NYSERDA CHP Assessment Report

ASSESSING THE CHP PLANT AT TOREN CONDOMINIUMS

October 9, 2013

Toren Condominiums

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.

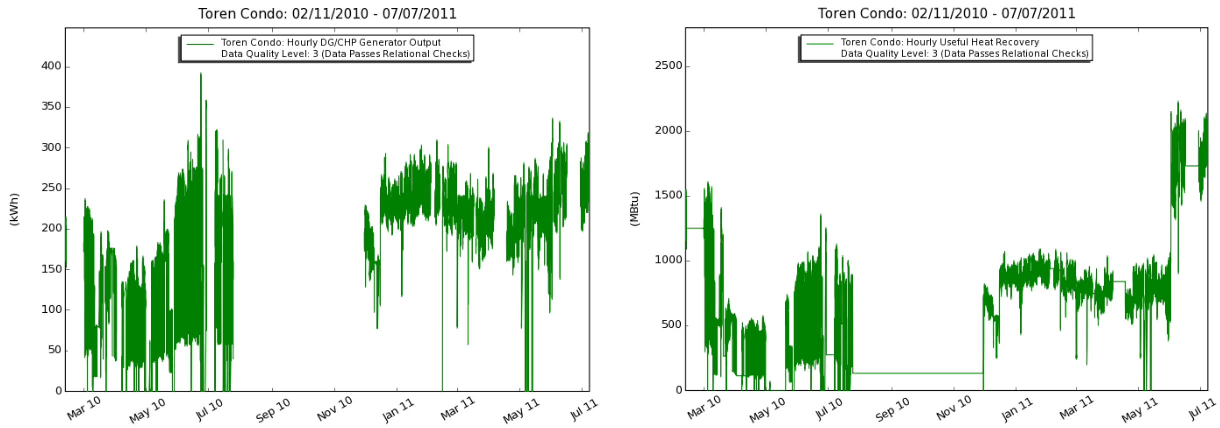

FIGURE 1 NYSERDA CHP WEBSITE PERFORMANCE GRAPHS

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 TOREN CONDOMINIUMS

Toren Condominium's (CHP) generation system supplies heat, hot water, air conditioning and electricity to the 300,000 sq ft mixed- use complex. The CHP units are powered by clean-burning natural gas and offset 500kW of electric demand on the ConEdison local distribution grid that has become strained due to the neighborhood's recent development.

The 37 story building offers 240 condominium homes with breathtaking floor-to-ceiling views of the Manhattan skyline and New York harbor as well as the opportunity to live in the most environmentally advanced high-rise residential building in New York.

THE SYSTEM

The Toren Condominium CHP plant consists of five Tecogen CM – 100 cogeneration units (Figure 3) capable of a total output of 500 kW. The central plant also includes six 1,700 MBH natural gas fired modular hot water boilers to supplement the heat recovery, if needed. The heat recovery is used for temperature control and domestic hot water.

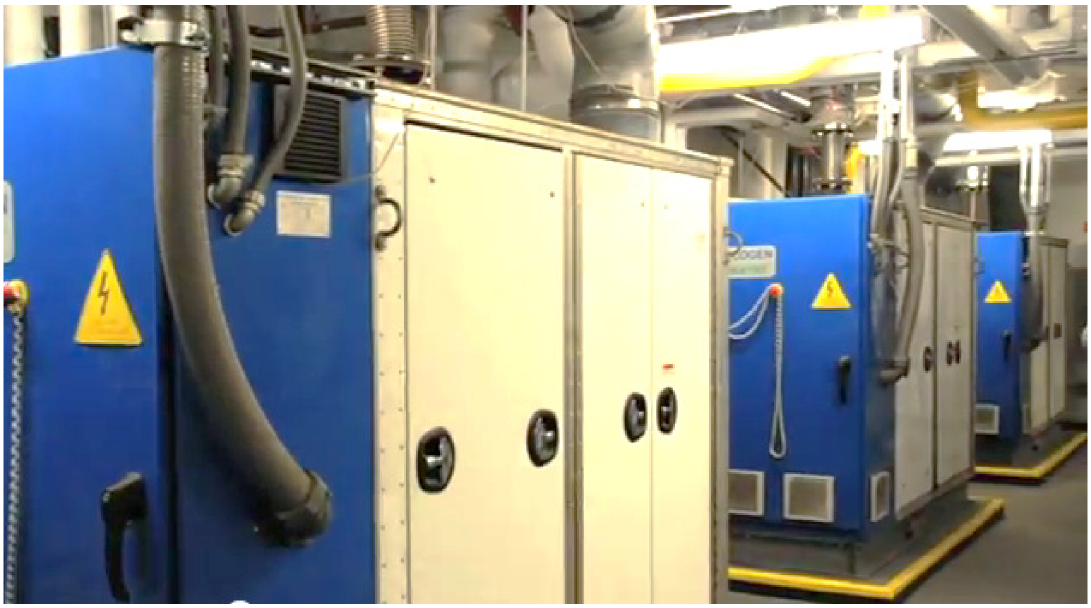

FIGURE 3 THREE OF THE FIVE TECOGEN CM – 100 COGENERATION UNITS

Toren's CHP plant is designed to automatically follow the building's electric demand. As demand for electricity increases and decreases within the building, the electrical output from each of the CHP modules also increases and decreases. Through sophisticated load control software built into each unit, the amount of electricity being purchased from Consolidated Edison, the electric utility in Brooklyn, can be maintained at less than 20kW.

FIGURE 4 ABSORPTION CHILLER

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 March of 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
March-10	673	91,855	1,254.0	517.2	24.5%	40.4%	64.9%
April-10	552	61,859	910.5	215.7	22.7%	23.2%	46.0%
May-10	720	83,408	1,128.7	132.3	24.7%	11.5%	36.2%
June-10	671	130,790	1,763.6	453.7	24.8%	25.2%	50.0%
July-10	398	77,311	1,031.5	214.5	25.1%	20.4%	45.5%
August-10							
September-10							
October-10							
November-10							
December-10	744	149,982	1,898.3	557.3	26.4%	28.8%	55.2%

[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.

January-11	744	179,442	2,267.5	669.2	26.5%	28.9%	55.4%
February-11	540	122,511	1,548.7	465.2	26.5%	29.5%	55.9%
March-11	689	143,930	1,823.6	516.5	26.4%	27.8%	54.2%
April-11	432	87,320	1,105.1	316.3	26.4%	28.1%	54.5%
May-11	744	146,596	1,859.9	527.6	26.4%	27.8%	54.2%
June-11	384	97,706	1,237.3	668.8	26.4%	53.0%	79.4%
July-11	624	171,107	2,171.4	1,144.7	26.4%	51.7%	78.1%
Total preceding 8 months	**4901**	**1,098,593**	**13,912**	**4,866**	**26.4%**	**34.3%**	**60.7%**

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

Table 1 presents annual data showing the engine-based CHP system's electric efficiency at 26.4% (HHV) range which is expected for this reciprocating engine generator. Useful thermal performance is 47.2% for the period (HHV based on fuel input). The moderate thermal efficiency indicates limited thermal use during the shoulder months. The chillers clearly started to operate as expected in June and July 2011 as indicated by the higher thermal efficiency.

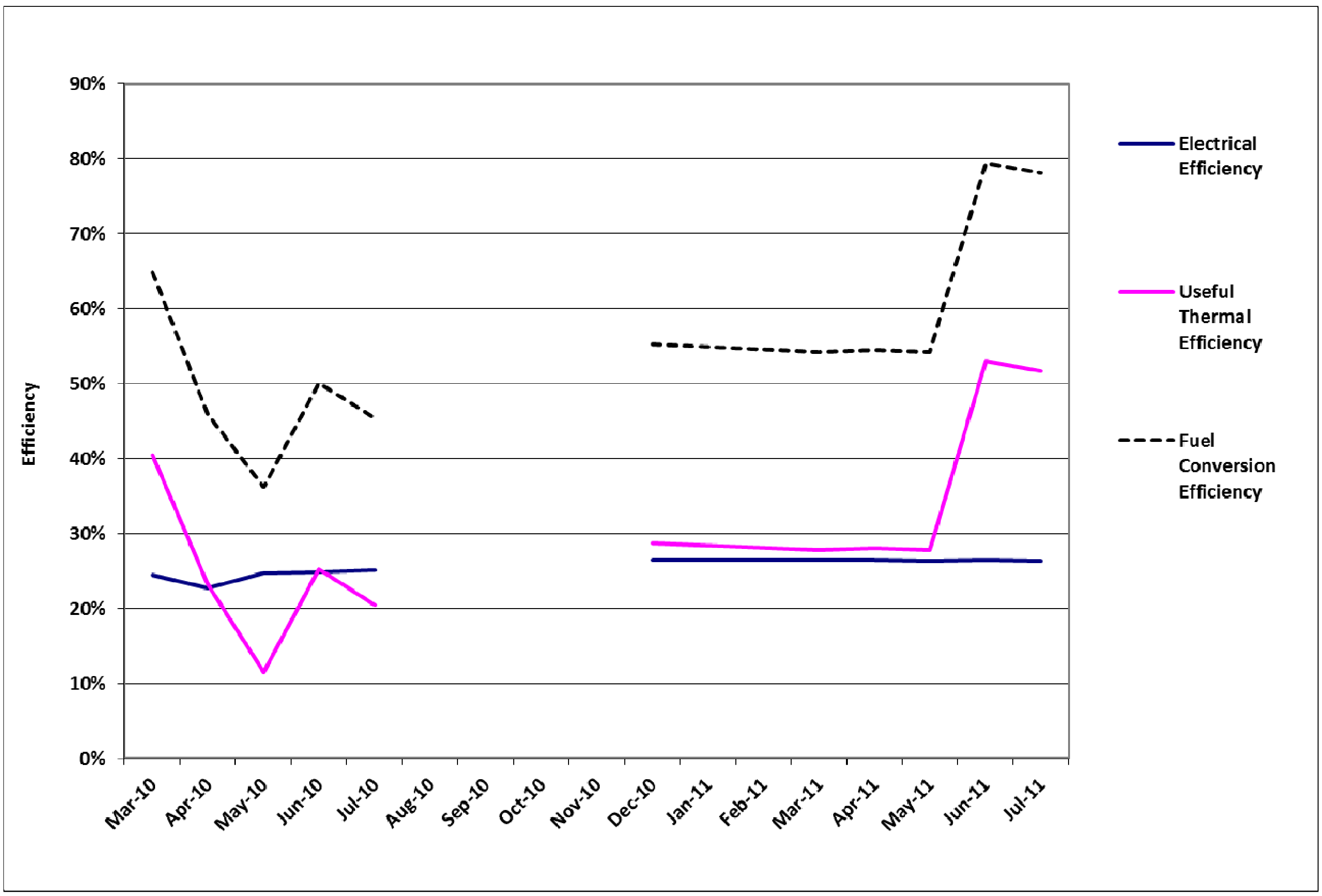

FIGURE 5 ELECTRIC, THERMAL AND FUEL CONVERSION EFFICIENCY BY MONTH

Figure 5 provides operating efficiency during the February – July, 2010 time period, showing a slight decline in CHP electric efficiency in the summer due to a drop in power output (lower engine part load heat rate), and a slight increase in useful thermal efficiency performance because the low power output means a higher percentage of thermal energy.

OPERATING SUMMARY

The CHP system consists of five reciprocating engine generators with a nominal capacity of 500 kW.

During the 7,937 hours that met the range and relational checks 60.7% of this time, the CHP system delivered above 200 kWh/h (Figure 13).

Generator output is limited to building electric load (electric load following) up until June 2010. Thermal loads show a slight dip in the middle of the day when space heating loads are modest. In April 2010, the units often shut down in the middle of the day, perhaps due to a lack of thermal load. During 2011, generally between 2 and 3 engine generators were operating 24/7.

In July 2010, the unit operated intermittently, often shutting down in the morning and afternoon. This appears to be due to operational issues with the engine. See the shade plot below.

The system appears to shut down at 11 pm each evening due to a data transfer issue that was fixed in early 2011 (the system was assumed to actually operate)

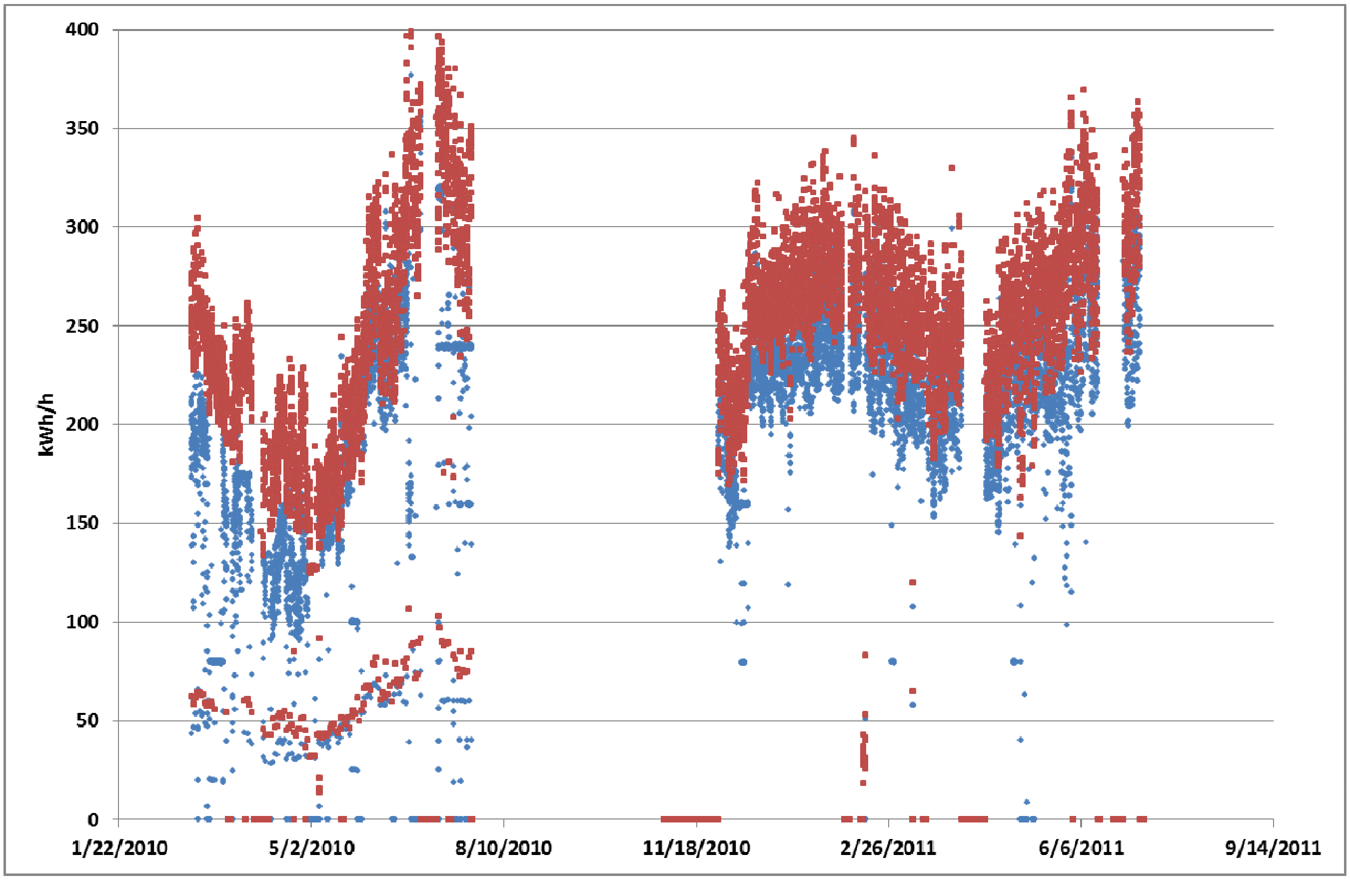

FIGURE 6 CHP POWER GENERATED VERSUS BUILDING LOAD BY MONTH

Figure 6 shows the electric load profile for Toren Condominium is operating in electric load following mode.

POWER GENERATION AND USEFUL THERMAL ENERGY

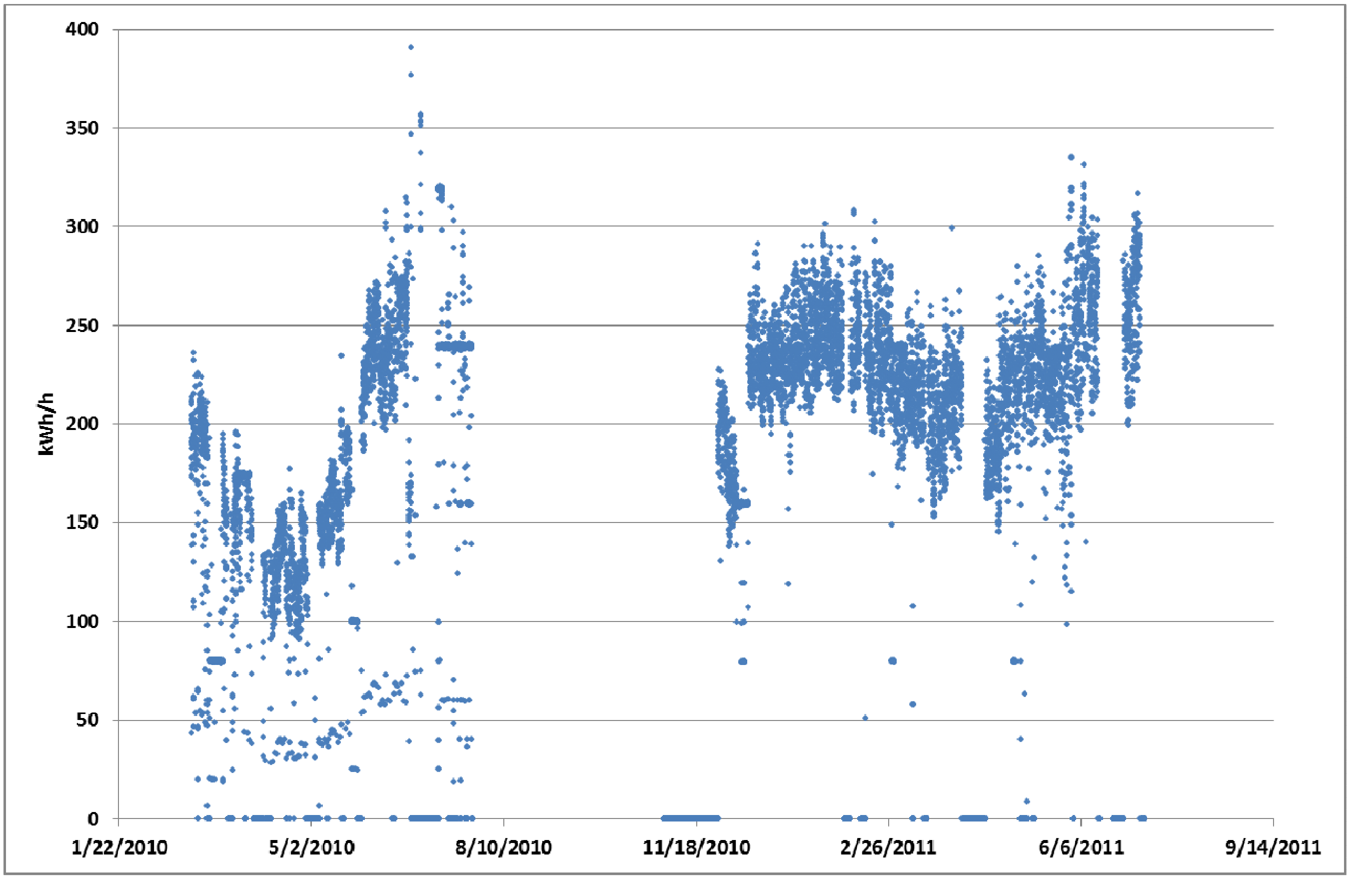

FIGURE 7 CHP POWER OUTPUT VERSUS TIME

Figure 7 breaks out the electric load profile for Toren Condominium from the previous graph. The ensuing power graphs show two to three generators running 24/7.

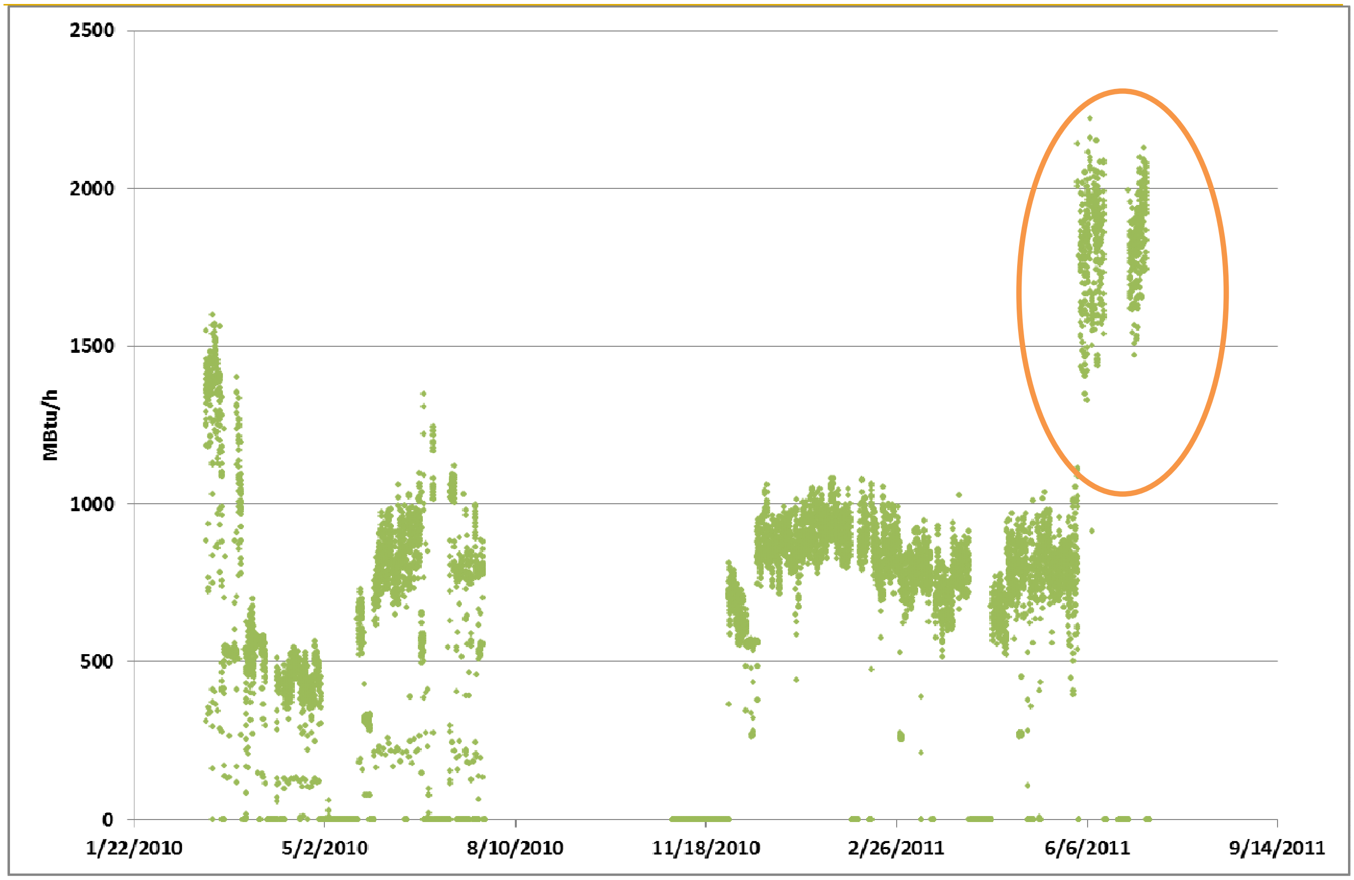

FIGURE 8 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 8 shows a useful thermal energy in MMBtu/h.

Useful thermal increase in June 2011 is due to the absorption chiller coming online.

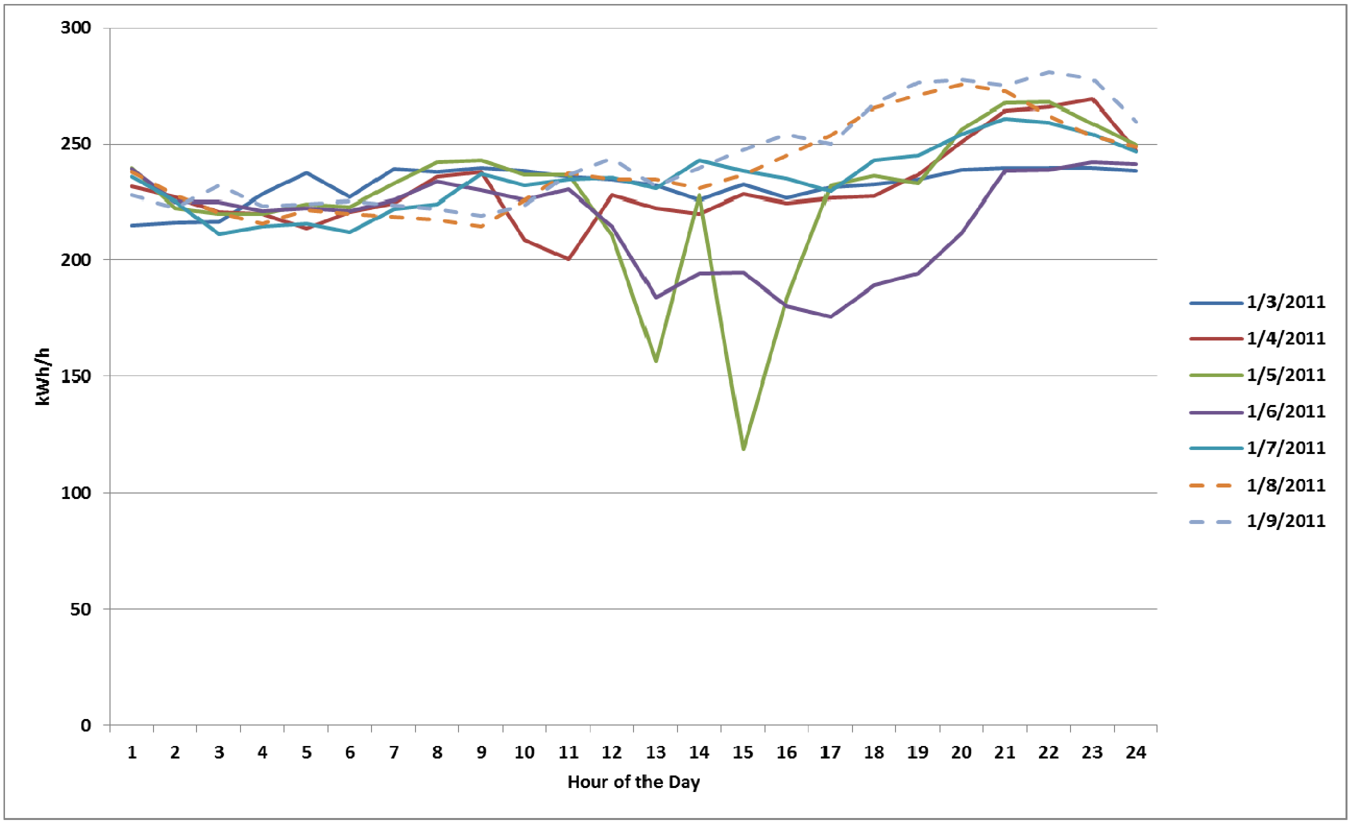

FIGURE 9 CHP POWER OUTPUT VERSUS TIME

Figure 9 covers the time period from January 3 – 9, 2011, providing CHP system power output by hour of the day pattern for the time period. January 8 is a Saturday.

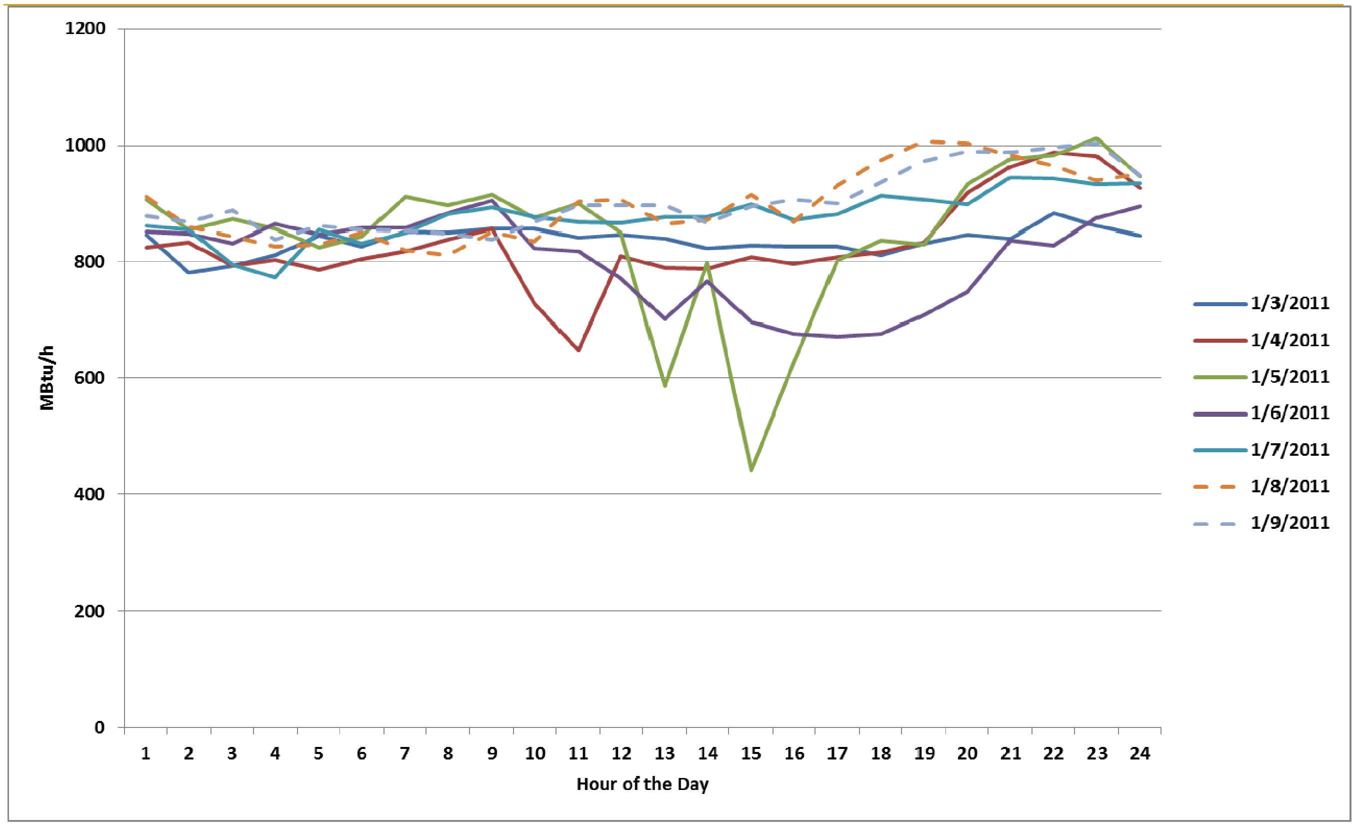

FIGURE 10 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 10 shows the 24 hour useful CHP recovered heat thermal load profiles from January 3 – 9, 2011.

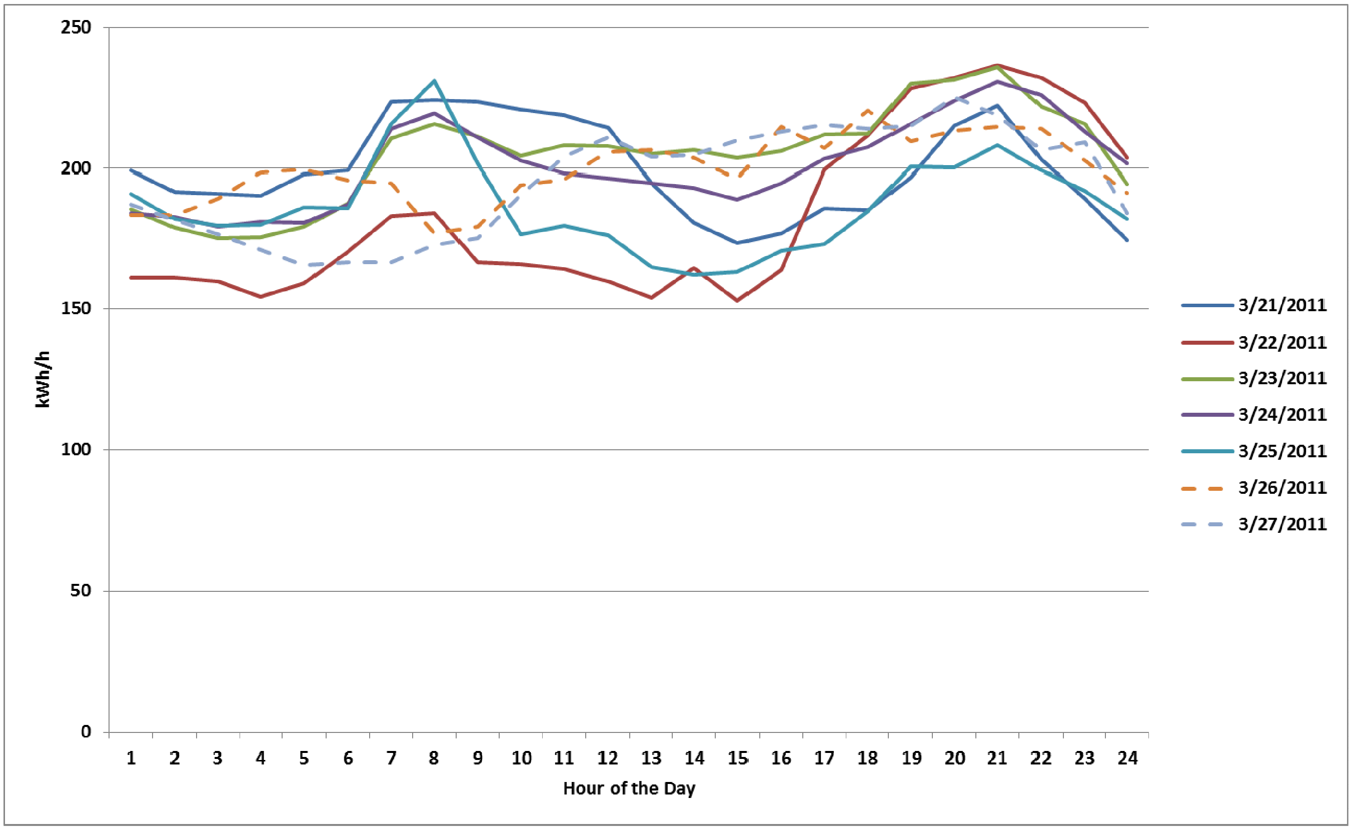

FIGURE 11 CHP POWER OUTPUT VERSUS TIME

Figure 11 covers the time period from March 21 – 27, 2011, providing CHP system power output by hour of the day pattern for the time period. March 26 is a Saturday.

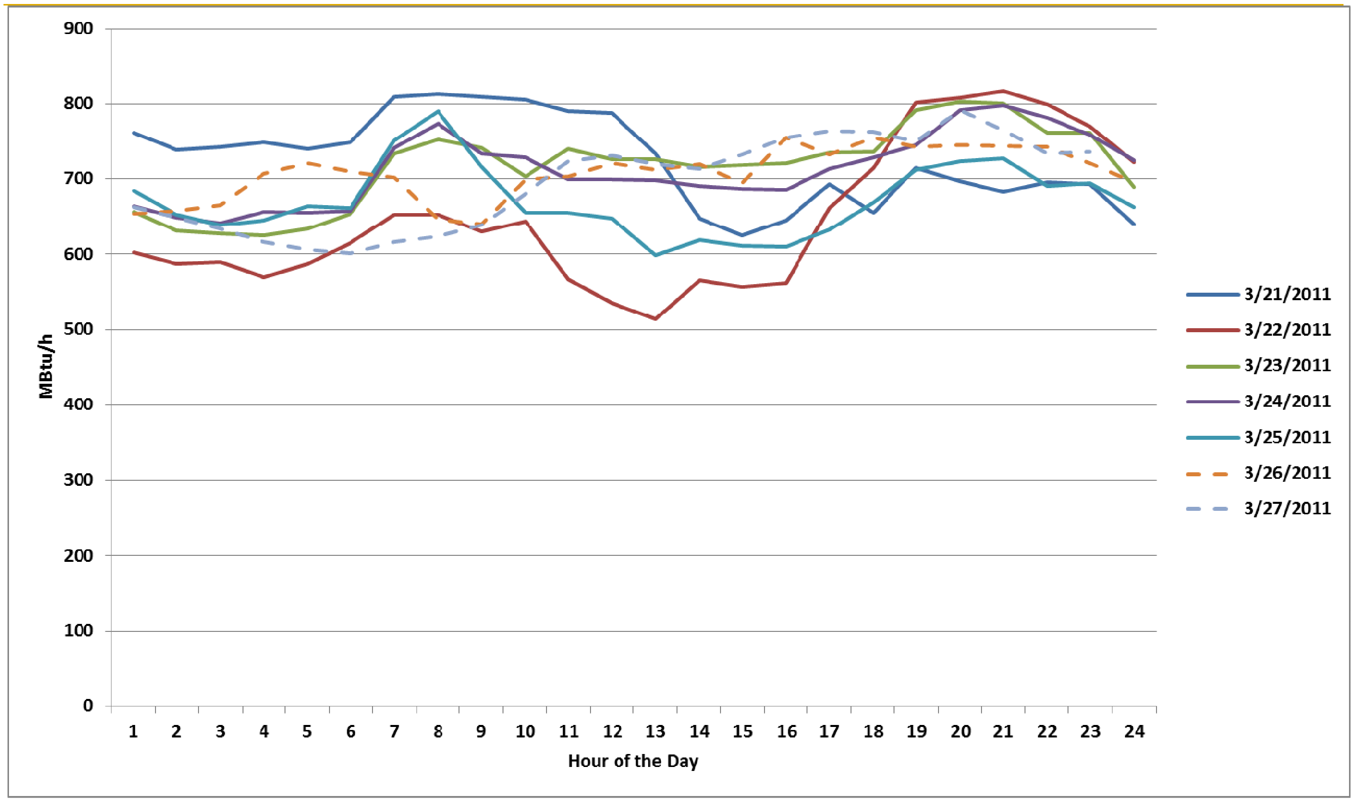

FIGURE 12 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 12 shows the 24 hour useful CHP recovered heat thermal load profiles from March 21 – 27, 2011.

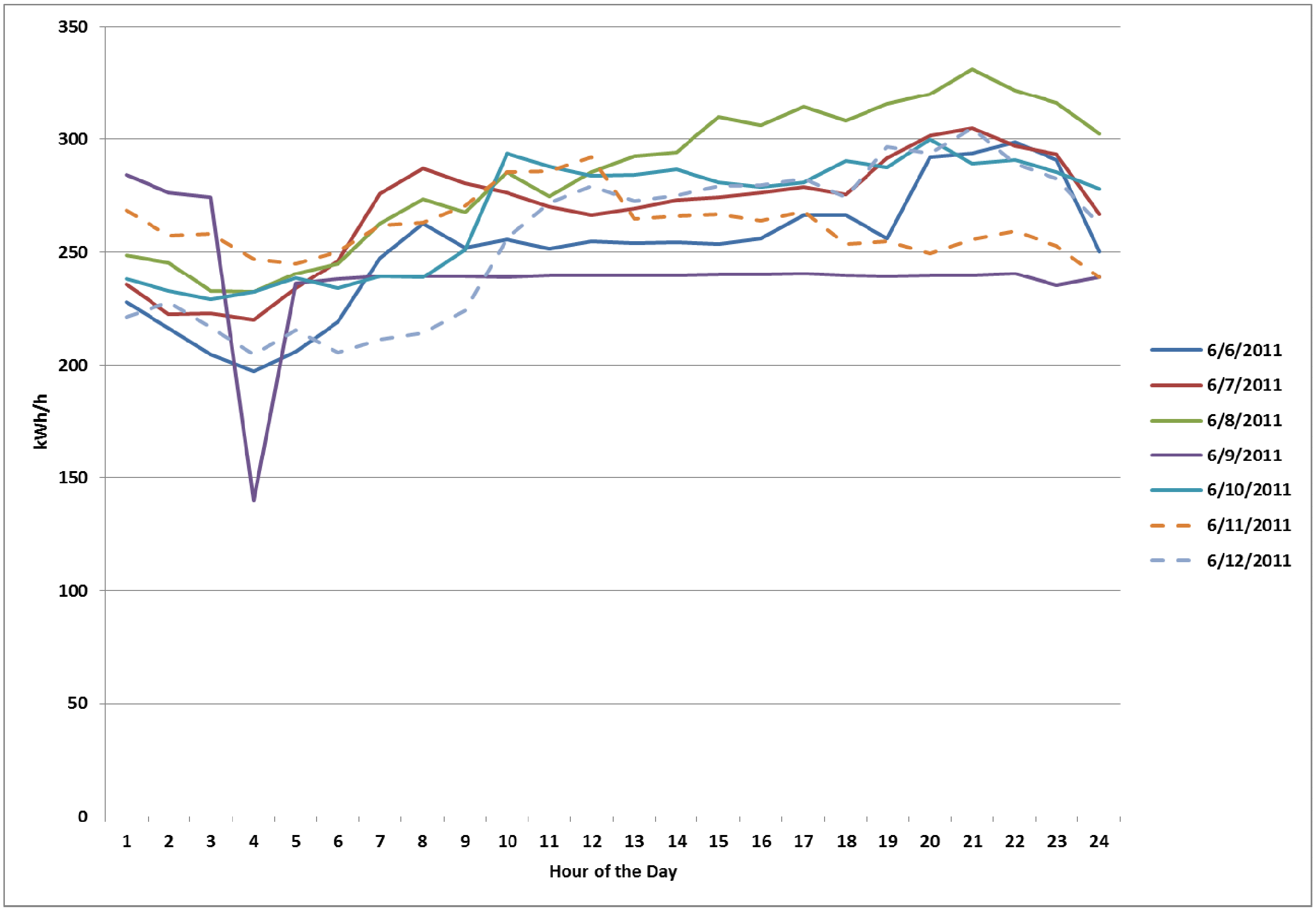

FIGURE 13 CHP POWER OUTPUT VERSUS TIME

Figure 13 covers the time period from June 6 – 12, 2011, providing CHP system power output by hour of the day pattern for the time period. June 11 is a Saturday.

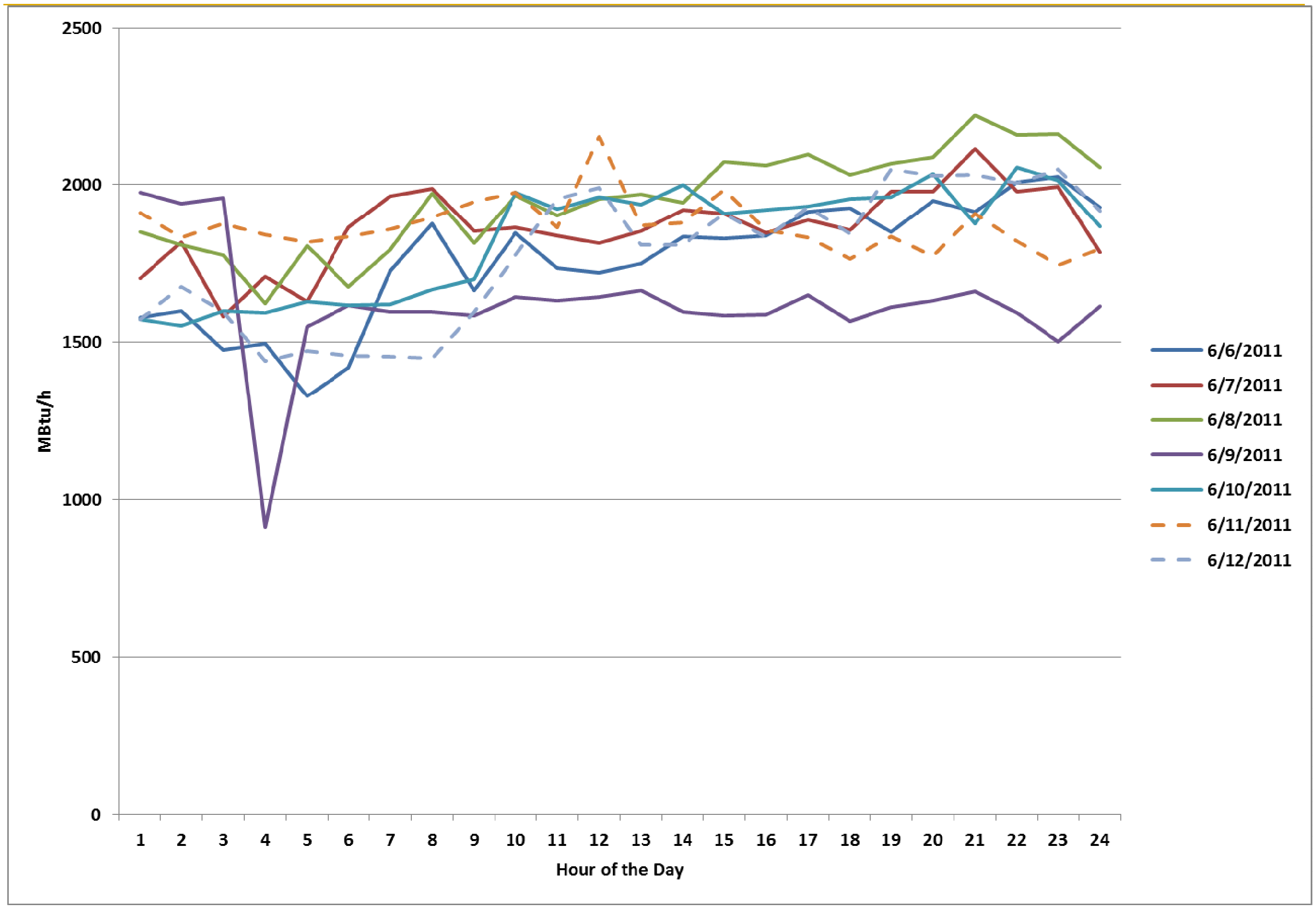

FIGURE 14 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 14 shows the 24 hour useful CHP recovered heat thermal load profiles from June 6 – 12, 2011. June 11 is a Saturday.

PERFORMANCE SUMMARY

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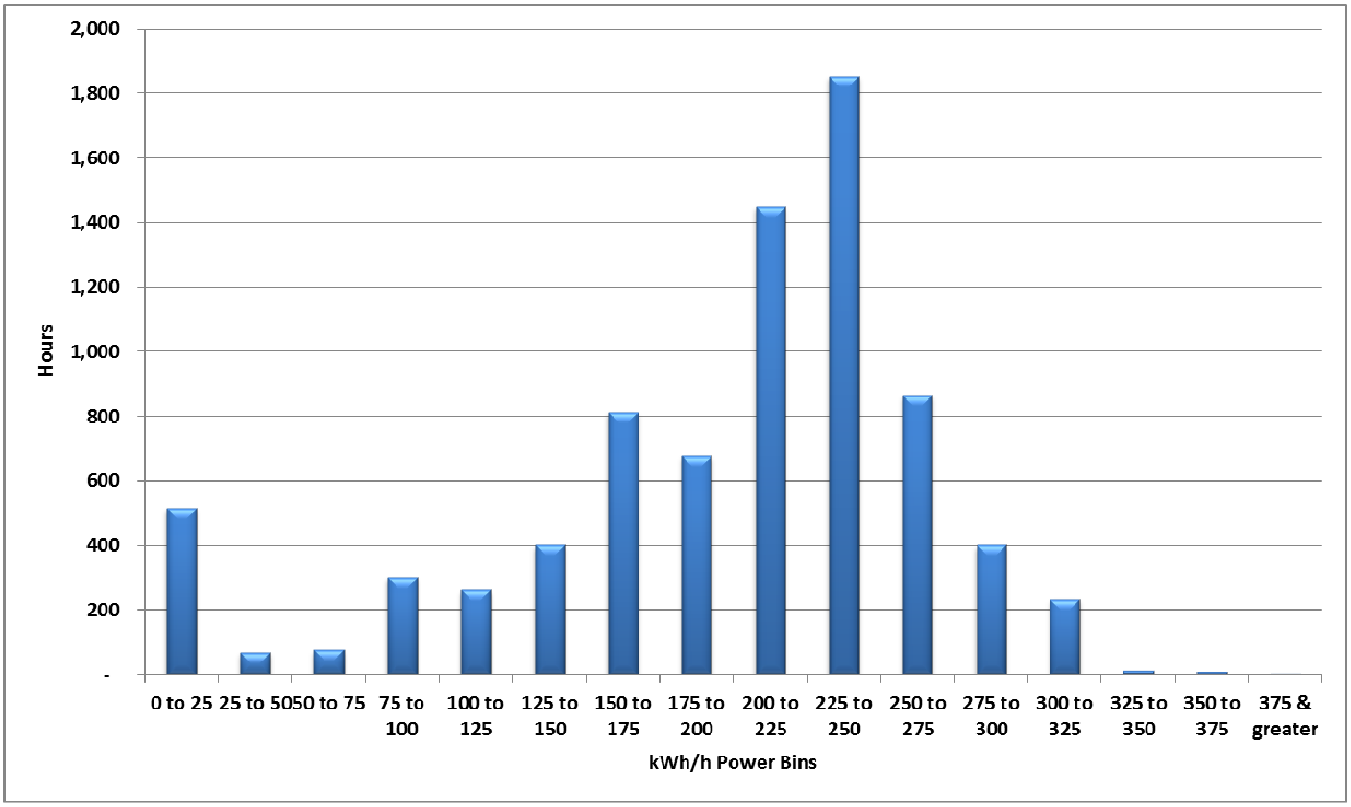

FIGURE 15 PERFORMANCE BY POWER BINS

LESSONS LEARNED

TABLE 2 SYSTEM EFFICIENCY[2]

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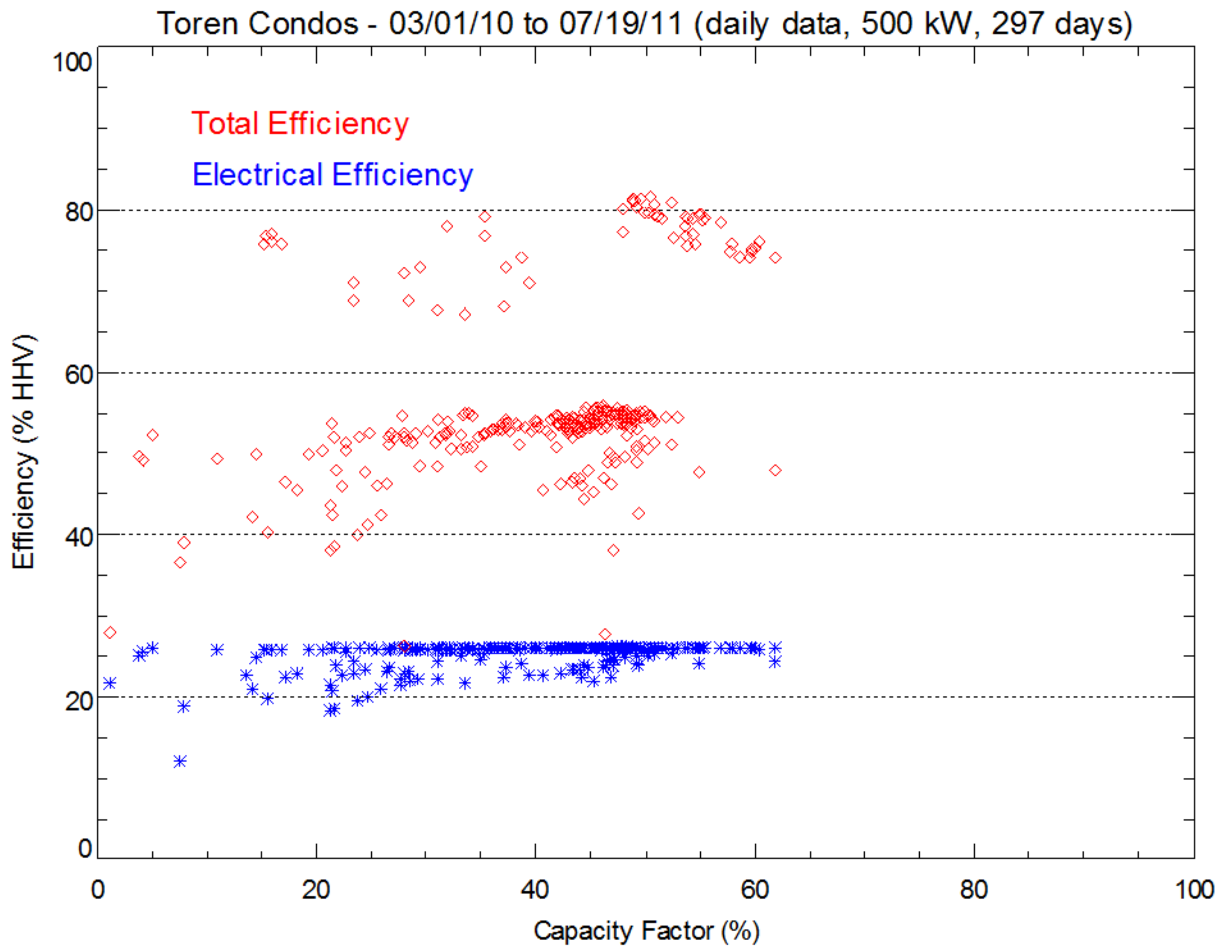

FIGURE 16 CAPACITY FACTOR[3]

Capacity Factor (Figure 16) presents the CHP generated power efficiency over the time period (297 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 62% of the generating capacity at about 26.5% power efficiency (HHV) during the last 12 months of Table 2. The electric capacity is determined, in-part, by the occupancy of the building as this new condominium becomes occupied. Note the generally flat nature of the electricity performance curve reflects a certain amount of model predictive calculation due to incomplete data. The useful thermal energy (heating, cooling and domestic hot water) operating efficiency during the most recent 12 month period in Table 2 averaged 34.4% thermal efficiency (HHV). The useful thermal energy performance falls into two distinct patterns – the lower cluster for heating which trails off in performance and power is reduced and the higher cluster which related to the absorption chiller.

Consistent operation of the absorption chiller in the summer months clearly had a big impact on the useful heat recovery. Absorption chillers that can run base-loaded to meet building cooling loads can greatly improve summertime heat recovery.

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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.

Supplemental data in Figure 17 shows that increased occupancy through the latter half of 2011 and the first half of 2012 has increased the CHP performance.

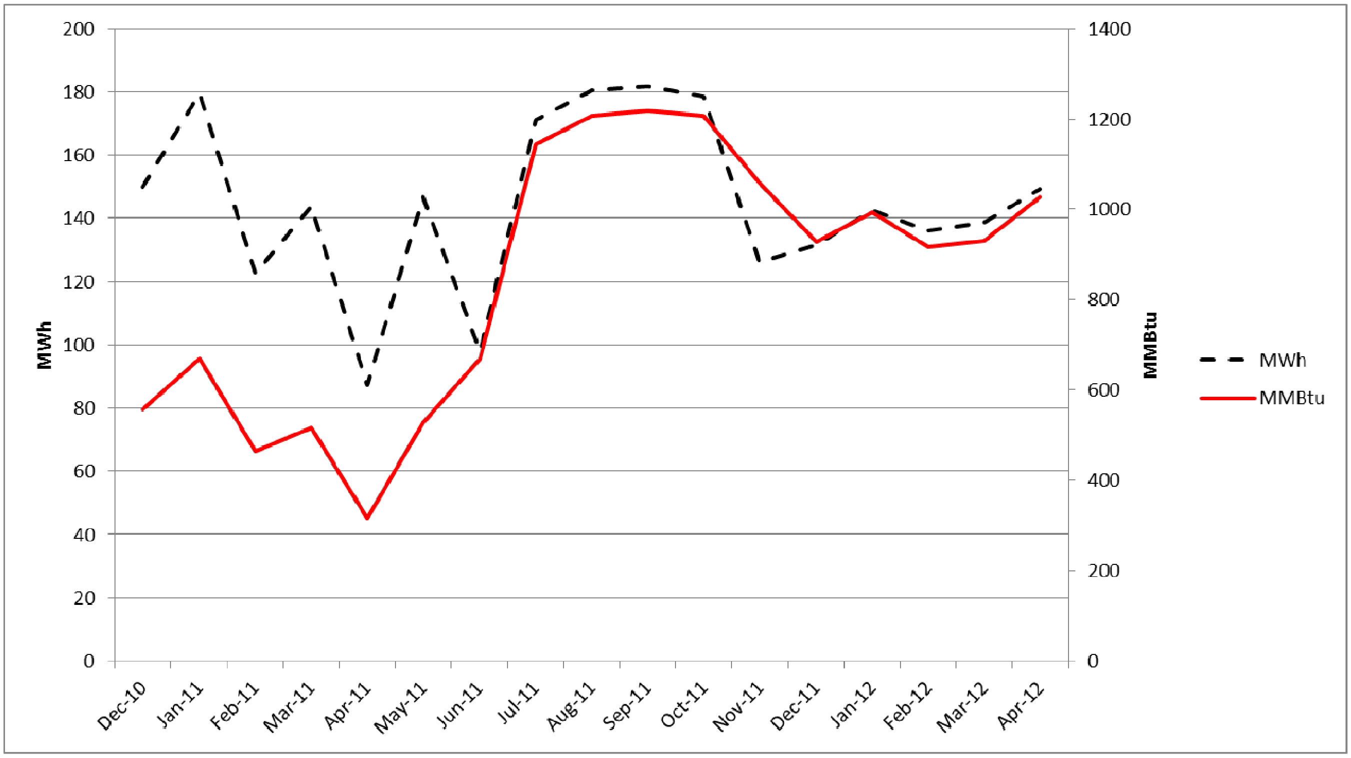

FIGURE 17 SUPPLEMENTAL PERFORMANCE DATA

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 columns labeled "Plant Power Output (kW)" in the data files from Energy Concepts. This 15-minute interval energy data is summed into hourly data.
2. **DG/CHP Generator Gas Use (total cubic feet)** The data for Generator Gas Input comes from the data point "Plant Total Gas Use (scf)" in the data files from Energy Concepts. This data is provided in standard cubic feet for each 15-minute interval and summed into hourly data.
3. **Useful Heat Recovery (total MBtu)** The Useful heat Recovery is obtained from the columns of data labeled "HX-3 Flow", "HX-3 Primary Entering Temp", and "HX-3 Primary Leaving Temp" in the files obtained from Energy Concepts. These points are used to calculate the heat recovery for each interval. This 15-minute data is summed into hourly data.

Data Collection and quality for this site ranges from 0% through 100% during three months. (Table 3) Data quality on this site is an issue.

TABLE 3 SITE DATA QUALITY

	Percentage of Good Data		
	Power	Gas Use	Useful Heat
March-10	92.1%	92.2%	89.1%
April-10	78.1%	78.1%	77.9%
May-10	98.9%	98.9%	98.9%
June-10	95.4%	95.2%	90.9%
July-10	68.3%	68.3%	67.8%
August-10			
September-10			
October-10			
November-10	3.3%	0.0%	3.3%
December-10	100.0%	100.0%	100.0%
January-11	100.0%	100.0%	100.0%
February-11	83.3%	83.3%	83.3%
March-11	93.9%	93.9%	93.9%
April-11	61.1%	61.1%	61.1%
May-11	100.0%	100.0%	99.6%
June-11	68.2%	68.2%	68.2%
July-11	85.8%	85.8%	85.8%