

**MONITORING PLAN
FOR THE
PURECELL 400 FUEL CELL
AT
VERIZON NYC CLINTON AVE
IN BROOKLYN, NY**

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Submitted to:

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Appendix A – Monitoring System Details

Introduction

This plan describes our approach to monitoring the performance of the fuel cell system installed at 547 Clinton Ave. in Brooklyn, NY. The ClearEdge 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 electricity in addition to standby power in the event of a power grid failure.

System Description

The PureCell® Model 400 unit is installed physical location on site. 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.



Figure 1. PureCell 400 Unit

Monitoring System

The monitoring system has been designed to capture the electrical performance of the system. Table 1 summarizes the measurements that will be captured at the site.

Data is extracted from the Power Plant Controller (PPC) via MODBUS TCP. The Obvius AcquiSuite EMB 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
Exp1-1	FGP	GASPULSE	Gas Meter Pulser	pulse	CF		
Exp1-2	AHT	HTALARM	Status	Boolean/Int	On/Off		
Exp1-3	ABR	BRALARM	Status	Boolean/Int	On/Off		

Channel / Source	Data Pt	Description	Instrument / Meter	Signal / Register	Eng Units	Wire	Notes	
Fuel Cell 1	Modbus TCP	FG1	Fuel flow rate, FC1	PPC1	7173	kg/h	Float	page 12 of FCFR
	Modbus TCP	FGcum1	Cumulative fuel consumed at standard temperature	PPC1	7191	m ³	Float	page 12 of FCFR
	Modbus TCP	WFC1	Electrical power output, FC1	PPC1	10535	kW	Float	page 12 of FCFR
	Modbus TCP	WFCcum1	Cumulative electrical power output, FC1	PPC1	7217	MWh	Float	page 12 of FCFR
	Modbus TCP	SWV1	Make-up water tank fill valve status, FC1	PPC1	763	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	EFF_ELEC1	Instantaneous electrical efficiency, FC1	PPC1	7505	%	Float	page 12 of FCFR
	Modbus TCP	FC_STATE1	Fuel cell state Number, FC1	PPC1	5	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	SGI1	Grid independent status, FC1	PPC1	60	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	SGC1	Grid connect status, FC1	PPC1	59	On/Off	Boolean/Int	page 12 of FCFR
	Modbus TCP	RTIME1	Cumulative load time hr, FC1	PPC1	7205	hrs	Float	page 12 of FCFR
	Modbus TCP	NALARM1	Total number of alarms, FC1	PPC1	21	Number	Unsigned Int	page 12 of FCFR
	Modbus TCP	FC_ISTATE1	Inverter State Number, FC1	PPC1	13	Number	Unsigned Int	page 12 of FCFR
	Modbus Dev 11	WREC_pos1	Energy Output through RECs meter, FC1	SHARK1	1100	kWh	Double	
	Modbus Dev 11	WREC_neg1	Energy Input through RECs meter, FC1	SHARK1	1102	kWh	Double	
Modbus Dev 11	WDREC1	Power through RECs meter, FC1	SHARK1	900	Watts	Float		

The monitoring system is based around the Obvius AcquiSuite EMB data logger. The layouts of the HRM and the connections with other network components of the Fuel Cell system are shown in Figure 3. A Babel Buster gateway device reads MODBUS data from the PPC and makes that data available to the Obvius data logger.

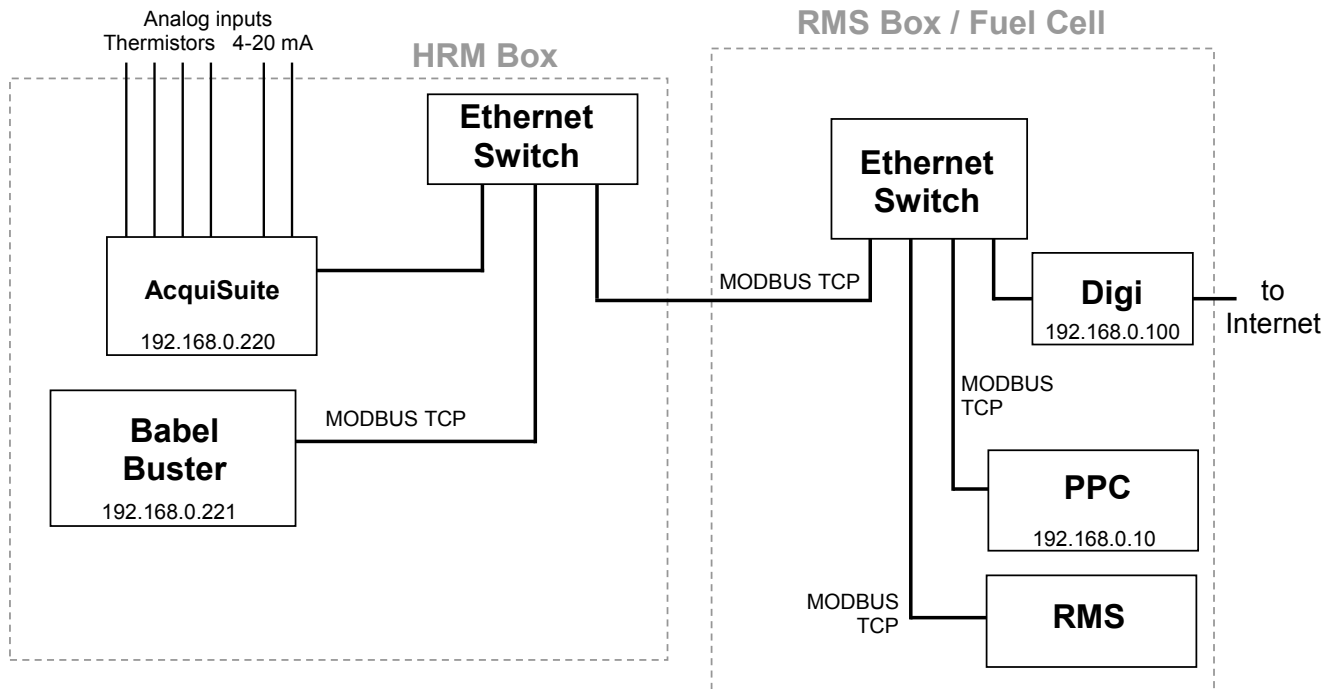


Figure 3. Layout of HRM, RMS and PPC Network

Calculated Quantities

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 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:

$$\eta_{\text{electrical}} = \frac{WFC}{LHV \times FG \times \frac{1}{3600}}$$

where:

- WFC - Power output (kW)
- FG - Generator gas input (kg/h)
- LHV - Lower heating value for natural gas (~48,667 kJ/kg)

Project Web Site

CDH will create a web site for Verizon NYC Clinton Ave 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 Verizon NYC Clinton Ave

Internet address: 166.141.147.136

Table 1. Summary of Major HRM Components

Obvius AcquiSuite EMB A8810	This datalogger reads data from the PPC and makes it available as BACnet data to the Babel Buster . All data are stored in the AcquiSuite EMB memory and transferred to the CDH Energy servers from this device.
Control Solutions Babel Buster BB2-7010-01	This gateway device makes data available to the PPC and manages communication.

Table 2. Summary of Data Sensors

Power Plant Controller PPC	This fuel cell controller provides data as MODBUS registers to the AcquiSuite EMB
Electro Industries Shark 100 Power Meter	This revenue grade power meter measures total import and export power of the fuel cell and provides a MODBUS RTU signal to the AcquiSuite EMB .

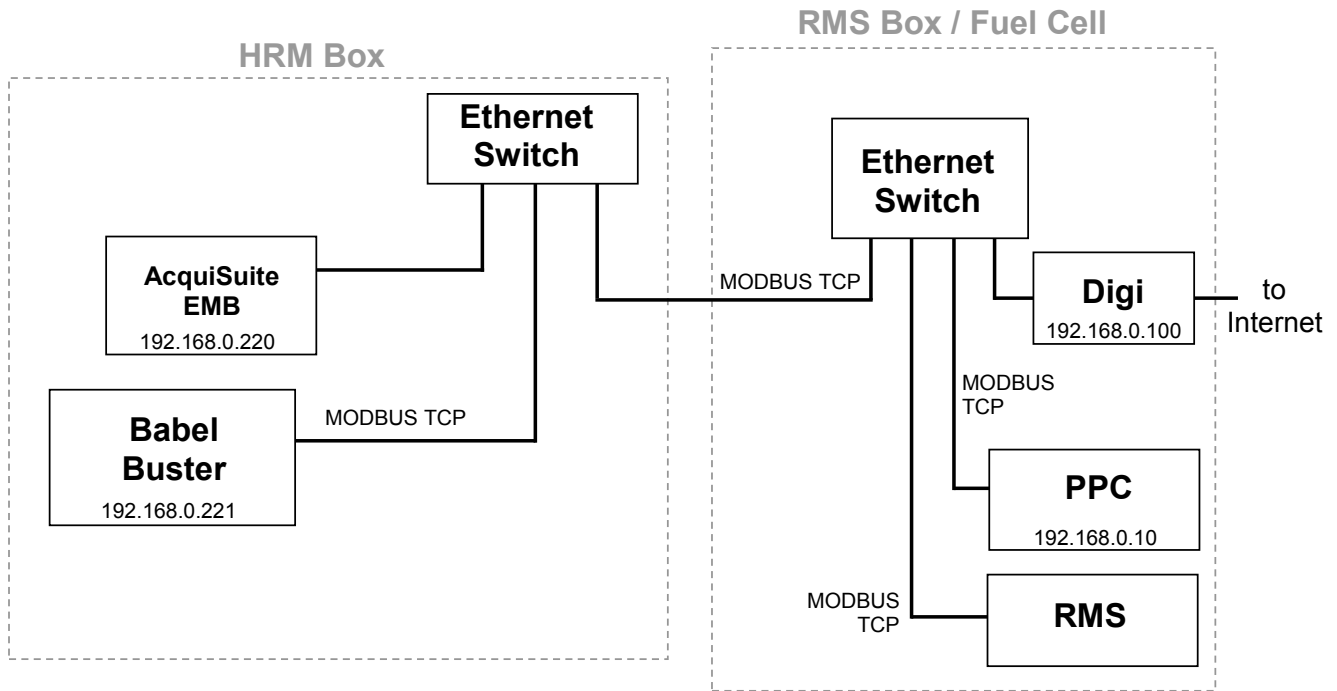


Figure 1. Layout of HRM and RMS Network

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 3. 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 RMS Interface	CSI Babel Buster 2 Multi-network Interface	Modbus TCP BACnet	192.168.0.221 192.168.0.221		
AcquiSuite	Obvius AcquiSuite	Modbus RTU		Master	
Exp Board 1	Obvius Expansion Board	Modbus RTU		Slave	1
Shark 1	Shark 100 Power Meter	Modbus RTU		Slave	201
Babel Buster RMS Interface	CSI Babel Buster 2 Multi-network Interface	Modbus RTU		Master	
Babel Buster RMS 1	CSI Babel Buster 2 Multi-network Interface	Modbus TCP	192.168.0.221		
PPC	UTC Power Power Plant Controller (PPC)	Modbus TCP	192.168.0.10		101

Table 4. Listing of Data Points Collected from all Devices

Babel Buster Variable	Source	CDH Name	CEP / Obvius Variable Name	Description	Native Units	Babel Buster MODBUS Address	Source Data Address	Source Data Type	Notes	Babel Buster Data Type	Eng Units
Exp1-1	FGP		GASPULSE	Gas – combined gas pulse	CF	145		pulse		Float	CF
Exp1-2	AHT		HTALARM	Status - Heat Trace Alarm	On/Off	147		Boolean/Int	Switch Closure	Boolean	On/Off
Exp1-3	ABR		BRALARM	Status - Beckwith Relay Alarm	On/Off	149		Boolean/Int	Switch Closure	Boolean	On/Off

Fuel Cell	AI	PPC	FG	FUEL	Description	Units	AI	PPC	Source Data Type	Notes	Fuel Cell	Eng Units
AI-1	PPC1	FG1	FUEL1	Fuel flow rate, FC1	kg/h	1	7173	Float			Float	kg/h
AI-2	PPC1	FGcum1	CUMFUEL1	Cumulative fuel consumed at standard temperature, FC1	m³	3	7191	Float			Float	m³
AI-3	PPC1	WFC1	KW1	Electrical power output, FC1	kW	5	10535	Float			Float	kW
AI-4	PPC1	WFCcum1	MWH1	Cumulative electrical power output, FC1	MWh	7	7217	Float			Float	MWh
BI-1	PPC1	SWV1	WTRVLV1	Make-up water tank fill valve status, FC1	On/Off	3001	763	Boolean/Int			Boolean	On/Off
AI-5	PPC1	EFF_ELEC1	EFFELEC1	Instantaneous electrical efficiency, FC1	%	9	7505	Float			Float	%
AI-6	PPC1	FC_STATE1	STATE1	Fuel cell state Number, FC1	Number	11	5	Unsigned Int			Float	Number
BI-2	PPC1	SG1	GISTATUS1	Grid independent status, FC1	On/Off	3002	60	Boolean/Int			Boolean	On/Off
BI-3	PPC1	SGC1	CGSTATUS1	Grid connect status , FC1	On/Off	3003	59	Boolean/Int			Boolean	On/Off
AI-7	PPC1	RTIME1	LOAD1	Cumulative load time hr, FC1	hrs	13	7205	Float			Float	hrs
AI-8	PPC1	NALARM1	NUMALARMS1	Total number of alarms, FC1	Number	15	21	Unsigned Int			Float	Number
AI-12	PPC1	FC_ISTATE1	ISTATE1	Inverter State Number, FC1	Number	23	13	Unsigned Int			Float	Number
AI-9	SHARK1	WREC1_pos	MWHREC1_pos	Energy Output through RECs meter, FC1	kWh	17	1100	Double			Float	kWh
AI-10	SHARK1	WREC1_neg	MWHREC1_neg	Energy Input through RECs meter, FC1	kWh	19	1102	Double			Float	kWh
AI-11	SHARK1	WDREC1	KWREC1	Power through RECs meter, FC1	Watts	21	900	Float			Float	Watts

= Data provided or received from PPCs via MODBUS TCP
 = Data from Shark Meters via MODBUS RTU
 = Data from sensors on Obvius AcquiSuite

Table 5. Sensor and Wiring Details for AcquiSuite

Channel / Source	Data Pt	Description	Instrument / Meter	Signal / Register	Eng Units	Wire	Notes
Exp1-1	FGP	GASPULSE	Gas Meter Pulser	pulse	CF		
Exp1-2	AHT	HTALARM	Status	Boolean/Int	On/Off		
Exp1-3	ABR	BRALARM	Status	Boolean/Int	On/Off		

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Obvius AcquiSuite EMB

The AcquiSuite EMB data logger produces a separate file of 1-minute data for each device. The read map for the data logger is given below.

Gas and Alarm Status

<u>Chan Name</u>	<u>Device</u>	<u>Column</u>
FGP,	mb-001,	1
AHT,	mb-001,	6
ABR,	mb-001,	11

PPC 1 (9608)

<u>Chan Name</u>	<u>Device</u>	<u>Column</u>
FG1,	mb-101	0
FGCUM1,	mb-101	1
WFC1,	mb-101	2
WFCCUM1,	mb-101	3
SWV1,	mb-101	4
EFF_ELEC1,	mb-101	5
FC_STATE1,	mb-101	6
SGI1,	mb-101	7
SGC1,	mb-101	8
RTIME1,	mb-101	9
NALARM1,	mb-101	10
ISTATE1,	mb-101	16

Shark Meter

WDREC	mb-201	9
WREC_pos	mb-201	15
WREC_neg	mb-201	16

Notes: mb-001 - AcquiSuite Expansion Boards
mb-101 - MODBUS Reads
mb-201 - MODBUS Reads