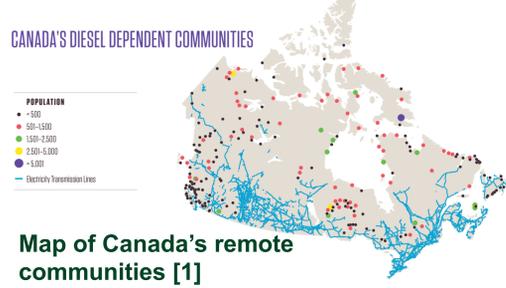


Review of Microgrid Renewable Projects in Northern Canada

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BACKGROUND

Canada's approximately 300 remote communities mostly scattered across the Northern areas are still encountering crucial community electricity access issues and their environmental impact. The access to affordable and effective electricity and heat remains a crucial challenge for Northern remote communities (NRC), forced to rely daily on locally generated electricity from multiple diesel based gensets, powering with fuel transported by water on barges, airplane or winter roads.



DIESEL OPERATION CONCERNS IN NRC [2]

Environmental concerns:

- Diesel powered generators contribute to climate change
- Large risk of fuel spills because of long distances transportation
- High greenhouse gas emissions due to the transportation of fuel on winter roads
- Aging and poorly maintained storage facilities leads to fuel tank leaks which can contaminate the soils and groundwater

Social concerns:

- Emissions from diesel generators could be threatening for the health of local residents
- Generators can be very noisy and disruptive, mainly in quiet remote communities
- Brownouts, power surges and even blackouts can occur if diesel generators are not properly maintained
- Extended power outages result in a lack of drinking water

Economic concerns:

- Electricity loads near the generation capacity limit contributes to high energy expenditures
- High transportation costs of diesel by water on barges, airplane or winter roads
- The high cost of energy and energy supply issues prevent the development of new infrastructures or business in NRC
- The cost of diesel in the future will continue to fluctuate

WHY FOCUS ON RENEWABLE ENERGY (RE) IN NRC

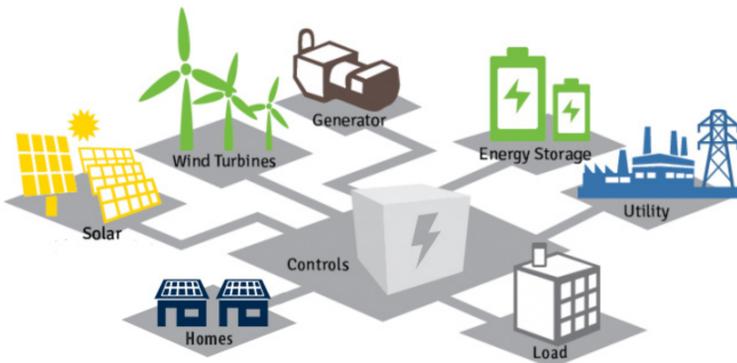
Renewable energy alternatives: Many of the remote communities have access to reliable renewable energy resources which, if efficiently managed can help generate substantial economic development benefits.

Main RE alternatives to diesel generation and used in microgrid system

- Small hydro
- Biomass
- Wind energy
- Solar energy

Benefits of microgrid system [2]

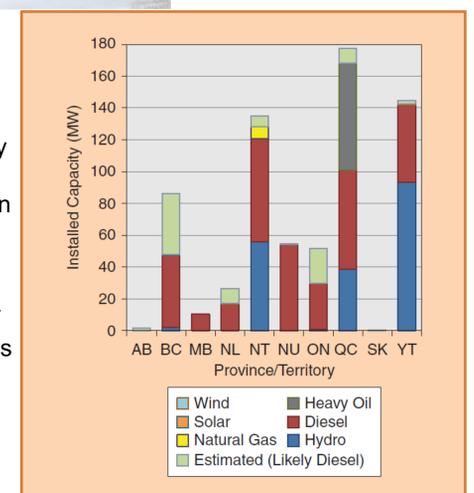
- Energy security
- Reduced environmental impacts
- Clean industry
- Health benefits
- Price hedging
- Shorter development timelines



A smart microgrid system can combine solar, wind power, diesel generators and battery storage to provide consistent and reliable power to consumers



A small wind-solar facility installed at the airport of the remote community of Peawanuck in Ontario [4]



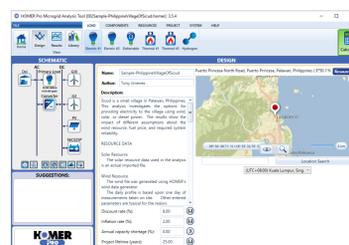
Current electricity generation in NRC: In recent years, many pilots projects have been undertaken for implementing RE in off grid applications, mainly with the effort to reduce reliance on diesel powered generators. Most of the NRC supply electricity via small hydro and oil based resources. The total NRC installed capacity is estimated at 615 MW, with 190 MW of hydropower, 330 MW of diesel powered generators, 67 MW of heavy fuel oil generators, and more than 7.7 MW of natural gas turbines, with the remaining capacity consisting of relatively small wind and solar systems [5]

Electrical equipment installed capacity by province and energy source in NRC [5]

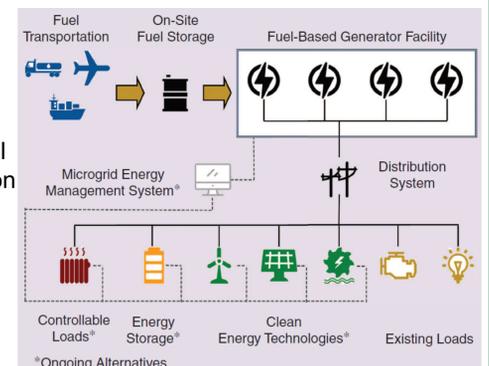
FUTURE DIRECTIONS

Microgrid Research Programme at the UofA:

- Simulation, optimization and sensitivity analysis of microgrid designs with HOMER (Hybrid Optimization Model for Electric Renewables)
 - **Simulation:** perform hourly energy balance of the year to determine feasibility and costs
 - **Optimization:** process of finding the least-cost configuration of a hybrid power system
 - **Sensitivity analysis:** method of examining the effects of variation in external factors (e.g., fuel price, wind speed)
- Implement a microgrid design with high RE penetration in Tuktoyaktuk
- Provide opportunities for training and employment in NRC
- Monitored a small wind generation system in a NRC



The implemented microgrid will be used to manage the injection of the maximum amount of RE without destabilizing the grid stability.



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- [2] Royer J. Natural Resources Canada. Status of remote/off-grid communities in Canada. <http://www.nrcan.gc.ca/energy/publications/sciences-technology/renewable/smartgrid/11916,2011> (Accessed: 2018-01-08).
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- [4] Arriaga M., Ehsan N., and Rutherford H. Renewable energy microgrids in northern remote communities. *IEEE Potentials*, 36:22–29, 09 2017.
- [5] Arriaga M., Cañizares C.A., Kazerani M. Northern Lights: Access to Electricity in Canada's Northern and Remote Communities. *IEEE Power and Energy Magazine*, 12 (4), 50-59, 2014.