MONITORING PLAN
FOR THE
PURECELL 400
AT
PRICE CHOPPER IN COLONIE, NY

Draft

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Submitted to:

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TABLE OF CONTENTS

Introduction

This plan describes our approach to monitoring the performance of the fuel cell system installed at the Price Chopper supermarket in Colonie, NY. The UTC Power PureCell™ Model 400 fuel cell provides clean and efficient electric power and thermal output to the store. This fuel cell is expected to supply most of the supermarket's electricity requirements in addition to standby power in the event of a power grid failure. The store will also recover heat from the fuel cell to use for space and Domestic Hot Water (DHW) heating as well as for driving an absorption chiller.

System Description

The PureCell® Model 400 is installed behind the supermarket. The fuel cell (FC) has separate electrical feeds for parallel operation with the utility or to provide backup power when isolated from the grid. The fuel cell is able to provide 400 kW of electrical power and up to 1.7 million Btu/h of heat. If fully utilized, the fuel cell can obtain a thermal efficiency near 90%.

Power Output:	400 kW 480V, 3ph
Heat Output:	1.71 MMBtu/h (low temp)
	0.79 MMBtu/h (high temp)

Figure 1. PureCell 400 Unit

Most of the thermal output from the FC is used to provide space conditioning and water heating for the store. The low temperature loop supplies 140ºF water to meet space heating loads including hot water coils and radiant floor heating circuits (see Figure 2 and 4).

The high temperature loop supplies 220ºF water to 1) the Yazaki chiller or 2) the DHW tank loads. Water from the high temperature loop can also be injected into the low temperature loop if extra heat is required for space heating (see Figure 2 and 4).

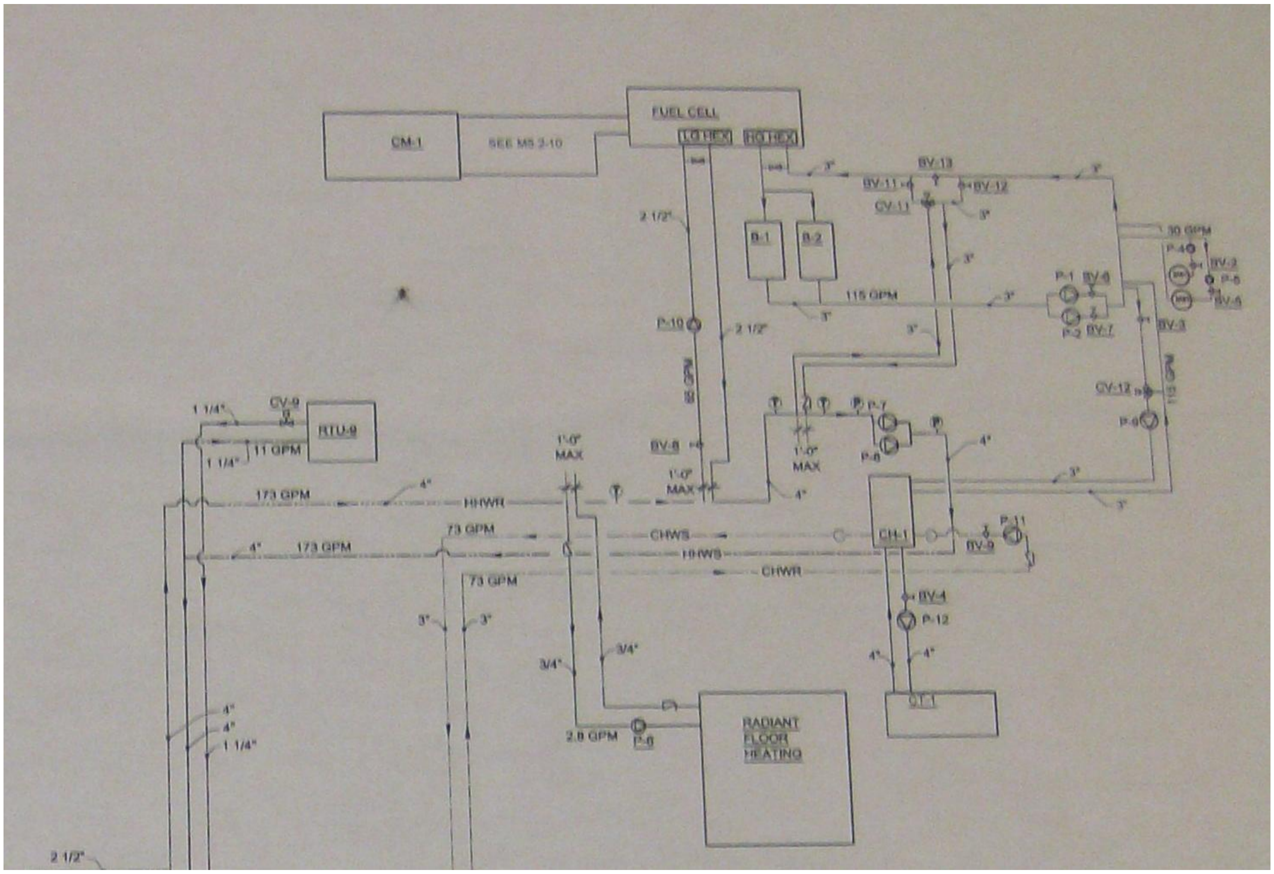

Figure 2. Piping Schematic at Price Chopper

The high temperature thermal output is supplied to a hot-water-driven 30-ton Yazaki absorption chiller (Figure 3) that can provide space cooling to the store.

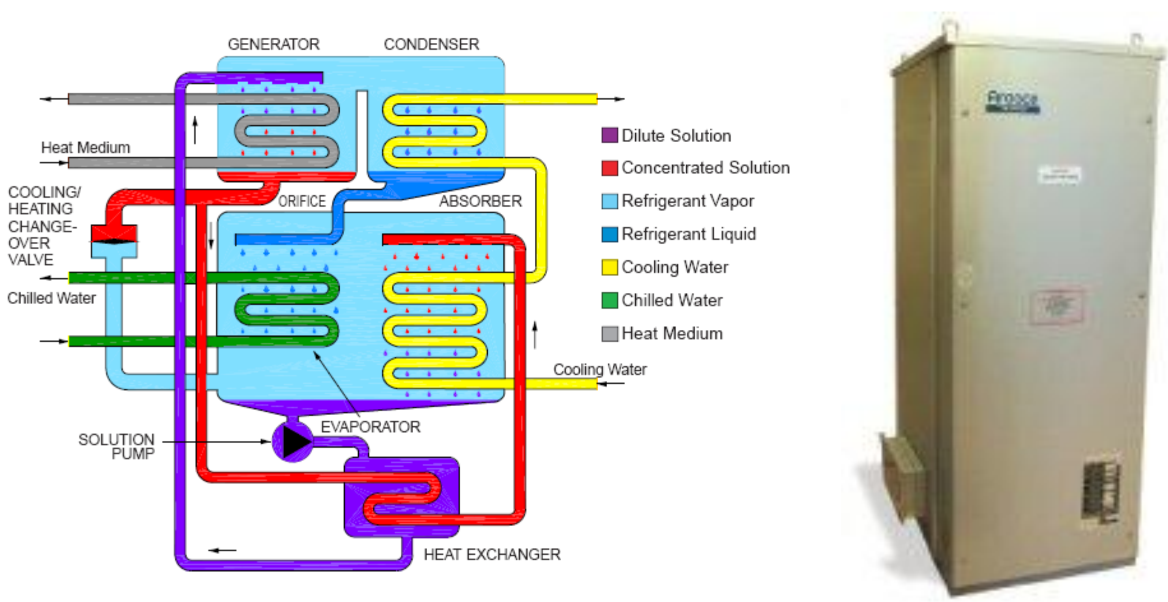

Figure 3. Yazaki Hot-Water-Driven Single Effect Absorption Chiller (from www.yazakienergy.com)

(Efficiency) Monitoring System

The efficiency monitoring system (EMS) has been designed to capture the electrical and thermal performance of the system. Table 1 summarizes the measurements that will be captured at the site.

Figure 4 shows where the measurements will be made in the thermal loops. Figure 5 and Figure 6 show the locations for the temperature measurements and flow meters in thermal circuits. Flow and temperature sensors are installed for four thermal loops: low temperature, high temperature, chilled water, and cooling water.

Data are extracted from the Power Plant Controller (PPC) via MODBUS TCP and from the two Shark Power Meters via MODBUS 485/serial connections. The Obvius AcquiSuite datalogger logs the required data.

Table 1. Summary of Measured and Collected Data at the Site

Channel / Source	Data Pt	Description	Instrument / Meter	Signal / Register	Eng Units	Wire	Notes
Main-1	TLS	Low Temp Supply Temp (from FC)	10k Thermistor, Type 2	bridge	°F	6	
Main-2	TLR	Low Temp Return Temp (to FC)	10k Thermistor, Type 2	bridge	°F	7	
Main-3	THS	High Temp Supply Temp (from FC)	10k Thermistor, Type 2	bridge	°F	4	
Main-4	THR	High Temp Return Temp (to FC)	10k Thermistor, Type 2	bridge	°F	5	
Main-5	TCHS	CHW Supply Temp (from Yazaki)	10k Thermistor, Type 2	bridge	°F	12	
Main-6	TCHR	CHW Return Temp (to Yazaki)	10k Thermistor, Type 2	bridge	°F	10	
Main-7	TCWS	Cooling Water Supply Temp (from FC)	10k Thermistor, Type 2	bridge	°F	bk/bl	
Main-8	TCWR	Cooling Water Return Temp (from FC)	10k Thermistor, Type 2	bridge	°F	br/wh	
EXP-1	FCH	Chilled Water Flow	SDI Flow Meter	4-20 mA	gpm	11	2 inch, sched 40 steel, 73 gpm
EXP-2	FH	High Temp Water Flow	SDI Flow Meter	4-20 mA	gpm	8	3 inch, sched 40 steel, 115 gpm
EXP-3	FL	Low Temp Water Flow	SDI Flow Meter	4-20 mA	gpm	9	2.5 inch, sched 40 steel, 85 gpm
EXP-4	FCW	Cooling Water Flow	Onicon F1100	4-20 mA	gpm	bl/rd/sh	2.5 inch, sched 40 steel, 60 gpm
Modbus Dev 1	WREC_pos	Energy Output through RECs meter	Shark 100	1100	kWh	Double	wire=13
Modbus Dev 1	WREC_neg	Energy Input through RECs meter	Shark 100	1102	kWh	Double	
Modbus Dev 1	WDREC	Power through RECs meter	Shark 100	900	Watts	Float	
Modbus Dev 2	WT_WREC_pos	Energy Output through Facility meter	Shark 100	1100	kWh	Double	
Modbus Dev 2	WT_WREC_neg	Energy Input through Facility meter	Shark 100	1102	kWh	Double	
Modbus Dev 2	WT_WDREC	Power through Facility meter	Shark 100	900	Watts	Float	
Modbus TCP	FG	Instantaneous Fuel Flow	PPC	7173	kg/h	Float	page 12 of FCFR
Modbus TCP	FGcum	Cumulative Fuel Consumption	PPC	7191	m³	Float	page 12 of FCFR
Modbus TCP	WFC	Instantaneous Power Output	PPC	10535	kW	Float	page 12 of FCFR
Modbus TCP	WFCcum	Cumulative Power Produced	PPC	7217	MWh	Float	page 12 of FCFR
Modbus TCP	EFF_ELEC	Instantaneous electrical efficiency (LHV)	PPC	7505	%	Float	page 12 of FCFR
Modbus TCP	FC_STATE	Fuel Cell Mode/State Number	PPC	5	Number	Unsigned Int	page 12 of FCFR
Modbus TCP	RTIME	Cumulative "Load" Time	PPC	7205	hrs	Float	page 12 of FCFR
Modbus TCP	NALARM	Total number of alarms	PPC	21	Number	Unsigned Int	page 12 of FCFR
Modbus TCP	SWV	Make-up water tank fill valve status	PPC	763	On/Off	Boolean/Int	page 12 of FCFR
Modbus TCP	SGI	Grid independent status	PPC	60	On/Off	Boolean/Int	page 12 of FCFR
Modbus TCP	SGC	Grid connect status	PPC	59	On/Off	Boolean/Int	page 12 of FCFR

Note: EXP = Obvius expansion board, device 003
Main = Obvius main board, device 250

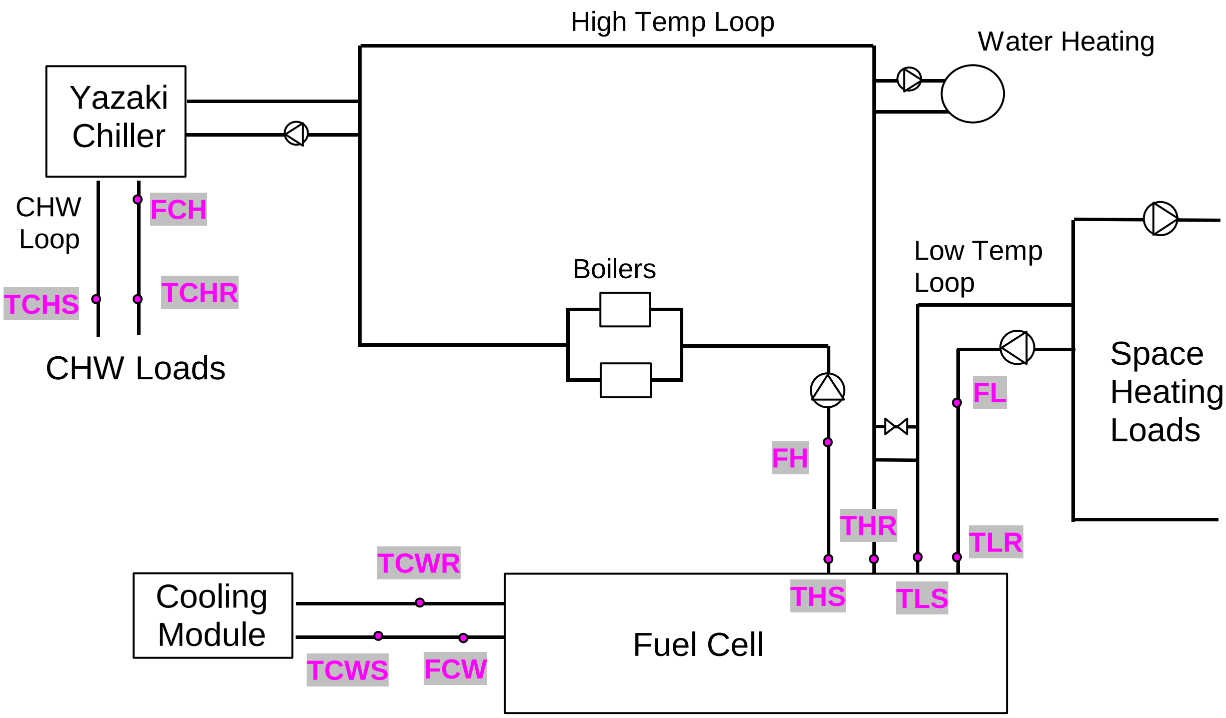

Figure 4. Schematic of Heat Transfer Loops in Fuel Cell System

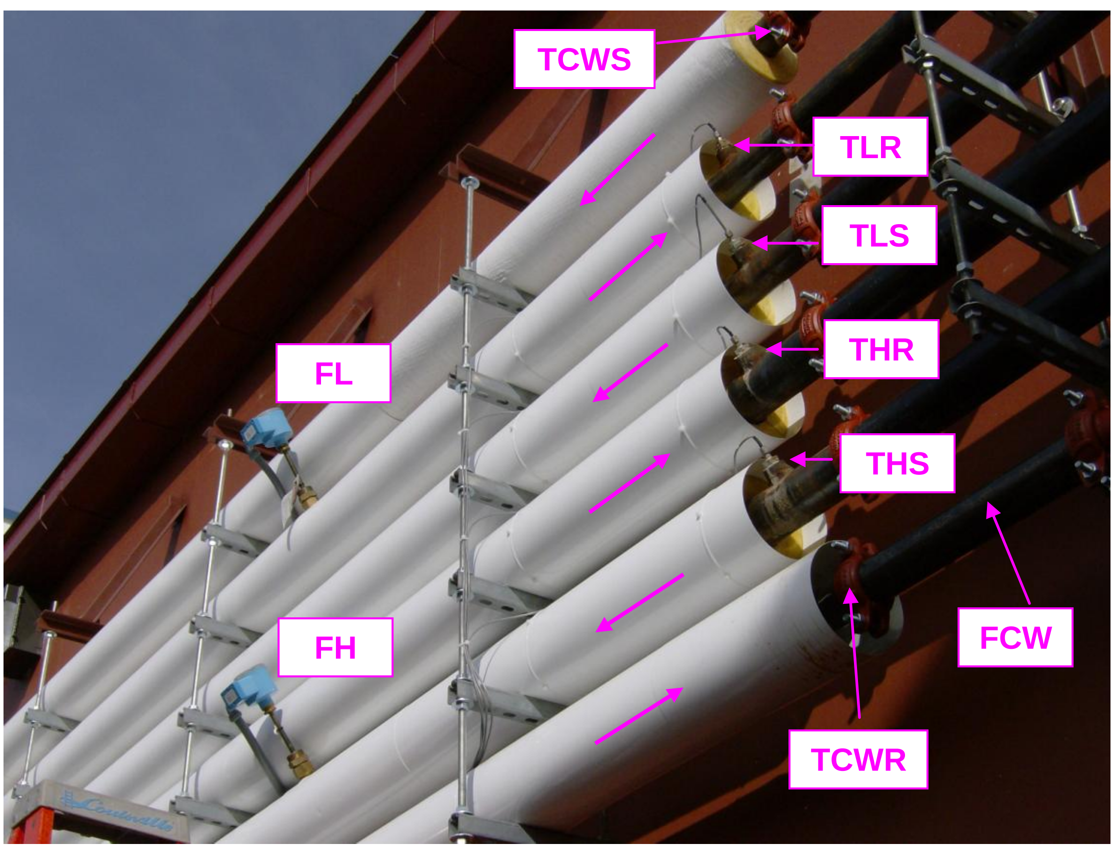

Figure 5. Locations of Temperature and Flow Sensors on Rear Wall of the Facility

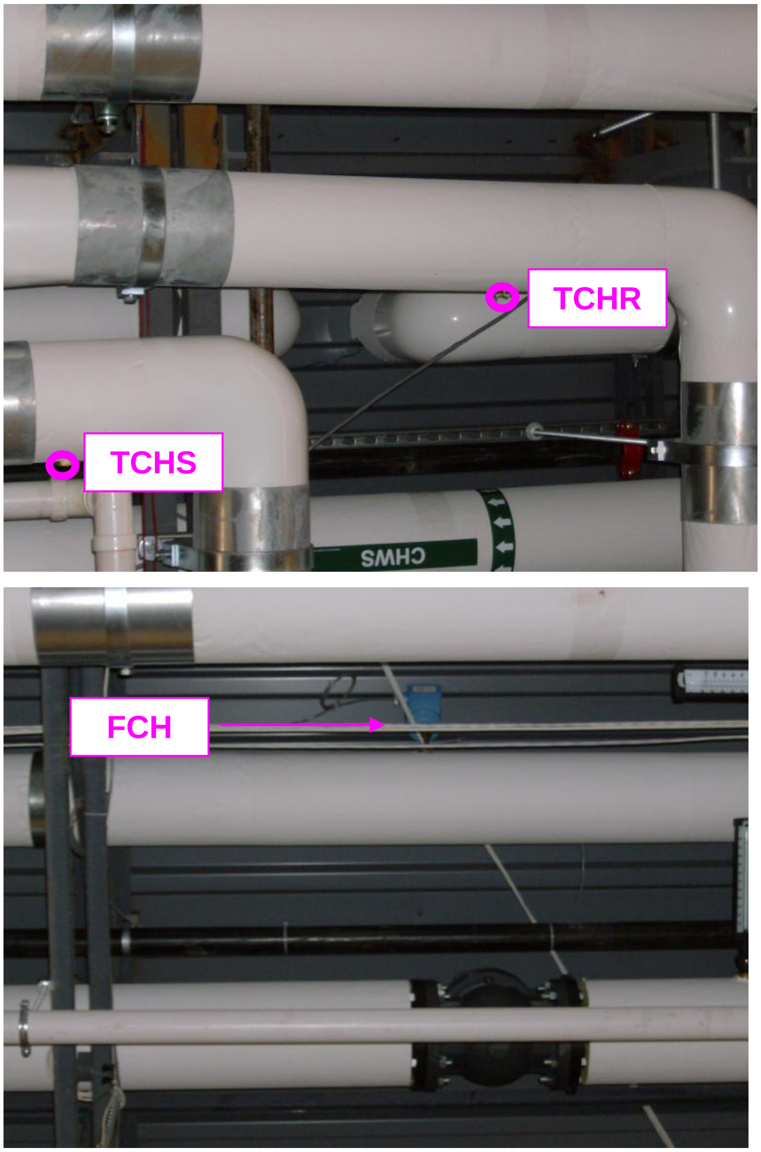

Figure 6. Location of Temperature Sensors and Flow Meter in Chilled Water Loop

The monitoring system is based around the Obvius AcquiSuite data logger. The layout of the EMS and the connections with other network components of the Fuel Cell system are shown in Figure 7. A Babel Buster gateway device reads MODBUS data from the PPC and Shark power meters and makes that data available to the Obvius data logger. The Babel Buster also makes the data from the Shark Meter available as MODBUS data for the Encelium/AEC Energy Kiosk at the store.

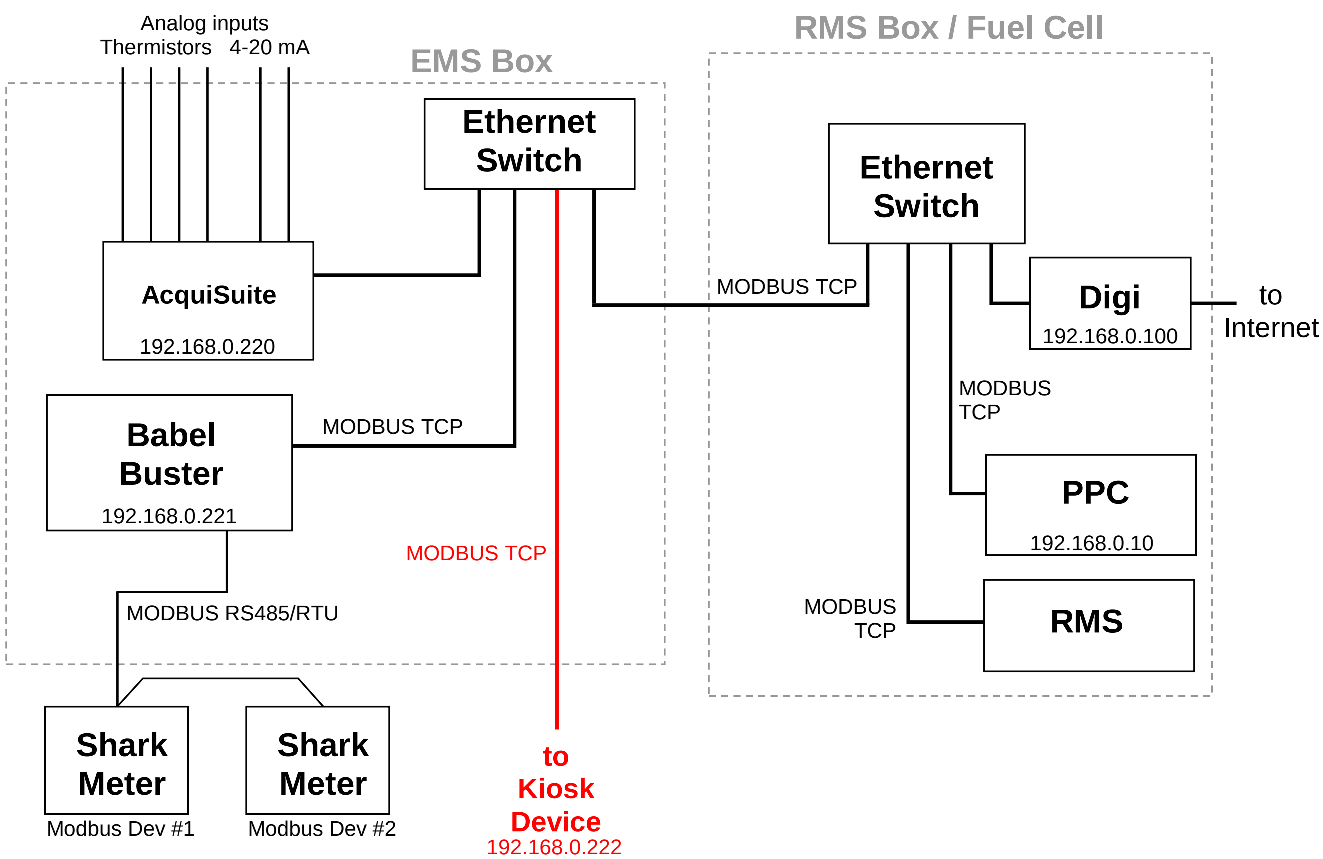

Figure 7. Layout of EMS, RMS and PPC Network

Calculated Quantities

Heat Recovery Rates

The data to determine the delivered heat recovery energy and the delivered cooling will be collected by the datalogger at each scan interval and then averaged for each 15-minute recording interval. The calculations listed below will be completed before the data are displayed on the web site:

$$Q_{lo} = \frac{1}{n}\sum_{i=1}^{n} k_{lo} \cdot FL_i \cdot (TLS_i - TLR_i)$$

$$Q_{hi} = \frac{1}{n}\sum_{i=1}^{n} k_{hi} \cdot FH_i \cdot (THS_i - THR_i)$$

$$Q_{ch} = \frac{1}{n}\sum_{i=1}^{n} k_{ch} \cdot FCH_i \cdot (TCHR_i - TCHS_i)$$

$$Q_{cw} = \frac{1}{n}\sum_{i=1}^{n} k_{cw} \cdot FCW_i \cdot (TCWS_i - TCWR_i)$$

where: Q_{xx} - Delivered heat recovery for loop *xx* (Btu/h)
(*xx* :: *lo* = low temp, *hi* = high temp,
ch = chilled water, *cw* = cooling water)
k_{xx} - density specific heat product constant for fluid in loop *xx*
i - i^{th} scan (or read)
n - number of scans in the averaging period

The loop fluid is expected to be water with ethylene glycol (e.g., DowFrost). The factor *k* is equal to:

Low Temp Loop: k_{lo} = 466.0 Btu/h·gpm·°F for 30% glycol at 130ºF
High Temp Loop: k_{hi} = 466.6 Btu/h·gpm·°F for 30% glycol at 180ºF
Chilled Water: k_{ch} = 464.7 Btu/h·gpm·°F for 30% glycol at 50ºF
Cooling Water: k_{cw} = 466.6 Btu/h·gpm·°F for 30% glycol at 180ºF

Assuming the loops all use 30% glycol.

The Useful and and Unused heat recoveries will be:

$$Q_{useful} = Q_{lo} + Q_{hi}$$

$$Q_{unused} = Q_{cw}$$

Power and Energy

Generally power meters can provide a host of data points, many of them redundant. Our approach, where possible, is to grab the register value associated with energy (kWh) and from that value determine the average power for each 15-minute interval. This average power value is defined as:

$$\text{kW}_{\text{avg}} = \frac{\text{kWh}}{\Delta t}$$

This average Power over a short time interval (15-minutes) is usually indistinguishable from the "demand" or instantaneous power data reported by most meters (most utilities use a sliding 15-minute interval). The fuel cell PPC and the Shark meter are both given as instantaneous kW. Cumulative reads are in kWh.

Efficiency Calculations

The electrical and total efficiency of the Fuel Cell, based on the lower heating value of the fuel, will be calculated using:

$$\eta_{electrical} = \frac{3.412 \cdot WFC}{LHV_{gas} \cdot FG \cdot 50.68}$$

$$\eta_{total} = \frac{(Q_{lo} + Q_{hi}) + (3.412 \cdot WFC)}{LHV_{gas} \cdot FG \cdot 50.68}$$

where:	$Q_{lo,hi}$	-	Useful heat recovery – low and high temperature loops (MBtu/h)
	WFC	-	Power output (kW)
	FG	-	Generator gas input (kg/h)
	LHV_{gas}	-	Lower heating value for natural gas (0.930 MBtu/ft^3)
	50.68	-	Conversion of kg to ft^3, using density = 0.0435 lb/ft^3
	3.412	-	Conversion of kW to MBtu/h

Chiller Efficiency

The thermal efficiency of the Yazaki chiller is expressed as the *COP*:

$$COP_{chiller} = \frac{Q_{ch}}{Q_{hi}}$$

Greenhouse Gas Calculations

To determine the reductions in greenhouse gas emissions for the fuel cell system, we need to measure or estimate the emissions from the fuel cell itself and then also estimate the emissions that would have occurred without the fuel cell meeting these loads. The displaced emissions include the CO_2 not emitted at the utility power plant because of lower electrical consumption and the CO_2 not emitted by an on-site furnace or boiler to meet the thermal output. Table 2 lists the emissions factors we will use for the displaced emissions.

Table 2. Displaced Emissions Factors

	Natural Gas	Electricity from Power Plant	
CO_2 emissions	12.06 lb per CCF	1.28 lb per kWh 0.98 lb per kWh 0.86 lb per kWh	Massachusetts Connecticut New York
NOx emissions	0.1 lb per CCF	2.45 lb per MWh 2.45 lb per MWh 2.45 lb per MWh	Massachusetts Connecticut New York

Notes: CCF ~ 100 MBtu
CO_2 data from EIA state-by-state summary, 1998-2000.
NOx data based on NY State.

The equations to calculate actual and displaced emissions are listed below:

$$\text{Displaced emissions} = (\text{kWh produced}) \times (\text{lb/kWh}) + \frac{(\text{thermal output, MBtu}) \times (\text{lb/CCF}) / 100}{0.80}$$

$$\text{Actual emissions} = (\text{Natural gas input, therms}) \times (\text{lb/CCF})$$

$$\text{Reduced Emissions} = (\text{Displaced emissions, lbs}) - (\text{Actual Emissions, lbs})$$

Project Web Site

CDH will create a web site for Price Chopper that provides access to all the historic data collected at the site. The website will provide custom, detailed plots and tables of the collected data from the site that will be updated once a day.

Data Transfer for Kiosk

CDH will work with Price Chopper's Kiosk vendor (AEC Energy / Encelium) to establish a data transfer process. We will provide the following data available via MODBUS TCP:

Fuel Cell Power (Watts)	Float32
Total Facility Meter Power (Watts)	Float32

Appendix A - Fuel Cell EMS at Price Chopper

Internet address: 166.143.143.157

Table 1. Summary of Major EMS Components

Obvius **AcquiSuite**	This datalogger includes thermistors and flow meters to measure thermal loads. It also reads MODBUS registers from the **Babel Buster**. All data are stored in the **AcquiSuite** memory and transferred to the CDH Energy servers from this device. The **AcquiSuite** can also create a file every few minutes that is used to generate the real-time screen.
Control Solutions **Babel Buster**	This gateway device reads data from the **PPC** (via MODBUS TCP) and the **Shark Meter** (MODBUS RS485) and makes it available as MODBUS data to the **AcquiSuite**. At Price Chopper, this device also makes data available to the **Kiosk**.
Power Plant Controller **PPC**	This fuel cell controller provides data as MODBUS registers to the **Babel Buster**.
Excelium **Kiosk**	This device presents performance data in the Store. It reads data from the **Babel Buster** via MODBUS TCP.

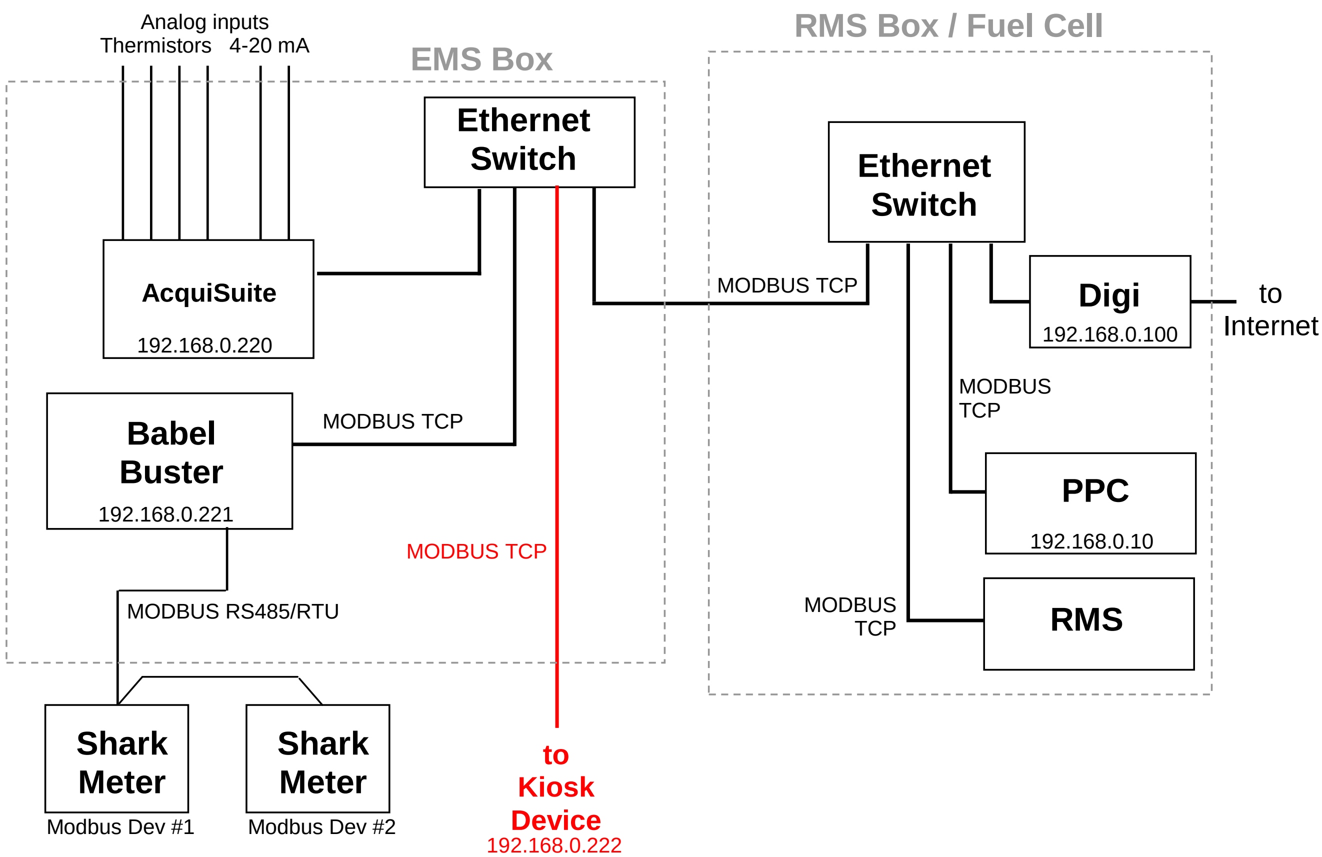

Figure 1. Layout of EMS and RMS Network

The Babel Buster provides all the communications (i.e., reads) between the devices on the network. It reads data from the PPC and Shark devices. It makes data available for the Obvius AcquiSuite datalogger to read. The AcquiSuite logs all the data. The Babel Buster also makes the data available to the Kiosk device.

Table 2. Network Devices and Addresses

Network Layout

Label	Device	Protocol	IP Address	MODBUS RTU Mode	MODBUS RTU Address
AcquiSuite	Obvius AcquiSuite	Modbus TCP	192.168.0.220		
Babel Buster	CSI Babel Buster 2 Multi-network Interface	Modbus TCP	192.168.0.221		
		Modbus RTU		Master	n/a
		BACnet	192.168.0.221		
PPC	UTC Power Power Plant Controller (PPC)	Modbus TCP	192.168.0.10		
Kiosk	Excelium Kiosk Device	Modbus TCP	192.168.0.222		
Shark	Shark 100 - REC Power Transducer	Modbus RTU		Slave	1
Shark	Shark 100 - Main Meter Power Transducer	Modbus RTU		Slave	2

Obvius AcquiSuite

The AcquiSuite data logger produces a separate file of 15-minute data for each device. The read map for the data logger is given below.

Chan Name	Device	Column
FG,	mb-001,	0
FGCUM,	mb-001,	1
WFC,	mb-001,	2
WFCCUM,	mb-001,	3
SWV,	mb-001,	4
EFF_ELEC,	mb-001,	5
FC_STATE,	mb-001,	6
SGI,	mb-001,	7
SGC,	mb-001,	8
RTIME,	mb-001,	9
NALARM,	mb-001,	10
WREC_POS,	mb-001,	13
WREC_NEG,	mb-001,	14
WDREC,	mb-001,	15
WT_WREC_POS,	mb-001,	18
WT_WREC_NEG,	mb-001,	19
WT_WDREC,	mb-001,	20
FCH,	mb-003,	0
FH,	mb-003,	5
FL,	mb-003,	10
FCW,	mb-003,	15
TLS,	mb-250,	0
TLR,	mb-250,	5
THS,	mb-250,	10
THR,	mb-250,	15
TCHS,	mb-250,	20
TCHR,	mb-250,	25
TCWS,	mb-250,	30
TCWR,	mb-250,	35

```
Notes:      mb-001 – MODBUS Reads
            mb-003 – Obvius Expansion Board
            mb-250 – AcquiSuite Main Board
```

Sensor Calibrations:

Thermistor #	Name	Wires	Input Channel	Offset
11	TCWR	White/Brown	8	2.1
12	TCWS	Black/Blue	7	2.5
	TLS	6	1	
	TLR	7	2	
	THS	4	3	
	THR	5	4	
	TCHS	12	5	
	TCHR	10	6	

Table 4. Sensor and Wiring Details for AcquiSuite

Channel / Source	Data Pt	Description	Instrument / Meter	Signal / Register	Eng Units	Wire	Notes
Main-1	TLS	Low Temp Supply Temp (from FC)	10k Thermistor, Type 2	bridge	°F	6	
Main-2	TLR	Low Temp Return Temp (to FC)	10k Thermistor, Type 2	bridge	°F	7	
Main-3	THS	High Temp Supply Temp (from FC)	10k Thermistor, Type 2	bridge	°F	4	
Main-4	THR	High Temp Return Temp (to FC)	10k Thermistor, Type 2	bridge	°F	5	
Main-5	TCHS	CHW Supply Temp (from Yazaki)	10k Thermistor, Type 2	bridge	°F	12	
Main-6	TCHR	CHW Return Temp (to Yazaki)	10k Thermistor, Type 2	bridge	°F	10	
Main-7	TCWS	Cooling Water Supply Temp (from FC)	10k Thermistor, Type 2	bridge	°F	bk/bl	
Main-8	TCWR	Cooling Water Return Temp (from FC)	10k Thermistor, Type 2	bridge	°F	br/wh	
EXP-1	FCH	Chilled Water Flow	SDI Flow Meter	4-20 mA	gpm	11	2 inch, sched 40 steel, 73 gpm
EXP-2	FH	High Temp Water Flow	SDI Flow Meter	4-20 mA	gpm	8	3 inch, sched 40 steel, 115 gpm
EXP-3	FL	Low Temp Water Flow	SDI Flow Meter	4-20 mA	gpm	9	2.5 inch, sched 40 steel, 85 gpm
EXP-4	FCW	Cooling Water Flow	Onicon F1100	4-20 mA	gpm	bl/rd/sh	2.5 inch, sched 40 steel, 60 gpm
Modbus Dev 1	WREC_pos	Energy Output through RECs meter	Shark 100	1100	kWh	Double	wire=13
Modbus Dev 1	WREC_neg	Energy Input through RECs meter	Shark 100	1102	kWh	Double	
Modbus Dev 1	WDREC	Power through RECs meter	Shark 100	900	Watts	Float	
Modbus Dev 2	WT_WREC_pos	Energy Output through Facility meter	Shark 100	1100	kWh	Double	
Modbus Dev 2	WT_WREC_neg	Energy Input through Facility meter	Shark 100	1102	kWh	Double	
Modbus Dev 2	WT_WDREC	Power through Facility meter	Shark 100	900	Watts	Float	
Modbus TCP	FG	Instantaneous Fuel Flow	PPC	7173	kg/h	Float	page 12 of FCFR
Modbus TCP	FGcum	Cumulative Fuel Consumption	PPC	7191	m³	Float	page 12 of FCFR
Modbus TCP	WFC	Instantaneous Power Output	PPC	10535	kW	Float	page 12 of FCFR
Modbus TCP	WFCcum	Cumulative Power Produced	PPC	7217	MWh	Float	page 12 of FCFR
Modbus TCP	EFF_ELEC	Instantaneous electrical efficiency (LHV)	PPC	7505	%	Float	page 12 of FCFR
Modbus TCP	FC_STATE	Fuel Cell Mode/State Number	PPC	5	Number	Unsigned Int	page 12 of FCFR
Modbus TCP	RTIME	Cumulative "Load" Time	PPC	7205	hrs	Float	page 12 of FCFR
Modbus TCP	NALARM	Total number of alarms	PPC	21	Number	Unsigned Int	page 12 of FCFR
Modbus TCP	SWV	Make-up water tank fill valve status	PPC	763	On/Off	Boolean/Int	page 12 of FCFR
Modbus TCP	SGI	Grid independent status	PPC	60	On/Off	Boolean/Int	page 12 of FCFR
Modbus TCP	SGC	Grid connect status	PPC	59	On/Off	Boolean/Int	page 12 of FCFR

Flow Meter Specs

Data Industrial 8SDI-1D1N10-0200	Brass, 1½-10 inch, 4-20mA, No Display
Serial Numbers FL = SDI-1-005452 FH = SDI-1-005435	

Table 5. Forwarded Addresses on Digi Modem

Forward TCP/UDP/FTP connections from external networks to the following internal devices:

Enable	Protocol	External Port	Forward To Internal IP Address	Forward To Internal Port
☑	UDP	47808	192.168.0.51	47808
☑	TCP	3389	192.168.0.199	3389
☑	TCP	8081	192.168.0.220	80
☑	TCP	8082	192.168.0.221	80
☑	FTP	8083	192.168.0.220	21
☑	TCP	8084	192.168.0.220	23
☑	FTP	0	0.0.0.0	0

Babel Buster XML File


```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<!-- Babel Buster BB2-7010 v2.10 configuration file -->

<configuration>

<modbus_devices>
   <dev id="1" ipaddr="192.168.0.10" unit="1" rate="1.000000" name="UTC PPC" swapped="1"/>
</modbus_devices>

<client_read>
   <rule localreg="1" remtype="hold_reg" remreg="7173" remfmt="float" dev="1" scale="0.000000" offset="0.000000" poll="1.00" bipunits="96" name="FUEL"/>
   <rule localreg="2" remtype="hold_reg" remreg="7191" remfmt="float" dev="1" scale="0.000000" offset="0.000000" poll="1.00" bipunits="96" name="CUMFUEL"/>
   <rule localreg="3" remtype="hold_reg" remreg="10535" remfmt="float" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="KW"/>
   <rule localreg="4" remtype="hold_reg" remreg="7217" remfmt="float" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="MWH"/>
   <rule localreg="3001" remtype="coil" remreg="763" remfmt="int" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="WTRVLV"/>
   <rule localreg="5" remtype="hold_reg" remreg="7505" remfmt="float" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="EFFELEC"/>
   <rule localreg="6" remtype="hold_reg" remreg="5" remfmt="uint" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="STATE"/>
   <rule localreg="3002" remtype="coil" remreg="60" remfmt="int" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="GISTATUS"/>
   <rule localreg="3003" remtype="coil" remreg="59" remfmt="int" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="CGSTATUS"/>
   <rule localreg="7" remtype="hold_reg" remreg="7205" remfmt="float" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="LOAD"/>
   <rule localreg="8" remtype="hold_reg" remreg="21" remfmt="uint" dev="1" scale="0.000000" offset="0.000000" poll="1.00" name="NUMALARMS"/>
</client_read>

<client_write>
</client_write>

<rtu_read>
   <rule localreg="9" remtype="hold_reg" remreg="1100" remfmt="double" unit="1" scale="0.000000" offset="0.000000" poll="0.00" name="MWHREC_pos"/>
   <rule localreg="10" remtype="hold_reg" remreg="1102" remfmt="double" unit="1" scale="0.000000" offset="0.000000" poll="0.00" name="MWHREC_neg"/>
   <rule localreg="11" remtype="hold_reg" remreg="900" remfmt="float" unit="1" scale="0.000000" offset="0.000000" poll="0.00" name="KWREC"/>
   <rule localreg="14" remtype="hold_reg" remreg="1100" remfmt="double" unit="2" scale="0.000000" offset="0.000000" poll="0.00" name="WT_MWHREC_pos"/>
   <rule localreg="15" remtype="hold_reg" remreg="1102" remfmt="double" unit="2" scale="0.000000" offset="0.000000" poll="0.00" name="WT_MWHREC_neg"/>
   <rule localreg="16" remtype="hold_reg" remreg="900" remfmt="float" unit="2" scale="0.000000" offset="0.000000" poll="0.00" name="WT_KWREC"/>
</rtu_read>

<rtu_write>
</rtu_write>

<rtu_device>
   <dev baud="9600" rate="0.000000" timeout="0.500000"/>
</rtu_device>

<bip_devices>
   <dev id="1" instance="1" timeout="2.000000" priority="10" name="BACNET BMS"/>
</bip_devices>

<bipclient_read>
</bipclient_read>

<bipclient_write>
</bipclient_write>

</configuration>
```

Table 3. Listing of Data Points Collected from all Devices

Babel Buster Variable	Source	CDH Name	UTC / Obvius Variable Name	Description	Native Units	Babel Buster MODBUS Address	Source Data Address	Source Data Type
AI-1	PPC	FG	FUEL	Fuel flow rate	kg/h	1	7173	Float
AI-2	PPC	FGcum	CUMFUEL	Cumulative fuel consumed at standard temperature	m^3	3	7191	Float
AI-3	PPC	WFC	KW	Electrical power output	kW	5	10535	Float
AI-4	PPC	WFCcum	MWH	Cumulative electrical power output	MWh	7	7217	Float
BI-1	PPC	SWV	WTRVLV	Make-up water tank fill valve status	On/Off	3001	763	Boolean/Int
AI-5	PPC	EFF_ELEC	EFFELEC	Instantaneous electrical efficiency	%	9	7505	Float
AI-6	PPC	FC_STATE	STATE	Fuel cell state Number	Number	11	5	Unsigned Int
BI-2	PPC	SGI	GISTATUS	Grid independent status	On/Off	3002	60	Boolean/Int
BI-3	PPC	SGC	CGSTATUS	Grid connect status	On/Off	3003	59	Boolean/Int
AI-7	PPC	RTIME	LOAD	Cumulative load time hr	hrs	13	7205	Float
AI-8	PPC	NALARM	NUMALARMS	Total number of alarms	Number	15	21	Unsigned Int
AI-9	SHARK	WREC_pos	MWHREC_pos	Energy Output through RECs meter	kWh	17	1100	Double
AI-10	SHARK	WREC_neg	MWHREC_neg	Energy Input through RECs meter	kWh	19	1102	Double
AI-11	SHARK	WDREC	KWREC	Power through RECs meter	Watts	21	900	Float
AI-14	SHARK	WT_WREC_pos	WT_MWHREC_pos	Energy Output through Facility meter	kWh	27	1100	Double
AI-15	SHARK	WT_WREC_neg	WT_MWHREC_neg	Energy Input through Facility meter	kWh	29	1102	Double
AI-16	SHARK	WT_WDREC	WT_KWREC	Power through Facility meter	Watts	31	900	Float
	EXP-1	FCH	FLOWCH	Flow rate – chilled water	gpm	SDI Meter	4-20 mA (0-120)	
	EXP-2	FH	FLOWHG	Flow rate – high grade heat	gpm	SDI Meter	4-20 mA (0-150)	
	EXP-3	FL	FLOWLG	Flow rate – low grade heat	gpm	SDI Meter	4-20 mA (0-120)	
	EXP-4	FCW	FLOWCW	Flow rate – coolant water	gpm	F1100	4-20 mA	
	Main-1	TLS	TEMPLGIN	Temperature – low grade heat return	°F	10k, Type 2	ohm (bridge)	
	Main-2	TLR	TEMPLGOUT	Temperature – low grade heat supply	°F	10k, Type 2	ohm (bridge)	
	Main-3	THS	TEMPHGIN	Temperature – high grade heat return	°F	10k, Type 2	ohm (bridge)	
	Main-4	THR	TEMPHGOUT	Temperature – high grade heat supply	°F	10k, Type 2	ohm (bridge)	
	Main-5	TCHS	TEMPCHIN	Temperature – chilled water return	°F	10k, Type 2	ohm (bridge)	
	Main-6	TCHR	TEMPCHOUT	Temperature – chilled water supply	°F	10k, Type 2	ohm (bridge)	
	Main-7	TCWS	TEMPCWIN	Temperature – coolant water return	°F	10k, Type 2	ohm (bridge)	
	Main-8	TCWR	TEMPCWOUT	Temperature – coolant water supply	°F	10k, Type 2	ohm (bridge)	

= Data from Shark Meter via MODBUS RTU

= Data provided or received from PPC via MODBUS TCP

= Data from sensors on Obvius AcquiSuite