BIOMETHANE AS AN OPTION FOR ON-FARM ENERGY PRODUCTION

Norma McDonald

OWS Organic Waste Systems

OWS COMPANY PROFILE

FIGURES

- DRANCO TECHNOLOGY DEVELOPED IN 1983
- OWS CREATED IN 1988
- SALES: $25-35 MILLION PER YEAR
- 80 PEOPLE

SUBSIDIARIES

- DRANCO NV (BELGIUM): operating and investment company (owns 52% of Nüstedt plant)
- OWS INC (Dayton, Ohio, USA since 1992; integrated Phase 3 Renewables 9/2009)
- BES GMBH (GERMANY, since 2008)

ACTIVITIES

- DESIGN & CONSTRUCTION OF ANAEROBIC DIGESTION PLANTS FOR SOLID AND SEMISOLID ORGANICS
- BIOGAS CONSULTANCY & SUPPORT
- BIODEGRADATION TESTING AND WASTE MANAGEMENT CONSULTANCY

DESIGN AND CONSTRUCTION OF AD PLANTS

27 FULL-SCALE PLANTS ON:

- FOOD/BIOWASTE: 14 DRANCO PLANTS

- RESIDUAL/MIXED WASTE: 9 DRANCO PLANTS

- ENERGY CROPS: 1 DRANCO-FARM PLANT (S/U 2006)

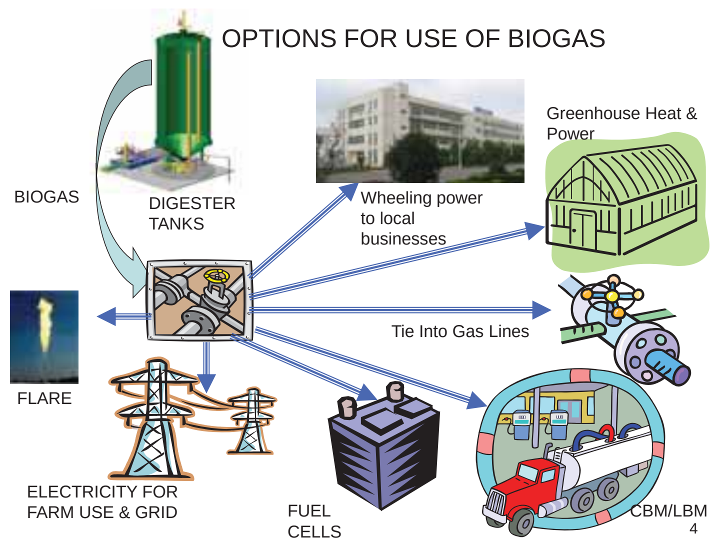
- ENERGY CROPS/FOOD WASTE: 3 WET AD PLANTS (S/U 2008)

- MANURE & CO-FEEDS: 3 WET AD PLANTS (S/U 2005-6)

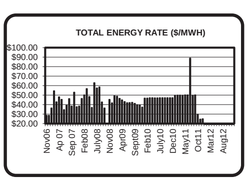
OWS RECENTLY SELECTED FOR NEW SITES:

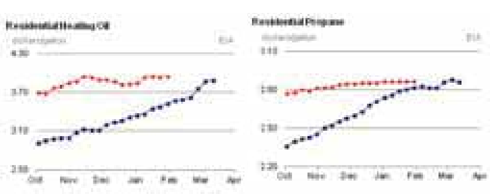
YORK (UK)	***CHAGNY (FR)***
NETHERLANDS	***ST PAUL (US)***
LA AREA (US)	***BOSTON (US)***
IOWA (US)	***INDIANA (US)***
HONG KONG	

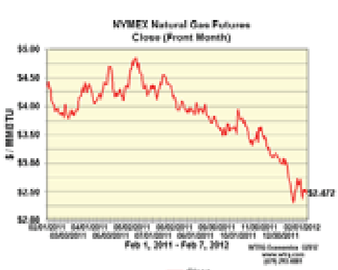
OPTIONS FOR USE OF BIOGAS

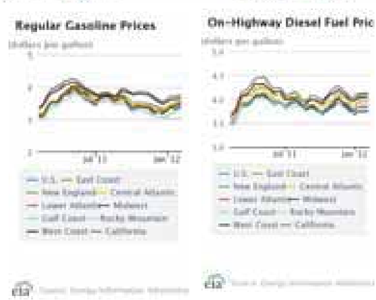


WHAT VALUE CAN YOU GET FOR THE ENERGY?





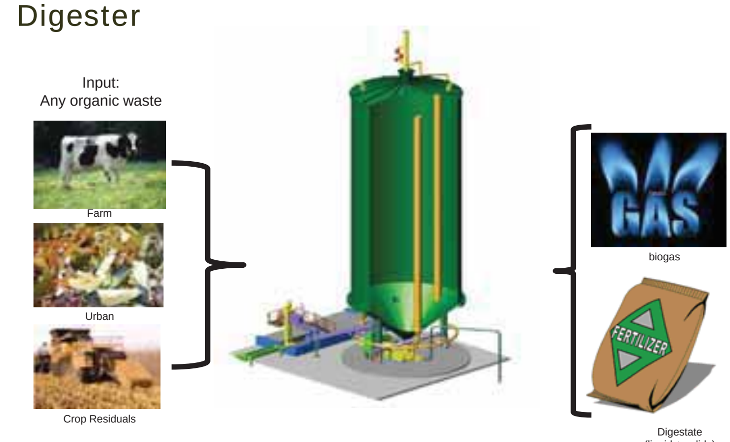




American biogas Council

Promoting the Anaerobic Digestion and Biogas Industries

Digester



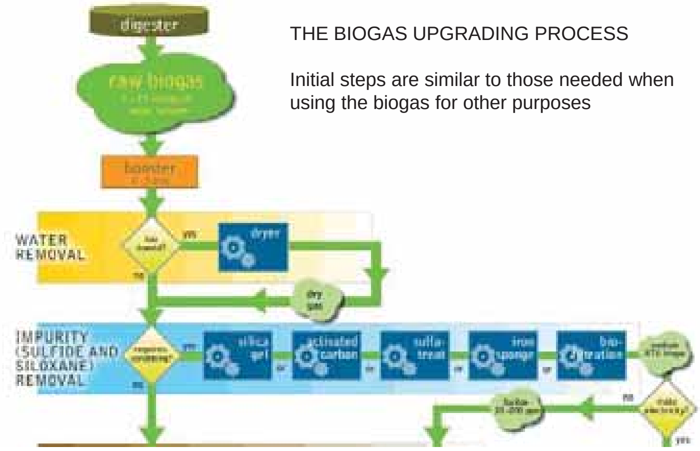
www.americanbiogascouncil.org

Raw Biogas Characteristics

- Pressure (less than 1 psig)
  - Common: 2 – 8 inches of water column
  - Municipal applications: up to 15 inches of water column
- Makeup by Major Constituents (assuming manure & cofeeds):

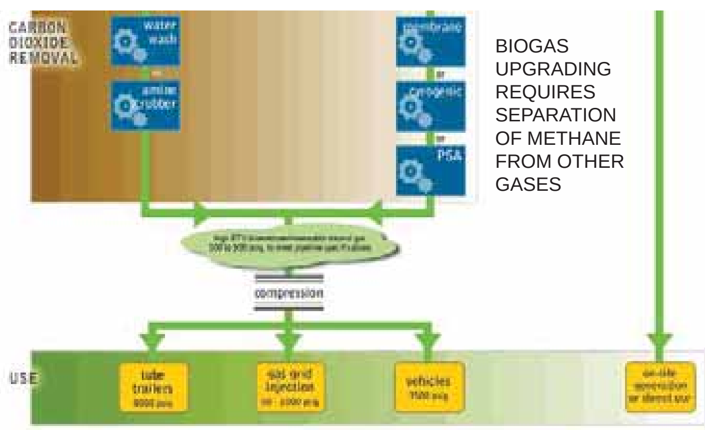
Constituent	Concentration
• Methane (CH_4)	55 to 65 %
• Carbon Dioxide (CO_2)	35 to 45 %
• Nitrogen (N_2)	0.4 to 1.2 %
• Oxygen (O_2)	0.0 to 0.4%
• Hydrogen Sulfide (H_2S)	0.02 to 0.4%

- Saturated with water



THE BIOGAS UPGRADING PROCESS

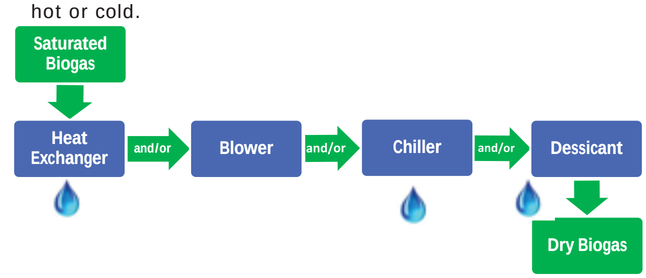
Initial steps are similar to those needed when using the biogas for other purposes



BIOGAS UPGRADING REQUIRES SEPARATION OF METHANE FROM OTHER GASES

Moisture removal

- Virtually all biogas needs free moisture removal, pipeline requires maximum removal
- Systems may use more than one step in combination
- The sequence of steps are often chosen depending on what steps are used to process the biogas. It may be ideal for the gas to be hot or cold.



Activated Carbon

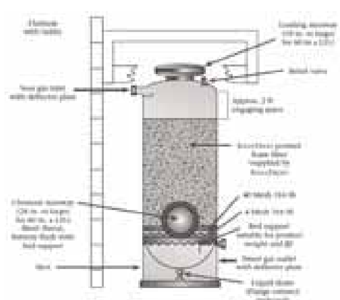
- Removes both sulfides (and siloxanes if present) by adsorption
  - process is non-selective
- Activated carbon is often used for its high surface area and catalytic properties
- Can be made from wood, coconut shells, charcoal
- Performance affected by gas temp. and moisture (better on dry, cool/warm gas)

Carbon

Carbon Vessels

Sulfatreat

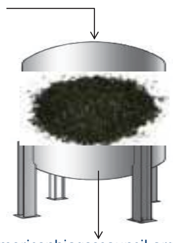
- Removes sulfides
- Uses unique combination of iron oxides react with sulfides (H_2S) to produce iron pyrite.
- Can be enhanced with water spray and low air injection if some oxygen is not an issue (vehicles)
- Can be single vessel or lead/lag with 2 vessels in series, single use or regenerated



SulfaTreat lead / lag vessel arrangement for sulfide removal

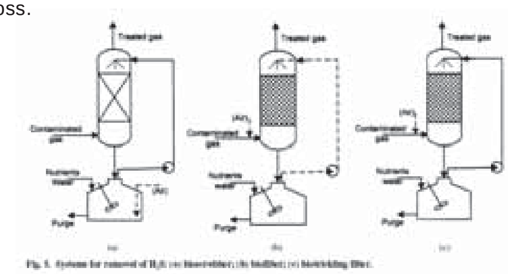
Iron Sponge

- Removes sulfides
- Iron sponge normally wood chips impregnated with iron oxide
- Upflow/Downflow of gas through packed bed of iron sponge
- Iron oxide (Fe_2O_3) reacts with sulfides (H_2S) to produce iron sulfide (Fe_2S_3) and water (H_2O
- Must drain excess water occasionally so as not to flood the bed
- Bed can be regenerated several times before needing replacement



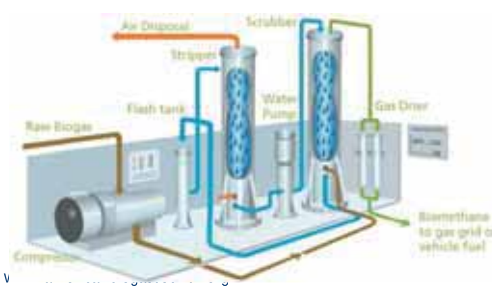
Biofiltration

- Removes sulfides
- Uses microbes living on a support matrix
- Microbes (and normally low level oxygen addition) consume H2S and precipitate as elemental sulfur
- Supplied as:
  - Above grade packed towers
  - Below grade systems filled with natural media like wood chips or peat moss.
- Three major types:
  - bioscrubber
  - biofilter
  - biotrickling filter



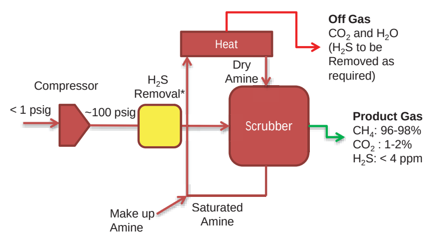
Water Wash

- Carbon dioxide and other polar molecules have a higher solubility in water than methane. Therefore water can be used to remove contaminants from biogas.
- If the contaminants are removed or 'scrubbed' at high pressure (~130 psig), the water can be continuously regenerated or 'stripped' in a separate low pressure vessel (~3 psig).
- Produces high quality biogas (renewable natural gas)



Amine Scrubber

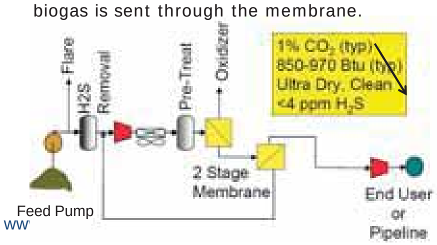
- Raw biogas enters and is pressurized up to 100 psig
- Biogas then flows upward through a packed column where the carbon dioxide (CO_2) and sulfides are absorbed within the counter flowing amine
- Once saturated amine leaves the scrubber and carbon dioxide is driven off to the atmosphere, the amine may be regenerated by heating it
- Produces high quality biogas (renewable natural gas)



*In some systems, the sulfides are removed in the packed column based on amine type and site conditions

Membrane Separation

- Membrane separates methane by **retaining** it ("retentate"). Undesirable molecules like carbon dioxide (CO_2), water (H_2O), sulfides (H_2S), and ammonia (NH_3) **pass through** the membrane ("permeate"). Produces high quality biogas (renewable natural gas).
- Polymer membranes for gas separation are typically formed into very thin, hollow fibers, clustered into modules consisting of thousands of fibers. A high pressure pump forces the gas through the fiber centers where it is collected with permeate from other fibers.
- To improve separation, multiple stages may be used. Two-stage systems are common (shown below) which increases the longevity of the membrane modules. Most installations include a desulfurization and drying step before raw biogas is sent through the membrane.



Pressure Swing Adsorption (PSA)

- An adsorbing material, either particulate (carbon molecular sieve or zeolite) or structured, preferentially adsorbs carbon dioxide and other highly adsorbed compounds at pressure (~100 psig) allowing methane to pass through
- Conventional systems have multiple tanks for separation, with only one in service at a time. Newer technology uses rotary valves, structured beds, smaller footprints, faster cycle times.
- Produces high quality biogas (renewable natural gas)

ON-FARM BIOGAS UPGRADING BACKGROUND

- Michigan Dairy
  - 2000 milking herd @ 8-12% TS, biofiber bedding
  - 1450 heifers @ 12-20% TS, straw/stover bedding
  - 350 calves @ 20-30% TS, straw bedding
- Biogas Plant
  - Original two digesters installed in 2006 with two 350kW gensets;
  - 50% expansion in 2007 to three digestion tanks
  - Increased biogas through co-feeding of ethanol and food processing waste
- Biogas Upgrading System (BUS) to Pipeline Quality – *On-farm, small-scale!*
  - H2S removal, chilling, moisture knockout
  - Primary Compression, moisture knockout
  - PSA gas separation
  - Revenue and energy delivery optimization approach – electric or pipeline gas

Pipeline Insertion Cost & Feasibility Determination

- Proximity to site
- Pressure: Maximum, minimum, operational fluctuation
- Gas Specifications: BTU value, H2S, CO2, O, H2O
- Odorization
- Monitoring and Metering Requirements

WASTE HEAT USAGE ?

DIGESTER HEATING

BIOFIBER DRYING

PROCESS OVERVIEW – NATURAL GAS

FEEDSTOCK SOURCE

PIPING & PUMPING

DIGESTION TANKS AND GAS STORAGE

GREATER MOISTURE REMOVAL REQUIREMENTS FOR COMPRESSION

GREATER H2S REMOVAL REQUIREMENTS TO MEET SPECS

PROCESS OVERVIEW – NATURAL GAS

COMPRESSION

UPGRADING

(PSA, WATER SCRUBBED, AMINE, MEMBRANE)

ODORIZATION & INSERTION

WASTE HEAT AVAILABILITY

- Biogas to boiler
- Compressor heat exchanger
- PSA exhaust gas

FIRST COMBINATION ON-FARM RENEWABLE ENERGY PRODUCTION FACILITY

SCENIC VIEW DAIRY

FENNVILLE, MI

FEED GAS: UP TO 170 CFM

PRODUCT GAS: ~75-85 CFM

INSERTION PRESSURE: 120-150 PSIG

BOTTOM LINE COMPARISON

ENERGY SALES

25,130 Total volume (1000 cft) of Natural Gas available for Pipeline / year

$175,912 Potential Natural Gas Revenue Stream / year

Price Range - Natgas price/1000cft			Revenue Range / year		
Low	Modeled	High	Low	Modeled	High
$4.000	$7.000	$10.000	$100,521	$175,912	$251,303

OR

3,057,014 Total volume (kWh) of Electricity Production / year

$115,555 Potential Electricity Revenue Stream / year

Price Range - Elec price/kWh			Revenue Range / year		
Low	Modeled	High	Low	Modeled	High
$0.030	$0.038	$0.060	$91,710	$115,555	$183,421

BOTTOM LINE COMPARISON

	Farm Only A	Farm + Elec B	Farm + Pipeline D
Revenue			
Sell Energy	$0	$90,903	$132,703
Sell Excess Bedding/Compost	$7,775	$7,775	$7,775
Sell Sulfur - Fertilizer	$145	$591	$642
Sell Emission Credits	$51,619	$58,028	$56,051
Total Revenue	$59,539	$157,296	$197,170

BOTTOM LINE COMPARISON

	Farm Only A	Farm + Elec B	Farm + Pipeline D
Operating Costs			
Gen-Set O&M	$13,140	$45,990	$13,140
PSA & Compressor			$90,666
Cost to remove Sulfur	$1,538	$6,262	$9,393
Other Oper Costs	$25,000	$25,000	$25,000
Total Operating Cost	$39,678	$77,252	$138,199
Total Cost of Goods Sold	($153,452)	($115,878)	($54,931)
General & Administrative Expenses	$10,000	$10,000	$10,000
Operating Income (before depr&Int)	$202,990	$263,173	$242,101

BOTTOM LINE COMPARISON – LOW VOLUME HURTS ROR OF PIPELINE SYSTEM

Capital Purchases			
Biogas Plant	$502,000	$502,000	$502,000
Gen-Set(s)	$75,000	$350,000	$75,000
Separator & Building	$100,000	$100,000	$100,000
Boiler	$10,000	$10,000	$10,000
PSA & Compressor			$315,000
Electrical and Interconnections	$100,000	$150,000	$250,000
Other Capital	$200,000	$200,000	$200,000
Total Capital Purchases	$987,000	$1,312,000	$1,452,000
Other Capital Cost			
Engineering & Admin	$49,350	$65,600	$72,600
Contingencies	$74,025	$98,400	$108,900
Total Other Capital Costs	$123,375	$164,000	$181,500
Total Capital Cost	$1,110,375	$1,476,000	$1,633,500
After grant ROR			
Simple payback (yrs)	4.1	4.2	5.1
10yr MIRR	7.0%	6.6%	3.2%
ROI (yrs)	7.1	7.4	9.8

FEEDSTOCK OPTIONS TO INCREASE BIOGAS PRODUCTION

ADDING JUST 5% CO-FEED

CAN GREATLY INCREASE BIOGAS PRODUCTIVITY

Assumptions:

Manure Volume - Gallons		10,950,000		
Assumed Total Solid %'s		8%		
Co-feed - Gallons		547,500		50% CH4 producer

INCREASE OF 175%

		22d	24d	28d
Biogas Production per year - cft		83,220,000	87,600,000	89,790,000
Biogas Flowrate - cft / minute		158	167	171
cft of methane per year		43,854,750	48,727,500	51,070,800
MMBTU's per year (millions)		46,137	52,980	56,115
MMBTU's per hour		5.3	6.0	6.4
	CFT CH4 PER DAY	120,150	133,500	139,920
Farm usage only MMBTU's factored for conversion efficiency	7,320			
Farm Usage % of Energy generated		16%	14%	13%
Energy generated % of farm usaage		630%	724%	767%

HIGHER POTENTIAL ENERGY SALES

ENERGY SALES

44,676 Total volume (1000 cft) of Natural Gas available for Pipeline / year

$312,732 Potential Natural Gas Revenue Stream / year

Price Range - Natgas price/1000cft			Revenue Range / year		
Low	Modeled	High	Low	Modeled	High
$4.000	$7.000	$10.000	$178,704	$312,732	$446,760

OR

5,434,692 Total volume (kWh) of Electricity Production / year

$205,431 Potential Electricity Revenue Stream / year

Price Range - Elec price/kWh			Revenue Range / year		
Low	Modeled	High	Low	Modeled	High
$0.030	$0.038	$0.060	$163,041	$205,431	$326,082

CAPEX INCREASES FOR HIGHER ELECTRICITY PRODUCTION – BUT PIPELINE SYSTEM STILL ADEQUATE

Capital Purchases			
Biogas Plant	$502,000	$502,000	$502,000
Gen-Set(s)	$75,000	$700,000	$75,000
Separator & Building	$100,000	$100,000	$100,000
Boiler	$10,000	$10,000	$10,000
PSA & Compressor			$315,000
Electrical and Interconnections	$100,000	$150,000	$250,000
Other Capital	$200,000	$200,000	$200,000
Total Capital Purchases	$987,000	$1,662,000	$1,452,000
Other Capital Cost			
Engineering & Admin	$49,350	$83,100	$72,600
Contingencies	$74,025	$124,650	$108,900
Total Other Capital Costs	$123,375	$207,750	$181,500
Total Capital Cost	$1,110,375	$1,869,750	$1,633,500

BOTTOM LINE COMPARISON

	Farm Only A	Farm + Elec B	Farm + Pipeline D
Revenue			
Sell Energy	$0	$180,779	$269,523
Sell Excess Bedding/Compost	$8,326	$8,326	$8,326
Sell Sulfur - Fertilizer	$151	$1,090	$1,141
Sell Emission Credits	$83,937	$96,681	$92,937
Total Revenue	$92,414	$286,877	$371,928

After grant ROR

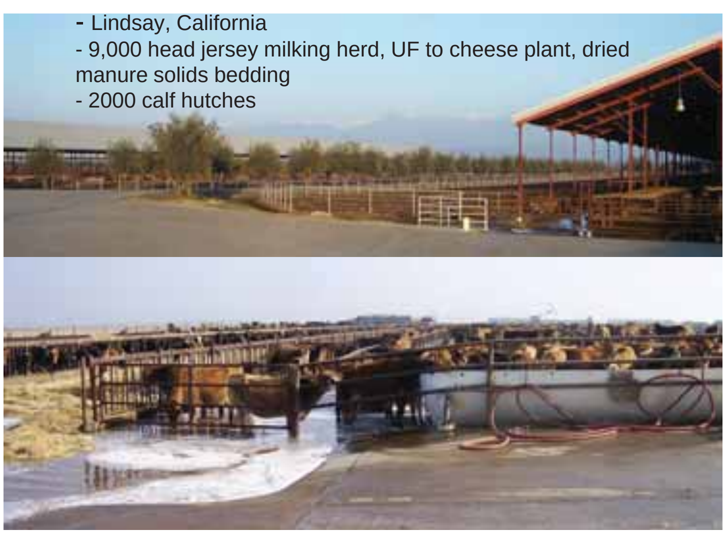
Simple payback (yrs)	4.1	4.6	3.3
10yr MIRR	6.8%	5.1%	10.7%
ROI (yrs)	7.3	8.4	5.3

WAS 7.4 yrs

was 9.8 yrs

HILARIDES DAIRY

- Lindsay, California
- 9,000 head jersey milking herd, UF to cheese plant, dried manure solids bedding
- 2000 calf hutches

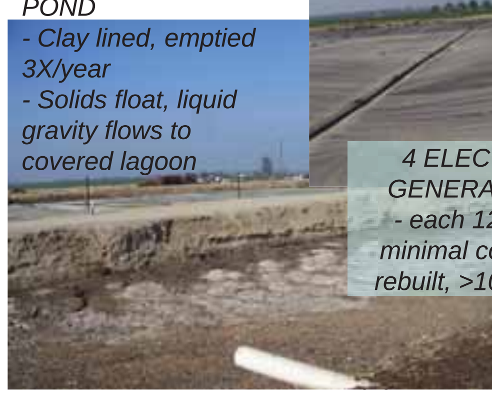


PRE-EXISTING SYSTEM

INITIAL SETTLING POND

- Clay lined, emptied 3X/year

- Solids float, liquid gravity flows to covered lagoon



TWO COVERED LAGOONS

- Ambient, no agitation, clay lined

4 ELECTRIC GENERATORS

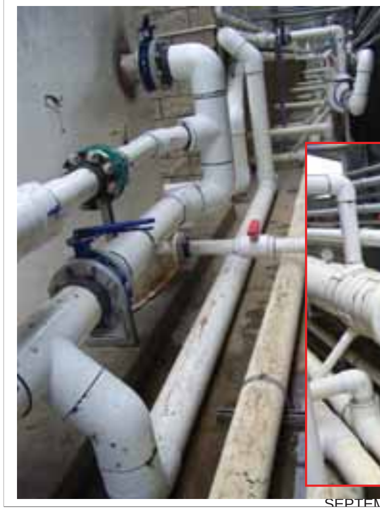
- each 125kW, minimal controls, rebuilt, >10yrs old

RECENT EXPANSION

- Covered 3rd lagoon, adding 18 million gallons
- Ambient, no agitation, ? Retention time
- Increased biogas capture by 70%

CONNECTING TO EXISTING BIOGAS LINES

- Tied into header, creating bypass loop
- Note use of S40 PVC (no freezing)

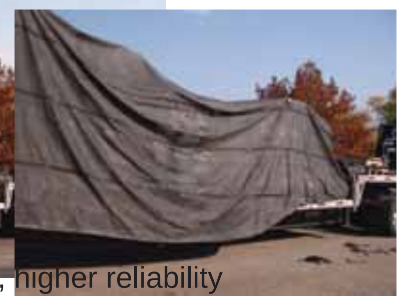


H2S REMOVAL

- Although PSA can remove H2S, preferable to remove H2S before upgrading – otherwise H2SO4 will form somewhere!
- Initially using lead-lag Sulfatreat vessels, used tanks, with "adaptations" to increase bed life and lower cost
- Researching additional options to lower cost further

Biogas Upgrading System – **BUS™ A**

- Switched to shop fabrication vs. field erection
- Performance check prior to shipment on entire system
- Shipped to site for faster installation

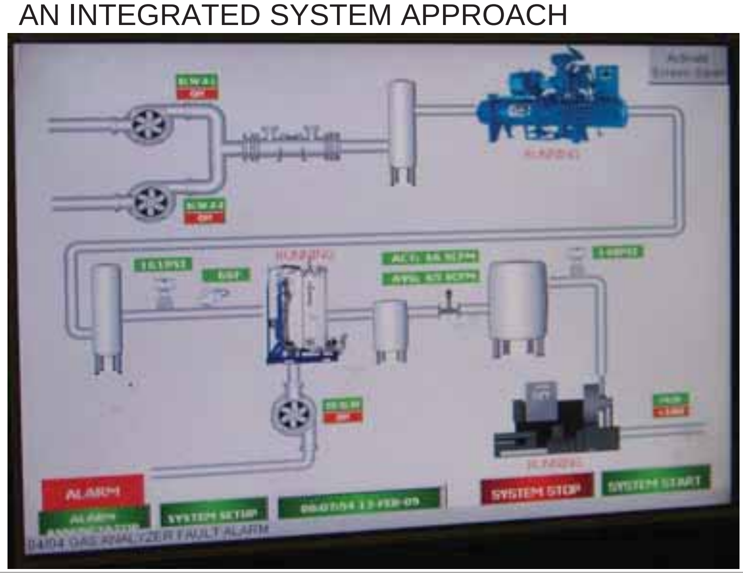


Lower cost, higher reliability

New System, New Building

Erected new 3-sided building to house BUS™, compression skid, and storage cylinders. (System could be outdoors in colder climate also with frost package added.)

AN INTEGRATED SYSTEM APPROACH



HIGH SIDE COMPRESSION

3600 psig, ~775 GDE/day

30hp three stage reciprocating compressor fills cascade storage vessels, 70,000 scf capacity, 15 hours of production time at nameplate capacity. CH4 concentration in biogas and PSA setting determine actual throughput of upgraded biomethane.

MILK TRUCKS RUNNING ON CBM (Compressed Biomethane)

Two new Peterbilt glider kits with Cummins-Westport natural gas engines. Fill time determined by pressure differential between CBM in storage and truck fuel tank. At max differential, fill time for 120 GDE is four minutes.

PICK UP TRUCKS TOO!

- Found six used CNG pickups on e-bay and purchased for farm use

WORLD AG EXPO 2009

http://wud.telefeed.com/#latestvideo

BY THE NUMBERS

- Fuel Value: 775 GDE per day, $2,325 @ $3/gal in CA
- CA Pollution tax avoidance of $0.04/mile, $186/day
- *Truck O&M: Less, but TBD*
- *Carbon Credits: TBD, may take as SOx or NOx*
- *Advanced Biofuel Production Tax Credit: TBD*
- Installed cost: $1.2 million, not including new lagoon cover or trucks. Interest & depreciation of $300/day, ignoring grant contribution
- Operating cost:
  - 90hp + 30 hp compression, about 90kW. At self-generated O&M of $0.03/kWh, $64.80/day
  - H2S removal, $200-400/day at projected bed life
  - Compressor oil, belts, plugs, TBD but budgeted for $20/day.
  - Labor, 30 minutes/day, $30/day

Net – About $1500-$1700 per day benefit