AFRESH DEMONSTRATION HOME

DESCRIPTION OF ENERGY SYSTEMS

[Energy Equipment Inventory]

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1 Background

1.1 History

The AFRESH Home is a project that showcases innovations in sustainable housing construction. The Home was developed using off-the-shelf technology, displaying a flexible and health conscious design with high quality building practices.

The home is designed to fit a typical urban lot that is 33 ft. by 122 ft. with rear lane access. It has two main living floors, a convertible attic space and an optional basement. Depending on occupant needs, the AFRESH Home can convert from a four-bedroom, single family home to a code-compliant duplex.

The creative ideas in AFRESH Home were the result of a team effort by Canada Mortgage and Housing Corporation, the British Columbia Institute of Technology, the Greater Vancouver Home Builders' Association, the Canadian Plywood Association, UBC School of Architecture and a host of product and service providers. The Home has received over 55,000 visitors since the house was moved on campus in 2000.

The house has been continuously retrofitted (in partnership with BC Hydro) since 2007 so that it could become a net energy producer (SoCE CESA Distributed Power Connection Study) and a test bed for BCIT's Smart Microgrid research (GAIT). This document evaluates only the energy management systems within the house.

1.2 Current Education and Research

The overall objective of AFRESH is to serve as a demonstration of a Net-Zero or beyond Net-Zero home. It also has sub-objectives from both educational and research perspectives.

Programs that utilize the AFRESH Home for educational purposes include:

- Interior Design
- Architectural and Building Technology
- Architectural Drafting
- Environmental Engineering

- Sustainable Energy Management
- Electrical
- Piping
- Carpentry
- Joinery

The AFRESH Home also serves as an applied research facility supporting research projects through the:

- Group for Advanced Information Technology – Smart Micro Grid
- Centre for Energy Systems Applications
- Building Science Centre
- Centre for Infrastructure Management

1.3 Energy Systems Overview

The AFRESH home has a series of energy systems that makes it different from every other buildings on campus. These are as follows:

1. Various technology of smart meters;
2. Building-integrated PV array;
3. Conventional PV array;
4. Water to water geoexchange heating & cooling;
5. Energy management system with storage capability (Gridpoint);
6. Natural gas combined heat and power fuel cell;
7. Electric Vehicle Charging Station;
8. Vertical Axis Wind Turbine (VBINE);
9. Demand Response Smart Appliances
10. LED lighting system
11. Wireless ZigBee programmable thermostats;

2 Energy Systems Description

This section outlines the energy systems found in the AFRESH house. Background information, technical specifications and status is provided for each category of equipment.

2.1 Metering

2.1.1 Background and General Description

There are a total of six different electrical meters located in AFRESH, demonstrating a variety of technologies (from wireless to power line communication) and communications protocols. The meters are installed for various systems. Some meters were installed as part of the BC Hydro / BCIT SoCE CESA Distributed Power Connection Study original (2006) MOU. Others were installed under the leadership of BCIT's GAIT group.

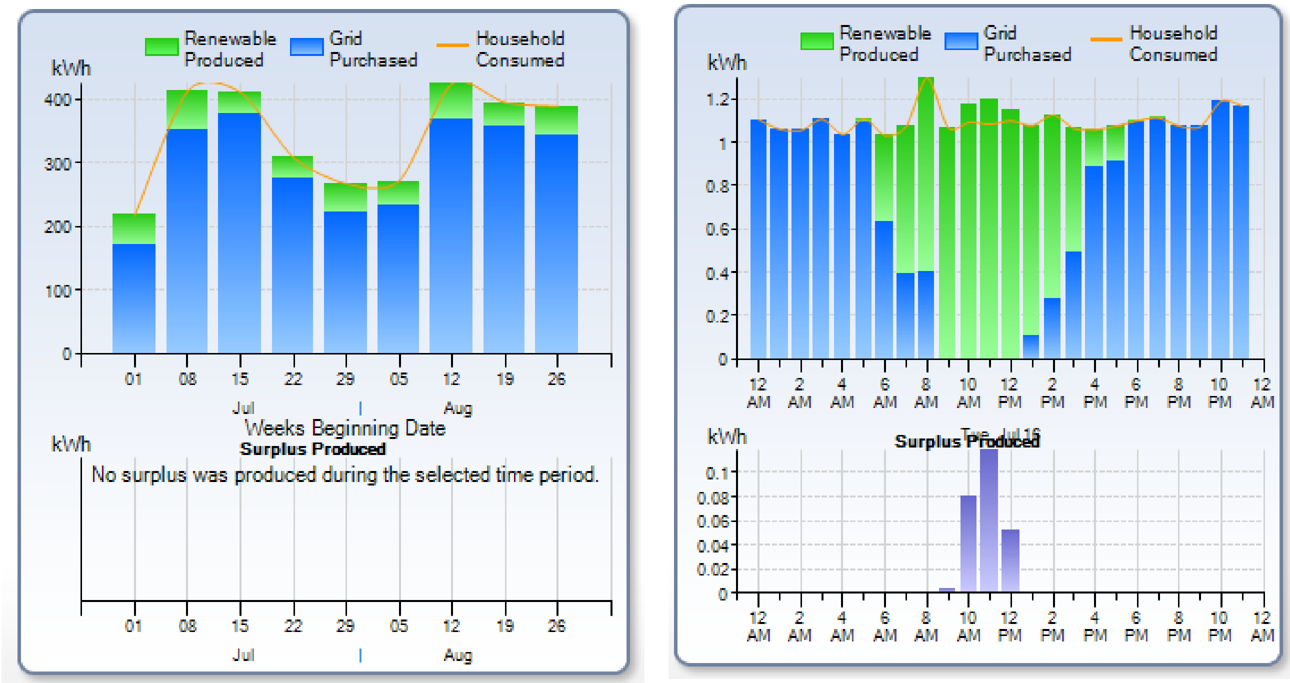
There is also one natural gas diaphragm meter solely used to monitor the fuel cell natural gas consumption.

2.1.2 Technical Specification

<u>Schneider Electric ION7650</u>

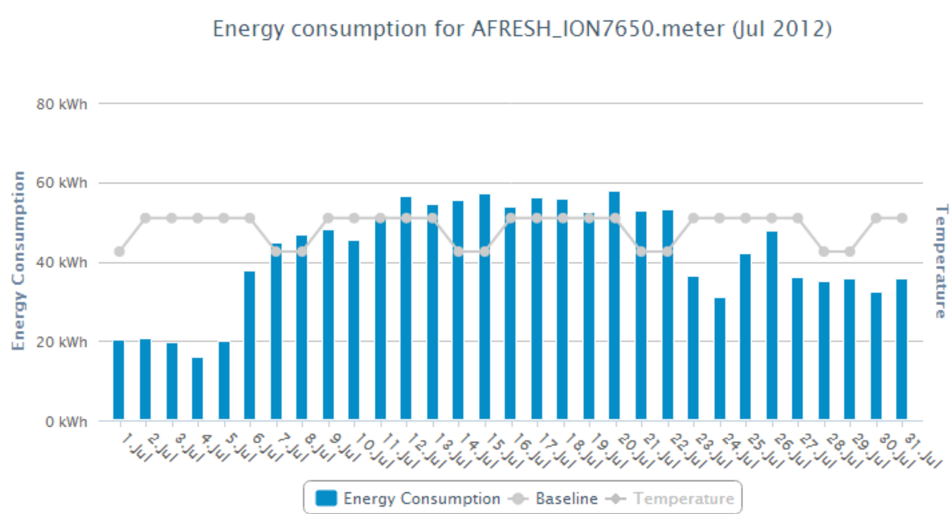
This meter was the first meter installed. It was installed as part of the BC Hydro / BCIT SoCE CESA Distributed Power Connection Study original (2006) MOU. This is a high-end meter that analyzes many specialized characteristics of power quality. It features many communications technologies including IP.

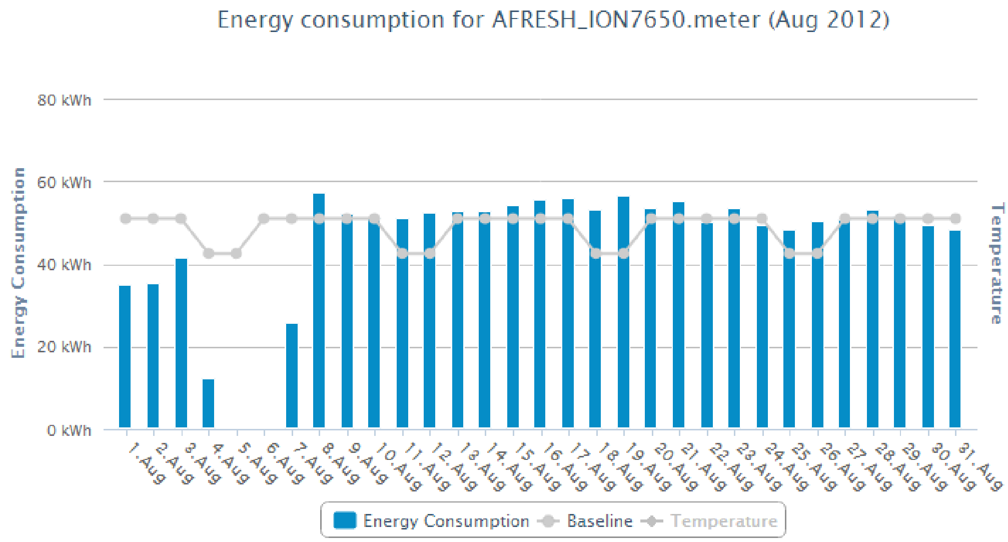
This meter has the capability to do net metering, and it is connected to the main electrical feed of the house. The GAIT EMS reading is from the Schneider meter (refer to EMS section later in this report). At this point, the house is never a net energy producer. On an annual basis, it consumes roughly 18,000 kWh and it purchases 15,000 from the grid. Only in the summer and only for a few hours there is a surplus of energy, but on a daily basis, the house still consumes more energy than it purchases (as shown in the figure below).



Extract from the GridPoint system / website

The figure above shows the net energy consumption by the AFRESH House during high PV productivity months (long daylight hours combined with few clouds) and low energy consumption months (low occupancy and reduced need for heating and lighting), i.e. July and August 2012). According to the Gridpoint system, the exact numbers for these two months are: 401 kWh produced, 2,696 kWh purchased from the grid for a total of 3,097 kWh consumed by the house. According to the EMS reading from the ION 7650, the consumption for these two months was 2,710 kWh, which is roughly the same amount of electricity.





Additional information from Schneider Electric on the ION7650:

"Ideal for both energy suppliers and consumers, and loaded with advanced functionality for monitoring key distribution points and sensitive loads, the PowerLogic® ION7650/7550 power and energy meter offers an unmatched feature set including advanced power quality analysis coupled with revenue accuracy, multiple communications options, web compatibility, and control capabilities."

*"The ION7650 adds symmetrical components measurement, fast transient detection, waveform capture at 1024 samples/cycle, and power quality compliance monitoring. Characteristics (**some features are optional**):*

- *Panel-mount, large customizable LCD display, available without display*
- *Optional remote color, touchscreen display*
- *Multilingual support for English, French, Spanish and Russian. User-configurable IEC or IEEE notations. 12/24 hour clock support in multiple date/time formats.*
- *3-phase, 4-quadrant metering, class 0.2 accuracy (IEC, ANSI)*
- *Voltage, current, neutral and earth current, power, frequency, power factor, demand, energy, and time-of-use metering*
- *Instrument transformer correction, transformer/line loss compensation*
- *IEC 61000-4-30 class A ed. 2, IEEE 519/1159, EN50160, IEC 61000-4-7/4-15 power quality compliance monitoring*
- *1024 samples/cycle waveform capture, transient capture (20 µs @ 50 Hz), sag/swell monitoring, harmonics measurement (up to 63rd), symmetrical components*
- *COMTRADE waveform format available directly from the meter*
- *Disturbance direction detection to indicate whether a disturbance originated upstream or downstream from the meter*
- *Setpoint learning to automatically learn what constitutes a sag, swell, transient or high and low setpoint*

- *Sequence-of-events, coincident minimum/maximum, historical trends, and high-speed snapshot recording, 1 ms resolution timestamping, GPS time synchronization*
- *analogue inputs, 4 analogue outputs, 16 digital status/counter inputs, 7 digital control/pulse outputs*
- *65 setpoints for alarms and control, 1/2 cycle response, multi-condition, call out on alarm*
- *communication ports: Ethernet, modem, RS-232/485, RS-485, front panel optical*
- *100Base–TX and 100Base–FX for faster Ethernet communication*
- *Protocols: Modbus RTU slave/master, Modbus TCP, DNP 3.0, MV-90, IEC 61850*
- *Ethernet and modem gateways to 31 devices on RS-485 port*
- *On-board web server, email for alarms and data, FTP server"*

<u>Quadlogic Mini Closet 5</u>

This meter was not installed as part of the BC Hydro / BCIT SoCE CESA Distributed Power Connection Study original (2006) MOU, but this information could not be 100% verified. This meter demonstrates the use of power-line communication technologies, and it also shows that the use of a narrow band can allow the data to flow through transformers. The transponder for the unit is located in Substation N in building NE1 and is connected via an Ethernet switch to a VPN connection to GAIT's EMS.

According to the manufacturer (Quadlogic):

"Power Line Communications, or PLC, is a method of transferring meter data via the existing electric power wires that serve each tenant in a building or customer on a utility grid. Quadlogic employs a patented method of PLC to move large amounts of metered data for residential and commercial and industrial (C&I) customers to a central collection point. This robust technology dynamically responds to the varying electrical noise conditions normally found on power lines or electrical distribution grids by changing frequency, phase etc. and is therefore able to maintain highly reliable data communication, including passing through distribution transformers. (Consult Quadlogic or local representative for project layout assistance.) The MiniCloset-5c includes PLC communications as a standard feature. In most installations, the meter data from the MiniCloset-5c is read remotely via PLC."

Also:

"When the MiniCloset-5c is read via PLC, one or more Scan Transponder-5's are required. The Scan Transponder-5 is the central data collector for Quadlogic metering systems. It communicates with Quadlogic meters over the existing electric wires that serve each tenant in a building or customer on a utility grid. The Scan Transponder-5 collects a data block from each meter in the system. The block contains all previously uncollected meter readings, interval readings and event logs. This data is stored in a non-volatile memory buffer. At regular intervals, the billing system communicates with the Scan Transponder-5 and uploads all of the information for billing or analysis purposes. The Scan Transponder-5 is a separate product and requires its own installation."

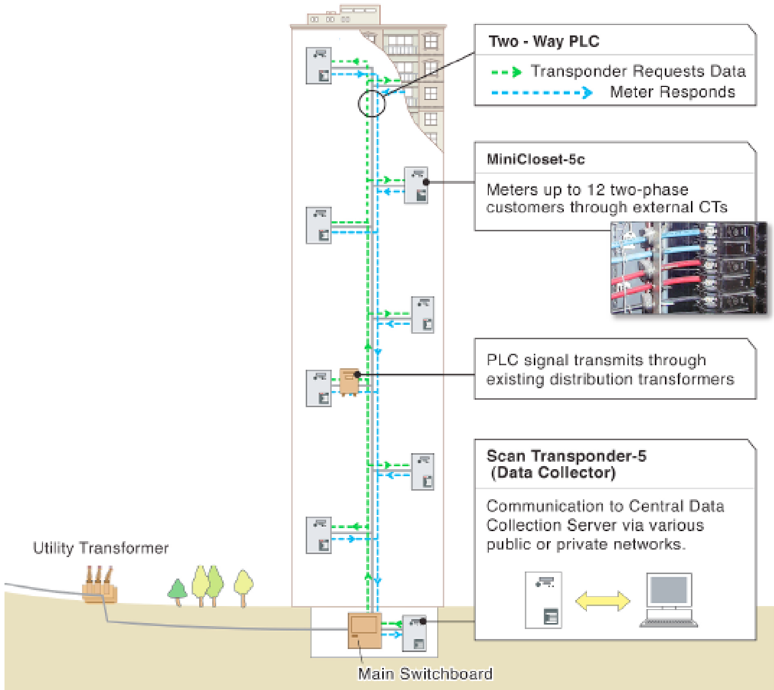
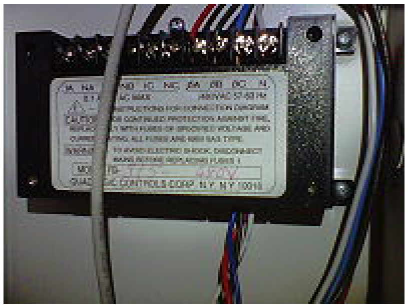
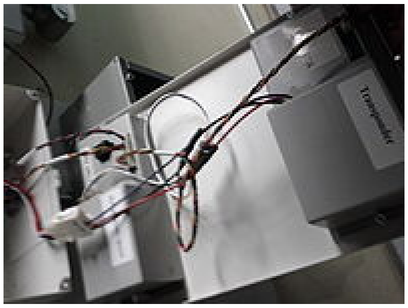
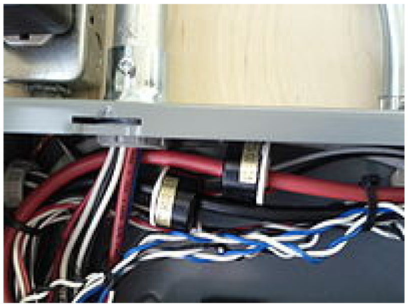


Figure 1-2. Typical Quadlogic metering system.







The specifications of the Mini Closet 5 are as follows:

Metered Voltage:	120, 208, 220, 230, 240, 277, 347, 380, 400, 416, 480,
	600 VAC
	Delta or Wye, 50/60 Hz
Secondary Current Input:	0.1 Amp or 5 Amp CT inputs available
Programmable:	
Four Quadrant Consumption &	
Delivered and received	(8) 3-phase meters, (12) network meters, or (24)
	single-phase meters (number of meter points available will
	vary by model)
Demand for each of the 24 channels:	Delivered and received: kW, kVARLeading,
	kVARLagging, kVA, Volts-squared hours, and amp-squared
	hours
Programmable Interval Data &	
Data and Peak Demand:	5 minutes to hourly time window (longer time intervals also
	available)
	Meter total and/or by phase
	Programmable to user-determined specific time blocks or
Demand Reset:	rolling time block demand
Real-time data per Phase:	Allows local reset of peak demand (kW) register
	Voltage, current, phase angle, power factor, THD, watts,
Time-of-Use:	VARs, VA, and frequency
	Up to 16 blocks per day available for all metering
Data Collection Options:	parameters (Exception: Pulse input data)
	IQ Software
	MV-90 TIM Module
	ASCII-based, open-data protocol
Pulse Datalogger Module (PDM-12):	Open-source data conversion program
	Collects data from up to 12 water, gas, or BTU meters
	Form A Dry Contact Inputs
	PDM connects to MiniCloset-5c via CAT5
	Maximum 4 PDM units to a MC-5c (daisy chain)
	Total of 48 discrete inputs total
	Pulses will count during a power outage
	Pulses can be logged in programmable intervals
Distance:	Power supplied by MiniCloset-5c
	Pulse meter to PDM - 300' max.(18 gauge min.)
Interrogating Signal Specifications:	All 4 PDM's to MC-5c - 300' CAT5 cable
	Min. Pulse Width:
	Power on - 50 msec.
	Power off - 500 msec.*
	Max. Pulse Rate:
	Power on - 10 pulses/sec max
	Power off - 1 pulse/sec max
	Peak voltage: 5.5V
	Peak current: not applicable
	Isolation: The interrogating signal is completely isolated
	from the AC line, with isolation barriers rated for
	at least 2.5 kV.
	Max. signal debounce tolerance: 20 msec.

It monitors the current from 8 circuits using 8 current transformers (CTs):

- CT Ratios: 100:0.1
- CT 1 and 2 monitor Panel HB feeder
- CT 3 and 4 monitor the air conditioner
- CT 5 is for the old PV and is not in use
- CT 6 monitors kitchen counter plugs
- CT 7 and 8 monitor bathroom heaters
- CT 9 and 10 monitor EV charger
- CT 11 and 12 monitor VBINE

Other notes:

- This product does not do net metering (at least below 0 kWh).
- The version of the Minicloset 5 currently installed was designed for a 240V household, and is not appropriate for AFRESH's "commercial" 208V.

Shark 100

This meter is used solely by the GridPoint C36 system. According to the manufacturer, the Shark 100 has the following characteristics:

· Front Mounted IrDA Port for PC Remote Read
· 0.2% Class Revenue Certifiable Energy and Demand Metering
· Meets ANSI C12.20 (0.2%) and IEC 62053-22 (0.2%) Accuracy Classes
· Revenue Grade
· 400+ Samples per Cycle Rate Measurement
· 57.6K Baud RS485
· Fits Both ANSI and DIN Cut-outs
· Power Quality Measurements (%THD and Alarm Limits)

The meter gets readings from 8 Current Transformers (CTs), measuring the electrical consumption on 8 different circuits. These circuits are:

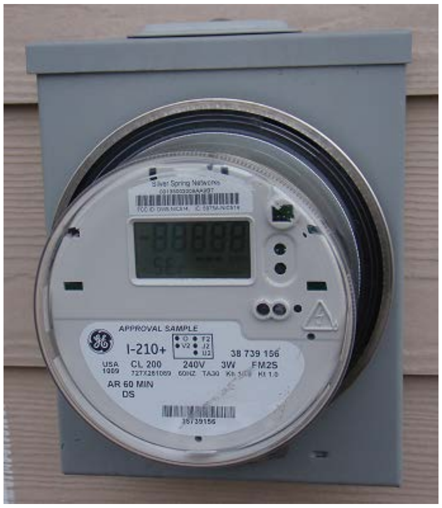
HVAC
Pool Pump
Electric Space Heater
Refrigerator
Other
PHEV
TV - Other
Lighting

Note: the pool pump is the AFRESH House's water-to-water heat pump. The Gridpoint system only allows you to select the name of the circuit form a drop-down menu, and the "pool pump" was the closest to the heat pump. The above table is a print screen from the Gridpoint web-accessed AFRESH page.

The meter also measures the electrical consumption from the house's main feed.

General Electric Smart Appliances Meter (Silver Spring GE 210+)

This meter was installed as part of the Demand-Response Smart Appliances Project with GE, led by the GAIT team. This meter is installed on an exterior wall of the AFRESH, and incorporates 2 radio antennas. A 900 MHz radio facilitates the NAN (Neighborhood Area Network) connection to the data aggregator that collects data from hundreds of meters. A 2.4 GHz ZigBee radio donated by GE facilitates the HAN (Home Area Network) that communicates with the smart appliances located inside the house.



The meter is part of a Silver Spring Networks demand response product. For more information, refer to http://www.silverspringnet.com/.

According to the Silver Spring website, the GE I-210+:
"The Silver Spring Networks' GE I-210+ single-phase meter Communications Module is an option board that installs easily and provides internal wireless networking advanced meter reading capability.

With the combination of our Communications Module and an I-210+™, you can bring low-profile-like functionality to existing products, creating a self-healing network for improved customer service and advanced metering functionality at every home. It ensures greater efficiency while improving customer satisfaction with a scalable platform for adding advanced services – both today and tomorrow.

The I-210+ Single phase Meter is an electronic watt-hour meter that measures energy consumption in single- phase services, delivering outstanding operational efficiency and reliable measurement. With its innovative, simplified sensor design and mechanical construction, it provides high quality, solid-state measurement performance, accuracy, and reliability.

- *One-watt transmitter provides full, two-way wireless communications*
- *Easily fits under the glass of the I-210+*
- *Enables over-the-air firmware upgrades and Communications Module programming to reduce expenses*
- *Supports Advanced Metering and Demand Response functions*
- *Provides full security and encryption to meet rigorous industry standards*
- *Compact, cost-effective construction saves space and simplifies installation and handling*
- *Large, easy-to-read LCD display minimizes reading errors"*

General Electric / Tantalus VBINE Meter

This meter was installed as part of the VBINE project, led by the GAIT team. It is installed on the an exterior wall of the "load bank shed" of the VBINE (in the backyard located on the north side of the AFRESH).

This is a GE / Tantalus VBINE Meter. Additional information was not available at the time of writing this report.

Brultech

Brultech ECM 1240 is a home energy monitor system. It is designed for 120V/240V home power. It is not designed for use in the 208V split phase system that originated from a 3-phase system that we have at BCIT (even though the AFRESH is categorized as residential, it is located in commercial setting).

Other notes:

- For the data to be accurate, a "fudge factor" would need to be applied to correct the error induced by the 208V problem described above.
- Very limited technical data was available at the time of writing this report. More information can be found at http://www.brultech.com/.

American Meter Company DTM-200 (natural gas)

The DTM-200 Diaphragm Gas Meter is a gas meter meant for laboratory test type situations and high accuracy.

This is the only natural gas meter attached to the AFRESH house. The house solely consumes natural gas through the hydrogen fuel cell. The Hyteon fuel cell's reformer extracts the hydrogen (H) from utility purchased natural gas (CH_4). This diaphragm meter solely measures the natural gas delivered to the fuel cell and is only read manually.

The technical specifications are as follows:

- Capacity: 200 CFH or 5600 LH
- Max Operating Pressure: 5 PSIG
- Measurement subdivisions range from .001 cubic foot to .01 cubic foot or from .01 liter to 1.00 liters.

Pulse Energy

This is not a meter per se.

The AFRESH House is equipped with a Pulse Energy terminal that allows for the viewing and analysis of the house's energy consumption, via Pulse's web-access software. The image below shows the Pulse Energy terminal located in the utility room of the AFRESH house.

The AFRESH House data can be monitored by visiting:

https://my.pulseenergy.com/dashboards/BCITAFRESH/#/location/117

2.2 Photovoltaic arrays

2.2.1 Background and General Description

Building-integrated PV array (approximately 1.9 kW):

Part of original Home 2000 project, the building-integrated photovoltaic (BIPV) panels use solar energy to supply electricity to the home.

Conventional PV array (1.14 kW):

Second-generation photovoltaic panels were installed on the Home's south facing roof as part of the BC Hydro / BCIT SoCE CESA Distributed Power Connection Study original (2006) MOU. Generating electricity using PVs is a key element of the MOU.

2.2.2 Technical Specifications

Building-integrated PV array (approximately 1.9 kW):

BIPVs were integrated with roof and window elements: Blue Photowatt solar cells are arranged in glass-on-glass panels with 1 cm to 1.6 cm spaces to allow daylighting of the third floor attic. This BIPV system provides on-site energy generation of approximately 1.9 kilowatts.

Conventional PV array (1.14 kW):

The six POLY-Si panels are not integrated with the building, but have been positioned for maximum efficiency by directly facing the sun (facing South) at the proper angle for Burnaby's latitude. This new array has a capacity of approximately 1.2 kilowatts (6 panels of 190 Watts each).

More technical information from the manufacturer on these six panels:

Maximum Power	P_{max}	170 W	175 W	180 W	185 W	190 W	195 W	200 W	205 W	210 W	215 W	220 W	225 W
Open Circuit Voltage	V_{oc}	32.2V	32.3V	32.4V	32.5V	32.6V	32.7V	32.8V	32.9V	33.0V	33.1V	33.2V	33.3V
Short Circuit Current	I_{sc}	7.54A	7.64A	7.72A	7.80A	7.98A	8.06A	8.24A	8.35A	8.48A	8.54A	8.68A	8.75A
Maximum Power Voltage	V_{mp}	26.3V	26.4V	26.5V	26.6V	26.7V	26.8V	26.9V	27.0V	27.1V	27.2V	27.3V	27.5V
Maximum Power Current	I_{mp}	6.47A	6.63A	6.80A	6.96A	7.12A	7.28A	7.44A	7.60A	7.75A	7.91A	8.06A	8.18A
Module Efficiency (%)		11.4	11.7	12.1	12.4	12.7	13.1	13.4	13.7	14.0	14.4	14.7	15.1
Cell Efficiency (%)		13.0	13.4	13.7	14.1	14.6	15.0	15.4	15.8	16.2	16.5	16.9	17.3
Tolerance		+/- 3%											
Temperature Coefficients of (P / V / I)		-0.45%/K / -0.32%/K / +0.04% / K											
Maximum System Voltage (IEC / UL)		1000V / 600V											

Electrical characteristics tested at Standard Test Conditions (STC), defined as: Irradiance of 1000W/m^2, Spectrum AM 1.5, and Cell temperature of 25 ±2°C.

2.3 Energy management system with storage capability (Gridpoint Connect C36)

2.3.1 Background and General Description

The PV cell and fuel cell generation technologies produce electricity for the AFRESH Home, with surplus electricity theoretically flowing to the BC Hydro grid. These distributed generation systems need an inverter to convert direct current (DC) to alternate current (AC) power. They also benefit from having an energy management system (computer and computer software) that manages battery storage for back-up use, conversion to or from the grid, and on-site use. It is important to note that the photovoltaic utilize the inverter in the energy management system (Gridpoint C36), while the fuel cell has its own inverter. The Gridpoint system has the capacity to switch power sources as needed, monitors itself, and gathers performance data. This GridPoint system has an online user interface, allowing Home occupants to monitor and control their energy use by accessing the systems remotely

2.3.2 Technical Specifications

The Gridpoint product installed in the AFRESH home is model Connect C36 (#C36-10-4). The following is installed in the AFRESH:

- One GridPoint Connect C36 unit (Model C36-10-4)
- One GridPoint AC Meter kit (Model Meter-200-1 also referred to as the Shark 100)
- Two GridPoint Load Manager units (Model 4560-1)

In BCIT's system two loads can be controlled (2 relays located in Load Manager #1 and Load Manager #2). Currently, the loads being controlled are:

- Electrical heater in the 2nd floor bathroom
- Plug-in Hybrid Electric Vehicle (PHEV)

At the time of writing this report it was unclear if the PHEV was really being controlled. It is possible that this is only how the Load Manger has been labeled, but nothing is connected to it. Further investigation would be needed to clarify this point.

Also, 3 circuits can be on the secure load (fed by batteries in case of blackout). They are currently labeled:

- Laptop
- Refrigerator/freezer
- Coffee Maker

At the time of writing this report it was unclear if these were true labels or temporary labels.It is not clear whether or not the refrigerator/freezer was really on the secure load, and if the laptop and coffee maker's exact plugs were being controlled. Further investigation would be required to clarify this point.

There are 8 CTs connected to the GridPoint Connect C36. They measure:

HVAC
Pool Pump
Electric Space Heater
Refrigerator
Other
PHEV
TV - Other
Lighting

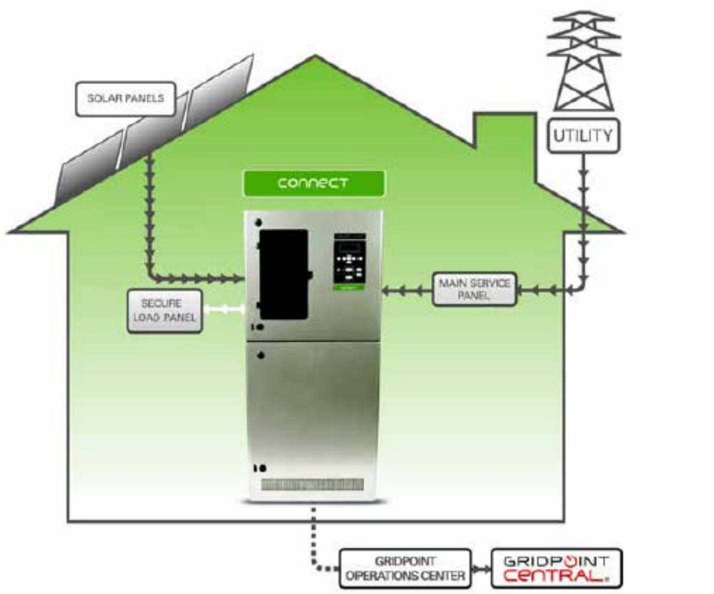
Note: the pool pump is actually the heat pump (see Shark 100 comments in an earlier section).

These CTs do not measure all the electricity consumed in the house, only the loads connected to them. To know the total consumption of the house, the reader must refer to the main feed measurement, also displayed in GridPoint.

According to the manufacturer of the Gridpoint C36:

"Your renewable energy system consists of several key components (Figure 1). At the core is your GridPoint Connect appliance. The other key elements that integrate and are used with your appliance include:

- ***Renewable Energy Source**: GridPoint Connect currently supports up to two independent photovoltaic (PV) arrays. Additionally, you may connect a GridPoint approved device like a wind turbine or generator.*
- ***Utility Grid Integration**: GridPoint Connect is grid-tied, meaning it works in tandem with utility power. Typically, the installer will have you contact your utility company before installation to begin net metering service. Through this service, you receive a credit on your monthly electricity bill for any excess power you generate. Please check with your local utility company first. Not all utility companies allow net metering.*
- ***Secure Load Panel**: The Secure Load Panel is an additional circuit panel that isolates key circuits and appliances you have chosen to place under the protection of the GridPoint Connect appliance. These may include security systems, refrigerators, freezers, sump pumps, fans, lights, and electronics. Your installer can guide you in selecting the circuits to protect."*



"Your GridPoint appliance gathers performance information continuously and actively communicates with our network operations center to ensure optimal performance. And with GridPoint Central®, our online energy portal, your Connect appliance provides visibility into your energy usage, intelligence that can help you lower your energy consumption and reduce your energy costs."

Currently available to BCIT staff:
Basic GridPoint Central Service.

Currently not available to BCIT staff:
"The GridPoint Central premium services package offers the same benefits as the basic services package while adding the ability to automatically reduce energy consumption and costs. With the premium services package, you're able to apply the information provided by the basic services package to create personal energy profiles that automatically and cost effectively manage your energy usage based on consumption patterns and utility rate schedules. For example, through your energy profile you can turn off high energy consuming appliances when utility rates are high or when your home or business is unoccupied. The GridPoint Central personal energy profiles are easy to use and can be continually modified to allow you to refine how you use energy. With one click you choose an active profile (for example, "winter," "summer" or "vacation") and instruct your GridPoint appliance(s) to manage your protected circuits based on the selected profile's settings. The result is worry-free energy management that can reduce consumption and costs without disruption to your lifestyle or business operations."

AC Ratings:

AC Voltage	120 VAC nominal
AC Voltage Range	108-132V
AC Output Voltage Regulation	5%
AC Phasing Configuration	Single
AC Operating Frequency	60 Hz
AC Input Current (Charging)	20A
AC Pass-through Current	60A
AC Inverter Current	30A (in backup mode)
Maximum Continuous Operating Power	3.6 kVA
Inverter Efficiency	91% (CEC Certified)
Backup Surge	70A for 160 mS 50A for 5 Sec
Typical AC Transfer Switch Speed at Power Failure	5-10 milliseconds
Total Harmonic Distortion	2% VAC THD (Inverting mode) 5% THD per UL1741 (Selling mode)

DC Ratings:

Battery String	48V battery (nominal) (40-60V)
Solar Charger Efficiency	98%
Battery Charging Current	120 Amps DC
MPPT Input Voltage Range	66 to 135 volts
Number of PV Subarrays	2
PV Rated Open Circuit Voltage	125V Max per array
PV Rated Operating Voltage	66v Min per array
PV Max Subarray Current	60A max
PV Max Subarray Power	3.2 kWp
PV Array Ground Fault Protection	60 amps DC
Overall System Efficiency	90%
Battery Temperature Sensor	Included

Energy Storage:

Rated Storage	7 / 10 hours at 1kW AC Avg Load
Battery Capacity	210 / 310 Ah @ 48 VDC (8 hr rate to 1.75 VDC)

All installed inside the Gridpoint C36 system are acid-lead. It is unclear whether or not they are still in good working order.

The data for the house from GridPoint can be viewed at:

https://central.gridpoint.com/Public/Login.aspx?ReturnUrl=%2fPages%2fDashboard.aspx

username: BCIT
password: afresh2011

2.4 Natural gas combined heat and power fuel cell (0.5 kW electricity, 1 kW heat)

2.4.1 Background and General Description

This system was part of the BC Hydro / BCIT SoCE CESA Distributed Power Connection Study original (2006) MOU. Generating electricity using a hydrogen Fuel Cell is a key element of the MOU. The fuel cell has been running for only a few months and it is now out of order.

2.4.2 Technical Specifications

The system is a combined heat and power unit with 0.5 kW electricity and 1 kW heat. The Hyteon includes a built-in reformer, fuel cell, and inverter. The electricity is produced on demand as there is no storage of hydrogen. The hydrogen is produced from a utility fed natural gas. The electricity is sent to the GridPoint system in AC. The heat produced from the reform process is sent via insulated flex pipes to a hot water storage tank. There are provisions to connect the geoexchange system to this hot water tank in order to enhance the performance of the heating system. This connection was not completed at the time of writing this report.

2.5 Electric Vehicle Charging Station

2.5.1 Background and General Description

The acquisition and installation was led by the GAIT group. The EV charging station was donated by Power Up in Victoria. This was not part of the official BC Hydro / SoCE CESA Distributed Power Connection study MOU document, but referred to in some other unofficial documents as being part of the study.

2.5.2 Technical Specifications

The EV Charging station is a ShorePower Technologies/CUBE S2100 and SemaConnect. The company is out of Portland, Oregon. It supports charging electric vehicles at a sustained rate of 32A / 208V using the J1772 standardized connector for electric vehicles. It also supports charging 12A / 120V using a standard wall socket with ground fault protection. The company doesn't sell that model anymore, they package in a much more sleek package now. Information about the company can be found at www.semaconnect.com.

2.6 Vertical Axis Wind Turbine (VBINE)

2.6.1 Background and General Description

This project is not part of the official BC Hydro / SoCE CESA Distributed Power Connection study MOU document. Project led by GAIT, BC Hydro purchased and donated to BCIT a 5 kW (up to 6 kW according to the manufacturer) vertical axis wind turbine from VBINE Energy, a firm based out of Saskatchewan. The wind turbine has been physically installed on a fifty foot pole equipped with a hydraulic raising and lowering system, in close proximity to BCIT's AFRESH home. It is electrically connected to the AFRESH home, but it is not sending electricity to the house.

The purpose of this project is to connect the VBINE to the AFRESH home's electrical system; to install data communication gear to monitor electrical generation of the wind turbine; and to integrate this generation data into GAIT's EMS. In the bigger picture, the overall purpose of installing the VBINE is to research the issues that arise when integrating renewable energy resources (such as wind), into grid-connected and off-grid scenarios. The VBINE installation also provides BCIT students and faculty with a novel educational opportunity, as this is BCIT's first wind turbine installation.

2.6.2 Technical Specification

The VBINE has a capacity 5 kW (maybe 6kW) at winds of 12 m/s. It starts rotating at low wind speed: 2.1 m/s.

<u>More details regarding the electrical connection:</u>

1. Electrical connection of grid-interactive inverter to panel HA in AFRESH house-utility room
2. With 40 amp, 2 phase circuit breaker in panel HA in the AFRESH utility room
3. With CTs in panel HA
4. All data communication equipment in the AFRESH utility room

<u>More details regarding the inverter:</u>

Originally, the VBINE wind turbine was shipped with an inverter from Aurora. However, VBINE requested that the Aurora inverter be swapped out for a DTI Gale 6 inverter. The DTI unit allows the VBINE to start generating electricity at lower wind speeds.

<u>More details regarding the Metering and Data Communication:</u>

There are three separate ways to monitor the electrical generation of the VBINE wind turbine – namely, via the Quadlogic meter already installed at AFRESH, via a Home Energy Monitor from Brultech Research Inc., and via a data connection to the inverter.

Also, a GE meter (Silver Spring Networks product) was installed. See the metering section for more details.

2.7 Demand Response Smart Appliances

2.7.1 Background and General Description

Led by GAIT with assistance from SoCE, this project is not part of the official BC Hydro / SoCE CESA Distributed Power Connection study MOU document. The GE Smart Appliances were donated by GE/ BC Hydro in anticipation of the Microgrid Symposium that we hosted in the summer of 2010. Smart appliances work hand-in-hand with smart meters, and can be programmed to reflect user needs based on energy costs. The appliance has a modem that receives real-time rate information and peak-time rates from a smart meter, allowing the appliance to function according to how it is programmed. For example, if the user programs the dishwasher to only be able to run during non-peak times when rates are low, the dishwasher will refuse to start if the user tries to engage it during a peak time. These smart appliances have override switches to allow users to override the programming without altering it, for times when an appliance must be used that does not conform to the user's programming.

The smart appliances all have ZigBee interfaces (2.4 GHz), and can communicate with the GE smart meter installed on the exterior of AFRESH near the EV charging station. That GE meter has communication gear inside from Silver Spring Networks. It is designed to use a secure web portal to send pricing signals to that meter from Silver Springs Network's server down in the San Francisco Bay area.

2.7.2 Technical Specifications

Antenna for data exchange with GE/Silver Springs meter on the other side of the wall

The smart appliances located in the house are as follows. No technical data each was available at the time of writing this report.

- Dishwasher (General Electric Company / PDWT585R00SS)
- Microwave (General Electric Company / PVM1873SN1SSC)
- Refrigerator (General Electric Company / PSQS6YGYADSS)
- Washer (General Electric Company / WPDH8910k0WW)
- Dryer (General Electric Company / PSQS6YGYADSS)

2.8 Lighting

2.8.1 Background and General Description

All the interior lights were replaced to LED (from compact fluorescent) in 2012 as part of SoCE Factor IV initiative. This project is not part of the official BC Hydro / SoCE CESA Distributed Power Connection study MOU document.

2.8.2 Technical Specifications

- 11 Phillips 7-Watt LED dimmable flooding white (4000K) screw-in bulbs (part # 7E26PAR20-E)
  - Replacing 15-Watt CFL
- 22 Phillips 6-Watt LED non-dimmable bright white (5000K) screw-in bulbs (part # 6E26A19AEGAA)
  - Replacing 15-Watt CFL
- 2 Phillips 10-Watt LED "MR16" dimmable soft white (3000K) bulbs (part # 3PM5 E335104)
  - Replacing 50-Watt Halogen MRI

2.9 HVAC

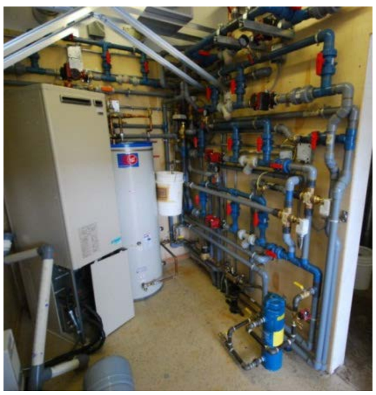
2.9.1 Background and General Description

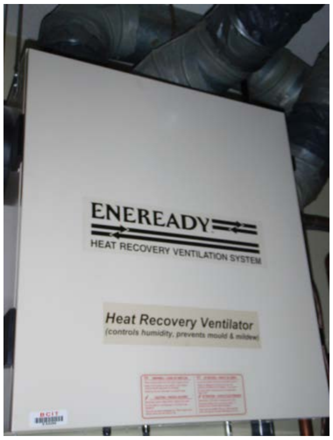
This is a forced air heating system using a geo-exchange plus water-to-water heat pump system. This system was not part of the BC Hydro / BCIT SoCE CESA Distributed Power Connection Study original (2006) MOU but installed at the same time. The project was led by the SoCE Piping department.

The AFRESH HVAC includes separate systems for each floor, each including heating and cooling coils, air handlers and ducts. The separated systems ensure that air, odors, sounds, and fire do not travel between floors. All air handling units are equipped with a Heat Recovery System also known as Heat Recovery Ventilation (HRV).

There is an old A/C unit providing cooling in the summer, as the current geoexchange system cannot run in cooling mode (see status section for more details). This A/C unit only provides cooling to the attic. **This unit will be removed in April 2014. Also, the HVAC coils will be replaced with proper ones and smart pumps will be installed. The retrofitted system will allow running the geoexchange system in cooling mode during the summer while by-passing the heat pump ("free cooling from regular ground temperature").**

Everything except the geoexchange system was installed as part of the original AFRESH Home 2000 project.





2.9.2 Technical Specifications

Limited information was available at the time of writing this report. Some specifications include:

- Heat Pump HP-1 (Model EW030R10SSA)
  - Compressor
    - 208/230V
    - 1 phase
    - RLA 15.4
    - LRA 83.0
- Pump: Unknown
- AHU: Armstrong Air conditioning Ltd (Model EFC08SAA-1A)
- Chilled Water Storage (CHWS): Allied Engineering Company (Model EPP-60-SC)
- Hot Water Storage Tank / Single wall heat exchanger: REX
- HRV: Eneready 1000 series, 115V 1.2 Amps
- Temperature sensors: Unknown – might not exist
- Flow Meter: Unknown – might not exist
- Old A/C: Concept (model 1000/SCU10E24A-1)

The geoexchange system has been setup with 9 modes of operations. The 9 modes are:

1. Heating from ground
2. Heating while making CHW
3. Make CHW while rejecting heat
4. Cooling while heating DHW
5. Cooling while rejecting heat
6. Passive cooling using ground
7. Passive heating using ground
8. Heating from fuel cell
9. Reject heat from fuel cell

2.10 Wireless ZigBee programmable thermostats;

2.10.1 Background and General Description

These thermostats were installed as part of the Gridpoint system, therefore they were not part of the original BC Hydro / SoCE MOU.

Wireless Zigbee thermostats allow users to program desired indoor temperatures for times of day, as well as for days of the week. This allows users to save energy by reducing heating loads while away from home or while sleeping. Though any thermostat can be set to any temperature, users often do not think to reduce temperatures at the times when heating requirements are less. The ability to program the thermostat ensures that savings will be achieved. In addition, wireless programmable thermostats allow users to alter their settings using an online interface, thereby allowing access to the thermostat from anywhere in the Home, as well as remotely.

Energate's powerful Pioneer Series sets a new standard for smart thermostats. Incorporating next generation’s technology beyond the features found in today's most sophisticated thermostats, Energate's Pioneer Series of smart thermostats provides unparalleled performance with an exceptional user interface to meet your current and future needs.

2.10.2 Technical Specifications

The ZigBee thermostats are on a separate network that in theory communicates with the Gridpoint system. The Gridpoint has a web portal that allows users to program the thermostats from their desktops.

It is not clear what Zigbee version it is, probably 1.0 or older.

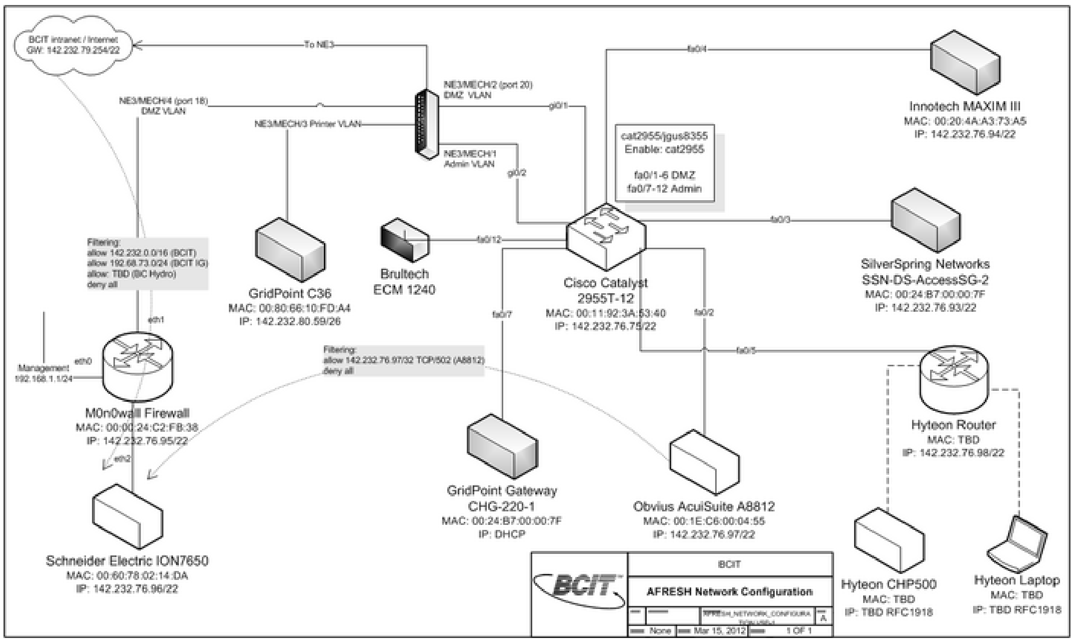
2.11 Network

2.11.1 Background and General Description

All of these networks are supporting the communication of the data. The only network related to the original 2006 MOU between SoCE CESA and BC Hydro is the Schneider meter ION 7650 to the ION Enterprise system, which is currently owned and managed by GAIT. This in theory allows BC Hydro to address the AFRESH house energy consumption.

2.11.2 Technical Specifications

There are many networks in the AFRESH house. The figure below gives a partial overview of those networks.



2.12 EMS Integration and Generation Data Visualization

2.12.1 Background and General Description

Not part of the original BC Hydro / SoCE MOU, the GAIT Microgrid Energy Management System (EMS) was developed to visualize real-time and historical electrical power consumption and generation on the BCIT Burnaby campus.

The electricity generation from AFRESH can be seen at:

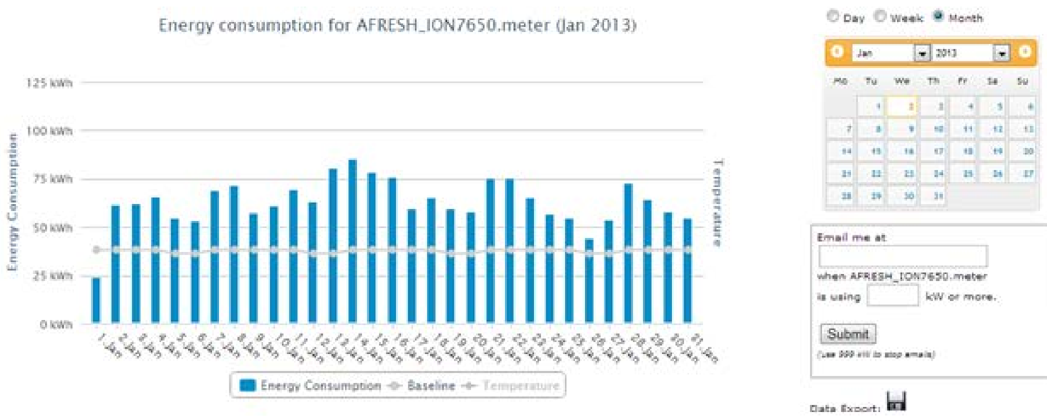
http://ems.bcit.ca/?page=generation&profileName=campus_generation&deviceIds=143

The electricity consumption from AFRESH can be seen at:

http://ems.bcit.ca/?page=consumption&profileName=campus_consumption&deviceIds=147
Or
http://ems.bcit.ca/factor4

2.12.2 Technical Specifications

The meter connected to the EMS is the Schneider 7650. The data is sent to an R&D version of the Schneider Enterprise System, (owned by GAIT and separated from the BCIT Facilities Ion Enterprise) and read by the EMS from there.



Data extracted on 2013-02-25 for February 2012 to February 2013:

	A	B
1	Timestamp	Interval Active Energy Delivered(kWh)
2	2/1/2012 0:00	1892.917969
3	3/1/2012 0:00	1859.199219
4	4/1/2012 0:00	1136.476563
5	5/1/2012 0:00	774.1054688
6	6/1/2012 0:00	641.2460938
7	7/1/2012 0:00	1306.386719
8	8/1/2012 0:00	1403.773438
9	9/1/2012 0:00	1023.359375
10	10/1/2012 0:00	954.890625
11	11/1/2012 0:00	1312.792969
12	12/1/2012 0:00	960.8710938
13	1/1/2013 0:00	1944.4375
14		15210.45703