NYSERDA CHP Assessment Report

ASSESSING THE CHP PLANT AT THE NYC MARRIOTT DOWNTOWN

October 9, 2013

NYC Marriott Downtown

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.

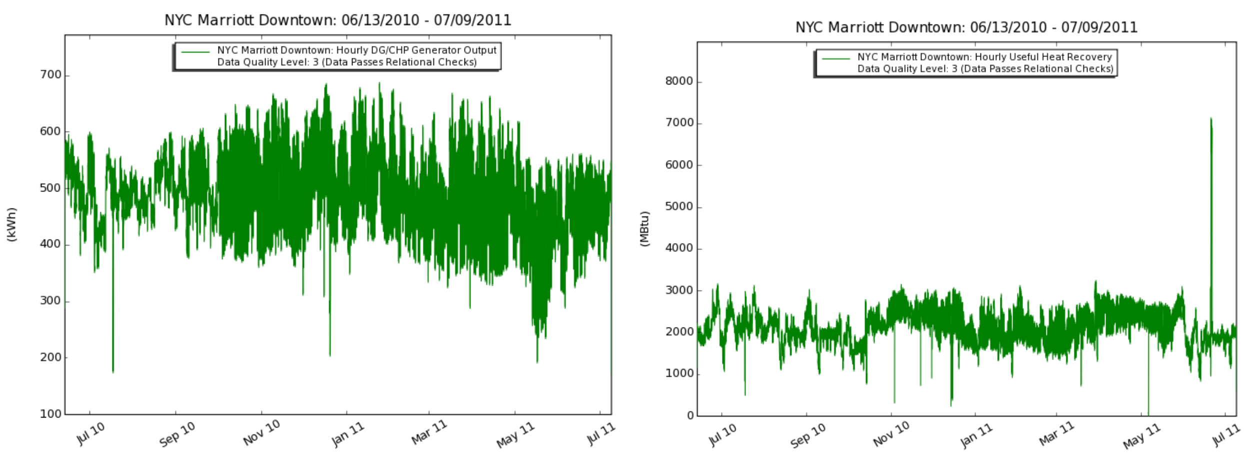

FIGURE 1 NYSERDA CHP WEBSITE PERFORMANCE GRAPHS

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 MARRIOTT HOTEL CENTRALLY LOCATED IN LOWER MANHATTAN

This is the only Marriott Hotel centrally located in Lower Manhattan, New York City's Financial District, within walking distance to Wall Street and the NYSE. This Lower Manhattan hotel features 497 newly renovated guest rooms, including 7 suites.

THE SYSTEM

The Carrier PureComfort CHP system installed at the New York Marriott Downtown consists of two Carrier PureComfort systems that utilize several Capstone 60 Microturbines and a Carrier exhaust fired absorption chiller on each system.

1. The first CHP system (System "A") uses five (5) 60 kW microturbines to produce up to 239 kWnet of electrical output and 149-tons of chilled water output.
2. The second system (System "B") uses six (6) 60 kW microturbines to produce up to 285 kWnet of electrical output and 173-tons of chilled water output.

Both chillers have the capability to act as heat exchangers during the heating season to provide 1,381 MBtu/h (System A) and 1,660 MBtu/h (System B) of hot water.

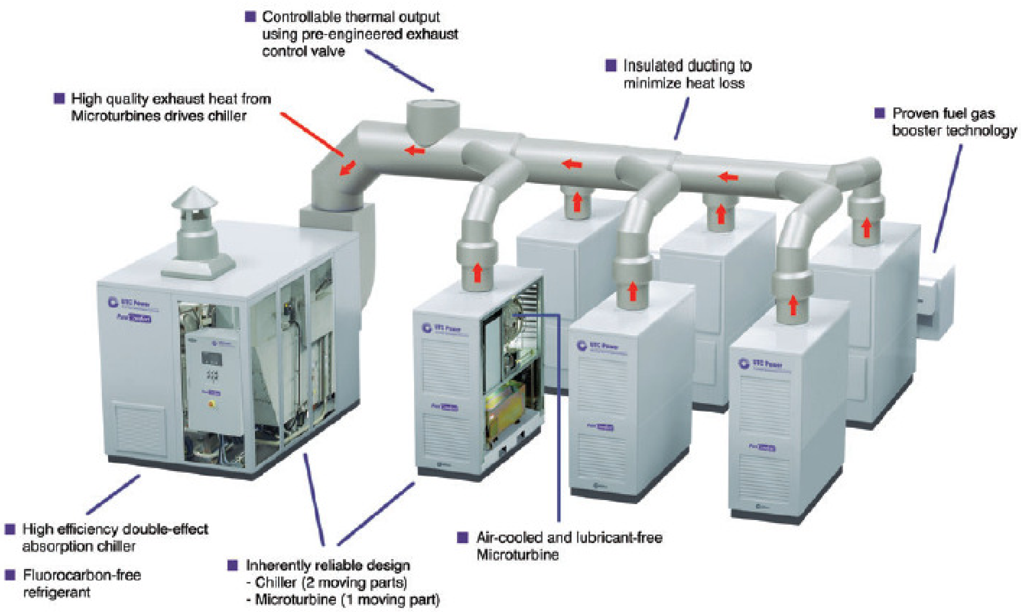

FIGURE 3 TYPICAL PURECOMFORT SYSTEM CONFIGURATION

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 June, 2010.

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
June-10	419	213,937	4,817.1	907.5	14.9%	18.5%	33.3%
July-10	731	351,287	4,583.2	1,635.8	25.6%	35.0%	60.6%
August-10	737	370,921	4,669.4	1,474.3	26.6%	31.0%	57.5%
September-10	717	367,113	4,569.3	1,409.6	26.9%	30.2%	57.1%
October-10	739	395,780	4,861.5	1,472.6	27.2%	29.7%	56.9%
November-10	709	375,918	4,515.4	1,755.1	27.9%	38.1%	66.0%
December-10	734	398,111	4,599.8	1,696.0	29.0%	36.1%	65.1%
January-11	741	402,197	4,568.3	1,531.8	29.5%	32.9%	62.3%
February-11	667	335,356	3,860.7	1,403.5	29.1%	35.6%	64.7%
March-11	741	376,197	4,353.5	1,634.9	28.9%	36.8%	65.7%
April-11	718	361,306	4,391.9	1,801.3	27.5%	40.2%	67.7%
May-11	742	333,967	4,306.3	1,735.0	26.0%	39.5%	65.4%
June-11	715	339,229	4,438.8	1,385.2	25.6%	30.6%	56.2%
July-11	740	358,422	4,749.1	1,546.6	25.3%	31.9%	57.2%
August-11	670	342,413	4,331.2	1,291.2	26.5%	29.2%	55.7%
Total	**8633**	**4,386,009**	**53,545.8**	**18,662.8**	**27.4%**	**34.2%**	**61.6%**

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

OPERATING SUMMARY

The CHP system consists of 524 kW of microturbine nameplate net capacity and 3,864 MBtu/hr cooling capacity (assuming a 1.2 COP this equals 3,220 MBtu useful heat input) or 3,941 MBtu heating capacity. During the 10,520 hours that met the range and relational checks 78.7% of this time, the CHP system delivered greater than 280 kWh/h (Figure 14).

[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.

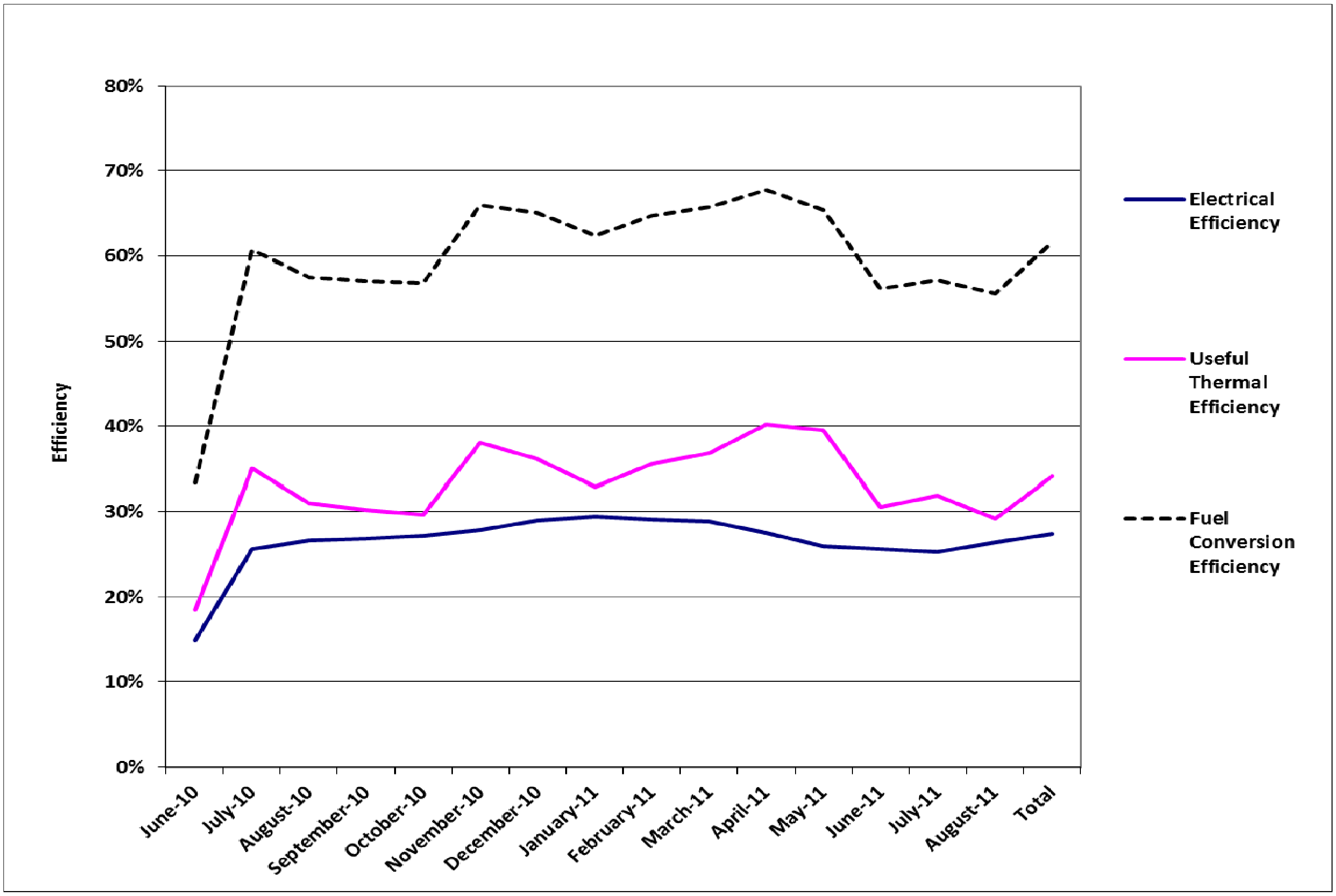

FIGURE 4 2010 CHP SYSTEM EFFICIENCY BY MONTH

Figure 4 provides operating efficiency during 2010 showing declining electric and useful thermal efficiency performance.

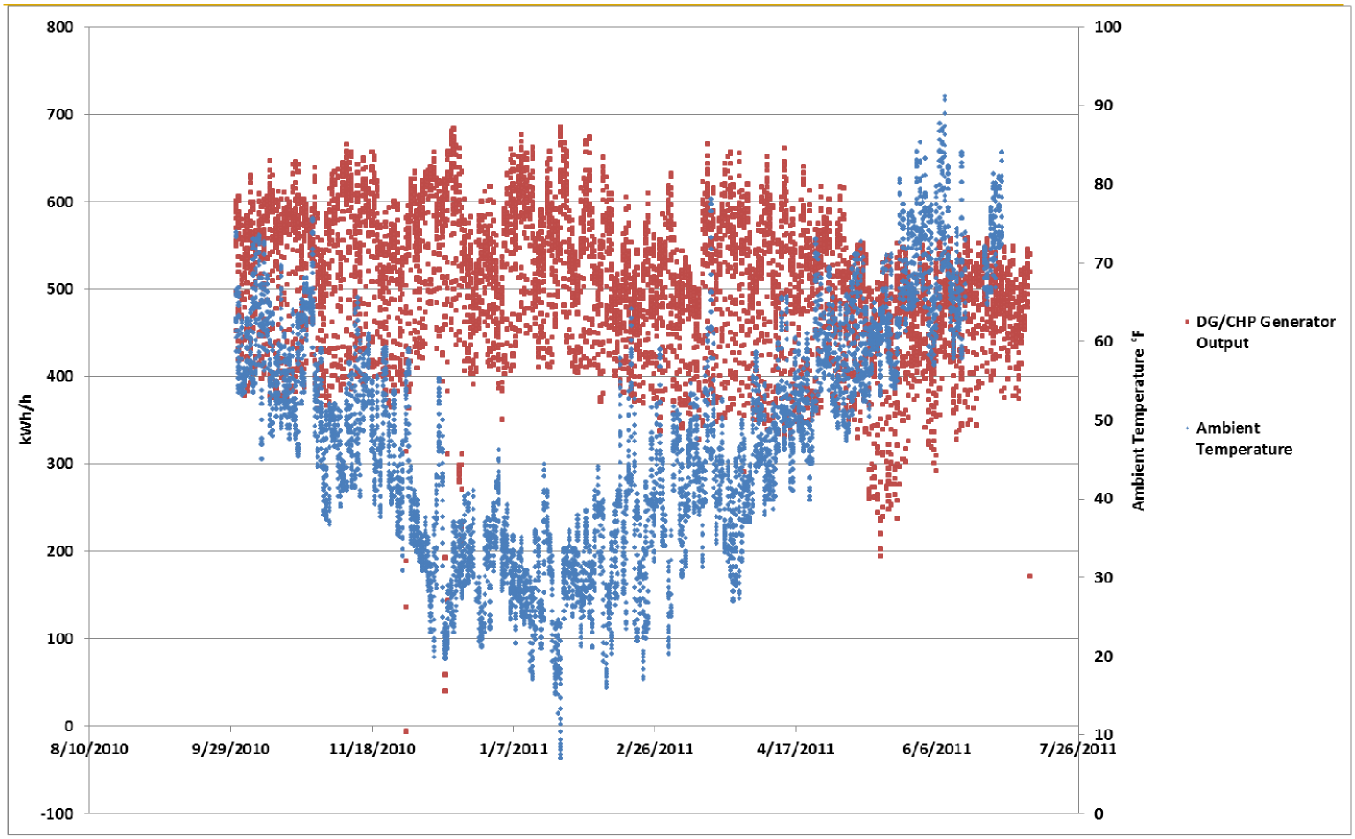

FIGURE 5 CHP POWER VERSUS AMBIENT TEMPERATURE BY MONTH

Figure 5 shows consistent microturbine performance versus ambient temperatures below 75°F.

POWER GENERATION AND USEFUL THERMAL ENERGY

Figures 5-7 provide insight into the CHP system power performance and Table 2 provides the CHP system power performance explanation with respect to Figure 6.

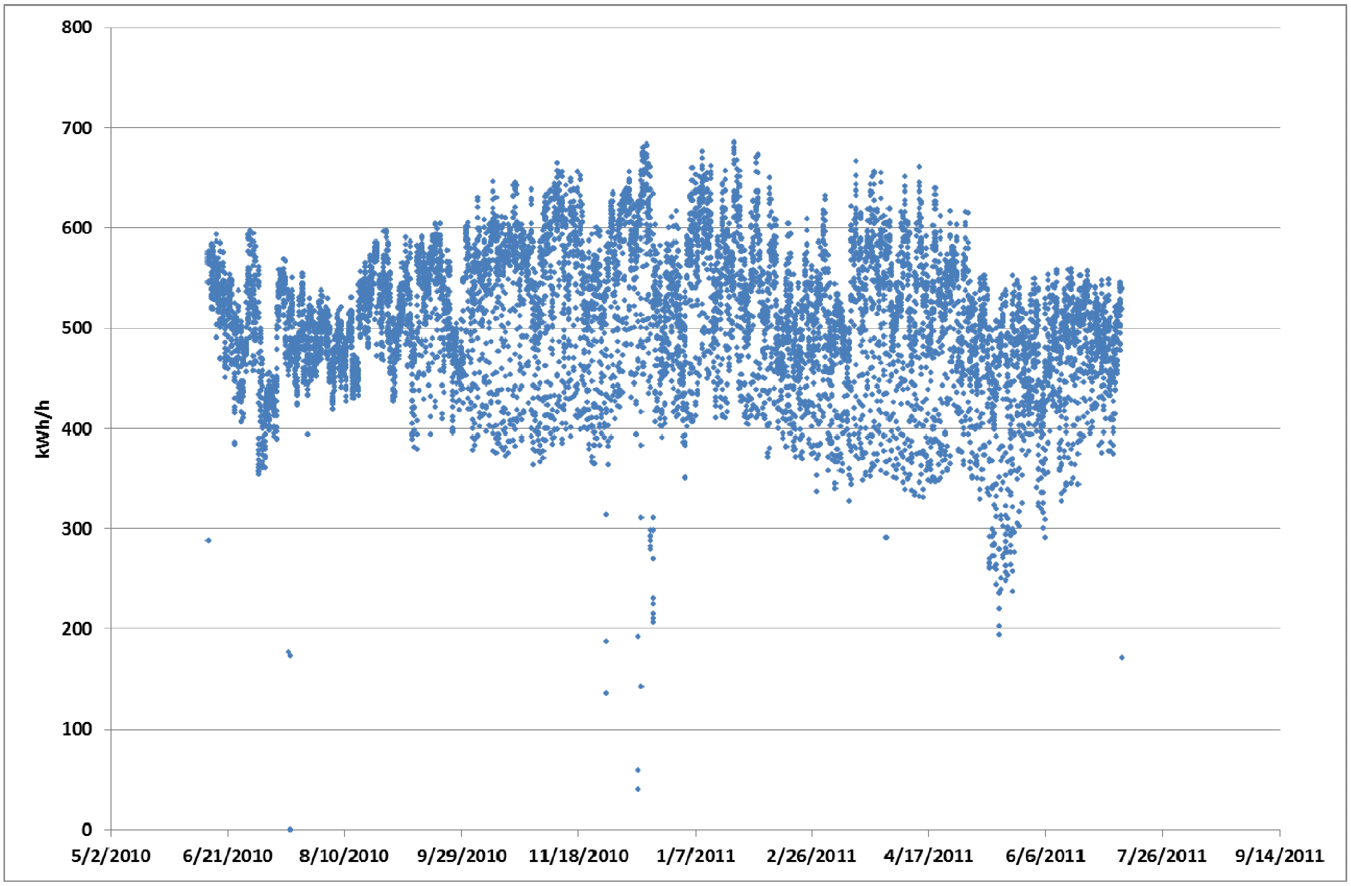

FIGURE 6 CHP POWER OUTPUT VERSUS TIME

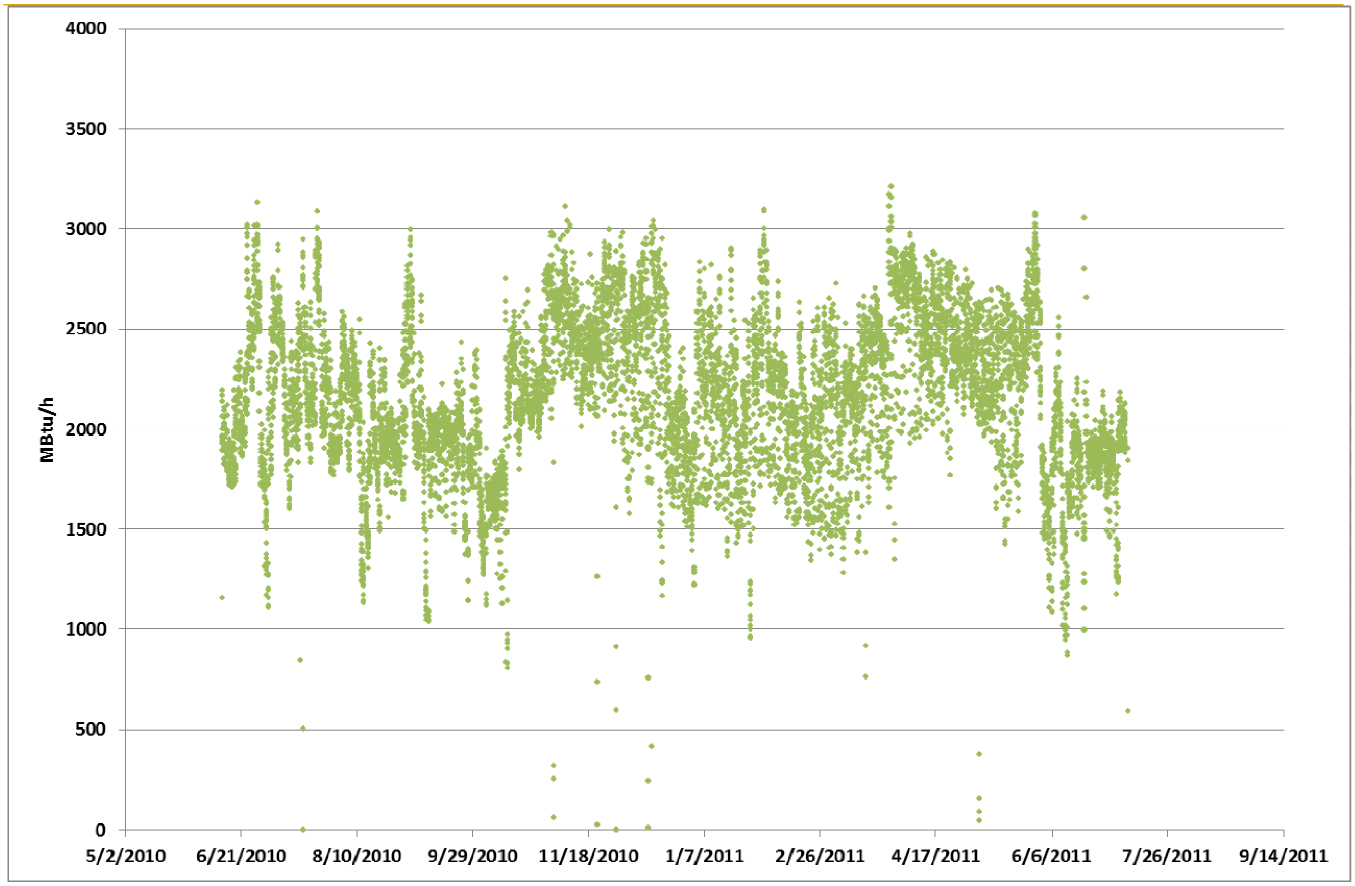

FIGURE 7 CHP USEFUL THERMAL OUTPUT VERSUS TIME (MBTU/HR)

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

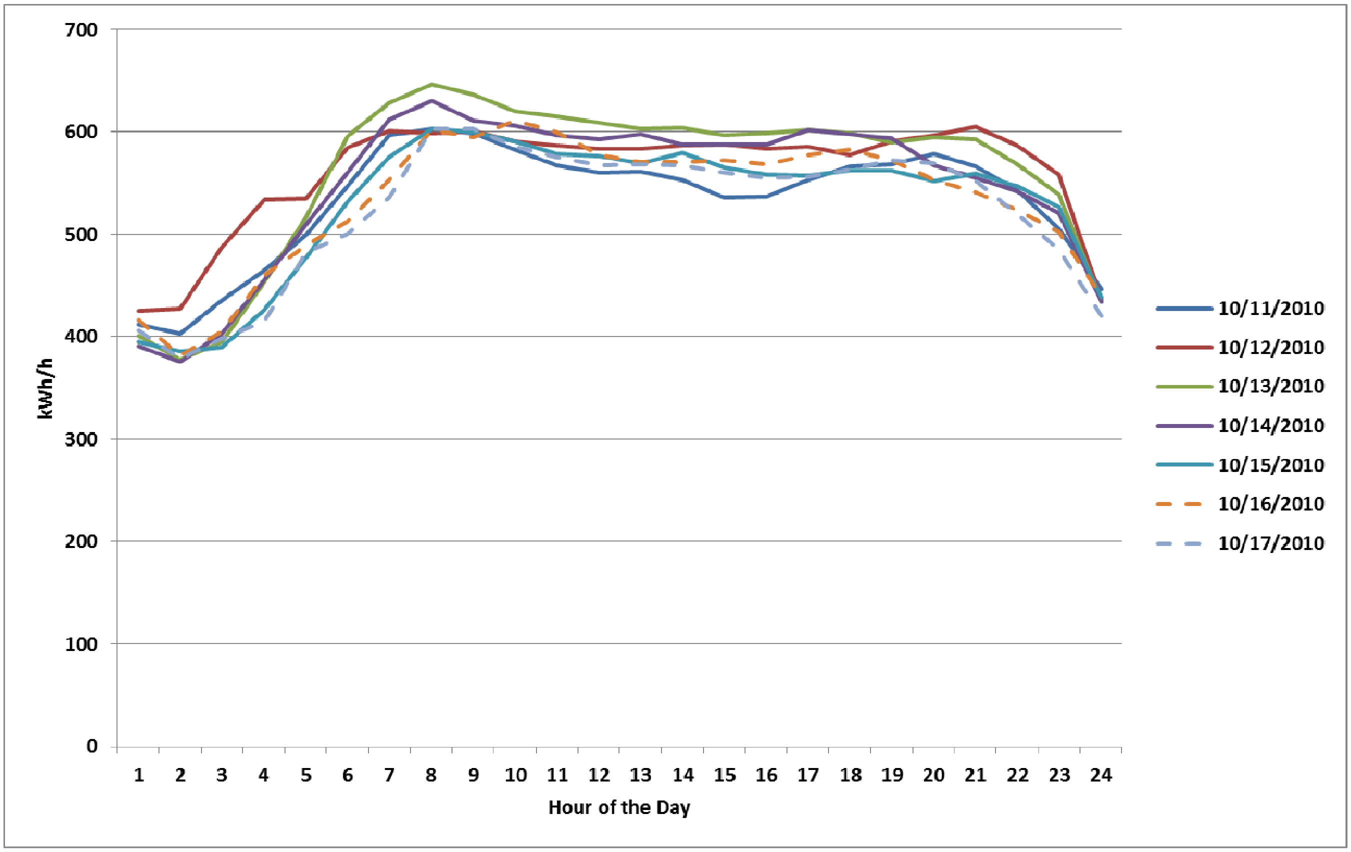

FIGURE 8 CHP POWER OUTPUT VERSUS TIME

Figure 8 covers the time period from October 11 – 17, 2010 providing CHP system power output by hour of the day pattern for the time period. October 16 is a Saturday. Figure 8 shows that all days have similar load profiles, implying the system follows the facility electric load.

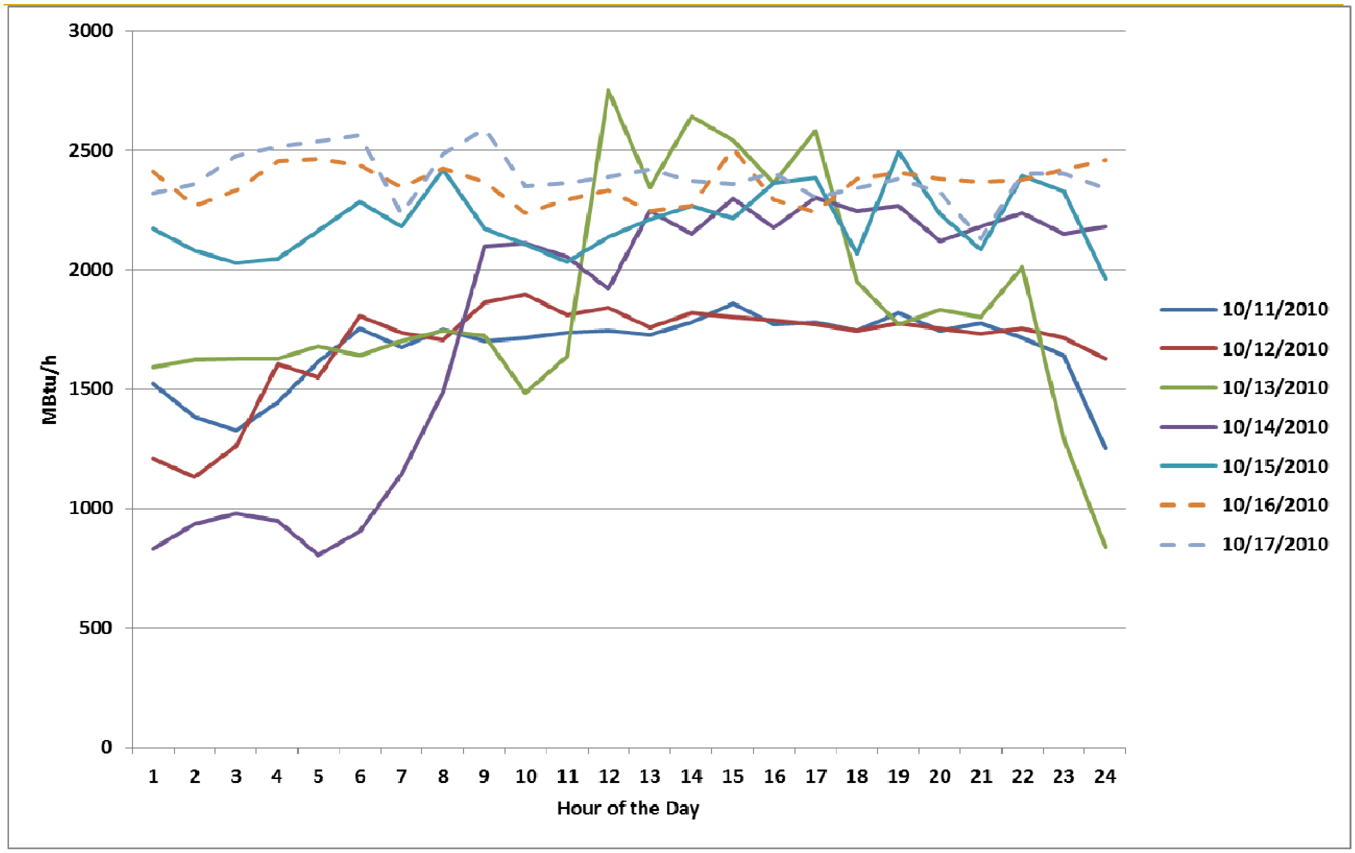

FIGURE 9 CHP USEFUL THERMAL OUTPUT VERSUS TIME

The 24 hour useful CHP recovered heat thermal load profiles from October 11 – 17, 2010 (Figure 9) show a very consistent thermal load pattern. October 16 is a Saturday. The thermal load profile does not follow the power curve in Figure 8.

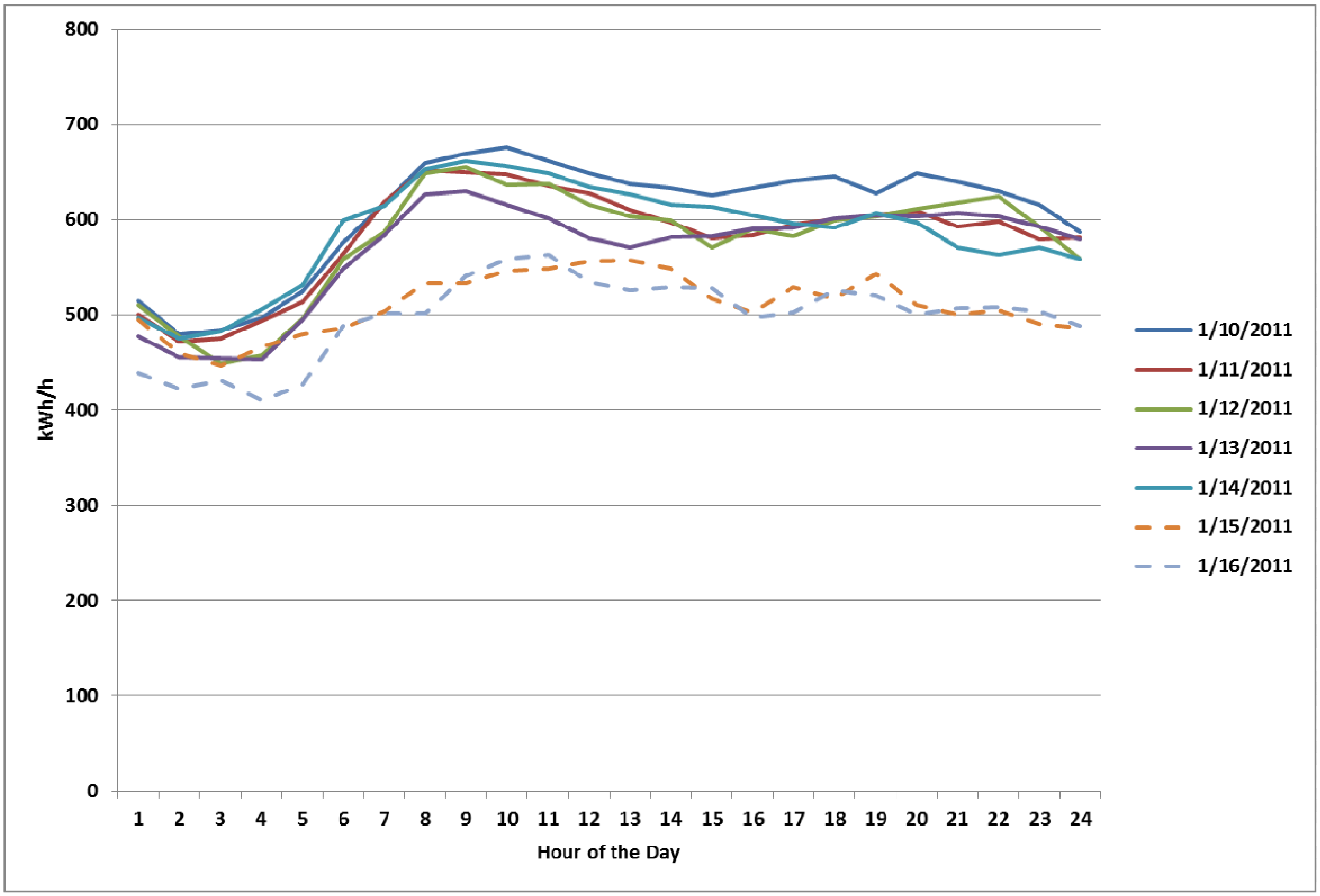

FIGURE 10 CHP POWER OUTPUT VERSUS TIME

Figure 10 covers the time period from January 10 – 16, 2011 providing CHP system power output by hour of the day pattern for the time period. January 15 is a Saturday. Figure 10 shows that all days have a power loading profile that was consistent day-to-day with slightly lower loading on the weekend.

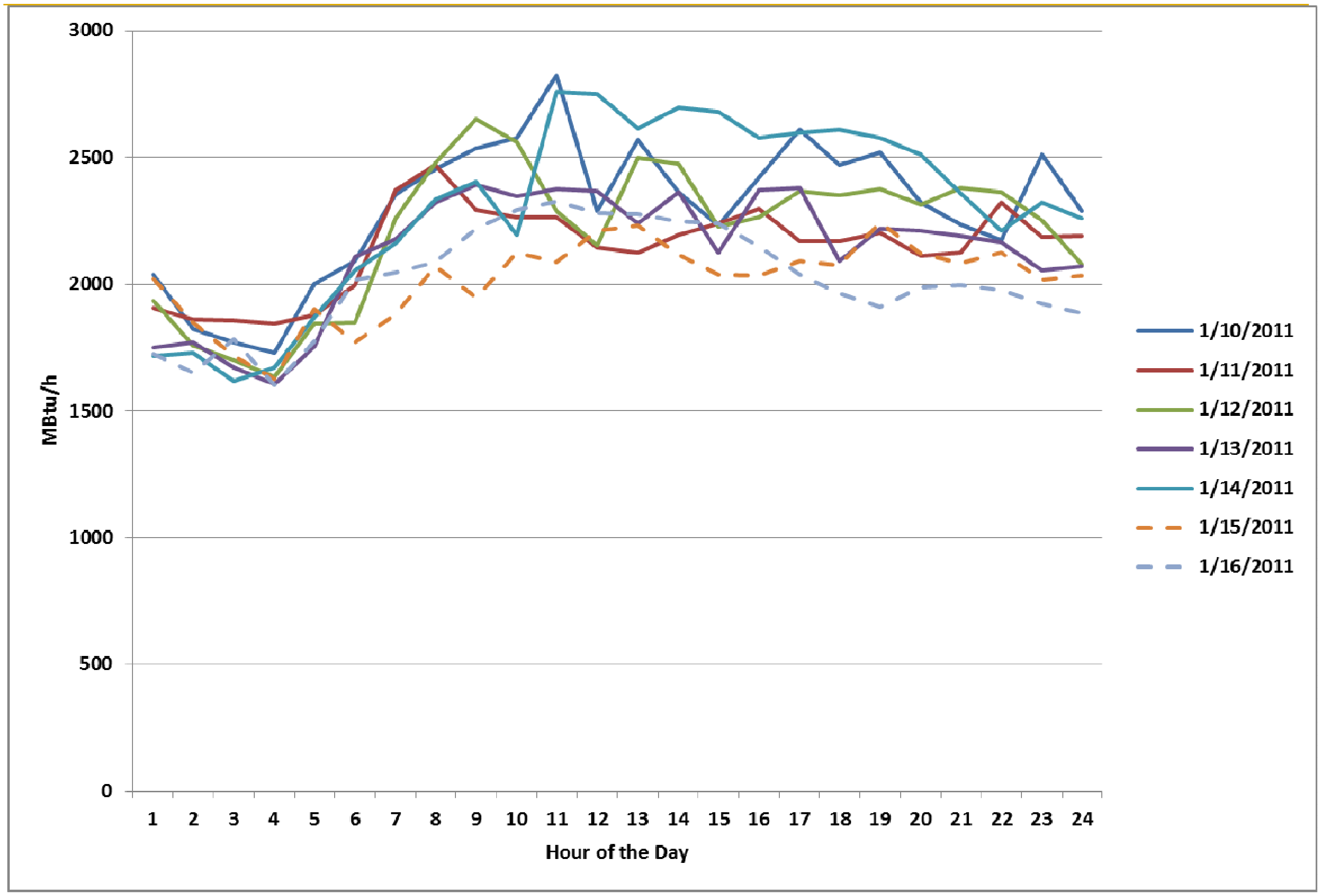

FIGURE 11 SELECTED DAY CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 11 shows the 24 hour useful CHP recovered heat thermal load profiles from January 10 – 16, 2011 (Figure 11). The thermal load profile follows the power curve in Figure 10. January 15 is a Saturday.

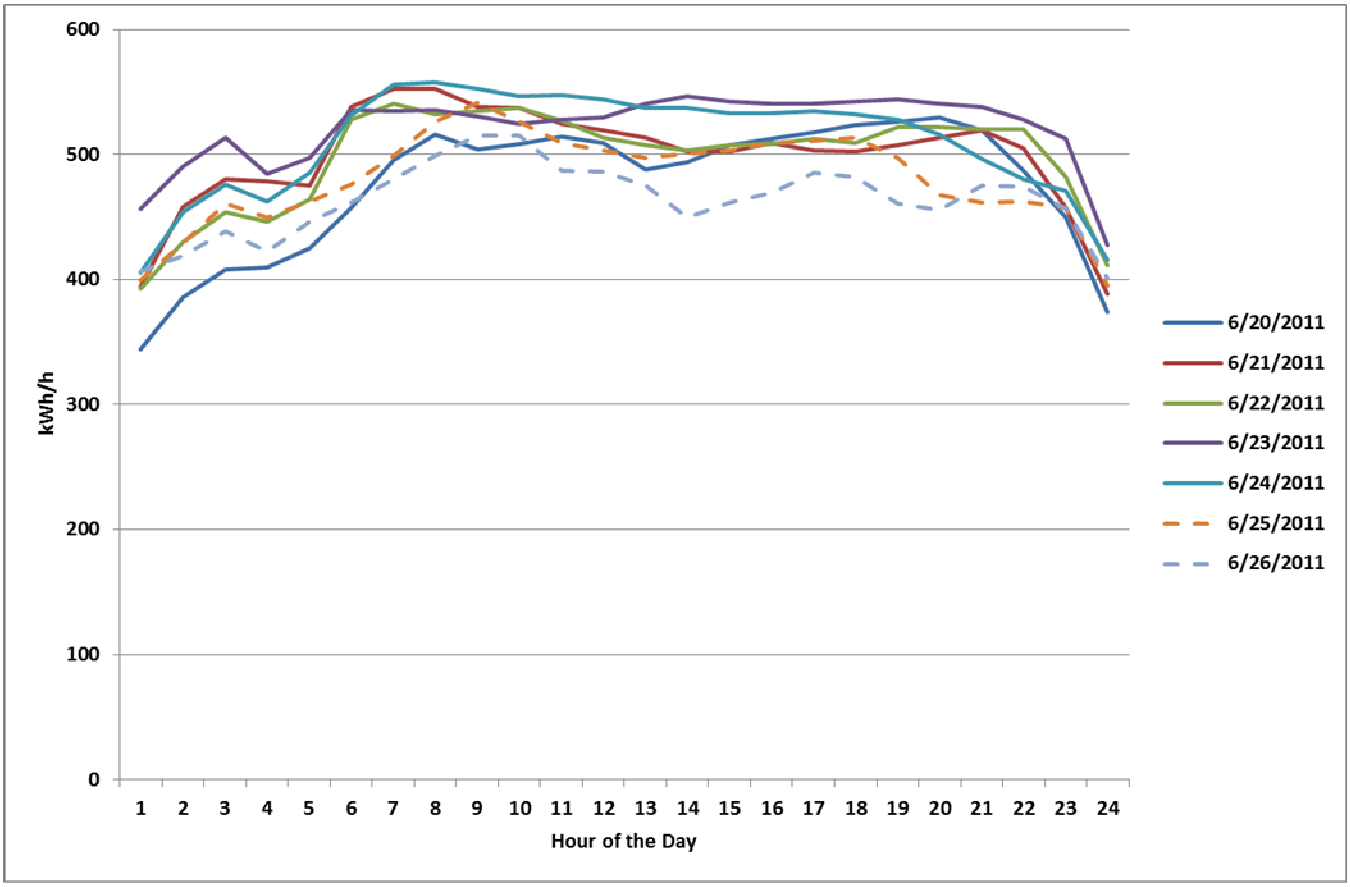

FIGURE 12 CHP POWER OUTPUT VERSUS TIME

Figure 12 covers the time period from June 20 - 26, 2011 providing CHP system power output by hour of the day pattern for the time period. June 25 is a Saturday. Figure 12 shows that all days have a power loading profile that was consistent day-to-day.

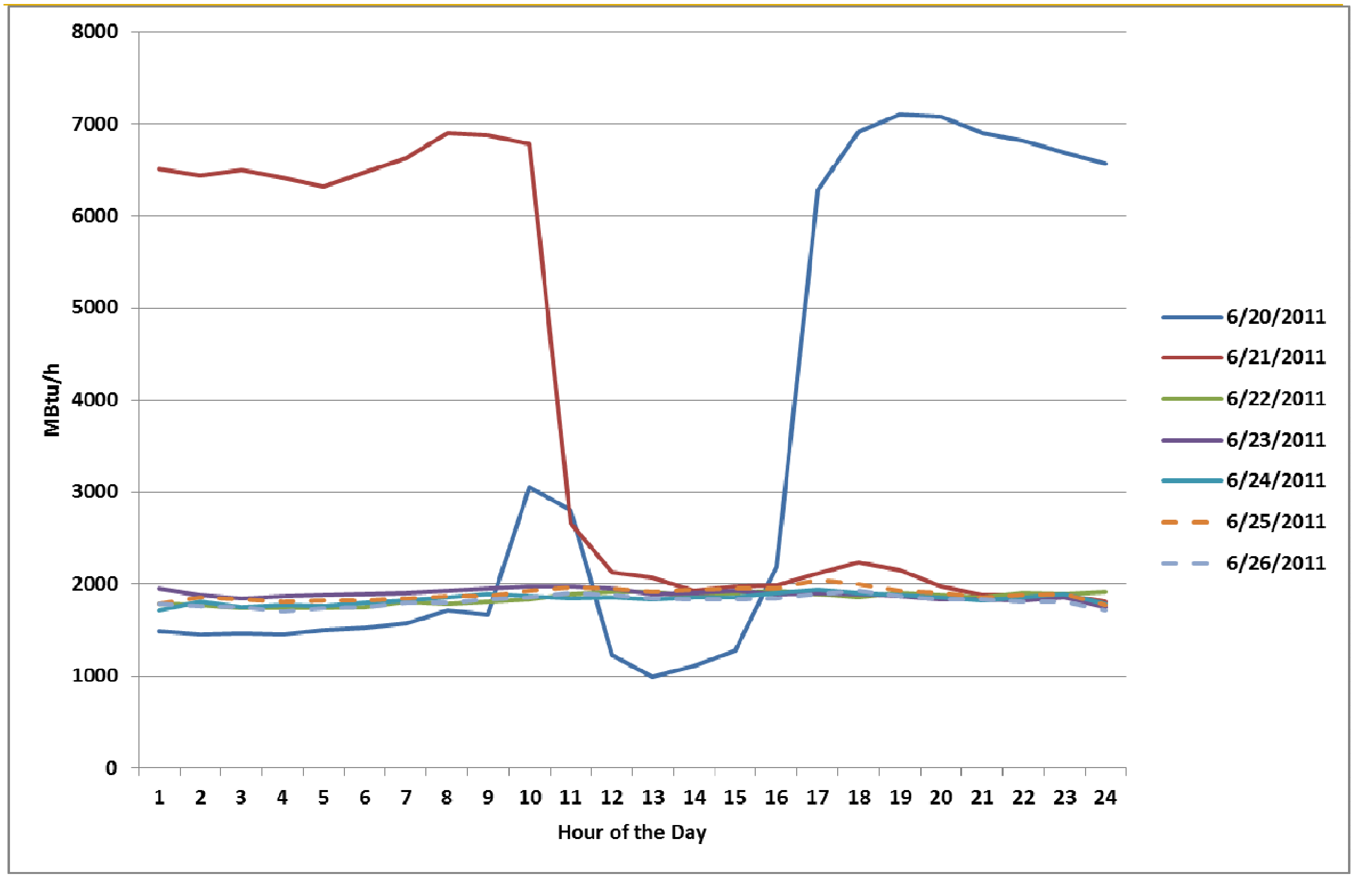

FIGURE 13 SELECTED DAY CHP USEFUL THERMAL OUTPUT VERSUS TIME

The 24 hour useful CHP recovered heat thermal load profiles from June 20 - 26, 2011 (Figure 13). The thermal load profile follows the power curve in Figure 12. June 25 is a Saturday. Thermal energy profile for June 20 and 21 show extremely high useful thermal energy with a thermal/ electric "T/E" ratio of 3.5 versus the expected 0.8 to 1.5 This indicated an out of range data set.

PERFORMANCE SUMMARY

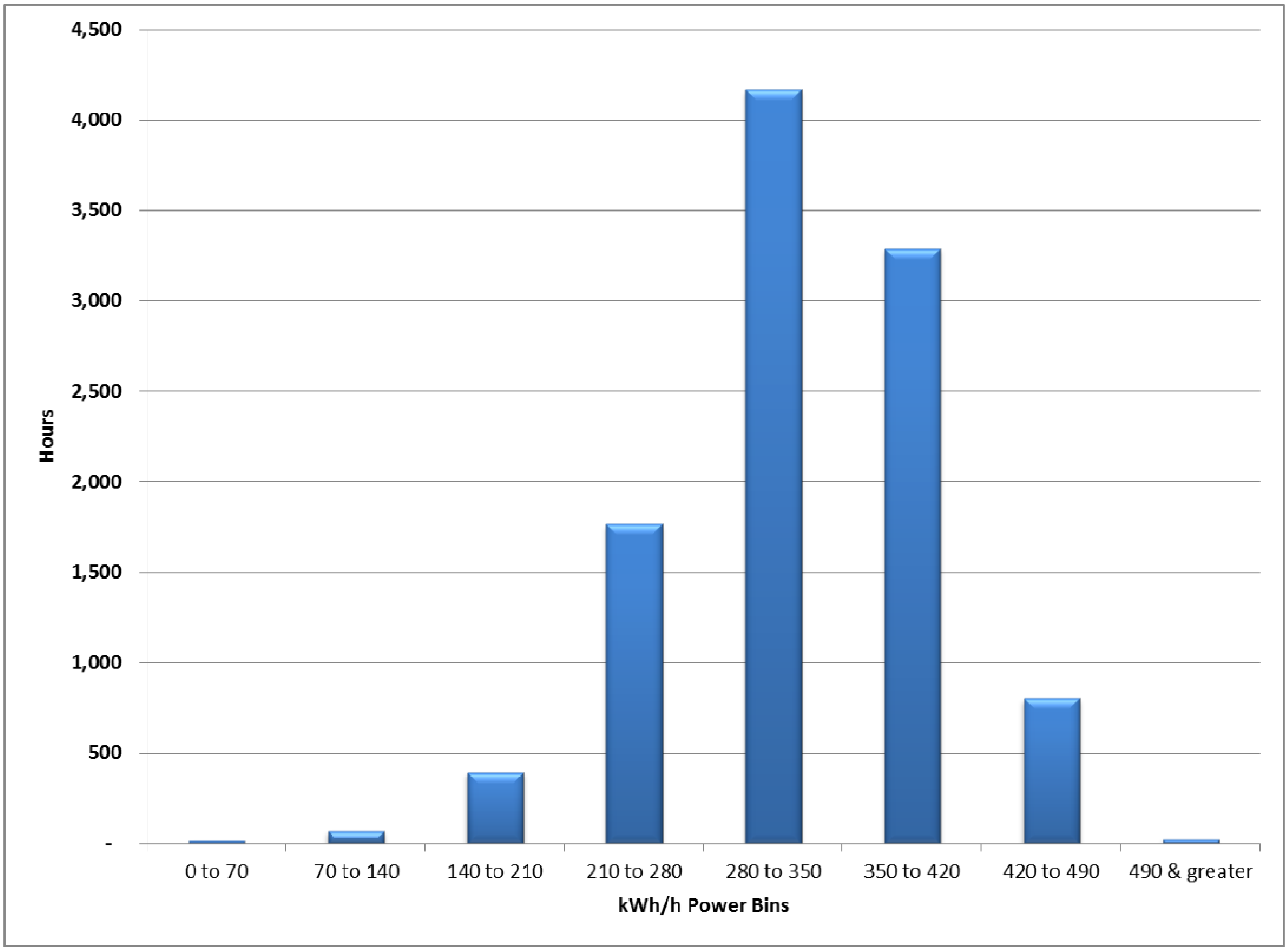

FIGURE 14 OPERATING HOURS BY POWER BINS

During the 10,520 hours that met the range and relational checks 78.7% of this time, the CHP system delivered greater than 280 kWh/h (Figure 14).

LESSONS LEARNED

TABLE 2 SYSTEM EFFICIENCY[2]

	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
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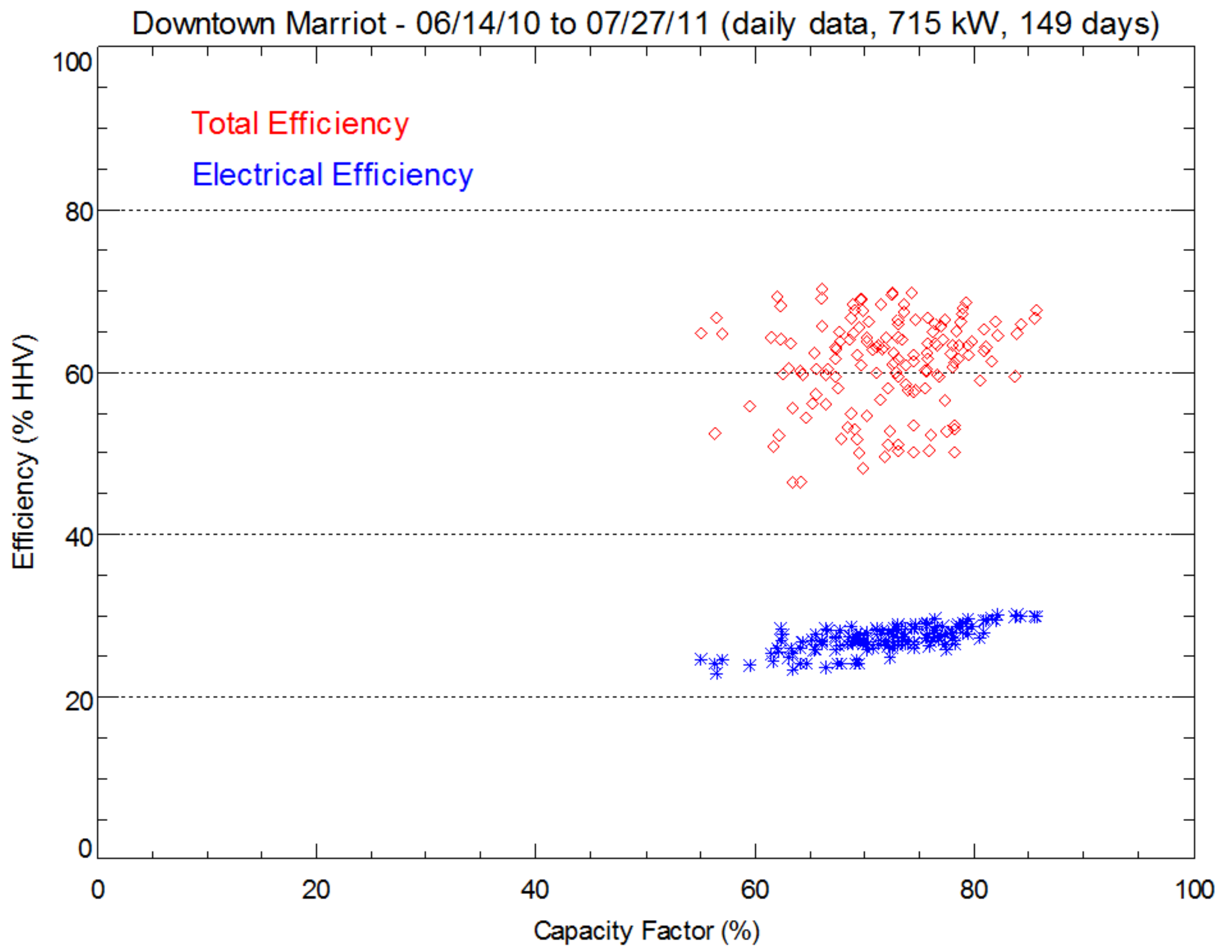

FIGURE 15 CAPACITY FACTOR[3]

Capacity Factor (Figure 15) presents the CHP generated power efficiency over the time period (149 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 operating in electric load following mode 27.4% power efficiency (HHV). The two microturbine arrays show Brayton cycle performance plus parasitic degradation as capacity reduces. The useful thermal energy for heating, cooling and DHW increases as power capacity is reduced indicating thermal load matching is greater at 60% than it is at 80%. The heat recovery system is 34.2% thermally efficient (HHV).

This system operated in an electric load following mode for the entire period. The thermal loads (useful thermal output) in the DG/CHP data base are the sum of the heating and cooling output of the four-pipe chiller. One shortfall of the DG/CHP is inability to separately capture these different thermal outputs. It is difficult to fully understand and gauge performance with these different thermal outputs combined together.

[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.

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)** The Generator Output comes from the data channels called WREC_POS_A and WREC_POS_B. This is an accumulator for the generator output. The difference between consecutive intervals is used to determine the output for each hour.
2. **DG/CHP Generator Gas Use (total cubic feet)** The data for Generator Gas input comes from the data channel labeled FG. This channel provides the fuel flow rate in kg/hour and is converted into standard cubic feet and averaged to determine the quantity of fuel used for each hour.
3. **Useful Heat Recovery (total MBtu)** The flow rate, supply temperature, and return temperature of the high and low grade water loop, (FH,THS,THR and FCH,TCHS,TCHR), are used to determine the amount of heat which is rejected from the system. This is determined at a rate which is averaged across the hour.

Data Collection and quality for this site for much of the period is in the high 90th percentile or at 100%. (Table 3) Exceptions are March 2011 for all parameters and May/June 2011 for kWh and Useful Heat in the mid-70th and 80th percentiles.

The large seasonal swings in useful thermal energy negatively impact the CHP system efficiency and economics. This system should be studied with respect to adding summer thermal capacity.

Following energy efficiency trends depicted in Table 1 and Figure 5 can provide owner/operators with valuable guidance with respect to operation and maintenance requirements of the CHP system to maintain peak performance.

Data Collection and quality for this site for much of the period is in the high 90th percentile or at 100% with the exception being June 2010. (Table 3)

TABLE 3 PERCENTAGE OF GOOD DATA

	Percentage of Good Data		
	Power	Gas Use	Useful Heat
June-10	58.2%	97.8%	58.2%
July-10	98.3%	96.4%	99.3%
August-10	99.1%	95.8%	100.0%
September-10	99.6%	96.5%	100.0%
October-10	99.3%	98.7%	100.0%
November-10	98.5%	99.3%	97.6%
December-10	98.7%	100.0%	99.7%
January-11	99.6%	98.9%	100.0%
February-11	99.3%	97.5%	100.0%
March-11	99.6%	97.3%	100.0%
April-11	99.7%	97.5%	100.0%
May-11	99.7%	97.2%	99.9%
June-11	99.3%	96.4%	100.0%
July-11	99.5%	95.8%	100.0%
August-11	99.3%	96.0%	100.0%