EVCO

MECHANICAL CORPORATION
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Attn: Mr. Jason Block

Re: Monitoring Plan for 300kW CHP System at Roosevelt Landings

1: SUMMARY

This monitoring plan was developed to meet NYSERDA's CHP measurement and verification requirements as they are outlined in Appendix A2 of PON 1931, the incentive mechanism that underlies the stated project. The continuously monitored data points described here were selected to quantify the performance of the CHP system and support operations and maintenance of the associated equipment. The data collected from the site is stored both locally on a data-logger and remotely in a cloud-based application called **Clockworks**. The cloud-based application, Clockworks, facilitates data exploration, reporting and downloading over the Internet, as well as automated fault detection and diagnostics for the CHP system. Overall, the monitoring system for the 300 kW CHP plant at Roosevelt Landings is intended to extend beyond historical measurement and verification of performance to include a real-time operations and maintenance tool.

2: CHP SYSTEM

2.1 Overview

The CHP system intended for Roosevelt Landings has a 300 kW electric generation capacity, and is tied into the domestic hot water system to deliver up to 160,000 therms of hot water a year, or displace that equivalent amount of domestic hot water boiler operation. The system will not export power to the grid however it will be capable of black-start operation in the case of a power outage.

2.2 Power Generating Equipment

The prime movers for the CHP system are natural gas fired reciprocating engines in three (3) 100 kW packaged cogeneration units, otherwise known as Tecogen's Inverde product line. The units are inverter-based, issuing power at 480 VAC, 3-phase and 60 hertz, at a manufacturer's listed electric efficiency of 30% (LHV).

2.3 Heat Recovery System

The Inverde units cogenerate heat at a maximum thermal output of 727,000 BTU/hr, which when combined with their electric power output, yields a manufacturer's listed system efficiency of nearly 93% (LHV).

2.4 Facility Load Details

The facility is a multi-family housing complex on Roosevelt Island with approximately 1,000 units, apartment-level electric heat, and a central domestic hot water plant. The domestic hot water system consumes roughly 240,000 therms per year. The CHP system will co-generate electric power for the building in which the system is housed, and supplement domestic hot water production from the existing bank of steam boilers.

2.5 Estimated Annual Performance

The annual performance of the total CHP system is summarized below in Table 1

Displaced DHW Therms	CHP Gas Input (Therms)	CHP Operating Hours	CHP Dump Hours	Electric Output (MWHr)	Parasitic Loss (MWHr)
140,000	250,000	7,000	875	2,100	40

Table 1 Estimated annual performance of the CHP system

3: Monitoring System

3.1 Monitoring System Overview

The monitoring system for the CHP plant will calculate the following quantities based upon 5 minute interval measurements on the system:

- Total heat (hot water) produced by the CHP system, and delivered to the DHW system or dump radiator
- Total electricity output from the CHP system to the building
- Total fuel input to the CHP prime movers
- Parasitic electricity consumption of the appliances that comprise the system: pumps and dump radiator fans
- Total fuel input to the stand-by boilers

The combination of these values will enable the monitoring system to characterize the CHP system's overall AFUE (actual fuel utilization efficiency), and compare the system's performance against anticipated operation. All continuous electrical power measurements will be made with stand-alone electricity meters that issue time-averaged values for various power factors (kW, and kWh) through a MODBUS serial data connection. Parasitic electrical losses will be estimated by making initial hand-held electrical measurements on the consumption of those parasitic loads, followed by continuous monitoring of when those loads are active. All thermal energy measurements will also be made by stand-alone BTU-meters that issue a time average value for thermal energy factors (totalized BTUs and BTUs/hr) through a MODBUS serial data connection.

The totalized gas consumption for the CHP system and stand-by boilers will be measured by utility grade meters, with a pulse output and associated pulse counter that issues a MODBUS register for the collection of the gas meter data. Additional data points reflecting operation of the system, including control valve positions, pump status, outside air temperature, mixed water temperature and other plant-level measurements will be collected via a MODBUS serial data connection to the Computrols BAS that is used to control the CHP system and ancillary plan equipment. A Campbell Scientific CR-1000 will be connected via MOBUS serial data port to the Computrols BAS as well as the stand-alone energy meters in order to log all data on site and deliver it to the cloud-based monitoring system, Clockworks.

3.2 Schematic

Please see appended schematic drawing with labeled locations of data points

3.3 Tabular Data Point Summary

Table 2 includes the data points included for the continuous monitoring system.

Data Source	Date Point Name	Description	Eng Units	Sensor Type
Pulse counter to MODBUS	FGC	CHP system gas use	Cubic feet	Gas Meter[1]
Pulse counter to MODBUS	FGB	Stand-by boiler gas use	Cubic feet	Gas Meter[1]
MODBUS data from meter	WPC	Electrical energy and power output from CHP stem	kW, kW-hrs, Volts, Amps, KVA, Hz	Veris MODBUS
Computrols BAS	DHWP1	Runtime on pump 1 for the domestic HW	Time (hours)	Computrols BAS and Veris CT
Computrols BAS	DHWP2	Runtime on pump 2 for the domestic HW	Time (hours)	Computrols BAS and Veris CT
Computrols BAS	CGP1	Runtime on pump 1 for the CHP fluid	Time (hours)	Computrols BAS and Veris CT
Computrols BAS	CGP2	Runtime on pump 2 for the CHP fluid	Time (hours)	Computrols BAS and Veris CT
Computrols BAS	DRV	Dump radiator valve position	% position	Computrols BAS & valve signal

[1] Gas meters are utility grade, temperature and pressure compensated meters

Computrols BAS	OAT	Outdoor air temperature	F	Computrols BAS and 10 K Type III
Computrols BAS	DWST	Hot water supply temperature	F	Computrols BAS and 10 K Type III
Computrols BAS	DWRT	Hot water return temperature	F	Computrols BAS and 10 K Type III
MODBUS data from meter (multiple registers)	CHPBTU	CHP system thermal energy output	BTU, water flow (GPM), Supply and return Temperature (F)	PEMCO flow and temperature differential BTU meter

Table 2 Tabular summary of continuously monitored data points

Date Point Name	Description	Eng Units	Sensor Type
WPD	Parasitic power consumption of the dump radiator	kW	Handheld power meter
WPDHWP	Parasitic power consumption of the DHW pumps	kW	Handheld power meter
WPCGP	Parasitic power consumption of the CHP fluid pumps	kW	Handheld power meter
EMISSIONS	Measurement of combustion emission compositon	PPM	Handheld emissions meter

Table 3 Table of one-time measured data to establish parasitic loads and emissions

Data points **FGC** and **FGB** will measure gas consumption of the entire domestic hot water plant, including the CHP plant and stand-by boilers, respectively. The position of the dump radiator valve, **DRV**, will determine when the thermal output of the CHP system is delivered to the building or exhausted to the atmosphere. **DRV** in conjunction with **WPD** will also be used to calculate the parasitic loads associated with the dump radiator fans. **WPDHWP** and **WPCGP**, in conjunction with the data from **DHWP1**, **DHWP2**, **CGP1**, and **CGP2** will be used to calculate the energy losses due to pump operation. Finally, **WPC** and **CHPBTU** will be used to calculate the total energy output of the CHP system, measured as the electrical and thermal-BTU generation, respectively.

3.4 NYSERDA Required Monitoring Objectives

This M&V plan satisfies the following NYSERDA M&V objectives, as set forth in Appendix A2 of PON 1931:

No.	Description	Data Necessary to Meet Objective[2]
1	Quantify the variation of DG/CHP system power output, gas consumption, and efficiency over wide ranges of annual operating conditions	FGC, WPC, CHPBTU
2	Quantify external parasitic loads	WPDHWP, WPCGP, WPD
3	Quantify the daily, weekly, and annual variation of total facility power use so that actual utility costs can be determine	Existing building complex utility meter
4	Determine the thermal loads imposed on the CHP system by the facility, and quantify the CHP system efficiency as a function of normalizing building operation characteristics, i.e. operating schedules, # of units and tenants, and outdoor conditions	CHPBTU, OAT
5	Quantify the displaced fuel use on auxiliary equipment and systems to confirm the benefit of heat recovery	FGC, FGB
6	Quantify the amount of thermal energy “dumped” by the CHP system in order to demonstrate a system heat balance	DRV, CHPBTU
7	Determine the impact of generator operation on power quality in the facility	WPC
8	Collect diagnostic data to confirm the DG/CHP system operates as expected and/or support maintenance and operation activities	CHPBTU, OAT, DWST, DWRT,
9	Develop performance maps of CHP equipment and components to verify manufacturer specifications	CHPBTU, WPC, FGC
10	Determine environmental emissions from DG/CHP equipment to quantify net emissions impacts of the system	EMISSIONS

Table 4 NYSERDA Required Monitoring Objectives

3.5 Data Storage, Communication, Analysis and Presentation

Data collected by the data logger will be stored locally with a sliding window of 3 days of data and also uploaded every 5 minutes via an Ethernet connection to our cloud-based monitoring system, Clockworks. Our cloud-based system Clockworks is a fully automated system for collecting, storing, analyzing and serving data over the Internet. It facilitates the deployment of automated fault detection and diagnostic algorithms, as well custom report generation, on the data collected from the site. Moreover, Clockworks analyzes the monitoring data every 24 hours, yielding a dashboard view of system performance that operators and other stakeholders can use daily to check on performance, monitor return on investment, and diagnose any deficiencies.

In addition to Clockworks for automated data collection and analysis, we will provide a web-based interface to the Computrols control system that will be used to operate the CHP system. Through that interface, operators will be able to change set-point values and update the control programming.