Denali Emerging Energy Technology Grant:

"Improving Cold Region Biogas Digestor Efficiency"

Year 2 Quarterly Report, Y2Q1 – March 15, 2011

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i. Y2Q1 Summary

The project is transitioning into Phase 2. Research has commenced in order to apply small-scale anaerobic digestors in various applications that may benefit peoples in Alaska who are interested in biogas technology.

During the past quarter, the project focused on resuming and improving a consistent and regimented feeding schedule in efforts to closely track changes in gas production and efficiency of conversion of food-to-biogas. This involved stringent daily protocols for obtaining gas measurements and accurate monitoring of tank activity. Currently, high rates of daily activity (i.e. production of biogas) are being recorded among all tanks within the 25°C room. We observe lower activity in Tank 1 in the 15°C room. Though biogas production occurred throughout much of the Phase 1 period, data collected on site remained inconclusive until only recently. The most recent assessment of gas production among the 15°C and 25°C rooms reveals almost all tanks containing psychrophilic cultures are active producers of biogas. Between the mesophile-only tanks, only the 25°C tank produces gas. The cold room mesophile-only tank does not. **These findings support our initial hypothesis very well, that the psychrophile and mixed cultures would produce more biogas than the conventional manure-cultures at the relatively cool temperatures of 15°C and 25°C.**

Several design elements were changed on the tanks to solve problems related to observed gas leaks when tanks were under positive pressure. Namely, the number of fittings and joints involved with the gas outflow system was initially very high and designed in such a way that repairs would be costly and time consuming in cases where fitting integrity was lost. Recurring issues with the gas outflow system resulted in several retrofits in order to reduce the likelihood of future leaks occurring among the tanks. Currently, the gas outflow system has been remodeled and the number of joints has been cut by more than half. Once completed, noticeable gas production was observed among tanks previously thought to be inactive.

Now in its second year of study, the project is starting to switch its focus away from intensive hypothesis-testing data collection efforts into more application-based research. The overarching goal of the Phase II research effort is to simulate a fully-functioning small-scale anaerobic digestor and test various applications that may serve Alaskans interested in the technology. **To date, we have already demonstrated the ability to collect biogas for use in conventional combustion applications.** Throughout the remainder to the project, efforts will focus on developing better gas collection systems and further demonstration/analysis of small-scale anaerobic digestor technology for Alaskan individual homes.

Finally, the project team along with Cordova High School (CHS) students made multiple appearances at various Alaskan State conferences during the last quarter. February 6-10, 2011 team members Casey Pape, Adam Low, and students from CHS science club traveled to Anchorage to present the project at the Alaskan Forum on the Environment (AFE). On February 14, 2011 the students again presented the project at the Emerging Energy Technology Grant meeting in Juneau. The project was received at AFE and in Juneau with excitement and enthusiasm. Following the meeting on February 14, 2011, students were invited to again present the project before the Alaska State Legislature and in a private meeting with Senator Lesil McGuire's office.

The project was recently featured by Alaskan Dispatch Magazine in an article on rural Alaska entitled, 'Biogas could bring new energy to rural Alaska'. January 17, 2011. http://www.alaskadispatch.com/article/biogas-could-bring-new-energy-rural-alaska?page=0,0

The project was also mentioned in Senator Lesil McGuire's recent press release on the 'Deadline for Emerging Energy Technology Fund Grant Applications Approaching'. Released March 3, 2011.

http://www.aksenate.org/mcguire/030311EmergingEnergyFund.pdf

ii. Schedule and milestone information

The project continues to closely follow the original outlined plan:

- Construct Digestors for Phase 1 by December 15, 2009 – Completed January 21 2010
- Commence Data Collection by February 1, 2010 – Achieved January 18, 2010
- June 25-27, 2010, project meeting onsite in Cordova (all team members present); High school student presentations
- Perform mid-term Analysis of Data by July 30, 2010 – Completed informally internally as a project team, and formally in Quarterly reports 2 and 3.
- Year 1 Q4 Report, December 15, 2010
- Phase II Scoping, deadline for revised report: **March 15, 2011**
- Phase I Report, including analysis of all Phase I data: **March 15, 2011**
- Year 2, Q1 Report: March 15, 2011 (this report)
- Year 2, Q2 Report due June 15
- Year 2, Q3 Report due September 15
- Final project report due September 30, 2011

ii.a) Personnel:

Cordova Electric Cooperative http://cordovaelectric.com/

Clay Koplin – Grant Administrator. Koplin has managed most of the financial aspects of the project thus far on behalf of the Cordova Electric Cooperative, serving as the project manager. Koplin serves as a technical advisor to the project.

University of Alaska, Fairbanks http://www.alaska.edu/uaf/cem/ine/walter/

Katey Walter Anthony – Research Director. Walter-Anthony acts as the primary investigator, and has spearheaded the scientific goals and directions of the project. She provides continual scientific expertise and project management. She contributed to the data analysis, interpretation and writing of this and all reports.

Casey Pape – Research Technician. Pape joined the project in early September, 2010, to replace Laurel McFadden as the primary project technician. Pape worked on-site in Cordova during the past quarter, maintaining the digestor experiment, including data collection, analysis, and troubleshooting. Pape led the preparation of the current quarterly report with assistance from other team members. Pape anticipates relocating to Fairbanks in March 2011, to continue working on the project with closer access to lab instruments, consultation with Walter Anthony and ACEP. Pape will travel intermittently to Cordova. Pape plans to remain with the project until its completion in September 2011.

Dane McFadden – Project Intern. Currently an undergraduate at Stanford University, Dane McFadden helped maintain digestor performance during August 2010. Job responsibilities included: maintaining daily gas data collection, feeding, chemistry measurements and gas sampling. McFadden will be using his experience here in Cordova as his required internship at

Stanford University and will generate an intern project report which will be submitted to the PI, the Denali Commission, and to Stanford University.

Laurel McFadden – previous Research Technician. McFadden, left the project and began graduate school at UAA in mid August 2010. McFadden was a key contributor to the project development and took the lead on organization and preparation for the initial construction and setup. McFadden completed the first draft of a Biogas Handbook for Alaskans, which will be submitted as a deliverable in final form to the Denali Commission by the end of the project.

Peter Anthony – Research Technician. Anthony consults on the project and continues to provide technical expertise to the maintenance and application of digestors. He participated in all on-site project meetings in Cordova and provided recommendations for simplification and winterization of the gas collection system in preparation for Phase 2. Anthony conducted the gas chromatography analyses of biogas composition for this report.

Jeffrey Werner – State FFA Director. Werner is interested in using the effluent from anaerobic digestors as a liquid fertilizer for agricultural crops. Located at the horticultural center at UAF, Werner remains enthusiastic about the possibilities of the potential uses of the once thought of waste product.

Cordova High School http://blogs.cordovasd.org/chs/

Adam Low – Science Teacher. Low was integral in bringing in student involvement via classroom curriculum and extracurricular projects. Low has been in charge of maintaining a consistent feeding regime and guiding student involvement with the project. While Pape was away from the project over Christmas vacation, Low had the added responsibility of maintaining gas flow and chemistry measurements as well as general troubleshooting. Additionally, Low has been working with science club students to set up a greenhouse experiment in which to test effluent samples for their potential use as a liquid fertilizer. Low also assisted in collecting and shipping effluent samples to other project colleagues in Germany in efforts to greater proliferate psychrophilic digestor technology.

Cordova High School Students – Volunteers. The students of Cordova High School have been highly involved with construction, feeding, maintenance, and public presentations for the project. They include the seventeen Chemistry class students and Science Club students (Craig Bailer, Ben Americus, Adam Zamudio, Sophia Myers, James Allen, Eli Beedle, Josh Hamberger, Keegan Crowley, Kris Ranney, and Carl Ranney). Ten students now share the responsibility of feeding the digestors on a daily schedule.

Student Craig Bailer in particular has been of great help to the project. Bailer maintained chemistry measurements while the UAF-technician (Pape) was away and proved to be more than competent at updating records as well as downloading flow data. In addition, Bailer has been assisting Low with other experiments in the Cordova Energy Center in preparations for Phase II of the project. In particular, Bailer has been working on a type of heat exchanger as part of a potential science fair project with the aim that it may be of use to the digestor project during Phase II.

SOLAR Cities http://solarcities.blogspot.com/

TH Culhane – Biogas Expert. With an extensive history in biogas technologies, Culhane developed the water-pressure tank design and provided extensive technical knowledge to the engineering of the project at its outset. He worked with and advised the on-site construction in

January 2010 and provides expert advice from his home base in Germany. Recently, Culhane requested a 1-L sample of psychrophilic effluent in efforts to test the success of psychrophilic digestors in different locations in Europe, Asia and Africa with different weather patterns and climate regimes as part of a tangential outreach project that Culhane and Walter Anthony have, funded by the National Geographic Society and Blackstone Ranch.

Sybille Culhane – Co-founder of SOLAR Cities. S. Culhane assisted in initial construction efforts and managing financial aspects of SOLAR Cities involvement.

Chena Hot Springs http://www.chenahotsprings.com/

Bernie Carl – Owner of Chena Hot Springs. Carl has expressed interest in deploying a digestor at Chena Hot Springs, and has offered space for testing a digestor in his greenhouse.

Others http://www.cordovaenergycenter.org/

Brandon Shaw – Website Development. Shaw designed the CordovaEnergyCenter.org website, where the project is hosted. He also assisted at the initial construction site, and was integral in the assembly of the flow meter system.

Keywords: Biogas, anaerobic digestor, reactor, psychrophiles, mesophiles, methane, methanogens, Alaska, cold-climate, thermokarst lakes, etc.

iii. Narrative summary of the project status and accomplishments to date, and addressing the following questions: is the project on schedule, is the project on budget, and what actions are planned to address any project problems.

iii.a) Notable Accomplishments:

Biogas production – Thorough understanding of variables that limit biogas – We now have an extensive dataset of daily biogas production from each of the tanks in the experiment. Currently we are producing high quantities of flammable gas (between 30 – 345L/day per 1000L tank). The gas produced is being release for the most part to the atmosphere which is undesirable due to the radiative and heat trapping properties of the gas. Our focus now is to capture the biogas being produce and begin experiments testing the flammability and applicability of the gas.

Proven flammability – One of the primary goals of this project was to determine if the psychrophiles that produce methane in thermokarst lakes could be harnessed in an artificial environment to produce biogas. With the initial production of biogas from both psychrophilic and mesophilic microbes we proved flammability possible (refer to Y1Q2 report).

Biogas from conventional anaerobic digests typically contains methane content between 40-60%. Recently it has been discovered that our biogas contains increasingly high concentrations of methane (50-82%). It is possible that the increased methane concentration(s) observed in our tanks are the result of using psychrophilic methanogens whereas typical anaerobic digestors commonly use mesophilic bacteria and archea found in bovine and animal manure. Additional measurements of gas content are needed to confirm consistency in this trend. Stable isotope analysis could also help distinguish pathways of methanogenesis in the manure-vs.-psychrophile tanks. If this high CH_4-content of psychrophilic biogags holds constant, then this is an important finding as it implicates the use of psychrophilic methanogens for improving the energy content of biogas as opposed to more common mesophilic anaerobic digestor systems.

Successful Chemical Remediation of Digestor Tanks – As mentioned before in section iii.a) early in the experiment, observed declining pH was foreseen as a potential threat to the digestor(s) microbial health and action was taken to restore pH to previous levels. Ideally, digestor psychrophilic and mesophilic-communities perform under optimal conditions at a pH of around 6.8-7.2, observing tank pH(s) much lower than this (pH 3.5 – 6) was an indication that the tanks were acidifying and VFA's were likely being produced in large quantities. From this point chemical remediation was determined necessary to stop the digestors from potentially "crashing" or "souring" from prolonged exposure to low pH.

Remediation was performed in two steps. The first step involved stoppage of the initial feeding schedule as specified in the project proposal. Stopping feeding was a necessary step as it was essential to minimize the amount of variability in the tanks while alkalinity was restored. The second step entailed adding calculated quantities of Calcium Carbonate, Lime, and Sodium Hydroxide in order to bring the pH back to the initial conditions. Care had to be taken to restore the pH in a gradual manner as to not "shock" the microbial communities. Slow remediation was also essential as over treating the tanks could cause them to become too basic, as anaerobic digestor bacteria are particularly sensitive to increased ammonium concentration and this is to be avoided as even slightly basic tanks can cause total failure of mesophilic communities (pers. com. TH Culhane). All digestors are now at relatively stable pH values with the exception of Tank 3.

Proven High Methane Content of Biogas – GC analysis of gas samples collected from tanks 1, 4, 5, and 6 shows high levels of detected methane in most cases. Preliminary analysis shows that methane concentrations have increased since the onset of Phase I research. To some extent this is an indication that we are observing healthy proportions of microbes in several tanks enough to support active methanogenesis. More work will have to be performed on the GC in order to understand long term trends and behavior of our tanks, but the initial results seem promising.

Student education – This project has the fortunate opportunity of involving High School students in a primary scientific study. Cordova High School students have the unique ability to see some of the technical aspects and complications that go along with scientific research. The science club and chemistry class provide an excellent platform to organize student involvement. Previously, students have had the opportunity to troubleshoot and take the lead on feeding procedures for the project resulting in several very clever and innovative ideas being implemented.

The students of Cordova High School have presented on the project several times now and have been received well with each new appearance. The students demonstrate a thorough understanding of the issues involved with conducting new technology research as well as the factors that contributed to lessons learned during this project. CHS students and teacher Low are presently preparing projects for the

Alaska State science fair in which many are using biogas-inspired projects. More will be reported after the students have attended, but generally the project can be thought of as very successful in its educational aspects for local students.

Community outreach – We have had the opportunity to present our project ideas and preliminary results at meetings with the Alaska Power Association and Alaska state legislators in Juneau, and at a variety of conferences, including the Alaska Forum on the Environment and the Alaska Rural Energy Conference. Five Cordova High School students traveled to present at the Alaska Rural Energy Conference in Fairbanks. Titles of our project presentation at the Alaska Forum on the Environment and Alaska Rural Energy Conference were:

Walter Anthony, K., Culhane, TH., Koplin, C., McFadden, L., Low, A. "Improving Cold Region Biogas Digestor Efficiency." McFadden, L. Alaska Forum on the Environment. Anchorage, Alaska. February 8-12, 2010.

Walter Anthony, K., Culhane, TH., Koplin, C., McFadden, L., Low, A. "Improving Cold Region Biogas Digestor Efficiency." Low, A., Hess, E., Allen, J., Americus, I., Americus, B., Zamudio, A. Alaska Rural Energy Conference. Fairbanks, Alaska. April 27-29, 2010.

New Scientist article featuring this project: 'Cold climates no bar to biogas production'. November 4, 2010.
http://www.newscientist.com/article/mg20827854.000-cold-climates-no-bar-to-biogas-production.html
Unfortunately no final reference was made to the Denali Commission as the funders of this research. Interviewees informed the writer of the funding source, but did not have the opportunity to ensure that the information was included in the printed article.

The project was recently featured by Alaskan Dispatch Magazine in an article on rural Alaska entitled, 'Biogas could bring new energy to rural Alaska'. January 17, 2011. http://www.alaskadispatch.com/article/biogas-could-bring-new-energy-rural-alaska?page=0,0

Low, A. "Youth Participation: Improving Cold Region Biogas Digestor Efficiency." Low, A., Bailer, C., Allen, J., Americus, B., Zamudio, A. Alaska Forum on the Environment. Anchorage, Alaska. February 8, 2011.

Walter Anthony, K., Culhane, TH., Koplin, C., Low, A., Pape, C. "Improving Cold Region Biogas Digestor Efficiency." Low, A., Bailer, C., Allen, J., Americus, B., Zamudio, A. Denali Commission Public Forum on the Emerging Energy Technology Grant. Juneau, Alaska. February 14-15, 2011.

The project was also mentioned in Senator Lesil McGuire's recent press release on the 'Deadline for Emerging Energy Technology Fund Grant Applications Approaching'. Released March 3, 2011.
http://www.aksenate.org/mcguire/030311EmergingEnergyFund.pdf

Last year the chemistry students took a class trip to the Alaska Power Association in Feb. 2010. Students C. Bailler, D. Hess, C. Morrissett, J. Smyke, S. Lindow, and T. Kelley presented on the project and it was received well among those who attended the meeting. The project team intends to present at next years' Alaska Rural Energy Conference in Juneau, Sept. 27-29, 2011.

Biogas Handbook for Alaskans- McFadden completed the first draft of a Biogas Handbook for Alaskans, an instructional booklet specific to biogas production and applications for Alaskan communities. The Handbook will continue to be revised, and submitted as a deliverable in final form to the Denali Commission by the end of the project.

Website development- Website developer Brandon Shaw designed a site (www.cordovaenergycenter.org) for the Cordova Energy Center, the venue at which the biogas experiment has been conducted. The website provides a venue for students and community members to obtain information about the project and how to get involved. It is important to update the website often as a means to show visitors that the project is still underway, that is still producing results and that people are still encouraged to get involved.

iii.b) Project Status

The project is in the final wrap up stages of Phase I and research efforts are now turning towards applications of biogas according to Phase II of the original research proposal. Phase I involved the testing of several different blends of methanogenic microbial populations (mesophilic and psychrolphilic) in order to examine different characteristics of digestors that operate in cold environments. The primary goal of Phase I experiments were to construct and monitor six different anaerobic digestors and to try to maximize the amount of gas that can be produced in depressed temperature climates (please refer to the original research proposal for more details on Phase I goals and objectives). Researchers feel confident at this time that Phase I should wrap up as the current data set has satisfied interests to understand biogas production in depressed temperature environments (see Phase I Data Report for details).

We are pleased to report that many of the tanks are producing biogas from food waste material at high levels. Currently, we are observing flammable biogas production in Tanks 1, 4, 5 and 6 in large quantities (up to 345 L/day). Tanks 2 and 3 have not been producing gas in previous quarters and are not presently active despite increase feeding in Tank 2. Both tanks are suspected to be inactive at this time. We have remediated many of the problems elucidated in the last quarterly report (see Y1Q4 report).

During the past quarter, we began pilot-level experiments for Phase II, while at the same time maintained the Phase I and Phase 1.5 study to completion in effort to better understand yield and efficiency. The Cordova High School students took the lead on a greenhouse pilot study to test the potential for digestor effluent to serve as a liquid fertilizer in food production. In addition, the team demonstrated use of biogas in conventional applications at various conferences this quarter. UAF research technician Casey Pape is leading the project team in preparations for Phase II, to find usable applications for biogas produced from the anaerobic digestors. In the following months of this project, Phase II research will begin to incorporate data collection on the time and effort required to build and maintain biogas digestors; provide data to inform economic assessment of biogas technology in Alaska; and produce a Do-it-Yourself Biogas Handbook for Alaskans.

Phase 1.5: Gas flow measurements

At the time of the last quarterly report, it determined that the project's Sierra Instruments Top-Trak 820 Series Mass Flow Meters (installed February 18, 2010 to maintain continuous mass flow measurements of each tank), were not recording gas flow properly. The issue was remedied for the most part when gas flow through the meters was limited to specific times of day. The tanks therefore could build pressure in order to achieve higher rates of flow necessary for the flow meters to record biogas production accurately. This method has been demonstrated to be very effective and was used throughout the quarter to obtain daily total production of biogas. By the time this method was developed, Phase I efforts were in large part beginning final stages as research focus was shifting towards Phase II - implementing the produced biogas. Due to the lack of an extensive dataset that accurately demonstrated biogas production among all tanks, the research team proposed an intermediate phase in the second year first quarter to obtain a solid data set for hypothesis testing. At the same time we started planning Phase II research. The proposed study was entitled Phase 1.5 as it contained both elements of Phase I and Phase II (see Phase I Final Report for details regarding Phase 1.5).

The methodology used during Phase 1.5 was simple for the most part. Each of the tanks' gas outlet valves were closed for a period of several hours, allowing all biogas produced inside to accumulate within the headspace of each tank or remain dissolved in solution. As biogas began to accumulate within the vessel, the tanks would begin to distend in response to the accumulation of gas positive pressure within the tanks. After a period of about 6-8 hours, each tank valve was turning to the 'open' position and the gas was allowed to vent to the outside atmosphere. The large difference in pressure between the tank and ambient air (high ΔP) meant that a greater quantity of gas would flow through the mass flow meters in a shorter period of time. Within the range of three standard liters per minute (≤3 SLPM) the meters record mass flow rate with a high levels of precision so researchers aimed to vent the tanks within this set range. Once the tank achieved a pressure similar to that of the ambient air the tanks were closed and the cycle was repeated (for more information about the protocols mentioned here please refer to Y1Q4 report). This method proved highly effective at determining daily gas output with relatively few drawbacks.

The main disadvantage associated with venting according the method mentioned above is that it is very labor intensive. Venting every 6-8 hours meant that a researcher had to be near enough to the project in order to tend to and vent each tank three or four times a day. In addition, the tight range of flow in which the meters were calibrated meant that venting events had to be highly controlled, making it difficult to allow multiple project team members to vent each tank as this may result in highly variable interpretations of the data in a given day. As a result, the burden of responsibility to maintaining flow measurements was entrusted to the onsite technician (Pape). Therefore data could only be collected when researcher time could be dedicated to tending the tanks and the resulting dataset could not be maintained continuously throughout the quarter. However, recording biogas production using this method proved to be very effective and the project team was able to get very reliable estimates of daily gas production among each tank (Figure 1).

Table 1. Biogas summary data for Phase 1.5. The numbers present average gas production within a 24hr period for each tank. Data are not normalized by the volume of slurry inside each tank. Normalized data are presented in the Phase I Final Report. On several occasions, gas pressure contained in the headspace of the reactors caused tanks to expel some of their liquid contents from the tanks. Dates of occurrences of tanks spills are both documented and undocumented as students may not have reported a spill during several instances when researcher and teacher support was not available.

Gas Production Summary Data (Raw Data)

	15°C Room			25°C Room		
Date	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6
12/11/2010	28.3	0.0	0.0	126.6	151.4	0.4
1/17/2011	19.7	0.0	0.0	207.5	145.0	23.9
1/18/2011	21.2	0.0	0.0	257.1	162.9	27.5
1/19/2011	32.0	0.0	0.0	201.9	196.8	41.3
1/20/2011	48.8	0.0	0.0	330.2	318.0	90.8
1/21/2011	27.6	0.0	0.0	165.8	191.6	88.6
1/22/2011	40.0	0.0	0.0	237.8	279.9	207.9
1/23/2011	59.0	0.0	0.0	346.0	320.1	263.9
1/24/2011	49.7	0.0	0.0	141.0	169.1	115.1
1/26/2011	46.2	0.0	0.0	357.9	433.0	331.7
1/29/2011	35.2	0.0	0.0	175.3*	182.6	144.9
1/30/2011	35.2	0.0	0.0	175.3	182.6	144.9
1/31/2011	63.1	0.0	0.0	154.5	169.2*	136.1
2/1/2011	47.3	0.0	0.0	181.8	214.8	170.8
2/2/2011	46.4	0.0	0.0	179.0	235.7	150.1
2/3/2011	42.2	0.0	0.0	147.5*	140.3	101.8*
2/4/2011	33.3	0.0	0.0	231.2	230.5	220.2
2/25/2011	27.8	0.0	0.0	91.1*	147.9	113.4
2/26/2011	0.8	0.0	0.0	149.7	166.2*	157.0
2/27/2011	27.3	0.0	0.0	140.8	182.3	155.9
2/28/2011	51.2	0.0	0.0	140.5	190.6	162.5
3/1/2011	21.5	0.0	0.0	165.8	209.8	180.6
3/2/2011	40.6	0.0	0.0	155.3	186.5	168.6
3/3/2011	27.7	0.0	0.0	136.7	173.9	157.2
3/4/2011	24.4	0.0	0.0	144.5*	163.3*	163.2
3/5/2011	31.6	0.0	0.0	145.9	184.5	160.8
3/6/2011	17.9	0.0	0.0	152.4	196.8	165.1

3/7/2011	33.1	0.0	0.0	146.1	182.2	165.1
3/8/2011	38.9	0.0	0.0	162.6	203.0	145.9*
3/9/2011	37.4	0.0	0.0	166.3	198.1	157.1
3/10/2011	35.2	0.0	0.0	215.0	265.5	255.3
Average	**35.2**	**0.0**	**0.0**	**184.8**	**205.6**	**147.3**
Standard Dev	**13.0**	**0.0**	**0.0**	**63.6**	**61.9**	**69.6**
Total	**1090.6**	**0.0**	**0.0**	**5729.0**	**6373.9**	**4567.6**

* Days in which a documented leaks occurred (volume released is not known)

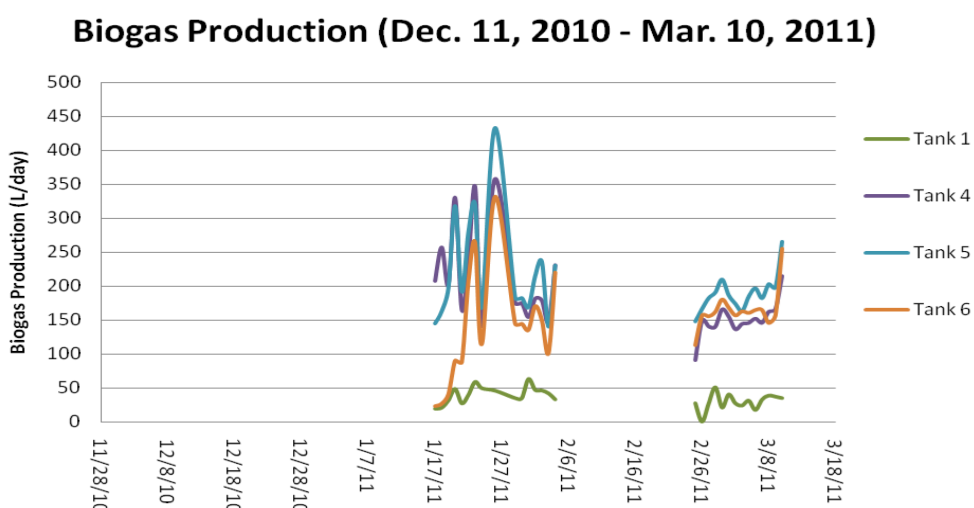

Figure 1. Current flow measurements from Phase 1.5 and graphical representation of un-normalized data presented in Table 1. Biogas production shows marked increase from the beginning of the week (01/17/11) and the end (01/23/11). Tank(s) # 2 and 3 valves were closed and were not observed to have produced gas above nominal levels for the entire period. Any noise recorded by the Serria Top-Track 820 mass flow meters was given a value of zero. Data gaps may exist during times where either no flow data was being recorded or data collected did not align with the above mentioned protocol(s).

Another drawback associated with sampling biogas on an hourly-based schedule is the increased potential for pressure buildup to cause a spill or seepage from the tanks. This mainly occurred when the pressure within the tanks increased to the point that effluent would rise to the top of the inlet tube - where food is typically put into the tanks - and spill onto the ground. In order for this to occur, the pressure of the gas within the tanks would have to exceed about two pounds of pressure (≥2 psi) (Equation 1). Several spills were documented from tanks in the 25°C room as they were the tanks with the greatest amount of activity. Though efforts were made to vent tanks in time to avoid spills, some inevitably occurred when the time between venting was too long. The primary negative result of a seeping tank was loss of viable bacteria and food media from which biogas can be produced, not inoculants exposure to air. Though any seepage of material from the tank was undesirable, any loss of biogas production could be directly attributed to loss of tank inoculants and ultimately be readjusted to the new tank volume. Still it is important to observe that the issues were known to have occurred on multiple occasions among all 25°C room tanks. More information on this issue will be presented later on in section *iii.f) Hurdles and Solutions*.

$$P = \rho g h$$

Where: ρ = the density of the fluid (64.4 lb/ft^3 for water)
g = the gravity const (32 ft/sec^2)
h = the height of the column (ft)

Equation 1. Hydrostatic pressure for a (non-moving) fluid in pounds per square inch. The height of the top of the tanks is about 3-4 ft above the waterline within the reactor.

At this time the project team is confident in the results obtained during Phase 1.5. We have answered many of the questions charged to the Phase I research. We are satisfied with the result of Phase I and are ready to begin research into Phase II.

For more information regarding data collected during Phase I please refer to the 'Phase I Data Report' submitted March 15, 2011. Supplemental chemistry data is provided at the end of this report (See Appendix I)

Tank Fitting and Joint Retrofit

In order to ensure that biogas production data was accurate among each of the tanks, researchers had to be confident that all gas leaving the tanks flowed exclusively through the flow meters installed on sight. At several points during the quarter seal integrity was elucidated to be an issue that ultimately compromised the observed trends among all of the tanks in the experiment. It was reported that at the beginning of the school year, over 15 joints were noted to be upstream of the Sierra Top-Track 820 Mass Flow meters, of which all were required to be air tight. In addition, each of these tank gas outlets were assembled in such a way that repairs could not be made easily if a leak were to develop. Ultimately, each of the tanks had weaknesses associated with joint and gas fittings which had to be addressed before results on Phase I could be deemed definitive or conclusive.

In the past, soapy water had uncovered several minute leaks among tanks 4 and 5 in the 25°C room. This method works well in cases where the leak is small enough that the amount of gas release is less than the amount of pressure buildup (or biologic rate in this case) within the tank. In this instance soapy bubbles would form around the leaking area as gas escaped to the atmosphere. Small leaks like these were discovered and usually remedied when fittings were tightened; however, large leaks could not be uncovered this way as the exchange of gases between the tanks an atmosphere would appear ubiquitous to the point that soap water would have no effect. This was suspected to be the case among Tank 6 in the 25°C room. In the last report (Y1Q4), decreased activity observed in Tank 6 was assumed to be due to the temperature threshold not being met for *mesophilic* bacteria to be active, though this seemed peculiar considering the activity of each of the other tanks within the 25°C room (Appendix I).

The team met on January 9, 2011 via teleconference to discuss the project status and upcoming transition to Phase II. Addressed in that meeting was the current concern that joints and fitting among the tanks may not be structurally sound. This was both a primary research interest in that leaks possibly compromised the findings of Phase I and also because the final project booklet intends to present a robust digestor design for ordinary Alaskan households to duplicate with high rates of success. The team concluded at that time that all leaks should be assessed at that time and any retrofits necessary be made in order to correct any issue with leaking tanks. Alternative testing methods later revealed several leaks present on Tank 6 and steps were taken in order to improve fittings on all tanks (Appendix II). Shortly after the repair was made on January 15, 2011, Tank 6's flow meter was reinstalled the tank started showing high levels of biogas production (Figure 2).

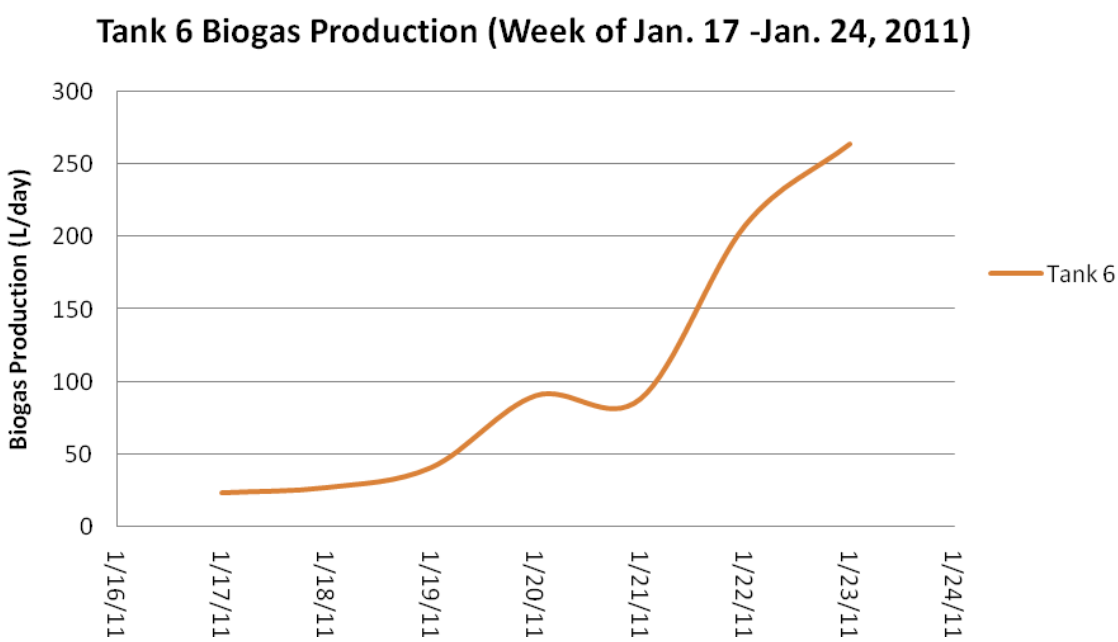

Figure 2. Flow data from Tank # 6 from Jan. 17-24, 2011. Leaks were uncovered and repaired on January 15, 2011 and biogas production was recorded shortly after. All biogas data measurements were recorded using Sierra Top-Track 820 Mass Flow meters which were installed on site since February 18, 2010. It is not known at this time how long the leaks uncovered where present within the system. All tanks have received a complete retrofit and no leaks have been reported since February 25, 2011.

Several additional leaks were uncovered among all producing tanks in the weeks that followed the first discovery in January. As the tanks were now experiencing elevated pressures associated with daily flow measurements the tanks were demonstrating leaks due to the increased positive pressure within each reactor vessel. Researchers were therefore convinced that an overhaul of all gas outlet systems was merited before Phase I research could reach any final conclusions. The last of the proposed retrofits was completed on February 25, 2011 and no leaks have been uncovered since. The new system improves on the old design by reducing the number of joint fittings and components by more than half. The new improvements will be used in the final handbook for Alaskans as the likelihood of leaks to develop has been greatly reduced using this design as well the cost and difficulty involved with installation and repair should a leak develop in the future (Appendix II).

As a result of the system repair, we now see flammable gas being produced in large quantities from tanks 1, 4, 5, and 6. We have carefully monitored the rates in production of biogas between these tanks and feel satisfied to make conclusive statements about the Phase I research.

Flammable biogas

Previous analysis of gas composition on a Shimadzu 2014 gas chromatograph equipped with a flame ionization detector revealed that CH_4 concentrations in gas flowing from the digestor tanks is up to 82% by volume (see Y1Q3 report). Composition data does not exists for current or catalogued biogas samples since the third quarter, but biogas from all producing tanks demonstrates positive flame test (Table 2). Weekly samples are now being collected from all producing tanks and will be analyzed when Pape returns to Fairbanks later in March (Appendix II). We expect to have an updated GC analysis of gas composition by the next quarterly report.

Currently, we are observing flammable biogas among four of the original six tanks. Tank 2 and 3 are not observed to be producing biogas and therefore no gas record exists. Though we are not able to say definitely at this time what the concentration of gases is or the percent methane content (% CH_4), the biogas produced on site has demonstrated flammability and applicability in many conventional gas applications (see *Phase II Progress*).

Table 2. Results of produced gas flammability tests. Positive results of the flammability test indicated usable biogas. Flame tests are now being conducted on Tanks 1, 4, 5 and 6. Last demonstration was conducted on March 10, 2011.

Tank	First positive flame	Last confirmed flame
1	1/31/10	03/10/11
2	NA	NA
3	1/22/10	2/1/10
4	2/1/10	03/10/11
5	1/21/10	03/10/11
6	1/26/10	03/10/11

For more information about GC analysis and this project please refer to *Project Status and Accomplishments* of the Y1Q3 report (section iii.a)).

Temperature control in the Connex

Temperature remains one of the most imporant factors that influences methanogenic metabolic rate (House 1978). The Connex used to house the digestors was designed by the project team to maintain two rooms at separate cold (15 °C) and tepid (25 °C) temperatures (as opposed to conventional biogas 37-40 deg C, 'warm' temperatures). The temperature is visually monitored by digital thermometers (less accurate) and recorded by (more accurate +/-0.47°C , Drift +/-0.1 °C/yr) dataloggers suspended in both rooms as well as inside the slurry of each digestor. Several dataloggers, suspended at different depths within some of the tanks, have not been downloaded since May 12, 2010 in an effort avoid opening the lids of the tanks and preserve the current anaerobic conditions of the experiment. Summary data from all tempertature loggers over the course of the experiment are illustrated in Figure 3.

Over the last quarter temperature conditions in Cordova reached unexpected lows that translated into decreased temperatures within the rooms inside the Connex. From December 15 2010 to March 15, 2011 average temperatures for the '15°C' and '25°C' rooms were 10.73°C and 22.05°C respectively, well below target values. Temperature regulation is presently controlled by researchers by checking on the experiment daily. If the temperature drops or climbs above the desired level, researchers reduce or increase the amount of heating by adjusting the radiator heating units in each room. This method has not proven affective at keeping the temperature constant as average hourly temperature for this quarter was 4.27°C and 2.85°C degrees cooler than the targets set in the Phase I study.

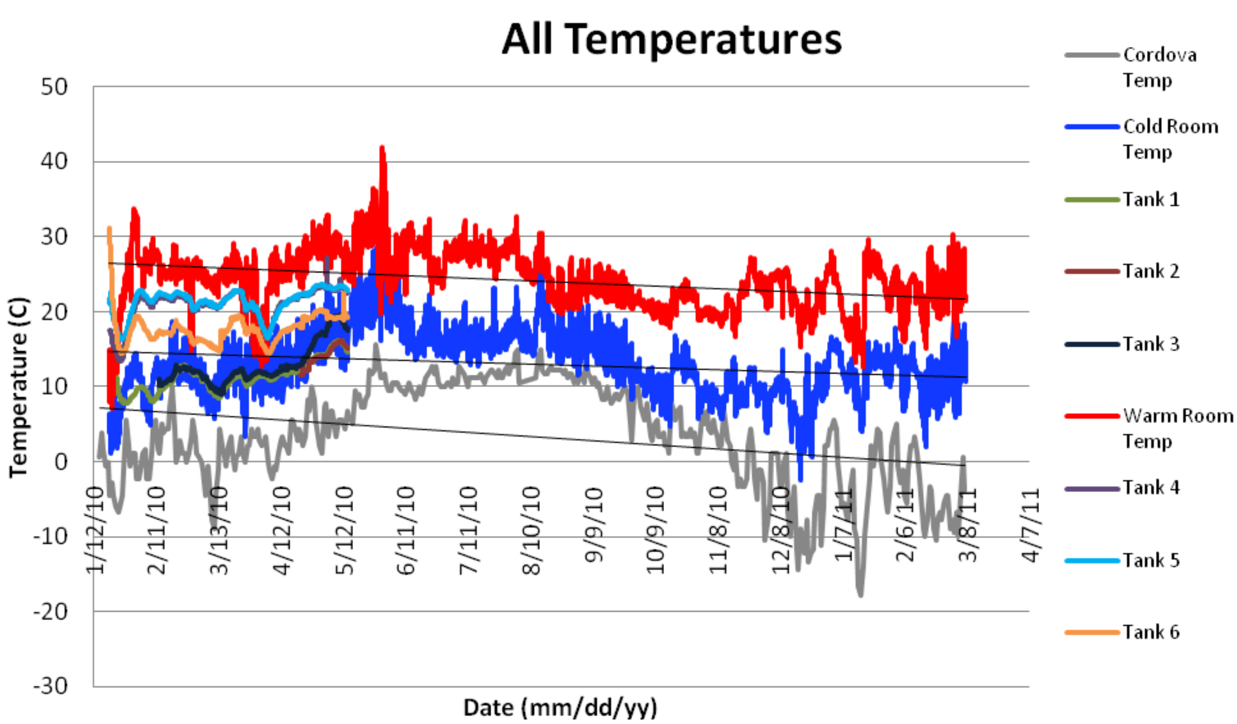

Figure 3. Mean hourly temperature of the data loggers in the Connex cold and tepid room, and mean daily temperature recorded in Cordova. As the temperatures in Cordova began to drop from temperate summer conditions, the Connex experienced a noticeable and unfavorable drop in temperature. Temperatures are still below their "set" values (of 15°C and 25°C respectfully), both rooms will need further heating inputs to meet project targets. Individual tank temperatures have not been downloaded since May 12 in an effort to maintain the anaerobic environment in the tanks (accessing the temperature loggers requires opening the tanks to the air). Biogas project temperatures are measured with Hoboware U22-001 Water Temp Pro V2 loggers recording hourly. Cordova temperature data was obtained from online sources (source: wunderground.com)

The project team has expressed concern with the electrical system currently being used to supply the Connex experiment with heat and power. With the help of Cordova Electric

Cooperative (CEC), the project is installing an updated electrical system that will help to regulate temperature more effectively as well as improve project safety. CEC linemen visiting the site also showed large areas of radiative heat loss throughout the Connex, demonstrating areas where insulation was inadequate. Currently, steps are being taken in to route additional power to the Connex which will reduce the amount of school liability as well as make efforts to regulate temperature easier in the future (Appendix III). Tentative completion date is set for the end of the second quarter of this year.

Phase II Progress

Phase I is drawing to a close and research interests are transitioning to the Phase II applications of biogas. The project team has detailed where emphasis will be placed in the coming months as work begins to demonstrate what small-scale anaerobic digestor technology will likely look like in Alaska (see Phase II Scoping report). These projects will be tested over the coming months and will be reported in the next quarter. For now Cordova High School teacher Adam Low, along with students from the school's science club are heading efforts to collect and test the gas. The students at CHS have already demonstrated the use of biogas for conventional applications such as boiling 100mL of water, powering a combustion engine (lawn mower) and have presented these findings at conferences in Anchorage and Juneau as well at the upcoming State Science Fair (Appendix III).

Through the remainder of the project, Cordova High School will likely take the lead on demonstrating applications of biogas. CEC interests at this time are in providing technical support as well as updating equipment located on site in order to conform to school and state regulations. At this time UAF researchers are will continue to focus on data acquisition involving more technical analysis of catalogued samples collected at the Cordova site. On March 25, 2011, UAF researcher Pape will be relocating back to Fairbanks in order to conduct said analyses. Pape will also begin to work closely with the Alaska Center for Energy and Power (ACEP) in the coming months in order to provide an economic assessment of the time and resources required to replicate projects like this one on the broader scale.

Of immediate research concern and interest is that of collecting biogas. Currently we are producing more gas than at any other point during the project, but are no longer attempting to collect it once measured. For now, collecting biogas so as to be used in applications is a primary research interest in the beginning of Phase II.

Gas Collection: Proof of Concept

As research interests to understand psychrophilic biogas production on the small-scale have been mostly satisfied at this time, the project team will now begin switching efforts into Phase II efforts with the issue of gas collection and storage being of primary focus in the days ahead. At the time of the last quarterly report it was determined that a bladder or waterless gas collection and pressurization system was the most likely candidate for taking hold in Alaska (refer to Y1Q4 report). For Alaskans requiring a low-tech solution to both collect and pressurize stored gas for usage, a bladder-type system has the most appeal for its simple use and maintenance requirements . Preliminary research into bladder collectors has proven the idea is effective in Alaska. Students at CHS have been using car tire inner tubes to demonstrate this idea (Appendix III). The inner tubes serve as a practical demonstration of how bladder storage containers could work for Alaskan residents; they are light, easily transportable and can be pressurized easily. To date, the CHS students have used inner tubes containing biogas for all science experiments and demonstration projects.

Further work will now be conducted to find bladder-type gas containers that can be applied on a larger household scale. The research team anticipates having a full-scale bladder gas container or alternative gas collection system operating at the Cordova site by June 30, 2011. From there, Phase II research efforts can continue to further pressurize and demonstrate biogas usage.

iii.c) Health and Safety

Conventional small-scale anaerobic digestors are generally considered to be non-hazardous when given proper ventilation and maintenance. Still anaerobic digestors are used for the synthesis of combustible gases and have some safety concerns associated with them.

Electrical and Power: The project site is maintained by electrical heat and power supply. At present, that electricity has been provided by extension cords that run from inside the school and out to Connex. The cords draw power from multiple outlets and run underneath doors from the back of the school gymnasium which is not allowed according to state electrical codes. These wires are exposed to the elements as well as encounter significant resistance from the amount and length of cords being used. During peak demand the breaker has been known to trip if the cords are not distributed properly between the devices and the school. We are currently trying to update the electrical system associated with the Connex in order to reduce an liability as well as improve the project electrical consumption efficiency.

Flammability: Biogas is very flammable and it is important that measures be taken to prevent any undesirable fires that may cause explosion. Currently no open flame is allowed within the Connex and students handling biogas are advised to wear appropriate eye protection at all times. Students conducting experiments with biogas are required to wear eye safety glasses and proceed under adult or teacher supervision. No injuries due to fire or explosions have been reported during this project though several fire alarms have been triggered when demonstrating biogas flammability was conducted without proper ventilation.

Ventilation: The build-up of certain gases in an enclosed space can be toxic. Biogas digestors produce methane, carbon dioxide, hydrogen sulfide, and other gases which can be deadly at high concentrations. It is apparent to anyone entering the Connex which houses the experiment that a very noticeable "barn-like" smell can be detected. This smell was significantly reduced once the new tank gas outlets were installed, but still the smell remains. It is thought at this time that current smells are from effluent reservoirs stored inside the Connex and not due to any leaks among the tanks. Tanks are monitored daily and do not pose any threat to human health.

Though the tanks are checked often for leaks, the inside of the Connex container has a very noticeable smell reminiscent of manure. The air is cycled daily to a certain extent when the Connex container is opened for daily download of the gas flow data. Tubes are connected to the tanks to allow lighter than air constituents escape the container. **The Cordova fire department has visited the site and tested it for noxious gases. The results of the fire departments' testing came up negative for any toxic gases.**

iii.d) Schedule of project

The project is still on schedule as defined by the original project outline. Phase I is drawing to a close and research efforts are beginning to focus on Phase II. Throughout the rest of the project research efforts will focus on applying biogas in a series of demonstration projects design to show biogas versatility as well as chemical and cost feasibility analysis to assess the practicality of small-scale digestors in Alaska. The final project report will be completed and submitted on September 15, 2011 including all the findings of Phase II research.

iii.e) Project budget

We anticipate that the budget is on target. At this time, the budget is not expected to exceed the grant, and the matching contribution is expected to significantly exceed the grant requirement. Clay Koplin will provide more details on the budget when he returns from out-of-state travel.

iii.f) Hurdles and solutions

Project problems and solutions were mentioned in iii.a, and are outlined in more detail here.

Confidence in biogas measurements: Due to offsets between the flow meter calibration levels and our gas production rates, we were not able, until this report, to provide the true values of biogas produced. Previous values represented averaged daily flow rates as opposed to cumulative daily gas production. Though this is generally an acceptable method for smoothing out noise in any data set, the true biogas production rates was underestimated. **Solution:** Casey Pape determined a new method to achieve our goal of daily gas production determinations by closing tanks, allowing them to swell with produced gas, opening the valves over a short period of time to allow high rates of gas flow within the level of the flow meter calibration. We now have an extensive dataset on the biogas production among tanks in the experiment and can make clear predictions about the future of biogas small-scale technology in Alaska. Data collection was completed on March 10, 2011 and the project report was submitted in the *Phase I Data report.* Date submitted March 15, 2011.

Other potential considerations:

The following factors are important considerations that generally can lead to problems in biogas technology. While we have no reason to think that any of these factors is causing a problem in our systems, for the sake of thoroughness, here we evaluate each as a potential problem in the context of our study.

Temperature fluctuation. Problem: It is a major goal of this study to preserve the 'cold' (15°C) and 'tepid' (25°C) conditions as was defined in the original project proposal for the purpose of incubation of microbes. The Connex constructed for the project is insulated with R-10 pink foam insulation, but has poor seals and air spaces that cause it to have a heat/cooling regime that mimics that of the local environment of Cordova. Over the course of this quarter, average temperatures for both 'cold' and 'tepid' rooms was 4.2°C and 1.9°C below target values respectively. This is not ideal and will need to be better monitored in the future as our impression of the day to day gas production is that it should be consistent if temperature and food inputs are maintained at a constant level. **Solution:** Although temperature variability is undesirable, we have tried to correct it each time it comes to the team's attention that it may be an issue. Currently there is interest to install power to the Connex container and will likely materialize in the coming weeks (Appendix II). CEC linemen have been dedicated to completing installation and work will likely be completed in time to be reported in the next quarterly report.

Logistical and management concerns:

Digestor/tank and fittings integrity. Problem: Generally speaking, the more holes and fittings installed on a digestor or any gas-holding container increases the chance for a leak to develop. At the beginning of the 2010-2011 scholastic year, the project gas outlet system installed on each of the tanks were known to have as many as 20-30 separate joints and fittings. This many fittings can make it very difficult to ensure the vessels remain anaerobic. In this experiment, leaks have already been uncovered among the secondary gas containment systems and resulted in biogas no longer being flammable in air. Simple tests of pressurizing the tanks revealed that many contained significant leaks that compromised researcher efforts to record gas flow. Much of the data may have been skewed during the Phase I study as tanks showing no signs of biogas production have been demonstrated to be active after leaks were repaired. Recurring issues continually compromised research efforts to understand gas production as multiple leaks were continually discovered among several tanks and within different joints throughout the gas outlet system. **Solution:** A meeting between team members via teleconference back in January 2011 resulted in a group decision to retrofit or repair any leaks that were thought to be obscuring Phase I results. Initially faulty joints were repaired with sealants and other compounds in effort the patch the existing system. This could be likened to a Band-Aid-type approach and was not ideal in the longer term. In the weeks that followed, positive pressure experiments revealed that many of the tanks had significant weak points and that ultimately the most effective way to resolve any issue was by retrofitting the entire gas outlet system on each of the tanks. The flow meters were properly mounted to the wall of the Connex and fitted with standard pipe thread fittings in order to allow for proper flow readings to take place. New valves and reinforced hose were installed in order to reduce the number of joints within the system by more than half. The new systems are generally cleaner and easier to maintain than previous designs and have demonstrated the ability to maintain pressure since the installation was completed (Appendix II). As of February 25, 2011 the last of the tank retrofits were completed and no leaks have been reported since. All tanks expected to be producing biogas exhibit the ability to maintain a positive pressure at this time. Soapy water test have not revealed any additional leaks and the problem is thought to be solved for the most part.

Balance of responsibilities. Problem: The project is designed to be conducted in joint partnership between Cordova High School, a public utility (CEC) and the University of Alaska, Fairbanks. Collective effort between these parties is necessary in order to maintain the project and pursue additional research development during the Phase II study. Students are very capable of feeding and maintain digestors from day to day, but both students and staff are ill-equipped to combat many of the more technical problems that arise due to the nature of an experiment of this type; however, as the project switches focus in its second year to less technical interests there will be decreased need for UAF staff to provide daily support and monitoring of the project. **Solution:** The project full-time technician (Casey Pape) will be relocating to Fairbanks, AK at the end of March in order to pursue further analysis of samples and data catalogued over the previous year as well as begin efforts to research options for upscaling biogas technology in Alaska. Adam Low and CHS students have done a wonderful job filling in for Pape while away on previous work commitments in the past and will no doubt maintain the project with a high level of professionalism once Pape relocates. The CHS students are eager to learn more from the project and begin investigating Phase II problems as well as conduct experiments using biogas. It will be an educator's challenge to come up with more challenging and constructive projects for students to include themselves in during the next phase of the project and researcher's challenge in order to maintain strong ties and communications with the research effort while in Fairbanks. Please see the Implementation Plan in the Phase II scoping report. Pape will travel back to the project site in Cordova occasionally in order to help facilitate project completion and deconstruction later this year.

References:

Gerardi, Michael. *The Microbiology of Anaerobic Digestors.* (New Jersey: John Wiley & Sons, Inc., 2003), 23 - 45.

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Walter Anthony, K. Vas, D., Brosius, L., Chapin, F. S. III, Zimov, S.A., and Zhuang, Q. 2010. Estimating methane emissions from northern lakes using ice bubble surveys. Limnol. Oceanogr.: Methods 8, 2010, 592–609.

Appendix I. (Chemical Data Supplement)

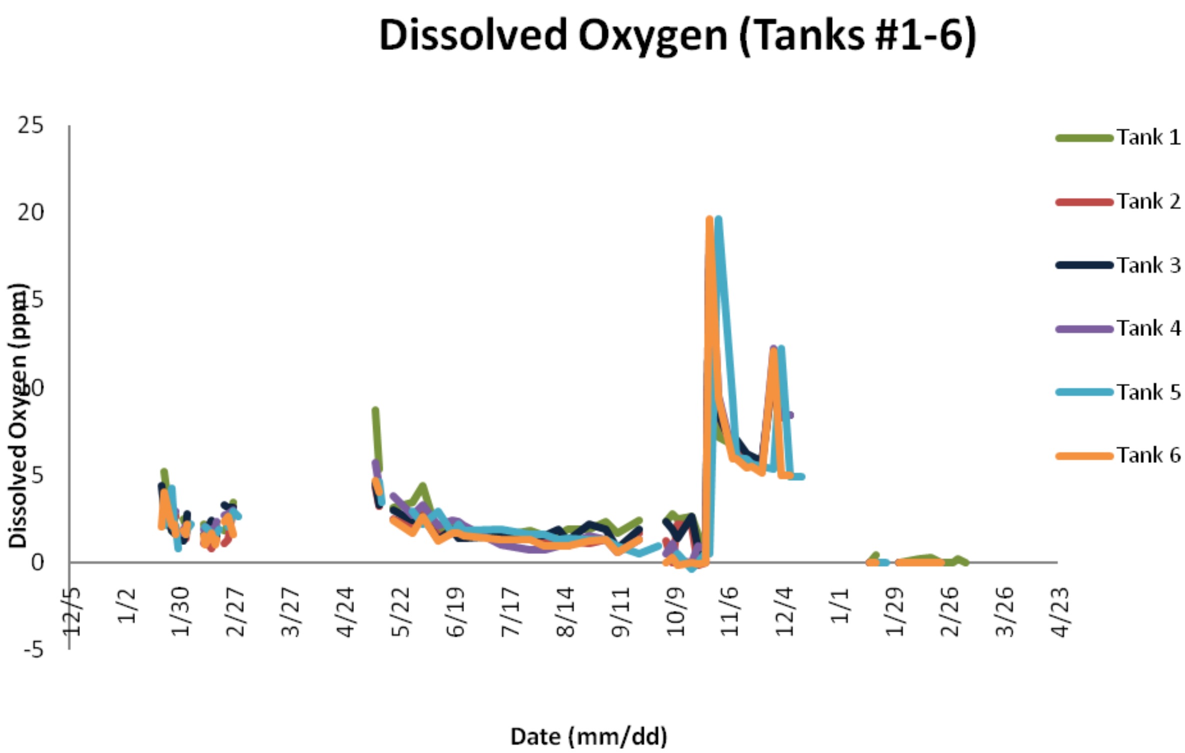


Figure 4. DO measurements were taken with an Xplorer GLX Pasco PS-2002 Multi-Datalogger until March 24, following which they have been taken by a Hanna HI9142 DO meter. As of October 1, 2010, the Hanna instrument could no longer be calibrated properly. Proper function was restored after servicing the instrument in December 2010.

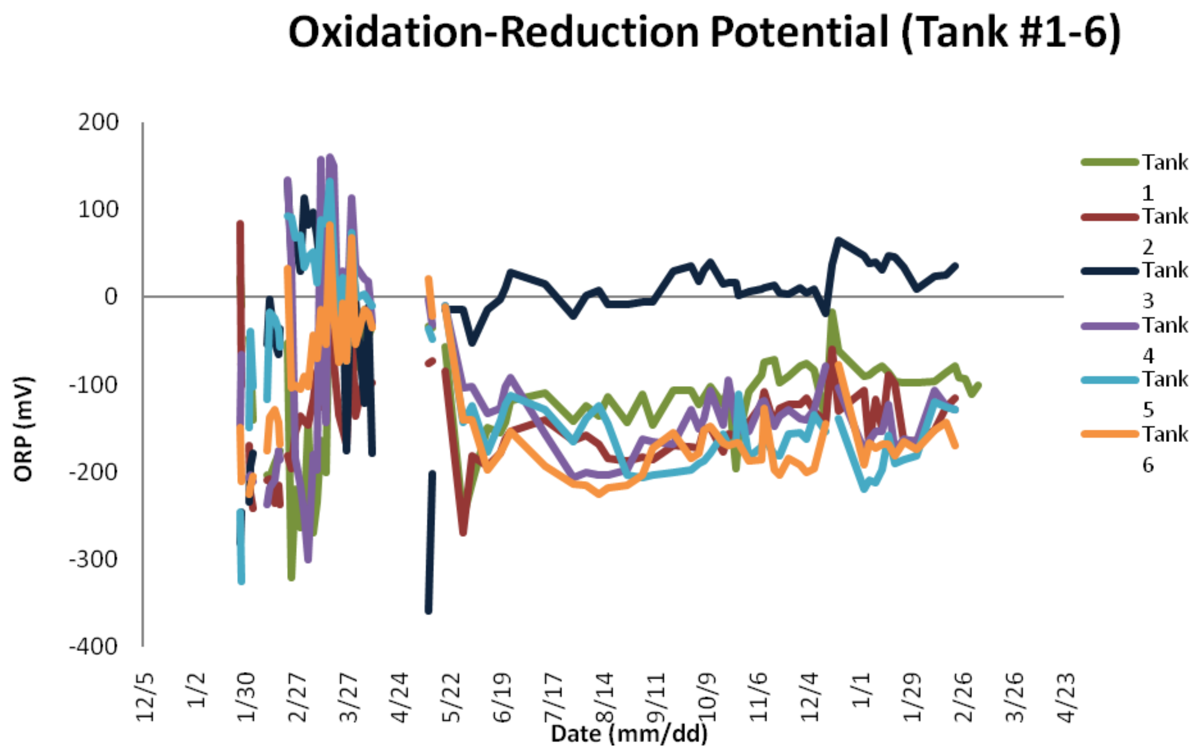


Figure 5. Oxidation-reduction potential (ORP) indicates the availability of oxidative molecules and ions in the system. ORP is a valuable measure as it determines the likelihood that bacteria will follow the methane fermentation pathway. For healthy methane production, samples should have an ORP of -300. From January 21-April 9, ORP was measured with an Xplorer GLX Pasco PS-2002 Multi-Datalogger. From May 10 forward, it was measured with an Oakton PC510 ORP meter.

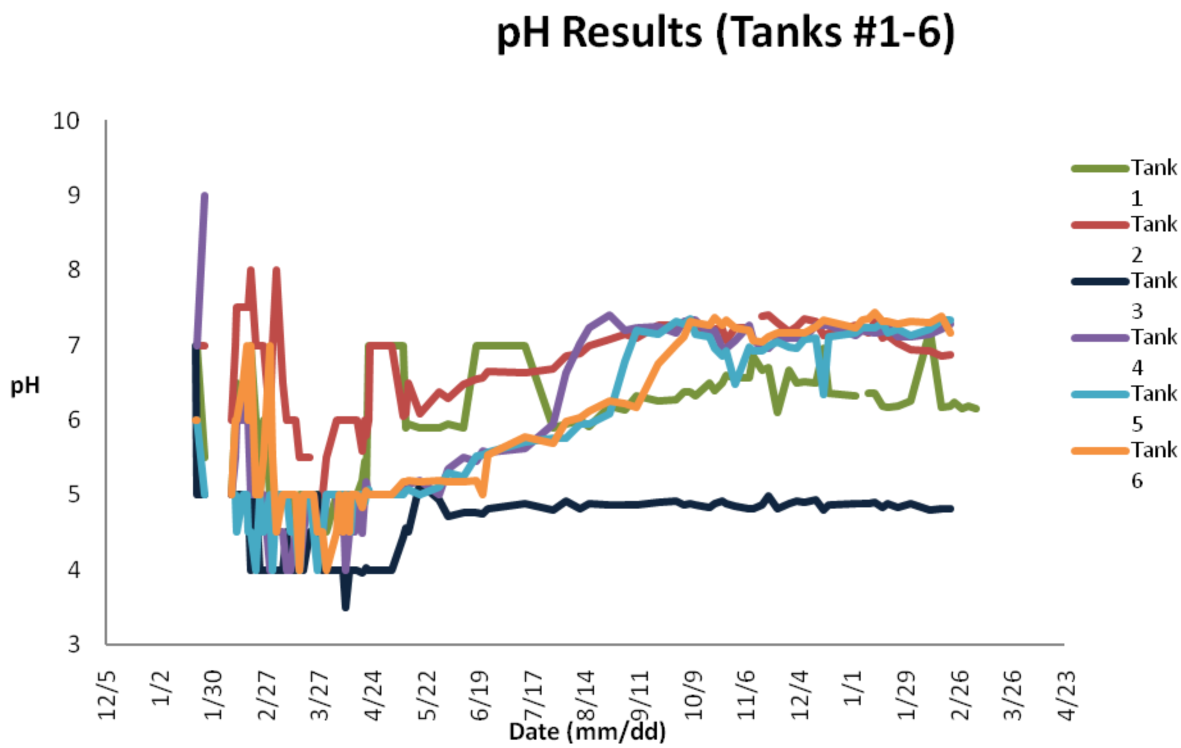


Figure 6. Results indicate that the pH in Tank 1 fell slightly since Y1Q3 report (currently pH 6.1). We halted daily feeding to allow the opportunity for pH to recover on its own, without reverting to chemical remediation treatments. pH was measured with Macherey-Nagel litmus paper January 21-April 16 2010, and with more precision using an Oakton PC510 pH meter since April 17, 2010 until the present.

Appendix II. (Joint and Electrical Retrofit)

Newly installed gas outlet system. Work was completed retrofitting all tanks on February 25, 2011. The new system only uses standard pipe and gas fittings and the sealant used is Teflon tape. This system is easy to maintain and service in case of future leaks.

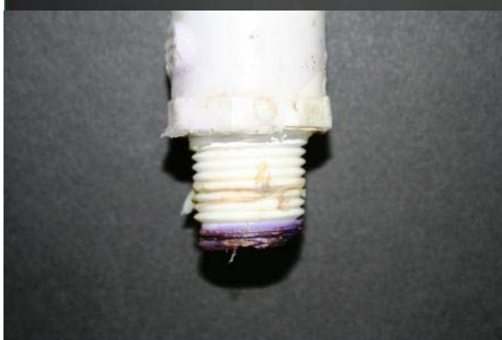
Picture of the old gas outlet system installed on Tank 5. The system was known to have several weaknesses and exhibited leaks on multiple occasions.

Tank 5 (left) was allowed to pressurize and fill Tank 6 (right). This was a test designed to uncover leaks that may have been present in Tank 6. Once Tank 6 was pressurized, soupy water was used to discover several leaks near the valve stem.

Flowing the install of new gas outlets among all of the tanks in the 25°C room each tank began demonstrating the ability to hold pressure. Here each tank is pictured accumulating biogas prior to a venting.

The old connections pictured above used cloth reinforced rubber tubing to connect the gas flow meters though the transducer (bottom) is intended for pipe fittings to be installed. The length installed upstream of the device is intended to allow for uniform flow that is not turbulent, causing a misread by the device.

The old valve stem is picture here to illustrate the redundant number of fittings used to contain gas within the tank. The separation at the bottom illustrates there were significant weaknesses and failures cause by this apparatus.



Several sealants and compounds used to connect the above valve stem have resulted in the wearing the threads of the thru hole on each of the tanks. Here you can see worn or rounded threads caused by using excessive amounts of sealant initially.

Picture depicting new “unworn” threads. Notice the sharpness of the edges which allow for an air-tight fit once installed.

Cordova Electric Cooperative CEO is pictured here using a thermal camera to uncover weaknesses in the Connex insulation. The team walked around the interior and perimeter of the project site highlighting the inefficiencies of the heating system.

CEC linemen seen here next to the Connex and the current electrical system used for heating and powering the project.

New power cable installed to route additional power to the project site. March 8, 2011.

Once installed, this Rhino ™ Spider circuit will be used to power the Connex. This system will be a significant improvement on what is currently in place and will conform to any state or local utility regulations as well as improve the overall electric consumption of the project.

Appendix III. (Pictures)

CHS student and teacher Adam Low pictured with Alaska State Senator Lesil McGuire. McGuire met with students following their presentation on Biogas to the Denali Commission, emphasizing the need for projects that include participation among Alaskan youth. The presentation was held in Juneau on February 14, 2011.

CHS students and teacher Adam Low pictured at the Alaska Forum on the Environment in Anchorage, AK. The conference was held between February 7-11, 2011 and the students participated in a variety of events show casing the project. The students presented posters on work with biogas as well as presented among other youth oriented projects.

CHS students presenting on the biogas project at AFE in Anchorage, AK. February 8, 2011.

Students Craig Bailer, and others working with CHS teacher Adam Low demonstrating the heating potential of biogas. Students later recorded a video showing the ability to boil water with biogas collected from the experiment.

Student Brian seen here fills an inner tube in order to use it in the student's classroom for science experiments. The inner tube demonstrates the idea that a simple and elegant containments system provided by using bags or other collapsible structure ultimately has several advantages over other previously explored collections systems.

Updated photos of the student greenhouse experiment. The interest here is in order to test if the effluent from each tank has potential liquid fertilizer benefits in addition to producing biogas.

Several different crops are being test for and more information will be available later.

The current project profile when viewed from outside. At this point the project has a very minimal footprint though more display may serve to better present the project to the public. Previous gas pressure systems have been dismantled and the project team has taken a minimalistic approach. As Phase II effort commence into full swing the outside appearance is likely to change somewhat in the coming months.