Arnold Schwarzenegger
Governor

DAIRY POWER PRODUCTION PROGRAM:

DAIRY METHANE DIGESTER SYSTEM 90-DAY EVALUATION REPORT - Castelanelli Bros. Dairy

PIER REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:

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 production 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 groundwater pollutants associated with storage and treatment of livestock wastes.

The California Energy Commission (CEC), acting under authority of the Legislative enactment in 2001 of SB5X (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, a total of 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, paid out over five years, which totals the same amount of a buydown grant.

The grant program is overseen by an advisory group comprised of 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 with the purpose of designing and installing a new covered lagoon digester.

In December 2004, there were 3,471 cows on the dairy, of which 1,526 were lactating cows, 900 heifers, 225 dry cows, 800 calves and 20 bulls. The cows are housed in freestall barns and drylots. The freestall barns are bedded primarily with sand.

III. Costs/Funding

The dairy owner was awarded a buydown grant for the amount of $320,000 to install a new covered lagoon digester system. It was estimated that the total project costs for the system would be $772,925 of which the dairy owner was eligible for up to 50 percent, not to exceed $2,000 per installed kilowatt. The grant amount was slightly less than fifty percent of total estimated costs for the project. To date, 75% of the grant has been paid to the dairy owner. As of January 2005, the dairy owner had spent approximately $670,000 on project completion, or $102,925 below the projected cost of the project. Final costs for the project have not yet been submitted. The dairy owner is currently calculating final costs, including dairy labor used for construction and installation. The dairy owner expects final costs to total approximately $800,000.

The dairy owner has also been approved for, but has not yet received, financial assistance through two additional grant programs. A grant of $166,580 has been reserved for this project by U.S. Department of Food and Agriculture (USDA) Rural Development through its Energy Efficiency and Renewable Energy Grant Program. Another $60,816 has been set aside for the dairy owner by Pacific Gas and Electric (PG&E) through its Self Generation Incentive Program. The dairy owner is currently in the process of filing the paperwork necessary to receive funds from these two grants.

The dairy owner operates the system himself. Monthly operating costs are approximately $600 per month. Costs include oil changes, inspections and routine maintenance. A great deal of time is spent by the dairy owner and staff maintaining the system and monitoring performance. Approximately 30 minutes to one hour per day is dedicated to the digester project. When an oil change or other maintenance is required, the time requirement is greatly increased. It takes approximately 2 hours to change the oil in the engine. Oil changes are scheduled every 400 hours, or approximately every 17 days (assuming the engine runs 24 hours/day).

IV. Timeline

The original application was submitted to Western United Resource Development, Inc. on December 17, 2001. After thorough screening and due diligence review of the application, the advisory group approved the project for funding in April 2002. It was originally expected that the project would be operational by September 30, 2002. However, due to a number of outside obstacles (as explained below), the system was not officially operational until October 1, 2004.

A "grand-opening" event was held at the dairy on October 19, 2004 to celebrate the startup of the system's ability to produce electricity. Representatives from the California Energy Commission; Pacific Gas & Electric; local, county, state and federal elected officials or staff and the grant administrator Western United Resource Development were on hand for the ceremony held by the dairy owner.

V. Outside Obstacles

Low milk prices have had a significant impact on most participants in the grant program. 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 over 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.

Another major roadblock to completion of this project was difficulty in obtaining a Rule 21 interconnection permit from PG&E so that the project could generate power parallel with the main grid. This project will take advantage of the 2003 net metering law, AB 2228 (Negrete McLeod), which allows the net electricity produced by a customer to be credited against electricity consumed. Though advantageous, the process to get the legislation passed, as well as the setup of the interconnection agreement with the utility company, was cumbersome and time consuming. AB 2228 sunsets on January 1, 2006. New net metering legislation is pending before the California legislature.

Working out the interconnection and net metering arrangements with PG&E took longer than initially expected, and delayed, beyond the dairy owner's control, the completion of the project. The utility interconnection agreement continued to prove elusive, with requirements changing several times. The dairy owner was required to resubmit his application to the utility company to satisfy all utility requests.

As of March 2004, the digester system was covered and producing usable biogas. All associated generation equipment was sitting in the shop, waiting for the utility company to determine if any necessary interconnection equipment was required. The dairy owner was notified that the generation equipment, as a "safety precaution," would require a redundant set of relays. This unforeseen equipment cost the dairy owner an additional $5,000.

As of July 2004, PG&E was on site and had installed power system upgrades and meters. All biogas/manure handling equipment was on site and installed. The only tasks remaining were subsystem testing, final utility testing and approval. Final utility testing was completed August 16-20, 2004.

In addition to numerous delays, it is estimated that the dairy owner incurred a total interconnection cost of approximately $35,000.

Though the dairy owner will take advantage of net metering, the current setup at the dairy precludes the dairy owner from realizing the full benefit of net metering. This is discussed further in Section IX of this report.

Net metering at the retail rate is presently prohibited. The generation credit available under net metering accounts for the generation component only. All other charges, including transmission charges, distribution charges, monthly customer charges, minimum charges, demand charges, and non-energy related charges are all calculated prior to the netting of energy supplied or produced and are charged on gross energy supplied to the dairy. There is no agreement with the utility company to purchase any excess electricity that may be produced.

VI. Animal Distribution

On average, from October through December 2004, there were about 3,534 animals on the dairy, of which about 1,608 were lactating or dry milk cows, the remainder being heifers, calves and bulls. The lactating cows are housed primarily in freestall barns where they spend approximately 21 hours each day. They spend the other three hours in the milking parlor. The dry cows, heifers and bulls spend approximately 12 hours in drylots and 12 hours in feed aprons. The calves are housed full time in a separate barn.

VII. Manure Collection & Processing

The milking parlor/sprinkler pen, freestall barns and feed aprons are all flushed with either fresh or recycled water two to three times daily. On average, the milking parlor/sprinkler pen is flushed with approximately 77,095 gallons per day of fresh water and 192,000 gallons per day of recycled water. The freestall barns and feed aprons are each flushed with approximately 1,152,000 gallons of recycled water per day. This equates to a total of 2,573,000 gallons of fresh and recycled water used each day to flush all areas. Recycled water constitutes about 97% of the water used for flushing on the dairy.

VIII. Biogas Utilization System

The flushed liquid is moved to a receiving tank and then lifted over an inclined screen separator to remove solids. The separated dry solids are used for bedding in the barns or for soil amendment on the dairy's cropland.

The screened liquid is charged to a lagoon digester. The dairy had two existing lagoons. The newer of the two lagoons, measuring 550 feet long x 150 feet wide x 28 feet deep, was topped with a floating cover to convert the lagoon to a digester, and to store the biogas. The cover is made of a high-density polyethylene material measuring approximately 80-mill thick.

The digester is fed intermittently, one to six times per day, and maintained at ambient temperatures. Approximately 642,330 gallons per day is fed to the digester. The anaerobic digester has an estimated hydraulic retention time of 40 days. A slow turning propeller within the lagoon helps prevent sedimentation, circulating the lagoon water to help cool the engine and heat the lagoon slightly.

In the original application, it was estimated that the system would produce 56,202 cubic feet per day of biogas with a methane content of 70%. The digester gas is used to drive a Caterpillar 3406T engine-generator unit with a 160 kW capacity.

Digester effluent is conveyed to the other existing lagoon where it is stored, mixed with irrigation water and used for land application or as recycled water for flushing.

IX. Biogas and Energy Production

In initial design specifications, it was estimated that the digester would produce 56,202 cubic feet of biogas per day from 1,600 lactating cows. In his original grant application, the dairy owner estimated an electricity production of 2,952 kWh/day with an engine capacity of 160 kW. Given an estimated average of 2,952 kWh/day, the engine was assumed to operate approximately 18.5 hours per day.

Although biogas was produced as early as March 2004, the system was officially operational as of October 1, 2004 and has been producing electricity from biogas on a continuous basis since that date. Originally, all biogas was being flared due to delays in the electrical interconnection process. To date, only a share of the available biogas is being used to fuel the 160kW generator; the excess biogas is currently unused and being flared.

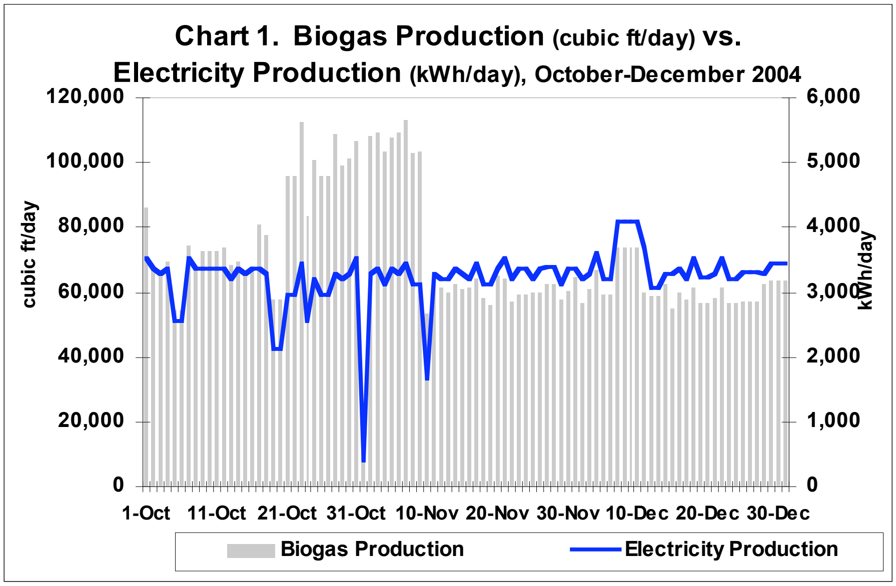
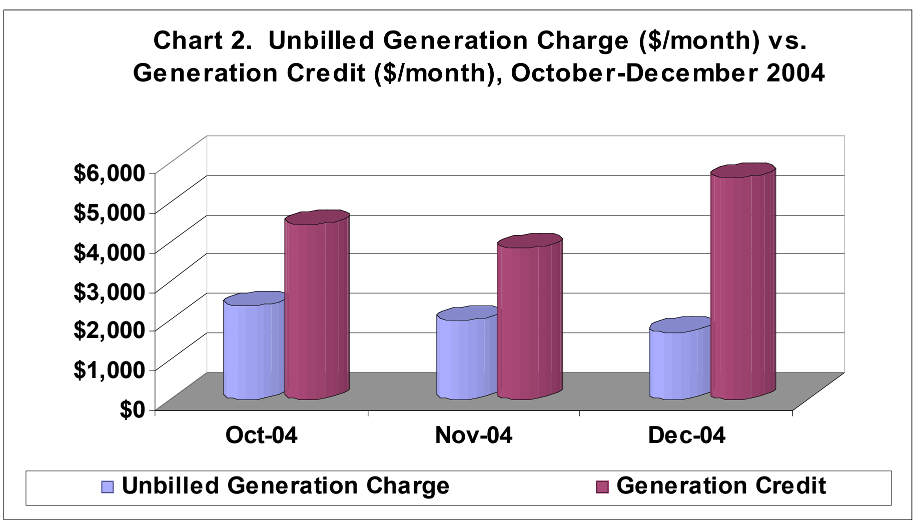


Chart 1 compares metered biogas production to electricity production for the 90-day startup period. The metered biogas output of the digester slightly declined from an average of about 79,681 cubic feet/day in October to about 71,177 cubic feet/day in November. A similar decline occurred in December, with metered biogas output falling to an average of 61,397 cubic feet/day. However, it must be noted that performance has far exceeded estimated output of 56,202 cubic feet/day in every month. Furthermore, it must be noted that biogas production has exceeded the generator capacity, forcing a great deal of biogas to be flared each month. It is estimated that up to 50% of the actual biogas production is flared each month.

Electricity production increased slightly from an average of 63,200 kWh/day in October to 66,080 kWh/day in November. Electricity production increased significantly in December to an average of 124,320 kWh/day. This was due primarily to a large reduction in down time for the month of December to 8 hours for the month. This was down from 36 hours in October and 39 hours in November. The system was operational an average of 22.8 hours/day in October, 22.7 hours/day in November and 23.7 hours/day in December. This is an improvement over the estimated 18.5 hours per day assumed in the application.

The current setup on the dairy is such that the generator is separate from the dairy's load and all the power produced by the biogas system is exported to the utility. Power is pulled back from the grid for use at various meters on the dairy. The dairy owner has approximately 20 meters on the dairy account.



As mentioned previously, for the purpose of net metering, the two rate components of a utility bill are the "generation rates"[1] and "other component rates" [2]. Under net metering provisions, the "generation charges"[3] for each meter are bundled and uncharged each month. A running total of these "unbilled generation charges" is kept for the account. For the three-month period October-December, unbilled generation charges averaged approximately $2,000 per month. The average generation rate per kWh was $0.037 for this period. Similarly, a "generation credit"[4] is compiled for the energy produced by the biogas system each month. The generation credit averaged $4,621 per month at an average generation rate of $0.057 per kWh. The "generation rate" for the unbilled charges differs from the "generation rate" for the credits due to different rate schedules applied to the meters involved. Chart 2 compares the monthly unbilled generation charges to the monthly generation credit.

The billed portion of the energy bills (all components except generation, or "other component rates") averaged approximately $3,791 per month October-December 2004. This compares to an average total electricity bill of approximately $6,200 for the period October-December 2003. It is estimated that the dairy owner is reducing his total electrical bills by approximately 30% from the same period (October-December) in 2003 under the current setup on the dairy.

Unfortunately, due to the setup of the meters on the dairy, the dairy owner is not reaping the full possible financial benefits of net metering. 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 $0.11 per kWh, depending on time-of-use). For any time-of-use in which the electrical production exceeds the usage, a generation credit is accrued, valued at the applicable generation rate (averaging approximately $0.058 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 on the dairy. Because of this, all the power produced by the biogas system is credited by the utility at the generation rate only (averaging $0.058 per kWh for October-December). 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

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[1] A ***generation rate*** is used to calculate the generation charge and the generation credit. Generation rates are a component of the utility's energy or "retail" rate. Generation rates vary by time of use (peak, partial-peak, and off-peak), by season, and by the type of rate schedule applied to individual meters. The combination of the generation rate and other component rates, as discussed in footnote 2 below, amounts to the full energy or "retail rate" for energy purchased by a utility customer.

[2] ***Other component rates***, charged on a per kWh basis, include, but are not limited to: Transmission Charges, Distribution Charges, Monthly Customer Charges, Minimum Charges, Demand Charges, and non-energy related charges. These fees are calculated according to the rate schedules applied to each meter and are calculated prior to the netting of energy supplied or produced, for all energy supplied. These fees account for the difference between the energy or "retail rate" and the generation rate.

[3] ***Generation charges*** are charged by the utility on net energy imported by the utility customer (power brought onto the dairy from the utility). Generation charges are calculated using a generation rate, as described in footnote 1 above. Generation charges are only a component of the total per kWh energy fees charged to the utility customer. Other utility rate components are discussed in footnote 2 above.

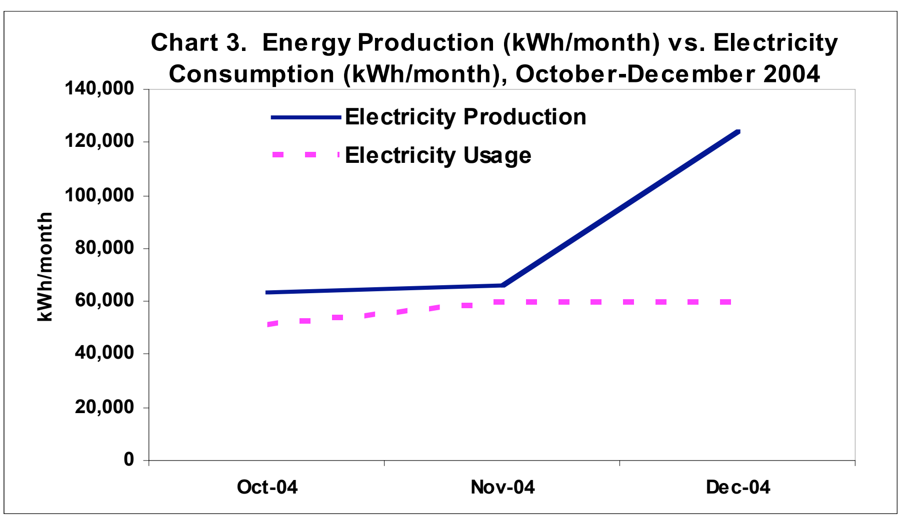
[4] A ***generation credit*** is a credit accrued for the net exportation of power to the utility at the applicable generation rate only. Other rate components are not included in the calculation of this credit.

charges by the generation credit, since this is the only financial benefit that will actually be realized (discussed further below). As mentioned above, this is approximately $2,000 per month.

There are some additional concerns with the current net metering situation:

1. As discussed above, under net metering, the utility tracks the generation credit earned by the dairy for the export of power. For the period October-December 2004, a generation credit of $13,863 was accrued. The utility also tracks unbilled generation charges for all the meters on the account. For October-December 2004, unbilled charges amounted to approximately $6,044. At the end of the 12-month period October 2004-September 2005 ("True-up period"), these credits and charges will be zeroed out. The utility is not required to pay for the unused portion of the generation credit. Therefore, from October-December 2004 alone, the dairy owner would lose approximately $7,819 in accumulated generation credits. This is free energy to the utility. This situation may improve during the summer months when the unbilled generation charges will be larger due to increased seasonal usage such as water pumps for irrigation, and so on.

2. As mentioned above, one way to make this project more economically feasible would be for the dairy owner to bring the load from a few of his largest meters to the generator. There are four large accounts at the dairy (milk barn, shop, separator pump, lagoon pump). On average, October 2003-February 2005, these four accounts used approximately 46,000 kWh per month. Currently, the dairy owner is producing anywhere from 63,000 to 124,000 kWh per month. Even with these loads connected to the generator, excess power will still be available. However, a greater financial benefit would be realized due to the ability to offset the usage at the current time-of-usage retail rate. The excess power produced would be credited at the generation rate. Had this been in place, an estimated average cost savings of approximately $4,349 per month could have been realized from October-December 2004. Of course, the largest possible financial benefit would come from being able to connect the entire dairy's usage to the generator. The dairy owner would reap the largest benefit during the summer months when power usage is increased due to irrigation pumps running. During June-August 2003, the dairy's power usage averaged approximately 107,000 kWh per month. This is more in line with achievable power production. Chart 3 compares monthly power consumption to monthly power production for the 90-day period October-December 2004.



3. The system is not running at full capacity. Additional biogas production available is for use, but putting in a second engine to produce electricity would currently be of no financial benefit to the dairy owner. As explained in items 1 and 2 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 other 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.

There are various scenarios under which a payback period can be estimated. The footnotes should be referenced for a full discussion.

Assuming average realized monthly electricity cost savings of $2,000 (offset of current unbilled generation charges), the estimated payback period for this project is approximately 20 years.[5] If usage from the four largest meters is offset (as discussed above), the monthly electricity cost savings are increased to $4,349 and the payback period is reduced to 9.2 years.[6] If it were possible to offset the entire dairy's usage at the full "retail rate" for the current meters, the monthly electricity cost savings would be approximately $4,900 per month and the estimated payback period would be reduced to 8.1 years.[7] Finally, if it were possible for the dairy owner to be credited the full retail rate for the entire amount of energy ***produced,*** estimated cost savings would average approximately $7,200 per month, reducing the payback period to 5.6 years.[8] Unfortunately, this option is not currently available since the total power that can be produced at the dairy cannot currently be consumed by the dairy and there are no power purchase agreements available from the utility.

These estimated monthly savings were averages calculated over the October-December 2004 study period. During the summer months, the average monthly cost savings could increase substantially under all scenarios and will, in fact, lower the estimated payback period. For example, under the current setup, unbilled generation charges could more than double during the summer months, reaching over $5,000. This could potentially increase the average monthly estimated benefit to somewhere closer to $2,700 per month and lower the estimated payback period to 14.7 years.[9]

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[5] Assumes $480,000 in out-of-pocket expenses for the dairy owner (total estimated project costs less the DPPP grant amount). When also including the two additional grants amounting to $227,396, out-of- pocket expenses are reduced to $252,604 and the estimated payback period is reduced to 10.5 years. Using a total project cost of $800,000 (assuming no grants were available), the estimated payback period is increased to 33.3 years.

[6] Assumes $480,000 in out-of-pocket expenses (total estimated project costs less the DPPP grant amount). When also including the two additional grants amounting to $227,396, out-of- pocket expenses are reduced to $252,604 and the estimated payback period is reduced to 4.8 years. Using a total project cost of $800,000 (assuming no grants were available), the estimated payback period is increased to 15.3 years.

[7] Using an average rate of $0.09 per kWh for the period October-December 2004. Assumes $480,000 in out-of-pocket expenses for the dairy owner (total estimated project costs less the DPPP grant amount). When also including the two additional grants amounting to $227,396, out-of- pocket expenses are reduced to $252,604 and the estimated payback period is reduced to 4.3 years. Using a total project cost of $800,000 (assuming no grants were available), the estimated payback period is increased to 13.5 years.

[8] Using an average rate of $0.09 per kWh for the period October-December 2004. Assumes $480,000 in out-of-pocket expenses for the dairy owner (total estimated project costs less the DPPP grant amount). When also including the two additional grants amounting to $227,396, out-of- pocket expenses are reduced to $252,604 and the estimated payback period is reduced to 2.9 years. Using a total project cost of $800,000 (assuming no grants were available), the estimated payback period is increased to 9.3 years

[9] Assumes $480,000 in out-of-pocket expenses for the dairy owner (total estimated project costs less the DPPP grant amount). When also including the two additional grants amounting to $227,396, out-of- pocket expenses are reduced to $252,604 and the estimated payback period is reduced to 7.7 years. Using a total project cost of $800,000 (assuming no grants were available), the estimated payback period is increased to 24.5 years.

X. Energy Usage

On average, October-December 2004, approximately 56,736 kWh/month or 2,172 kWh/day of electricity was needed to supply the electricity needed for the dairy. As mentioned previously, this average increases to approximately 107,353 kWh/month during the summer months (an 89% increase).

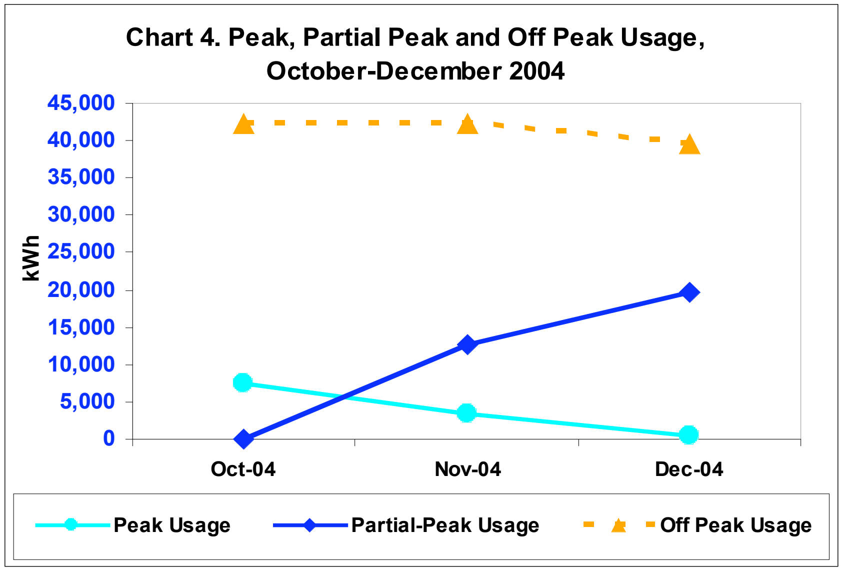
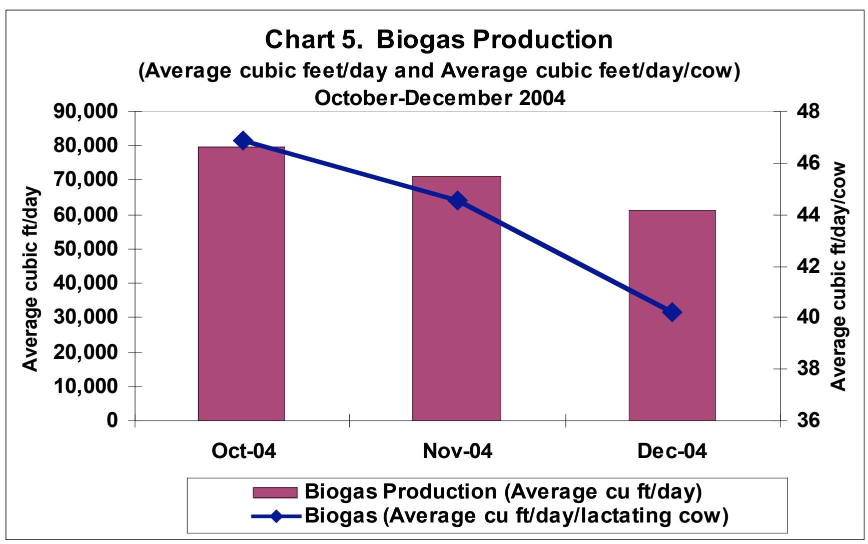


Chart 4 compares the peak, partial-peak and off-peak energy usage for the dairy during the 90-day study period. Electricity usage was primarily in the off-peak hours, with 74% of the usage falling in this category. 19% of the electricity usage on the dairy fell within the partial-peak category, with the remainder 7% in peak usage.

XI. System Performance

The performance of the system thus far has been in line with expectations. Table 1 compares the system design performance calculations with the actual performance for the 90-day period October 2004 through December 2004. Given that these are considered startup months and the data covers a very short period of time, these should be considered preliminary results.



In the initial design specifications, it was estimated that the digester would produce 56,202 cubic feet/day of biogas from 1,600 lactating cows, or 35.1 cubic feet/day of biogas per lactating cow. The daily biogas production was estimated to result in electricity production of 1.85 kWh per cow per day. For the 90-day period, the design calculations were exceeded, with an average biogas production of 44 cubic feet/day per cow for 1,608 lactating cows, resulting in an average electricity production of 1.94 kWh per cow per day. Chart 5 compares the average cubic feet of biogas production per day and per cow for October, November and December 2004.

As noted above, the average electricity production was 3,103 kWh per day compared to an originally estimated 2,952 kWh per day. If all the available biogas production were being utilized, this number would increase significantly.

The dairy owner has stated that there have not been any major problems thus far with operation of the digester system. Throughout the project startup phase, minor system adjustments were made. The dairy owner continues to monitor system performance and to make modifications as necessary. Some of the additional down time in October and November can be attributed to maintenance of the system and shutting down for the digester open house held in October.

Table 1: Digester Design and Actual Performance

	Design	**Actual October – December 2004 Average**
Cows (lactating)	1,600	1,608
Manure Slurry		
Total gallons per day	46,994	46,994
Digester Specifications		
Type	Covered Lagoon	Covered Lagoon
Digester Feeding Mode	Intermittent 1-6X per day	Intermittent 1-6X per day
Retention Time (days)	40	40
Gas Production		
Total Biogas (cubic feet per day)	56,202	70,751
Per Cow (per day)	35.13	44
Electrical Output		
Generator Capacity (kW)	160	160
Generator Availability (operational hours/day)	18.5	23
Total (kWh/year)	1,077,338	1,014,400
Total per day (kWh)	2,952	3,103
Total per cow (kWh/day)	1.85	1.94

XII. Heat Utilization

Due to the location of the generator, heat from engine cooling is not being captured or used elsewhere.

Currently, the dairy uses all gas and no propane. There is no recovery of heat to offset propane usage. October-December 2004, gas charges averaged $590 per month.

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	**October 2004**	**November 2004**	**December 2004**	**Average**
1. **Ease in operating the biogas production and biogas to electricity systems**	4	4	4	4
2. **Extent to which system gives advantage to your dairy manure management**	No comment	3	3	3
3. **Extent to which the system helps with odor control**	3	4	4	3.67
4. **Extent to which the system helps with reducing water use for manure management**	No comment	No comment	No comment	No comment
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**	4	4	4	4
7. **Any other comments or recommendations?**				