University of Illinois
at Chicago

Energy Resources Center
851 S. Morgan Street
Chicago, IL 60607-7054

Phone 312.413.5448
Fax 312.996.5620
www.CHPCenterMW.org

Dakota Station Site Report

Reliant Energy/Minnegasco

Midwest Regional CHP Application Center

Case Study MAC 2002-005

MIDWEST CHP APPLICATION CENTER

Prepared By: Leslie E. Farrar

September 2002

Table of Contents

1. Site Description

1.1. General

Minnegasco provides natural gas and home products and services to more than 680,000 customers in 246 Minnesota communities. Minnegasco has headquarters in Minneapolis, Minnesota. It is part of Reliant Energy, an international energy delivery and energy services company headquartered in Houston, Texas. The company can be found on the Web at www.minnegasco.com.

The Dakota Station is a natural-gas peak-demand-shaving facility that is part of the Minnegasco gas distribution system. Natural gas is liquefied and stored at the Dakota Station. The facility stores propane and liquefied natural gas to be used in winter periods of high fuel demand, when regional fuel supplies are lowest and Minnegasco's fuel acquisition prices are highest.

When Minnegasco wanted to install a clean and economical generating system to help manage their electricity costs at their Dakota Station; they looked to CHP as a means to accomplish this desire.

1.2. Site Location

The site is located 10 miles south of Minneapolis in Burnsville, Minnesota. The facility is located at about 700 feet above sea level.

1.3. Site Characteristics

The Dakota Station takes in natural gas and converts it to a liquid and stores it during the summer and spring months, when natural gas prices are lower and there is lower demand in their area for natural gas. The natural gas is cooled to -260 °F to liquefy it. The liquid natural gas is then stored in a 12 million gallon holding tank. This amount of liquefied gas is equivalent to approximately 1 billion cubic feet of natural gas that can be called upon for use during the winter when gas demand and natural gas prices are higher. By storing natural gas when its cost less, costs are reduced to the customer and the need to provide additional expensive pipeline capacity to meet peak natural gas demands is also lowered. Minnegasco also stores liquefied propane in a 5.5 million gallon refrigeration storage tank.

The natural gas liquefaction process draws a load of 500 kW_e, primarily during the spring and summer months. On average, the process runs for two to three months, but after some particularly severe winters, it has taken as long as six months to recover the proper inventory. When the plant is not liquefying natural gas, the natural gas processing plant load is reduced to 15 to 30 kW_e. Thus, for six to ten months of the year, the 30 kW_e unit can serve the entire load of the natural gas liquefaction center.

Through these processes, Minnegasco is able to more economically supply natural gas to its customers during the winter because of this stored fuel supply from its own storage tanks.

2. Market Segment Evaluation

While this application on the surface may appear to be limited to a very specific market segment - natural gas supply companies, it shows the benefits of utilizing CHP to

1. Meet seasonally cyclic demands,
2. Reduce energy cost by using CHP,
3. Save on energy costs, not only through energy efficiency but also through balancing energy demand; i.e., storing energy when it is less expensive (liquefying natural gas in the off-season) and making it more readily available during higher demand times (winter).

In essence, the way Minnegasco has applied CHP at its Dakota Station is a unique means of peak shaving, which could be applied more broadly at other utilities. These reduced costs can be passed on to the utility customers.

3. Technical Description

3.1. Overview of BCHP to Baseline/Original Installation

The Dakota Station (Minnegasco) uses two Capstone microturbine units. One 30 kW_e unit (Model 330) is used to reduce peak electric energy demand and usage during the natural gas liquefaction process and to supply the majority of its electricity at other times. Another Capstone microturbine, rated at 60 kW_e, is used to supply power to the refrigeration systems to keep 6,000,000 gallons of propane at -50°F. Prior to installing the microturbines, the plant purchased all of its electric power from a local electrical supplier.

For CHP utilization, the exhaust from the 30 kW_e unit is channeled to the station's climate control system, providing heating in the winter and dry air to the facility through a desiccant system in the summer, further reducing electric demands of the facility.

The Plant Manager, Todd Lind, says that he has set up the 30 kW_e unit for customers to view. Because Minnegasco is a gas utility, they hope to promote the use of microturbines among their customers.

Minnegasco also decided to purchase a second microturbine from Capstone, when the load on their liquid propane gas (LPG) plant exceeded the maximum loading capacity on the 40 year old gas reciprocating backup engine-generator for that facility. The Dakota Plant purchased the first 60 kW_e unit that Capstone shipped. Along with the previous backup engine-generator, the electric needs of the propane storage process can now be met during a total loss of offsite power. Minnegasco is also realizing savings by running the 60 kW_e unit in a "peak-shaving mode" during the summer in order to reduce the use of grid power from the local utility during the day when electric rates are higher. The microturbine is programmed to start itself in the morning and shut down at night when electric rates from the grid are less expensive than the cost to self-generate. Minnegasco is also conducting a feasibility analysis to determine if they can use heat generated by the 60 kW_e microturbine to run an absorption-cycle refrigeration system.

They have found that the Capstone microturbines are very easy to operate and control.

Minnegasco is also looking to install a microturbine at another facility, preferably a commercial building, to round out the experience gained at its Dakota plant.

3.2. BCHP System Design

3.2.1. Electrical Parameters

3.2.1.1. Overview

The natural gas liquefaction process draws a load of approximately 500 kW_e. On average, the process runs for two to three months during the spring and early summer. If natural gas usage has been high during a particular winter, it may take as long as six months to replenish the liquid supplies.

Supplemental and back-up power is purchased under a uniform general services rate from a local electrical supplier. (All of Reliant Energy's electric generating plants are located out of state.) The purchase contract is somewhat typical in that it consists of an energy usage component and an energy demand component. The demand component includes a fee for the peak usage during the month plus an additional fee based on its peak usage during the previous 12-month period.

When the liquefaction process is not operating, the plant load is 15 to 30 kW_e. Therefore, for six to ten months of the year, the 30 kW_e microturbine can serve the entire load of the facility, with power primarily going to lights, air compressors and security systems.

Using the microturbine has reduced the both the energy usage, as well as the demand charges. Also, by using the exhaust energy from the 30 kW_e microturbine, the electric demands of the facility are further reduced. Minnegasco can generate a kilowatt-hour with as little as 4,500 Btu's of incremental gas use.

Minnegasco decided to purchase a second microturbine, a 60 kW_e unit, from Capstone when the backup generator on their liquid propane gas (LPG) plant reached its maximum loading. The Dakota Plant purchased the first 60 kW_e unit that Capstone shipped. With the new microturbine and the previous backup engine-generator, the electric needs of the propane storage process can now be met during a total loss of offsite power

3.2.1.2. Electrical Generation Prime Mover

Capstone Microturbines	30 kW_e	60 kW_e
Heat Rate (LHV)	13,300 kj/kWh *(12,600 Btu/kWh)*	12,900 kj/kWh *(12,200 BTU/kWh)*
Fuel Flow	440,000 kj/h *(420,000 Btu/h)*	885,000 kj/h *(811,000 Btu/h)*
Exhaust Gas Temperatures	261°C *(500°F)*	305°C *(580°F)*
Total Exhaust Energy	305,000 kj/h *(290,000 Btu/h)*	571,000 kj/h *(541,000 Btu/h)*

3.2.1.3. Backup/Standby Power

A 40 year old gas reciprocating engine, along with the 60 kW_e microturbine is maintained to provide backup power to the propane refrigeration system in the event that offsite power is lost.

3.2.1.4. Grid Supply and Interconnection

Each local electric utility that can provide electricity to the Dakota Station (Northern States Power, Dakota Electric Association and Connexus Energy) has their own interconnection requirements.

Figure 3.2-1 shows the interconnection of the 30 kW_e microturbine to the grid and the system load at the Dakota Station. The unit is hard wired in grid connect mode and operated to follow load. Minnegasco did not purchase the dual mode controller, which would be needed in order to operate the unit in stand-alone mode. They did purchase the battery option. This allows the unit to start from a "black start" condition if the additional stand-alone operational control systems are added.

To start a unit, electric power is taken from the utility. Once the unit is online, the microturbines deliver electricity to the same bus as the utility.

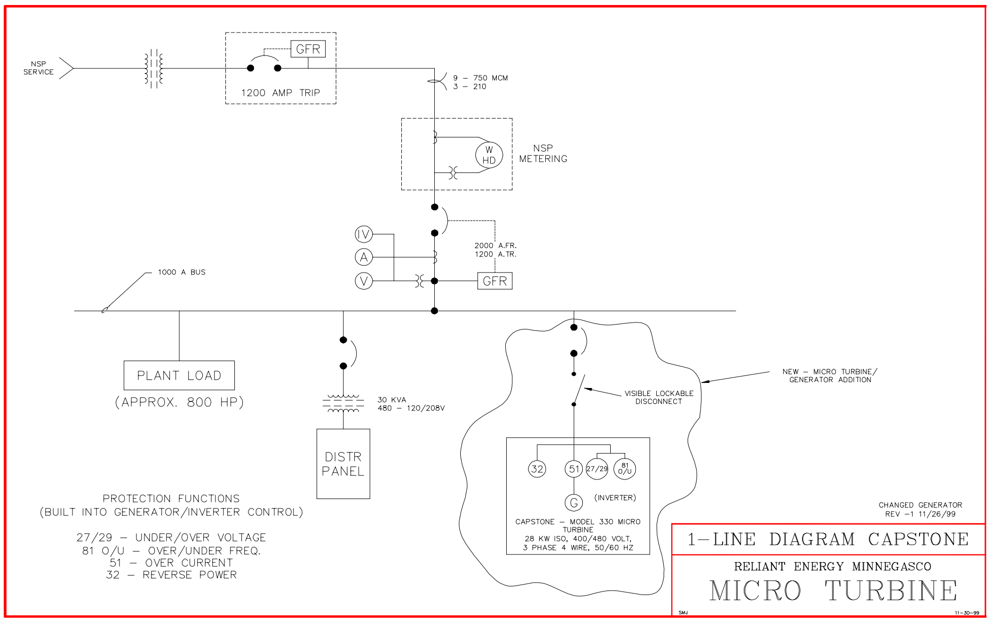

Figure 3.2-1: Single Line Electric Diagram for 30 kW_e Microturbine

3.2.1.5. Fuel Supply Description

Both microturbines use natural gas. The 30 kW_e unit requires 50 psi and the 60 kW_e unit requires 75 psi. Because the Dakota Station is a gas storage facility, natural gas is available at higher pressure than these and the gas pressure to the microturbines is reduced to supply the microturbines. Therefore, there are no parasitic energy losses due to running a compressor.

3.2.2. Thermal Recovery Systems

3.2.2.1. Heating and Cooling

The exhaust gases from the 30 kWe microturbine are provided to a Unifin Exhaust Heat Recovery unit that is used to provide heat to Dakota Station's climate control system. The microturbine can generate power with 4,000 Btu's of natural gas per kW_e (as opposed to 10,000 Btu's of coal per kW_e in a conventional power plant). The heat energy is used for facility heating in the winter and is supplied to two desiccant units for cooling and dehumidification in the summer.

Minnegasco is conducting a feasibility analysis to determine if it would be economically justifiable to recover heat application from the 60 kW_e unit to operate an absorption chiller. The feasibility analysis will look at the benefits of operating that unit all of the time to provide cooling versus just operating it in a peak shaving mode as it is currently being operated.

3.3. Original System Configuration

3.3.1. Energy Supply Parameters

3.3.1.1. Electrical Supply Description

Prior to installing the microturbines, all electricity was supplied from the local electric utility. Overall facility power demand and usage has not changed as a result of the addition of the microturbines.

3.3.1.2. Fuel Supply Description

No fuel changes have been made as a result of the addition of the microturbines. Since this facility is a gas liquefaction and storage facility, natural gas is readily available.

4. Energy Analysis (Baseline versus BCHP)

As previously discussed above, the natural gas liquefaction process draws a load of approximately 500 kW_e. On average, the process runs for two to three months during the spring and early summer. Once the liquefaction process is completed, the plant load is 15 to 30 kW_e; therefore, the 30 kW_e microturbine can serve the entire load of the facility.

Also as previously discussed, the 60 kW_e microturbine is used for their LPG plant. Initially it was purchased to support the facility, along with a 40 year old gas reciprocating engine-generator, in case of a loss-of-offsite power. After installing it, Minnegasco realized that they could save money by utilizing the unit in a "peak-shaving mode" during the day in the summer.

5. Financial Analysis (Baseline verses BCHP)

The 30-kW unit, a total cost between $45,000 and $50,000, provided energy savings of nearly $1,500 per month.

5.1. Project Cost

The 30-kW unit cost about $35,000 with the battery and communication software. The heat recovery unit was an additional $6,000. Minnegasco already owned the two desiccant units so no cost was included in the project for them. The electrical hook-up was approximately $4,000. The project totaled between $45,000 and $50,000 installed.

5.2. Annual Costs

5.2.1. Maintenance Costs

Very low maintenance costs had been incurred to date. The only maintenance activity, other than a change out of the digital power control (DPC) unit that failed within the first 100 hours of operation, has been cleaning and changing the air filter.

5.2.2. Operating Costs

5.2.2.1. Electrical Costs

The 30 kW_e microturbine produced an energy savings of approximately $1,500 per month depending on the season.

5.2.2.2. Operator Costs

The Dakota Station has not experienced any additional Operator costs associated with the microturbines.

6. Financial Considerations

The simple payback for this application is about a 2½ years, which may vary depending on fluctuating energy charges.

7. Operability Analysis

7.1. Efficiency

Capstone data claims that the generating efficiency of the unit is about 26 percent without heat recovery. When heat is recovered, the efficiency of the system increases to about 75 percent.

7.2. Reliability

The 30 kW_e unit had an electronics failure in the digital power controller (DPC) unit during the first 100 hours. It only took a couple of hours for the change out once the part arrived. Minnegasco has been satisfied with the service provided by the Capstone distributor from whom it purchased the units. The only other maintenance or repair activity has been cleaning and changing the air filter. There have been no other forced outages. The unit has run through winter temperatures dropping to –20°F and summer temperatures reaching 99°F.

7.3. Operational Performance

As of March 2002, the 30 kWe unit had operated very reliably for 16,244 hours, with the single exception of the early failure of the DPC unit discussed above.

The 60 kWe unit had operated for 5,762 hours as of March 2002.

8. Installation Analysis (Baseline versus BCHP)

8.1. Location Requirements for Installation

The installations of the microturbines were straightforward. A new pad had to be poured for the 30 kW_e unit and the 60 kW_e unit was placed on an existing pad. An electric disconnect was installed within 25 feet of the microturbines. The two units are connected in parallel to the grid. The power from each of the microturbines ties into a breaker at separate motor control centers, one for the natural gas liquefaction facility and the other for the LPG refrigeration process.

8.2. Time to Install

Minnegasco ordered the 30 kW_e unit in the fall of 1999; it was delivered in December of that year and installed in March 2000.

In August 2000, Minnegasco ordered the 60 kW_e unit. That unit was shipped in September, was received in early October and was installed in November 2000.

9. Environmental Considerations

Minnegasco has a Category D Permit at Dakota Station and is limited to 50 tons of NOx per year for all equipment at the site. The microturbine adds less than 1 ton per year. There are no additional requirements at this site.

10. Barriers/Incentives/Lessons Learned

10.1. Regulatory

- Reduced emissions versus other electric generator technology.

10.2. Technical

- Provides further energy savings through cogeneration for plant heating and cooling.
- Highest efficiency when exhaust heat is recovered for use in heating or cooling applications.

10.3. Financial

- Reduced energy costs by offsetting grid usage. Approximately $1,500 per month (season dependent).
- Reduced maintenance costs versus other electric generator technology.

10.4. Business Practices

- Minnegasco was looking for an application that they could use as a showcase for customers. The Dakota plant had the application that made the most sense.
- Contributes to utility customers' education of advanced energy technology
- 16,000+ hours of highly reliable service as of March 2002.