MEASUREMENT AND VERIFICATION PLAN

FOR

GATEWAY ONE BUILDING

Draft

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Submitted to:

New York State Energy Research and Development Authority
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1. Introduction

The Gateway One CHP System is located at One N Lexington Ave, White Plains, NY. This 530,000-square-foot, Class A office building is located across from the White Plains Metro-North Train Station in downtown White Plains.

The system includes one (1) Caterpillar natural gas fired engine-generator set with a rated output of 2,055 kW. The synchronous generator provides power to the building's three (3) electrical services through three (3) inverter-based power converter modules. The heat from the engine jacket and the exhaust heat exchanger is recovered by a heat recovery loop to meet building loads. The heat recovery loop circulates 550 gpm of hot water to a 500 ton absorption chiller and to a heat exchanger that serves the building's hot water heating system. Heat is used by the absorption chiller during the summer months and transferred to the building heating system in the winter and swing seasons. A dump heat exchanger rejects unneeded heat to the building's cooling tower system. The dump heat exchanger is controlled to maintain an acceptable return water temperature back to the engine.

Measured data will be collected at 15-minute intervals on this system to meet the requirements of the NYSERDA performance-based CHP program. This data will allow NYSERDA to provide the basis for the performance-based incentive payments under this program. The collected data will be loaded into the NYSERDA CHP database (chp.nyserda.ny.gov) over the two (2) year performance period. The data will be analyzed to confirm:

- The energy production and power output during the summer peak demand period meets the program requirements,
- The thermal and power output meet the requirements of 60% LHV fuel conversion efficiency (FCE) as defined in the NYSERDA CHP Systems Manual.

2. Data Collection and Instrumentation

The SCADA system at the site will be used to collect the required data. The system includes an OSISoft PI Historian at the site that gathers more than 400 points from the control system. Table 1 lists the data points required to quantify system performance. The schematics given in Figure 1 through Figure 4 indicate the locations of the data points in the system. The narrative below explains how these data points will be used to track and quantify system performance.

Figure 1 shows the main components of the CHP heat recovery system. The temperatures throughout the heat recovery loops (**TLS**, **TLR1**, **TLR2**, **TLR3**, **TLR4**, **TLR5**) can be used with the primary and secondary loop flow rates (**FL1**, **FL2**) to determine the useful thermal energy supplied by the engine. The chilled water temperatures and flow rate (**CHW_TLS**, **CHW_TLR**, **CHW_FL**) and the cooling output (**CHW_Q**) from the BTU meter will be used to evaluate and confirm the capacity and efficiency of the chiller. The building hot water loop measurements (**HHW_TLS**, **HHW_TLR**, **HHW_FL, HHW_Q**) provide a check to confirm total useful heat recovery measured on the secondary loop side.

Table 1. Monitored Data Points Required to Quantify Performance

No.	Data Point	Description	Units	Historian Address	Historian Tag / Description	Instrument / Sensor
1	FG_ACC	Natural Gas Flow (Accumulator)	CF	40010 Bit:4	FT-NG14 FLOW PULSE	Utility Pulse
2	WC1_kW	Power out of Power Converter 1	kW	40735	Watts - 3ph Total	IQ260 Power Meter
3	WC2_kW	Power out of Power Converter 2	kW	40785	Watts - 3ph Total	IQ260 Power Meter
4	WC3_kW	Power out of Power Converter 3	kW	40835	Watts - 3ph Total	IQ260 Power Meter
5	WC1_ACC	Energy out of Power Converter 1 (Accumulator)	kWh	TBD	W-hours, Total	IQ260 Power Meter
6	WC2_ACC	Energy out of Power Converter 2 (Accumulator)	kWh	TBD	W-hours, Total	IQ260 Power Meter
7	WC3_ACC	Energy out of Power Converter 3 (Accumulator)	kWh	TBD	W-hours, Total	IQ260 Power Meter
8	WConv1_kW	Power Converter 1 Power Out	kW	40356	Active Pwr Out	Power Converter
9	WConv2_kW	Power Converter 2 Power Out	kW	40406	Active Pwr Out	Power Converter
10	WConv3_kW	Power Converter 3 Power Out	kW	40456	Active Pwr Out	Power Converter
11	WCI1_kW	Power in to Power Converter 1	kW	40710	Watts - 3ph Total	IQ260 Power Meter
12	WCI2_kW	Power in to Power Converter 2	kW	40760	Watts - 3ph Total	IQ260 Power Meter
13	WCI3_kW	Power in to Power Converter 3	kW	40810	Watts - 3ph Total	IQ260 Power Meter
14	WCI1_ACC	Energy in to Power Converter 1 (Accumulator)	kWh	TBD	W-hours, Total	IQ260 Power Meter
15	WCI2_ACC	Energy in to Power Converter 2 (Accumulator)	kWh	TBD	W-hours, Total	IQ260 Power Meter
16	WCI3_ACC	Energy in to Power Converter 3 (Accumulator)	kWh	TBD	W-hours, Total	IQ260 Power Meter
17	WT_kW	Total Building Demand	kW	40643	DMD KW LOW	
18	WT_ACC	Total Building Energy (Accumulator)	kWh	40651	DMD KW HOUR LOW	
19	WG_Gross_kW	Average Gross Generator Power for Interval	kW	40669	GMR KW LOW	
20	FL1	Engine HW Loop Flow Rate	gpm	40212	FT_JCW01 FLOW RATE	Onicon F-1200
21	TLS	JW Engine Supply Temperature (Engine HW Loop)	F	40210	TT_JCW07 TEMPERATURE	
22	TLR5	JW Return Temperature to Engine (Engine HW Loop)	F	40209	TT_JCW02 TEMPERATURE	
23	TLR4	JW Return Temperature to Tower (Engine HW Loop)	F	40220	TT_JCW22 TEMPERATURE	
24	FL2	Load HW Loop Flow Rate	gpm	40221	FT_JCW21 FLOW RATE	Onicon F-1200
25	TLR1	JW Silencer Supply Temperature (Load HW Loop)	F	40244	TT_JCW15 TEMPERATURE	
26	TLR2	JW Supply Temperature After Chiller (Load HW Loop)	F	40253	TT_JCW17 TEMPERATURE	
27	TLR3	JW Temperature After HX (Load HW Loop)	F	40211	TT_JCW20 TEMPERATURE	
28	HHW_Q	Building Hot Water Loop Thermal Energy Use	MBtu/h	40154	Energy Rate	
29	HHW_FL	Building Hot water BTU - HW Flow through HX1	gpm	40158	Volume Rate	Onicon F-1200
30	HHW_TLS	Building Hot water BTU - Supply Temp from HX1	degF x100	40171	Supply Temperature	
31	HHW_TLR	Building Hot water BTU - Return Temp to HX1	degF x100	40172	Return Temperature	
32	CHW_Q	Chilled Water Thermal Energy Absorbed	MBtu/h	40104	Energy Rate	
33	CHW_FL	Chilled water BTU - CHW Flow through Chiller	gpm	40108	Volume Rate	Onicon F-1200
34	CHW_TLS	Chilled water BTU - Supply Temp from Chiller	degF x100	40121	Supply Temperature	
35	CHW_TLR	Chilled water BTU - Return Temp to Chiller	degF x100	40121	Return Temperature	
36	TGS	Exhaust gas In (Supply from Generator)	F	40245	TT_EX01 TEMPERATURE	
37	TGR	Exhaust Gas Out (Return after Boiler)	F	40246	TT_EX02 TEMPERATURE	

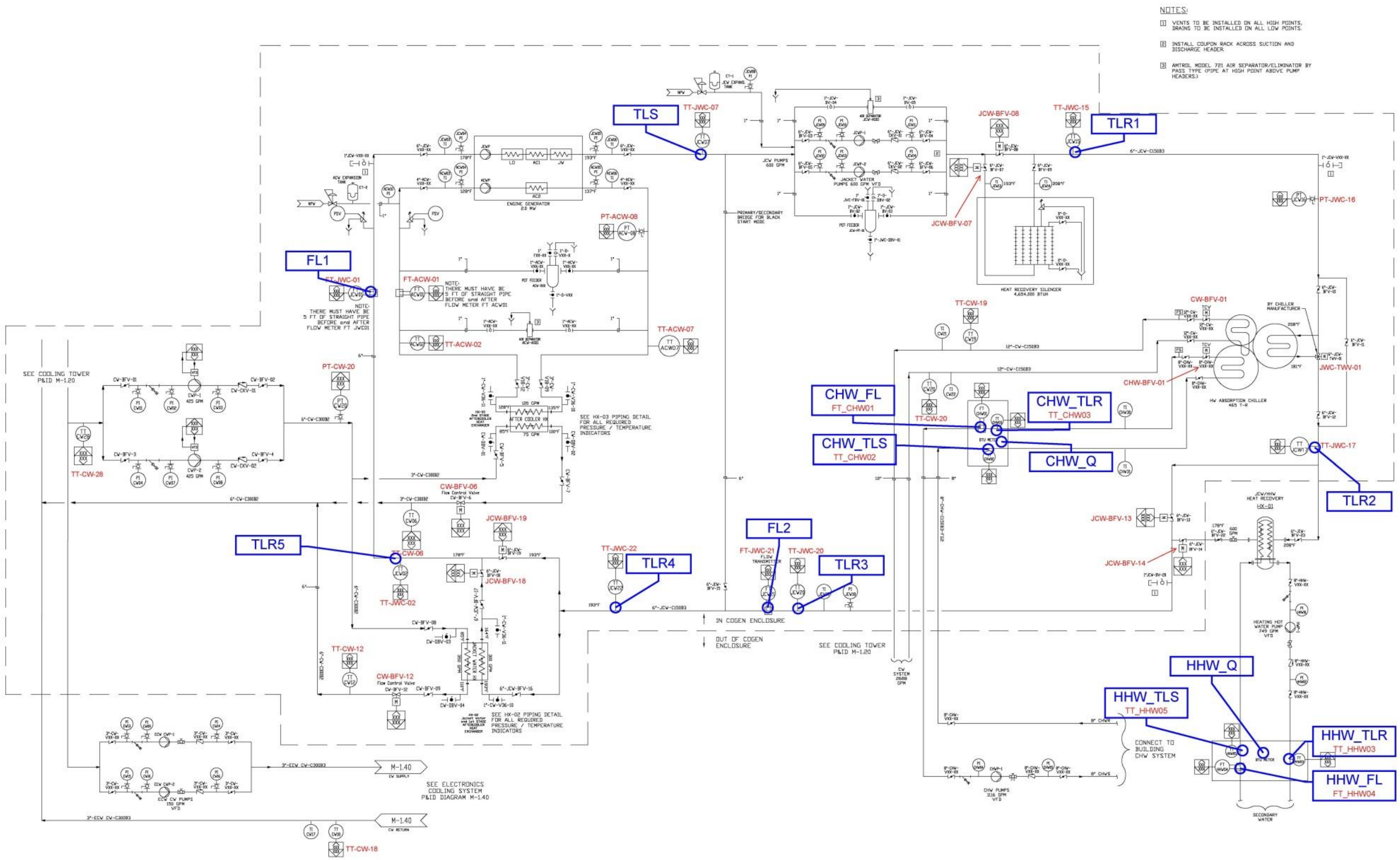

Figure 1. Schematic of CHP Heat Recovery System with Monitored Data Points Shown

Figure 2 shows the location of the monitored points on the engine exhaust (**TGS**, **TGR**). These points will be used for diagnostic purposes.

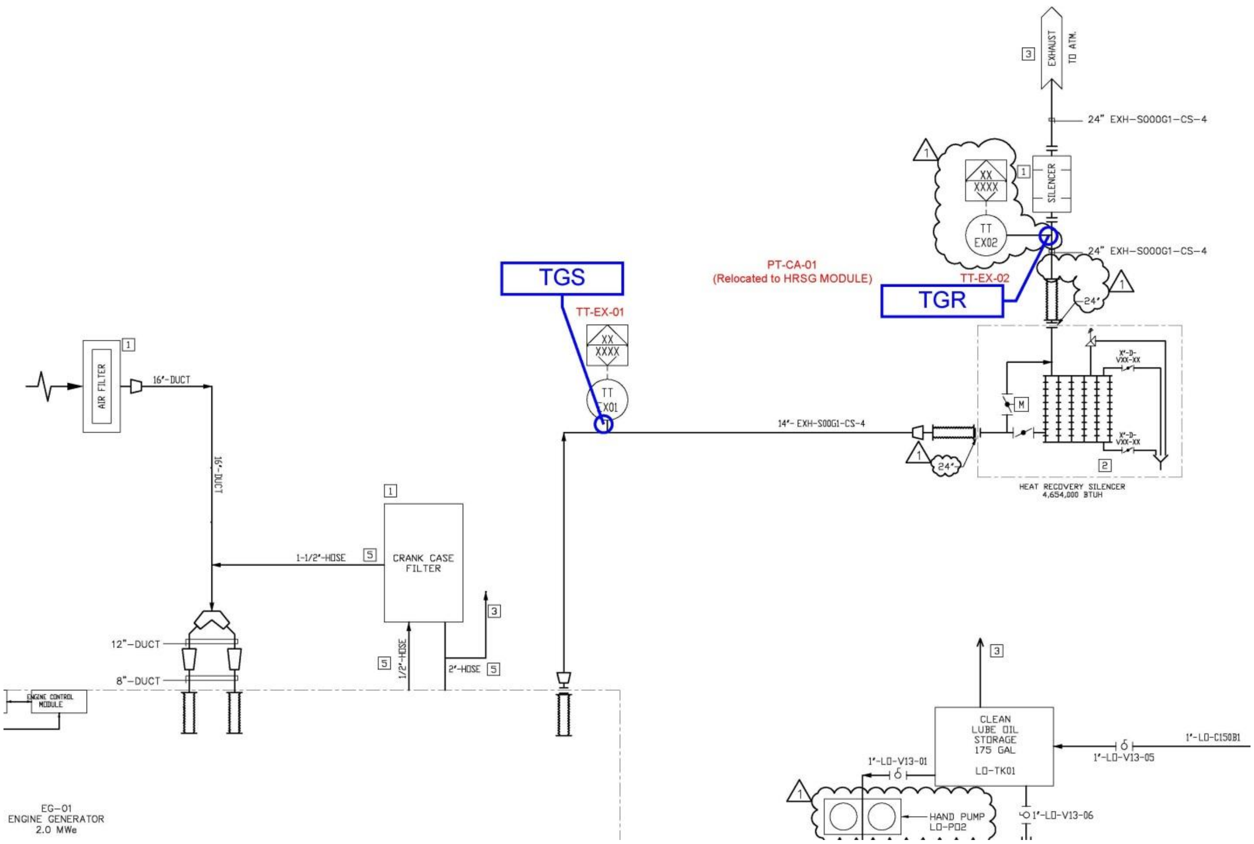

Figure 2. Schematic of Engine Exhaust with Monitored Data Points Shown

Figure 3 shows the gas meter room, and the location of the utility gas meter for the dedicated CHP system gas line (**FG**). This point will be used to calculate the system efficiency.

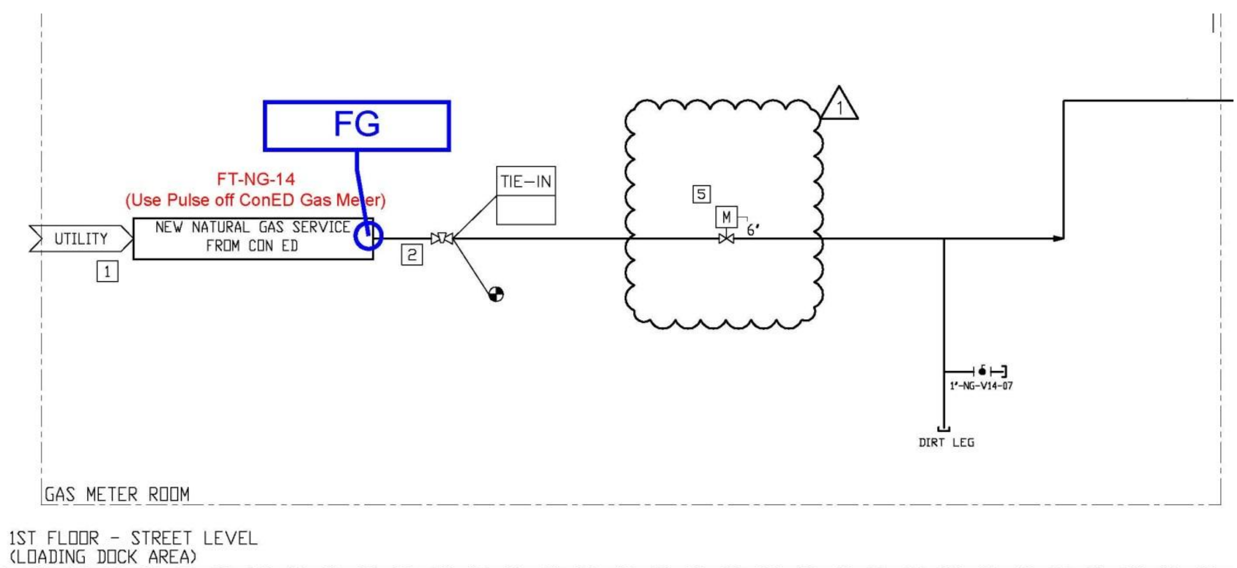

Figure 3. Schematic of Gas Meter Room with Monitored Data Point Shown

Figure 4 shows the revenue grade power meters before the three converters (**WCI1**, **WCI2**, **WCI3**), the power readings from the converters themselves (**WCONV1**, **WCONV2**, **WCONV3**), and the revenue grade power meters located after the converters (**WC1**, **WC2**, **WC3**). The meters after the converters will be used to determine the net generator output. The gross generator output measured at the generator (**WG_Gross**) will also be monitored (the difference between the net and gross output is the parasitic load). The total building energy use (**WT**) will also be measured to determine impact of on-site power generation on the facility.

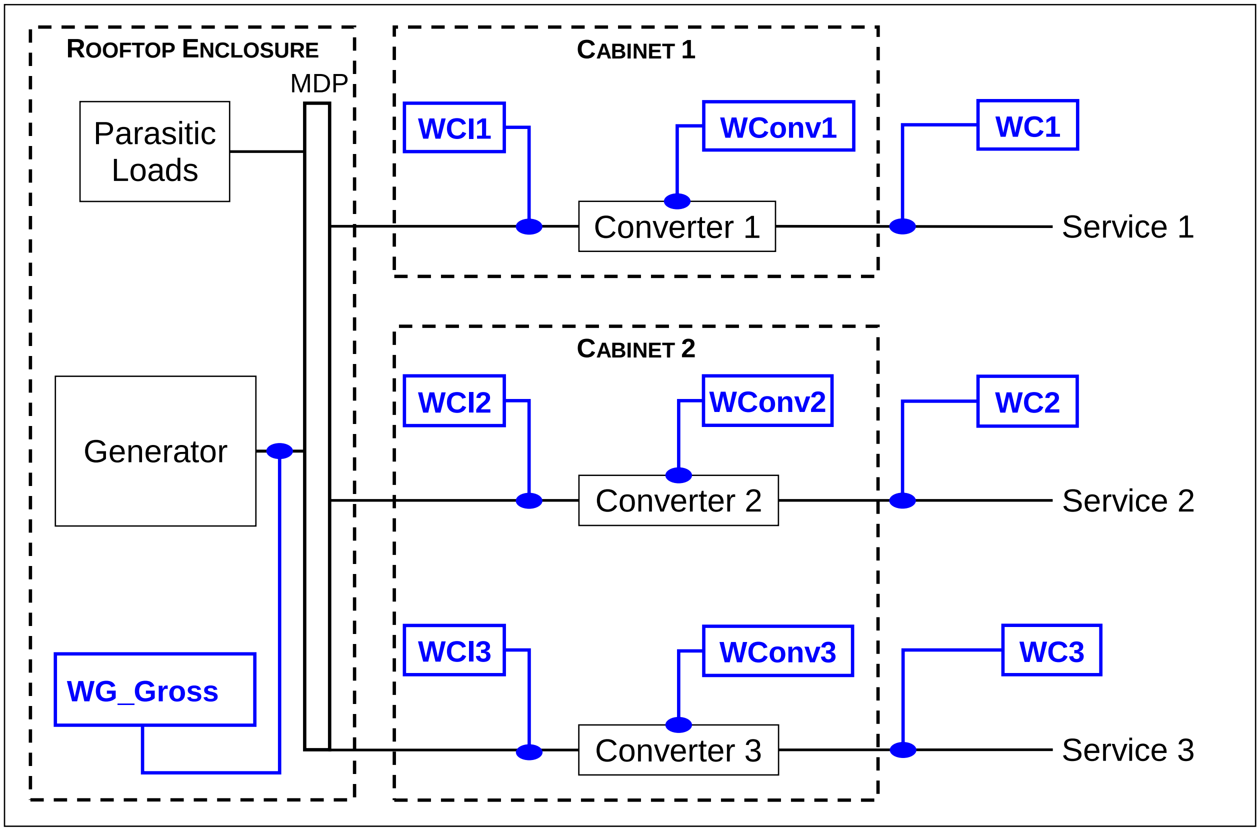

Figure 4. Electrical One-Line with Monitored Data Points Shown

Data Collection Process

Data is collected by the Andover BMS and then communicated to the OSISoft PI Historian installed by Gobeille Automation. The historian system will be programmed to generate a report containing the data listed in Table 1. These data points will be automatically averaged and logged to the report at 15-minute intervals. Each 15-minute record will be time and date stamped. The file will be a row-oriented comma separated values (CSV) file with sufficient resolution to accurately represent each reading. Once per day the file containing the last week of data will be automatically transferred to CDH Energy servers (the NYSERDA web site contractor) via Secure FTP (SFTP) .

3. Data Analysis Procedures

The collected data will be used to determine quantities required for the NYSERDA CHP website and for the incentive calculations. The calculation procedures are listed in Table 2.

Table 2. Calculations to Determine the Quantities of Interest to NYSERDA

CHP Website Variables	**Required Calculations**
WG_kW: Net Power Output (kW)	= **WC1_kW + WC2_kW + WC3_kW**
WG: Net Energy Output (kWh) (Uses interval data from accumulators)	= (**WC1** + **WC2** + **WC3**)
FG: Engine Gas Consumption (CF) (Uses interval data from accumulator)	= **FG**
QHR: Useful Heat Recovery (Btu/h)	= $\mathbf{k_{hw}}$ x **FL2** x (**TLR1** – **TLR3**)
QD: Unused Heat Recovery (Btu/h)	= $\mathbf{k_{hw}}$ x **FL1** x (**TLR4** – **TLR5**)
WT: Utility Power Consumption (kWh/h) (Uses interval data from accumulator)	= **WT**

Where: $\mathbf{k_{hw}}$ = product of specific heat and density for hot water loop fluid (pure water) at its operating temperature (~500 Btu/h-gpm-°F)

The other collected data from Table 1 will be used to independently confirm and check the calculations.

The net power output from the CHP system (**WG**) is directly measured in this case by measuring the output from the three power converters.

The fuel conversion efficiency of the CHP system, based on the lower heating value of the fuel, will be defined as:

where: **QHR** = Useful heat recovery (Btu/h)
WG = Net generator output (kW)
FG = Generator gas consumption (Std CF/h)
$\mathbf{HHV_{gas}}$ = Higher heating value for natural gas (1030 Btu per CF in NY for 2013). Where 0.9 is the conversion factor between HHV and LHV

The FCE can be calculated for any time interval. When converting to daily, monthly, or annual values, the each value is summed and then the formula is applied:

Where the summation is over the number of intervals in the period of interest.

Other quantities that may be of interest for diagnostic purposes include:

- Engine jacket heat recovery (Btu/h) = $\mathbf{k_{hw}}$ x **FL1** x (**TLS** – **TLR5**)
- Chiller heat input (Btu/h) = $\mathbf{k_{hw}}$ x **FL2** x (**TLR1** – **TLR2**)
- Heat Delivered to the building (Btu/h) = $\mathbf{k_{hw}}$ x **FL2** x (**TLR2** – **TLR3**)

  = **HHW_Q**
- Chiller COP = **CHW_Q/** (Chiller heat input)