Integrated Field Testing of Fuel Cells and Micro-Turbines

Final Report

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Abstract

A technical and economic evaluation of the prospects for the deployment of distributed generation on Long Beach Island, New Jersey concluded that properly sited DG would defer upgrading of the electric power grid for 10 years. This included the deployment of fuel cells or microturbines as well as reciprocating engines. The implementation phase of this project focused on the installation of a 120 kW CHP microturbine system at the Harvey Cedars Bible Conference in Harvey Cedars, NJ. A 1.1 MW generator powered by a gas-fired reciprocating engine for additional grid support was also installed at a local substation. This report contains installation and operation issues as well as the utility perspective on DG deployment.

EXECUTIVE SUMMARY

This report is based on work performed under a grant issued by The New Jersey Board of Public Utilities (NJBPU) Division of Energy to and Electrotek Concepts, Inc. to investigate the technical and economic challenges of implementing advanced distributed generation (DG) technologies on Long Beach Island, New Jersey and to implement grid-connected DG systems including microturbine and fuel cells. Conectiv Power Delivery (CPD)[1] (now Pepco Holdings, Inc.) served as the host utility and provided in-kind and major equipment support. A topical report entitled "Concept Development and Evaluation of the Prospects for the Deployment of DG on Long Beach Island" was submitted at the end of Budget Period 1 in February 2002 under Grant Agreement No. DE-PS36-00GO10499, Initiative on Cooperative Programs with States for RD&D, from the US DOE Office of Energy Efficiency & Renewable Energy.

In Budget Period 1, we conducted a technical and economic evaluation of the prospects for the deployment of DG on Long Beach Island (LBI). This work was performed with the combined efforts of Conectiv and Electrotek engineers. In Budget Period 2 demonstration systems were installed and operated pursuant to the recommendations of the topical report.

LBI is located six miles off the New Jersey coast with a permanent population of about 15,000 residents rising to well over 100,000 residents in the summer months. During the three month summer season, electricity supply to the island was constrained during the summer months. The result is a very poor load factor, which makes the application of DG a viable alternative to the normal "wires" solution.

Three facilities on LBI were evaluated for application of either fuel cells or microturbines. The results of this analysis indicated that the Harvey Cedars Bible Conference (HCBC) in Harvey Cedars, NJ on LBI was the most suitable facility for application of microturbines for generation of both electricity and heat.

Two 60kW Capstone CHP microturbines were installed at HCBC to provide electricity and heat to three buildings and stand-by power. An agreement between CPD and HCBC covering electricity and heat provided at a discount for supplying heat to HCBC.

Due to retrofit of an old facility, weather, and multiple vendors, there were a number of installation issues, which delayed commissioning of the HCBC system. In addition there were a number of equipment failures that delayed full system operation. Budget Period 2 is now complete with CPD continuing to operate and maintain the HCBC system.

A 1.25 MW CAT generator powered by a reciprocating gas engine was interconnected and demonstrated at Beach Haven Substation. After that test demonstration, it was

[1] During the project period, Pepco acquired Conectiv. The Conectiv Planning Office was the lead office for this project, which now is under Pepco Holdings, Inc. For purposes of this report, the host utility will be referred to as CPD.

decided to purchase a GE 1.1 MW generator powered by a reciprocating gas engine. This was pursuant to the recommendation made in Budget Period 1 of up to seven megawatts of DG required to defer upgrading of the distribution system existing at the time of the Budget 1 analysis.

Lessons learned include:

1. Microturbines operate most efficiently with a relatively high constant heat and/or cooling load with respect to electric output,

2. A higher contingency factor need to be considered when retrofitting an older facility,

3. If possible, a turnkey approach is desirable, and

4. The local electric utility has to consider several planning and reliability issues with regard to distributed generation installations in their service territory.

INTRODUCTION

Under the original BPU grant award, in collaboration with CPD, a technical and economic evaluation was conducted for the LBI planning area (see Figure 1) to assess the prospects for the deployment of DG on LBI. The results of the evaluation concluded that there were significant benefits to be derived from locating distributed generation capacity on LBI to enhance the reliability of power supply and lower electricity costs by deferring the upgrade of transmission lines to the island. In addition to internal combustion driven generation[1], the study focused on using microturbines or fuel cells to encourage the market entry of these environmentally efficient advanced power-generating systems.

Figure 1. LBI Planning Area

Fuel cells and/or microturbines for DG applications on LBI have several advantages. LBI is composed of high-density residential vacation housing. Residents have a low

[1] A one-megawatt gas-fired generator was installed at the Beach Haven Substation to provide additional grid support. However, the focus of this report is the discussion of the microturbine installation at Harvey Cedars Bible conference.

tolerance for pollution, noise and fuel storage. Fuel cells and microturbines are quiet, low emitters of air pollutant emissions and are fired by natural gas and therefore can easily be sited on local properties. Due to the relatively high capital cost of these technologies, CHP applications are necessary to achieve a higher economic performance. Since LBI is primarily a summer island, there are relatively few facilities that have a year around heat demand required for a CHP application. However, three facilities met this criterion – a community center, a school, and a bible conference center.

Power generating technologies evaluated for these facilities were the UTC PC 25 fuel cell and the Capstone 30kW and 60kW microturbines with the ability to co-generate thermal energy, usable for space heating and domestic hot water systems. To select and size generators for each of these facilities, the following analysis conditions were assumed:

- Generators are interconnected and synchronized and operate in parallel with the grid. The grid supplies electric load not supplied by the generators.
- Generators are embedded in the existing space heating and hot water system.
- Available thermal energy is first used for domestic hot water; remaining thermal energy available is used for supplemental input to the space heating system during the heating season.
- During the non-heating season, thermal energy in excess of what is used for domestic hot water is dissipated into the atmosphere through water or air-cooling devices.

Based on these conditions, various options were evaluated comprising:

- Several options with different numbers of generators and different modes of operation evaluated for each facility in comparison with the base case; and
- An option with load curtailment in stand-alone mode during the three summer months evaluated for each of the potential sites discussed below.

Due to the relatively high capital cost of microturbines and fuel cells, sites were initially considered that would have sufficient electric and heat load for installation of a combined heat and power (CHP) system and the need for more reliable electric power supply. Three organizations having facilities that appeared to satisfy these criteria and were initially receptive to considering a CHP installation were selected for evaluation: Long Beach Island Elementary School, St. Francis Community Center, and Harvey Cedars Bible Conference (refer to Phase 1 Report: " Integrated Field Testing Of Fuel Cells And Micro-Turbine*s,* Phase I Report, Concept Development and Evaluation of the Prospects for the Deployment of DG on Long Beach Island").

Long Beach Island Elementary School was rejected because it has a steam-based heating system, which is not compatible with the hot water CHP systems being considered. After extensive discussions and meeting with the St. Francis Community Center, it was determined that they did not feel the need for increased reliability for electricity supply that a CHP system would provide since they are a day-only facility.

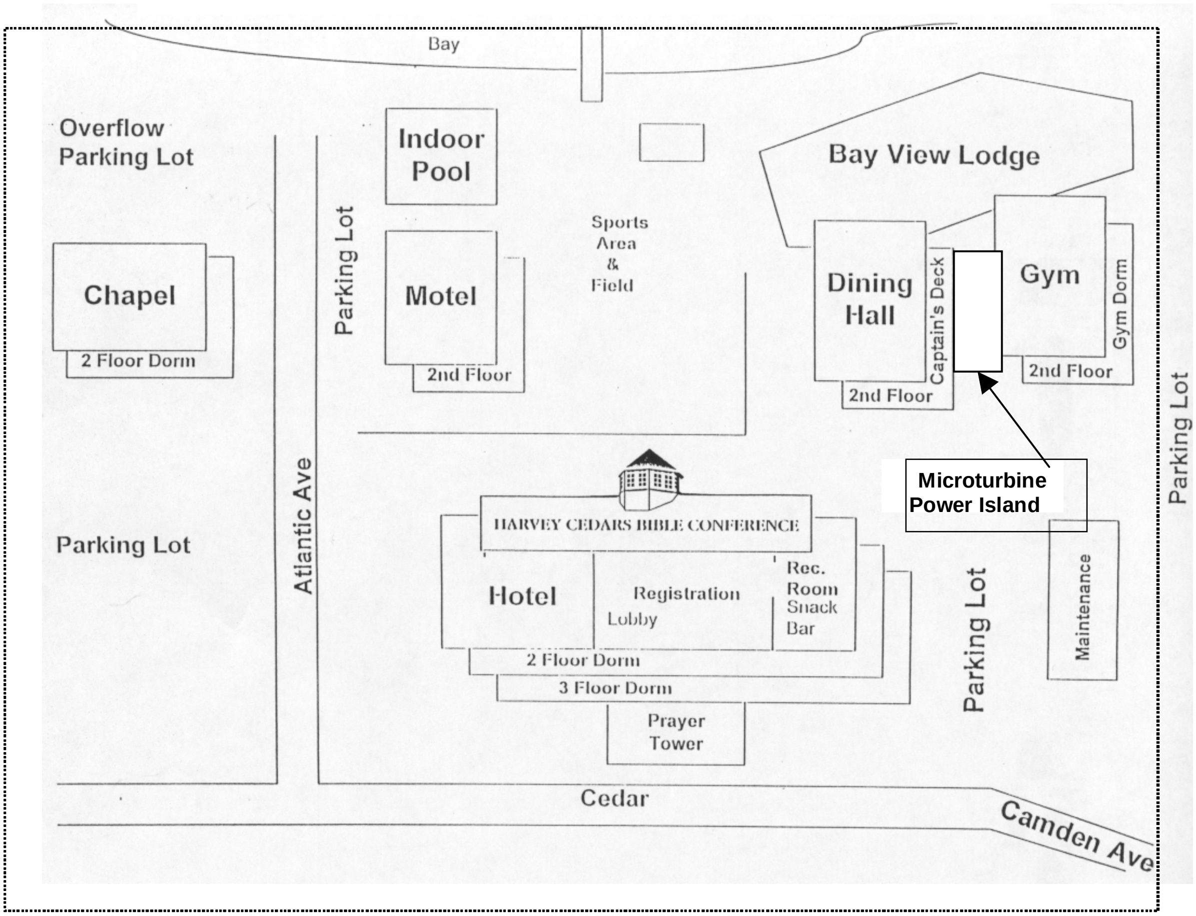
Conversely, Harvey Cedars Bible Conference, being a 24-hour facility, was receptive to obtaining the benefits of such a system including the emergency backup power it provides and therefore was finally selected for a microturbine based CHP installation.

The above analysis indicated that the microturbine when used for cogeneration has the potential to be a cost-effective generator for customer-sited generation on Long Beach Island. In contrast, the PC25 fuel cell did not show a comparable level of cost-effectiveness for this application. The savings realized could not overcome the relatively high cost of the 200kW PC25 fuel cell (net of subsidies). Two factors contributed to this result: 1) electric demand (about 60kW) of the Community Center during the heating season is insufficient to justify the capital cost of a 200kW unit, and 2) the fuel cell does not produce any external heat below 100kW due to the heat demand of the internal reformer thus negating the benefits of a CHP application. At this time, there is no known year around facility on Long Beach Island whose load is high enough to justify a PC25, the only fuel cell commercially available. As smaller fuel cell units become commercially available, the use of these very low polluting, quiet generators will be much more economically attractive.

The results of this analysis clearly indicated the efficacy of deploying advanced distributed generation on Long Beach Island. Use of distributed generation will improve system reliability and reduce system cost in an environmentally acceptable manner. Based on these findings, it was strongly recommended that the project proceed to Budget Period 2 for installation and testing. The second phase of the project consisted of implementing the recommendations of the analysis by installing, testing and monitoring distributed generation on LBI.

The present microturbine cogeneration system provides electric power, space and domestic hot water heating for three buildings at the Harvey Cedars Bible Conference site. Harvey Cedars Bible Conference is a year round facility, which encompasses educational programs, and on-site living facilities. It was founded in the year 1941 and provides a substantive addition to the economic and spiritual life of LBI. The three buildings are the hotel, dining hall with kitchen, and the Bay View Lodge as shown in Figure 2. The cogeneration system is grid connected allowing for parallel operation and supplying heating needs while also providing emergency power.

Figure 2: Harvey Cedars Bible Conference Map



The economics of CHP are enhanced by several available incentives. The New Jersey BPU has recently implemented tariffs on natural gas, which promote CHP and other measures for NG conservation. One of these incentives is a reduction in the delivery cost of NG for CHP installations amounting to $2.00 per therm. In addition, the BPU is considering a 40% subsidy on the capital cost of future CHP projects. Additionally, the StartSmart program offers rebates on related NG conservation equipment. The small generator tariff offered by Atlantic City Electric (formerly part of Conectiv) offers purchases of electricity in the form of capacity and energy payments supplied by small generators (less than 1 MW).

A 1.25 MW CAT generator powered by a reciprocating gas engine was interconnected and demonstrated at Beach Haven Substation. This generator was available to provide grid support during peak summer periods. Due to the relatively cool summer of 2004, the generator was operated minimally. Consequently there is insufficient operating data to include in this report.

After that test demonstration, it was decided to purchase a GE 1.1 MW generator powered by a reciprocating gas engine. This was pursuant to the recommendation made in Budget Period 1 of up to seven megawatts of DG required to defer upgrading of the distribution system existing at the time of the Budget 1 analysis. .

PROJECT DESCRIPTION

Two 60kW Capstone CHP units were installed at the Harvey Cedars Bible Conference (HCBC), Harvey Cedars New Jersey on Long Beach Island. These units are configured to supply electricity and heat as shown in Figure 2. The units are connected in parallel to the grid.[1] Ancillary equipment includes a dual mode controller as part of the switchgear lineup, which detects voltage drops on the grid and switches over to stand-alone mode for backup power supply. Description of the Capstone units can be found in Appendix A. Conceptual drawings of the installation can be found in Appendix B and on the attached files to this report.

Heat is supplied through use of a glycol filled main heating loop with heat exchangers at each building's boiler room. Heat demand is first supplied by waste heat from the microturbines. The existing boilers supply residual heat demand. Heat is measured by a Panametrics flowmeter (Model DF868) and two thermal probes at the outlet and inlet of the main heating loop.

DomeTech of Edison NJ performed the engineering design, United Technology Corp. Power supplied Microturbines AJ Mechanical constructed the skid and Carrier Corp conducted the installation. All the equipment procured for this project is listed in Appendix C.

BUDGET PLANNING AND ADMINISTRATION

CPD, the owner and operator of the system, required that the project have a break-even point within the first 10 years of operation. A rate of return analysis showed that this requirement could be met based on best information. Table 1 contains the internal rate of return analysis before procurement and construction of the CHP microturbine system and the gas-fired reciprocating engine.

Table 1. CPD Cash Flow Analysis for Long Beach Island

Capital Outlays							
Harvey Cedars Cogen Project							

[1] The microturbines supply facility demand up to their operating capacity. The grid supplies residual capacity. Excess microturbine supplied is flows back to the grid.

Design Engineering (DomeTech)		$37,550					
Capstone Microturbine & Ancillary Equipment		172,109					
Skid		63,500					
Installation		225,000					
Construction permit		4,500					
Transformer (utility) and metering		8,000	**Rebate Split**				
Communication		10,000	**CPD**	**Electrotek**			
	Subtotal	**$520,659**		**Capital**	**CPD In-Kind**	**Ekt Labor Hrs**	**Total**
Rebate (@35%)		$107,056	$107,056	$75,175	$35,000	$59,325	$169,500
Net Cost		**$413,603**					
1,100 kW NG Recip	$1,055,659						
Gas Recip/Generator		$525,000	.				
Rebate (@35%)		$166,750	$166,750	$17,000	$35,000	$28,000	$80,000
Net Cost of Recip/Generator		**$358,250**					
5-yr warranty		$10,000					
Rebate (@35%)		$3,500	$3,500				
Net Cost of warranty		**$6,500**					
Interconnection (Previously incurred)	$125,000 - Prior years cash outlay	$0					
Rebate (@35%)		$43,750	$43,750	$150,806			
Net Cost (Previously incurred)		**(43,750)**					
Net Cost for Recip&Interconnection	**Subtotal**	**$321,000**					
	Total Rebates		**$321,056**				**$249,500**
	Total CPD Net Outlays	**$734,603**					
Annual Net Revenue							
Cost/Revenue Item (CPD)	**2x60kW w/Cogen**	**1250kW NG Recip**					
NG Cost	($23,346)	($8,891)					
Maintenance	(979)	(1,625)	*First year cost then $2,500/yr				
Energy Saved	19,894	40,688					
Line loss credit	1,172	4,101					
Revenue (heat)	32,857	0					
Net Revenue	**$29,598**	**$34,272**					
***Includes rebate**							

Tax Benefits							
Year	**1**	**2**	**3**	**4**	**5**	**6**	
Tax savings (Cogen depreciation)	**$26,041**	**$44,628**	**$3,984**				
Tax savings (recip depreciation)		**$16,055**	**$27,515**	**$19,650**	**$14,033**	**$10,033**	
Salvage Values							
Microturbine Cogen	**$75,000**						
1250 kW NG Turbine/Generator	**$262,500**						
Year	**1**	**2**	**3**	**4**	**5**	**6**	
2 x 60 kW Cogen							
Net Capital	($413,603)						
Net Revenue	7,399	29,598					
Depreciation	6,510	44,628	$3,984				
Salvage Value			$75,000				
Benefit/cost of tax loss/gain			$100,613				
Subtotal	**($399,694)**	**$74,226**	**$179,597**				
1,100 kW NG Recip							
Net Capital		($321,000)					
Net Revenue		34,272	33,397	33,397	33,397	$33,397	$167,860
Depreciation		17,918	27,515	21,930	32,113	$22,960	
Salvage Value						$262,500	
Benefit/cost of tax loss/gain						-$38,276	
Subtotal		**($268,810)**	**$60,912**	**$55,327**	**$65,510**	**$280,581**	
Total	**($399,694)**	**($194,584)**	**$240,508**	**$55,327**	**$65,510**	**$280,581**	
			IRR=	**2.40%**			

Also, an agreement was drafted and signed by all parties between CPD and Harvey Cedars Bible Conference (see Appendix D). This agreement includes responsibilities and indemnities of the respective parties and billing for electricity and heat.[1]

INSTALLATION ISSUES

Retrofit

HCBC was established in 1941 in a 100-year-old hotel (now the administration building) adding additional buildings since that time. Due to the age of the facility, there were

[1] There is no change in HCBC is billing for electricity. A formula based on the heat delivered is contained in the agreement with a discount of 20% from a comparable use of gas to fuel the HCBC boilers.

several adjustments that had to be made in order to accommodate installation of the system:

1. The kitchen was not to code due to a high temperature oven next to the main electric control pane. The stove and hood were positioned away from the panel and a sink moved to the vacated space.

2. A new sidewalk was installed between the Dining Hall/kitchen and the Hotel due the laying of a heating line between the buildings.

3. A large bush was removed to allow the switchgear lineup to be installed.

4. The main transformer was replaced to allow compatibility with turbine output and grid supply.

5. The telephone line inside the facility was upgraded to aid in communication with the microturbines.

Permits

Construction permits were obtained from Borough of Harvey Cedars. Because of the low emissions from the microturbines, no air or coastal permits were required.

Protection

Compliance with Conectiv grid protection requirements was satisfied although the Conectiv Protection staff noted the following concerns:

> The primary protection concern was the connection of the interface transformers between the Conectiv utility source and the micro-turbine units/customer load. The initial design had two delta-wye transformers connected between the utility 12kV system and the generator's voltage sensing equipment. The delta-wye connection prevented the protective voltage functions in the micro-turbines and the Dual Mode Controller (DMC) from being able to detect a ground fault condition on the utility system and thus the necessity to initiate a generator disconnect. The critical need was that the protective devices in the micro-turbines and DMC be able to sense phase-to-ground voltage that is proportional to the utility 12kV phase-to-ground voltage. Either the voltage sensing functions needed to be connected ahead of the 12kV/480 volt transformer or all transformers between the 12kV system and the voltage sensing equipment needed to be wye-wye connected. The interface transformer was consequently replaced with a wye-wye type and the 480/208-120 volt transformer was relocated to the load side of the sensing equipment.
>
> The proposed protection functions and settings described in "Application Notes – Protective Relay Functions for Capstone Micro-Turbines", dated July 2001, did not fully satisfy IEEE 1547 requirements. The latest draft of IEEE P1547 "Draft Standard for Interconnecting Distributed Resources with Electric Power Systems"

available at that time required a slightly more restrictive set of Over Voltage protection requirements. As such, Conectiv requested that the time delay on the Primary Over Voltage Trip be reduced from 1.9 seconds to 1.0 second. Conectiv also requested that the set point on the Fast Over Voltage Trip be reduced from 125 % down to 120 % (576 Volts L-L = 332 Volts L-G). These changes would make the voltage protection consistent with Section 4.2.3 Table 1 of P1547. With these minor setting adjustments made, Conectiv was satisfied with the protective functions in the micro-turbine controllers. Since the time of this installation, IEEE 1547 has been adopted as a Final Standard and is the basis for Conectiv's interconnection criteria.

A final concern was the operation mode of the Dual Mode Controller (DMC). While not a protection issue, there was a concern that the mode of operation could result in longer temporary outage times to the customer. A momentary outage and high speed reclose of the source feeder circuit would normally only cause a 15-20 cycle momentary interruption to the customer. It appeared that the DMC operation would lengthen this momentary interruption time to at least 2 seconds.

Wiring

There were several wiring issues as shown on Table 2.

Table 2. HCBC Wiring Issues

Unit	Problem	Resolution
Dual Mode Controller (DMC)	5V induced voltage on disconnected signal wire affecting DMC operation	<u>Control wiring from the DMC to the MT</u> 1. Installation of 1" rigid conduit from the Dual Mode Controller (DMC) to the Micro-Turbine (MT). a. The conduit will run approx 52' underground to the building. Conduit will go thru the building to the other side where the MT's are located. All total the run is approximately 200'. b. Sealed weatherproof flexible metal conduits will be installed at conduit terminations. 2. Installation of 14 awg 12-conductor shielded control wires through the rigid conduit and terminate the wires at the DMC and MT. a. 10 conductors are utilized; remaining two conductors must be tied to ground at the same location as the shield. b. Terminate shield at MT chassis connection. 3. Test DMC operation for proper transfer to stand-alone mode when utility supply is interrupted.
Microturbine Modem	Noise on telephone line within property boundaries preventing modem from making a connection	Verizon to install a shielded and outdoor-rated line to replace current phone line.
Fuel Gas Booster (FGB)	Unshielded wire in a plastic conduit	<u>Control & Power wiring from the FGB to the MT</u>

	connecting the FGB to the microturbines affecting operation of unit.	1. Install ½" rigid conduit from the Fuel Gas Booster (FGB) to the Master Micro-Turbine (MT). a. Sealed weatherproof flexible metal conduits will be installed at conduit terminations. 2. Install a 4-conductor shielded control wire thru the rigid conduit and terminate the wires at the FGB and MT. a. 20-AWG-control wire recommended. Installer must confirm that terminations at FGB and MT will accept control wire larger than 20-AWG without damage. b. Terminate shield at MT chassis connection. c. Install ferrite on control cable, 5 turns near MT termination point. 3. Install ½" rigid conduit for the High Voltage wiring from the FGB to the MT. a. Sealed weatherproof flexible metal conduits will be installed at conduit terminations. 4. Install 12 AWG Type MTW power wires through rigid conduit and terminate wires at the FGB and MT

OPERATION ISSUES

In addition to the wiring problems cited above, several problems developed during the commissioning phase causing protracted time delays. These included:

1. DMC Relay Replacement -- A time delay relay failed and was replaced.

2. New battery for turbine #2 -- The battery did not hold a charge that is sufficient to restart the microturbine in stand-alone mode. It is suspected that at least part of the reason is due to the fact that the battery should be re-charged periodically if the microturbines are not operating and these microturbines did not operate for an extended period of time.

3. EMI filter and pre-charge board failures -- This is a symptom of another problem, specifically the fact that unshielded wire was run between the microturbines and the fuel gas boosters which is out of the microturbine installation specifications

4. Fuse replacements on Unit 2 -- This happened during one of the incidents where the EMI[1] filter and pre-charge board failed. We believe the cause is the same as #3.

[1] The EMI filter is the electromagnetic interference filter - it conditions the incoming AC source producing a 'clean' signal.

5. Two turbine engine replacements on turbine #2 -- This is currently being investigated. UTC Power is working diligently with its supplier, Capstone Turbines, to understand the root cause of these failures so that corrective actions can be put in place to prevent further problems.

6. Skid Deficiencies -- AJ Mechanical, the supplier of the custom built skid supporting the power island went out of business during the project period. Several leaks and wiring connections were found to be faulty and were subsequently repaired.

PERFORMANCE

Electric

Although the units were running at full output for most of the startup period, the operational incidents noted above resulted in several periods of unit down time. Table 3 indicates that for several months microturbine output exceeded HCBC demand resulting in reverse electricity flow into the grid. However in those months with excessive down time, the grid was required to provide residual electric load.

Table 3. Microturbine Grid Input (kwh)

Month	Total Consumption	Microturbine Output	Grid Input
Jul-04	88708	56607	-32101
Aug-04	56975	58369	1394
Sep-04	43930	3860	-40070
Oct-04	18537	5670	-12867
Nov-04	10118	25811	15693
Dec-04	24061	40672	16611
Jan-05	17162	35728	18566
Feb-05	20996	36872	15876
Mar-05	16607	17699	1092
Apr-05	15709	31643	15934
May-05	18022	1506	-16516
Jun-05	40852	53040	12188
Jul-05	62906	38601	-24305
Aug-05	66276	25245	-41031

Heating

The contribution to heating the HCBC facility could not be determined during the project period due to following:

1. The Panametrics meter was not calibrated for data acquisition until late in the project period resulting in insufficient collection of heat data.

2. The units were online an insufficient amount of time to collect meaningful data after the meter was calibrated.

UTILITY PERSPECTIVES

The host utility, CPD, raised several issues with respect to planning and reliability:

1. For short duration outages, this unit tripping off line can increase the load on a circuit temporarily and that will need to be planned for by much more detailed tracking techniques.

2. For longer duration outages. This unit will start in back up mode but will shut off and put the customer back on the normal source after it comes back. If systems like this were to proliferate, the utility may need to request that these customers continue to operate in stand alone for perhaps an hour or more after restoration to alleviate the "cold load pickup" level when the circuit first comes back on. If this customer who may normally have a cogen on turns into a load because of transition operations immediately after a circuit is re-energized it will contribute to even higher load making it more difficult to get the circuit back in service.

3. Eventually small units like even the 120KW cogens will make it difficult for load forecasting and planning the system. The load may not be there one peak period but then if the unit is offline based on its operating triggers, it may be there at another time.

4. For an electric utility having customers install these behind the meter, it can cause an economic challenge. The system was built to accommodate the customer's demand which now is eliminated most of the year but may appear at any moment the equipment ceases to operate. Since the utilities main revenue is based on the energy throughput, it will have lost significant revenue but will still have to supply the same capacity to the customer. If rates aren't carefully crafted, other customers will bear the financial burden for the grid support of the customer with the cogen.

5. No matter how much cogen is installed on the distribution system, to support an area, a major system disturbance can knock it off line. Most major generating sites have multiple paths out so they will not be bottled even if one transmission line trips. With a distribution feeder, you have radial service and it is more prone to outages. So as a consequence, it makes DG on the distribution much more

vulnerable to tripping and once the system has gone into low voltages or other problems, it will be difficult to start the DG.

6. Notwithstanding #5, there are many hours where DG can operate normally and hence support the electrical system. The only way to guarantee it is useful is to have centralized control or price signals going to the customers meter and hence to the generator.

7. Coordinating a project at a customer site increases the schedule and cost significantly because everything must conform with a schedule acceptable to the customer.

8. Because this system was in front of the customer meter electrically, there was no impact to the customer's bill.

ADDITIONAL PERSPECTIVES NOTED BY THE PROJECT TEAM

1. The challenge of the economy of scale was not lost on this project. There were as many problem details with this project as if it were quite a bit bigger and so that is going to be a barrier to seeing a tremendous increase in customer owned cogen.

2. This project was relatively new in that many had not been done and although quite a bit of time went into pre-design work, many of the problems could not be envisioned.

3. The thermal demands are far trickier to predict than most people anticipate. A true survey must be done that covers a significant period of time to determine true demand for heat as the basis for specifying a cogen system.

4. It is necessary to have sufficient heat load to run the units economically. This requires operating unit output at a level commensurate with thermal load. However, if the thermal load is low consequently running at low unit output and the units go into stand-by load, electric output may be too low to meet demand.[1]

5. For a project of this nature, it would be much better approached as a turnkey project to reduce risk and keep the line of responsibility clear. Having so many parties, even though we worked to minimize them, made the project much more difficult and expensive -- a project management firm, a design firm, a build firm, another fabricator and then the equipment representative and then the sponsoring utility all were involved and made for a huge amount of overhead.

[1] This problem is being investigated to determine whether a software solution can be developed to resolve this issue.

CONCLUSION

Distributed generation can have a significant role in an electric distribution system providing grid support and stand-by power in the case of a power outage. However, there were several lessons learned in installing and operating a DG system at a private facility.

Lessons learned included:

1. A detailed profile of thermal demand needs to be established before specifying the cogen system,

2. Microturbines operate most efficiently with a relatively high constant heat and/or cooling load with respect to electric output

3. A higher contingency factor need to be considered when retrofitting an older facility,

4. If possible, a turnkey approach is desirable, and

5. The local electric utility has to consider several planning and reliability issues with regard to distributed generation installations in their service territory