City of
Santa Rosa
Utilities Department

August 5, 2011

Abby Young
BAAQMD
939 Ellis St
San Francisco, CA 94109

Re: BAAQMD Project # 2008-133

Dear Abby,

Enclosed you will find the City of Santa Rosa's Progress Report 4 and Final Summary for our Aquatic Biomass to Fuel Project.

If you have any questions, please contact me at (707) 543-3366.

Sincerely,

Nicole Dorotinsky
Research and Program Coordinator
City of Santa Rosa

55 Stony Point Rd • Santa Rosa, CA 95401
Phone: (707) 543-3366 • Fax: (707) 543-4505
www.srcity.org

Bay Area Air Quality Management District
Climate Protection Grant Program
FINAL REPORT

PROJECT INFORMATION:

BAAQMD Project # 2008-133 **Date of Report: 08/5/2011**

Organization Name: City of Santa Rosa

Person Completing Report: Nicole Dorotinsky (Name) (Phone #) (707) 543-3366

(E-mail) ndorotinsky@srcity.org

Fiscal Sponsor Approval of Report (if applicable): ____________________

Project Title: Aquatic Biomass to Fuel

FISCAL INFORMATION:

	Grant	Match
1. Total Project cost:	$ 75,000	$ 31,239
2. Project costs incurred to date:	$ 75,000	$ 80,495
3. Project costs invoiced to date:	$ 37,500	
4. Project costs reflected in this invoice:	$ 37,500	

INCLUDED IN REPORT:

Project Status & Task Deliverables
Final Project Summary
Publications
Digester Operation Manual
Final Invoice

PROJECT STATUS

Summary

The past six months have been crucial to the success of the Fuel from Aquatic Biomass Project, located at the City of Santa Rosa Laguna Treatment Plant. During this reporting period we continued operating the dual Vertical Flow Anaerobic Digestion (VF-AD) bioreactors and carried out long-term testing of a feedstock composed of equal parts of aquatic vegetation, crude glycerol and wine leees. The VF-AD reactors stably performed throughout the period, giving high methane yields (0.52-0.55 m^3 kg^{-1} volatile material added) and soilds reduction (66.1-69.0%). Methane produced by the system is utilized to generate electricity for charging electric vehicles that operate at the site and the remaining solids composted for use in on-site strawberry beds. To remove corrosive hydrogen sulfide, the biogas outflow each reactor has been directed through a biological scrubber, in which denitrifying bacteria oxidize and thereby remove H_2S from the gas phase. Since installation, the scrubbers have continued to operate efficiently without failure. For future research, we would like to investigate the capacity of the gas scrubbers to remove ammonia from the biogas, which would prevent the formation of nitrogen oxides during combustion.

All deliverables specified in the funding agreement have been completed. Below are descriptions of each required deliverable established in the Reporting Schedule for Report 4.

Task Descriptions

<u>Task 2.2: Initiate Digester Operation</u>

Deliverable A: Detailed report on digester operation

During the majority of final reporting period both vertical flow anaerobic digestion (VF-AD) reactors were fed every other day with a 142 L mixed feedstock containing 3.8% (wt/vol), as water-free material, equal proportions of red wine lees (Hanna Winery, Santa Rosa CA) crude glycerol byproduct from biodiesel manufacture (Yokayo Biofuels, Ukiah CA), and aquatic. The feedstock mixture supported stable and efficient VF-AD reactor performance, including the high yields of methane and substantial reductions in the density of volatile solids (Table 1).

Table 1. Performance of anaerobic digestion reactors fed with a 1:1:1 mixture of aquatic vegetation, wine lees and crude glycerol from 29 December 2010 to 17 June 2011.

	Reactor	
Characteristic	**West**	**East**
Biogas		
methane yield (m^3 kg^{-1} dry weight added)	0.48	0.46
methane yield (m^3 kg^{-1} volatile material added)	0.55	0.52
methane concentration (%, vol/vol; n = 23)[a]	61.3 ± 4.1	61.3 ± 4.4
Volatile solids		
feed (% total solids; n = 4)[b]	81.3 ± 0.9	80.8 ± 0.7
effluent (% total solids; n = 4)[b]	53.8 ± 3.3	56.3 ± 2.5
reduction (%)[b]	69.0 ± 4.1	66.1 ± 4.9
Volatile acids		
feed (mg L^{-1} acetic acid; n = 4)[b]	1193 ± 135	1230 ± 134
effluent (mg L^{-1} acetic acid; n = 4)[b]	142.5 ± 8.5	150.0 ± 12.3

reduction (%)[b]	87.5 ± 2.0	87.3 ± 2.0
pH, feed (n = 5)[b]	4.62 ± 0.11	4.58 ± 0.11
pH, effluent (n = 23)[a]	7.12 ± 0.05	7.18 ± 0.06
Alkalinity, feed (mg L^{-1} $CaCO_3$; n =4)[b]	490 ± 115	485 ± 78.1
Alkalinity, effluent (mg L^{-1} $CaCO_3$; n =4)[b]	2325 ± 118	2625 ± 103
NH_3, effluent (mg L^{-1}; n =23)[a]	193 ± 96	234 ± 77

[a]Values mean ± SD
[b]Values mean ± SE

Crude glycerol replaced dairy manure as a feedstock component on October 16 and November 29 2010 to the west and east reactors, respectively, resulting in a dramatic increase in methane output from 0.21 ± 0.6 m^3 kg^{-1} DW to 0.47 ± 0.1 m^3 kg^{-1} DW. This increase is likely due to a variety of factors including the better digestibility of glycerol (Fountoulakis et al., 2010; Ma et al., 2008; Siles López et al., 2009) and an increase in the C/N ratio to 20 resulting from substitution of manure with crude glycerol. The original feedstock mixture has a C/N ratio of 11, below the ideal ratio range of 20 to 30 that has been found in several studies to promote higher rates of biogas production and a higher proportion of methane in the biogas (Hills, 1979; Yadvika et al., 2004; Yen & Brune, 2007).

Deliverable B: Detailed report on fugitive methane emissions

The system plumbing and tank closures have been confirmed to be gas-tight. A key modification to the original tanks was the substitution of the 16-inch threaded hatch at the top of each tank with a bolted hatch (Figure 1A) carried out in April 2010. Over the course of the entire experimental period the biogas-generating potential of the feedstocks was reduced by 90.0 ± 4.7% (mean ± SE, n = 6) by passage through the reactors. Since the effluent is aerobically composted most of this remaining bio-accessible material is not likely to be converted to methane; in fact, methane emission was not been detected from the compost piles (Figure 1B).

Figure 1. (A) Gas-tight hatch on east bioreactor; and (B) effluent drying and composting bin.

Task 2.5: Utilize Methane and Off-set Electricity Use
Deliverables: Detailed report on electricity generation and use and electrical schematic

Biogas from the each VF-AD reactor is passed through a biological sulfide scrubber which lowers H_2S in the biogas from >200 ppm to levels that are undetectable (<1 ppm) using an MSA Orion Gas Analyzer. Removal of the H_2S is necessary to prevent corrosion of the gas storage and electrical generator equipment. Scrubbed biogas is temporarily held in a 3.6 m^3 capacity diaphragm tank (one per reactor) and is compressed to 25 psi into a 300 gallon capacity metal storage tank. As needed, the biogas is used to power a 6.6 kW electrical generator (Yamaha model EF6600DE).

A total of 489 m^3 of methane has been produced by the system since the tanks were fully sealed on 28 April 2010 until 17 June 2011. Assuming a typical 28% efficiency of the electrical generator 1438 kWh[1] of electricity could be generated from the methane produced by the VF-AD. The electric carts utilized at the Laguna Treatment Plant require approximately 20 kWh per charge. Thus, the amount of gas

[1] 10.51 kWh / 1 m^3 methane, http://www.epa.gov/cmop/resources/converter.html

produced was sufficient to power 72 full charges of the electric carts. Of the 417 days for which data was analyzed 62.4% of the total energy production occurred within the 170 days of the current reporting period beginning on 29 December 2011, indicating the increased efficiency of operations.

An electrical schematic of the site can be found in Appendix A.

Task 3.1: Perform Life Cycle Cost Analysis

Deliverables: Complete system analysis including detail of methodologies

Energy consumption at the project site was calculated based on estimated heat loss from the bioreactors and electrical power consumption by equipment necessary to operate the system. The formula for heat loss (H) from a given insulated surface area is:

$H = A(T_{in} – T_{out})/R$

where:

A, the surface area of each bioreactor equals 195 ft^2

T_{in}, the temperature inside the bioreactors equals 95°F;

T_{out}, the average temperature outside of the bioreactors equals 59.1°F;

R, the insulation value of the bioreactor polyurethane foam coating equals 15 ft^2 h °F btu^{-1}.

Power consumption, where not specified by the manufacturer, was calculated based on Ohm's law: P = VI

For cost-offset calculations the weight of methane produced by the bioreactors was multiplied by a conversion factor of 23 as specified by the Regional Greenhouse Gas Initiative (http://www.rggi.org) to obtain equivalent weight of carbon dioxide (CO_2e). A carbon offset price of $10 per ton CO_2e was used for calculations (http://www.carbonfund.org). The $1.026361 per therm was the retail price charged by Pacific Gas and Electric as of June 2011. Landfill dumping costs were obtained from the County of Sonoma (http://www.sonoma-county.org/tpw/pdf/transfer_fees.pdf). A price estimate of $16 per cubic meter of compost was obtained from a market survey of costs for typical high volume soil amendments.

Energy yields per unit of substrate fed under current operating conditions for our VF-AD reactors are similar to those previously obtained from a VF-AD reactor (Biljetina et al., 1987). Of the energy available from flame combustion of the methane produced by a bioreactor an estimated 25% would be required to heat the bioreactors (Tables 2 & 3)[†], which is typical of anaerobic digesters that do not operate on waste heat from a generator (Wisconsin Focus on Energy, 2009), 15% for heating the entering feedstock, and 11% for other on-site uses (Table 2). The highest calculable benefit from a small VF-AD reactor would be savings from lowering disposal costs (Table 3) but the full benefits of AD, which include odor control and pest suppression, are difficult to quantify. A larger VF-AD system would have a greater lifecycle value since heating and maintenance costs decrease per unit of volume. There are a wide range of payback periods estimated for real-world AD systems (Lusk, 1998; Nelson & Lamb, 2002; Rapport et al., 2008), many of which have biogas production efficiencies much lower than provided by VF-AD.

Table 2. Daily energy requirements per VF-AD bioreactor

Operation	kWh
Feedstock mixing/grinding	0.18
Lighting	0.25
Recirculation	0.84
Heat loss	3.28
Feed heating [a]	1.65
Metabolic heat contribution [b]	(0.36)
Total energy requirement	**5.84**[c]

[a] $Q = W_f C_p (T_2 - T_1)$, from Turovskiy & Mathai (2006)

[b] Themelis & Kim (2002)

[c] Represents 55% of the gross energy yield (5.84 kWh /10.7 kWh)

Table 3. Annual value projections for a two-reactor system

Category	$
Net energy production [a]	120
CO_2e offset	139
Soil amendment	115
Dumping fee offset	1,578
Total calculable value	**1,952**

[a] Energy value of methane calculated assuming use of gas for heating.

[†] i.e. (3.28 kWh − 0.36 kWh) / 10.7 kWh * 100 = 25%; values from Tables 2 and 3.

During this report period the following presentations were given on the project:

Cohen M, "Fuel from Aquatic Biomass: A multidisciplinary project," Japan Society for the Promotion of Science USA Multidisciplinary Science Forum. Seattle, WA. March 11, 2011.

Cohen M, "Integrating Biofuel Production with Wastewater Polishing and Crop Management," CSU Biofuels Taskforce, 23th Annual Meeting of the CSU Program for Biotechnology. Anaheim, CA. January 6, 2011.

The following publications were released:

McCallum, Kevin (June 8, 2011) SR Wins two awards for environmental Creativity. The Press Democrat.

Clark L (June 15, 2011) Green mind. *North Bay Bohemian.*
http://www.bohemian.com/bohemian/06.15.11/blast-1124.html

The Buzz (June 8, 2011) Santa Rosa wins environmental award for algae project. *AlgaeIndustryMagazine.com*.
http://www.algaeindustrymagazine.com/santa-rosa-wins-environmental-award-for-algae-project/

PROJECT SUMMARY (maximum 4 pages), reflections on entire project:

1. Describe any unanticipated outcomes from your project (good or bad).

We were very pleased by exemplary performance of the reactors in processing the unique combination of substrates (Table 1, page 3). In addition, the site became a testing ground for biological removal of hydrogen sulfide from biogas. The two installed scrubbers completely removed H_2S from the biogas and thus prevented corrosion of the gas compression and electricity generating equipment.

2. Describe how your project did or didn't follow your original work plan.

The following issues presented themselves and were remedied:

- The on-demand hot water heater at the site could not deliver sufficient water for diluting the feedstock and therefore the feedstock was delivered into the reactors at ambient temperature; since the feed represents only 1/30th of the total liquid volume in the reactors the resultant change in temperature was <1ºC and, therefore, did not adversely affect the microbial community.
- The gas flow meters were found to not be properly calibrated by the manufacturer (Sage Meters, Inc.) and thus calibration had to be conducted on site by use of a gas displacement device.
- Initially reactors failed to maintain gas pressure due to a failure of the threaded hatches on top of the reactors to fully seal. New bolted hatches were installed which fixed the issue.
- As constructed, the PVC gas outflow lines combined into a common line that entered into the biological sulfide scrubber before being compressed for later combustion by the electric generator. Anomalies in flow readings led us to realize that this combining of gas streams resulted in occlusion of gas flow from the upstream-most (west) bioreactor. Gas piping was rearranged to separate the two gas flows.
- The In-Sink-Erator grinding apparatus specified in the original plan was inadequate to the task and was replaced by installation of a BearCat chipper/shredder.
- Gas diagram tanks (3.6 m^3 capacity) were added to receive the biogas outflow from each reactor in order to prevent the wasteful cycling of gas by the compression pumps, as was specified in the original design.

As mentioned above, biological H_2S removal was not part of the work plan but was added later and has performed very well. The biogas scrubbers were inoculated with a mixture of microorganisms obtained from Sonoma County's Sulfur Creek and Calistoga 'Old Faithful' Geyser that colonized the approximately 30 m^2 of packing material surface area (NuPac #2, Lantech Products, Inc.) in each scrubber. Nitrate in tertiary-treated water misted in the scrubbers serves as an electron acceptor for the denitrifying and anammox bacteria that colonize the surfaces. The 155 L void volume within the packing material was several times more than was necessary to handle even high flow rates of up to 3 L min^{-1} from the VF-AD reactors; similar systems can achieve near complete removal of H_2S when operating with retention times well below one minute (Syed et al., 2006).

3. Describe any partnerships that were created by your project.

Sonoma State University: Dr. Michael Cohen, project principal investigator.

California Strawberry Commission: Provided funds for research project to test, in part, the suitability of composted digestate as a soil amendment.

CSUPERB: California State University Program for Education and Research Biotechnology: Provided funds and supplies for student researchers.

California Energy Commission: Provided some matching funds for project construction and testing.

R.S. Duckworth Construction: Construction of the CAS.

Brown & Caldwell: Anaerobic digester system blueprints.

Harmony Farm Supply & Nursery: Provided strawberry plants for soil amendment tests.

Dr. Mark Mazzola, USDA-ARS: Collaborated on the California Strawberry Commission-funded research project to test composted digestate as a soil amendment.

Hanna Winery: Contribution of reactor feedstocks wine lees and aquatic vegetation.

Yokayo Biofuels: VF-AD processing of crude glycerol by-product of biodiesel manufacture.

DenBeste Transportation: Transport of inocula for the reactors.

CadTrak Engineering: Developing a device to remove small particles from wastewaters.

Skye Davis Multi Image/Video Multimedia Production

4. Lessons learned: what would you do differently, had you the opportunity to repeat this project? Other lessons learned?

The original engineering drawings should *not* serve as blueprints for a future construction of a VF-AD system but do provide valuable guidance when taken into consideration along with the experiences related in this report that have led us to make the following recommendations:

- Plastic tanks are a suitable reactor vessel but the screw-on hatches *must* be replaced with a gas-tight design.
- Selection and placement of gas flow meters within the system must be carefully considered. Though there was considerable consultation of the project engineer with the meter manufacturer and supplier, the original gas flow meter setup was not suitable for the task. We have calibrated the meters on site and have changed the placement of the meters such that they are downstream of a water trap and hydrogen sulfide scrubber.
- Reactor outflows should not be combined into a common pipe if one intends to measure gas flow from a system with multiple bioreactors even when the meters are placed upstream of the confluence point.
- To avoid clogging, plumbing for feedstock delivery and recirculation of reactor contents should be greater than the 1.5 inch diameter utilized in the system and elbows should be minimized. Pumps should be designed to shut off automatically in the case of development of a clog.
- The thermostat-controlled heat tracer system is well-suited for maintaining tank temperature within the narrow range of 95 $\pm$ 1°F. Heating the culture while it was being brought up to the final volume and substrate concentration, rather than after, could have potentially prevented the large vacillation in pH that we observed upon turning on the heating system (Task Force on Anaerobic Sludge Digestion, 1987).
- The mixing period should allow for at least 1 volume of culture contents to recirculate and the recirculant should be withdrawn above the region of the cone bottom containing settled solids whereas during feeding the mixing should occur from the bottom of the reactor cone. Now that the recirculation plumbing system appears to be operating clog free we would like to test the effect of dividing the recirculation period at intervals over the course of the day.
- To save costs, a manometer on a bioreactor can serve double duty as an overpressure release point rather than installing expensive commercial pressure release devices, which we found to be unreliable and have therefore stopped using.
- The energy required for heating the feed mix and the bioreactors themselves constitutes the majority of the total operational energy needs. Therefore, net energy production could be greatly increased if the VF-AD system were to be coupled to a solar heating unit. The feedstock mixing station overhang is south-facing and would accommodate solar panels.

- To more precisely monitor energy usage at the site an electricity meter should be installed.

5. What additional opportunities and/or funding has this project leveraged?
    - \$25,000 award from Green Giant.
    - \$90,565 California Strawberry Commission research grant to Sonoma State University and USDA-Agricultural Research Service to study, in part, the usefulness of composted VF-AD reactor-derived digestate as a soil amendment.
    - \$25,000 from CSUPERB for student research support.

6. For what types of activities do you believe future funding is needed?
    - Test and optimize the biogas scrubbers for their ability to remove ammonia. Removal of ammonia from the biogas could potentially eliminate the production of nitrogen oxides from the electric generator and thereby facilitate the wider utilization of anaerobic digestion by obviating this air quality concern.
    - Couple the anaerobic digestion process with constructed wetland-based wastewater scrubbing by bubbling CO_2 generated during biogas combustion into the aquatic scrubber to promote plant uptake and growth.
    - Expand Channelized Aquatic Scrubbers (CAS) to increase vegetation yield.
    - Test the ability of slag, a steel manufacturing waste product, to remove phosphorus from wastewater passed through the CAS.
    - Scale up project.
    - Investigate application of system in winery settings and its potential for use in developing countries.

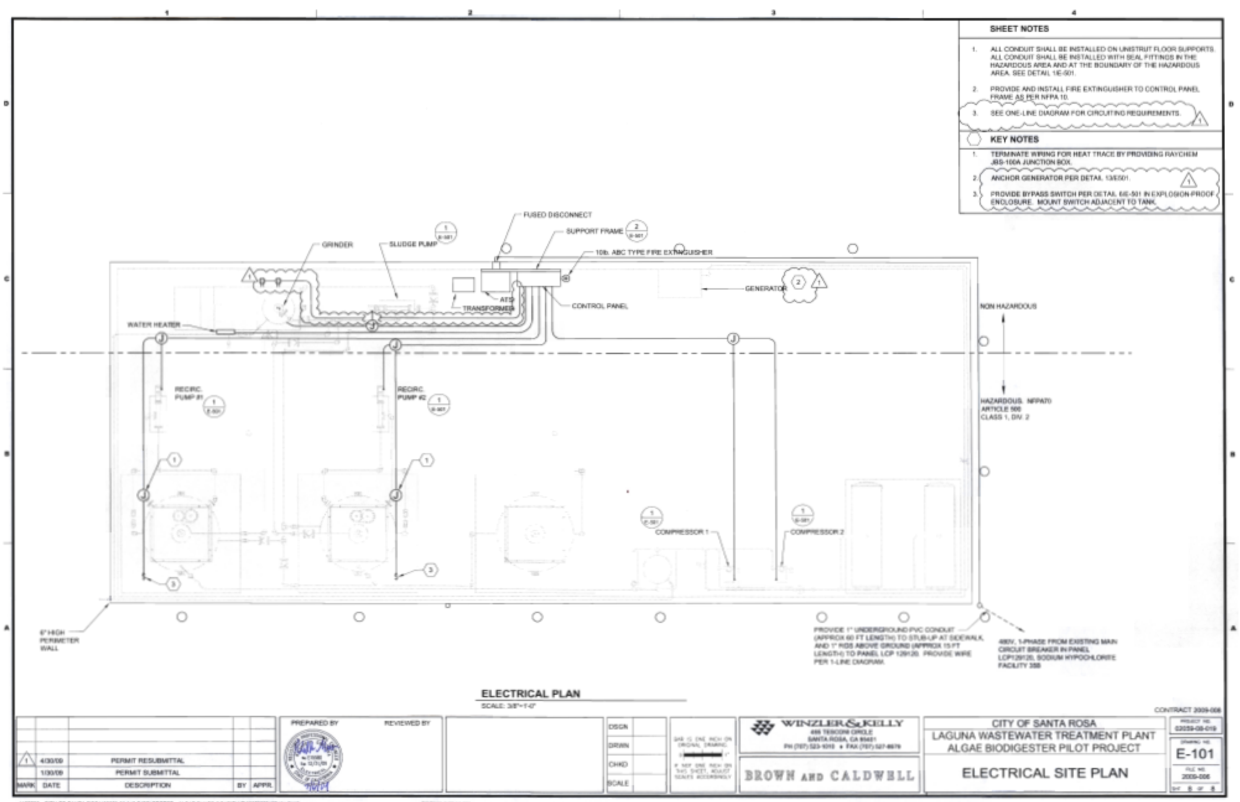
7. Quantify the results of your project (actual results only, not estimated or anticipated results unless specified) in terms of the following statistics:
    - GHG reduction: **11.24** tons eCO2 reduced
    - Projected future GHG reduction as a result of project: **1.1** tons eCO2 reduced per month
    - Energy and/or fuel savings: Net electricity production = **9.4** kWh per day
    - Financial savings: **\$252** from electricity and soil amendment production (does not factor in construction costs)
    - Permanent jobs created (specify full or part-time): None
    - Temporary jobs/internships/consulting jobs created (estimate hours) **9000 hrs since beginning of grant**
    - Number of public meetings held: **20** (includes tours and presentations at public events)
    - Number of people attending public meetings: approximately **1000**
    - Number of youth directly reached by specific activities (attended meetings, participated in a class or assembly, etc.): **200**
    - Any other interesting statistics

      Won the following awards:

      Green Giant Green Award 2011
      ACWA Teddy Roosevelt Award 2009
      Pearson Education Award 2009
      IREC Innovation Award 2008
      ICLEI Climate Innovation Award 2008

Appendix A

Electrical site plan



References:

Biljetina, R., Srivastava, V.J., Chynoweth, D.P. 1987. Anaerobic digestion of water hyacinth and sludge. in: *Aquatic plants for water treatment and resource recovery*, (Eds.) K.R. Reddy, W.H. Smith, Magnolia Publishing, Inc. Orlando, Florida, pp. 725-738.

Fountoulakis, M.S., Petousi, I., Manios, T. 2010. Co-digestion of sewage sludge with glycerol to boost biogas production. *Waste Management*, **30**(10), 1849-1853.

Hills, D.J. 1979. Effects of carbon: Nitrogen ratio on anaerobic digestion of dairy manure. *Agricultural Wastes*, **1**(4), 267-278.

Lusk, P. 1998. Methane recovery from animal manures: The current opportunities casebook. National Renewable Energy Laboratory.

Ma, J., Van Wambeke, M., Carballa, M., Verstraete, W. 2008. Improvement of the anaerobic treatment of potato processing wastewater in a UASB reactor by co-digestion with glycerol. in: *Biotechnology Letters*, Vol. 30, Springer Netherlands, pp. 861-867.

Nelson, C., Lamb, J. 2002. Final report: Haubenschild farms anaerobic digester. The Minnesota Project.

Rapport, J., Zhang, R., Jenkins, B.M., Williams, R.B. 2008. Current anaerobic digestion technologies used for treatment of municipal organic solid waste. California Integrated Waste Management Board. IWMB-2008-011.

Siles López, J.Á., Martín Santos, M.d.l.Á., Chica Pérez, A.F., Martín Martín, A. 2009. Anaerobic digestion of glycerol derived from biodiesel manufacturing. *Bioresource Technology*, **100**(23), 5609-5615.

Syed, M., Soreanu, G., Falletta, P., Béland, M. 2006. Removal of hydrogen sulfide from gas streams using biological processes - A review. *Canadian Biosystems Engineering*, **48**, 2.1-2.14.

Task Force on Anaerobic Sludge Digestion. 1987. *Anaerobic sludge digestion*. Water Pollution Control Federation, Alexandria, VA.

Themelis, N.J., Kim, Y.H. 2002. Material and energy balances in a large-scale aerobic bioconversion cell. *Waste Management & Research*, **20**(3), 234-242.

Turovskiy, I.S., Mathai, P.K. 2006. *Wastewater sludge processing*. John Wiley & Sons, Inc., Hoboken, New Jersey.

Wisconsin Focus on Energy. 2009. Farm anaerobic digesters: Producing energy from waste. REN-2003-0709.

Yadvika, Santosh, Sreekrishnan, T.R., Kohli, S., Rana, V. 2004. Enhancement of biogas production from solid substrates using different techniques--a review. *Bioresource Technology*, **95**(1), 1-10.

Yen, H.-W., Brune, D.E. 2007. Anaerobic co-digestion of algal sludge and waste paper to produce methane. *Bioresource Technology*, **98**(1), 130-134.

SR wins two awards for environmental creativity

By KEVIN McCALLUM
THE PRESS DEMOCRAT

Santa Rosa has recently won two awards for innovative environmental projects.

One came from the Department of Energy for helping add a high number of solar arrays to homes and businesses in Sonoma County, enough to produce 29 megawatts of electricity.

The other award was for an experimental project using algae to clean wastewater and using the vegetation to generate electricity.

Together the projects demonstrate that Santa Rosa continues to take a leadership role in environmental sustainability, said Dell Tredinnick, a city project development manager.

"We have blown away the competition," Tredinnick said of the solar initiative.

It was the second consecutive year the city has won the federal "Steel on the Roof" award. The award recognizes that Santa Rosa, since becoming a Solar America City in 2008, has added more solar capacity than any other city in the program, even far larger ones such as San Diego, Tredinnick said.

There are several reasons the city is a solar standout. One is because solar projects throughout Sonoma County count toward the city's statistics. The other reason is that the city has more than 250 days of sunshine per year. Another is easy financing through the popular Sonoma County Energy Independence Program, he said. The program loans money to homeowners for energy efficiency upgrades and allows them to repay the loans on their property tax bills.

The other award was particularly gratifying to Caden Hare, who manages a project at the city's Laguna Treatment Plant, which uses algae and other native aquatic plants to clean wastewater.

That's because, unlike other awards the project has won, this one came with a prize of $25,000.

The "Green Giant" awards were presented at a star-studded ceremony in Los Angeles last month that "felt like the Academy Awards," Hare said.

Hare is a former student at Sonoma State University who developed the project as an intern and now manages it as a temporary employee for the city.

Though the contest was ready to award him the cash, Hare signed the check over to the city because without the city's support the award wouldn't have been possible, he said.

He's hoping to explore new ways of boosting the production of biogas from the project, which has been used to produce electricity for golf carts but could have other uses.

He's also hoping to find natural ways of making the gas less corrosive, and of removing phosphorus from the waste stream. Currently, the aquatic plants excel at removing nitrogen, as well as a host of pharmaceuticals, such as birth control medication, which can interfere with the sexual development of fish and other creatures.

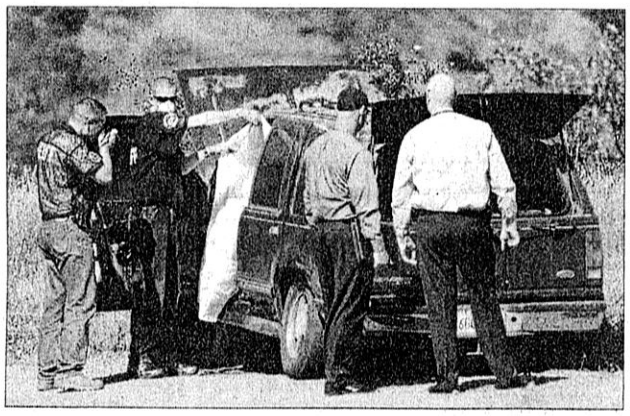
Tredinnick said the cash award is welcome because as budgets tighten, nonessential operations like this project run the risk of being cut. He hopes that's not the case.

"I feel very fortunate that we're able to do this research," Tredinnick said.

Hare noted the project is largely funded by grants.

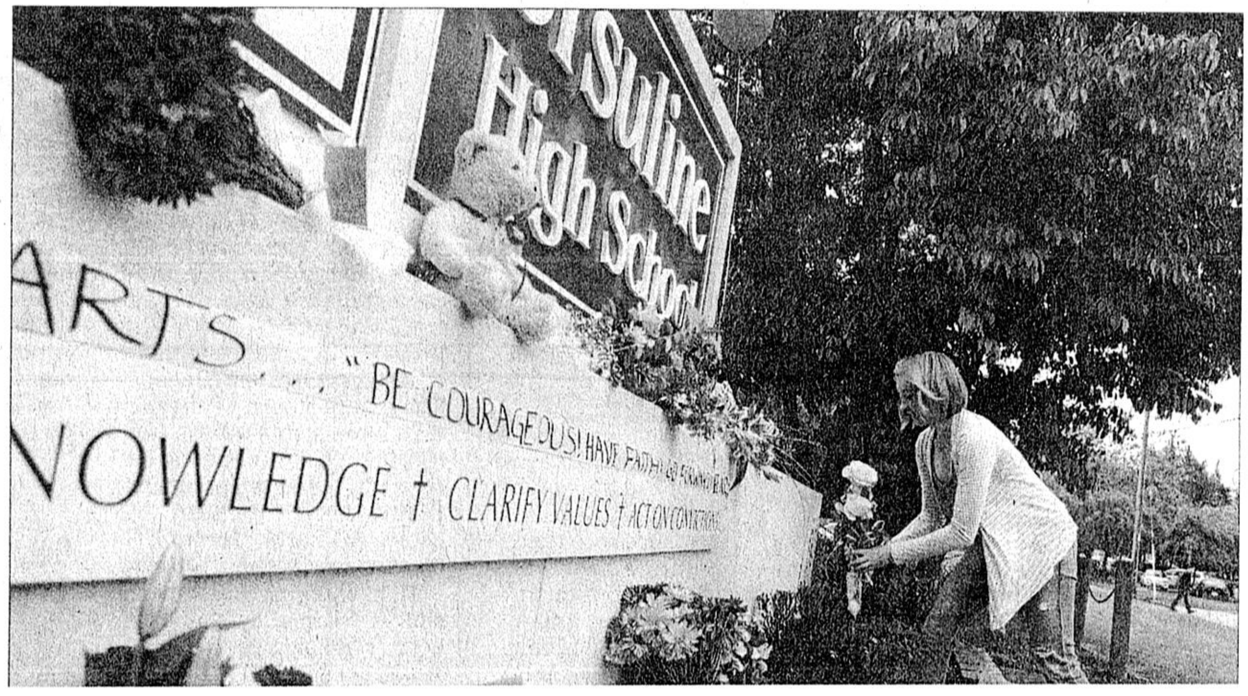
"There was no crash and no skid. But the gas can makes it suspicious."

LT. STEVE BROWN
Sonoma County Sheriff's Office



CRISTA JEREMIASON / The Press Democrat

Sheriff's detectives take photos of a burned body inside an SUV on Highway 128 near Cloverdale on Tuesday.

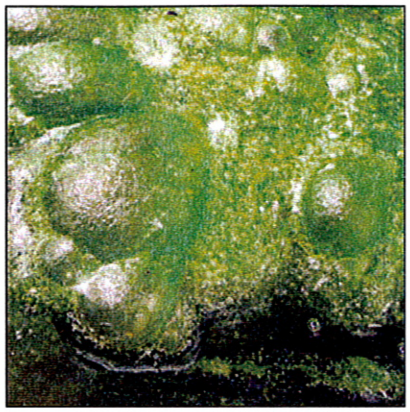


bohemian.com News, music, movies, restaurants & wine culture in Sonoma, Marin and Napa counties

news 06.15.11

News Blast

By Leilani Clark



Green Mind

In May, the city of Santa Rosa's project development team received a $25,000 award for its Fuel from Aquatic Biomass (FAB) project. Created in conjunction with Sonoma State University, the innovative energy-production program uses aquatic vegetation to treat wastewater while producing renewable energy. A video about the project, created by SSU intern Caden Hare only two days before the submission deadline, was selected as a finalist by public online voting. Soon after, Hare was flown to Los Angeles to walk the "green carpet" and receive the Green Civic Leader cash prize. "It was just such an amazing experience," he says. "It felt like the Academy Awards."

The money will be used to expand the project, including studies on how to treat byproducts of steel manufacturing in wastewater. With inquires about FAB arriving from the Department of Energy, it's clear that Hare and the project development team are on the right track toward better ways to clean up our water.

Keep the Peace

In the land of wine and roses, it's all too easy to forget that the United States continues to wage deadly and costly wars. As a reminder, Rep. Lynn Woolsey hosts a call for an end to permanent U.S. warfare on June 18. A vocal opponent of the wars in Iraq and Afghanistan, Woolsey has famously spoken on the floor of the House of Representatives on the subject nearly 400 times. As the promised time for a military drawdown in Afghanistan grows closer, Woolsey is joined by Norman Solomon, Code Pink and Iraq Veterans Against War for a day of grassroots activism. "It's Time for Peace" takes place Saturday, June 18, at San Rafael City Plaza. Fourth and Court streets, San Rafael. 1-2:30pm. 415.507.9554.

Send a letter to the editor about this story.

metroactive

Santa Rosa Wins Environmental Award for Algae Project

June 8, 2011
AlgaeIndustryMagazine.com

Kevin McCallum of the Santa Rosa, CA *Press Democrat* reports that Santa Rosa has won a "Green Giant" award at the recent Green Awards, in Los Angeles, for an experimental project using algae to clean wastewater, and then using the biomass to generate electricity. The award was presented to Caden Hare, who manages a project at the city's Laguna Treatment Plant that uses algae and other native aquatic plants to clean wastewater. Hare is a former student at Sonoma State University who developed the project as an intern, and now is a temporary employee for the city.

Hare is hoping to explore new ways of boosting the production of biogas from the project, which has so far been used to produce electricity for golf carts. He's also hoping to find natural ways of making the gas less corrosive, and of removing phosphorus from the waste stream. Currently, he notes, the aquatic plants excel at removing nitrogen, as well as pharmaceuticals such as birth control medication, which can interfere with the sexual development of fish and other creatures.

Though the contest was ready to award Hare $25,000, he signed the check over the city because without the city's support the award wouldn't have been possible, he said. Dell Tredinnick, a city project development manager, said the cash award is welcomed because as budgets tighten, non-essential operations like this project can run the risk of being cut. But he hopes that's not the case. "I feel very fortunate that we're able to do this research," Tredinnick said.

Go to HOME Page

Twin Bioreactor Operations Manual[†]

Table of Contents

[†] Revised August 2011.

Overview

This manual should enable the operator to maintain the environmental conditions required for healthy methanogen communities. The discipline of regular feedings, maintaining the optimal bioreactor temperature (35 degrees Celsius) and pH (6.8 to 7.2) will, if fastidiously followed, prevent catastrophic die-off of the methanogen communities.

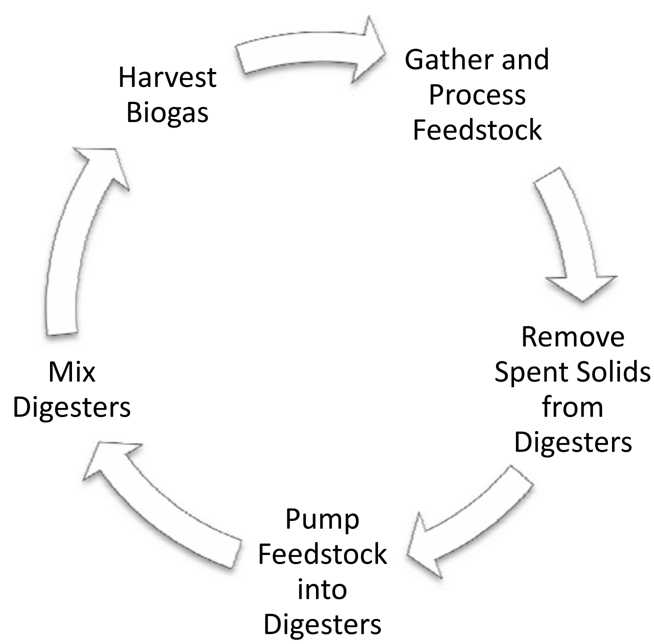
The Goal

The primary goal is to maintain the methanogen population needed to investigate how changing environmental conditions affect mesophilic methanogen biogas production. The following operations are necessary to maintain a healthy methanogen population:

- feeding the microbes
- mixing the reactor liquor
- harvesting the biogas production
- operating the electrical generator
- recording the bioreactor conditions
- presenting the data generated

Remember that "bio" means life; the operator must understand the impact of the operation of the equipment on the organisms that convert the biomass into biogas.

The Process



The operator gathers food (called "feedstock," or "substrate") and processes that food to make it suitable for microbial consumption and compatible with the pumps and plumbing system. Operator removes the residual solids (called "digestate") from the digesters, and then pumps the food into the digesters. Operator mixes the digesters to ensure proper accessibility of food to the microbial community, and harvests the resulting biogas. Throughout, the operator must monitor how well the food is being digested. One way to do this is to use the rate of biogas production as an indicator of how well digestion is proceeding. Taking samples, bringing them to the lab, and analyzing the results is another important way to do this. It is imperative to pay close attention to the surroundings to make sure that everything looks and sounds as it should.

Standard Position

Standard Position is the position of all site equipment when the bioreactors have an active methanogen community, but no active process is ongoing. ("active process" here refers to what the operator is doing, as the microbes are always active.) Active processes are:

- feeding
- digestate removal
- bioreactor contents mixing
- biogas harvesting
- sampling
- electrical generator operation
- equipment repairs/maintenance
- electric vehicle recharging

Active processes require the presence of the site operator. Accordingly, when you arrive at the site and leave the site all equipment must be in Standard Position. Record the readings of all meters and gauges before moving equipment settings out of Standard Position and again after restoring all equipment settings to Standard Position.

Equipment check for Standard Position:

- All sample valves, closed
- Bioreactor lower cone valve, closed
- Bioreactor lower cylinder valve, open
- Bioreactor post circulation pump is directed to the upper bioreactor
- Bioreactor dome top entry valve, open
- Bioreactor dome top exit valve, open

- Bioreactor Sage meter entry valve, open
- Bioreactor Sage meter exit valve, open
- Bioreactor gas valves leading to biogas compressor, closed
- Bioreactor gas valves leading to biogas H2S scrubber, open
- H_2S scrubber entry valve, open
- H_2S scrubber exit valve, open
- Gas valves leading to PG&E meter, open
- PG&E meter entry valve, open
- PG&E meter exit valve, open
- Gas valves leading to Bladder Tank, open
- Bladder Tank entry valve, open
- Bladder Tank exit valve, closed
- Biogas compressor entry valve, closed
- Biogas compressor exit valve closed
- Compressed Biogas Tank entry valve, closed
- Compressed Biogas Tank exit valve, closed
- Compressed Biogas Tank vent valve, closed
- Generator biogas fuel line, closed
- Charging Station power, off
- Bioreactors' heater power, on
- Sage meter power, on
- Meter data logger power, on
- The Drain Hoses are attached to their hanger next each Bioreactor's Post Circulation Pump Valve
- Biogas Compressor Bypass entry valve, closed
- Biogas Compressor Bypass exit valve, closed
- The Main Electrical Panel has all switches are in the on position except for the grinder, charge point, overhead lights, and biogas compressors 1 & 2.
- All pumps, off
- All lights, off

Substrates

The substrate is a blend of Aquatic Biomass (AQ), Manure Solids (MN), Glycerol (GY), and Wine Lees (LL). As fed the substrate is 40% AQ, 40% MN, and 20% LL or 40% AQ, 40% GY, and 20% LL. The quantity per feeding is the ratio of the net dry weight of the biomass in kilograms fed divided by the total volume of the solution. The ratio is set by the experiment. The current target feed is 5%. The dry weight table gives the current dry weight analysis per substrate. For quick reference the mixture weights are posted next to the feed tank. Upon establishing the volume required to provide the goal feed weight, volumetric measurements can be used for more efficiency.

Before weighing the substrate it has to be prepared. Preparation begins with inspecting the substrate upon its arrival at the site. Substrate will come from many locations and in various conditions. Rarely can it be used as presented. You must eliminate non-biomass (rocks, sand, metal, plastic), woody stems, keratin, and stringy lignin rich fibers. Even if these materials did not singly jam the pumps (which they do), in the aggregate they coalesce into a plug in the bioreactor pipes.

Aquatic Biomass

Aquatic Biomass (AQ) is a blend of the fresh water aquatic plants on hand. Currently we collect Algae, *Lemnae* (duckweed), *Azolla*, *Ludwigia*, and *Hydrocotyle*. *Ludwigia* is woody at certain stages. All aquatic biomass will have rocks in it (scooped up during harvesting). Rocks, acorns, pine needles, non-aquatic plant woody stems, plastic, and other items found in the AQ will all need to be removed from the mix.

Manure Solids

The Manure Solids (MS) used as feed come from dairy cows. Depending on how it is collected, the MS can include stones, keratin (hoof trimmings and hair), sand, and undigested feed (such as hay, silage, almond shells, barley, corn and soy). Currently, the Barretta Dairy, a certified organic dairy, donates the manure comprising the substrate mix. The certification means that the dairy minimizes the use of antibiotics and avoids using hormones in the feedstock. The Barretta manure is an ideal condition with the exception of the presence of bedding sand. Straw, if present, has a higher lignin content, making it mostly indigestible for methanogens, and must be removed from the feed.

Glycerol

Glycerol (GY) is a byproduct of biodiesel manufacturing. Yokayo Biofuels uses restaurant waste oils and fats to make their biodiesel, and they deliver their waste glycerine to the digester site. As received the Glycerol is a blend of glycerol, methanol, potassium oleate, and potassium hydroxide. The Glycerol components can separate and must be mixed to maintain a uniform feed.

Wine Lees

Due to the nature of winemaking it is rare to find any contaminant in lees. Nonetheless, at some stages of winemaking, the lees can sometimes contain significant amounts of diatomaceous earth. Another condition of concern is the formation of a gelatinous mass; such formations need to be broken up before use.

Blending

Aquatic Biomass

The aquatic biomass will be at different levels of hydration. The aquatic biomass should be shredded into a pulp. In that form it is roughly 90-95% water. Even the more fibrous forms of Hydrocotyle and Ludwigia are rendered into pulp by the shredder.

Manure Solids

Manure Solids generally come with either straw or sand, depending on which is used by the dairy for bedding. When sand is used, it gets tracked into the manure deposited in the dairy aisles. Dilution of the Manure Solids during the course of blending with the other substrates causes most of the sand to settle out of suspension. When straw is used, it will need to be picked out of the suspension.

Glycerol

Vigorous stirring will homogenize the Glycerol components to provide a uniform feed.

Wine Lees

Vigorous mixing will fragment the gelatinous clusters of lees, facilitating the formation of a uniform suspension.

Substrate Mixing

To increase efficiency, when feeding 3.8% (wt/vol) substrate* into each digester's 1125 gallon (4258 liter) capacity, feed for both bioreactors can be simultaneously prepared by gathering:

- 10 gallons (37.85 liters) of AQ
- 10 gallons (38 Liters)of MN [or 2.4 liters of GY in substitution of MN]
- 5 gallons (34 liters) of LL into a mixing tank
- 27 gallons (102 liters) of water

If GY is substituted for MN, the GY will be added separately in 1.7 liter portions to the feed tank. Thorough mixing at this stage will permit woody and long fibrous materials to rise to the liquor's surface enabling their removal. The sand, rocks, and other dense materials will settle to the bottom centimeter of the mixing tank. When you are satisfied that the mix tank liquor is free of destructive materials, evacuate half of the liquor into the feed tank.

Feeding

Pre-feeding

By the time you've removed the destructive materials you'll place about 22.5 gallons (85 liters) of the mix tank into the feed tank per bioreactor plus 1.7 liters of GY when GY is substituted for MN. Dilute the liquor in the feed tank to 37.7 gallons (142 liters). When the diluted liquor is homogenous it is ready to be pumped into its respective bioreactor.

Feeding Procedure

1. Confirm whether the site is in Standard Position

2. Record the bioreactor site conditions:

   - Time and weather conditions
   - Sage Meter: cumulative production, instantaneous flow, flow temperature, flow wattage
   - PG&E Meter: cumulative production

* Includes, in addition to solids, the organic liquid component of the crude glycerol and wine lees.

- Dome Manometer: dome pressure
- Bioreactor Liquor Temperature
- Ambient Temperature
- Post Biogas Compression Pump: pressure
- Compressed Biogas Tank: pressure
- Bladder Tank: balloon radius

3.

    a. Change the Bioreactor Upper Cylinder valve to the closed position
    b. Change the Bioreactor Lower Cone valve to the open position
    c. Attach the digestate discharge hose to the Bioreactor Post Circulation Pump valve
    d. Direct discharge hose to a drain area
    e. After thorough mixing, open the loaded Feed Tank discharge valve
    f. Clear any clumping in the Bioreactor Sight Tube. To do so, climb the ladder to the top of the Bioreactor Sight Tube
    g. Close the valve leading to the Bioreactor dome
    h. Open the top access valve
    i. Vigorously move the clearing rod though the Bioreactor Sight tube liquor until the liquor is translucent
    j. Close the top access valve
    k. Open the valve leading to the Bioreactor dome

4.

    a. Sage Meter entry valve, close
    b. Sage meter exit valve, close

5. H_2S Scrubber Overflow Tube, capped

6.

    a. PG&E Meter entry valve, close
    b. PG&E Meter entry valve, close

7. Bladder Tank entry valve, close

8. Bioreactor meter by pass valves to the Compressed Biogas Tank, open

9.

    a. Low pressure Sensor Bladder valve, open
    b. Compressed Biogas Bypass Regulator output valve to Bioreactor, open
    c. Compressed Biogas Bypass Regulator input valve to Bioreactor, open

10. Compressed Biogas Tank input valve, open. While walking to the Bioreactor Post Circulation Pump valve, confirm that the Bioreactor Dome pressure has increased

11. Bioreactor Post Circulation Pump valve, move to the discharge position

12.

  a. Climb the ladder to the upper Bioreactor Sight Tube and observe the falling liquor level. When the liquor level indicates 37.5 gallons are about to be discharged
  b. Descend the ladder, go first to the Bioreactor Post Circulation Pump valve, and move it to the recirculate position
  c. Immediately thereafter, walk to the Compressed Biogas Tank and close the input valve
  d. Compressed Biogas Bypass Regulator input valve to Bioreactor, close
  e. Compressed Biogas Bypass Regulator output valve to Bioreactor, close
  f. Low pressure Sensor Bladder valve, close
  g. Open the valves connecting the Bioreactor Dome to the H_2S Scrubber and Bladder Tank. While feeding, the pressure build up will vent into the Bladder Tank

13. Confirm that the feed line T-valves are directed to the Bioreactor to be fed

14.

  a. Simultaneously turn on the Feed Tank and Bioreactor Recirculation Pump
  b. Observe the lowering substrate (feed) liquor level. Watch for and remove any stray pieces of substrate that may potentially cause a plumbing blockage. Make sure that a vortex forms as the liquor descends. When the feed liquor is pumped out
  c. Stop the pump and place 3 gallons of water into the Feed Tank
  d. Turn the pump on until the 3 gallons are pumped
  e. Place a gallon of water into the feed tank
  f. Close the Feed Tank exit valve
  g. Turn off the Bioreactor Circulation Pump
  h. Close the Meter Bypass valves

15. Repeat the process for the second Bioreactor

16.

  a. At the end of feeding, allow the dome pressure to increase to at least 6 cm, then harvest biogas into the Bladder Tank
  b. Reopen the PG&E Meter valves to the H_2S Scrubber and on to the Bladder Tank

17.

  a. To harvest biogas, first open the Sage Meter input valve
  b. Second, slowly open the Sage Meter exit valve so the flow of biogas does not exceed 25 liters/minute. When the dome pressure is reduced to 6 cm
  c. Close the Sage Meter entry valve, then close the Sage Meter exit valve. Let the dome pressure adjust to atmospheric pressure

18. After the dome pressure is adjusted to atmospheric pressure, uncap the H_2S Scrubber Overflow Tube

19.

a. In order to move biogas from a Bladder Tank to the Compressed Biogas Tank, first close the Sage input and exit valves for both bioreactors
b. Close PG&E input and exit valves for both bioreactors
c. Close the bioreactors H_2S Scrubber input and exit valves
d. For the Bladder Tank to be harvested, open the bypass valves leading to the main line serving the compression pumps
e. Turn on the compression pumps
f. Open the compression pumps input valves
g. Open the compression pumps exit valves
h. Open slowly the Compressed Biogas Tank input valve. Immediately begin monitoring the radius of the Bladder tank balloon
i. When the Bladder Tank balloon radius is approaching 10 cm, turn off the power to the Compression Pump motors
j. Close the Compressed Biogas Tank input valve
k. Close the Biogas Compressor exit valves, followed by closing the Biogas Compressor input valves
l. Close the Bioreactor bypass valves leading to the Biogas Compressor
m. Reopen the bioreactors H_2S Scrubber input and exit valves
n. Reopen the PG&E Meter input and exit valves
o. Reopen the Sage Meter input valve
p. Reopen the Sage Meter exit valve slowly so that the biogas flow does not exceed 25 liters/minute

20. When the site activities are complete, record the bioreactor site conditions as indicated above

21. Restore the bioreactor site to Standard Position

22. Confirm that the bioreactor site is restored to Standard Position

Bioreactor Liquor Mixing

The drain hoses have to be switched from Intra-Bioreactor Mixing to Inter-Bioreactor Mixing.

Intra Bioreactor Mixing Procedure

1. Confirm whether the site is in Standard Position.

2. Record the bioreactor site conditions:

- Time and weather conditions
- Sage Meter: cumulative production, instantaneous flow, flow temperature, flow wattage
- PG&E Meter: cumulative production
- Dome Manometer: dome pressure
- Bioreactor Liquor Temperature
- Ambient Temperature
- Post Biogas Compression Pump: pressure
- Compressed Biogas Tank: pressure
- Bladder Tank: balloon radius

3. Sage Meter entry valve, close

4. Sage meter exit valve, close

5. H_2S Scrubber Overflow Tube, capped

6. Turn both Circulation Pumps on simultaneously and record the start time

7. Record the stop time (84 minutes)

8. When the dome pressure exceeds 6 cm, harvest biogas into the bladder tank until the dome pressure is reduced to 6 cm

9.
   a. To harvest biogas, first open the Sage Meter input valve
   b. Slowly open the Sage Meter exit valve so the flow of biogas does not exceed 25 liters/minute
   c. When the dome pressure is reduced to 6 cm close the Sage Meter entry valve
   d. Close the Sage Meter exit valve. Do not let the dome pressure fall below 6 cm during circulation

10.
   a. At the end of the circulation period, turn off both circulation pumps simultaneously. Allow the bioreactor dome pressure to readjust to non-pumping conditions
   b. Slide the manometer height marker to the top of the meniscus of the atmosphere side of the manometer. Keep adjusting the height marker until the meniscus is higher than the height marker
   c. When the meniscus is higher than the height marker, reduce the remaining the dome pressure to atmospheric conditions by first opening the Sage Meter input valve, then opening the Sage Meter exit valve. Do not allow the gas flow to exceed 25 liters/minute

d. After the dome pressure is adjusted to atmospheric pressure, uncap the H_2S Scrubber Overflow Tube

11.

a. In order to move biogas from a Bladder Tank to the Compressed Biogas Tank, first close the Sage input and exit valves for both bioreactors
b. Close PG&E input and exit valves for both bioreactors
c. Close the bioreactors H_2S Scrubber input and exit valves
d. For the Bladder Tank to be harvested, open the bypass valves leading to the main line serving the compression pumps
e. Turn on the compression pumps
f. Open the compression pumps input valves
g. Open the compression pumps exit valves
h. Open slowly the Compressed Biogas Tank input valve. Immediately begin monitoring the radius of the Bladder tank balloon
i. When the Bladder Tank balloon radius is approaching 10 cm, turn off the power to the Compression Pump motors
j. Close the Compressed Biogas Tank input valve
k. Close the Biogas Compressor exit valves, followed by closing the Biogas Compressor input valves
l. Close the Bioreactor bypass valves leading to the Biogas Compressor
m. Reopen the bioreactors H_2S Scrubber input and exit valves
n. Reopen the PG&E Meter input and exit valves
o. Reopen the Sage Meter input valve
p. Reopen the Sage Meter exit valve slowly so that the biogas flow does not exceed 25 liters/minute

12. When the site activities are complete, record the bioreactor site conditions as indicated above

13. Confirm that the bioreactor site is restored to Standard Position

Inter Bioreactor Mixing Procedure

1. Confirm whether the site is in Standard Position

2. Record the bioreactor site conditions:

- Time and weather conditions
- Sage Meter: cumulative production, instantaneous flow, flow temperature, flow wattage
- PG&E Meter: cumulative production
- Dome Manometer: dome pressure
- Bioreactor Liquor Temperature

- Ambient Temperature
- Post Biogas Compression Pump: pressure
- Compressed Biogas Tank: pressure
- Bladder Tank: balloon radius

3.
    a. Change the Bioreactor Upper Cylinder valve to the closed position
    b. Change the Bioreactor Lower Cone valve to the open position
    c. Attach the inter circulation hoses from the Bioreactor Post Circulation Pump valve to the other Bioreactor feed line bypass
    d. Move the Bioreactor Post Circulation Pump valve to flow to the discharge position
    e. Open the valves leading to the other Bioreactor bypass valve
    f. Open the other bioreactor feed line bypass valve
    g. Sage Meter entry valve, close

4. Sage meter exit valve, close

5. H_2S Scrubber Overflow Tube, capped

6. Turn both Circulation Pumps on simultaneously and record the start time

7. Calculate the stop time (21 minutes)

8. When the dome pressure exceeds 6 cm, harvest biogas into the bladder tank until the dome pressure is reduced to 6 cm

9.
    a. To harvest biogas, first open the Sage Meter input valve
    b. Slowly open the Sage Meter exit valve so the flow of biogas does not exceed 25 liters/minute
    c. When the dome pressure is reduced to 6 cm, first close the Sage Meter entry valve, then close the Sage Meter exit valve. Do not let the dome pressure fall below 6 cm during circulation

10.
    a. At the end of the circulation period, turn off both circulation pumps simultaneously
    b. Allow the bioreactor dome pressure to readjust to non-pumping conditions
    c. Slide the manometer height marker to the top of the meniscus of the atmosphere side of the manometer. Keep adjusting the height marker until the meniscus is higher than the height marker
    d. When the meniscus is higher than the height marker, reduce the remaining the dome pressure to atmospheric conditions by first opening the Sage Meter input valve, then opening the Sage Meter exit valve. Do not allow the gas flow to exceed 25 liters/minute
    e. After the dome pressure is adjusted to atmospheric pressure, uncap the H_2S Scrubber Overflow Tube

11.
   a. In order to move biogas from a Bladder Tank to the Compressed Biogas Tank, first close the Sage input and exit valves for both bioreactors
   b. Close PG&E input and exit valves for both bioreactors
   c. Close the bioreactors H_2S Scrubber input and exit valves
   d. For the Bladder Tank to be harvested, open the bypass valves leading to the main line serving the compression pumps
   e. Turn on the compression pumps
   f. Open the compression pumps input valves
   g. Open the compression pumps exit valves
   h. Open slowly the Compressed Biogas Tank input valve. Immediately begin monitoring the radius of the Bladder tank balloon
   i. When the Bladder Tank balloon radius is approaching 10 cm, turn off the power to the Compression Pump motors
   j. Close the Compressed Biogas Tank input valve
   k. Close the Biogas Compressor exit valves, followed by closing the Biogas Compressor input valves
   l. Close the Bioreactor bypass valves leading to the Biogas Compressor
   m. Reopen the bioreactors H_2S Scrubber input and exit valves
   n. Reopen the PG&E Meter input and exit valves
   o. Reopen the Sage Meter input valve
   p. Reopen the Sage Meter exit valve slowly so that the biogas flow does not exceed 25 liters/minute

12. When the site activities are complete, record the bioreactor site conditions as indicated above

13. Restore the bioreactor site to Standard Position

14. Confirm that the bioreactor site is restored to Standard Position

Sampling

Sampling must be taken from homogenous liquor.

Harvesting Biogas

Biogas harvesting is performed in the same fashion as excess dome pressure is bled during feeding. Harvesting can be done during feeding, during circulation, and passively.

Plumbing, Electrical, & Mechanical Equipment and Diagrams

See the Plans for the City of Santa Rosa Laguna Wastewater Treatment Plant Algae Biodigester Pilot Project City Contract No. 2009-008 January 2009 Permit B09-0347 Approved 7/23/2009.

See the Equipment Manuals Folders.

Site Visitors

A site visitor is anyone other than the Twin Biodigesters Operator. The operator's accompanying responsibility is that site visitors must be briefed on how they can be on the site and accomplish their goals without compromising their safety or the bioreactors operation.

Safety

Sanitation, electricity, mechanical entanglement, corrosive substances, dangerous vapors, enclosed spaces, and mechanical lockout must all be taken into consideration. The site has out of necessity many elevations. The use of water and the nature of the substrates can create slippery areas. The materials processed can cause skin irritation. The shredder can spit back non substrate materials and shreds biomaterials almost instantaneously on contact with the cutting blades. The movement of the substrates requires shifting or lifting with forces sometimes exceeding 75 pounds. Accordingly protective gear and clothing (rubber boots, long sleeves, gloves, goggles) are required while working at the site.

Index

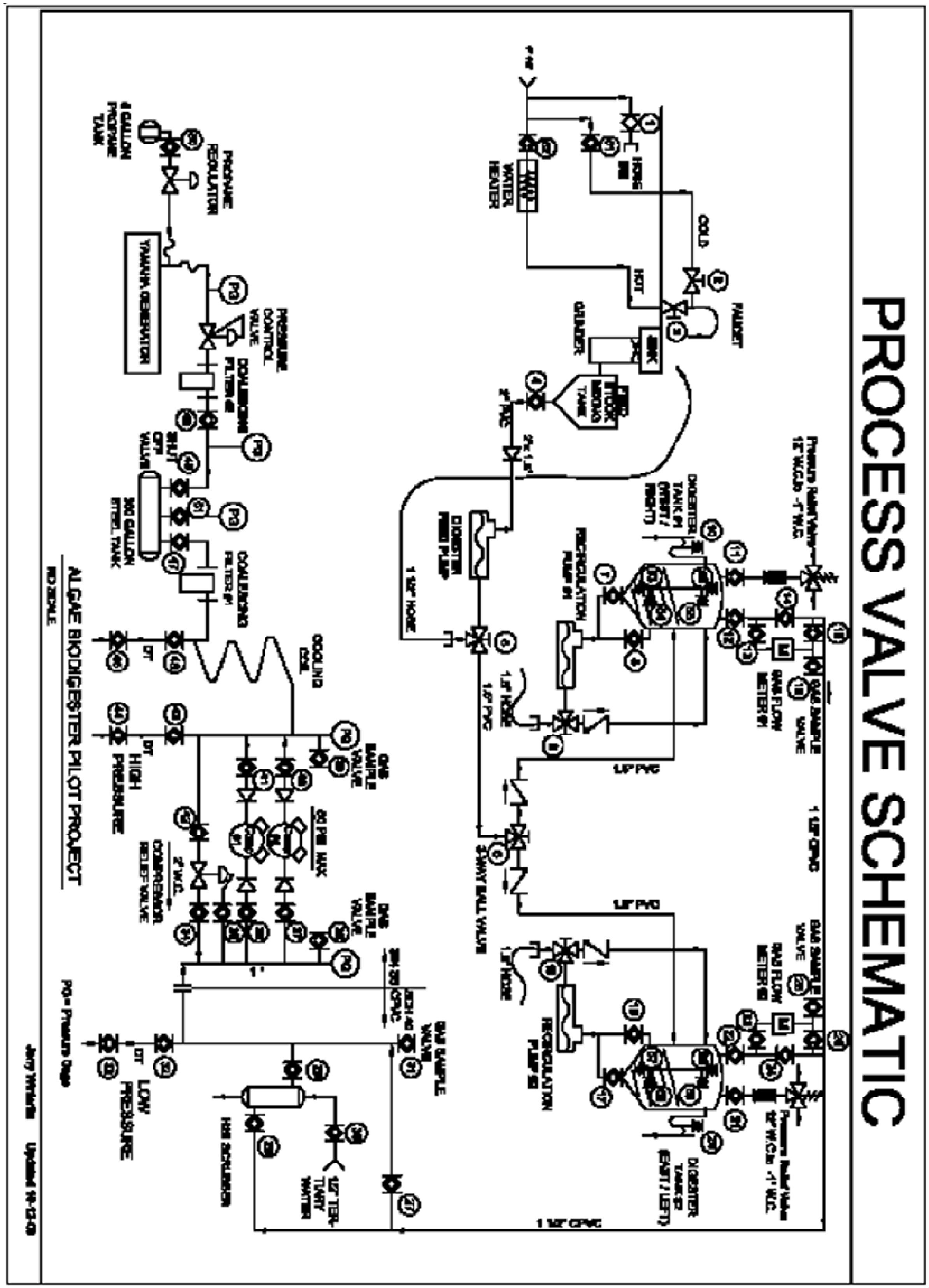
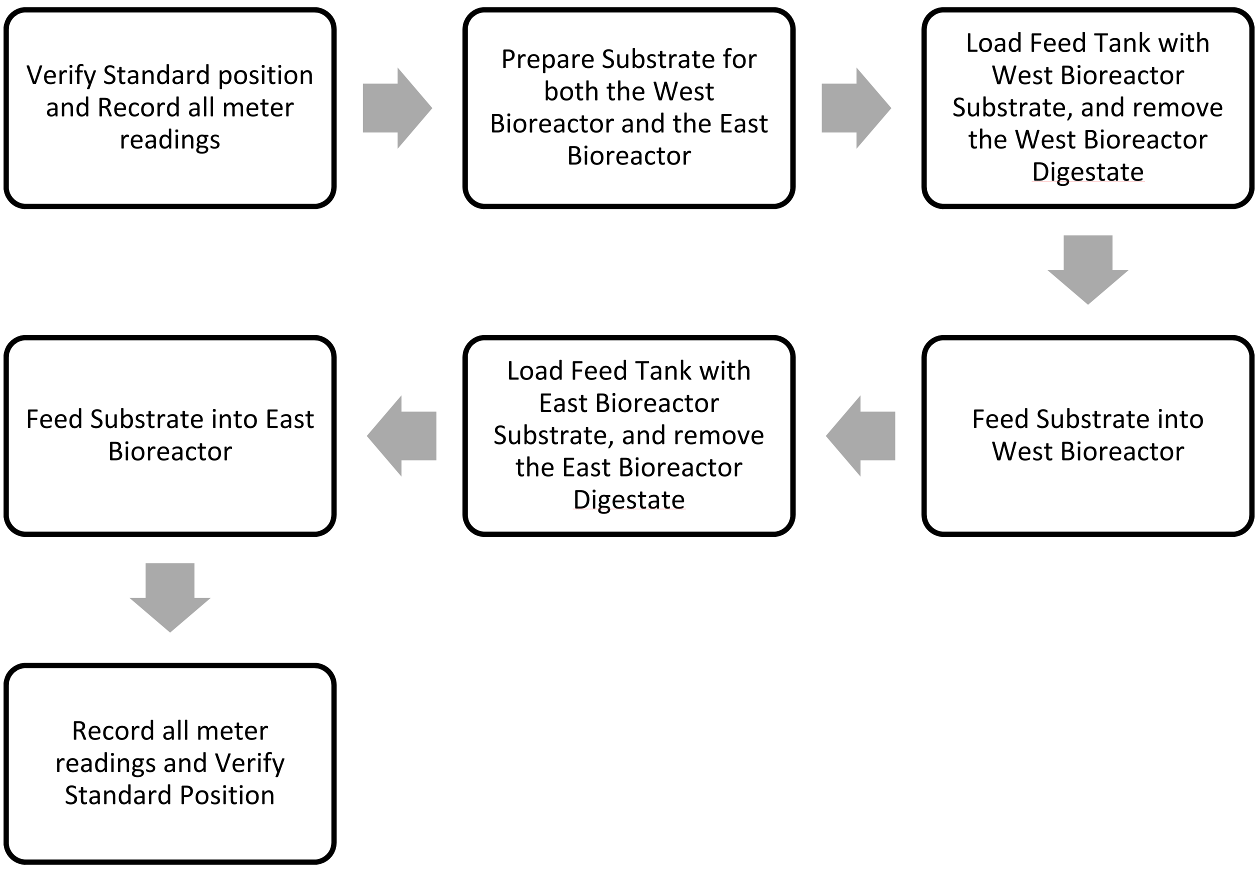

PROCESS VALVE SCHEMATIC
ALGAE BIODIGESTER PILOT PROJECT
TANKA GENERATOR
PRESSURE CONTROL VALVE
PROPANE REGULATOR
WATER HEATER
FAUCET
COLD
HOT
DIGESTER FEED PUMP
RECIRCULATION PUMP #1
RECIRCULATION PUMP #2
GAS FLOW METER #1
GAS FLOW METER #2
GAS SAMPLE VALVE
COOLING COIL
HIGH PRESSURE
LOW PRESSURE
COMPRESSOR RELIEF VALVE
3-WAY BALL VALVE
H2S SCRUBBER
1 1/2" CPVC
1/2" PVC
1 1/2" HOSE
PG= Pressure Gage

Diagram 1

The Feed Process



City of Santa Rosa California

INVOICE

Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

Invoice Date: 07/29/11
Project #: 2008-133

Attention: Abby Young

Billing Period: 01/11/2011 – 6/30/11
Aquatic Biomass to Fuel

Detail of Billing:

As per Climate Protection Grant Agreement No. 2008-133 between the Bay Area Air Quality Management District and the City of Santa Rosa Utilities Department. The City of Santa Rosa has completed the tasks and deliverables set forth in Progress Report 3 of Appendix A in the Grant Agreement. The City has not received payment for the invoice sent with Progress Report 2. I have contacted the BAAQMD several times regarding payment and have yet to receive it. The amount invoiced is the remaining contract amount.

Amount Due This Invoice: $37,500

Please make check payable to:
City of Santa Rosa

Submit to:
Nicole Dorotinsky
55 Stony Point Rd
Santa Rosa, CA 95401