NYSERDA CHP Assessment Report

ASSESSING THE CHP PLANT AT RIVER POINT TOWERS

October 9, 2013

River Point Towers

NYSERDA New York State Energy Research and Development Authority

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BACKGROUND

The New York State Research and Development Authority (NYSERDA) web-based DG/CHP data system has been providing performance information on CHP systems for the past ten years. This system includes monitored performance data and operational statistics for NYSERDA's Distributed Generation (DG)/Combined Heat and Power (CHP) demonstration projects including:

- Monitored Hourly Performance Data
- Operational Reliability and Availability Data
- Characteristics of Each Facility and its Equipment

The Monitored Hourly Performance Data portion of the database allows users to view, plot, analyze, and compare performance data from one or several different DG/CHP sites in the NYSERDA portfolio. It allows DG/CHP operators at NYSERDA sites to enter and update information about their system. The database is intended to provide detailed, highly accurate performance data that can be used by potential users, developers, and other stakeholders to understand and gain confidence in this promising technology.

The Operational Reliability Data portion of the database is intended to allow individual facility managers to better understand reliability, availability, and performance of their particular units and also determine how their facilities compare with other units. Information on reliability and availability performance will enable potential onsite power users to make a more informed purchase decision, and will help policy makers quantify reliability benefits of customer-sited generation.

NYSERDA's web-based DG/CHP data system provides general equipment information and detailed performance data, however, data alone does not provide the complete picture with respect to CHP systems design or performance.   This report seeks to explain the performance data presented in the two fundamental output graphs: kW/h versus time and Useful MBtu/h versus time.

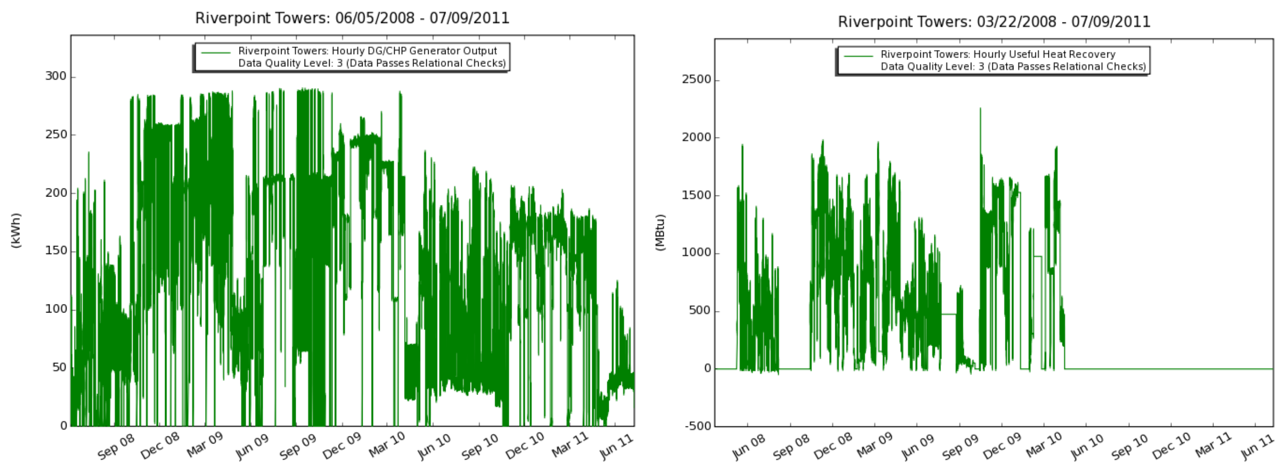

FIGURE 1 NYSERDA CHP WEBSITE PERFORMANCE GRAPHS

This report provides an explanation for system performance trends and anomalies by further assessing the data supporting these two graphs and, where necessary, conducts interviews of the developers, owners and operators.

THE SITE

FIGURE 2 RIVER POINT TOWERS, BRONX, NEW YORK

River Point Towers is a 412 unit residential building located in Bronx, NY. Peak summer electrical demands typically approached 600 kW. Natural gas use was high year round due to the operation of a steam driven absorption chiller.

River Point operates as a cooperative which gives the residents an acute sense of the costs involved maintaining the facility and related services. All of the building's utilities are centrally distributed; electricity is metered at a single entrance. Two steam boilers provide heat to separate hot water loops used for space heating and DHW. A steam driven absorption chiller used for air conditioning was causing fuel consumption to peak in summer.

Because of these circumstances, River Point chose to install a CHP system, technology that could impact all of the utility services. River Point worked with American DG Energy who took responsibility for its ongoing maintenance and operation. Four 75 kW Tecogen CHP modules were installed along with a 200-ton engine driven chiller that should curtail use of the absorption machine.

THE SYSTEM

Four 75 kW engine-generator sets were installed at the site to produce electricity and hot water. The generators will provide about 70% of the site's electricity. Heat recovered from the engines offsets steam used for space heating and DHW production. Excess heat can be diverted to an outdoor swimming pool or a cooling tower depending on the season.

FIGURE 3 SINGLE CHP MODULE SHOWN DURING INSTALLATION

The CHP system is configured around four 75 kW natural gas fired engine-generator sets. Electricity is produced in parallel with the utility grid; the output can be modulated to follow the thermal or electric load. The latter scheme will be employed during the utility's designated on-peak periods. Waste heat from the engine jackets and exhaust is recovered as 230°F hot water which is circulated through a series of heat exchangers on the return side of the space heating and DHW distribution systems, thus reducing the existing boiler's fuel consumption. The resulting piping arrangement gives priority to the thermal loads in the order shown (space heating, domestic hot water heating and then pool heating). Any excess heat can be diverted to an outdoor pool or rejected through a cooling tower installed with the new chiller through a separate heat exchanger dedicated to this purpose. (see Figure 4)

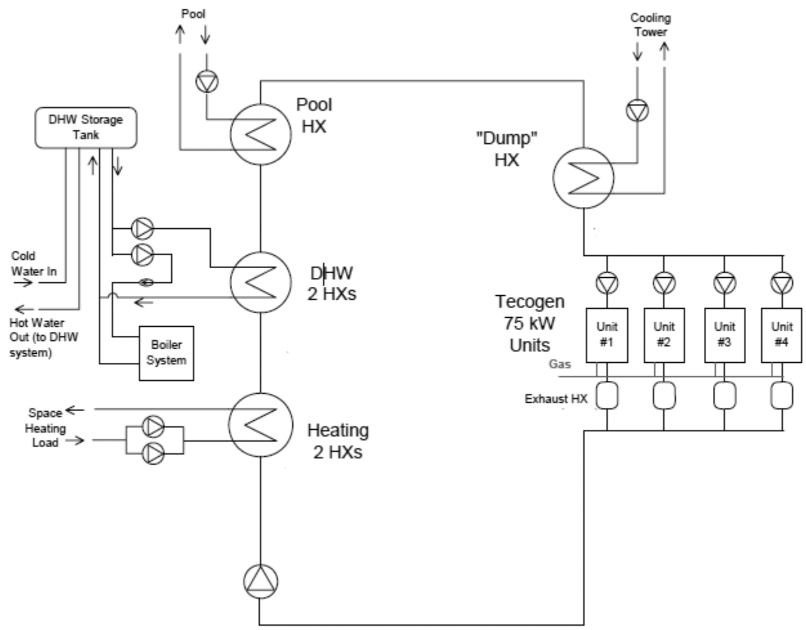

FIGURE 4 SIMPLIFIED CHP SCHEMATIC

FIGURE 5 EXHAUST HEAT RECOVERY HEAT EXCHANGER

FIGURE 6 HEAT EXCHANGER NETWORK SERVING END USES

PERFORMANCE

The New York State Energy Research and Development Authority (NYSERDA) offers certain incentives to promote the installation of clean, efficient, and commercially available CHP Systems that provide summer on-peak demand reduction. Incentives are performance-based and correspond to the summer-peak demand reduction (kW), energy generation (kWh), and fuel conversion efficiency (FCE) achieved by the CHP system on an annual basis over a two-year measurement and verification (M&V) period.

Table 1 provides the data results taken since Jun, 2008. Data quality for this site has been sporadic with several months having good data, while other months the relational checks indicate false failures when the units cycle on and off. November 2010 through April of 2011 data quality is at or near 100%.

TABLE 1 SYSTEM EFFICIENCY[1]

	Hours of Good (Pwr) Data	Net Electric Output (kWh)	Natural Gas Use (MCF)	Useful Heat Output (MMBtu)	Electrical Efficiency	Useful Thermal Efficiency	Fuel Conversion Efficiency
January-09	744	116,935	1,533.0	381.7	25.5%	24.4%	49.9%
February-09	672	146,985	1,901.0	448.3	25.9%	23.1%	49.0%
March-09	744	154,288	1,967.9	361.9	26.2%	18.0%	44.3%
April-09	720	142,401	1,889.5	723.1	25.2%	37.5%	62.7%
May-09	744	52,964	742.9	348.9	23.9%	46.0%	69.9%
June-09	720	91,073	1,210.7	325.5	25.2%	26.4%	51.5%
July-09	744	158,976	2,064.9	194.7	25.8%	9.2%	35.0%
August-09	507	88,962	909.3	21.4	32.7%	2.3%	35.0%
September-09	720	86,266	172.7	52.5		29.8%	29.8%
October-09	744	69,525	856.1	252.0	27.2%	28.9%	56.0%
November-09	720	149,690	1,909.0	971.5	26.2%	49.9%	76.1%
December-09	744	146,958	1,899.4	805.7	25.9%	41.6%	67.5%
January-10	744	166,475	2,141.4	164.8	26.0%	7.5%	33.6%
February-10	672	145,432	1,898.7	20.3	25.6%	1.0%	26.7%
March-10	744	125,951	1,637.2	770.7	25.7%	46.1%	71.9%
April-10	720	50,248	686.0	232.5	24.5%	33.2%	57.7%
May-10	744	71,901	1,033.7	-	23.3%	0.0%	23.3%
June-10	567	38,014	393.7	-	32.3%	0.0%	32.3%
July-10	744	51,873	507.0	-	34.2%	0.0%	34.2%
August-10	744	50,527	492.5	-	34.3%	0.0%	34.3%
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January-11	744	105,541	1,729.5	-	20.4%	0.0%	20.4%
February-11	672	99,739	1,681.4	-	19.8%	0.0%	19.8%
March-11	744	101,821	1,707.0	-	20.0%	0.0%	20.0%
April-11	720	86,933	1,448.5	-	20.1%	0.0%	20.1%
May-11	744	20,160	131.6	-	51.3%	0.0%	51.3%
June-11	720	35,703	143.9	-	83.0%	0.0%	83.0%
July-11	743	28,218	18.2	-	518.8%	0.0%	518.8%
Total preceding 12 months	**8759**	**843,374**	**12,222**	**-**	**23.1%**	**0.0%**	**23.1%**

Note: All efficiencies based on higher heating value of the fuel (HHV)

[1] Efficiency data is collected using all data points flagged as high quality data. Generally there is good correlation between the data quality of net electric output, natural gas use and useful heat rejection. Anomalies do occur, particularly with respect to natural gas use which causes distortions in the results. If efficiency results are out of normal range, the most likely cause is poor quality concurrent data which can be corroborated by the Site Data Quality table located in the Lessons Learned section of this report.

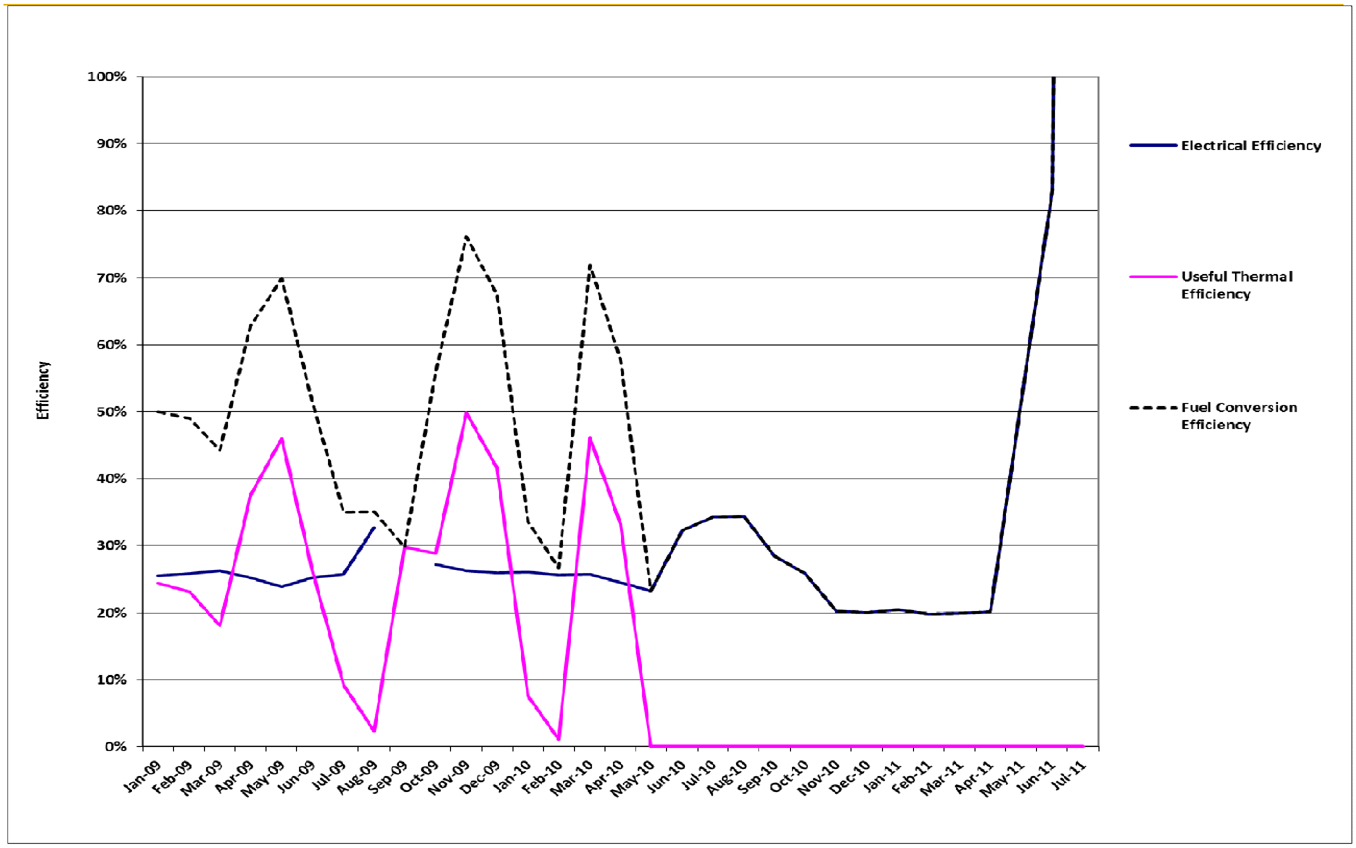

FIGURE 7 ELECTRIC, THERMAL AND FUEL CONVERSION EFFICIENCY BY MONTH

Figure 7 provides operating efficiency during January, 2008 through July of 2011.

OPERATING SUMMARY

The CHP system consists of five reciprocating engine generators with a nominal capacity of 300 kW.

During the 26,633 operating hours that met the range and relational checks only 28% of this time, mostly due to problems with the relational checks when the unit cycles, the CHP system delivered over 175 kW/hr (Figure 16).

November 2010 through April of 2011 data quality is at or near 100%. This provides an understanding of the generator performance with efficiency around 20% HHV. This is an indication of cycling or general performance degradation.

This project was the subject of continuous piping changes which impacted the thermal performance and data gathering, making much of the thermal information suspect. Finally, in May of 2010, heat recovery data collection was purposely stopped since the sensors were no longer in the correct position to properly record useful heat recovery. This site never satisfied the requirements for NYSERDA's performance-based CHP incentive program.

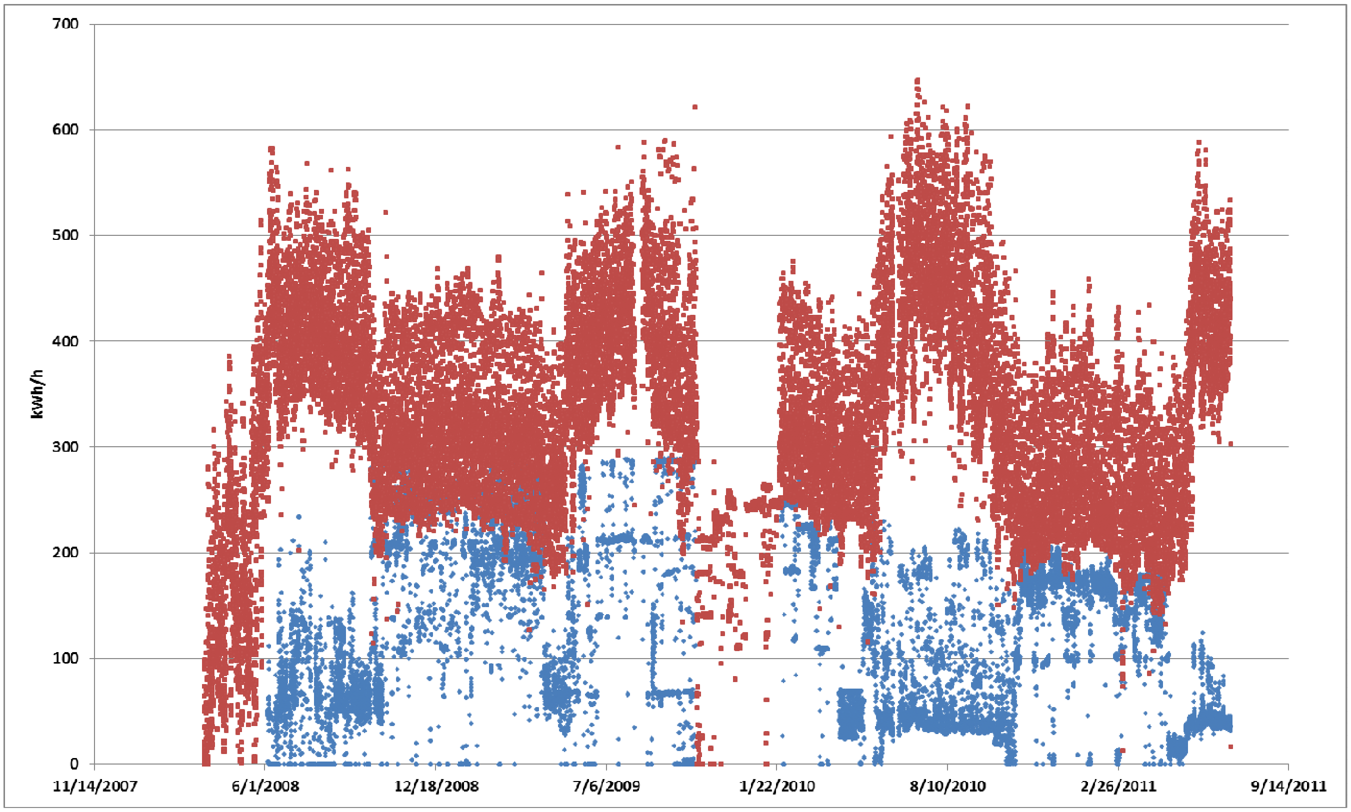

FIGURE 8 CHP POWER GENERATED VERSUS BUILDING LOAD BY MONTH

Figure 8 shows the electric load profile for River Point Towers.

POWER GENERATION AND USEFUL THERMAL

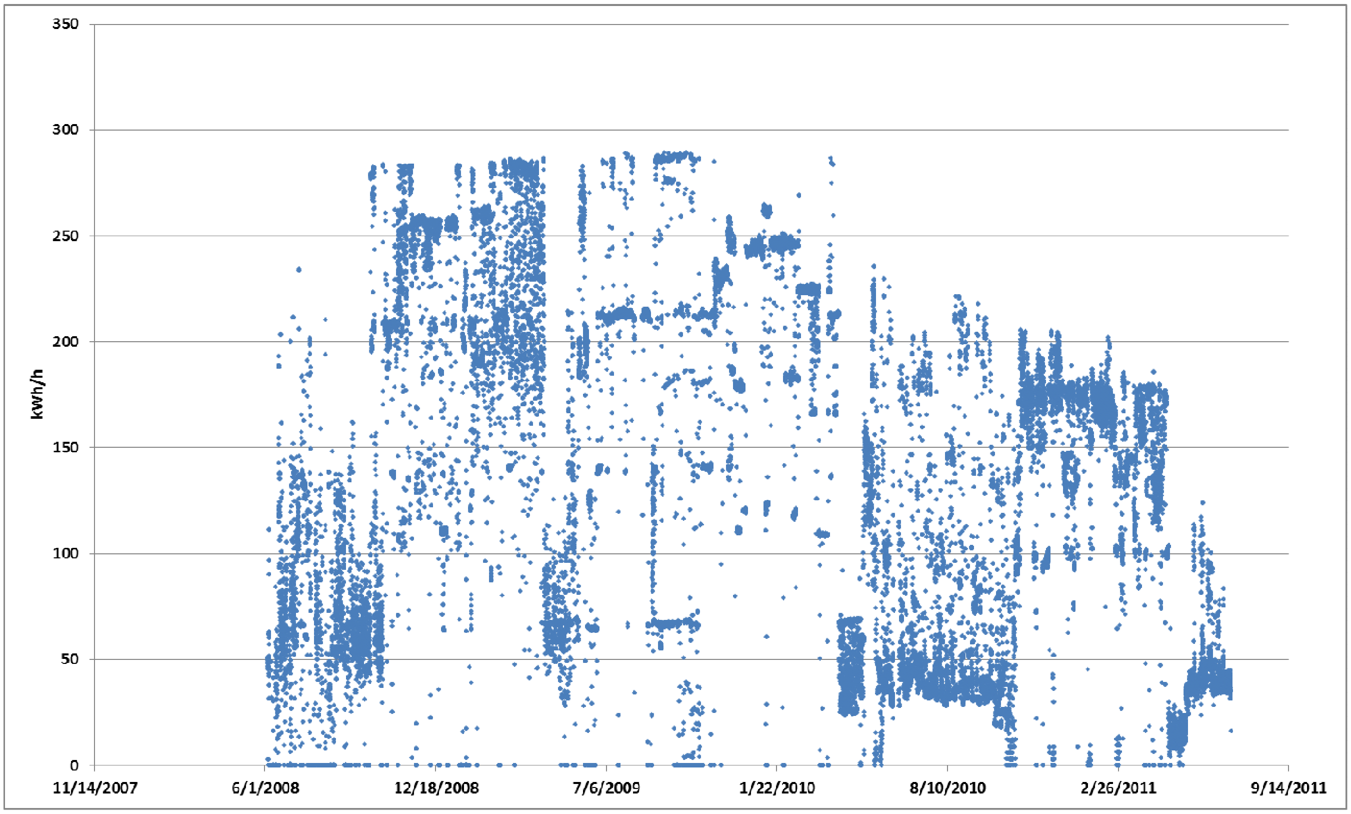

FIGURE 9 CHP POWER OUTPUT VERSUS TIME

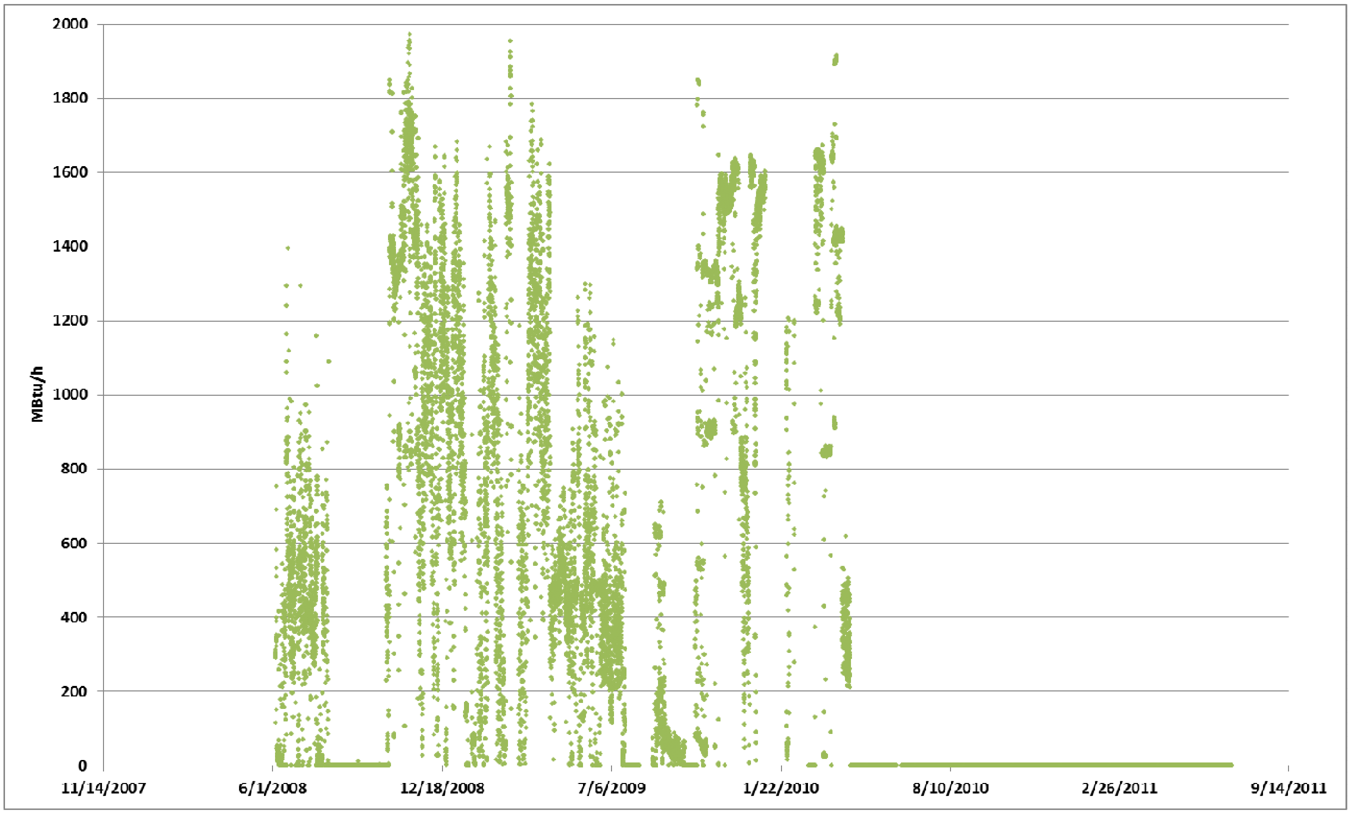

FIGURE 10 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Note that on the following weekly graphs, weekend days are highlighted as dashed lines to quickly distinguish their operating characteristics.

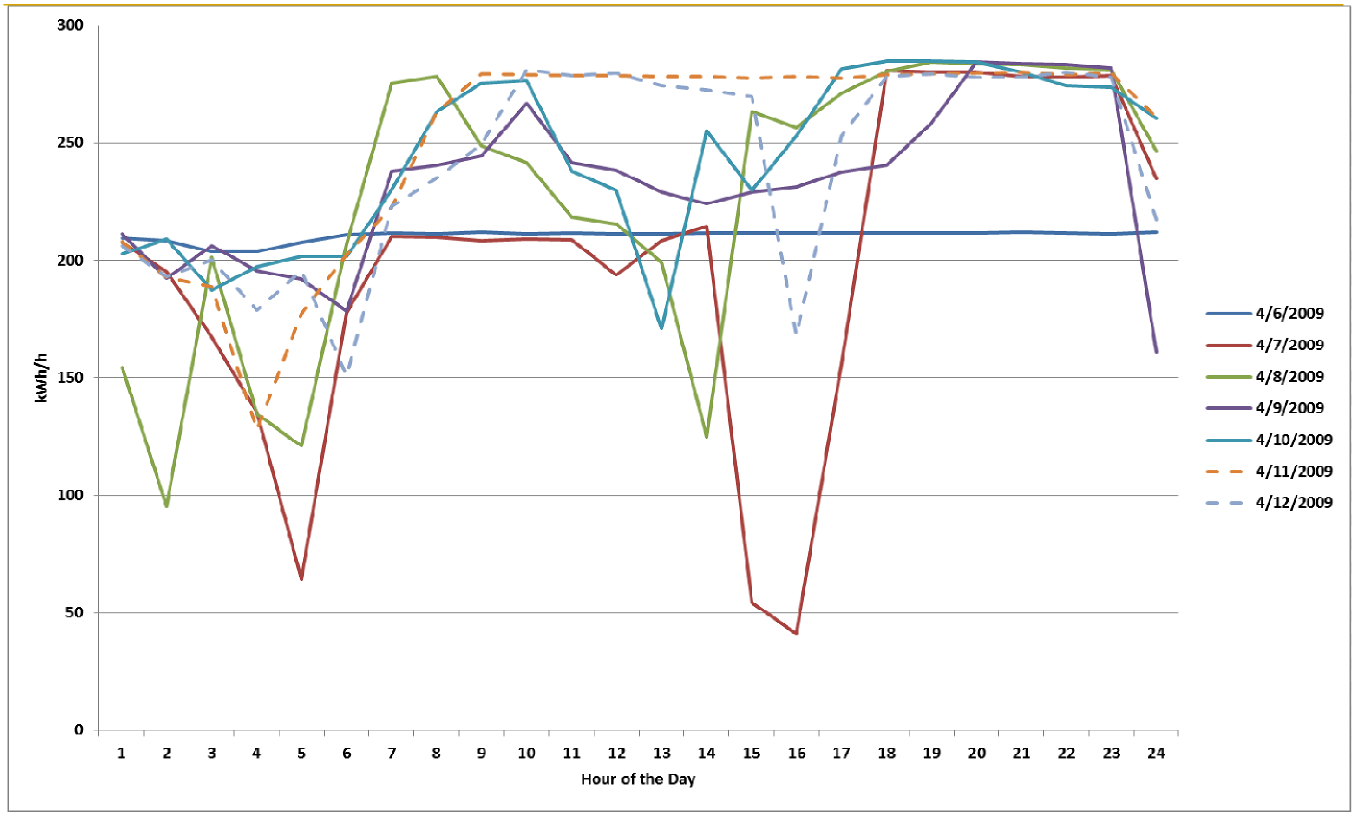

FIGURE 11 CHP POWER OUTPUT VERSUS TIME

Figure 11 covers the time period from April 6-12, 2009, providing CHP system power output by hour of the day pattern for the time period. April 11 is a Saturday.

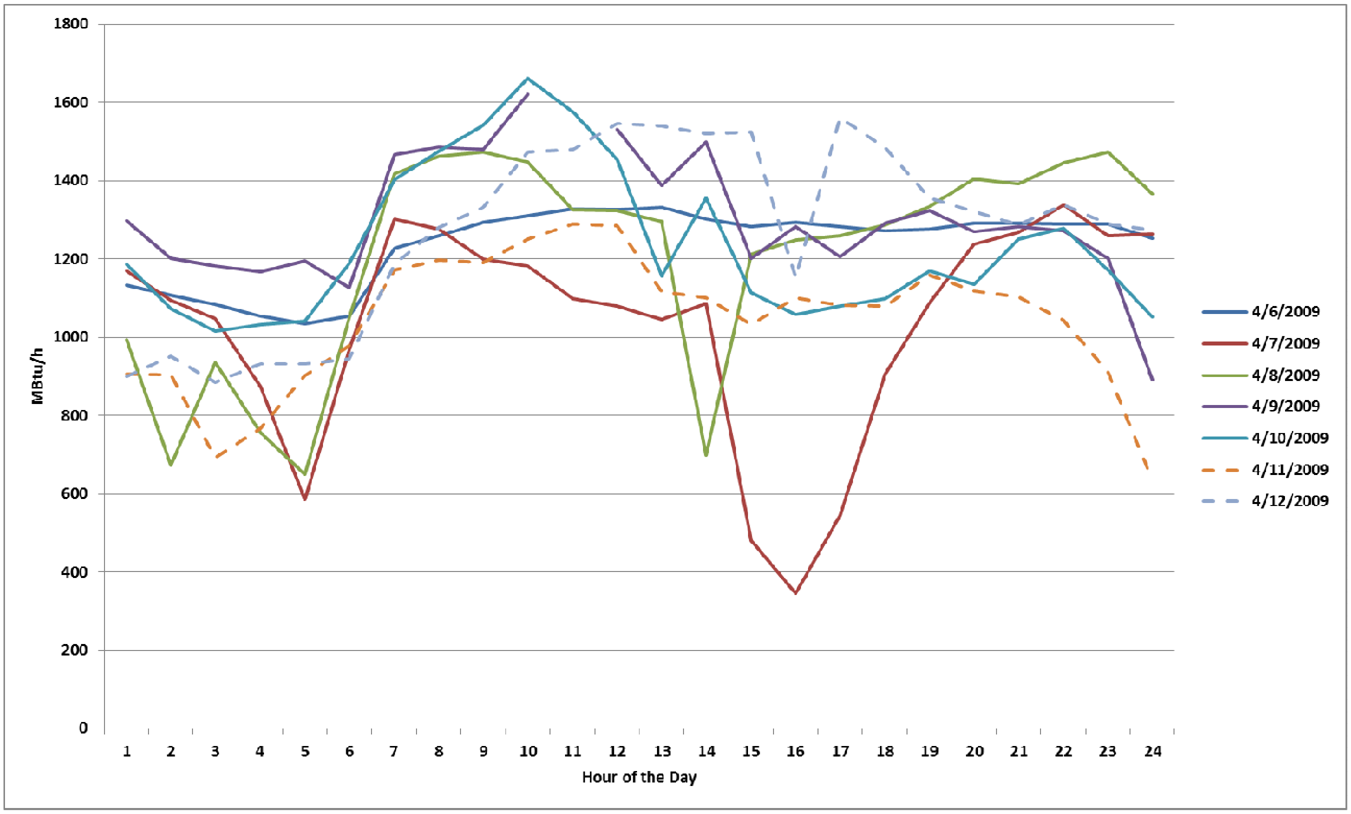

FIGURE 12 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 12 covers the time period from April 6-12, 2009, providing CHP system power output by hour of the day pattern for the time period. April 11 is a Saturday.

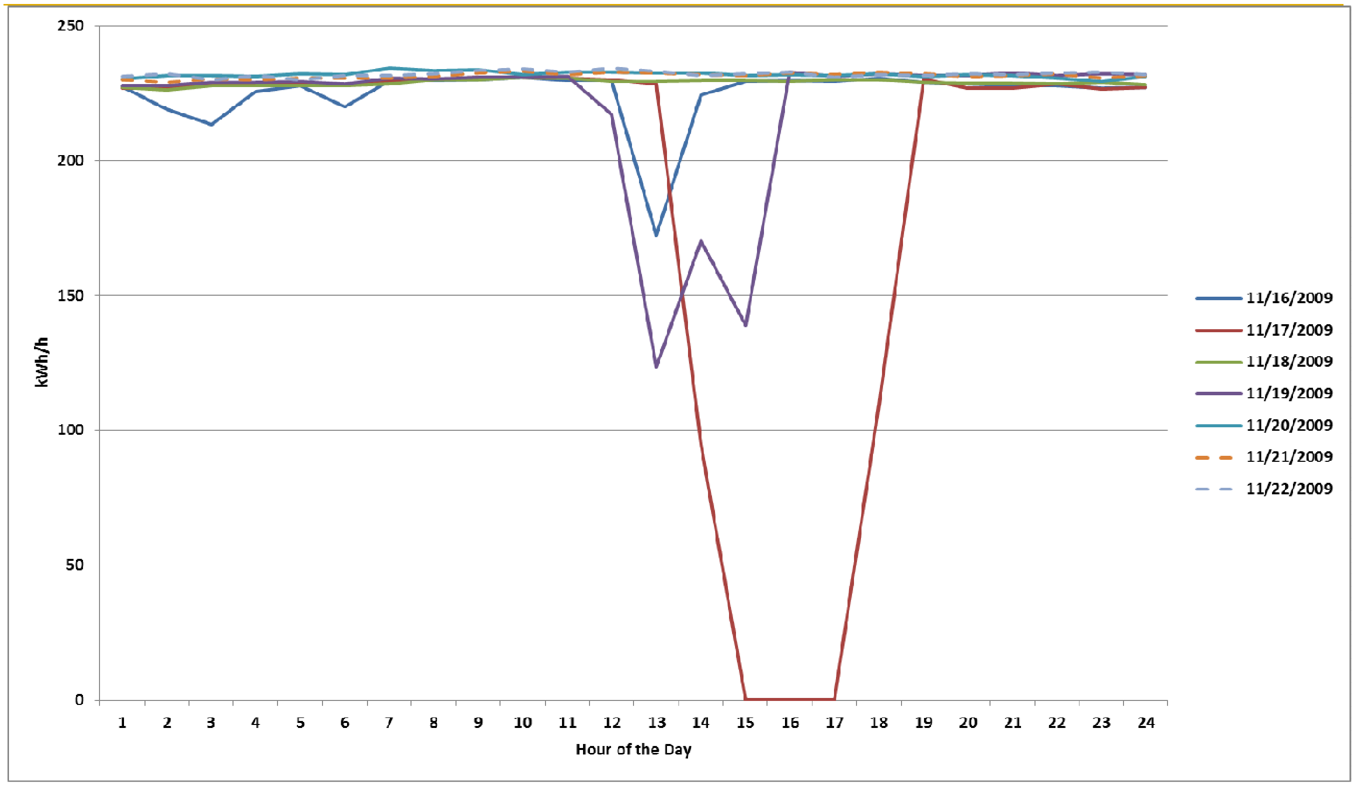

FIGURE 13 CHP POWER OUTPUT VERSUS TIME

Figure 13 covers the time period from November 16-22, 2009, providing CHP system power output by hour of the day pattern for the time period. November 21 is a Saturday.

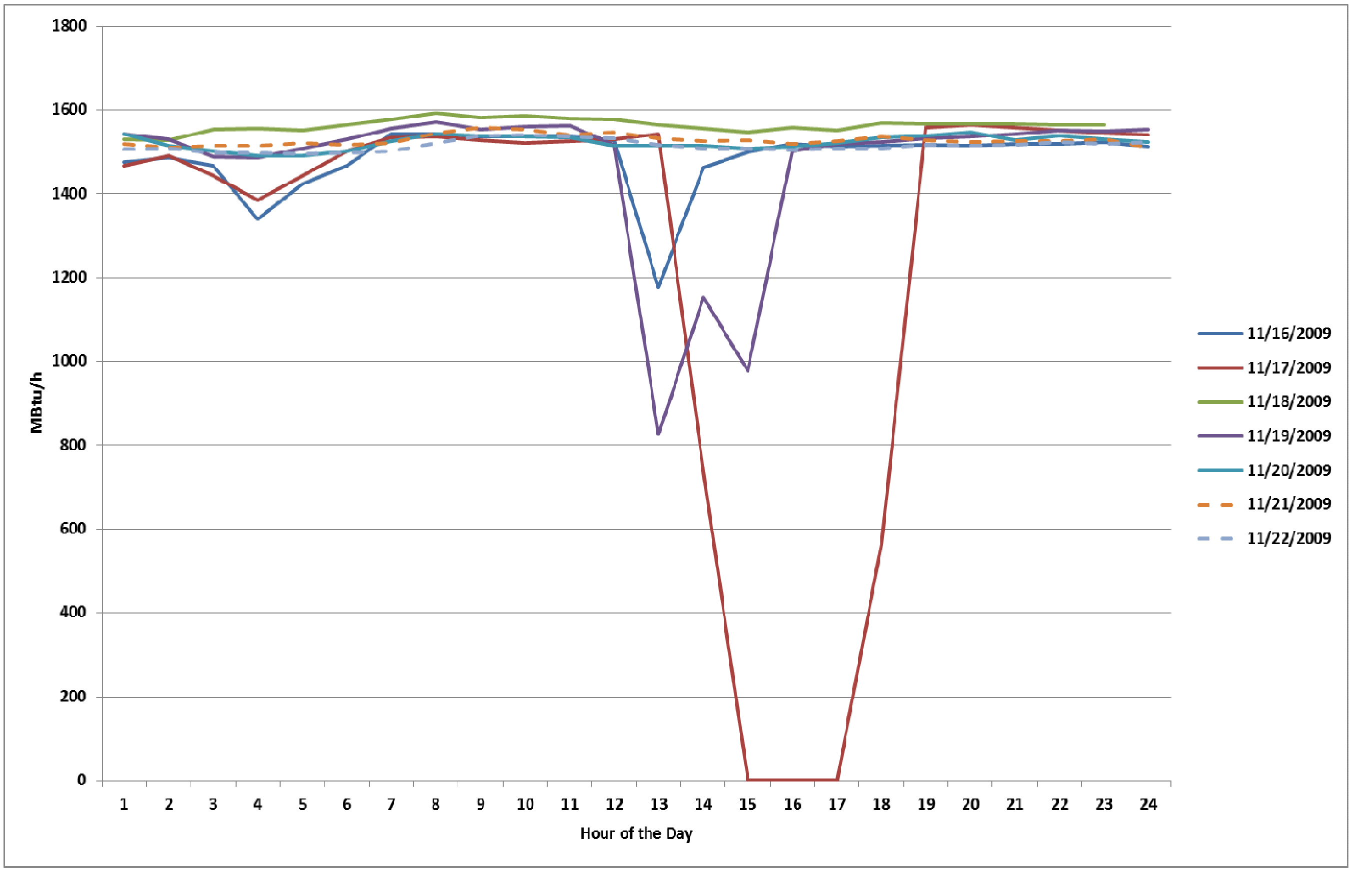

FIGURE 14 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 14 shows the 24 hour useful CHP recovered heat thermal load profiles from November 16-22, 2009. November 21 is a Saturday.

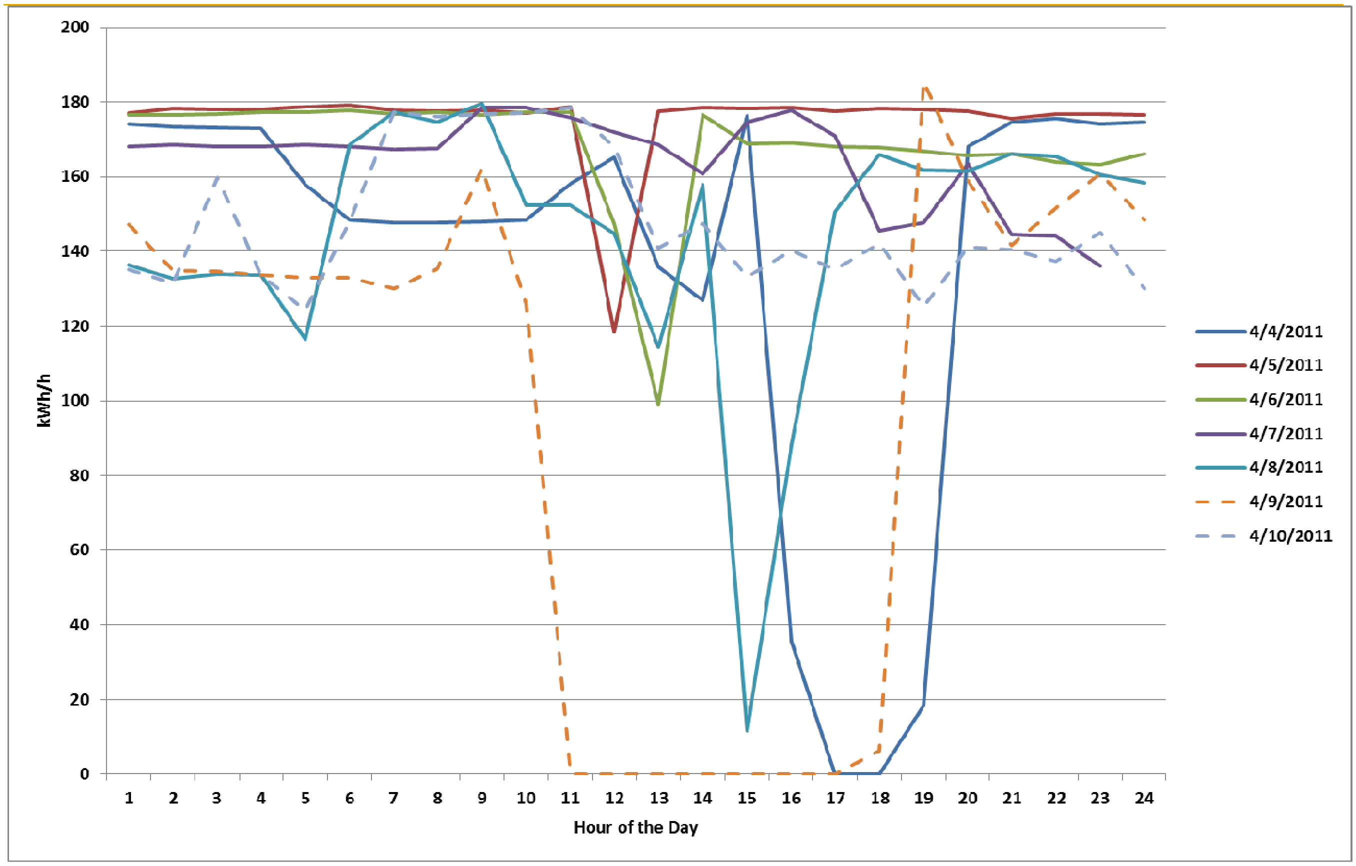

FIGURE 15 CHP POWER OUTPUT VERSUS TIME

Figure 15 covers the time period from April 4-10, 2011, providing CHP system power output by hour of the day pattern for the time period. April 9 is a Saturday.

No useful heat recovery was measured after April 15, 2010.

PERFORMANCE SUMMARY

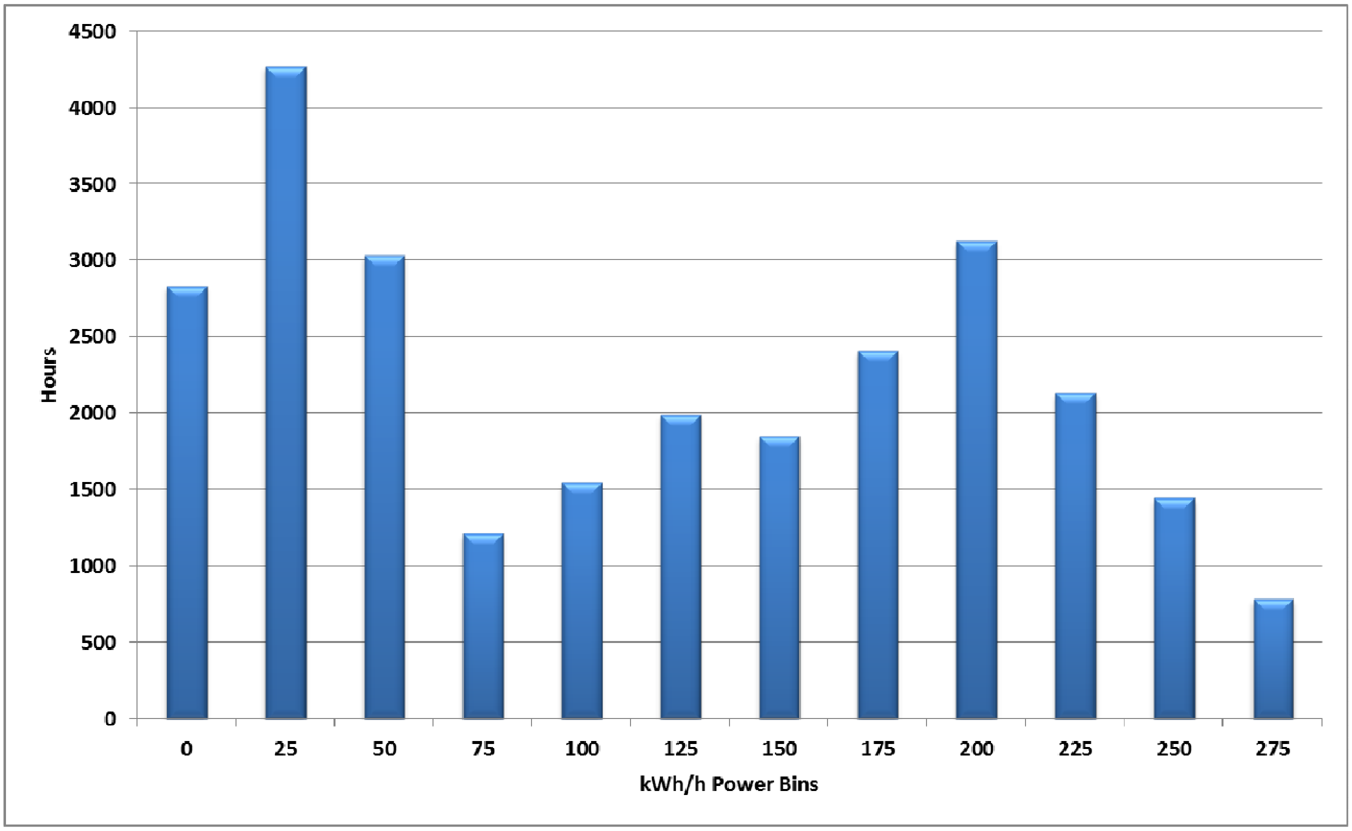

FIGURE 16 PERFORMANCE BY POWER BINS

During the 26,633 operating hours that met the range and relational checks only 28% of this time, the CHP system delivered over 175 kW/hr (Figure 16).

TABLE 2 SYSTEM EFFICIENCY[2]

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Four 75 kW Tecogen rich burn engine-generator sets were installed at the site to produce electricity and hot water. The generators provide about 70% of the site's electricity. Heat recovered from the engines offsets steam used for space heating and DHW production.

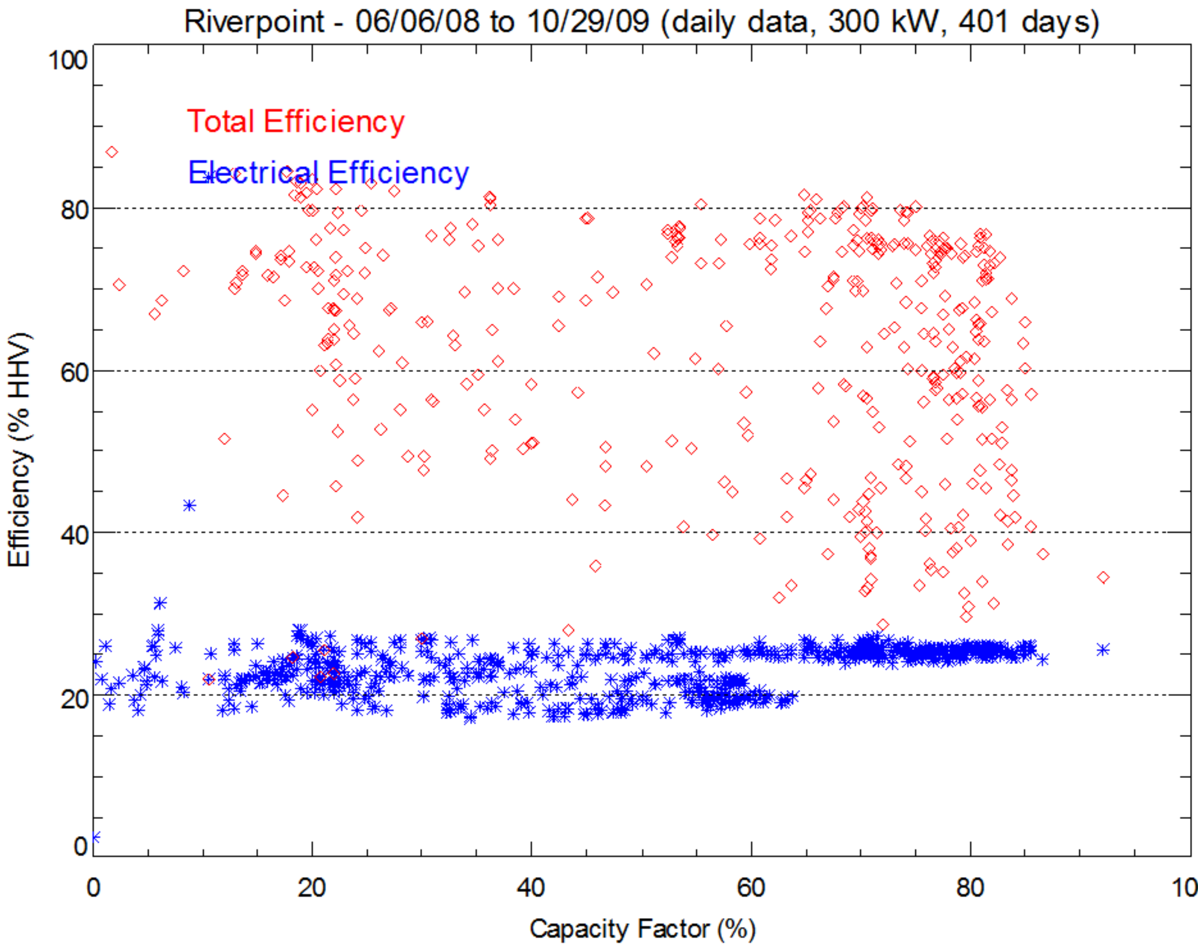

FIGURE 17 CAPACITY FACTOR[3]

Capacity Factor (**FIGURE 17**) presents the CHP generated power efficiency over the time period (854 days). This Figure provides a very good overview of the CHP power capacity versus site power requirements and a good understanding of the useful thermal energy recovered. The Figure shows the system generally operated between 1% and 85% of the generating capacity at about 26.40% power efficiency (HHV) during the Figure period and 23.1% power efficiency (HHV) during the last 12 months of Table 2. Note the efficiency scatter below 62% power efficiency (HHV) is largely due to cycling. The useful thermal energy (heating only) operated at high efficiency during the winter months (upper grouping) and lower during the summer months, averaging 24.56% thermal efficiency (HHV) during the Figure time period, and no thermal data was recorded after May 2010.

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[3] The data shown in the Capacity Factor graph passes all data quality checks and therefore, in some cases where data quality is poor, leaves out a significant amount of data points.

NYSERDA

This site had several issues and changes across the monitoring period. At some of the poor electrical efficiency observed during the period confirms the impact that cycling has on performance. At this site like other sites with reciprocating engines electrical efficiencies drop from the high 20s to the lows 20s when units reach the high temperature jacket water limit and cycle on and off.

This system did not originally have a dump radiator, but one was added part way through the monitoring period. Systems without dump radiators can operate properly, though they require predictable thermal loads.

APPENDIX A: KEY DATA MEASURES AND QUALITY

The three key parameters contributing to system energy efficiency were DG/CHP Generator Output, DG/CHP Generator Gas Use and Useful Heat Recovery (total MBtu). These parameters were measured at this site as follows:

1. **DG/CHP Generator Output (total kWh)** Three power transducers and seven current sensors are installed on-site to measure the net generator power. Two transducers measure the power output through two transformers to the main 208V building feed while the third measures a 480V panel containing parasitic and nonparasitic loads. One-time power measurements are used along with the statuses to calculate the parasitic loads. The non-parasitic power is calculated by taking the 480V power minus the calculated parasitic power. The non-parasitic power is then added to the power through the transformer to calculate the net generator output. This 15-minute data is then summed into hourly data for the online database.
2. **DG/CHP Generator Gas Use (total cubic feet)** Data for this point comes from a utility gas pulse output installed on the meter serving the engines. The 15-minute data is summed into hourly data for the online database.
3. **Useful Heat Recovery (total MBtu)** The Useful Heat Recovery is integrated from loop temperature and flow on a 5-second interval. The heat recovery is calculated by taking the temperature difference between the loop leaving the engines and before the dump radiator (in °F) and then multiplied by the total flow (in gallons) and the heating content factor for pure water (8.33 Btu-F-gal). The 15-minute heat recovery is summed for the hourly data.

Data collection and quality for this site ranges from 16% to 100%. (Table 3)

TABLE 3 SITE DATA QUALITY

	Percentage of Good Data		
	Power	Gas Use	Useful Heat
January-09	100.0%	99.9%	76.7%
February-09	100.0%	100.0%	85.7%
March-09	100.0%	100.0%	56.6%
April-09	100.0%	100.0%	97.9%
May-09	100.0%	99.9%	98.9%
June-09	100.0%	99.3%	99.7%
July-09	100.0%	100.0%	67.1%
August-09	68.1%	48.1%	16.0%
September-09	100.0%	24.3%	41.8%
October-09	100.0%	99.6%	60.5%
November-09	100.0%	99.9%	100.0%
December-09	100.0%	100.0%	92.5%
January-10	100.0%	100.0%	21.9%
February-10	100.0%	100.0%	20.4%
March-10	100.0%	99.7%	99.3%
April-10	100.0%	100.0%	100.0%
May-10	100.0%	96.2%	100.0%
June-10	78.8%	51.1%	78.8%
July-10	100.0%	44.2%	100.0%
August-10	100.0%	54.4%	100.0%
September-10	100.0%	61.7%	100.0%

October-10	100.0%	89.7%	100.0%
November-10	100.0%	100.0%	100.0%
December-10	100.0%	100.0%	100.0%
January-11	100.0%	100.0%	100.0%
February-11	100.0%	100.0%	100.0%
March-11	100.0%	100.0%	100.0%
April-11	100.0%	97.2%	100.0%
May-11	100.0%	70.0%	100.0%
June-11	100.0%	30.1%	100.0%
July-11	100.0%	8.5%	100.0%