MONITORING PLAN
FOR THE
PURECELL 400
AT THE
COCA-COLA BOTTLING PLANT IN ELMSFORD, NY

Draft

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Introduction

This plan describes our approach to monitoring the performance of the fuel cell system installed at the Coca-Cola Bottling Plant in Elmsford, NY. The UTC Power PureCell™ Model 400 fuel cell provides clean and efficient electric power and thermal output to the facility. This fuel cell is expected to supply a portion of the facility's electricity requirements in addition to partial standby power in the event of a power grid failure. The plant will also recover heat from the fuel cell to use for space and Domestic Hot Water (DHW) heating.

System Description

The PureCell® Model 400 is installed along the side of the plant. 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

The thermal output from the FCs is used to provide space conditioning and water heating for the facility. Output from both fuel cells combines into a single low-temperature hot water loop before entering the facility. This low temperature loop supplies 140^{o}F water to meet space heating loads (see Figure 2 and 4).

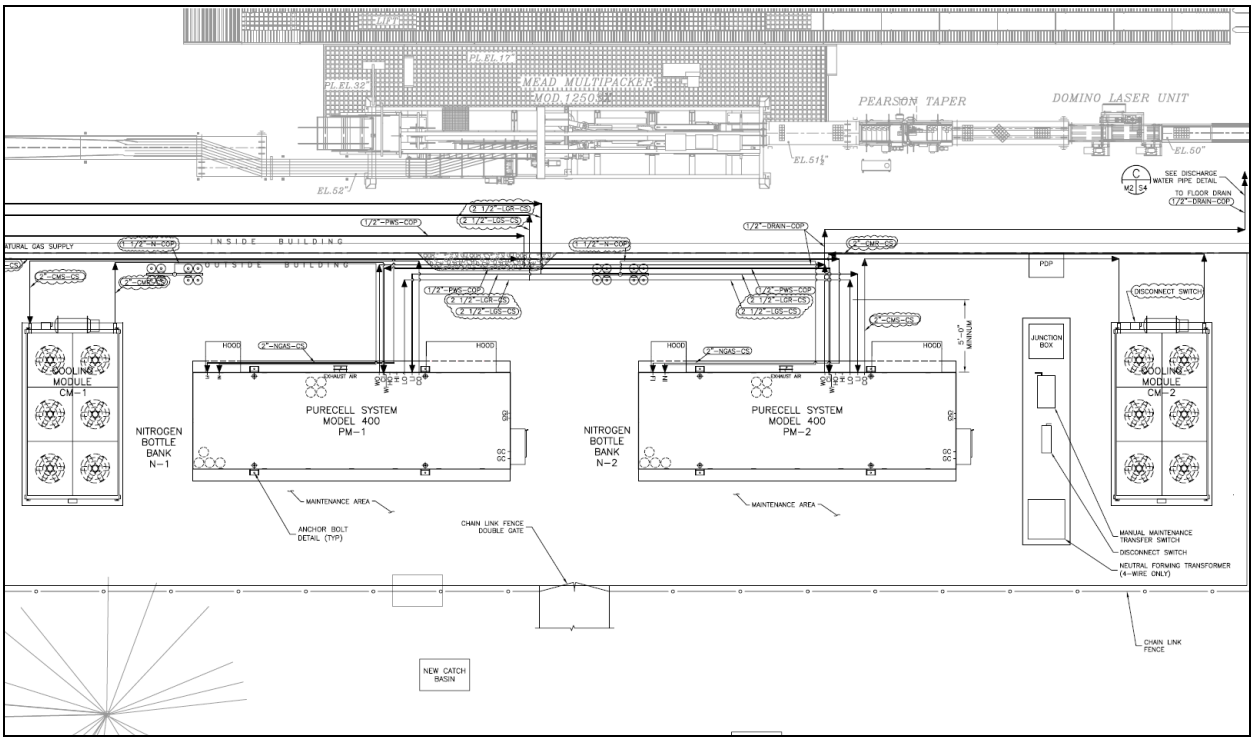

Figure 2. Piping Schematic at Coke

Heat Recovery Monitoring System

The heat recovery monitoring system (HRM) 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 3 shows where the measurements will be made in the thermal loops. Figure 4 and Figure 5 show the locations for the temperature and flow measurements in thermal circuits. Flow and temperature sensors are installed for two thermal loops for each fuel cell: low temperature and cooling water.

Data are extracted from the Power Plant Controller (PPC) via MODBUS TCP. 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 Data (Power)	Notes
Fuel Cell 1 (9527)	Main-1	TLS1	Low Temp Supply Temp	10k Thermistor, Type 2	bridge	°F	8	
	Main-2	TLR1	Low Temp Return Temp	10k Thermistor, Type 2	bridge	°F	9	
	Main-3	TCWS1	Cooling Water Supply Temp	10k Thermistor, Type 2	bridge	°F	10	
	Main-4	TCWR1	Cooling Water Return Temp	10k Thermistor, Type 2	bridge	°F	11	
	EXP-1	FL1	Low Temp Water Flow	Onicon F1111	4-20 mA	gpm	7 (14)	2.5 inch, sched 40 steel, 50 gpm
	EXP-2	FCW1	Cooling Water Flow	Onicon F1111	4-20 mA	gpm	12 (13)	2 inch, sched 40 steel, 60 gpm
	Modbus TCP	FG1	Instantaneous Fuel Flow	PPC1	7173	kg/h	Float	page 12 of FCFR
	Modbus TCP	FGcum1	Cumulative Fuel Consumption	PPC1	7191	m³	Float	page 12 of FCFR
	Modbus TCP	WFC1	Instantaneous Power Output	PPC1	10535	kW	Float	page 12 of FCFR
	Modbus TCP	WFCcum1	Cumulative Power Produced	PPC1	7217	MWh	Float	page 12 of FCFR
	Modbus TCP	EFF_ELEC1	Instantaneous electrical efficiency (LHV)	PPC1	7505	%	Float	page 12 of FCFR
	Modbus TCP	FC_STATE1	Fuel Cell Mode/State Number	PPC1	5	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	RTIME1	Cumulative "Load" Time	PPC1	7205	hrs	Float	page 12 of FCFR
	Modbus TCP	NALARM1	Total number of alarms	PPC1	21	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	SWV1	Make-up water tank fill valve status	PPC1	763	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGI1	Grid independent status	PPC1	60	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGC1	Grid connect status	PPC1	59	On/Off	Boolean/Int	page 12 of FCFR
Fuel Cell 2 (9526)	Main-5	TLS2	Low Temp Supply Temp	10k Thermistor, Type 2	bridge	°F	4	
	Main-6	TLR2	Low Temp Return Temp	10k Thermistor, Type 2	bridge	°F	5	
	Main-7	TCWS2	Cooling Water Supply Temp	10k Thermistor, Type 2	bridge	°F	2	
	Main-8	TCWR2	Cooling Water Return Temp	10k Thermistor, Type 2	bridge	°F	3	
	EXP-3	FL2	Low Temp Water Flow	Onicon F1111	4-20 mA	gpm	6 (15)	2.5 inch, sched 40 steel, 50 gpm
	EXP-4	FCW2	Cooling Water Flow	Onicon F1111	4-20 mA	gpm	1 (16)	2 inch, sched 40 steel, 60 gpm
	Modbus TCP	FG2	Instantaneous Fuel Flow	PPC2	7173	kg/h	Float	page 12 of FCFR
	Modbus TCP	FGcum2	Cumulative Fuel Consumption	PPC2	7191	m³	Float	page 12 of FCFR
	Modbus TCP	WFC2	Instantaneous Power Output	PPC2	10535	kW	Float	page 12 of FCFR
	Modbus TCP	WFCcum2	Cumulative Power Produced	PPC2	7217	MWh	Float	page 12 of FCFR
	Modbus TCP	EFF_ELEC2	Instantaneous electrical efficiency (LHV)	PPC2	7505	%	Float	page 12 of FCFR
	Modbus TCP	FC_STATE2	Fuel Cell Mode/State Number	PPC2	5	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	RTIME2	Cumulative "Load" Time	PPC2	7205	hrs	Float	page 12 of FCFR
	Modbus TCP	NALARM2	Total number of alarms	PPC2	21	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	SWV2	Make-up water tank fill valve status	PPC2	763	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGI2	Grid independent status	PPC2	60	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGC2	Grid connect status	PPC2	59	On/Off	Boolean/Int	page 12 of FCFR

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

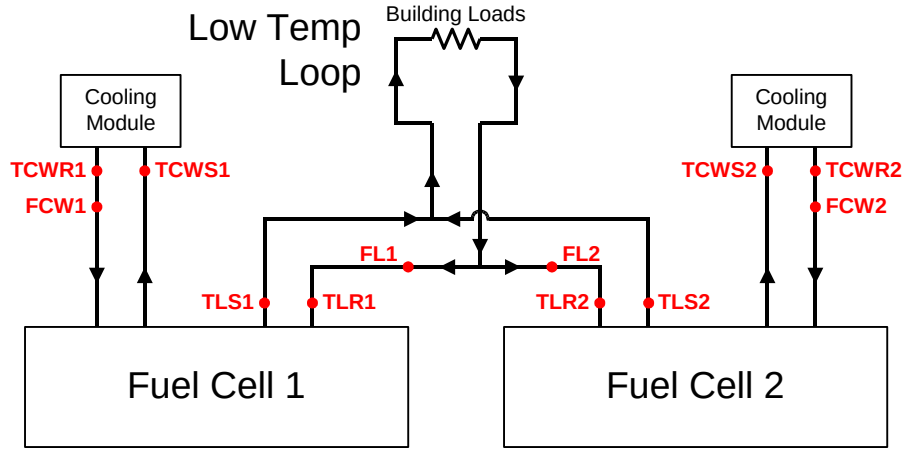

Figure 3. Schematic of Heat Transfer Loops in Fuel Cell System

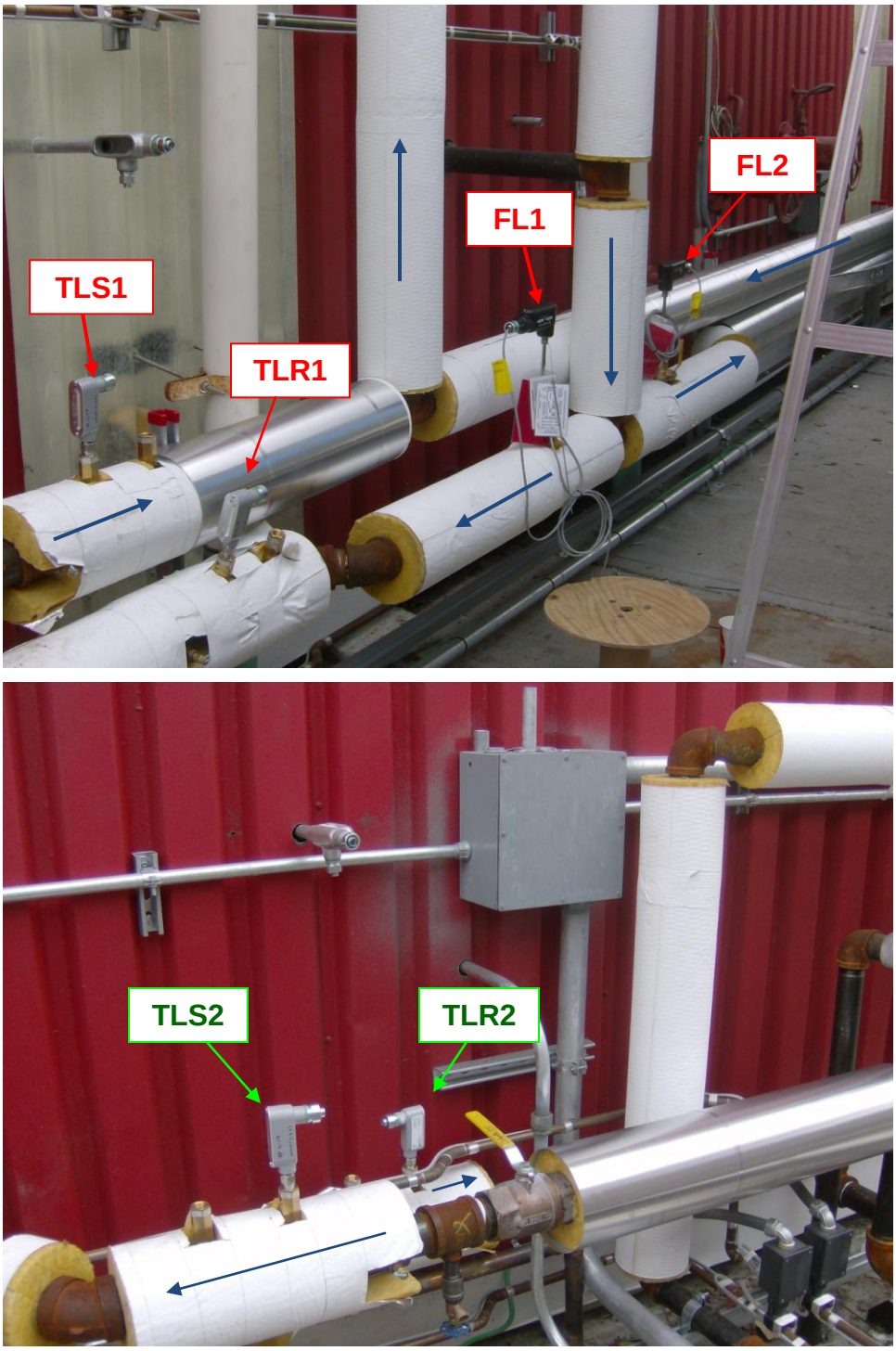

Figure 4. Locations of Temperature and Flow Sensors in Low Grade Loop

Figure 5. Locations of Temperature and Flow Sensors in Cooling Module Loops

The monitoring system is based around the Obvius AcquiSuite data logger. The layout of the HRM and the connections with other network components of the Fuel Cell system are shown in Figure 6. A Babel Buster gateway device reads MODBUS data from the PPC and makes that data available to the Obvius data logger.

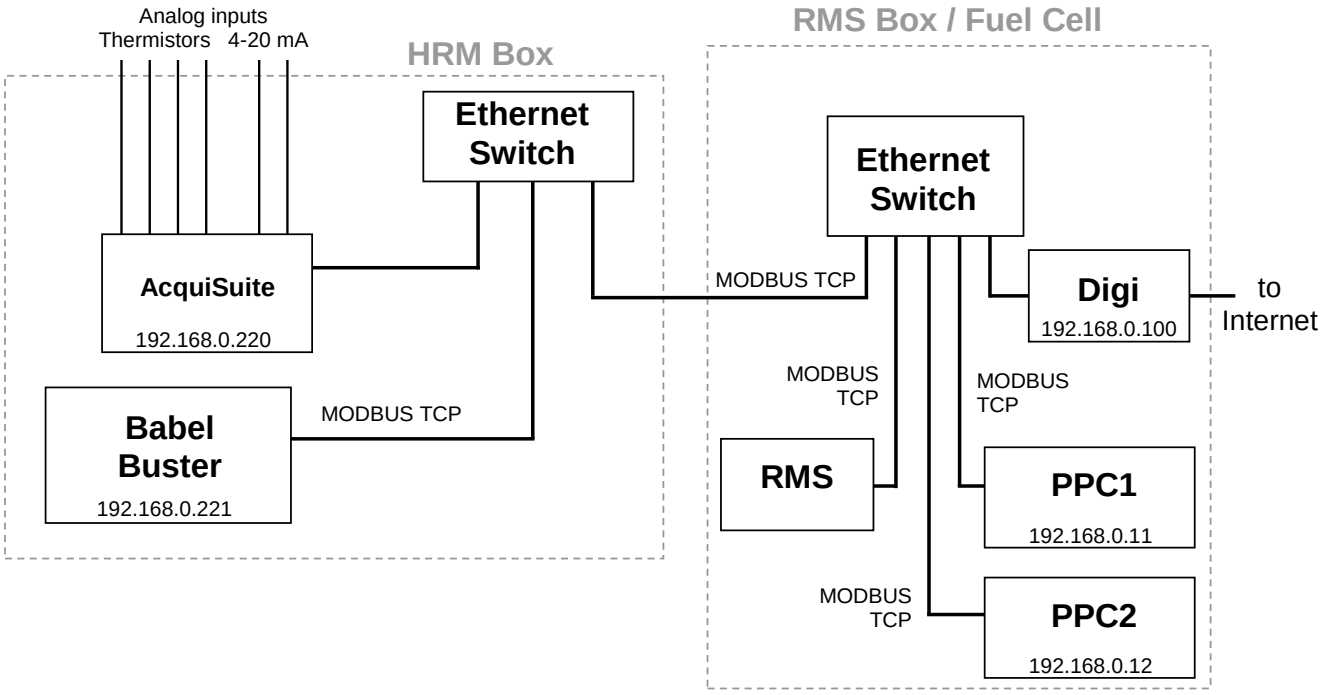

Figure 6. Layout of HRM, RMS and PPC Network

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:

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

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

where: Q_{xx} - Delivered heat recovery for loop *xx* (Btu/h)
(*xx* :: *lo* = low temp, *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 propylene glycol (e.g., DowFrost). The factor *k* is equal to:

Low Temp Loop: k_{lo} = 475.2 Btu/h·gpm·°F for 20% glycol at 130ºF
Cooling Water: k_{cw} = 459.3 Btu/h·gpm·°F for 40% glycol at 180ºF

Assuming the low grade loop uses 20% glycol and the cooling loop uses 40% glycol.

The Useful and and Unused heat recoveries will be:

$$Q_{useful} = Q_{lo}$$

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

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:

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

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 is 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:

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

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

where: Q_{lo} - Useful heat recovery – low temperature loop (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

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	Massachusetts
		0.98 lb per kWh	Connecticut
		0.86 lb per kWh	New York
NOx emissions	0.1 lb per CCF	2.45 lb per MWh	Massachusetts
		2.45 lb per MWh	Connecticut
		2.45 lb per MWh	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 Coca-Cola 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.

Appendix A – Fuel Cell HRM at the Coca-Cola Bottling Plant

Internet address: 166.141.147.127

Table 1. Summary of Major HRM Components

Obvius **AcquiSuite** A8812	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** BB2-7010	This gateway device reads data from the **PPC** (via MODBUS TCP) and makes it available as MODBUS data to the **AcquiSuite**.
Power Plant Controller **PPC**	This fuel cell controller provides data as MODBUS registers to the **Babel Buster**.

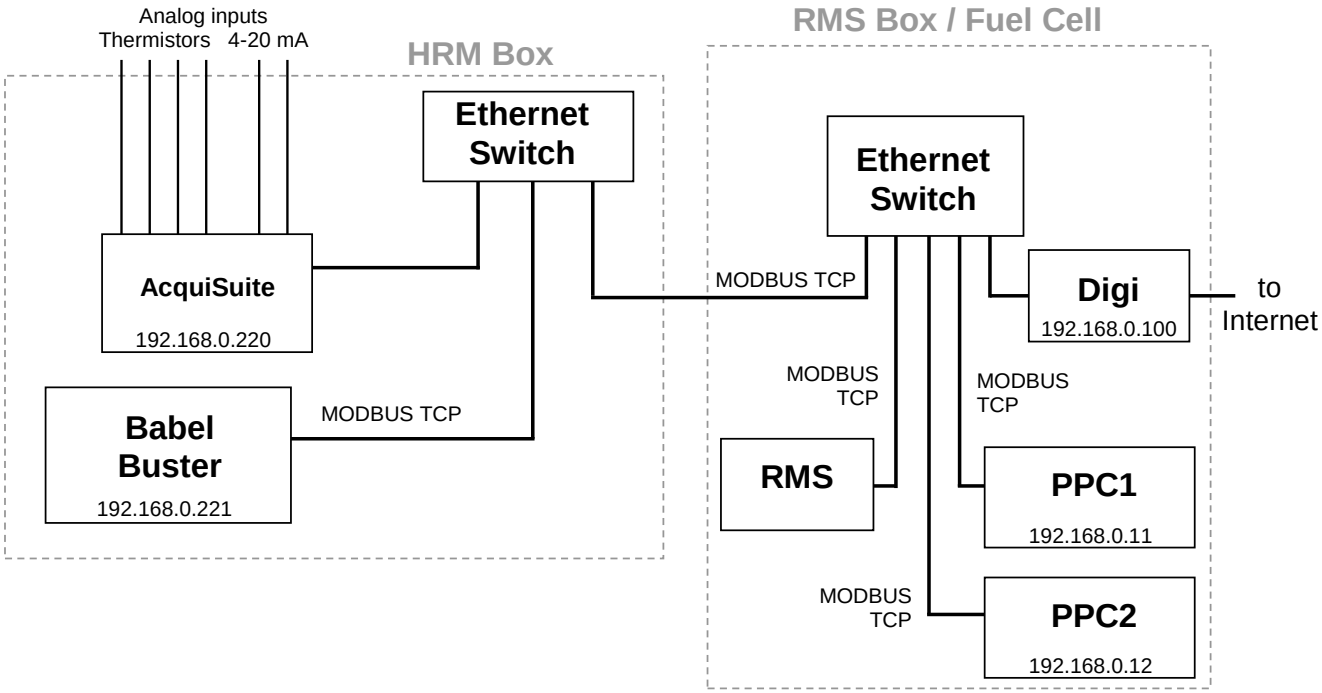

Figure 1. Layout of HRM and RMS Network

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

Table 2. Network Devices and Addresses

Network Layout

Label	Device	Protocol	IP 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
PPC1	UTC Power Power Plant Controller (PPC) Unit 1	Modbus TCP	192.168.0.11
PPC2	UTC Power Power Plant Controller (PPC) Unit 2	Modbus TCP	192.168.0.12

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	Notes	Babel Buster Data Type	Eng Units
Fuel Cell 1 (9527)	AI-1	PPC1	FG1	FUEL1	Fuel flow rate	kg/h	1	7173	Float		Float	kg/h
	AI-2	PPC1	FGcum1	CUMFUEL1	Cumulative fuel consumed at standard temperature	m^3	3	7191	Float		Float	m^3
	AI-3	PPC1	WFC1	KW1	Electrical power output	kW	5	10535	Float		Float	kW
	AI-4	PPC1	WFCcum1	MWH1	Cumulative electrical power output	MWh	7	7217	Float		Float	MWh
	BI-1	PPC1	SWV1	WTRVLV1	Make-up water tank fill valve status	On/Off	3001	763	Boolean/Int		Boolean	On/Off
	AI-5	PPC1	EFF_ELEC1	EFFELEC1	Instantaneous electrical efficiency	%	9	7505	Float		Float	%
	AI-6	PPC1	FC_STATE1	STATE1	Fuel cell state Number	Number	11	5	Unsigned Int		Float	Number
	BI-2	PPC1	SGI1	GISTATUS1	Grid independent status	On/Off	3002	60	Boolean/Int		Boolean	On/Off
	BI-3	PPC1	SGC1	CGSTATUS1	Grid connect status	On/Off	3003	59	Boolean/Int		Boolean	On/Off
	AI-7	PPC1	RTIME1	LOAD1	Cumulative load time hr	hrs	13	7205	Float		Float	hrs
	AI-8	PPC1	NALARM1	NUMALARMS1	Total number of alarms	Number	15	21	Unsigned Int		Float	Number
		Main-1	TLS1	TEMPLGIN1	Temperature – low grade heat return	°F	39	ohm (bridge)		10k, Type 2	Float	Ohms
		Main-2	TLR1	TEMPLGOUT1	Temperature – low grade heat supply	°F	41	ohm (bridge)		10k, Type 2	Float	Ohms
		Main-3	TCWS1	TEMPCWIN1	Temperature – coolant water return	°F	51	ohm (bridge)		10k, Type 2	Float	Ohms
		Main-4	TCWR1	TEMPCWOUT1	Temperature – coolant water supply	°F	53	ohm (bridge)		10k, Type 2	Float	Ohms
		EXP-1	FL1	FLOWLG1	Flow rate – low grade heat	gpm	55	4-20 mA (0-80)		Onicon F1111	Float	mA x 1000
		EXP-2	FCW1	FLOWCW1	Flow rate – coolant water	gpm	57	4-20 mA (0-84)		Onicon F1111	Float	mA x 1000
Fuel Cell 2 (9526)	AI-41	PPC2	FG2	FUEL2	Fuel flow rate	kg/h	81	7173	Float		Float	kg/h
	AI-42	PPC2	FGcum2	CUMFUEL2	Cumulative fuel consumed at standard temperature	m^3	83	7191	Float		Float	m^3
	AI-43	PPC2	WFC2	KW2	Electrical power output	kW	85	10535	Float		Float	kW
	AI-44	PPC2	WFCcum2	MWH2	Cumulative electrical power output	MWh	87	7217	Float		Float	MWh
	BI-11	PPC2	SWV2	WTRVLV2	Make-up water tank fill valve status	On/Off	3011	763	Boolean/Int		Boolean	On/Off
	AI-45	PPC2	EFF_ELEC2	EFFELEC2	Instantaneous electrical efficiency	%	89	7505	Float		Float	%
	AI-46	PPC2	FC_STATE2	STATE2	Fuel cell state Number	Number	91	5	Unsigned Int		Float	Number
	BI-12	PPC2	SGI2	GISTATUS2	Grid independent status	On/Off	3012	60	Boolean/Int		Boolean	On/Off
	BI-13	PPC2	SGC2	CGSTATUS2	Grid connect status	On/Off	3013	59	Boolean/Int		Boolean	On/Off
	AI-47	PPC2	RTIME2	LOAD2	Cumulative load time hr	hrs	93	7205	Float		Float	hrs
	AI-48	PPC2	NALARM2	NUMALARMS2	Total number of alarms	Number	95	21	Unsigned Int		Float	Number
		Main-5	TLS2	TEMPLGIN2	Temperature – low grade heat return	°F	119	ohm (bridge)		10k, Type 2	Float	Ohms
		Main-6	TLR2	TEMPLGOUT2	Temperature – low grade heat supply	°F	121	ohm (bridge)		10k, Type 2	Float	Ohms
		Main-7	TCWS2	TEMPCWIN2	Temperature – coolant water return	°F	131	ohm (bridge)		10k, Type 2	Float	Ohms
		Main-8	TCWR2	TEMPCWOUT2	Temperature – coolant water supply	°F	133	ohm (bridge)		10k, Type 2	Float	Ohms
		EXP-3	FL2	FLOWLG2	Flow rate – low grade heat	gpm	135	4-20 mA (0-80)		Onicon F1111	Float	mA x 1000
		EXP-4	FCW2	FLOWCW2	Flow rate – coolant water	gpm	137	4-20 mA (0-84)		Onicon F1111	Float	mA x 1000

= Data from PPC via MODBUS TCP

= Data from sensors on Obvius AcquiSuite

Babel Buster XML File

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

<configuration>

<modbus_devices>
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   <dev id="2" ipaddr="192.168.0.12" unit="1" rate="1.000000" name="UTC PPC 2" swapped="1"/>
   <dev id="3" ipaddr="192.168.0.220" unit="250" rate="1.000000" name="Acquisuite Main Board"/>
   <dev id="4" ipaddr="192.168.0.220" unit="3" rate="1.000000" name="Acquisuite Exp Board"/>
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<client_read>
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   <rule localreg="2"    remtype="hold_reg" remreg="7191"  remfmt="float"  dev="1"  scale="0.000000" offset="0.000000" poll="1.00" name="CUMFUEL1"/>
   <rule localreg="3"    remtype="hold_reg" remreg="10535" remfmt="float"  dev="1"  scale="0.000000" offset="0.000000" poll="1.00" name="KW1"/>
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   <rule localreg="47"   remtype="hold_reg" remreg="7205"  remfmt="float"  dev="2"  scale="0.000000" offset="0.000000" poll="1.00" name="LOAD2"/>
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   <rule localreg="61"   remtype="hold_reg" remreg="11"    remfmt="double" dev="3"  scale="0.000000" offset="0.000000" poll="1.00" name="Acquisuite TLR2"/>
   <rule localreg="66"   remtype="hold_reg" remreg="13"    remfmt="double" dev="3"  scale="0.000000" offset="0.000000" poll="1.00" name="Acquisuite TCWS2"/>
   <rule localreg="67"   remtype="hold_reg" remreg="15"    remfmt="double" dev="3"  scale="0.000000" offset="0.000000" poll="1.00" name="Acquisuite TCWR2"/>

   <rule localreg="68"   remtype="hold_reg" remreg="5"     remfmt="double" dev="4"  scale="0.000000" offset="0.000000" poll="1.00" name="Acquisuite FL2"/>
   <rule localreg="71"   remtype="hold_reg" remreg="7"     remfmt="double" dev="4"  scale="0.000000" offset="0.000000" poll="1.00" name="Acquisuite FCW2"/>
</client_read>

<rtu_read>
   <!-- No Shark Meters -->
</rtu_read>

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

</configuration>
```

Table 4. Sensor and Wiring Details for AcquiSuite

	Channel / Source	Data Pt	Description	Instrument / Meter	Signal / Register	Eng Units	Wire Data (Power)	Notes
Fuel Cell 1 (9527)	Main-1	TLS1	Low Temp Supply Temp	10k Thermistor, Type 2	bridge	°F	8	
	Main-2	TLR1	Low Temp Return Temp	10k Thermistor, Type 2	bridge	°F	9	
	Main-3	TCWS1	Cooling Water Supply Temp	10k Thermistor, Type 2	bridge	°F	10	
	Main-4	TCWR1	Cooling Water Return Temp	10k Thermistor, Type 2	bridge	°F	11	
	EXP-1	FL1	Low Temp Water Flow	Onicon F1111	4-20 mA	gpm	7 (14)	2.5 inch, sched 40 steel, 50 gpm
	EXP-2	FCW1	Cooling Water Flow	Onicon F1111	4-20 mA	gpm	12 (13)	2 inch, sched 40 steel, 60 gpm
	Modbus TCP	FG1	Instantaneous Fuel Flow	PPC1	7173	kg/h	Float	page 12 of FCFR
	Modbus TCP	FGcum1	Cumulative Fuel Consumption	PPC1	7191	m^3	Float	page 12 of FCFR
	Modbus TCP	WFC1	Instantaneous Power Output	PPC1	10535	kW	Float	page 12 of FCFR
	Modbus TCP	WFCcum1	Cumulative Power Produced	PPC1	7217	MWh	Float	page 12 of FCFR
	Modbus TCP	EFF_ELEC1	Instantaneous electrical efficiency (LHV)	PPC1	7505	%	Float	page 12 of FCFR
	Modbus TCP	FC_STATE1	Fuel Cell Mode/State Number	PPC1	5	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	RTIME1	Cumulative "Load" Time	PPC1	7205	hrs	Float	page 12 of FCFR
	Modbus TCP	NALARM1	Total number of alarms	PPC1	21	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	SWV1	Make-up water tank fill valve status	PPC1	763	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGI1	Grid independent status	PPC1	60	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGC1	Grid connect status	PPC1	59	On/Off	Boolean/Int	page 12 of FCFR
Fuel Cell 2 (9526)	Main-5	TLS2	Low Temp Supply Temp	10k Thermistor, Type 2	bridge	°F	4	
	Main-6	TLR2	Low Temp Return Temp	10k Thermistor, Type 2	bridge	°F	5	
	Main-7	TCWS2	Cooling Water Supply Temp	10k Thermistor, Type 2	bridge	°F	2	
	Main-8	TCWR2	Cooling Water Return Temp	10k Thermistor, Type 2	bridge	°F	3	
	EXP-3	FL2	Low Temp Water Flow	Onicon F1111	4-20 mA	gpm	6 (15)	2.5 inch, sched 40 steel, 50 gpm
	EXP-4	FCW2	Cooling Water Flow	Onicon F1111	4-20 mA	gpm	1 (16)	2 inch, sched 40 steel, 60 gpm
	Modbus TCP	FG2	Instantaneous Fuel Flow	PPC2	7173	kg/h	Float	page 12 of FCFR
	Modbus TCP	FGcum2	Cumulative Fuel Consumption	PPC2	7191	m^3	Float	page 12 of FCFR
	Modbus TCP	WFC2	Instantaneous Power Output	PPC2	10535	kW	Float	page 12 of FCFR
	Modbus TCP	WFCcum2	Cumulative Power Produced	PPC2	7217	MWh	Float	page 12 of FCFR
	Modbus TCP	EFF_ELEC2	Instantaneous electrical efficiency (LHV)	PPC2	7505	%	Float	page 12 of FCFR
	Modbus TCP	FC_STATE2	Fuel Cell Mode/State Number	PPC2	5	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	RTIME2	Cumulative "Load" Time	PPC2	7205	hrs	Float	page 12 of FCFR
	Modbus TCP	NALARM2	Total number of alarms	PPC2	21	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	SWV2	Make-up water tank fill valve status	PPC2	763	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGI2	Grid independent status	PPC2	60	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGC2	Grid connect status	PPC2	59	On/Off	Boolean/Int	page 12 of FCFR

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

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
FG1,	mb-001,	0
FGCUM1,	mb-001,	1
WFC1,	mb-001,	2
WFCCUM1,	mb-001,	3
SWV1,	mb-001,	4
EFF_ELEC1,	mb-001,	5
FC_STATE1,	mb-001,	6
SGI1,	mb-001,	7
SGC1,	mb-001,	8
RTIME1,	mb-001,	9
NALARM1,	mb-001,	10
FG2,	mb-001,	30
FGCUM2,	mb-001,	31
WFC2,	mb-001,	32
WFCCUM2,	mb-001,	33
SWV2,	mb-001,	34
EFF_ELEC2,	mb-001,	35
FC_STATE2,	mb-001,	36
SGI2,	mb-001,	37
SGC2,	mb-001,	38
RTIME2,	mb-001,	39
NALARM2,	mb-001,	40
FL1,	mb-003,	1
FCW1,	mb-003,	6
FL2,	mb-003,	11
FCW2,	mb-003,	16
TLS1,	mb-250,	1
TLR1,	mb-250,	6
TCWS1,	mb-250,	11
TCWR1,	mb-250,	16
TLS2,	mb-250,	21
TLR2,	mb-250,	26
TCWS2,	mb-250,	31
TCWR2,	mb-250,	36

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

Sensor Calibrations:

Thermistor #	Name	Wire	Input Channel	Mult	Offset
4-17	TLS1	8	Main-1	—	-2.20
4-18	TLR1	9	Main-2	—	-2.30
4-11	TCWS1	10	Main-3	—	-2.40
4-16	TCWR1	11	Main-4	—	-1.70
4-31	TLS2	4	Main-5	0.99877	0.11
4-20	TLR2	5	Main-6	—	-2.80
4-32	TCWS2	2	Main-7	0.99848	0.05
4-30	TCWR2	3	Main-8	0.99761	-0.06