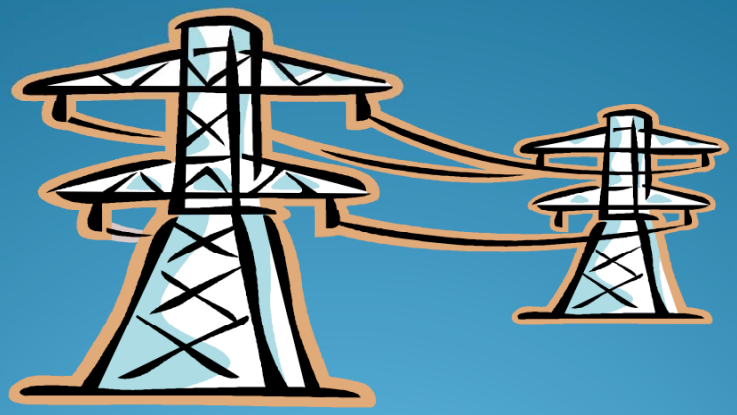
Overview of BC-Hydro/BCIT Smart Microgrid

Hassan Farhangi

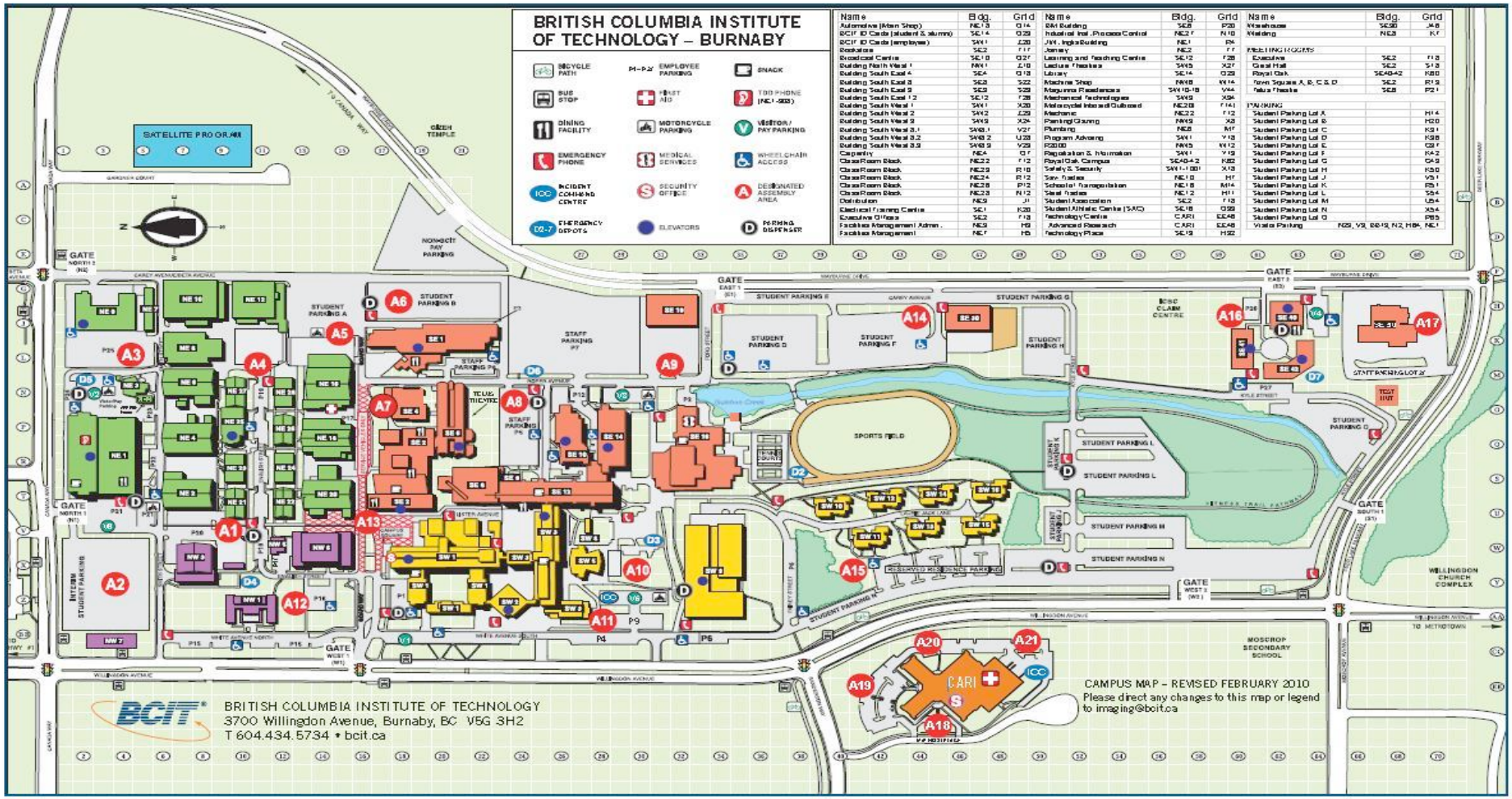
July 2010



BC Hydro/BCIT's Smart Microgrid

Canada's first campus based Smart Microgrid at BCIT's Burnaby Campus

BCIT's Burnaby Campus



Research Objectives

- Development of a Smart Microgrid to enable:
  - Provisioning Methods for Smart Termination Points (Meters, Data Aggregators, Appliances, Sensors, Controls, etc)
  - Integration Solutions for Alternative Sources of Energy (Co-Generation thru Wind, Solar, Thermal, Bio-Mass, etc)
  - Innovative Network Architecture and Topology for Smart Grid

- Operational Analysis and Qualification of Grid's:
  - Resilience, Reliability, Security and Scalability
  - Data Collection, Command & Control algorithms
  - Forward/backward compatibility with up & coming technologies

- Development of Interface Protocols & Models to ensure:
  - Interface with Utility Back-office tools (Billing, Load Management, Service Provisioning, Asset Management, Outage Restoration, etc)
  - Seamless end-to-end deployment, operation & maintenance
  - Easy & Intuitive human interface for operators & customers

Research Areas

- Visualization and integrity of time-sensitive data collected from across the termination points
- Event forecasting & real-time responses
- Distributed control to prevent cascading failures or for the graceful degradation of user services based on grid priorities
- Real-time wide-area control to manage power generation and prevent over-provisioning
- Context-dependent control of components to achieve robust, fault-tolerant, or graceful performance degradation
- End-to-end integration of front-end and back-end Smart Grid functions
- Integration of alternative energy generation systems and co-generation

BC Hydro/BCIT's Microgrid Phases

Phase 1: Construction of Microgrid (2008-2010)

- Completion of Smart Metering on designated loads
- Development of Load Control Devices for Afresh/Dorms
- Integration of Comm Network (Zigbee, WiMax and Fiber backhaul)
- Integration of Co-Gen, Solar Modules and Wind Turbine
- Completion of protection/islanding of BCIT Campus
- Retrofitting and Integration of AFRESH with Microgrid
- Dev of BCIT EMS system (target 10% annual saving)

Phase 2: Research and Development (2010-2015)

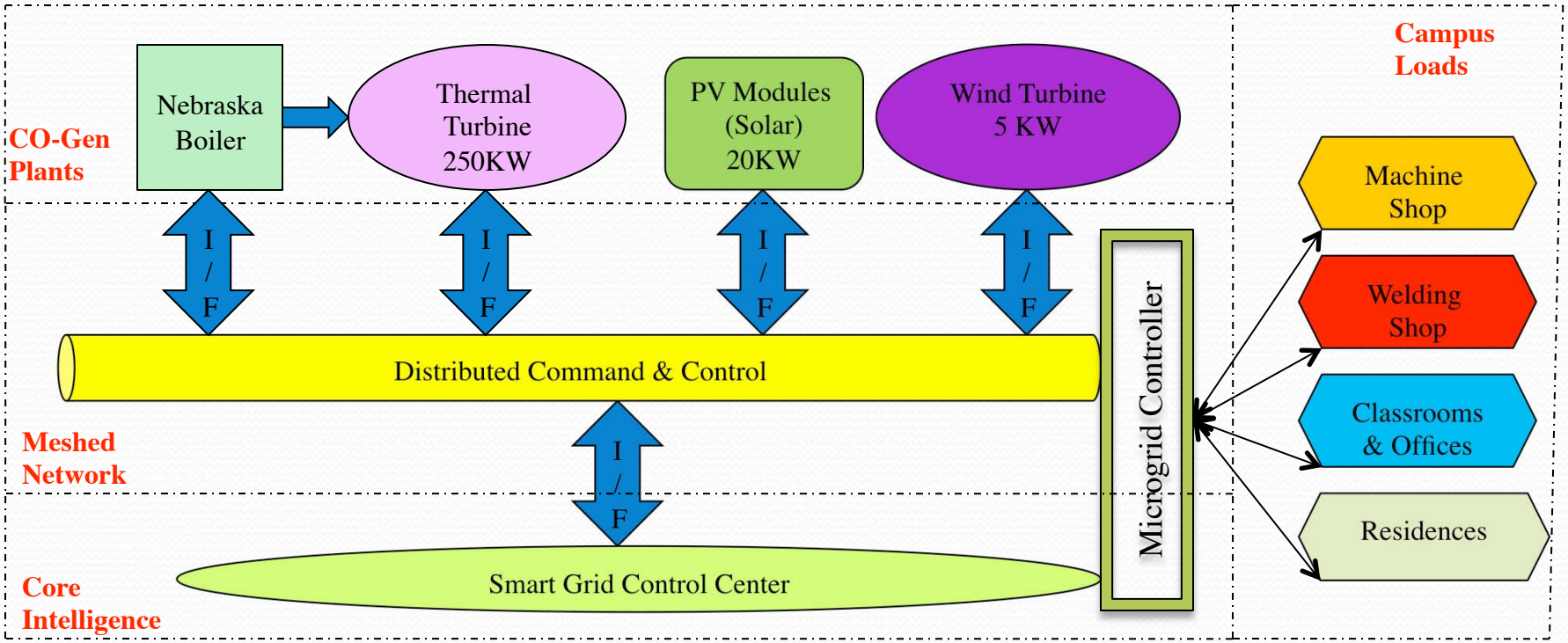
- Research thru NSERC Strategic Network (UoNB, McGill, UoT, UoWO, UoA, UBC, SFU, UVIC and BCIT)

Phase 3: Microgrid Commercialization (2015-2017)

- Setup of Industry Canada's NCE (Network of Centers of Excellence) in pan-Canadian Smart Grid technology

BCH/BCIT Smart Microgrid

BC-Hydro/BCIT's Smart Microgrid Topology

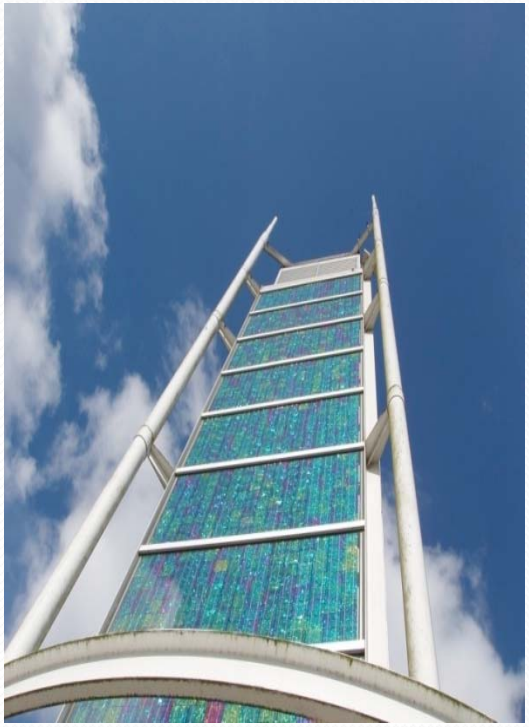


Thermal Co-Gen

- Fed by Nebraska Boiler
- New advanced multi-fuel boiler in Building SE8
- Combined Heat and Power (CHP)
- To be used for educational and research purposes
- Rated at ~ 250 kW

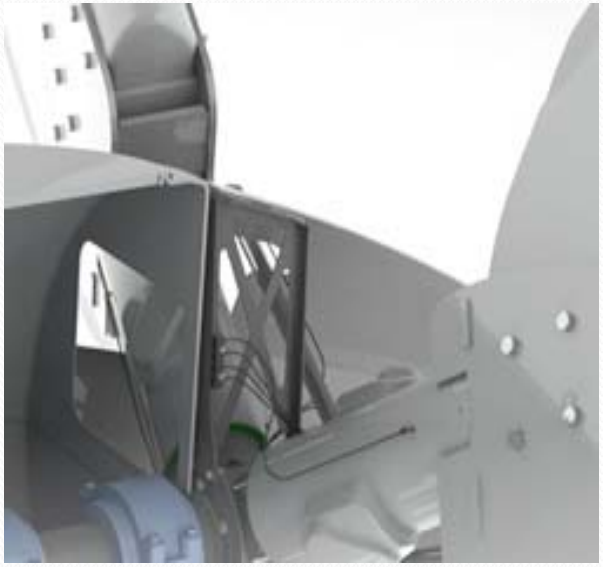
PV Co-Gen

- First Generation Solar Tower (2kw on each side, 8kw nominal capacity)
- Various PV installations on the campus with total capacity of 14 kw
- High efficiency PV cells to be installed on Gateway building with a nominal capacity of 17 Kw
- Number of sunny days quite limited
- Purpose of PV Co-Gen is to study its integration issues with the Microgrid



Wind Turbine

- 5Kw vertical axis wind turbine to be installed close to AFRESH
- Number of windy days are limited in the lower mainland
- Wind speed is not high in Burnaby
- Purpose of wind Co-Gen is to study its integration issues with the Microgrid

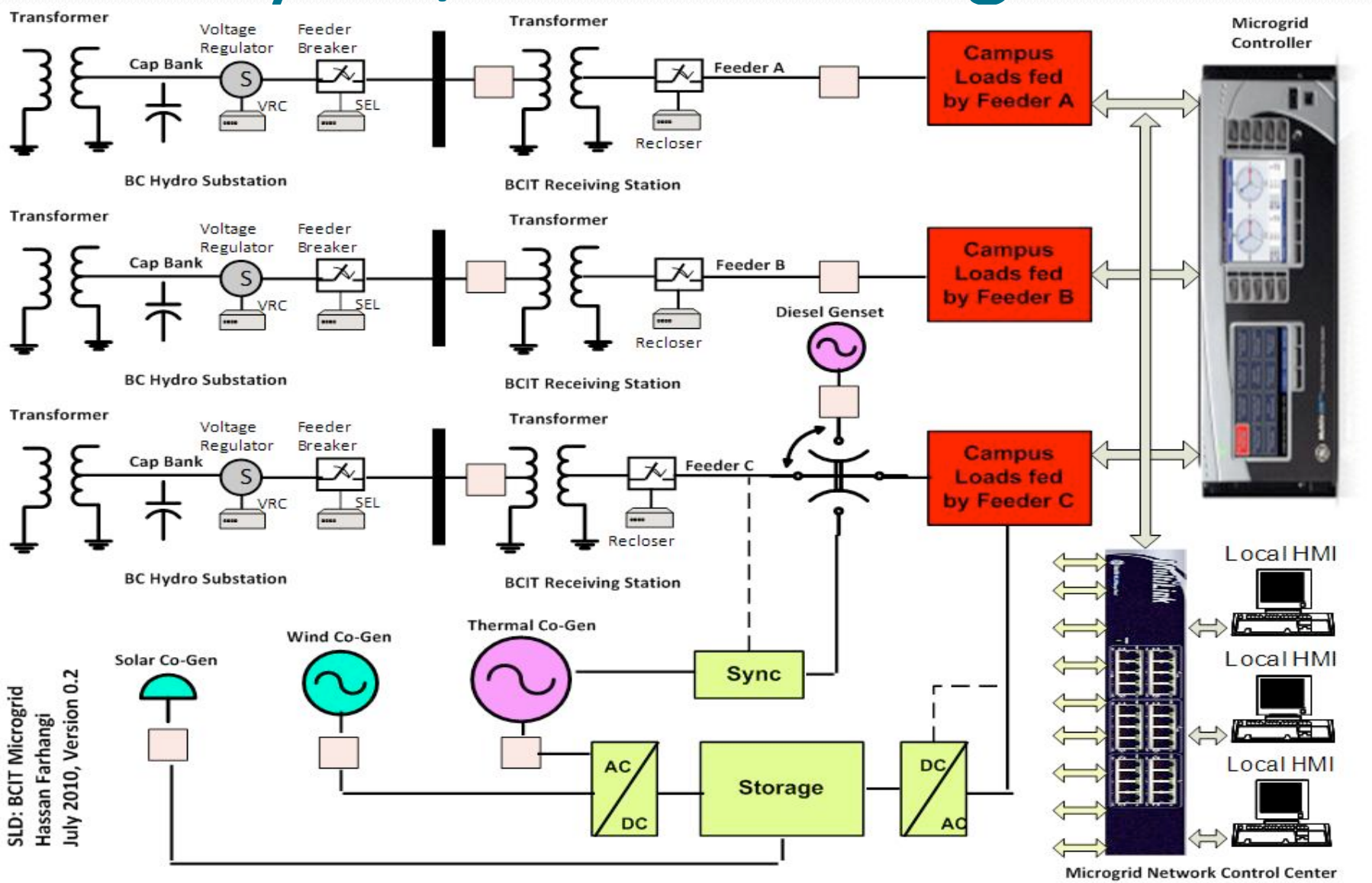


Net-zero Nanogrid

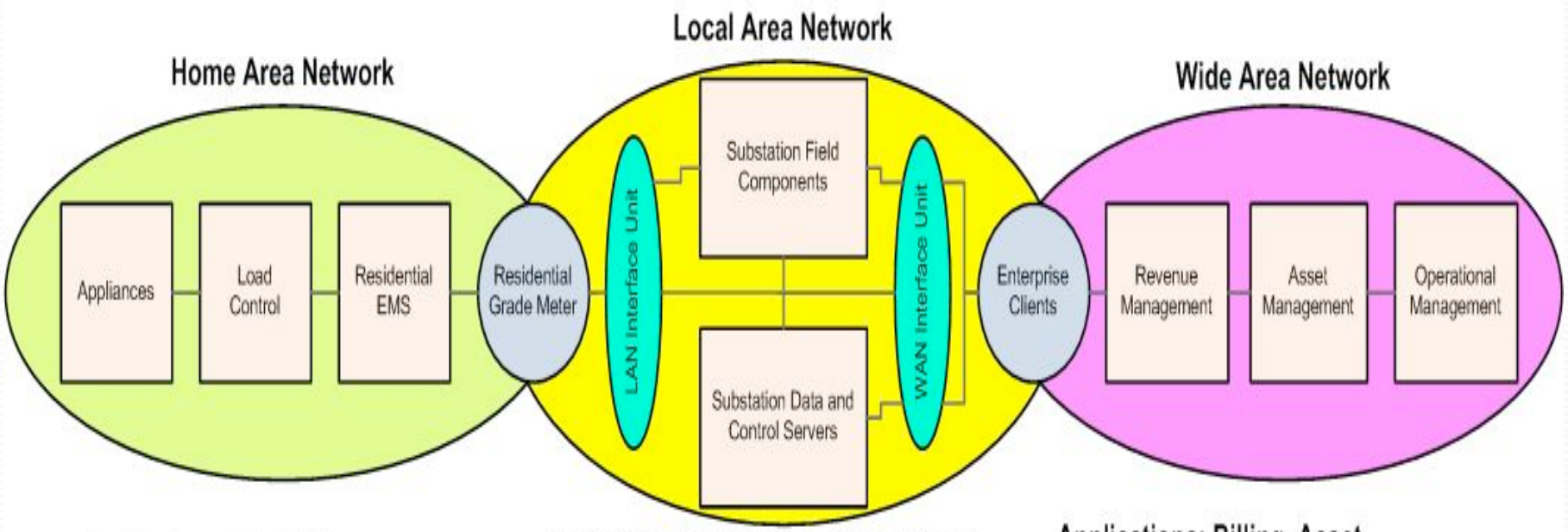
- Known as AFRESH Home
- Different Smart Metering Schemes
- Solar panels
- Geo-thermal
- Fuel cell
- EV charging station
- Smart Appliances
- Residential EMS

Core Intelligence : BCIT's SGCS

BC Hydro/BCIT's Microgrid SLD



BC Hydro/BCIT Smart Microgrid Communication System Topology



Applications: DR, EMS
Communication Technology: Zigbee, HomePlug
Protocol: Smart Energy Profile 2.0

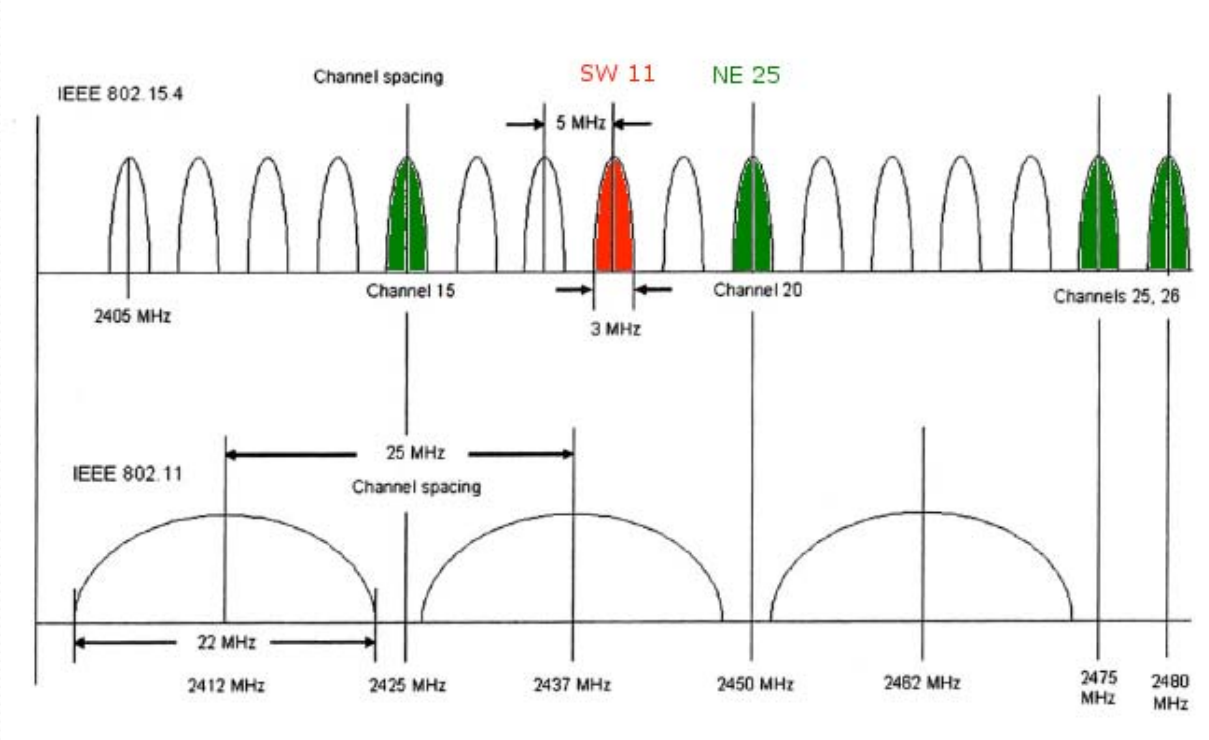
Applications: Substation Automation & Feeder Management
Communication Technology: NB PLC, HomePlug, ISM RF
Protocol: ANSI C12.22 (for metering), IEC-61850 (for Substation)

Applications: Billing, Asset Management, Outage Management
Communication Technology: WiMax 16D/E, Fibre
Protocol: TCP/IP

BCH/BCIT Smart Microgrid AMI

- Smart Meters are installed in various buildings and on some target loads to be monitored
- Technologies chosen based on challenging environments (e.g. PLC in Welding shop, etc)
- Different MDMS need to be integrated under utility EMS
- Issues were discovered (e.g. reliability of technologies)

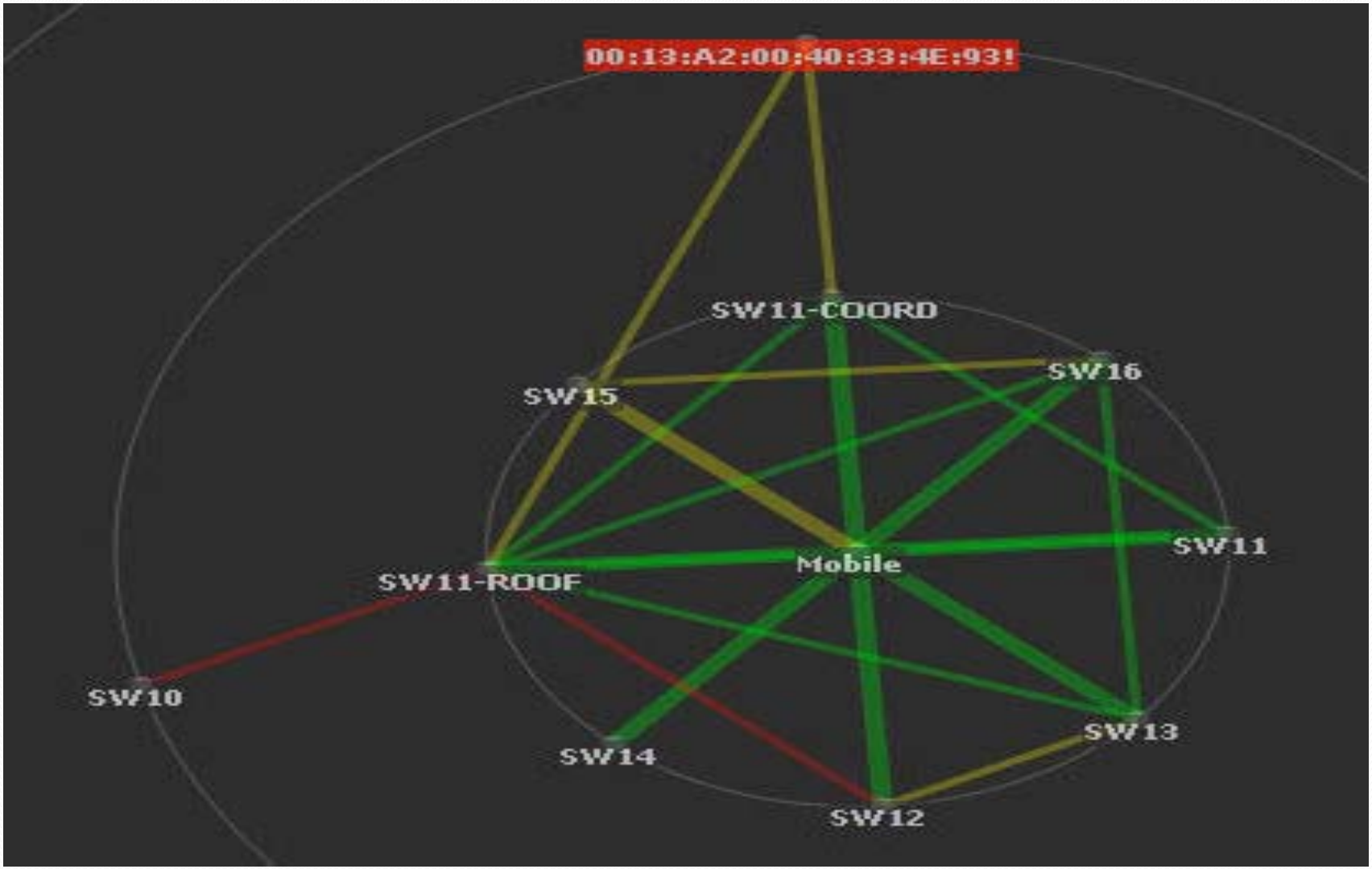
Zigbee & WiFi Interference



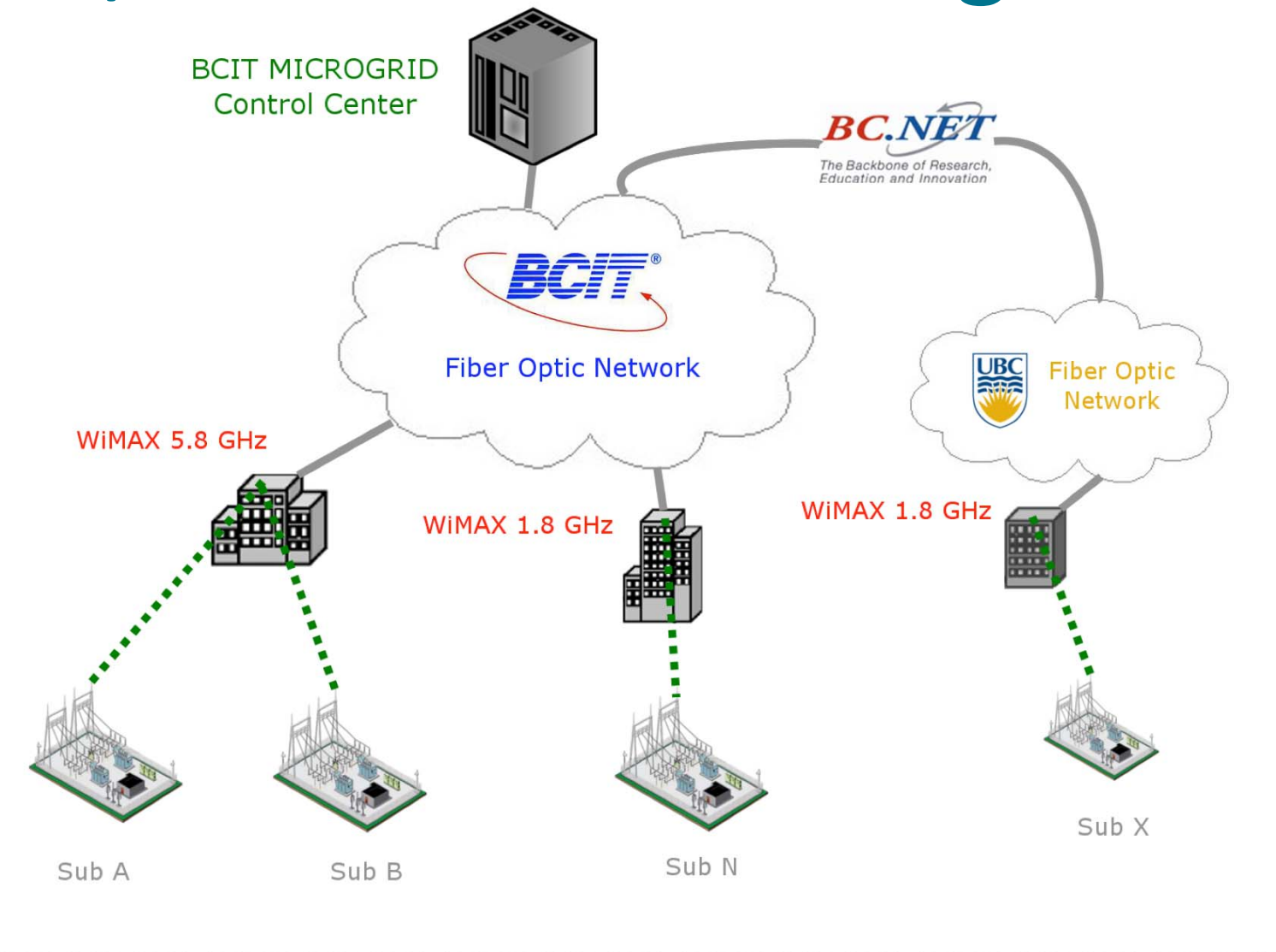
Location	Usage of WiFi channels at BCIT Resident area, %		
	1	6	11
SW10	2	1	2
SW11	2	0	3
SW12	0	2	3
SW13	2	1	2
SW14	2	2	1
SW15	1	2	2
SW16	3	1	1
Total	**34%**	**26%**	**40%**

Location	Usage of Wi-Fi channels		
	1	6	11
NE01	21	17	11
NE08	2	1	0
NE09	0	1	1
NE25	4	4	1
Total	**43%**	**37%**	**21%**

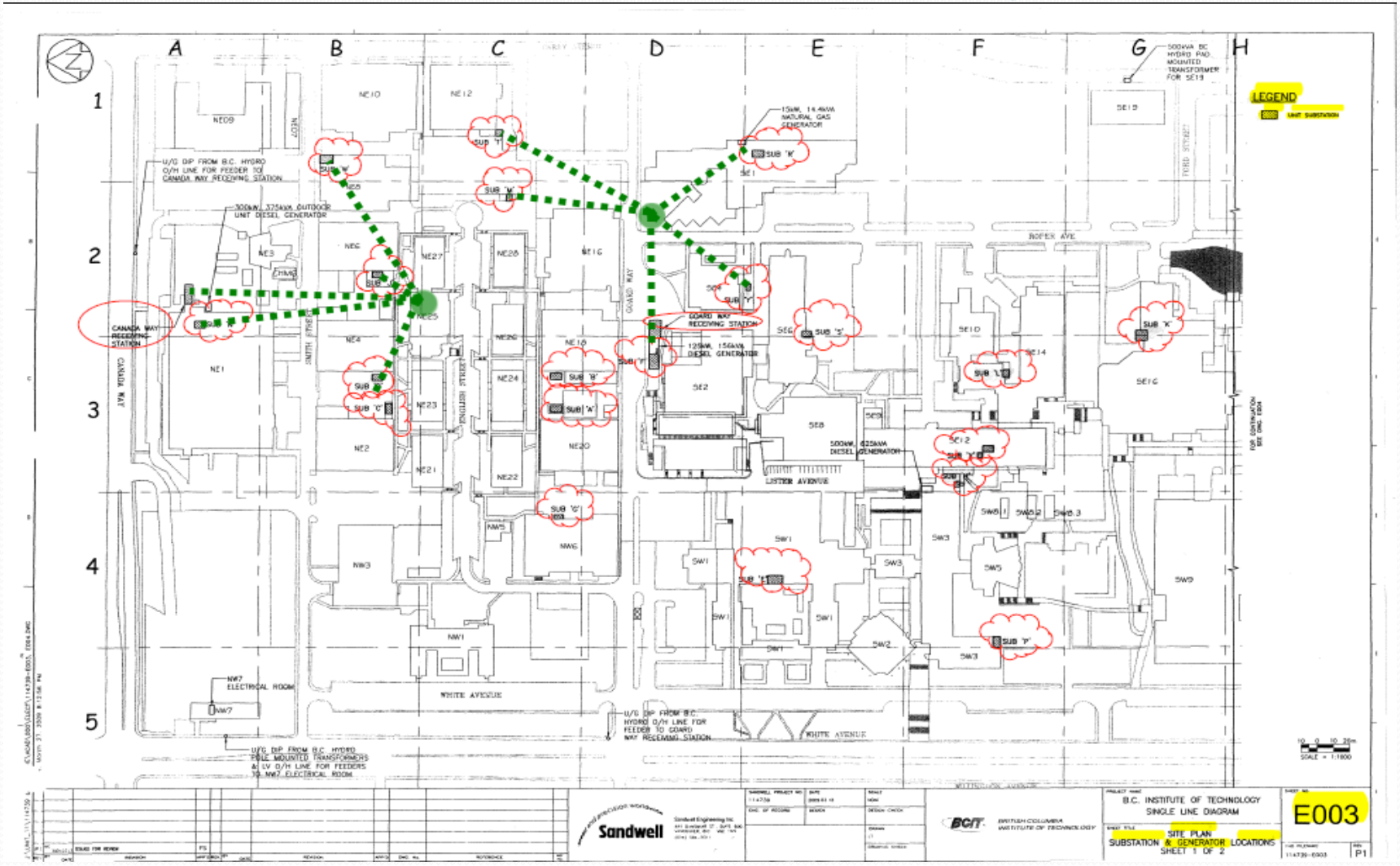
Frequency & Network Planning



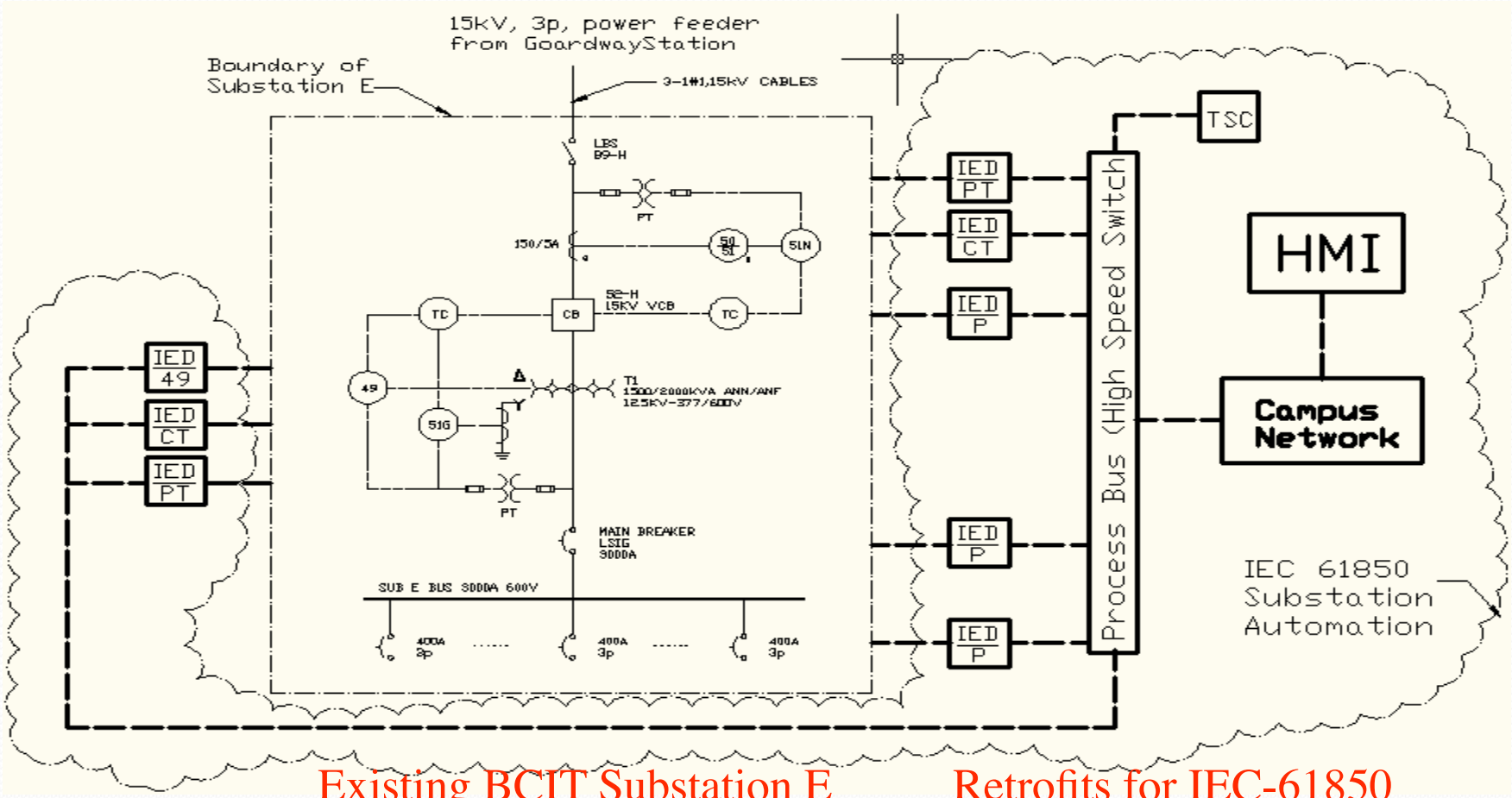
BCH/BCIT Smart Microgrid WAN



BCH/BCIT Smart Microgrid WAN

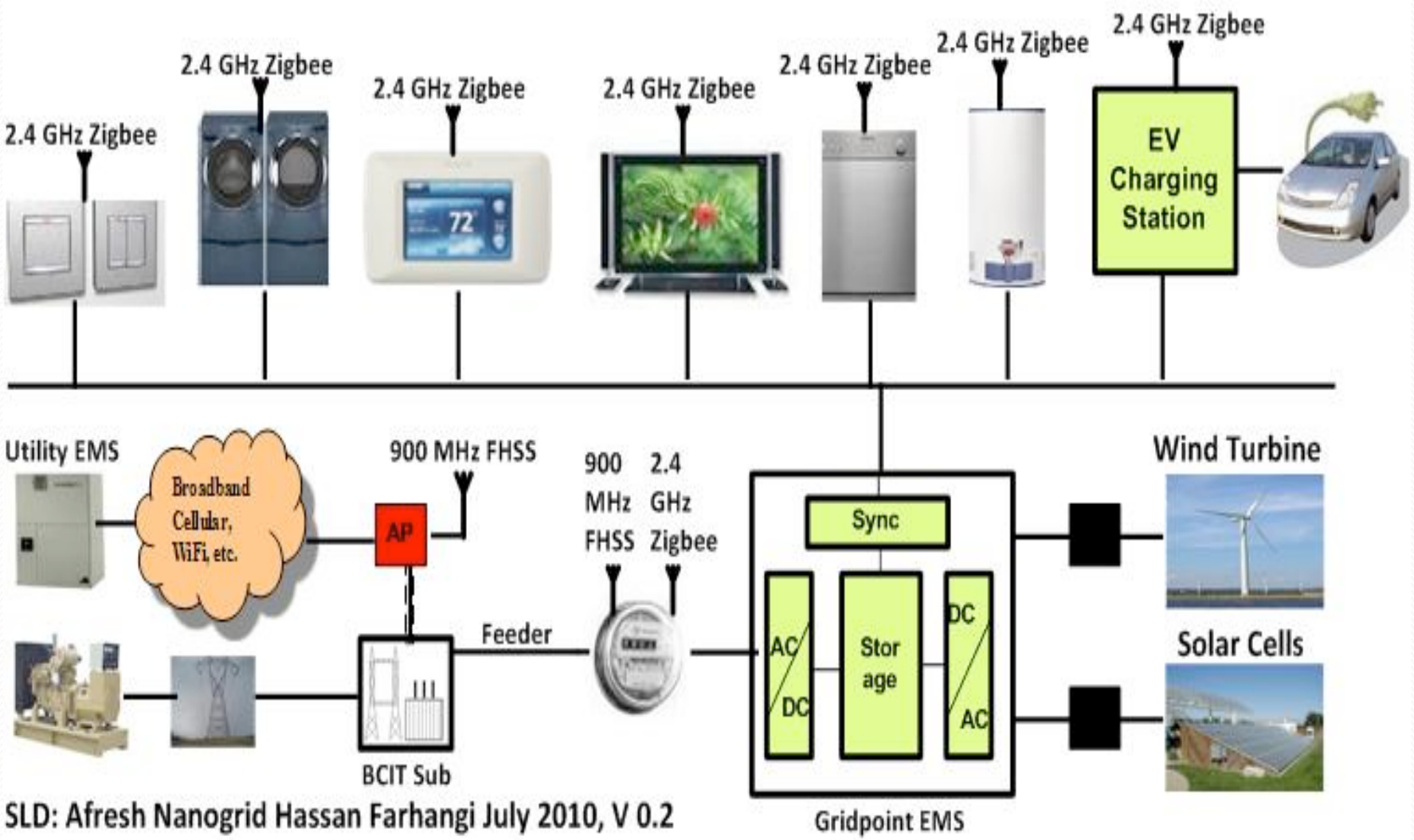


Substation Automation



Existing BCIT Substation E Retrofits for IEC-61850

Afresh Nanogrid SLD



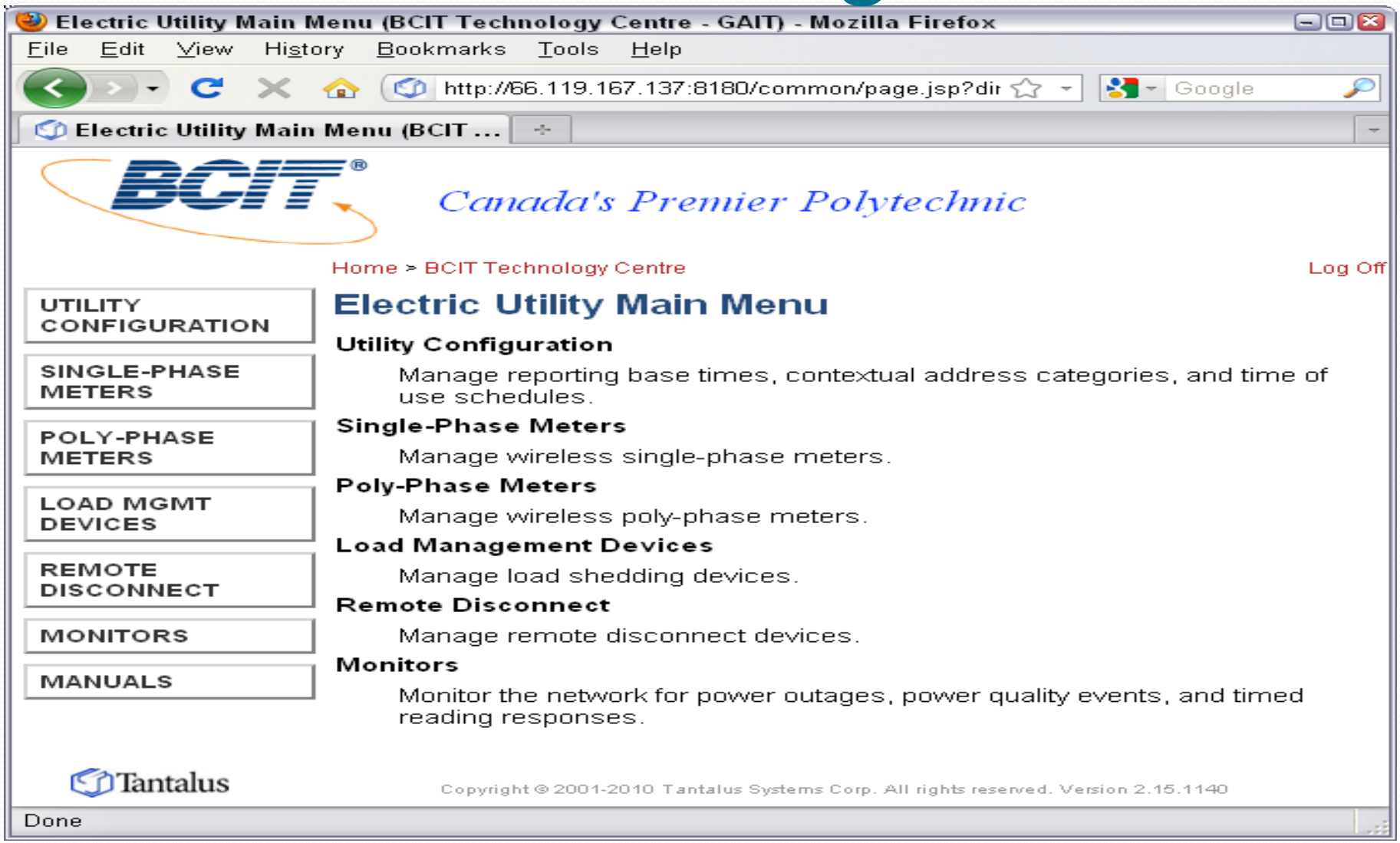
Smart Microgrid Subprojects

1. Energy Management System
2. Maquinna Residence AMI
3. North Campus AMI
4. AFRESH Smart Appliances
5. Wind Co-Gen at Afresh
6. Solar Co-Gen at Gateway
7. Full Islanding of Package 4
8. Smart Grid Control Center
9. Microgrid Controller
10. Substation Automation

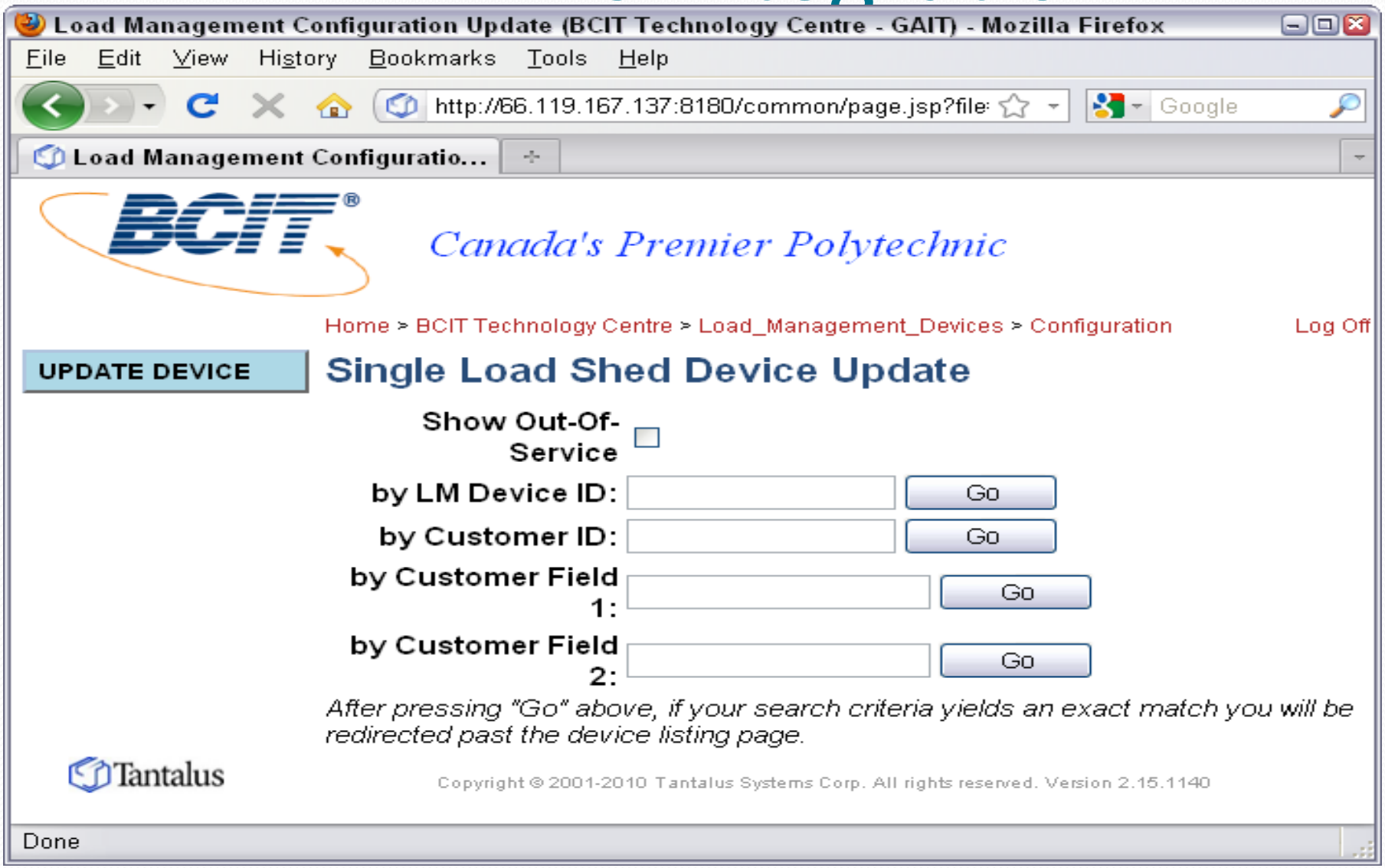
EMS - Energy Mgmt System

- Build campus load consumption profiles
- Integrate co-gens
- Sensors Network
- Integrate pricing signals (demand response)
- Enable time shifting of load
- Peak Shaving
- Smart Appliances

MDMS Integration



MDMS Integration



Energy Management System

- EMS is the control centre for the microgrid
- Being developed in 3 phases:
  - Basic EMS – shows current and past energy consumption (i.e. what's happening)
  - Enhanced EMS – makes recommendations to control centre operators to reduce consumption and / or carbon footprint
  - Advanced EMS – incorporates Intelligent Agents to make autonomous decisions about portions of the microgrid

Maquinna Residence

- Background
  - 7 Residence buildings
  - 4 suites per building = 28 suites total
  - 12 students per suite = 336 residence students
  - Houses completely electrically powered
  - Houses essentially identical
  - Focus on Demand Response

Maquinna Residence

- Problems
  - Lots of waste
  - little incentive to conserve
  - no real-time metering
  - awareness of issues low
- Solution
  - Smart meters
  - EMS Residence Portal
  - Create Awareness

EMS Residence Portal

- Designed to increase awareness of electrical consumption
- Targets to reduce consumption by modifying consumer behavior
- Portal design was based on Social science research
- Consumers sensitive to how they're doing versus their neighbours
- Focus on empowering consumers to make the right energy choices

EMS Residence Portal

BCIT : : applied research : : microgrid residence portal - Mozilla Firefox

File Edit View History Bookmarks Tools Help

BCIT : : applied research : : micr...

BRITISH COLUMBIA INSTITUTE OF TECHNOLOGY

bcit.ca

applied research at bcit

home

microgrid consumer portals

Residence Portal

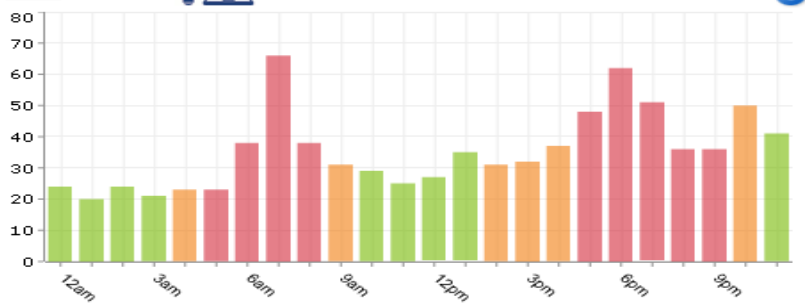
- overview
- consumption
  - > all houses
    - » SW10 - Nootka
    - » SW11 - Salish
    - » SW12 - Chilcotin
    - » SW13 - Carrier
    - » SW14 - Kootenay
    - » SW15 - Nisga'a
    - » SW16 - Haida
- resources
- competition
- contact us

Related Links

- applied research at BCIT
- GAIT
- BCIT Sustainability Initiative

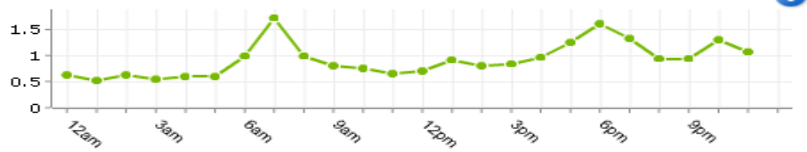
energy consumption: SW14 - Kootenay

kWh $$$



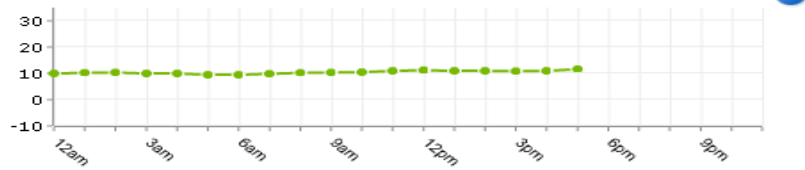
Carbon Dioxide Emissions CO_2e for BC Hydro

kg



Outdoor Temperature Degrees Celsius

Average



Monday Jan. 11, 2010

< Day Week Month >

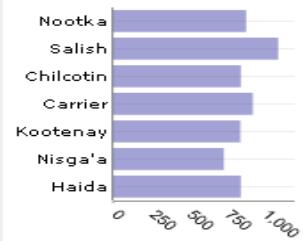
Kootenay Footprint

Total Per Person Per m^2

kWh	848.0 kWh
$$$	$ 110.88
CO_2	22.0 kg

House Comparison

kWh $$$ CO_2



bcit.ca | technology changes everything

top

EMS Residence Portal

BCIT : : applied research : : microgrid residence portal - Mozilla Firefox

File Edit View History Bookmarks Tools Help

BCIT : : applied research : : micr...

BRITISH COLUMBIA INSTITUTE OF TECHNOLOGY

bcit.ca

applied research at bcit

home

microgrid consumer portals

Residence Portal

- overview
- consumption
  - > all houses
    - » SW10 - Nootka
    - » SW11 - Salish
    - » SW12 - Chilcotin
    - » SW13 - Carrier
    - » SW14 - Kootenay
    - » SW15 - Nisga'a
    - » SW16 - Haida
- resources
- competition
- contact us

Related Links

- applied research at BCIT
- GAIT
- BCIT Sustainability Initiative

energy consumption: SW14 - Kootenay

Monday Jan. 11, 2010

< Day Week Month >

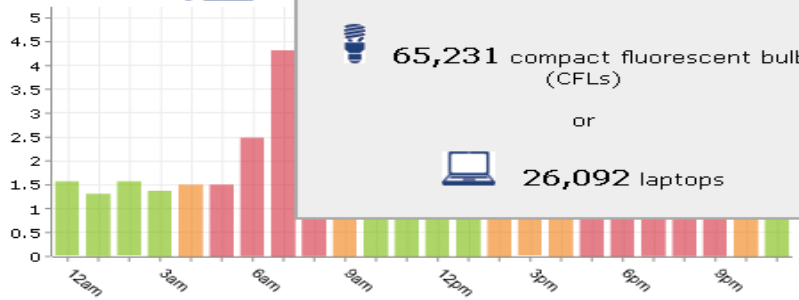
kWh $$$

848.0 kWh consumed in this period could power for the same period:

65,231 compact fluorescent bulbs (CFLs)

or

26,092 laptops



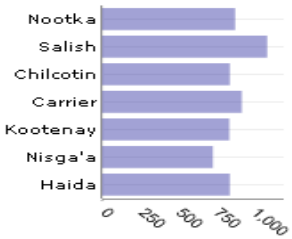
Kootenay Footprint

Total Per Person Per m^2

kWh	848.0 kWh
$$$	$ 110.88
CO_2	22.0 kg

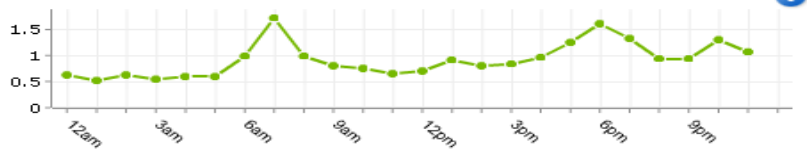
House Comparison

kWh $$$ CO_2



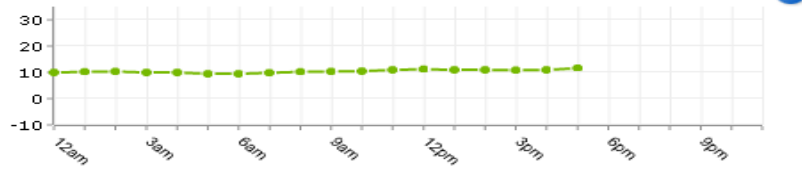
Carbon Dioxide Emissions CO_2e for BC Hydro

kg



Outdoor Temperature Degrees Celsius

Average

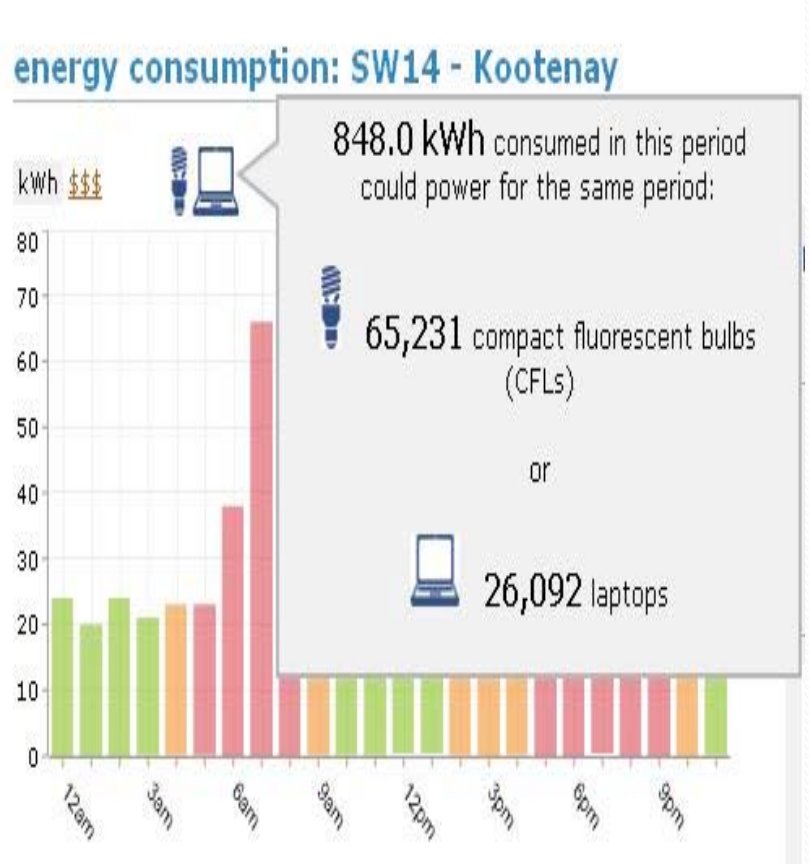


bcit.ca technology changes everything

top

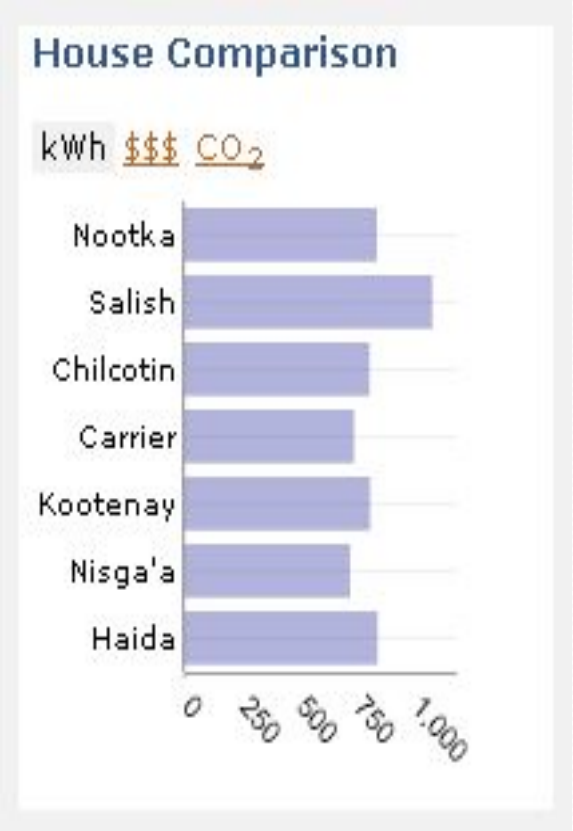
Energy Equivalents

- Students, and many people unsure what kWh means
- Dollars and cents help, but BC Electricity rates are among lowest in world
- EMS shows energy equivalents in units that are meaningful to students



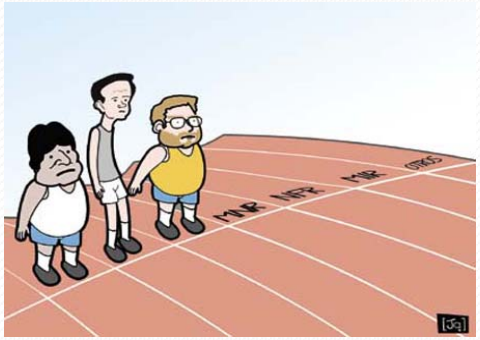
Residence Competition

- Provides incentive to conserve
- Makes electrical consumption visible
- Provides opportunity to test research theories about consumer behaviour
- Lets utilities know what does and doesn't work



Residence Competition

- 7 essentially identical residence “houses”
- Each house divided into 4 suites
- 12 students per suite, 48 per house
- Houses completely electrical powered (no gas)
- Smart meters installed on each house
- Challenge: student don’t pay for power
- Solution: competition!

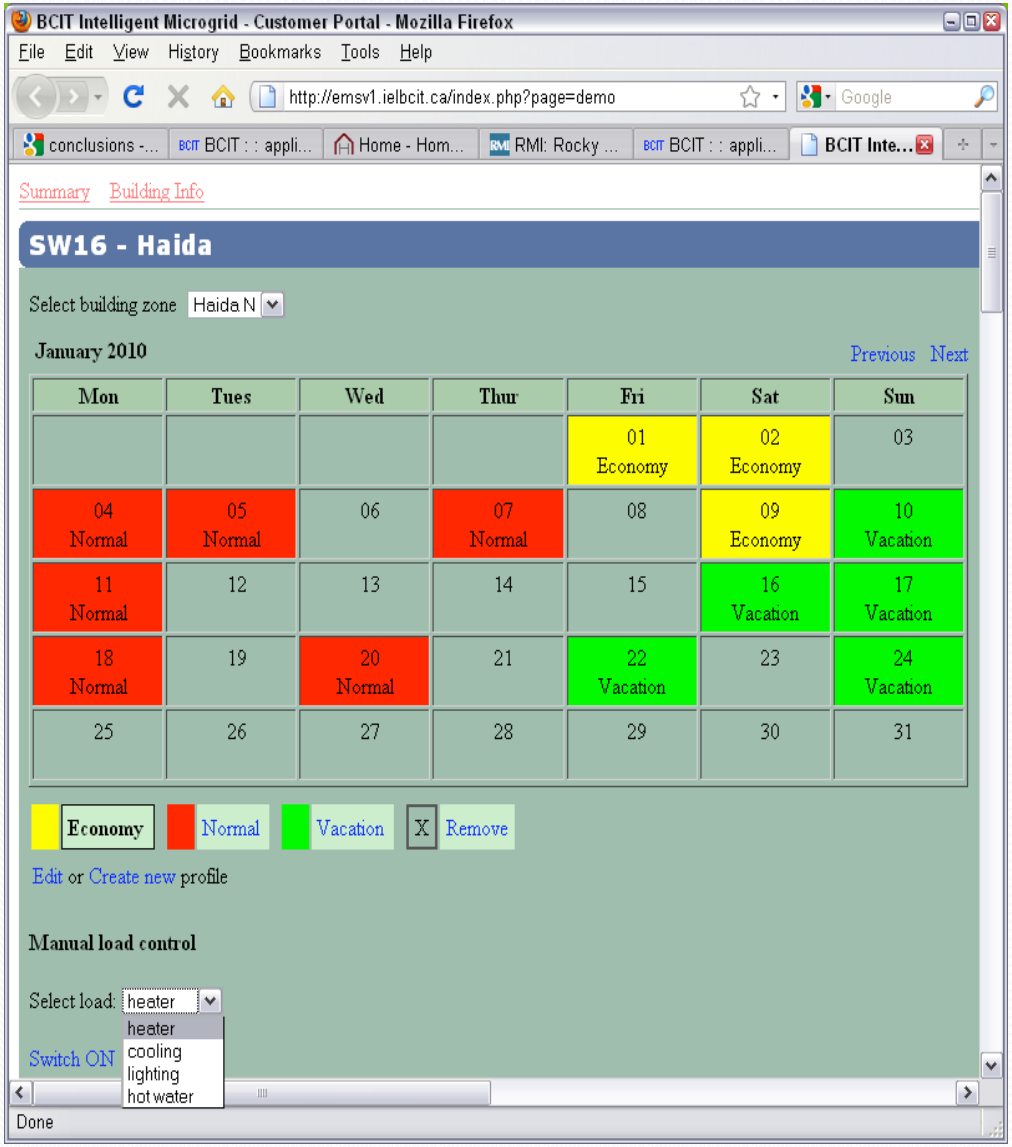


Competition Results

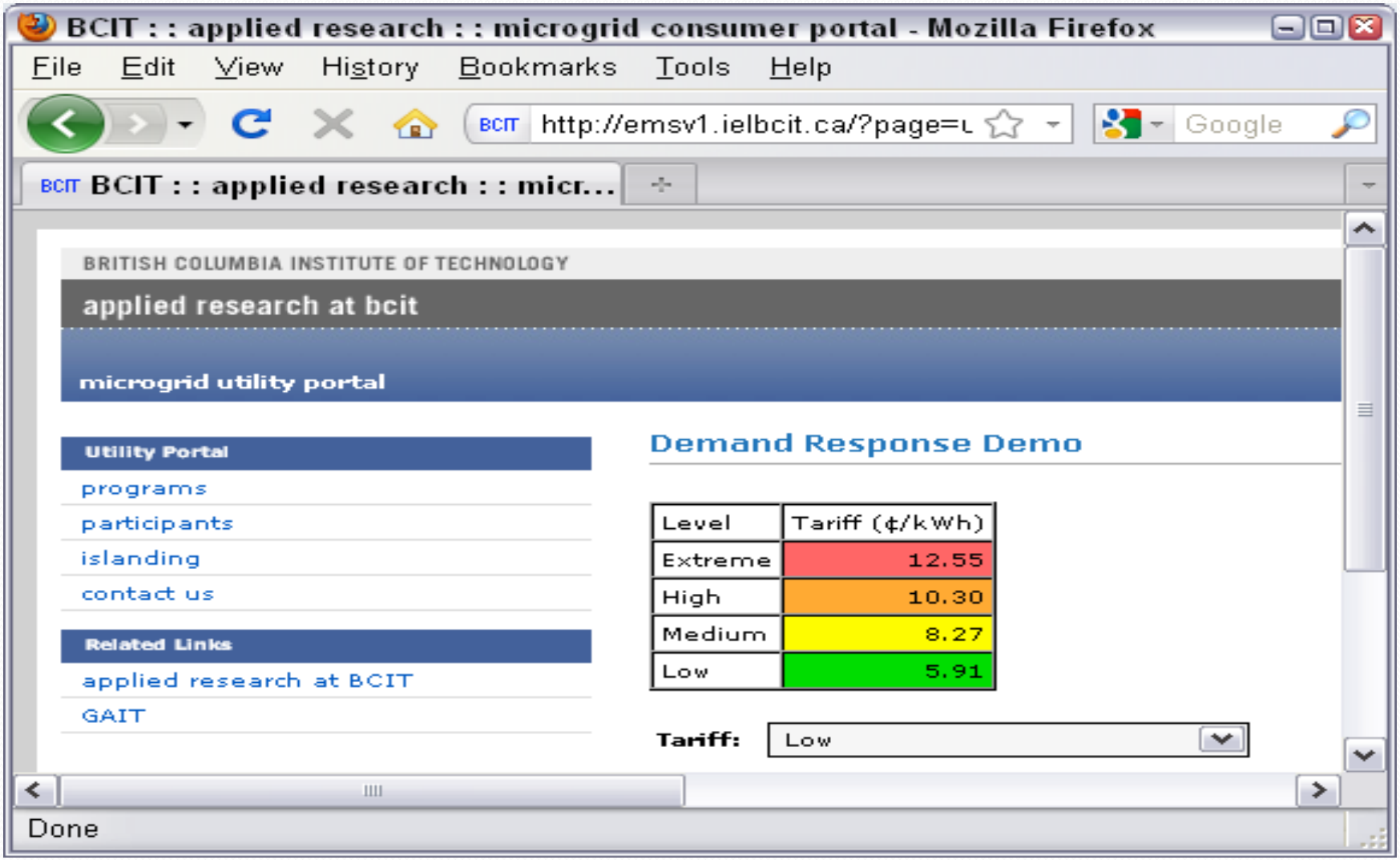
- 21% overall reduction in consumption
- Over 30% reduction in winning house
- GREAT response from students!
  - Level of interest very high
  - Many were studying by flashlight
  - Motivated by competition

Residence DR

- Focus on Load Control through scheduling
- Targets baseboard heaters, hot water tanks, lighting, etc.
- EMS directly communicates with load control boxes



Demand Response



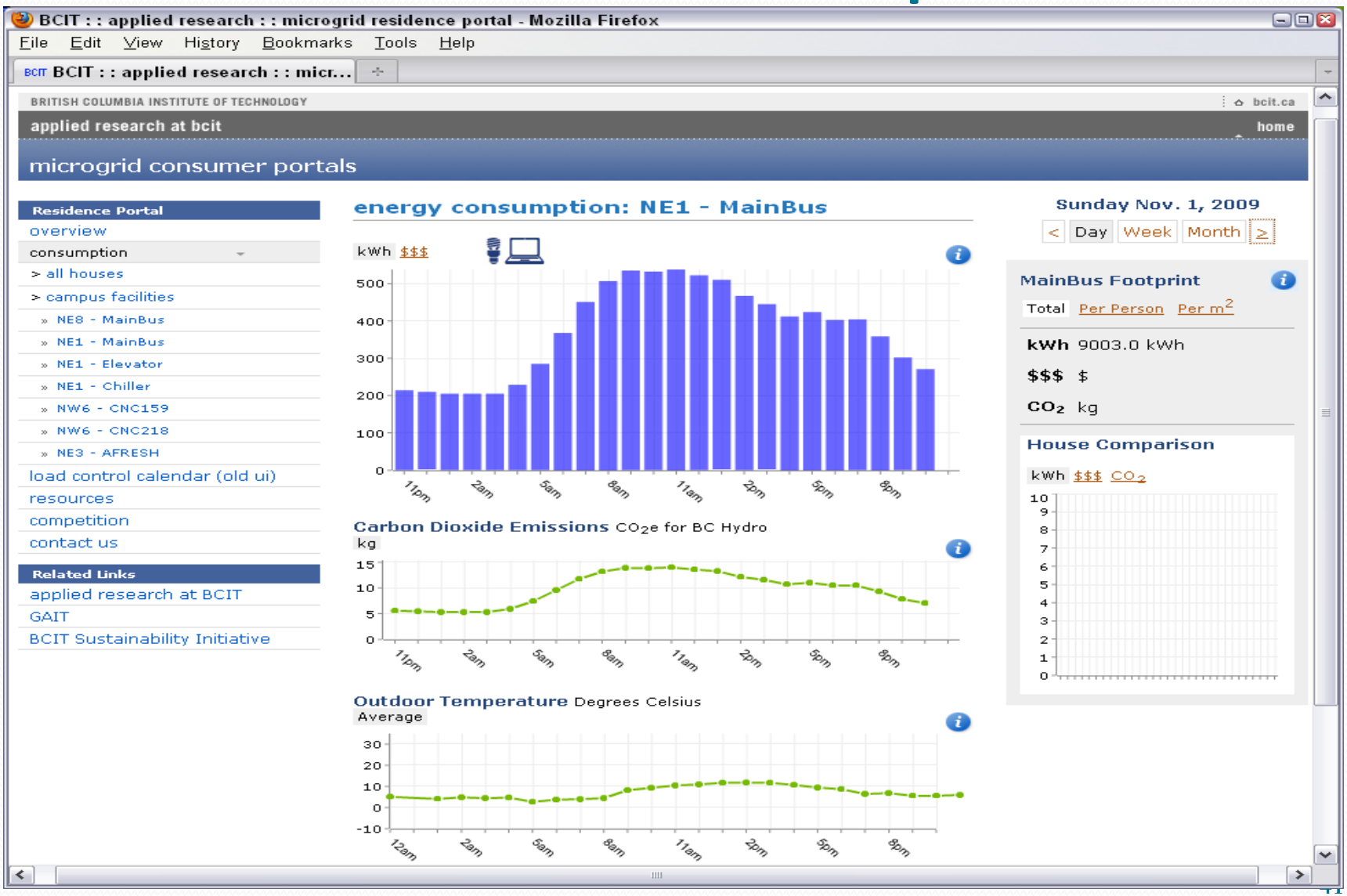
Residence IHD

- In-Home Displays
- Zigbee and/or HomePlug enabled:
  - baseboard heat thermostats
  - hot water tank thermostats
  - outlets & switches
  - Smart appliances

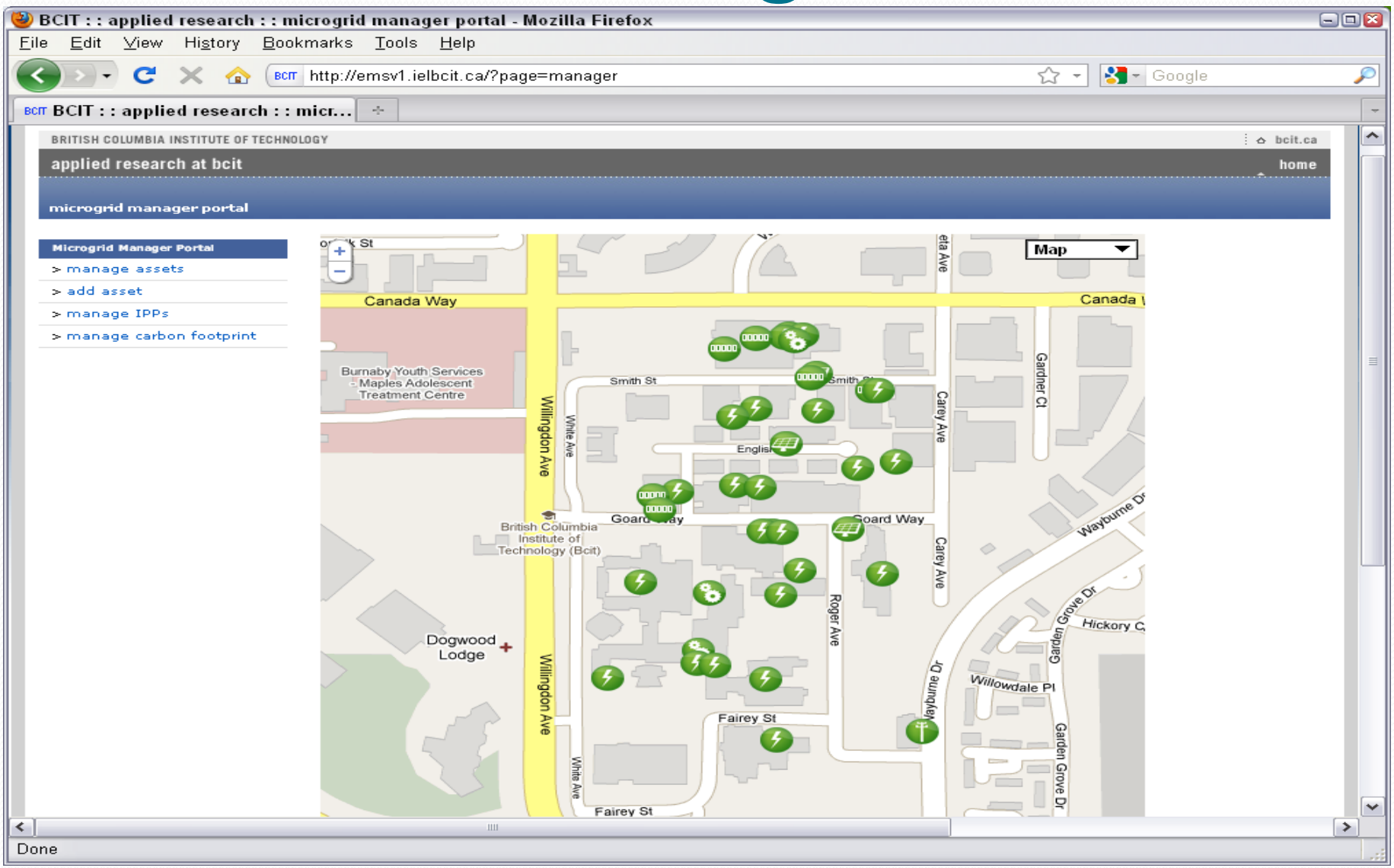
North Campus AMI

- Smart meters installed in the North Campus:
  - NE1 Main Buswork
  - NE1 Chiller
  - NE1 Elevator
  - NE3 – AFRESH Home
  - NW6 – CNC Machine 1
  - NW6 – CNC Machine 2
  - NE8 – Welding Shop
- NE2 Joinery and NE4 Carpentry use PLC Meters to test communication in 'noisy' environment

EMS – North Campus



Asset Management

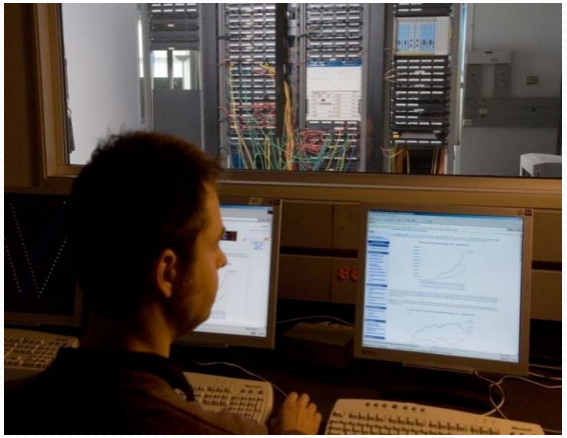


Conclusions

BCH/BCIT's Smart Microgrid Initiative is about:

- Providing new and unique educational/training services for students, faculty and industry
- Reducing the carbon footprint and energy costs
- Helping utilities modernize their services & assets
- Mitigating critical infrastructure risks, security, reliability and vulnerability
- Creating a 'sandbox' where new technologies and solutions can be developed, tested and qualified

Questions?



Come see us – we love to demo!

- Hassan Farhangi, PhD
- BCIT Technology Centre
- Wing B, CARI Building
- Hassan_Farhangi@bcit.ca
- Tel: 604-456-8074
- http://www.bcit.ca/microgrid