CLARKSON UNIVERSITY, DG/CHP SYSTEM NOTES

The CHP system at Clarkson University consists of three (3) 65-kW Carrier microturbines and a Carrier absorption chiller packaged onto a Carrier Pure Comfort system. The turbines have a combined gross output of 195 kW. The system uses heat from the turbine exhaust to drive an absorption chiller/heater that provides chilled and hot water to two buildings on campus. The system has a maximum chilled water output of 100-125 tons, and a maximum hot water output of 798 MBtu/h. No dump radiator is utilized for rejection of excess heat, instead turbine exhaust is bypass around the chiller.

The CHP system provides electricity, hot and chilled water to the Technology Advancement Center (TAC). Hot water is also provided to the science center as backup for the campus hot water system (but manual tie in valves are operated for this configuration). Also excess electricity (above what the TAC requires) is provided to the Science Center building.

The system will operate in grid parallel mode to meet the full electrical needs of the TAC and partial electrical needs of the Science Center. During a utility outage, the dual mode controller will drop the connection to the Science Center and power the entire TAC building as an emergency load. A manual transfer switch allows the TAC to be powered off the grid while the CHP system is down for any reason.

Monitoring of the listed data points will be accomplished via the Siemens BMS, which can connect to the Trane BMS and Carrier RMS systems via BACnet. All channels will be sampled at a minimum rate of a 1-minute sampling interval, and averaged or summed into 15-minute data records. The collected data will be used to determine the net power output of the system as well as the fuel conversion efficiency (FCE).

The timestamp in the raw data files is in Eastern Standard Time. All graphical figures on the website are presented in Eastern Standard Time. This means that during the Daylight Savings Time period from the first Sunday in April until the last Sunday in October the monitored data plots, CSV output and standardized PDF reports are in Eastern Standard Time and do not obey Daylight Savings time rules. Presenting data in Standard Time throughout the year is common practice for graphical time series plotting because it eliminates skipping an hour in April and duplicating an hour in October.

<u>DG/CHP Generator Output (total kWh)</u>
The data for Generator Output comes from 15-minute data. The column of origin for this data point is labeled "TAC_MICROTURBINE_KW" in the data files received from the Siemens BMS**.** This 15-minute interval energy data is averaged into hourly data.

<u>DG/CHP Generator Output Demand (peak kW)</u>
The Generator Output Demand comes from 15-minute data. The column of origin for this data point is labeled **"**TAC_MICROTURBINE_KW**"** in the data files. The highest value from the 15-minute data during an hour is used for the Output Demand in the online database.

DG/CHP Generator Gas Input (cubic feet)

The data for Generator Gas Input comes from 15-minute data. The column of origin for this data point is labeled "TAC_MICROTURBINE_NG_INPUT" in the data files received from the Siemens BMS. The data is averaged into hourly data for the online database.

Total Facility Purchased Energy (total kWh)

There is no data available for this point from the Siemens

Total Facility Purchased Demand (peak kW)

There is no data available for this point from the Siemens

Other Facility Gas Use (cubic feet)

There is no data available for this point from the Siemens.

Total Facility Energy (total kWh) and Total Facility Demand (peak kW)

These two data points are the sum of the DG/CHP Generator Output and Total Facility Purchased data points.

Unused Heat Recovery (total MBtu/h)

There is no data available for this point from the Siemens

Useful Heat Recovery (total MBtu/h)

The Useful Heat Recovery comes from 15-minute data for the hot and chilled water loops. The hot water recovery is calculated using data from the columns: "TAC_MICROTURBINE_HWF ", "TAC_MICROTURBINE_HWR ", "TAC_MICROTURBINE_HWS ". The chilled water heat recovery is calculated using data from the columns: "TAC_MICROTURBINE_CWF ", "TAC_MICROTURBINE_CWR ", "TAC_MICROTURBINE_CWS ".The 15-minute data is averaged for the hourly online database

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Status/Runtime of DG/CHP Generator (hrs)

The generators are defined as being fully on for a 15-minute interval if the generator output is greater than 20 kW for the period (the fully-loaded capacity is 195 kW). The status is given a value of 0.25 if the generator output is above 20 kW. The 15-minute data is then summed into hourly data for the online database.

Ambient Temperature (avg °F)

The Ambient Temperature comes from hourly sampled conditions at the Rochester Airport (Airport Code ROC) available at http://www.wunderground.com. The hourly data from the weather underground (which is often recorded at irregular time intervals) is assigned to the closest hour for the Ambient Temperature in the online database.

Total CHP Efficiency (%)

The Total CHP Efficiency is calculated from the online hourly database as the sum of the Useful Heat Recovery and the DG/CHP Generator Output, converted from kWh to MBtus, divided by the DG/CHP Generator Gas Input. The gas input is converted to MBtus using the Lower Heating Value (LHV) of the fuel which is 0.930 MBtu/cubic foot (Natural Gas).

<u>Electrical Efficiency (%)</u>
The Electrical Efficiency is calculated from the online hourly database as the DG/CHP Generator Output, converted from kWh to MBtus, divided by the DG/CHP Generator Gas Input. The gas input is converted to MBtus using the Lower Heating Value (LHV) of the fuel which is 0.930 MBtu/cubic foot (Natural Gas).

Data Quality Checks

The Data Quality Checks consist of three levels of verification: does the data exist, does the data pass reasonable range checking and does the data pass relational checks. The methodology for applying the data quality begins by creating a contiguous database. This is necessary to maintain compatibility between the many sites on the server. Next, the data received for this site is fit into the database, in this case we are using 15-minute data. For any period where there is data, the data quality level is set to 3 for "Passes Relational Checks". We then work backwards to identify data that does not meet Relational and/or Range Checking.

The next step is to apply the relational checks. Relational checks attempt to identify data which is uncorroborated by the rest of the data set. For instance, data received indicating a DG/CHP Generator output when the gas use is zero is suspect. For data failing a relational check, the data quality level is set to 2 for "Data Passes Range Checks".

The last step is evaluating the range checks. The range checks consist of reasonable high and low values based on facility and DG/CHP Generator information. Data that falls outside the defined range for the database value has its data quality level set to 1 for "Data Exists."

It is necessary to work backwards when applying data quality checks to insure that data gets set to the lowest applicable data quality level. It is possible for data to pass the relational check and fail the range check and such data will be set to a data quality level of 1 for "Data Exists."

Table 1. Data Quality Definitions

Data Quality Levels	**Description**	**Definition**
3	Passes Relational Checking	This data passes Range Checks and Relational Checks. This is the highest quality data in the data set.
2	Passes Range Checks	This data passes the Range Checks but is uncorroborated by Relational Checks with other values.
1	Data Exists	This data does not pass Range Checks. This data is found to be suspect based on the facility and/or CHP equipment sizing.
0	Data Does Not Exist	This data is a placeholder for maintaining a contiguous database only.

Details on the Range and Relational Checks are found below.

Relational Checks

These checks are applied to the 15-minute data before it is converted to hourly data. If any of the 15-minute data points fails the relational check, the data for the entire hour is marked as failed.

Table 2. Relational Checks for Clarkson

Evaluated Point	Criteria	Result
FG	WG > 20 and FG <=0	DQ Level for FG set to 2

Notes: FG – DG/CHP Generator Gas Use
WG – DG/CHP Generator Output
WG_KW – DG/CHP Generator Demand

Range Checks

These checks are applied to the 15-minute data before it is converted to hourly data. If any of the 15-minute data points fails the range check, the data for the entire hour is marked as failed.

Table 3. Range Checks for Clarkson

Data Point	Hourly Data Method	Upper Range Check	Lower Range Check
DG/CHP Generator Output	Average	220 kWh	0 kWh
DG/CHP Generator Output Demand	Maximum	220 kWh	0 kW
DG/CHP Generator Gas Use	Average	1050 cubic feet/hour	0 cubic feet
Total Facility Purchased Energy	Sum	220 kWh	0 kWh
Total Facility Purchased Demand	Maximum	220 kWh	0 kW
Other Facility Gas Use	Sum	N/A	N/A
Unused Heat Recovery	Sum	800 MBtu	0 MBtu
Useful Heat Recovery	Average	800 MBtu	0 MBtu
Status/Runtime of DG/CHP Generator	Sum	0.25 hrs	0 hrs
Ambient Temperature	Average	125°F	-30°F

Notes: Data failing the Range Check has the data quality level set to 1 for “Data Exists”

ASERTTI Protocol Adherence

This site adheres fully to the ASERTTI Long-Term Monitoring Protocol. All required performance parameters are provided. The data is averaged and summed into 15-minute intervals as per the protocol. In addition, most of the optional parameters are available at this site.

Monitoring Notes

11/04/2009

The website has been posted. Presently the fuel use is being set to no data until multipliers are provided for that data channel.