NYSERDA CHP Assessment Report

ASSESSING THE CHP PLANT AT FONDA FULTONVILLE CSD

October 9, 2013

Fonda Fultonville CSD

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.

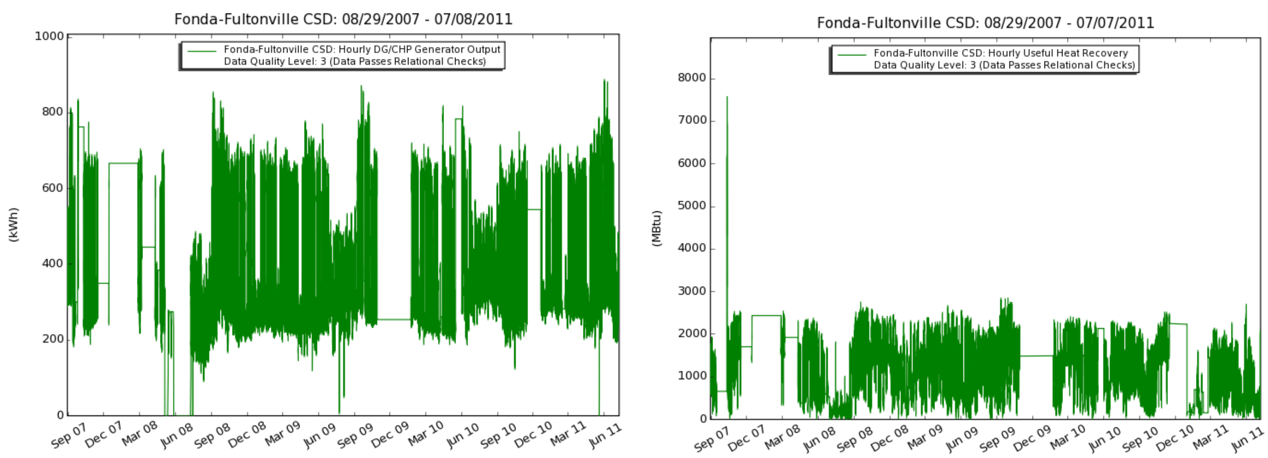

FIGURE 1 NYSERDA CHP WEBSITE PERFORMANCE GRAPHS

This report provides 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 FONDA-FULTONVILLE CENTRAL SCHOOL DISTRICT COMPLEX

The Fonda-Fultonville Central School District provides educational services for grades K-12 on a single campus. Operating the facility creates an electric load that can approach 1 MW. Rising energy prices forced the school to consider various energy conservation measures (ECMs) including CHP technologies.

Like any other business, schools strive to minimize the cost of incidentals that divert resources from primary needs. Unpredictable increases in energy costs can be particularly disruptive to schools operating on fixed annual budgets. Fonda-Fultonville was particularly sensitive to the cost incurred for electricity and sought means to limit the impact of rising rates.

THE SYSTEM

Fonda-Fultonville installed a CHP system configured on four identical, natural gas fueled engine-generator sets. A fifth, large diesel generator provides backup power. The school now generates all of its own electricity and has disconnected from the utility grid.

The district worked with Atlantic Energy Services, Inc. to develop a CHP project that ultimately led to the school becoming independent of the utility grid. This was done through an energy services performance contract that guaranteed Fonda-Fultonville a minimum monetary savings. The resulting plant was configured on multiple engine-generator sets having a combined capacity of 1,320 kW. All of the school's electricity is now generated onsite. Heat recovered from the engines provides seasonal space heating and cooling.

FIGURE 3 ENGINE-GENERATORS IN SOUND ATTENUATION ENCLOSURES

Fonda-Fultonville's CHP system is configured on four 330 kW, natural gas fueled engine-generator sets. A separate 1,000 kW diesel generator was installed as backup. The plant operates independent of the utility grid; no electricity is purchased or exported from the site. Automatic controls sequence the operation of each generator and modulate the electrical output to match the load. Waste heat from the engine coolant jackets and exhaust is recovered in a common hot water loop. The heat can be used directly to offset the thermal load on the existing boiler plant or diverted to a 250 ton absorption machine that produces chilled water for air conditioning. Excess heat can be rejected to ambient through individual radiators when the school's thermal load is at a minimum.

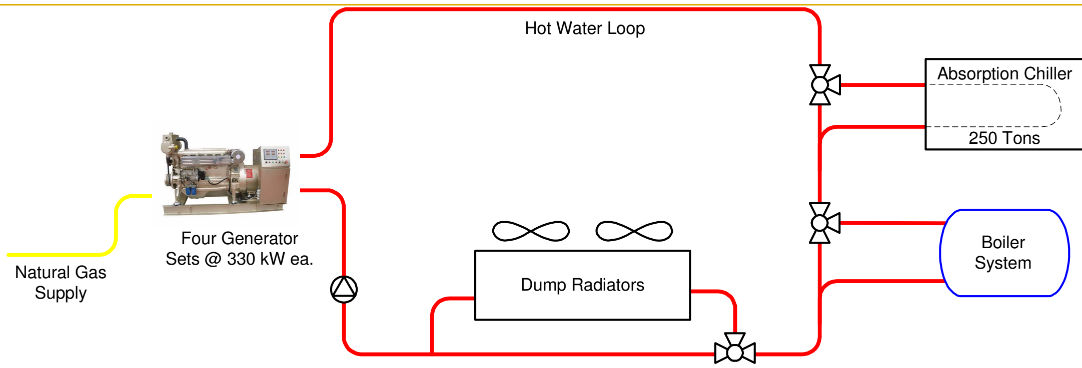

FIGURE 4 SIMPLIFIED SYSTEM SCHEMATIC

FIGURE 5 EXHAUST HEAT RECOVERY UNIT AT REAR OF ENGINE

FIGURE 6 ABSORPTION CHILLER PROVIDES AIR CONDITIONING

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 provides the data results taken since January 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
January-10	203	74,844	701.1	184.0	35.7%	25.7%	61.4%
February-10	648	221,218	2,057.0	559.4	36.0%	26.7%	62.6%
March-10	614	224,409	2,085.8	920.9	36.0%	43.3%	79.3%
April-10	528	187,887	1,798.2	652.1	35.0%	35.6%	70.5%
May-10	344	121,151	1,201.4	355.3	33.7%	29.0%	62.7%
June-10	598	237,928	2,409.2	593.3	33.0%	24.1%	57.2%
July-10	744	270,177	2,950.4	935.1	30.6%	31.1%	61.7%
August-10	744	267,042	2,799.4	952.5	31.9%	33.4%	65.3%
September-10	720	261,581	2,804.8	426.8	31.2%	14.9%	46.1%
October-10	744	251,998	2,523.6	963.8	33.4%	37.4%	70.9%
November-10	375	135,934	1,328.5	649.1	34.2%	47.9%	82.1%
December-10	240	77,270	1,017.0	0.1	25.4%	0.0%	25.4%
January-11	744	284,528	2,868.0	69.8	33.2%	2.4%	35.6%
February-11	496	177,754	1,939.1	16.6	30.7%	0.8%	31.5%
March-11	720	277,253	2,889.0	333.9	32.1%	11.3%	43.4%
April-11	720	248,304	2,530.3	596.0	32.8%	23.1%	55.9%
May-11	744	286,573	3,224.6	385.1	29.7%	11.7%	41.4%
June-11	720	301,468	3,386.1	370.4	29.8%	10.7%	40.5%
July-11	743	236,144	2,605.7	363.0	30.3%	13.7%	44.0%
Total preceding 12 months	**7710**	**2,805,849**	**29,916.0**	**5,127.0**	**31.4%**	**16.8%**	**48.2%**

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.

OPERATING SUMMARY

This school operates year-round. However, it should be noted that this upstate school has only modest cooling loads during the summer. Unfortunately, the thermal data quality needs to be improved for 2011 to fully determine this performance metric. Data from the CHP system showed Fuel Conversion Efficiency ranging between 57% and 82% between January and November of 2010. After that time the useful thermal energy data dropped dramatically.

FIGURE 7 CHP SYSTEM EFFICIENCY BY YEAR

POWER GENERATION AND USEFUL THERMAL ENERGY

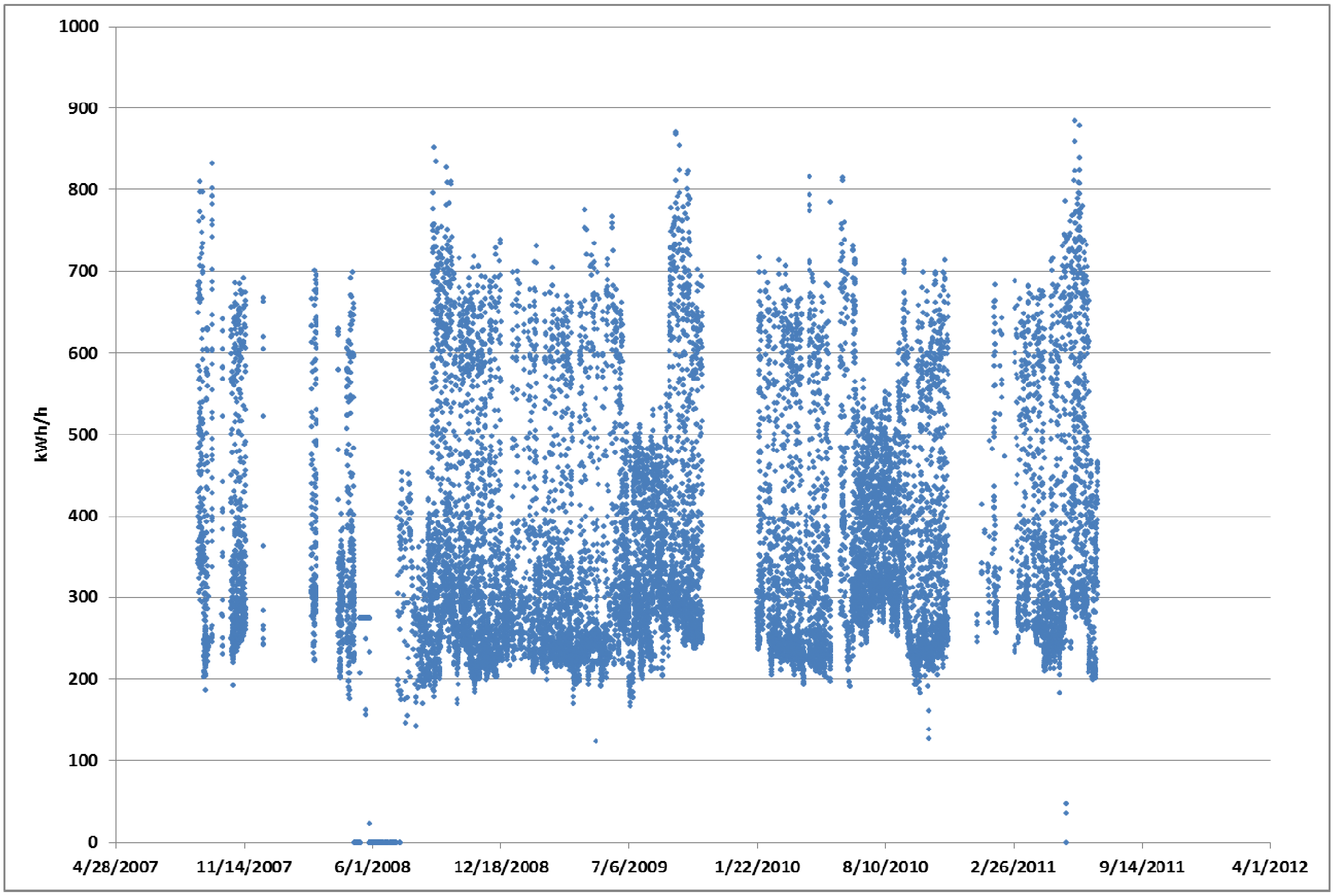

FIGURE 8 CHP POWER OUTPUT VERSUS TIME (KWH/H)

Figure 8 shows a general operating pattern indicating 24/7 operation of at least one generator except for certain periods where the data indicated the system is not operating.

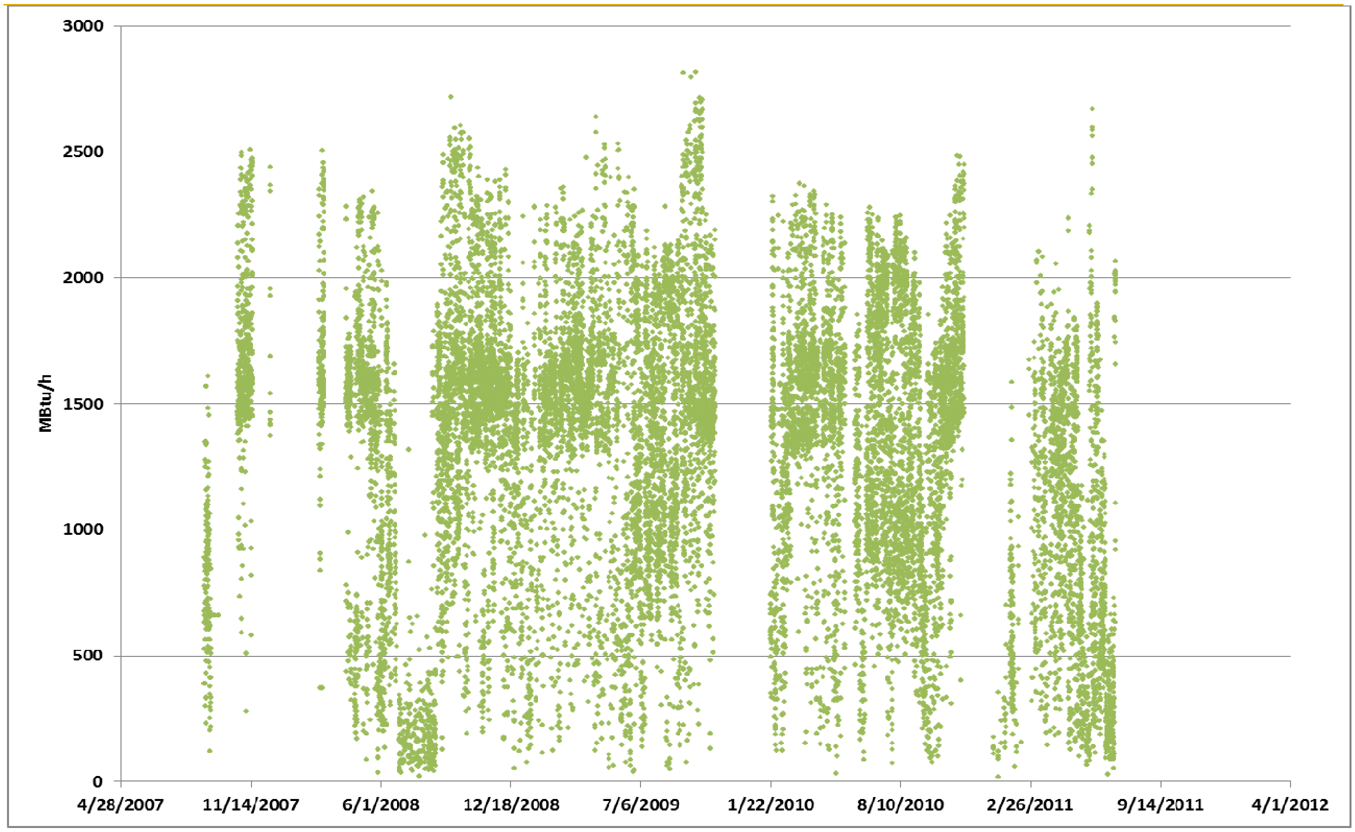

FIGURE 9 CHP USEFUL THERMAL OUTPUT VERSUS TIME (MBTU/HR)

Figure 9 shows a general under loading of the available thermal energy.

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

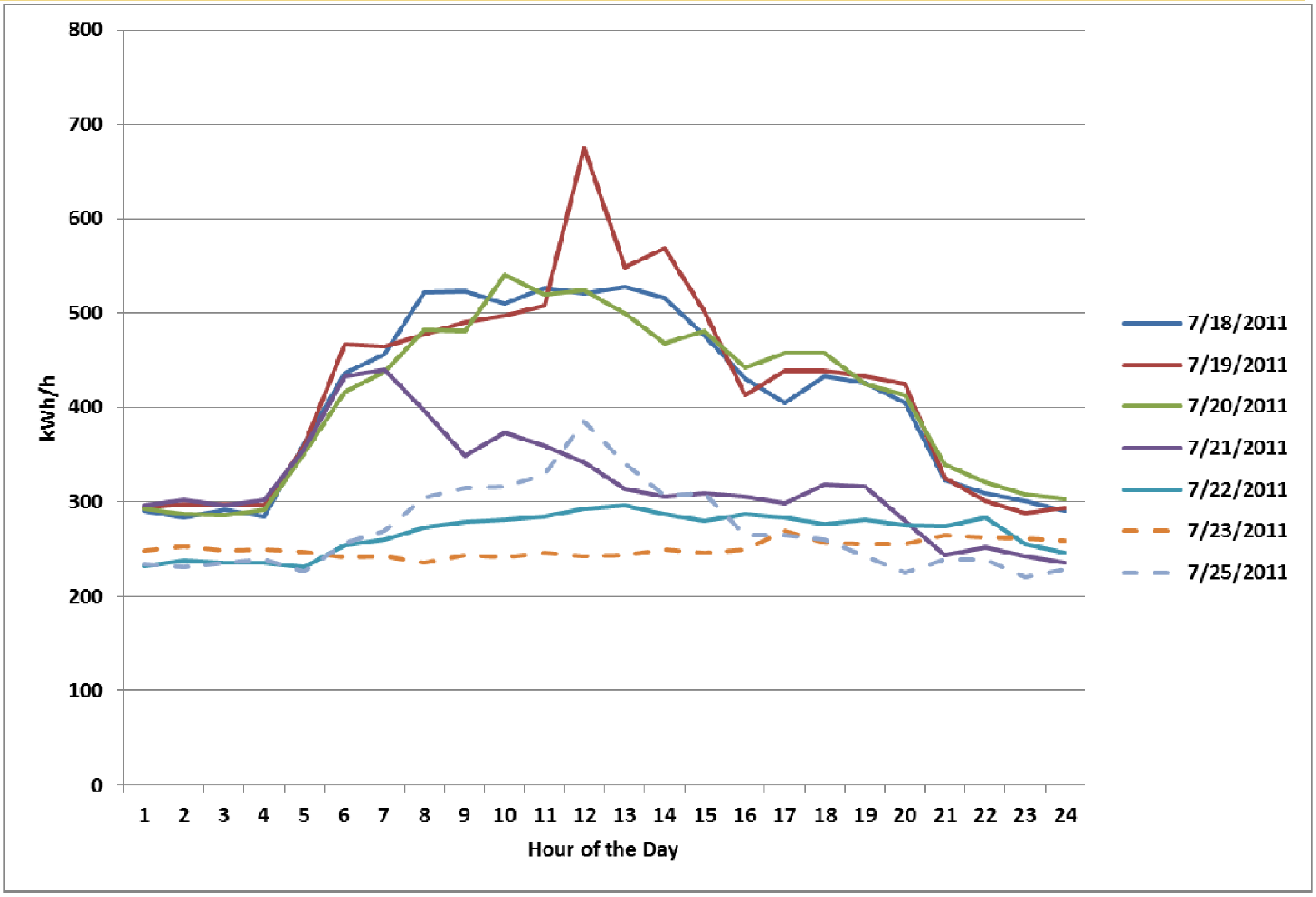

FIGURE 10 CHP POWER OUTPUT VERSUS TIME

Figure 10 covers the time period from July 18 – 25, 2011 providing CHP system power output by hour of the day pattern for the time period. July 23 is a Saturday. Figure 10 shows similar patterns for Monday-Wednesday. Thursday tapers off in the morning; Friday is lightly loaded as is the weekend. Examining the useful thermal pattern for the same week confirms that the system is not following the thermal load (see Figure 11). Figure 8 shows several data acquisition gaps in the early morning and late night hours of the day.

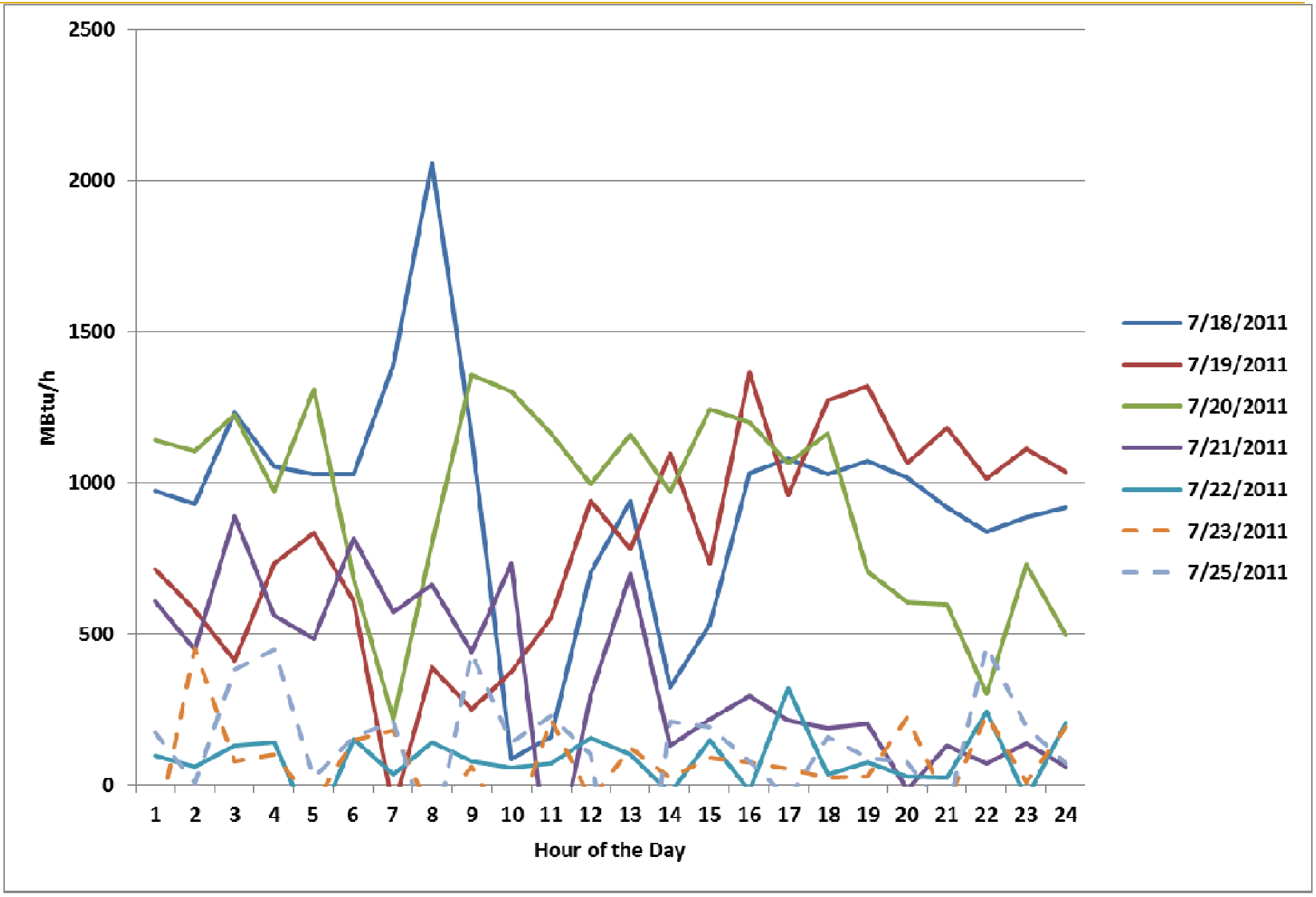

FIGURE 11 CHP USEFUL THERMAL OUTPUT VERSUS

The 24 hour useful CHP recovered heat thermal load profiles from July 18 – 25, 2011 (Figure 11) indicate a domestic hot water and cooling load is being served by the absorption chiller on weekdays and likely only domestic hot water is serviced on the weekend. (July 23 is Saturday) It should be noted that the thermal data quality is low for this month. This school district complex operates year-round, but loads are modest in the summer.

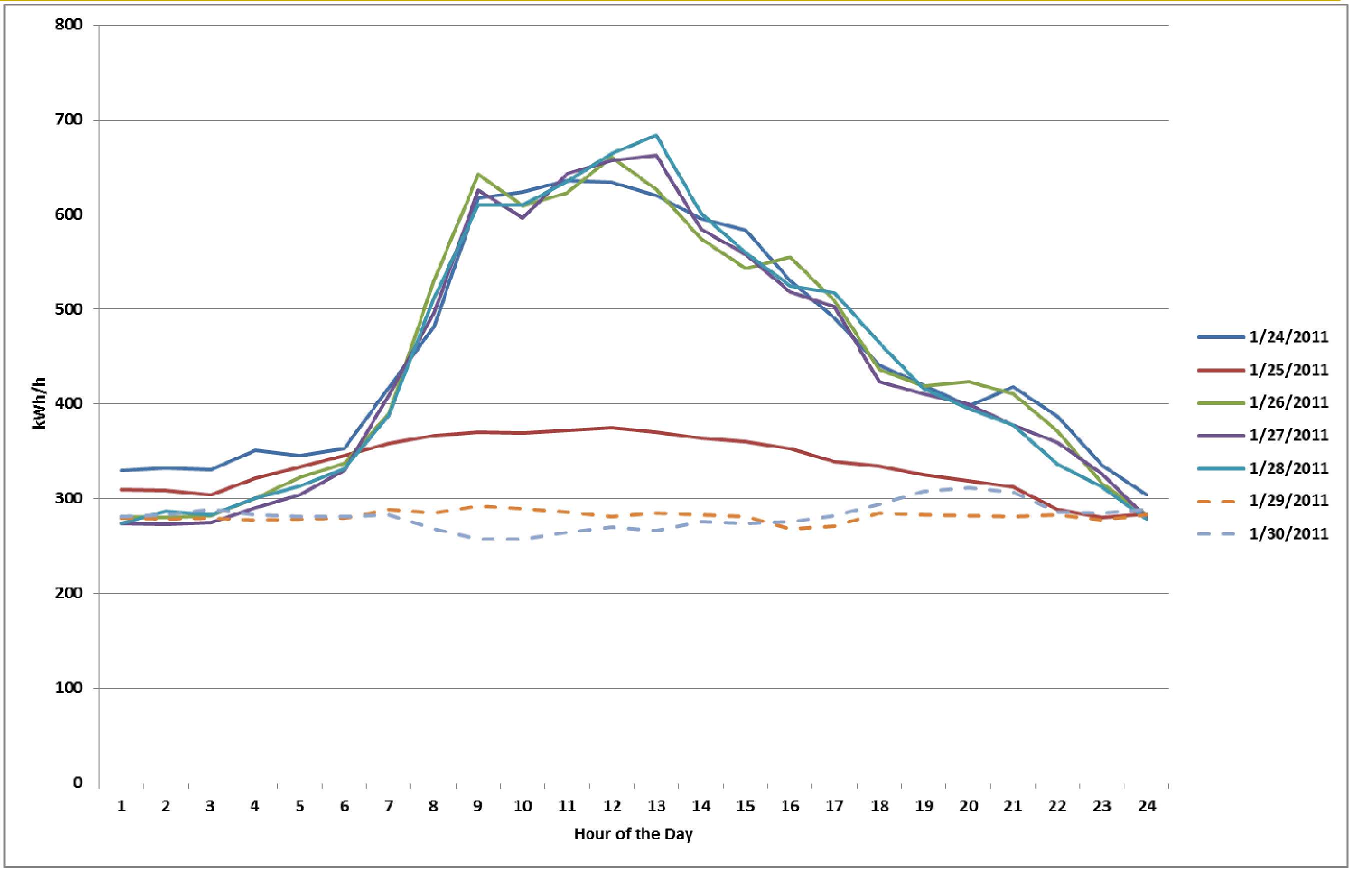

FIGURE 12 CHP POWER OUTPUT VERSUS TIME

Figure 12 covers the time period from January 24–30, 2011 providing CHP system power output by hour of the day pattern for the time period. January 29 is a Saturday. Figure 12 shows Monday, Wednesday, Thursday and Friday with a power loading typical of an operating school. Tuesday and on the weekend it appears that one engine is fully loaded all day. The usage patterns confirm electric load following. Examining the useful thermal pattern for the same week provides little information regarding the useful thermal heat because of the limited data quality (Figure 13).

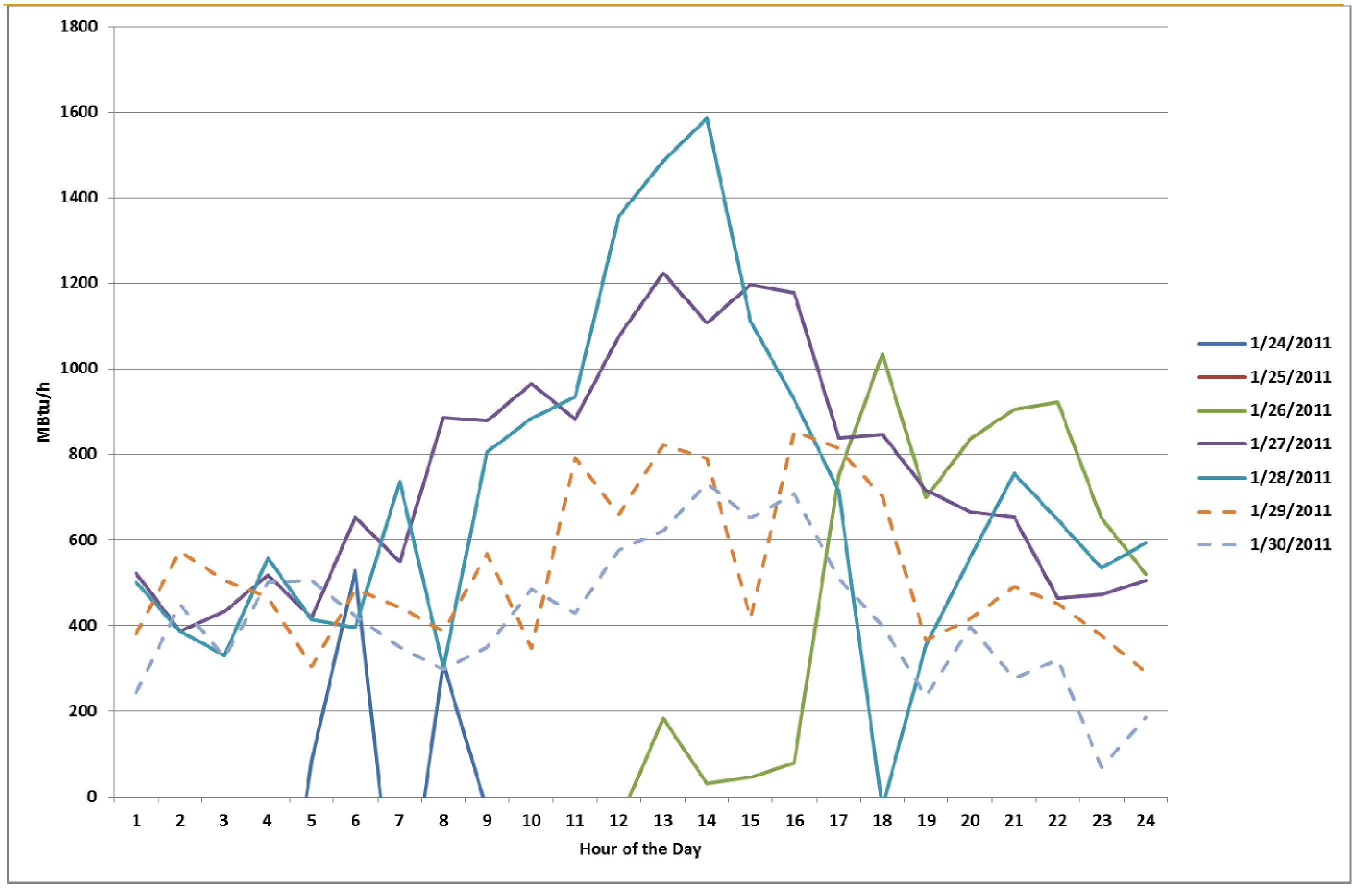

FIGURE 13 CHP USEFUL THERMAL OUTPUT VERSUS TIME

The 24 hour useful CHP recovered heat thermal load profiles from January 24-30, 2011 (Figure 13) show a very inconsistent thermal load pattern which is largely due to the poor thermal data quality at this site.

PERFORMANCE SUMMARY

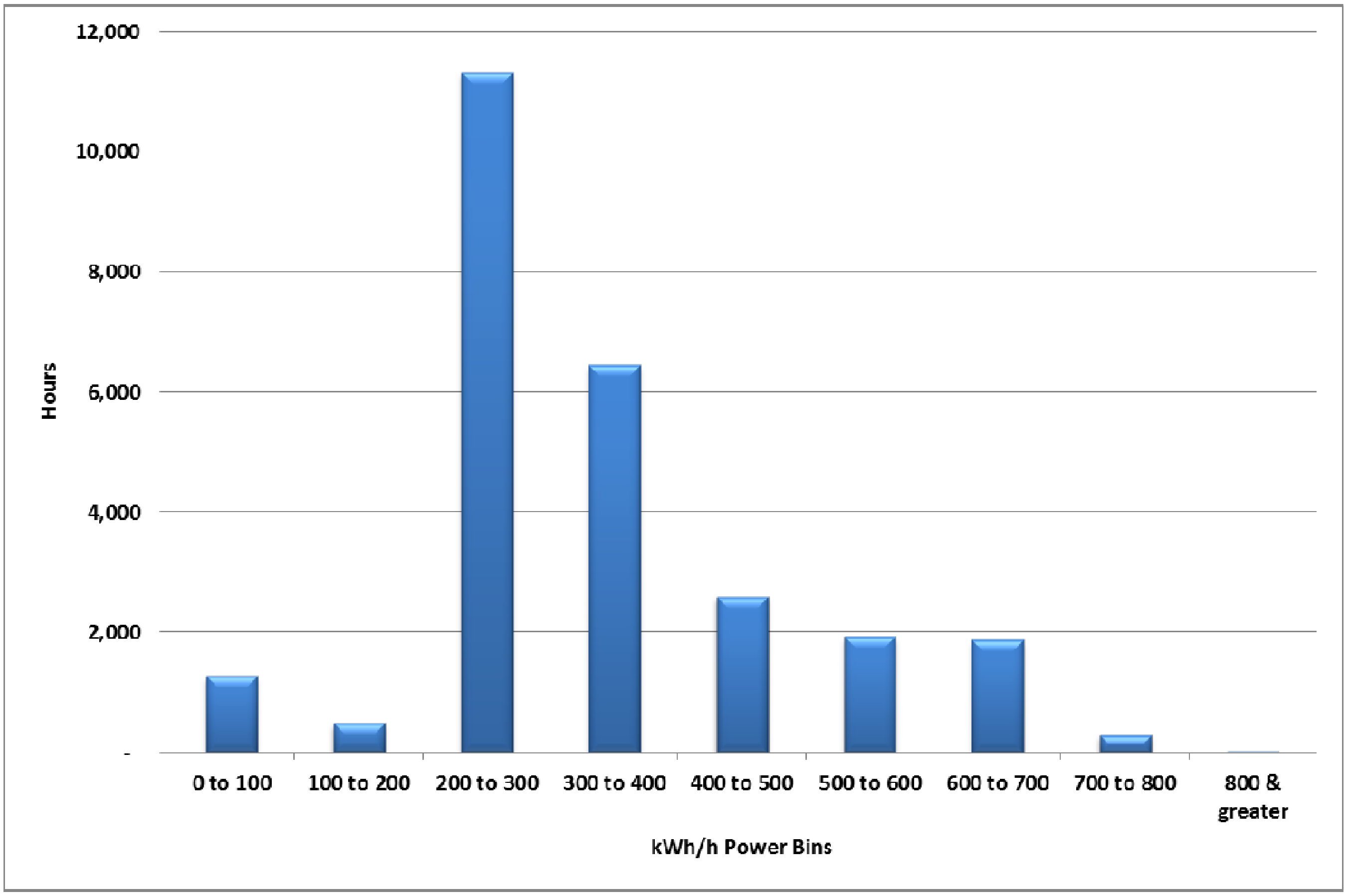

FIGURE 14 PERFORMANCE BY POWER BINS

During the 26,259 hours that met the range and relational checks 93.3% of this time, the CHP system delivered greater than 200 kWh/h (Figure 14). 43.1% of the time the system delivered between 300 and 400 kWh/h which could be accomplished by one of the four engines.

TABLE 2 SYSTEM EFFICIENCY[2]

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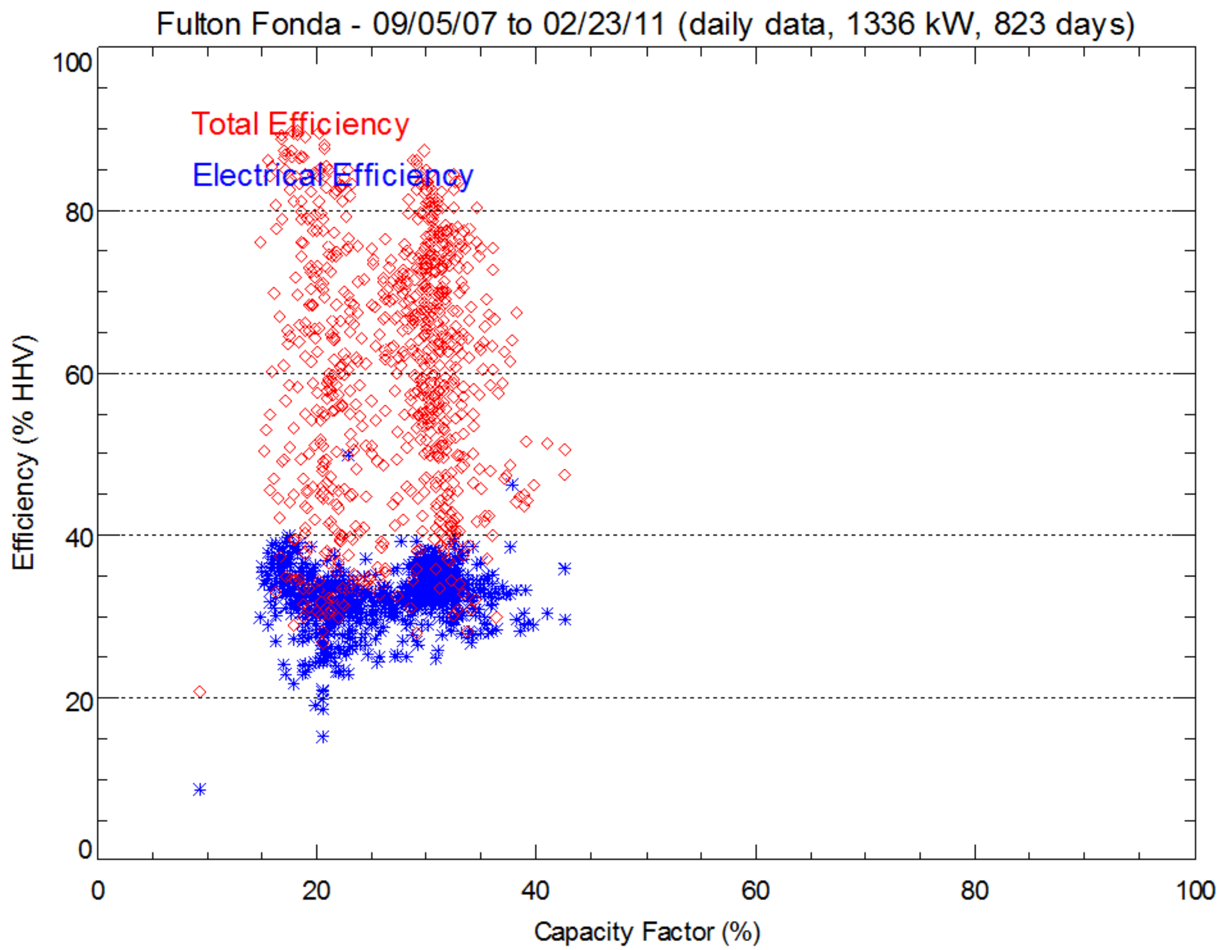

FIGURE 15 CAPACITY FACTOR[3]

Capacity Factor (Figure 15) presents the CHP generated power efficiency over the time period (823 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 operated between 15% and 40% of the generating capacity at about 31.4% power efficiency (HHV). This system is grid independent and is designed to meet the electric load. Note the double camel hump in electric efficiency clearly showing performance clustering around the two engine generators that are operating. Operating less that 40% of system capacity indicates that the site has N+2 units installed which might be considered over capacity. The useful thermal energy (heating and cooling) operates coincidently when power demand is required which accounts for the average 16.8% thermal efficiency (HHV). Note the heat recovery for cooling during the summertime in schools is generally limited to staff offices, events and summer school, if provided by the district, yielding limited cooling requirements.

[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

When CHP systems are used to provide power independent from the grid, the utilization of the available capacity (i.e., load factor) is typically poor. The FCE typically suffers because the system was sized to meet electrical not thermal needs.

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 Wattnode power transducers are installed on-site to measure the net generator power. One transducer measures the gross power output of the eight engines and the other two measure parasitic loads associated with the power generation. The difference between the gross power and the parasitic power is calculated on a 15-minute interval. 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. The meter has a resolution of 1000 ft^3 making the data coarse on an hourly basis. The data for this channel is best viewed on a daily basis.
3. **Useful Heat Recovery (total MBtu)** The Useful Heat Recovery is calculated from loop temperature and flow averages on a 15-minute interval. The heat recovery rate is calculated by taking the temperature difference between the loop leaving the engines and before the dump radiator (in °F) is then multiplied by the flow rate (in gpm) and the heating content factor for pure water (0.488 Btu/h-F-gpm). The 15-minute heat recovery rate is averaged for the hourly data.

Data from the CHP system showed Fuel Conversion Efficiency ranging between 57% and 82% between January and November of 2010. After that time the useful thermal energy data dropped dramatically.

TABLE 3 SITE DATA QUALITY

	Percentage of Good Data		
	Power	Gas Use	Useful Heat
January-10	27.7%	27.7%	22.3%
February-10	96.4%	96.3%	63.5%
March-10	84.1%	84.0%	77.9%
April-10	77.2%	77.2%	64.9%
May-10	49.7%	49.7%	38.9%
June-10	86.8%	86.6%	68.2%
July-10	100.0%	100.0%	89.5%
August-10	100.0%	99.9%	91.0%
September-10	100.0%	99.9%	57.8%
October-10	100.0%	99.7%	91.5%
November-10	52.1%	51.7%	51.8%
December-10	33.1%	33.1%	0.1%
January-11	100.0%	100.0%	17.1%
February-11	78.4%	78.4%	3.8%
March-11	96.8%	96.6%	39.7%
April-11	100.0%	100.0%	69.2%
May-11	100.0%	100.0%	57.0%
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