Arnold Schwarzenegger
Governor

DAIRY POWER PRODUCTION PROGRAM

DAIRY METHANE DIGESTER SYSTEM 90-DAY EVALUATION REPORT - VAN OMMERING DAIRY

PIER CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
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WESTERN UNITED RESOURCE DEVELOPMENT, INC.

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I. Program Background

The purpose of the Dairy Power Production Program (DPPP) is to encourage the development of biologically based anaerobic digestion and gasification ("biogas") electricity generation projects on California dairies. Objectives of the program include developing commercially proven biogas electricity systems that can help California dairies offset the purchase of electricity and providing environmental benefits by potentially reducing air and ground water pollutants associated with storage and treatment of livestock wastes.

The California Energy Commission (Energy Commission), acting under authority of the Legislative enactment in 2001 of Senate Bill 5X (Section 5(b)(5)(C)(i)), appropriated and encumbered funding for the Dairy Power Production Program (DPPP). Western United Resource Development, Inc. (WURD), was selected by the Energy Commission as the contractor for this program.

To date, 14 projects have been approved for grants totaling $5,792,370. The projects have an estimated generating capacity of 3.5 megawatts.

Two types of assistance were made available for the grant program: buydown grants, which cover a percentage of the capital costs of the proposed biogas system, and incentive payment grants for generated electricity. Buydown grants cover up to 50% of the capital costs of the system based on estimated energy production, not to exceed $2,000 per installed kilowatt, whichever is less. Electricity generation incentive payments are based on 5.7 cents per kilowatt-hour of electricity generated by the dairy biogas system, which totals the same amount as a buydown grant paid out over five years.

The grant program is overseen by an advisory group comprising representatives from the California dairy industry; California Department of Food and Agriculture; California Energy Commission; California State Water Resources Control Board; Sustainable Conservation; University of California; and U.S. Environmental Protection Agency AgSTAR Program.

II. Dairy Profile

The dairy owner applied for a buydown grant from the Dairy Power Production Program to design and install a new plug flow digester.

During the 90-day study period, June-August 2005, there were an average of approximately 718 cattle on the dairy, of which 480 were lactating cows, 90 dry milk cows, 54 heifers, 67 calves, and 27 bulls. The milking cows are currently housed in drylot pens. Dry cows are housed in drylot pens as well as pasture.

The dairy facility occupies 200 acres, including 11 acres of surrounding pasture.

Open lot dairy

III. Costs/Funding

The dairy owner applied for DPPP funding for the installation of a new plug flow digester system. At the time of application for funding, total project costs were estimated at $489,284. The dairy owner was awarded a buydown grant in the amount of $244,642. The grant has been paid in full.

The dairy owner also received funding from the United States Department of Food and Agriculture (USDA) National Resources Conservation Service (NRCS)for $150,000, through the Environmental Quality Incentives Program (EQIP).

To date, the dairy owner has spent approximately $832,838 on project completion, or $343,554 over the projected cost of the project. A large component of the over-expenditures came from significant increases in building supplies such as lumber and concrete. During the three-year period between application for grant funding and project completion, costs for these construction materials nearly doubled. Additionally, it is estimated that the dairy owner incurred an unanticipated $33,000 in interconnection costs and $20,000 for county permits.

The dairy owner operates the system himself. Operating costs include oil changes, inspections and routine maintenance. The dairy owner and staff spend much time maintaining the system and monitoring performance. Approximately 1 to 2 hours per day is dedicated to the digester project. When an oil change or other maintenance is required, the time requirement is increased. It takes approximately 1 hour to change the oil in the engine. Oil changes are scheduled every 300 to 350 hours, or approximately every 12 to 14 days (assuming the engine runs 24 hours/day). Operating costs for oil, oil sampling, spark plugs, air cleaner, valves, filters, and time spent monitoring the system amount to approximately $1500 per month.

IV. Timeline

The grant application was submitted to Western United Resource Development, Inc., on December 17, 2001. After thorough screening and diligent review of the application, the advisory group approved the project for funding in March 2002. It was originally expected that the project would begin operating by September 30, 2002. However, due to a number of outside obstacles (as explained below), the system was not officially operational until June 1, 2005. Some biogas and electricity was produced as early as February 2005, but not continually.

A grand opening event was held at the dairy on July 25, 2005, to celebrate the startup of the system's ability to generate electricity. Representatives from the California Energy Commission, USDA Natural Resources Conservation Service, California Regional Water Quality Control Board, RCM Digesters, the state Senate, county planning, general public, media, and the grant administrator Western United Resource Development were on hand for the ceremony and tour of the dairy and digester.

Digester grand opening

V. Outside Obstacles

Low milk prices have significally affected program participants. Beginning in late 2001, low milk prices began to put a strain on a dairy farmer's ability to obtain funds to invest in methane digester projects. Prices received by dairy farmers were at the lowest levels witnessed in more than 25 years. Though dairy markets are typically cyclical in nature, producers experienced more than 20 months of extremely low prices. These low prices were, in most months, below a dairy producer's cost of producing milk.

Additionally, the process of obtaining the necessary county permits for construction of the system proved to be lengthy. It is estimated that the county permit process alone delayed construction by two and a half years. As previously mentioned, the dairy owner had hoped to have the digester operating by September 2002 and expected it to cost about $490,000. By the time permits were obtained, the cost of construction materials had escalated, adding hundreds of thousands of dollars to project expenses. Finally, the project experienced several weather-related delays, including extremely wet conditions during the winter of 2005.

This project is taking advantage of the 2003 net metering law, Assembly Bill 2228 (Negrete McLeod), which allows net electricity generated by a customer to be credited against electricity consumed. Though advantageous, the process of getting this legislation passed was cumbersome and time consuming, and issues with the utility interpretation of tariffs had to be worked out with the California Public Utilities Commission. AB 2228 sunsets January 1, 2006; however new legislation, AB 728 (Negrete McLeod) was recently signed by the Governor. This bill extends and expands the biogas net metering program indefinitely.

VI. Animal Distribution

On average, from June through August 2005, there were about 718 animals on the dairy, of which 570 were lactating or dry milk cows, and 54 were heifers. The remaining animals were calves and bulls. The lactating cows are currently housed in drylot pens where they spend approximately 21 hours each day. The other three hours are spent in the milking parlor. Three freestall barns are currently under construction and are expected to be completed in 2007. Upon completion, these freestall barns will house the lactating cows. The dry cows are housed primarily in drylot pens where they typically spend half their time on the feed aprons. Some dry cows are also kept on surrounding pasture.

VII. Manure Collection & Processing

Currently, inflow to the digester comes primarily from the feed aprons. The feed aprons are scraped approximately two times per week. A trailer-mounted vacuum unit with a capacity of 2,500 gallons is currently used to collect the manure used for the plug flow system. However, as previously mentioned, three freestall barns are under construction. Upon completion of the freestall barns, it is estimated that inflow to the digester will increase from the current 2,500 gallons twice a week to approximately 14,799 gallons per day. The freestall barns will be scraped daily.

Upon completion of the freestall barns, manure will be dumped into a 30,000 gallon mix tank for adjustment of digester-feed solids concentration. The manure will be diluted with parlor wastewater down to 12% total solids.

VIII. Biogas Utilization System

Plug flow digester before cover installed

A manure pump moves the mixed manure intermittently (1-6 times per day) to a 30 x 130 x 12 foot-deep, concrete mesophilic (35°C or 95°F) plug flow digester having a hydraulic retention time of approximately 24 days. The digester is covered with a flexible, impervious top. To enhance decomposition of the manure, waste heat from the engine is re-circulated through the digester's heating coils to heat the digester to approximately 100^{o}F.

Plug flow digester

At the time of the grant application, it was estimated that the system would produce approximately 38,291 cubic feet per day of biogas. The produced biogas, with an estimated 70% methane, is used to power a 130-kW capacity Caterpillar 3406 engine. With a system capacity of 130 kW, it was originally estimated that 2,331 kWh per day of electricity would be generated.

Digested manure flows out of the digester into a concrete effluent storage tank located between the digester and mixing tank. From there, it is pumped to a screw press separator where most of the liquid is extracted. Currently, the separated solids are composted for bedding. Composted solids may also eventually be made available for landscaping sales. The liquid effluent flows to a storage pond for additional aerobic treatment before being used for irrigation on surrounding pasture.

Screw press separator

IX. Biogas and Energy Production

The biogas collected under the white polypropylene cover is piped to the natural gas engine generator. Electricity generated by the system is shipped 800 feet in an underground conduit to the local utility for partial credit under net metering provisions (discussed further below).

In the initial design specifications, it was estimated that the digester would produce 38,291 cubic feet of biogas per day from manure collected from approximately 600 lactating cows. In his grant application, the dairy owner estimated an electricity production of 2,331 kWh/day with a capacity of 130 kW. Given an estimated average of 2,331 kWh/day, it was assumed that the engine would operate approximately 18 hours per day. Design estimates assumed approximately 75% of total potential electricity generation would be reached.[1]

[1] Total potential energy production of 1,138,800 kWh/year would assume a 130 kW capacity engine running 24 hours/day and 365 days/year. The designer's original estimates called for a total production of 850,745 kWh/year, or 75% of potential energy production, based on 18 hours per day of engine operation.

Although biogas was produced as early as February 2005, the system was officially operational as of June 1, 2005, and has been producing electricity from biogas continuously since that date. During the 90-day startup period, approximately 40% of the biogas produced was flared and, consequently, not used for power production. The dairy owner cites inconsistent biogas production experienced in late afternoons as the main reason for flaring. Because of the inconsistencies of biogas in the afternoons, the generator frequently ran out of biogas, leading to consumption of electricity at peak prices. The dairy owner is hopeful that completion of the three freestall barns will correct these problems. Upon completion, additional manure will be collected, leading to a more consistent output of biogas throughout the day.

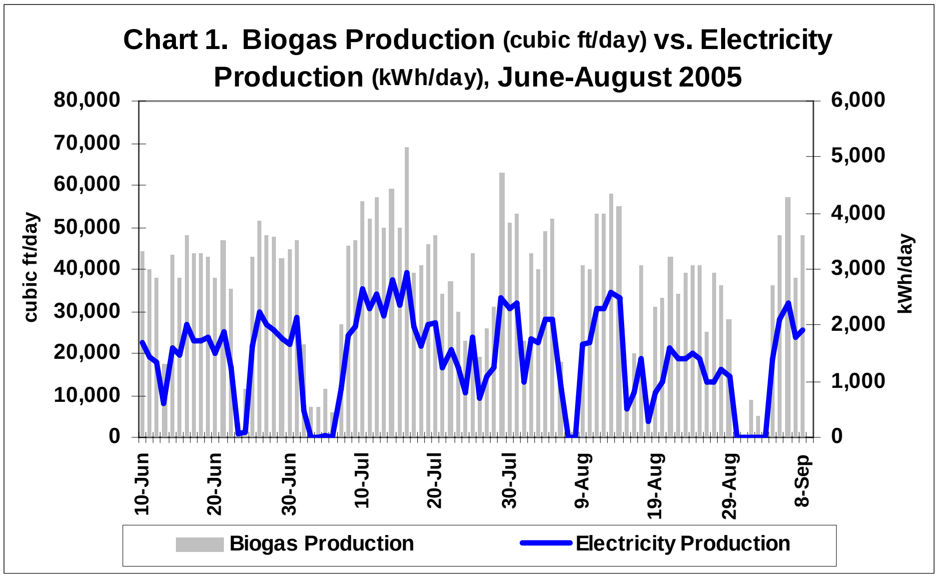


Chart 1 compares biogas production to electricity production for the 90-day startup period from June 2005 to August 2005. The biogas output of the digester steadily increased from an average of about 35,611 cubic feet/day in June to about 39,207 cubic feet/day in July. However, biogas production declined from July to August, with biogas falling to an average of 32,300 cubic feet/day. The system experienced increased downtime each month with 137 hours of down-time in June, 156 hours in July, and 186 hours in August.

Downtime occurred for a number of reasons, including maintenance such as oil and valve changes and excitement errors when the signal from the utility was lost or when the system was not operating in proper voltage range.

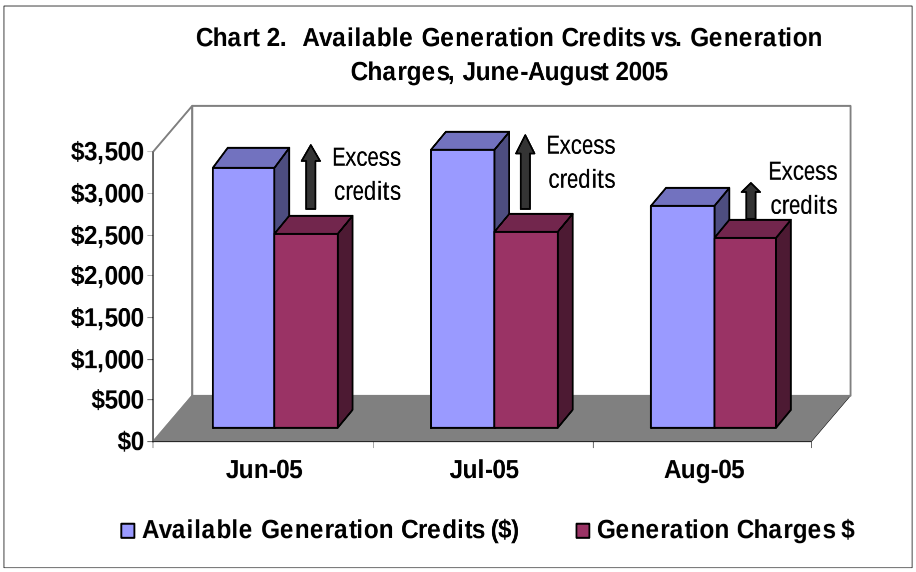
Electricity production reached an average of 1,318 kWh/day in June and rose to 1,547 kWh/day in July. Electricity production fell to an average of 1,206 kWh/day in August. Electricity production per operational hour of the system varied month to month, reaching 66.8 kW per hour in June, rising to 83.1 kW per hour in July, and then falling to 67.7 kW per hour in August. The system was operational an average of 20 hours/day in June, 19 hours/day in July, and 18 hours/day in August. This is in line with (surpassing slightly) the estimated 18 hours per day assumed in the grant application.

Engine generator room

As previously mentioned, to date, the dairy has taken advantage of the 2003 net metering law, AB 2228 (Negrete McLeod), which allows electricity generated by a customer to be credited against electricity consumed. The local utility, San Diego Gas & Electric (SDG&E), uses an electric meter to measure and track the amount of electricity produced and the amount of electricity consumed during each billing period. This is done on a time-of-use basis according to the customer's rate schedule. Twelve monthly billing cycles commencing on the anniversary date of final interconnection is considered the "relevant period."

At the end of each monthly billing period, a credit is given for energy generated at the dairy. Only the generation rate component of the total retail rate (less generation surcharges) is used in the calculation of generation credits. All other charges, including, but not limited to, transmission charges, distribution charges, public goods charges, nuclear decommissioning charges, monthly basic service fees, minimum charges, demand charges, and non-energy related charges, are calculated prior to the netting of energy supplied or produced, for all energy supplied to the dairy.

Generation credits are applied towards the generation component[2] of the total utility bill due each month. SDG&E offers the customer an opportunity to "bank" monthly credits. This credit can be applied to future generation related charges. However, any available generation credit dollars above generation charge dollars remaining at the end of the 12-month or "relevant" period are not paid out by the utility and forfeited by the customer.



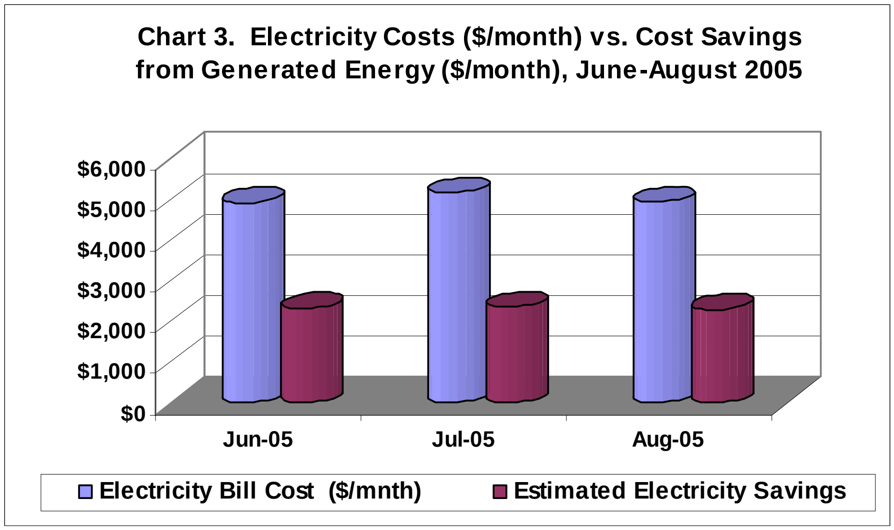
The main dairy meter and six residential accounts are included in net metering on the dairy. Chart 2 compares the monthly available generation credit dollars to the actual generation charges for all seven accounts at the dairy for the 90-day period June-August, 2005. As explained above, any excess generation credits can be banked for application against future generation charges but are forfeited at the end of the 12-month period. Generation credits from energy produced on the dairy amounted to $3,153 in June, $3,362 in July and $2,674 in August. However, generation charges for those months were lower, resulting in total excess generation credits of $2,193 for the 90-day period.

The average total retail rate of electricity for the dairy was approximately $0.15 per kWh. On average, the generation credit rate for power generated by the dairy was $0.07 per kWh.

Chart 3 compares monthly electricity costs to the realized cost savings from generated electricity for the 90-day period. Here, realized cost savings are the generation credits actually applied toward generation charges each month. Again, the dairy owner will not be

[2] Referenced as "Electric Energy" on monthly utility bills.

compensated for any excess generation credits remaining at the end of the relevant period[3]. During the 90-day period June through August 2005, a total estimated cost savings of approximately $6,996, or an average of $2,332 per month was realized.[4] An additional $2,191 in cost savings could have been realized if the excess generation credits could have been used, however, this was not the case during the time frame analyzed.



Assuming an average monthly electricity cost savings of $2,332, the estimated payback period for this project is approximately 15.7 years.[5]

Unfortunately, due to the setup of the meters on the dairy, the dairy owner is not reaping the full possible financial benefits of electricity production. Full benefit would be realized if the generator were connected to the dairy's load. If that were the case, as electricity was produced, the electricity usage for the dairy would be offset (in other words, the amount of electricity imported from the grid would be greatly reduced). This would reduce the total power purchased from the utility and would be valued at the full "retail rate" (averaging approximately $0.15 per kWh, depending on time-of-use).[6] For any time-of-use in which the electrical production exceeds the usage, a generation credit would be accrued, valued at the applicable generation rate (averaging approximately $0.07 per kWh, depending on time period produced). Under this scenario, the greater benefit comes from being able to offset the load at the dairy.

However, as mentioned above, the digester system is set up so that all power produced by the biogas system is sent to the grid, while the dairy imports from the grid all of the electricity needed for use at the dairy. Because of this, all the power produced by the biogas system is credited by the utility at the generation rate only (averaging $0.07 per kWh for June-August 2005). Under the current setup, the dairy owner is unable to offset any of his usage at the full retail rate. Therefore, he is unable to reap the benefits of offset usage during peak hours. So, realistically, the estimated cost savings each month is only the offset of unbilled generation charges by the generation credit, since this is the only financial benefit that will actually be realized. As mentioned above, this amount is approximately $2,332 per month.

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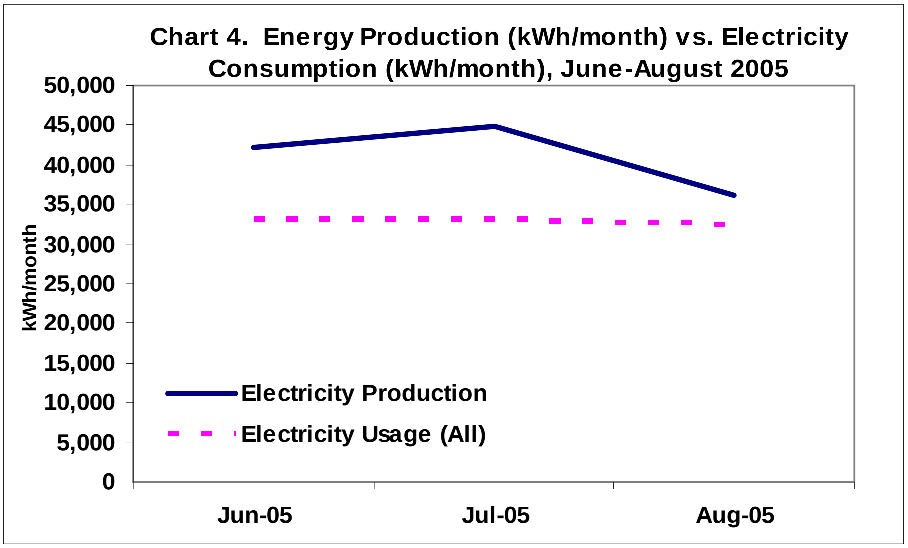
[3] Relevant period runs February 2005 to February 2006.

[4] The average generation credit rate was $0.07 per kWh for the June-August 2005 period.

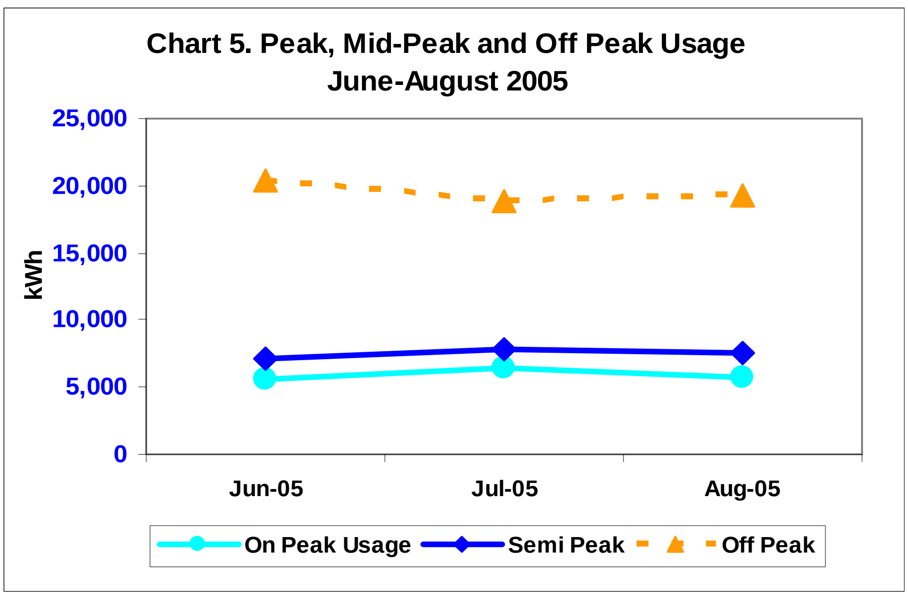
[5] Assumes $438,196 in total out-of-pocket expenses for the dairy owner above total grant funding of $394,642. Using a total project cost of $832,838 (or without grant funding), the estimated payback period is increased to 29.8 years. This does not include cost savings to due the possible sale of byproducts or offset of natural gas or propane needs.

[6] Assumes demand charges would be reduced, which may not be the case.

Also, the system is not running at full capacity. Additional biogas production is available for use but is currently being flared. As explained above, there is already excess production at the dairy. Though the dairy owner would receive a generation credit for any additional energy produced, he would not have high enough unbilled generation charges on his seven accounts to offset the credit. At the end of 12 months, the unused generation credits would be zeroed out at no financial benefit to the dairy owner.



The dairy owner plans to connect a portion of the energy load at the dairy to the generator, but it will be some time before the process is complete. The dairy owner is also hopeful that someday the utility will be required to purchase the excess energy produced on the dairy. However, there are currently no power purchase agreements available to biogas customer generators and no requirement for the utility to pay the full retail rate for this energy. Net metering is currently the only benefit available to the dairy owner.



X. Energy Usage

On average, approximately 32,868 kWh/month or 1,085 kWh/day of electricity is needed to supply the on-farm electric needs. This includes the usage for the main dairy operations as well as six residential accounts.

Chart 4 compares electricity usage for all seven accounts to electricity production each month.

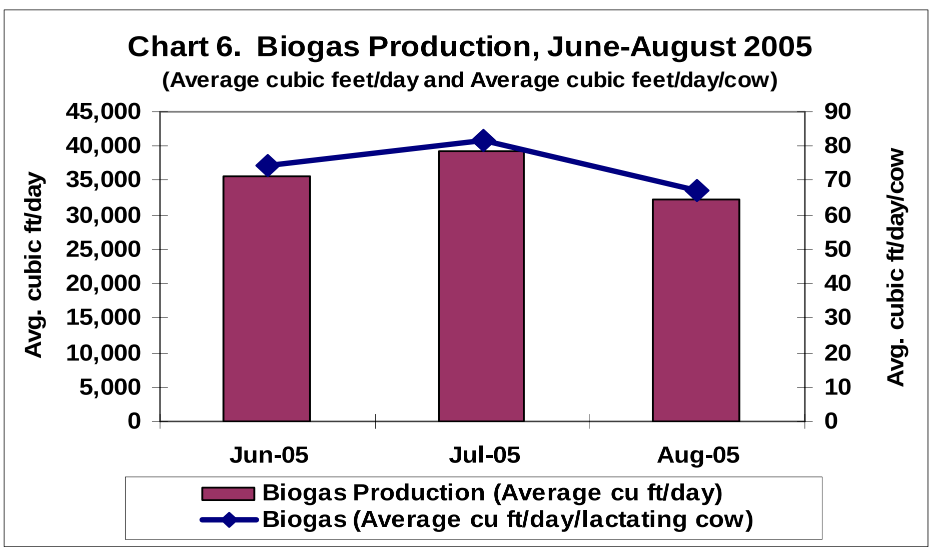
Chart 5 compares the on-peak, semi-peak and off-peak energy usage in June, July, and August. Electricity usage is primarily in the off-peak hours, with 59% of the usage falling in this category; 23% of the electricity usage on the dairy falls within the semi-peak category, with the remaining 18% in off-peak usage.

XI. System Performance

The performance of the system thus far has been somewhat below expectations. Table 1 compares the system design performance calculations with the actual performance for the 90-day period June through August 2005. Given that these are considered startup months and the data covers a very short period, these results should be considered preliminary.

In the initial design specifications, it was estimated that the digester would produce 38,291 cubic feet/day of biogas from 600 lactating cows, or 63.8 cubic feet/day of biogas per lactating cow. The daily biogas production was estimated to result in electricity generation of 3.90 kWh per cow per day. For the 90-day period studied, the design calculations for biogas were matched, with an average biogas production of 74.4 cubic feet/day per cow for an average of 480 lactating cows.

The average electricity generation metered by the dairy owner was 1,427 kWh per day compared to an originally estimated 2,331 kWh per day. This resulted in an average electricity generation of 2.97 kWh per cow per day. This lower figure was because 40% of the available biogas was flared during this period. Chart 6 compares the average cubic feet of biogas production per day and per cow for June, July, and August 2005.



Because the project is still in the startup phase, some system adjustments and improvements have been required. The dairy owner continues to monitor system performance and to make modifications as necessary.

The dairy owner reports numerous shutdowns. As previously mentioned, the major problems faced thus far with the operation of the digester system have been due to excitement errors. It is possible that engine system shutdowns are due to the high voltage and SDG&E system transients that kick off sensitive equipment. The dairy owner is working with the designer to improve the system and feels that all necessary corrections will be made to make the system more manageable. The dairy owner is also hopeful that the completion of the freestall barns will help improve system performance as waste will be collected more consistently.

Table 1: Digester Design and Actual Performance

	Design	**Actual June – August 2005 Average**
Cows (lactating)	600	480
Manure Slurry		
Total gallons per day	14,799	5,000 to 6,000
Digester Specifications		
Type	Plug flow	Plug flow
Digester Feeding Mode	Intermittent (1-6x per day)	Intermittent (1-6x per day)
Retention Time (days)	24	24
Gas Production		
Total (cubic feet per day)	38,291	35,706
Per Lactating Cow (per day)	63.8	74.4
Electrical Output		
Generator Capacity (kW)	130	130
Generator Availability (operational hours/day)	18	19
Total (kWh/year)	850,745	520,696 *
Total per day (kWh)	2,331	1,427
Total per cow (kWh/day)	3.89	2.97

*As noted, 40% of available biogas was flared during this period.

XII. Heat Utilization

Recovered heat is currently used to heat the digester in order to maintain a temperature of approximately 100°F. This has been helpful in enhancing manure decomposition.

The dairy currently uses propane for heating purposes. At this time, location logistics prohibit the use of recovered heat in the milking barn. Currently, installing a gas line to the milking barn is not feasible. The dairy owner plans to construct a new milking barn in the future and plans will include the use of recovered heat from the digester.

XIII. Dairy Owner Qualitative Feedback

On a scale from one to four, the dairy owner was asked to rate his experience in a number of areas concerning the digester project. The specific questions, along with their monthly and average rankings, are included in Table 2.

Table 2: Qualitative Questions

Questions Ranked 1-4, with 1=poor and 4=excellent	**June 2005**	**July 2005**	**August 2005**	**Average**
1. **Ease in operating the biogas production and biogas to electricity systems**	1	2	2	1.7
2. **Extent to which system gives advantage to your dairy manure management**	3	3	3	3
3. **Extent to which the system helps with odor control**	4	4	4	4
4. **Extent to which the system helps with reducing water use for manure management**	2	2	2	2
5. **Extent to which system helps address electricity issues important to your dairy operation**	3	3	3	3
6. **Overall satisfaction with the system so far**	2	2	3	2.3
7. **Any other comments or recommendations?**				