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CASE STUDIES OF COVERED LAGOON DIGESTERS ON CALIFORNIA DAIRY FARMS

- ❖ Four working digesters on dairies in California
- ❖ All utilize covered lagoons ranging from 0.8 to 45 million gallons
- ❖ Three utilize internal combustion (IC) engines from 80 to 700 KW electricity for interconnection with PG&E and one produces scrubbed biomethane for pipeline sale to PG&E

Covered Lagoon Digester Straus 250-Cow Dairy Marshall, CA: Operating since 2004



**800,000 gal. Covered Lagoon Digester . Inputs: 20,000 gallons/day
manure flush + creamery wastewater @ 40-day HRT
Recent clean-out of lagoon after 9 years revealed no solids
accumulation**

75 KW Engine-Generator and Exhaust Heat Exchanger



**Waukesha Induction generator provided power for dairy farm,
engine heat produced hot water for parlor washing, from 2004-2009**

New Synchronous Generator just installed April, 2009.

COSTS and INCOME

CAPITAL COST

Covered Lagoon Digester & Slurry Handling	\$140,000
Biogas Handling, Engine-Generator, Building and Utility Interconnect	<u>\$140,000</u>
Total Capital Cost	\$280,000

ANNUAL INCOME

Electrical Income:	\$50,000
Estimated Heat Income	<u>\$5,000</u>
Total Annual Income	\$ 55,000

Covered Lagoon Digester Giacomini 300-Cow Dairy Point Reyes, CA: Operating since 2009



2,500,000 gal. Covered Lagoon Digester
Inputs: 55,000 gallons/day manure flush + cheese process wastewater
45-day HRT

Gas Handling and H₂S Removal



**Carbon Canister Hydrogen Sulfide Removal,
Refrigerated Gas drier and blower**

80 KW Engine-Generator and Exhaust Heat Exchanger



Provides power for cheese plant, dairy parlor, engine heat produces hot water for milking and cheese process heat

COSTS and INCOME

CAPITAL COST

Covered Lagoon Digester & Slurry Handling	\$250,000
Biogas Handling, Engine-Generator, Building and Utility Interconnect	<u>\$200,000</u>
Total Capital Cost	\$450,000

ANNUAL INCOME

Digester system start-up June 2009, generator running @ 50 to 75 KW for 12 to 24 hours per day, income yet to be determined since on net metering with PG&E.

Covered Lagoon Digester Joseph Gallo 5000-Cow Dairy Atwater, CA: Operating since 2004



45-million gal Covered Lagoon Digester
Inputs: 1-1/2 million gallons/day manure flush + cheese plant Wastewater
30-day HRT

Hydrogen Sulfide Removal



**Iron Sponge
H₂S Scrubber**

**97to 99% Removal
Efficiency**

or

5 to 20 PPM H₂S

300 KW ENGINE-GENERATOR & 3-Way Catalyst for 9 ppm NOX



**Caterpillar Synchronous Generator
Provides electrical power for cheese plant
Engine heat produces steam for cheese process**

400 KW ENGINE-GENERATOR & Waste Heat Recovery



This generator added in 2005
Provides electrical power for cheese plant
Engine heat produces steam for cheese process and
radiator pre-heats air for whey drier

ENGINE WASTE HEAT TO RADIATOR HEATING OF WHEY DRIER AIR



COSTS AND INCOME

CAPITAL COST

Estimated Capital Cost(Digester System Only) \$2,500,000

Estimated Annual Operating Costs:

H2S Scrubber - change iron sponge 40,000

Engine-Generator Maintenance @.023/kwhr 128,000

Maintenance @ 2 % of Non-Generator cost 20,000

Total annual operating cost: \$188,000

ANNUAL INCOME

300 KW + 400 KW Engine-Generators

Electricity @ \$0.10 per Kwhr , \$600,000

Process heat recovery in equivalent

Propane , 145,000 gal/yr @ \$1.00/gal \$145,000

Total Annual Income \$745,000

Simple Payback: ~4.5 yrs

BIOENERGY SOLUTIONS COVERED LAGOON DIGESTER VINTAGE DAIRY

BIOGAS UPGRADING - PIPELINE INJECTION:

- ❖ Liquid Volume : 37.3 million Gallons
- ❖ Double Liner 60 mil HDPE with 200 mil geonet
- ❖ Leak detection system and sludge removal pipes
- ❖ Covered with 60 mil HDPE anchored in concrete
- ❖ Cover has gas relief valves and rainfall pumps

DOUBLE LINER INSTALLATION WITH LEAK DETECTION REQUIRED FOR TIER 1 WATER QUALITY PERMIT



243,000 SQUARE FEET LAGOON COVER WITH GAS RELIEF VALVE AND RAINFALL PUMP



BIOGAS UPGRADING SYSTEM FOR HIGH PRESSURE(650 PSI) INJECTION INTO PG&E PIPELINE, CO₂ <1% AND H₂S < 4 PPM



PERMITTING ISSUES: ENERGY GENERATION USING ANAEROBIC DIGESTION OF LIVESTOCK WASTE

WASTEWATER. ALL FARMS REMAIN UNDER ZERO DISCHARGE RULES FOR DIGESTER EFFLUENT. THE CAFO PERMITS CONTROL FACILITIES AND OPERATIONS.

GOVERNING AGENCY: CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS: [HTTP://WWW.WATERBOARDS.CA.GOV/](http://www.waterboards.ca.gov/)

FOR NEW LAGOONS, CAN BE EITHER TIER I – EXPEDITED REVIEW (TIER I) BUILD DOUBLE-LINED LEACHATE COLLECTION PONDS TO STORE WASTEWATER – VINTAGE DAIRY

OR TIER II : SINGLE LINER EITHER CLAY OR SYNTHETIC, WITH MONITORING WELLS INSTALLED, TAKES LONGER FOR REVIEW- STRAUS, GALLO AND GIACOMINI

REGULATIONS GOVERNING AIR EMISSIONS FROM ENERGY RECOVERY SYSTEMS

THE PERMIT REQUIREMENTS WILL VARY DEPENDING ON LOCAL AIR QUALITY. ALL AREAS OF THE COUNTRY ARE CLASSIFIED BY THEIR ATTAINMENT STATUS WITH NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS) FOR SIX POLLUTANTS - SULFUR DIOXIDE, PARTICULATE MATTER, NITROGEN DIOXIDE, CARBON DIOXIDE, LEAD, AND OZONE.

AREAS THAT MEET THE NAAQS FOR A PARTICULAR AIR POLLUTANT ARE CLASSIFIED AS IN "ATTAINMENT" FOR THAT POLLUTANT; EXAMPLE: NORTH COAST - GIACOMINI & STRAUS

AREAS THAT DO NOT MEET THE NAAQS ARE CLASSIFIED AS IN "NONATTAINMENT" FOR THAT POLLUTANT; EXAMPLE : SAN JOAQUIN VALLEY – GALLO AND VINTAGE DAIRIES

**GOVERNING AGENCY: CA AIR RESOURCES BOARD:
[HTTP://WWW.ARB.CA.GOV/PERMITS/PERMITS.HTM](http://www.arb.ca.gov/permits/permits.htm)**

REGULATIONS GOVERNING AIR EMISSIONS FROM ENERGY RECOVERY SYSTEMS : NOX EMISSIONS FROM ENERGY CONVERSION

COMBUSTION OF BIOGAS -- IN AN ENGINE, TURBINE, OR BOILER -- GENERATES NITROGEN OXIDES (NOX). FOR BIOGAS COMBUSTION SOURCES, NOX IS LIKELY TO BE THE EMISSION OF GREATEST CONCERN TO STATE AIR POLLUTION REGULATORS. NITROGEN OXIDES CONTRIBUTE TO THE FORMATION OF ATMOSPHERIC OZONE AND FINE PARTICULATE MATTER. OBTAINING A PERMIT MAY REQUIRE SELECTION OF A COMBUSTION DEVICE WITH LOW NOX EMISSIONS.

IN CALIFORNIA, NOX LIMIT IS 9 PPM FOR NEW ENGINES IN NON-ATTAINMENT REGIONS

NOX EMISSIONS FROM ENERGY CONVERSION , CONT.

LEAN-BURN ENGINES INJECT BIOGAS INTO THE COMBUSTION CHAMBER ALONG WITH AIR THAT IS IN EXCESS OF THE STOICHIOMETRIC MIX. THIS TYPE OF ENGINE PROVIDES BOTH GREATER ENGINE POWER OUTPUT AND FEWER NOX EMISSIONS THAN A COMPARABLE NATURALLY ASPIRATED ENGINE. IN RECENT YEARS, MANUFACTURERS HAVE DEVELOPED ENGINES WITH VERY LOW NOX EMISSIONS. CATALYSTS CAN BE USED TO FURTHER REDUCE NOX EMISSIONS.

**IN CALIFORNIA NON-ATTAINMENT REGIONS—
CATALYSTS WILL BE REQUIRED TO MEET 9 PPM
NOX LIMIT!**

NOX EMISSIONS FROM ENERGY CONVERSION , CONT.

TURBINES AND BOILERS:

WITH MODERN DESIGNS, GAS-FIRED BOILERS AND TURBINES EMIT LEVELS OF NOX THAT ARE LOWER THAN FUEL INJECTED LEAN BURN INTERNAL COMBUSTION ENGINES. FOR TYPICAL FARM SCALE SYSTEMS, ADDITIONAL CONTROLS SHOULD NOT BE REQUIRED TO OBTAIN A PERMIT.

FLARES:

IN CALIFORNIA, RESTRICTIONS ARE BECOMING TIGHTER FOR LOW NOX FLARES IN APPLICATIONS OF GAS SCRUBBING FOR PIPELINE INJECTION. LOW NOX FLARES OF THE TYPE SEEN AT LANDFILLS ARE VERY EXPENSIVE ~ \$150,000 TO 200,000

SOX EMISSIONS FROM ENERGY CONVERSION

COMBUSTION OF BIOGAS ALSO CAN GENERATE SULFUR OXIDES (SOX). SULFUR OXIDES ARE GENERATED WHEN BIOGAS CONTAINING HYDROGEN SULFIDE AND OTHER REDUCED SULFUR COMPOUNDS ARE COMBUSTED.

IN SOME AREAS, OBTAINING A PERMIT MAY REQUIRE INSTALLATION OF A SCRUBBING TECHNIQUE TO REMOVE HYDROGEN SULFIDE AND OTHER REDUCED SULFUR COMPOUNDS BEFORE BIOGAS COMBUSTION.

IN CALIFORNIA, H₂S SCRUBBING IS REQUIRED TO PREVENT CONTAMINATION OF CATALYSTS TO CONTROL NO_x FOR ELECTRIC GENERATION, AND TO MEET H₂S LIMITS FOR PIPELINE CH₄