Arnold Schwarzenegger
*Governor*

# DAIRY POWER PRODUCTION PROGRAM:

# DAIRY METHANE DIGESTER SYSTEM 90-DAY EVALUATION REPORT - Meadowbrook Dairy

**PIER REPORT**

*Prepared For:*
**California Energy Commission**
Public Interest Energy Research Program

*Prepared By:*

WESTERN UNITED RESOURCE DEVELOPMENT, INC.

June 2005
CEC-500-2005-117


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Dairy Power Production Program Project No. 230-B

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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 (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 CEC 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, which totals the same amount as a buydown grant paid out over five years.

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 plug flow digester.

In October 2004, there were 2,466 cows on the dairy, of which 2,121 were lactating cows. The milking cows are in dry lot pens, as are the dry cows and heifer calves.

The main dairy facility occupies 40 acres on a 160-acre parcel with an additional 320 acres of surrounding cropland. The dairy owns and manages another 1,100-acre farm approximately 100 miles from the main dairy site. Between the two areas of cropland, the dairy owner grows enough feed (alfalfa, barley and Sudan) to meet the feed requirements of his entire herd.

## 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 $524,898. The dairy owner was awarded a buydown grant in the amount of $262,449. To date, 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) in the amount of $200,000, through the Environmental Quality Improvement Program.

As of August 2004, the dairy owner had spent approximately $800,000 on project completion, or $275,102 over the projected cost of the project. A large component of the over-expenditures came from extra concrete work on the digester tank. The size of the tank was increased and the rebar doubled in order to meet NRCS steel and concrete requirements. Additionally, extra expense was incurred as material and construction costs increased due to the time frame difference between estimation and the actual time of construction one and a half years later. The initial estimate was also too low and did not allow enough money for quality construction.

Prior to commencement of the digester system construction, the dairy owner installed a complete waste and rainwater management system in anticipation of the digester project and to meet and surpass state and regional water quality regulations. As part of this system, a new lagoon, mixing chamber, pivots, and all associated pumps and electrical were installed. Costs for the water management system totaled approximately $300,000; these costs were not included in the $800,000 total digester project costs mentioned above.

The dairy owner operates the system himself. Operating costs for oil, spark plugs, air cleaner, valves, filters, and time spent monitoring the system amount to approximately $560 per month.

## 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 March 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 August 1, 2004.

A “grand-opening” event was held at the dairy on November 16, 2004 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, California Assembly, county planning, 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 participants in the 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.

Additionally, the process of obtaining the necessary building permits for construction of the system proved to be lengthy. It is estimated that the permit process alone delayed construction by six to eight months. Some delay, approximately 95 days, came with extra concrete work done on the digester tank in order to meet NRCS requirements. Time spent on this extra work was about double what was originally planned.

Another major roadblock to completion of this project was difficulty in obtaining a Rule 21 interconnection permit from Southern California Edison (SCE) so that the project could generate power parallel with the main grid. Additionally, SCE made several personnel changes over the course of the project, and as a result, SCE generated numerous requests for design changes.

This project is expected to take advantage of the 2003 net metering law, AB 2228 (Negrete McLeod), which allows the net electricity generated by a customer to be credited against electricity consumed. Though advantageous, the process to get the legislation passed, as well as the set-up of the interconnection agreement with the utility company, was cumbersome and time consuming.

Final details are still being worked out with the utility company regarding the set-up of net metering capabilities on the dairy. Unfortunately, to date, the dairy owner has not fully benefited from the production of power due to these delays. All SCE requirements have been in place since August; however, the meters are still not programmed correctly, and a new billing structure has not been put in place. The dairy owner has paid approximately $27,000 to SCE for mandated safety equipment; however, the equipment has yet to be installed. On September 12, 2004, SCE programmed the meter for "test mode." Therefore, the dairy owner is not being compensated for his full power production. The dairy owner has relayed to SCE that all necessary permits and requirements have been met, but he is still waiting for SCE to re-program the meter. The dairy owner is hopeful that, eventually, all meters on the dairy (including two for housing) will be included in net metering.

The dairy owner is also hopeful that all necessary details will soon be in place for net metering to begin. It is expected that upcoming utility bills will reflect the use of generated electricity on the dairy. SCE is waiting to supply the dairy owner with his October utility bills until all new net metering billing details are finalized. Therefore, October utility bill details are not available for inclusion in this report. There is no agreement with the utility company to purchase any excess electricity that may be generated.

## VI. Animal Distribution

On average, from August through October 2004, there were about 3,232 animals on the dairy, of which about 2,466 were lactating or dry milk cows, and 146 were heifers. The remaining animals were calves and bulls. The dairy is an open pen drylot facility. The lactating cows are housed primarily in drylot pens where they spend approximately 21 hours each day. The other three hours are spent in the milking parlor. The dry cows are housed in drylot pens where they typically spend half their time on the feed aprons.

## VII. Manure Collection & Processing

On average, the dairy uses approximately 70,000 gallons per day of fresh water. The cows drink approximately 30,000 gallons of this daily, and the other 40,000 gallons are used in the dairy operation. This 40,000 gallons is used three different times. Initially, the water pre-cools the milk, is collected and used to wash the cows, and then is separated and either used to adjust the digester input or mixed with fresh water and used to irrigate cropland. The feed aprons are scraped once daily. Two trailer-mounted vacuum units are used to collect the manure; one unit has a capacity of 2,400 gallons, the other holds 3,750 gallons. Manure from the feed pad is dumped into a mix tank for adjustment of digester-feed solids concentration. The manure is diluted with parlor wastewater down to 12% total solids. The dairy collects and processes through the digester approximately 40% of the manure and waste generated daily; the other 60% is collected from the drylot pens, composted, and managed separately.

## VIII. Biogas Utilization System

A manure pump moves the mixed manure intermittently (from 6 am to 1 pm) to a 32 x 156 x 14-foot deep, concrete mesophilic (35°C or 95°F) plug flow digester having a hydraulic retention time of about 19 days. The digester is covered with a flexible, impervious top. Approximately 20,242 gallons per day are fed to the digester. To enhance decomposition of the manure, waste heat from the engine is used to heat the digester to approximately 101°F.

At the time of the grant application, it was estimated that the system would produce approximately 57,187 cubic feet per day of biogas. The produced biogas, with an estimated 70% methane, is used to power a

160-kW capacity Caterpillar 3406TA engine. With a system capacity of 160 kW, it was originally estimated that 3,188 kWh per day would be generated.

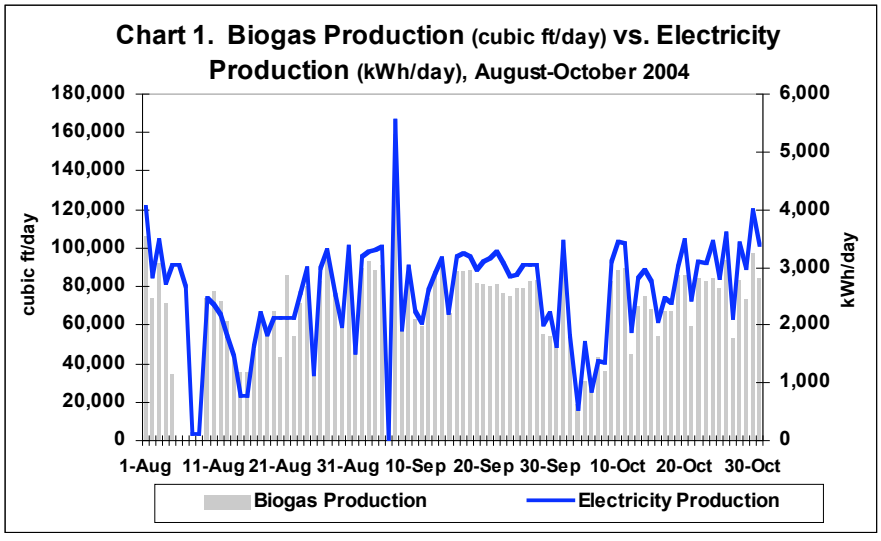
Digested manure flows out of the digester into a concrete effluent storage tank from which it is pumped to a screw press separator. The separated solids are composted and are being shipped to the off-site farm as a backhaul. The dairy owner plans to mix the digested solids with green waste, possibly bark beetle pine, to be sold to a potting soil manufacturer. The liquid effluent gravity flows to a waste storage pond where it is then used for irrigation on surrounding cropland.

## IX. Biogas and Energy Production

In the initial design specifications, it was estimated that the digester would produce 57,187 cubic feet of biogas per day from about half of the manure from 1,900 lactating cows. In his original grant application, the dairy owner estimated an electricity production of 3,188 kWh/day with a capacity of 160 kW. Given an estimated average of 3,188 kWh/day, it was assumed that the engine would operate approximately 20 hours per day.

Although biogas was produced as early as June 2004, the system was officially operational as of August 1, 2004 and has been producing electricity from biogas on a continuous basis since that date. However, as previously explained, arrangements with the utility company are yet to be finalized so that the dairy owner can be fully credited for electricity generation.

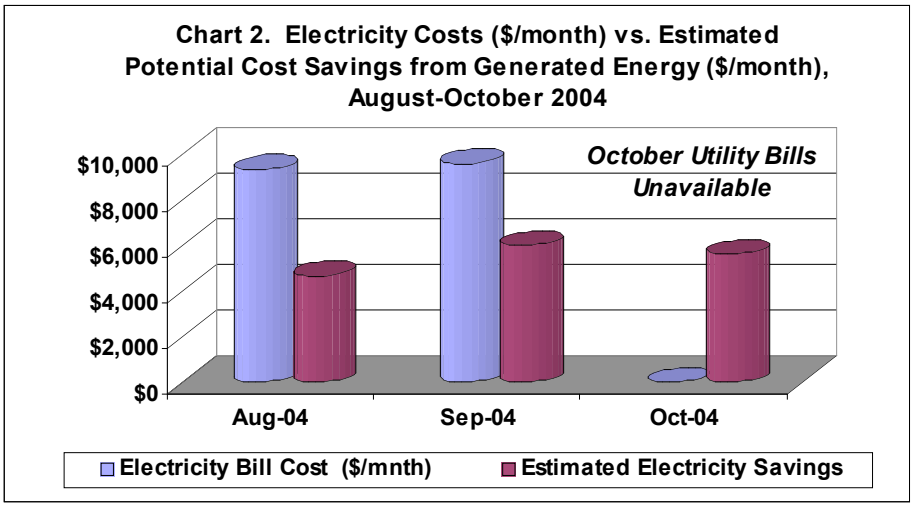
Chart 1 compares biogas production to electricity production for the 90-day startup period. The biogas output of the digester steadily increased from an average of about 57,910 cubic feet/day in August to about 77,787 cubic feet/day in September. Biogas production declined slightly in October from September, with biogas output reaching an average of 68,039 cubic feet/day. However, it should be noted that the system experienced more down time in October than in either August or September, with 100 hours of down time in October, 37 hours in September, and 72 hours in August. The biogas measured is gas that went into the engine, and does not include gas that was flared when the engine was either off or being run in limited output mode during startup and benchmarking.



Electricity production reached an average of 2,224 kWh/day in August and rose to 2,821 kWh/day in September. Electricity production declined slightly to an average of 2,608 kWh/day in October. However, electricity production per operational hour of the system increased each month, from 101 kW per hour in August to 124 kW per hour in September, and then to 125 kW per hour in October. The system was operational an average of 22 hours/day in August, 23 hours/day in September and 21 hours/day in October. This is in-line with (surpassing slightly) the estimated 20 hours per day assumed in the application.

Under the SCE net metering program, an electric meter is used to measure and track the "net" difference between 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. At the end of each billing period, a credit is given for any energy generated that is in excess of the energy consumed. If energy consumption is greater than the energy produced, the customer is billed the difference. SCE offers the customer an opportunity to "bank" charges for electricity produced in excess of consumption in the form of a credit. This credit can be applied to most future energy-related charges. However, any credits remaining at the end of the 12-month billing period are not paid out by the utility, and are forfeited by the customer. In months to come, the utility bills for the dairy should reflect this procedure. However, as previously mentioned, this is not yet the case.

Chart 2 compares monthly electricity costs to the estimated potential cost savings from generated electricity for the 90-day period. On average, the generation cost of electricity was approximately $0.0693 per kWh on the dairy. Had the dairy owner been able to fully utilize net metering during the 90-day period, August through October 2004, a total estimated cost savings of approximately $16,267, or an average of $5,422 per month could have been experienced.[1] The estimated rate used is a weighted average per kWh energy generation rate only, and does not include additional costs such as customer charges, demand charges, distribution, transmission, minimum charges, various bond charges, costs for public benefit electricity-related programs, taxes, etc. When these additional charges are included, the cost per kWh increases to an average of $0.2245 per kWh. Unfortunately, under net metering, these other charges will likely apply on the net imports of electricity to the dairy, and will consequently extend the payback period. To fully analyze how net metering will be implemented on the dairy,




[1] This uses an average energy generation rate of $0.0677 per kWh for August, $0.0708 per kWh for September, and the average of the two ($0.0693) per kWh in October, multiplied by the energy production for each month.

the SCE bills, once obtained, will need to be closely examined. It is likely that offsets in total utility costs will be a reduction in net electricity imports to the dairy, combined with the credit given for any net electricity generation.

Assuming an average monthly electricity cost savings of $5,422, the estimated payback period for this project is approximately 5.2 years.[2]

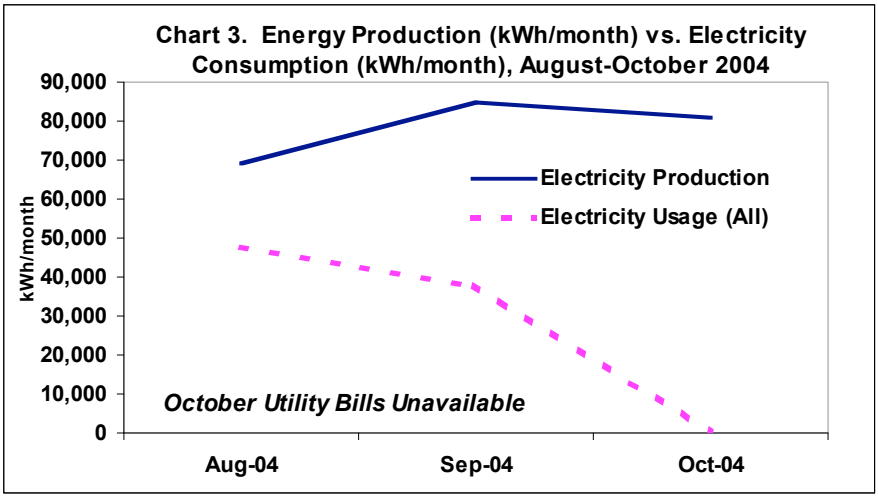
## X. Energy Usage

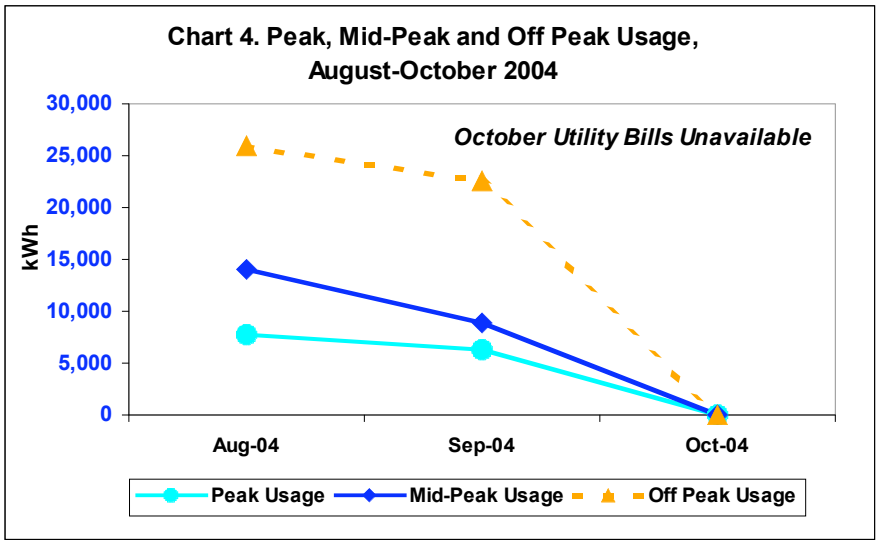
On average, approximately 42,778 kWh/month or 1,415 kWh/day of electricity is needed to supply the on-farm electric needs.[3] This includes the usage for the main dairy operations as well as a submersible water pump.

The dairy owner is hopeful that two housing meters will eventually be included in net metering. The dairy owner plans to construct a new office building and scale house and ultimately include them in net metering as well.

Chart 3 compares electricity usage for the dairy to electricity production for each month. Once again, it is likely that the usage figures are reduced slightly due to the fact that the "test" meter was in place during a portion of this time period.

Chart 4 compares the peak, mid-peak and off-peak energy usage in August and September for the dairy. Again, October utility bills are unavailable for inclusion in this report. Electricity usage is primarily in the off-peak




[2] Assumes $337,551 in total out-of-pocket expenses for the dairy owner above total grant funding of $462,449. Using a total project cost of $800,000 (i.e., without grant funding), the estimated payback period is increased to 12.3 years. This does not include cost savings to due the possible sale of byproducts or offset of natural gas or propane needs.

[3] These usage figures may be reduced slightly from historical figures due to the fact that the "test mode" meter installed may have tracked a portion of the energy generated on the dairy.

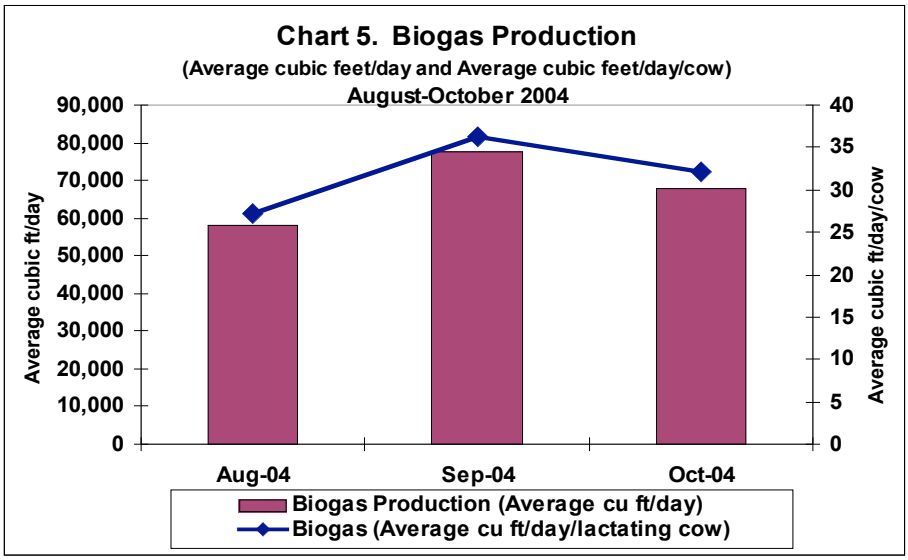
hours, with 57% of the usage falling in this category; 27% of the electricity usage on the dairy falls within the mid-peak category, with the remaining 17% in off-peak usage.

## 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 August 2004 through October 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 57,187 cubic feet/day of biogas from about half of the manure from 1,900 lactating cows, or 30.1 cubic feet/day of biogas per lactating cow. The daily biogas production was estimated to result in electricity generation of 1.68 kWh per cow per day. For the 90-day period studied, the design calculations for biogas were matched, with an average biogas production of 31.84 cubic feet/day per cow for an average of 2,133 lactating cows. This resulted in an average electricity generation of 1.20 kWh per cow per day. Chart 5 compares the average cubic feet of biogas production per day and per cow for August, September and October 2004.

As noted above, the average electricity generation was 2,551 kWh per day compared to an originally estimated 3,188 kWh per day.




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 major problems faced thus far with the operation of the digester system have been with the control panel. The dairy owner feels that the design of the electrical and control system is overly complicated and that it is easily susceptible to shutting down due to small system failures. The dairy owner reports numerous shutdowns, even though the level of biogas has been sufficient to keep the system running. The designer reports that some of the engine system shutdowns are due to the high voltage and SCE system transients that kick off sensitive equipment. The dairy owner is currently working with the designer to improve the control system and feels that all necessary corrections will be made to make the system more manageable.

Additionally, the dairy owner is considering the installation of a second engine to be fueled by manure generated by heifers currently located at a different site. The second engine would be similar in size to the current system, but would not run 24 hours per day.

**Table 1: Digester Design and Actual Performance**

| | Design | Actual August – October 2004 Average |
|---|---|---|
| **Cows** (lactating) | 1,900 | 2,133 |
| **Manure Slurry** | | |
| **Total gallons per day** | 20,242 | 20,242 |
| **Digester Specifications** | | |
| **Type** | Plug flow | Plug flow |
| **Digester Feeding Mode** | Intermittent 1-6X per day | Intermittent 1-6X per day |
| **Retention Time** (days) | 19 | 19 |
| **Gas Production** | | |
| **Total** (cubic feet per day) | 57,187 | 67,912 |
| **Per Lactating Cow** (per day) | 30.10 | 31.84 |
| **Electrical Output** | | |
| **Generator Capacity** (kW) | 160 | 160 |
| **Generator Availability** (operational hours/day) | 20 | 22 |
| **Total** (kWh/year) | 1,163,647 | 931,144 |
| **Total per day** (kWh) | 3,188 | 2,551 |
| **Total per cow** (kWh/day) | 1.68 | 1.20 |

## XII. Heat Utilization

Recovered heat is currently used to heat the digester in order to maintain a temperature of approximately 101°F. This has been helpful in enhancing the decomposition of manure.

At the dairy facility, natural gas, rather than propane, is used for heating purposes. At this time, there is no cost savings associated with the use of recovered heat. The dairy owner is considering using the excess heat to produce hot water for flushing of the calf pens or for circulating warm water underneath the calf pens in the winter. If this implemented, a possible cost savings could occur.

## 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**<br>Ranked 1-4, with 1=poor and 4=excellent | **August 2004** | **September 2004** | **October 2004** | **Average** |
|---|---|---|---|---|
| 1. **Ease in operating the biogas production and biogas to electricity systems** | 2 | 2 | 2 | 2 |
| 2. **Extent to which system gives advantage to your dairy manure management** | 4 | 4 | 4 | 4 |
| 3. **Extent to which the system helps with odor control** | 3 | 3 | 3 | 3 |
| 4. **Extent to which the system helps with reducing water use for manure management** | 3 | 3 | 3 | 3 |
| 5. **Extent to which system helps address electricity issues important to your dairy operation** | 4 | 4 | 4 | 4 |
| 6. **Overall satisfaction with the system so far** | 3 | 3 | 3 | 3 |
| 7. **Any other comments or recommendations?** No answer | | | | |