SYRACUSE UNIVERSITY GREEN DATA CENTER
NYSERDA MONITORING PLAN

BHP ENERGY LLC

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BACKGROUND INFORMATION

Syracuse University has completed construction of the new Green Data Center on its South Campus. This 11,900 square foot Data Center is powered by a 780KW MicroTurbine-based Combined Heat, Cooling and Power (CHCP) plant. The new Data Center is the University's primary production Data Center.,

The design of the Data Center DG-CHCP system is comprised of two arrays of six Capstone model C65 packaged MicroTurbines, with N+1 redundancy in each array. The system is capable of simultaneously producing AC and DC power. Each array can direct the turbine exhaust from the turbines to a heat exchanger for use in comfort heating, and/or to a double-effect absorption chiller to provide cooling for IT equipment, and air conditioning. The primary load for the system is the Data Center but connections allow for heating and cooling of the adjacent building (at 621 Skytop Rd) as well.

The DG-CHCP system is configured to support both a stand-alone secure power system, and connection to the power grid. Power may be either exported to or imported from the grid at this connection. Power generated by the MicroTurbines will be used to supply the IT equipment in the data center, and the mechanical support equipment in the Datacenter on the secure stand-alone system. Other available power generated by the system is exported to loads within the University's South Campus power system. No power export at the point of service from the local utility is expected.

Thermal energy, both hot and chilled water, will be used to first serve the cooling and heating loads within the Datacenter. Any additional available thermal energy will then be used to meet HVAC and domestic water heating loads in the 621 Skytop Road Building.

As conceived, the system will follow a thermal load dispatch priority. The heating and cooling load of the datacenter will be supported along with a portion or the entire load of the adjacent building 621. Power generated will support the secure data center load. Depending on the coordination between the thermal and electrical load, excess power will be exported to the campus grid, or power will be imported to support any shortfall. This permits optimized operation for best thermal efficiency. An onsite propane gas storage and delivery system is available for MicroTurbine operation in the event of an unexpected disruption in the natural gas supply. A 17-minute battery back-up system is also available in the event that both the fuel source and the grid are lost.

For more details of operation, refer to the Syracuse University Green Data Center DG-CHP Project proposal (PON No. 1241) dated 12/10/2008 and also attached.

I. Documenting System Details

A. Equipment

1. Basic Equipment and System Overview
   The Distributed Generation/Combined Heat and Power (DG/CHP) system consists of the following equipment and sub-systems:

   a) Twelve (12) 65 KW Natural Gas fired Capstone Hybrid UPS MicroTurbines
   b) Two (2) Cain Heat Exchangers of 2,200,000 BTU/Hr capacity each
   c) Two (2) 150 Ton capacity Thermax Double Effect Absorption Chillers
   d) One (1) Enersys Battery Backup System consisting of 344 flooded lead-acid cells with capacity to supply backup emergency power for 17 minutes
   e) One (1) Backup Propane system to supply propane-air mixture mimicking the properties of natural gas. 1962 gallons (24 hour supply) in an underground storage tank.

   Notes:

   - Six turbines power the Data Center with a redundant system of six turbines.
   - The turbines are also connected to the University electrical grid and are capable of exporting power to the grid if required by system conditions.
   - The turbines generate 65 KW each to power the data center. The exhaust heat energy supplies heat to the Cain Heat Exchangers to make hot water and also supplies heat to the absorption chillers to make chilled water for use in the data center and the adjacent building.

2. Power Generating Equipment
   b) Capstone Hybrid MicroTurbines (each)
      - Net Power Output – 65 KW
      - Fuel source – Natural Gas - 7 psi
      - Operating Voltage – 480 VAC / 400 VDC
      - Electrical service – 3 phase -4 wire AC and DC
      - Frequency Operating Range – 60 HZ AC
      - Electrical Efficiency – 29% LHV
      - Natural Gas Turbine Inlet Pressure – 75-80 psig
      - Net Heat Rate - 11,800 Btu /kWh
      - Max. NOx Emissions – 9 ppmvd
      - Exhaust gas Temperature – 588 F
      - Number of Micro Turbines – 12

3. Heat Recovery System

a) Cain Heat Exchangers Model HRSR-348C26ALP
   - Design Pressure – 150 psig
   - Exhaust Flow Rate – 5184 SCFM
   - Exhaust Gas Entering Temperature – 588 F
   - Exhaust Gas Leaving Temperature – 220F
   - Liquid Flow rate – 240 gpm
   - Heat Recovered – 2.275 million Btu/hr

b) Thermax Absorption Chillers
   - Cooling Capacity – 155 T
   - C.O.P – 1.3
   - Chilled Water Flow – 371 USGPM
   - Chilled Water Temperature – Inlet – 55F
   - Chilled Water Temperature – Outlet – 45F
   - Exhaust gas flow rate -23251 lb/hr
   - Exhaust Gas Temperature – Inlet – 588F
   - Exhaust Gas Temperature – Outlet – 356F

c) Displaced Thermal Equipment

   Due to redundancy requirements at the site, no existing equipment will be retired or placed off-line due to the installation of the DG-CHP equipment.

4. Backup Propane System

   An underground 1,920 gallon (24 hour supply) of LPG gas is furnished to supply backup fuel to the turbines in the event of a natural gas failure.

5. Battery Backup System

   A 344 cell, lead acid, 400 volt battery system is furnished to supply back-up power to the data center in the event of multiple failures. This will allow adequate time for a systematic shutdown of the computer systems

6. Facility Load Details

a) University Green Data Center
   - 11,900 square foot facility (6000 square foot data center raised floor with 5900 square foot power center and maintenance area)

b) Building 621 – Heating and cooling loads that can be effectively served by the DG-CHP system in the Datacenter.

c) Electric Utility Details
   - Electric Utility Meters – Part of Syracuse University Campus Electrical Grid

- Original and current electric and gas tariff info – Please refer to the Syracuse University Green Data Center DG-CHP Project proposal (PON No. 1241) dated 12/10/2008 and also attached.

B. System Schematics

See the attached drawings - for basic system schematic

1. N-1PID
2. N-2PID
3. N-3PID
4. N-4PID

C. Feasibility Study and Estimated Annual Performance

Refer to the Syracuse University Green Data Center DG-CHP Project proposal (PON No. 1241) dated 12/10/2008 and also attached.

II. Data Collection and Monitoring

The Monitoring Objectives are listed below in Table 1.

Number	Objective	Data Necessary to meet Objective
1	Measure (continuous) the input primary energy source (natural gas) consumed by the system	Natural gas totalizer(s)
2	Measure (continuous) the electrical power provided by the system to the secure (stand alone) power grid of the data center	Electric power meter (s)
3	Measure (continuous) the electrical power provided to the University power grid or drawn from the University power grid	Electric power meter (s)
4	Measure (continuous) the electrical power provided to or drawn from the system batteries	Electric power meters
5	Quantify (individual measurements projected over time) electrical parasitic loads (gas compressors, pumps, electronics)	Electric power meters
6	Measure (continuous) the production of useful heat output.	Flow and temperature instruments
7	Measure (continuous) the production of cooling.	Flow and temperature instruments
8	Quantify (individual measurements) the operation of supplemental equipment to support the system.	Individual assessment
9	Measure (continuous) the system exhaust energy released to the environment to verify the system energy balance.	Flow and temperature instruments

10	Measure (continuous) heat rejected by chillers to cooling towers	Flow and temperature instruments

Table 1. NYSERDA Monitoring Objectives

A. **Monitored Data Points**

The data points to satisfy the Objectives in Table 1 are show on the system schematic drawings and listed in Table 2. The continuously monitored data points shown on the system schematic drawings and in Table 2 were selected to quantify the performance of the DG-CHP system. The system schematic drawings show the location of each monitored point in the system. The DG-CHP system includes 12- 65KW Capstone Hybrid Micro Turbines with integrated heat recovery. Exhaust heat energy from the Micro Turbines will pass through the Cain Heat Exchangers to produce hot water for space heating in Building 621 next door as well as providing hot water to the Thermax Chillers to aid in the chilled water process. Exhaust heat is also directed to the Chillers for the chilled water process. The existing air cooled chiller serving Building 621 will remain in service but is estimated to operate at only 10% of its historical hours due to the proposed DG-CHP system in the Data Center.

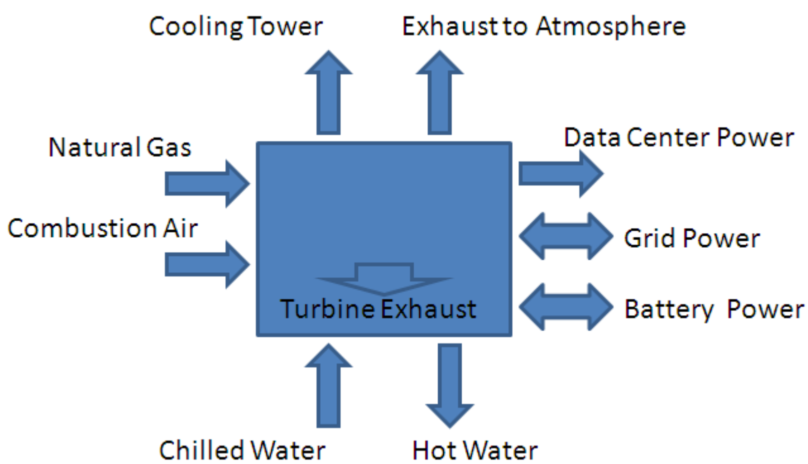
	Description	**Tag**	**Instrument**
1	AC Power – Grid Connection	2 locations	Square D Power Logic ION 7650
	AC Power – Load Connection	4 locations	Shark 200
2	DC Power – Batteries	Volts and amps, 2 locations	Laurel Electronics DC Voltage transmitter, 50 ma Shunt for current
3	Natural Gas	FT-1016, 2016	Roots SERIES B3: 5M175 with Mercury compensator
4	Exhaust Flow, Combined Turbine	FT-1017, 2027	Kurz Series 454FT Insertion Mass Flow Transmitter
5	Exhaust Flow, Chiller	FT-1019, 2029	Kurz Series 454FT Insertion Mass Flow Transmitter
6	Exhaust Temperature, Combined Turbine	TE-1019, 2019	Kurz Series 454FT Insertion Mass Flow Transmitter
7	Exhaust Temperature Chiller	TE-1019, 2019	Kurz Series 454FT Insertion Mass Flow Transmitter
8	Exhaust Temperature Heat Exchanger Stack	TE-1021, 2021	Omega Platinum RTD
9	Exhaust Temperature Chiller Stack	TE-1020, 2020	Omega Platinum RTD
10	Hot Water Flow	FT-4012, 4016	V-Cone, Rosemont DP Transmitter
11	Hot Water Temperature	TE-4011, 4013, 4015	Omega Platinum RTD

12	Chilled Water Flow	FT-4005, 4007	V-Cone, Rosemont DP Transmitter
13	Chilled Water Temperature	TE-4025, 4035, 4036	Omega Platinum RTD
14	Cooling Water Flow	FT-4001, 4003	V-Cone, Rosemont DP Transmitter
15	Cooling Water Supply Temperature	TE-4031, 4033, 3020	Omega Platinum RTD
16	Combustion Air Temperature	TE-1024, 1025, 1026, 1027, 1028, 1029, 2024, 2025, 2026, 2027, 2028, 2029	Capstone Microturbine Controller (via Modbus)
17	Turbine Room Ambient Air Temperature	TE-1013, 2013	Omega Platinum RTD

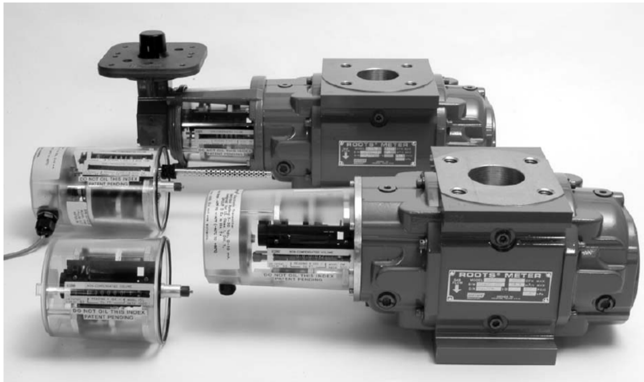
Table 2. Monitoring Points and Instruments

III. Summary Narrative

The DG-CHP system is instrumented to permit the calculation of the total efficiency of the system. The energy flows in the system are illustrated below.



A. **Natural Gas:** The primary energy input is natural gas from the local utility (National Grid). Gas flow to each of the microturbine sets (A-side and B-side) is measured by a set of two revenue-grade Dresser Industries, Roots gas meters equipped with Mercury compensators to correct the volume flow measurement for temperature and pressure and provide a flow in true standard condition measurement (in SCFM). The gas meter output is a form-A pulse signal that is connected to a digital input on the PLC-based control system.



Combustion air temperature is measured by an RTD located at the inlet grill of a central microturbine. The RTD signal is converted at the instrument head to a transmitted 4-20 ma signal and read by the central PLC-based control system on an analog input. Turbine inlet temperature is also reported to the control system by each microturbine over a Modbus network.

B. **Electric Power:** The unique Hybrid UPS microturbines employed on this project have three electrical connections. These are 480VAC grid connect side connected to the university grid, 480VAC stand alone side, connected to the data center load, and a 400 VDC connection to a battery bank. Power to the utility connection is measured by a Square D PowerLogic Ion 7650 electric meter. The power meter measures electric power exported to or imported from the campus grid. It is connected to the control system by a Modbus network link.

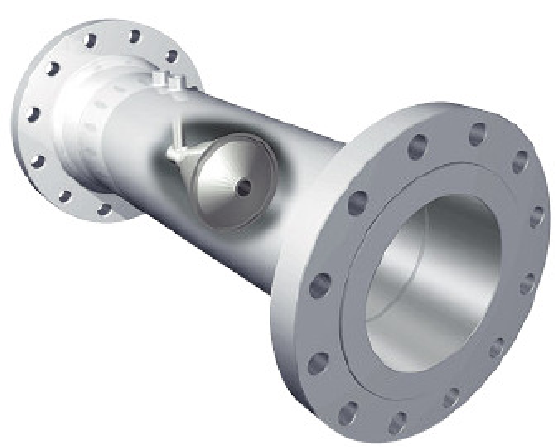
Power to the data center load is measured by four Shark 200 power meters. These meters also communicate to the central control system using a Modbus network.

Power to and from the 400 VDC battery strings is measured by a set of four DC voltage transmitters. Two if the transmitters measure the line voltage of each (A-side and B-side) strings and the other transmitters measure the current by employing a shunt resistor.

C. **Thermal Output:** In addition to the electric power output, the microturbines generate thermal output as exhaust that is used to provide both heating and cooling. The exhaust flow and temperature is measured to determine the thermal power consumed by the absorption chillers used to generate chilled water for cooling, and by the heat exchanger used to generate hot water for heating. Flow and temperature are measured by four Kurz thermal dissipation Insertion Mass Flow Meters.

These meters are mounted in the two (A-side and B-side) 20-inch common exhaust ducts and measure microturbine exhaust flow and temperature for the total microturbine output and the portion going to the chiller. The remainder of the exhaust gas that is diverted to the heat exchanger is determined by the difference between these two measurements. Exhaust from the two heat exchangers and the two chillers exits the data center through two stacks that penetrate the roof. The temperature of each stack is measured by RTDs. All of the flow and temperature signals are sent via 4-20 ma transmitted signals to analog inputs in the PLC-based control system.

D. **Hot and Chilled and Cooling Water:** Hot Chilled and Cooling water flows are measured by in-line V-Cone flow instruments. Flow is measured at the inlets of each heat exchanger and each chiller. The V-Cone is a differential pressure type flow instrument. Each of the V-Cones is outfitted with a Rosemount differential pressure transmitter producing a 4-20 ma signal that is transmitted to an analog input in the common PLC-based control system.



Temperature at the common inlet and for each heat exchanger outlet and each chiller outlet is measured by RTDs in thermowells inserted into the piping.

E. **Control System:** All of the system data is accumulated into a PLC-based control system. The system employs a set of Allen Bradley ControlLogix PLCs communicating using Ethernet communications. The system provides reliable interface to instruments and networks and communicates with PCs using RSLinx and RSView software allowing for data in engineering units to be logged and stored as common comma-delimited files suitable for importing into spreadsheets or a database.

F. **Energy Balance:** The data collected will allow calculation of the overall DG-CHP system energy balance and overall system efficiency as required by NYSERDA. The university intends to make reports of the operating data available NYSERDA.

IV. Communications and Data Retrieval Procedures

The university intends to make reports of the operating data available NYSERDA on a periodic basis conforming to NYSERDA requirements. Data will be taken by a PLC-based control system and then transmitted to a database to be stored and archived.

V. NYSERDA Data System Description

A. **General:** The proposed database will import data from the PLC system via a local Ethernet network and create a 68 word flat file (comma separated) on a 15 minute interval. Each 15 minute interval will be a unique record in the database with date and time stamp. Data will be formatted as floating point values. A separate computer will function as a Web server and allow downloading records via the Internet. The web server will download the requested records from the data base server.

B. **Database:** The data base will interface to the PLC system operating the process and collecting real-time data. This connection is via a local Ethernet network. During each 15 minute interval data is recorded by the PLC as 68 values in a tag based array. At the end of the interval the array is transmitted to the data base using RSLynx Gateway (a Rockwell software driver). A record is created in the server that is identified by date and time and contains the 68 data points. This process continues 24 hrs a day. The data will be organized into 24 hour records.

C. **Web Page:** A separate computer operating as a web server will be accessible via the Internet. A single dedicated web page will allow downloading of the records from the database server. A request is made via manual input on the web page, indicating the period of time (by start and end date) for which data is desired. The web server processes the request and queries the data server for the records. A single larger flat file is then available for download containing the data requested. The file will be formatted as comma separated variables, each 15 minute interval comprised of 68 floating point values, and capable of being opened in an Excel spread sheet. A static table identifying the variables will be available displayed on the web page.