Cabrini Terrace Combined Heat and Power

NYSERDA CHP Monitoring Plan

Cabrini Terrace
900 West 190th Street
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CABRINI TERRACE CHP SYSTEM DOCUMENTATION:

CHP SYSTEM OVERVIEW:

CHP Units
There will be two CHP generating units in the installation:

CHP-1

- Manufacturer - Intelligen Power Systems (IPS)
- Fuel – natural gas
- Electrical capacity - 55 kW
- Thermal capacity – 313,000 BTUH (3.13 therms)
- Electrical interconnection – parallel induction through automatic protective relay system

CHP-2

- Manufacturer - Intelligen Power Systems (IPS)
- Fuel – natural gas
- Electrical capacity - 80 kW
- Thermal capacity – 383,000 BTUH (3.83 therms)
- Electrical interconnection – synchronous (black start capable) connected to “islanded” load panel (PLP) serving building common area loads

Manufacturer “cut sheets” for the CHP units are provided in the ATTACHMENTS section.

CHP Fuel Supply:
A new natural gas meter and a supply riser system will be required to provided fuel to the CHP units. The new meter will be installed in the existing gas meter room. Natural gas fuel will be provided to the CHP generators under the Con Edison rate, Rider H, for eligible distributed generation installations. The installation for the CHP gas riser will include a new hermetic Natural Gas Booster Compressor (Con Edison approved item and installation procedure) to increase the pressure from the 4 inches of water street inlet minimum to a minimum of 14 inches of water as required by the CHP units. The new Con Edison meter for Rider H will be equipped with pulse output for monitoring purposes.

DHW Heating Components
Primary utilization of the thermal output from the CHP installation will be heating of the DHW supply for the building. DHW load is currently met by the boiler on #6 oil. CHP system components that will provide DHW production include the following:

- HX-DHW (CHP Room) – brazed plate double-walled heate exchanger which will provide transfer of CHP thermal output to potable water in the new DHW storage tanks. HX-DHW is located in the CHP Room.
- ST-DHW1, ST-DHW2 – double glass-lined storage tanks with capacities of 1,040 gallons each. Potable water supply from the building will flow into these tanks to be heated by the CHP thermal output before returning on demand to the boiler and building DHW mixing valve.
- P-4 – circulates DHW in the storage tanks through the HX-DHW and back to the tanks. Circulation of DHW to the heat exchanger and flow to and from the building are independent circuits. P-4 will be discontinue circulation once storage tank temperature reachs 165 degrees.

Garage Space Heating

The parking garage is currently heated by two unit heaters using low pressure steam from the boiler. When not required for DHW production, thermal output from the CHP units will be diverted to two new units heaters (GUH-1, GUH-2) in the garage. These unit heaters will use the the CHP thermal output to offset the steam required in the two existing heaters.

Mechanical Balance of Plant:

The remainder of the main components in the CHP system include the following:

- HBR – heat balance radiator located on the parking garage roof to provide "dumping" capacity for thermal output from the CHP units which is not required for DHW heating or for the garage unit heaters. Flow of CHPHW to the HBR will be controlled by control valve CV-HBR based on control signals provided by the CHP control panels based on the temperature of the CHPW on the outlet side of the HX-DHW. The HBR fan is VFD-driven from the CHP control panel based on CHPHW temperature at the HBR outlet (return) connection.
- EF-1, EF-2 – ventilation fans which will ventilate the CHP Room to outdoors as required to maintain temperature at or below the set point.
- CV-GUH, CV-HBR – these control valves regulate flow of CHPHW to the garage unit heaters (GUH-1, GUH-2) and to the heat balance radiator
- Sensors and data collection components associated with the Monitoring and Data Acquisition system. The RMDA system is described in further detail later in this report.

Affected Site Areas

There are three areas within Cabrini Terrace where CHP components will be located or system connections made into existing systems.

- Utility Room – located on the first floor next to the building lobby. Electrical and natural gas service connections for the local distribution systems are located in this room along with gas and electrical metering and most of the electrical switchgear and distribution panels.
- Boiler Room – CHP DHW sysem connections to building cold water supply and to the building DHW system are originate in the existing boiler room. The CHP DHW system is connected in such a manner as to provide pre-heating of potable water before it flows through the existing boiler DHW heat exchanger and on to the existing DHW mixing valve, all of which are located in the boiler room.
- CHP Room – an enclosure built in the parking garage to house the majority of the CHP installation main components including the CHP units, control panels, DHW storage tanks and associated heat exchanger and circulating pump.
- Parking garage – in addition to the CHP Room, two unit heaters will be installed in the garage to utilize CHP thermal output to offset steam that is currently used to heat the garage in the winter. This will only take place if there is sufficient thermal energy in the CHPHW after it heats the DHW in the HX-DHW.

A mechanical site plan for Cabrini Terrace and a mechanical schematic for the CHP installation are included in the ATTACHMENTS section.

EXISTING FACILITY OVERVIEW:

Cabrini Terrace consists of 217 individual apartments of varying floor plans, with an estimated occupancy for this analysis of 2 persons per apartment for a total occupancy of 438 people. There are also common spaces on the first floor including the lobby, mail room, laundry room, and other community rooms. Cabrini Terrace has an attached, single story (above ground) garage structure with an open roof. Neighboring facilities include other multi-family residences with a school facility to the south. A basic site plan for Cabrini Terrace is included in the ATTACHMENTS.

Major Mechanical Systems:
Cabrini Terrace is currently equipped with the following major mechanical components/systems:

Boilers:
One Federal FST 300 boiler is installed to provide low pressure steam (less than 15 psig) for production of Domestic Hot Water (DHW) and facility heating. Currently Cabrini Terrace uses #6 heating oil as it's boiler fuel. Natural gas is supplied to the facility but it is used in domestic applications such as cooking and laundry dryers. The burner is an Industrial Combustion DEG-145P, capable of burning either heating oil or natural gas. Currently there is no natural gas connection to the burner other than for pilot gas.

Domestic Hot Water:
Hot water demand is met by a heat exchanger coil in the boiler. There is currently no DHW storage capacity installed in Cabrini Terrace. DHW storage is being added as part of the CHP installation.

Heating Systems:
Heating is provided by low pressure steam distributed to the dwelling units and common spaces from the boiler room. Steam is also supplied to a pair of unit heaters in the garage.

"Central" Coolers/Chillers/Air Handlers:
Apartments are cooled by their own air conditioners. The CHP installation will help meet the electrical load imposed by these units in the peak summer load period.

The lobby is cooled by an electric chiller rated at 5 tons with ducted distribution throughout the lobby.

Current Utility Rates - Electric:
Electrical supply for the buildings meters is provided by Con Edison under Con Edison's SC RA-8, residential redistribution with third party commodity supply. Master meter/submeter electrical distribution supplies the apartments and the parking garage.

Once the CHP system is commissioned, electrical service will be provided under Con Edison Rate RA-14, Standby Service. The Cabrini Terrace CHP installation will meet the criteria for exemption from billing under the actual RA-14 rate structure and will continue to be billed under its current rate.

Current Utility Rates – Natural Gas:
Natural gas is supplied for domestic loads (cooking, laundry) under Con Edison rate 2. Domestic hot water (DHW) loads are met by the existing # 6 oil-fueled, low pressure steam boiler located in the boiler room.

CHP OUTPUT UTILIZATION

Thermal Utilization

CHP thermal output will be recovered and used to heat/pre-heat the DHW supply for the building and then to heat the parking garage. Both of these thermal loads will offset boiler steam/firing. The two CHP units have a thermal capacity of 700,000 BTUH and the design temperature for the CHPHW leaving the CHP units is 190 °F.

DHW load is currently met by heaters in the existing #6 oil fired boiler, which will remain in service for heating load and to provide supplementation/backup to the CHP DHW heating. The boiler may be shut down during the summer once the CHP installation is fully commissioned if the building so chooses. Two new DHW storage tanks are included in the CHP room to provide thermal storage capacity. Each tank has a cacity of 1,040 gallons. The tanks provide thermal storage capacity to meet DHW demand during peak periods, reducing supplemental firing of the boiler. They will also reduce the amount of thermal output from the CHP units that has to be "dumped" during low demand periods.

Heat transfer between the CHP hot water circulation system (CHPHW) and the DHW will take place in heat exchanger HX-DHW, a double-walled, brazed plate heat exchanger. Pump P-4 will circulate potable water from the storage tanks through the HX-DHW and back to the tanks. P-4 will be shut down if storage tank temperatures reach 165 °F. Circulation between the storage tanks and the building DHW system will according to demand, with the storage tanks connected upstream of the boiler DHW coil as pre-heaters. The DHW from the storage tanks will pass back through the boiler heating coil and on to the existing building DHW mixing valve. The boiler will be able to provide any additional heating required using its existing control systems and set points.

Two "unit heaters", GUH-1 and GUH-2, are being installed in the garage, outside of the CHP Room, and in proximity to the current steam unit heaters. CHPHW flow to the heaters is controlled by CV-GUH based on the CHPHW temperature at the outlet of the CV-GUH. The initial set point for the CV-GUH will be 175 °F. When the CHPHW is above the set point, the CV-GUH will divert CHPHW to the garage heaters. The fans in the garage heaters will be activated by an aquastat on the CHPHW outlet for each fan, cycling on when the CHPHW temperature leaving the fan is above the set point (also initially 175 °F). A thermostat in the garage will override the aquastat for the fans, preventing fan operation when the garage temperature is above 70 °F. The setpoints are subject to adjustment as experience with system operation is acquired.

Dumping of excess thermal energy will take place through the heat balance radiator, HBR. CHPHW flow to the HBR is controlled by CV-HBR with an initial set point of 175 °F for CHPHW leaving the outlet port of the CV (returning to CHP engines). The HBR fan will be controlled by a VFD based on CHPHW temperature leaving the HBR, returning CV-HBR "cold" port. The target temperature from the HBR to the CY-HBR will be 170 °F to provide a colder source into the mixing valve to enable it to achieve the 175 °F outlet mixed temperature. This set point will be adjusted based on operational experience.

Electrical Utilization

Participation in PON 1241 requires that the CHP installation provide standby power and black-start capacity, using the "prime movers" of the CHP installation. In the Con Edison service area, this will necessitate either the use of inverter-based CHP units, of which there are currently only two, or the installation of CHP units which are isolated from the distribution grid and serve designated loads. Some facilities may be able to identify and isolate loads which match the synchronous CHP unit electrical capacity, but this will be difficult for many facilities such as Cabrini Terrace where the common area loads are relatively small and cyclical in nature (elevators, house water pumps, lobby cooling). This isolated operation scenario will require the CHP unit to follow the load on it, resulting in variation in the thermal output as well.

The load being met by the synchronous CHP at Cabrini Terrace will be the "priority" loads that would be picked up on loss of grid if a basic standby generator were installed. The cyclical nature of these loads and the need to accommodate variation of the loads makes it necessary for the electrical capacity of CHP-2 to be higher than the typical loads to allow it to meet the moementary peaks as motors and other loads cycle. The need to operate at levels well below the synchronous unit capacity imposes a utilization loss on the synchronous unit.

The basic electrical configuration of the Cabrini Terrace CHP is as follows:

- The 55 kW CHP unit (CHP-1) is an induction unit and will be connected in parallel with the existing electrical distribution grid through an approved protective relay installation (IPR). The output from CHP-1 will simply offset the power that would have been delivered from the local Con Edison distribution system. The facility loads are such that the induction unit electrical output must be able to follow the facility load if they are low enough or the IPR will trip the unit on reverse power.

- CHP-2, rated at 80 kW, is a synchronous unit capable of "black start" operation, operating isolated from the electrical grid and supplying priority electrical loads through the existing PLP distribution panel. The PLP panel feeds the common area loads for the building including:

    - elevators
    - house fresh water pumps
    - access/egress lighting circuits in hallways and stairs
    - lobby 5 ton cooler and emergency medical storage refrigerator
    - boiler and required systems (pumps) for winter operation on loss of grid
    - power supply for the City Wide Mobile Wireless Network cellular towers

  The synchronous unit will be "backed up" by the existing distribution grid through a "break-before-make" automatic transfer switch (ATS). Transition will not be "flicker free" but it will be automatic should the CHP-2 unit be out of service. The priority loads will be met by the synchronous unit at all times, with transfer back to the local distribution grid only when it is necessary for the synchronous unit to be off line.

  Based on historical billing data for the common area loads, the load being carried by the CHP-2 will vary between 30 and 60 kW, with periods of spike loading due to inrush on motors and cycling of loads such as the boiler. Any generator which is islanded in this manner to a variable load must not be loaded to its rated capacity except for short periods of load cycling or in-rush. Islanded operation of a generator will generally result in significantly reduced utilization due to the need to keep reserve capacity available and not trip the generator on overloads.

Feasibility Study and Estimated Annual Performance

The CHP installation at Cabrini Terrace was developed through an feasibility study carried out by DSM Engineering Associates which considered the CHP installation along with assessment of the economic performance of the solar PV array, which has since been installed on the garage roof. Based on the findings of the feasibility study, Cabrini Terrace has included CHP in the development of its Energy Reduction Plan under the Multi-Family Performance Program, though funding for the CHP installation was not included in the MFPP ERP. NYSERDA awarded a demonstration grant to Cabrini Terrace for the CHP installation through PON 1241.

Table 1 below shows an updated economic analysis of the installation carried out in November of 2009. This update was done to reflect the actual implementation costs for the project after the processes of bid solicitation and evaluation were completed. The final cost of the project came in higher than the projected costs in the PON 1241 and the building requested review of economic performance before proceeding with the project. Payback under the new, final project costs is between 6 and 8 years according to variations in gas costs and the level of demand savings achieved.

Table 1 - Revised Project Economic Summary

CURRENT DEVELOPMENT BUDGET	**GEM/IPS 80kW Synch, 55 kW Parallel**	
Engineering	65,000	(20% reduction)
Construction Contract	628,720	GEM
Gas Alternates	18,000	
Commissioning	-	
Open House	-	
Automated Reporting	15,000	
Con Edison Tie-In Fees	10,000	
Other		
Other		
TOTAL	**736,720**	

FINANCING COSTS		
Total Development Costs	736,720	
Less: NYSERDA Grant	(306,000)	
Total Costs to CTOC	430,720	
Annual Debt Cost (assuming 1% loan, 8 years)	**(56,045)**	8

	CO-GEN BASIC ANALYSIS							
	Assumptions:							
A	Electric Cost	$	0.19	per KWH (demand included)				
B	Gas Cost	$	1.04	per Therm		$	1.17	Blr equiv gas
C	Electricity Produced (net of parasitic energy)		665,547	KWHs				
D	Gas Used for Co-Gen		77,986	Therms				
E	Gas Equivalent Saved by Co-Gen on DHW		39,875	Therms				
F	Co-Gen Maintenance Annual Maintenance Costs	$	16,638	(2.25 cents/kWH)				
	Annual Costs and Benefits:	**Base Case**		**Max Demand**		**65 gas**		
	Electric Savings (A x C)	$	107,631	$	117,638	$	107,631	
	Gas Costs of Running Co-Gen (B x D)	$	(81,161)	$	(81,161)	$	(73,209)	
	DHW Savings (B x E)	$	46,693	$	46,693	$	46,693	
	Co-Gen Maintenance Costs (F)	$	(16,638)	$	(16,638)	$	(16,638)	
G	Net Benefits before Financing Costs	$	56,525	$	66,532	$	64,477	
	Simple Payback (years)		7.6		6.5		6.7	
H	Financing Costs:	$	(56,045)	$	(56,045)	$	(56,045)	
	LCCA Payback (years)		8.0		7.0		7.0	
	Net Benefit (Cost) (G+H)	**$**	**480**	**$**	**10,487**	**$**	**8,432**	

NYSERDA MONITORING PLAN OVERVIEW:

CHP System Schematics and NYSERDA Monitoring Points :
The following drawings/schematics are provided as attachments (separate files) to this document

- CHP Electrical 1-Line Diagram (Dwg E-1.0-AB)
- CHP Mechanical Flow Diagram (Dwg M-100)
- Cabrini Terrace CHP Mechanical Site Plan (Dwg M-300)

Also included in the ATTACHMENTS are NYSERDA Monitored Points Table 1 and Table 2 listing the data points in the CHP installation that are being monitored and the basic details concerning collection of the data and accessing it, collection interval, and instrumentation. Table 1 lists the data that will be collected automatically while points requiring manual data collection methods are listed in Table 2.

Cabrini Terrace data point nomenclature has been developed following the naming convention suggested in ***Appendix A of the NYSERDA Monitoring and Data Collection Standard for DG/CHP Systems (Dec 29, 2004).***

Monitoring Objectives:

The Cabrini Terrace CHP monitoring plan has been designed to meet the Primary Monitoring Objectives as defined in Table 2 of the Monitoring and Data Collection Standard for Distributed Generation/Combined Heat and Power (DG/CHP) Systems manual. The monitoring objectives and associated data points from the Cabrini Terrace CHP system are as follows:

1) *Quantify variation of DG/CHP system power output, gas consumption, and efficiency over a wide range of annual operating conditions:*

CHP power output (WG-CHP1, WG-CHP2) and the pulse output from the CHP gas service meter (FG-G-TOT) will be collected in the CHP control panels and made available to data collection system for processing and storage.

Gross Electrical efficiency will be calculated for a given time interval by converting the fuel input to the units and the electrical output into common units (BTU or kW). The electrical output divided by the fuel input for a given time interval will provide the gross electrical efficiency. Net electrical efficiency will be determined by subtracting the calculated total parasitic loads (described below) from the gross electrical output and the dividing by the fuel input. These efficiencies will be determined for hourly, daily, and monthly intervals, with other intervals available as required for reporting. Unit conversions and efficiency calculations will be carried out external to the CHP data collection system. Details on external data handling and processing are provided in the EXTERNAL DATA PROCESSING AND REPORTING section of this report.

2) *Quantify external parasitic loads:*
"Parasitic" electrical loads for the Carbini Terrace CHP systems are those electrical loads external to the CHP generator unit which are required for the operation of the CHP system(s). These parasitic electrical loads include:

- Electrical power consumed by the gas booster, GB (WP-GB). The gas booster will operate continuously and power consumption will be calculated based on the status indication from the

CHP control panel (S-GB) and instantaneous power consumption measured with a hand power meter on a periodic basis (annual or bi-annual). Power consumed over a given time period is the product of the most recent power consumption reading and the hours in service as determined from the S-GB status indication.

The control system and design of the gas booster is such that electrical load will be constant – no VFD or multi-speed control or option is included. Because load is expected to remain constant on the booster, the "snap shot" power consumption readings are the basis for calculation of parasitic loads GB. Initially, as part of commissioning of the system, the power consumption of GB will be determined with each CHP unit on line individually and together. Combined with status data on the booster and the CHP unit electrical loads, the GB parasitic load can be determined from external "lookup" in a table derived from the readings at various typical loads on GB.

- CHPHW circulation pump power consumption (WP-P-CHP1, WP-P-CHP2). These pumps are located inside the CHP cabinets and will operate continuously at steady load. Pump power consumption will be calculated based on the status indication from the CHP control panel for each pump (S-P-CHP1, S-P-CHP2) and instantaneous power consumption measured with a hand power meter on a periodic basis (annual or bi-annual). Power consumed over a given time period is the product of the most recent power consumption reading and the hours in service as determined from the pump status indication for each interval.

  The control system and design of these pumps are such that electrical load will be constant on each – no VFD or multi-speed control or option is included. Because load is expected to remain constant on these pumps when each CHP unit is on line, the "snap shot" power consumption readings will accurate basis for calculation of parasitic loads for these pumps. Combined with status data on the pumps, the pump parasitic loads can be accurately calculated.

- DHW storage tank/HX-DHW circulating pump P-4 power consumption (WP-P-4). This pump will operate only when the DHW storage tank temperature is below 165 ºF. Pump power consumption will be calculated based on the status indication from the CHP control panel for this pump (S-P-4) and instantaneous power consumption measured with a hand power meter on a periodic basis (annual or bi-annual). Power consumed over a given time period is the product of the most recent power consumption reading and the hours in service as determined from the pump status indication for each interval.

  The control system and design of this pump is such that electrical load will be constant – no VFD or multi-speed control or option is included. Because load is expected to remain constant, the "snap shot" power consumption readings will accurate basis for calculation of parasitic load, combined with status data.

- CHP Room exhaust fans (EF-1, EF-2) power consumption (WP-EF-1, WP-EF-2). EF-1 is controlled by a VFD in the CHP control panel based on CHP Room ambient temperature and power consumption will be derived from the output VFD power to the fan. EF-2 is either on or off, controlled from the CHP control panels based again on CHP Room temperature. EF-2 power consumption will be calculated based on the status indication from the CHP control panel for this pump (S-EF-2) and instantaneous power consumption measured with a hand power meter on periodic basis (annual or bi-annual). Power consumed over a given time period is the product of the most recent power consumption reading and the hours in service as determined from the pump status indication for each interval.

The control system and design of EF-2 is such that electrical load will be constant – no VFD or multi-speed control or option is included. Because load is expected to remain constant, the "snap shot" power consumption readings will accurate basis for calculation of parasitic load, combined with status data.

- Heat Balance Radiator (HBR) fan power consumption (WP-HBR). HBR fan operation is controlled by VFD in the CHP control cabinet. Its power consumption will be derived from the output VFD output to the fan motor.

- Garage unit heaters (GUH-1, GUH-2) power consumption is not a parasitic electrical load for the CHP installation. The operation GUH-1 and GUH-2 will offset the operation of fans for the garage unit heaters. The power consumption of the GUH-1 and GUH-2 will not be deducted as part of the parasitic load.

Typically the parasitic power consumption for a given device will be calculated by determining the total time during a given interval the device was in service based on the device status data throughout the given interval. Where power consumption of the device is determined from "snap shot" readings such as the periodic readings with hand-held power meters on constant load equipment, the power consumption data will be combined with the in-service time from the status data to calculate the power consumption through the time period (kWH). If necessary, the snap shot data will be converted into kW if it was taken as volts and amps.

Power consumption for parasitice loads for which actual power consumption data from VFDs is available is calculated by summation of the power data across the desired time interval. Parasitic power consumption will be determined for hourly, daily, and monthly intervals, with other intervals available as required for reporting. Unit conversions and efficiency calculations will be carried out external to the CHP data collection system. Details on external data handling and processing are provided in the EXTERNAL DATA PROCESSING AND REPORTING section of this report.

3) *Quantify the daily, weekly, monthly, and annual variation of total facility power use (or power purchased from the utility) so that total actual utility costs can be determined:*

   Monitoring of purchased utility power (W-BLDG) will be achieved using pulse outputs from the Con Edison building "master" meter. The pulse outputs will be connected to the CHP control panels in the CHP Room.

4) *Determine the thermal loads imposed on the CHP system by the facility (useful thermal output supplied to the facility) to measure the total CHP efficiency of the system on a daily, monthly, and annual basis; quantify the variation of these loads with ambient conditions and operating schedules;*

   The thermal output of the Cabrini CHP installation and the thermal loads it meets for the building will be determined from a flow meter in the CHPHW circulation system and data from temperature sensors located as required in the CHPHW piping to provide the temperature differentials required to determine thermal transfers across the CHP units and the loads. The flow meter and temperature sensor outputs are collected by the CHP control panels. Data required for each thermal transfer is as follows:

- *BTU Output of CHP units (QHR-CHP)*
  CHPHW flow, THR-HI, THR-LO

- *BTU Useful Output supplied to building systems. (Q-BLDG)*
  CHPHW flow, T-BLDGHI, T-BLDGLO

Calculation of these thermal transfers will be carried out as part of the external data processing. Each thermal transfer rate is calculated as follows:

$$Q_{BTUH} = Flow_{GPM}\ X\ (T_{HI} - T_{LO})\ X\ (Heat\ Transfer\ Conversion_{\ Min\ to\ Hour})$$

- *Flow will be as measured by the flow meter*
- *T_{HI} and T_{LO} will be as measured by the sensors associated with the subject heat transfer*
- *The heat conversion factor is 500 for water and 470 for 30% glycol solution*

CHP total efficiency for a given time period will be calculated based on the fuel consumption, electrical ouput, and thermal output during the specific time period. This calculation will be carried out through spreadsheet analysis external to the CHP data collection system for standard intervals as required for reporting. Total system efficiency, or fuel conversion efficiency, will be calculated as follows:

$$E_{FCE} = Fuel\ Input \div \sum Useful\ Energy\ Produced$$

$$\sum Useful\ Energy\ Produced = \sum(WG\text{-}CHPn) - \sum(Parasitic\ Elect) + Q\text{-}BLDG$$

- *E_{FCE} - Fuel conversion efficiency*
- *Fuel Input – gas fuel supplied (converted to common energy units)*
- *CHP electrical output and parasitic electrical loads, and useful thermal energy produced (Q-BLDG) are all converted to common energy units*

Hourly ambient temperature data from the closest available weather data collection point (Central Park) will collected from Weatherbank or other similar source as part of the data processing external to the CHP data collection system. The hourly weather data will be used to analyze the impact of ambient conditions on the thermal and electrical loads for the building and the efficiency and utilization of the CHP installation output. Additional information on the data processing external to the CHP data collection system is provided in the EXTERNAL DATA PROCESSING section of this report.

5) *Quantify the displaced fuel use on auxiliary equipment and systems to confirm the benefit of heat recovery:*

Fuel use data for the low pressure steam boiler (#6 oil) is available only from the oil delivery billing data. Fuel offset by the CHP in for DHW production will be calculated based boiler efficiencies as at various firing rates collected as part other energy-related work in the facility through the MFPP program. The heat transferred to the building DHW from the CHP system will be limited to DHW during the non-heating season. Offset fuel for operation of the garage unit heaters (GUH-1, GUH-2) will be calculated by deducting typical DHW loads, once established, from total heat transferred to the building (measured heat transfer is for both DHW and garage heating combined). Offset fuel from garage heating will be an estimate under any circumstances since there is no current metering of steam use by the existing unit heaters in the garage and the operation of GUH-1 and GUH-2 will not necessarily preclude operation of the existing heaters.

6) *Quantify the amount of available thermal energy that is unused or "dumped" by the CHP system in order to demonstrate a system "heat balance".*

- *BTU Rejected by heat dump (Q-HBR)*
  CHPHW flow, T-HBRHI, T-HBRLO

Calculation of the heat rejected by thermal transfers through the HBR will be carried out as part of the external data processing. The heat rejection thermal transfer rate is calculated as follows:

$$Q_{BTUH(HR)} = Flow_{GPM} \text{ X } (T\text{-}HBRHI - T\text{-}HRBLO) \text{ X } (Heat\ Transfer\ Conversion\ _{Min\text{-}Hour})$$

- *Flow will be as measured by the flow meter*
- *T-HBRHI and T-HBRLO will be as measured by the sensors in the CHPHW system as shown in the included drawing M-100. Note that the sensors are located before the CHPHW system divides for the HBR and after the HRB control mixed (CV-HBR) output port. This position has been selected to provide the required temperature differential across the HRB without requiring and additional flow meter in the CHPHW piping.*
- *The heat conversion factor is 500 for water and 470 for 30% glycol solution*

Table 3 in the Monitoring and Data Collection Standard summarizes additional objectives that are considered optional. These objectives are not directly addressed by the Monitoring Plan described herein. However, the manufacturer of the CHP units and associated control panels also collects operational data from the installation in order to provide maintenance services and unplanned outage response. Their data collection is carried out to achieve Objectives 8 and 9 – diagnostic/operational data to support maintenance and performance evaluation and verification of specification compliance.

As required and provided for by NYSERDA through contracted emissions analysis vendors, the Cabrini Terrace CHP units will be available as pre-arranged with the facility for initial commissioning testing of the CHP unit emissions. Periodic re-evaluation will be supported as required and arranged for by NYSERDA.

EXTERNAL DATA PROCESSING AND REPORTING

DSM Engineering Associates (DSMEA) will provide data acquisition and processing of NYSERDA monitoring data for the Cabrini Terrace CHP installation. The CHP unit control panels will provide the data acquisition functions and some data processing such as heat transfer calculations based on incoming flow and temperature data for a given heat transfer. The control panels will not store the data – they will pass the data as a continuous MODBUS date stream to an external data collection and processing system.

The external data collection and processing system will consist of a local data collection and storage computer (LDCS) located in the CHP Room, with the control panel MODBUS connection passing the CHP monitoring data to it. Data will be recorded on intervals of no more than 15 minutes, with shorter intervals being used for data requiring averaging to capture short transients. The LDCS computer will perform some preliminary data processing as required to capture the MODBUS data stream and extract only those data points required for monitoring. The data will be stored with a "date-timestamp" attached to the record for each interval in Comma Separated Variable (CSV) format. The LDCS will also serve as a backup data archive in the event that data previously sent to the FTP server is lost or corrupted.

DSMEA has commissioned the development and deployment of automated "script" routines that will be resident on the DSMEA FTP server to automatically download the NSYERDA monitoring CSV files at intervals of no more than 12 hours. The data will be transferred automatically from the LDCS at Cabrini Terrace to the DSMEA FTP server by these scripts. Connection to the LDCS is flexible – internet, cellular, and phone with dial-up modem have all been used for remote data collection by DSMEA in its "True Use" metering projects.

The processing of the CSV files into data format acceptable to the NYSERDA Data Integrator will be accomplished using spreadsheet applications which will import the CSV data from the FTP server and incorporate it into these spreadsheets to archive the data and prepare it for transmission on a daily basis to the NYSERDA Data Integrator. Initial website presentation of the data will through the NYSERDA Distributed Generation website.

If Cabrini Terrace requests additional reporting capability such as customized reports on performance or a "near real time" visual presentation of the CHP operational status and performance, these will be developed as "value added" services by DSMEA.

ATTACHMENTS

1. Cabrini Terrace CHP NYSERDA Monitoring Points Tables

(The following attachments are provided as separate PDF files)

2. CHP unit specifications
    a. IPS 55 kW induction unit CHP-1
    b. IPS 80 kW synchronous unit CHP-2
3. CHP Electrical 1-Line Diagram (Dwg E-1.0-AB)
4. CHP (cogeneration) Mechanical Flow Diagram (Dwg M-100)
5. Cabrini Terrace Mechanical Site Plan (Dwg M-300)

Cabrini Terrace Monitoring Points Table 1 – Automatic Data Points

Data Point Tag	System/ Equipment	Parameter	Units	Interval	Meter	Collection Point	Dwg
WG-CHP-1	CHP-1	CHP1 Electrical Output	kW	15 Minute	CHP internal metering	CHP Control Pnl MODBUS Out	CTOC M-100-NMP
WG-CHP-2	CHP-2	CHP2 Electrical Output	kW	15 Minute	CHP internal metering	CHP Control Pnl MODBUS Out	CTOC M-100-NMP
QHR-CHP	CHPHW	Total CHP Heat Recovered	BTU	15 Minute	BF-CHPHW, T-HRHI, T-HRLO	CHP Control Pnl MODBUS Out, Integrated in panel	CTOC M-100-NMP
Q-BLDG	CHPHW	CHP Heat to Bldg DHW and garage heating	BTU	15 Minute	F-CHPHW, T-BLDGHI, T-BLDGLO	CHP Control Pnl MODBUS Out, Integrated in panel	CTOC M-100-NMP
Q-HBR	CHPHW	CHP Heat rejected by HBR	BTU	15 Minute	F-CHPHW, T-HBRHI, T-HBRLO	CHP Control Pnl MODBUS Out, Integrated in panel	CTOC M-100-NMP
FG-G-TOT	CHP-1, CHP-2	Total fuel gas flow to CHP	Therms	15 minute	Utility gas meter (pulse outputs)	CHP Control Pnl MODBUS Out	CTOC M-100-NMP
W-BLDG	Building Elect Meter	“Purchased Power”	kWH	15 Minute	Bldg Elec Utility Meter	CHP Control Pnl MODBUS Out	CTOC M-100-NMP
S-P-CHP1	Pump P-CHP2	Pump run time	hours		CHP panel status input	CHP Control MODBUS Out	CTOC M-100-NMP
S-P-CHP2	Pump P-CHP2	Pump run time	hours		CHP panel status input	CHP Control MODBUS Out	CTOC M-100-NMP
S-P-4	Pump P-4	Pump run time/status	hours		CHP panel metering	CHP Control Pnl MODBUS Out	CTOC M-100-NMP
S-GB	Gas Booster GB	Gas booster run time/status	hours		CHP panel metering	CHP Control Pnl MODBUS Out	CTOC M-100-NMP
WP-EF-1	EF-1	Pump power consumption	kWH	15 minute	CHP panel VFD output	CHP Control MODBUS Out	CTOC M-100-NMP
WP-EF-2	EF-2	Pump power consumption	kWH	Bi-annual	Hand power meter	EF-2 power connections	CTOC M-100-NMP
S-EF-2	EF-2	Pump run time/status	hours		CHP panel status input	CHP Control MODBUS Out	CTOC M-100-NMP
WP-HBR	HBR	Pump power consumption	kWH	15 minute	CHP panel VFD output	CHP Control MODBUS Out	CTOC M-100-NMP

Cabrini Terrace Monitoring Points Table 2 – Manual/Periodic Data Points

Data Point Tag	System/ Equipment	Parameter	Units	Interval	Meter	Collection Point	Dwg
WP-P-CHP1	Pump P-CHP-1	Pump power consumption	kWH	Bi-annual	Hand power meter	P-CHP1 power connections	CTOC M-100-NMP
WP-P-CHP2	Pump P-CHP2	Pump power consumption	kWH	Bi-annual	Hand power meter	P-CHP2 power connections	CTOC M-100-NMP
WP-P-4	Pump P-4	Pump power consumption	kWH	Bi-annual	Hand power meter	P-P-4 power connections	CTOC M-100-NMP
WP-GB	Gas booster GB	Pump power consumption	kWH	Bi-annual	Hand power meter	GB power connections	CTOC M-100-NMP
WP-EF-2	EF-2	Pump power consumption	kWH	Bi-annual	Hand power meter	EF-2 power connections	CTOC M-100-NMP