MONITORING PLAN
FOR
GOLUB HEADQUARTERS CCHP PROJECT

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Submitted to:

New York State Energy Research and Development Authority
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Submitted by:

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On Behalf of

Golub Corporation
1520 Maxon Road
Schenectady, NY 12305
PON 1241 Agreement No. 11183

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Project Information

Carrier Corporation is the ESCO for the new Golub Headquarters Office Building combined cooling, heat and power plant project. This M&V plan is specifically written for this project's participation in NYSERDA's PON 1241 - for Distributed Generation as Combined Heat and Power. This project consists of designing, building, operating and maintaining a 195 kW microturbine-based combined cooling heat and power (CCHP) plant at the new Golub / Price Chopper headquarters office building.

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The "Site" is:

Golub Headquarters Office Building
1520 Maxon Road
Schenectady, NY 12305

Golub Corporation Headquarters Office Building
Measurement &Verification Plan

This document describes the measurements, sensors, and data logging equipment proposed to quantify the performance of the combined cooling heat and power plant being installed at the new Golub headquarters in Schenectady, NY. The planned CCHP system for the Golub headquarters office building will provide electricity to displace purchases from the local utility, and thermal energy in the form of chilled water and hot water to support the building space conditioning needs. The microturbine is expected to operate at full power continuously, and maintain high overall annual efficiency by providing heating and/or cooling on demand.

System Overview:

The CCHP system is designed as a permanent installation. The standard operating mode will be for the microturbines to operate in parallel with the local utility, providing a total of 180 kW net electrical power. The CCHP plant is also designed to provide up to 180 kW of grid-independent power to critical loads, including the ability to provide "flicker-free" power to a subset of these loads. The microturbines are able to transition automatically to grid-independent operation upon loss of grid power and have black start capability to start up without the utility grid. The office building will also be equipped with a 2000 kW diesel back-up generator.

The installation of the microturbine based CCHP system will provide electricity, cooling and heating. The CCHP system will consist of one UTC Power PureComfort® Model 195M system, which is composed of three 65 kW microturbines (Figure 1.) and one exhaust-driven absorption chiller (Figure 2.). The microturbines are located on the roof of the building and the absorption chiller heater is installed in the penthouse mechanical room that houses the building's three natural gas-fired hot water boilers and two electric chillers. See Appendix A for reference to the UTC Power Corporation's proposal for PON 1241 for this facility.

Figure 1. Microturbines during installation

Figure 2. Absorption Chiller during installation

Power Generating Equipment:

The PureComfort® Model 195M includes three Capstone microturbines that provide 195 kW, 480 VAC, 3 Phase, 60 Hz. The fuel input for the microturbines is natural gas. There is a gas pack booster for each microturbine to boost the fuel supply pressure to the microturbines to 75 psig. See Table 1 for performance data. Additional technical information and equipment schedules are located in Appendix B for reference.

	ISO Day – 59° F Simultaneous Mode
Gross Power Output	195 kW
Net Power Output	180 kW
Cooling Output	125 RT
Heating Output Max 140° F	904 MBh
Gas Consumption, LHV	2,295 MBh
Total Efficiency – Power and Cooling, LHV	92% Net
Total Efficiency – Power and Heating, LHV	66% Net
Microturbine Exhaust Gas Temp.	568 ° F
Chiller Exhaust Temp. Heating / Cooling	239 ° F / 226 ° F

Table 1. Performance Specifications for PureComfort® Model 195M

Heat Recovery System:

The PureComfort® Model 195M utilizes a UTC Power-proprietary, high-efficiency, double-effect absorption chiller/heater to provide energy in the form of either hot or chilled water. The chiller will provide chilled water to the building central chilled water system in parallel with the facility's electric chillers. Hot water from the chiller will be used as a pre-heater for the building hydronic system. The PureComfort® can be controlled to provide cooling and heating simultaneously, with priority given to either heating or cooling (see above Table 1. for heating and cooling performance specifications). See Table 2. for equipment nameplate data that will be operating in parallel with the CCHP.

Identifier	Manufacturer	Capacity
CH-1	York: YKDRDSQ3-CHG	250 Tons
CH-2	York: YKDRDSQ3-CHG	250 Tons
B-1	LOCKINVAR PBN2000	1700 MBH (Output)
B-2	LOCKINVAR PBN2000	1700 MBH (Output)
B-3	LOCKINVAR PBN2000	1700 MBH (Output)

Table 2. Additional Equipment

Facility Load Details

The Golub facility is a new six story; 240,000 square foot high-performance office building located in Schenectady, NY and is being constructed in summer and fall of 2009. The planned use of the building is typical office work, with weekday operating hours approximately between 7:00 a.m. and 7:00 pm. and a typical occupancy of 700-800 people. The projected peak electrical load, without the CCHP system, is 850 kW, a peak cooling load of 400 tons, and a peak thermal load of over 5 MMBTU/hr. Total annual consumption was projected to be 2,498,200 kWh and 22,260 MMTBUs of natural gas (without the CCHP).

Without the CCHP system the building would be under National Grid's SC3 T&D 2.2-15kV tariff. The use of the CCHP system will move the entire building under National Grid's SC7 tariff. Natural gas service to the building will be from National Grid under their SC7 Small Volume Monthly Balancing tariff. There will be one electric utility meter and one gas utility meter.

System Schematics

The 480V, 60-Hz electrical output from the natural gas powered microtubines (MT 1-3) will be tied into the electrical distribution panels at the facility. The waste heat (568° F) from the exhaust of the microturbines is used to power the absorption chiller/heater (CH-3). A diverter valve prior to the inlet of the chiller/heater regulates the exhaust gas flow depending on the cooling/heating load requirements. The absorption chiller/heater (CH-3) supplies hot water (140/175° F) to the building hot water loop and chilled water (44° F) to the building chilled water loop. A cooling tower (CT-1) provides cooling water (74° F) to the chiller/heater (CH-3). Figures 3.0, 4.0, and 5.0 are the building system schematics. Figure 6.0 shows the data points that will be monitored continuously.

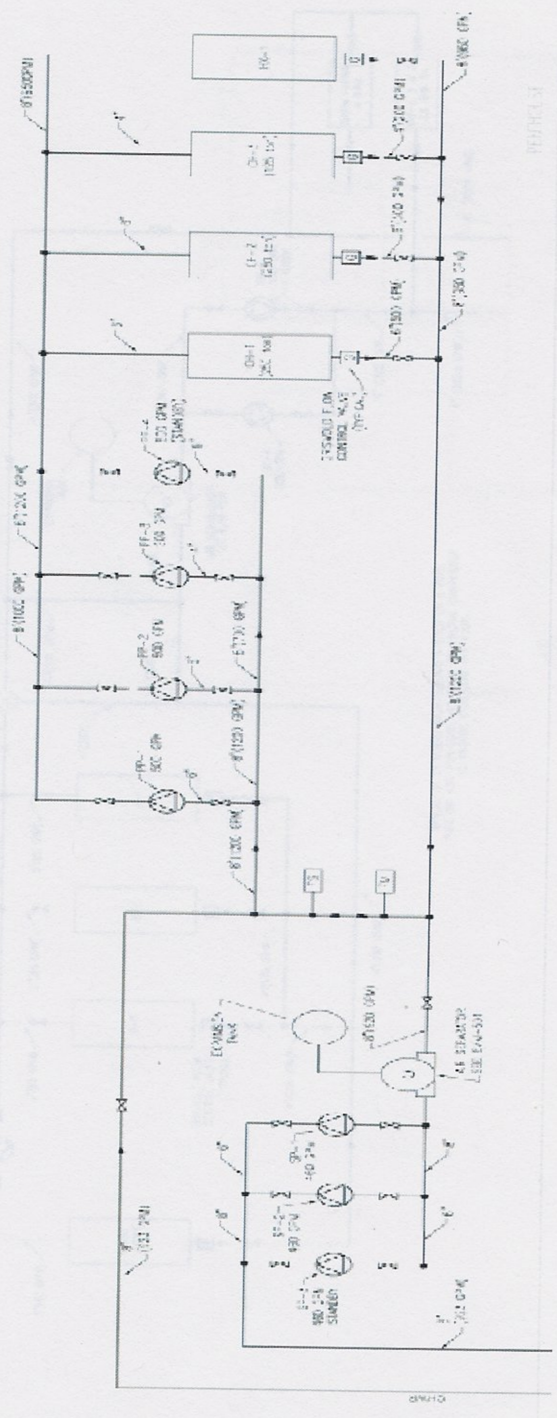

Figure 3. Building Chilled Water Schematic

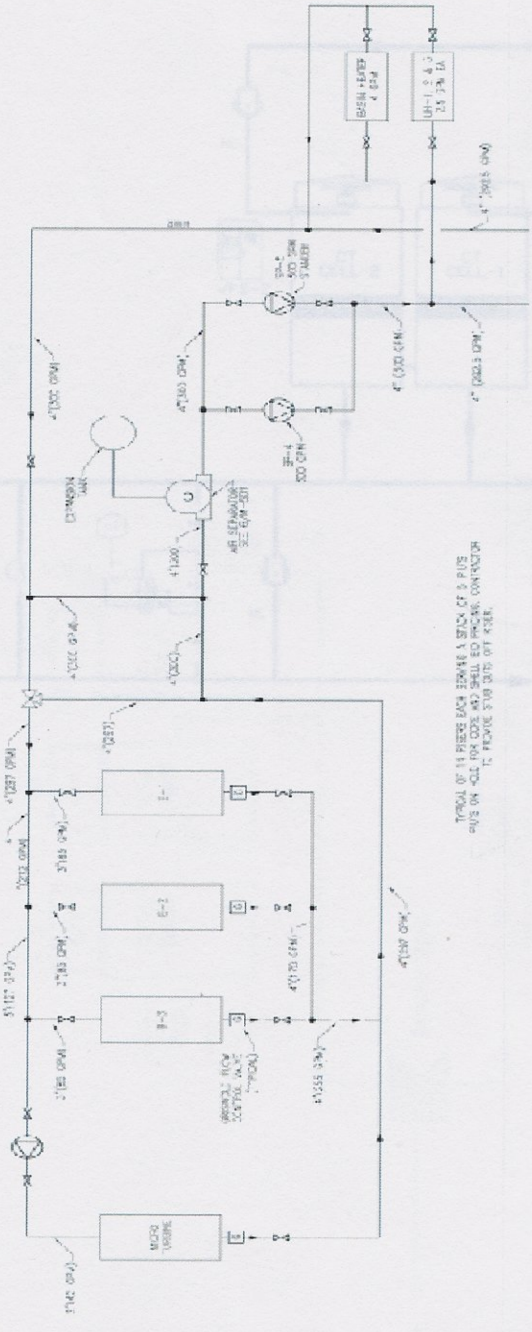

Figure 4. Building Hot Water Schematic

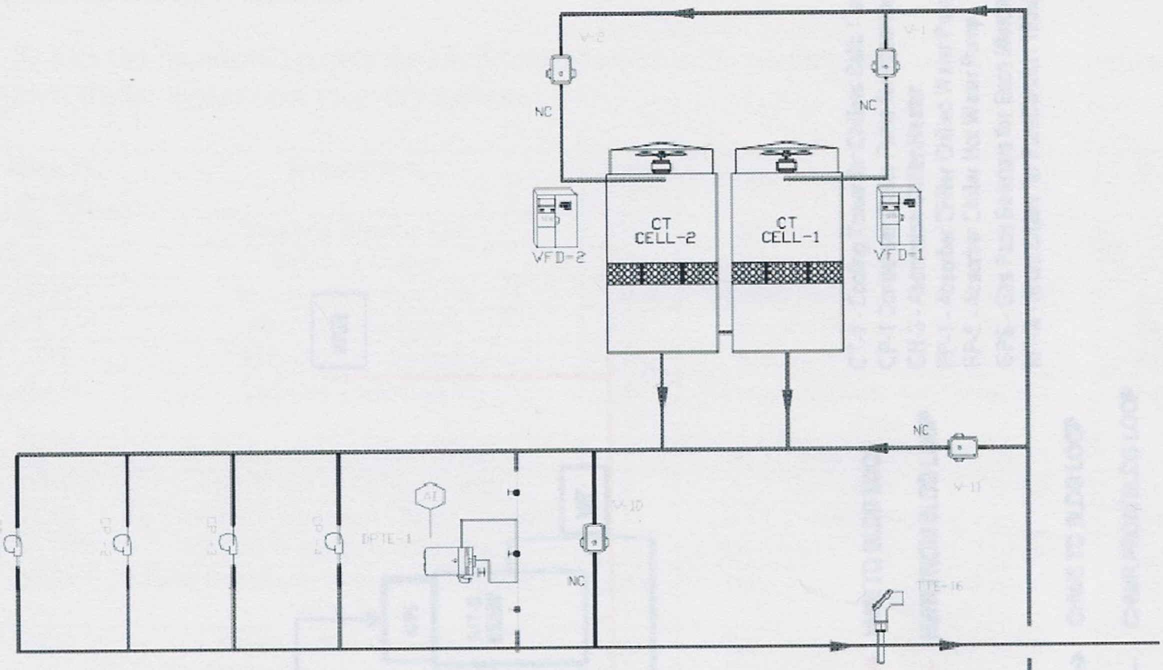

Figure 5. Building Condenser Water Schematic

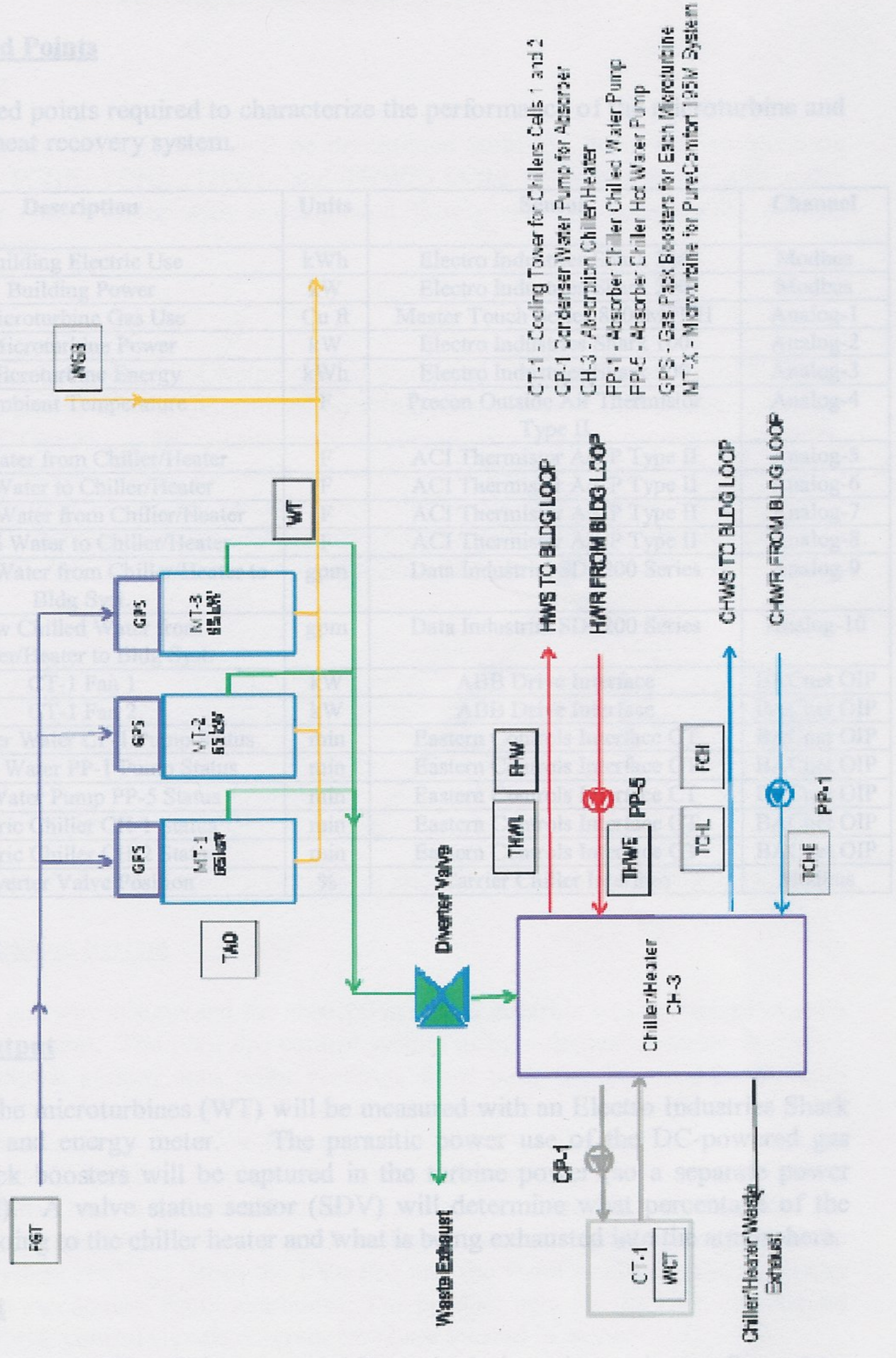

Figure 6. System Schematic Showing Sensor Locations

Description of Monitored Points

Table 3. lists the monitored points required to characterize the performance of the microturbine and absorption chiller heater heat recovery system.

No	Data Pt. Name	Description	Units	Sensor	Channel
1	WGB	Building Electric Use	kWh	Electro Industries Shark 200	Modbus
2	WGB_kW	Building Power	kW	Electro Industries Shark 200	Modbus
3	FGT	Microturbine Gas Use	Cu ft	Master Touch Series 8800MPNH	Analog-1
4	WT_kW	Microturbine Power	kW	Electro Industries Shark 100	Analog-2
5	WT	Microturbine Energy	kWh	Electro Industries Shark 100	Analog-3
6	TAO	Ambient Temperature	F	Precon Outside Air Thermistor Type II	Analog-4
7	THWL	Hot Water from Chiller/Heater	F	ACI Thermistor A/CP Type II	Analog-5
8	THWE	Hot Water to Chiller/Heater	F	ACI Thermistor A/CP Type II	Analog-6
9	TCHL	Chilled Water from Chiller/Heater	F	ACI Thermistor A/CP Type II	Analog-7
10	TCHE	Chilled Water to Chiller/Heater	F	ACI Thermistor A/CP Type II	Analog-8
11	FHW	Flow Hot Water from Chiller/Heater to Bldg Syst.	gpm	Data Industrial SDI 200 Series	Analog-9
12	FCH	Flow Chilled Water from Chiller/Heater to Bldg Syst.	gpm	Data Industrial SDI 200 Series	Analog-10
13	WCTC1	CT-1 Fan 1	kW	ABB Drive Interface	BACnet OIP
14	WCTC2	CT-1 Fan 2	kW	ABB Drive Interface	BACnet OIP
15	SCWP1	Condenser Water CP-1 Pump Status	min	Eastern Controls Interface CT	BACnet OIP
16	SCHPP1	Chilled Water PP-1 Pump Status	min	Eastern Controls Interface CT	BACnet OIP
17	SHWPP5	Hot Water Pump PP-5 Status	min	Eastern Controls Interface CT	BACnet OIP
18	SCH1	Electric Chiller CH-1 Status	min	Eastern Controls Interface CT	BACnet OIP
19	SCH2	Electric Chiller CH-2 Status	min	Eastern Controls Interface CT	BACnet OIP
20	SDV	Diverter Valve Position	%	Carrier Chiller Interface	Modbus

Table 3. Data Point List

Microturbine Power Output

The electrical output of the microturbines (WT) will be measured with an Electro Industries Shark 100 utility grade power and energy meter. The parasitic power use of the DC-powered gas compressors and gas pack boosters will be captured in the turbine power (so a separate power transducer is not needed). A valve status sensor (SDV) will determine what percentage of the microturbine exhaust is going to the chiller heater and what is being exhausted into the atmosphere.

Microturbine Gas Input

The gas input to the turbines (FGT) will be measured by a single insertion style gas flow meter located in the dedicated gas line to the microturbines.

Temperatures and Flows

The thermal outputs from the chiller/heater will be determined from the flows and temperature differences (FHW, FCH, TCHE, TCHL, THWL, and THWE) in the hot water and chilled water entering and leaving the chiller/heater with a designated flow meter and temperature sensors mounted within thermo-wells.

Parasitic Power

The absorption chiller heater associated hot water, chilled water and condenser water pumps (PP-5, PP-1, and CP-1) parasitic power will be determined by combining one-time power measurements (WCWP1, WCHPP1, WHWPP5) with continuously recorded component runtimes (SCWP1, SCHPP1, SHWPP5). The cooling tower parasitic power (WCT1) will be continuously monitored by interfacing with the cooling tower fan variable speed drives via BACnet protocol. Cooling tower CT-1 serves both the absorption chiller and electric chillers. Therefore, the parasitic power of the cooling tower fans will only be taken into account when the absorption chiller is operating alone.

Name	Description	Eng Units	Sensor Type
WCWP1	Absorption Chiller Condenser Pump Power	kW	Handheld Pwr Meter
WCHPP1	Absorption Chiller Chilled Water Pump Power	kW	Handheld Pwr Meter
WHWPP5	Absorption Chiller Hot Water Pump Power	kW	Handheld Pwr Meter

Table 4. One-Time Measured Data Collected

The product data and cut sheets for the metering equipment and sensors are located in Appendix C.

Data Collection and Retention System

The PureComfort® RMS gateway system and the absorption chiller controls will be integrated with a Carrier i-Vu Pro control system. The i-Vu Pro control system using a dedicated server will view and record all PureComfort® system data point readings from both the PureComfort® RMS gateway and the absorption chiller controls via Modbus communication. Data will be recorded continuously every 5 minutes from the i-Vu Pro system. The i-Vu Pro system will also be integrated with the customer's building management system for viewing and recording data as needed. The i-Vu system will have a dedicated broadband connection (static IP) which allows the data to be accessible to Carrier and NYSERDA as well as the customer for data acquisition and the capability for real time system readings. Both the i-Vu Pro and the PureComfort® RMS gateway systems are located in the mechanical room penthouse. The product data for the i-Vu Pro control system and the PureComfort® control signals diagram E602 are located in Appendix D.

If a power outage occurs the i-Vu pro control system and the PureComfort® RMS gateway are both on emergency power to prevent the loss of data as well as communication. Data will be inspected for loss of data and data abnormalities due to the malfunction of equipment, disturbances, and changed initial conditions

Calculations

Electric Power Output

The net power output of the microturbine will be calculated using the power reading from the Microturbine (WT) minus the parasitic load power (WP) outputs (including the cooling tower only when the absorber is operating alone).

$$WT = WT\_kW - WP$$

WTN = WT − WP

Where

$$WP = WCTC1 + WCTC2 + WCWP1 + WCHPP1 + WHWPP5$$

WCTC1 and WCTC2	=	power outputs of the cooling tower fans
WCWP1	=	power output of condenser water pump for absorber
WCHPP1	=	power output of chilled water pump for absorber heat recovery
WHWPP5	=	power output of hot water pump for absorber hear recovery

Thermal Outputs

The total useful thermal output of the heat recovery system is calculated by summing the thermal outputs of cooling and the heating produced by the absorption chiller using temperature sensors and flow readings.

$$Q_{Total} = QC + QH$$

$$QC = k \times [FCH \times (TCHL - TCHE)]$$

Where k is equal to 500 Btu/hr-gpm-°F for water 44 °F

$$QH = k \times [FHW \times (THWL - THWE)]$$

Where k is equal to 487 Btu/hr-gpm-°F for water at 175 °F

The combined electrical thermal net efficiency is calculated

$$\eta\ CHP = \frac{WT\ (kW) + PQ_{Total}\ (kW)}{P_{Fuel\ Input}(kW)} \times 100$$

Where

$$PQ_{Total}\ (kW) = \frac{Q_{Total}(MBtu/hr)}{3.412\ \frac{MBtu}{kWh}}$$

$$P_{Fuel\ Input}(kW) = FGT\ \left(\frac{Ft3}{min}\right) \times \left(\frac{60\ min}{hour}\right) \times \text{Fuel LHV}\ \left(\frac{Btu}{Ft3}\right) \times \frac{kWh}{3412\ Btu}$$

LHV= .930 $MBtu/Ft^3$ Natural Gas

The logging interval will be every 15 minutes. Real time, daily, monthly, and annual values can be calculated using the above equations by summing the monitored values over the number of desired time intervals.

For example:

$$QH = k \times \sum[FHW \times (THWL - THWE)] \times \text{time interval (15 min = .25 hr)}$$