Building Sustainable First Nation Communities: Alternative Energy Systems in Ontario's Northern Remote Communities

By Philip R. Walsh and Jason Wu*

Introduction

Ontario has 127 First Nation communities and the largest number of First Nation people in Canada according to the 2006 census. For 29 of these communities located in northern Ontario (See Figure 1) the only way to access them on a year-round basis is to do so by air (versus winter road access). Of these communities, 25 rely on diesel fuel for electricity generation. Typical energy and infrastructure costs in these remote communities are very high compared to those in the grid-connected communities in Southern Ontario for a number of reasons. These include higher transport costs for fuel and equipment, a smaller and more dispersed population, higher operating and maintenance costs, specialized infrastructure required for use in cold climates, and the greater need for space heating. Among the 25 communities, 9 function as Independent Power Authority (IPAs) responsible for their own power generation with support from the Canadian government for purchasing diesel fuel and ensuring that it is delivered to these northern communities via the winter road system. The remaining 16 communities are serviced by Hydro One Remotes Communities Inc., a subsidiary of the Ontario provincially-owned electricity transmission utility.

Over the last decade, these communities have experienced shorter winter road seasons and weaker ice conditions that have limited the amount of diesel fuel that can be trucked and subjecting these communities to the risk of insufficient supply unless supplied by air. This latter supply method is extremely costly. Table 1 highlights the size of certain remote communities, their diesel consumption, electricity output and associated greenhouse gas emissions.

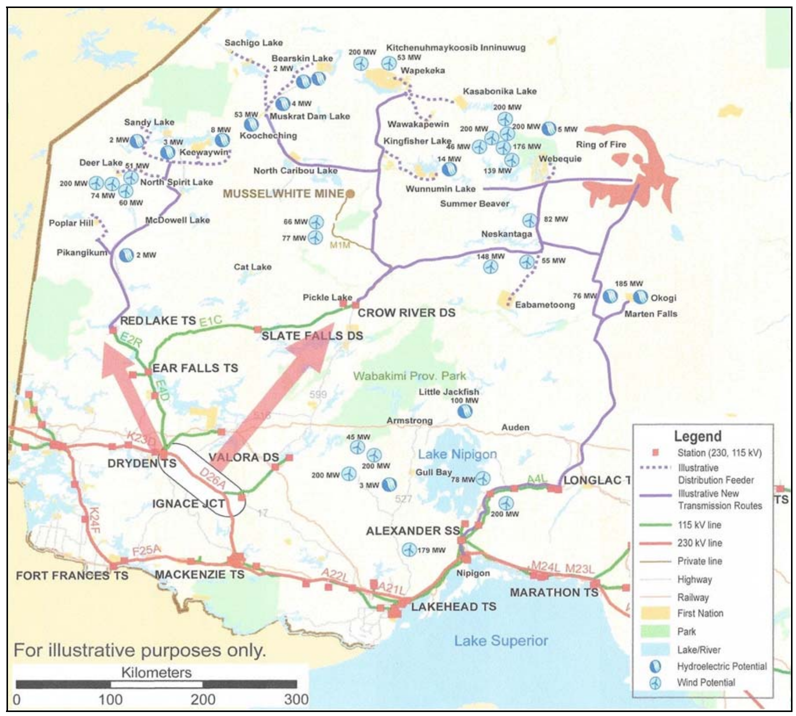

Figure 1. Remote Communities of Northern Ontario with Proposed Transmission Connections

These conditions have also led to increased potential for environmental damage resulting from tanker spills and breaking through the ice roads. Within these communities, large tank farms are used to store the diesel fuel and the electricity generation stations are connected via a distribution system. Again, this distribution format creates environmental risks associated with spills, with the Federal government responsible for remediation.

Demand Side Management in Remote Communities

Studies have shown that the principle demand for electricity in Canada's remote communities (aside from the aggregate of residential homes) comes from the operation of: 1) health centres; 2) schools; 3) gymnasiums; 4) cultural centres; 5) wharfs; 6) band offices; and 7) water treatment plants. Within these structures the highest energy usage is associated with baseboard heaters, hot water heaters, HVAC systems, and flood lights. For a typical household in a remote community, the single greatest use for electricity is space heating, accounting for approximately 49% of total electricity consumption, followed by appliances and lighting (27%), domestic water heating (21%), and cooking (3%).

Energy Efficiency Solutions

The most effective means to reducing electricity demand and the need for diesel fuel supply to remote communities is the implementation of energy con-

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	Population	Diesel Consumption (L/year)	Electricity Output (GWh/yr)	Transport fuel Consumption (L) Road	Air	35% Road & 65% Air	Emissions from electricity Gen CO_2e (tonnes)	Emissions from delivery trips-CO_2e (tonnes) Road	Air	34% Road & 65% Air
Eabametoong	1,140	1,730,000	6.17	13,589	871,765	571,403	4980	38	5656	3690
Kee-Way-Win	320	660,000	2.36	5,184	332,581	217,992	1910	15	2158	1408
Muskrat Dam L.	255	390,000	1.38	3,063	196,525	128,813	1110	9	1275	832
Neskantaga F.N.	265	530,000	1.9	4,163	267,072	175,054	1530	12	1733	1130
North Spirit Lake	255	490,000	1.74	3,849	246,916	161,843	1410	11	1602	1045
Peawanuck	139	340,000	1.23	2,671	171,329	112,299	990	8	1112	725
Pikangikum	2,443	3,710,000	13.22	29,142	1,869,507	1,225,379	10660	82	12129	7913
Wawakapewin	47	60,000	0.22	471	30,235	19,817	180	1	196	128
Weenusk	225	340,000	1.22	2,671	171,329	112,299	980	8	1112	725
Wunnumin	490	590,000	2.09	4,635	297,307	194,872	1690	13	1929	1258
Total	5,579	8,840,000	31.53	69,439	4,454,566	2,919,772	25,440	195	28901	18854

Source: Arriaga, M. et al. 2012. (Transport fuel consumption and emissions are calculated with values from Hydro One 2012a)

Table 1. Remote Community Energy Consumption

servation and energy efficiency measures. As the cost of electricity generation in these communities is very high relative to urbanized areas in Southern Ontario, the most basic of upgrades to household appliances can create substantial saving over time. Possible energy efficiency options include, but are not limited to: 1) lighting; 2) hot water tank insulation; 3) low flow showerheads; 4) occupancy sensors; 5) building weather-stripping; and 6) equipment timing.

Supply Side Management in Remote Communities

With the concerns raised regarding the practicality of continuing to supply remote communities with diesel for power generation, renewable energy technology options can be considered as a means of meeting their existing and future electricity demand.

Wind Turbines

Wind power is a candidate for an alternative energy system in remote communities in Northern Ontario. Table 2 highlights the costs and benefits associated with remote wind turbine costs. By its very nature, wind turbines are usually site-specific applications and current technologies exist to meet smaller-scale demand scenarios as those presented by these remote communities. However, one of the greatest disadvantages of wind power is the intermittent pattern of its electricity generation. Due to the temporal and spatial variations of wind penetration, the electricity generated by wind turbines often exhibits nonlinear and unbalanced loads and can lead to a number of power quality issues including harmonics, voltage and frequency fluctuations.

Yet, wind turbines may be combined with existing diesel generators in remote communities and the electricity from the wind turbines can be used to offset some, if not all, of the diesel generation when the wind is blowing, while the diesel generators or energy storage systems (batteries) can come online during other periods or for peak power demand.

Low temperature and icing conditions in remote areas present additional challenges for wind turbines but lessons from previous projects in the Yukon, Canada and several European countries including Finland, Norway, and Sweden suggest that properly designed wind turbines can function as expected in harsh sub-Arctic environments.

Capital cost	• $2,100 to $2,500 /kW installed
Electricity generating cost	• 6-9 ¢/kWh
Benefits	• Decent lifespan (~25 years) • Minimal environmental impact
Difficulties	• Access to capital • Efficiency determined by wind condition • Intermittent power generation

Table 2. Wind Turbine Costs and Benefits

Solar Photovoltaic/passive Solar

For remote communities, the size and modularity of photovoltaic (PV) panels can provide an advantage for energy supply in terms of system packaging and installation. Individual homes or larger power plants can be fitted with solar PV to supplement or offset their own electricity demand. In recent years the cost of solar PV technology has dropped significantly and it can be expected that solar PV power generation will become more economically viable in the near future as the associated costs continue to decrease. A summary of costs and benefits associated with solar PV is shown in Table 3. Previous applications of PV in sub-Arctic conditions in northern Canada have demonstrated the durability and reliability of this technology in extreme climate.

In addition, passive solar energy can also be used directly for water and space heating purposes and can produce significant amounts of heat for buildings, especially when the technology can be incorporated into building construction through, for example, solar exposure maximization in new building design or the retrofitting of passive solar in exterior fascia of existing buildings.

Capital cost	•$9,000 to $10,000 per kW installation capacity
Electricity cost	• 65-80 ¢ per kWh
Benefits	• Long lifespan (30+ years) • Low O&M cost • Good reliability
Difficulties	• Expensive upfront investment • Relatively low capacity factor • High electricity price

Table 3 – PV Solar-electric Costs and Benefits

Small-scale Hydroelectricity

For remote communities in northern Ontario another renewable energy source is hydroelectric. With well-established technology and relatively easy operation and maintenance requirements, run-of-river system design can eliminate the need for a dam on the main river by diverting a portion of the river's main stream toward water turbines and therefore minimizing the impact on the surrounding environment as compared to traditional large-scale hydro projects. The costs for new installations can vary significantly depending on location and size (See Table 4) but these systems do benefit from a typically high capacity factor that provides for greater power density and generation efficiency. Run-of-river hydroelectric when compared to other renewable energy technologies is impacted less by fluctuations of energy source and with generally gradual changes in water levels combined with predictable seasonal variations these systems require less power storage capacity and backup systems.

Capital cost	• $1,750 to $10,000 per kW installation capacity • Estimated project costs - $250,000 for a 500 kW project - $15,000,000 for a 6 MW project
Electricity cost	• ~ 5-20 ¢ per kWh
Benefits	• Long year lifespan (30-50+ years) • High capacity factors (70-80%) • Stabilizes long-term electricity costs • On-grid application can offer competitive rates and reduce the need for subsidies
Difficulties	• Environmental impacts • Long construction period • Long payback time

Table 4 – Run-of-river Hydro-electric Costs and Benefits

Recent Developments in Integrating Remote Communities into System Supply

In 2012, the Ontario Power Authority (OPA) proposed a plan whereby power transmission facilities would be constructed beyond the City of Dryden to connect remote communities in northern Ontario. Basing their plan on forecasts that the cost of supplying electricity through the supply of diesel fuel would increase by 500 percent over the next 40 years from $CDN 68 million in 2012 to $CDN 350 million in 2053, a projected investment of $900 million to $1 billion from parties that would benefit from the transmission project would result in a payback period 20 to 25 years. According to the OPA, this project would avoid up to $600 million of diesel costs in total.

Conclusions

Despite the recent study supporting the construction of electricity transmission connections into those areas of northern Ontario to service remote communities, the alternative of displacing diesel fuel power generation with renewable energy technologies remains a viable solution. Combining demand-side management solutions with these supply-side management strategies would offer remote communities the opportunity to undertake community-based energy system design that will lead to more efficient use of energy while reducing the environmental impact and risks associated with their current power generation methods.