MEASUREMENT AND VERIFICATION PLAN

FOR

DG/CHP SYSTEM
AT
ALBANY MEDICAL CENTER

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Submitted to:

New York State Energy Research and Development Authority
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1. Introduction

The Albany Medical Center is installing a Mercury 50-6000R natural gas fired turbine CHP system that will produce 4.5 MW of electrical power. The turbine is outfit with a heat recovery steam generator (HRSG) that can produce 12,500 lb/h of steam at 100-psig using only the turbine exhaust, or up to 54,600 lb/h of 100-psig steam when the HRSG duct burner is firing. The turbine and HRSG duct burner are fueled by natural gas at a rate of 40.8 MMBtu/h LHV (43,849 CFH) for the turbine alone, and 88.5 MMBtu/h (95,140 CFH) with the turbine and duct burner operating. Based on the supplied energy balance, the system has a rated CHP efficiency of 69% LHV without the duct burner firing, and 79% LHV with the duct burner firing.

Based on the DEA submittal, the system is anticipated to displace 4,117 kW of peak demand, and provide 29,000,000 kWh/year of electricity. This performance equals 7,044 EFLH of turbine operation. The projected performance incentive for the project reaches the program cap of $2,000,000, with $1,200,000 tied to annual performance as determined by monitoring and verification (M&V). The project has an 3,000 kW contract demand reduction (kWspc).

2. Instrumentation

In order to quantify the performance of the proposed CHP system, the CHP system fuel input, net electrical output, and useful thermal output must be measured. To capture these energy flows, an instrumentation plan was developed by CDH Energy and reviewed with the developer Cogen Power and system integrator Rovisys. The instrumentation plan covers the location and type of sensors necessary to provide the appropriate measurements of the energy flows of the system.

Data Logger

No dedicated data logger is used for the Albany Medical Center CHP system. The Rovisys data integration platform, will collect information from the remote PLCs located at each major component, assemble the data into a report conforming with the NYSERDA requirements, and deliver the report daily to the CDH energy servers. The Rovisys system interfaces with PLCs at the turbine skid, heat recovery steam generator (HRSG), deaerator/feedwater system, balance of plant (BOP) PLCs including electrical switchgear monitoring, and gas compressor skid, using the appropriate protocol for each PLC (e.g. Modbus, BACnet, HART, etc).

In accordance to the instrumentation plan, Cogen Power will supply the instrumentation listed below for use in meeting the NYSERDA CHP program monitoring requirements. The table provides a description of the data points monitored, sensors, and their host PLC.

Table 1. Instrumentation Supplied By Cogen Power

Data Point	Description	PID Label	Drawing Number	Sensor	Data Source	Notes
WG_kW	Gas Turbine Gross Electrical Output	DMMF-G1	E-113	Schweitzer Engineering Laboratories SEL-734 Power Meter	BOP Modbus	13 kV meter located in protection relay, true power output
WG_kWh	Gas Turbine Gross Electrical Output	DMMF-G1	E-113	Schweitzer Engineering Laboratories SEL-734 Power Meter	BOP Modbus	13 kV meter located in protection relay, Accumulated Energy Production
WPAR1_kW	Parasitic Load MCC-1 GTG1/HRSG-1	DMMF	E-103	Siemens 9510/9610 Power Meter	BOP Modbus	480 V meter, 3-phase demand
WPAR1_kWh	Parasitic Load MCC-1 GTG1/HRSG-1	DMMF	E-103	Siemens 9510/9610 Power Meter	BOP Modbus	480 V meter, Accumulated energy
WPAR2_kW	Parasitic Load MCC-4 Gas Compressor	DMMF	E-103	Siemens 9510/9610 Power Meter	BOP Modbus	480 V meter, 3-phase demand
WPAR2_kWh	Parasitic Load MCC-4 Gas Compressor	DMMF	E-103	Siemens 9510/9610 Power Meter	BOP Modbus	480 V meter, Accumulated energy
FS_gross	CHP Gross Steam Flow	FE-1	M-113	Rosemount 3051SMV3M12G3R2A11A1AC12 0 to 60,000 lb/hr	HRSG PLC	Gross steam flow from HRSG
FS_DA	CHP DA Steam Flow	FE-101	M-113	Averaging Pitot Tube Mass Flow Transmitter	BOP Modbus	Steam flow directed to deaerator
TS	CHP Steam Temeprature	TE-1	M-113	3-wire RTD 100 Ohm JMS Southeast 3EDBNK9BSPZZYZM3	HART Signal from FS_gross meter	
PS	CHP Steam Temeprature	PIT-2	M-113	Rosemount 3051TG3A2B21AS5B4Q4M5K5 Pressure Transducer -14.7 to 800 PSIG	HRSG PLC	Steam drum pressure
TC	CHP Condensate Temperature	TE-114	M-117	MgO Mineral Insulated Thermocouple	DA/FW PLC	Either bulk tank temperature or line temperature - as displayed on PLC HMI
FG	Turbine Gas Consumption	FM-586	M-122	Micromotion Coriolis Meter F200S419CCAAEZZZZ	Gas Booster PLC	Temperature and pressure compensated mass flow meter
FGB	Duct Burner Gas Consumption	FE-4	M-123	Rosemount 3051SMV3M11G3R2A11A1AC12C 0 to 60,000 SCFH	HRSG PLC	Temperature compensated differential pressure meter

Onsite Installation

No on site installation work is performed by CDH Energy.

Communications

All communications from the Rovisys system to the internet are supplied via AMC internal network. The Rovisys system will upload the data report once per day to the CDH Energy server via sFTP using the following credentials:

- Protocol: sFTP (port 22)
- Server: data.cdhenergy.com
- Username: albanymedical
- Password: rovisys5532

On Site Support

The site will be responsible for providing access to all areas necessary for verification of sensors.

3. Data Analysis

The collected data will be used to determine the net power output of the system as well as the fuel conversion efficiency (FCE).

Peak Demand or Peak kW

The peak electric output or demand for each power reading will be taken as the average kW in a fixed 15-minute interval (0:00, 0:15, 0:30, etc), or

$$\text{kW} = \sum_{15\text{min}} \frac{\text{kWh}}{\Delta t} = \sum_{15\text{min}} = \frac{\text{kWh per interval}}{0.25\,\text{h}}$$

and the net power output from the CHP system is defined as:

$$\mathbf{WG_{net} = WG - (WPAR1 + WPAR2)}$$

Where:

WG_{net}	-	Net output from gas turbine (kWh or kW)
WG	-	Gas turbine gross output (kWh or kW)
WPAR1	-	Parasitic load MCC-1 GTG1/HRSG-1 (kWh or kW)
WPAR2	-	Parasitic load MCC-4 Gas Compressor (kWh or kW)

Heat Recovery Rates

Heat recovery from the CHP system is achieved in the form of steam production from the HRSG. Steam conditions (temperature and pressure) are monitored leaving the HRSG to set the enthalpy of steam delivered, and determine the amount of superheat delivered. Useful heat recovery in the form of 85-PSIG steam is calculated by:

$$\mathbf{QU = (h_g(TS) - h_f(TC)) \times FS / 1000.}$$

Where:	QU	-	Useful heat recovery (MBtu or MBtu/h)
	h_g(TS)	-	Enthalpy of HRSG steam at 85-psig (stipulated) and steam temperature TS (Btu/lb)
	TS	-	HRSG steam temperature (deg F)
	h_f(TC)	-	Enthalpy of HRSG condensate (before deaerator) at 85-psig and temperature TC (Btu/lb)
	TC	-	Condensate temperature (deg F)
	FS	-	Net Steam Flow (lb/h) (FS_gross – FS_DA)

Fuel Input

Fuel input to the CHP system is measured by two gas meters. The first meter is a corilois meter that measures the high pressure gas leaving the gas compressor and entering the turbine. The second meter is a temperature compensated differential pressure meter that measures the low pressure gas to the HRSG duct burner.

Total gas input to the CHP system is:

$$\mathbf{FG_{tot} = FG + FGB}$$

Where:	FG_{tot}	-	Total natural gas input (CF or CF/h)
	FG	-	Gas turbine natural gas input (CF or CF/h)
	FGB	-	Duct burner natural gas input (CF or CF/h)

Calculated Quantities

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

$$FCE = \frac{QU + 3{,}413 \cdot (WG)}{0.9 \cdot HHV_{gas} \cdot FG_{tot}}$$

Where:

	QU	=	Useful heat recovery (Btu) (QUD+QUB)
	WG	=	Engine generator net output (kWh)
	FG_{tot}	=	Generator gas consumption (Std CF)
	HHV_{gas}	=	Higher heating value for natural gas (~1030 Btu per CF). 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:

$$FCE = \frac{\sum^{N} QU + 3{,}413 \cdot \sum^{N} (WG)}{0.9 \cdot HHV_{gas} \cdot \sum^{N} FG}$$

Where N is equal to the number of intervals in the period of interest.

Appendix A

System Schematic and Cut Sheets for Key Sensors and Instruments

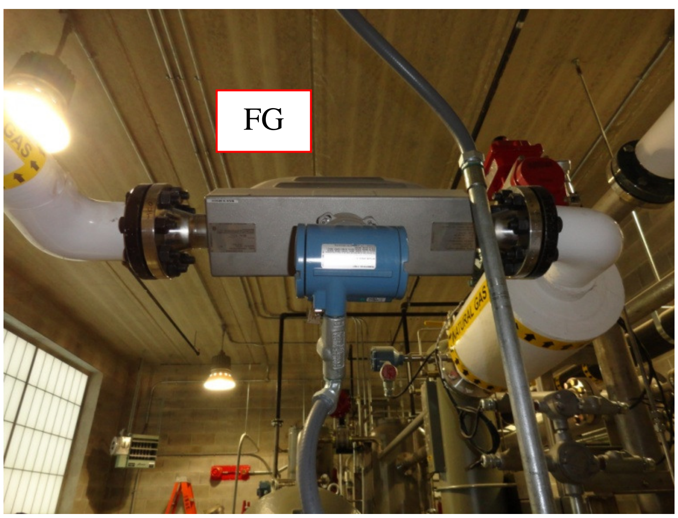
Appendix B

Site Photos

Gas Turbine

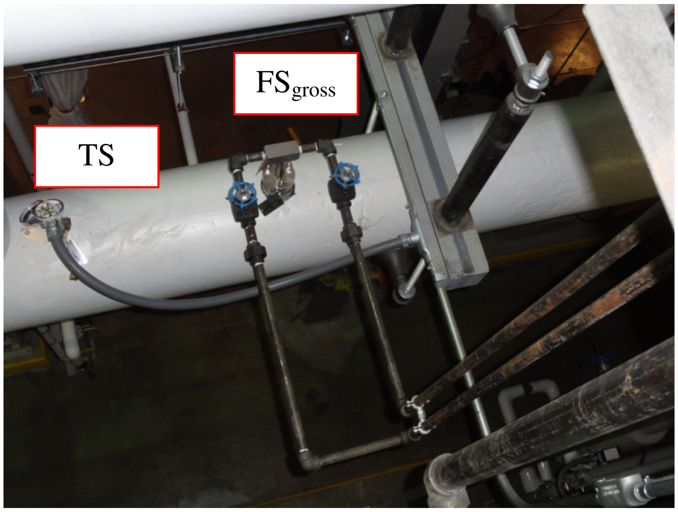
Heat Recovery Steam Generator (HRSG)

Gas Compressor

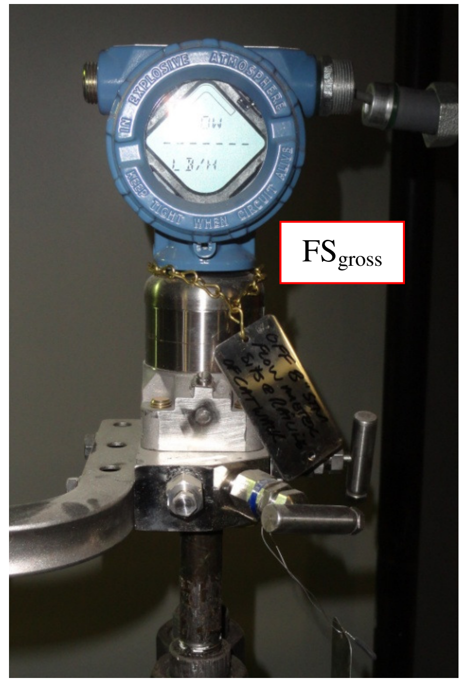


Turbine Gas Meter (FG)

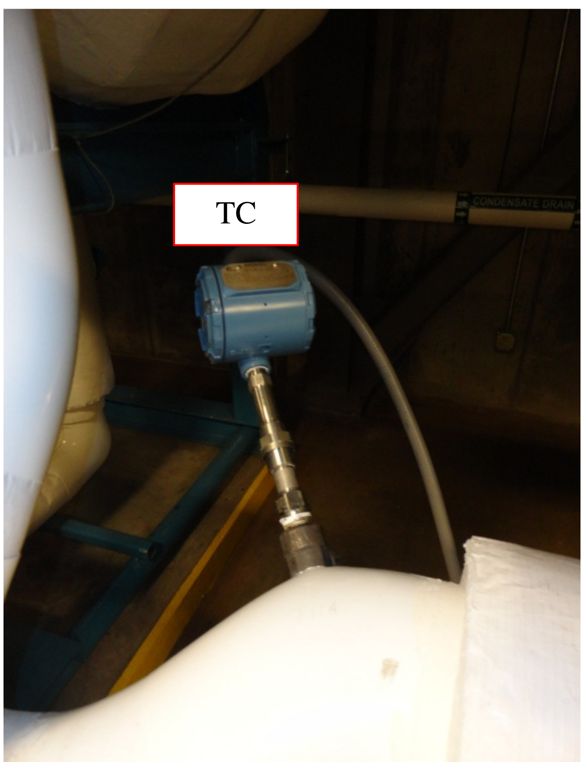
Duct Burner Gas Meter (FGB)



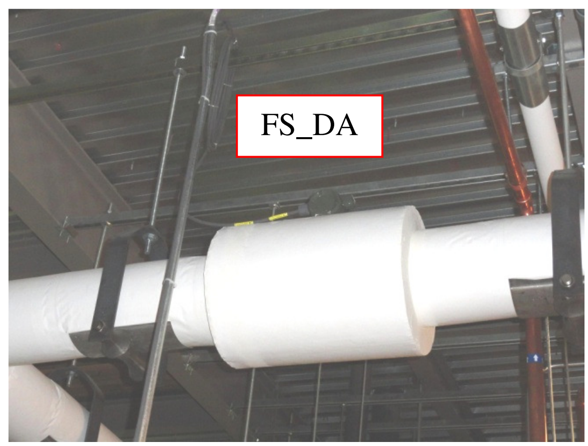
HRSG Gross Steam Meter (FS_{gross}) and Temperature (TS)



HRSG Gross Steam Meter (FS_{gross})



Condensate Return Temperature (TC) at Surge Tank



Deaerator Steam Flow (FS_DA)

at Mezzanine above DA Tank

Gas Compressor Power Transducer MCC-4 (WPAR2)

CHP Parasitic Loads MCC-1 (WPAR2)

Gas Turbine Gross Output Power Transducer SEL-724 (WG)