St. Elizabeth Medical Center

NYSERDA Agreement 15923

Task 7 - Develop a Monitoring Plan

The Contractor shall develop a plan to install and operate equipment which will collect and document 15 minute interval data that monitors the performance of the new CHP system throughout the Monitoring Period (Monitoring Period). Such data shall be electronically transferred at least once per day to NYSERDA's Data Integration Agent for public display at http://chp.nyserda.org. The Monitoring Plan shall account for total site electric power and fuel use to compare with the baseline energy data in order to quantify the economic and efficiency impacts of the new CHP System. Sufficient data shall be collected in order to calculate the annual overall efficiency of the CHP System based on the higher heating value (HHV) of the fuel input. Sufficient data shall be collected in order to calculate hourly electric, fuel, and recovered-and-beneficially-used thermal energy load profiles of the CHP System for each day throughout each year. Monitoring parameters for the site shall include but not be limited to: power output, natural gas usage, other fuel usage, grid supplied electricity demand and usage, and utility-supplied steam demand and usage if applicable. Monitoring parameters for each prime mover of the CHP System shall include but not be limited to: power output, heat recovered-and-beneficially-used, fuel use and run hours. CHP System emissions shall be monitored during CHP System commissioning (as described under Task 11) in order to validate the manufacturer's performance specifications (to be reported in the CHP System Installation Report described under Task 0). The Monitoring Plan shall include discussions of pertinent topics such as: description of CHP System configuration; monitoring objectives; data needs; monitoring locations and parameters; monitoring equipment (specifying equipments' range and sensitivity); calibration of equipment; data collection frequency; data warehousing; data analysis and "timely" QA/QC (to ensure monitoring sensors routinely function properly), and; data reporting format. The Monitoring Plan shall be consistent with NYSERDA's Monitoring and Data Collection Standard,

Deliverable: Detailed written Monitoring Plan

The Contractor has completed the Monitoring Plan as documented in the attached.

MONITORING AND DATA COLLECTION STANDARD

for

DISTRIBUTED GENERATION/COMBINED HEAT AND POWER (DG/CHP) SYSTEM

ST. ELIZABETH MEDICAL CENTER

June, 2010

St. Elizabeth Medical Center

NYSERDA Agreement 15923

Submitted to:

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
17 Columbia Circle
Albany, New York 12203-6399
Attn: Edward Kear

Submitted by:

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Monitoring Plan Description

Table 1. CHP Equipment and Site Details

System Overview	• 3 Caterpillar G3516TA 770 kW generators • 375 ton absorption chiller • Excess power to be exported to utility • Utility to provide standby power when needed • Emergency power available from on-site standby generators in the event of simultaneous loss of power from CHP plant and utility • Heat recovered from the generating plant in the form of steam or hot water will be used to meet the hospital's requirements for space heating and cooling, process heat and DHW. Heat thus generated will displace fuel requirements of existing dual fuel boilers which will continue to be maintained and used during periods when CHP plant is not operated for economic reasons.

Power generating equipment	• 3 Caterpillar G3516TA generators
	  o 770 kW capacity (each generator)
	  o 480 volts
	  o 3 phase
	  o 60 Hz
	• Synchronous generators
	• Natural gas fuel
	• 6 standby generators with aggregate nameplate capacity of 1,575 kW

Heat recovery system and displaced thermal equipment	o See Attachment A - Feasibility Study for description of heat recovery system o Existing boilers to provide backup service Three 500 hp Burhman boillers Natural gas or number 2 fuel oil
Facility load details	o See Attachment A - Feasibility Study o Electricity is currently provided by National Grid under their Service Class 3A rate schedule. Upon commissioning of the CHP service for standby service will be provided under SC7. Service is currently metered through a single meter. Upon commissioning service from the utility will measured through a single meter and sales of excess power to the utility will be measured through a separate meter. Alternatively purchase from and sales to the utility may be metered through a single bi-directional meter. Gas service is currently provided under national Grid's gas tariff.

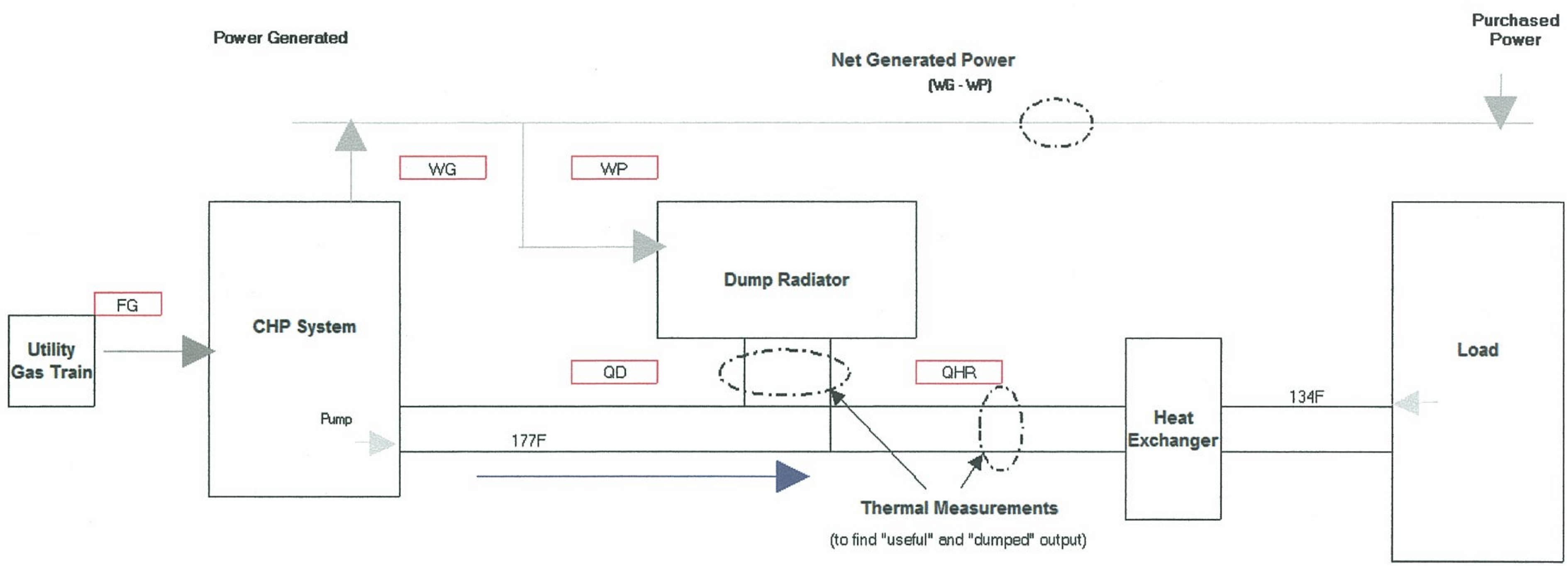
System Schematic

The following Exhibits S, S1, S2, and S3 are simplified schematics of the planned CHP plant. The following chart is utilized for these and related exhibits to provide consistent naming conventions.

DATA POINT MEASURED		
A - TYPE	B - Medium	C - Location
T - Temperature	A - Air	O - outdoor
P - Pressure	G - natural gas	I - indoor
RH - Relative humidity	CH - chilled water	E - entering
W - Power (kW)	CW - cooling water	L - leaving
F - Flow	HW - hot water	
S - status/runtime	S - Steam	
V - Volts	CT - cooling tower	
I - Current/amps	B - Boiler	
HZ - frequency	K - Generated power	
Q - Btu heat	P - Parasitic	
	D - Dumped heat	
	HR - Heat recovered	
	WP - Purchased power	
	WS - Power sold	

Exhibit S

St Elizabeth Medical Center
Schematic CHP System

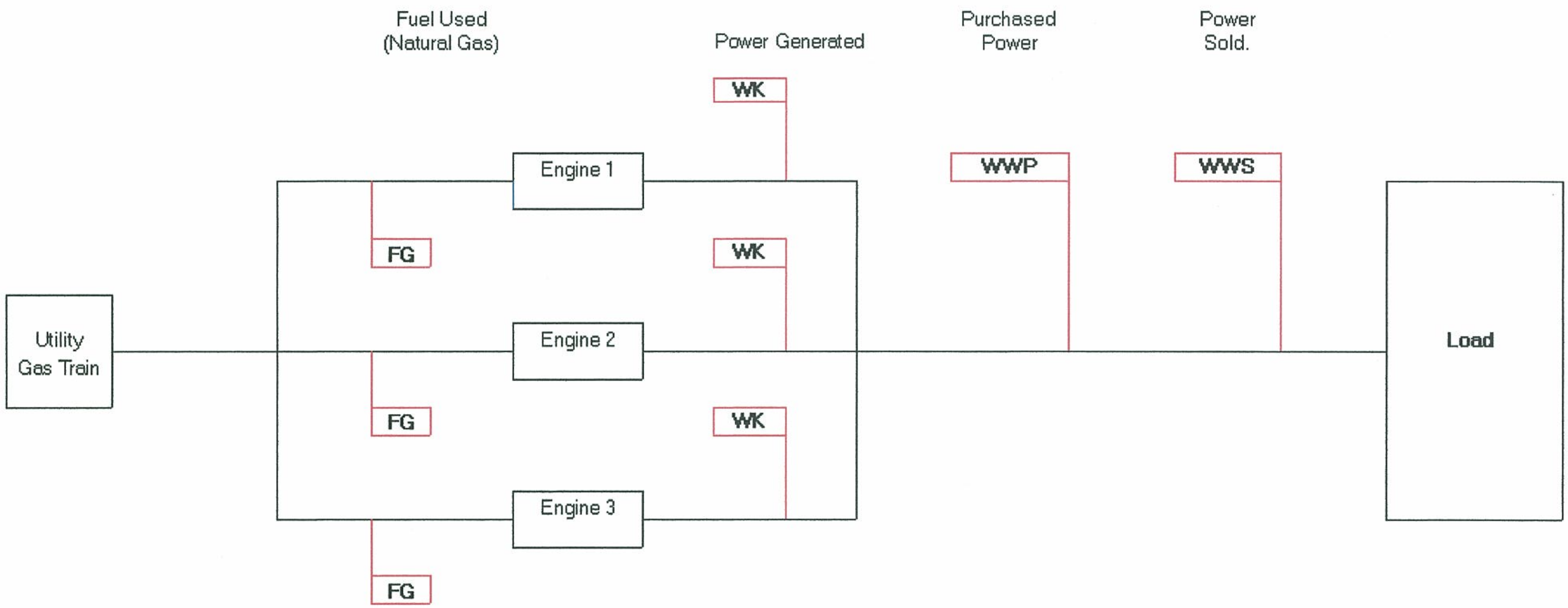


Measured Data Points

WG	- Power generated
WP	- Parasitic power (external)
FG	- Natural gas delivered by the utility
QHR	- Useful heat recovery
QD	- Dumped or unused heat

Exibit S1

St Elizabeth Medical Center
Schematic CHP System
Electric Measurements
(WK + WWP -WWS

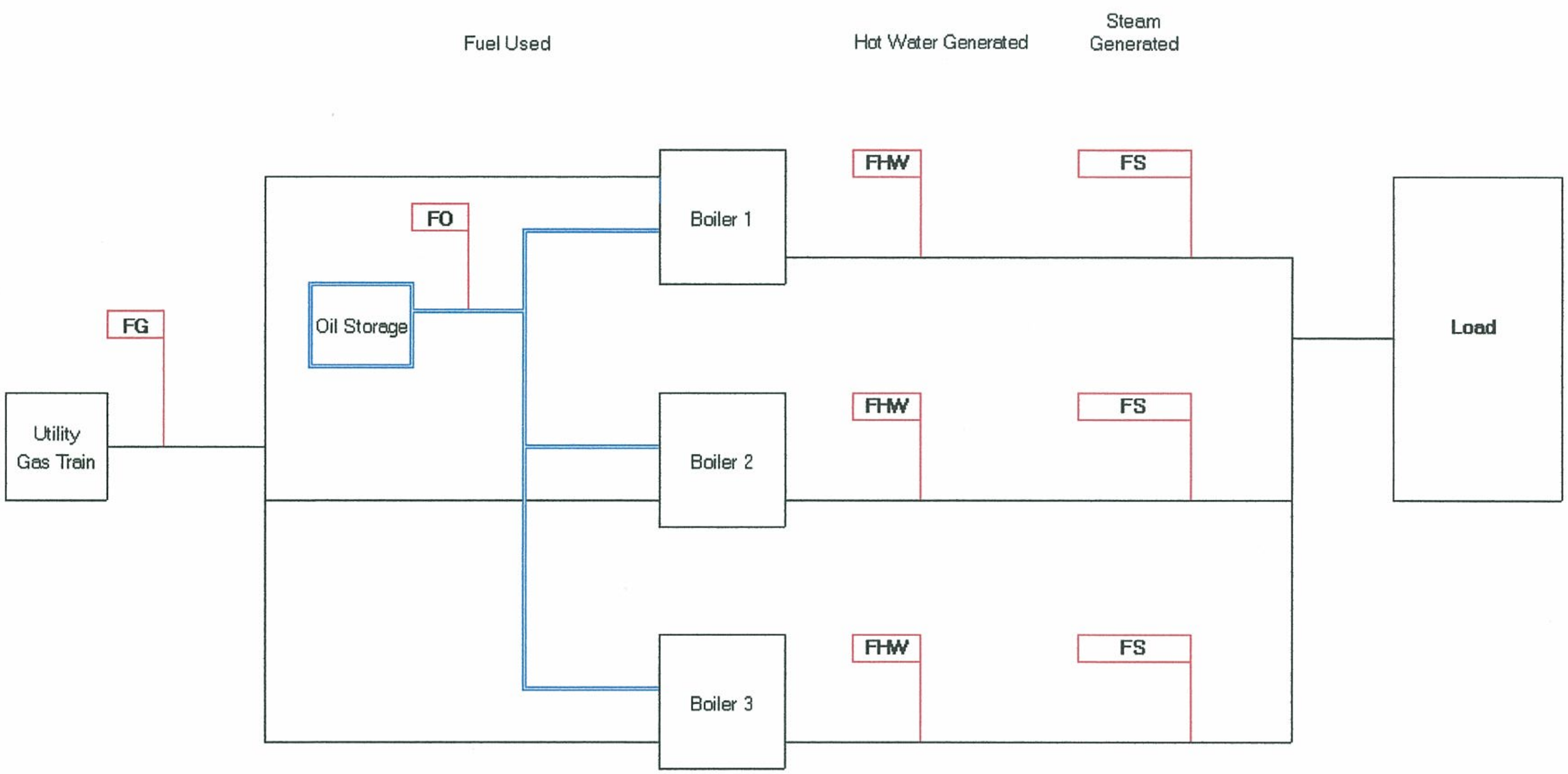


Measured Data Points

FG - Natural Gas delivered by Utility
WK - Electric power (kWh) generated by CHP System
WWP - Electric power purchased from Utility
WWS - Electric power Sold to Utility

Exibit S2

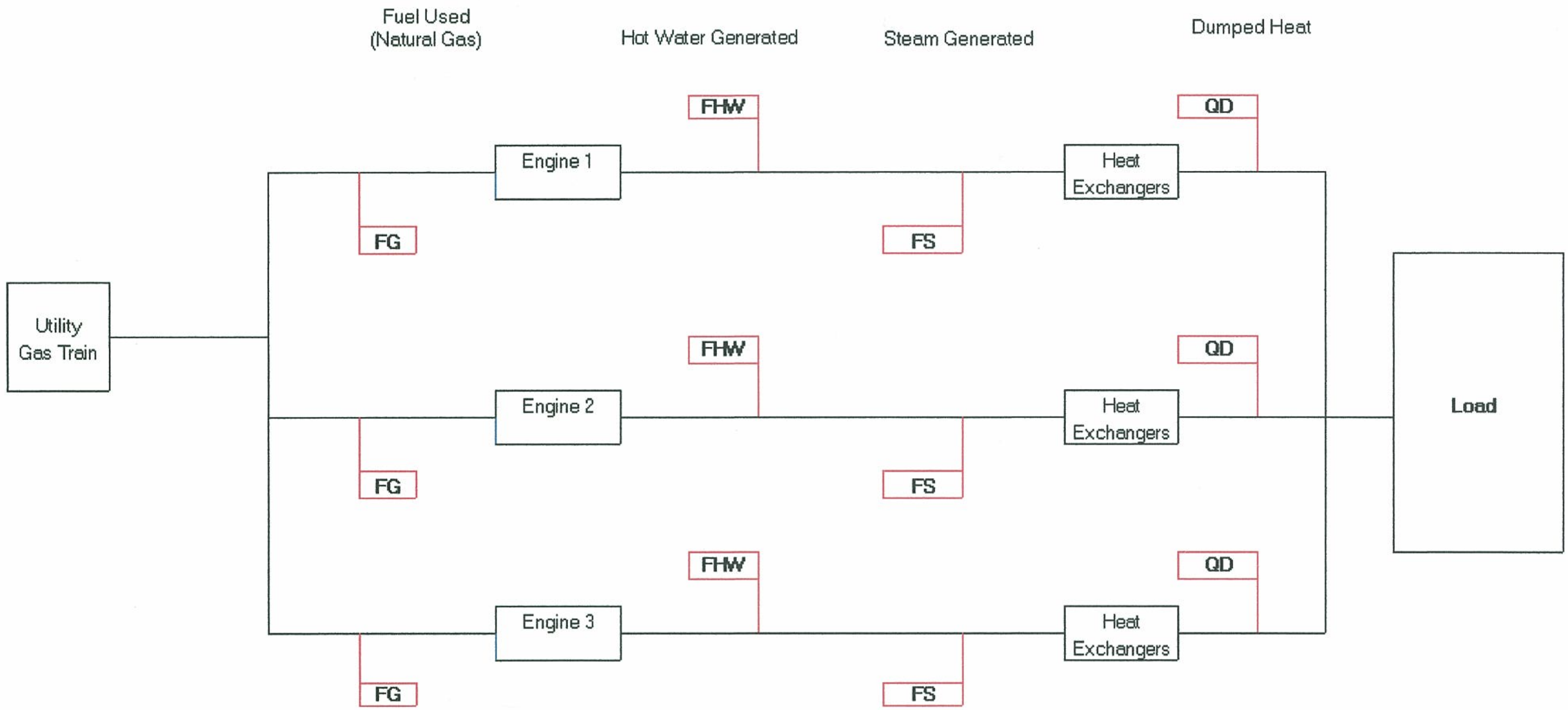
St Elizabeth Medical Center
Schematic CHP System
Alternate Boiler Measurements
(FG+FO=FHW+FS)



Measured Data Points
FG - Natural Gas delivered by Utility
FO - Fuel Oil from storage tanks
FHW - Hot water generated by boilers
FS - Steam generated by boilers

Exibit S3

St Elizabeth Medical Center
Schematic CHP System
Thermal Measurements
(FHW +F S QDW)



Measured Data Points
FG - fuel used
FHW - BTUs of hot water generated by the CHP plant
FS - BTUs of hot steam generated by the CHP plant
QD - BTUs of heat exhausted (dumped)

Feasibility Study and Estimated Annual Performance

See Attachment A - Feasibility Study

Monitoring Objectives

Table 2. Primary Monitoring Objectives

No.	Objective	Data Necessary to Meet Objective
1.	Quantify the variation of DG/CHP system power output, gas consumption, and efficiency over wide range of annual operating conditions.	WG, FGG, TAO
2.	Quantify external parasitic loads (e.g. gas compressors, pumps, dump radiators, etc.)	WP
3.	Quantify the daily, weekly, monthly, and annual variation of total facility power use (or power purchased from utility) so that actual utility costs can be determined.	WT
4.	Determine the thermal loads imposed on the CHP system by the facility (or the 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 ofthese loads with ambient conditions and operating schedules so the findings from this site can be extended to other climates.	QHR (or integrated flows and temperatures), TAO
5.	Quantify the displaced fuel use on auxiliary equipment and systems to confirm the benefit of heat recovery.	Boiler fuel use, total facility fuel use (FGT), chiller electric consumption
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.	QD (or integrated flows and temperatures)
7.	Determine the impact of generator operation on power quality in the facility (power factor, KVAR, frequency, total harmonicc distortion); measure at generator output and/or main service entrance	Volts, amps, kVA, hz,THD,etc (total and/or per phase)
8.	Collect diagnostic data to confirm the DG/CHP system operates as expected and/or support of maintenance and operation activities.	Component statuses, intermediate temperatures, pressures
9.	/develop performance maps of CHP equipment and components to verify manufacturer specifications	QHR, flows, temperatures, statuses, etc.
10.	Determine environmental emissions from DG/CHP equipment to quantify net emissions impact of the system.	CO, NOx, THC, etc.

Monitoring Hardware Issues

Monitoring devices will provide near real time data collection for all electric and gas monitoring points. These data will be totalized to 15 minute and 1 hour intervals and cataloged for future reference. They will also be used to create a daily report of economic performance and system efficiency. The daily results will be summarized to a weekly, monthly and annual report for presentation to management. These reports will be available on-line (with authorized access codes) and in hard copy.

Data will be transmitted to NYSERDA every 15 minutes for posting to their CHP performance website.

Reported measurements shall include:

kW_{avg} - measured kWh per measurement interval

kWh_{total} - measured kW x time interval

kW_{peak} - measured peak electric demand per time interval to approximate utility billing

$q = k * \sum\{gpm*(T_{in}-T_{out})\} * (\text{time interval})$ - measured and logged output thermal energy for each source producing thermal output (boilers and CHP).

Attachment A

Feasibility Study

Report on Results of

CHP Feasibility Study

for

St. Elizabeth Medical Center

Submitted by:
IES, LLC

1030 Glencove Road
Syracuse, New York 13204

October 2008

Executive Summary

This report presents the results of a study of the economic feasibility of designing and installing a Combined Heat and Power ("CHP") plant for the benefit of St. Elizabeth Medical Center ("SEMC"). The study was conducted by IES, LLC ("IES") in accordance with a scope of work outlined in the Engagement Letter executed on August 19, 2008 by SEMC.

As detailed in this report, SEMC should be able to realize an average annual energy cost savings of approximately $895,000 over 15 years and an annual average energy cost savings of approximately $842,000 over the payback period of 7.9 years. Included in this savings forecast is approximately $100,000 associated with currently existing New York State Energy Demand Programs, approximately $100,000 associated with our Economic Dispatch Program and approximately $126,000 associated with sales of excess energy to National Grid.

The CHP Facility will be installed in the "old" boiler house after removal of the old, non-functioning boilers. Total estimated costs for the demolitions and removal of the old boilers and installation of the new CHP plant is currently forecast at approximately $6,700,000 resulting in a simple payback of 7.9 years. The installation cost is subject to refinement until the contractor bids are received and accepted during the design phase of the project.

It is currently anticipated that the CHP plant will comprise two Caterpillar 820 kW natural gas fired reciprocating engines with heat recovery and one Caterpillar 600 kW natural gas fired reciprocating engine, all with heat recovery. A small absorption chiller will be installed to take advantage of the potential for heat recovery during the cooling period. The need for sound attenuation is to be addressed in the installation process. We presently believe that the units can be exhausted using the existing exhaust stack in the old boiler house, thus eliminating any significant visual change in the campus portrait. It is anticipated that the emissions levels will be within existing DEC permits at SEMC.

The CHP Facility will service only the main campus electric account as the regulatory cost and the installation cost associated with the servicing other accounts outweighs the benefits to be derived from servicing these accounts.

The new facility will qualify for National Grid's SC 7 Standby Rate and be able to avail itself of the elimination of the CTC included in the contract demand charge as a result of the efficiency of the CHP Facility. Also sales to National Grid will be made under Service Classification SC 6, which requires the utility to buy back any excess electric power produced by the CHP at then current market rates.

Load Profiles

Creating accurate profiles of electric and thermal usage and the coincidence of those energy requirements is the most important first step in evaluating the economic benefit of installing a Combined Heat and Power plant. Following is a discussion of the energy requirements for St. Elizabeth Medical Center and the results of our analysis.

Electric

The St. Elizabeth campus has multiple electric and gas service connections with National Grid. However, based on our study, we believe it is economically feasible for the CHP plant to displace only the energy requirements now provided through the main campus electric meter (account # 8948768105) and the main gas meter (account # 2799036107). The following summary for the main electric service is based on the 2007 utility billing information for that meter.

Account #	Service Class	Delivery Voltage	Peak Demand (kW)	Usage (kWh)
8948768105	SC3A	Primary	2,318	11,993,827

(See Appendix A for details)

There are two other facilities (2206 Genesee St. and 2212 Genesee St.) which we originally considered serving electrically from the central CHP plant. However, the net benefit to be derived by serving these accounts electrically (approximately $15,000 annually) is outweighed by the capital cost of connecting them. The primary prohibiting cost factors are the National Grid aggregation fee (approximately $52,000 -see tariff analysis below) and the cost of crossing Genesee Street, either by directional drilling or trenching the highway, both of which are costly and present problems.

One of these facilities (2206 Genesee St. - account #4848766105) may benefit from the installation of a small stand-alone generating plant. Based on 2007 billing data this account has an average peak demand of approximately 96 kW and thermal requirement of 2,900 MMBtu per year. A 75 kW Tecogen unit may be a good match for this facility. The other facility has a very small thermal load and probably would not benefit from the use of CHP technology.

Thermal

The campus has a single natural gas delivery service provided by National Grid through a single meter. Gas is distributed to the boilers and other locations through Hospital owned facilities. The gas commodity is purchased from a gas marketer. The delivered gas provides fuel for the boilers and any other uses on campus such as cooking. For purposes of modeling the projected savings we assumed that non-boiler use of natural gas is 10% of the delivered gas. This estimate is probably high, but since there are no sub-meters to more accurately measure the gas usage we prefer to use a conservative estimate. To the extent that non-boiler usage of natural gas is lower than this estimate the annual savings would be greater (more opportunity to utilize the recoverable heat from the CHP plant) but not enough to distort the results.

The boilers produce steam at 60 psig, which is distributed through the campus and reduced or converted to hot water at or near the point of use. There are no direct hot water lines from the boiler house to the hospital or other facilities.

The following summary for the main natural gas service is based on the 2007 utility billing information for the account shown below.

Account #	Service Class	Usage (MMBtu)		
		Total	Estimated Non-Heating/Cooling	Net
2799036107	SC7	77,258	7,726	69,532

(See Appendix A for details)

The methodology for creating the load profiles shown in Appendix A was to use the monthly billing information from National Grid and convert that information to hourly usage using our models. While this does not precisely mirror St Elizabeth's hourly electric and thermal requirements, we believe that the results are sufficiently accurate to determine the coincidence of electric and thermal usage.

Total Usage (MMBtu)

Following is a summary of total energy consumption at the St. Elizabeth campus. The campus consumes considerably more thermal energy than electric energy, which is typical for hospitals and even many industrial companies. The significance of this is that we should be able to utilize most of the heat produced by the CHP plant.

	Electric MMBtu	Thermal MMBtu	Total MMBtu
January	3,086	9,217	12,303
February	3,192	9,501	12,693
March	3,078	8,813	11,890
April	3,611	6,687	10,298
May	4,294	4,819	9,114
June	3,975	3,960	7,935
July	3,917	4,047	7,964
August	3,880	3,838	7,717
September	2,852	4,043	6,895
October	2,860	5,078	7,938
November	3,163	7,655	10,818
December	3,015	9,601	12,616
Total	40,923	77,258	118,181

(Electric usage is converted to MMBtus at the rate of 3,412 Btus per kWh)

Potential Additional Recovery

As shown below, during the months of May through October the CHP plant would generate more thermal output than could be used by the campus facilities. This may present an opportunity to utilize a small absorption chiller to reduce the load on the electric chillers. We have included an estimate of the capital cost of such an installation in our analysis but can not do a separate cost/benefit analysis until we get into the preliminary design phase to determine where it would be located and the cost of getting hot water or steam to the chiller.

	Thermal Requirements MMBtu	Thermal Generated MMBtu	Potential for Additional Recovery MMBtu
January	8,295	3,572	
February	8,551	6,498	
March	7,931	5,581	
April	6,018	4,268	
May	4,337	4,910	572
June	3,564	4,786	1,222
July	3,642	4,885	1,243
August	3,454	5,521	2,067
September	3,639	3,896	257
October	4,570	5,129	559
November	6,890	5,504	
December	8,641	7,527	
Total	69,532	62,075	5,920

We assumed that heat could be recovered from the exhaust in the form of steam or hot water and that steam could be recovered from the jacket cooling system.

Boiler Efficiency:

Assumed boiler to be 85% efficient with 5% steam losses.

Economic Dispatch:

Because of hourly variations in market prices we assumed the CHP plant would be operated using our economic dispatch system. The plant would be operated when the marginal cost of generation is lower than the marginal cost of purchasing (generally during peak hours) and shut down when the opposite is true.

Sales to National Grid:

At times when the plant is operating at less than full capacity to meet the requirements of the facility but the facility has a need for the thermal output of the CHP Plant, the excess power will be sold to National Grid under the SC 6 tariff.

Demand Response:

We assume that St. Elizabeth would participate in various NYISO demand response programs.

Plant location:

We assume that the plant would be located in the lower level of the existing old boiler hose after demolition and removal of the unused equipment. The cost of demolition and removal are included in the project cost of the new CHP plant.

Attachment B

Control System Design and Operating Sequence

6. The cogeneration system control switchboard shall include a Load Demand system (Generator Sequencing) accomplished by the programming of the Master PLC.

   a) All load sharing parameters shall be field adjustable and enacted during operation without interruption of automatic system operation.

   b) The load demand system will include two (2) separate sets of set points which shall be utilized based on the current mode of operation. The Load Demand system shall be designed to differentiate between operation in parallel with the utility (import or base load modes) and operation without the utility source connected (isolated bus mode).

   c) Typical parameters and set points are:

Parameter	Import or Base Load Mode Set point	Isolated Bus Mode Set point
Max Gen Load	95%	85%
Load Delay	30 seconds	5 seconds
Minimum generator load	55%	45%
Maximum stop time	20 seconds	20 seconds
Next Genset Delay	60 seconds	30 seconds
Max Start Time	120 seconds	60 seconds
Reduced Generator Delay	30 seconds	10 seconds
Minimum Gens on Bus	0	2
Load Demand enable time delay	30 minutes	60 minutes
Automatic Load Demand Enable	Enabled	Disabled

   d) The system operator shall be allowed to modify the numerical priority of each cogeneration unit via the HMI touch screen.

   e) The system operator shall be allowed to enable or disable automatic engagement of the load demand mode via the HMI touch screen. The load demand system shall be separately enabled for parallel modes (Import Level or Baseload) and Isolated mode. When the load demand system is disabled all available units will continue operate indefinitely proportionally sharing the system load.

7. The cogeneration system control switchboard shall include a load shed system which shall be initiated by conditions that cause the station bus

frequency to drop below standard frequency as an indication of system overload.

a) The under frequency load shed system shall only be active during operation in the isolated bus mode.

b) The setting of the bus frequency monitor shall be field adjustable and shall incorporate adjustable time delays to avoid unnecessary operation due to momentary load surges.

c) The objective of the load shed circuits is to provide contact signals to drop selected loads (during commissioning and island condition) so as to avoid overloading of the on-bus running engine generator sets.

d) The load shed system will function to provide two sets of dry form "C" contacts, for six (6) stages of load shed, wired to terminal board points for customer use.

C. Sequence of Operation

1. Initial Conditions – Each of the subsequent sections describes a sequence of operation which shall commence based upon the pre-existing system conditions. These are defined as follows:

a) Plant not in operation (system mode=off)
(1) 52U1 – closed
(2) 52U2 – open
(3) 52F1 – closed
(4) 52IT – closed
(5) 52GM – closed
(6) 52G1, 52G2, 52G3 – open (all units off)
(7) 52L1 – closed

b) Plant in operation - Import Level or Base Load Operation (system mode = base load **or** import level)
(1) 52U1 – closed
(2) 52U2 – open
(3) 52F1 – closed
(4) 52IT – closed
(5) 52GM – closed
(6) 52G1, 52G2, 52G3 – one or more closed and associated unit(s) running
(7) 52L1 – closed

c) Plant in operation – Isolated Bus (system mode = Isolated Bus)
(1) 52U1 – open
(2) 52U2 – open
(3) 52F1 – closed

(4) 52IT – closed
(5) 52GM – closed
(6) 52G1, 52G2, 52G3 – one or more closed and associated unit(s) running
(7) 52L1 – closed

2. Utility Source Transfer – Open Transition

a) When the transfer control mode switch is set to "open transition" and if the cogeneration system is off (system mode = off) the station operator shall be allowed to initiate a utility source transfer via the HMI touch screen.

b) Plant not in operation (system mode = off)

(1) Upon initiation, the 52U1circuit breaker will trip open.

(2) After the expiration of an adjustable transfer time delay the 52U2 circuit breaker will close.

(3) The system shall remain on this source until further station operator intervention.

(4) A Subsequent initiation of the source transfer control will repeat the above steps transferring back to the original utility source.

3. Utility Source Transfer – Closed Transition

a) When the transfer control mode switch is set to "closed transition" and if the cogeneration system is in the off, base load, or peak shave mode the station operator shall be allowed to initiate a utility source transfer via the HMI touchscreen.

b) Plant not in operation (system mode = off)

(1) Upon initiation, all available cogeneration units shall be automatically programmed into operation with automatic closing the each generator set's circuit breaker under control of the automatic synchronizing devices.

(2) After closure of the generator circuit breakers, the auto load control circuit shall initiate "soft loading" of the genset until the utility contribution is reduced to zero.

(3) When the utility import level reaches zero the 52U1 circuit breaker will trip open.

(4) The system control switchboard will then automatically

synchronize plant voltage and frequency to the second utility source. Once the plant has been synchronized with the utility the 52U2 circuit breaker will be automatically closed returning the system to utility parallel operation.

(5) Immediately after paralleling to the utility all generators on line will be programmed out of operation, by soft unloading, tripping its associated generator circuit breaker, and continue to run unloaded (in cooldown mode).

(6) Each unit will automatically shut down after its normal cooldown period expires.

(7) The system shall remain on this source until further station operator intervention.

(8) A Subsequent initiation of the source transfer control will repeat the above steps transferring back to the original utility source.

c) Plant in operation - Import Level or Base Load Operation (system mode = base load **or** import level)

(1) Upon initiation the output of the cogeneration plant will be adjusted up or down to achieve a zero power transfer across the 52U1 circuit breaker.

(2) When the power transfer reaches zero the 52U1 circuit breaker will trip open.

(3) After the expiration of an adjustable transfer time delay the cogeneration system control will actively synchronize voltage and frequency with the second utility source.

(4) Upon matching the voltage and frequency of the cogeneration plant to the utility source the 52U2 circuit breaker will automatically close.

(5) Immediately upon utility circuit breaker closure the system shall return to its previous mode of operation and set point and continue to operate in parallel with this source until further station operator intervention.

(6) A Subsequent initiation of the source transfer control will repeat the above steps transferring back to the original utility source.

4. Isolated Operation – Open Transition

a) When the transfer control mode switch is set to "open transition" and if the cogeneration system off (system mode = off) the station operator shall be allowed to transition the system to the Isolated Bus mode via the HMI touch screen.

b) Plant not operation (system mode = off)

(1) Upon initiation, all available cogeneration units shall be automatically programmed into operation.

(2) The first unit to reach rated voltage and frequency will synchronize with the utility source.

(3) When synchronous conditions are achieve the cogeneration system control shall execute a fast open transfer between the 52GM and the cogeneration unit circuit breaker (52G1, 52G2 or 52G3). The 52GM shall be tripped and upon positive confirmation that the 52GM circuit breaker is open, immediately close the cogeneration unit circuit breaker (52G1, 52G2 or 52G3), effectively transferring all facility loads supplied from the 52L1 circuit breaker to the isolated generation bus.

(4) After the transfer of the 52L1 is complete the remaining cogeneration units shall synchronize to the isolated bus and automatically close the associated circuit breaker under control of the automatic synchronizing devices.

(5) Once the number of generators on-line meets or exceeds a programmable minimum number or generators on-line the system shall enable all six (6) load shed circuits and simultaneously trip open the 52U1 (or 52U2) circuit breaker.

(6) After the expiration of an adjustable transfer time delay cogeneration system shall close the 52GM circuit breaker re-energizing the facility.

(7) After the plant main circuit breaker (52GM) is closed and the isolated bus has achieved acceptable voltage and frequency the six (6) load shed circuits will be added on a timed basis in accordance with section 2.2B.7 above.

(8) The plant will continue to operate in the isolated bus mode until further action is taken by the station operator.

5. Isolated Operation – Closed Transition

a) When the transfer control mode switch is set to "closed transition" and if the cogeneration system is in the off, base load, or peak shave mode the station operator shall be allowed to initiate Isolated bus operation via the HMI touchscreen.

b) Plant not operation (system mode = off)

(1) All available cogeneration units shall be automatically programmed into operation with automatic closing the each generator set's circuit breaker under control of the automatic synchronizing devices.

(2) After closure of the 52GM circuit breaker, the auto load control circuit shall initiate "soft loading" of the gensets until the utility contribution is reduced to zero.

(3) When the utility import level reaches zero the 52U1 (or 52U2) circuit breaker will trip open.

(4) The plant will continue to operate in the isolated bus mode until further action is taken by the station operator.

c) Plant in operation - Import Level or Base Load Operation (system mode = baseload **or** import level)

(1) Upon initiation all currently off-line, available cogeneration units shall be automatically programmed into operation with automatic closing the each generator set's circuit breaker under control of the automatic synchronizing devices.

(2) Once the number of generators on-line meets or exceeds a programmable minimum number or generators on-line the cogeneration plant output will be adjusted up or down to achieve a zero power transfer across the closed utility circuit breaker.

(3) When the power transfer reaches zero the currently closed utility source circuit breaker (52U1 or 52U2) will trip open.

(4) The plant will continue to operate in the isolated bus mode until further action is taken by the station operator.

6. Utility Parallel – Import Level Operation

a) When the cogeneration system is off or operating in the base load, or Isolated bus modes (system mode = off **or** base load **or** isolated bus) the station operator shall be allowed to change the system mode to Import Level operation via the HMI touch screen.

This transition can be initiated either automatically by the cogeneration system control's Plant Operation Dispatch System as described in section 2.2B.4 above or by remote signal from the Economic Dispatch System as described in section 2.2B.5 above

b) Plant not operation (system mode = off)

(1) When the system mode is transitioned to Import Level mode the lowest priority unit shall be automatically programmed into operation with automatic closing the generator set's circuit breaker under control of the automatic synchronizing devices.

(2) After closure of the generator circuit breaker, the auto load control circuit shall initiate "soft loading" of the unit until the utility contribution is reduced to the programmed import level or the unit reaches its full load output.

(3) The system control switchboard shall then program additional unit(s) into operation, if necessary to reduce the utility import level to the preset value as described in above utilizing the set points for parallel mode.

(4) The plant shall continue to operate in parallel with the utility source.

(5) The system control switchboard's load control system shall increase or decrease the total plant output to maintain the utility contribution at the preset import level.

(6) The plant will continue to operate in the Import Level mode and automatically programmed into/out of operation based on the total system load as described earlier, with each generator paralleled to the generation bus sharing the available system load proportionally.

c) Plant in operation - Base Load Operation (system mode = base load)

(1) When the system mode is transitioned to Import Level mode the plant output will be adjusted until the utility contribution is increased or reduced to the pre-programmed import level.

(2) If necessary additional cogeneration unit(s) will automatically programmed into/out of operation based on the total system load.

(3) The plant shall continue to operate in parallel with the

utility source.

(4) The system control switchboard's load control system shall increase or decrease the total plant output to maintain the utility contribution at the preset import level.

(5) The plant will continue to operate in the Import Level mode and automatically programmed into/out of operation based on the total system load as described earlier, with each generator paralleled to the generation bus sharing the available system load proportionally.

d) Plant in operation – Isolated Bus Operation (system mode = Isolated Bus)

(1) When the system mode is transitioned to Import Level mode the system control PLC will prompt the station operator to choose which utility source to commence parallel operation with.

(2) Upon the station operator selecting the desired source the system control switchboard will then automatically synchronize plant voltage and frequency to the selected utility source. Once the plant has been synchronized with the utility the appropriate utility circuit breaker (52U1 or 52U2) will be automatically closed.

(3) The plant output will be adjusted until the utility contribution is increased or reduced to the pre-programmed import level.

(4) If necessary additional cogeneration unit(s) will automatically programmed into/out of operation based on the total system load.

(5) The plant shall continue to operate in parallel with the utility source.

(6) The system control switchboard's load control system shall increase or decrease the total plant output to maintain the utility contribution at the preset import level.

(7) The plant will continue to operate in the Import Level mode and automatically programmed into/out of operation based on the total system load as described earlier, with each generator paralleled to the generation bus sharing the available system load proportionally.

7. Utility Parallel – Base Load Operation

a) When the cogeneration system is off or operating in the import level, or Isolated bus modes (system mode = off **or** import level **or** isolated bus) the station operator shall be allowed to change the system mode to Import Level operation via the HMI touch screen. This transition can be initiated either automatically by the cogeneration system control's Plant Operation Dispatch System as described in section 2.2B.4 above or by remote signal from the Economic Dispatch System as described in section 2.2B.5 above

b) Plant not operation (system mode = off)

(1) When the system mode is transitioned to Base Load mode the lead unit shall be automatically programmed into operation with automatic closing the generator set's circuit breaker under control of the automatic synchronizing devices.

(2) After closure of the generator circuit breaker, the auto load control circuit shall initiate "soft loading" of the unit until the total CHP plant output reaches the programmed setpoint or the unit reaches its full load output.

(3) The system control switchboard shall then program additional unit(s) into operation, if necessary to achieve and maintain the base load preset.

(4) The plant shall continue to operate in parallel with the utility source.

(5) The system control switchboard's load control system shall maintain total plant output at the preset base load preset.

(6) The plant will continue to operate in the Base Load mode maintaining total plant output at the Base Load set point with each generator paralleled to the generation bus sharing the available system load proportionally.

c) Plant in operation – Import Level Operation (system mode = import level)

(1) When the system mode is transitioned to Base Load mode the plant output will be adjusted up or down until the total plant output reaches the pre-programmed base load set point.

(2) If necessary additional cogeneration unit(s) will automatically programmed into/out of operation based on the base load set point.

service to the St. Elizabeth's Medical Center facility for multiple subsequent and/or simultaneous source failures.

b) Each of the three (3) prime electrical sources (utility source 1 via 52U1, utility source 2 via 52U2 or the CHP plant via 52GM) shall be assigned a numerical priority.

c) The priority of each source will be visible to the station operator via the HMI touchscreen.

d) The CHP plant shall be factory set as the lowest priority. This parameter shall not be allowed to be edited by the station operator.

e) The priority of each utility source will be preset by the station operator via the HMI touchscreen.

f) While deriving electrical service from any single source (utility source 1 via 52U1, utility source 2 via 52U2 or the CHP plant via 52GM) the failure of that source as sensed by each sources protective relay shall result in the immediate transition to the available source with the highest priority.

g) Automatic Utility Source Transfer (system mode = off)

(1) If the system is not in operation (or unavailable) and the current utility source failures as sensed by the utility monitoring circuits located in the system control switchboard, the associated utility source circuit breaker will trip open

(2) After the expiration of an adjustable transfer time delay the other utility source circuit breaker will close.

(3) The system shall remain on the alternate source until either subsequent station operator intervention or failure of the alternate utility source.

h) Automatic Standby Operation – Black Start (system mode = off):

(1) During this mode of operation the system shall issue the Call-to-Run signal to the EMS as described in section 2.2C.9 below.

(2) During this mode of operation the Run Enable signal generated by the EMS will **NOT** be required to start **OR** continue operation of a cogeneration unit as described in section 2.2C.9 below.

(3) The plant shall continue to operate in parallel with the utility source.

(4) The system control switchboard's load control system shall maintain total plant output at the preset base load preset.

(5) The plant will continue to operate in the Base Load mode maintaining total plant output at the Base Load set point with each generator paralleled to the generation bus sharing the available system load proportionally.

d) Plant in operation – Isolated Bus Operation (system mode = Isolated Bus)

(1) When the system mode is transitioned to Base Load mode the system control PLC will prompt the station operator to choose which utility source to commence parallel operation with.

(2) Upon the station operator selecting the desired source the system control switchboard will then automatically synchronize plant voltage and frequency to the selected utility source. Once the plant has been synchronized with the utility the appropriate utility circuit breaker (52U1 or 52U2) will be automatically closed.

(3) Upon closure of the 52U1 or 52U2 circuit breaker the plant output will be adjusted up or down until the total plant output reaches the pre-programmed base load set point.

(4) If necessary additional cogeneration unit(s) will automatically programmed into/out of operation based on the base load set point.

(5) The plant shall continue to operate in parallel with the utility source.

(6) The system control switchboard's load control system shall maintain total plant output at the preset base load preset.

(7) The plant will continue to operate in the Base Load mode maintaining total plant output at the Base Load set point with each generator paralleled to the generation bus sharing the available system load proportionally.

8. Automatic Standby Operation:

a) Design intent – the system control switchboard shall include adequate automatic procedures designed to restore electrical

(3) If the system is not in operation and automatic standby operation is required due to the failure of **both** the utility power sources as sensed by the utility monitoring circuits located in the system control switchboard, the system control switchboard shall issue a system alarm, issue a signal to the EMS (Energy Management System) indicating the initiation of the system black start procedure and initiate a pre-programmed black start time delay (adjustable from 0 to 15 minutes).

(4) Return of utility source prior to black start:

(a) If prior to the expiration of the black start time delay described above, if **either** utility source returns to acceptable voltage and frequency and remains stable for a pre-programmed time delay (adjustable from 0 to 120 seconds), the system will suspend the black start procedure and **if necessary** initiate a utility source transfer as described in section 2.2C.2 above to the acceptable utility source.

(b) Upon confirmation that the acceptable utility source breaker is closed and that the voltage and frequency of the source have remained stable the system shall issue a system alarm indicating that the black start procedure was aborted, return the system to the off mode and discontinue the black start signal issued to the EMS.

(5) If **BOTH** utility sources remain unacceptable until the expiration of the black start time delay the system shall enable all six (6) load shed circuits and trip open **and** lock-out both utility circuit breakers (52U1 & 52U2) and the Paralleling Switchgear Main circuit breaker (52GM).

(6) Upon confirmation that the 52U1, 52U2 and 52GM are all in the open position, the lowest priority available generator shall be signaled to start. After this unit has attained operating voltage and frequency, its associated generator circuit breaker will be automatically closed energizing the dead bus.

(7) Once the generation bus reaches stable and acceptable voltage and frequency all remaining available cogeneration units shall be signaled to start and synchronize to the isolated bus and automatically close the associated circuit breaker under control of the automatic synchronizing devices.

(8) Once the number of generators on-line meets or exceeds a programmable minimum number or generators on-line the system shall close the 52GM circuit breaker re-energizing the facility.

(9) After the plant main circuit breaker (52GM) is closed and the isolated bus has achieved acceptable voltage and frequency the six (6) load shed circuits will be added on a timed basis in accordance with section 2.2B.7 above.

(10) The plant will continue to operate in the isolated bus mode.

(11) If after a pre-programmed time delay (adjustable from 0 to 60 minutes), the isolated bus continues to operates within acceptable voltage and frequency limits, the system control switchboard will engage the load demand mode and program out of operation any unnecessary units, utilizing the set points for isolated bus mode.

(12) Upon return of the utility power source, as sensed by the utility monitoring circuits, the system control switchboard will issue a system alarm to notify the station operator but continue to operate in isolated bus mode until either subsequent station operator intervention or failure of the CHP system.

i) Automatic Standby Operation (Cogeneration System **in** operation):

(1) If a utility outage occurs affecting the utility source that the system is operating in a parallel with, (in baseload or import control mode), the protective relaying located in the utility control cabinet will trip open and lock out the affected utility circuit breaker (52U1 or 52U2). The system control switchboard shall immediately transition to an isolated bus mode and continue supplying the facility loads and all available (non-running) generators will be signaled to start and parallel with the bus.

(2) If after a pre-programmed time delay (adjustable from 0 to 30 minutes) the other utility source remains acceptable, the system control switchboard shall automatically and actively synchronize the isolated system bus to the acceptable utility source and close the associated utility source circuit breaker (52U1 or 52U2).

(3) Upon closure of the utility source circuit breaker the system will immediately transition back to the previous system operation mode (baseload or import level control)

and adjust the plant output to reach the previous baseload or import level setpoint.

(4) If after a pre-programmed time delay (adjustable from 0 to 60 minutes), utility source continues to operate within acceptable voltage and frequency limits, the system control switchboard will engage the load demand mode and program out of operation any unnecessary units, utilizing the set points for parallel mode.

9. Unit Start

a) During all modes of operation should the system control switchboard for any reason initiate operation (starting) of a cogeneration unit, it shall first generate a Call-to-Run signal for that particular unit to the EMS (Energy Management System). Upon receipt of this signal the EMS shall programmatically initiate the peripheral pumps, fans and associated miscellaneous equipment necessary for operation of the unit "Called-to-Run". Upon completion of it's start-up procedure and proof that all necessary systems have achieved the desired state, the EMS shall then issue a Run Enable signal to the system control switchboard.

b) Upon receipt of the Run Enable signal from the EMS the system control switchboard shall then initiate engine start and execute the remaining start-up procedure.

c) At any point during the operation of each cogeneration unit, if the EMS Run Enable signal is interrupted, the paralleling switchgear after the expiration of a pre-programmed time delay (adjustable from 0 to 120 seconds) shall initiate shutdown of the affected unit.

10. Unit Failure

a) Should a cogeneration unit fail to start, fail to automatically parallel or develop a critical running monitored fault, the control system shall cause the engine to automatically shutdown with its circuit breaker automatically tripped open.

b) Subsequently, the next available unit as defined by the programmable engine priority will be automatically started and paralleled to the bus to maintain the plant output as required by the current operational mode (import level or baseload).

D. System Integration

1. To provide effective and coordinated control of the Cogeneration Facility the System control switchboard must be integrated with several internal

and external systems which will provide operation conditions and status of external devices. In addition, the System control switchboard must provide control signals to some of these devices.

2. The System control switchboard manufacturer is responsible for coordination of the method of communication between the System control switchboard and all internal and external devices, and must supply all necessary equipment, accessories and programming necessary (which are internal to the System control switchboard) to furnish a complete and functional system.

3. The following devices and components which are exterior to the System control switchboard must be included in the System Integration Plan to be developed and coordinated by the System control switchboard Manufacturer:

a) EMS (Energy Management System) Integration

(1) Plant Operation – several signals as described throughout this document must be passed between the EMS and the system control switchboard in real time to safely operate the cogeneration system.

(2) Data Acquisition by EMS

(a) Coordinate and document necessary data acquisition and integration between System control switchboard and the EMS.

2.1 DESIGN AND CONSTRUCTION:

A. General Design Information:

1. The control system switchgear shall be comprised of individual cubicles for each engine generator set plus auxiliary cubicle or cubicles as required and shall be factory assembled to form a station switchboard line-up. The switchboard line-up shall be free standing, self-supporting, NEMA 1 (IP-20) metal enclosed for indoor service with internal steel barriers forming control, breaker, bus compartments plus removable screw secured rear sheets for access to the bus compartments and hinged front doors. Rear access shall be required and available.

B. Specific Design Information:

1. Paralleling Switchgear - Main bus shall be 480 / 277 volt, three phase, four wire, 4000 amp, 100KAIC, copper. Approximate dimensions of this line up shall be 90 inches high x 55 inches long x 58 inches deep. The new paralleling controls shall consist of two (2) new cubicles --- configured as follows: