MEASUREMENT AND VERIFICATION PLAN

FOR

DG/CHP SYSTEM
AT
JEWISH HOME AND HOSPITAL
GREENWALL PAVILION

Revised
August 20, 2012

Submitted to:

New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203-6399

Submitted by:

CDH Energy Corp.
PO Box 641
2695 Bingley Rd
Cazenovia, NY 13035
(315) 655-1063
www.cdhenergy.com

Project Team:

NYSERDA Project Manager:

Jim Hastings
518-862-1090 ext3492

Developer/Applicant:

Gene Holand, Jewish Home and Hospital
2545 University Avenue
Bronx, NY 10468
Tel 718-410-1220

Jeff Glick, Tecogen Inc.
45 First Avenue
Waltham, MA 02451
Tel: 781-466-6481
Fax: 781-466-6466
jeffrey.glick@tecogen.com

Ron Mineo, PE,
Genesys Engineering
629 Fifth Avenue, Building 3
Pelham, New York 10803
Tel: 914-633-6490
Fax: 914-633-6951
rmineo@genesysengineering.net

NYSERDA QC Contractor:

Adam Walburger, CDH Energy
PO Box 641
2695 Bingley Rd
Cazenovia, NY 13035
315-655-1063
walburger@cdhenergy.com

NYSERDA M&V Contractor:

Adam Walburger, CDH Energy
PO Box 641
2695 Bingley Rd
Cazenovia, NY 13035
315-655-1063
walburger@cdhenergy.com

1. Introduction

Jewish Home and Hospital has submitted an application to the NYSERDA CIPP program to install a CHP system at the Greenwall Pavilion at the Bronx Campus in New York, New York. The CHP system includes three (3) Tecogen CM-100 100 kW engine generator units. Thermal output from the units will be used to meet various hot water loads in the facility, and run hot-water absorption chillers during the summer. A dump radiator will reject any unneeded thermal energy.

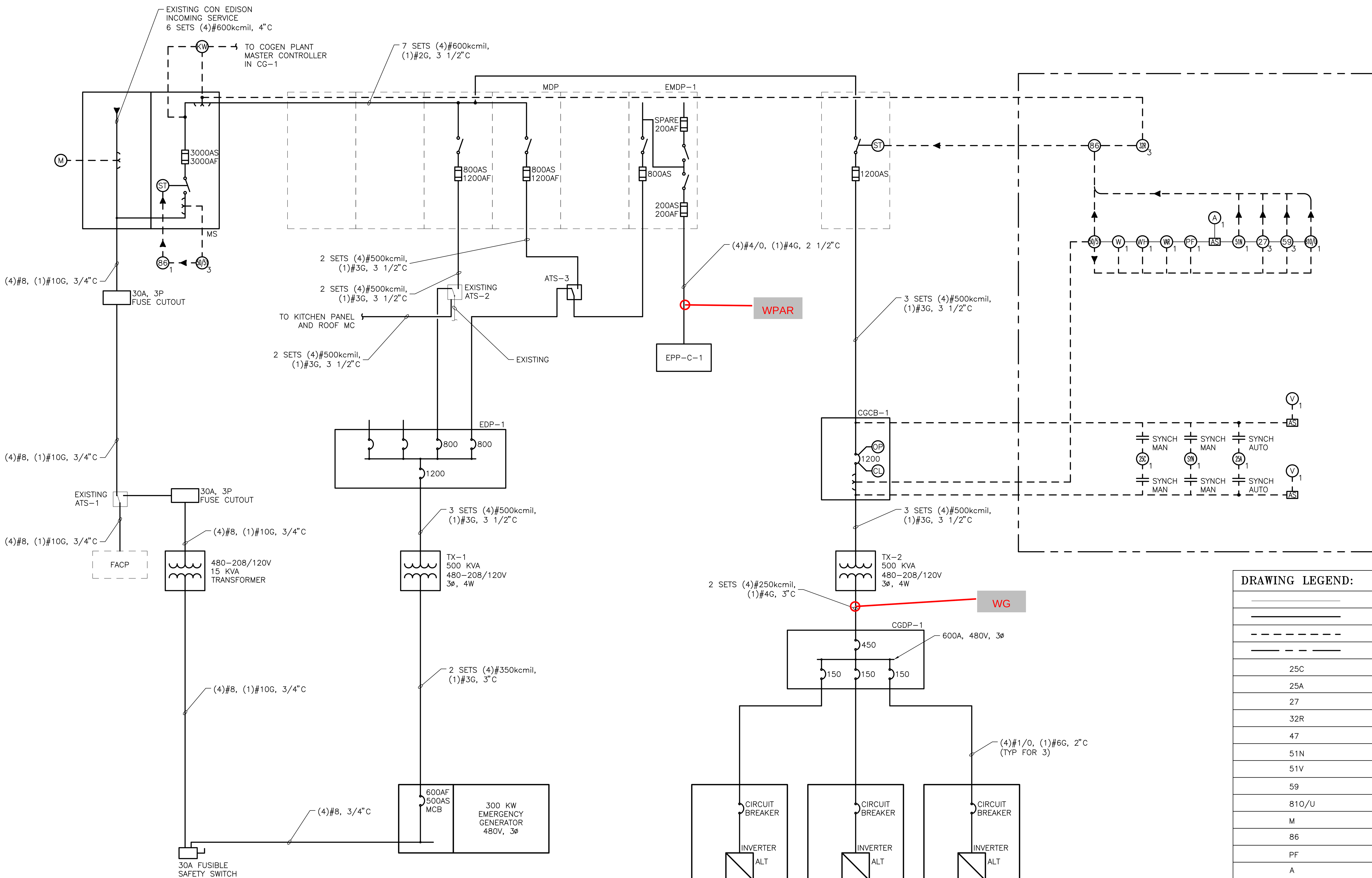
2. Instrumentation

In order to quantify the performance of the proposed CHP system, the CHP system fuel input, net electrical output, and useful thermal output must be measured. To capture these energy flows, an instrumentation plan was developed by CDH Energy and presented to the applicant, Jewish Home and Hospital. The instrumentation plan covers the location and type of sensors necessary to provide the appropriate measurements of the energy flows of the system.

In accordance to the instrumentation plan, Jewish Home and Hospital will supply the instrumentation listed Table 1 below for use in meeting the NYSERDA CHP program monitoring requirements.

Table 1. Instrumentation Supplied By Jewish Home and Hospital

Point	Instrument	Output Type	Sensor Location	Notes
Facility Power	None	Monthly utility billing	n/a	• WT
Generator Power Output	WNB-3D-480-P w/ CTS-2000-600 CTs	Pulse output 34.625Wh/pulse	Cogen Interconnection Panel CGDP-1	• WG • Meter location is gross power output
System Parasitic (Combined)	WNB-3Y-208-P w/ CTS-0750-100	Pulse output 2.5 Wh/pulse	Parasitic Load Panel EPP-C-1	• WPAR
Generator Gas Input	Utility pulse meter	Monthly billing data collected via internet	At gas service entrance	• FG
Heat recovery loop flow rate	SDI 1D1N-2-0-0200	Pulse output 1 gallon / pulse	Existing Meter	• FL
Heat recovery loop temperatures	Veris TBA-D0 10K Type II Thermistor	Resistance	Strap on sensors with thermal conductive paste.	• TLS0, TLS, TLR1, TLR2, TLR3, TLR4 (by CDH energy)



DRAWING LEGEND:

	EXISTING TO REMAIN
	NEW WIRING AND EQUIPMENT
	NEW CONTROL WIRING
	NEW ENCLOSURES
25C	SYNCHROCHECK
25A	AUTO SYNCHRONIZER
27	UNDERVOLTAGE
32R	3-PHASE REVERSE POWER
47	PHASE SEQUENCE VOLTAGE
51N	GROUND OVERCURRENT
51V	OVERCURRENT VOLTAGE RESTRAINT
59	OVERVOLTAGE
81O/U	OVER/UNDER FREQUENCY
M	CONED REVENUE METER
86	LOCKOUT RELAY
PF	POWER FACTOR METER
A	AMMETER
SS	SYNCHRO-SWITCH
AS	AMMETER SWITCH
SYN	SYNCHROSCOPE
F	FREQUENCY METER
V	VOLT METER
VS	VOLTMETER SWITCH
VAR	VOLT AMPERE REACTIVE METER
KW	KILOWATT METER
WH	WATTHOUR METER
ST	SHUNT TRIP
OP	OPEN BREAKER
CL	CLOSE BREAKER
SYNCH AUTO	SYNCH CONTROL SWITCH

100% DRAWINGS
ISSUED FOR CONSTRUCTION

THE JEWISH HOME & HOSPITAL LIFECARE SYSTEM

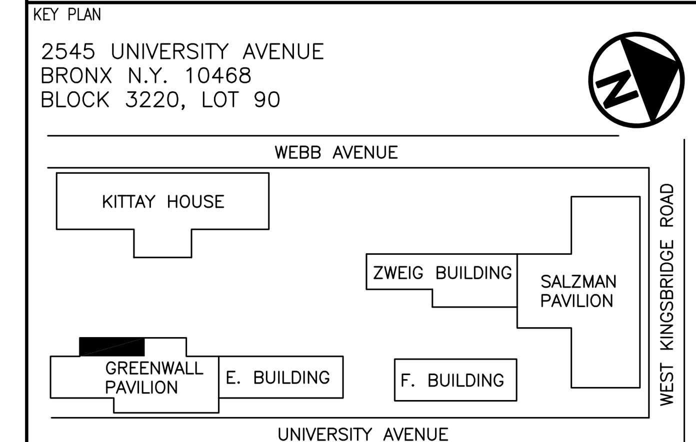
No.	Date	Revision

CLIENT

THE JEWISH HOME AND HOSPITAL

KEY PLAN

2545 UNIVERSITY AVENUE
BRONX N.Y. 10468
BLOCK 3220, LOT 90



LOCATION PLAN
NOT TO SCALE

Genesys Engineering P.C.

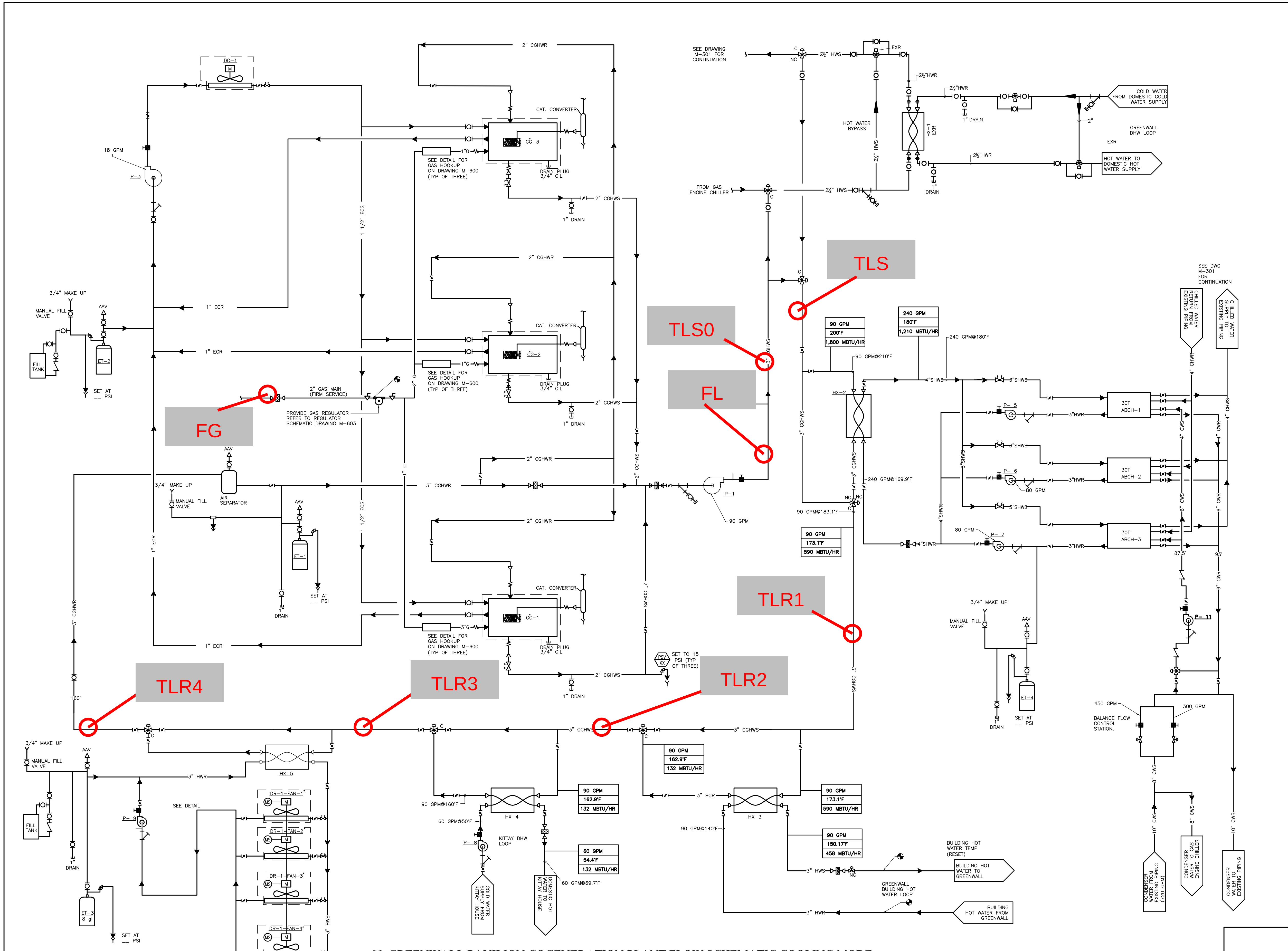
629 Fifth Avenue
Suite 111
Pelham, New York 10803
TEL (914) 663-6490
FAX (914) 633-6951

Pine West Plaza
Bldg. 5, Suite 503
Albany, New York 12205
TEL (518) 862-1199
FAX (518) 862-0516

JOB NAME: GREENWALL – COGENERATION

DRAWING TITLE: ELECTRICAL PARTIAL ONE LINE

Genesys JOB No.: 0234.00–000–GEN–2006
DRAWN BY: REP
SCALE: NONE
CHECKED BY: REP
DATE: 03-09-2007
SHEET NUMBER: E-101



1 / M-300 GREENWALL PAVILION COGENERATION PLANT FLOW SCHEMATIC COOLING MODE

SCALE: NONE

100% DRAWINGS
ISSUED FOR CONSTRUCTION

THE JEWISH HOME & HOSPITAL LIFECARE SYSTEM

No.	Date	Revision
1	04-27-07	DEA SUBMISSION

CLIENT

THE JEWISH HOME AND HOSPITAL

KEY PLAN

2545 UNIVERSITY AVENUE
BRONX N.Y. 10468
BLOCK 3220, LOT 90

WEBB AVENUE · KITTAY HOUSE · ZWEIG BUILDING · SALZMAN PAVILION · GREENWALL PAVILION · E. BUILDING · F. BUILDING · UNIVERSITY AVENUE · WEST KINGSBRIDGE ROAD

LOCATION PLAN
NOT TO SCALE

Genesys Engineering P.C.

629 Fifth Avenue
Suite 111
Pelham, New York 10803
TEL (914) 663-6490
FAX (914) 633-6951

Pine West Plaza
Bldg. 5, Suite 503
Albany, New York 12205
TEL (518) 862-1199
FAX (518) 862-0516

JOB NAME: GREENWALL – COGENERATION

DRAWING TITLE: GREENWALL PAVILION FLOW SCHEMATIC

Genesys JOB No.: 0234.00-000-GEN-2006

SHEET NUMBER: M-300

DRAWN BY: ASR/JVP
SCALE: NOTED
CHECKED BY: JVP
DATE: 03-09-2007

DISTRIBUTION PANEL SCHEDULE

DESIGNATION MAIN BUS / CAPACITY VOLTAGE ARRANGEMENT	PROTECTIVE DEVICE					FEEDER	SERVICE	REMARKS
	NUMBER	TYPE	FRAME (AMPS)	POLES	TRIP (AMPS)	SIZE		
CGDP-1 600A. BUS 208Y/120 V 3ø, 4W 100% NEUTRAL & GRD. BUS	1	MCCB	600	3	450	2 SETS (4)#250kcmil, (1)#4G, 3"C	TX-2	WG
	2	MCCB	225	3	150	SEE E-201	FROM CG-1	–
	3	MCCB	225	3	150	SEE E-201	FROM CG-2	–
	4	MCCB	225	3	150	SEE E-201	FROM CG-3	–

DISTRIBUTION PANEL SCHEDULE

DESIGNATION MAIN BUS / CAPACITY VOLTAGE ARRANGEMENT	PROTECTIVE DEVICE					FEEDER	SERVICE	REMARKS
	NUMBER	TYPE	FRAME (AMPS)	POLES	TRIP (AMPS)	SIZE		
EDP-1 1200A. BUS 208Y/120 V 3ø, 4W 100% NEUTRAL & GRD. BUS	1	–	–	–	–	–	SPARE	–
	2	–	–	–	–	–	SPARE	–
	3	MCCB	800	3	800	2 SETS 4-#500 KCMIL, #3G	ATS-2	1
	4	MCCB	800	3	800	2 SETS 4-#500 KCMIL, #3G	ATS-3	–

WPAR

PANELBOARD SCHEDULE

PANEL DESIGNATION: EPP-C-1
SERVICE: 208Y/120 VOLTS 3 PHASE 4 WIRE
MAINS: 225A AMPS
MAIN CIRCUIT BREAKER: – AMPS
MAIN LUGS ONLY: MLO

LOCATION: CELLAR CHILLER ROOM
GROUND BUS: YES
ISOLATED GROUND BUS: –
NUMBER OF POLES: 42
MOUNTING TYPE: SURFACE
REMARKS: –

SERVICE TO:	O.C.	No.	No.	O.C.	SERVICE TO:
P-1 3 HP	30	1, 3, 5	2, 4, 6	15	P-2 1 HP
P-3 7.5 HP	40	7, 9, 11	8, 10, 12	15	P-4 0.5 HP
P-5 1.5 HP	15	13, 15, 17	14, 16, 18	40	P-6 7.5 HP
P-7 0.5 HP	15	19, 21, 23	20, 22, 24	20	ABCH-1,ABCH-2,ABCH-3
DR-1,DC-1	50	25, 27, 29	26, 28	20	BATTERY CHARGER
			30	20	JACKET WATER HEATER
SPARE	20	31	32	–	SPACE
SPARE	20	33	34	–	SPACE
SPARE	20	35	36	–	SPACE
SPARE	20	37	38	–	SPACE
SPACE	–	39	40	–	SPACE
SPACE	–	41	42	–	SPACE

(BRANCH CIRCUITS: phases A B C)

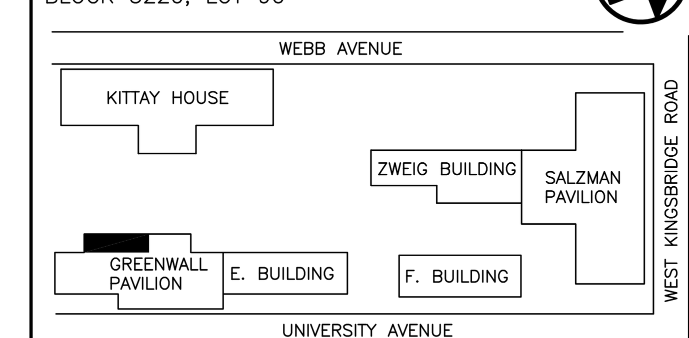
100% DRAWINGS
ISSUED FOR CONSTRUCTION

THE JEWISH HOME & HOSPITAL LIFECARE SYSTEM

No.	Date	Revision

CLIENT
THE JEWISH HOME AND HOSPITAL

KEY PLAN
2545 UNIVERSITY AVENUE
BRONX N.Y. 10468
BLOCK 3220, LOT 90



LOCATION PLAN
NOT TO SCALE

Genesys Engineering P.C.
629 Fifth Avenue
Suite 111
Pelham, New York 10803
TEL (914) 663-6490
FAX (914) 633-6951

Pine West Plaza
Bldg. 5, Suite 503
Albany, New York 12205
TEL (518) 862-1199
FAX (518) 862-0516

JOB NAME: GREENWALL – COGENERATION
DRAWING TITLE: ELECTRICAL SCHEDULES
Genesys JOB No.: 0234.00-000-GEN-2006
DRAWN BY: REP
SCALE: NONE
CHECKED BY: REP
DATE: 03-09-2007
SHEET NUMBER: E-300

Data Logger

Readings for the installed instrumentation are recorded by an Obvius Acquisuite data logger provided and installed by CDH Energy. The data logger samples all sensors approximately once per second and records one-minute totals (of pulse or digital sensors) or averages (of analog sensors). The one minute readings of heat recovery temperatures and flows are used to provide an accurate calculation of heat transfer on the heat recovery loops, which are all continuous flow loops.

Based on the number of monitored data points (10), the logger has sufficient memory to store 30-days of data if communications with the logger are interrupted. The data are downloaded from the data logger once per day via a phone line provided by the site/applicant. The data areloaded into a database, checked for validity, and posted on the NYSERDA web site.

Onsite Installation

CDH Energy has installed a data logger panel at a location in the cogeneration room agreeable to the site and developer. The monitoring system panel is approximately 2 ft x 2 ft x 1 ft. The panel is mounted near a 120 VAC power receptacle (it will require 1 amp or less). The panel is conveniently located relative to the sensors listed above as well as the communications line provided by the site.

Communications

CDH installed a phone sharing module (Phone Stick) in order to share Tecogen's existing phone line for the TECOCHILL unit closest to the data logger without disrupting the chiller. The phone number for the data logger is:

Data Logger Phone Number (TecoChill Line): (718) 410-1656,,*2

The network interface on the logger is unused. The data logger IP address is 192.168.40.50, and when accessing the data logger on site, the PC address must be set to 192.168. 40.2.

The data logger modem uses a PPP dial-up connection, with the logger acting as the PPP-host. The modem setup is the default setting for the internal modem. The logger IP address on the PPP-connection is 10.0.0.1 and the dial-in computer IP address is 10.0.0.2

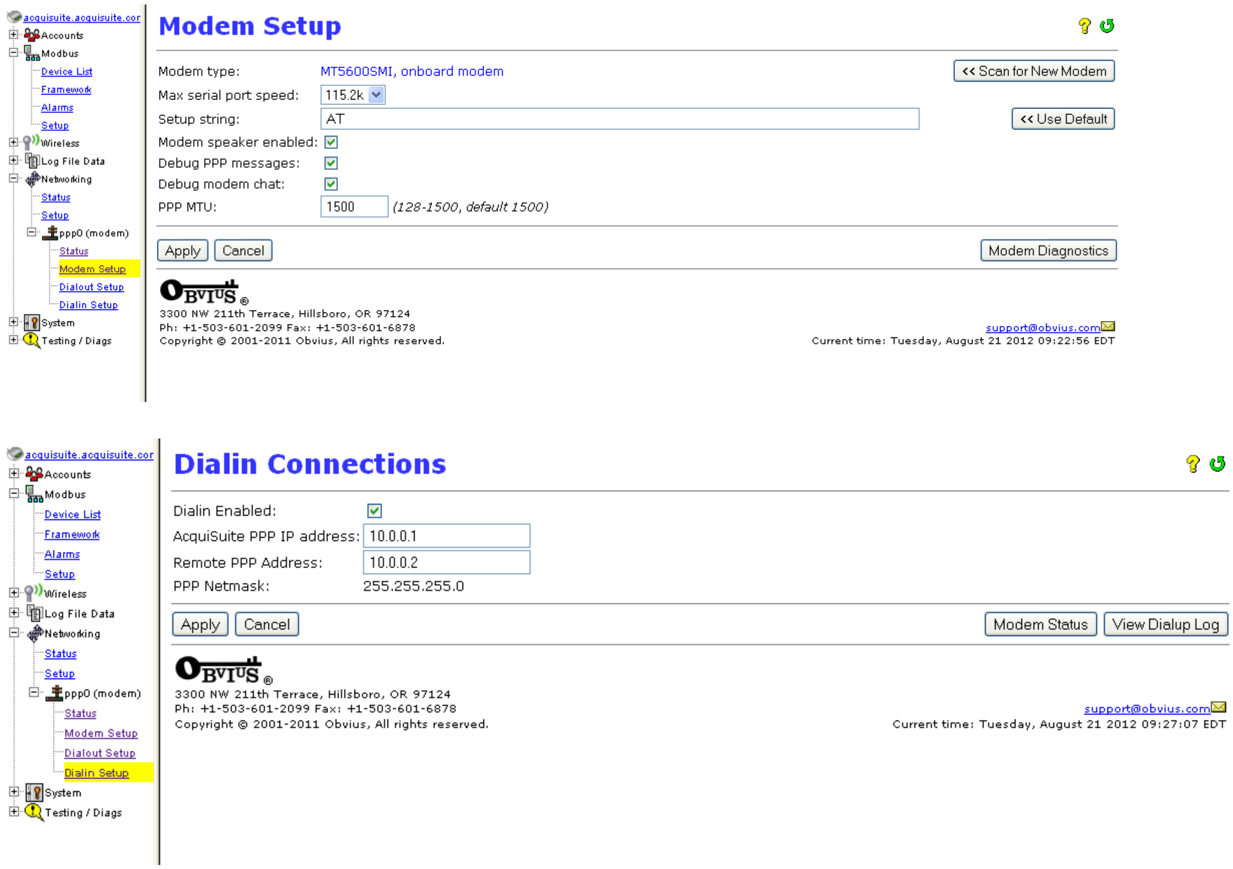


Figure 4. Dial In Configuration – Greenwall Logger

<u>On Site Support</u>

The facility is also responsible for facilitating interaction with the existing controls contractor to determine the best way to share the signal from the existing heat recovery flow meter.

The site will be responsible for providing access to all areas necessary to complete the monitoring installation, as well as any return trips for verification of sensors or service to the monitoring system.

3. Data Analysis

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

Table 2. Summary of Monitored Data Points

No.	Data Point	Description	Engineering Unit
1	WG	Generator Electrical Output (Gross)	kW/kWh
2	WPAR	Parasitic Load Electrical Consumption	kW/kWh
3	FG	Combined Generator Fuel Input	CF
4	FL	Glycol Loop Flow Rate	gallon/GPM
5	TLS0	Glycol Loop Supply Temperature	deg F
6	TLS	Glycol Loop Return Temperature from engine chiller glycol loop and Greenwall DHW HX1	deg F
7	TLR1	Glycol Loop Return Temperature from Abs. Chiller HX2	deg F
8	TLR2	Glycol Loop Return Temperature from Greenwall HW HX3	deg F
9	TLR3	Glycol Loop Return Temperature from Kittay DHW HX4	deg F
10	TLR4	Glycol Loop Return Temperature from Dump Radiator HX5	deg F

Peak Demand or Peak kW

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

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

The location of the generator power meter measures the combined gross output of all three engine generators. The net power delivered is determined by subtracting out the parasitic power measured for the combined parasitic power loads in panel EPP-C-1. Pumps P-2 and P-4 in panel EPP-C-1 were determined to not be associated with the source side of the heat recovery loop. Non-CHP parasitic loads Pump P-2 and Pump P-4 were measured to determine the power level to subtract from the measured parasitic energy. Pump P-2 had a measured power of 250 W, and Pump P-4 was not operating. Further one-time measurements will be performed to determine the variability in these pump loads, but the order of magnitude of the pump power was very low compared to the observed generator power of 110 kW, indicating that removing these pumps will not amount in a substantial change in system performance.

Heat Recovery Rates

The heat recovery rates will be calculated offline based on the 1-minute data collected. The piping arrangement at this site allows for multiple heat rates to be determined with 3 temperature sensors and one flow reading on the heat recovery loop:

Useful heat recovery (**QU**) = K·Σ [FL1·(TLS-TLR3)] / n

Rejected (unused) heat recovery (**QR**) = K ·Σ [FL1·(TLR3-TLR4)] / n

The loop fluid is expected to be a glycol-water mixture. The factor K will be determined based on a periodic reading of the fluid properties with a refractometer to determine the glycol concentration. The factor K is approximately 500 Btu/h-gpm-°F for pure water and approximately 480 for 20% glycol. 'n' is the number of scan intervals included in each recording interval (e.g., with 1 sec scans and 1-minute data, n=60).

Other heat recovery temperatures will be used for diagnostic purposes to verify if the system is operating in accordance with the proposed operation described in the original EA.

Calculated Quantities

The net power output from the CHP system, WG_{net}, will be defined as the gross power from the engines, WG, minus the parasitic power, WPAR.

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

$$FCE = \frac{QU + 3{,}413 \cdot (WG_{net})}{0.9 \cdot HHV_{gas} \cdot FG}$$

where: QU = Useful heat recovery (Btu) (QU)
WG_{net} = Engine generator net output (kWh) (WG – WPAR)
FG = Generator gas consumption (Std CF)
HHV_{gas} = Higher heating value for natural gas (~1030 Btu per CF).
Where 0.9 is the conversion factor between HHV and LHV

The FCE can be calculated for any time interval. When converting to daily, monthly, or annual values, the each value is summed and then the formula is applied:

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

where: N = The number of intervals in the period of interest

Appendix A

Cut Sheets for Key Sensors and Instruments

Greenwall Pavilion CHP M&V instrumentation Plan

No.	Data Point	Description	Units	Sensor	Signal Type	Multiplier/Pulse Rate?	Note
1	WG	Generator Electrical Output (Gross)	kW/kWh	Watt Node WNB-3D-480-P with 600 A CTs	Pulse	34.625 Wh/pulse	Install between CDGP-1 main and TX-2 on 480 VAC side
2	WPAR	Parasitic Load Electrical Consumption	kW/kWh	Watt Node WNB-3Y-208-P with 100 A CTs	Pulse	2.5 Wh/pulse	Install on EPP-C-1 main
3	FG	Combined Generator Fuel Input	CF	Utility Pulser	Pulse	TBD	Monthly utility data will be used until meter pulser installed.
4	FL1	Glycol Loop Flow Rate	gallons/GPM	Existing SDI 1D1N20-0200	Pulse	1	Data logger acts a pulse splitter
5	TLS0	Glycol Loop Supply Temperature	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	CDH Energy supplied strap on sensor
6	TLS	Glycol Loop Return Temperature from engine chiller glycol loop and Greenwall DHW HX1	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	CDH Energy supplied strap on sensor, optional diagnostic temp.
7	TLR1	Glycol Loop Return Temperature from Abs. Chiller HX2	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	CDH Energy supplied strap on sensor, optional diagnostic temp.
8	TLR2	Glycol Loop Return Temperature from Greenwall HW HX3	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	CDH Energy supplied strap on sensor, optional diagnostic temp.
9	TLR3	Glycol Loop Return Temperature from Kittay DHW HX4	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	CDH Energy supplied strap on sensor
10	TLR4	Glycol Loop Return Temperature from Dump Radiator HX5	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	CDH Energy supplied strap on sensor
11	WT	Total Facility Energy / Power	kW/kWh	n/a	n/a	n/a	Can be obtained on a monthly basis from ConEd Bills
12	FGT	Total Facility Gas Consumption	CF	n/a	n/a	n/a	Can be obtained on a monthly basis from ConEd Bills
13	TAO	Ambient Temperature	deg F	n/a	n/a	n/a	Can be obtained from Internet NCDC website

Note:
Engine glycol flow rate (**FL**) will use a singal splitter on the existing control system SDI flow meter.

CHP Efficency Calculations:

Net Power WG_{net} = (WG) - (WPAR)

Useful Heat QHU = 480 x FL x (TLS - TLR3)

Dumped Heat QHD = 480 x FL x (TLR3 - TLR4)

Fuel Conversion

$$FCE = \frac{QHU \cdot \Delta t + 3.412 \cdot (WGnet)}{LHV_{gas} \cdot FG}$$

FLOW SENSOR WITH INTEGRAL FLOW TRANSMITTER

SDI SERIES

DESCRIPTION

The **SDI Series Flow Sensor with Integral Flow Transmitter** is Data Industrial's latest product in their dependable line of flow meters for liquids. The direct insertion models are available in either brass or stainless steel material and can be installed or removed in piping systems that are not pressurized. The hot tap stainless steel models include an isolation valve and mounting hardware that enables flow meter installation and removal while the piping system is pressurized; system shutdown is unnecessary. Hot tap stainless steel models are also available for bidirectional flow measurement.

The four-blade impeller is rugged and non-fouling and requires no custom calibration. The **SDI Series** is available with a frequency output, analog output, and scaled-pulse output and the display is optional. Stainless steel models are available with a PEEK (polyetheretherketone) tip for high (up to 300°F) fluid temperatures, or a PPS (polyphenylene sulfide) tip for more moderate fluid temperatures.

SDI Insertion

FEATURES

- ***Direct insertion or hot tap installation***
- ***Fits pipe sizes 1.5" to 36"+ (3.8 to 91+ cm)***
- ***Mounts in 1" NPT tap, weld-on or pipe saddle***
- ***1% accuracy***
- ***Low pressure drop***
- ***Optional 8 character 3/8" (0.95 cm) LCD***
- ***NEMA 4X enclosure standard***
- ***Bidirectional models available***
- ***Field programmable with optional software***

SPECIFICATIONS

Operating voltage	8-35 VDC
Output impedance	750Ω @ 24 VDC
Accuracy	±1% of flow rate
Max pressure	
Stainless steel	1000 psig (6895 kPa)
Brass	600 psig (4137 kPa)
Max fluid temp	300°F (149°C) (PEEK tip) 180°F (82°C) (PPS tip)
Ambient temp range	14° to150°F (20° to 65°C)
Design flow range	0.3 to 20 fps (.09 to 6.1 mps)
Display	One-line eight-character 3/8" (0.95 cm) LCD
Pressure drop	0.5 psig (3.45 kPa) or less
Enclosure	NEMA 4X, polypropylene with Viton-sealed dacrylic cover
Electrical connection	Screw terminals with 1/2" (1.27 cm) conduit connection
O-Ring	Viton (standard)
Shaft	Tungsten carbide (standard)
Impeller	Stainless steel (standard)
Bearing	Torlon (standard)
Warranty	1 year

ORDERING INFORMATION

MODEL	DESCRIPTION
SDI	Flow sensor with integral transmitter
MATERIAL	
0D1N	Stainless steel insertion w/PPS tip for 1.5" to 10" pipes
0D2N	Stainless steel insertion w/PPS tip for 12"" to 36" pipes
0D3N	Stainless steel insertion w/PPS tip for 36"+ pipes
1D1N	Brass insertion w/PPS tip for 1.5" to 10" pipes
1D2N	Brass insertion w/PPS tip for 12" to 36" pipes
1D3N	Brass insertion w/PPS tip for 36"+ pipes
2D1N	Stainless steel insertion w/PEEK tip for 1.5" to 10" pipes
2D2N	Stainless steel insertion w/PEEK tip for 12" to 36" pipes
2D3N	Stainless steel insertion w/PEEK tip for 36"+ pipes
0H1N	Stainless steel hot tap w/PPS tip for 1.5" to 10" pipes
0H2N	Stainless steel hot tap w/PPS tip for 12" to 36" pipes
0H3N	Stainless steel hot tap w/PPS tip for 36"+ pipes
2H1N	Stainless steel hot tap w/PEEK tip for 1.5" to 10" pipes
2H2N	Stainless steel hot tap w/PEEK tip for 12" to 36" pipes
2H3N	Stainless steel hot tap w/PEEK tip for 36"+ pipes
OUTPUT	
0	Standard frequency pulse
1	4-20 mA
2	Scaled pulse
5	Bidirectional, 4-20 mA + direction (hot tap, PPS tip only)
6	Bidirectional, scaled pulse (hot tap, PPS tip only)
DISPLAY	
0	No display
1	LCD option (not available with output option 0)
CONSTRUCTION	
0200	Viton O-ring, Carbide shaft, stainless steel impeller, Torlon bearing (std)
1200	EPDM O-ring, Carbide shaft, stainless steel impeller, Torlon bearing

SDI 2D1N 1 1 0200 **Example: SDI2D1N11200** Flow sensor with integral transmitter, stainless steel insertion with PEEK tip, 4-20 mA output, display, standard construction.

RELATED PRODUCTS

A-SDI	**Programming kit**
A-1027	**Hot tap adapter nipple**
8132030	**Ball valve for hot tap installation (required)**

PROGRAMMABLE ANALOG FLOW TRANSMITTER
MODEL 310

DESCRIPTION

The **Model 310 Programmable Analog Flow Transmitter** is a loop-powered device that converts the signal from a 200 or 4000 Series flow sensor into a linear 4-20 mA signal. An integral, adjustable electronic filter dampens the analog output for smooth, stable operation. The microprocessor-based **Model 310** is configured from a computer, allowing it to be ordered pre-configured, or it can be field-configured. One Model A301-20 programming kit will configure all **Model 310** transmitters.

NEW!

310-00

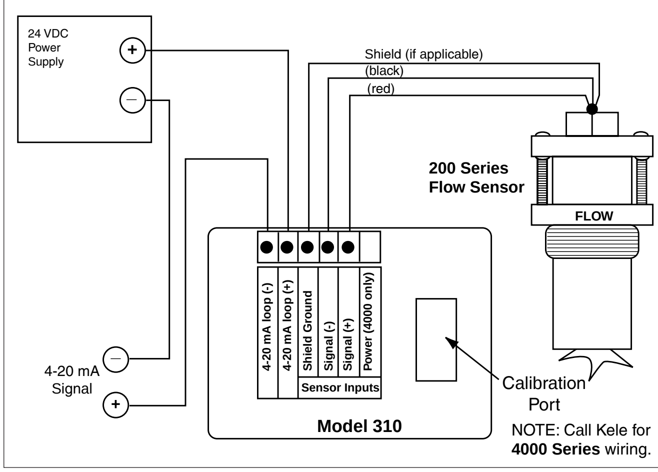
FEATURES

- ***4-20 mA loop powered***
- ***Compact size***
- ***Computer programmable***
- ***Electronic signal dampening***

SPECIFICATIONS

Power requirements	
Loop input voltage	9-35 VDC
Max loop resistance	750Ω @ 24 VDC
Accuracy	0.1% FS
Input frequency	0-1 kHz
Output response time	Varies with filter, typically 1 sec 10% to 90% step response
Operating temp	32° to 158°F (0° to 70°C)
Dimensions	1.75"H x 3.65"W x 1.0"D (4.4 x 9.3 x 2.5 cm)
Warranty	1 year

WIRING



ORDERING INFORMATION

MODEL	DESCRIPTION
310	Programmable analog flow transmitter
	MOUNTING
00	Transmitter only
01	Transmitter in NEMA 4X enclosure
02	Transmitter in metal enclosure
03	Transmitter in plastic enclosure
04	Transmitter with DIN rail mount
	OPTIONS
XR	Pre-configured option

310 – **00** – **XR** ***Example:*** **310-00-XR** Preconfigured programmable analog flow transmitter for field mounting

For preconfigured flow sensors, specify pipe size, schedule, and maximum flow rate at time of order.

RELATED PRODUCTS

A301-20 **Programming kit (cable and software)**

Continental Control Systems

WATTNODE®

Advanced Pulse Output AC Power Measurement

THE WATTNODE is a true RMS AC watt-hour transducer with pulse output (solid state relay closure) proportional to kWH consumed. The WATTNODE provides accurate measurement at low cost to meet your needs for sub-metering, energy management and performance contract applications.

277/480 VAC 120/240

Easy Installation saves you time and money. The WATTNODE is small enough to fit entirely within a standard electrical panel and the screw terminals unplug for easy wiring.

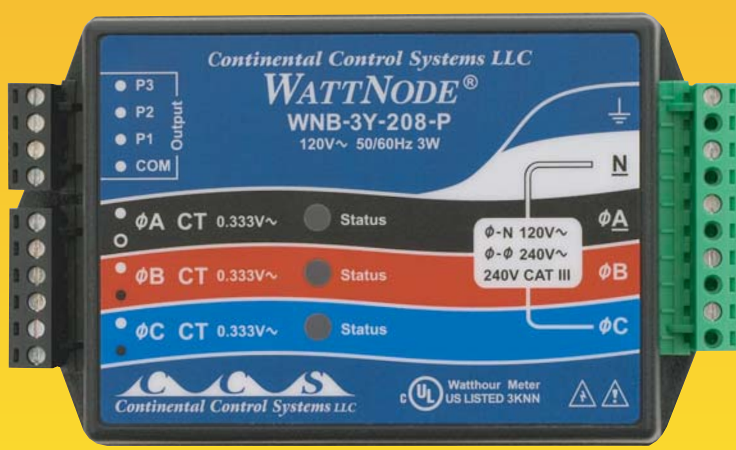
The Advanced Output includes separate pulse channels for positive and negative power, for net metering and PV metering. Optional models are available with one pulse output channel per measurement phase, which can be used to monitor each phase independently or to monitor three separate single-phase circuits with one WattNode.

Our Diagnostic LEDs provide a per-phase indication of power (green flashing), negative power (red flashing), and advanced diagnostics (yellow flashing) to help troubleshoot connection problems, like swapped CTs, or excessive line voltage. See the User's Guide for a full description.

The Pulse Series family measures 1, 2, or 3 phases in 2, 3 or 4 wire configurations. With voltage ratings from 120 to 600 VAC and current transformer (CT) rating from 5 to 4000 amps, there is a WATTNODE combination to meet your AC power measurement requirements.

ACCURACY of the WATTNODE is is 0.5% of reading over a wide range of power factors and harmonic content. You get true kWH measurements even with switching power supplies and variable speed drives.

Our Safe CTs, with internal burden resistors produce a voltage proportional to the load current. At rated current voltage is only 0.333 VAC. Split-core CTs quickly install on existing wiring and solid-core CTs cost less for new wiring.



C UL US LISTED

(888) 928-8663

Continental Control Systems LLC
3131 Indian Road, Suite A
Boulder, CO 80301 USA
(888) 928-8663 Fax (303) 444-2903
sales@ccontrolsys.com

www.ccontrolsys.com

- **Advanced Pulse Output**
  Separate pulse channels for positive and negative power. Optional models are available with one pulse output channel per measurement phase.
- **Small Size**
  Can be installed in existing service panels or junction boxes.
- **Uses Safe CTs**
  Output limited to one volt.
- **Line Powered**
  No external power supply required.
- **Digital Signal Processing**
  Accurate kWH measurement over a wide harmonic range.
- **Detachable Terminal Blocks**
  Easy to install and remove.

SPECIFICATIONS

WATTNODE®

Advanced Pulse Output AC Power Measurement

Measurement Configurations

Single phase: 2-wire or 3-wire

Three phase: 3-wire or 4-wire

Electrical

Line Powered

Operating Voltage Range: +15%, -20% of nominal

Power Line Frequency: 50/60 Hz

CT Input: 0.333 VAC

Pulse Output

Optoisolated, solid state relay closures handle up to maximum 60 VDC & to 5mA

Standard: 4.00 Hz Bidirectional Output

Optional: 0.01 Hz to 600 Hz Bidirectional Output Models

Optional: Per-Phase Output Models 0.01 Hz to 150 Hz available

Accuracy

Normal Operation: Line voltage: 80% - 115% of nominal

Power factor: 1.0

Frequency: 48 - 62 Hz

Ambient Temperature: 25˚C

Current: 5% - 100% of rated current

Accuracy: ±0.5% of reading

Environmental

Operating Temperature: -30˚C to +55˚C (-22˚F to 131˚F)

Operating Humidity: 5 to 90% (RH)

Mechanical

Enclosure: High impact, UL rated, ABS plastic

Size: 3.3” x 5.6” x 1.25”

Connectors: UL, CSA recognized, detachable, screw terminals (14AWG), 600V

Optional LCD Display

Display: Eight digits, each 0.43" high

Reset: Wired remote and configurable front panel button

Enclosure: Panel mount box, 2.95" x 1.52"

Battery: Lithium 2/3A, replace every four years

MADE IN THE USA

(888) 928-8663

Continental Control Systems

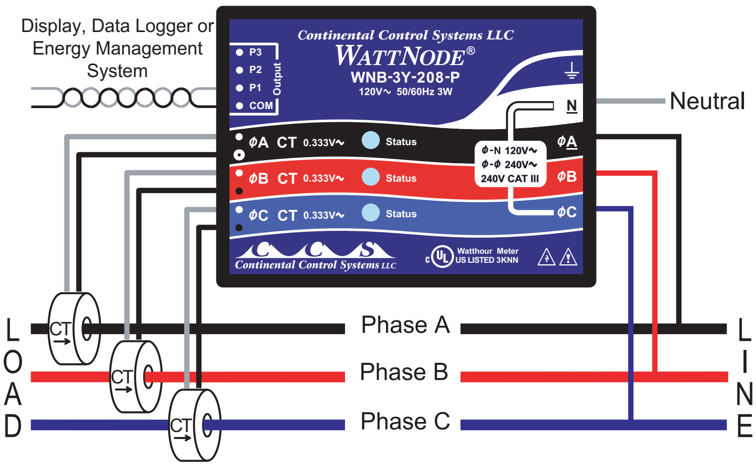
3131 Indian Road, Suite A

Boulder, CO 80301

(888) 928-8663   Fax (303) 444-2903

sales@ccontrolsys.com

www.ccontrolsys.com



MODELS

Model	VAC Line To Neutral	VAC Line To Line	Phases	Wires
WNB-3Y-208-P	120	208-240	3	4
WNB-3Y-400-P	230	400	3	4
WNB-3Y-480-P	277	480	3	4
WNB-3Y-600-P	347	600	3	4
WNB-3D-240-P	120	208-240	3	3
WNB-3D-400-P	230	400	3	3
WNB-3D-480-P	277	480	3	3

LCD Displays

Model	Displays	Units
LCDA-E	Energy	WH, kWH, or MWH
LCDA-P	Power	W or kW
LCDA-EP	Energy & Power	WH, kWH, or MWH & W or kW

OPENING CURRENT TRANSFORMERS (SPLIT-CORE)

Model	Inside Diameter	Rated Amps
CTS-0750	0.75"	5, 15, 30, 50, 70, 100, 150
CTS-1250	1.25"	70, 100, 150, 200, 250, 300, 400, 600
CTS-2000	2.00"	600, 800, 1000, 1200, 1500
CTB	Bus Bar	600, 800, 1200, 2000, 3000 (custom)

TOROIDAL CURRENT TRANSFORMERS (SOLID-CORE)

Model	Inside Diameter	Rated Amps
CTT-0300	0.30"	5, 15, 30
CTT-0500	0.50"	15, 30, 50, 60
CTT-0750	0.75"	30, 50, 70, 100
CTT-1000	1.00"	50, 70, 100, 150, 200
CTT-1250	1.25"	70, 100, 150, 200, 250, 300, 400

Current Transformer Output Voltage: 0 - 0.333 VAC @ rated current

Specialty Temperature Sensors

High Accuracy Specialty Sensors

DESCRIPTION

The **TA Series** offers two styles of sensors, the flexible TA and the rigid TAR. These sensors average the temperature read across the entire length of the copper tubing, making them ideal for duct temperature measurements.

The **TB** strap-on sensor uses a clamp to secure the unit to a pipe, and a copper sensing plate for fast temperature response. The TB is perfect for secondary measurement of water temperature typical in retrofit applications. All TB Series temperature sensors include a steel mounting box for wire termination and easy conduit connection.

The **TRA Series** stainless steel remote probe is designed for high accuracy in remote temperature sensing applications. These units can be used in numerous refrigeration applications, or they can be mounted on pipes for chilled or heated water temperature sensing. All TRA Series temperature sensors are easily installed and include a durable stainless steel sensing probe and a two-wire twisted pair wire with strain relief.

FEATURES

TA/TAR Averaging Sensors

- Temperature averaging sensors average the temperature across the duct in 6′, 12′, or 24′ (1.8 m, 3.6 m, or 7.3 m) lengths for the flexible probe and 12″, 18″, 24″, 30″, 36″, or 48″ (0.3 m, 0.5 m, 0.6 m, 0.8 m, 0.9 m, or 1.2 m) for the rigid probe...cover all your averaging applications with one line
- Copper tubing enhances response time

TB Pipe Surface Sensor

- Secondary measurement of water temperature...ideal for retrofit applications
- Pipe clamps allow for easy installation on pipes up to 12″ in diameter

TRA Probe Sensor

- Durable stainless steel sensing probe for long sensor life

SPECIFICATIONS

5 Year Warranty

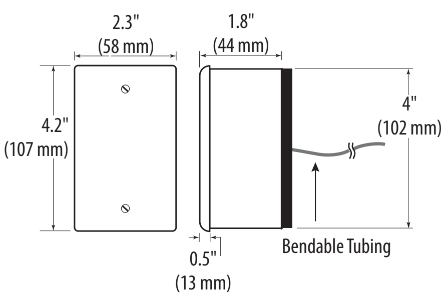
Wiring	22 AWG; 2-wire:RTD/Thermistor
Linitemp:	
Input Power	5 to 30VDC
Output	1µA/°C or 10mV/°C
Operating Temperature	**TA, TB, TAR:** -25° to 105°C (-13° to 221°F) **TRA:** Probe -25° to 105°C (-13° to 221°F), Wiring -20° to 80°C (-4° to 176°F)
Resistive:	
RTD/Thermistor	See table, facing page
Accuracy:	
Calibration Error	1.5°C (2.7°F) typical; 2.5°C (4.5°F) max. at 25°C (77°F)*
Error over Temperature	1.8°C (3.24°F) typical; 3.0°C (5.4°F) max. over 0° to 70°C (32° to 158°F) range; 2.0°C (3.6°F) typical, 3.5°C (6.3°F) max. over -25° to 105°C (-13° to 221°F) range

**Room temperature error documented on each unit.*

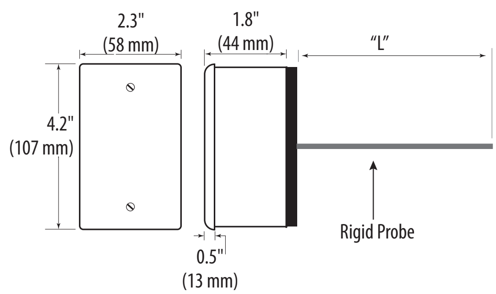
VERIS INDUSTRIES™

DIMENSIONAL DRAWINGS

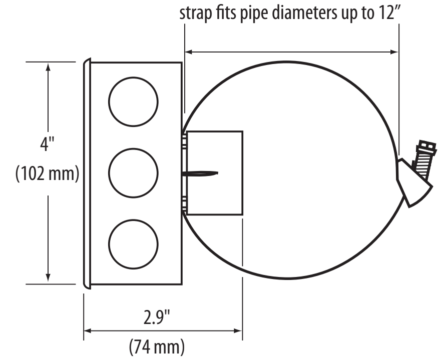
TA Model



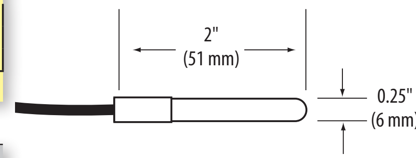
TAR Model



TB Model



TRA Model



Class	Pt RTD		THERMISTOR											
Type	100 Ohm	1000 Ohm	2.2k	3k	10k Type 2	10k Type 3	10k Dale	10k 3A221	10k "G" US	20k	20k "D"	100k	10k Type 2	10k Type 3
Accuracy	±0.3°C	±0.3°C	±0.2°C	±0.2°C	±1.0°C	±0.2°C	±0.2°C	±1.1°C	±0.2°C	Consult	Consult	Consult	±0.1°C 20/70°C	±0.1°C
	0.0385 curve	0.0385 curve	0/70°C	0/70°C	-50/150°C	0/70°C	-20/70°C	0/70°C	0/70°C	Factory	Factory	Factory	±0.2°C 0/20°C	0/70°C
Temp. Response*	PTC	PTC	NTC	NTC	NTC	NTC	NTC	NTC	NTC	NTC	NTC	NTC	NTC	NTC
													High Accuracy	

*PTC: Positive Temperature Coefficient

*NTC: Negative Temperature Coefficient

STANDARD RTD AND THERMISTOR VALUES (Ohms Ω)

°C	°F	100 Ohm	1000 Ohm	2.2k	3k	10k Type 2	10k Type 3	10k Dale	10k 3A221	10k "G" US	20k NTC	20k "D"	100k	10k Type 2	10k Type 3
-50	-58	80.306	803.06	154,464	205,800	692,700	454,910	672,300	-	441,200	1,267,600	-	-	692,700	454,910
-40	-40	84.271	842.71	77,081	102,690	344,700	245,089	337,200	333,562	239,700	643,800	803,200	3,366,000	344,700	245,089
-30	-22	88.222	882.22	40,330	53,730	180,100	137,307	177,200	176,081	135,300	342,000	412,800	1,770,000	180,100	137,307
-20	-4	92.160	921.60	22,032	29,346	98,320	79,729	97,130	96,807	78,910	189,080	220,600	971,200	98,320	79,729
-10	14	96.086	960.86	12,519	16,674	55,790	47,843	55,340	55,252	47,540	108,380	122,400	553,400	55,790	47,843
0	32	100.000	1000.00	7,373	9,822	32,770	29,588	32,660	32,639	29,490	64,160	70,200	326,600	32,770	29,588
10	50	103.903	1039.03	4,487	5,976	19,930	18,813	19,900	19,901	18,780	39,440	41,600	199,000	19,930	18,813
20	68	107.794	1077.94	2,814	3,750	12,500	12,272	12,490	12,493	12,260	24,920	25,340	124,900	12,500	12,272
25	77	109.735	1097.35	2,252	3,000	10,000	10,000	10,000	10,000	10,000	20,000	20,000	100,000	10,000	10,000
30	86	111.673	1116.73	1,814	2,417	8,055	8,195	8,056	8,055	8,194	16,144	15,884	80,580	8,055	8,195
40	104	115.541	1155.41	1,199	1,598	5,323	5,593	5,326	5,324	5,592	10,696	10,210	53,260	5,323	5,593
50	122	119.397	1193.97	811.5	1,081	3,599	3,894	3,602	3,600	3,893	7,234	6,718	36,020	3,599	3,894
60	140	123.242	1232.42	561.0	747	2,486	2,763	2,489	2,486	2,760	4,992	4,518	24,880	2,486	2,763
70	158	127.075	1270.75	395.5	527	1,753	1,994	1,753	1,751	1,990	3,512	3,100	17,510	1,753	1,994
80	176	130.897	1308.97	284.0	378	1,258	1,462	1,258	1,255	1,458	2,516	2,168	12,560	1,258	1,462
90	194	134.707	1347.07	207.4	-	919	1,088	917	915	1,084	1,833	1,542	9,164	919	1,088
100	212	138.506	1385.06	153.8	-	682	821	679	678	816.8	1,356	1,134	6,792	682	821
110	230	142.293	1422.93	115.8	-	513	628	511	509	623.6	1,016	816	5,108	513	628
120	248	146.068	1460.68	88.3	-	392	486	389	388	481.8	770	606	3,894	392	486
130	266	149.832	1498.32	68.3	-	303	380	301	299	376.4	591	456	3,006	303	380
Sensor Codes		B	C	E	F	D	H	J	S	R	M	U	T	W	Y

To compute Linitemp Temperature:

2-Wire version (1µA/°C)

µA reading - 273.15=Temperature in °C

3-Wire version (10mV/°C)

mV reading/10 - 273.15 = Temperature in °C

TEMPERATURE

ACCESSORIES

Klipet mounting clip for TA probe (AA64)

AA64

ORDERING INFORMATION

Strap-on Brackets

TB [ ]

- **A** = 2 1/2" max. diameter
- **D** = 8" max. diameter
- **E** = 12" max. diameter

TRA Remote Probe

Sensor Type [ ]

- **B** = 100R platinum, RTD
- **C** = 1k platinum, RTD
- **D** = 10k T2, Thermistor
- **E** = 2.2k, Thermistor
- **F** = 3k, Thermistor
- **G** = 10k CPC, Thermistor
- **H** = 10k T3, Thermistor
- **J** = 10k Dale, Thermistor
- **K** = 10k w/11k shunt, Thermistor
- **M** = 20k NTC, Thermistor
- **N** = 1800 ohm, Thermistor
- **P** = 10mV/°C, Linitemp
- **R** = 10k US, Thermistor
- **S** = 10k 3A 221, Thermistor
- **T** = 100k, Thermistor
- **U** = 20k "D", Thermistor
- **W** = 10k T2 high accuracy, Thermistor
- **Y** = 10k T3 high accuracy, Thermistor
- **Z** = 10k E1, Thermistor

Cal Certificate [ ]

- **0** = None
- **1** = 1 point Cal validation
- **2** = 2 point Cal validation

Examples:

TB	D	C	2
TRA	F	1	

NOTE: For 4-20 mA transmitter output, order sensor with the 100 Ω platinum RTD and accessory AA10xx.

Flexible Probe Length

TA [ ]

- ***M** = 6' (1.8m)
- **H** = 12' (3.6m)
- **J** = 24' (7.3m)

Rigid Probe Length "L"

TAR [ ]

- **E** = 12" (0.3m)
- **F** = 18" (0.5m)
- **G** = 24" (0.6m)
- **N** = 30" (0.8m)
- **K** = 36" (0.9m)
- **P** = 48" (1.2m)

Sensor Type [ ]

- **B** = 100R platinum, RTD
- **C** = 1k platinum, RTD
- **D** = 10k, T2, Thermistor
- **H** = 10k, T3, Thermistor
- **J** = 10k, Dale, Thermistor
- **M** = 20k, NTC
- **N** = 1800 ohm, Thermistor
- **P** = 10mV/C, Linitemp
- **R** = 10k US, Thermistor

Cal Certificate [ ]

- **0** = None
- **1** = 1 point Cal validation**
- **2** = 2 point Cal validation***

** Available with sensor types J,N,P*

*** The 18", 24", 30", 36", and 48" Rigid probes are calibrated to 22.5°C only.*

**** Available for all Flexible probe lengths. Not available for Rigid probes longer than 12".*

Examples:

TA	H	C	2
TAR	F	N	1

Appendix B

Instrumentation, Wiring Schematic, and Installation Details

Instrumentation, Wiring Schematic, and Installation Details

Site Visits

March 23, 2012	Initial site visit. Datalogger and sensors rough in. DAS system operational but incomplete. Communications not operational (Adam Walburger).
March 30, 2012	Datalogger and sensors rough in continued. DAS system operational, awaiting gas meter installation and communications start-up (Adam Walburger).
April 24, 2012	Datalogger and sensors rough in completed. DAS system operational, awaiting gas meter installation, third Tecogen engine start-up, and communications start-up (Adam Walburger).
July 12, 2012	On site to install Phone Stick to share phone line with TECOCHILL unit. Net Power (WG) power transducer stopped functioning on June 19, 2012. Awaiting gas meter installation, new WG power transducer installation, and third Tecogen engine start-up (Adam Walburger).
August 20, 2012	Reconfigured phone stick to work with existing TecoChill phoneline. Nightly data collection begins. Replaced WG power transducer with a Watt Node WNB-3D-408-P to prevent overvoltage damage. Tecogen units #1 and #3 are down for service.

Description of Monitored Data Points and Schematics

Table B-1 lists the monitored points installed at the site. The wiring schematic for the logger are shown in Figure B-1 and Figure B-2.

Table B-1. Monitored Data Point List

Greenwall Pavilion Logger Terminations							
Logger Input	**Data Point**	**Description**	**Units**	**Sensor**	**Signal Type**	**Multiplier/Pulse Rate**	**Note**
CH-1	FL	Glycol Loop Flow Rate	gallons/G	Existing Kele SDI 1D1N-2-0-0200	Pulse	1 gallon/pulse	Data logger acts a pulse splitter
CH-2	WG	Generator Electrical Output (Gross)	kW/kWh	WattNode WNB-3D-480-P 600 A Cts	Pulse	34.625 Wh/pulse	Installed between CDGP-1 main and TX-2 on 480 VAC side
CH-3	WPAR	Parasitic Load Electrical Consumption	kW/kWh	WattNode WNB-3Y-208-P 100 A CTs	Pulse	2.5 Wh/pulse	Installed on EPP-C-1 main
CH-4	FG	Combined Generator Fuel Input	CF	Utility Pulser	Pulse	TBD	Monthly utility data will be used until meter pulser installed.
CH-5							
CH-6							
CH-7							
CH-8							
EXP-1-1	TLS	Glycol Loop Return Temperature from engine chiller glycol loop and Greenwall DHW HX1	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-2	TLR1	Glycol Loop Return Temperature from Abs. Chiller HX2	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-3	TLR2	Glycol Loop Return Temperature from Greenwall HW HX3	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-4	TLR3	Glycol Loop Return Temperature from Kittay DHW HX4	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-5	TLR4	Glycol Loop Return Temperature from Dump Radiator HX5	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-6	TLS0	Glycol Loop Supply Temperature	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-7							
EXP-1-8							

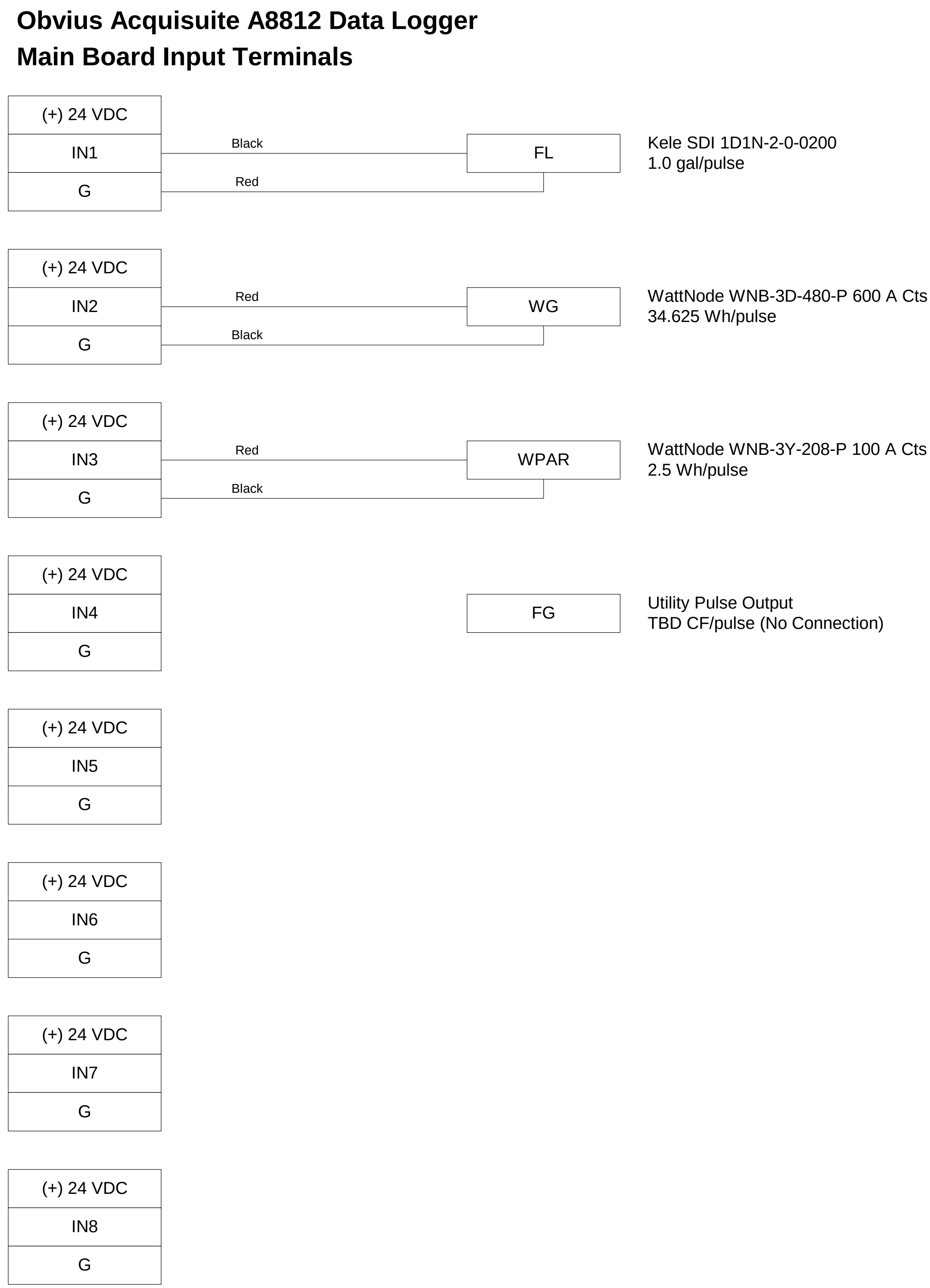


Figure B-1. Obvius Data Logger Wiring Schematic

Figure B-2. Obvius Expansion Board Wiring Schematic

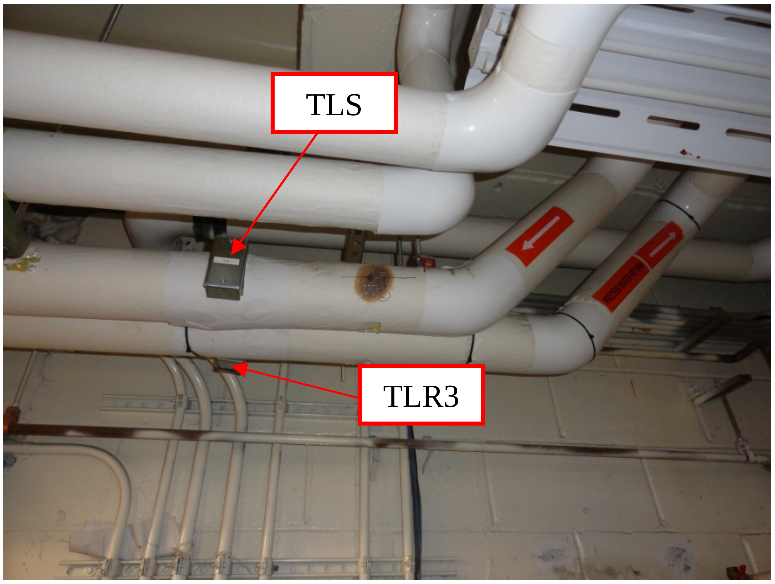
<u>Photos of Installed Sensors</u>

*Generator Power Transducer (**WG**)*

*Generator Power Transducer (**WG**) Typical 600 A CT and Fluke Flexible CT for Verification*


*Parasitic Load Panel EPP-C-1 and Power Transducer (**WPAR**)*


Obvius Data Logger



*Heat Recovery Temperature Sensors (**TLS**, **TLR3**) – After Engine Chiller HX, After HR Loads (Useful Heat Recovery) – In CHP Room*

*Heat Recovery Temperature Sensors (**TLR4**) – After Dump HX – In CHP Room*

*Heat Recovery Temperature Sensors (**TLS0**) – Before Engine Chiller HX (Diagnostic) – In CHP Room*

*Heat Recovery Temperature Sensors (**TLR1**) – After Absorption Chillers (Diagnostic) – In Boiler Room*

*Heat Recovery Temperature Sensors (**TLR2**) – After Greenwall Space Heating HX (Diagnostic) – In Boiler Room*

*CHP Gas Meter (**FG**) – No Pulse Output Installed Yet*

CHP Unit #1 and #2 (Operable)

CHP Unit #3 – Inoperable – April 2012

Engine Chiller

Absorption Chillers (1 of 3 typ)

HX2 – *Absortion Chillers*

HX3 – *Greenwall HW*

HX-4 Kittay Radiator

HX-5 Dump Radiator

Verification of Sensors

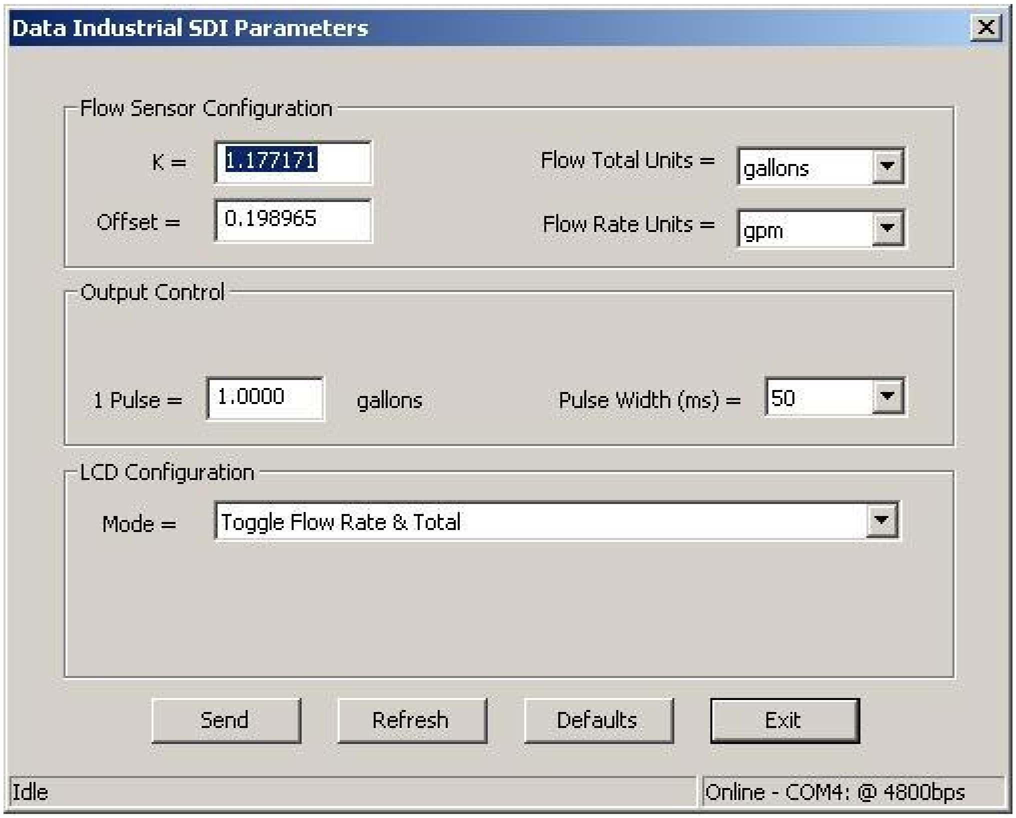
Flow Data

The main CHP heat recovery flow meter FT-1 (**FL**), has been reconfigured to be compatible with the Obvius data logger. The pulse constant has been changed to 1.0 gallon/pulse and the data logger is operating as a signal splitter, providing a solid state switch closure contact corresponding to the flow meter pulses, back to the CHP control system. Changing the pulse constant will result in a change in flow reported by the CHP control system, and should be conveyed to the control contractor.

The flow output from the heat recovery flow meter (**FL**) was found to be low compared to both the design flow, and an independent measurement performed with an ultrasonic flow meter.

Table B-2. Flow Rate Readings

Sensor/Output	**Flow (GPM)**	**Notes**
SDI Flow meter (reading by Badger/SDI software at meter)	78.9 – 79.4 GPM	Low compared to Design and Ultrasonic
Data logger (reading SDI Flow meter pulse output at 1 gal/pulse)	77 GPM	Consistent with SDI Output, requires correction at database level (1.23 gal/pulse)
Design Flow	90 GPM	
Fuji PortaFlow Ultrasonic	94.3 – 96.0 GPM	Consistent with Design



SDI Flow Meter Configuration Screen

*SDI Flow Meter (**FL**)*

PortaFlow Ultrasonic Transducer

Portaflow Ultrasonic Reading

<u>Power Transducer Data</u>

The power transducer datalogger and sensor system was compared with independent readings from a Fluke 39 handheld sensor for verification in Table B-3.

Table B-3. Power Transducer Readings

Sensor	DAS Reading (kW)	Fluke 39 Reading (kW)	Difference (kW)
WG– CHP Gross Output	*111.3 kW*	*110 kW*	*1.3 kW*
WPAR – CHP Parasitic Power Panel	11.8 kW	11.1 kW	0.7 kW

WG – CHP Gross Output power transducer failed June 19, 2012. Verification will be performed on the replacement power transducer once it has been installed.

Table B-4. Replacement Power Transducer Reading Performed August 20, 2012

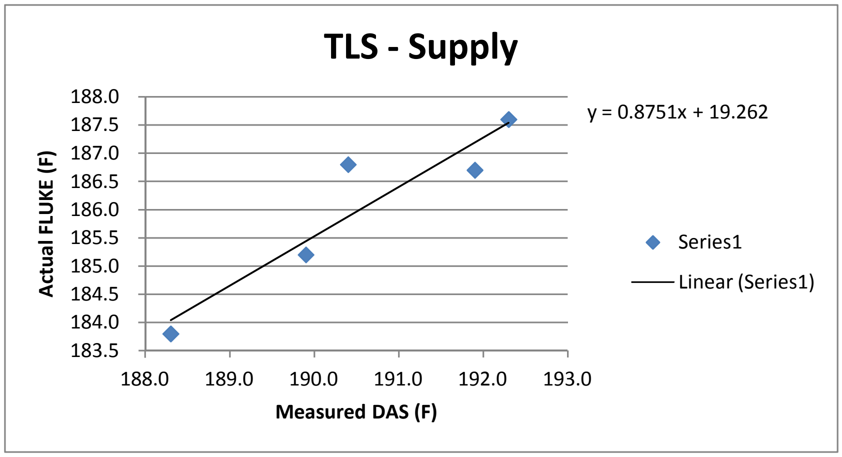
Sensor	DAS Reading (kW)	Tecogen Display Reading (kW)	Difference (kW)
WG– CHP Gross Output	78.6	78 – 79 kW	0.4 kW

Heat Recovery Loop Temperature Data

The heat recovery loop DAS systems were compared with independent readings from a Fluke handheld temperature probe for verification.

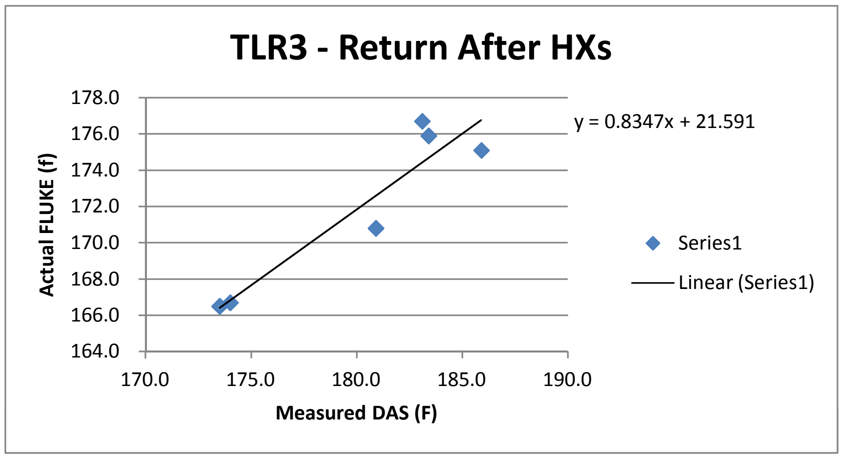
TLS

FLUKE	DAS	Difference
188.3	183.8	4.5
191.9	186.7	5.2
190.4	186.8	3.6
189.9	185.2	4.7
192.3	187.6	4.7
	AVG	4.5



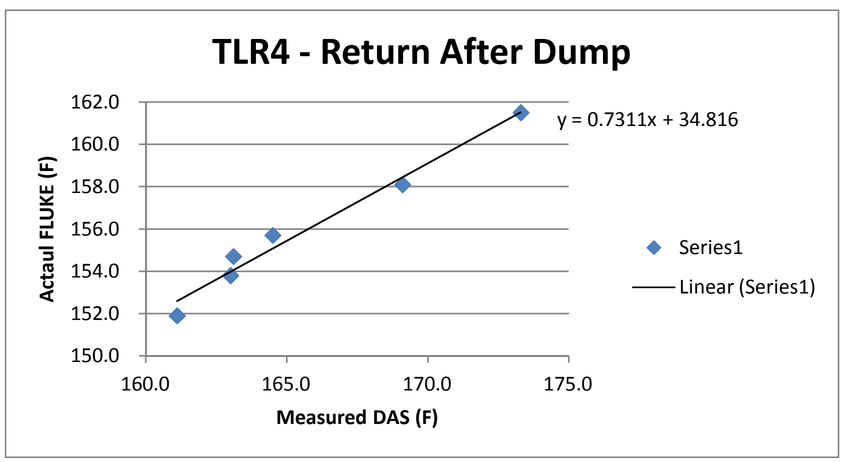
TLR3 - Return after HXs

FLUKE	DAS	Difference
183.1	176.7	6.4
174.0	166.7	7.3
185.9	175.1	10.8
183.4	175.9	7.5
173.5	166.5	7.0
180.9	170.8	10.1
	AVG	8.2



TLR4 - Return after Dump

FLUKE	DAS	Difference
161.1	151.9	9.2
173.3	161.5	11.8
164.5	155.7	8.8
169.1	158.1	11.0
163.0	153.8	9.2
163.1	154.7	8.4
	AVG	9.7



Instrumentation, Wiring Schematic, and Installation Details

Site Visits

March 23, 2012	Initial site visit. Datalogger and sensors rough in. DAS system operational but incomplete. Communications not operational (Adam Walburger).
March 30, 2012	Datalogger and sensors rough in continued. DAS system operational, awaiting gas meter installation and communications start-up (Adam Walburger).
April 24, 2012	Datalogger and sensors rough in completed. DAS system operational, awaiting gas meter installation, third Tecogen engine start-up, and communications start-up (Adam Walburger).
July 12, 2012	On site to install Phone Stick to share phone line with TECOCHILL unit. Net Power (WG) power transducer stopped functioning on June 19, 2012. Awaiting gas meter installation, new WG power transducer installation, and third Tecogen engine start-up (Adam Walburger).
August 20, 2012	Reconfigured phone stick to work with existing TecoChill phoneline. Nightly data collection begins. Replaced WG power transducer with a Watt Node WNB-3D-408-P to prevent overvoltage damage. Tecogen units #1 and #3 are down for service.

Description of Monitored Data Points and Schematics

Table B-1 lists the monitored points installed at the site. The wiring schematic for the logger are shown in Figure B-1 and Figure B-2.

Table B-1. Monitored Data Point List

Greenwall Pavilion Logger Terminations							
Logger Input	Data Point	Description	Units	Sensor	Signal Type	Multiplier/Pulse Rate	Note
CH-1	FL	Glycol Loop Flow Rate	gallons/G	Existing Kele SDI 1D1N-2-0-0200	Pulse	1 gallon/pulse	Data logger acts a pulse splitter
CH-2	WG	Generator Electrical Output (Gross)	kW/kWh	WattNode WNB-3D-480-P 600 A Cts	Pulse	34.625 Wh/pulse	Installed between CDGP-1 main and TX-2 on 480 VAC side
CH-3	WPAR	Parasitic Load Electrical Consumption	kW/kWh	WattNode WNB-3Y-208-P 100 A CTs	Pulse	2.5 Wh/pulse	Installed on EPP-C-1 main
CH-4	FG	Combined Generator Fuel Input	CF	Utility Pulser	Pulse	TBD	Monthly utility data will be used until meter pulser installed.
CH-5							
CH-6							
CH-7							
CH-8							
EXP-1-1	TLS	Glycol Loop Return Temperature from engine chiller glycol loop and Greenwall DHW HX1	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-2	TLR1	Glycol Loop Return Temperature from Abs. Chiller HX2	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-3	TLR2	Glycol Loop Return Temperature from Greenwall HW HX3	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-4	TLR3	Glycol Loop Return Temperature from Kittay DHW HX4	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-5	TLR4	Glycol Loop Return Temperature from Dump Radiator HX5	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-6	TLS0	Glycol Loop Supply Temperature	deg F	Veris TB 10k Type II Thermistor	Resistance	n/a	Strap on thermistor
EXP-1-7							
EXP-1-8							

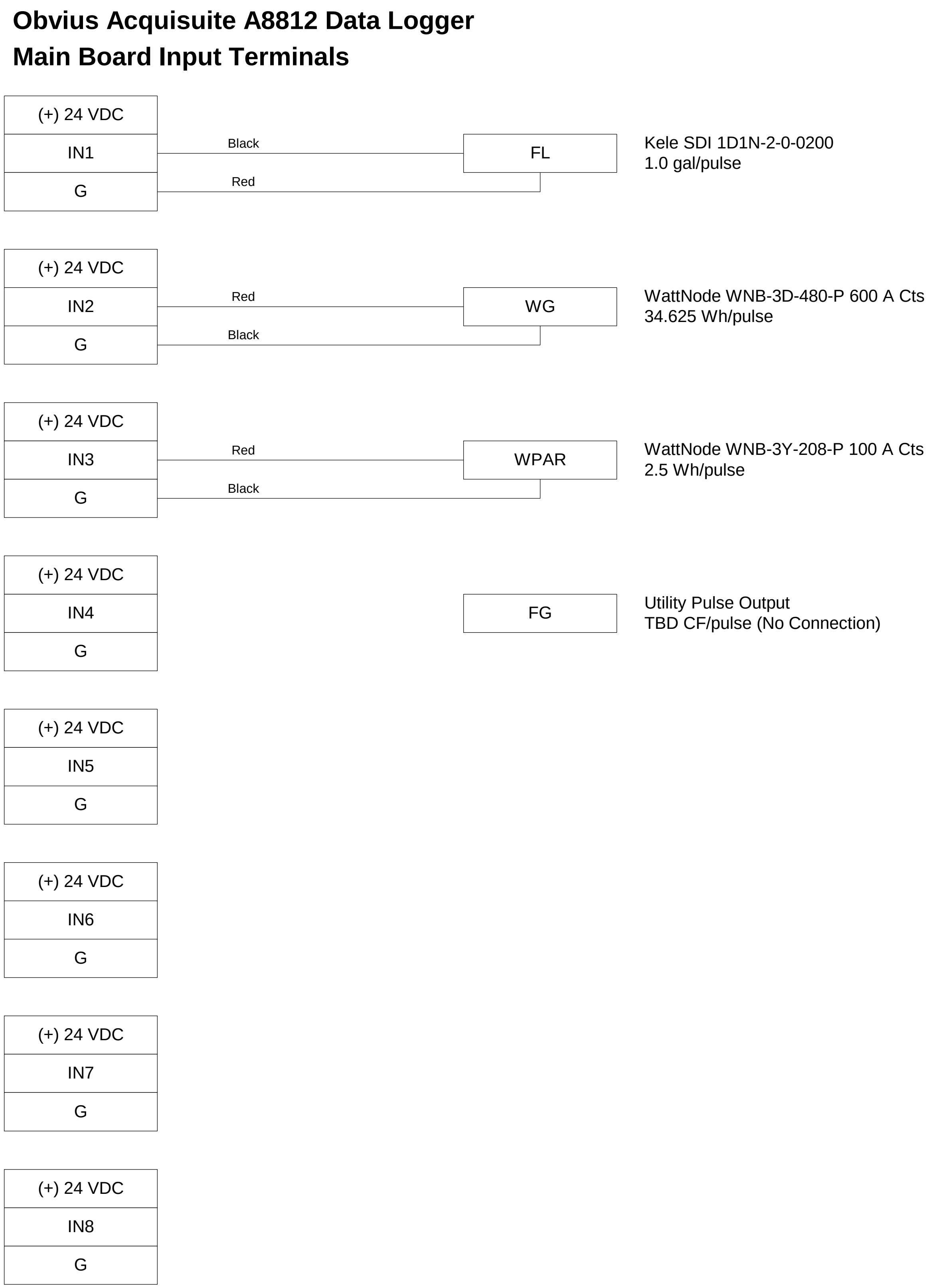


Figure B-1. Obvius Data Logger Wiring Schematic

Figure B-2. Obvius Expansion Board Wiring Schematic

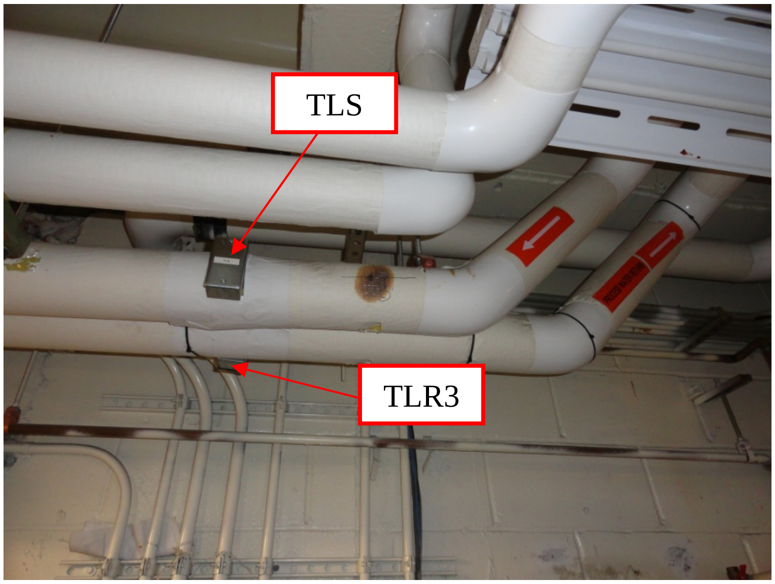
Photos of Installed Sensors

*Generator Power Transducer (**WG**)*

*Generator Power Transducer (**WG**) Typical 600 A CT and Fluke Flexible CT for Verification*

*Parasitic Load Panel EPP-C-1 and Power Transducer (**WPAR**)*

Obvius Data Logger



*Heat Recovery Temperature Sensors (**TLS**, **TLR3**) – After Engine Chiller HX, After HR Loads (Useful Heat Recovery) – In CHP Room*

*Heat Recovery Temperature Sensors (**TLR4**) – After Dump HX – In CHP Room*

*Heat Recovery Temperature Sensors (**TLS0**) – Before Engine Chiller HX (Diagnostic) – In CHP Room*

*Heat Recovery Temperature Sensors (**TLR1**) – After Absorption Chillers (Diagnostic) – In Boiler Room*

*Heat Recovery Temperature Sensors (**TLR2**) – After Greenwall Space Heating HX (Diagnostic) – In Boiler Room*

*CHP Gas Meter (**FG**) – No Pulse Output Installed Yet*

CHP Unit #1 and #2 (Operable)

CHP Unit #3 – Inoperable – April 2012

Engine Chiller

Absorption Chillers (1 of 3 typ)

HX2 – Absortion Chillers

HX3 – Greenwall HW

HX-4 Kittay Radiator

HX-5 Dump Radiator

Verification of Sensors

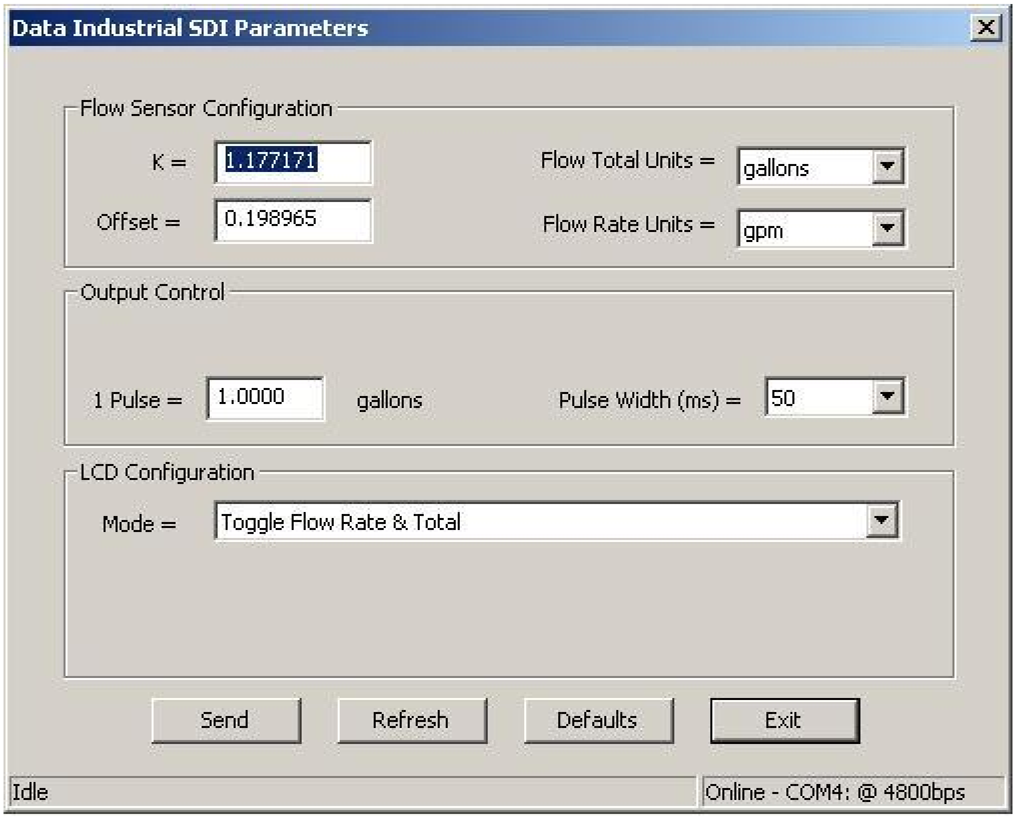
Flow Data

The main CHP heat recovery flow meter FT-1 (**FL**), has been reconfigured to be compatible with the Obvius data logger. The pulse constant has been changed to 1.0 gallon/pulse and the data logger is operating as a signal splitter, providing a solid state switch closure contact corresponding to the flow meter pulses, back to the CHP control system. Changing the pulse constant will result in a change in flow reported by the CHP control system, and should be conveyed to the control contractor.

The flow output from the heat recovery flow meter (**FL**) was found to be low compared to both the design flow, and an independent measurement performed with an ultrasonic flow meter.

Table B-2. Flow Rate Readings

Sensor/Output	**Flow (GPM)**	**Notes**
SDI Flow meter (reading by Badger/SDI software at meter)	78.9 – 79.4 GPM	Low compared to Design and Ultrasonic
Data logger (reading SDI Flow meter pulse output at 1 gal/pulse)	77 GPM	Consistent with SDI Output, requires correction at database level (1.23 gal/pulse)
Design Flow	90 GPM	
Fuji PortaFlow Ultrasonic	94.3 – 96.0 GPM	Consistent with Design



SDI Flow Meter Configuration Screen

*SDI Flow Meter (**FL**)*

PortaFlow Ultrasonic Transducer

Portaflow Ultrasonic Reading

Power Transducer Data

The power transducer datalogger and sensor system was compared with independent readings from a Fluke 39 handheld sensor for verification in Table B-3.

Table B-3. Power Transducer Readings

Sensor	DAS Reading (kW)	Fluke 39 Reading (kW)	Difference (kW)
WG– CHP Gross Output	*111.3 kW*	*110 kW*	*1.3 kW*
WPAR – CHP Parasitic Power Panel	11.8 kW	11.1 kW	0.7 kW

WG – CHP Gross Output power transducer failed June 19, 2012. Verification will be performed on the replacement power transducer once it has been installed.

Table B-4. Replacement Power Transducer Reading Performed August 20, 2012

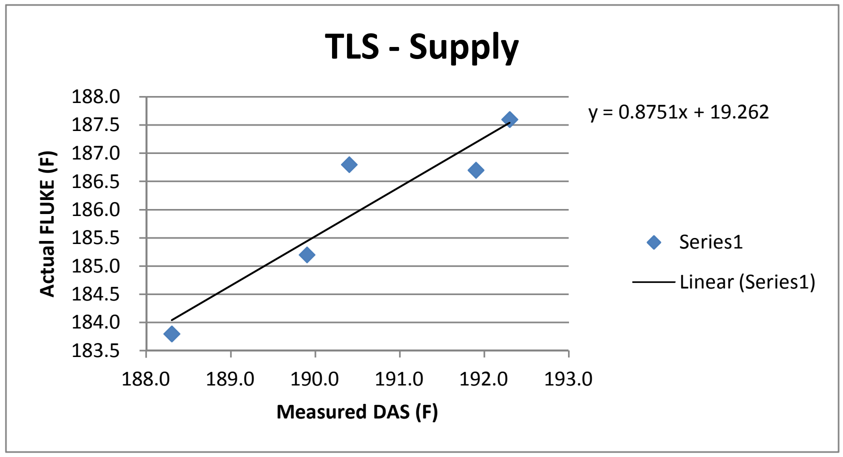
Sensor	DAS Reading (kW)	Tecogen Display Reading (kW)	Difference (kW)
WG– CHP Gross Output	78.6	78 – 79 kW	0.4 kW

<u>Heat Recovery Loop Temperature Data</u>

The heat recovery loop DAS systems were compared with independent readings from a Fluke handheld temperature probe for verification.

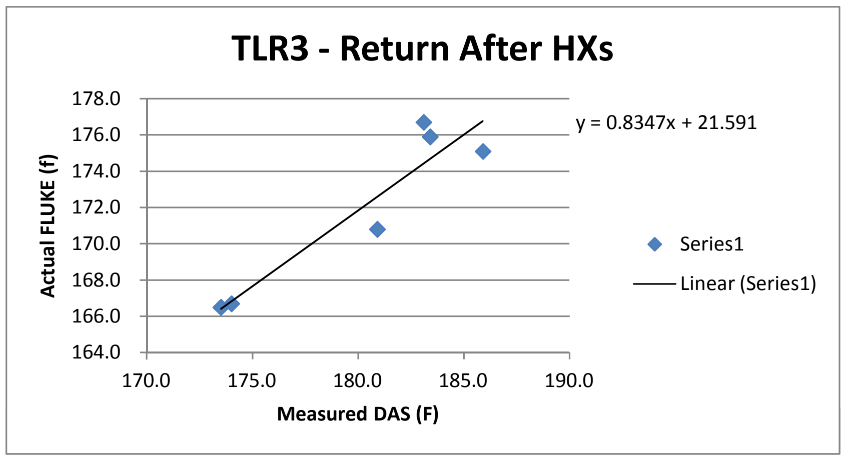
TLS

FLUKE	DAS	Difference
188.3	183.8	4.5
191.9	186.7	5.2
190.4	186.8	3.6
189.9	185.2	4.7
192.3	187.6	4.7
	AVG	4.5



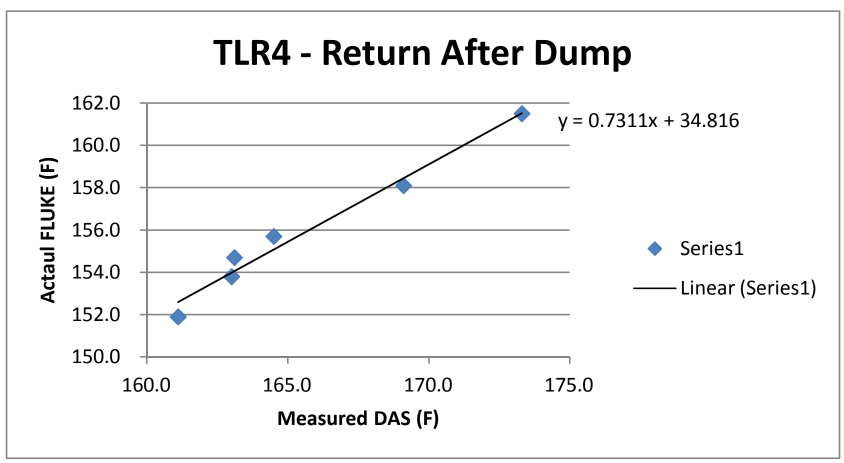
TLR3 - Return after HXs

FLUKE	DAS	Difference
183.1	176.7	6.4
174.0	166.7	7.3
185.9	175.1	10.8
183.4	175.9	7.5
173.5	166.5	7.0
180.9	170.8	10.1
	AVG	8.2



TLR4 - Return after Dump

FLUKE	DAS	Difference
161.1	151.9	9.2
173.3	161.5	11.8
164.5	155.7	8.8
169.1	158.1	11.0
163.0	153.8	9.2
163.1	154.7	8.4
	AVG	9.7



Greenwall CHP - Flow Meter Verification

Fuji Portaflow Data

Date	FLOW RATE gal/min	TOTALIZER gal
5/22/2013 10:18	72.8924	142395.243
5/22/2013 10:19	84.4167	142471.552
5/22/2013 10:20	81.0175	142553.949
5/22/2013 10:21	73.1713	142629.337
5/22/2013 10:22	80.6289	142706.45
5/22/2013 10:23	79.9195	142789.88
5/22/2013 10:24	74.3091	142864.549
5/22/2013 10:25	83.9012	142941.563
5/22/2013 10:26	81.4373	143025.892
5/22/2013 10:27	74.369	143101.39
5/22/2013 10:28	82.4467	143178.339
5/22/2013 10:29	81.6665	143262.137
5/22/2013 10:30	73.61	143338.099
5/22/2013 10:31	82.804	143415.635
5/22/2013 10:32	83.1121	143498.335
5/22/2013 10:33	74.8857	143574.583
5/22/2013 10:34	80.9979	143652.35
5/22/2013 10:35	81.7161	143734.614
5/22/2013 10:36	76.749	143809.627
5/22/2013 10:37	80.4195	143889.541

Duration	20	minutes
Total Gallons	1494.298	gallons
Average Flow	74.7149	GPM

DAS Data (SDI Paddlewheel)

Date	Time	Accumulator gal	Flow Rate gpm
5/22/2013	10:14:00	41218088	
5/22/2013	10:15:00	41218160	72
5/22/2013	10:16:00	41218220	60
5/22/2013	10:17:00	41218284	64
5/22/2013	10:18:00	41218352	68
5/22/2013	10:19:00	41218408	56
5/22/2013	10:20:00	41218472	64
5/22/2013	10:21:00	41218540	68
5/22/2013	10:22:00	41218600	60
5/22/2013	10:23:00	41218664	64
5/22/2013	10:24:00	41218728	64
5/22/2013	10:25:00	41218788	60
5/22/2013	10:26:00	41218852	64
5/22/2013	10:27:00	41218920	68
5/22/2013	10:28:00	41218980	60
5/22/2013	10:29:00	41219040	60
5/22/2013	10:30:00	41219112	72
5/22/2013	10:31:00	41219168	56
5/22/2013	10:32:00	41219232	64
5/22/2013	10:33:00	41219300	68
5/22/2013	10:34:00	41219360	60

Duration	20	minutes
Total Gallons	1200	gallons
Average Flow	60	GPM

Flow Ratio (Measured/Acutal) 1.25