NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

Remote Northern Microgrids in Canada

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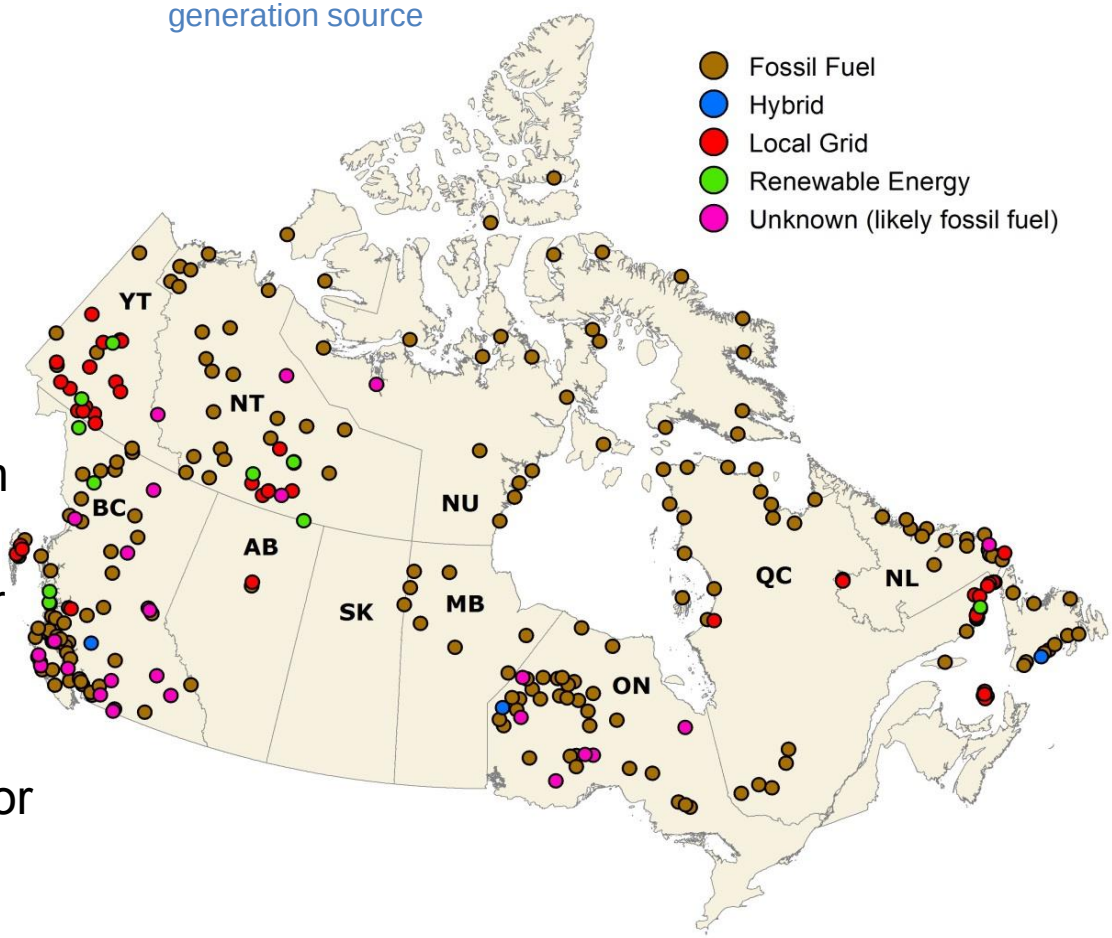
Remote Communities in Canada

- Mainly 3 territories and 4 provinces
  - Approximately 291 communities (~ 195,000 ppl)
  - 170 Aboriginal communities (~ 130,000 ppl)

- Many fly-in communities with no roads
  - Sea-lift (boat) in summer
  - Air-lift (plane) in winter (long)
  - Some have “ice” roads for winter delivery

Approx. 79% of remote communities use oil-based fuel as their main electricity generation source



Northwest Territories Microgrid

- Cost of electricity is very high (i.e. un-subsidized costs range from 0.65 to 2.30$ per kWh)
- Population est. 2015: 43,595
- Solar PV strategy :
  - NWT has a goal to deploy PV systems up to 20% of the average load in diesel communities
  - Investigating ways to deploy solar systems sized at up to 75 % of the average load
  - Net-metering policy 2014

Source : Northwest Territories Government Energy Action Plan report:
http://www.iti.gov.nt.ca/publications/northwest-territories-energy-action-plan-december-2013
Source: IEA-RETD Residential Prosumer study:
http://iea-retd.org/wp-content/uploads/2014/09/RE-PROSUMERS_IEA-RETD_2014.pdf

Solar PV in the NWT

(last updated in July 2015; 36 PV systems)

Sachs Harbour: 1 system, 4.3 kW

Paulatuk: 2 systems, 6.7 kW

Colville Lake: 1 system, 135 kW

Fort Good Hope: 1 system, 5.0 kW

Tulita: 1 system, 10 kW

Gameti: 1 system, 5.0 kW

Wekweeti: 1 system, 4.2 kW

Whati: 1 system, 5.0 kW

Fort Simpson: 4 systems, 119 kW

Nahanni Butte: 1 system, 4.8 kW

Jean-Marie River: 1 system, 1.3 kW

Fort Liard: 1 system, 20 kW

Inuvik: 5 systems, 26.5 kW

Norman Wells: 1 system, 2.9 kW

Behchoko: 1 system, 4.8 kW

Edzo: 1 system, 5.0 kW

Yellowknife: 6 systems, 48.5 kW

Fort Providence: 1 system, 15 kW

Lutsel K'e: 1 system, 35 kW

Hay River: 3 systems, 62.5 kW

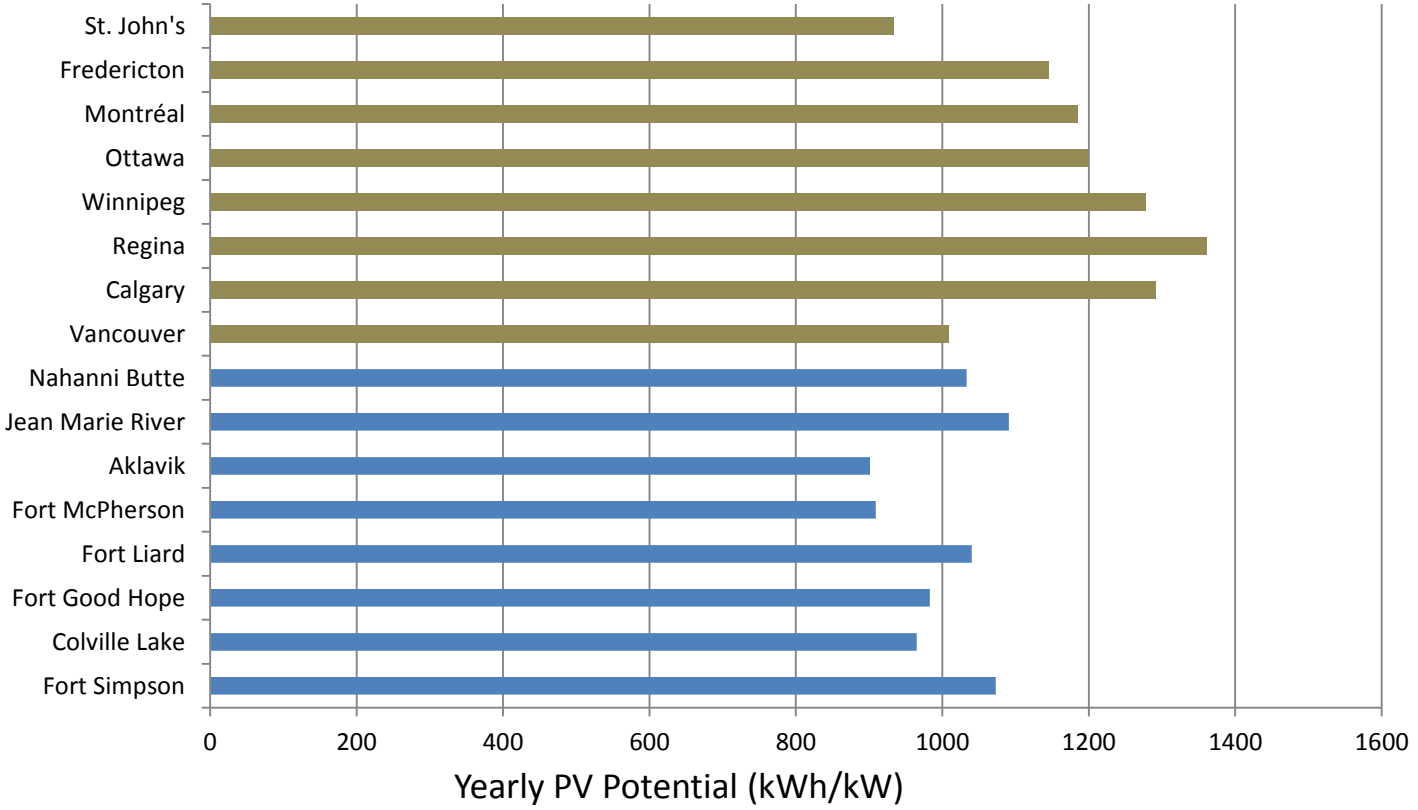
Fort Smith: 1 system, 0.5 kW

Dispelling the Myth – Northern PV Potential

The PV potential is not nearly as different as might be expected…

Major Canadian Cities
933 – 1361 kWh/kW

Remote NWT communities
901 – 1091 kWh/kW



…and the cost of diesel electricity production in the NWT makes PV very competitive

Optimized PV-Diesel Microgrid

The benefits of PV offsetting diesel consumption **aren't realized unless** diesel controls and demand management are optimized for fuel efficiency.

Ways to optimize this are:

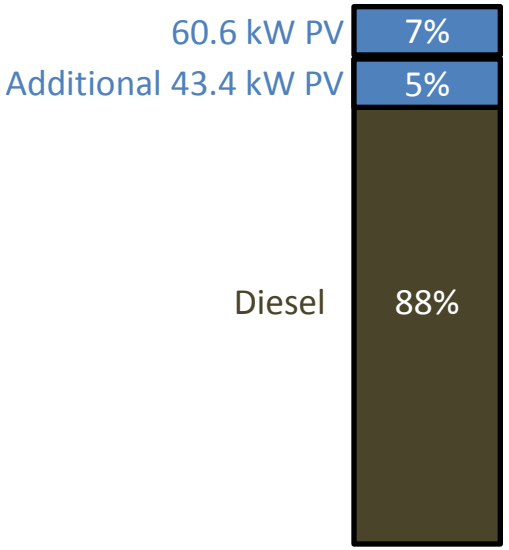
1. Optimizing the diesel generator sizing and controls - if PV production is high, a large generator can be turned off and a smaller generator turned on
2. Implementing demand side management program in the communities

Diesel fuel savings or GHG offsets

Fort Simpson PV-Diesel Microgrid

- First large government utility owned PV system in 2012
- 104 kW of PV installed in a northern location and operated by Northwest Territories Power Corporation (NTPC)
- Funded by Government of NWT

Fort Simpson power System

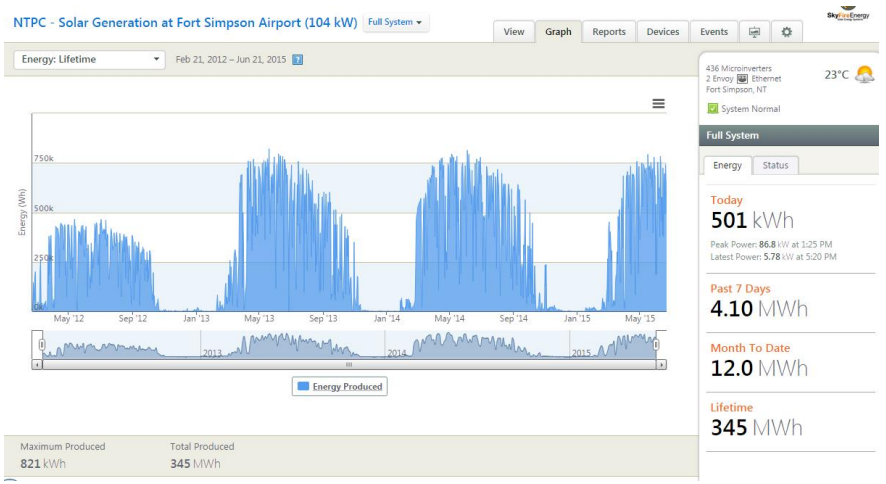


Research interests :

- Improve NRCan Solar PV map accuracy north of 60th parallel:

  http://pv.nrcan.gc.ca/index.php?n=1293&m=u&lang=e

- Monitor performance of modules and degradation rate in Nordic climate compared to moderate climate locations
- Enphase micro-inverter in “extreme” cold weather



Colville Lake Solar PV-Battery-Diesel Integration

- 135 kW of solar PV installed and 200 kWh lithium-ion batteries in ISO 20-foot container to withstand extreme arctic conditions down to -50°C (commissioning Sept. 2015)
- Target annual savings of between 12,000 and 15,000 litres of diesel per year - reduce diesel engine runtime by up to 25 per cent in the winter and up to 75 per cent in the peak summer months.
- Optimize operation in diesel saving and diesel-off mode during the summer months

Source: NTPC https://www.ntpc.com/smart-energy/how-to-save-energy/colville-lake-solar-project

Wind-Diesel Microgrid
Diavik Mine – Northwest Territories

2014 wind farm results	
Energy produced	19.9 gigawatt hours*
% availability	97.5%
Diesel offset	4.9 million litres
CO_2-e offset	14,068 tonnes
Fuel savings	~$6 million
11% of mine's power	

* 19.9 gWh would power 37,300 sixty watt light bulbs for 1 year.

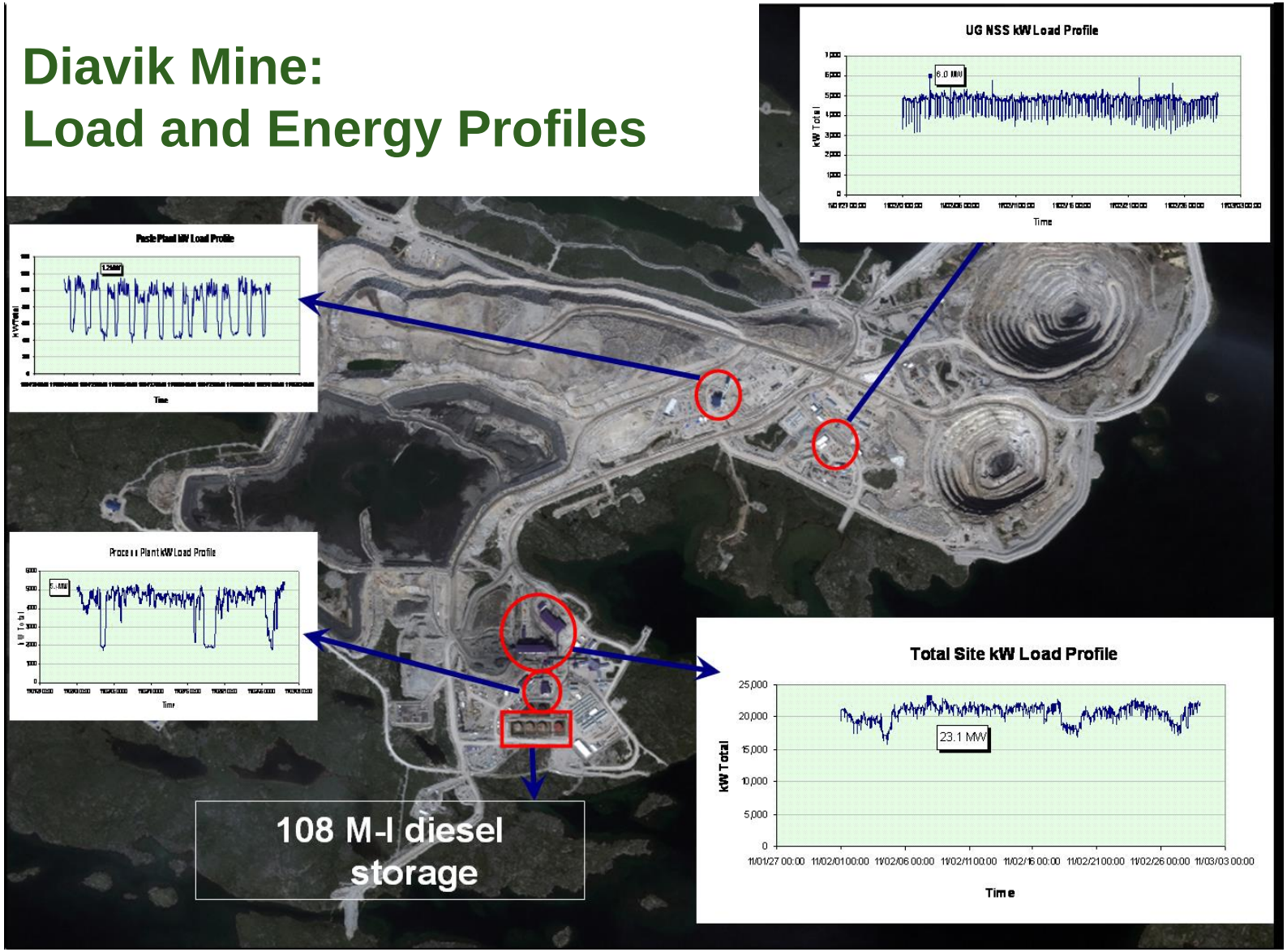
Results since start up*	
Energy produced	38.9 gigawatt hours
% availability	89.7%
Diesel offset:	9.6 million litres
Carbon CO_2-e offset	27,367 tonnes
Fuel savings	~$11.5 million
Peak power penetration	55%
10% of mine's power needs	

* October 2012 to December 2014.

- Wind plant availability 97.5% in 2014!
- Arctic mine with wind-diesel microgrid
- 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

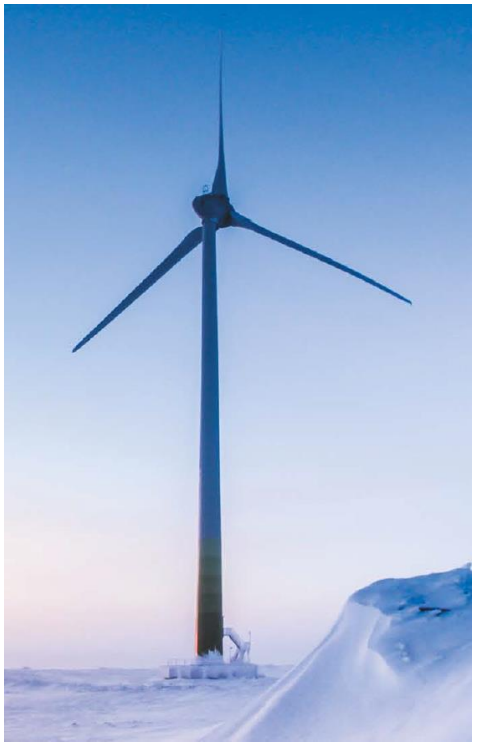
Source:
- http://www.nrcan.gc.ca/mining-materials/publications/aboriginal/bulletin/8816
- Sustainability Report March 2015: http://www.ddcorp.ca/docs/default-source/default-document-library/diavik-2014-sustainable-development-report.pdf?sfvrsn=2

Diavik Mine: Load and Energy Profiles



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

Second Wind-Diesel Microgrid, Raglan Mine, Nunavik Region, Quebec

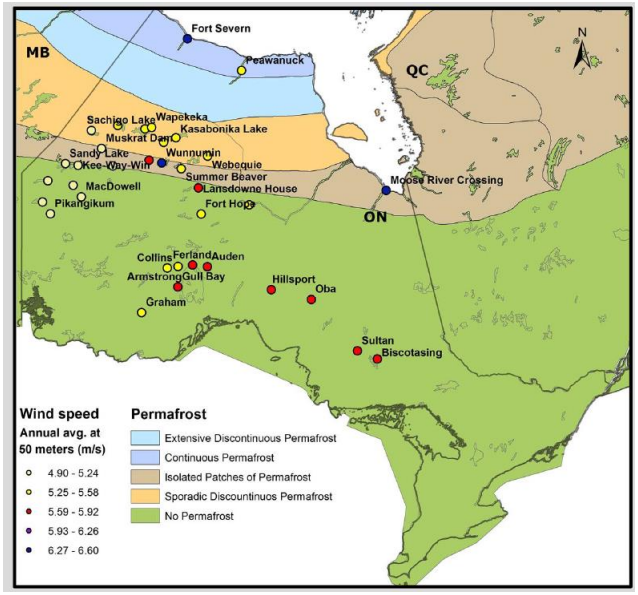


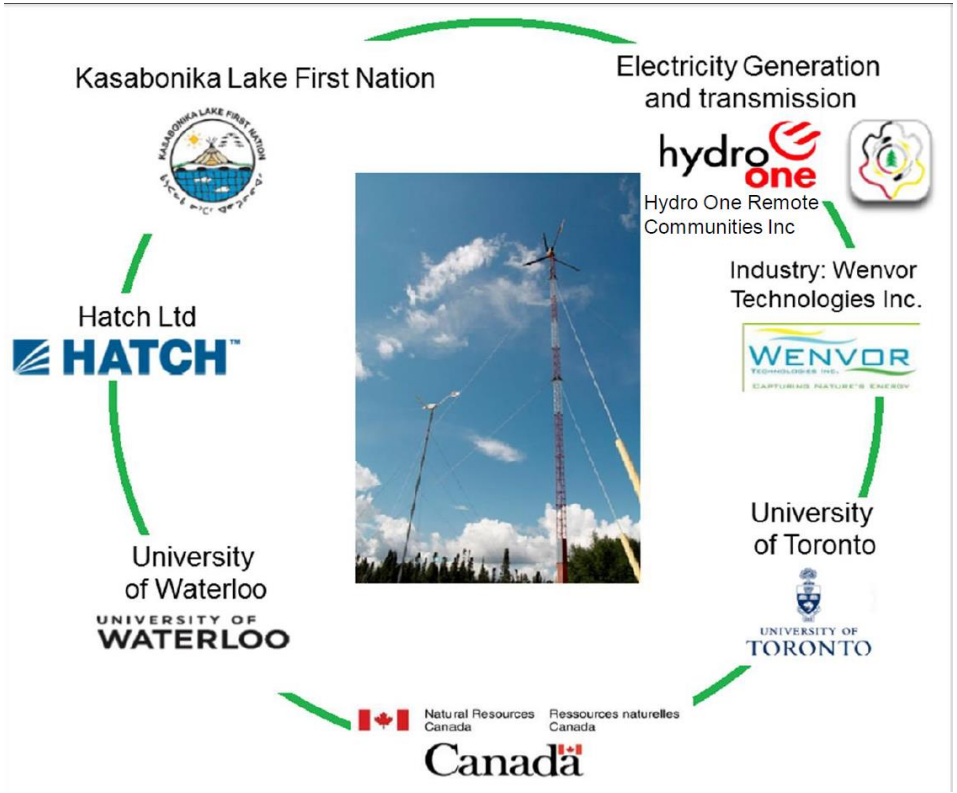
- Five-year project aims to significantly reduce the remote Raglan Mine's reliance on diesel and improve its emissions performance
- First 3 MW Enercon wind turbines installed in 2015 with heated blade, special permafrost steel-base foundation, high wind resistance (withstanding blizzards of over 120 km/h and operate in temperatures as low as -40°C)
- Completed full system design including turbine generation, energy storage, and microgrid smart control technologies to achieve high wind-power penetration.
- Research on storage options : flywheel, battery and hydrogen energy to provide active power control, power smoothing, and spinning reserves

Sources: https://www.hatch.ca/AR2015/Hatch-AR15.pdf and http://www.enercon.de/p/downloads/WB_012015_GB.pdf

Kasabonica Remote Microgrid, Northern Ontario

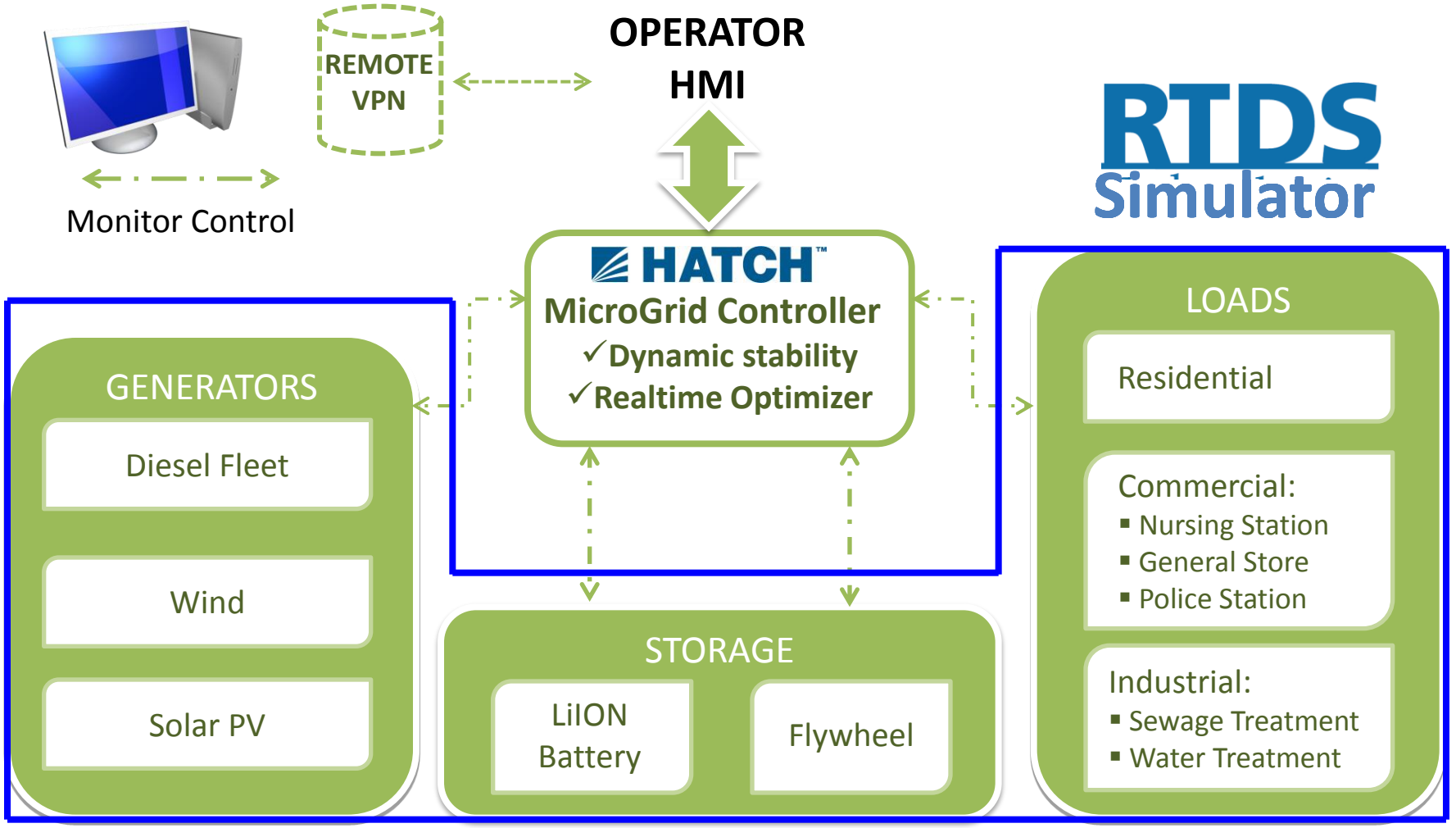
- Development of a "**Utility Grade** Controller for Remote Microgrids with High Penetration Renewable Generation"
- Feasibility and system planning study for wind and PV



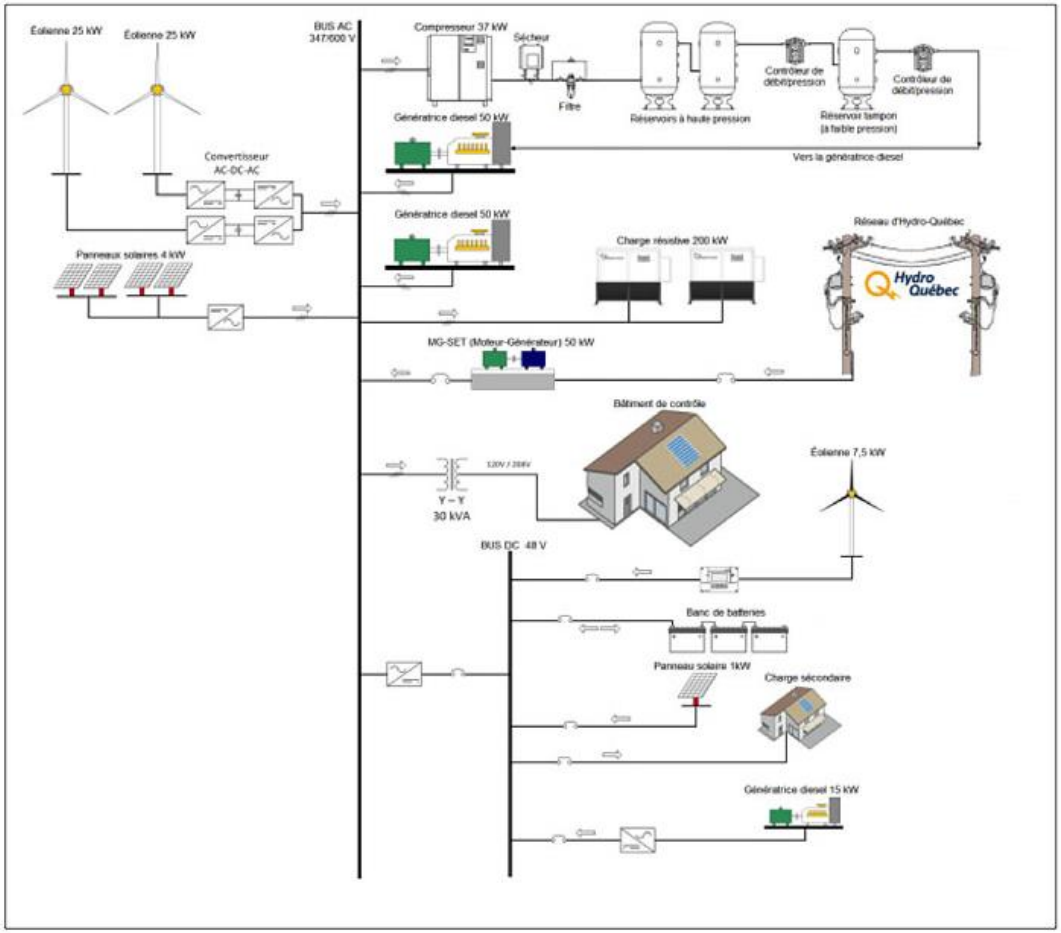


University of Toronto-Hatch Lab Facility

Microgrid Controller-in-the-Loop Simulations



Wind and Microgrid Test Facility - 2015



Annual report TechnoCentre Éolien, Gape, Québec web link:
https://www.eolien.qc.ca/en/documentation-en/annual-reports.html

Characteristics: Two interconnected AC and DC buses.

1) a 4MW wind power plant whose output is distributed via a direct connection to the Utility Distribution Power System North American grid;

2) an AC and DC off-grid system (left diagram of microgrid facility)

Equipment:

- 4 MW wind grid connected and 57.5 kW wind off grid
- photovoltaic power plant
- diesel power plant
- compression, cooling and compressed air storage chain
- heat exchanger
- resistive load
- secondary loads
- battery bench
- measurement instruments and a data acquisition system
- power command and management system
- remote monitoring system
- motor-generator that is used to control the voltage and frequency of the micro-grid
- other equipment such as: control cabinets, interface modules

Cold Climate R&D Collaboration

Renewables in remote Microgrids

September 15th to 17th 2015

Yellowknife, Northwest Territories, Canada.

The conference will bring together 100-150 leading experts, community members, manufacturers and researchers from across North America with the goal of promoting economic development, environmental sustainability and energy security.

http://www.bullfrogpower.com/remotemicrogrids2015/index.cfm

2015 Arctic Energy Summit

28-30 September

Fairbanks, Alaska

https://arcticenergysummit.institutenorth.org/

Alaska Center for Power and Energy: http://acep.uaf.edu/projects/global-applications-program.aspx

Alaska Energy Authority Programs: http://www.akenergyauthority.org/Programs

To learn more about CanmetENERGY Smart Grid Research go to our webpage:
www.nrcan.gc.ca/energy/electricity-infrastructure

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