Barren Lands First Nation

Community Energy Plan

2017

Options and Issues:

Barren Lands First Nation
Community Energy Plan

Prepared for:

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Contents

Executive Summary

The Barren Lands First Nation has partnered with Aki Energy Inc. to develop a Community Energy Plan with financial support from Indigenous and Northern Affairs Canada.

Aki has produced a series of individual technical reports that examine a comprehensive range of options and issues for the supply of energy for Barren Lands First Nation and using energy in the community more efficiently. This report integrates and summarizes these technical reports into a single, easier-to-read document and addresses gaps not covered by the individual reports.

The intent of this report is to advance the discussion about how Barren Lands First Nation can meet its objective of ending its reliance on diesel fuel and heating oil. A summary of energy supply options and recommendations presented in this report can be found in Appendix B.

The scope of this report is focused on an integrated strategy for the sustainable supply and efficient use of energy in existing and future community buildings, facilities and housing in Brochet. Excluded from the project's scope is transportation, as there are limited options for the community to reduce transportation-related energy use given its location.

The foundation for energy supply planning in Barren Lands First Nation must be based on a sound forecast of the community's future energy use and peak demand. Current projections by Manitoba Hydro for the next two decades are based on a simple 'business-as-usual' extrapolation of previous rates of growth. There is significant potential to change this trajectory through a comprehensive range of demand-side management efforts outlined in this report. This issue needs to be addressed as soon as possible.

The next step for the Barren Lands First Nation, using information from this report and support by Aki, is for the Band to identify a preferred long-term energy path for the community and the priorities for implementation. These community decisions can then be used as a basis for discussion by Brochet' leadership with INAC, Manitoba Hydro and other key external stakeholders.

List of Acronyms

BTU	British Thermal Unit
CSA	Canadian Standards Association
CMHC	Canada Mortgage and Housing Corporation
CFL	Compact Fluorescent Light
DSM	Demand-Side Management
ERAAES	Environmental Remediation and Alternative Energy Systems
FSG	Fixed-Speed (Diesel) Generation
GSHP	Ground Source Heat Pump
INAC	Indigenous and Northern Affairs Canada
HAWT	Horizontal Axis Wind Turbine
HOMER	Hybrid Optimization of Multiple Energy Resources
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt Hour
LED	Light-Emitting Diode
LEDP	Lands and Economic Development Services Program
MARRC	Manitoba Association for Resource Recovery Corporation
ORC	Organic Rankine Cycle
PV	Photovoltaics
UL	Underwriters' Laboratory
ULC	Underwriters' Laboratory of Canada
VAWT	Vertical Access Wind Turbine
VSG	Variable-Speed (Diesel) Generation

1.0 Introduction

1.1 Project Background, Objectives and Scope

Project Background

The Barren Lands First Nation ('Brochet') has partnered with Aki Energy Inc. ('Aki') to develop a Community Energy Plan ('CEP'). Financial support for this initiative has been provided by the Lands and Economic Development Services Program ('LEDSP') operated by Indigenous and Northern Affairs Canada ('INAC').

Aki is an award-winning, non-profit social enterprise. Aboriginal-owned and based in Winnipeg, Aki works in partnership with First Nations throughout Manitoba to develop strong local economies through sustainable development initiatives.

For this project, Aki assembled and was supported by a team of energy efficiency and renewable energy experts from several other organizations. A list of Aki's Project Team and their contact details can be found in Appendix A.

Project Objectives

The objectives of this project are to:

- identify and explore a broad range of energy supply and energy management options for consideration by Barren Lands First Nation that are consistent with the Sustainable Development Strategy adopted by the community in March 2016;
- advance the discussion about how Barren Lands First Nation can meet its objective of ending its reliance on diesel fuel and heating oil; and
- facilitate development of a comprehensive, long-term CEP that is supported by the residents of Barren Lands First Nation that can form the basis of discussion and negotiation with other stakeholders with respect to implementation.

Project Scope

The scope of this project has focused on an integrated strategy for the sustainable supply and efficient use of energy in existing and future community buildings, facilities and housing in Brochet. Excluded from the project's scope is transportation.

As a small, remote northern community connected to the rest of the province primarily by a winter road system and by air, there are limited options for Barren Lands First Nation to reduce transportation-related energy use. However, there are still some measures that the community can choose to take, especially for the transportation of people and goods within the community. These measures should be considered for future versions of the Barren Lands First Nation Community Energy Plan.

1.2 Purpose and Organization of this Report

Purpose of Report

Aki's Project Team has produced a series of individual technical reports that examine a comprehensive range of options and issues for the supply of energy for Barren Lands First Nation and using energy in the community more efficiently. This Options and Issues Report integrates and summarizes these technical reports into a single, easier-to-read document that also addresses some gaps not covered by the individual reports.

The next step is for Barren Lands First Nation with the assistance from this report and support by Aki, is for the Band to identify its preferred long-term energy path for the community and priorities for implementation. Based on the community's decisions, this report will be revised by Aki to serve as an inaugural Community Energy Plan that Barren Lands First Nation can use as a basis for discussion with INAC, Manitoba Hydro and other external stakeholders.

Organization of this Report

The remaining sections of this report are organized as follows:

Section 2.0 Community Energy Profile provides background and context about the supply and use of energy in Barren Lands First Nation including its cost. Special attention is paid in this section to providing information about community's reliance on electricity produced by diesel generators which are approaching the end of their service life. A brief overview is also provided about the 'ERAAES Project' now underway to use renewable energy, biomass and a lake water heat system to reduce the community's dependence on diesel-generated electricity.

Section 3.0 Demand-Side Management: Options and Issues is based on a series of energy and water audits conducted on community buildings and facilities and a representative sample of homes. Recommendations based on these audits are presented in this section for retrofitting existing buildings and houses in Barren Lands First Nation and establishing improved energy efficiency standards for new construction that better reflect the high cost of energy and severe climate.

Section 4.0 Imported Non-Renewable Energy Sources: Options and Issues presents the results of a preliminary feasibility study that examined connecting Barren Lands First Nation to electricity supplied from the SaskPower grid, most of which is generated from non-renewable sources. A brief explanation is provided in this section about why two other potential sources of renewable energy for the community, natural gas and propane, were screened but dropped for further consideration. A brief introduction to the benefits of advanced diesel is provided. Finally, this section also discusses and provides some suggestions for a small project the community is embarking upon to collect and use waste oil for space heating in a public works building.

Section 5.0 Local Clean Renewable Energy: Options and Issues examines several options to use clean renewable energy to significantly reduce and even eventually eliminate the community's reliance on diesel-generated electricity and heating oil. These options hydro-generated electricity (connecting to Manitoba Hydro's provincial electricity grid or building a small-scale hydro generation system using the Cochrane River); using biomass energy for electricity generation and heating; solar and wind generated electricity; and geothermal for heating.

Section 6.0 Integrating the Options analyzes the results from a software program called HOMER that was used to examine several scenarios about integrating select options mentioned above to significantly reduce or eliminate the community's dependence on diesel generated electricity. This section also discusses other energy-related community infrastructure that would be needed or be desirable to integrate and manage multiple sources of energy supply.

Section 7.0 Kick Starting a Barren Lands First Nation Sustainable Social Enterprise discusses how the community can maximize the local economic, employment and social benefits of implementing the energy supply and demand side management options outlined in this report.

Section 8.0 Recommended Next Steps outlines the recommended next steps to finalize the Barren Lands First Nation Community Energy Plan, engage external stakeholders to support the Plan, and begin its implementation.

Except for Sections 7.0 and 8.0, all other sections begin with a summary of 'Major Findings and Recommendations' by Aki's Project Team. These sections conclude with a listing of 'Additional Information' that identify any individual technical reports produced by the Aki Team and, in some cases, other external sources of relevant information.

1.3 Relationship to Other Community Plans

The development of any additional community plans to support the community's Sustainable Development Strategy (e.g., land use and zoning, construction by-laws, economic development strategy, etc.) should be informed by the Community Energy Plan that emerges from the work described in this Options and Issues Report.

1.4 Limitations of this Report

Caution should be exercised when considering the major findings and recommendations in this report. In some case, there is a comparatively higher degree of confidence in the findings and a lower risk of proceeding with the recommendations. This is true, for example, with the findings and recommendations in Section 3.0 that deal with retrofitting existing buildings, facilities and homes that are based on a series energy audits conducted in the community.

In other cases, findings and recommendations are based on a preliminary analysis or prefeasibility study. For these situations, a more in-depth feasibility analysis would be prudent before taking further action. This is especially true of the findings and recommendations in Sections 5.0 and 6.0.

Readers of this report are also encouraged to refer to the individual studies and reports produced by Aki's Project Team from which the findings and recommendations of this Options and Issues have been derived.

2.0 Community Energy Profile

2.1 Diesel-Generated Electricity

Major Findings and Recommendations:

- *Manitoba Hydro's diesel generation system for Barren Lands First Nation has proven to be reliable but many of the generator units are nearing the end of their service life.*
- *Unlike other customers who are connected to Manitoba Hydro's main electrical grid, residential customers are limited to a 60-amp service. This limitation is an inconvenience and precludes the option of using electricity as a primary heating source.*
- *The burden of the high cost of electricity in Barren Lands First Nation relative to typical household incomes will likely much become worse over the next five years. Manitoba Hydro is seeking a cumulative rate increase of almost 50% over the next five years.*
- *Based on 'business-as-usual, Manitoba Hydro is forecasting that energy use and peak demand in the community will increase by a total of 20% over the next two decades. However, this load forecast does not consider the impact that an aggressive demand-side program or the ERAAES project now underway can have to reduce or eliminate this growth.*

Discussion

System Description – Barren Lands First Nation is one of only four communities in Manitoba that is not connected to the main Manitoba Hydro electrical grid and relies upon diesel-generated electricity. This exclusive dependency in Barren Lands First Nation on non-renewable fossil fuel for electricity generation will be significantly reduced by the Environmental Remediation and Alternative Energy Systems (ERAAES) Project now underway – see Section 2.4 ERAAES Project for more details.

The Lac Barren Lands First Nation Diesel Generating Station in Barren Lands First Nation was originally designed and built by Manitoba Hydro in the early 1980s. It was later upgraded in the 1990s when the Unit No. 2, 3 and 4 'gensets' (a combination of a diesel engine and an electrical generator) were replaced with larger units and the power distribution and cabling replaced. The Unit No. 1 generator was retained and utilized as the station house generator.

The generating station was subsequently expanded and the Unit No. 5 generator installed. The expansion also allowed space for two more generators to be installed to accommodate future growth in electricity use by the community. However, in 2012 this additional space was utilized to accommodate a new fire protection system.

Service Limitations – Residential customers in Barren Lands First Nation and the other off-grid communities in Manitoba were originally restricted by Manitoba Hydro to a 15-amp service to control the cost of diesel service. In the early 1990s, Hydro's generating and distribution facilities in these communities were upgraded to support 60-amp electrical service. However, the continuing use of a 60-amp service does not permit the residents of Barren Lands First Nationto electricity as a prime source of space heating which requires 200-amp service.

System Efficiency – Only about one-third of the diesel fuel used by a conventional constant speed diesel generator is converted into electricity. The remaining energy is rejected as heat through the diesel engine's exhaust and cooling system. Some of this rejected heat can be recovered and used for other purposes to boost overall system efficiency (e.g., heating water and sewer lines in winter).

Advanced diesel technology that vary generator speed to better match changing electrical loads and use improved combustion techniques and controls can improve efficiency. For a discussion about option of using advanced diesel for Brochet, refer to sub-section 4.3 later in this report.

Manitoba Hydro reports that the diesel generators at the Lac Barren Lands First Nation Generating Station in Barren Lands First Nation produce, on average, about 3.64 kWh of electricity per litre of diesel fuel – see Figure 1 below. A litre of diesel fuel has the energy equivalent of about 10.64 kWh per litre. This means that the diesel generators for Barren Lands First Nation are about 34% efficient at converting diesel fuel into electricity (10.64 / 3.64 x 100 = 34.2%).

Figure 1 – Diesel Generators Fuel Efficiency

Diesel Generating Station	**Fuel Efficiency** (kWh/l)
Brochet	3.14
Lac Brochet	3.64
Shamattawa	3.59
Tadoule Lake	3.17
Five-year Average	**3.38**

Reliability and Service Life – A reliable source of electricity is critical in any community, especially for an isolated community in a very cold northern environment such as Brochet.

According to Manitoba Hydro the diesel generators in Brochet, and the other three off-grid Manitoba First Nations (Brochet, Tadoule Lake and Shamattawa), have proven to be very reliable. For example, the report on *Recommendations for Reducing or Eliminating the Use of Diesel Fuel to Supply Power in Off-Grid Communities* completed by Manitoba Hydro in 2009 noted that generator availability was 99.6% in the two previous years.

For planning purposes, a 20-year engine life is assumed for diesel generators. Generally, planned overhauls occur about every 2.5 years at typical cost around $190K. End-of-life projections are based on individual engine operating hours.

The four main diesel generators in the Lac Barren Lands First Nation Diesel Generating Station are rapidly approaching the end of their useful service life based on current levels of usage (see Figure 2 on next page). However, these end-of-life projections can be extended by the introduction of additional renewable energy generation and energy efficiency measures in the community.

In a July 2015 report, Manitoba Hydro expressed concern that the Generating Station will not be capable of reliably meeting the forecast load growth for the community over the next three years. As back-up, a 1250 kW mobile generator has been placed in the community to provide back-up capacity in the event of prolonged outage.

A July 2015 Capital Project Justification report completed by Manitoba Hydro for a new diesel generating station in Barren Lands First Nation adjacent to the existing station estimated the capital cost to be $53.7-million with $45.8-million (85%) to be contributed by INAC. This also includes replacement of the existing diesel storage tank farm and upgrade of staff accommodations. More recent estimates provided by Manitoba Hydro to INAC indicate a projected capital cost of $84-million.

Electricity Use, Peak Demand and Load Forecast – ‘Business-as-usual’ projections supplied by Manitoba Hydro forecast continued growth in electricity use (MW.h) and demand (kW) over the next two decades in Barren Lands First Nation (see Figure 3 on next page). However, these projections are based on a simple extrapolation of previous rates of growth. They do not consider the remaining potential to reduce electricity use outlined in Section 3.0 of this Options and Issue Report and the impact of the ERAAES Project now underway in the community.

The rate of projected growth from 2016/17 to 2036/37 for Barren Lands First Nation is 19% for electricity use (from 3433.3 to 4,096.2 MW.h) and 20% for peak demand (from 754 kW to 905 kW).

Aki’s Project Team was not able to obtain clarifications it sought from Manitoba Hydro to better understand the load history and Hydro’s load forecast for the community. For example, there have been some unusually large year-to-year increases and decreases in electricity use and demand.

The above load forecast uncertainties notwithstanding, preliminary results from the energy audits by Aki’s Project Team of buildings, facilities and housing in the communities indicate that most, if not all projected load growth in the community over the next two decades can be offset cost-effectively through a comprehensive program demand side management program (refer to Section 3.0 for more details).

Electricity Rates – There are two issues related to electricity rates that need to be considered in energy planning for Brochet:

1. The burden of the high cost of electricity in Barren Lands First Nation will likely become much worse over the next several years due to rate increases being sought by Manitoba Hydro.
2. The rates that different classes of users pay do not reflect the actual cost of service. This creates a major distortion in who pays and who benefits from efforts to use energy more efficiently in the community.

Manitoba Hydro has three rate classes for electricity in Barren Lands First Nation depending on whether the customer is a Residential, General Service or Government and First Nations account – see Figure 4 on next page. These rates are anticipated to rise significantly. In May 2017, Manitoba Hydro applied to the Public Utility Board (PUB) for a general rate increase. The utility's financial health has deteriorated and its financial plan includes five years of 7.9 per cent rate increases each year starting in 2017. An interim increase of 3.36% effective August 1, 2017 has been granted by the PUB. Public hearings on Hydro's full rate application will begin in December.

Previous rate application filings with the PUB by Manitoba Hydro indicate that the average cost of diesel service for Barren Lands First Nation and the other three off-grid First Nations is the range of about $0.60 per kWh. This excludes any remediation costs for diesel fuel spills.

Figure 4 – Current Diesel Electricity Rates (effective August 1, 2017)

Diesel rates

Residential - Tariff no. 2017-03	
Monthly basic charge not exceeding 60 Amp	$8.08
plus energy charge	8.196¢/kWh

Notes:
Minimum monthly bill is the monthly basic charge.
The residential rate applies to all residential services in the diesel communities, provided the service capacity does not exceed 60A, 120/240 V, single phase.

General service - Tariff no. 2017-40	
Monthly basic charge	$21.91
plus energy charge:	
first 2,000 kWh @	8.609¢/kWh
balance of kWh @	42.617¢/kWh

Notes:
Minimum monthly bill is the monthly basic charge.
The general service diesel rate applies to all commercial accounts excluding those classed as Government and/or First Nation education.

Government and First Nation education - Tariff no. 2017-41	
Monthly basic charge	$21.91
plus energy charge	$2.59382/kWh

Notes:
Minimum monthly bill is the monthly basic charge.
The First Nation education rate is applicable to all diesel First Nation facilities providing instructional services for members of the diesel First Nations, including schools, teacherages and student residences.

Greenhouse Gases and Other Emissions – The diesel-generated electricity and fuel oil used for heating homes and buildings in Barren Lands First Nation results in relatively high per capita greenhouse gas emissions and potentially negative impacts on local air quality.

The most recent data for Manitoba is that each kWh of electricity generated in the province results in the equivalent of about 4 grams of carbon dioxide being emitted. In Brochet, each kWh of diesel-generated electricity results in an average of about 740 grams of carbon dioxide.

Burning diesel fuel and heating oil can also have negative impact on local air quality in Brochet. Besides carbon dioxide, the combustion of diesel fuel and heating oil results in the release of nitrogen oxide (NOx), carbon monoxide, hydrocarbons and particulate matter into the air, all of which have known negative impacts on human health. However, it is unknown whether any air quality measurements have occurred in the community to determine whether provincial and/or federal clean air requirements or guidelines are being met.

Although diesel engines used in vehicles have been regulated for many years, emissions standards for diesel engines used to generate electricity are more recent. For example, limits on emissions for stationary diesel generators by the U.S. Environmental Protection Agency only began on January 1, 2007.

2.2 Heating Oil

Major Findings and Recommendations:

- *Space heating is the largest single end-use of energy for the 27 non-residential buildings in Brochet. Heating oil is the only energy source used for heating in almost all these facilities.*
- *Space heating and domestic water heating are the largest end uses of energy in most of the approximately 140 homes in the community. Heating oil is the dominant form of energy used to meet these needs.*
- *The high cost of heating oil in Barren Lands First Nation relative to typical household incomes already places a major burden on families. The potential for future increases in the price of oil presents a major economic risk to the community.*
- *Heating oil used is a major contributor to Brochet's relatively high per capita greenhouse gas emissions and negative impacts on local air quality. This can be reduced by accelerating the replacement of old heating oil equipment with new, more efficient equipment.*
- *The widespread use of heating oil is also contributing to other environmental concerns in the community including indoor air quality concerns and impacts from leaks and spills from storage tanks.*

Discussion

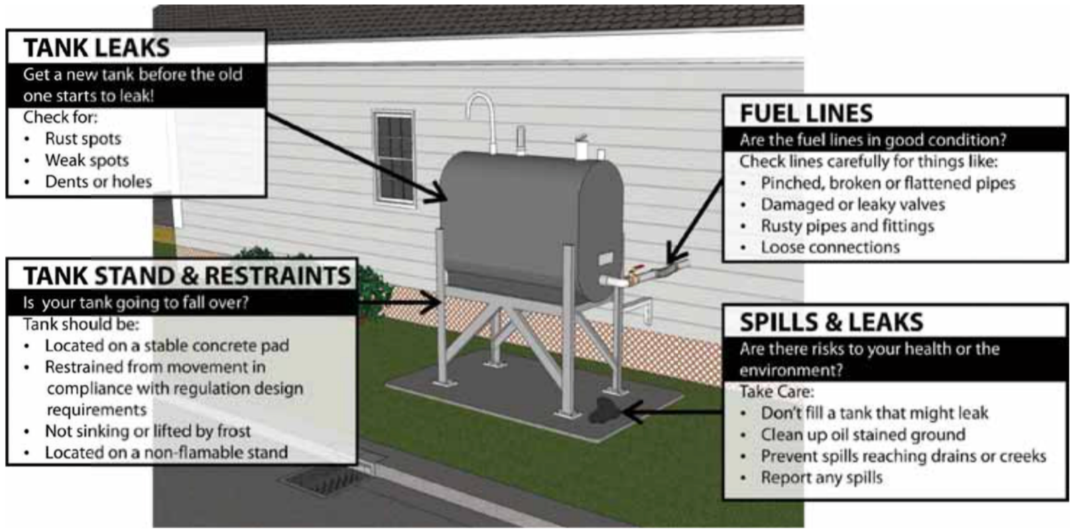
Distribution - Heating oil is brought into Barren Lands First Nation on the winter road system. Distribution is managed by the Band. Storage tanks for individual buildings and homes are filled on as needed basis from the Band holding tanks.

Storage problems – A major issue for the community is leakage and spillage from heating oil storage tanks and the resulting contamination of soil and surrounding environment. Except for the buildings associated with the nursing station, storage tanks throughout the community do not have double walls or double bottoms to contain leaks. These storage tanks generally do not rest on stable foundations and are not attached to the exterior walls of the homes and buildings they serve. As a result, the tanks move independently due to seasonal freeze-thaw cycle which can result on stress and leakage from the connecting piping.

Tracking consumption – Because heating oil is not metered like electricity, it can be challenging to accurately track consumption. Maintaining clear, accurate delivery records will be essential to track the impact of energy efficiency measures discussed in Section 3.0.

Oil price – Heating oil is typically the most expensive energy source in Manitoba for heating. On a historical basis, the current world price of oil is moderate and relatively stable at around $50 U.S. per barrel. However, *Canada's Energy Future 2017* published by the National Energy Board projects the price of crude oil in constant 2016 dollar terms will reach $80 U.S. per barrel by 2027, a 60% increase. If this scenario unfolds as envisioned by the NEB, it will place budgets for heating homes buildings in Barren Lands First Nation under considerable strain.

Figure 5 – Inspection checklist for heating oil storage tanks



Greenhouse gases and other emissions – As noted above in sub-section 2.1, fuel oil used for heating homes and buildings in Barren Lands First Nation along with diesel-generated electricity is resulting in relatively high per capita greenhouse gas emissions and negative impacts on local air quality.

There are no standards in Canada for emissions from oil-fired furnaces, boilers or water heaters. There are, however, minimum energy performance standards for this type of equipment. As older equipment in Barren Lands First Nation reaches the end of its life and is replaced with new, more efficient equipment, the result will be a reduction in emissions.

Additional Information

Aki Team Reports – For more in-depth information about recommendations for reducing the use of heating oil in the houses, community buildings and facilities in Brochet, please refer to these reports produced by the Aki Team:

- *Barren Lands First Nation Building Energy Assessment Audits (April 2017)* by Demand Side Energy Consultants
- *Final Summary Report: Residential Energy and Water Audits in Manitoba's Off-Grid Communities* by prairieHOUSE Performance Inc.
- *ecoENERGY Energy Efficiency Evaluation Reports* for each of the 12 homes that were subject to an energy and water audit by prairieHOUSE Performance Inc.

Further Reading – For more information about the installation, maintenance and standards for heating oil tanks, please refer to these publications:

- *A Guide to Home-heating Oil Tanks* published the Yukon Housing Corporation.
- *CSA-B139 Series-15 "Installation Code for Oil Burning Equipment"* available from the CSA Group.

2.3 Wood Heating

Major Findings and Recommendations:

- *Despite the relatively recent introduction of oil heating in the community, wood heat remains an important source of heating and cooking for many households in Brochet.*
- *Many of the wood stoves being used in Barren Lands First Nation are low-efficiency. This results not only in higher energy use, but also presents health risks to community members.*
- *A long-term, community-based program to identify low-efficiency wood stoves In Barren Lands First Nationand replace them with high-efficiency, U.S. EPA-certified models should an essential element of the community's long-term energy plan.*
- *A Band Council resolution should be considered that mandates that any new installations of wood stoves in the community be high-efficiency, certified models.*

Discussion

Wood is a very important energy source to most indigenous communities, including Brochet. Wood is sought after for heating and cooking because of its cost competitiveness, local availability, cultural preference and home comfort value.

Prior to 2010, most homes in Barren Lands First Nation were heated with wood. Between 2010 and 2012, they were converted to diesel as part of a federal government initiative. However, wood heating remains an important form of supplemental, and is some cases, a primary source of home heating.

Because of the nature of how wood is collected and distributed, it is difficult to make an accurate estimate of how much wood is being used for heating in the community. Extrapolating from other remote Indigenous communities in the Boreal ecosphere, a conservatively estimate is that perhaps 40-45% of thermal heat load for housing in Barren Lands First Nations being met through wood stoves.

Many of the wood stoves being used in the community are not efficient, lack a fan or other method to distribute heat and tend to have creosote build-up in their chimneys. These stoves also have negative health impacts due to their high emissions of fine particulates. Compared to high-efficiency wood stoves certified by the U.S. Environmental Protection Agency, uncertified wood stoves that are common in Barren Lands First Nation are likely emitting three to four times the amount of fine particulates that can cause or exacerbate chronic and acute respiratory and other diseases.

The poor heat distribution of wood stoves results in two other costly problems in northern indigenous communities: burst water pipes from freezing and mold due to fluctuations in heating and poor air circulations and venting.

As part of the community's clean energy strategy, there is an opportunity to introduce an Indigenous High-Efficiency Wood Stove Program in Brochet. This would involve:

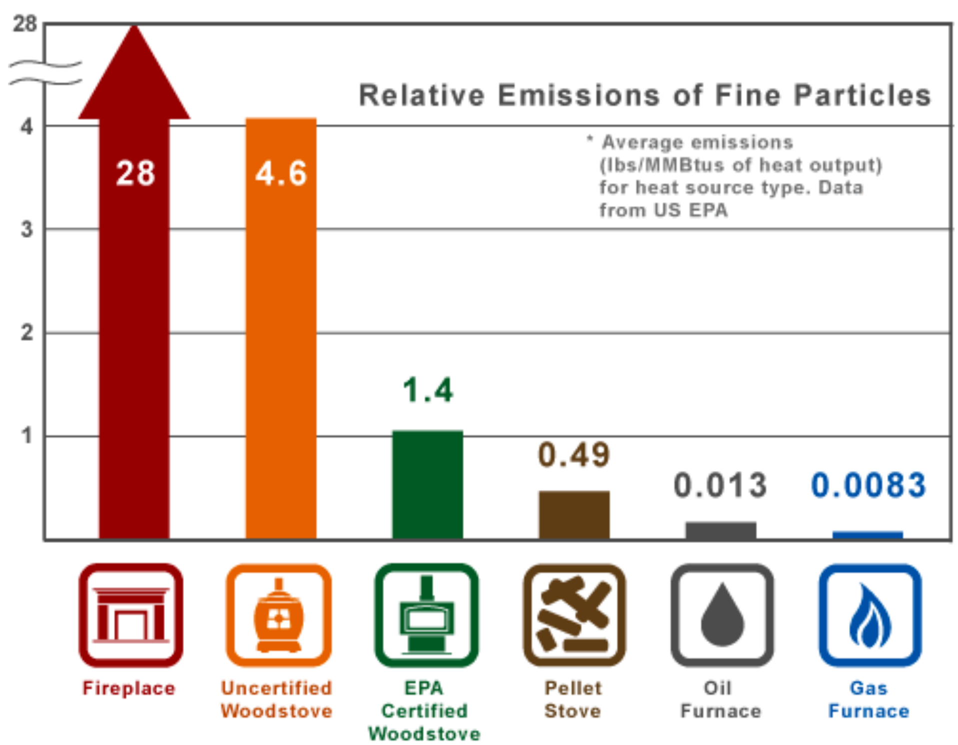
- gaining support for the initiative through consultation with community elders and members;

- taking an inventory of existing wood stoves in the community to determine their type and likely efficiency;
- demonstrating the use and assessing the performance of the two major types of high-efficiency, U.S.EPA-certified wood stoves (catalytic and non-catalytic) in several homes; and
- based on the demonstration and evaluation ramp-up the long-term replacement of the remaining low-efficiency, uncertified wood stoves in the community.

To reduce cost, either the bulk purchase of new, high-efficiency stoves or establishment of a preferred supplier list and pricing scheme should be explored.

In addition to a replacement program for existing installations of wood stoves, it would also be desirable to pass a Band Council Resolution mandating that any new installations of wood stoves in the community be high-efficiency, certified models.

Figure 6 – Emissions of fine particulates from wood and other energy sources



Additional Information

Aki Team Reports – For more information about wood heating and recommendations for implementing a high-efficiency wood heating program for Brochet, please refer to this report produced by the Aki Team:

- *Barren Lands First Nation Building Energy Assessment Audits (March 2017)* by Lumos Clean Energy Advisors.

3.0 Demand-Side Management: Issues and Options

3.1 Retrofitting Community Buildings and Facilities

Major Findings and Recommendations:

- *Although some progress has been made in some areas to reduce energy use in the community buildings and facilities in Brochet, overall energy use has risen over the past decade.*
- *Energy audits of eight community buildings have identified many retrofit opportunities with very attractive payback periods.*
- *An overall target of reducing energy use in community buildings and facilities by 20% to 25% appears possible.*

Overview of Option

This option would consist of targeted retrofit measures and capital upgrade projects to improve the energy performance of community buildings and facilities.

Discussion

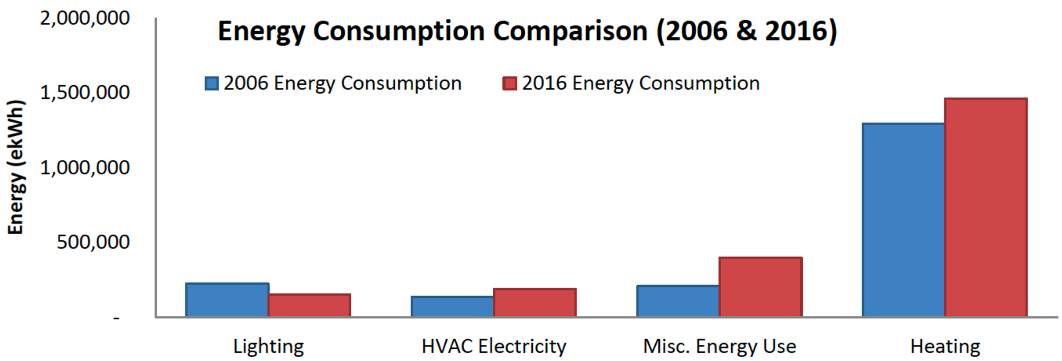
The Aki Project Team conducted ASHRAE Level 1 Walk-Through Screening Audits on eight community buildings and facilities (see Figure 8 below). Two of these buildings that appeared to have the most promise for retrofitting were selected for more detailed ASHRAE Level 2 Audits.

Figure 8 – Community buildings and facilities selected for energy audits

Building Name	Floor Area (m^2)	Electricity (kWh/yr)	Fuel Oil (l/yr)	Cost ($/yr)	BEPI (ekWh/m^2)	GHG (tCO2e)
Nursing Station	787	142,880	21,979	$385,424	481	163
Perimeter Airport	294	45,000	48,089	$164,515	1,910	165
Water Treatment Plant	330	173,340	15,935	$80,883	1,044	168
Band Office	840	64,238	16,029	$35,681	281	90
Community Hall	204	18,042	4,959	$51,299	350	27
Daycare	446	4,853	3,868	$4,709	104	14
Northern Store	664	173,340	16,230	$81,193	524	169
Firehall	45	4,813	5,451	$18,150	1,420	19
Total	**3,610**	**626,506**	**132,541**	**$821,855**	**6,114**	**815**

The energy consumption for this group of buildings was compared to an earlier study conducted in 2006. It was found that although progress has been made in reducing energy use for lighting, energy use for all of the other categories (heating, HVAC, miscellaneous loads) has increased over the past ten years (see Figure 9).

Figure 9 – Energy Consumption Comparison



Based on the Level 1 and Level 2 energy audits, there are many retrofit opportunities for these community buildings and facilities with very attractive paybacks (see Figure 10 below).

Figure 10 – Energy Retrofit Measures

Measure	Electricity (kWh)	Fuel Oil (ekWh)	Cost Savings	GHG	Project Cost	Payback
Roof Insulation from R-40 to R-60	-	29,067	$2,842	7	$50,110	9
Improve Weather Sealing	-	14,660	$1,433	4	$5,356	4
Install Smart Metering/MT&R	-	182,837	$17,875	47	$3,500	0
Install Programmable Thermostats	6,308	146,270	$16,950	42	$1,226	0
Implement CO2 and Demand Ventilation	-	9,724	$951	3	$2,700	3
Insulate Domestic Hot Water Piping	-	806	$79	0	$155	2
Fluorescent to LED Conversion	41,497	(14,513)	$16,010	26	$10,267	1
MH & HPS to LED Conversion	5,773	-	$2,425	4	$4,107	1
Install Occupancy Sensors	18,714	(4,593)	$7,411	12	$19,389	2
Install VFDs on hydronic heating pumps	5,464		$4,119	4	$15,000	4
Reduce Indoor Temperature		34,358	$3,223	9	$0	-
Optimize Water Plant	18,429		$8,331	13	$25,000	3
Replace 6 LPF toilets with 4.8 LPF	-	-	$893	-	$2,975	3
Replace 8.3 LPM faucets with 0.5 LPM			$75	-	$700	9
Total	**96,186**	**398,614**	**$82,541**	**171**	**$139,786**	**1.3**

Overall, it appears feasible to target an overall energy savings of 20% to 25% energy savings for community buildings and facilities through cost-effective retrofits and capital upgrade projects over the next five years (the actual savings potential varies from building to building).

Additional Information

Aki Team Reports – For more in-depth information about the results and recommendations of the energy audits for the community buildings and facilities in Brochet, please refer to this report produced by the Aki Team:

- *Barren Lands First Nation Building Energy Assessment Audits (April 2017)* by Demand Side Energy Consultants

2.2 Energy Standards for New Community Buildings

Major Findings and Recommendations:

- *Because of the high cost of energy in Brochet, new community should exceed the minimum requirements of the National Energy Code for Buildings based on life-cycle costing.*
- *It would be prudent to take advantage of technical support and incentives offered by Manitoba Hydro's New Buildings Program. Maximizing these incentives requires adopting a target of at least a 20% over the NECB.*

Overview of Option

This option would involve adopting a standard for the design and construction of any future community buildings to exceed those of the *National Energy Code of Canada for Buildings 2015* (NECB). This standard would require that life-cycle costing be used for the features of new buildings that impact energy performance to better reflect the harsh climate and high energy costs in Brochet.

Discussion

The energy efficiency requirements of the NECB do not reflect the high cost of energy in remote, off-grid communities such as Brochet. In planning any future community buildings, it would be desirable to instead use life-cycle costing for the energy-related features to balance the construction costs against long-term operating costs for energy.

As a minimum, it would make sense to take advantage of the technical support and incentives offered through Manitoba Hydro's New Buildings Program. This program offers an incentive of up to $10,000 for energy modelling which is an important tool to assist with life-cycle costing. Hydro also offers an incentive ranging from $0.50 to $2.00 per sq. ft. of floor area depending on how much the building exceeds the Manitoba Energy Code for Buildings (the MECB is based on the NECB and is virtually identical) – see Figure 11 on next page.

For Brochet, setting a target for new community buildings of at least 20% better than the MECB would be appropriate.

Additional Information

Further Reading – Information about the Manitoba Hydro Power Smart New Buildings Program is available at this link.

Figure 11 – Manitoba Hydro New Buildings incentive levels

Building energy target (% better than MECB)	Incentive factor ($/sq. ft)
5	0.50
6	0.60
7	0.70
8	0.80
9	0.90
Power Smart designation levels (10 to 20%)	
10	1.00
11	1.10
12	1.20
13	1.30
14	1.40
15	1.50
16	1.60
17	1.70
18	1.80
19	1.90
20	2.00

3.3 Retrofitting Existing Housing Stock

Major Findings and Recommendations:

- *Detailed audits on a representative sample of homes in Barren Lands First Nation have revealed that there is a significant potential to cost-effectively reduce energy use for space heating, water heating, major appliances, lighting and vehicle block heaters in most homes in the community.*
- *An aggressive energy retrofit initiative for homes in the community can reduce the size and cost of the energy-supply options discussed elsewhere in this report.*
- *There is also potential to reduce the energy needed to distribute, collect and treat water and wastewater through a comprehensive program to replace toilets, showerheads and faucet aerators in homes throughout the community.*
- *To maximize local benefits, community members should* be trained to conduct audits on the remaining homes and undertake as much of the retrofit work as possible.

Overview of Option

This option would involve conducting streamlined energy and water audits on as many of the homes in the community as possible. These audits would identify and prioritize cost-effective measures for each house to reduce energy use for space heating, water heating, major appliances, lighting and miscellaneous plug loads (e.g., vehicle block heaters, electric heating cables for plumbing lines, etc.). Measures to conserve water (e.g., high efficiency toilets, water-saving showerheads, etc.) would also be identified.

Working with external partners, especially Manitoba Hydro's Power Smart initiative, community members would be trained to conduct these audits and undertake as much of the retrofit work as possible.

Discussion

To inform and support Aki's development of a retrofit strategy for existing homes in Brochet, detailed energy and water audits were conducted on a sample of homes in the community. The following are some key findings and recommendations that emerged from these audits:

Space heating – A potential reduction of 25% to 33% in annual space heating consumption (currently oil) is feasible for a significant portion of homes in Barren Lands First Nation through modest, cost-effective building envelope upgrades (e.g., adding insulation, replacing windows, reducing air leakage, etc.) to Manitoba Hydro's Power Smart standards. In many cases, these retrofits need to be coupled with improvement to ventilation systems to improve indoor air quality and better control excessive moisture to minimize the risk of mold and improve the durability of the homes.

Domestic water heating – Typical savings in the order of about 1,000 kWh per year appear feasible in most homes through a combined strategy of retrofitting water-saving showerheads, aerators for taps, pipe insulation and horizontal drain water heat recovery devices. Implementation of these measures will need to be monitored carefully to ensure that they don't result in freezing sewer lines.

Major appliances – Additional cost-effective electricity savings are possible through a community-wide program to replace older major appliances such as refrigerators, freezers and clothes washers/dryers with ENERGY STAR models.

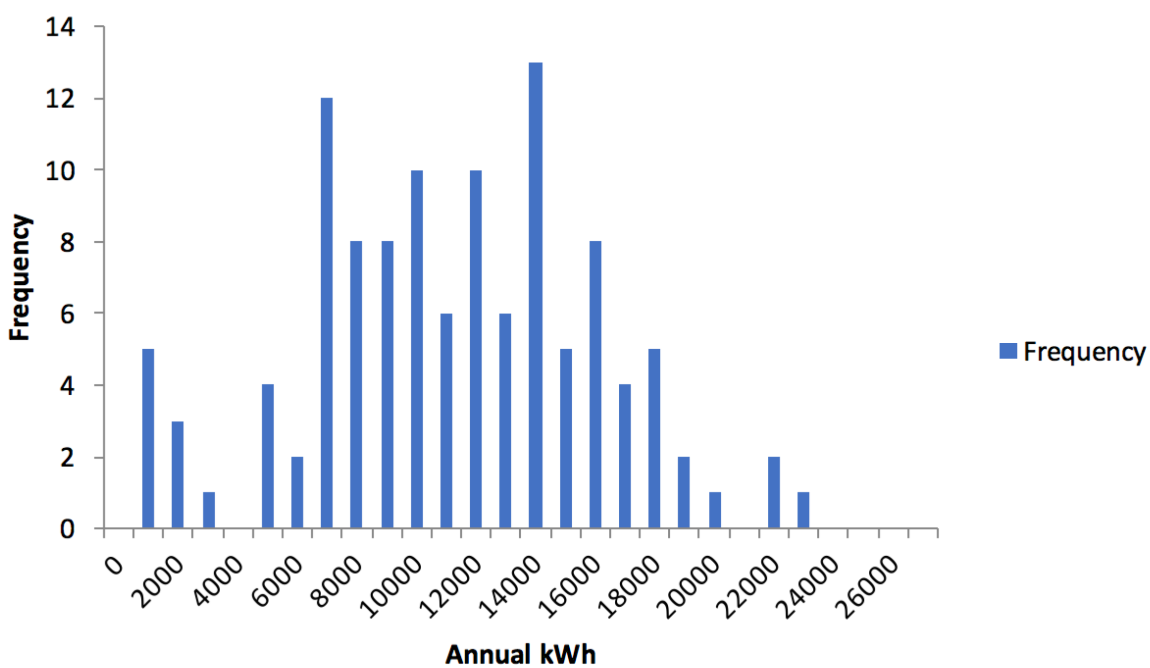
Lighting – The remains significant potential in the community to replace existing incandescent and compact florescent lighting in homes with more efficient LED lighting.

Vehicle block heaters – Installing 'smart power receptacles' to automatically control and reduce electricity use for vehicle block heater plugs should be explored.

Water – The audits have also found that that there is a significant opportunity to replace existing toilets in homes throughout the community with fixtures that use much less water while maintaining proper flush performance to reduce the energy need to distribute, collect and treat water and wastewater.

The energy audits conducted for this project revealed a wide range of electricity use between different homes – see Figure 12 below. In planning a comprehensive retrofit program for the community, priority should be given to auditing and retrofitting those homes with above-average levels of energy use.

Figure 12 – Annual Residential Electricity Consumption



For some of the retrofit measures listed above, it should be noted that the savings will be reduced somewhat by 'interactive effects' (i.e., less waste heat from more efficient appliances and lighting will increase space heating loads during the winter). The impact of these interactive effects will be reduced by the fact that oil-fired furnaces are typically at least twice as efficient as diesel-generated electricity.

Finally, it is important to also recognize that a comprehensive initiative to maximize the energy retrofitting of housing in the community will reduce the size and cost of the energy-supply options discussed elsewhere in this report.

Additional Information

Aki Team Reports – For more in-depth information about options, issues and analysis for retrofitting the existing housing stock in Brochet, please refer to the following reports produced by the Aki Team:

- *Final Summary Report: Residential Energy and Water Audits in Manitoba's Off-Grid Communities* by prairieHOUSE Performance Inc.
- *ecoENERGY Energy Efficiency Evaluation Reports* for each of the 12 homes that were subject to an energy and water audit by prairieHOUSE Performance Inc.

Further Reading – Information about residential savings, rebates and loans offered by Manitoba Hydro through its Power Smart initiative are available through this link.

3.4 Energy Standards for New Housing

Major Findings and Recommendations:

- *There is a reoccurring pattern of homes being built in Barren Lands First Nation using energy-related construction standards that do not adequately reflect the community's harsh climate and high energy costs.*
- *New homes in Barren Lands First Nation should be designed and built to exceed the minimum energy-efficiency requirements of the National Building Code of Canada. It is recommended that the Performance Path of Manitoba Hydro's Power Smart for New Homes Program be used with an energy performance target of 50% better than minimum code requirements.*
- *Adopting this stringent energy performance standard will have several other co-benefits (more comfortable, greater resistance to condensation and mould, improved durability, more resilient, etc.)*

Overview of Option

This option would involve adopting design, construction and quality assurance standards for new homes that significantly exceed those used in the past in the community and the current minimum energy efficiency standards of Section 9.36 of the *2015 National Building Code of Canada.*

These more stringent standards would better reflect the higher occupancy, harsh climate and high energy costs in Brochet. These improved standards would also have co-benefits beyond reducing energy use and the burden of high energy bills – they would also result in new homes that are more comfortable, resilient, durable and healthier for the members of the Barren Lands First Nation who occupy them.

Discussion

The detailed energy audits of a representative sample of homes in Barren Lands First Nation conducted for this project revealed numerous examples of construction details being used in the community that are resulting in sub-optimal energy performance and significant problems with respect to comfort, durability, moisture control and indoor air quality.

Since April 2014, CMHC has required First Nations to provide a Certificate of Building Code Compliance for new houses built with CMHC funding under Section 95 of the National Housing Act. However, there are problems with this approach.

The primary problem is that *National Building Code of Canada* is only a set of minimum requirements. In a remote, northern community with a harsh climate and high energy prices, there is a compelling case to go well beyond minimum code requirements.

This problem has been recognized by Manitoba Hydro and their Power Smart New Home Program. It offers incentives for two options:

Prescriptive Path - Homes must incorporate at 10 prescriptive energy savings measures. These homes will achieve an energy rating equivalent to 20% better than a conventional home built to minimum code requirements.

Performance Path – Homes must be designed with energy modeling and receive a scaled, progressive incentive ranging from $1,500 to $12,000 for increasing levels of performance (see Figure 13 below).

Figure 13 – Manitoba Hydro Energy Performance and Energy Modelling Rebates

Energy performance[1]	Base incentive	Energy modelling rebate[2]	Total available incentive
20% better than	$1,200.00	$300.00	$1,500.00
25% better than	$1,300.00	$300.00	$1,600.00
30% better than	$1,450.00	$300.00	$1,750.00
35% better than	$1,600.00	$500.00	$2,100.00
40% better than	$1,750.00	$500.00	$2,250.00
45% better than	$2,250.00	$500.00	$2,750.00
50% better than	$2,750.00	$500.00	$3,250.00
55% better than	$3,250.00	$500.00	$3,750.00
60% better than	$3,750.00	$750.00	$4,500.00
65% better than	$4,500.00	$750.00	$5,250.00
70% better than	$5,250.00	$750.00	$6,000.00
75% better than	$6,000.00	$750.00	$6,750.00
80% better than	$6,750.00	$750.00	$7,500.00
85% better than	$7,750.00	$750.00	$8,500.00
90% better than	$8,750.00	$750.00	$9,500.00
95% better than	$10,000.00	$750.00	$10,750.00
100% better than	$11,250.00	$750.00	$12,000.00

[1] Relative to the local code house for the jursidiction.
[2] Energy modelling rebate not to exceed 100% of actual project modelling costs.

Additional Information

Aki Team Reports – For more in-depth information about problems observed with the energy-related performance of the existing housing stock in Brochet, please refer to the following report produced by the Aki Team:

- *Final Summary Report: Residential Energy and Water Audits in Manitoba's Off-Grid Communities* by prairieHOUSE Performance Inc.

Further Reading – Information about the technical requirements for the Manitoba Hydro Power Smart for New Home Program can be found at this link.

4.0 Imported Non-Renewable Energy Sources: Issues and Options

4.1 SaskPower Electrical Grid Connection

Major Findings and Recommendations:

- *Connecting Lac Barren Lands First Nation along with Barren Lands First Nation to SaskPower's electrical grid via Wollaston Lake would be high.*
- *A preliminary high-level assessment of capital cost to service both communities ranges from $189 to $518-million depending on the type of transmission line.*
- *Based on this high-level cost estimate, other renewable energy supply options and aggressive demand-side management would be much less costly.*

Overview of Option

Because Barren Lands First Nation is relatively close to the Manitoba-Saskatchewan provincial boundary, the Aki Project Team conducted a preliminary assessment of the technical and economic feasibility of connecting the community plus Barren Lands First Nation to the Saskatchewan Power grid at Wollaston Lake (see Figure 14 below).

Figure 14 – Potential connection to SaskPower Grid

Discussion

SaskPower – Owned by the Government of Saskatchewan, SaskPower is the principal electric utility in the province. North Point Energy Solutions, a wholly-owned subsidiary of SaskPower, provides access to the utility's transmission system to transport electricity to its wholesale customers or wheel power across the province to other jurisdictions.

SaskPower's electrical grid extends to the unincorporated community of Wollaston Lake and adjoining First Nations community of Wollaston Post, the administrative center for the Hatchet Lake Denesuline Nation in Northeast Saskatchewan.

Technical and Regulatory Issues – Eextending an electrical transmission line from Wollaston Lake to Barren Lands First Nation would be a major undertaking that faces several technical and regulatory challenges that include:

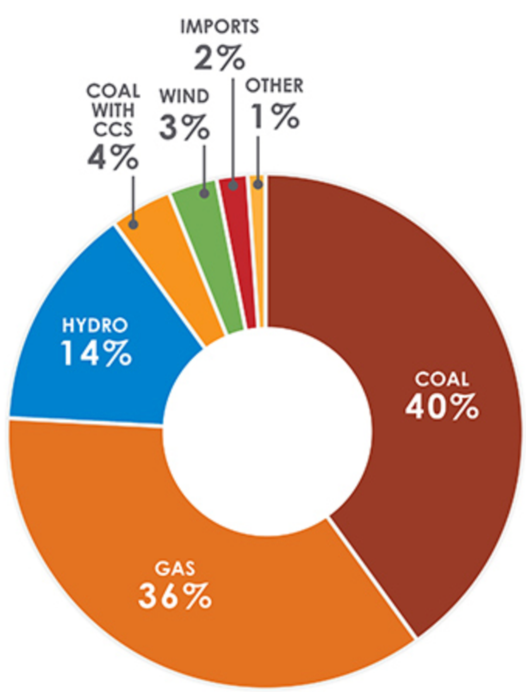
1. Lack of all-season road access
2. Complicated terrain
3. Regulatory approval
4. Environmental assessment process

Preliminary Economic Assessment – A preliminary estimate is that the cost to connect both Lac Barren Lands First Nation(Brochet) and Barren Lands First Nation to the SaskPower grid would be very expensive ranging from $428 to $518-million. The use of a less reliable twin pole design rather than lattice towers would reduce the projected cost to about $189 to $223-million.

Neither of these cost estimates includes any provision for SaskPower transmission upgrades to Wollaston Lake or overhead costs for the transmission construction company.

Greenhouse Gases and Other Emissions – Another factor to consider about this option is that electricity supplied by SaskPower comes mostly from non-renewable fossil fuels (see Figure 15 below).

Figure 15 – SaskPower electricity generation mix



Additional Information

For a more in-depth discussion of this option, see the report *Assessment of Connecting Manitoba Remote Communities to the Saskatchewan Power Grid* produced for Aki by Lumos Clean Energy Advisors.

4.2 Natural Gas Service

Major Findings and Recommendations:

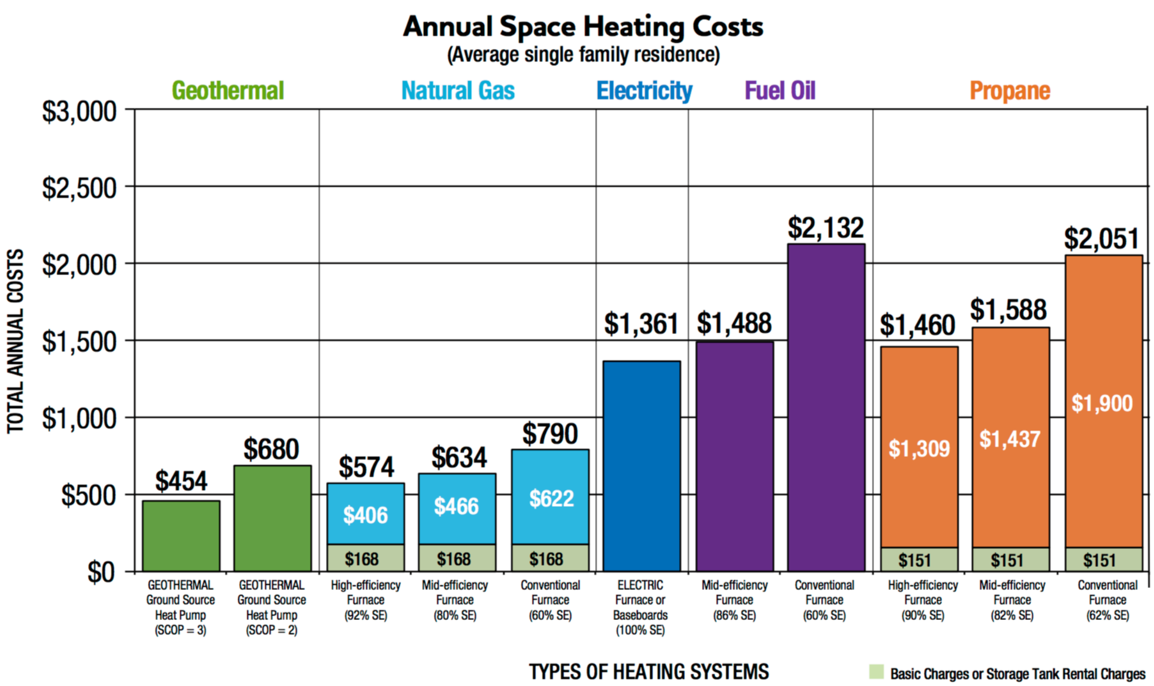
- *Displacing diesel-generated electricity and heating oil in Barren Lands First Nation with natural gas would be attractive due the lower cost for natural gas and the fact that it is a cleaner energy source.*
- *Although it is a more desirable source of energy than diesel fuel or heating oil, extending natural gas pipeline service is impractical due to logistical challenges and the high capital cost driven by the community's long distance to Centra Gas's existing network.*

Overview of Option

This option would involve extending a pipeline from the Centra Gas natural gas network in Southwestern Manitoba to service Barren Lands First Nation(and potentially the other off-grid First Nations in Northern Manitoba). The existing diesel generation station and heating systems for homes and community buildings and facilities would be switched from oil to gas-fired equipment and individual oil storage tanks removed.

Using natural gas rather than diesel fuel and heating oil in the community would have major advantages: it is a significantly less expensive source of energy (see Figure 16 below for Southern Manitoba) and is a cleaner source of energy in terms of greenhouse gases and other emissions. A further advantage is that natural gas would eliminate the risk of soil and water contamination posed by diesel fuel and heating oil.

Figure 16 – Annual Space Cost Comparison for an Average Single-Family Residence



Discussion

Although this would be an option, it was deemed to be impractical due to logistical and capital cost barriers.

Extending a natural gas pipeline over several hundred kilometers from Southwestern Manitoba to Barren Lands First Nation over often challenging terrain would be technically possible but prohibitive from a construction cost perspective. There are other communities in Manitoba much closer to the existing Centra Gas network than Barren Lands First Nation where it has been found to be impractical to extend natural gas service.

Additional Information

Aki Team Reports – Because connecting the community to the Centra Gas natural gas network did not pass an initial screening for consideration for the Barren Lands First Nation Community Energy Plan, the Aki Team did not produce a separate report on this option.

4.3 LNG and Propane Service

Major Findings and Recommendations:

- *Displacing diesel-generated electricity and heating oil in Barren Lands First Nation with either LNG (liquefied natural gas) or propane would be attractive because these are cleaner energy sources.*
- *This option has been deemed to be impractical due to logistical challenges of reliably delivering LNG or propane by truck over the short winter road season and safely and economically storing a sufficient quantity of gas as a hedge against supply interruptions.*
- *Propane faces the additional disadvantage that it usually offers little or no price advantage over diesel fuel or home heating oil.*

Overview of Option

This option would involve trucking either LNG or propane to Barren Lands First Nation using the winter road system and storing a sufficient quantity (up to two years) as a buffer against supply interruption. The existing diesel generation station and heating systems for homes and community buildings and facilities would be switched from oil to gas-fired equipment and individual oil storage tanks removed. This would also provide an opportunity to address the excessive oversizing of heating equipment that is common in the community.

Using natural gas rather than diesel fuel and heating oil in the community would have major advantages: it is a significantly less expensive source of energy (see Figure 18 on next page) and is a cleaner source of energy in terms of greenhouse gases and other emissions. A further advantage is that natural gas would eliminate the risk of soil and water contamination posed by diesel fuel and heating oil.

Figure 17 – Example of LNG delivery by truck

Discussion

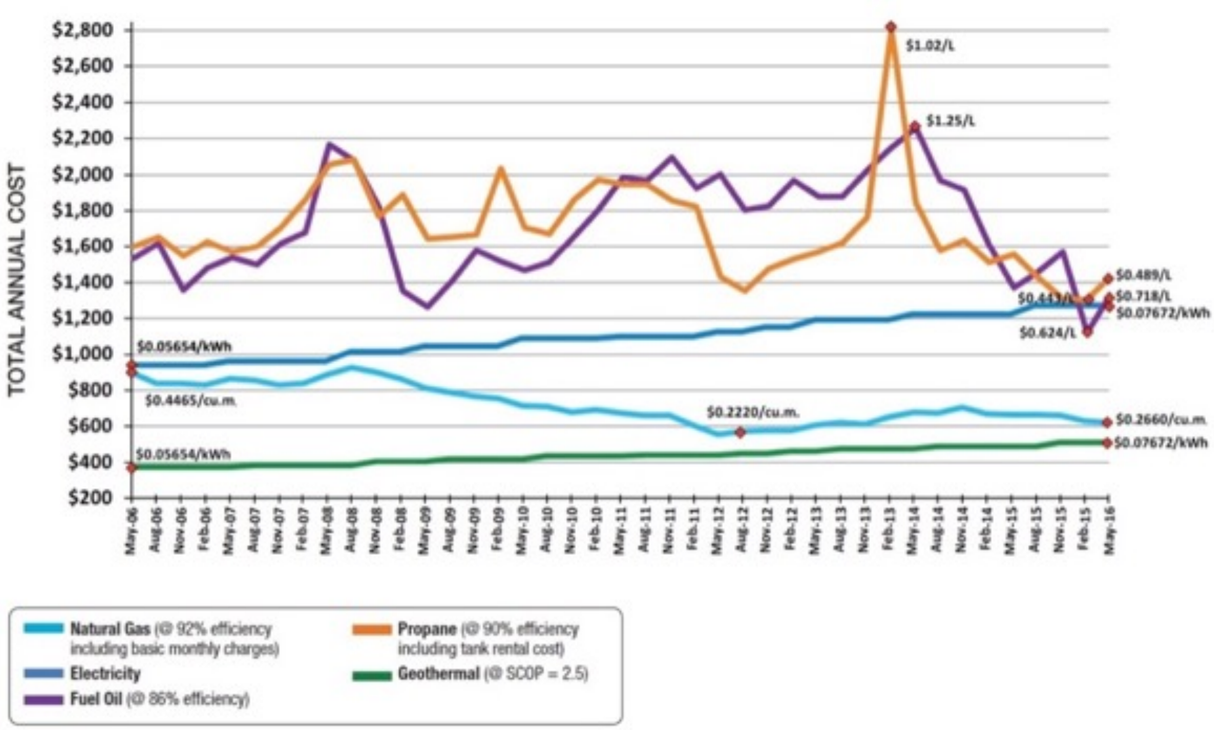
Because it is cleaner burning and offer a cost advantage, there has been some interest in using LNG to displace diesel fuel and heating oil in remote, northern communities and mining projects. However, this approach is still in infancy.

The largest example in Canada of this substitution so far is the Whitehorse Diesel–LNG Conversion Project. Commissioned in 2015, this project involved the installation of two modular LNG-fueled generators to replace Yukon Energy's ageing diesel generation equipment and to provide flexible and reliable back-up power to supplement Yukon's renewable hydroelectric and wind power. More information about this project can be found at this link.

Although cleaner burning, substituting either LNG or propane for diesel fuel and heating oil in Barren Lands First Nation has been deemed impractical. Delivering LNG or propane by truck over the short and often unpredictable winter road season would be difficult. A major barrier would be safely and economically storing a sufficient quantity of gas as a hedge against supply interruptions.

Propane faces the additional disadvantage that it usually offers little or no price advantage over diesel fuel or home heating oil – see Figure 16 below.

Figure 18 – Energy Cost Trends in Manitoba (2006 to 2016)



Additional Information

Aki Team Reports – Because LNG and propane did not pass an initial screening for consideration for the Barren Lands First Nation Community Energy Plan, the Aki Team did not produce a separate report on this option.

4.4 Advanced Diesel

Major Findings and Recommendations:

- *Although reliable, the aging conventional, fixed-speed diesel generators and controls now deployed in Barren Lands First Nation are a barrier to adding a high penetration level of renewable energy sources to the community's electrical grid.*
- *More advanced, variable-speed diesel generators and power management controls would address this issue by linking energy supply closer to energy demand. Because it is more efficient, this technology also has the potential to reduce electricity costs and emissions for the community.*
- *Replacing the existing conventional, fixed-speed diesel generators in Barren Lands First Nationas they reach the end of their service life with advanced, variable-speed diesel generators and controls is a potentially attractive option for option. However, because this is a relatively new technology, a more in-depth analysis is needed. This includes reviewing the operating experience for this technology in other remote, northern communities.*

Overview of Option

This option consists of replacing the existing conventional, fixed-speed diesel generators in Barren Lands First Nationthat approach the end of their service life with more advanced, variable-speed diesel generators and power management controls (i.e., 'Advanced Diesel').

Discussion

Fixed-speed, synchronous generators convert the mechanical output of a diesel engine into electrical power for the grid. To maintain electrical frequency, they operate at one-speed. This basic approach has been followed for more than 100 years.

Fixed speed generators have a major limitation when used in a microgrid that integrates significant amounts of renewable energy such solar photovoltaic-generated electricity and wind power. In these cases, fixed-speed generators have difficulty maintaining speed, and therefore frequency, when the renewable energy output changes rapidly due to events such as cloud cover or inconsistent wind conditions (see sub-section 6.4 for an explanation and discussion of microgrids). This causes fixed-speed generators to hunt for frequency which can destabilize the microgrid and therefore often results in a need to curtail renewable energy supplies or increase costs by add energy storage.

A further issue with fixed-speed diesel generators is that they become less fuel-efficient and produce more greenhouse gases and other emissions as their load decreases. Running fixed-diesel engines that power these generators consistently at low to moderate loads can also increase maintenance problems and costs.

In contrast, variable-speed advanced diesel generators operate at higher efficiency at all loads. This is accomplished by decoupling the diesel engine speed from electrical frequency at all loads allowing the generator set to run at the most advantageous speed at any given load. The result is that compared to conventional fixed-speed units, variable-speed advanced diesel generators have better fuel economy, longer engine life, produce fewer emissions and provide lower cost electricity (in the range of 20% to 30%).

Despite their disadvantages, conventional fixed-speed diesel generators have some major advantages compared to advanced variable-speed generators: they are a far more proven and widely available technology with a long track-record of usage in remote, northern communities.

Because advanced, variable-speed generators are a comparatively new technology, a careful assessment of their feasibility for Barren Lands First Nation that includes a review of this technology's performance in other similar communities is needed.

Additional Information

For a more discussion about how 'Advanced Diesel' potentially fits into a high penetration renewable energy strategy for Brochet, please refer to these reports:

- *Provision of Technical and Economic Studies for a 100% Renewable Penetration Scenario for Brochet, Lac Barren Lands First Nation and Tadoule Lake (March 2017)* by Soft White 60.
- *Strategic Clean Energy Options Assessment & Implementation Plan: Comparing Alternative Approaches to Meet Long-term Energy Requirements for Off-Grid Manitoba First Nations & Scoping a Plan for Implementation* produced for Aki by Lumos Clean Energy Advisors.

4.5 Waste Oil Heating

Major Findings and Recommendations:

- *The new waste oil handling and heating system to be installed in a public works building in Barren Lands First Nation has the potential to displace a useful amount of heating oil. However, the amount of heating oil displaced will not be known until the system is operational and amount of waste oil collected is tracked.*
- *The new system will also address an existing environmental and community concern of how to properly dispose of used oil and oil products.*
- *The new waste oil system complies with all provincial regulations and is approved by the Canadian Standards Association (CSA), Underwriters' Laboratory (UL) or the Underwriters' Laboratory of Canada (ULC).*
- *Caution should be used to accept used oil and oil products only from trusted sources in the community. Mixing special wastes can be dangerous and void the manufacturer's warranty.*
- *Maintenance of the system will be essential. The equipment should be serviced on a regular basis by a qualified service contractor or local community staff with appropriate training, and in accordance with the manufacturer's recommendations.*

Overview of Option

This option involves installing a waste oil heater in a public works building in Brochet.

Waste oil heaters refer to boilers, furnaces and space heaters that are specifically designed to burn used oil and many other waste oil products (e.g., transmission oil, hydraulic oil, diesel sludge, cooking and vegetable oils, etc.) – see Figure 19 on next page.

When waste oil heaters first became popular, they were often not recommended, because the technology and testing methods were not yet established. However, in recent years, the technology has significantly improved and use of waste oil heaters has increased.

Discussion

MARCC Waste-Oil Furnace Initiative – The Manitoba Association for Resources Recovery Corp. (MARRC) is a non-profit organization formed by manufacturers and marketers to develop, administer and implement a province-wide stewardship program for used oil, used oil filters and used oil containers.

In a remote community like Brochet, shipping used oil and other waste oil products is costly and the fossil fuel used in their transportation to a centralized processing facility in Southern Manitoba outweighs any benefit. MARRC has recognized the use of waste-oil heaters as a safe, environmentally-preferable alternative.

In cooperation with MARRC, funding has been approved under a different program to install and begin operating a waste oil unit in Barren Lands First Nationby approximately March 2018. The unit purchased is a 50kW (175,000 BTU) forced-air furnace which is large enough to provide most (if not all) of the heat requirements of one of the public works buildings in the community.

It is not yet possible to estimate the amount of oil that will be consumed in this unit as the community does not yet have a calculated inventory of waste oil nor is it know how much waste oil is can be recovered. However, given that this unit can consume engine oil, diesel sludge, old diesel and old gasoline, the demand for new heating oil will be offset. The exact amount will be known once the units are operational and oil consumption is tracked.

Figure 19 – Example of used oil handling and forced-air furnace system

Regulations and Standards – It will be important for Barren Lands First Nation to ensure that the waste oil handling and heating system to be installed in the community fully complies with all applicable regulations for health, safety and fire.

Each province and territory in Canada has its own set of rules for the licencing and burning of oil. In Manitoba, the provincial government has enacted the Used Oil, Oil Filters and Containers Stewardship Regulation. Details about this regulation and other requirements for the handling, storage, transportation and burning of waste oil can be obtained through the Hazardous Waste

Program of the Environmental Approvals Branch of Manitoba Sustainable Development – see this link for contact details.

In addition, Manitoba also regulates the safety of oil-fired heating systems through the Manitoba Building Code and Manitoba Fire Code. Information about the installation requirements under these codes can be obtained through the Office of the Fire Commissioner – see this link for contact details.

Operation and Maintenance Issues – It can be dangerous to mix special wastes (e.g., solvents, brake fluid, anti-freeze, etc.) with used oil that is to be burned in a waste oil heater. It may also void the manufacturer's warranty. It will be important to ensure that Barren Lands First Nation staff who deal with used oil and the waste oil burner are educated about this hazard and only accept used oil and oil products from trusted sources.

It will also be essential that maintenance requirements provided by the manufacturer are closely followed to ensure the safe operation of the waste oil heating system. Maintenance procedures can be very involved. It is therefore recommended that the system be serviced on a regular basis by a qualified service contractor, manufacturer's representative or local community staff with appropriate training to ensure that the system is in proper operating condition. Annual verification that this has been done should be required.

Additional Information

Aki Team Reports – Because of the small scale of this option, the Aki Team did not produce a separate report on this option.

5.0 Local Clean Renewable Energy: Issues and Options

5.1 Connection to Manitoba Hydro Electrical Grid

Major Findings and Recommendations:

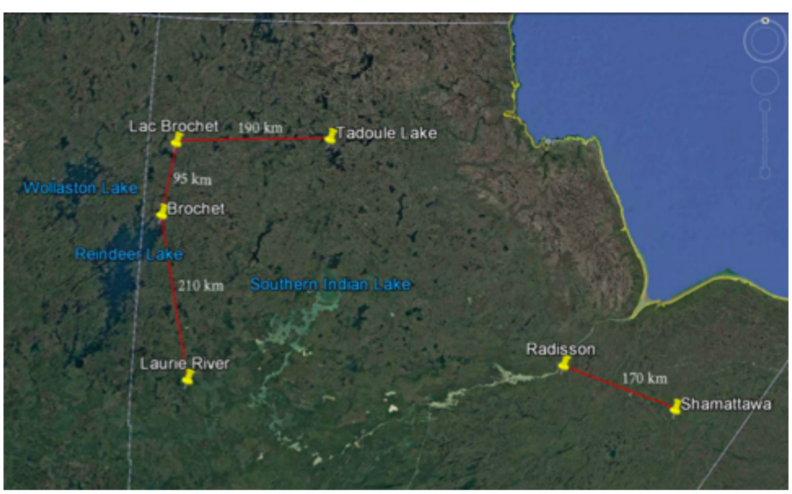
- *Connecting Barren Lands First Nation to Manitoba Hydro's main electrical grid would need to be part of larger project to also connect Barren Lands First Nation(and possibly Tadoule Lake) to Hydro's Laurie River Generating Station via Lynn Lake.*
- *A preliminary high-level assessment of capital cost to service all three communities is approximately $575-million. The costs to upgrade from 60 to 200-amp service within the community is not included in this estimate.*
- *Ignoring costs, connecting Barren Lands First Nation to the grid could be a good option to displace both diesel-generated electricity and use of heating oil.*
- *A detailed feasibility study would provide more accurate costs. However, it appears from the high-level cost estimate produced for this report that other renewable energy supply options and aggressive demand-side management, would be much less costly and require shorter lead times.*

Overview of Option

This option would part of a larger project to extend Manitoba Hydro's main electrical grid to connect Tadoule Lake, Lac Barren Lands First Nation(Brochet) and Barren Lands First Nation with an overhead transmission line to Hydro's Laurie River Generating Station via Lynn Lake (see Figure 20 below).

Under this option, the existing diesel generators diesel storage tank farm in Barren Lands First Nation would be decommissioned. The electrical distribution system in the community would be upgraded and homes and community buildings and facilities converted to 200-amp service and electric heating.

Figure 20 –Proposed Transmission Lines to Manitoba's Off-Grid Communities



Discussion

Ignoring the construction cost, connecting Barren Lands First Nation to the grid would be a good option to displace both diesel-generated electricity and use of heating oil. As a result, there have been past efforts to study the option of extending electricity from Manitoba Hydro's main grid to Barren Lands First Nation and the other three off-grid communities in Manitoba (i.e., Brochet, Tadoule Lake and Shamattawa). This includes a November 2008 Generating Resource Screening Study by Manitoba Hydro that conducted a preliminary analysis of three options to reduce or eliminate 60-amp diesel-fired generation in the non-grid communities (the other two options studied were to augment diesel generation with wind power and small hydroelectric generation).

More recently, a July 2015 Capital Project Justification report was completed by Manitoba Hydro for a new diesel generating station in Barren Lands First Nation adjacent to the existing station, plus replacement of the existing diesel storage tank farm and upgrade of staff accommodations. This report by Hydro stated the following:

> It should also be noted that the Remote Diesel Communities Committee (RDCC) is currently performing a high level evaluation of the construction of a transmission line connecting the community of Lac Brochet to the Manitoba Hydro grid and decommissioning the existing diesel generating station. A transmission line would also service the communities of Brochet and Tadoule Lake. It is not known when that committee's evaluation will be available, but it is known that installation of a new transmission line would be many years away given the time needed to negotiate a cost-sharing agreement, conduct environmental licensing, and design and construct. With the current state of the diesel equipment, delaying installation of a new generation station will place the community at risk of unreliable power.

Aki's Team was not able to obtain a copy of the RDCC's evaluation noted above, and therefore conducted its own high level evaluation (see report listed in 'Additional Information' below for details).

Additional Information

For a more in-depth discussion and additional insights about this option, please refer to these reports:

- *Assessment of Connecting Manitoba Remote Communities to the Manitoba Power Grid* produced for Aki by Lumos Clean Energy Advisors.
- *Manitoba Hydro Generating Resource Screening Study: Barren Lands First Nation and Lac Barren Lands First Nation(November 2008)* by Manitoba Hydro.
- *Capital Project Justification – Lac Barren Lands First Nation New Diesel Plant (July 2015)* by Manitoba Hydro.

5.2 Small-Scale Hydro

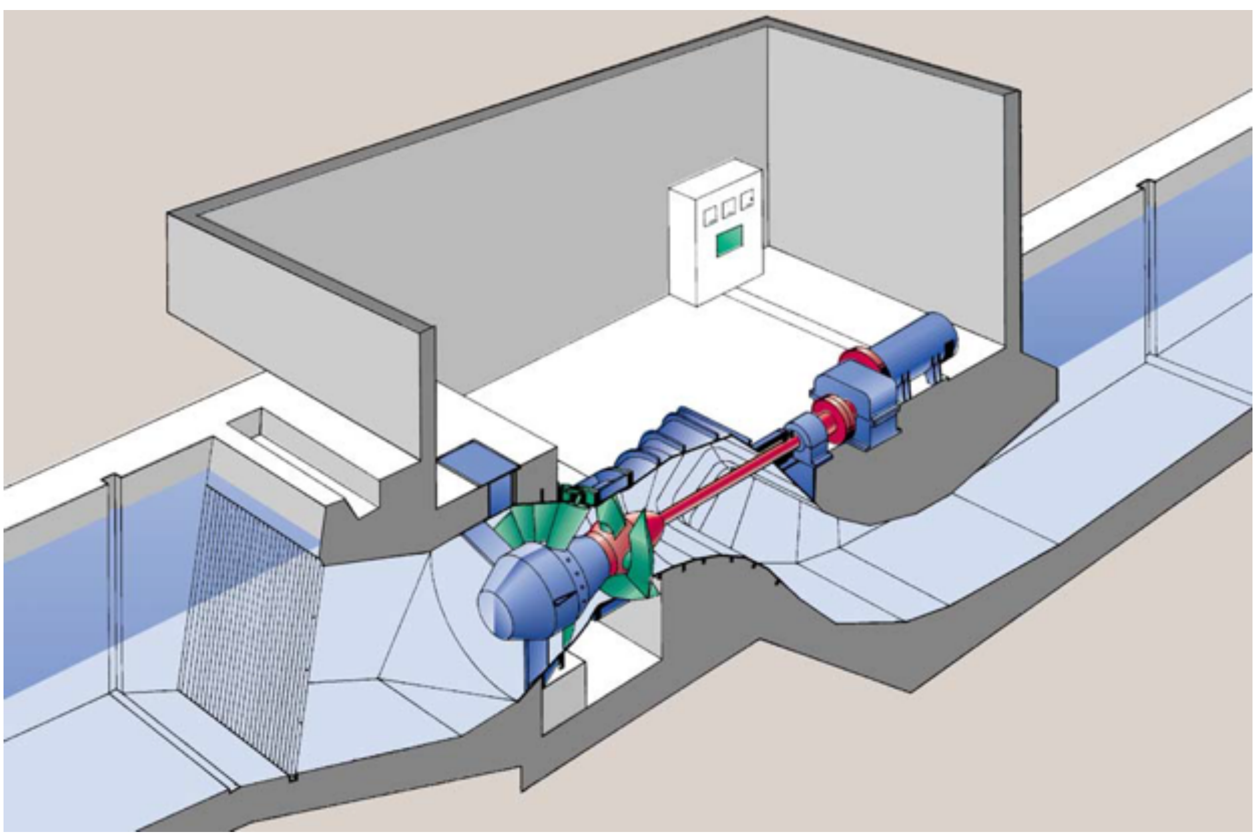
Major Findings and Recommendations:

- *There is the potential to build a small hydro generating station on the Cochrane River to serve the combined electrical needs of Lac Barren Lands First Nation(Brochet) and Barren Lands First Nation or to build a dedicated station for each community.*
- *There have been multiple studies of this option. One of the most recent (2009) found that small-scale hydro would be more expensive than running the existing diesel generation facilities in both communities.*
- *A December 2016 update estimated that the cost of a dedicated hydro generating station for Barren Lands First Nation only would range in cost for $110 to $145-million.*
- *A small hydro generating station would need a long lead time (at least five years and as many as ten years) to complete the necessary studies and design work, secure licencing and construct the facility.*

Overview of Option

This option would consist of building small hydro generation station on the Cochrane River to serve the combined electrical demand for both Lac Barren Lands First Nation(Brochet) and Brochet. Another option would be construct a dedicated hydro station for each community.

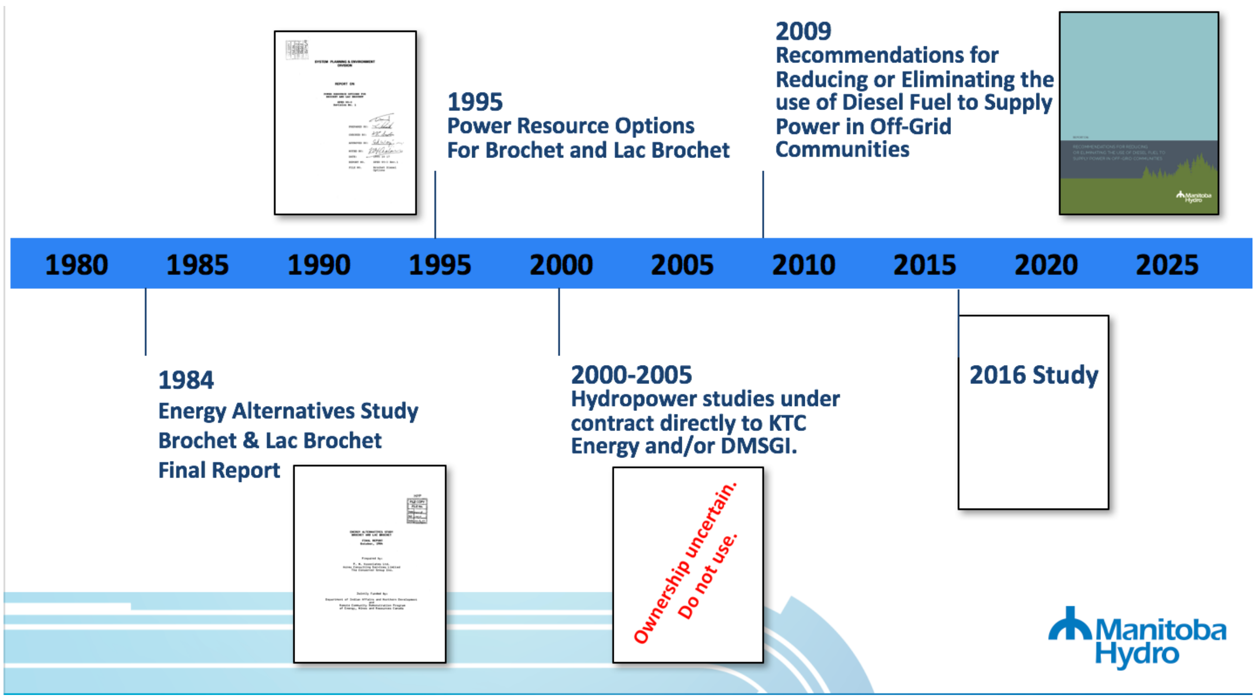
Figure 21 – Cut-away of small scale hydro generation station



Discussion

Since 1984, there have been multiple screening studies and major reports of the technical and economic feasibility of small hydropower options on the Cochrane River to serve Barren Lands First Nationand Lac Barren Lands First Nation(see Figure 22 below).

Figure 22 – Timeline of Hydropower Reports for Barren Lands First Nation and Lac Barren Lands First Nation(Brochet)



The 2009 study by Manitoba Hydro looked at building a small hydro station for both 60-amp and 200-amp service levels. Under average flow conditions, diesel generation was forecast not to be required over the study period (to 2041) with the small hydro station satisfying the combined energy and capacity requirements of both communities.

Under dependable flow conditions, the small hydro plant was forecast to meet the combined energy and capacity requirements for the 60-amp option for Barren Lands First Nation and Lac Barren Lands First Nation until 2027. From 2028 onwards, the existing diesel generation station at Lac Barren Lands First Nation would be needed. These options appear to be based on a 'business-as-usual' scenario with respect to the projected growth in electricity use in the community and therefore do not consider the potential impact of aggressive demand-side management.

For the 200-amp service option, the small hydro station capacity is not adequate to meet peak capacity demand under both dependable and average flow conditions over the study period.

Based on Manitoba Hydro's now-outdated 2006 fuel price forecast, both options result in higher costs relative to continued operation of the diesel generating stations at Barren Lands First Nation and Lac Brochet.

A December 2016 update from Manitoba Hydro estimated that the capital cost of a dedicated small-hydro generation station for Barren Lands First Nation would cost from $110 to $145-million. The cost to get better information for the next stage of design was estimated at $50 to $100K. Between $10 to $30-million and three to seven years would be required to complete all pre-construction studies and licensing. Construction would take another two or three years.

Additional Information

For a more in-depth discussion and additional recommendations about this option, please refer to these reports:

- *Small Hydro Project Potential (March 2017)* produced for Aki by Lumos Clean Energy Advisors.
- *Recommendations for Reducing or Eliminating the Use of Diesel Fuel to Supply Power in Off-Grid Communities (2009)* by Manitoba Hydro.
- *Barren Lands First Nation Small Hydropower Cost Estimate Update (December 2016)* by Manitoba Hydro.

5.3 Wind Energy

Major Findings and Recommendations:

- *There are many technical challenges to installing, integrating and operating a community-scale wind energy system in a cold, remote community (such as Brochet) that depends on diesel-generated electricity. Targeting a 'low' rather than a 'medium' or 'high level' of penetration of wind energy significantly reduces complexity and these risks.*
- *Cold-climate wind technology continues to mature. Despite many early failures, there are a growing number of successful projects across the north that demonstrate that wind-diesel hybrid power systems can be a viable option for remote communities. Based on this experience, the feasibility of wind energy for Barren Lands First Nation should be explored in more depth as part of a comprehensive local renewable energy strategy for the community.*
- *There is a lack of wind data for Brochet. This is a major barrier since the economic merits of a wind energy system will depend heavily on local wind speeds and, to a lesser extent, their distribution throughout the year.*
- *Detailed wind data should be collected for Barren Lands First Nation as soon as possible for a minimum of 12 months and then assessed to determine whether wind-generated electricity should be part of the community's energy mix. A suggested schedule and protocol for this wind monitoring that involves local community resources has been developed by Aki.*
- *An initial cost estimate to purchase a suitable 34-meter tall meteorological wind monitoring tower for Barren Lands First Nation is approximately $16,000. Depending on the number of towers, it would cost about $12,000 to charter a plane to fly the equipment to Brochet. Shipping by truck during the winter road season is another option.*
- *The Prairie Agricultural Machinery Institute (PAMI) has successfully installed and removed several wind monitoring towers in Manitoba and could by contracted to assist Brochet. Aki has requested a preliminary estimate from PAMI for this service.*

Overview of Option

This option would involve collecting detailed wind data for Barren Lands First Nation and, if a sufficient wind resource is confirmed, installing one or two small or medium-scale wind turbines to provide electricity to the community.

Wind is a form of local renewable energy. The terms 'wind energy' or 'wind power' refer to the process of converting wind into mechanical power for a specific task (e.g., pumping water, grinding grain) or, more commonly, to generate electricity.

Aki's analysis of wind energy options for the Barren Lands First Nation CEP has focused on generating electricity with wind turbines. The balance of this *Overview of Technology* sub-section provides several general comments and insights about this technology. This background will enable non-technical readers to better understand the major findings and recommendations about wind-generated electricity for Barren Lands First Nation that has been prepared by the Aki Team.

Wind Resource Assessment – Wind energy is a variable energy resource since its output varies with changes in wind speed. The wind resource available within a reasonable distance to a community is a key factor in determining the economic viability of a wind-diesel project.

The energy content of wind is proportional to the cube of the wind speed. This means that even small changes in the wind speed that a wind turbine is exposed to can have a significant impact on its output of electricity. For example, a small increase in wind speed from 6.0 to 7.0 meters per second (m/s) – 22 to 25 kilometers per hour (km/h) – will increase output by almost 60%.

Local airport wind speed records and data from the Canadian National Wind Atlas can be a preliminary screening tool to rule out communities which obviously do not have an adequate wind resource.

As a rule-of-thumb, communities with an average annual wind speed that exceed 6 m/s (22 km/h) can be screened in and communities with wind speeds less that 5 m/s can be screened out for further consideration. Communities with wind speeds between 5 and 6 m/s could be screened in for consideration if taking advantage of the local topography (e.g., hill or ridge, open area with few or no trees, etc.) might yield a significant increase in wind speed.
Wind speed typically increase significantly with height.

Caution should be used with wind speed data recorded at lower levels above the ground (e.g., at 10 meters) at airports and elsewhere. This can lead to significant underestimation of actual wind speeds at higher levels (i.e., 30 meters and higher) where most wind turbines operate.

Wind Turbines – Wind turbines have blades or rotors which turn in moving air. They spin a shaft, often connected to gearbox, which drives a generator to make electricity.

Wind turbines vary widely in terms of the peak amount of electricity they can generate. They can be classified as follows:

1. *Small wind turbine* – Maximum rated power capacity from 20 watts to 100 kW (1 kW = 1,000 watts).
2. *Medium wind turbine* – Maximum rated power capacity from 100 kW to 1 MW. (1 MW = 1,000 kW or 1,000,0000 watts).
3. *Large wind turbine* – Maximum rated power capacity of more than 1 MW.

For comparison, the annual peak electricity load in Barren Lands First Nation is just under 900 kW (0.9 MW). Most community-scale wind energy systems in remote communities utilize medium capacity wind turbines.

Although there are some novel approaches to modern wind turbines, most fall into two basic groups: horizontal axis wind turbines (HAWTs) and vertical axis wind turbines (VAWTs) – see Figures X and Y on pages 37 and 38.

Except for a few niche applications, VAWTs are generally inferior and much less common than HAWTs. For this reason, the analysis of wind energy options for the Barren Lands First NationCEP has been limited to HAWTs.

Wind Turbine Towers – Towers and their foundations to support a wind turbine represent a major portion of the cost of wind energy project. There are three general types of towers: free-standing tubular towers, guyed tubular towers and lattice towers.

Unless erected directly on exposed bedrock, free-standing tubular towers usually require a substantial concrete foundation. Aggregate and concrete in isolated communities (such as Brochet) is expensive and often available only on a seasonal basis.

Some towers are 'self-erecting'. Most free-standing towers, especially taller ones, require a crane for erection. This presents both logistical and cost challenges in a remote community. Guyed tubular towers or lattice towers have reduced foundation and anchoring requirements and therefore can be less expensive to install.

Lattice towers are less desirable than tubular towers in locations where icing is a problem since they provide more surface area for ice to accumulate.

Tower height is another important factor that requires careful analysis to optimize the performance of wind energy system. Taller towers increase the amount of wind energy that can be captured but cost more and present greater logistical challenges than shorter towers.

Wind Penetration Levels – A critical design factor that impacts the complexity and feasibility of a wind-diesel hybrid power system is how much energy is coming from wind.
Called the 'wind penetration level', there are three classifications of systems:

1. *Low penetration* – Less than 50% of peak demand (kW) and 20% of average annual electricity use (kWh) is provided by wind.
2. Medium Penetration – 50 to 100% of peak demand and 20 to 50% of average annual electricity use is provided by wind.
3. *High penetration* – More than 100% of peak demand and at least 50% of average annual electricity use is provided by wind.

Low penetration systems use 'off the shelf' technology and are relatively easy to implement. Medium penetration systems are more complex and require a higher level of skill to design, operate and maintain. High penetration systems are very complex and require a sophisticated control system and additional components to store electricity and regulate voltage and frequency. Because high penetration systems are expensive they require a good wind resource to be economical.

There are many different approaches to designing and building a community-scale wind-diesel power system. However, any wind energy system in a remote community can benefit from remote monitoring and access. This allows expert oversight and troubleshooting of system performance to reduce maintenance, improve reliability and minimize downtime.

Advantages and Limitations – Wind energy has both advantages and limitations, some of which are general in nature and others that are specific to a small, remote community in a cold northern environment such as Brochet:

- *Renewable, non-polluting* – Unlike diesel-generated electricity, wind is a free, local renewable energy resource that does not emit greenhouse gases, odours or other air pollutants. A hybrid wind-diesel generating system can reduce diesel consumption does not eliminate the risks associated with transporting and storing diesel fuel.
- *Other environmental impacts* – Although wind energy systems have considerably less environmental impact that diesel-generated electricity, there can be some concern about the noise produced by the blades or rotors of the wind turbine if it is located to close to homes or other buildings.

  Depending on the site, there may also be aesthetic (visual) impacts to consider. Through proper siting of a wind turbine and tower, the risk to birds, bats or other local wildlife can be minimized.

Figure 23 – Examples of horizontal axis wind turbines with a free-standing tubular tower (left) and a lattice tower (right)

Figure 24 – Example of a vertical axis wind turbine

- *Cost effectiveness* – The cost of wind power has declined dramatically during the past decade. However, the technology still requires a higher initial investment than diesel generators. However, when wind energy systems are compared to diesel-generated electricity on a 'life-cycle cost' basis, wind power can be competitive because there is no fuel to purchase, maintenance requirements are less and more local employment is possible.
- *Variability* – Wind turbines are an intermittent source of energy. They normally begin to generate electricity when wind speeds reach at least 3 to 4 m/s (about 11 to 14 km/h and stop operating at about 20 m/s (about 72 km/h) to prevent equipment damage. Unless combined with storage, not all winds can be harnessed to match the timing of demand for electricity.
- *Performance and reliability* – Although wind energy is considered a mature technology, experience with its application in remote, northern communities is still at a relatively early stage. Many early wind-diesel systems installed as pilot or demonstration projects in Alaska and Northern Canada experienced problems and did not perform as expected. However, more recent installations have demonstrated improved performance and reliability

Wind Energy Issues and Options for Brochet

Local Wind Resource – The Aki Team sought local

wind resource data for Barren Lands First Nation from these three sources:

1. *Canadian Wind Energy Atlas (CWEA)* – There are two versions of the CWEA.:
   - One version is a national map with a resolution of 25 x 25 km that expresses wind energy at a height of 50 meters – see Figure 25 on next page.
   - The other version is an online, interactive map of Canada with a resolution of 5 x 5 km that presents wind speeds and wind energy at heights of 30, 50 and 80 meters above ground – see this link.
2. *Manitoba Hydro 80-Meter Wind Map* – In 2006, Manitoba Hydro commissioned a wind map of the province. This map has a resolution of 136 x 136 meters and therefore is much more detailed then the CWEA.

   Manitoba Hydro's map shows estimated wind speeds at a height of 80 meters. Although large wind turbines with hub height of 80 meters are feasible in Southern Manitoba, they cannot be considered an option for remote communities in Northern Manitoba (including Brochet) due to logistical constraints.
3. *Environment Canada 10-Meter Wind Speeds* – Environment Canada has weather stations throughout Manitoba, some of which record wind speeds throughout the year at an industry standard height of 10 meters above ground level (a strong wind regime at 10 meters is often indicative of a good wind resource at greater heights). Unfortunately, Environment Canada does not have a weather station in Brochet.

Based on an analysis of the available wind resource data, Aki Team's has made the following observations and conclusions:

- The CWEA estimates that the average annual wind speed for Barren Lands First Nation at 30 meters above ground is in the range of 6.0 to 7.0 m/s.
- Average wind speed alone does not provide a complete picture of how the wind varies throughout the year at a site of interest. Wind-generated energy production estimates require a site's complete wind speed distribution profile, not just the average wind speed.
- Due to logistical challenges, wind turbines in Barren Lands First Nation will likely be restricted to heights of between 30 to 50 meters above ground.
- Extrapolating the estimated average annual wind speed from Manitoba Hydro's 80-Meter Wind Map to the desired height of 30 to 50 meters creates additional uncertainties.
- A reasonable assessment of the wind energy potential for Barren Lands First Nation will require a rigorous, site-specific monitoring program for a minimum of 12 months.

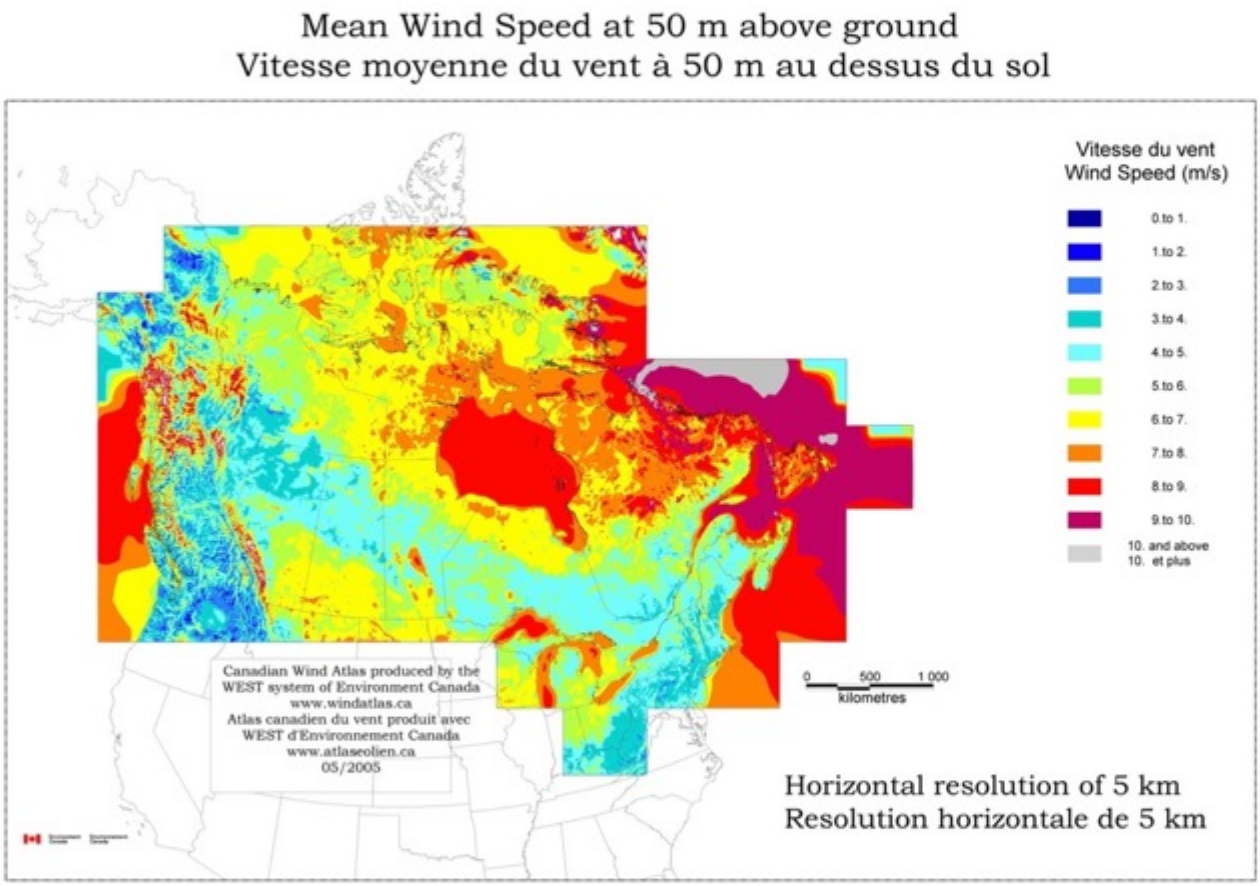


Figure 25 – Canadian Wind Energy Atlas

Wind Monitoring Strategy – The following are key issues and recommendations for the wind monitoring strategy and protocol developed by Aki for Brochet:

1. *Wind monitoring technique* – There are two common approaches to wind monitoring:

- ‘LiDAR’ (Light Detection and Ranging): This technique uses rapid pulses from a laser light to generate high quality data on wind speed and direction at multiple heights.
- ‘Met’ (meteorological) towers – This method uses a tall metal pipe supported with several guy wires anchored to the ground. A series of monitoring sensors (e.g., anemometer to measure wind speed, wind vane to record wind direction, etc.) are attached to the tower with horizontal booms – see Figure 26 below.

Aki recommends that multiple met towers rather than LiDAR be used for the wind monitoring in Brochet. Although logistically more challenging to transport and install/remove, met towers offer several other advantages compared to LiDAR (i.e., they are less expensive; they make it more feasible to collect wind data from multiple sites simultaneously; usable data is recorded even if one of the sensors fails or is damaged).

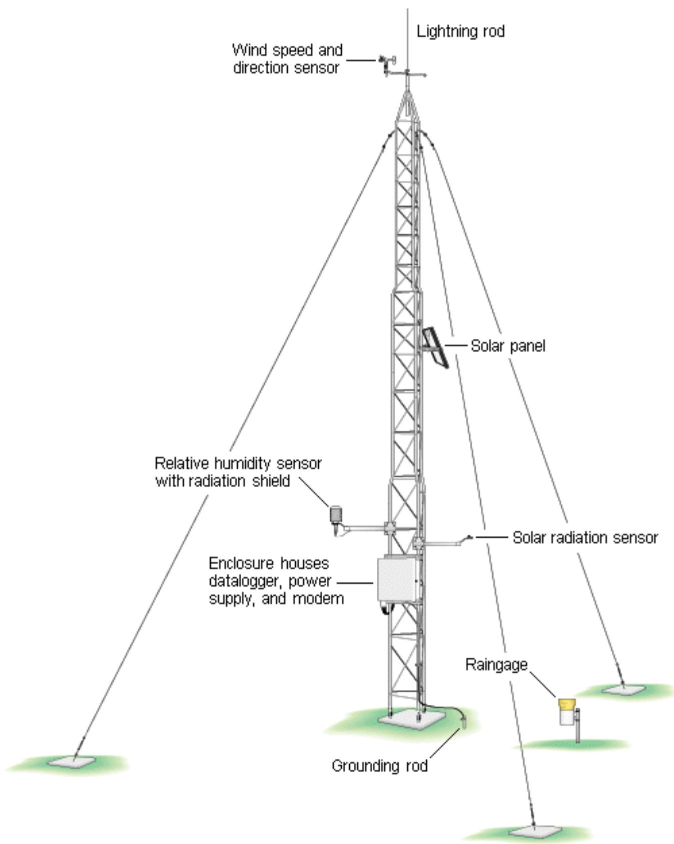


Figure 26 – Meteorological (‘met’) tower for wind monitoring

2. *Community acceptance* – Acceptance by community members of proposed sites for the met towers should be obtained before they are installed. Met tower installations should be limited to areas that are not sacred sites or ecologically-sensitive areas. Local knowledge will also be useful to determine which areas near the community are likely to have the strongest winds due to geological features (e.g., the ‘Big Hill’), road or trail access plus enough open space to assemble and erect the towers.

3. *Use of local community resources* – Experience in other jurisdictions has shown that involvement of community members will enhance the chances of a successful wind monitoring program in Brochet. In addition to providing support for choosing the location of the met towers, one of more community members can assist with the transportation, site preparation, assembly, erection and removal of the met towers. A community member can also be used to periodically monitor the tower and help address any problems (e.g., adjust loose guy wires, replace a failed sensor, etc.).

Wind Turbine Suitability – Wind energy, especially large-scale projects such as the St. Leon and St. Joseph wind farms in Southern Manitoba, is a mature technology experiencing strong growth on a global basis. However, there are several issues that make wind energy more challenging for Barren Lands First Nation and other off-grid First Nations in Northern Manitoba.

The first issue is scale. Large wind turbines are much more effective for generating electricity than medium or small wind turbines. The weight and size restrictions imposed on the winter road system that connects Barren Lands First Nation makes it impractical to transport the large, heavy wind turbines, long blades and massive cranes that were used for the wind farms in Southern Manitoba.

The second issue is extreme cold weather performance. Unlike large wind turbines, there are a relatively small number of suppliers (e.g., Northern Power Systems) that offer 'artic' wind turbines that have a long track record of performance in a climate as cold as Brochet. There are many examples of wind projects across the north that have either failed or fallen short of expectations. However, there are also a growing number of successful projects in Canada's Far North and Alaska that demonstrate that wind is a viable option for remote, off-grid northern communities provided that the project is properly designed, installed and maintained.

The third issue is maintenance. As a remote community, having a wind turbine that is reliable to minimize the need for expensive maintenance or repairs will be an important consideration for Brochet.

Integration with Other Renewables – Consistent with vision and values expressed in the *Barren Lands First Nation Sustainable Development Strategy*, Aki's Team conducted a prefeasibility analysis of several scenarios using different combinations and penetration levels of renewable energy systems (including wind) to completely displace the use of diesel fuel in Brochet.

Wind energy-related highlights from this analysis include the following:

- Three of the scenarios for 100% renewable energy penetration for the community include wind energy with some battery storage.
- The level of wind penetration was determined by a software tool for optimizing micro-grid design (HOMER Pro) to include a single 100 kW wind turbine with a 50-meter hub height for one scenario and two 100 kW wind turbines (also at 50-meter hub heights) for the other two scenarios.
- The lowest cost scenario over a 25-year planning horizon (Case 3) includes two 100 kW wind

turbines.

- An additional advantage of incorporating wind turbines (combined with solar photovoltaics and battery storage) is that it will provide more diversity of supply since wind power can be available both day and night, year-round.

For a more complete summary of the 100% renewable energy penetration scenarios and their analysis, please refer to Section '6.0 Integrating the Options'.

Additional Information

Aki Team Reports – For more in-depth information about wind energy issues, options and analysis for Brochet, please refer to the following reports produced by the Aki Team:

- *Development of a Wind-Energy Resource Assessment Strategy for Manitoba's Off-Grid First Nations (March 2017)* by Marc Arbez, P. Eng.;
- *Assessing Potential for Wind Power-Diesel Hybrid Option for Manitoba Remote Communities (March 2017)* by Lumos Clean Energy Advisors; and
- *Provision of Technical and Economic Studies for a 100% Renewable Penetration Scenario for Brochet, Lac Barren Lands First Nation and Tadoule Lake (May 30, 2017)* by Soft White 60.

Further Reading – For more information about wind energy, including its application in northern, remote communities, here are suggested publications:

- *Alaska Isolated Wind-Diesel Systems: Performance and Economic Analysis* prepared for the Alaska Energy Authority.
- *Wind Energy for the Rest of Us: A Comprehensive Guide to Wind Power and How to Use It* by Paul Gipe.

5.4 Solar Energy

Major Findings and Recommendations:

- *Several active and passive solar energy technologies were considered for Barren Lands First Nation by the Aki Team. Two of these technologies, concentrating solar power and solar water heating were eliminated from further consideration due to concerns that their performance and reliability in a cold, remote community remains unproven.*
- *Two other forms of solar energy, building integrated solar heating and community-scale photovoltaic-generated electricity should form a modest part of a diversified and integrated local renewable energy strategy for Brochet.*
- *Whether more photovoltaic-generated electricity should be added to the community's energy mix beyond the ERAAES project should be part of a full feasibility study.*
- *If more photovoltaic capacity is to be added, fixed PV panels are recommended rather than a single or dual-axis tracking system to reduce maintenance requirements and maximize reliability.*
- *An investment in a battery energy storage system, in combination with other renewables (wind and biomass), will smooth out the daily fluctuations in electricity production from the photovoltaics due to clouds or other shading and the transition from day to night.*

Overview of Options

This option would involve using solar energy to produce heat and/or electricity for Barren Lands First Nationusing either passive or active technology.

Solar is a form of local renewable energy. The terms 'solar energy' or 'solar power' refer to harnessing the radiant light and heat from the sun through a range of different technologies.

Solar technologies are broadly classified as either 'passive' or 'active'. An example of passive solar technology is orienting a house so that its south-facing windows maximize heat gain from the sun during the winter. An example of active solar technology is using photovoltaics panels to convert sunlight directly into electricity.

The balance of this *Overview of Technology* sub-section provides general comments and insights about the types of solar energy technology considered by the Aki Team for Brochet. This background will enable non-technical readers to better understand Aki's major findings and recommendations about this technology for the community.

Concentrating Solar Power – Concentrating solar power (CSP) use mirrors or lenses with tracking systems to focus a large area of sunlight onto a small area – see Figure 27 on next page. The resulting heat can then be used directly (e.g., heating buildings, industrial processes, etc.) or indirectly to generate electricity.

A major advantage of CSP systems is that they can be designed to store some of their heat for periods with little or no sun.

Figure 27 – Concentrating solar power research and demonstration project
for northern communities at Red River College

Solar Water Heating – Solar water heating systems include solar collectors (most often roof-mounted) and storage tanks to provide hot water. There are two types of solar water heating systems: active systems which have circulating pumps and controls and passive systems that do not – see Figures 28 and 29 on next page.

Passive solar water heaters are simpler, more reliable and less expensive than active systems. However, they aren't appropriate in areas where temperature frequently fall below freezing. In cold climates, active systems circulate a non-freezing heat transfer fluid to avoid freezing problems. This added complexity increases costs and maintenance requirements.

Most solar water heaters are installed as a small, separate system on individual houses and buildings rather than as a larger community-scale system.

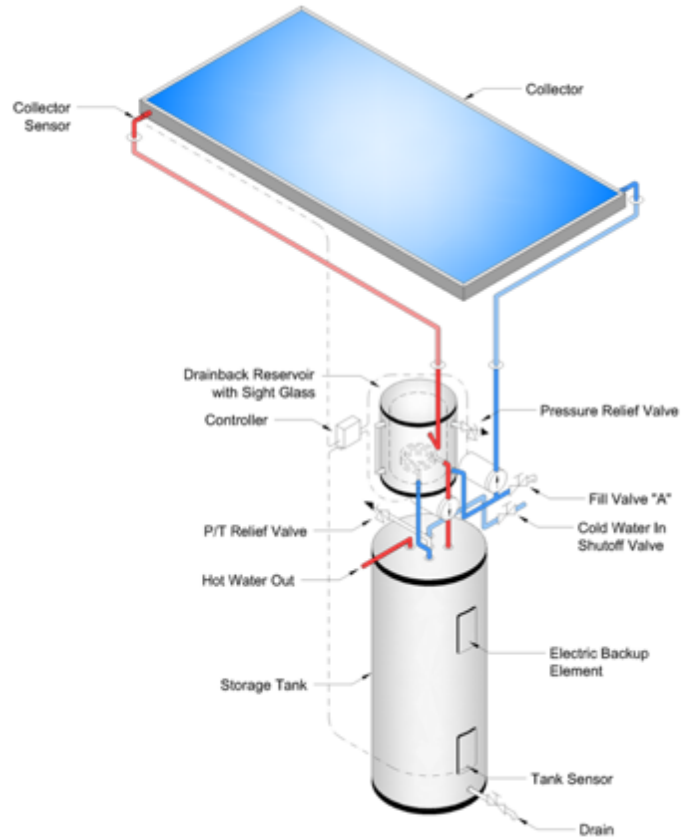


Figure 28 – Active solar water heating systems

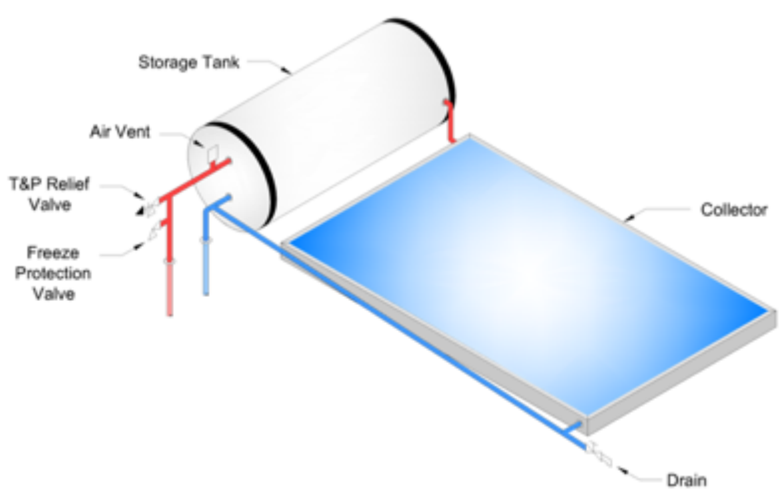


Figure 29 – Passive solar water heating system

Building Integrated Solar Heating – This approach uses dark-coloured, perforated metal panels (sometimes referred to as ‘transpired solar collectors’) mounted on the sun-facing sides of a building. When exposed to sun, air drawn through the perforations in these panels preheat fresh outdoor air drawn into a building to replace stale air exhausted from the building. This heated air is distributed throughout the building via its ventilation system or dedicated fans and ducting. For summer operation, a bypass is used to avoid heating the building.

The following is a schematic of how building integrated solar heating works:

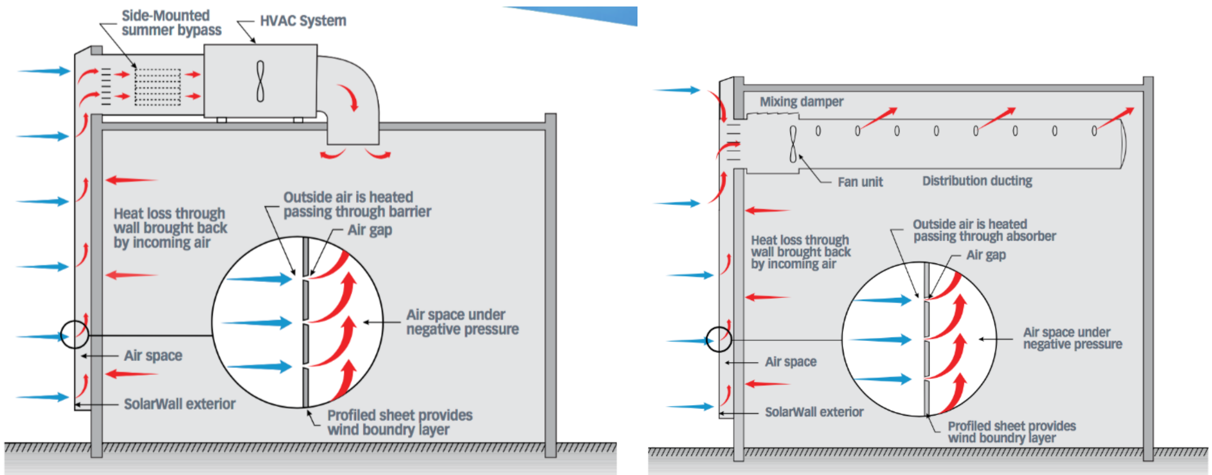


Figure 30 – Building integrated solar heating

Better known by the brand name ‘Solarwall’, this is a simple, cost-effective and low-risk renewable energy technology. It has also proven to perform well in cold climates with numerous working examples in Manitoba in commercial, institutional, industrial and apartment buildings.

Figure 31 – SolarWall integrated into a credit union building in Winnipeg

Solar Photovoltaic Electricity – A solar photovoltaic (PV) system converts light directly into electricity. A typical solar PV system consists of a solar array that consists of:

- PV panels composed of many PV modules and individual PV cells;
- an inverter, cabling and other electrical controls to convert the electricity from direct current (DC) to alternating current (AC); and
- hardware to support the solar array.

The solar array can be ground-mounted or installed on the roof or wall of a building or house. The array can be fixed or employ a tracking system (single or dual axis) to follow the daily and seasonal movement of the sun to boost the amount of electricity generated.

Most PV systems are connected to the electrical grid and feed surplus power into the grid. Because PV systems only generate power when the sun is shining, the addition of battery storage can be used to supply power at night.

PV-generated electricity is a reliable, mature technology. It has experienced rapid growth in recent years driven largely by changes in public policy, advances in technology and a steep decrease in cost. There are a growing number of successful examples of PV systems that have been installed in remote, northern communities.

Figure 32 – Example of ground-mounted solar PV array (Lutsel K'e Dene First Nation, NWT)

Discussion

Recommended solar technologies – Of the solar technologies described above, solar photovoltaic electricity and building integrated solar heating (‘SolarWall’) have the most potential for Barren Lands First Nation based on their cost-effectiveness and ability to perform reliably in cold climates.

Although very seasonal, Barren Lands First Nation has a reasonably good solar resource potential (see map below – Figure 33). Expanding the use of photovoltaics in the community beyond that already being installed through the ERAAES project now underway (see sub-section 2.4) as part of a broader, integrated renewable energy generation strategy is a viable option (see sub-section 6.1).

From a design perspective, building integrated solar heating is a good fit for northern, remote communities such as Barren Lands First Nation due to the frequent use of metal panel cladding. The feasibility of employing this technology should always be considered in the design process for new community buildings and for existing buildings undergoing a major renovation or recladding.

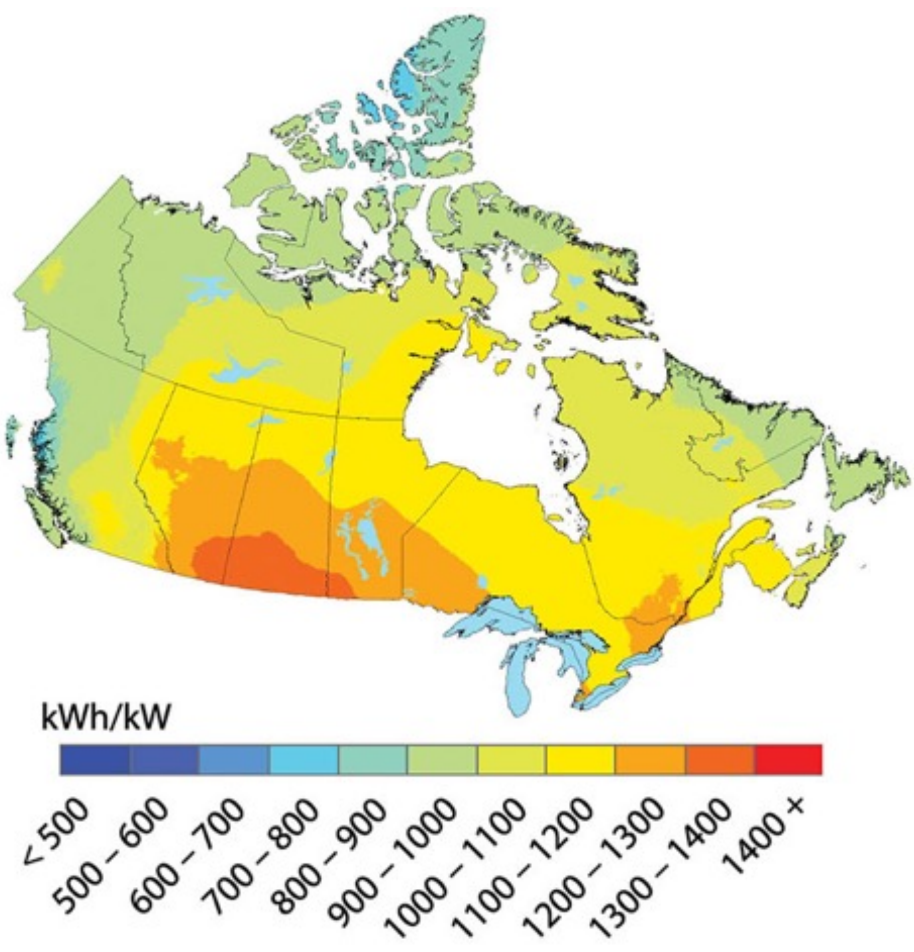


Figure 33 – Photovoltaic potential map for Canada

Technologies Not Recommended – The feasibility of using CSP to provide heat and electricity for remote, northern communities (such as Brochet) has been the subject of a research and demonstration project undertaken by the University of Manitoba in cooperation with Red River College (RRC) and funding from Manitoba Hydro and the Federal Government – see this link for more details.

This CSP project installed at RRC's main Winnipeg campus has encountered weather-related operating problems. Because of these difficulties, CSP has been judged by Aki's Team as a technology that is not yet sufficiently developed for cold climates. As a result, CSP has been eliminated for further consideration as part of a renewable energy strategy for Brochet.

Solar water heating is not recommended for deployment in Barren Lands First Nation due to maintenance, reliability and performance concerns in a harsh northern climate. A simpler, more cost-effective and robust approach to solar water heating for the community would be to install additional photovoltaic capacity coupled with electric water heaters.

Additional Information

Aki Team Reports – For more in-depth information about solar energy issues, options and analysis for Brochet, please refer to the following report produced by the Aki Team:

- *Provision of Technical and Economic Studies for a 100% Renewable Penetration Scenario for Brochet, Lac Barren Lands First Nation and Tadoule Lake (May 30, 2017)* by Soft White 60.

5.5 Geothermal Energy

Major Findings and Recommendations:

- *There is a lack of detailed data about the potential high and medium temperature geothermal resource that could potentially be tapped to generate electricity for Brochet. The limited data that exists for Northern Manitoba suggests a low potential.*
- *Given that there is a lack of working examples of geothermal energy systems in small, remote communities in Canada, this technology was included for further analysis for the Barren Lands First Nation CEP.*
- *Low temperature geothermal heat pumps may be a viable technology for Brochet. Their technical and economic viability should be considered for new community buildings and housing developments in the community.*

Overview of Option

'Geothermal energy' is a renewable source of energy. It consists of two types: the constant flow of heat from the core of the earth to the surface and the energy of the sun that is stored near the surface of the earth on a seasonal basis.

Geothermal resources are broadly categorized into three types:

- High temperature (greater than 150° C)
- Medium temperature (80° C to 150° C)
- Low temperature (less than 80° C)

The temperature of a geothermal resource impacts both the technology needed to develop the resource and its potential use. These uses range from producing electricity to heating buildings, homes and hot water.

High and Medium Temperature Geothermal – The most common application of high and medium temperature geothermal resources is to produce electricity. Because the energy flow is constant, these types of geothermal energy systems can operate at a much higher capacity than solar or wind power which must wait for the sun shine or the wind to blow.

There are many examples of high and medium temperature geothermal power plants in the U.S. and elsewhere in the world. Despite having enormous geothermal energy resources, this technology has not been used in Canada.

Low Temperature Geothermal – Low temperature geothermal energy can either be used directly or in conjunction with a heat pump. In a typical direct application, geothermal water is used with a simple heat exchanger to provide space heating or water heating.

With heat pump systems, a fluid is circulated through a loop embedded either horizontally or vertically in the ground or placed in a body of water. The heat energy added to the circulating fluid is captured by the heat pump and used for space and water heating. The process can be reversed to provide cooling.

Discussion

The high and medium temperature resource in or near Barren Lands First Nation is uncertain. The limited mapping of heat flow measurements from the earth taken in Northern Manitoba indicate that this resource is at the low-end of the scale (see maps below – Figures 34 and 35.

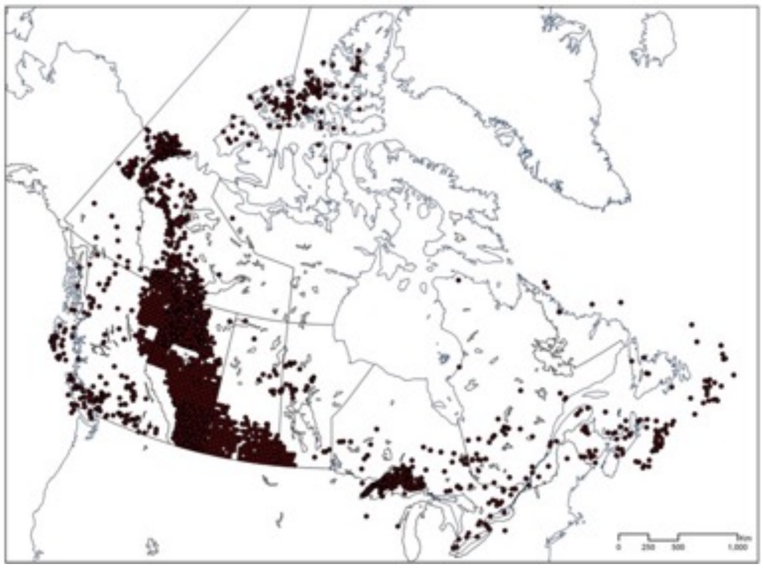


Figure 34 – Map of heat flow measurements across Canada

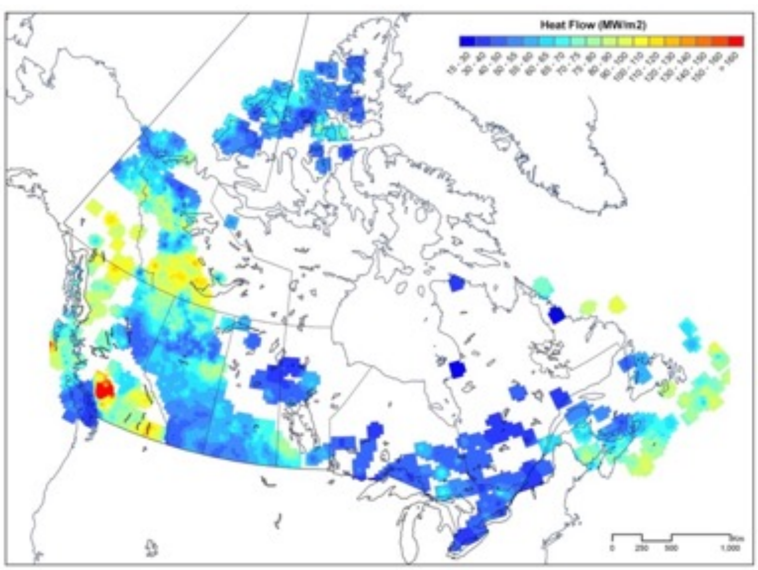


Figure 35 – Heat flow map of Canada

In contrast, low temperature geothermal resources have potential for Barren Lands First Nation using geothermal heat pumps (also called 'ground source heat pumps', 'earth energy systems' and 'geo-exchange energy systems'). These are a well-proven, mature technology. Aki has worked with several First Nations in Manitoba to develop successful geothermal heat programs for their communities.

Additional Information

Aki Team Reports – High and medium temperature geothermal energy did not pass an initial screening for consideration for the Barren Lands First Nation CEP. As result, the Aki Team did not produce a separate report on this technology.

As noted above, low temperature geothermal energy using heat pumps is a much more viable option for new and existing community buildings and housing in Brochet. See section 3.0 'Demand Side Management: Issues and Options' in this report for comments about this technology.

Further Reading – For more information about solar energy, including its application in northern, remote communities, here are suggested sources:

- *Geothermal Energy Resource Potential of Canada* published by the Geological Survey of Canada provides an in-depth review of geothermal resources in Canada, summary of previous research and priorities for further work to exploit this resource.
- *Ground Source Heat Pumps* by Natural Resources Canada. This online publication introduces how these systems work; their benefits; sizing, design and installation considerations; and provides information on maintenance, operating costs, life expectancy and warranties.

5.6 Biomass Energy

Major Findings and Recommendations:

- *A biomass-fueled Organic Rankine Cycle (ORC) generation system, when combined with photovoltaics, wind and battery-based energy storage, is projected to be the lowest cost scenario for Barren Lands First Nation to achieve 100% renewable energy penetration.*
- *There appear to be sufficient potential long-term supplies of wood for an ORC system in the community. However, this should be verified by a more in-depth analysis.*
- *Although a well-proven technology elsewhere, there is lack of operating experience with ORC systems in Canadian remote, northern communities like Brochet. This risk needs to be addressed.*

Overview of Options

Biomass is another of form of renewable energy. The term 'biomass energy' refers to use of wood or plant-based materials, either directly by burning or indirectly after first converting it to a biofuel, to produce heat, electricity and/or mechanical power.

Aki's analysis of biomass energy options for the Barren Lands First Nation CEP has focused on wood, the most abundant source of biomass readily available to the community. This analysis assumed that the wood is used with a specific technology ('Organic Rankine Cycle' or ORC) to generate both electricity and heat ('combined heat and power' or CHP).

The balance of this *Overview of Technology* sub-section provides a brief introduction to biomass CHP systems that use ORC technology. This background will enable non-technical readers to better understand Aki's major findings and recommendations about these technologies for Brochet.

Combined Heat and Power – CHP, often called 'cogeneration', is the process of generating electricity and useful heat from a power plant at the same time. The main advantage of CHP is efficiency. Some energy is rejected as waste heat in the production of electricity with a conventional power plant. However, with CHP a significant portion of this thermal energy is recovered and used.

Although small-scale biomass CHP systems are relatively rare in Canada, they are increasingly common in Europe where electricity prices are more expensive (see link to ORC World Map under 'Additional Information' below).

Organic Rankine Cycle Power Systems – An ORC power system continuously converts thermal energy (heat) into electricity. Unlike a conventional power plant which uses water (vaporized into steam) as a working fluid, an ORC system operates at low pressure and uses an organic fluid with a low boiling point. This enables it to use low temperature heat from many different sources, such as various forms of renewable energy (i.e., solar, geothermal, biomass) or waste heat from industrial or other processes, to produce electricity. ORC systems may also avoid the need to have an operator constantly in attendance.

Figure 36 – Example of Organic Rankine Cycle (ORC) power plant

Discussion

Wood Supply – There are two potential sources of supply of wood for either an ORC generation system in Barren Lands First Nation or a district heating system:

1. Local fire-killed trees that are still standing in forest burn areas near the community; and
2. Provincial Forestry Management Units (FMUs) located along the winter road system to the community and in the Lyn Lake area.

Based on provincial government and University of Manitoba reports, there appears to be abundant local sources of wood from fire burnt areas. There is also ample truck capacity and winter road duration to supply a full year's supply at a reasonable cost (projected to be $137 per tonne).

At present rates of electricity use and heating demand, it appears that there is a sufficient supply of wood near Barren Lands First Nation and the two-other nearby First Nations at Barren Lands First Nationand Tadoule Lake to provide these communities 100% biomass electricity generation and heating for 50 to 200 years. However, a more in-depth analysis should be conducted to confirm whether local fire-burned trees are sufficient or whether additional wood will be required from the FMUs along the winter roads to Barren Lands First Nation and near Lynn Lake.

Reliability – Biomass-fueled ORC generation systems have proven reliable in many applications throughout Europe and North America. However, there isn't experience using these systems in northern off-grid, communities in Canada such as Brochet.

The perception that ORC generation is more complex than conventional diesel generation is partially correct. However, the risk of failure of this technology can be mitigated by a combination of:

- adequate training of local operation and maintenance personnel in Brochet;
- an appropriate maintenance contract with a reputable ORC equipment supplier; and
- leaving the existing Manitoba Hydro diesel generators in place as back-up with enough stored diesel fuel for one year of operation at 100% of the community load.

Integration with Other Renewables – A noted previously, Aki's Team conducted a prefeasibility analysis of several scenarios using different combinations and penetration levels of renewable energy systems (including biomass) to completely displace the use of diesel fuel in Brochet.

Highlights from this analysis related to biomass-fueled ORC generation system utilizing wood include the following:

- Six of the scenarios for 100% renewable energy penetration for the community include biomass-fueled ORC as the backbone for generating electricity for the community.
- The level of biomass-fueled ORC generation in these scenarios was high ranging from 88% to 100% of the community's annual electricity use.
- The lowest cost scenario over a 25-year planning horizon (Case 3) includes biomass-fueled ORC generation combined with photovoltaics, wind and battery storage.

For additional discussion of the 100% renewable energy penetration scenarios and their analysis, please refer to subsection '6.3 Integrating the Options - HOMER Pro Analysis'.

Additional Information

Aki Team Reports – For more in-depth information about solar energy issues, options and analysis for Brochet, please refer to the following report produced by the Aki Team:

- *Provision of Technical and Economic Studies for a 100% Renewable Penetration Scenario for Brochet, Lac Barren Lands First Nation and Tadoule Lake (May 30, 2017)* by Soft White 60.

Further Reading – For more information about solar energy, including its application in northern, remote communities, here are suggested sources:

- *Knowledge Center Organic Rankine Cycle is an information hub dedicated to the promotion of ORC technology.*
- *ORC World Map provides a searchable map of all organic cycle units installed throughout the world.*

6.0 Integrating Options

6.1 Energy Storage

Major Findings and Recommendations:

- *Integrating battery-based energy storage is a viable option to increase the penetration level of solar photovoltaic-generated electricity and wind power for Brochet. There are no technical barriers but the community's remote location will increase costs and make access to on-site technical support more challenging.*
- *Although costs are declining and the technology is improving, the high cost of battery energy storage limits the amount that can economically employed for the community.*
- *Of several renewable energy scenarios examined for Brochet, the analysis found that where intermittent renewable generation is present, a significant battery capacity must also be available, especially for solar.*

Overview of Options

This option would consist of integrating energy storage in the form of batteries to store electricity from renewable energy sources (i.e., solar photovoltaic and wind) to increase the amount of diesel-generated electricity they can displace in Brochet.

Discussion

There are a wide range of energy storage technologies. One of the most rapidly growing forms of energy storage is to use batteries (most often lithium ion) to increase the penetration level and value of renewable energy sources such as photovoltaic-generated electricity and wind power. This is accomplished by storing electricity to smooth out daily variations in production and power quality from renewables due to clouds or changes in wind speeds or to shift daytime energy production to night-time use.

Although costs continue to decline and the technology is improving, storing electricity with batteries, even at a utility-scale, remains a relatively expensive approach. As a result, it is important to take an integrated approach to renewables that minimizes the amount of battery storage that is required.

For Brochet, there are no major technical barriers to the use of battery-based energy storage to boost the penetration of renewable energy sources. The community's remote location will, however, increase the cost of their installation and require additional planning to ensure access to trained personnel for maintenance and troubleshooting.

Several scenarios were examined by the Aki Project Team with respect to the optimal balance of renewable energy supply and battery energy storage for Barren Lands First Nation(see sub-section 6.5). This analysis found that where intermittent renewable generation is present, a significant battery capacity must also be available, especially for solar. During the summer, there is a relatively large amount of solar energy available, but the electricity load is at its lowest and the excess solar energy cannot be stored very long.

Wind power is somewhat less a contributor to this effect because it can charge the battery at any time during the day and across all seasons. This connection between cost per kW of intermittent power and the necessary battery capacity tends to make all intermittent sources more expensive from an initial capital outlay perspective than would be expected in other regions.

Additional Information

Aki Team Reports – For more in-depth discuss about the role of battery energy storage for Brochet, please refer to these reports produced by the Aki Team:

- *Provision of Technical and Economic Studies for a 100% Renewable Penetration Scenario for Brochet, Lac Barren Lands First Nation and Tadoule Lake (May 30, 2017)* by Soft White 60.
- *Solar Storage Integration with Remote Diesel: Displacing Diesel Fuel with Renewable Solar Power (March 2017)* by Lumos Clean Energy Advisors.

6.2 Smart Micro-Grid

Major Findings and Recommendations:

- *Upgrading the conventional electrical grid in Barren Lands First Nation to a 'smart microgrid' is an essential part of a strategy to displace diesel-generated electricity with significant amounts of renewable energy while ensuring reliability and power quality.*
- *An additional benefit of a smart microgrid will be the ability to achieve a higher degree of energy efficiency and peak demand reduction than is possible with the community's existing conventional power grid.*

Overview of Options

This option would consist of converting the conventional electrical power in Barren Lands First Nation to a 'smart microgrid' through the addition of smart grid controller; replacement of conventional fixed-speed diesel generators with advanced variable speed units and power management controls; and smart energy meters for all home, buildings and facilities in the community.

Discussion

A 'smart microgrid' are part a profound change in the way that communities generate and use electrical energy. They is a small community-scale electrical power network that combines a variety of energy supply and advanced operational and control measures that enable the integration of high levels of renewable energy and achieve gains in energy efficiency and reducing peak demand.

This option would not only reduce overall energy use and peak electrical demand in Brochet, it is an essential element to enable the integration of a high degree of renewable energy generation and some battery-based energy storage while ensuring reliability and power quality in the community.

Over time, this smart microgrid would be enhanced as old household appliances and equipment in the community, especially water heaters, reach the end of their service life and are replaced with new, more efficient units that can communicate and potentially react to signals from the grid.

Additional Information

Aki Team Reports – For more in-depth discuss about a smart microgrid for Brochet, please refer to these reports produced by the Aki Team:

- *Provision of Technical and Economic Studies for a 100% Renewable Penetration Scenario for Brochet, Lac Barren Lands First Nation and Tadoule Lake (May 30, 2017)* by Soft White 60.
- *Solar Storage Integration with Remote Diesel: Displacing Diesel Fuel with Renewable Solar Power (March 2017)* by Lumos Clean Energy Advisors.

6.3 HOMER Pro Analysis

Major Findings and Recommendations:

- *Based on an prefeasibility analysis using HOMER Pro software, the most economic case was found to be a combination of using biomass in an Organic Rankine Cycle-generator along with modest amounts of solar photovoltaics, wind power and battery electric storage.*
- *This diverse combination of renewable energy supply options was deemed to likely be a preferred option from a community and environmental perspective.*
- *Given that the HOMER Pro prefeasibility analysis confirm that renewable electricity sources have good potential in Brochet, a full feasibility is recommended.*

Methodology

A prefeasibility analysis was conducted by the Aki Team on both energy supply and demand-side management considerations outlined in this report for Brochet. This analysis utilized HOMER Pro software to produce technically feasible electrical resource scenarios that are optimized for the lowest levelized cost of energy (LCOE) that be realized for the community.

The HOME analysis is based on a 25-year planning horizon. It accounts for hourly wind speeds and solar insolation values, along with 15-minute loads for the community's existing fixed-speed diesel generators plus equipment data to represent battery energy storage, Organic Rankine Cycle (ORC) electricity generation, and advanced variable-speed diesel generators.

The accuracy of the results from the HOMER Pro optimization process is related to the confidence level of the input of technical and cost data. In this analysis, in addition to data from manufacturer's equipment specifications plus data embedded in the HOMER Pro generation data library, a portion of input data had to be estimated to represent specific generation and/or storage devices. The Aki Team's HOMER Pro modellers have extensive experience in this area. We surmise that the LCOE values presented in this report are equivalent to a Class 4 or Class D level, with accuracy estimated to be between -30% to +50%.

Discussion

An overview of the mix of the energy supply options included in each of the nine scenarios examined with HOMER Pro is presented in Figure 37. The results of the projected capital and operating costs from HOMER Pro Analysis are presented in Figure 38.

For a 100% penetration of renewable electrical energy generation, the best economic combination was found to be Case 3 which included biomass (ORC), solar (PV), wind power and battery storage. Case 3 represents a diversity of renewable energy supply options and was deemed to be a preferred option from a community and environmental perspective.

It is important to note that the analysis projects that there is ample waste heat (200%) from the ORC to heat the entire community. The excess waste heat available can be used for additional uses including food security systems such as greenhouses, or additional economic development via a hotel and laundromat. This aspect of implementing a biomass power plant to replace the reliance on diesel fuel should be considered a strong decision point in the final determination of power options.

Overall, the HOMER Pro prefeasibility analysis shows that renewable electricity sources have good potential to be realizable in Brochet. It is therefore recommended that a full feasibility study be pursued for the electrical energy and associated heating options for the community.

Additional Information

Aki Team Reports – For more in-depth discussion about the HOMER Pro analysis results and resulting recommendations for Brochet, please refer to this report produced by the Aki Team:

- *Provision of Technical and Economic Studies for a 100% Renewable Penetration Scenario for Brochet, Lac Barren Lands First Nation and Tadoule Lake (May 30, 2017)* by Soft White 60.

Figure 37 – HOMER Analysis Scenarios

Scenario	Biomass (ORC)	Solar Photovoltaics	Wind	Battery Storage	Advanced Diesel (VSG)	Conventional Diesel (FSG)
100% Renewable Energy						
Case 1	●	●		●		
Case 2	●				●	
Case 3	●	●	●	●		
Case 4		●	●	●	●	
Case 5	●		●	●		
Case 6	●	●		●	●	
Case 7	●					
Diesel-Only						
Case 8					●	
Case 9						●

ORC – Organic Rankine Cycle
VSG – Variable-speed generators
FSG – Fixed-speed generators

Figure 38 – Projected Capital and Operating Costs from HOMER Analysis

Scenario	Capital Cost (millions)	Operating Cost (millions/year)	Life-Cycle Cost of Energy (¢/kWh)[1.]	Average Operating Cost (¢/kWh)[2.]
100% Renewable Energy				
Case 1 Biomass (ORC), Solar (PV), Batteries	$18.0	**$1.4**	58.9	29.6
Case 2 Biomass (ORC), Advanced Diesel	$14.0	$1.6	55.4	32.7
Case 3 Biomass (ORC), Solar (PV), Wind, Batteries	**$18.4**	**$1.4**	59.2	29.3
Case 4 Solar (PV), Wind, Batteries, Advanced Diesel	$12.1	$2.8	77.8	58.2
Case 5 Biomass (ORC), Wind, Batteries	$17.6	**$1.4**	57.4	**28.8**
Case 6 Biomass (ORC), Solar (PV), Batteries, Advanced Diesel	$14.7	$1.5	**55.2**	31.2
Case 7 Biomass (ORC)	$17.8	$1.5	60.4	31.5
Diesel Only				
Case 8 Advanced Diesel	$10.2	$3.4	87.9	71.4
Case 9 Conventional Diesel	**$8.8**	**$4.7**	**113.3**	**99.0**

Red bold text – highest cost
Green bold text – lowest cost
kWh – kilowatt hour

Notes:
1. Includes capital and operating costs.
2. Includes only operating costs.

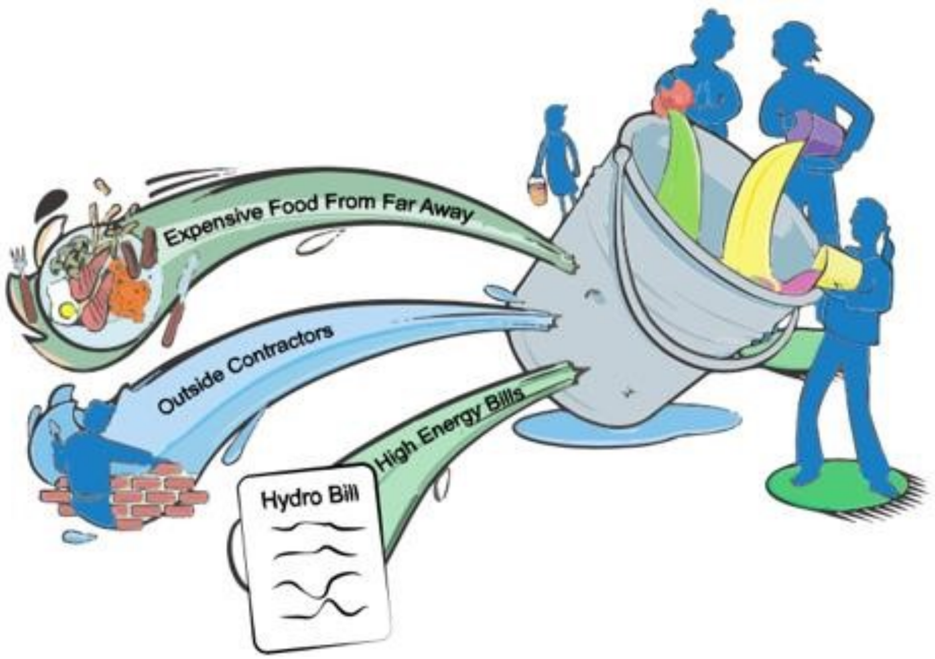
7.0 Kick Starting a Barren Lands Sustainable Social Enterprise

7.1 Fixing the 'Leaky Bucket Economy'

Unemployment rates on First Nations, including Brochet, are much higher than in other Canadian communities. One of the main reasons is because most goods and services are brought into the community from outside, delivered by outside companies.

The concept of the 'leaky bucket economy' is a helpful guide (see Figure 39 below). Financial resources are being poured into this bucket from several sources (e.g., federally funded infrastructure projects, social assistance dollars, earned income, etc.).

Figure 39 – The 'Leaky Bucket Economy'



In most First Nations, the vast majority of this money flows right back out of the community, being used to hire outside consultants, contractors, to cover the cost of expensive diesel and food flown in from the south. The bucket leaks. Most of the financial resources that enters the community doesn't stay for long. Most of it flows south, chiefly benefitting people who are not Indigenous.

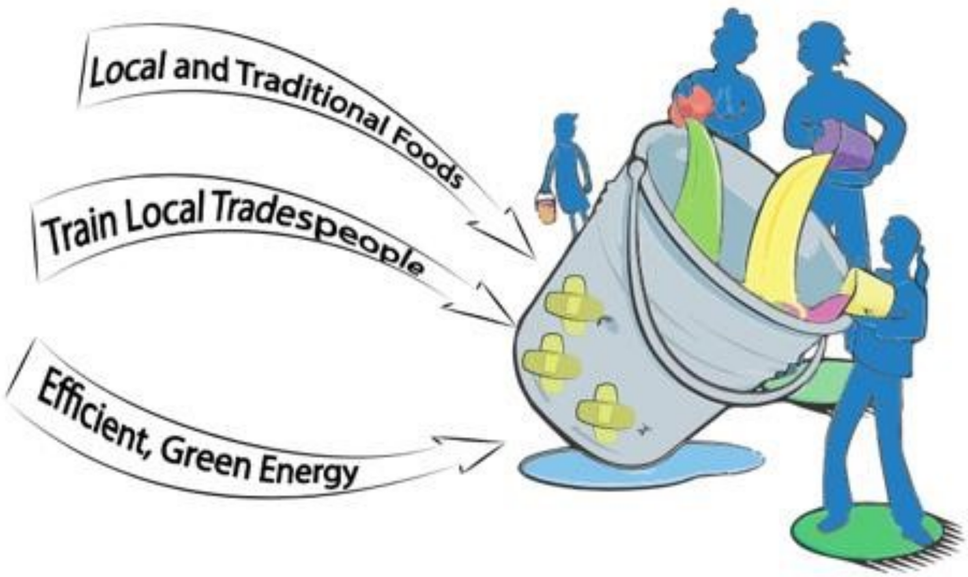
While these number reflects the high costs, they are understated because:

1. Manitoba Hydro is seeking to increase electricity rates by almost 50 per cent over the next five years. While diesel is used for electricity in Brochet, legislation requires that residential rates must be the same across the province.
2. Also, while it is not known what will happen with the cost of diesel in the immediate future, it is general knowledge that for every dollar spent on diesel for space heating, another dollar eventually spent on its cleanup.
3. Because practically all energy used in Barren Lands First Nation is imported. People who might otherwise be working using local options to meet the community's energy needs, are unemployed. This increases social assistance rates and other poverty-related costs.

Plugging the Leaks – To create prosperous communities, it is essential to begin to plug some of the holes in the bucket. This happens when communities take steps to replace outside consultants, contractors, and goods and services with local resources. When this happens, money is kept circulating in the local economy, building local wealth and prosperity.

Investments in energy efficiency and renewable energy in First Nations have the potential to create significant long term local employment and local economic development.

Figure 41 – Plugging leaks in the Barren Lands First Nation local economy



The first step to achieving this is to ensure that First Nation members have the training to install and then maintain local energy systems recommended in this report such as insulation, wind power, biomass, geothermal and solar.

Aki Energy and its First Nation partners have already installed over $7-million of geothermal energy at 350 homes on five different First Nations. All labour required for these retrofits was completed by First Nation members. Aki has developed a strong training strategy that means First Nation members are most qualified to do the installations but also the maintenance and trouble shooting.

The standard capital project model employed by Indigenous and Northern Affairs Canada makes it difficult for First Nations to capitalize on projects to create local training and employment opportunities. When capital projects go out to tender, First Nations rarely have the capacity to bid competitively against large, experienced contractors. When large contracting companies take on projects in Northern communities, they bring in experienced labour from the south. Where local sourcing requirements exist, they are often met in superficial ways, with no meaningful skills transfer to local community members. While this approach may make sense in some scenarios where work is highly technical, both energy efficiency retrofits and some elements of renewable energy development provide opportunities for job creation and local business development.

The second and more transformative step is to change the relationship between INAC and the First Nation so that a Band-owned and operated social enterprise is selling renewable heat and power to the Federal government rather than the Federal government paying outside companies to import energy from the outside.
Social enterprises are non-profit businesses. Governments all over the world are realizing the benefits of working with social enterprises because, in addition to providing goods and services at market rates, they can be set up to hire people with barriers to employment. This in turn reduces costs in other areas such as social assistance, policing, and court related costs.

Scotland decided 10 years ago to change it procurement practises so that social enterprises would be providing more goods and services. Every public tender issued in Scotland either must be negotiated with a social enterprise or include a community benefit clause. As a result, there are now 5,200 social enterprises there and 45 percent of these hire people with barriers to employment.

In Manitoba, Manitoba Housing hires social enterprises to do now over $6 million a year in trades-based work. This makes sense to them because these social enterprises (including BUILD, Manitoba Green Retrofit, New Directions, Brandon Neighbourhood Development Corporation, and the North End Community Development Corporation) hire their tenants.

Social Enterprise for Community Development – A Social Enterprise is a modern business with Indigenous principles. Social Enterprises are more than just making money – it is about creating positive outcomes for the communities they operate in, and taking care of the planet.

Unlike a traditional business where the primary goal is to create profit for shareholders, a social enterprise has a ‘triple bottom line’ – people, planet and profit. This business model uses economic good sense to find solutions to problems such as poverty, high food prices, or building a healthier environment for future generations. This strategy provides several proposals looking at how to create business capacity and local training and employment opportunities through the sustainable development goals and objectives outlined in this document.

7.2 Creating Economic Development Through Smart Energy Investments

INAC can take a similar approach with social enterprises to ensure people living on First Nations can have access to work installing renewable energy and energy efficiency systems and then use these skills to springboard into other sectors such as HVAC, carpentry or plumbing, or to do work in other First Nations as the need for these services present themselves.

Residential and commercial energy efficiency upgrades are also labour intensive, highly repetitive and most aspects of the retrofit require a relatively low skill level to complete. Many of the skills gained performing energy efficiency upgrades are highly transferrable to the broader trades sector. Because of this, investments in energy efficiency upgrades provide an excellent opportunity to train and employ local tradespeople, creating local employment and economic development opportunities.

As will be shown in this report, there are plenty of local energy options that, over time, can eliminate the need for diesel usage in Brochet. Using local energy, rather than importing energy, is not a new concept in Brochet. As recently as the mid-90s, First Nations in Northern Manitoba heated their homes primarily with wood stoves, gathering wood from locally available sources. In contrast to diesel fuel, using wood for heat created local employment and income generation opportunities for anyone able to harvest wood to sell by the cord at the Band office or supply to meet their personal needs.

While we are not advocating a return to inefficient wood stoves for heat, this example demonstrates the shift that has occurred from using locally available resources which create employment and keeps wealth in the community, to energy sources that facilitate the transfer of large sums of money from First Nations to large energy companies while creating few or no local jobs and significant environmental damage.

In addition to the direct jobs created by training local installers to complete energy efficiency retrofits, there are indirect economic benefits resulting from household and community building energy bill reductions. These reductions will result in additional income available to households and the Band to spend on other priorities, resulting in positive multiplier impacts throughout the local economy.

Reduced energy use also means that residential and commercial consumers throughout the community are less vulnerable to rapid, significant increases in energy prices.

Like energy efficiency, smart investments in renewable energy creates opportunities to both reduce energy costs in First Nations communities and create local employment. ‘Renewable energy’ is a broad term that encompasses many different types of sustainable energy sources, many of which are discussed in this report. Solar energy, solar thermal (i.e., hot water heating), geothermal, biomass energy and wind are all examples of renewable energy sources.

While almost all renewable energy sources discussed in this report have the potential to create short-term employment opportunities when the system is installed, this section focusses on biomass energy, one of the major long-term job creation opportunities discussed in this report.

Until 1994, Manitoba's off-grid First Nations relied on wood for heat. The required wood was harvested from the local environment for personal use, or sold by the cord at the Band Office, creating a source of income for people in the community. Modern day biomass systems are significantly more efficient and cleaner than traditional wood stoves. A single district biomass energy system could create heat for an entire community, connecting to households through a system of underground pipes and modern equipment can make it easier to harvest enough wood to meet the community's needs. Biomass harvesting is low skilled and labour intensive, and flexible enough to be accessible to people who are looking for employment that accommodates traditional land use activities such as hunting and fishing, other seasonal employment or family commitments.

Business development opportunity – The implementation of the recommendations made in this report provide a significant business development and local employment creation opportunity. Energy efficiency retrofits on all cost effective residential and commercial buildings in the community would create multi-year employment for local construction crews. Permanent employment positions could be created operating and maintaining renewable energy systems, as well as harvesting local biomass energy sources.

Barren Lands First Nation has decided that it is in its own interests to establish its own social enterprise that would take the responsibility for: a) Residential energy retrofits

b) Commercial energy retrofits
c) Operation and maintenance of renewable energy systems
d) Biomass wood harvesting and processing (where applicable)

In addition, the social enterprise would engage in:

e) Partnering with existing educational institutes such as Red River College, or non-profits training institutes such as BUILD Inc. to train local workers with the skills needed.
f) Negotiate the price for this heat with entities currently paying for that heat (school, nursing station, RCMP buildings, etc.
g) Collect the payments for supplying the heat.
h) Dedicate surpluses to expanding the renewable energy systems eventually to all buildings on the First Nation.
i) Create and maintain operating reserves from its revenues.
j) Provide routine maintenance and repair on renewable energy systems in the community.

We recommend that the firm be a social enterprise to make explicit that the goals are to maximize benefit to the community. The social enterprise can be operated as a partnership with INAC and outside resources can be hired when expertise is required. Goals of the social enterprise could would:

- Maximize the local benefit of money spent on heat • Maximize local jobs.
- Maximize local economic development.
- Minimize and eventually eliminate the use of petroleum fuels.

As a revenue source, the energy management aspect of the company could have current purchasers of diesel enter into heating supply contracts with the company as a supplier of heat from renewable sources. While people not familiar with this approach may feel it is risky, it can be set up so that the social enterprise is compensated only for delivering the renewable heat. In this way, it is very accountable and transparent.

Aside from managing the harvesting and processing of biomass for wood heat, which would provide long term employment to community members, constructing and operating the renewable energy systems and implementing energy efficiencies represent significant opportunities for local jobs, and for economic and community development at Brochet. This can also be done below current diesel costs.

Much of the required work may initially need to be led by installers with expertise in renewable energy and energy efficiency installation. However, an essential provision of their contract needs to be a requirement to provide training and employment to local people.

Long term business development – In creating a local social enterprise responsible for building and maintaining renewable energy and energy efficiency systems, this project would be one of the first of its kind in Canada.

In addition to multi-year employment creation building and maintaining renewable energy systems, harvesting biomass and conducting energy efficiency retrofits on community buildings and households, there is room for continued business development providing training and services to other off-grid communities in the region.

Access to financing/equity – There are financial advantages to launching a social enterprise. Recent years have seen the development of a significant market in ethical investing, with investors interested in supporting and seeking financial returns through investments in companies whose work benefits communities and the environment. These investors will often provide patient capital, or capital with below market rates of return. There are investment funds specifically interested in developing and investing in Indigenous-owned social enterprise. These financing dollars are available if governments agree to pay investors back out of the savings (in this case utility bill reductions) that they are enjoying.

Access to grant funding – Incorporation as a social enterprise also allows opportunities for grant funding to support business expansion and initial capital investments in equipment and training. Social enterprises such as BUILD also require training dollars to support their employees. These dollars usually come in the form of government funding as training such as driver's licensing, trades-based tutoring, and financial literacy are not things that regular contractors offer. The best training approaches also include parenting, financial literacy, and access to Elders and cultural ceremonies.

7.3 Business Development Support

Aki Energy is an Indigenous, non-profit social enterprise that works with First Nations to support sustainable economic development. Aki Energy provides on-the-ground training and business development support to help communities build business, create local jobs and prosperity. Aki Energy can partner with Barren Lands First Nation to ensure success.

Aki Energy provides business development support in the form of mentoring and organizational capacity building including:

1. Administration management training
2. Financial management training
3. Project management training

Aki Energy can also offer trades training and support such as:

1. Energy efficiency installation training
2. Renewable energy system installation and maintenance training
3. Construction site management

Aki Energy has significant experience in working with First Nations to build create local jobs and build local businesses in the sustainable energy sector. To date, we have worked with six Manitoba First Nations to support the development of local renewable energy installation companies. After partnering with Aki Energy, Fisher River Builders from Fisher River Cree Nation are now some of the largest geothermal energy installers in Western Canada.

INAC can support Barren Lands First Nation to set up its own social enterprise and then to pay that social enterprise for delivering renewable heat and power at rates that they were going to pay anyway. The cost of providing this support would be $500,000 over five years with costs declining over time to be nil at the end of year 5. It would be recommended that INAC work with Barren Lands First Nation to determine how this money can best be spent to ensure the long-term sustainability of the social enterprise.

8.0 Recommended Next Steps

This section outlines the recommended next steps to finalize the Barren Lands First Nation Community Energy Plan, engage external stakeholders to support the CEP, and begin its implementation.

8.1 Step One – Complete Community Consultation

In addition to consultations that have recently occurred between representatives from Aki's Project Team, the Chief and Band Council, it is recommended that a further face-to-face meeting also occur in Barren Lands First Nation with community members. The purpose of this community meeting would be to:

- share a high-level overview of the energy supply and demand-side management options and issues presented in this report; and
- determine what is the community's preferred path and priorities that should be reflected in the Barren Lands First Nation Community Energy Plan.

Of importance will be gain a better understanding of how aggressively the community wants to be in its transition away from its reliance on diesel-generated electricity and heating oil that has begun with the ERAAES Project now underway.

8.2 Step Two – Finalize and Approve Community Energy Plan

Using feedback already received from the Chief and Council, plus the additional input from the community as described in Step One, a revised version of this report will be produced by Aki. Assuming this plan is acceptable to the Chief and Council, it is recommended that it be formally adopted as an extension of the Barren Lands First Nation Sustainable Development Strategy through a Band Council Resolution.

8.3 Step Three – Engage Support from Other Stakeholders

Implementation of the Barren Lands First Nation Community Energy Plan will require engaging key external stakeholders and gain their support, especially INAC, Manitoba Hydro and CMHC. Some adjustments to the CEP will likely be needed to reflect the discussions and negotiations with these stakeholders.

8.4 Step Four – Build Capacity to Maximize Community Benefits

A priority should be to begin building capacity through training and other measures as outlined in Section 7.0 of this report to maximize the benefits of the community economic and social benefits of the CEP. The momentum that has begun with the ERAAS Project should be sustained with other projects, such as the retrofitting of existing houses and buildings in the community, that can be quickly implemented.

8.5 Step Five – Track Progress and Update Plan

Finally, it will be important for the community's leadership to track progress in implementing the Community Energy Plan and communicating its progress with community members and external stakeholders. A commitment should also be made to periodically review and update the plan to adapt to changing circumstances, new information from any feasibility studies undertaken and opportunities that emerge.

Appendix A – Aki Project Team and Contact Details

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Appendix B – Summary of Energy Supply Recommendations

Imported, Non-Renewable Energy Options

Option	Include in Community Energy Plan?	Capital Cost [1]	Operating Cost [2]	Reliability [3]	Environmental Benefits [4]	Community Benefits [5]
SaskPower Electrical Grid Connection	✗	●	○	⊙	○	⊙
Natural Gas Service	✗	●	○	●	⊙	⊙
LNG or Propane Service	✗	⊙	●	⊙	⊙	○
Conventional Diesel (FSG)	✗	⊙	●	●	○	○
Advanced Diesel (VSG)	✓	⊙	⊙	⊙	⊙	⊙
Waste Oil Heating	✓	○	○	●	●	●

✓ – Yes

✗ – No

VSG – Variable-speed generators

FSG – Fixed-speed generators

● – High

⊙ – Medium

○ – Low

Local, Clean Renewable Energy Options

Option	Include in Community Energy Plan?	Capital Cost [1]	Operating Cost [2]	Reliability [3]	Environmental Benefits [4]	Community Benefits [5]
Manitoba Hydro Electrical Grid Connection	✗	●	○	●	●	●
Small-Scale Hydro	✗	●	○	◉	●	●
Biomass (ORC)	✓	◉	◉	◉	●	●
Solar	✓ Photovoltaics ✓ Solar Air Heating ✓ Passive Solar ✗ Concentrating Solar ✗ Solar Hot Water	● ○ ○ ● ●	○ ○ ○ ○ ○	● ● ● ○ ○	● ● ● ● ●	◉ ◉ ◉ ◉ ◉
Wind	✓	●	○	◉	●	◉
Geothermal	✓ Low temperature (GSHPs) ✗ High/medium temperature (electricity generation)	◉ ●	○ ○	● ●	● ●	● ◉

✓ – Yes

✗ – No

ORC – Organic Rankine Cycle

GSHPs – Ground Source Heat Pumps

● – High

◉ – Medium

○ – Low

Notes:

1. Refers to capital cost per peak kW and annual kWh generation capacity relative to other options listed in table.
2. Includes annual cost of fuel supply and maintenance costs per kW and kWh relative to other options listed in table.
3. Based on subjective assessment of each option’s reliability specific to operating in a remote, northern community such as Brochet.
4. Relative to base case (i.e., conventional, fixed-speed diesel generation). Includes avoidance of negative impacts on residents, land, water and wildlife from transportation and storage of fuel; reductions in greenhouse gas emissions; and avoidance of other emissions that may negatively impact the local air quality in the community. Includes reduction in energy costs plus opportunities for community ownership and creation of local employment in construction, operation and maintenance.