

# Microgrid Research Activities in Canada

Jeju 2011 Symposium on Microgrids  
May 26-27, 2011



Steven Wong - CanmetENERGY



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada 

# Outline



- Introduction and Theme
- Smart Microgrids
- Smart Zones
- Remote (Isolated) Communities
- Summary
- Appendix
  - Publications

# Smart Microgrids

## Motivation and Drivers



- Microgrids are a step to smart grid adoption
  - Necessary to demonstrate and ease transition for incumbent utilities
  - Necessary for the adoption of intermittent energy sources and achievement of clean energy goals
  - Necessary for GHG reductions from transportation sector

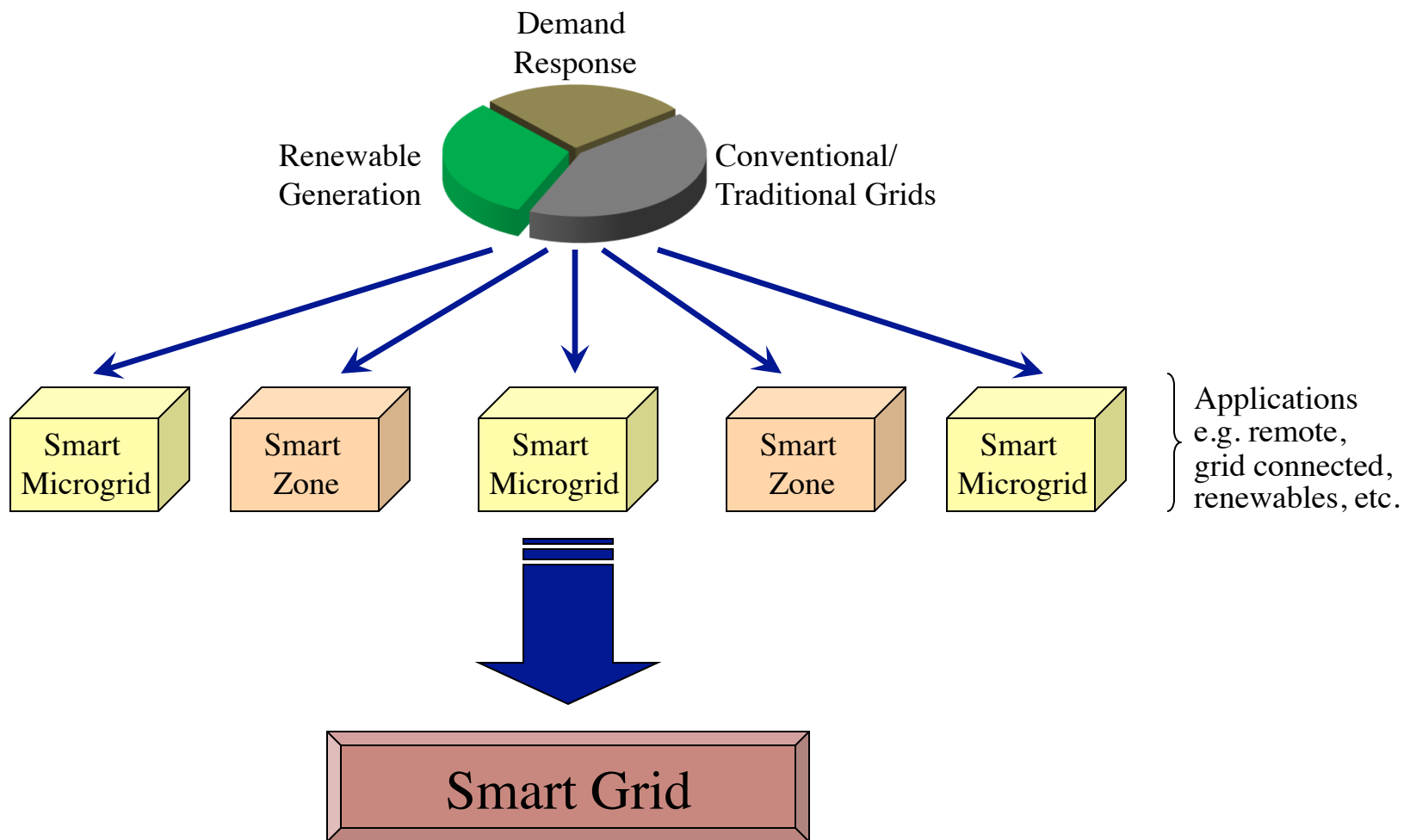
“Canada faces \$62 billion (2010 dollars) of distribution investments over the next 20 years.”

- The Conference Board of Canada

[http://www.conferenceboard.ca/press/newsrelease/11-04-07/Investment\\_Of\\_More\\_Than\\_15\\_Billion\\_Annually\\_Would\\_Meet\\_Future\\_Electricity\\_Needs.aspx](http://www.conferenceboard.ca/press/newsrelease/11-04-07/Investment_Of_More_Than_15_Billion_Annually_Would_Meet_Future_Electricity_Needs.aspx)

# Smart Microgrids

## Smart Grid/Microgrid Vision



# Smart Microgrids

## Canadian S.M.G. Research Network



- Over 10 research institutions, 8 utilities and 24 technology providers/end customers
- Testbed at BCIT
- Research themes
  1. Operation, control, and protection
  2. Planning, optimization, and regulatory issues
  3. Communication and information technologies

[http://www.nserc-crsng.gc.ca/Partners-Partenaires/Networks-Reseaux/NSMGNet-NSMGNet\\_eng.asp](http://www.nserc-crsng.gc.ca/Partners-Partenaires/Networks-Reseaux/NSMGNet-NSMGNet_eng.asp)



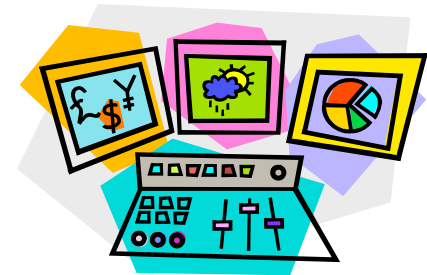
People. Discovery. Innovation.

# Smart Microgrids

## Network – Theme 1



- *Operation, Control, and Protection of Intelligent Microgrids*
  - Control, Operation, and Renewables for Remote Microgrids (*Univ. of Toronto*)
  - Distributed Control, Hybrid Control, and Power Management (*Univ. of Toronto*)
  - Status Monitoring, Disturbance Detection, Diagnostics, and Protection (*Univ. of Alberta*)
  - Operational Strategies and Storage Technologies to Address Barrier for Very High Penetration of DG Units (*McGill*)



# Smart Microgrids

## Network – Theme 2



- *Intelligent Microgrid Planning, Optimization and Regulatory Issues*
  - Cost-benefits Framework - Secondary Benefits and Ancillary Services (*McGill*)
  - Energy and Supply Security Considerations (*Univ. of Toronto*)
  - Demand Response Technologies and Strategies - Energy Management and Metering (*Univ. of Waterloo*)
  - Integration Design Guidelines and Performance Metrics - Study Cases (*Univ. of Manitoba*)

# Smart Microgrids

## Network – Theme 3



- *Intelligent Microgrid Communication and Information Technologies*
  - Universal Communication Infrastructure (*UBC*)
  - Grid Integration Requirements, Standards, Codes and Regulatory Considerations (*McGill*)
  - Distribution Automation Communications: Sensors, Condition Monitoring and Fault Detection (*Univ. of New Brunswick*)
  - Integrated Data Management and Portals (*BCIT*)





# Smart Microgrids

## Selected Projects (Grid Connected)



Energy Storage and Demand Response for  
Near-Capacity Substation

BC Hydro (Clean Energy Fund)

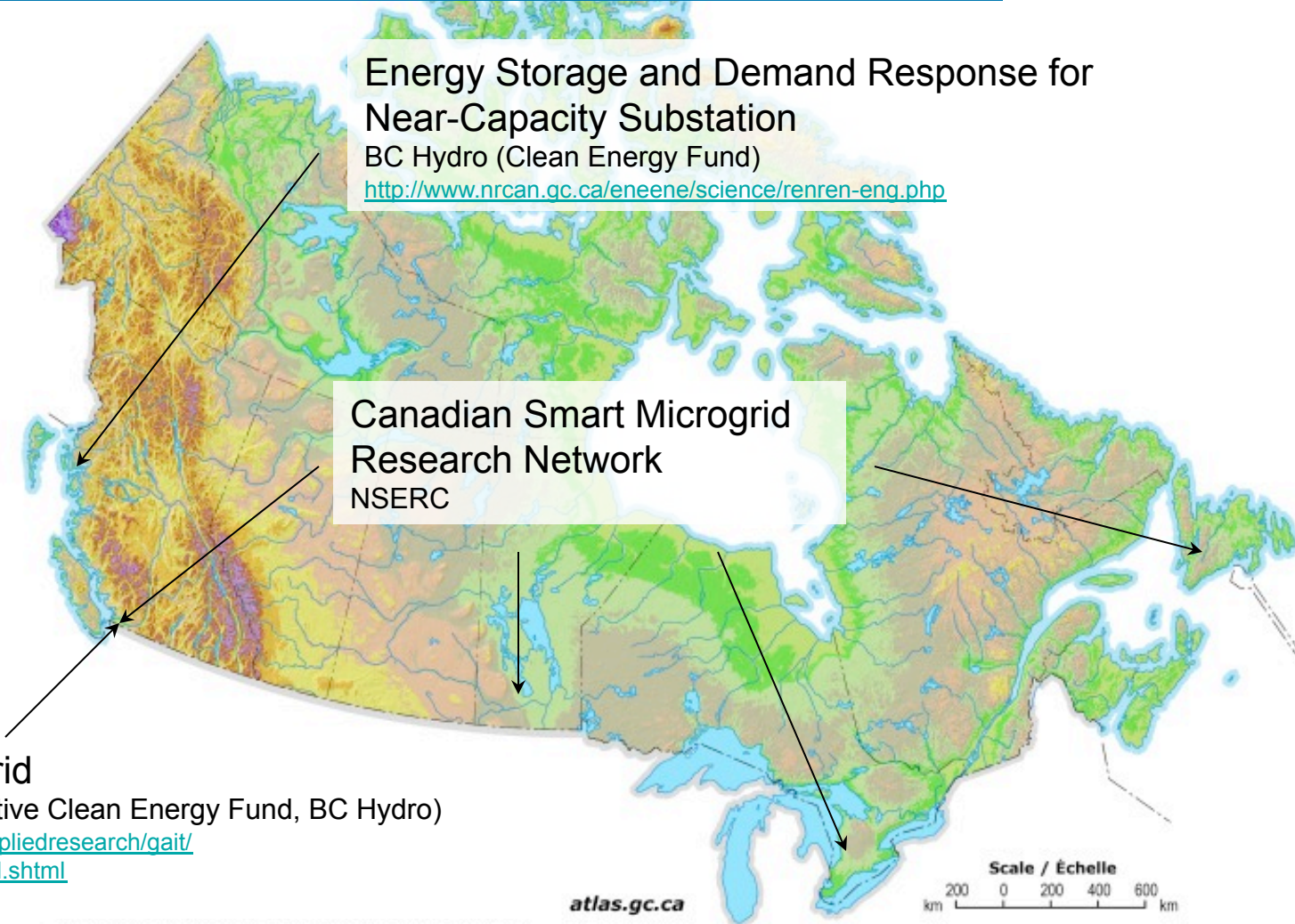
<http://www.nrcan.gc.ca/eneene/science/renren-eng.php>

Canadian Smart Microgrid  
Research Network  
NSERC

BCIT Microgrid

BCIT (BC Innovative Clean Energy Fund, BC Hydro)

<http://www.bcit.ca/appliedresearch/gait/focusareas/smartgrid.shtml>

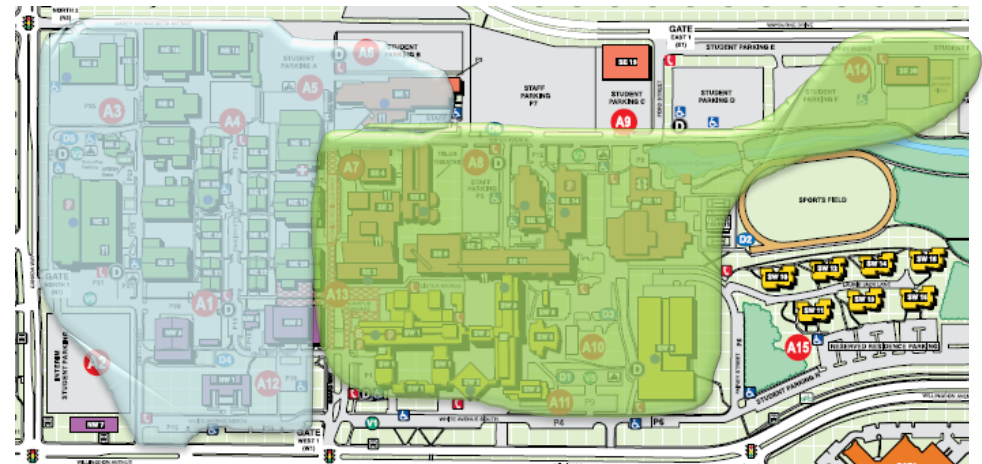
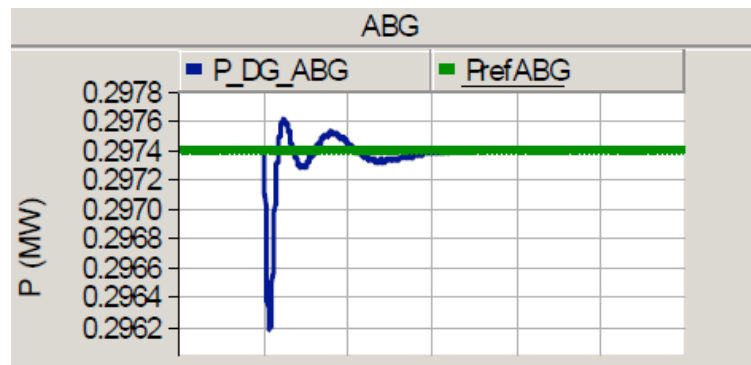


# Smart Microgrids

## Smart EcoCampus Microgrid Research Project



- Simulate BCIT campus (microgrid) with DER
  - CHP microturbines
  - Distributed storage – deep cycle batteries
- Examine control strategies (switching) during grid connected, islanded and transition modes



# Smart Microgrids

## Smart EcoCampus Microgrid Research Project

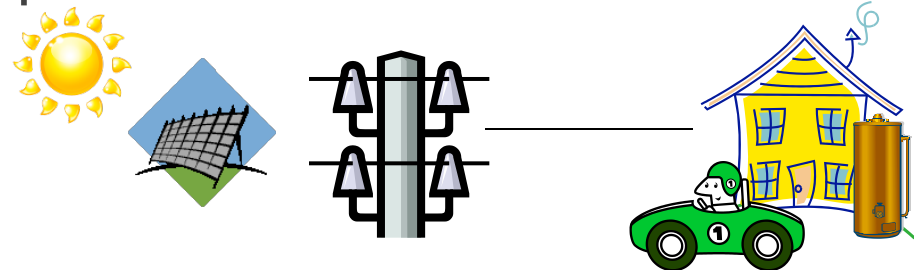


- Communication infrastructure
  - Multiple technologies installed and tested in harsh environments
  - Intelligent agent based energy management software under development
- Field tests for DR/DM
  - SMIs and Smart Appliances
  - Various demand response structures tested

# CanmetEnergy/SmartZone

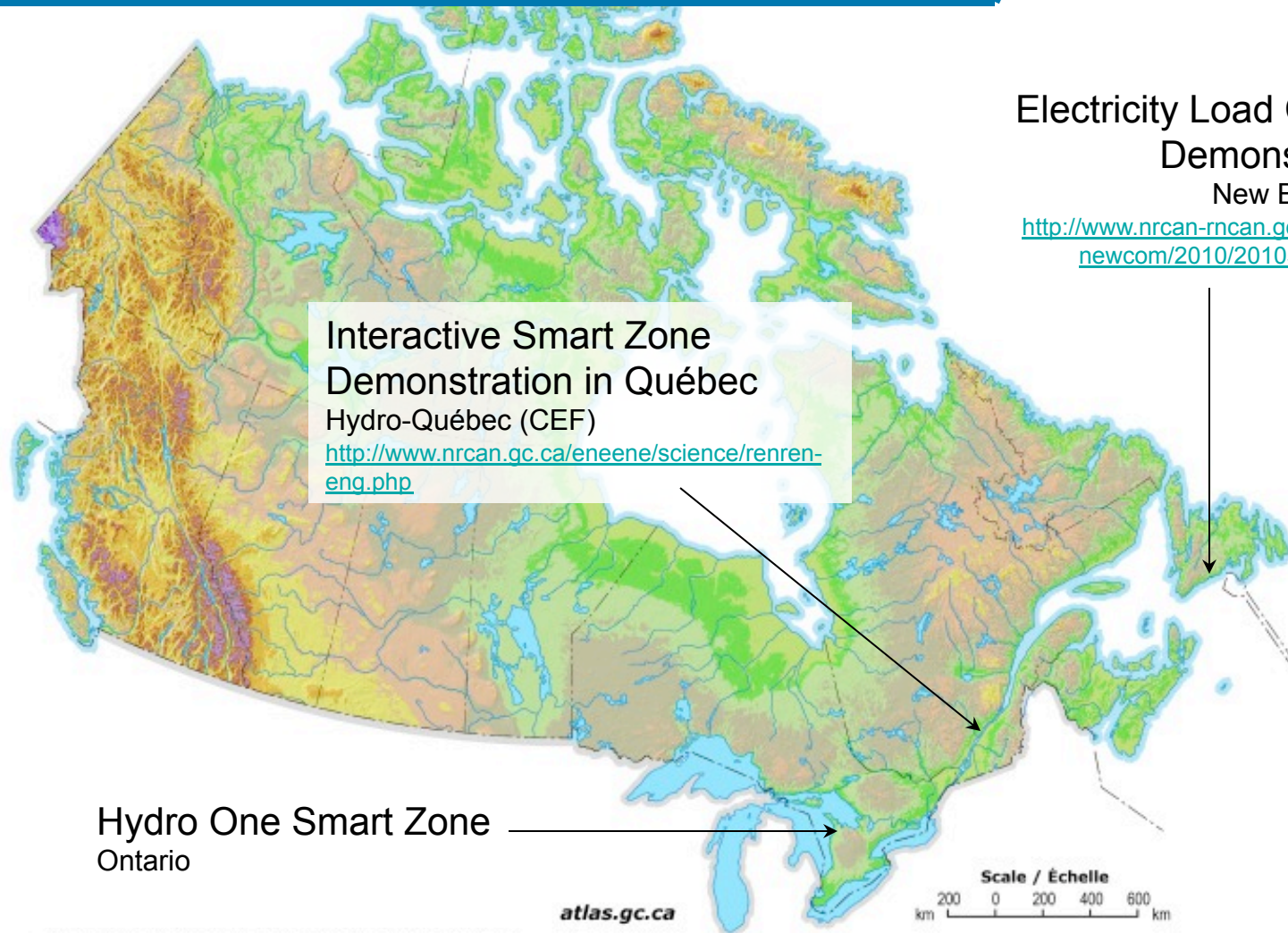


- Model power flow in an interactive area
  - Renewable DG, storage, demand response, PHEV/PEV, feeders, etc.
- Investigate and assess
  - Performance of grid architecture and equipment
  - Impact of climatic variability on generation and load profiles
  - Mobility, and storage patterns





# Selected Smart Zone Demonstrations



# Remote Microgrids

## Motivation and Drivers



- Canada has 300 remote (isolated) communities, home to 200,000 people.
- Majority rely on fossil fuel generation e.g. diesel, natural gas
- Microgrid concepts creates opportunities for
  - Reduced fuel consumption (and GHG emissions)
  - Increased renewables
  - Empowerment

# Remote Microgrids

## Selected Projects



### Hartley Bay, BC

Village of Hartley Bay, Pulse Energy (ICE)

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

### Bella Coola, BC

BC Hydro, GE, PowerTech (Gov't of BC, Sustainable Development Technology Canada)

<http://www.powertechlabs.com/news-room/press-releases/bc-community-to-reduce-ghg-emissions-with-hydrogen-assisted-renewable-power-system-harp/>

### Nemiah Valley, BC

NRCAN

[http://canmetenergy-canmetenergie.nrcan-nrcan.gc.ca/eng/renewables/integration\\_der/publications.html?2011-015](http://canmetenergy-canmetenergie.nrcan-nrcan.gc.ca/eng/renewables/integration_der/publications.html?2011-015)

### Ramea Island, NL

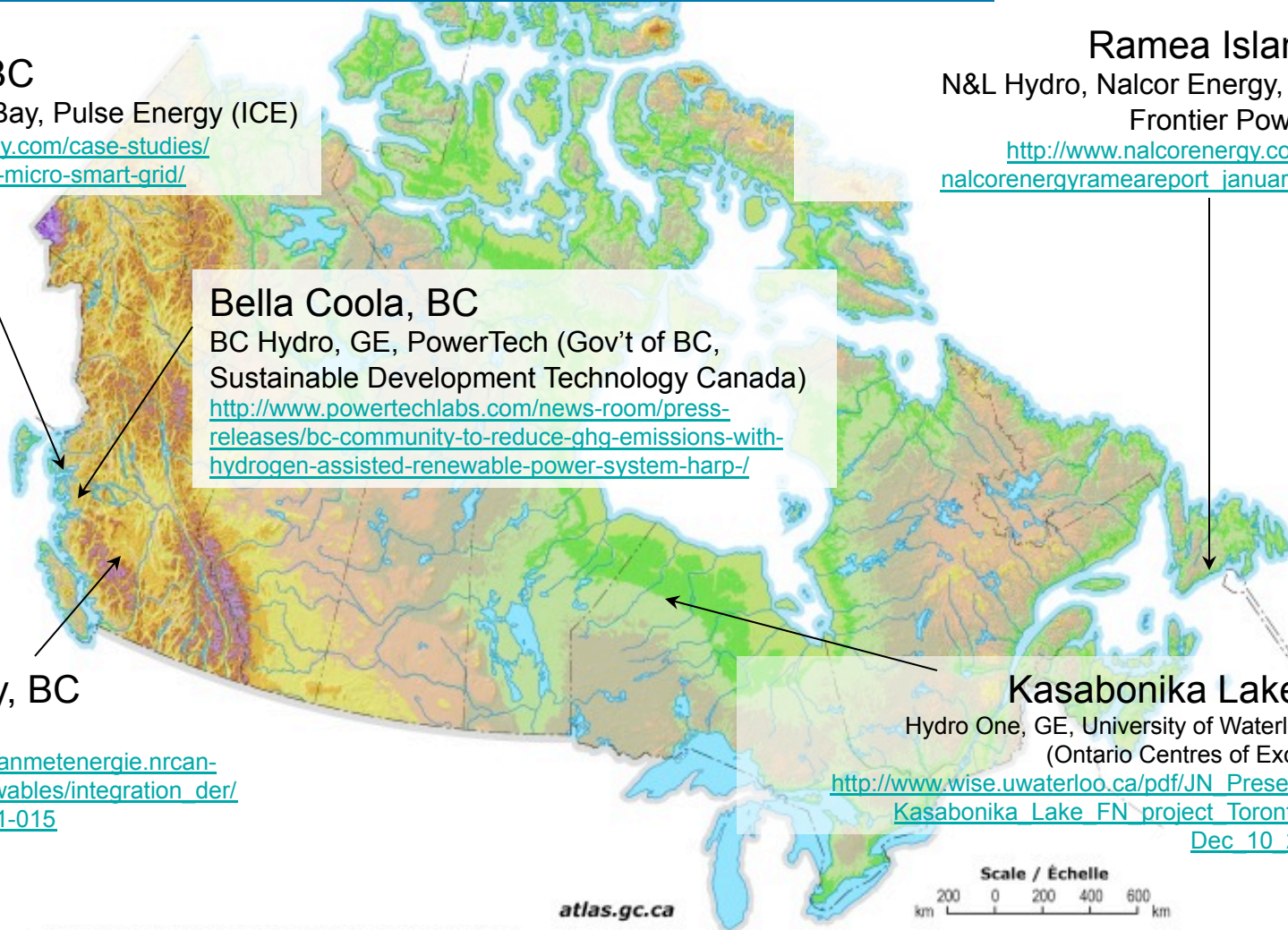
N&L Hydro, Nalcor Energy, NRCAN, Frontier Power, et al.

[http://www.nalcorenergy.com/assets/nalcorenergyrameareport\\_january2010.pdf](http://www.nalcorenergy.com/assets/nalcorenergyrameareport_january2010.pdf)

### Kasabonika Lake, ON

Hydro One, GE, University of Waterloo, et al. (Ontario Centres of Excellence)

[http://www.wise.uwaterloo.ca/pdf/JN\\_Presentations/Kasabonika\\_Lake\\_FN\\_project\\_Toronto\\_MAA-Dec\\_10\\_2009.pdf](http://www.wise.uwaterloo.ca/pdf/JN_Presentations/Kasabonika_Lake_FN_project_Toronto_MAA-Dec_10_2009.pdf)



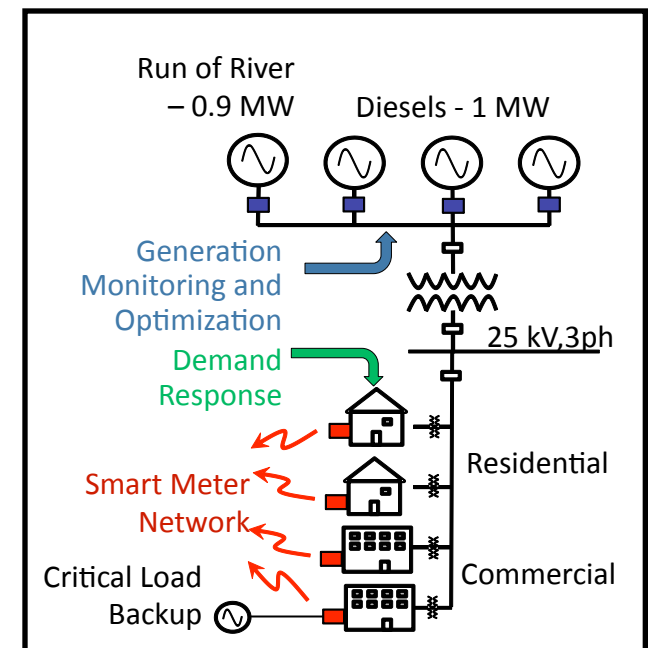
Scale / Échelle  
200 0 200 400 600  
km km

# Hartley Bay

## Energy Management and RoR Hydro



- Remote northern community in BC
  - Population: 200
  - Average demand 150 kW to 260 kW
- Projects
  - Energy management system
    - w/ Pulse Energy
  - Asset management
  - Run-of-river hydro



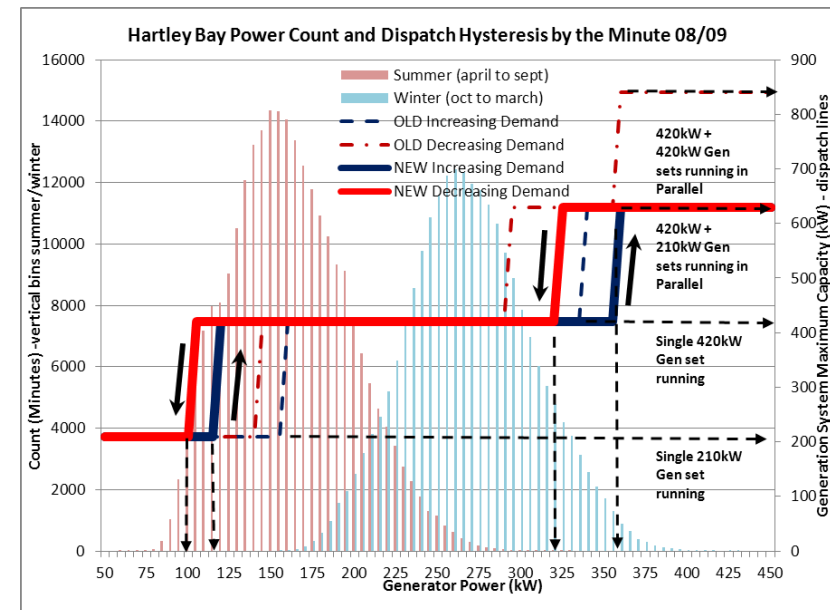
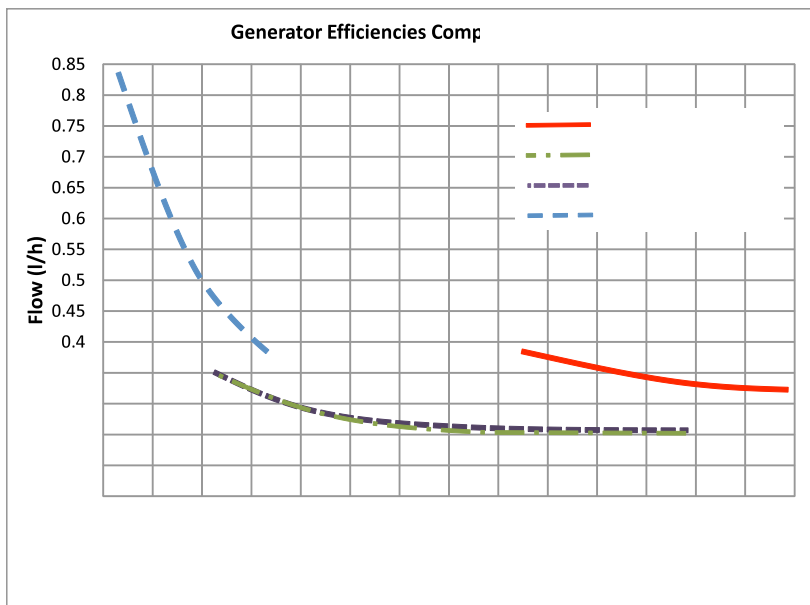


# Hartley Bay

## Energy Management and RoR Hydro



- Adjust diesel generator setpoints
  - Operate closer to nameplate
- Estimated \$77,000 in annual savings

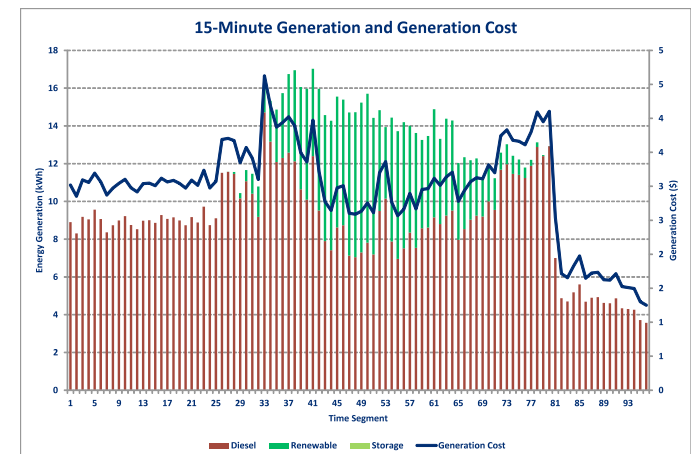


# Remote Microgrids Dispatch Tool



- Simple to use Excel based tool
- Analyzes diesel generator dispatch options
- Models:
  - Demand (15 min intervals for 1 year)
  - Supply from renewables
  - Feeders and transformers

‘Beta’ TBA



# Course on Microgrids



- Introduces power engineers to microgrids, including their characteristics; islanding and protection; and operation and control.
- Presentation and course notes will be available for free:  
[http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/integration\\_der/training\\_courses.html](http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/integration_der/training_courses.html)

## Available Soon!

# Selected 2010/2011 Canadian Publications



- M. B. Delghavi and A. Yazdani, "An Adaptive Feedforward Compensation for Stability Enhancement in Droop-Controlled Inverter-Based Microgrids," to appear in IEEE Transactions on Power Delivery, Paper no. TPWRD-00617-2010, accepted February 2011.
- A. Zamani, T. S. Sidhu and A. Yazdani, "A Protection Strategy and Microprocessor-Based Relay for Low-Voltage Microgrids," to appear in IEEE Transactions on Power Delivery, Paper no. TPWRD-00749-2010, accepted February 2011.
- A. Mehrizi-Sani and R. Iravani, "Potential Function Based Control of Microgrid in Grid-Connected and Islanded Modes", to appear in the IEEE Trans. On Power Systems
- M. Z. Kamh, and R. Iravani, "Unbalanced Model and Power Flow analysis of Microgrids and Active Distribution Systems", IEEE Trans. Vol. TPWRD-25, No. 4, pp. 2851-2158, October 2010
- Jinwei He; Yun Wei Li; , "Analysis and design of interfacing inverter output virtual impedance in a low voltage microgrid," Energy Conversion Congress and Exposition (ECCE), 2010 IEEE , vol., no., pp.2857-2864, 12-16 Sept. 2010
- Yan Li; Yun Wei Li; , "Power Management of Inverter Interfaced Autonomous Microgrid Based on Virtual Frequency-Voltage Frame," Smart Grid, IEEE Transactions on , vol.2, no. 1, pp.30-40, March 2011
- Y. A.-R. I. Mohamed and A. Radwan "Hierarchical control for robust micro-grid operation and seamless mode transfer in active distribution systems," IEEE Transactions on Smart Grid, in press.

# Questions

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Steven Wong

CanmetENERGY, Natural Resources Canada,  
1615 Lionel-Boulet Blvd., PO Box 4800,  
Varennnes, Quebec, CANADA J3X 1S6

[st Wong@nrcan.gc.ca](mailto:st Wong@nrcan.gc.ca)

[http://canmetenergy.nrcan.gc.ca/eng/renewables/integration\\_der.html](http://canmetenergy.nrcan.gc.ca/eng/renewables/integration_der.html)