

Overview of Smart Grid and Microgrid R&D in Canada

Presentation at International Microgrid Symposium

Dr. Lisa Dignard-Bailey

Santiago, Chile

September 12, 2013

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Presentation Outline

- Background
- Quick facts - Electricity in Canada
- NRCan Smart Grid R&D and Knowledge-Sharing
- Remote Microgrid Conference Highlights
- Remote Community Applications
- Canadian Smart-Microgrid Research Network Update
 - BCIT Campus Microgrid Highlights
- Microgrid publications

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Natural Resources Canada (NRCan)

- **Mandate:**

- Enhance the responsible development and use of Canada's resources, including energy, forests, minerals and metals.

- **Four strategic priorities:**

1. Expanding markets and global partnerships
2. Unlocking resource potential through responsible development
3. Innovating for competitiveness and environmental performance
4. Leveraging S&T knowledge for safety and security risk management

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Three Energy Research Laboratories -



Devon, Alberta

- Oil sands and heavy oil



Varennes, Quebec (near Montreal)

- Buildings
- Industrial processes
- Renewables
- Smart grid
- RETScreen
- International Clean Energy Decision Support Centre

Ottawa, Ontario

- Buildings and communities
- Industrial processes
- Clean electricity
- Bioenergy
- Renewables
- Transportation



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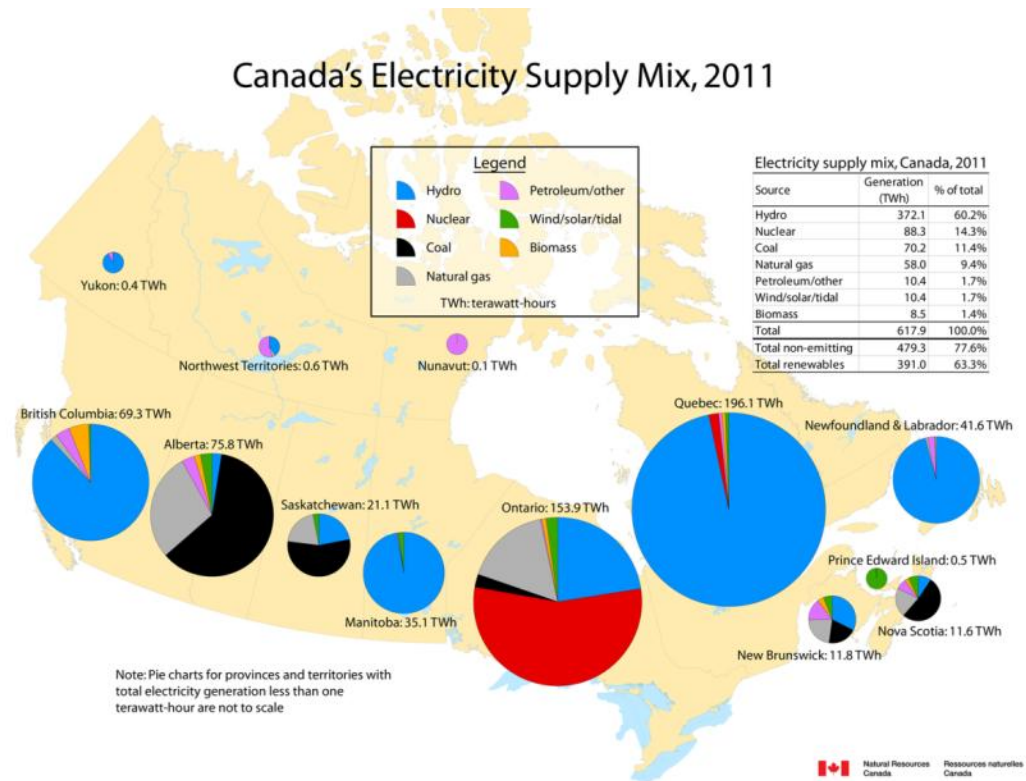
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Electricity in Canada

- 10 provinces, 9 balancing areas and 2 territories and 292 remote grids
- 60% of hydro generation, 14% nuclear, 11% coal, 13% Natural gas, 1.7% wind, 1.7% other petrol. fuel (2011)
- 2 wholesale markets (Ont. and Alb.) 7 vertically-integrated utilities and several municipal-owned utilities
- 97 164 MW load (not-coincident): Mostly winter peaking (except Ontario)
- 526 TWh : Residential (28 %)
- North-south interconnected with U.S.
- Low price in 10 provinces - Residential 9 cents (on average), but national disparities (5 to 14 cents per kWh)
- High cost in remote communities and three northern territories (Yukon, NWT, Nunavut)



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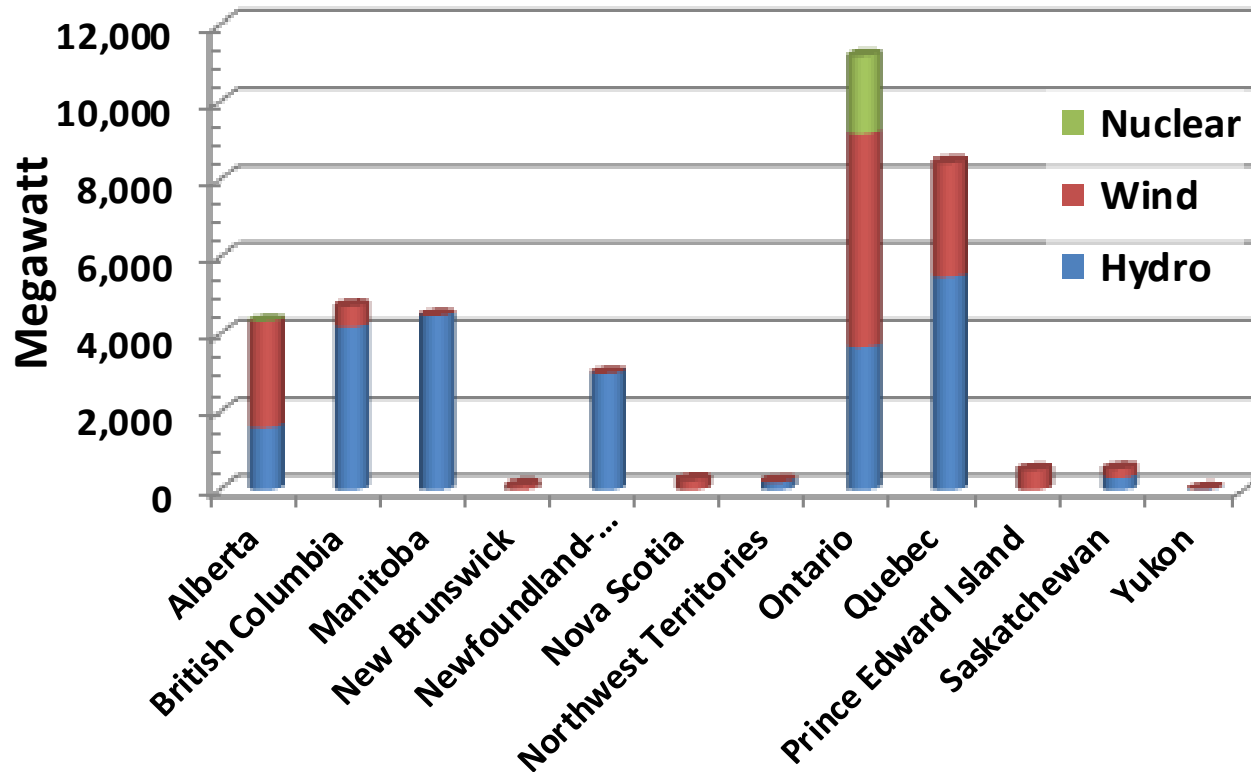
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Clean Electricity Supply Planned

Future hydro, wind and nuclear generation capacity projected or committed by province (Total : 37,800 MW)



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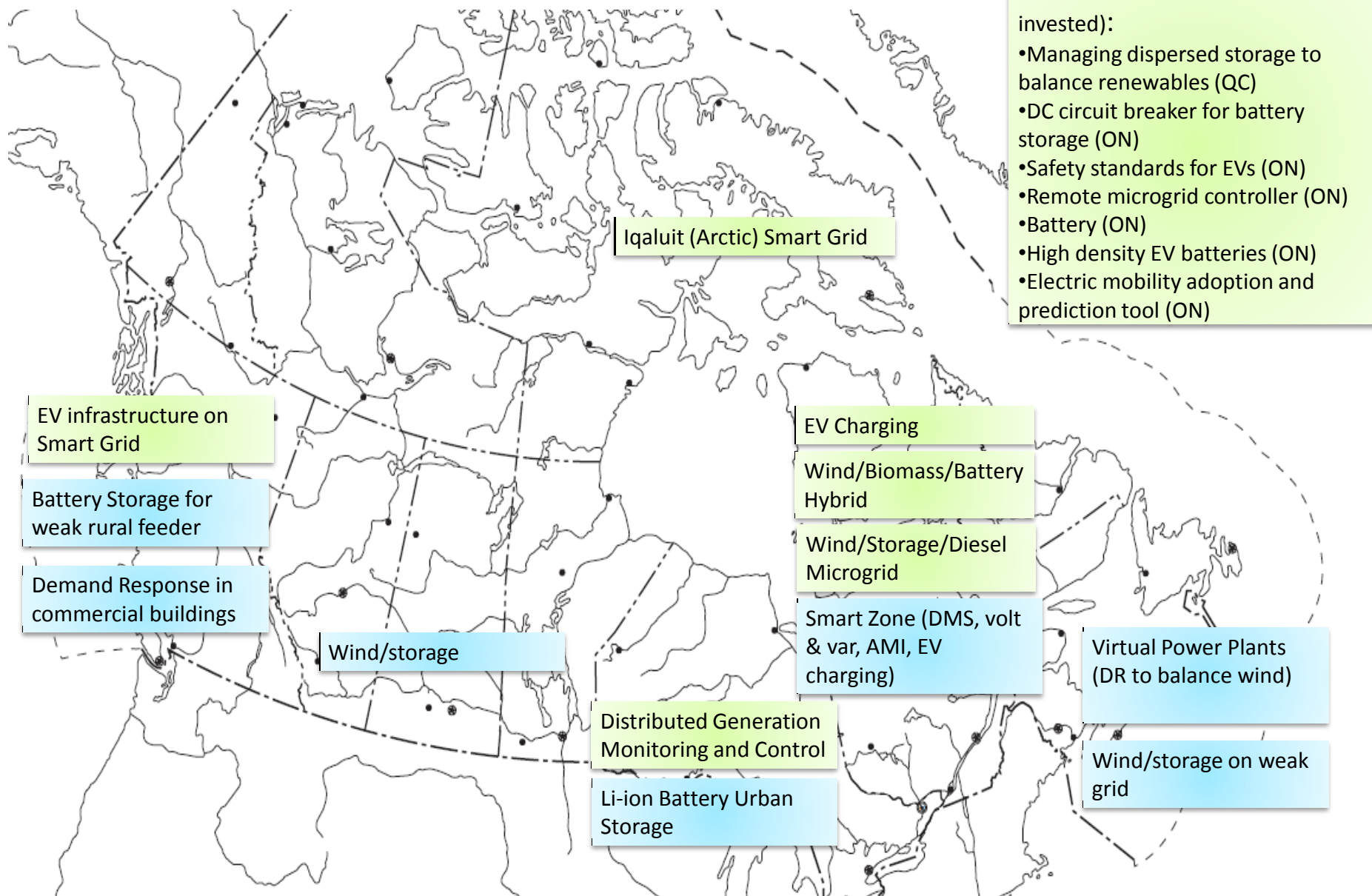


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NRCan-Funded External Smart Grid R&D



ecoEI Research (\$11.35M

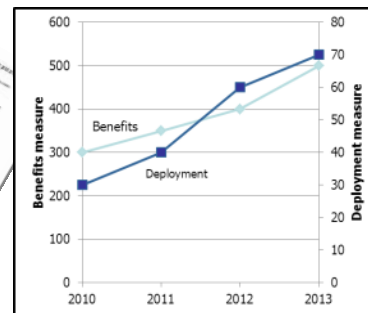
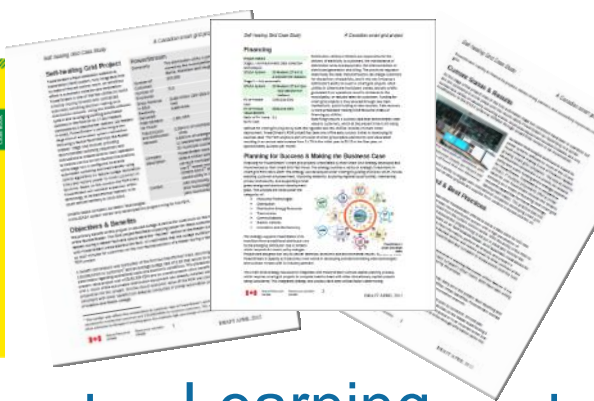
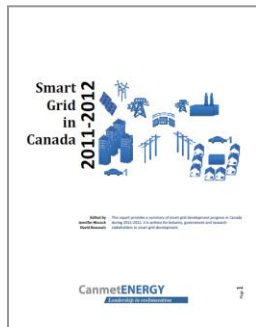
invested):

- Managing dispersed storage to balance renewables (QC)
- DC circuit breaker for battery storage (ON)
- Safety standards for EVs (ON)
- Remote microgrid controller (ON)
- Battery (ON)
- High density EV batteries (ON)
- Electric mobility adoption and prediction tool (ON)

ecoEnergy Innovation Initiative (ecoEI demonstration) additional \$8 M invested : <http://www.nrcan.gc.ca/energy/science/2314>

Clean Energy Fund (CEF Demonstration) (\$51M invested, \$121.5M projects): <http://www.nrcan.gc.ca/energy/science/programs-funding/1514>

CanmetENERGY – Smart Grid Knowledge Sharing



Awareness + Learning + Analyzing + Applying

[Annual Report on Smart Grid in Canada](#)

4 Case Studies (Ontario AMI, PowerStream FDIR, HQ Distributed Automation, PowerShift Atlantic)

Smart Grid Metrics Pilot in Ontario and New Brunswick

White papers prepared with NREL "[Smart Grid contribution to variable renewable resource integration](#)"

[ISGAN Case Book: Spotlight on Advanced Metering Infrastructure](#)

[2 videos \(PowerStream & Veridian\)](#)

Publication: [Smart Grid to balance renewable energy: Contributing Distributed Energy Resources](#)

Webinar "[Unlocking Markets](#)"
[Smart Grid Standards Roadmap](#)

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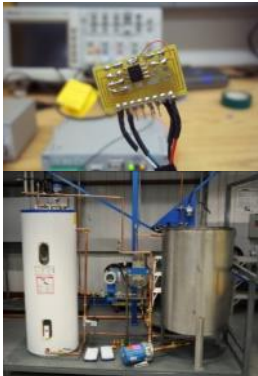
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CanmetENERGY Smart Grid R&D Program - Outputs

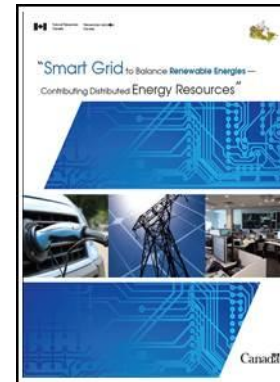
Technologies & demos



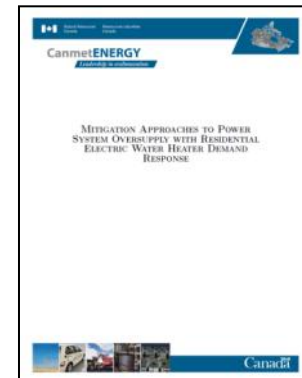
Project Case Study



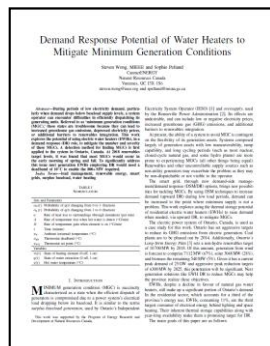
Technology scan



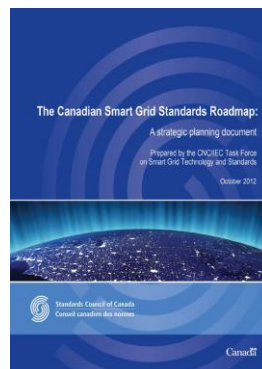
Technical reports



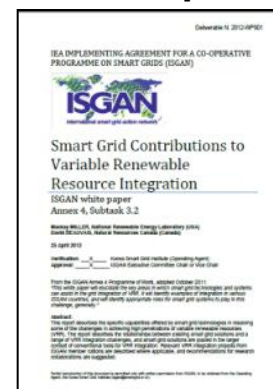
Scientific publication



Standard Roadmap



White Papers



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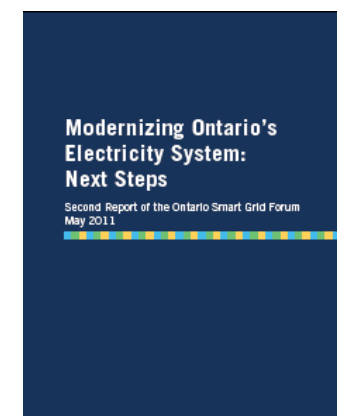
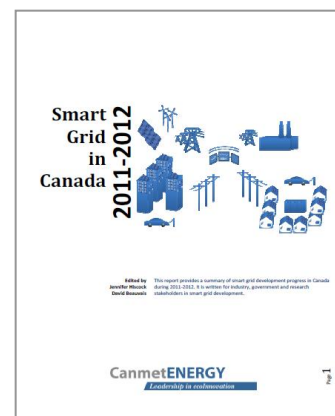
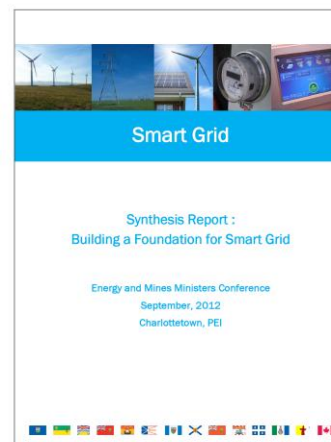
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Smart Grid - National Collaboration

- Federal/Provincial collaboration
- Smart Grid Standard Roadmap
- Annual Report "Smart Grid in Canada"
- Smart Grid Metrics Pilot
- Organization of Webinars/workshops/conferences



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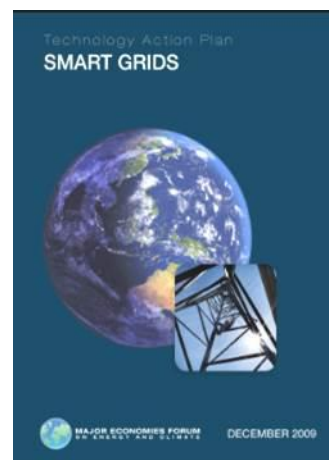
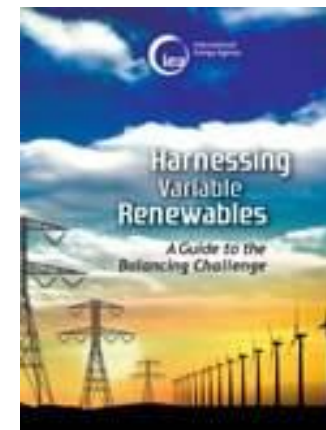
Smart Grid - International Collaboration

- International Smart Grid Action Network (ISGAN) with 24 countries
 - Demonstration project review
 - Advanced Metering Case Book
 - Active Demand Case book
- White papers for decision-makers

- IEA - Smart Grid Roadmap

- Grid Integration of Variable Renewable (IEA GIVAR)

- Major Economies Forum (MEF) Technology Action Plan



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Case Study Completed: PowerShift Atlantic



Focus of the project:

Determine if **load shifting** can provide an economic and effective **alternative to building new supply** side ancillary services for the integration of wind with minimal or no disruption to participating customers.

Finance : 32 M\$ over 5 years

50% by the consortium and 50% by NRCan (Clean Energy Fund)

Physical elements:

Two Virtual Power Plants to connect up to 2000 customer demand-side technologies

Preliminary Results:

- 3.25 years into a 5 year project
- The two Virtual Power plants (VPP), with 4 different aggregators
- 2.57 MW connected in NS, 4.32 MW connected in NB (target is 20 MW)
- Approximately 900 customers connected
- Majority of planned installations completed by Sept 30, 2013
- Participant satisfaction: 75 %



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Case Study Completed: PowerStream Self-Healing Grid

- Self-healing grid - 20 feeders, 2 transformer stations
 - Stage 1: semi-automatic (recommendations to operator control)
 - Stage 2: fully-automatic (system control)
- Benefit/Cost: 6:1 based on customer value of outage time reduced and operational savings
- Embedded within Smart Grid Strategy
- Lessons Learned:
 - Build in communication delays for accurate
 - Customer engagement plan
 - Strategy is essential for rate recovery
 - Participation in Ontario Smart Grid Forum

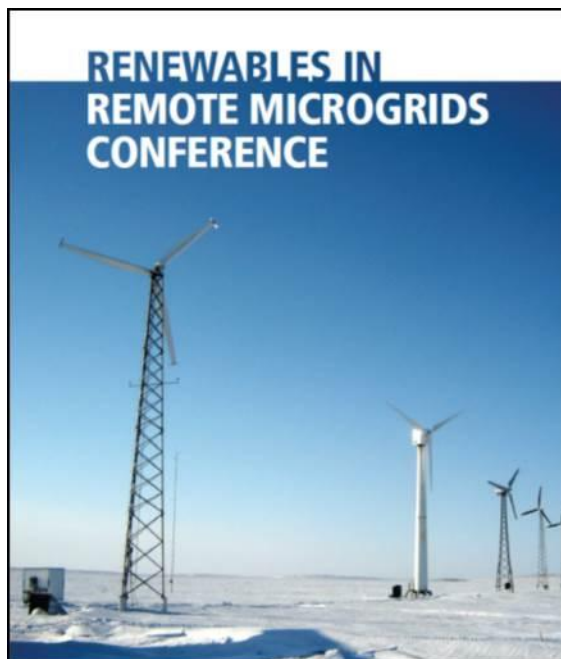


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Remote Microgrid Conference, Toronto, Canada June 25-26, 2013



Pre-conference June 24, 2013 :
Microgrid Introduction Short Course

Conference URL and Presentation
Link:

www.bullfrogpower.com/remotemicrogrids/presentations.cfm

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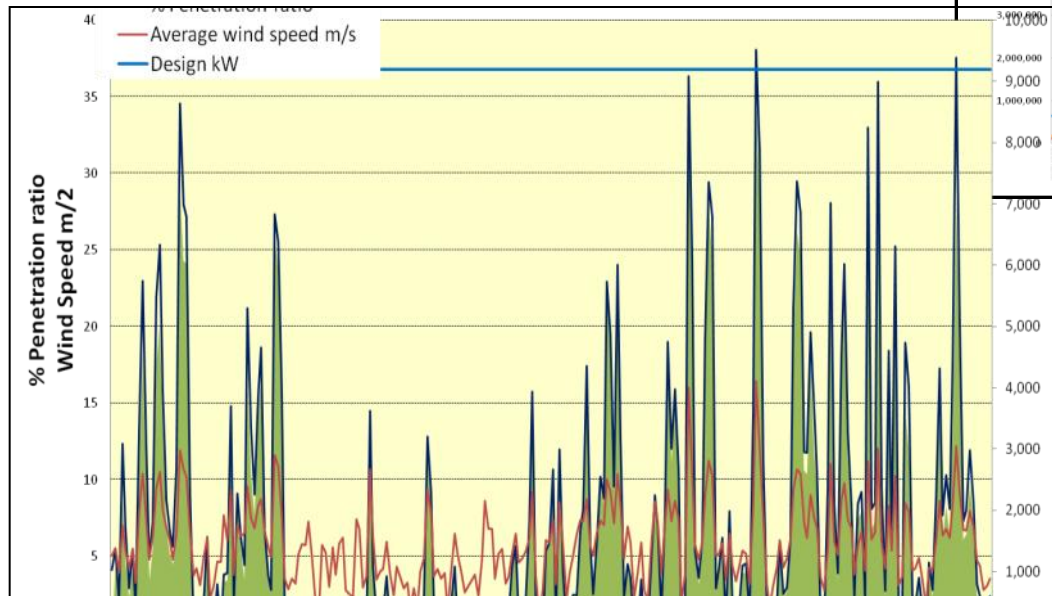
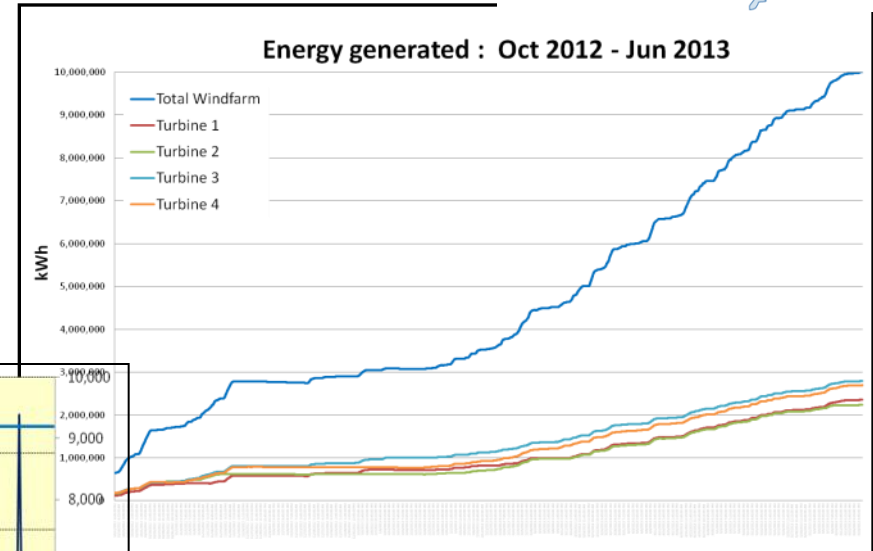
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Conference Highlight: Diavik Mine Remote Northern Microgrid, NWT

- First wind-diesel system at mining site
- Four 2.3 MW Enercon Wind turbines (9.2 MW total), direct drive, gearless generator, Blade de-icing system
- Target: reduce diesel consumption by 10% (YTD >2.0M liters), 8 yr payback



Source: Liezl van Wyk, Presentation at Renewable for Remote Microgrids Conference, Toronto, 26 June 2013.
VIDEO: http://www.diavik.ca/rio-apps/riotinto_videorepository/single_video.asp?id=22515

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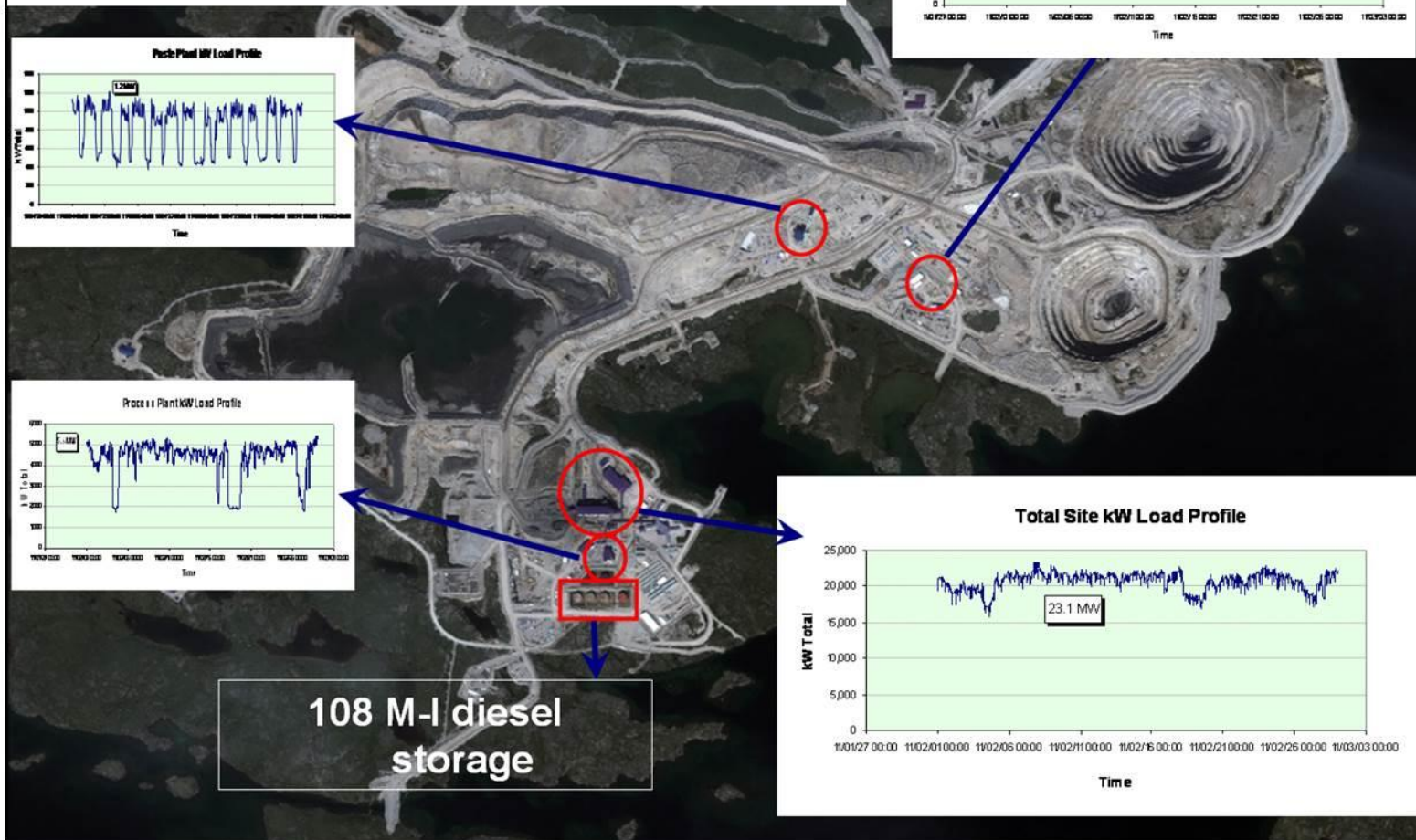


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Diavik Mine, NWT: Load and Energy Profiles



Source: Liezl van Wyk, Renewable for Remote Microgrids Conference, Toronto, 26 June 2013.



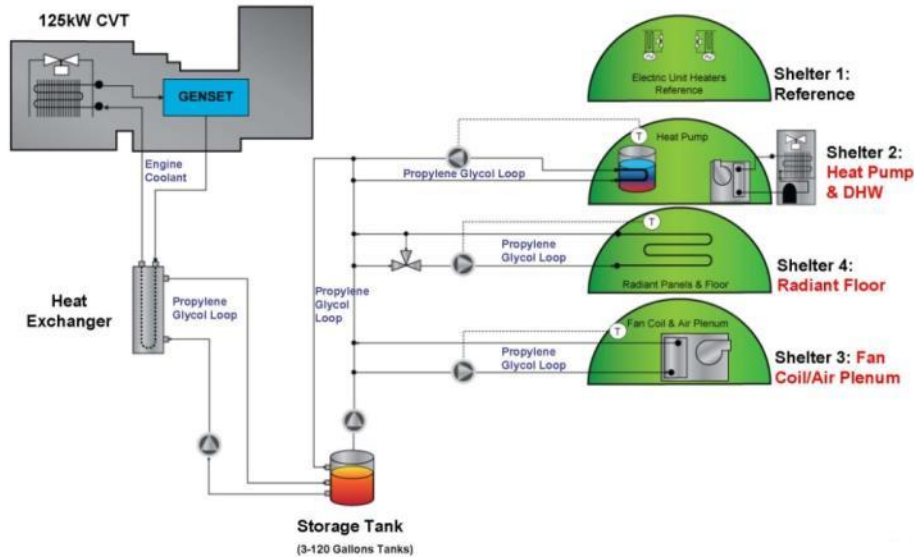
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Defense Research Highlight: Camp Power and Energy Demonstration Activities



- Heat Exchangers – heat pumps, heat storage/transfer
- Power Management
- Energy storage
- Efficient load control / consumption schemes



CanmetENERGY Research Partner.

Source : Project manager Gisele Amow, DRDC, presentation at Renewables in Remote Microgrids Conference, Toronto, June 26, 2013

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Canada's Remote Communities Energy Database, June 2013

- **Report:**
http://canmetenergy.nrcan.gc.ca/sites/canmetenergy.nrcan.gc.ca/files/files/pubs/2013-118_en.pdf
- **URL to access RC Database:**
<http://www2.nrcan.gc.ca/eneene/sources/rc-bce/index.cfm?fuseaction=admin.home1>



Remote Communities Database

The Remote Communities Energy Database is a tool that aims to collect and show pertinent factual information about the generation and use of electricity and other energy sources for all remote communities of Canada. It uses a web driven application so this information can be viewed by anyone with a web access and be easily updated and maintained.

This data is collected from a number of sources, including from Aboriginal Affairs and Northern Development Canada (AANDC), Natural Resources Canada (NRCAN) and various stakeholders involved in these communities. Information shown is public information that is available from Statistics Canada, from remote communities themselves, from publicly available reports or from public web sites. Its availability in one site where data can be collected and searched is what makes it a powerful tool.

[Advanced Search](#)

[Login](#)

Map of Canada by Province and Territory

Click on the province or territory on the map or in the table below to see a list of communities of that region



Click on a province name in the table below to see a listing of active remote communities in that province.

Number of Active Remote Communities by Province and Territory

Province/Territory	Aboriginal	Non aboriginal	First Nation	Innu	Inuit	Metis	Commercial	Settlement
British Columbia	25	61	25	0	0	0	7	79
Alberta	0	2	0	0	0	0	0	2
Saskatchewan	1	0	1	0	0	0	0	1
Manitoba	4	3	4	0	0	0	0	7
Ontario	25	13	25	0	0	0	0	38
Québec	21	26	6	1	14	0	0	47
New Brunswick	0	0	0	0	0	0	0	0
Nova Scotia	0	0	0	0	0	0	0	0
Prince Edward Island	0	0	0	0	0	0	0	0
Newfoundland and Labrador	17	12	0	2	5	10	0	29
Northwest Territories	33	5	27	0	6	0	2	36
Nunavut	26	0	0	0	26	0	0	26
Yukon	21	1	21	0	0	0	1	21
Total:	173	123	109	2	51	10	10	286

Date Modified: 2011-07-29

Canada's Remote Communities Energy Database, June 2013

- Collect and show factual information about generation and use of electricity and other energy sources for all remote communities of Canada



Summary

General Information

		Record Status	Active
Community Name	Ramea		
Province/Territory	Newfoundland and Labrador	Region	Island
Latitude (°)	47.51667	Longitude (°)	-57.38333
Aboriginal?	NO	Aboriginal Group	
Aboriginal Denomination			
Community Type	Settlement	Access to Community	Seaway
Population	1224	Date of census	2006

Electricity Service Provider

Service Provider	N&L Hydro
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Main Power Source

Main Power Source	Hybrid
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Fossil Fuel Power Plant

Fossil Fuel Used	Diesel		
Total FF Capacity (kW)	2775	Capacity Review Year	

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Learning from Remote Community Microgrid Projects

➤ Two Poster Presentations

Hartley Bay, BC

Smart Grid/Demand Response (2011)

Village of Hartley Bay, Pulse Energy

<http://www.pulseenergy.com/case-studies/hartley-bay-and-pulse-micro-smart-grid/>

Arviat (R&D), NU

Diesel-Wind-CHP-Storage (2005)

Ramea (Island), NL

Wind-Diesel (2004)

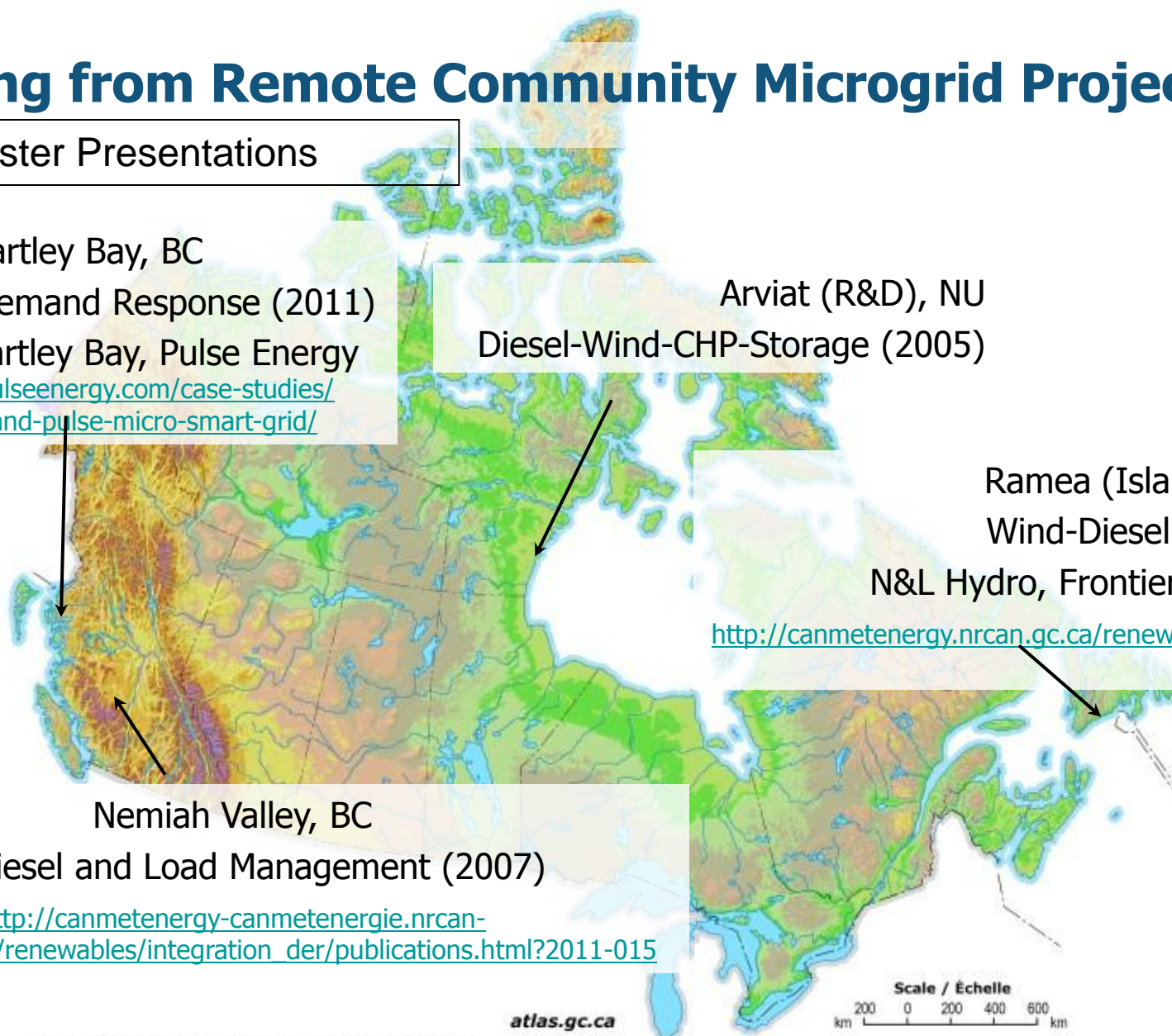
N&L Hydro, Frontier Power

<http://canmetenergy.nrcan.gc.ca/renewables/wind/464>

Nemiah Valley, BC

PV-Diesel and Load Management (2007)

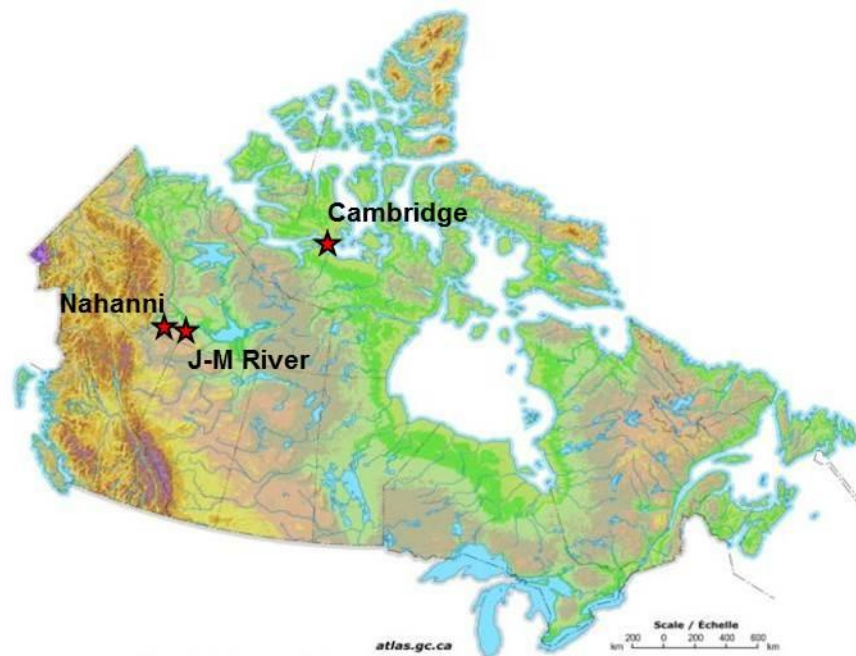
http://canmetenergy-canmetenergie.nrcan-nrcan.gc.ca/eng/renewables/integration_der/publications.html?2011-015



Performance Assessment Tool for Remote Electrical Microgrids (PATREM)

Developed a detailed 15 minutes step performance assessment tool that will enable grid planners and operators to study :

- Efficient control and monitoring of the diesel power plant through dispatch strategy to reduce fuel consumption and GHG emissions;
- Improve the remote grid components efficiency;
- Integrate demand side and demand response strategies;
- Enabling maximum penetration and use of renewables (small hydro, wind, photovoltaics).



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PATREM Models and Functions

Models:

- *Diesel generators*
- *Transformers and Feeders*
- *Battery Storage*

Profiles

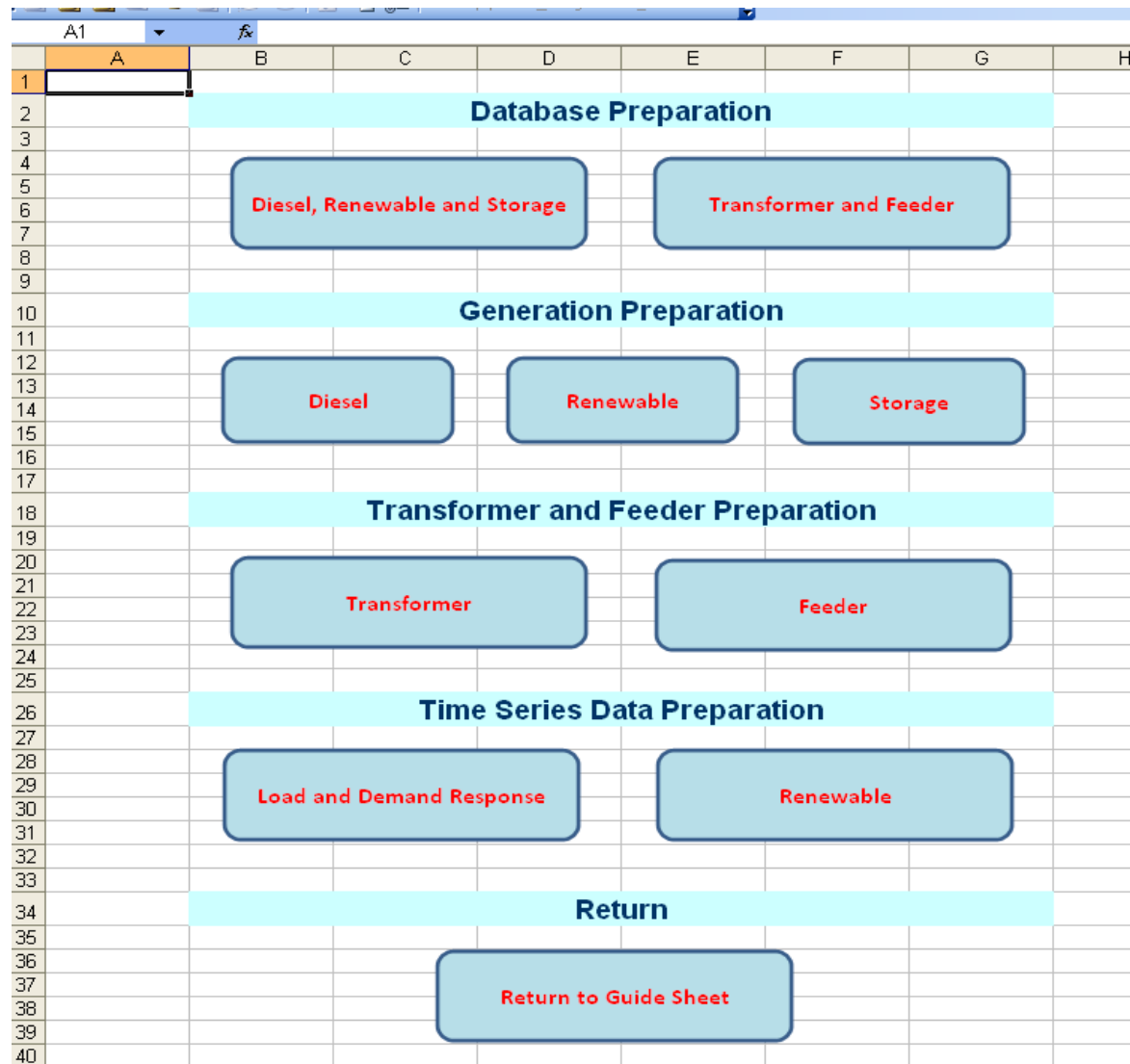
- *Load and Renewable generation*

Functions

- *Diesel heat rates and dispatch*
- *Demand side management*

Calculations

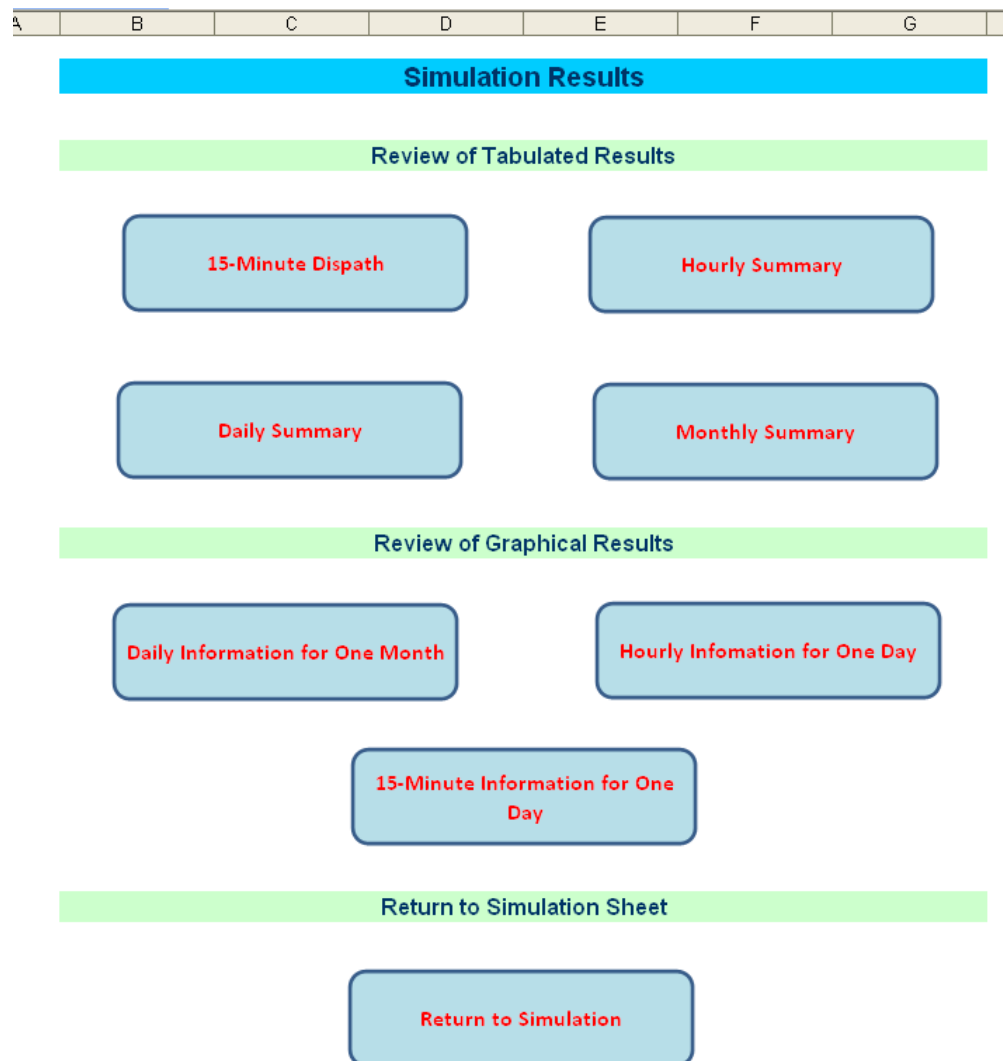
- *Diesel Consumptions*
- *Generation Costs*
- *GHG emissions*



PATREM Results Sheets

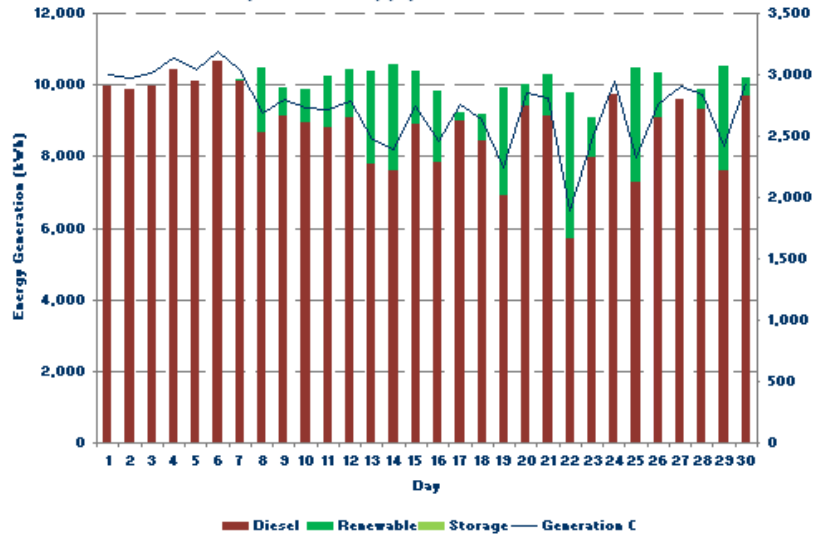
- Results can be presented in;
 - *15-minute information for the target day*
 - *hourly information for the target day*
 - *daily information for the target month*

- Results include:
 - *Generation (diesel, renewable and storage)*
 - *Generation costs*
 - *Fuel usage*
 - *GHG emissions*

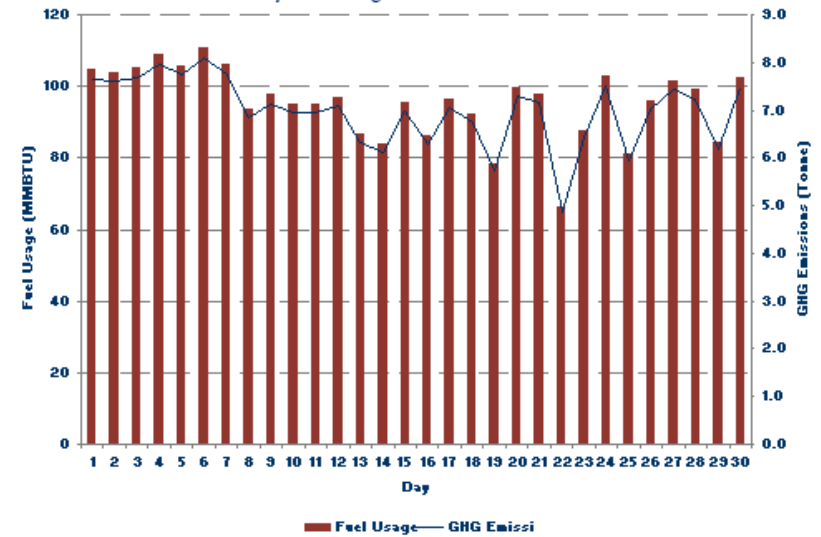


PATREM Operation-Graph Sheet

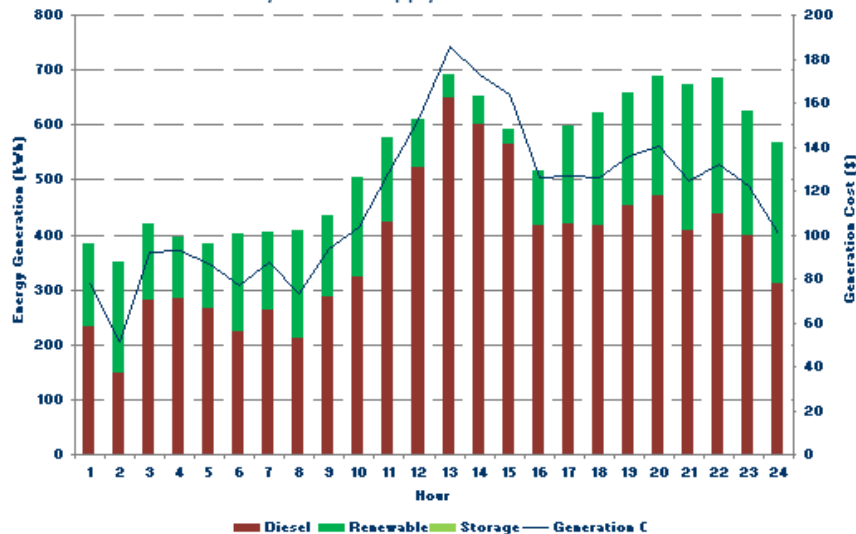
Daily Demand Supply Balance and Fuel Cost



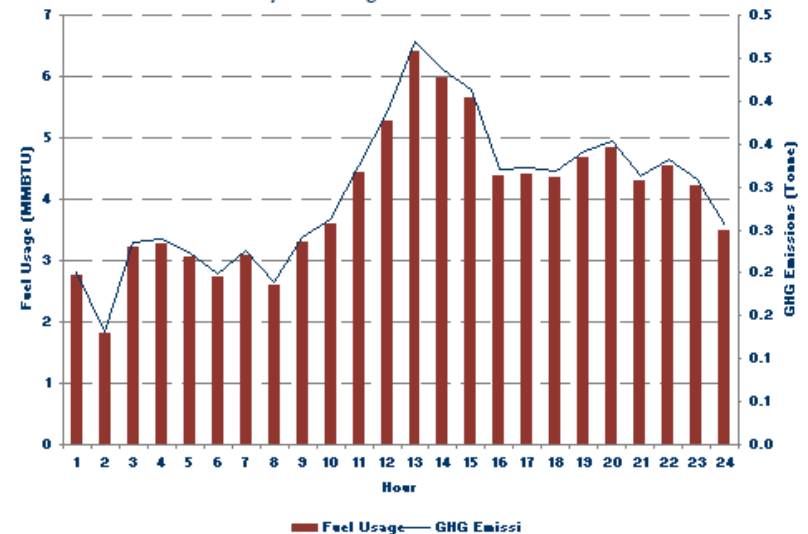
Daily Fuel Usage and GHG Emissions



Hourly Demand Supply Balance and Fuel Cost



Hourly Fuel Usage and GHG Emissions



PATREM Capabilities

- **The tool capabilities include:**
 - *Incorporating 15 minutes step real-time data files for demand and generation;*
 - *Allowing users to use their own equipment parameters;*
 - *Calculating power loss in remote grid (transformers and feeders);*
 - *Calculating fuel consumptions and GHG emissions;*
 - *Investigating and simulating scenarios to improve and optimize the generation/loads performance in remote grid including applying genset dispatch strategies, re-sizing the gensets and applying energy conservation.*
 - *Investigating and simulating scenarios to integrate renewable resources for operational planning purposes (small hydro, wind, PVs {assumed centralized}).*

Project manager: Tarek.El-fouly@NRCan.gc.ca

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Smart Microgrid Research Network (www.Smart-Microgrid.ca)

Purpose

- Develop Canadian knowledge and expertise in smart grids
- Train highly qualified people to meet the needs of utilities and companies within Canada

Composition

- Over 40 research institutions, utilities, and technology providers and end customers.

Themes

- Operation, control, and protection
- Planning, optimization, and regulatory issues
- Communication and information technologies

Funded by the National Science and Engineering Research Council (NSERC) and contributing research partners

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Smart Microgrid Network Meetings (NSMG-Net)



Microgrid 2010 Workshop, Vancouver



NSMG-Net 2011 AGM, Toronto



NSMG-Net 2012 AGM, Montreal



NSMG-Net 2013 AGM, Vancouver



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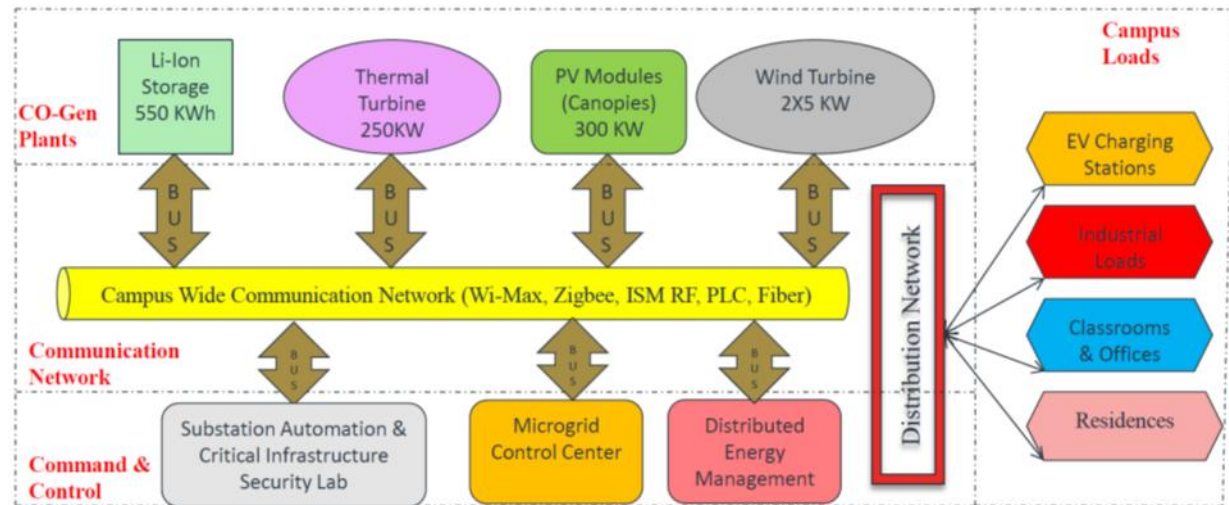
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Highlights:

BCIT Campus Microgrid



Source Hassan Farhangi, BCIT , www.smart-microgrid.ca/publications/

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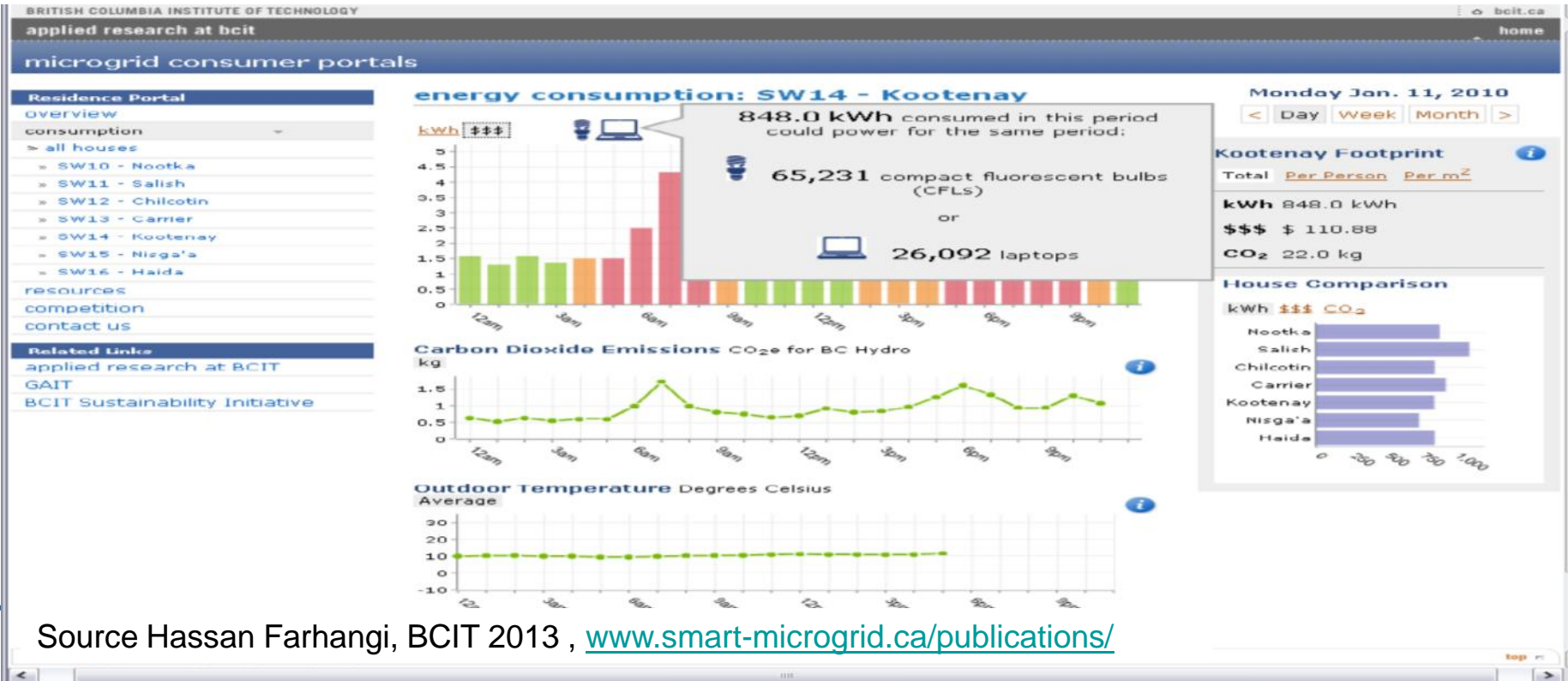
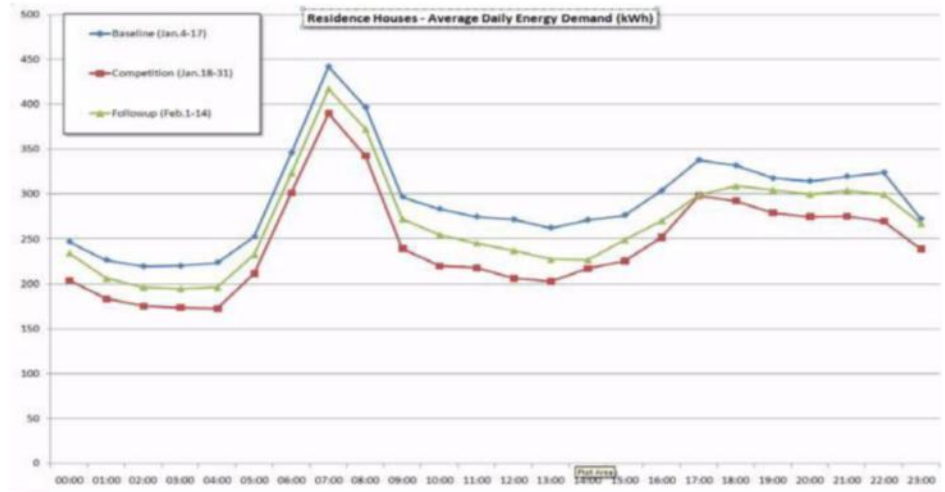


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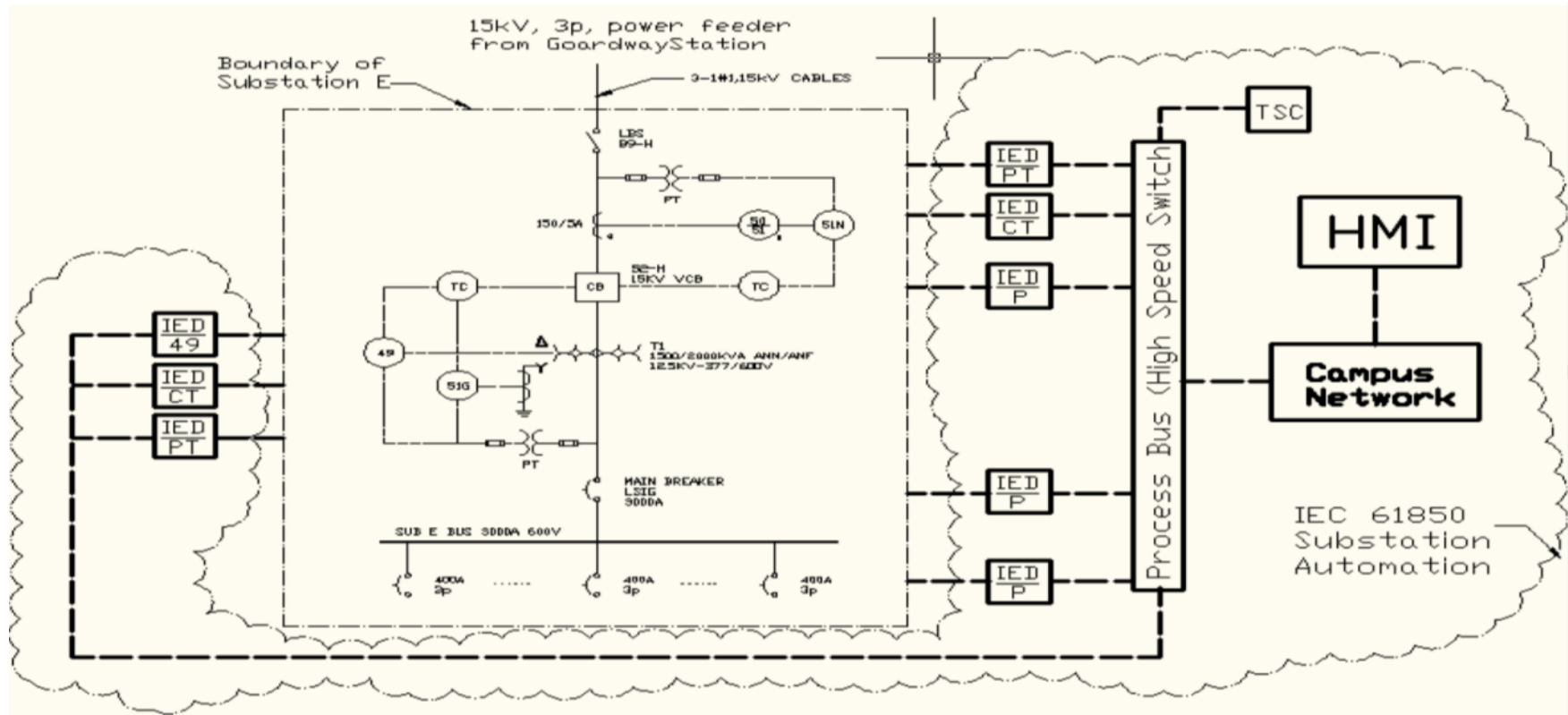
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BCIT Campus Consumer Portal and DR Results Student Residence Competition



BCIT Campus – Substation Retrofit and Implementation of IEC 61850 Standard



Existing BCIT Substation E

Retrofits for IEC-61850

Source Hassan Farhangi, BCIT , www.smart-microgrid.ca/publications/

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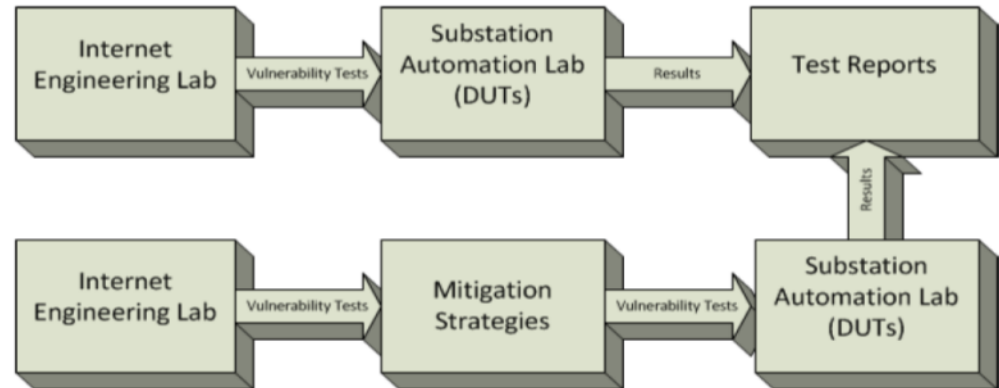
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BCIT Microgrid - Critical Infrastructure Security Test Lab

- Broad range of vulnerability testing: Scada, firewall, malformed data packets, network performance, etc.
- Testing relays IEC61850 and interoperability : ABB, SEL, Schneider, Siemens-RuggedCom.



Source Hassan Farhangi, BCIT , www.smart-microgrid.ca/publications/

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Microgrid Publications

1. Arefifar, S.A.; Mohamed, Y.A.I.; EL-Fouly, T. H M, "**Supply-Adequacy-Based Optimal Construction of Microgrids in Smart Distribution Systems**," *IEEE Transactions on Smart Grid*, vol.3, no.3, pp.1491-1502, Sept. 2012.
2. Arefifar, S.A.; Mohamed, Y.A.-R.I.; EL-Fouly, T.H.M., "**Optimum Microgrid Design for Enhancing Reliability and Supply-Security**," *IEEE Transactions on Smart Grid* , vol.4, no.3, pp.1567,1575, Sept. 2013.
3. Kamh, M.Z.; Iravani, R.; El-Fouly, T.H.M., "**Realizing a smart microgrid — Pioneer Canadian experience**," *Power and Energy Society General Meeting, IEEE*, 22-26 July 2012.
4. Kamh, M.Z., Iravani, R, **Advanced Feeder Automation and Fault Detection Techniques for a BCIT Microgrid**, Report # 2012-271 (RP-TEC) , CanmetENERGY, Varennes Research Centre, Natural Resources Canada.
5. Kamh, M.Z., Iravani, R, **Modeling and Simulation of BCIT Campus Microgrid with Multiple On-site DER Units**, Report # 2012-272 (RP-TEC), CanmetENERGY, Varennes Research Centre, Natural Resources Canada.
6. Wrinch, M.; EL-Fouly, T. H M; Wong, S., "**Demand response implementation for remote communities**," *Electrical Power and Energy Conference (EPEC)*, *IEEE*, pp.1-5, 3-5 Oct. 2011.
7. Wrinch, M.; Dennis, G.; EL-Fouly, T.H.M.; Wong, S., "**Demand response implementation for improved system efficiency in remote communities**," *Electrical Power and Energy Conference (EPEC)*, *IEEE*, pp.105-110, 10-12 Oct. 2012.

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