids to lagoon, creamery wastewater added.
Digester Parameters

- **800,000 gal. Covered Lagoon Digester**
  - Inputs: 15,000 gallons/day manure flush + 4,000 gallons per day creamery wastewater

- **40+ Day Hydraulic Retention Time**
  - Psychrophilic, 20-25 degrees C Temperature

- **75 KW Electrical Generation**
  - Provides power for dairy farm, engine heat produces hot water for parlor and digester heating
9000 Sq.Ft. Floating Cover

800,000 Gal. Covered Lagoon Digester, 9,000 square feet Floating Cover
● Moisture Trap at Covered Lagoon

● Drip Trap
● Blower
● Gas Meter
● Safety Valves at Engine-Generator
Biogas Engine Generator Shed
Waukesha 75 KW Engine-Generator
75 KW Engine-Generator and Exhaust Heat Exchanger
### COSTS and INCOME

#### CAPITAL COST

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered Lagoon Digester &amp; Slurry Handling</td>
<td>$140,000</td>
</tr>
<tr>
<td>Biogas Handling, Engine-Generator, Building and Utility Interconnect</td>
<td>$140,000</td>
</tr>
<tr>
<td><strong>Total Capital Cost</strong></td>
<td><strong>$280,000</strong></td>
</tr>
</tbody>
</table>

#### ANNUAL INCOME

<table>
<thead>
<tr>
<th>Description</th>
<th>Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Income:</td>
<td>$50,000</td>
</tr>
<tr>
<td>Estimated Heat Income</td>
<td>$5,000</td>
</tr>
<tr>
<td><strong>Total Annual Income</strong></td>
<td><strong>$55,000</strong></td>
</tr>
</tbody>
</table>
Covered Lagoon Digester
Joseph Gallo Dairy Dairy
Atwater, California
Joseph Gallo Dairy

5000 Dairy Cows - Free-Stall, Flushed Feed Lane & Dirt Lot Dairy
Joseph Gallo Dairy

Typical California Drylot Feedlane
**Retrofitted** for Flush Manure Handling
Flushwater Solids Settling & Screen Separator
Valley Air Solutions

Digester Parameters

- 40-million gal Covered Lagoon Digester
  Input: 1-million gallons/day @ $1/2$ % Total Solids, includes 200,000 gallons cheese plant wastewater produces 288,000 cubic feet of biogas per day

- 40+ Day Hydraulic Retention Time
  Psychrophilic, 15-25 degrees C Temperature

- 300 KW Electrical Generation at present
  Provides power for cheese plant, and provided engine heat produces steam for cheese process

- Biogas potential for a 2\textsuperscript{nd} 300 KW unit
  ~ 600 KW Total Electrical Potential
40-Million Gallon Covered Lagoon

Digester - 1250’ X 270’ X 22’
(BTW: Not Recommended)
40-Million Gallon Covered Lagoon

7.5 Acre HDPE Lagoon Cover
Hydrogen Sulfide Removal

Iron Sponge H2S Scrubber

97% Removal Efficiency

or

<20 PPM H2S
Gas Conditioning

- Gas Dryer
- Gas Blower
- Safety Valves

- Flare
- Pressure Valve
Overflow Storage Lagoon

60 Million Gallon Secondary Holding Pond
Biogas Pipeline & Gas Handling

Biogas Pipeline and Gas Handling leading to Engine
Biogas Engine Generator Shed

Engine, Generator, Electrical Switchgear, Steam Boiler
Caterpillar 3412
300KW Engine-Generator
300 KW Engine-Generator & Exhaust Steam Boiler
## COSTS and INCOME

### CAPITAL COST

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagoon Construction &amp; Flush Retrofit</td>
<td>$700,000</td>
</tr>
<tr>
<td>Cover and Installation</td>
<td>$350,000</td>
</tr>
<tr>
<td>Biogas Handling and Pipeline</td>
<td>$250,000</td>
</tr>
<tr>
<td>Electric Generator, Utility, Engineering</td>
<td>$700,000</td>
</tr>
<tr>
<td><strong>Total Capital Cost</strong></td>
<td><strong>$2,000,000</strong></td>
</tr>
</tbody>
</table>

(Add Second 300KW Generator) ($300,000)

**Total Capital Cost (@ 600KW)** ($2,300,000)

### ANNUAL INCOME

( @ 600 KW)

<table>
<thead>
<tr>
<th>Description</th>
<th>Income</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
<td>$275,000</td>
<td>($550,000)</td>
</tr>
<tr>
<td>Heat</td>
<td>$125,000</td>
<td>($250,000)</td>
</tr>
<tr>
<td><strong>Total Annual Income</strong></td>
<td><strong>$400,000</strong></td>
<td><strong>($800,000)</strong></td>
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</table>
Lessons Learned

- Covered lagoons most appropriate digestion technology on CA flush dairy
- Biogas quality is important related to engine life and air quality
- Favorable utility rates vital to continued financial viability of projects
- Cogeneration makes maximum use of renewable energy from methane
- Air and Water Quality Regulations will play larger role than energy in CA
- Use of Technology can Save Labor and Improve System Reliability
## Methane & Hydrogen Sulfide Combusted or Removed

<table>
<thead>
<tr>
<th>Hypothetical Model</th>
<th>3000 Cows</th>
<th>5000 Cows</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Methane</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ 60-70% V</td>
<td>900</td>
<td>1440</td>
</tr>
<tr>
<td>Tons/yr</td>
<td>Combusted</td>
<td>Combusted</td>
</tr>
<tr>
<td><strong>Hydrogen Sulfide</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ 900 to 1500 PPM V</td>
<td>3.5</td>
<td>5.9</td>
</tr>
<tr>
<td>Tons/yr</td>
<td>Removed</td>
<td>Removed</td>
</tr>
</tbody>
</table>

Note: The above figures are variable depending upon ration, flush frequency, type of housing, type of digester, etc
Doug Williams
877 - 430 - 7600
doug.williams@valleyairsolutions.com
Valley Air Solutions

Dairy/AG Waste & Energy Solutions

- Waste Lagoons
- Odor Reduction
- Methane Reduction
- Gas Purification
- Waste to Energy
- Site Plans/Studies
- Subsidy Assistance

NRCS Anaerobic Treatment Lagoon

Covered Lagoon Methane Recovery

Electricity Generator

Methane Flare

Gas Purification

GOOD

- Meets SJ Valley Requirements
- No Green House Gas Reductions
- No Hydrogen Sulfide Removal
- No Electricity Generation
- No Self Generation Rebate/Subsidy

Upgradable

BETTER

- Exceeds SJ Valley Requirements
- Green House Gases Reduced
- No Hydrogen Sulfide Removal
- No Electricity Generation
- No Self Generation Rebate/Subsidy

Upgradable

BEST

- Exceeds SJ Valley Requirements
- Green House Gases Reduced
- Hydrogen Sulfide Removal
- Electricity Generation
- Self Generation Rebate/Subsidy

*
Valley Air Solutions
877-430-7600
Hydrogen Sulfide Removal and Biogas Purification
Valley Air Solutions

Hydrogen Sulfide Removal, Biogas Conditioning & Monitoring

Performance Guaranteed
Protects Investment
Iron Sponge Technology
Advanced Sponge Media
Retrofit Existing Digester
Minimal Maintenance
Installations Worldwide

H2S Removal / Purification
- Hydrogen Sulfide Removal
  Less than 20 PPM H2S or 98% Removal Efficiency
- Self Generation Rebate Eligible
- Spent Media Field Spreadable
- Media Replacement
  Quarterly if @ 3000 PPM H2S
  Bi-Annual if @ 1500 PPM H2S
- Onsite Maintenance Available

Important Contaminant Removal
GOOD

Complete Gas Conditioning & H2S Removal / Purification
- Moisture Removal (Gas Drying)
- Pressurization / Compression
- Non-Resettable Gas Flow Meter
- Gas Temperature
- Gas Sampling & Analysis Available

Maximum Gas Preparation
BETTER

Biogas Monitoring, Complete Gas Conditioning & H2S Removal / Purification
- Monitor CH4, H2S, CO2 & O2
- Digester Upset Warning
- Pipeline Leak / Problem Warning
- Extended Service Intervals
  Use less Oil, Save on Service Labor
- Smart Media Replacement
  Alerts as needed up to Annually

Maximum Investment Protection
BEST
FLAT FEE PRELIMINARY
FLUSH DAIRY DIGESTER DESIGN
Designed by Dr. Doug Williams, P.E.

A custom preliminary digester design*
including:
- All Preliminary Engineering
- Rough Site Sketch
- Estimated Electricity Production
- Covered Lagoon Dimensions
- Recommended Vendor List
- Major Equipment List & Costs
- Financing & Subsidy Source List

All for one flat fee! Fee credited towards full digester system! No further obligation.

CUSTOMER QUOTE
"Our primary goal was to build a simple and easy to use digester. Dr. Doug Williams' design is just that and now it saves Joseph Gallo Farms $1000 every day."

- Carl Morris, Joseph Gallo Farms

* Additional design and engineering needed for a complete system. Ask for offer details, restrictions and limitations apply. © Valley Air Solutions
FLOW METER WITH DATA LOGGER FOR DAIRY LAGOONS / AG WASTEWATER

- Instantaneous Flow Measurement
- Totalized Flow Measurement
- Daily Totalized Flow Data Logging
- PVC or Carbon Steel Construction
  - Fits PVC Pipes 2” up to 12”
  - Fits Steel or PVC Pipes 2” up to 80”
- Magnetic Measurement Technology
  - Single or Dual Sensors
- Retrofit into Existing Pipework
- No Liner or Grounding Ring Needed
- Corrosion Resistant to Wastewater
- Easy Field Repairability
- Tamper Resistant / Password Protected
- Direct Substitute for ISCO Meter

"For a permanent meter installation, any of the tube magmeters would be an excellent choice. They are unaffected by solids or trash in the water and will work well with both clean and dirty water. ... keep a running total of water pumped from the pond and are easy to read."

“Flow meters tested on dairy lagoon water”
California Agriculture, Research Article Jul-Sept 2003

Full Pipe Requirement Easy to Meet

Applications:
1. Flow Rate Measurements for Comprehensive Nutrient Management
2. Historical Monitoring of Daily Wastewater Totalized Flow Discharge
3. Covered Lagoon Digester Influent and Effluent Flow Monitoring
4. NRCS Anaerobic Treatment Lagoon Monitoring and Management
Lagoon Design, Engineering, Lining and Covering

<table>
<thead>
<tr>
<th>Top</th>
<th>Bottom</th>
<th>None</th>
<th>HDPE</th>
<th>None</th>
<th>Polypropylene</th>
<th>Polypropylene</th>
<th>Polypropylene</th>
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<tr>
<td>Features &amp; Benefits</td>
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<tr>
<td></td>
<td>Water Tight</td>
<td>UV Resistant</td>
<td>Water Tight</td>
<td>UV Resistant</td>
<td>Strength</td>
<td>Clean Out</td>
<td>Pre-Fabrication</td>
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<table>
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<tr>
<th>Upgrades</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Flow Meter</td>
<td>Top Cover</td>
<td>Gas Recovery</td>
<td>Generator</td>
<td>Flow Meter</td>
<td>Top Cover</td>
<td>Gas Recovery</td>
</tr>
</tbody>
</table>

- **GOOD**
  - (Water)
- **BETTER**
  - (Water)
- **BETTER**
  - (Air)
- **BEST**
  - (Water & Air)

**Our Services**:  
1. Pre-Fabricated Materials and Advice for the Do-It-Yourselfer  
2. NRCS Anaerobic Treatment Lagoon Design & Engineering  
3. Lagoon Preparation and Earth Moving  
4. Field Installation of Liner and/or Cover (You Prepare Lagoon)  
5. Field Installation of Cover on Our Lagoon Design (or Possible Retrofit to Existing Lagoon)  
6. Turnkey Design, Engineering, Materials and Installation

*Ask for offer details, restrictions and limitations apply. © Valley Air Solutions
Valley Air Solutions

Model VAS-841-N4X
Biogas & Digester Gas Sensor Monitoring System

Description
The Model VAS-841-N4X is an eight channel Biogas sensor monitoring and alarm system housed in a NEMA 4X weatherproof enclosure. The system design uses a microprocessor based control card to supervise and display the condition of virtually any type of field mounted gas detection sensor with either a 4-20mA or serial RS-485 output. Biogas sensor types include Methane, Hydrogen Sulfide, Carbon Dioxide, Oxygen, Ammonia and others. The controller is completely user programmable. A backlit alpha/numeric display provides indication of gas type and current reading in normal operation. The alpha/numeric display is also used to provide simple menu driven operator interface during system programming including selection of gas type, range of sensitivity, alarm level adjustment and alarm relay configuration. Some of the unique features of the Model 841 are logging of calibration, 8-hour time weighted average (TWA), peak exposure level (PEL), and alarm accident history. Logged data is date/time stamped and can be displayed on the 4-line LCD or the data can be downloaded to a PC.

Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>NEMA 4X Dust Tight Weather Proof Enclosure</td>
<td></td>
</tr>
<tr>
<td>Sensor Input Options: 4-20mA or Serial RS-485</td>
<td></td>
</tr>
<tr>
<td>3 Adjustable Alarm Level Relays, 1 Fault Condition Relay</td>
<td></td>
</tr>
<tr>
<td>Calibration History and Alarm Event Logging</td>
<td></td>
</tr>
<tr>
<td>Integral 1-hour Stand-by Battery</td>
<td></td>
</tr>
<tr>
<td>RS-485 Serial</td>
<td></td>
</tr>
<tr>
<td>Alarm Level, Alarm Output Options</td>
<td></td>
</tr>
</tbody>
</table>

Order Guide
Order by part number VAS-854-088010-090
www.valleyairsolutions.com

Biogas FT2 Plus

Model Biogas FT2 Plus Gas Mass Flow Meter & Temperature Transmitter

PRODUCT DESCRIPTION
The Model FT2 Thermal Mass Flowmeter and Temperature Transmitter measures two important process variables in one rugged instrument. The FT2 measures gas flow rate in standard units without the need for temperature or pressure compensation. It provides isolated 4 to 20 mA and pulse outputs for flow rate and 4 to 20 mA output for process gas temperature. The pulse output in normally used for totalization. You choose the flow rate and temperature engineering units. An optional on-board 2 x 16 character, backlit display is available to view flow rate, total, elapsed time, process gas temperature, and alarms. The display is also used in conjunction with the Configuration Panel to configure flowmeter settings such as 4 mA and 20 mA for flow rate and temperature, pulse output frequency scaling, pipe area, zero flow calibration, flow filtering (smoothing), display configurations, diagnoses and high or low alarm limits. It also permits review of raw flowmeter data useful when troubleshooting. If you prefer, you can view measurements and set parameters with an optional handheld Palm Terminal instead of the on-board Display and Configuration Panel.

FT2 is available in insertion and inline models. The insertion model is easily installed by drilling a ½” hole in the pipe and welding on a ½” NPT coupling. A supplied compressing fitting secures the probe in place. The inline models is available in ½” to 6” size and include built-in flow conditioners that eliminate the need for long, straight pipe runs. The meter can be ordered with flange or NPT end connections. Both models are supplied with 316 stainless steel wetted materials standard or Hastelloy C-276 as an option.

RS232 for connecting a Palm Terminal or RS422 & RS485 Modbus, Profinet-DP, DeviceNet and Ethernet gives the FT2 flexible communications capability. The FT2 is an advanced Thermal Mass Flowmeter and Temperature Transmitter for you most challenging gas flow measurement applications.
Model VDP-ECT-NR1AA
Dairy & AG Wastewater Magnetic Flow Meter System

Description
The VDP Wastewater Magnetic Flow Meter System consists of the flowtube, transmitter and data logger. Valley Air Solutions’ Magnetic flowmeters are a cost effective wastewater measurement solution for many dairy, agriculture and other applications compared to conventional flow technology, because they improve on-site measurement performance and decrease costs associated with maintenance. The VDP system uses unique sensing technology, which eliminates the large and costly magnetic coils used in conventional magnetometers, as well as the need for a flowtube liner. The VDP flowtubes are constructed from polyvinylchloride (PVC) to be low cost and lightweight. They are intended for use in plastic pipework in sizes 2" - 12". All VDP wastewater flow meters offer a uniquely high signal-to-media noise ratio, up to 3x higher than conventional AC, and up to 30x higher than pulsed DC magnetometers.

<table>
<thead>
<tr>
<th>VDP Flowtube Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlined PVC flowtube construction</td>
<td>Lowest cost Valley Air Solutions wastewater flowtube for use with plastic piping systems; Low process pressures and temperatures;</td>
</tr>
<tr>
<td>No flowtube liner required</td>
<td></td>
</tr>
<tr>
<td>Single Sensor</td>
<td>Accuracy and low cost; Second sensor for enhanced accuracy; Functions accurately with one sensor</td>
</tr>
<tr>
<td>Totally encapsulated sensor components</td>
<td>Magnetic coils and other sensors components encapsulated within a block of insulating material up to 1&quot; thick; Field replacement without hydraulic recalibration; Reduces costs associated with stocking spare parts;</td>
</tr>
<tr>
<td>Patented coil excitation</td>
<td>Fast time constant of 30 milliseconds; High signal-to-noise ratio for high insensitivity to media noise; Accuracy unaffected by electrode coatings such as manure, sewage, grease, pulp, calcium carbonate, algae or similar; Media conductivity to &gt; 0.06 μS/cm</td>
</tr>
<tr>
<td>Internal grounding electrode</td>
<td>No grounding rings normally required</td>
</tr>
<tr>
<td>Flowtubes manufactured to any length</td>
<td>Meets ISO/DS 13559 for many sizes; Simplifies installation (no spacers or alteration)</td>
</tr>
<tr>
<td>Flexible ordering configurations</td>
<td>Single sensor PVC standard for lowest cost; Dual sensor, carbon steel flow tubes and flange options customizable to save you time</td>
</tr>
</tbody>
</table>

Revision C - Valley Air Solutions VDP Wastewater Flow Meter System
Valley Air Solutions

Dairy/AG Waste Solutions

- Waste Lagoons
- Odor Reduction
- Waste to Energy
- Methane Reduction
- Site Plans/Studies

Methane Flare

Electricity Generation

NRCS Anaerobic Treatment Lagoon

Covered Lagoon Methane Recovery

Gas Purification

GOOD  Upgradeable  BETTER  Upgradeable  BEST