NYSERDA CHP Assessment Report

ASSESSING THE CHP PLANT AT LONG ISLAND JEWISH MEDICAL CENTER

October 9, 2013

Long Island Jewish Medical Center

NYSERDA New York State Energy Research and Development Authority

DISCLAIMER OF WARRANTY

Information contained on this web site is provided "as is," without warranty of any kind. In particular, the New York State Energy Research and Development Authority ("NYSERDA"), its employees, officers, and members, and the State of New York, make no warranties or representations, expressed or implied, as to the fitness for a particular purpose or merchantability of any product, apparatus, downloaded computer software product, service, or the usefulness, completeness, or accuracy of any processes, methods, downloaded computer software product, or other information contained, described, disclosed, or referred to herein. NYSERDA, its employees, officers and members, and the State of New York, make no representation that the use of any product, apparatus, process, method, downloaded computer software product, or other information will not infringe on privately owned rights.

DISCLAIMER OF LIABILITY

In no event shall NYSERDA, its employees, officers or members, or the State of New York be liable for any direct, indirect, punitive, incidental, special, or consequential damages or any damages whatsoever including, without limitation, damages for loss of use, data, or profits, arising out of or in any way connected with the use or performance of this web site, the provision of or failure to provide services, or for any information, software, products, services, or graphics obtained through this web site, or otherwise arising out of the use of this web site, whether based on contract, tort, strict liability, or otherwise, even if NYSERDA, its employees, officers and members, and the State of New York have been advised of the possibility of damages.

DISCLAIMER OF ENDORSEMENT

Reference to any specific product, service, process, or method by trade name, trademark, service mark, manufacturer or otherwise on this web site does not constitute an implied or expressed recommendation or endorsement, or favoring by NYSERDA, its employees, officers or members, or the State of New York, and shall not be used for advertising or product endorsement purposes.

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.

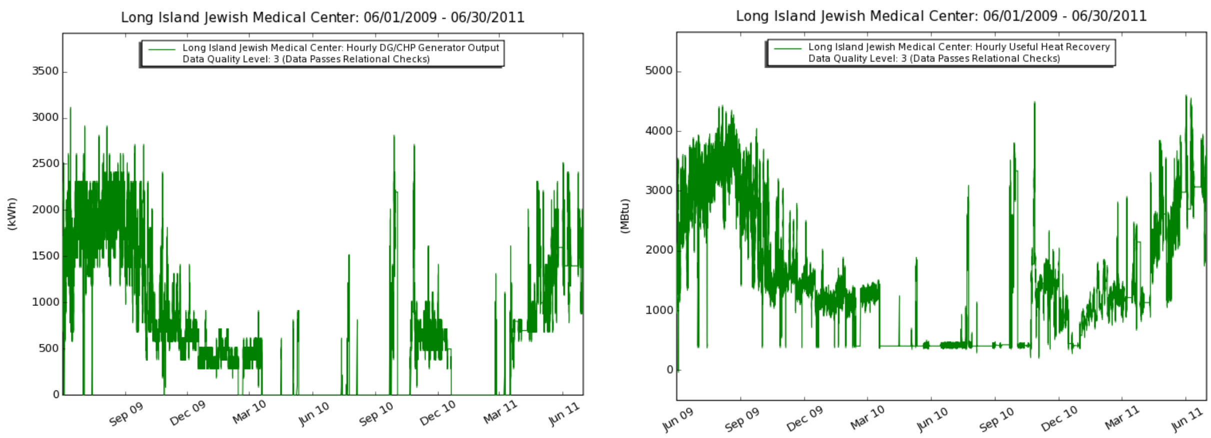


FIGURE 1 NYSERDA CHP WEBSITE PERFORMANCE GRAPHS

This report provides 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 LONG ISLAND JEWISH MEDICAL CENTER

Long Island Jewish Medical Center shares the title of the clinical and academic hub of the North Shore-Long Island Jewish Health System. It is an 827-bed voluntary, non-profit tertiary care teaching hospital serving the greater metropolitan New York area. The 48-acre campus is 15 miles east of Manhattan on the border of Queens and Nassau Counties.

LIJ comprises three divisions: Long Island Jewish Hospital, Schneider Children's Hospital and The Zucker Hillside Hospital for behavioral healthcare. Long Island Jewish Hospital is a 452-bed tertiary adult care hospital with advanced diagnostic and treatment technology, and modern facilities for medical, surgical, dental and obstetrical care. It features the Heart Institute, Pain and Headache Treatment Center; comprehensive pulmonology programs for asthma, emphysema and sleep disorders; The Center for New Life with private labor-delivery-recovery suites and a high-risk pregnancy program, and the Institute of Oncology.

THE SYSTEM

The CHP System consists of two 1,425-kW GE Jenbacher J420 GS natural-gas-fueled reciprocating engine driven electric generating units. One of the engines serves as a stand-by unit. The electric power generated by the engines will be used solely to power the central plant's cooling and steam generating systems and their respective auxiliary components, including all the pumps, cooling towers, electric chillers, boilers, and fans. Thermal energy will be recovered from each of the engine blocks and from a heat recovery silencer on each of the engines' exhaust systems. The recovered heat will then be used to preheat the steam system condensate returning from the campus and to drive a single stage absorption chiller. The exhaust heat exchanger on each engine produces steam.

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.

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-09	708	1,150,700	11,711	1,944	32.9%	16.3%	49.2%
July-09	744	1,329,300	13,217	2,345	33.7%	17.4%	51.1%
August-09	744	1,511,201	14,934	2,617	33.9%	17.2%	51.0%
September-09	720	1,142,000	11,604	1,993	32.9%	16.8%	49.8%
October-09	744	696,600	7,442	1,331	31.3%	17.5%	48.9%
November-09	718	512,501	5,666	1,126	30.3%	19.5%	49.8%
December-09	744	419,600	4,875	994	28.8%	20.0%	48.8%
January-10	719	326,000	4,013	876	27.2%	21.4%	48.6%
February-10	672	202,299	2,617	661	25.9%	24.7%	50.6%
March-10	743	199,500	2,459	686	27.1%	27.4%	54.5%
July-10	744	65,900	801	440	27.5%	53.8%	81.3%

[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.

August-10	672	1,600	24	278	22.5%	--	--
September-10	287	206,500	2,297	447	30.1%	19.1%	49.2%
October-10	502	158,800	1,814	454	29.3%	24.5%	53.8%
November-10	646	435,900	4,853	929	30.1%	18.8%	48.8%
December-10	405	166,901	2,001	318	27.9%	15.6%	43.5%
January-11	624			652			
February-11	600	8,700	95	768	30.7%	--	--
March-11	380	152,499	1,659	504	30.8%	29.8%	60.5%
April-11	479	512,199	5,560	1,124	30.8%	19.8%	50.6%
May-11	524	694,800	7,505	1,324	31.0%	17.3%	48.3%
June-11	597	959,300	9,942	1,968	32.3%	19.4%	51.7%
July-11	575	696,000	7,416	1,428	31.4%	18.9%	50.3%
Total preceding 12 months	**6,291**	**3,993,201**	**43,166**	**10,195**	**31.0%**	**23.2%**	**54.1%**

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

OPERATING SUMMARY

The CHP system consists of two 1,425-kW engine driven electric generators with a nominal capacity of 2,850 kW. Note that originally one generator was classified as standby, but in July and August of 2009, the CHP system produced power as high as 2,400 kWh/h, indicating both generators were running. During the 5,325 operating hours between June 2009 and March 2010 that met the range and relational checks 38.5% of this time, the CHP system delivered between 500 and 1,000 kW/hr (Table 3). In some cases power and gas use goes to zero but the heat recovery remains greater than zero because steam flow meters do not go to zero.

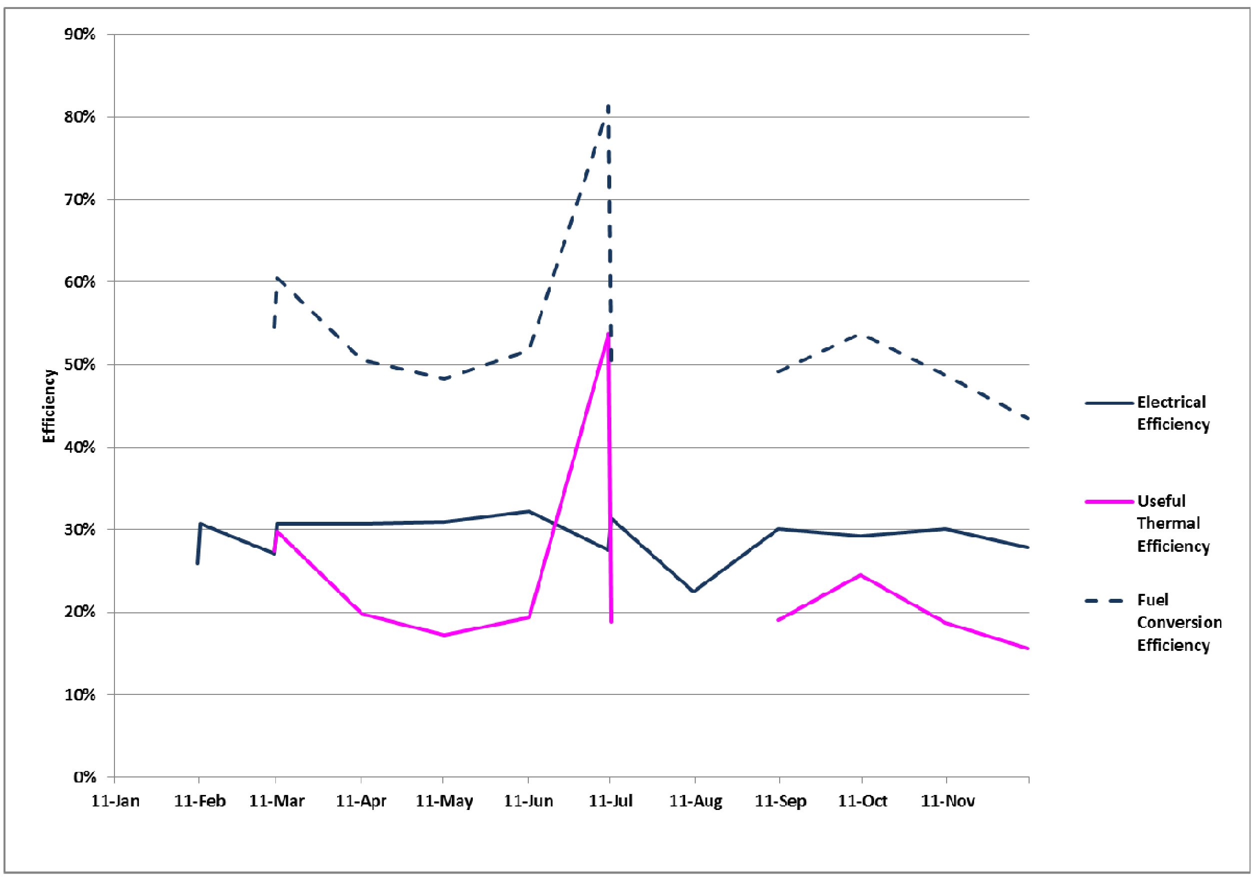


FIGURE 3 CHP SYSTEM EFFICIENCY BY MONTH

Figure 3 provides operating efficiency during the February – July 2011 time period showing relatively stable electric efficiency (see Table 1), and low useful thermal efficiency performance.

POWER GENERATION AND USEFUL THERMAL ENERGY

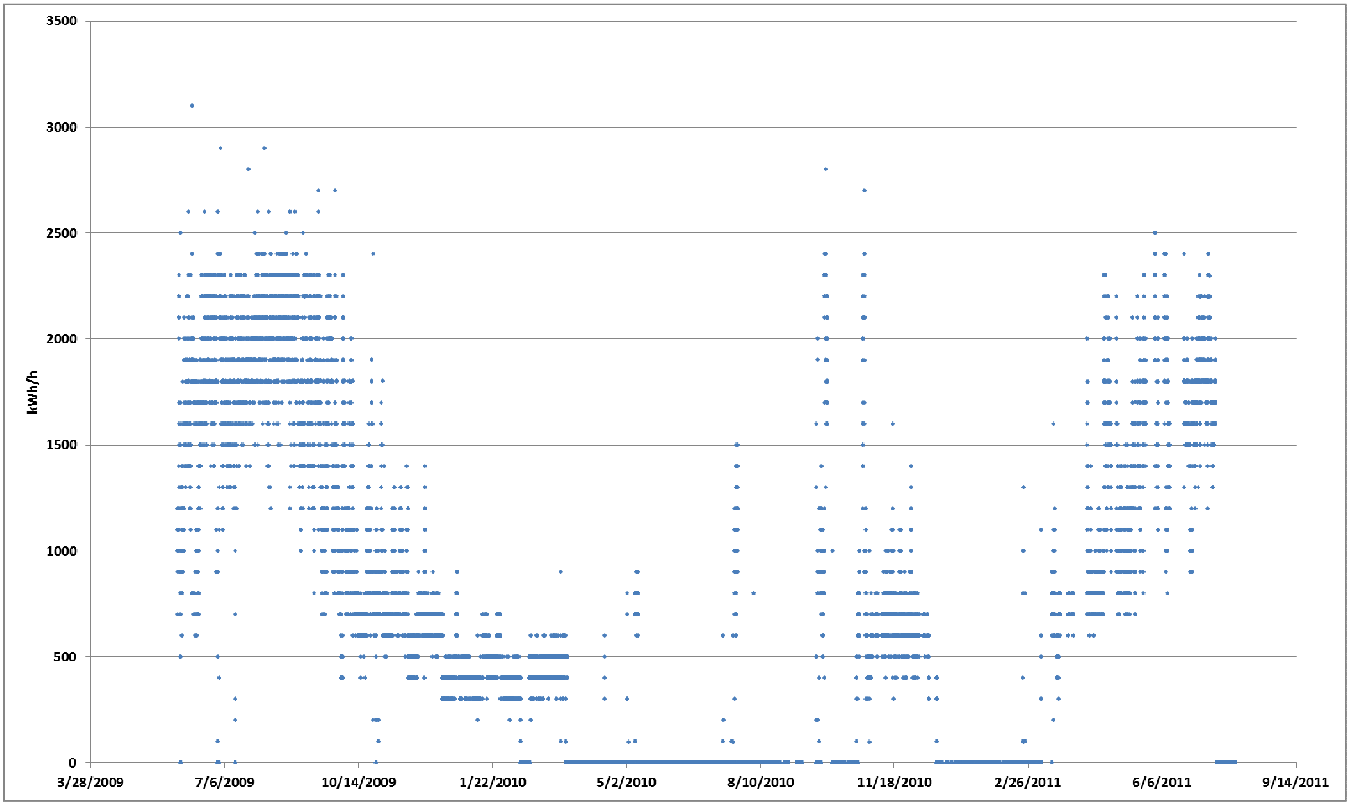


FIGURE 4 CHP POWER OUTPUT VERSUS TIME

Figure 4 shows a clear operating pattern with discrete set points.

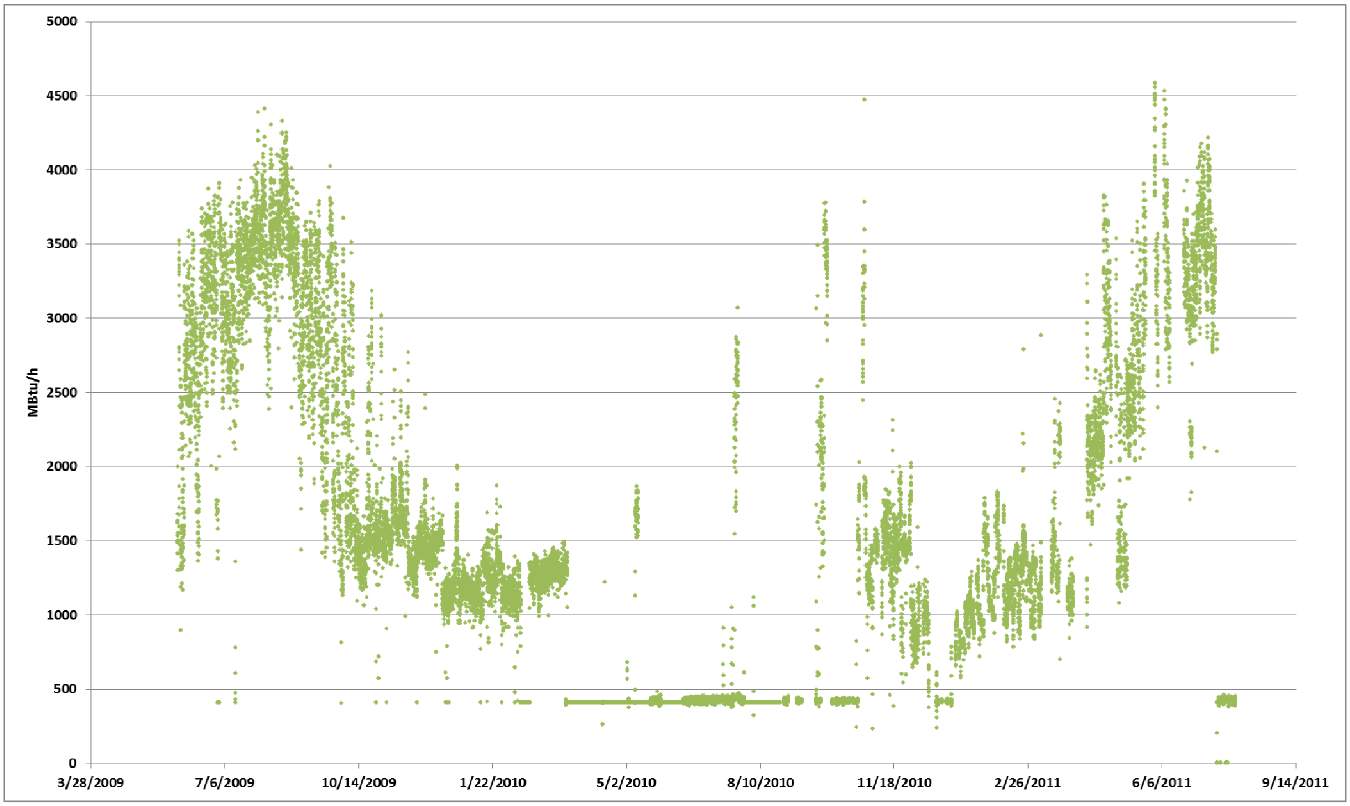


FIGURE 5 CHP USEFUL THERMAL OUTPUT VERSUS TIME

Figure 5 shows a cyclical pattern with lower winter heat recovery and summer heat recovery and a load shape identical to the power curve in Figure 4. This predominately indicates an electric load following operating regime. The heat recovery does not go to zero when the system is off primarily due to the steam flow meters not going to zero when there is not steam flow.

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

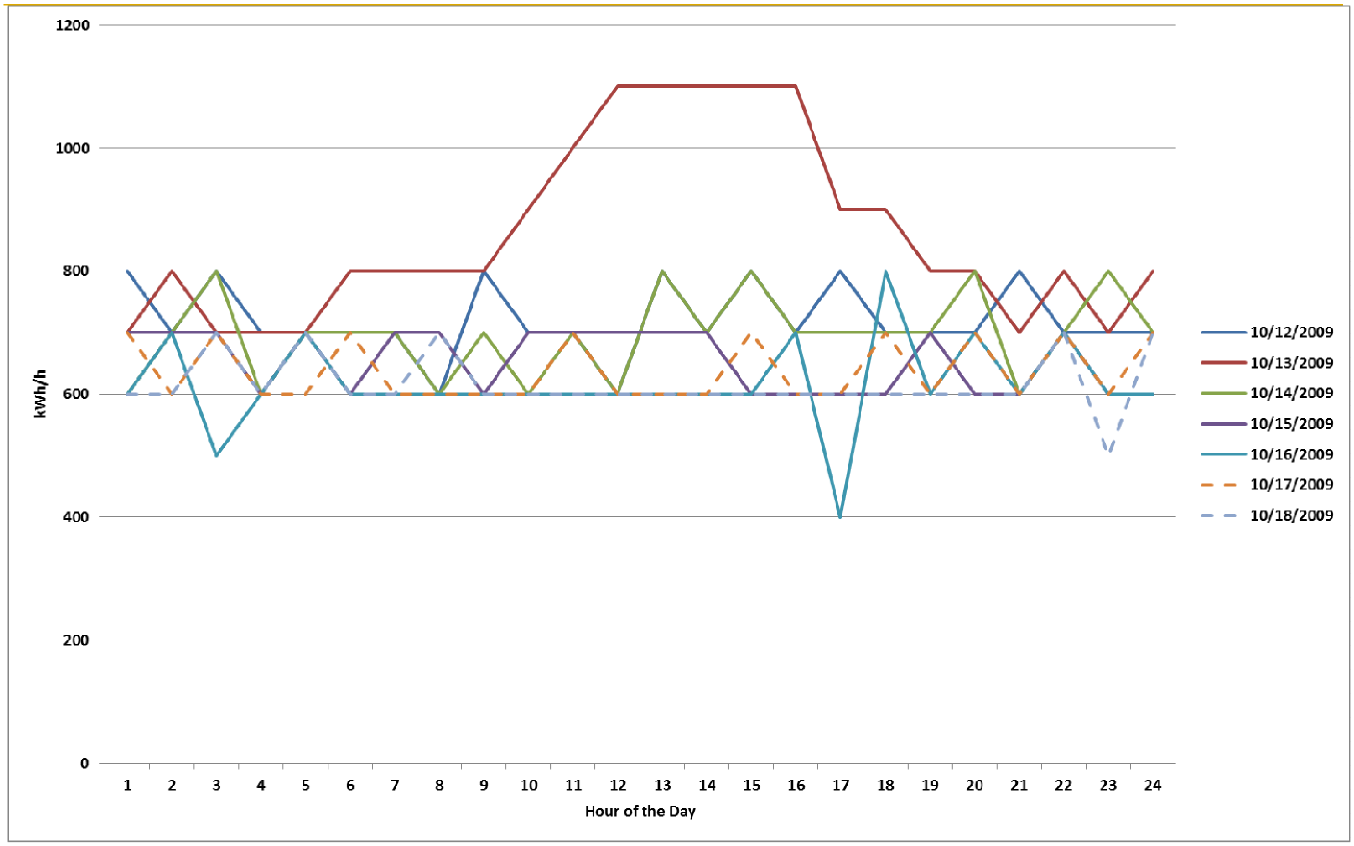


FIGURE 6 CHP POWER OUTPUT VERSUS TIME

Figure 6 covers the useful CHP recovered thermal load profiles from October 12 - 18, 2009. Figure 13 shows consistent summertime thermal loading 24 x 7. October 17 is a Saturday.

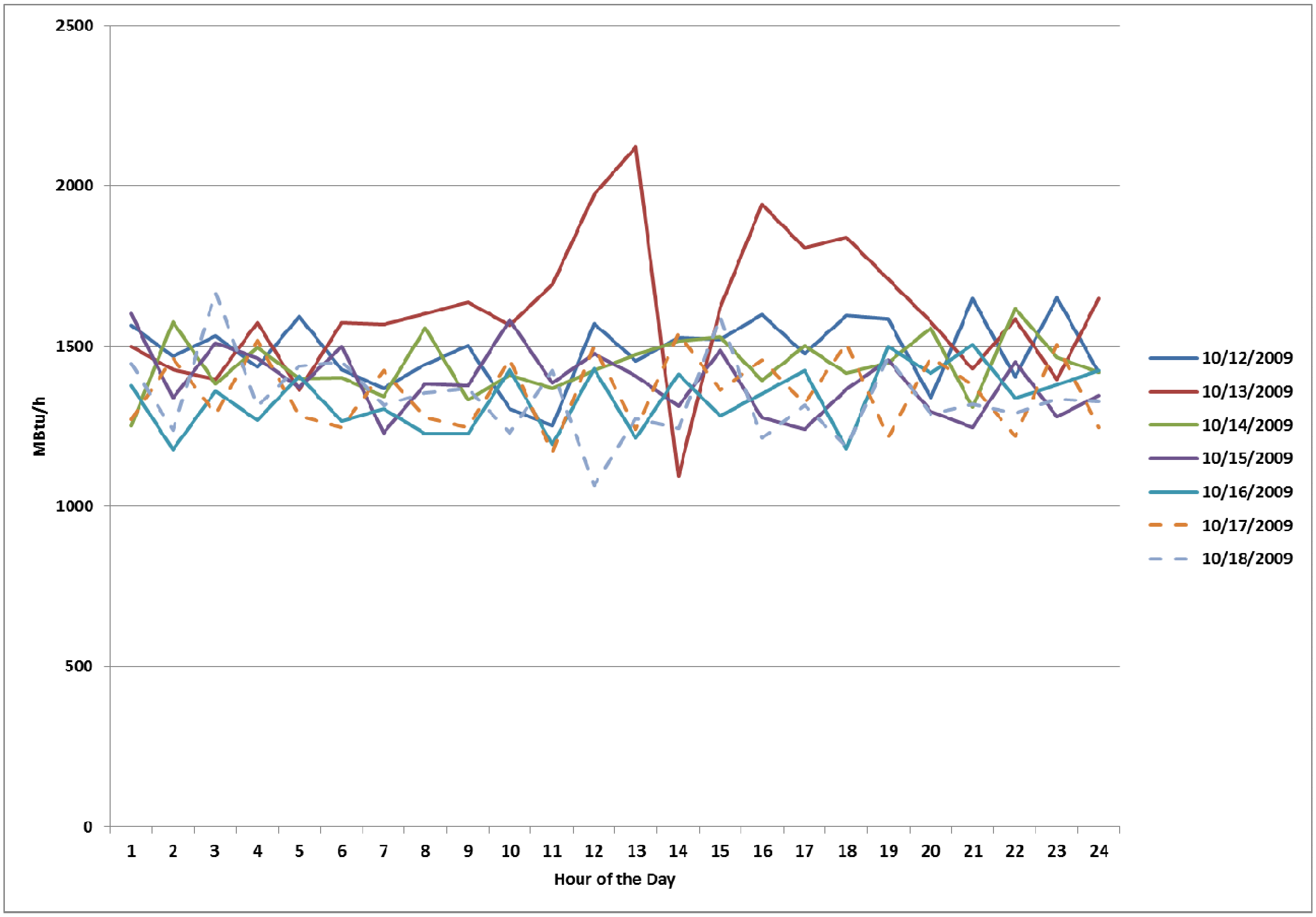


FIGURE 7 CHP USEFUL THERMAL OUTPUT VERSUS TIME

The 24 hour useful CHP recovered thermal load profiles from October 12 - 18, 2009 (Figure 7) show a very consistent thermal load pattern.   October 17 is a Saturday.

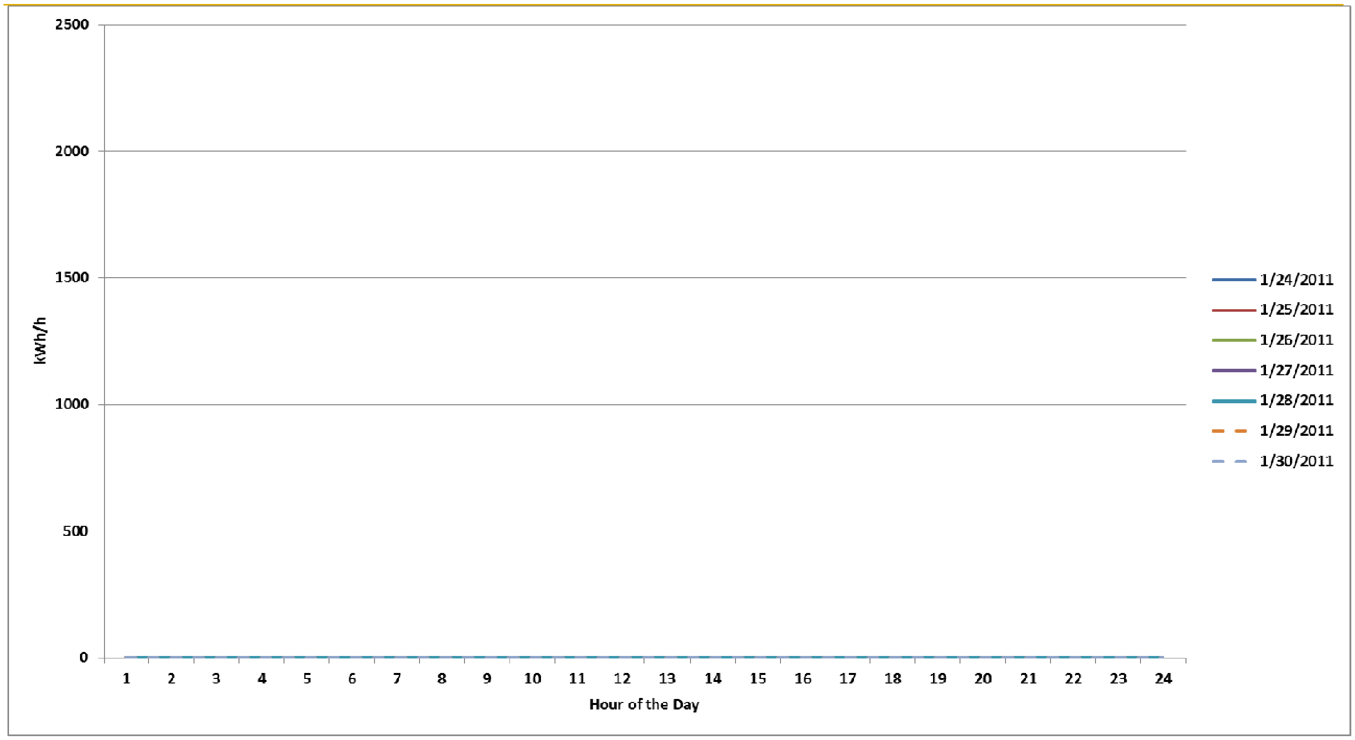


FIGURE 8 CHP POWER OUTPUT VERSUS TIME

Figure 8 covers the time period from January 24 - 30, 2011. The CHP system did not operate for the time period. January 29 is a Saturday.

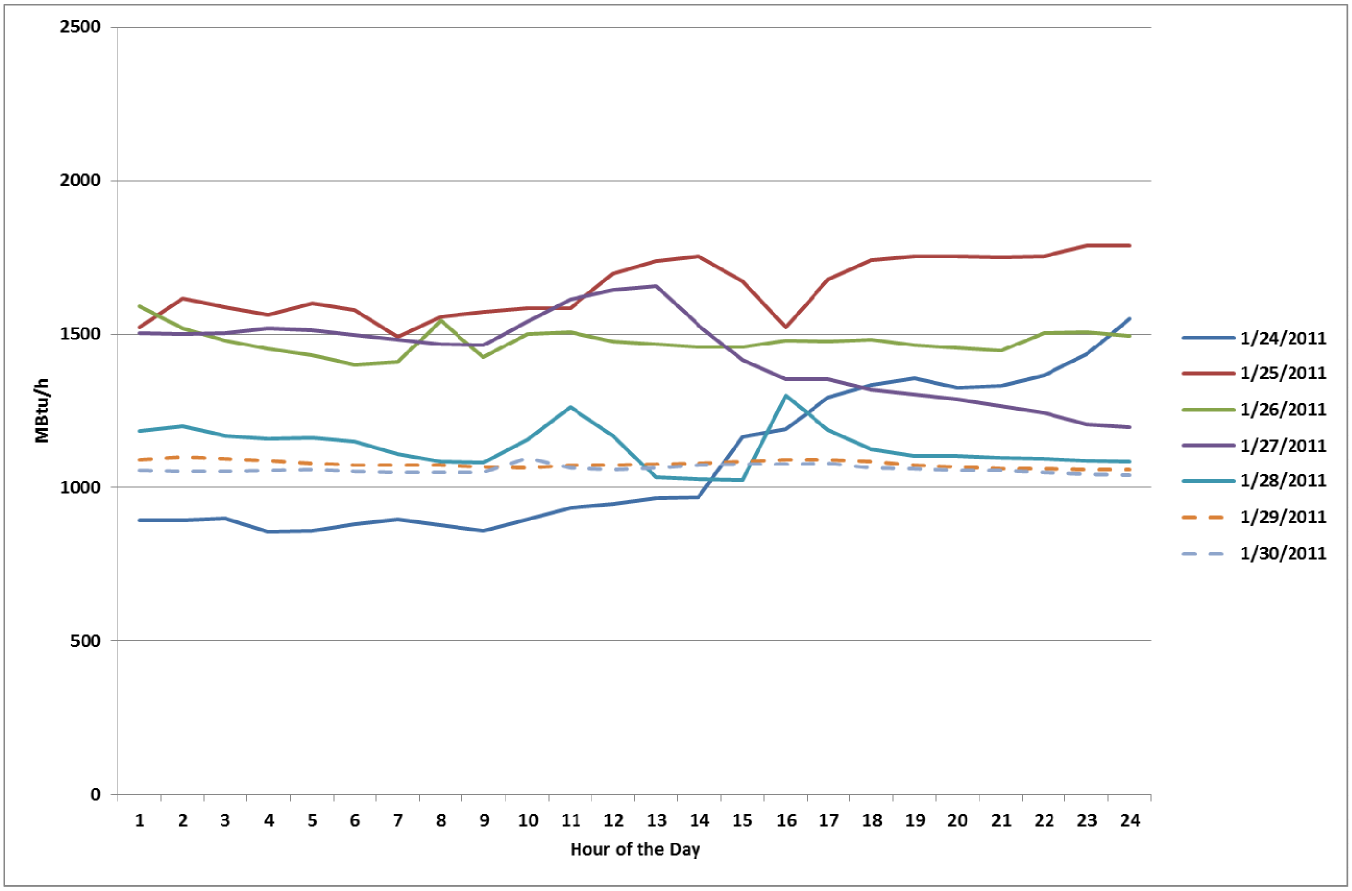


FIGURE 9 CHP USEFUL THERMAL OUTPUT VERSUS TIME

The 24 hour thermal load profiles from January 24 - 30, 2011. Figure 11 shows an unusual situation where the CHP system is shut down useful thermal energy is supplied. This occurred because part of the data stream was lost for this period and the steam flow meters do not completely go to zero when the system is off. January 29 is a Saturday.

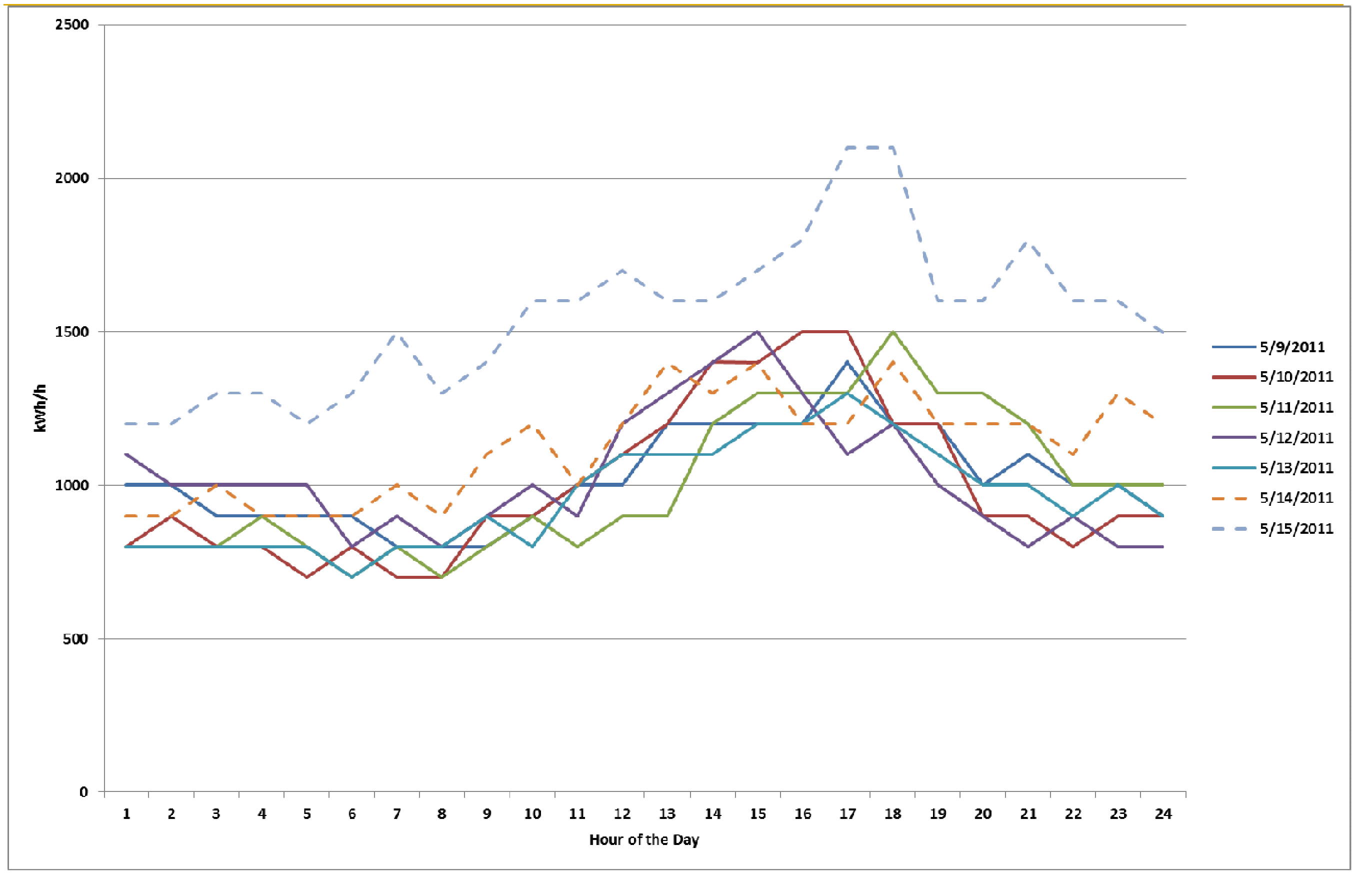


FIGURE 10 CHP POWER OUTPUT VERSUS TIME

Figure 10 covers the time period from May 9 – 15, 2011 providing CHP system power output by hour of the day pattern for the time period. May 14 is a Saturday. Figure 7 presents a distinctive stepped pattern of operation.

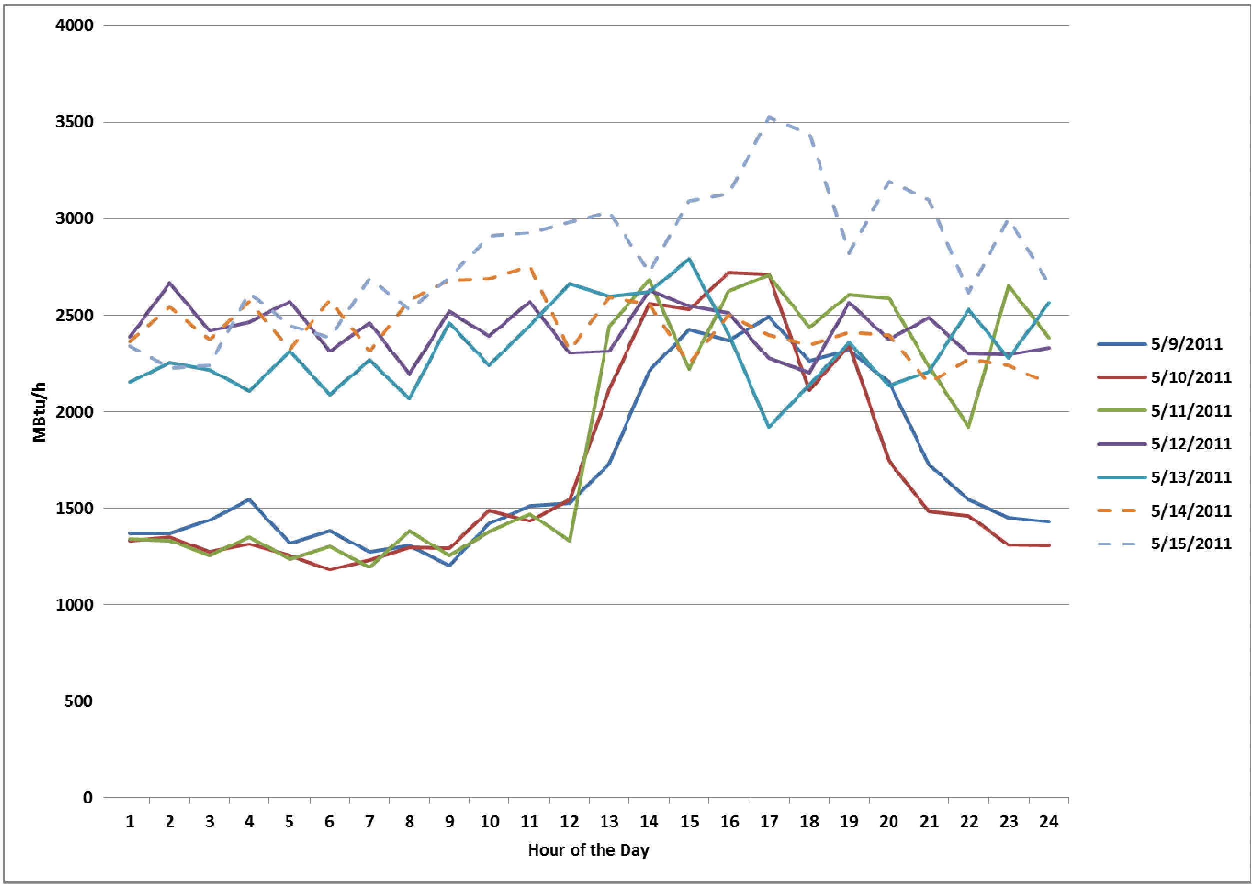


FIGURE 11 CHP USEFUL THERMAL OUTPUT VERSUS TIME

The 24 hour useful CHP recovered thermal load profiles from May 9 – 15, 2011. Figure 11 shows typical springtime variable thermal. May 14 is a Saturday.

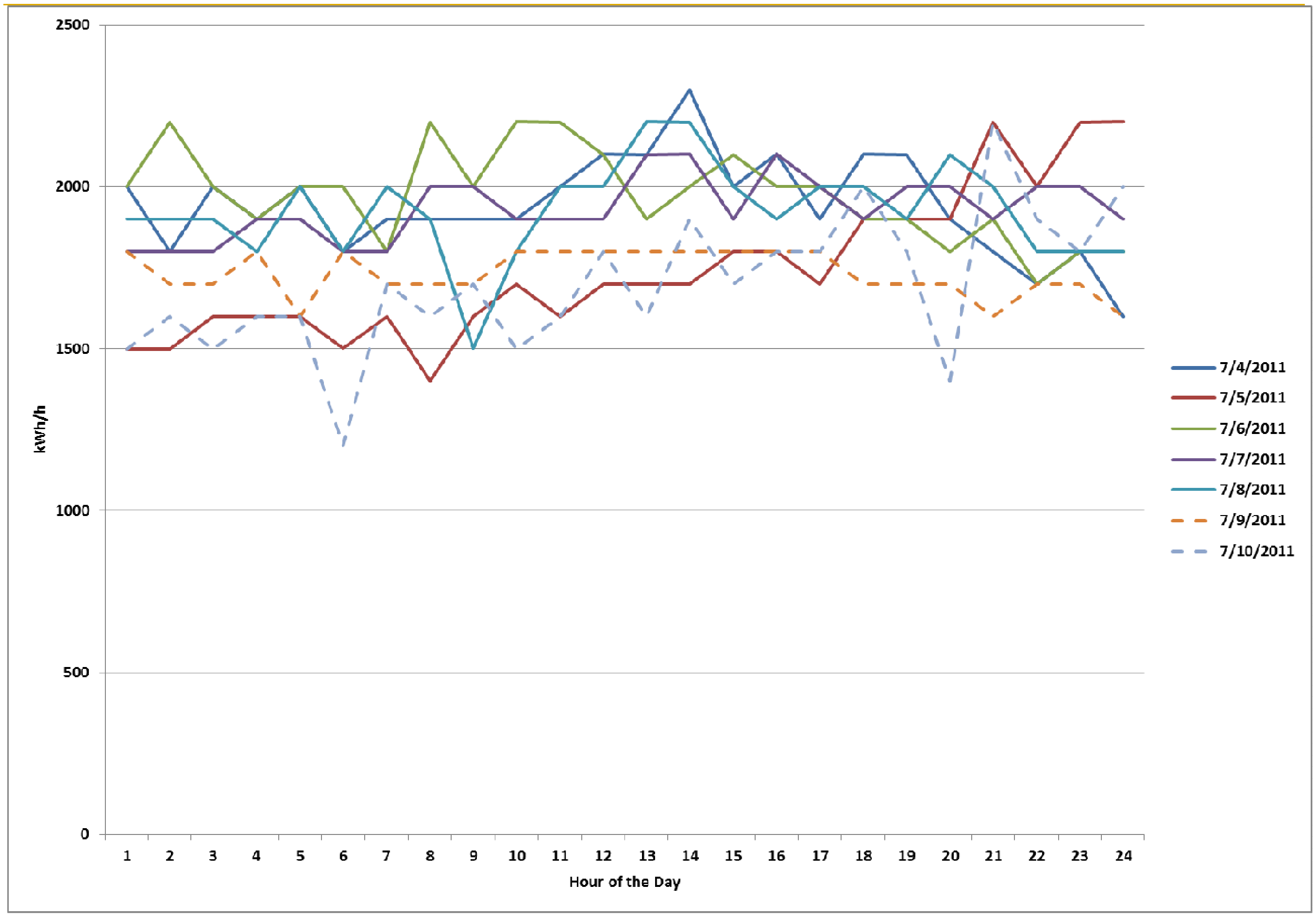


FIGURE 12 CHP POWER OUTPUT VERSUS TIME FIGURE 10

Figure 12 covers the time period from July 4 – 10, 2011 providing CHP system power output by hour of the day pattern for the time period. July 9 is a Saturday.

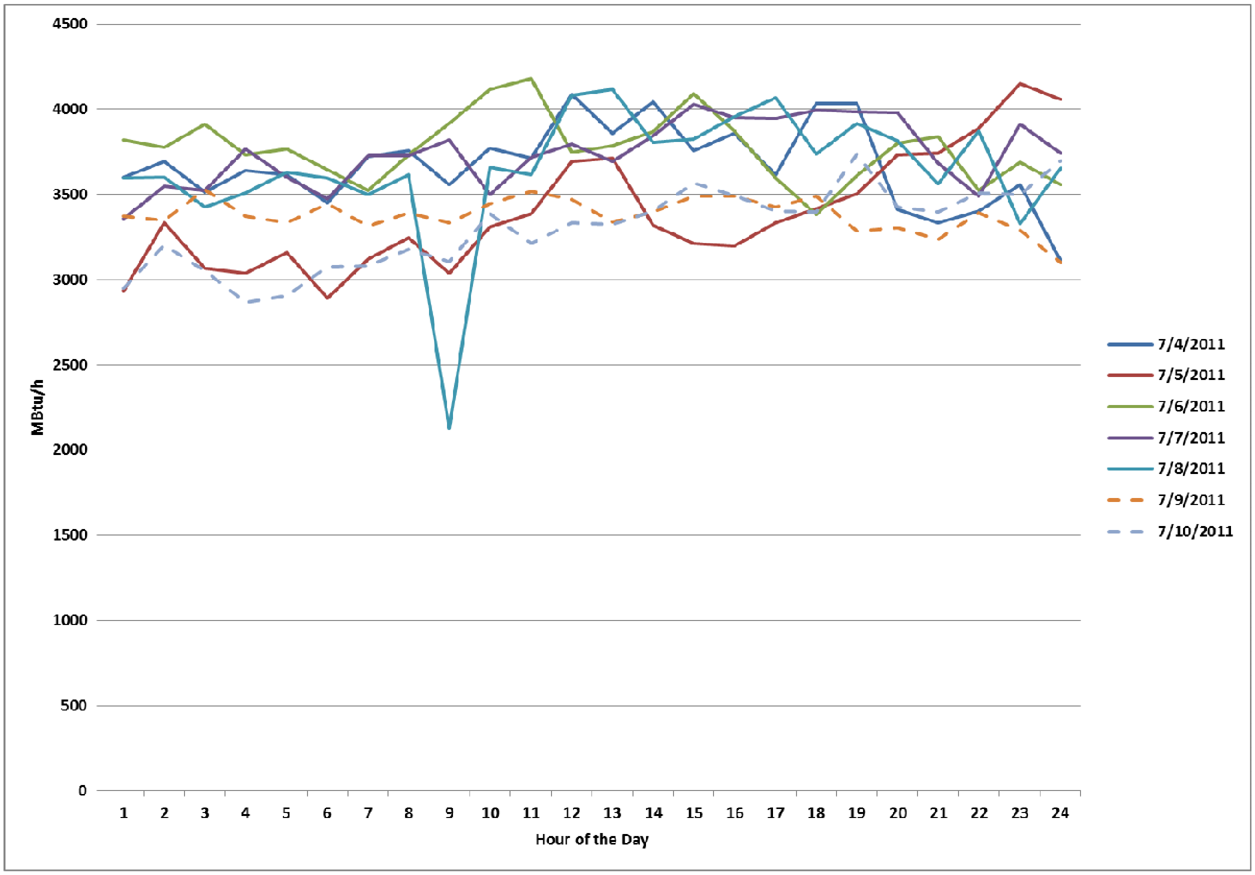


FIGURE 13 CHP USEFUL THERMAL OUTPUT VERSUS TIME

The 24 hour useful CHP recovered heat thermal load profiles from July 4 – 10, 2011. Figure 13 shows consistent summertime thermal loading 24 x 7. July 9 is a Saturday.

PERFORMANCE SUMMARY

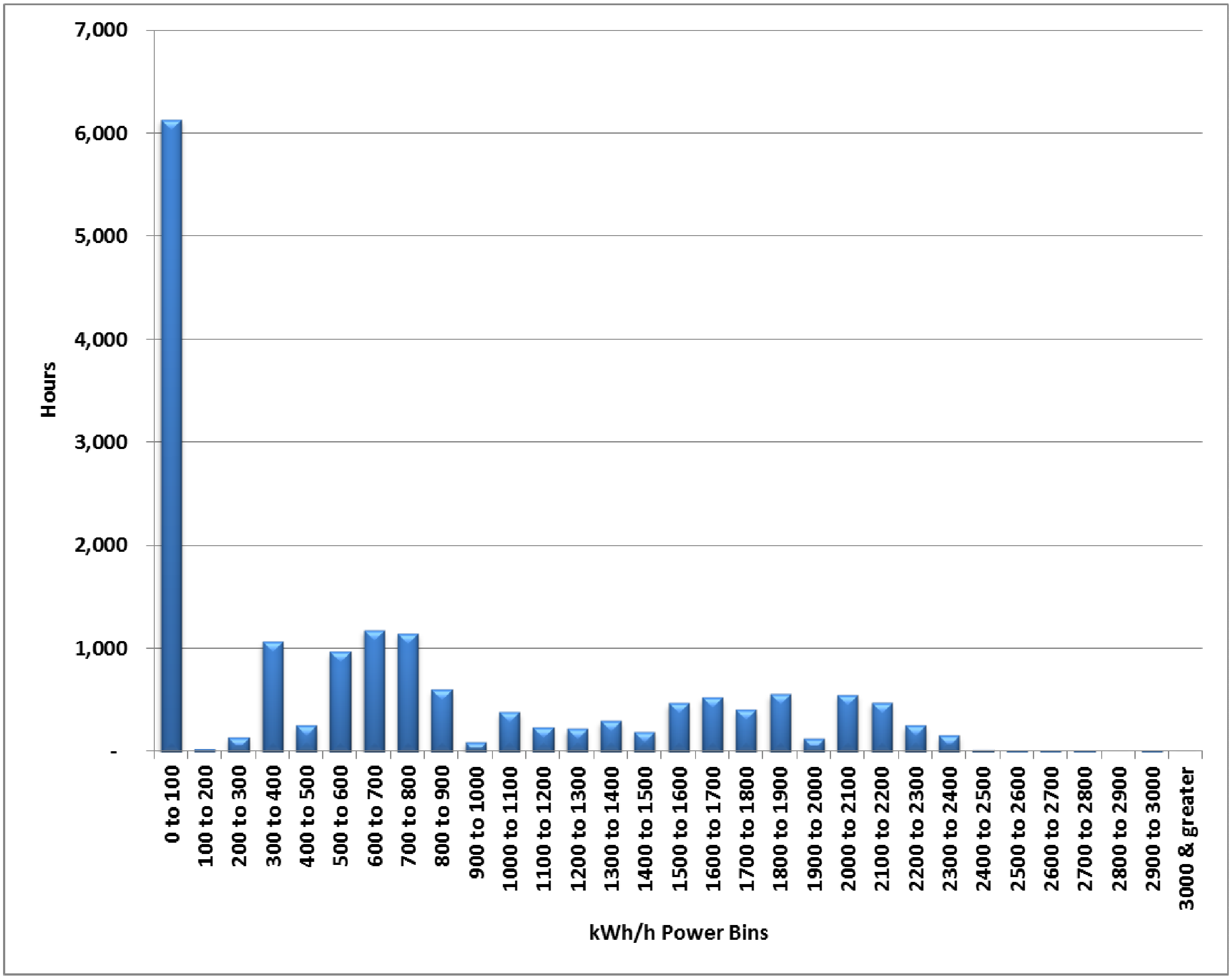


FIGURE 14 OPERATING HOURS BY POWER BINS

During the 16,474 operating hours between June 2009 and July 2011 that met the range and relational checks 23.6% of this time, the CHP system delivered between 500 and 900 kWh/h (Figure 14). 70.3% of the time the system operated under 1 MW and 37.2% of the time the system operated under 100 kWh/h or not at all.

LESSONS LEARNED

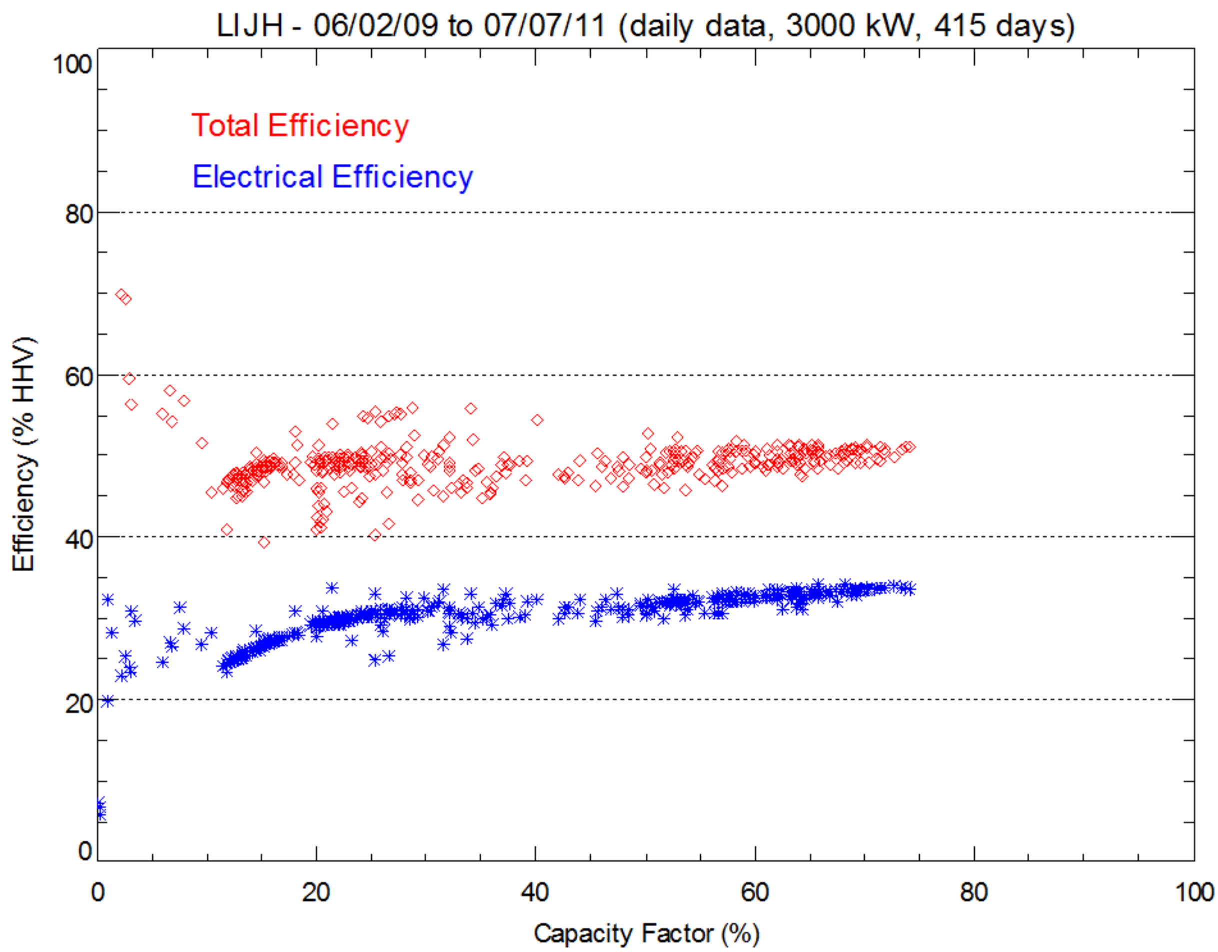
TABLE 2 SYSTEM EFFICIENCY[2]

	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
June-09	708	1,150,700	11,711	1,944	32.9%	16.3%	49.2%
July-09	744	1,329,300	13,217	2,345	33.7%	17.4%	51.1%
August-09	744	1,511,201	14,934	2,617	33.9%	17.2%	51.0%
September-09	720	1,142,000	11,604	1,993	32.9%	16.8%	49.8%
October-09	744	696,600	7,442	1,331	31.3%	17.5%	48.9%
November-09	718	512,501	5,666	1,126	30.3%	19.5%	49.8%
December-09	744	419,600	4,875	994	28.8%	20.0%	48.8%
January-10	719	326,000	4,013	876	27.2%	21.4%	48.6%
February-10	672	202,299	2,617	661	25.9%	24.7%	50.6%
March-10	743	199,500	2,459	686	27.1%	27.4%	54.5%
April-10							
May-10							
June-10							
July-10	744	65,900	801	440	27.5%	53.8%	81.3%
August-10	672	1,600	24	278	22.5%	--	--
September-10	287	206,500	2,297	447	30.1%	19.1%	49.2%
October-10	502	158,800	1,814	454	29.3%	24.5%	53.8%
November-10	646	435,900	4,853	929	30.1%	18.8%	48.8%
December-10	405	166,901	2,001	318	27.9%	15.6%	43.5%
January-11							
February-11	600	8,700	95	768	30.7%	--	--
March-11	380	152,499	1,659	504	30.8%	29.8%	60.5%
April-11	479	512,199	5,560	1,124	30.8%	19.8%	50.6%
May-11	524	694,800	7,505	1,324	31.0%	17.3%	48.3%
June-11	597	959,300	9,942	1,968	32.3%	19.4%	51.7%
July-11	575	696,000	7,416	1,428	31.4%	18.9%	50.3%
Total preceding 12 months	**6,291**	**3,993,201**	**43,166**	**10,195**	**31.0%**	**23.2%**	**54.1%**

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

The CHP System consists of two 1,425-kW GE Jenbacher J420 GS natural-gas-fueled reciprocating engine driven electric generating units. One of the engines serves as a stand-by unit. The electric power generated by the engines will be used solely to power the central plant's cooling and steam generating systems and their respective auxiliary components, including all the pumps, cooling towers, electric chillers, boilers, and fans. Thermal energy is recovered from each of the engine blocks and from a heat recovery silencer on each of the engines' exhaust systems. The recovered heat is used to preheat the steam system condensate returning from the campus and to drive a single stage absorption chiller. The exhaust heat exchanger on each engine produces steam.

[2] 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.



15 CAPACITY FACTOR[3]

Capacity Factor (Figure 15) presents the CHP generated power efficiency over the time period (415 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 31.0% power efficiency (HHV). The useful thermal energy for boiler feedwater preheating and for a single effect absorption chiller operates when required by the thermal load. The heat recovery system is 23.2% thermal efficient (HHV).

The medical center was required by the electric utility to install the system as an island. Therefore, the system could not export to the grid or even the remainder of the medical campus. The capacity curve follows the electric demand curve of the electric power generated by the engines will be used solely to power the central plant's cooling and steam generating systems and their respective auxiliary components, including all the pumps, cooling towers, electric chillers, boilers, and fans.

[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 data for Generator Output comes from an accumulator of power use throughout the day. The columns of origin for this data point are labeled "LIJ.GEG.CG.1:TOT ACT OUT" and "LIJ.GEG.CG.2:TOT ACT OUT" in the data files received from WSP Flack + Kurtz. The difference between consecutive records is calculated for the energy use during the interval. 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 an accumulator of gas use throughout the day. The column of origin for this data point is labeled "EC.GEN.GAS.METER" in the data files received from WSP Flack + Kurtz. The difference between consecutive records is calculated for the gas use during the interval. This 15-minute interval gas data is summed into hourly data.
3. **Useful Heat Recovery (total MBtu)** The Useful Heat Recovery comes from 15-minute data. The total heat recovery for the system is calculated as follows:
    a. QHR =E*(G1SF +G2SF)+K*(G1WRF*(G1WST-G1WRT)+G2WRF*(G2WST-G2WRT)
    b. QHR = Total Heat Recovery
    c. E = 1000. Btu/lb
    d. K = 438
    e. G1SF = Steam flow from generator 1
    f. G2SF = Steam flow from generator 2
    g. G1WRF = Cogen 1 water flow rate
    h. G1WST = Cogen 1 water supply temperature
    i. G1WRT = Cogen 1 water return temperature
    j. G2WRF = Cogen 2 water flow rate
    k. G2WST = Cogen 2 water supply temperature
    l. G2WRT = Cogen 2 water return temperature

    The resulting 15-minute data is averaged into hourly data. (See table 4 for point names in raw data file)

The data at this site is provided by a third party in the form of comma-separated value (CSV) files. There is one file for each day containing 15-minute data for 41 data points. From these 15 minute values, the hourly database is formed. It is unclear whether the 15-minute data is sampled or averaged across the interval. It is also unclear whether the heat recovery rates are integrated across the 15-minute interval, averaged or sampled. The details for each individual data point are outlined below.

This particular site uses manual data collection resulting in significant data gaps. Table 3 provides insight into the data quality. The default value for poor or missing data is zero; therefore, monthly summary data with low percentage of useful data causes distortions in reported results.

TABLE 3 DATA QUALITY

	Percentage of Good Data		
	Power	**Gas Use**	**Useful Heat**
June-09	98.3%	99.9%	99.7%
July-09	100.0%	100.0%	100.0%
August-09	100.0%	100.0%	100.0%

September-09	100.0%	99.7%	100.0%
October-09	100.0%	99.9%	100.0%
November-09	99.7%	99.7%	100.0%
December-09	100.0%	100.0%	100.0%
January-10	99.0%	99.0%	99.2%
February-10	100.0%	100.0%	99.9%
March-10	100.0%	100.0%	100.0%
April-10	100.0%	100.0%	99.9%
May-10	100.0%	100.0%	99.9%
June-10	100.0%	100.0%	100.0%
July-10	100.0%	100.0%	100.0%
August-10	90.4%	90.4%	90.4%
September-10	39.9%	39.9%	40.0%
October-10	67.5%	67.3%	67.7%
November-10	89.7%	89.7%	89.7%
December-10	54.5%	57.6%	54.8%
January-11	83.9%	83.9%	83.9%
February-11	89.3%	89.3%	89.3%
March-11	51.1%	51.1%	51.6%
April-11	66.5%	66.4%	66.7%
May-11	70.4%	70.4%	71.0%
June-11	82.9%	82.8%	83.3%
July-11	79.3%	79.3%	79.3%

There appears to be no correlation between data availability and reported fuel use and system energy outputs at this site. However, there is a clear correlation between power generation, fuel usage and useful thermal energy.

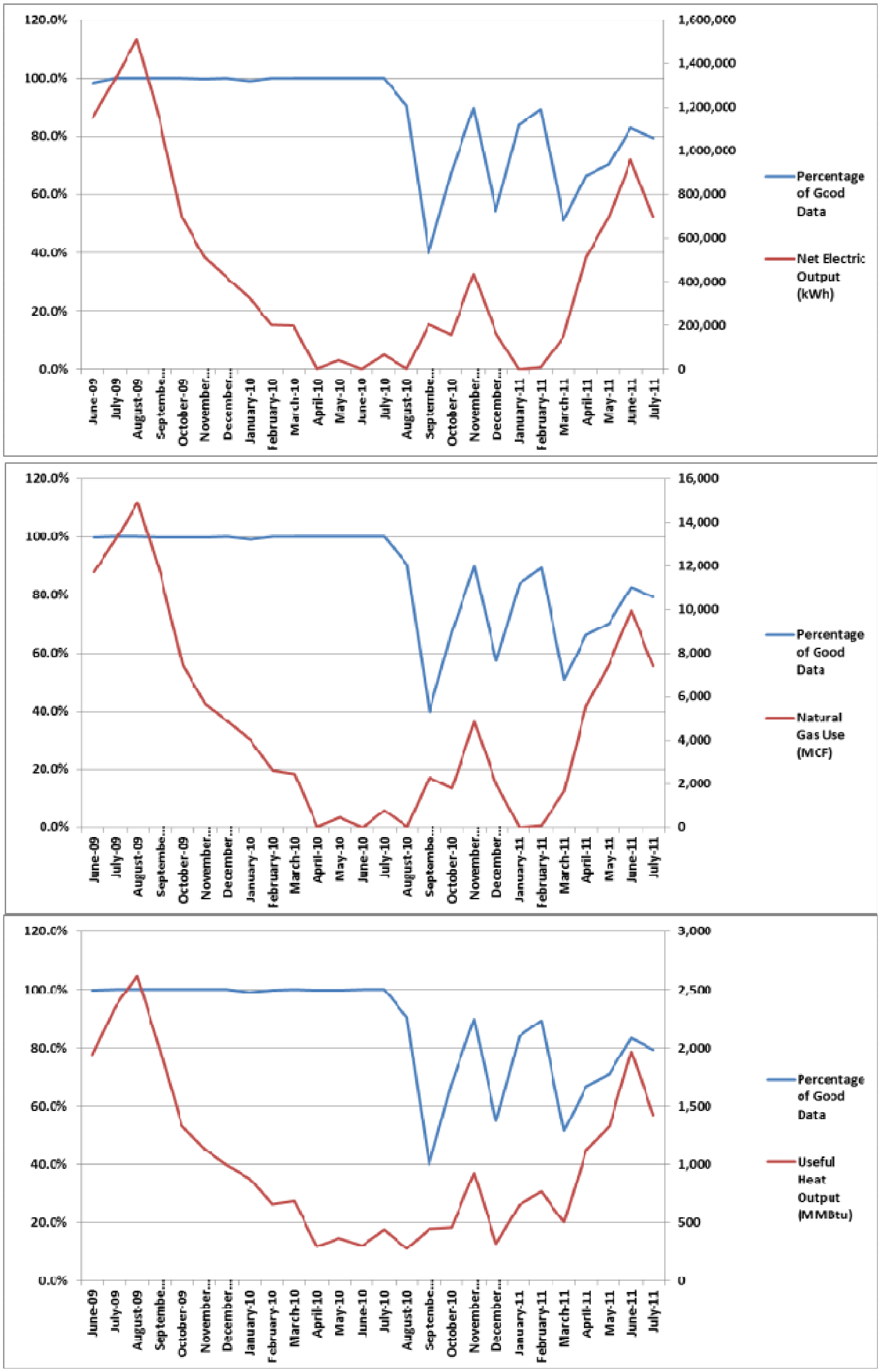


FIGURE 16 CORRELATION BETWEEN DATA QUALITY, KWH, FUEL AND USEFUL HEAT