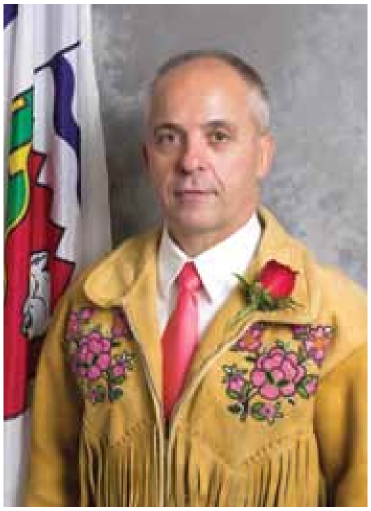
A VISION
for the NWT Power System Plan

December 2013

NT ENERGY
Pursuing our Potential

Minister's Message



The NWT's significant energy resources have the potential to grow our economy, support major projects and lower consumer costs while reducing our environmental impacts. It is time to harness that potential by identifying immediate opportunities to integrate renewable energy sources, and increase the use of natural gas. Expanding the NWT grid to connect our existing hydro systems together with communities, industry and the rest of Canada will create the backbone transmission infrastructure necessary to unlock our enormous potential.

We are implementing robust and cost-effective energy technologies that have a proven track record in the north. The Inuvik Liquefied Natural Gas power project will be the first of many similar projects in the NWT that will displace diesel with lower cost, cleaner burning natural gas. Building on the success of the 104kW solar project in Fort Simpson, we will begin a solar/battery hybrid project in Colville Lake, later this year. These projects will enhance our energy efficiency and reduce environmental impacts, but more transformative change is needed to stabilize and reduce the cost of energy in our communities.

A NWT Grid, supported by an intertie with the rest of Canada, will stabilize costs by creating an efficient energy market that can support northern hydro and other renewable energy sources to grow our economy sustainably. Public ownership of the NWT grid will require significant investments and provide lasting benefits to our communities and our economy. Future hydro generation projects will enjoy the benefits of a long-term market for power and can be built in partnership with Aboriginal governments and the private sector.

Northerners from across the NWT played a critical role in shaping the approach. In November 2012, an NWT Energy Charrette brought together energy experts and NWT residents from government, industry, and non-government sectors. The key issues and objectives that came out of that collaborative process defined the focus of the vision.

This is only the beginning of dialogue and collaboration with residents, communities and Aboriginal governments. As economic opportunities emerge and energy technologies change, we will continue to make improvements that enhance efficiency and connect more communities to the NWT grid.

The NWT needs an energy highway in order to turn vision into reality. I am pleased to present a road map for moving the territory forward.

J. Michael Miltenberger
Minister
Northwest Territories Power Corporation

Executive Summary

The vision for the NT Power System Plan ("NTPSP") provides a 20-year outlook for developing the necessary resources and systems to provide reliable, clean, and socially acceptable power for the communities and industries of the Northwest Territories ("NWT"). In the absence of an interconnected system, the communities and industries of the NWT are consigned to a future of power generation using imported diesel (a high-cost, price-volatile, and environmentally undesirable fuel source). This unpredictable and uncontrollable price risk suppresses industrial development and economic growth.

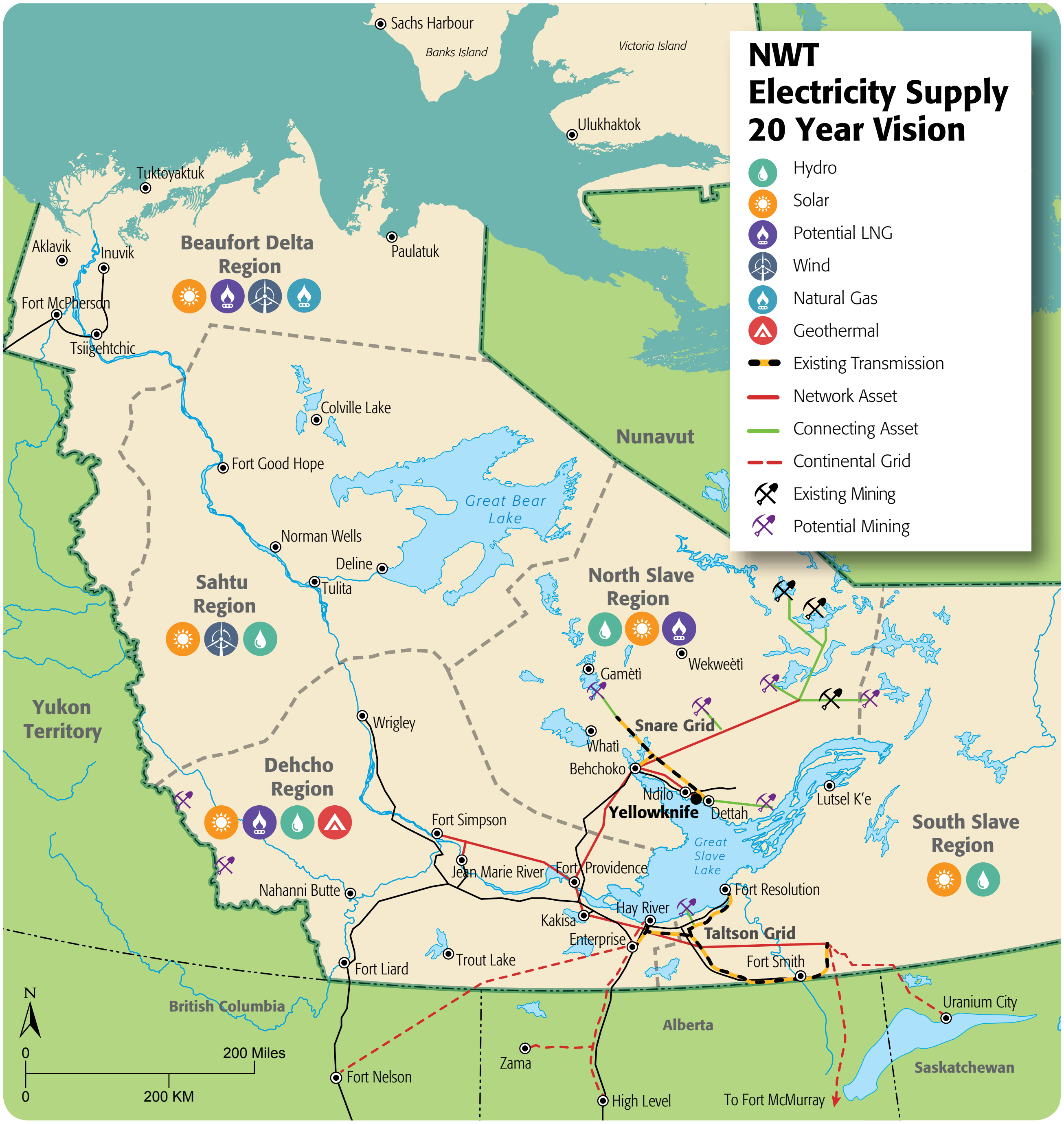
The NTPSP proposes an interconnection of the existing Snare and Taltson transmission grids to create single synchronous grid (the "NWT Grid"). The NWT Grid allows for better use of the existing (and underutilized) hydroelectric generation assets by reducing the need for diesel generation. The timing of such an expansion is dependent upon the ability and willingness of the Federal and Territorial Governments to finance and backstop the requisite investments and also upon the engagement of new and existing industrial customers to cooperatively extend the proposed NWT Grid outward.

In addition to the creation of the synchronous NWT Grid, the NTPSP explores the potential of an interconnection with southern markets, smaller regional grid expansions, firm power options for replacing diesel generation, and intermittent power options for offsetting diesel fuel consumption.

The NTPSP also discusses new emerging fuel sources and renewable energy resources that offer potential energy solutions for communities and regions in the NWT. Liquid Natural Gas is a potential fuel source that could displace diesel as the primary fuel source for many NWT communities. The NTPSP envisions that regional energy solutions should be tailored to the needs of the region in order to maximize efficiency of generation.

Like any planning exercise, the NTPSP is constrained by the uncertainty of the future. There are factors that we can be reasonably certain about (such as the increasing costs of diesel) and other factors we cannot know with any certainty (such as future metals and commodity prices, which will directly affect the appetite for investors to develop new mines or other industries in the NWT). Fortunately, this uncertainty about the future does not undermine the essential value of planning to establish a framework for achieving ultimate system goals.

Figure 1 – NWT Electricity Supply 20 Year Vision



A summary of the NTPSP recommendations is presented in Table 1:

Table 1 – Summary of NTPSP Recommendations

Category	0 → 5 Year Recommendations	6 →20 Year Recommendations
Creating an NWT Grid	▪ Pre-feasibility work for Snare Grid and Taltson Grid interconnection ▪ Secure commitment for funding	▪ Design and construction of a Snare Grid and Taltson Grid Interconnection ▪ Expansion of NWT grid to support economic development
Pursue an Intertie with Saskatchewan and Alberta	▪ Initiate discussions with SaskPower to confirm opportunity for a Power Purchase Agreement ▪ Initiate discussions with Alberta	▪ Construct interconnection between NWT Grid and SaskPower Grid ▪ *ALTERNATIVE*: Construct interconnection with Alberta
Undertaking Regional Initiatives: Regional Grid Expansion	▪ Pursue an extention from Snare Grid to Whatì ▪ Pursue an extention from Taltson Grid to Fort Providence and Kakisa	▪ Extend Taltson Grid to Fort Simpson via Jean Marie River
Undertaking Regional Initiatives: Firm Power Options for Replacing Diesel	▪ LNG Implementation Study and pilot project for Inuvik ▪ LNG Feasibility Studies: o Fort Simpson (Dehcho) o Fort McPherson (Beaufort Delta) o Yellowknife (North Slave)	▪ Additional LNG Feasibility Studies: o Fort Liard (Dehcho) o Jean Marie River (Dehcho) o Wrigley (Dehcho) o Tsiigehtchic (Beaufort Delta) o Tuktoyaktuk (Beaufort Delta)

Category	0 → 5 Year Recommendations	6 →20 Year Recommendations
Undertaking Regional Initiatives: Intermittent Power Options for Offsetting Diesel	▪ Continue to collect data, design work, and costing work for Storm Hills Wind Project ▪ Achieve the installation of photovoltaic generation in five communities ▪ Feasibility work for solar installations in: o Colville Lake (Sahtu) o Jean Marie River (Dehcho) o Lutsel K'e (South Slave) o Nahanni Butte (Dehcho)	▪ Additional wind feasibility studies: o Paulatuk (Beaufort Delta) o Sachs Harbour (Beaufort Delta) o Tuktoyaktuk (Beaufort Delta) o Ulukhaktok (Beaufort Delta) ▪ Continue to add solar installations as per GNWT Solar Energy Strategy (to achieve 20% of average load). Potential communities include: o Gamètì (North Slave) o Whatì (North Slave) o Wekweètì (North Slave) o Fort Providence (Dehcho) o Kakisa (Dehcho) o Trout Lake (Dehcho) o Fort Simpson (Dehcho) o Fort Good Hope (Sahtu) o Norman Wells (Sahtu) o Tulita (Sahtu) o Deline (Sahtu) o Aklavik (Beaufort Delta) o Paulatuk (Beaufort Delta) o Sachs Harbour (Beaufort Delta) o Tuktoyaktuk (Beaufort Delta) o Ulukhaktok (Beaufort Delta)

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1. Introduction

The NT Hydro group of companies faces unique challenges as an electric utility. The NWT's 41,500 residents inhabit a large territory covering 1.3 million km^2. The challenges created by serving relatively few customers in small communities spread out over a large land area means that in many cases the most cost-effective method of providing electricity has been (and continues to be) diesel generation.

However, the resource landscape in North America is changing as conventional oil and gas supplies dwindle, fossil fuel prices rise, and environmental impact awareness increases. Breakthroughs in unconventional extraction technologies for shale oil and gas, will ensure a supply of fossil fuel energy resources is available into the future. However the cost of extracting these non-conventional resources is higher than the cost of extracting conventional energy resources, thereby elevating prices for crude oil, and increasing diesel fuel costs in the NWT. In contrast, the abundance of North American based natural gas is projected to provide commodity price stability for the cleanest of the fossil fuels over the coming years. As a result, the growing market for Liquefied Natural Gas (LNG) presents an economic and environmental advantage to the diesel base case that needs to be pursued for the NWT in the near term.

Communities in the NWT are understandably concerned about the environmental and social impacts of continuing to rely on imported diesel fuel to serve their electrical needs. Diesel generation creates greenhouse gas emissions, particulate pollution and significant machine noise within communities. Communities and industries are also exposed to high and increasing electricity prices due to the volatile global market for diesel.

The Northwest Territories is poised to take advantage of rising global commodity prices via potential growth in the NWT mining and oil & gas industries. However, in order to support these industries, large quantities of reasonably priced electrical energy is required. As a result, finding energy solutions that will mitigate the rising cost of diesel generation and help meet the potential electricity requirements of heavy industry give impetus to considering the expansion of the Northwest Territories electrical transmission and generation systems.

2012 Energy Charrette

2. Purpose of the NT Power System Plan

2.1 Purpose

The initial concept of developing the NTPSP arose when NT Energy was developing its strategic plan in 2011. At that time, it was determined that a long term plan was needed to map out energy priorities and to understand what options were available to develop energy infrastructure and stabilize energy costs in the NWT. This work was supplemented by the NWT Energy Charette which was held in November 2012 by the Department of Industry, Tourism and Investment. The Charette brought together energy stakeholders and experts from government, industry, non-government organizations and consulting sectors to discuss opportunities and challenges for the NWT's energy sector. The input from the Charette was invaluable to the development of the NTPSP.

The purpose of this document is to provide a long term vision for electrical power development in the NWT. Consideration of the following objectives is important to achieving the purpose:

1) Improving electrical affordability for NWT citizens;
2) Ensuring reliable electrical supply for NWT citizens;
3) Reducing environmental impacts;
4) Enabling economic development and job creation;
5) Elevating the priority of community and aboriginal initiatives; and
6) Achieving NWT energy self-sufficiency.

To achieve these objectives, the following major themes are to be investigated:

1) Grid Expansion – Connection of the Snare and Taltson grids to create the NWT Grid, interconnection to southern provinces and transmission grid expansion in the north.
2) Preparing for Industrial Development – Mining and oil & gas development are expected to create opportunities for supplying electricity in the future.
3) Review of Firm and Intermittent Generation Options for Offsetting Diesel – Review of generation options for the many NWT communities that are currently served primarily by diesel generators.

2.2 NT Power System Plan Objectives

This section contains a description of the NT Power System Plan System objectives.

1. Improving Electrical Affordability

Improving the affordability of electrical energy in the NWT is a key objective of this 20 year vision. Stabilizing electricity rates will help close the gap between prices in the Northwest Territories and the rest of Canada, and will also help NWT residents and businesses who are already facing high costs of living.

2. Ensuring Reliable Electrical Supply

Currently, the bulk of electrical energy generated in the territory comes from either hydroelectric or diesel sources, with limited penetration of natural gas and non-hydroelectric renewable energy technologies. Although both hydroelectricity and redundant diesel generation are reliable sources of energy, ensuring reliable generation continues to be a matter of safety during colder times of year, and minimizes the disruptions to daily life.

3. Reducing Environmental Impacts

Although very reliable and well suited to harsh northern conditions, one of the principal drawbacks of diesel-fired electricity generation is the associated pollution, both from greenhouse gas emissions (GHG) and air quality perspectives. Diesel-fired generation has high greenhouse gas emissions per unit of electricity produced, typically involves exhaust particulate emissions in close proximity to the communities they serve, and is a source of continuous diesel engine noise. Reducing environmental impacts associated with electricity generation is another objective of the NTPSP.

4. Economic Development and Job Creation

A reliable and comparatively cost effective electricity supply can be a source of economic development and job creation in the NWT. Economic development and job creation for residents of the NWT is expected in two main forms:

- Development, construction and operation of new sources of electrical supply and transmission within the NWT.
- Development, construction and operation of resource extraction facilities (e.g. mines and oil & gas), because attractive energy prices support the economic development of these and other industries.

5. Elevating the Priority of Community and Aboriginal Initiatives

Prioritizing the involvement of communities and Aboriginal Governments is also a fundamental objective. Local involvement in the planning, control, operation and ownership of electrical generation can help achieve specific community objectives and improve self-reliance.

6. NWT Energy Self-Sufficiency

The NWT is currently not self-sufficient from an energy point of view because of its reliance on diesel imports to power most of the isolated communities in the territory. Expanding the territories' energy supply portfolio to include facilities that are not reliant on imported fuel sources such as diesel will increase the energy self-sufficiency of the territory.

2.3 Evaluation Criteria

In order for any proposed NTPSP to most effectively meet the above stated objectives, solutions were considered and evaluated using the following criteria:

Economic Impacts	Technical Viability	Environmental Impact	Social Impact

The criteria were selected on the basis of meeting the NTPSP objectives as follows:

Economic Impacts	
Description	The economic impacts criterion primarily measures the economic impact a given resource or scenario will have on electricity rates (prices) in the NWT when compared to diesel-fired generation.
Objectives Addressed	Objective 1 – Improving Electrical Affordability Objective 4 – Economic Development and Job Creation
POSITIVE	Resource options that are less expensive than diesel.
NIL	Resource options that are comparable to diesel (including diesel itself).
NEGATIVE	Resource options that are more expensive than diesel generation.

Technical Viability	
Description	The technical viability criterion encompasses the following factors: • Availability of local energy generation sources • Geographic location of customers • Access to communities, if the fuel must be externally sourced • Complexity of using the resource • Whether or not the resource is proven in the NWT • Resource reliability • Ability to provide reliable energy whenever it is required (a.k.a: firm energy)
Objectives Addressed	Objective 2 – Ensuring Reliable Electric Supply Objectives 1, 3-6 – This criterion ensures that all of these objectives are pursued realistically and without incurring excessive risk.
HIGH	Generally, the resource is available in the NWT, it is a reliable source of energy, it can be deployed in the target communities, and the expertise required to maintain and operate the resource can be sustained over the long term.
MEDIUM	A mix of High and Low characteristics.
LOW	Generally, the resource is difficult to deploy in the NWT, it is an intermittent source of energy, challenges exist deploying it in the target communities, and the expertise required to maintain and operate the resource may be difficult to sustain over the long term.

Environmental Performance	
Description	The environmental performance criterion focuses on a resource or scenario's impact on greenhouse gas emissions ("GHGs"), other air quality considerations (such as particulate matter), and the land-use footprint of a project.
Objectives Addressed	Objective 3 – Reducing Environmental Impacts
HIGH	The resource produces little/no GHGs and little/no air pollution and the resource footprint is small compared to the benefits.
MEDIUM	The resource may produce some GHGs and/or air pollution in a localized area, but the overall footprint and air shed impact is manageable.
LOW	The resource produces significant quantities of GHGs and/or air pollution for the benefits and/or the land impact is large relative to the benefits.

Social Benefits	
Description	The social benefits of a given resource or scenario are considered to be its impact on the following factors: • Electrical interconnection of remote communities • Economic growth and job creation • NWT Energy Self-Sufficiency / Independence • Local Health Impacts • Community, cultural, and aboriginal values
Objectives Addressed	Objective 2 – Ensuring Reliable Electrical Supply Objective 5 – Diversifying Energy Supplies and Financing Objective 6 – Elevating the Priority of Community/Aboriginal Initiatives
HIGH	Generally, the resource increases electrification of remote communities, promotes economic growth and job creation, improves energy self-sufficiency, has no/negligible negative heath impacts and promotes community, cultural and aboriginal values.
MEDIUM	A mix of High and Low characteristics.
LOW	Generally, the resource does not increase electrification of remote communities, does not promote economic growth and job creation, does not improve electrical self-sufficiency, may have negative health impacts and does not clearly promote community, cultural and aboriginal values.

3. Current NWT Electrical System

3.1 Northwest Territories

The NWT electrical system is characterized by relatively small clusters of customers separated by large distances as shown in Figure 2. As a result, electric system solutions that are appropriate for electric utilities in the comparatively densely populated regions of southern Canada are not directly transferrable to the NWT.

Figure 2 – Existing Electrical Infrastructure of the NWT

Whereas southern Canadian utilities have the population and industrial density necessary to support building high-capacity transmission lines to interconnect customers to large centralized electricity generation sites, for many communities in the NWT it is more economically practical to avoid interconnecting transmission lines and instead install and operate isolated or "islanded" generators located close to customer loads (i.e. each generator is typically located within the community it serves).

Although most communities and industrial load centres are electrical islands, there are two multi-community electrical grids[1] in the NWT; the Snare grid serves Yellowknife, Dettah, N'Dilo and Behchoko and the Taltson grid serves Fort Resolution, Fort Smith, Hay River and Enterprise (see Figure 7). The electrical energy for these grids is provided primarily by hydroelectric plants, supplemented by diesel generators that are available to provide additional capacity and backup during hydro and transmission outages.

The communities and industrial sites not connected to either the Snare or Taltson grids rely on local thermal[2] generation for their primary electric supply. Most thermal generators in the NWT burn diesel fuel, but in Norman Wells and Inuvik natural gas is used as well. The Diavik Diamond Mine is an exception which supplements diesel generation with a 9.2 MW renewable energy wind farm.

Other solar and energy resources are present as well, but these resources contribute a small fraction of the overall electrical energy production in the NWT. Figure 3 contains a map of existing solar generation in the NWT[3].

Northwest Territories Power Corporation Transmission Line

1 The term "grid" is used to mean any network of transmission or distribution lines that are connected together.
2 "Thermal" generation is any form of electricity generation that burns a fuel to generate electricity. Examples include diesel generation, natural gas generation, and biomass generation.
3 The Fort Simpson solar installation (104 kW) is the only installation in the NWT with an installed capacity greater than 100 kW.

Figure 3 – Existing Solar Generation in the NWT

The charts below show the regional breakdown of electrical demand and energy consumption[4] in the NWT. Three quarters of the power is consumed in the North and South Slave regions. Three quarters of the generation is from hydro, a clean, green, and economical source of electricity. Approximately one quarter of the generation burns diesel, which is subject to fluctuating fuel costs and carries an environmental footprint associated with GHG and particulate production. A small amount of gas-generated electricity is purchased to serve Norman Wells.

4 Electrical consumption values do not include isolated industrial sites such as mines in the North Slave Region or oil processing facilities at Norman Wells, which operate their own generation.

Figure 4 –
NWT Peak Electrical Demand by Region (MW; 2010)[5]

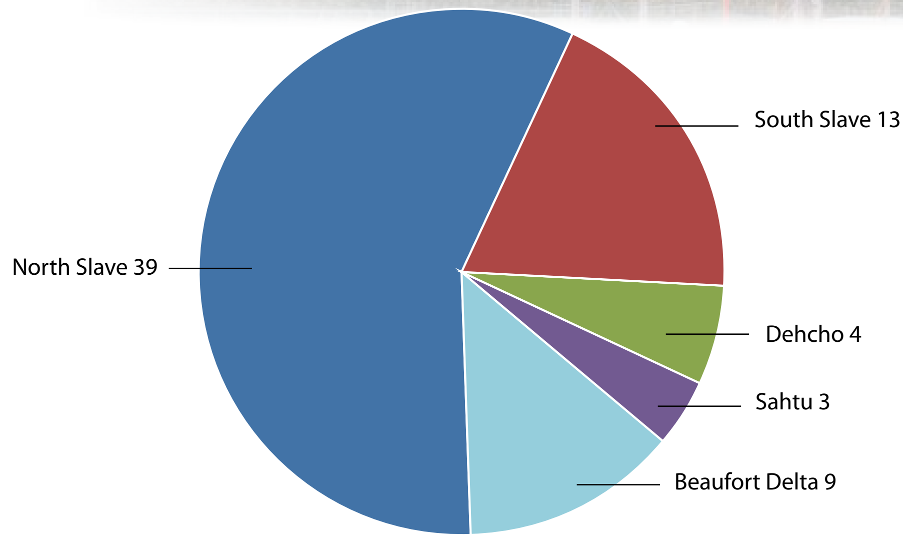


Figure 5 –
NWT Annual Energy Consumption (GWh; 2010)

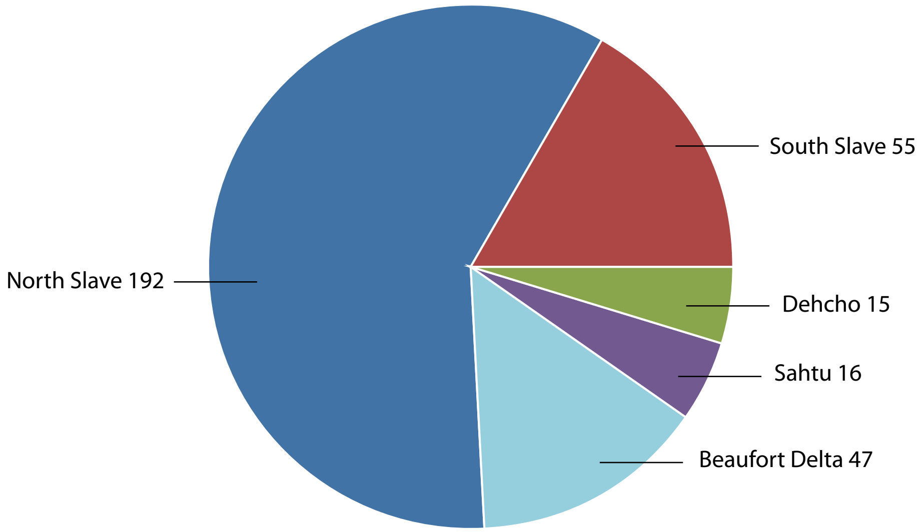
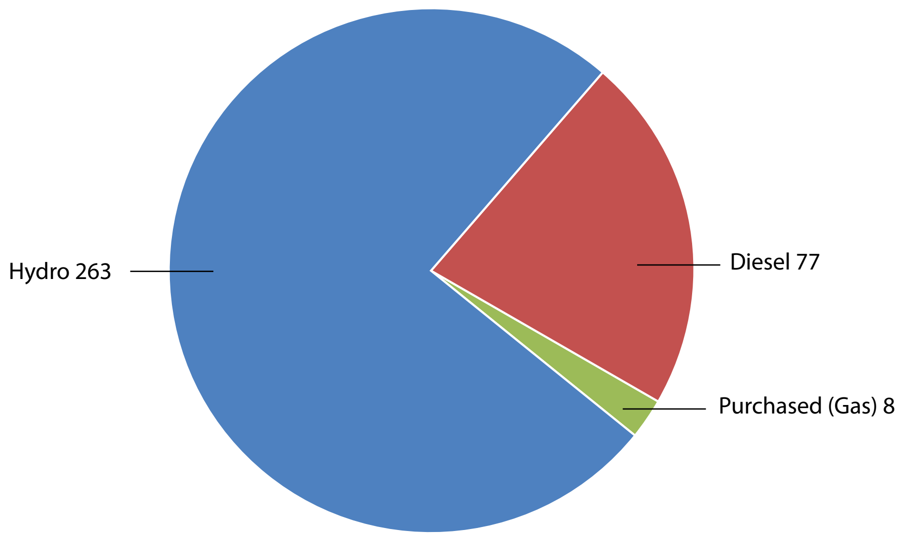


Figure 6 –
NWT Electrical Generation by Fuel Type (GWh; 2013/14)



5 Source: "NTPC General Rate Application 2012/13 and 2013/14," Northwest Territories Power Corporation, Hay River, NT, March 2012. - 2013/14 was chosen to reflect the shortage of natural gas based generation from Inuvik.

The factors contributing to potential electrical load growth in the NWT are:

- Population growth;
- Oil exploration in the Sahtu region; and
- Mining activity in the North and South Slave regions;

Some of the factors related to electrical generation in the NWT are:

- Depletion of natural gas supply in Inuvik in 2013 as a catalyst for developing new electrical energy supply sources;
- Redundancy and backup requirements dictate that isolated communities and industry have generation installed that is generally twice the peak requirements; and
- Surplus energy on the Taltson and Snare hydro systems goes unused every year and represents lost opportunities for revenue.

South Valley Spillway, Taltson River

3.2 North Slave Region

The North Slave region encompasses the area between Great Slave Lake and Great Bear Lake as shown in Figure 7. The load/resource mix for the region is listed in Table 2.

Figure 7 – North Slave Region Communities and Electrical Infrastructure

Table 2 – Generation and Load in the North Slave Region

Community	Installed Generation (kW)	2010 Consumption (GWh)	2010 Peak Load (kW)[6]
Gamètì	612 (diesel)	0.97	250
Wekweètì	380 (diesel)	0.61	153
Whatì	975 (diesel)	1.57	390
Snare Grid Behchoko Dettah N'Dilo Yellowknife	29,200 (diesel) 37,000 (hydro)	188.94	38,590
	TOTAL:	192.09	39,383

The majority of the population of the North Slave region (Yellowknife, Behchoko, Dettah, and N'Dilo) is interconnected with the Snare Grid via 240 km of transmission lines. Power for this grid is provided primarily by hydroelectric plants and supplemented with diesel generation. The diesel generation is required during the winter to meet very brief periods of peak energy demands, and when there are hydro plant or transmission outages. The communities of Gamètì, Whatì, and Wekweètì are not connected to the Snare Grid and are powered by diesel generators.

Although there is limited water (energy) storage available at the Snare system hydro plants, up to 25% of available energy is currently spilled[7] in warmer months, when water levels are high and power needs are lower.

Most of the North Slave communities have year round road access via paved highway, but Gamètì, Whatì and Wekweètì only have winter road access.

The North Slave region is home to three of the four mines currently in operation in the NWT, and this region holds the most promise for development of future mines and their associated new electrical loads.

6 Source: "Community Analysis Generation Index " NT Energy, Yellowknife, NT, December 2012. - Annual consumption and peak load are interpreted from this report.

7 "Spilled" energy refers to water that must be allowed to bypass the hydroelectric turbines rather than being stored or being used to generate electricity.

3.3 South Slave Region

The South Slave region is bounded on the north by Great Slave Lake, on the east by Nunavut and on the south by the Provinces of Saskatchewan and Alberta, as shown in Figure 8. Table 3 lists the load/resource mix for this region.

Figure 8 – South Slave Region Communities and Existing Electrical Infrastructure

Table 3 – Generation and Load of the South Slave Region

Community	Installed Generation (kW)	2010 Consumption (GWh)	2010 Peak Load (kW)[1]
Lutsel K'e	820 (diesel)	1.46	340
Taltson Grid Hay River Enterprise Fort Resolution Fort Smith	6,700 (diesel) 18,000 (hydro)	53.4	12,844
	TOTAL:	54.86	13,184

Fort Smith, Fort Resolution, Enterprise[9], and Hay River[9] are connected to the Taltson Grid that distributes electricity produced by the Taltson Hydroelectric Plant located northeast of Fort Smith, and several backup diesel generators via 465 km of transmission lines. Lutsel K'e is the only isolated diesel powered community in the region and it does not have any road access.

The Taltson hydroelectric facility has an installed capacity of 18 MW which is undersized relative to the hydrological potential of the location. An estimated 50% of the available water (energy) is spilled and not used to generate electricity because of the lack of load demand in the existing Taltson Grid.

8 Source: "Community Analysis Generation Index" NT Energy, Yellowknife, NT, December 2012.

9 In this NWT Power System report, the communities of Hay River and Enterprise are considered with the South Slave Region communities because of their interconnection to the Taltson Grid, although these communities are physically located within the Dehcho Region administrative boundaries.

3.4 Dehcho Region

The communities, generation resources and electric system of the Dehcho region are shown in Figure 9.

Figure 9 – Dehcho Region Communities and Existing Electrical Infrastructure

The Dehcho Region communities and their generation and load characteristics are listed in Table 4[10]. The primary source of energy for each of these communities is diesel generation with a small quantity of solar available in Fort Simpson. Year round road access is in place for all the communities of the Dehcho region except Nahanni Butte and Trout Lake, which are accessed via winter roads.

10 With the exception of the communities of Hay River and Enterprise, which are interconnected with the Taltson Grid and therefore listed in Table 2 in the South Slave Region section.

Table 4 – Generation and Load of the Dehcho Region

Community	Installed Generation (kW)	2010 Consumption (MWh)	2010 Peak Load (kW)[11]
Fort Liard	1,320 (Diesel)	2,727	550
Fort Providence	1,480 (Diesel)	2,942	650
Fort Simpson	3,210 (Diesel 104 (Solar)	7,636	1,660
Jean Marie River	230 (Diesel)	248	85
Kakisa	300 (Diesel)	358	109
Nahanni Butte	230 (Diesel)	397	120
Trout Lake	397 (Diesel)	447	121
Wrigley	781 (Diesel)	642	180

Northwest Territories Power Corporation solar installation in Fort Simpson

11 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012.- Annual consumption and peak load are interpreted from this report.

3.5 Sahtu Region

The communities and generation resources of the Sahtu region are shown in Figure 10.

Figure 10 – Sahtu Region Communities and Existing Electrical Infrastructure

Norman Wells relies on purchased electricity from the natural gas powered oil facility operated by Imperial Oil Resources Limited (IORL), and diesel generation maintained for backup purposes. None of the communities in this region have year round road access, but four of the communities are situated along the Mackenzie River shoreline. The Sahtu region holds high potential for oil and gas development in the NWT. The generation and load characteristics of the Sahtu Region communities are listed in Table 5 below.

Table 5 – Generation and Load of the Sahtu Region

Community	Installed Generation (kW)	2010 Consumption (MWh)	2010 Peak Load (kW)[12]
Colville Lake	240 (Diesel)	406	120
Deline	1,140 (Diesel)	2,533	550
Fort Good Hope	1,230 (Diesel)	2,650	696
Norman Wells	2,120 (Diesel) and IORL[13] Facility (Nat. Gas)	8,402 (Natural Gas) 0.388 (Diesel)	1,500
Tulita	1,100 (Diesel)	2,212	580

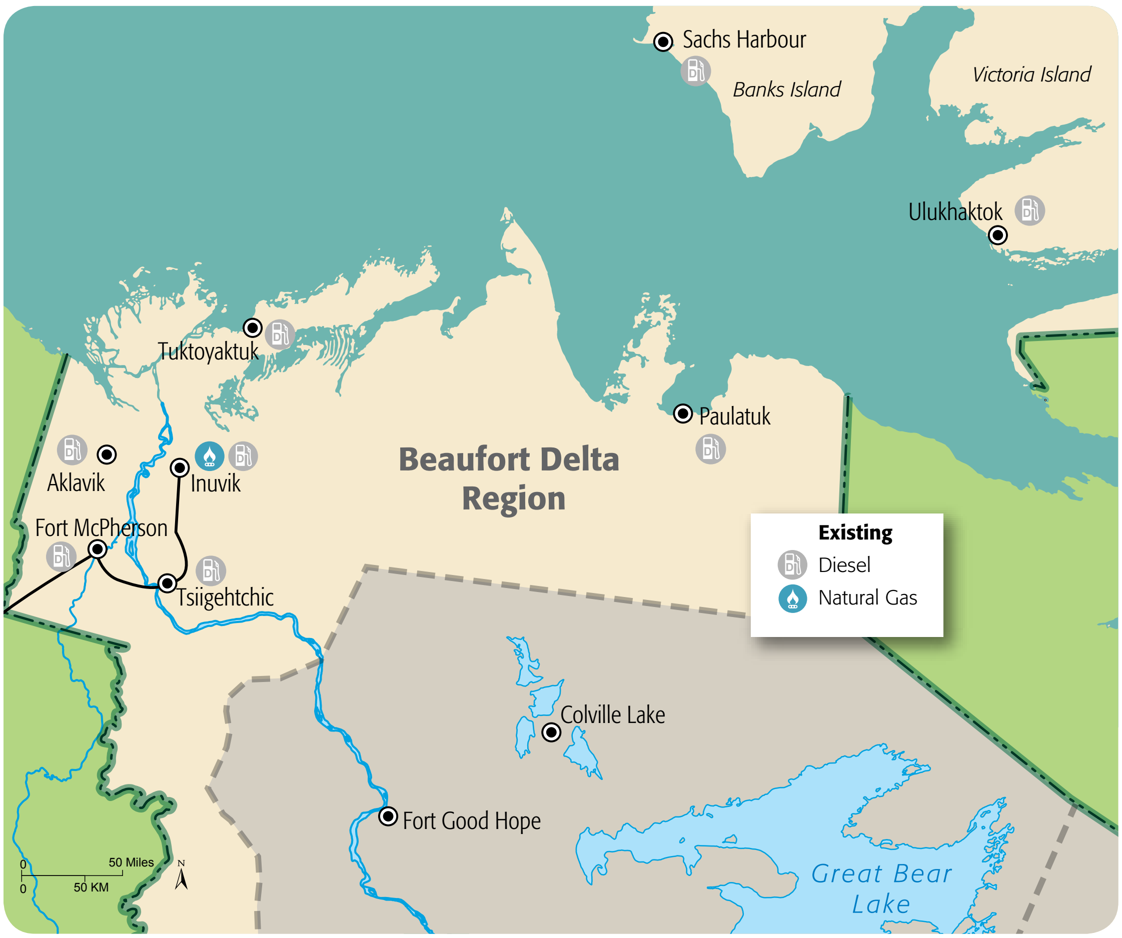
12 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012. - Annual consumption and peak load are interpreted from this report.

13 IORL – Imperial Oil Resources Limited.

3.6 Beaufort Delta Region

The communities and generation resources of the Beaufort Delta are shown in Figure 11.

Figure 11 – Beaufort Delta Communities & Existing Electrical Infrastructure



The Beaufort Delta region of the NWT is furthest from the established Taltson and Snare grids. There are eight communities between these two regions, and the electric generation and load characteristics of each of these communities are listed below in Table 6.

Table 6 – Generation and Load of the Beaufort Delta Region

Community	Installed Generation (kW)	2010 Consumption (MWh)	2010 Peak Load (kW)[14]
Aklavik	1,280 (Diesel)	2,890	580
Fort McPherson	1,825 (Diesel)	7,636	1,660
Inuvik	7,800 (Diesel) 7,700 (Nat. Gas)	28,237	4,879
Tsiigehtchic	500 (Diesel)	664	175
Paulatuk	840 (Diesel)	1,385	243
Sachs Harbour	795 (Diesel)	929	190
Tuktoyaktuk	2,205 (Diesel)	3,662	844
Ulukhaktok	1,160 (Diesel)	1,833	400

The generators for these communities are all deployed in a redundant fashion with the total installed generation being at least twice the peak demand and distributed between two or more similarly sized generating units. Inuvik, the third largest community in the Northwest Territories, has been supplied with natural gas from the nearby Ikhil natural gas field since 1999, and utilizes natural gas in its generation mix. However, the Ikhil natural gas supply will run out prior to 2015. Integration of LNG for electricity supply is underway now and shows promise as a medium term replacement of the near depleted Ikhil gas field.

Ventures West transports LNG to Inuvik.

14 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012. - Annual consumption and peak load are interpreted from this report.

4. Regional Load / Resource Balance

This section examines the drivers and potential for load growth in the NWT, and the adequacy of current facilities (including end-of-life replacements) to meet the demand.

4.1.1 Factors Affecting Load Growth

Residential electricity demand is primarily dependent on population growth, whereas commercial demand is largely dependent on growth in the government and service sectors. Industrial load growth is primarily related to the addition of individual mining and oil & gas facilities (although process changes at existing facilities can also cause load growth or reduction).

4.1.1.1 Population

Load has grown at a low rate since 2007/2008[15] with an average annual growth rate of only one half-percent. Population projections[16] imply a similar growth rate continuing in the future. The relationship of population growth to electrical load growth is not one-to-one since the number of individuals in a household can vary and new technology can drive load density per person higher over time (e.g. historical trend from one TV per household to multiple TVs). To be conservative from a supply adequacy perspective, a 1% growth rate for energy and capacity demand in the NWT has been assumed.

4.1.1.2 Industry

Load growth in the industrial sector is typically the result of discrete developments rather than the incremental organic growth seen in the residential and commercial sectors. The decision to proceed with industrial projects is primarily driven by commodity prices and the cost of extraction. The main potential for industrial growth in the NWT is the development of new mines in the North Slave region and Oil & Gas extraction facilities in the Sahtu region. Appendices A and B, respectively, examine these two important sectors more closely.

4.1.2 Supply Adequacy

4.1.2.1 North Slave Region

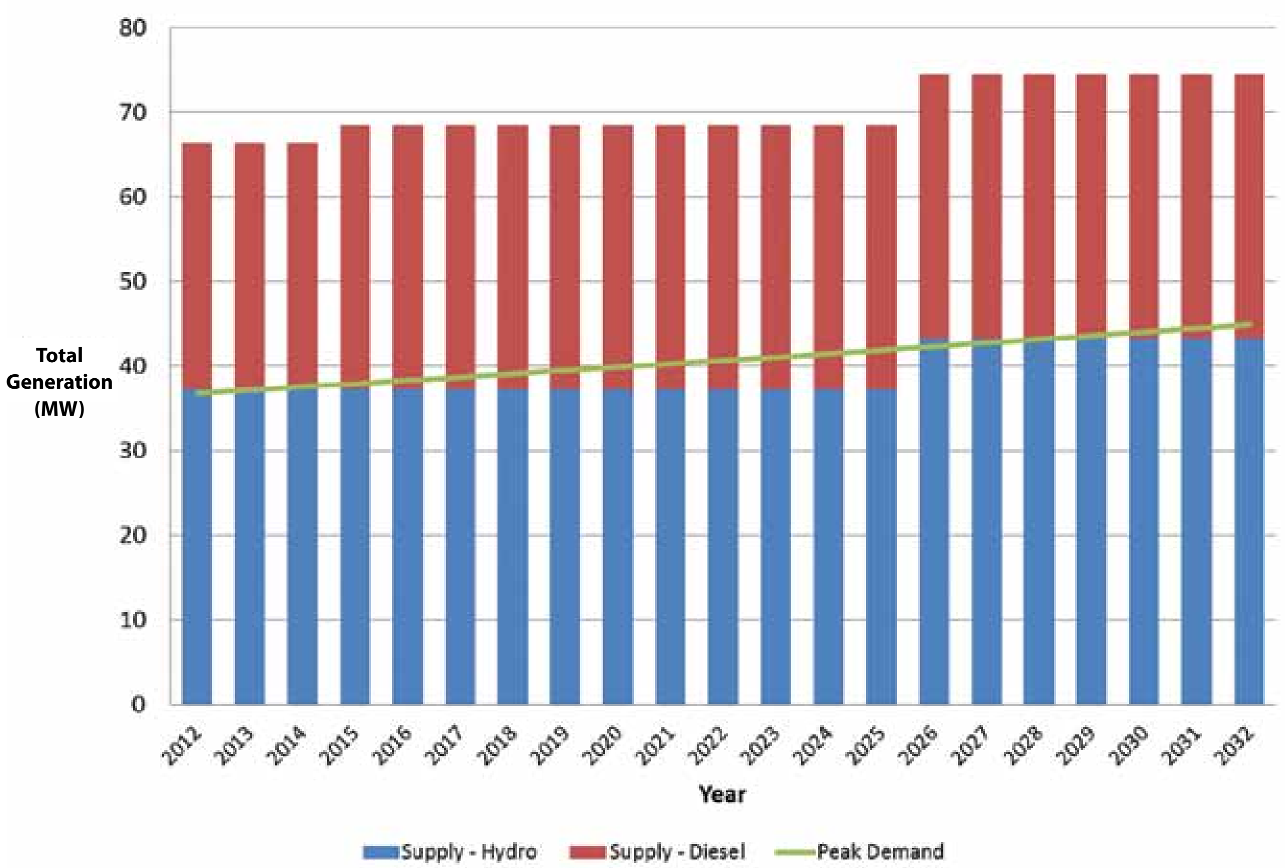
Snare Grid

The Snare Grid in the North Slave region is supplied by a mix of hydroelectric and diesel facilities. The hydroelectric facilities supply the majority of the energy and capacity, and the diesel facilities are primarily used during peak use periods, or as backup when a plant or transmission outage makes the hydro unavailable. The age of some of the back-up diesel units (40+ years) would suggest that replacements in the range of 5 to 10 MW at Jackfish may be necessary within the planning horizon. The projected annual supply and demand characteristics for the Snare Grid are shown in Figure 12. The figure indicates that the Snare system's ability to meet peak requirements with hydropower has been reduced to the point that diesel will be required as further load growth occurs.

15 Source: "Table 2.1 System Sales – 2007/08 Test Year Forecast Compared to 2012/13 Test Year Forecast, NTPC General Rate Application 2012/13 and 2013/14," Northwest Territories Power Corporation, Hay River, NT, March 2012.

16 Source: "Population Projections, by Community; Northwest Territories, 2011 – 2031," Northwest Territories Bureau of Statistics, Yellowknife, NT. 2011.

Figure 12 – Snare Grid Supply and Demand Outlook



The increases in total generation in 2026 are due to expected upgrades of existing facilities for reliability and backup purposes. The system's ability to meet the peak load requirements is based on the total generation less the single largest component. In the case of the Snare system that component is the Snare transmission line which effectively removes 29MW of capacity. Removal of the Snare hydro system leaves 37 MW of installed capacity which just meets the forecasted peak. Customer owned generation within the City of Yellowknife amounts to roughly 3 MW of further capacity. Additional loads may emerge if the Fortune Minerals, Nico Project, Tyhee or Avalon mining proceed or the Whati Transmission Line Project is pursued. A new industrial customer would require investments in transmission and installed generation, but due to the uncertainty of when exactly any particular load may come on line, they have not been included in the base case planning horizon. The best option for new generation would need to consider the business case for hydro expansion, diesel or centralized LNG as initial and long term supply options. Generation redundancy will need to be examined as circumstances change and factored into the 20 year planning horizon.

The Snare Hydro System consists of the four hydroelectric facilities on the Snare River, as well as the Bluefish Hydro Facility. Average potential power generation from the Snare Hydro System is highest between the months of May and October, peaking at over 35 MW in August. Between December and April, the average potential power generation drops, declining to less than 25 MW in March. Although power generation from the Snare Grid must be supplemented with diesel generation during the winter peak demand hours, a considerable quantity of energy is spilled throughout the remainder of the year. It is estimated that 40 GWh are spilled annually, or over 25% of potential energy on the Snare Hydro System.

The communities of Gamètì, Wekweètì and Whatì are not connected to the Snare Grid. Supply adequacy for these communities is separately discussed in Section 4.1.2.3.

4.1.2.2 South Slave Region

Taltson Grid

The Taltson Grid loads are primarily supplied by the Taltson Hydro facility, with three diesel facilities providing backup generation. The Taltson Hydro facility is capable of generating 18 MW of firm (i.e. always available) generation, but currently spills a significant amount of water because the average Taltson Grid load is typically only 8-12 MW. The annual supply and demand characteristics for the Taltson Grid are shown in Figure 13.

Figure 13 – Taltson Grid Supply and Demand Outlook

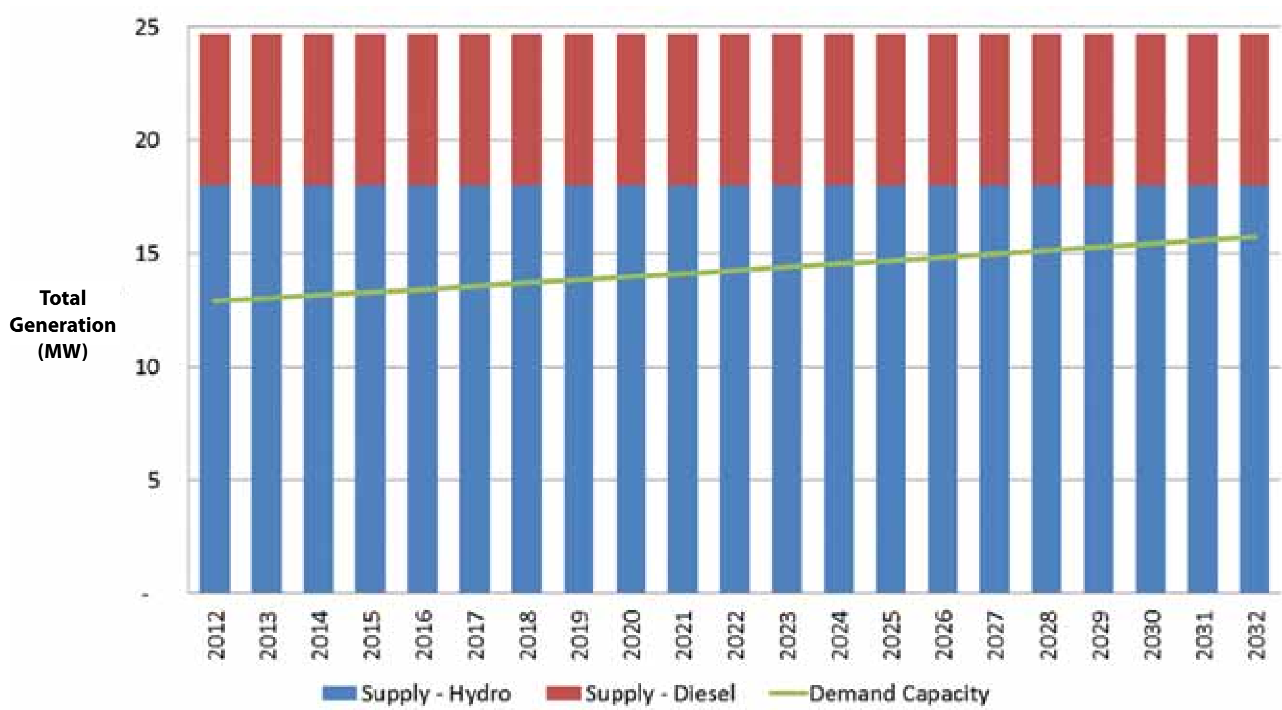
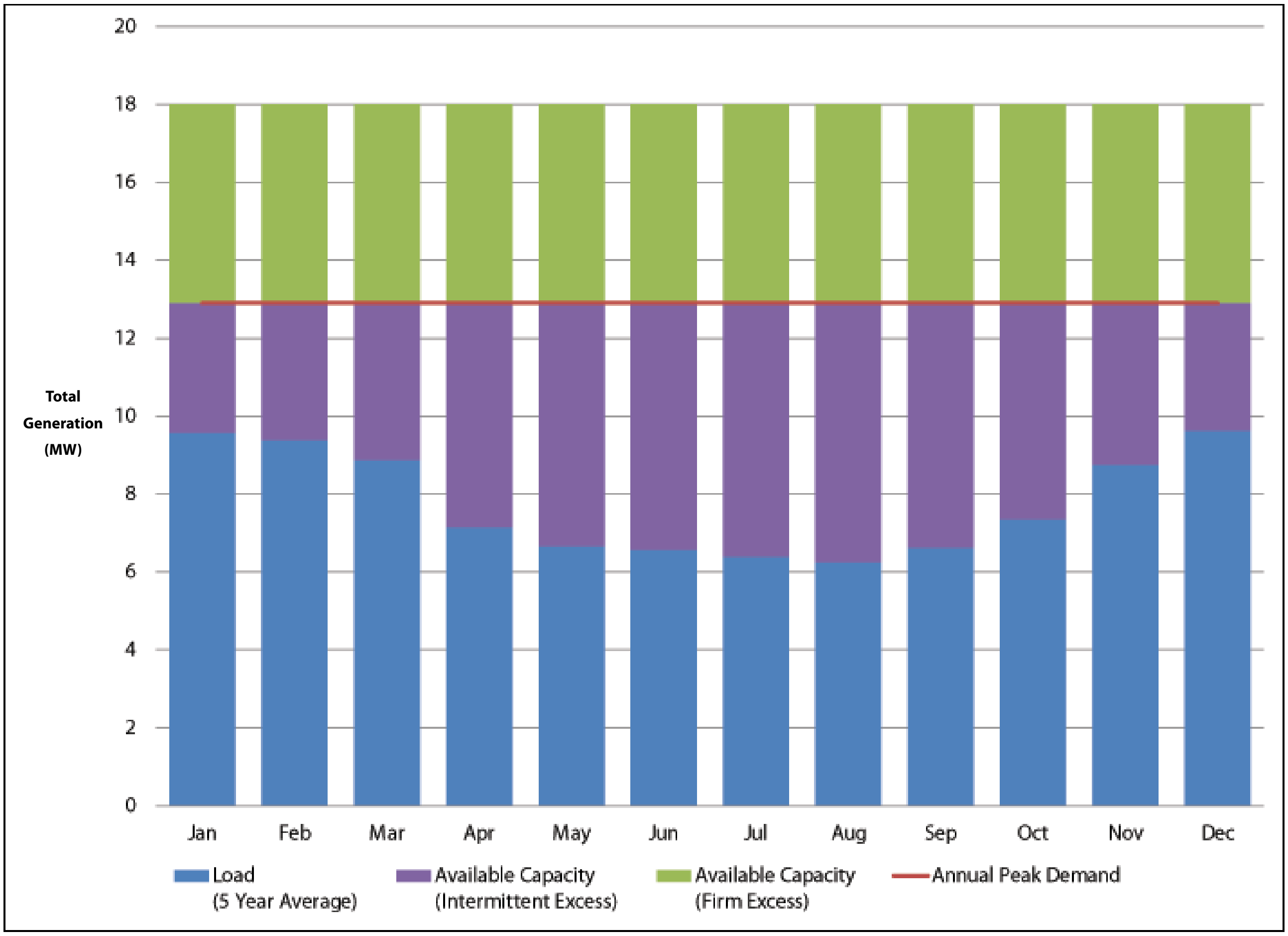


Figure 14 shows that the monthly peak demand on the Taltson grid is less than the available capacity of the Taltson hydroelectric facility. At the end of 20 years the peak demand is expected to amount to less than 90% of the available hydro capacity. Therefore, the existing Taltson Hydro facility is capable of meeting the energy and capacity needs in the Taltson Grid for the foreseeable future, before accounting for the existing backup diesel facilities. Additional loads could also arise if the proposed Tamerlane and Avalon mining projects proceed to construction.

Figure 14 – Taltson Hydro Facility – Monthly Supply and Demand Characteristics



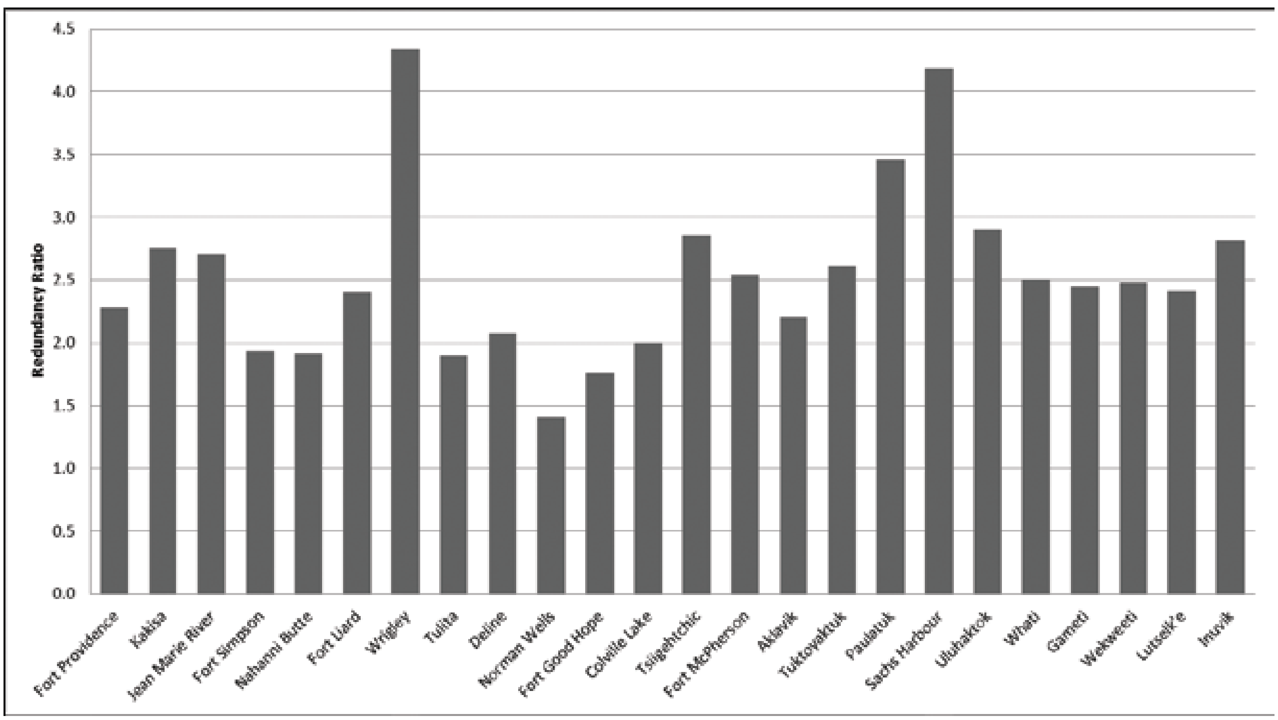
The community of Lutsel K'e is not connected to the Taltson grid and supply adequacy for this community is discussed separately below.

4.1.2.3 Dehcho, Sahtu and Beaufort Delta

The communities of the Dehcho, Sahtu and Beaufort Delta Regions, as well as the communities of Gamètì, Wekweètì, Whatì and Lutsel K'e in the North and South Slave Regions, are off-grid "electrical islands". None of these communities are connected to a transmission grid, and with a few exceptions they rely exclusively on local diesel generation. The existing diesel generation in each community is adequate to meet forecast electrical demand requirements over the planning horizon and generating equipment can be replaced on a "like-for-like" basis as individual units reach end of life.

Generation plants are all sized to meet redundancy requirements because each community's generating plant must be capable of meeting the peak load with its largest generating unit out of service. A ratio comparing the total generation capacity to the peak load was calculated as an indicator of redundancy for each community. The results of this analysis are displayed in Figure 15. Inuvik has unique circumstances and is not shown in the chart, but is addressed separately in the next section.

Figure 15 – Capacity Ratio (Supply to Demand) of non-Grid Communities



Communities typically maintain a redundancy ratio of two or greater and given the low expected load growth, the communities generally have enough installed generation to meet their peak demand PLUS required redundancy over the 20 year planning horizon. Specific communities may require incremental generation increases but these can be handled on a case-by-case basis as individual diesel units are replaced at the end of their service lives.

4.1.2.4 Inuvik

While Inuvik is not a grid connected community, electricity has largely been supplied by natural gas fired generation rather than diesel generation. Unfortunately, the local natural gas reserves are nearing depletion and are forecasted to be exhausted prior to 2015. The existing gas generation was already taken out of service to help extend the life of the gas supply for other users. As a result, additional diesel generation was required to meet back-up and load growth requirements. The Public Utilities Board has approved the replacement of one of the smaller diesel generators with a much larger one, and modification of one of the existing natural gas generators for diesel fueled operation. The installed diesel generation capacity at Inuvik is 10.1 MW, and installed natural gas generation capacity is 5.6 MW. The historical peak load is 5.8 MW set in February 2008, and the new diesel capacity will meet projected back-up and projected load growth for the duration of the NTPSP. Concurrently, NT Energy managed the construction of a Liquified Natural Gas supply project commissioned in December 2013 that is projected to meet the electricity needs for Inuvik for the next 20 years. The installation would rely on a mix of up to 80% natural gas and 20% diesel.

Installation of Northwest Territories Power Corporation’s LNG tanks in Inuvik.

5. Resource Options

This section reviews different resource options that could be used to meet the NTPSP objectives listed in Section 3.2, and evaluates each resource type against the criteria described in Section 3.3. The results are set out as an Evaluation Dashboard for each resource.

5.1 Diesel

Diesel Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH	Installation Cost $/kW
NIL *Status quo*	**HIGH** *Universally viable*	**LOW** *GHG emissions, air quality*	**LOW** *Imported fuel; local health*	**$350**[17]	**$3,000**

Diesel generation is presently installed in almost every community in the NWT, and in particular in remote locations not connected to the Snare or Taltson Grids. Diesel generation is a reliable, easily installed and maintained source of electricity supply and this is reflected in its rankings as a technically viable energy resource that comprises the baseline for economic comparison. However, as environmental awareness and fuel prices have increased, the generation of GHGs, local air & noise pollution, and continuing dependence on an imported price-volatile fuel makes diesel less attractive on a social, environmental and potentially economic basis going forward.

5.2 Liquefied Natural Gas

Liquefied Natural Gas Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH	Installation Cost $/kW
POSITIVE *Improved vs. diesel*	**HIGH** *Universally viable*	**MEDIUM** Lower *GHG emissions*	**LOW** *Imported fuel; medium if LNG produced in NWT*	**$300**[18]	**$1,000** *(bi-fuel)*[19]

Liquefied natural gas (LNG) is natural gas cooled to -162 °C, the point at which it transitions from its normal vapor state to a liquid state. LNG contains six hundred times more energy density than gas in vapor form. As long as LNG is kept cold it can be transported safely by conventional means such as truck, train, or ship, rather than exclusively by pipeline.

Natural gas prices in North America are currently at historic lows, thus making LNG a potentially attractive imported fuel source. Furthermore, "bi-fuel" kits can be retrofit onto existing diesel generators to allow these

17 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012. Reflects marginal cost of existing generation for comparison purposes. It is expected that building new diesel generation would result in a somewhat higher cost of energy.

18 This price is highly dependant on the cost of LNG transportation from southern BC. We expect LNG facilities to develop nearer to NWT (in either northern BC or AB) in the next three to five years, which would drop the Cost of Energy accordingly.

19 Source: LNG installation cost was provided by NT Energy and represents the cost to install a bi-fuel kit onto an existing diesel engine. March 8, 2013

generators to operate using a blend of natural gas or diesel fuel. Natural gas generation technologies score well on economic and technical criteria because natural gas prices are forecast to remain lower than diesel prices and natural gas generation technology is robust and can be installed and maintained in the NWT. Additionally, natural gas scores better on the environmental performance because its GHG production and air pollution is 25 % lower than compared to diesel generation. However, like diesel generation, there are few local social benefits associated with LNG generation and the NWT would remain captive to the cost volatility of external energy markets unless the NWT can make use of NWT natural gas reserves. The feasibility of using LNG as a fuel source needs evaluation on a community basis to assess the specific costs associated with diesel to "bi-fuel" generator conversions and LNG transportation. Furthermore, supply chain challenges associated with transporting LNG to winter road communities in the NWT needs to be resolved if LNG is to be a widespread fuel source for the NWT.

The Inuvik energy options report[20] found LNG to be the best alternative to diesel and indicated that LNG may be competitive with diesel in other communities which have year-round road access. Inuvik has the additional advantage of already having natural gas generation in place thus reducing its capital costs for fuel switching when compared to a diesel-only community.

5.3 Solar

Solar Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH	Installation Cost $/kW
NEGATIVE *Subsidy required*	**MEDIUM** *Intermittent*	**HIGH** *No GHGs, small footprint*	**HIGH** *Renewable; self sufficiency*	**$590 - $830**	**$9,000 - $14,000**

In this 20-year vision, the solar generation resources considered are photovoltaic panels which convert sunlight directly into electricity. The main benefit of solar generation is that it has a zero cost fuel source (i.e. the sun) and zero air emissions. However, although the economic viability of solar generation has increased greatly in the past decade, at this time it remains as a more expensive source of energy compared to diesel, and it only provides energy when the sun is shining (e.g. intermittent) rather than when the energy is needed. Given that there is little sunlight during the peak electrical demand winter months in the NWT, a solar project could only act intermittently to offset other, already-installed generation during the off-peak season. As a result, solar generation is not considered a resource option for primary resource planning purposes, but is considered as a potential offset for diesel generation in order to reduce the environmental impacts associated with diesel generation.

The GNWT published a Solar Energy Strategy in 2012 to address the challenge of incorporating solar photovoltaic energy as a generation alternative to diesel generation for Communities. This strategy "establishes a bold target of displacing 10 percent of diesel electricity generation. "The aim is to deploy systems, sized up to 20 percent of the average load in communities served by diesel generation over the next five years. The NTPSP assumes that funding is available for the subsidies required to allow solar installations to break even with diesel and expects one to two solar projects in the 50 – 100 kW size range to proceed in the 2013/14 timeframe.

The Sahtu Region will be the first region to demonstrate the deployment of a utility-scale hybrid solar PV system. Construction is scheduled for the summer of 2014 in Colville Lake. If the hybrid system proves successful it will be

20 Source: "Transition from Natural Gas Biomass District Energy Financial Analysis," Associated Engineering, June 2012.

an option for other thermal communities in the NWT to consider.

5.4 Wind

Wind Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH[21]	Installation Cost $/kW[21]
NEGATIVE *Subsidy required*	**MEDIUM** *Intermittent*	**HIGH** *No GHGs, small footprint*	**HIGH** *Renewable; self sufficiency*	**$360 - $770**	**$3,500 - $23,000**

Wind generation involves using a turbine to harness wind energy and drive an electric generator. Similar to solar generation, wind-generated electricity is potentially attractive because it has a zero cost fuel source, and generates zero-air emissions. However, like solar generation, wind is intermittent and when no wind is blowing, no power is generated. Again similar to solar generation, a wind project cannot be a primary generation option and is only evaluated as an offset to diesel generation.

A wind farm consisting of four 2.3 MW turbines is in operation at the Diavik diamond mine as an offset to the diesel generation installed at the mine. Similar installations may be viable elsewhere in the NWT where the wind energy can be used to offset diesel generation costs.

5.5 Biomass

Biomass Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH	Installation Cost $/kW (BC)
POSITIVE *Improved over diesel*	**MEDIUM** *Viability being evaluated*	**MEDIUM** *renewable but produces GHGs*	**LOW** *Imported fuel; local health*	*Unknown[22]*	*Unknown*

"Biomass" refers to the burning of natural organic material (typically wood, but also algae, agricultural crops, and municipal waste by-products) for the production of electricity, and the potential use of waste heat for other purposes such as industrial processes or district heating. In the NWT, biomass is already used at a household level for 10% of the current space heating energy requirements. Biomass is considered less polluting than hydrocarbon-based (e.g. diesel) electrical generation because the carbon released by burning biomass would have been released when the biomass decayed naturally.

Several commercial biomass heating projects are already in use around the NWT. The prospects for expansion of biomass generation are dependent on supply of biomass material (e.g.: wood pellets). It is unlikely that biomass can be a large-scale option for territorial scale generation, but at a community level it is most economic when the heat load is the target market and electricity is a by-product.

21 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012. - The cost estimates for wind installations assumes that projects can be financed with a 0% rate of return.

22 The costs for biomass produced energy vary significantly by fuel source, plant size and access-type, and there was insufficient information available at the time of writing to estimate a value for this table.

Challenges for biomass generation include:

- The need for qualified individuals to operate power-generation-sized boilers.
- Small electrical and heating loads are normally insufficient to achieve the scale required for economically viable combined heat and power (CHP) plants.
- Biomass fuel supply can be costly, especially when transport and storage is considered, and achieving a stable long-term supply can be difficult.

5.6 Geothermal Electricity Production

Geothermal Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH	Installation Cost $/kW
NEGATIVE *Subsidy required*	**LOW** *Depends on availability*	**HIGH** *No GHGs, small footprint*	**HIGH** *Renewable; self sufficiency*	*Unknown*	*Unknown*

Geothermal energy refers broadly to energy that is derived from heat found within the earth. For the purposes of this document, geothermal energy is focused on geothermal energy for electricity production that requires a naturally occurring geothermal feature that is a source of high temperature heat (>80°C). Because the likelihood of finding and developing a suitable source of geothermal energy suitable for electricity production over the 20-year planning horizon is very low, geothermal energy is not considered a viable resource option for the purpose of the NTPSP. It is acknowledged that geothermal sites were investigated in the Fort Liard area for a project about 1 MW in size, but their suitability for producing electricity has not been demonstrated on a proven basis. As a result, geothermal electricity generation is not considered a viable generation option for electricity resource planning purposes.

5.7 Hydroelectricity (Run-of-River/Small – 1 MW scale)

Hydroelectricity (Small) Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH[23]	Installation Cost $/kW[23]
NIL *Varies; average close to diesel*	**MEDIUM** *Regional*	**HIGH** *No GHGs*	**HIGH** *Low stream use impact*	**$375 - $625**	**$4,000 - $30,000**

"Small" hydroelectricity is typically used to refer to projects that generate electricity on a community scale. Hydroelectricity has several benefits: it has zero emissions, is renewable, and has competitive capital costs when compared to other renewable generation (such as solar or wind). The main drawback of small hydroelectric projects is the high fixed capital cost and the site specific nature of the water resource. Due to the small load size of the NWT Communities, most small hydroelectric facilities cannot be optimally sized in a way which makes small hydroelectricity an economic generation option.

23 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012. - The cost estimates for small hydro installations assumes that projects can be financed with a 0% rate of return.

5.8 Hydroelectricity (Medium – 10 MW scale)

Hydroelectricity (Medium) Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH[24]	Installation Cost $/kW[24]
POSITIVE *Varies regionally*	**MEDIUM** *Proven; regional*	**HIGH** *No GHGs*	**MEDIUM** *Waterway use impacted*	**$85 - $135** + transmission interconnection	**$6.5 - $9.5k** + transmission interconnection

Medium sized hydroelectric projects are those on the order of tens of megawatts of generation capacity, and potentially have some water storage capability. The Snare and Taltson Grids are currently powered primarily by medium sized hydroelectric projects. These projects are appropriate generation sources for large communities, grids, or industrial projects that have comparably large electric loads. Some options for future projects include La Martre Falls, Snare Site 7, and the Taltson Expansion.

The La Martre Falls Hydroelectric Facility (La Martre) is a proposed run-of-river project with a capacity of 13.2 MW. La Martre is located approximately 18 km southeast of Whatì, and approximately 60 km southwest of Snare, putting it in close proximity to the Snare Grid. The levelized cost of electricity for La Martre is $134 per MWh (2012) according to the "La Martre Falls Hydroelectric Development Final Feasibility Report (March 2012)". Snare Site 7 (Site 7) is a proposed 12.5 MW run-of-river hydroelectric project located approximately 100 km northeast of existing Snare hydro facilities. The latest cost estimates have shown that the cost to construct the 13.2 MW La Martre project is substantially lower than the cost of a 12.5 MW facility at Site 7.

Medium hydroelectric projects often have some ability to impound water, thus making them able to store energy. As a result, these resource options are generally more reliable sources of supply than are small hydro projects, even though their generation output is still dependent on seasonally variable water flows, and they often still require supplemental resources. For example, the Snare Grid must rely on the large Jackfish diesel facility during peak winter periods.

Hydroelectricity (Large →100 MW scale)

Hydroelectricity (Large) Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH[25]	Installation Cost $/kW[25]
POSITIVE *Varies regionally*	**MEDIUM** *Proven; regional*	**MEDIUM** *No GHGs, large project footprint*	**MEDIUM** *High enviro-impact; job creation*	**>$50** + transmission interconnection	**>$2.5k** + transmission interconnection

Large hydroelectric facilities are those on the order of hundreds of megawatts (100 MW to 300 MW in the cases studied), which could independently serve most or the entire territorial load if properly interconnected. Typically these large plants also include the ability to store large quantities of water between seasons, meaning that the water can be stored during the highest water flow times of year for use during the highest demand times of the

24 Cost estimates for medium sized hydroelectric installations are based on studies previously carried out that analyzed the prospective La Martre, Snare 7, and Taltson Expansion projects, provided by NT Energy.

25 Source: "Great Bear River Review of Hydroelectric Potential," Williams Projects Ltd., Claresholm, AB, May 2003. - The costs in this report are in 2002 $CAD, and been escalated to 2012 $CAD using CPI.

year. Potential projects are on the Great Bear (125+ MW) and Taltson (200 MW) Rivers. However, it is unlikely that any of the potential projects will be economically feasible until grid expansion objectives are achieved. Resources of this type should be re-evaluated depending on the success of grid expansion efforts and load growth.

5.10 Transmission System Expansion

Transmission Expansion Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH	Installation Cost $/km[26]
NIL *Typically break even v. diesel*	**HIGH** *Universally viable*	**HIGH** *Offset isolated diesel*	**HIGH** *Reliability; econ. growth*	*n/a*	**$350 - $600k**

Expansion of the transmission system refers to:

- Connecting remote, isolated communities and mines to the existing provincial and continental grid and;
- Connection of the existing Snare and Taltson grids into a single NWT grid.

Such transmission system connections provide many benefits including allowing communities to access economically stable, reliable, and cleaner hydroelectric resources while maintaining their current diesel-electric infrastructure for system redundancy and reliability.

Cost is the main challenge that connecting communities via transmission presents. Although replacing local diesel generation with centralized hydroelectric generation (provided from existing assets) represents an ongoing cost savings, these savings do not necessarily justify the capital costs of the long transmission lines needed to reach many of the remote communities in the NWT. In cases where a very small community is located far from the grid, it is unlikely that it would be economic to connect that community unless some other load (such as a mine or other communities) could also be served by the same line.

Furthermore, the above discussion of connecting communities to the Snare or Taltson grids generally only applies to the southern communities in the territory. Communities located further north (roughly Wrigley and north) would require an extremely large transmission line to be built, and this is unlikely unless a correspondingly large increase in industrial activity in the northwest of the territory takes place.

In addition to connecting remote communities, connecting the two existing Snare and Taltson grids would present benefits as well. There is currently excess energy at the Taltson plant that remains unused due to the small loads of the connected communities. Meanwhile, the hydro generation on the Snare Grid does not have enough energy during peak winter months when water levels are at their lowest and must sometimes rely on diesel generation for peak power periods. Not only would connecting the two grids address this generation-load mismatch issue, it would also allow the Taltson site to be even more fully utilized if it could be connected to industrial (e.g. mine) projects north of Yellowknife.

26 Cost estimates are derived from reports that examined the expansion of the Snare and Taltson transmission systems.

5.11 Intertie with Continental Grids

Continental Intertie Resource Dashboard					
Economic Impacts	Technical Viability	Environmental Performance	Social Benefits	Cost of Energy $/MWH	Installation Cost $/km
POSITIVE *Low $ imports, revenue*	**HIGH** *Well defined situation*	**MEDIUM** *Large project footprint*	**HIGH** *Economic growth driver*	**$120** *+ transmission costs*	**$350 - $600k**

Interconnection with Continental Grids refers to connecting the NWT's transmission system with one or more of the Saskatchewan, Alberta or British Columbia provincial grids. There is no electric grid in Nunavut, and an interconnection with the Yukon's electric grid would be extremely long, therefore those two alternatives are not considered in this report.

Interconnection with the continental grid would require transmission to be built from the existing Taltson Grid to one or more of the provincial grids (which are connected to the rest of North America). There are several benefits of such an interconnection. A continental intertie would provide a source of reliable electricity supply in the event of a planned or forced outage in the NWT. Additionally, it would provide access to ancillary electrical system services such as frequency control, which would improve power quality and reliability. Likewise, energy and ancillary services could be sold to the interconnected provinces during periods when there was an electricity surplus in the NWT.

A further benefit arising from a continental grid intertie is that new generation can be sized based on economic efficiency rather than the constrained number of electricity customers in the NWT. As a result, economically attractive projects larger than the NWT's needs could then be pursued, with any excess power sold to the interconnected southern provinces, thereby providing an additional revenue stream for the NWT.

The main challenge facing an interconnection is the large capital cost. Transmission lines are expensive, and this is especially true for very long lines because these normally require higher operating voltages and sophisticated mid-line voltage control equipment.

Interconnection with a southern province would also require a willing provincial counter-party. None of the Saskatchewan, Alberta or British Columbia provincial grids are especially robust in close proximity to the NWT border at present, thus such a project would require discussions and coordination with the appropriate provincial utilities.

5.12 Summary of Resource Options

The resource options can be grouped into the categories of firm, intermittent and those not recommended at this time. Firm resources are sources of electrical generation that can be dispatched at any time to a specific level of output to meet the load serving requirements. These are the primary resources used in developing a plan for meeting the electrical needs of a region. Transmission options are included in this category because interties between regions can be treated as dispatchable resources in addition to the other benefits they provide.

Diesel-offset resources are intermittent sources of electrical generation with variable electrical output based upon the available fuel (e.g.: wind speed or insolation intensity). These secondary energy sources help to offset diesel consumption, but are generally more costly per unit of energy produced than existing diesel facilities.

The tables below summarize the firm and diesel-offset resources considered in the development of the NT Power System Plan.

Firm Resources Summary Table						
Resource	Economic Impact	Technical Viability	Environ. Performance	Social Benefits	Cost of Energy	Installation Cost
Diesel	**NIL** *Status quo*	**HIGH** *Universally viable*	**LOW** *GHG emissions, air quality*	**LOW** *Imported fuel*	$350 /MWh	$3k /kW
LNG	**POSITIVE** *Improved over diesel*	**HIGH** *Universally viable*	**MEDIUM** Lower *GHG emissions, less risk of spills during transport*	**LOW** *Imported fuel*	< $350 / MWh[27]	$1k /kW *(Bi-fuel retrofit)*
Hydroelectric (Medium)	**POSITIVE** *Varies regionally*	**MEDIUM** *Proven; regional*	**HIGH** *No GHGs*	**MEDIUM** *Waterway use impacted*	$85 - $135 /MWh +Tx	$6.5k - $9.5k /kW +Tx
Transmission Expansion	**NIL** *Typically break even v. diesel*	**HIGH** *Universally viable*	**HIGH** *Offset isolated diesel*	**HIGH** *Reliability; econ. growth*	*Does not create energy*[28]	$350k - $600k /km
Continental Intertie	**POSITIVE** *Low $ imports, revenue*	**HIGH** *Well defined situation*	**MEDIUM** *Large project footprint*	**HIGH** *Economic growth driver*	$120 /MWh	$350k /km (Approx.)

Note that for the hydroelectric projects, the energy and installation costs contain a "+Tx" caveat, which means that the final costs of energy and installation will depend on the amount of transmission required to connect the project to the desired loads.

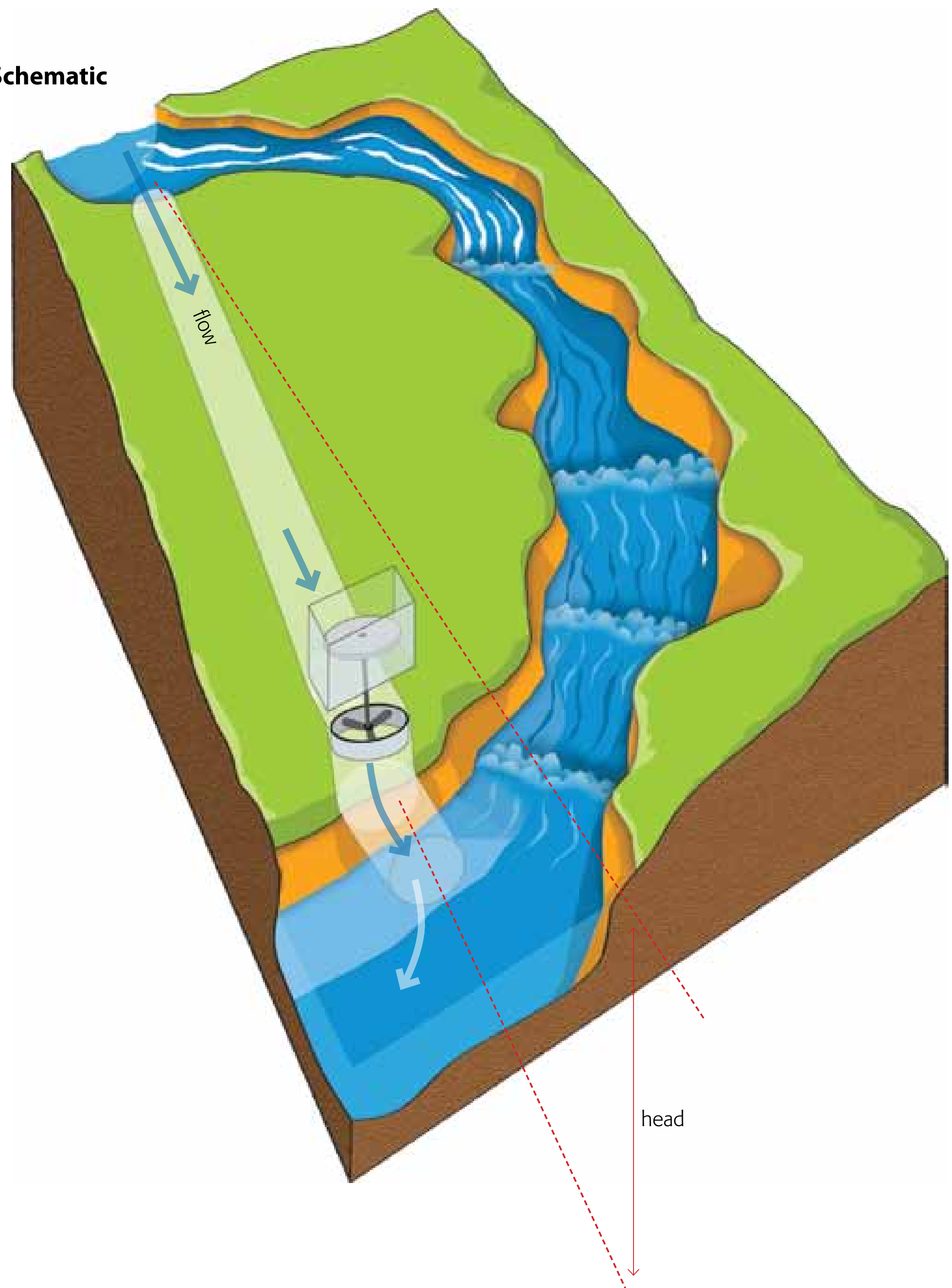
Diesel-Offset Resources Summary Table						
Resource	Economic Impact	Technical Viability	Environ. Performance	Social Benefits	Cost of Energy	Installation Cost

27 This price is highly dependent on the cost of LNG transportation from southern BC. LNG facilities may be developed nearer to NWT (in either northern BC or AB) in the next three to five years, which would drop the Cost of Energy accordingly.

28 While construction of transmission does not provide energy directly, the benefits of connecting the Snare and Taltson grids include stabilizing the cost of hydro generation and reducing the need to expand diesel backup (e.g. Yellowknife).

Solar	**NEGATIVE** *Subsidy required*	**MEDIUM** *Intermittent*	**HIGH** *No GHGs, small footprint*	**HIGH** *Renewable; self sufficiency*	$590 – $830 / MWh	$9k - $14k /kW
Wind	**NEGATIVE** *Subsidy required*	**MEDIUM** *Intermittent*	**HIGH** *No GHGs, small footprint*	**HIGH** *Renewable; self sufficiency*	$360 - $770 / MWh	$8k - $23k /kW
Hydroelectric (Small / Run-of-River)	**NIL** *Varies; average close to diesel*	**MEDIUM** *regional*	**HIGH** *No GHGs*	**HIGH** *Low stream use impact*	$375 - $625 / MWh	$40k - $230k /kW

Run of the River Schematic



6 NT Power System Plan System Structure

The vision for the NTPSP presented in Section 7 is divided into two main categories:

- Major Projects – Projects that affect more than one region or that affect external jurisdictions.
- Regional Plans – Regionally focused analysis that addresses the electrical requirements of individual communities within each region.

This 20-year vision proposes two Major Projects:

- NWT Grid Project – interconnecting the existing Snare and Taltson Grids and extending northeast of Yellowknife.
- Southern Intertie Project – interconnecting either the existing Taltson Grid or the combined NWT Grid with one or more of the Provinces adjacent to the NWT (i.e.: Saskatchewan, Alberta and/or British Columbia).

Regional Plans look at the needs of a large number of communities which have some similarities. One similarity that all the individual communities share is that they are all electrically isolated from each other, and must presently be electrically self-sufficient, including redundant generation to ensure that electricity remains available after the loss of any single generating unit. Another common trait is that all of these communities are primarily served by diesel-fuelled generation, with the exception of Norman Wells (and until recently Inuvik) where natural gas is used to fuel electrical generation.

The following planning steps were undertaken for each region:

1. Identify the unique aspects of the region

In this step, the key local considerations to be addressed when evaluating resource options are listed. These local considerations are taken down to the individual community level, as appropriate.

2. Analyze & rank the resources within the categories of Transmission, Non-diesel firm and Diesel-offset

The applicable resources are ranked based on the four criteria identified in Section 3.3. This step includes a discussion of why some resources are more or less applicable than others for each region or specific community, and identifies where insufficient community, technical or economic information is available to recommend a specific resource option.

3. Recommendations

Recommended resource options and the affected communities are summarized. Solutions are presented in the form of an "option evaluation dashboard" to allow for a comparison of the recommended resource options using the common criteria applied throughout the Power System Plan.

The resource categories identified in Step 2 above are not uniformly applicable in each community or region. For example, the cost of new transmission lines is a function of line length, which means that interconnecting isolated communities to either the existing Snare or Taltson Grids is not practical for communities situated far from these grids.

Similarly, non-diesel firm resources such as Liquid Natural Gas (LNG) or Biomass-fired generation, and hydropower with water storage are not practical for every community. These resources share an important feature of diesel generation, which is that it can be dispatched to meet load demand whenever needed.

However, transportation challenges (for LNG and Biomass) and the rarity of ideal sites near communities (hydro), means that these alternatives are often not practical or feasible for many communities. In these cases, it still makes the most sense to serve these communities using reliable and well-understood diesel generation.

The third resource type, diesel offset, refers to resources that cannot reliably serve as base loaded firm resources because of their intermittent nature, but they can offset at least some diesel consumption when they operate. These resources include wind and solar. Since these resources do not eliminate the need to have adequate diesel generation to serve peak loads with full redundancy, their economic justification is based solely upon the amount of diesel fuel they are able to offset. In many cases, the diesel offset does not provide enough financial benefit to support implementation, although social and environmental goals such as using locally available resources (wind and sunshine), creating local employment and reducing emissions of greenhouse gases (GHGs) and particulates and generator noise may qualify specific resources for external subsidies.

6.1 Economic Considerations

Due to the vast distances, sparse population and lack of local generating resources, developing a reliable and low-cost power system to serve communities and industries in the Northwest Territories is economically and technically challenging. This sparse load situation compounds the problems faced by planners everywhere in creating economically robust plans for power system expansion.

The most readily accessible resource for electric generation in the NWT is hydropower, but developing a power system to more fully utilize this clean and abundant local resource requires establishing a larger core electric grid, and then expanding that system outward to reach additional communities and industrial load centres.

Building new generation sources in order to meet additional industrial demand is very challenging from an energy planning perspective. The timing of industrial developments is driven by market and commodity forces and is usually unpredictable.

Since the NWT is such a large geographic area, new generation sources should be situated in the most optimal location so that they can service a region while keeping transmission costs to a minimum.

This need for both hydroelectric generation and transmission to supply future loads has created a "chicken & egg" situation. Establishing a core grid to provide access to low cost hydroelectric power (see Section 7.2.1 NWT Grid) involves making capital project expenditures that cannot be immediately recovered in the electric tariffs paid by existing NWT customers. However, providing access to low-cost reliable hydroelectric power is effectively a prerequisite to enabling robust regional economic development and related growth of the industrial (e.g. mines), commercial and residential load base required to pay for NWT Grid.

In the absence of an integrated grid system to gather and distribute power from existing and proposed hydroelectric facilities, isolated communities and industrial loads in the NWT will have little option but to continue burning diesel fuel as the primary source of electric power into the indefinite future.

Breaking the cycle of dependence upon imported diesel fuel to power communities and industries in the NWT will necessarily require initial investment by government to overcome the economic barriers to developing NWT Grid and the other non-diesel projects identified in this Power System Plan.

7 Twenty Year Plan

7.1 Introduction

This section looks at Major Projects and Regional Plans over the 20 year planning horizon. The initiatives discussed in this section are:

- Major Projects
  - NWT Grid (Interconnection of Snare and Taltson systems and extending northeast of Yellowknife)
  - Interconnection with Saskatchewan, Alberta and/or British Columbia provincial grids
- Regional Plans for:
  - North Slave Region
  - South Slave Region
  - Dehcho Region
    - Fort Providence - Hay River Interconnection
  - Sahtu Region
  - Beaufort Delta Region

7.2 Major Projects

7.2.1 NWT Grid

7.2.1.1 Description

Developing an NWT Grid would consist of the following two components:

- Connecting the Snare and Taltson Grids via a 240 kV transmission line around the west end of Great Slave Lake (as shown in Figure 16), referred to as the West Slave Transmission Line.
- Extending the NWT Grid Northwest of Yellowknife to a North Slave Transformer Station (as shown in Figure 17) to allow new customers to connect to the grid.

An NWT Grid would be created by interconnecting the existing Snare Grid (located in the North Slave Region) and the Taltson Grid (located in the South Slave Region) and extending the NWT Grid Northeast of Yellowknife to a North Slave Transformer Station located within the North Slave Geological Province.

The preferred routing for a transmission line is around the west end of Great Slave Lake (as shown in Figure 16). The 240 kV transmission line, referred to as the West Slave Transmission Line, would be constructed from the Taltson generating site to the Snare System. The grid would then be extended from the Snare System into the Slave Geological Province (as shown in Figure 18). Additional information on the transmission expansion is available in Section 5.10. Once established, the NWT Grid would expand opportunistically as new industrial loads and generating resources are interconnected to the system. In addition, the grid would be extended outward to reach nearby communities whenever these extensions became practical to implement.

Figure 16 – West Slave Transmission Line (WSTL)

7.2.1.2 Benefits of NWT Grid

Creating a larger interconnected transmission grid will deliver a number of important benefits:

- Improved and more flexible load/resource balance in both long and short term.
- Timely and more economic integration of new loads and generation.
- Facilitate integration of intermittent renewable resources by hydroelectric assets.
- Economic development.
- Reducing environmental impacts.
- Improved reliability due to quicker recovery from power outages.
- The greater system inertia of larger grid is a benefit to industrial customers with synchronous drives/ motors and sensitive process loads.

In addition, access to a larger hydro-based grid provides a lower cost energy resource for new industrial loads and improves the arbitrage opportunities for any future connections to the Alberta and/or Saskatchewan Provincial grids. Creating a robust interconnected grid can be considered critical infrastructure for maintaining and growing a sustainable economy in the Northwest Territories.

7.2.1.3 NWT Grid Challenges & Opportunities

There are a number of challenges and opportunities associated with the creation of the NWT Grid.

Challenges:

- Long regulatory timelines.
- Project financing.
- Distance between existing Snare and Taltson Grids and potential mine customers.
- Challenging terrain and geotechnical conditions.
- Crossing the Mackenzie River.
- Harsh climate and short construction season.

Opportunities:

- Facilitates mining development and extends the service lives of existing and new mines in NWT by providing a cost-effective electric supply solution, thereby reducing mine operating costs.
- Offset or eliminate GHG emissions associated with diesel generation at communities and mines.
- Aboriginal participation in generation projects.
- Enhance economic opportunities of interconnecting with neighbouring jurisdictions.

7.2.1.4 Existing Load/Resource Balance

Creation of the NWT Grid would amalgamate the large hydro generation resources on the existing Snare and Taltson Grids. While the hydro facilities on the Snare Grid have excess energy (water) which is spilled throughout the year whenever Snare Grid loads are too light to utilize available hydraulic energy, they are peak constrained during periods of high demand and must be supplemented with diesel generation. The Taltson Grid has excess hydro capacity and energy, and a significant amount of hydraulic energy is wasted each year in the form of spilled water at the Taltson Facility.

The combined NWT Grid would effectively eliminate the requirement to run diesel generation for peak load duty or as hot standby/reserves, and would offset GHG production and reduce fuel costs. NWT Grid would also be more flexible than separated systems for serving new loads and interconnecting new resources, and the excess energy on the combined system would likely be sufficient to power a new mining load. Additionally, the NWT Grid would have greater frequency stability than the separate Snare and Taltson Grids.

In particular, the proposed Taltson Expansion (discussed below in Section 7.2.1.7) would be more economically viable and beneficial in the context of NWT Grid. Interties with southern jurisdictions would similarly become more feasible and economically beneficial.

The existing resources and loads in the combined NWT Grid are summarized in the tables below.

Table 7 – NWT Grid Resources (Existing)

Resource Type	Capacity (MW)	Avg. Energy per Annum (GWh)
Hydro	55.25	433.1[29]
Diesel	35.9	251.6

Table 8 – NWT Grid Loads (Existing)

Load Type	Capacity (MW)	Avg. Energy per Annum (GWh)
Residential and Commercial	50.6	235.2[30]
Industrial		8.8

7.2.1.5 Requirements for Implementing NWT Grid

Creating NWT Grid will involve a complex process of project funding, approvals and construction. Operational changes will be required once the existing Snare and Taltson Grids are joined together. The benefits are far-reaching. The major steps in the process are:

- Obtain project funding commitment, approvals and licenses
- Construct Snare – Taltson transmission interconnection and extend into the North Slave
- Integrate new industrial customers into the system – via the North Slave Transformer Station (NSTS)
- Coordinate dispatch and operation of Snare and Taltson generation

7.2.1.6 Taltson Snare Interconnection Route

The preferred routing for a transmission line to interconnect the existing Snare and Taltson Grids to create NWT Grid transits around the west end of Great Slave Lake, as shown in Figure 17. A 240 kV transmission line, referred to as the West Slave Transmission Line, would be constructed from the Taltson generating site to Yellowknife. This transmission voltage maximizes the benefits of interconnecting the two grids because a lower-voltage line would be severely capacity constrained over this distance. A shorter line between Hay River and Behchoko, the two closest points on each grid was also considered, but was rejected. Although this shorter project would be relatively economical, it would not create a practical grid interconnection because the terminal sites at Hay River and Behchoko are separated by long & weak transmission lines from the generation and load centers of the Taltson and Snare grids, respectively. The NWT grid would extend northeast of Yellowknife and terminate at a North Slave Transformer Station (NSTS).

In order to span the Mackenzie River, an aerial transmission crossing appears to be the most likely option. Given the linear mass of a 240 kV conductor (approximately 25 kg per meter), this was considered too heavy to span the Dehcho Bridge by conduit or transmission line hanger. Furthermore, ice scour from large ice floes in the Mackenzie River likely make a submarine crossing too costly.

29 The total available energy for the Snare and Taltson hydro system was estimated based on info from the Charrette (Snare) and a firm capacity of 18 MW from Taltson.

30 Source: NTPC General Rate Application 2012/13 and 2013/14," Northwest Territories Power Corporation, Hay River, NT, March 2012. - This value Includes Wholesale and General Service loads.

Figure 17 – NWT Grid

Alternative projects that have been considered to connect the Snare and Taltson Grids are economically prohibitive, technically challenging or unacceptable to communities in the NWT due to current social and environmental concerns.

7.2.1.7 Developments Enabled or Facilitated by NWT Grid

Taltson Expansion

Creation of the NWT Grid would be a prerequisite for economically developing the Taltson Expansion. The Taltson Expansion would nearly triple existing Taltson Hydro capacity by adding 50 MW of new generation. The Taltson Expansion would also enhance the benefits of creating the NWT Grid and would facilitate additional infrastructure and economic development in the Northwest Territories.

The combined NWT Grid resources with the addition of the Taltson Expansion would likely entirely eliminate the present requirement for diesel generation to serve peak loads on the Snare system, and would enable grid interconnection of approximately 60 MW of additional load. This configuration would also allow electricity interchange with Saskatchewan and/or Alberta if the required transmission interties were constructed.

Mine Development and Life Extension

The mining industry is a key economic driver in the NWT. Creation of NWT Grid will provide a lower cost energy resource to facilitate development of new mines and to extend the productive lives of existing mines.

Three mines are currently operating in the North and South Slave Regions and Table 9 contains a summary of existing and proposed mining developments in the NWT. The data is based on the latest information and is subject to change based on future economic conditions.

Table 9 – Existing and Proposed Mines

Facility	Capacity (MW)	In Service Date	Expected Decommission Date / Operating Lifetime
Diavik	27	2003	2023
Ekati	15	1998	2019
Snap Lake	15	2008	2028
Avalon Thor Lake	10	-	22 Years
Gahcho Kue	10	-	12 Years
NICO	15	-	21 Years
Yellowknife Gold	10	-	20 Years

Figure 18 presents an interconnection scenario for the proposed and existing mining projects in the NWT. Note the 240 kV transmission segment from Yellowknife to the mining loads in the region. The network would terminate at the North Slave Transformer Station (NSTS) and new mine customers would be required to build spur lines from their mine sites to connect to the NWT network.

Figure 18 – Mining Development Scenario

Even with the development of the Taltson Expansion, La Martre hydro project, and utilizing energy presently spilled at the existing Snare generation facilities, a capacity shortage within the NWT Grid is likely. The development of Snare Site 7 or an interconnection to southern markets would be required to serve all of the mining loads.

7.2.2 Southern Intertie Options

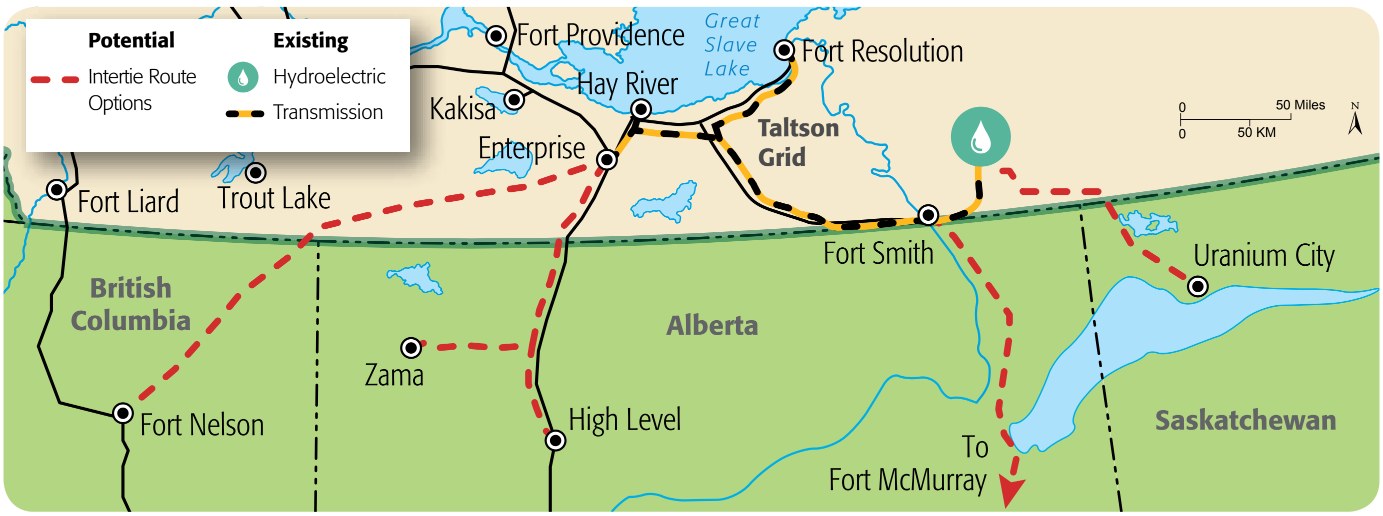
Interconnecting islanded power systems such as the Snare or Taltson Grids with a larger electrical system can deliver significant system benefits, including generation reserve sharing, frequency stability, rapid outage restoration, and the ability to buy and sell power within the NWT and to external markets.

Creation of an NWT Grid cannot be done in isolation and is interdependent with development of a southern intertie in order to maximize the economic potential of creating legacy infrastructure in the NWT. The southern intertie will establish the economic foundation which will facilitate development of an energy marketplace for the NWT.

NWT shares borders with Saskatchewan, Alberta, Yukon and Nunavut. Possible interties to Yukon and Nunavut were dismissed due to the long distances and difficult terrain that must be crossed to implement a Yukon intertie, and because of the long distances and lack of grid infrastructure in Nunavut.

Interties to Saskatchewan, Alberta and British Columbia were therefore evaluated against the cost of interconnection, potential revenues, and transmission system impacts and benefits. Figure 19 below shows a map of possible intertie routes.

Figure 19 – Possible Intertie Route Options



Saskatchewan Intertie

An intertie with Saskatchewan would connect directly from the existing Taltson Hydro plant to Uranium City in Saskatchewan. The northern portion of the Saskatchewan grid is weakly connected to the southern portion of the Saskatchewan power system via a 138 kV line that passes through Manitoba. Northern Saskatchewan is a rapidly growing load area due to mineral extraction developments, and the area is presently underserved by local generation. The provincial utility SaskPower is investigating a number of new power resource developments in the area, but the area may remain generation deficient for an extended period if mine development outpaces generation resource developments.

A Saskatchewan Intertie therefore presents a potential market opportunity for excess Taltson energy, and would provide many of the system benefits associated with connecting to a larger grid, notwithstanding the relative weakness of the Northern Saskatchewan electric system. Saskatchewan does not have an open power market, so any power sales or purchases would have to be negotiated bi-laterally with SaskPower.

In addition, the intertie between Taltson and Uranium City is the shortest possible transmission link to any southern electric system, so the cost aspects of this intertie are the lowest of all those considered in this section.

Alberta Intertie

There are three possible termination points in Alberta for a NWT intertie. In northwest Alberta, connections could be made with the 144 kV ATCO Electric system at either Zama Lake or High Level. In northeast Alberta, a connection could be made at Fort McMurray, or possibly north of Fort McMurray.

Alberta has an open power market, so arbitrage opportunities would exist to buy low and sell high in this market, especially considering the storage and dispatch capabilities of the existing Taltson Hydro and proposed Taltson Expansion projects. Alberta also has an ancillary service market, so services such as spinning reserves, automatic generation control and intermittent renewable firming could be traded in this market. Power can also be purchased through this market as required to serve peak loads, or opportunistically when Alberta prices are low (the Alberta market clears at $0/MWh from time to time when wind generation is high and all loads are being served by must-run or non-dispatchable resources). The system marginal price has cleared at $0/MWh 85 times since 2003, and 68 times since 2010.

The shortest Alberta intertie route would terminate at Zama Lake, and a High Level termination is only slightly longer but quite similar in all other respects. The transmission line route would follow the highway along the Hay River for most of its length, so access for line construction activities would be excellent throughout. This part of the Alberta system is relatively weak, but is adequately robust to support likely maximum interchange volumes with NWT.

The Fort McMurray area is generation self-sufficient and usually transfers net power back into the core Alberta system, so it would represent a very robust terminal for an intertie. However, the intertie transmission line would be long, and would traverse difficult terrain with numerous large lake and river crossings, discontinuous permafrost, and muskeg. There is also no year round access or permanent roads to any area of the intertie route, so construction costs would be high, due to transmission route remoteness, the requirement for all-winter construction, and high transportation costs for construction materials.

It is noteworthy that the Alberta power system continues to expand north of Fort McMurray as new projects are developed. These projects are never expected to advance as far north as the Peace River, but each incremental project extends the Alberta grid closer to Fort Smith, thereby reducing the capital outlay required to interconnect with the Taltson Grid.

Another important ongoing potential development is the proposed 1,300 MW hydroelectric plant on the Slave River near Fort Smith. As older coal thermal generating plants in Alberta approach expected retirement in the early 2020's, it is not certain that they will be replaced with similar coal plants. If the coal plants are retired and not replaced, it will create significant opportunities for new clean power developments.

British Columbia Intertie

An intertie with BC would connect into the Fort Nelson transmission area. Fort Nelson is weakly connected to the Alberta Interconnected Electrical System (AIES) via a long 138 kV transmission line, with most of the Fort Nelson area load presently served by local natural gas generation. Shale gas extraction developments in the Fort Nelson area are driving expansion of the local electric system, but to date this area has not been directly connected with the main BC Hydro system. Because of these limitations, an intertie with this area would provide minimal operational benefits to the NWT. Power interchange would be technically restricted due to the relative weakness of the Fort Nelson system, and all purchases and sales would likely flow through BC Hydro's marketing affiliate Powerex, thus making profitable energy arbitrage or ancillary service marketing difficult to achieve.

It is possible that this situation will evolve if Fort Nelson area loads and generation grow significantly and the transmission system extends closer to the BC/NWT border, or if BC Hydro constructs a connector between its main system and the Fort Nelson area.

Southern Intertie – Summary

Of the three provinces adjacent to the NWT, Saskatchewan and Alberta provide the best opportunities for interties. An intertie with Saskatchewan is the lowest cost and most immediately feasible option, although negotiations with SaskPower would be necessary to confirm the opportunity to establish a bilateral power purchase agreement. An intertie into either northwest or northeast Alberta would be more costly (unless the Slave Hydro project is developed), but would provide the opportunity to participate in an open market for energy and ancillary services. An intertie with British Columbia is not presently economically or technically compelling, although that situation could change as the electric system in northeast BC develops.

7.3 North Slave Region

The major NTPSP components that will affect the North Slave Region and Lutsel K'e are addressed in the NWT Grid and Southern Intertie sections above. As mentioned above and in Appendix A, mining activity is a catalyst for the development of new generation sources in these regions.

Four non-grid communities in the North Slave Region is likely to remain unconnected to NWT Grid over the 20-year planning horizon:

- Gamètì (North Slave)
- Lutsel K'e (South Slave)
- Wekweètì (North Slave)

As can be seen in Figure 20, access to these communities is a challenge as none have year-round road access and Wekweètì and Lutsel K'e don't have any road access.

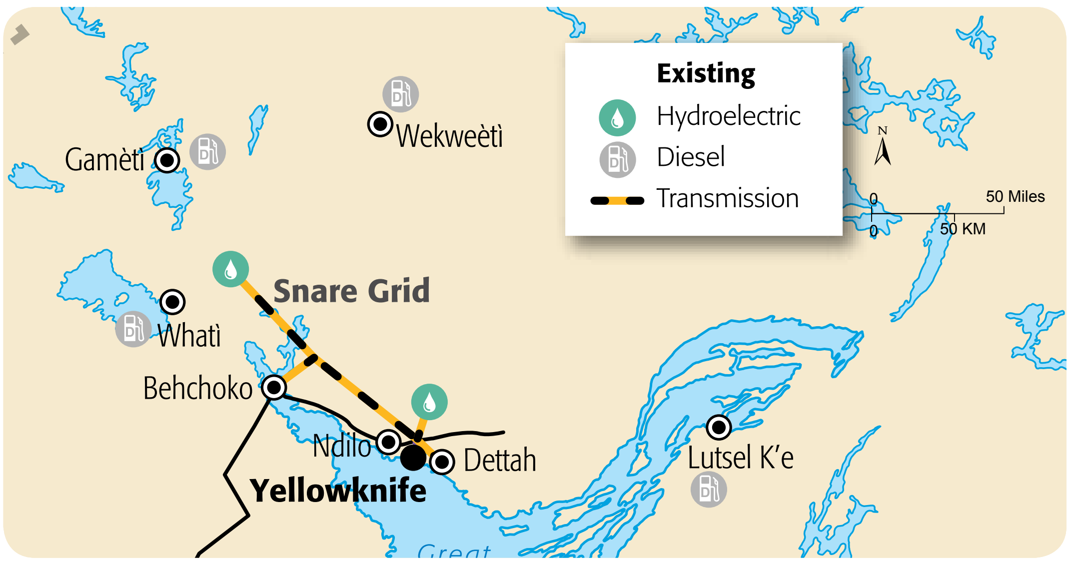
Figure 20 – Existing Electrical Infrastructure in non-Grid Communities of the North Slave Region

The resource options evaluated for these communities were:

1) Snare Grid expansion

2) Non-Diesel Firm Power Options

3) Renewable Resources for Diesel Offset



Snare Grid Expansion

The small size of electrical load in these communities and the distance to the Snare Grid (Taltson Grid for Lutsel K'e) make extending transmission lines to them economically challenging. The best prospect is Whatì, which has the largest load and is closest to the Snare Grid. Building a transmission line to Whatì would provide the best opportunity to connect a diesel community to hydropower in over 40 years. This project may proceed in the 2014-15 timeframe. The other communities require greater subsidies for smaller loads.

Non-Diesel Firm Power Options

Firm dispatchable resource options which could displace diesel include LNG and biomass, but the challenges of transportation and fuel storage render these unfeasible for most remote communities.

The prospects for road connected communities in the North Slave relying on LNG merit further study, particularly as part of a solution that facilitates the timely supply of energy to large mine loads such as Nico and Avalon. A single, road connected LNG plant to serve communities and industry may provide the best opportunity to integrate LNG in the North Slave.

A centralized LNG plant in the Yellowknife area could provide a lower cost fuel and lower GHG emissions than the diesel base case, when a suitable customer base materializes. A LNG plant would add operational stability to the Snare system, residual heat to the City of Yellowknife and energy to the larger grid expansion system. LNG generation could also be considered for replacement of the diesel units as the Jackfish Plant continues to age or should rapid load growth occur. Construction timelines should also be relatively short, likely in the two year timeframe.

A LNG Plant would improve system reliability and redundancy needed to add new customers to the Snare system and provide long term benefits to the continental grid. The LNG plant would provide the necessary back-up to NWT loads during outages or planned maintenance to the transmission system. Load growth that is met by LNG will allow NTPC to optimize the use of the excess hydro power, on the Snare system that is seasonally available today. Additionally, as the cost of power on the continental system exceeds the marginal cost of power production from a LNG plant, it would be called into service for those periods and produce revenues that would benefit all rate payers of the NWT.

Centralized LNG generation and transmission expansion is therefore an attractive option for any potential customers that could be added to the Snare system and would complement the larger NWT grid expansion objectives.

North Slave Region – Firm

North Slave Region – Firm Power Options				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
Evaluate the Potential to Build an LNG Plant in the Yellowknife Area to provide additional generation, residual heat, operational stability to the Snare System and complement the NWT grid expansion objectives.	**POSITIVE** *Lower fuel cost*	**HIGH** *Proven technology*	**MEDIUM** *Moderate GHG's and low air pollution*	**POOR** *Imported fuel*

Renewable Resources for Diesel Offset

Since these communities will not directly benefit from the hydropower resources available on NWT Grid, alternative technologies may be considered to reduce the GHG and particulate emissions from the diesel generation currently serving these communities. The renewable resources available to offset diesel include solar, wind, and small hydro.

An analysis of potential solar, wind and small hydro generation implementation was conducted by NT Energy[31]. Unfortunately subsidies are required for all generation options. Table 10 shows the diesel displaced and the subsidy required to implement solar, wind and hydro in the four communities.

Table 10 – Low Emission Technology Subsidy Evaluation

		Solar	Wind	Hydro
Gamètì	**Subsidy Per Lifetime kWh**	$0.21		$0.35
	Diesel Displaced	2.23%		100%
Lutsel K'e	**Subsidy Per Lifetime kWh**	$0.18	$0.18	$0.38
	Diesel Displaced	2.71%	19.07%	100%
Wekweètì	**Subsidy Per Lifetime kWh**	$0.22		
	Diesel Displaced	2.64%		
Whatì	**Subsidy Per Lifetime kWh**	$0.18	$0.60	$0.06
	Diesel Displaced	2.44%	6.41%	95%

The Solar Energy Strategy promotes the use of solar energy technology to reduce consumption and reliance on fossil fuels for electricity generation. The North and South Slave Regions have the best relative potential for solar generation in the Northwest Territories[32]. However, subsidies are required to break even with continued diesel operation.

The wind profile in the North and South Slave regions is relatively modest compared to other NWT regions. Potential wind generation analysis was conducted for Lutsel K'e and Whatì. While the subsidy required to implement wind generation in Whatì is unfeasibly high, wind remains an option for future consideration in Lutsel K'e if a large subsidy can be secured.

Small hydro generation was investigated in three of the communities, with the lowest subsidy required for the community of Whatì.

31 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012.

32 Source: "Community Analysis Generation Index", NT Energy, Yellowknife, NT, December 2012.

North Slave Regions – Options For Diesel Offset				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
Extend Snare Grid to Whatì	**NEGATIVE** *Requires Subsidy*	**HIGH** *Proven technology*	**HIGH** *Offsets diesel*	**HIGH** *Reliable; econ. growth*
To meet GNWT Solar Energy Strategy install solar in communities to achieve target of 20% of average load.	**NEGATIVE** *Requires Subsidy*	**MEDIUM** *Intermittent, seasonally poor*	**HIGH** *Lower GHGs than diesel*	**HIGH** *Renewable; self-sufficiency*

North Slave Isolated Communities Next Steps

None of the options evaluated for the four isolated communities can proceed without subsidies to break even with the cost of continued diesel operation. Diesel generation has been used to this point and it makes sense to continue using Diesel until transportation and fuel storage issues can be solved for LNG and/or biomass, or the cost of renewables such as solar, wind and small hydro come down.

A centralized LNG plant in the Yellowknife area that could rely on existing diesel storage and minimal LNG storage does have the potential to provide lower cost fuel, GHG emission reductions, and residual heat provided that there is a sufficient customer base to warrant an investment in new generation. This would have to include one or more industrial customers in the North Slave region linking into the Snare grid. Table 11 summarizes these findings and Figure 21 shows the existing system with the possible additions.

Table 11 – North Slave Region – Options to Pursue

Recommended Option	Action	Community
Snare Grid Expansion	Extend Snare Grid to Whatì	Whatì
Centralized LNG Plant and transmission spurs to new industrial customers	Feasibility study to examine business case for LNG plant	Yellowknife
Intermittent – Diesel Offset	To meet GNWT Solar Energy Strategy install solar in communities to achieve target of 20% of average load.	Gamètì Lutsel K'e Whatì Wekweètì

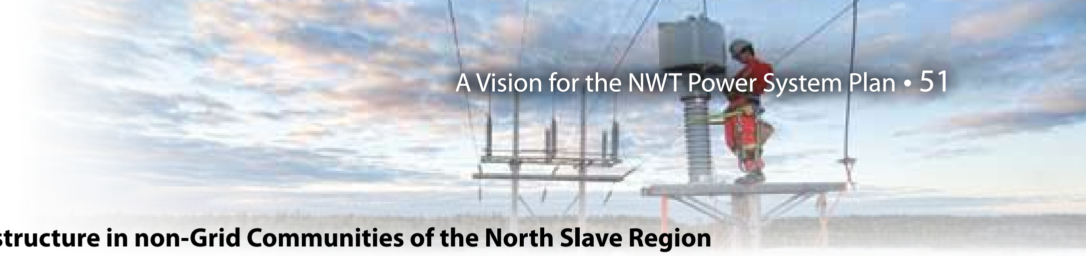
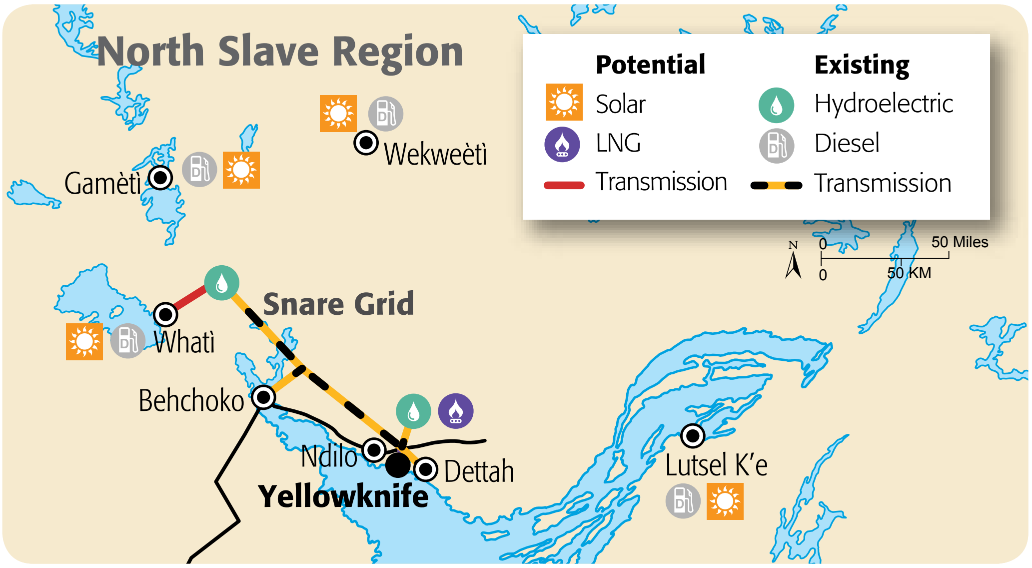


Figure 21 – Possible Electrical Infrastructure in non-Grid Communities of the North Slave Region



7.4 Dehcho Region

Figure 22 shows the existing electrical infrastructure in the Dehcho Region. The communities of Hay River and Enterprise are presently connected to the Taltson Grid. Most of the other communities in the Dehcho Region are located hundreds of kilometers from the Taltson Grid, and all are presently served by community diesel generation (there is a 104kW solar installation at Fort Simpson).

Figure 22 – Existing Electrical Infrastructure in the Dehcho Region

Electric loads in the region are not growing rapidly, and in most cases existing generation capacity in each community will be adequate over the planning horizon. Therefore new resources will only be needed as existing diesel plants reach end of life, or as required to achieve diesel fuel offsets and other non-power related goals. The resource options evaluated for the Dehcho region are as follows:

1) Taltson Grid Expansion

2) Non-Diesel Firm Power Options

3) Renewable Resources For Diesel Offset

Taltson Grid Expansion

Several stages of Taltson grid expansion were evaluated:

- Hay River to Fort Providence via Kakisa
- Fort Providence to Fort Simpson via Jean Marie River
- Interconnecting the remaining Dehcho communities to an expanded Taltson grid.

After evaluating these transmission options (see Table 3) it is apparent that a significant subsidy is needed to extend the Taltson Grid to Fort Providence via Kakisa, and then on to Fort Simpson via Jean Marie River. This evaluation is based upon constructing a new 72 kV transmission extension from Hay River to Kakisa Junction, and a 25 kV line from that point to Fort Providence. The benefits of grid expansion are far reaching and significant but should be considered in the same light as other public infrastructure projects like a public highway. These are necessary to lower the cost of living in communities and regions and grow our economy over time.

Table 12 – Low Emission Technology Subsidy Evaluation

Community	Subsidy Required for $0 NPV (8% Discount Rate)
Fort Simpson via Fort Providence	$96 M
Fort Providence via Kakisa	$13 M

Note: The costs for the transmission line to Fort Providence via Kakisa are based on a 2009 study by Northland Utilities. This transmission line is currently in the preliminary design phase, and the estimated cost should be revised after more detailed study.

Dehcho Region – Taltson Grid Expansion				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
Grid Expansion -Pursue extension from Taltson Grid to Fort Providence via Kakisa	**NEGATIVE** *Subsidy required*	**HIGH**	**HIGH** *No GHGs*	**HIGH** *Good Reliability*
Grid Expansion - Pursue extension from Taltson Grid to Fort Simpson via Fort Providence	**NEGATIVE** *Subsidy required*	**HIGH**	**HIGH** *No GHGs*	**HIGH** *Good Reliability*

Transmission expansion to the other Dehcho Region communities is uneconomic due to the high costs associated with the long transmission distances, and the minimal economic benefits from diesel offset.

Note that the nature of the Taltson Grid expansion to Fort Providence and Fort Simpson would change if the 240 kV West Slave Transmission Line is built between the Snare and Taltson Grids to create NWT Grid. Although the 72/25 kV and 240 kV lines are not necessarily mutually exclusive, the 240 kV West Slave Transmission Line facilities would be fully capable of supplying the intermediate load centres.

It should be noted however that the cost of substations needed to step down voltage from 240 kV to an intermediate transmission voltage and then again to the local supply voltages at Fort Providence (and ultimately Fort Simpson), would probably equal or even exceed the cost of extending the 72 kV grid from Hay River.

Non-Diesel Firm Power Options

Diesel remains the most economically viable firm generation resource for isolated communities that cannot be feasibly connected to the Taltson Grid. Of the non-diesel firm generation options evaluated for these communities, LNG is the most economically attractive diesel fuel displacement option. Since using LNG as a generation fuel is less expensive and more easily implemented than biomass, it is the most favourable non-diesel firm power option for communities with all season road access to support regular year round trucking of imported LNG (i.e.: Wrigley, Fort Simpson, Jean Marie River, Fort Liard).

Biomass could remain an option for the seasonal road access communities of Trout Lake and Nahanni Butte (although not economically attractive), but the extra costs associated with stockpiling fuel for an entire year during the winter road trucking season make this option unattractive. As a result, it is recommended that Trout Lake and Nahanni Butte remain with diesel as their primary firm power resource.

According to the Geothermal Favourability Report[33] issued by the Government of the Northwest Territories, the Dehcho and South Slave Regions appear to have the greatest geothermal potential in the NWT. However, the estimated costs of geothermal resource development for Fort Liard show that it is not an economic resource option for this community without subsidy, and by extension not likely economic in other communities with less favourable geothermal potential.

Dehcho Region – Firm Power Options				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
LNG	**POSITIVE** *Lower fuel cost*	**HIGH**	**MEDIUM** *Moderate GHGs and Low Air Pollution*	**POOR** *Imported fuel*

33 Source: "*Geothermal Favourability Map*," EBA Engineering Consultants Ltd., April 2010.

Options for Diesel Offset

Since all the Dehcho communities except Trout Lake & Nahanni Butte already have diesel displacement options, these two remaining communities remain potential candidates for diesel offset projects. None of the diesel offset options (solar, wind, & site specific small hydro) identified in this plan are less expensive than continuing to use diesel generation, so any diesel offset projects would require a subsidy. Solar is the most feasible diesel offset option. The communities of Jean Marie River, Nahanni Butte and Trout Lake are potential candidates for solar hybrid projects.

Dehcho Region – Diesel Offset Options				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
Solar	**NEGATIVE** *Subsidy required*	**MED** *Intermittent, seasonally poor*	**HIGH** *No GHGs*	**POSITIVE** *Renewable, Self-sufficiency*

Dehcho Recommended Actions

Table 13 summarizes the recommended actions for each Dehcho isolated community.

Table 13 – Dehcho Region – Options to Pursue

Recommended Option	Action	Community
Grid Expansion –Taltson to Fort Providence via Kakisa	Extend line from Taltson system to Fort Providence via Kakisa.	Fort Providence Kakisa
Grid Expansion –Taltson to Fort Simpson via Fort Providence	Extend line from Taltson system to Fort Simpson via Fort Providence.	Fort Simpson Jean Marie River
Firm Power "bi-fuel conversion"– LNG study	Investigate the potential to modify existing diesel plants to burn up to 70% LNG.	Wrigley Fort Simpson Jean Marie River Fort Liard
Intermittent – Diesel Offset	Investigate installation of solar under the GNWT solar initiative.	Trout Lake Nahanni Butte Fort Providence Kakisa

Figure 23 shows the existing system with the planned additions.

Figure 23 – Possible Electrical Infrastructure in the Dehcho Region

7.5 Sahtu Region

The five permanent communities of the Sahtu Region are located far from the existing Snare and Taltson Grids as shown in Figure 24. All the communities except Norman Wells are served with diesel generation and there is no year round road access to any of these communities. Norman Wells is served with electricity generated from natural gas produced at the Imperial Oil Resources Limited (IORL) oil stabilization facilities. The natural gas supplies at this site are projected to last for the 20 year planning horizon[34].

34 Source: "*Energetic Model for the Town of Norman Wells*," Nexx Energy. Available: http://www.nexxenergie.com/pdf/en/7.pdf

Figure 24 – Existing Electrical Infrastructure in the Sahtu Region

The main resource options evaluated for the Sahtu region are as follows:

1) Regional Transmission Grid

2) Non-Diesel Firm Power Options

3) Options for Diesel Offset

Regional Transmission Grid

The communities of the Sahtu region are located in excess of 600 km from Snare and Taltson Grids, which is too great a distance to be able to build technically or economically feasible transmission connections without much larger loads. A connection would not make sense in any case because the loads required to make the connection feasible would exceed the available surplus energy on the existing systems and require the construction of new hydro resources.

Transmission interconnections between communities in the Sahtu region are similarly uneconomic because the long distances between relatively small communities do not provide sufficient benefits to offset the cost of transmission.

As discussed in Appendix B, Petroleum exploration activities in the region may ultimately lead to development of significant additional resource extraction facilities and associated electric loads. Depending upon the scale of these facilities and the presence or absence of natural gas as a by-product of production to enable on-site generation, additional firm power supplies may be required in the region. It may prove economical to create electric distribution or even transmission infrastructure to link production facilities to centralized power generation if the required lines are not extremely long.

Ultimately, if these petroleum exploration developments lead to significant load growth without producing commensurate volumes of natural gas to use as a generation fuel, it may become feasible to consider interconnecting one or more production fields to a hydro generation project on the Great Bear River. Given the enormous scale and cost of even the smallest possible Great Bear River hydro project, a very large and long life load cluster would be required to justify the investment. It is unlikely that this situation will occur over the planning horizon, but the concept should be revisited as circumstances change.

Non-Diesel Firm Power Options

The Great Bear River has tremendous hydropower potential, but at a scale too large for the current system without new industrial development on a large scale. Deline has identified mini-hydro project nearby, but requires a subsidy to match diesel prices. Further feasibility work is proposed in 2014-15 to evaluate the potential of a run of river mini-hydro project to meet community needs.

LNG cannot be reliably shipped year round thus creating storage issues during the freeze-up and thawing periods of the year when neither barging nor winter roads are available. This is compounded by the fact that both propane and diesel storage are considerably less costly than LNG. LNG will likely remain uncompetitive with diesel until either transportation linkages improve or LNG storage costs come down considerably. Therefore, local sources of natural gas that prove economically viable may present the best opportunity for Sahtu communities to rely on natural gas.

Sahtu Region – Firm Power Options				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
Continue feasibility study of mini-hydro on the Bear River.	**NEGATIVE** *Requires a subsidy*	**HIGH** *Proven technology*	**HIGH** *Lower GHGs than diesel*	**HIGH** *Renewable; self-sufficiency*

Options for Diesel Offset

Solar installations sized to achieve the Solar Energy Strategy target of 20% of average load could be considered for all communities in this region. While subsidies are required to break even with diesel, they are lower in the Sahtu region than the average required solar subsidy for the NWT.

The Sahtu Region will be the first region to demonstrate the deployment of a utility-scale hybrid solar PV system. Construction is scheduled for the summer of 2014 in Colville Lake. The demonstration project will test the benefits of a hybrid system that will integrate a 50 kw solar PV array with a newly planned diesel/battery plant. Feasibility studies completed to date indicate that a hybrid system is capable of not only improving system reliability but is also capable of allowing the diesel engines to be shut down for extended periods of the day during the summer. A hybrid system installation of this nature is the first of its kind for the NWT. If the approach proves successful it will be an option for other thermal communities in the NWT to consider.

The wind resource at Norman Wells is strong at an average 6.3 m/s, producing a diesel break-even subsidy lower than solar, although Norman Wells is primarily natural gas powered. A site assessment is needed to identify the best location for a wind monitoring station that would be suitable for a turbine. The wind resource at Deline is too poor to support an economically viable project.

Sahtu Region – Options For Diesel Offset				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
Solar installations for all communities to achieve Solar Energy Strategy target of 20% of average load.	**NEGATIVE** *Requires a subsidy for diesel offsets*	**MEDIUM** *Intermittent, seasonally poor*	**HIGH** *Lower GHGs than diesel*	**HIGH** *Renewable; self-sufficiency*
Feasibility of Wind Installation in Norman Wells	**NEGATIVE** *subsidy for diesel offsets*	**MEDIUM** *Intermittent*	**HIGH** *Lower GHG's than diesel*	**HIGH** *Renewable; self-sufficiency*

Sahtu Recommended Next Steps

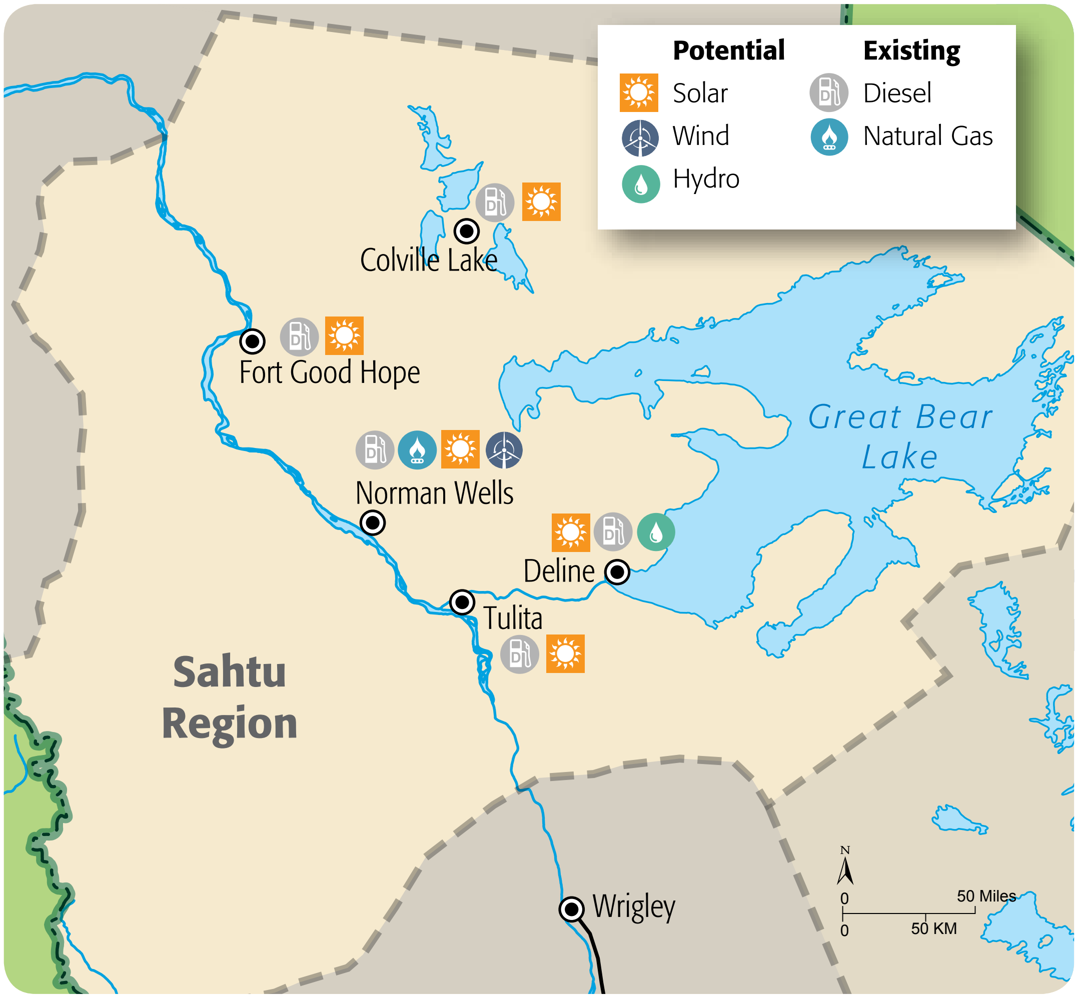
Table 14 summarizes the actions and communities affected by the recommended options.

Table 14 – Sahtu Region – Options to Pursue

Recommended Option	Action	Community
Firm Power – mini-hydro on the Bear River	Continue feasibility study on the Bear River	Deline
Intermittent – Diesel Offset	Site specific feasibility study of wind project	Norman Wells
Intermittent – Diesel Offset	Solar installations for all communities to achieve Solar Energy Strategy target of 20% of average load.	Colville Lake Fort Good Hope Norman Wells Tulita Deline

Figure 25 shows the existing system with the planned additions.

Figure 25 – Possible Electrical Infrastructure in the Sahtu Region

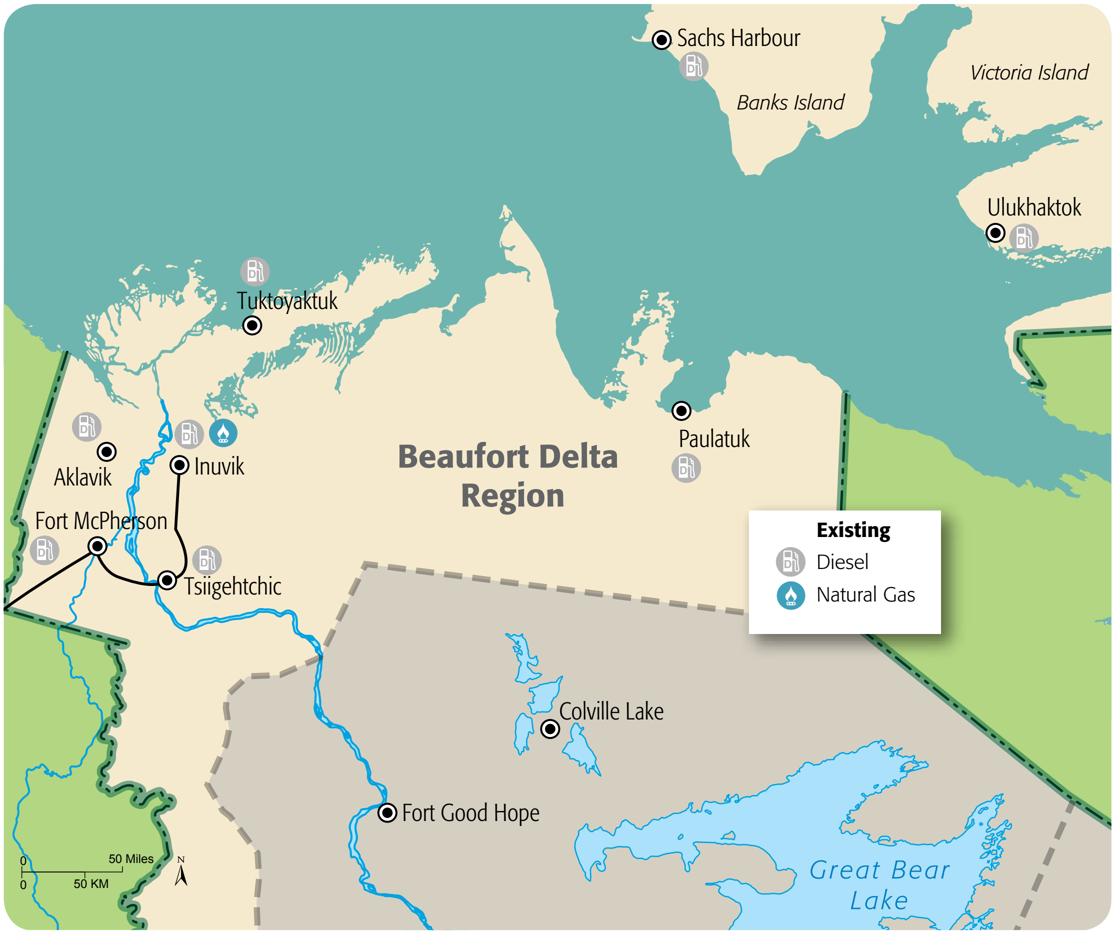


7.6 Beaufort Delta Region

As can be seen in Figure 26, the eight communities of the Beaufort Delta region are isolated and remote. All the communities except Inuvik are served with diesel generation. Inuvik has had natural gas generation, but the local natural gas supply will run out prior to 2015, the LNG Plant will rely on a mix of up to 80% natural gas and 20% diesel once the supply chain is fully functional.

The vast distances between communities in the Beaufort Delta region preclude the consideration of electrical connections between communities, and it would not be economically feasible to connect them with each other and even less feasible to consider a connection to either of the existing Taltson or Snare Grids.

Figure 26 – Existing Electrical Infrastructure in the Beaufort Delta Region



The main resource options evaluated for the Beaufort Delta Region are as follows:

1) Regional Transmission Grid

2) Non-Diesel Firm Power Options

3) Options for Diesel Offset

Regional Transmission Grid

As can be seen in Figure 26, the eight communities of the Beaufort Delta region have no existing or nearby transmission infrastructure to join together. The nearest transmission infrastructure is the Snare and Taltson grids to the distant south. As a result, the comparatively small community loads and large distances between communities preclude interconnecting any transmission infrastructure between communities or to neighbouring regions.

Firm Power Options

Because road access to Fort McPherson, Inuvik and Tsiigehtchic is reliable for most of the year except during spring break-up when neither ferries nor winter roads are available, LNG can be reliably shipped to these communities. The issues of temporarily unavailable road access can be overcome with suitable, but more costly, LNG storage design, but it is more cost effective to rely on diesel back-up and diesel storage. Should the planned all-season road to Tuktoyaktuk be built, LNG could be feasible there as well. The LNG project currently being completed in Inuvik will help determine if LNG electricity generation is economically feasible for other road connected thermal communities. Community specific analysis of LNG viability for Fort McPherson, Tuktoyaktuk and Tsiigehtchic should be considered as the LNG supply chain is proved out for Inuvik. Given the small size of these communities it will be necessary to explore options for minimizing the LNG containment, storage and vaporization costs.

Beaufort Delta Region – Firm Power Options

Recommended Option	Economic Impacts	Technical Viability	Environmental Performance	Social Impacts
Evaluate results of LNG electricity generation project in Inuvik.	**POSITIVE** *Lower cost fuel*	**HIGH** *Proven technology*	**MEDIUM** *Lower GHGs than diesel*	**LOW** *Imported Fuel*
Community specific LNG feasibility studies for Fort McPherson, Tsiigehtchic and Tuktoyaktuk.	**NIL** *Cost basis will be determined by study*	**HIGH** *Proven technology*	**MEDIUM** *Lower GHGs than diesel*	**LOW** *Imported Fuel*

Options for Diesel Offset

The wind resource is excellent at Paulatuk, Sachs Harbour and Ulukhaktok, but additional data is needed to confirm wind potential at Storm Hills near Inuvik. Even though all of these communities would require a subsidy to allow the projects to break even with diesel, the wind subsidy is lower than the subsidy required for solar, except at Paulatuk. The wind subsidy would be much lower than the solar subsidy for an installation in Inuvik.

Site-specific wind monitoring and feasibility studies should be considered for Paulatuk, Tuktoyaktuk, Sachs Harbour, and Ulukhaktok to complement the ongoing monitoring at Inuvik. The ongoing monitoring at Inuvik could lead to a 1 -2 MW wind project in the 2014/15 timeframe.

If the funding is not available for wind study, then to meet the GNWT Solar Energy Strategy install solar sized to achieve the target of 20% of average load could be considered for Aklavik, Tuktoyaktuk, Paulatuk, Sachs Harbour and Ulukhaktok. This will offset diesel usage, although significant subsidies will be required to implement.

Beaufort Delta Region – Options For Diesel Offset				
Recommended Option	**Economic Impacts**	**Technical Viability**	**Environmental Performance**	**Social Impacts**
Continued wind study in Inuvik, and initiate wind studies for Paulatuk, Tuktoyaktuk, Sachs Harbour and Ulukhaktok.	**NEGATIVE** *Requires Subsidy*	**MEDIUM** *Intermittent*	**HIGH** *Lower GHGs than diesel*	**HIGH** *Renewable; self-sufficiency*
To meet GNWT Solar Energy Strategy install solar in communities to achieve target of 20% of average load.	**NEGATIVE** *Requires Subsidy*	**MEDIUM** *Intermittent, seasonally poor*	**HIGH** *Lower GHGs than diesel*	**HIGH** *Renewable; self-sufficiency*

Beaufort Delta Region Recommended Next Steps

Table 15 summarizes the actions and communities affected by the recommended options.

Table 15 – Beaufort Delta Region – Options to Pursue

Recommended Option	Action	Community
Firm Power – LNG implementation	Evaluate implementation of LNG electricity generation for Inuvik project.	Inuvik
Firm Power – LNG study	Investigate LNG as alternative to firm power provided by diesel.	Fort McPherson Tsiigehtchic Tuktoyaktuk
Intermittent – Diesel Offset	Continue wind study in Inuvik, wind studies for Tuktoyaktuk, Sachs Harbour and Ulukhaktok.	Inuvik Paulatuk Sachs Harbour Tuktoyaktuk Ulukhaktok
Intermittent – Diesel Offset	To meet GNWT Solar Energy Strategy install solar in communities to achieve target of 20% of average load.	Aklavik Paulatuk Sachs Harbour Tuktoyaktuk Ulukhaktok

Figure 27 shows the existing system with the planned and possible additions.

Figure 27 – Possible Electrical Infrastructure in the Beaufort Delta Region

7.7 Plan Summary

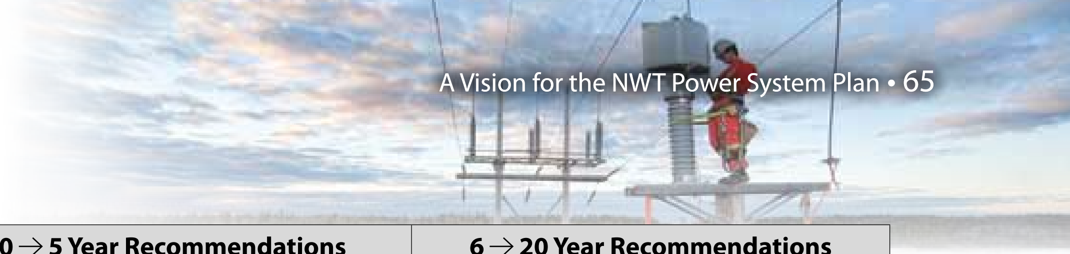
The purpose of the 2013 NTPSP is to provide a vision for electrical power development in the NWT for the next twenty years. The objectives of the plan are:

- Improving electrical affordability for NWT citizens
- Ensuring reliable electrical supply for NWT citizens
- Reducing environmental impacts
- Enabling economic development and job creation
- Achieving NWT energy self-sufficiency
- Elevating the priority of community and aboriginal initiatives

To meet the above objectives, the NTPSP makes a series of recommendations are as presented in Table 16 (including both 0→5 year recommendations and 6→20 year recommendations).

Table 16 – Summary of NTPSP Recommendations

Category	0→5 Year Recommendations	6→20 Year Recommendations
Creating an NWT Grid	▪ Pre-feasibility work for Snare Grid and Taltson Grid interconnection ▪ Secure commitment for funding	▪ Design and construction of a Snare Grid and Taltson Grid Interconnection ▪ Expansion of NWT grid to support economic development
Pursue an Intertie with Saskatchewan and Alberta	▪ Initiate discussions with SaskPower to confirm opportunity for a Power Purchase Agreement	▪ Construct interconnection between NWT Grid and SaskPower Grid ▪ *ALTERNATIVE*: Construct interconnection with Alberta
Undertaking Regional Initiatives: Regional Grid Expansion	▪ Pursue extension from Snare Grid to Whatì ▪ Pursue extension from Taltson Grid to Fort Providence via Kakisa	▪ Extend Taltson Grid to Fort Simpson via Jean Marie River
Undertaking Regional Initiatives: Firm Power Options for Replacing Diesel	▪ LNG Implementation Study and pilot project for Inuvik ▪ LNG Feasibility Studies: o Fort Simpson (Dehcho) o Fort McPherson (Beaufort Delta) o Yellowknife (North Slave)	▪ Additional LNG Feasibility Studies: o Fort Liard (Dehcho) o Jean Marie River (Dehcho) o Wrigley (Dehcho) o Tsiigehtchic (Beaufort Delta) o Tuktoyaktuk (Beaufort Delta)



Category	0 → 5 Year Recommendations	6 → 20 Year Recommendations
Undertaking Regional Initiatives: Intermittent Power Options for Offsetting Diesel	▪ Continue to collect data, design work, and costing work for Storm Hills Wind Project ▪ Achieve the installation of photovoltaic generation in five communities ▪ Feasibility work for solar installations in: o Colville Lake (Sahtu) o Jean Marie River (Dehcho) o Lutsel K'e (South Slave) o Nahanni Butte (Dehcho)	▪ Additional wind feasibility studies: o Paulatuk (Beaufort Delta) o Sachs Harbour (Beaufort Delta) o Tuktoyaktuk (Beaufort Delta) o Ulukhaktok (Beaufort Delta) ▪ Continue to add solar installations as per GNWT Solar Energy Strategy (to achieve 20% of average load). Potential communities include: o Gamètì (North Slave) o Whatì (North Slave) o Wekweètì (North Slave) o Fort Providence (Dehcho) o Kakisa (Dehcho) o Trout Lake (Dehcho) o Fort Simpson (Dehcho) o Fort Good Hope (Sahtu) o Norman Wells (Sahtu) o Tulita (Sahtu) o Deline (Sahtu) o Aklavik (Beaufort Delta) o Paulatuk (Beaufort Delta) o Sachs Harbour (Beaufort Delta) o Tuktoyaktuk (Beaufort Delta) o Ulukhaktok (Beaufort Delta)

Appendix A: Mining Market Assessment and Case Study

The NWT is expected to see a period of economic growth, fuelled by increased mining activity in the North Slave region. The electrical demand that such projects will have for grid electricity represents an opportunity to expand the NWT transmission system. The Snare/Bluefish and Taltson hydro plants were built to serve mines, and these legacy assets now generate 75% of the power consumed in the NWT (excluding mines with self-generation).

Currently, mine operations are powered by onsite diesel-fueled generation with no expectation of legacy assets remaining after mining operations cease because the 15 year operating life of an average mine is short compared to the normal expected life 40+ years for hydropower plants and transmission lines. This mining case study explores the possibility of energizing new mines with generation assets that will remain in operation as legacy assets after mine operations cease. Benefits include reduced mine operations costs, new customers for NTPC, and legacy power system assets which can reduce long term electricity supply costs in the NWT. Challenges include economic, scheduling, regulatory and environmental hurdles.

1 Mining Market Conditions & Analysis

1.1 Operating Mines

None of the mines in operation today are connected to a transmission grid, and all are forecast to be closed in the next 15 years. Table 1 lists the mines currently operating in the NWT along with their expected closure date.

Table 1 – Operating Mines in the Northwest Territories

Operating							
Developer	**Project**	**Commodity**	**Region**[1]	**Phase**	**Estimated Closure Date**	**Regulatory Status**	**Load (MW)**
[2]BHP Billiton	Ekati Diamond Mine	Diamond	North Slave	Operating Mine	2019	Permitted	
Diavik Diamond Mines	Diavik Diamond Mine	Diamond	North Slave	Operating Mine	2023	Permitted	27
DeBeers	Snap Lake Diamond Mine	Diamond	North Slave	Operating Mine	2028	Permitted	15
North American Tungsten	Cantung Mine	Tungsten	Dehcho	Operating Mine/Closure	2014	Permitted	4

1.2 Proposed Mines

A number of mines are currently under development in the NWT. Table 2 below lists mines that meet the following criteria:

- Either at or beyond the advanced exploration stage
- Into the environmental review process
- Have a reasonable likelihood of reaching operating status

1 Please see the map in Section 3 showing the regions of the NWT.
2 BHP Billiton sold its 80% stake in Ekati to the Dominion Diamond Corporation in April 2013.

Table 2 – Proposed Mines in the Northwest Territories

Proposed								
Developer	**Project**	**Commodity**	**Region[3]**	**Phase[4]**	**Estimated Open Date**	**Estimated Closure Date**	**Regulatory Status[5]**	**Load (MW)**
Seabridge	Courageous Lake	Gold	North Slave	Advanced Exploration	Unknown	Unknown	Permitted	45
Tamerlane	Pine Point	Lead, Zinc	South Slave	Advanced Exploration	2013	2.5 years after open	Permitted	6
Diamond North Resources (Snowfield)	Drybones Bay	Diamond	North Slave	Advanced Exploration	Unknown	Unknown	Permitted	Unknown
Canadian Zinc	Prairie Creek	Lead, Zinc Silver	Dehcho	Mine Development	2013	14 years after open	EA – Completed	5
Fortune Minerals	Nico	Gold, Cobalt, Bismuth, Copper	North Slave	Mine Development	2014	15 years after open	EA – awaiting ministers decision	18
De Beers	Gatcho Kue	Diamond	South Slave	Mine Development	2013	15 years after open	EIR – Public Hearings Completed	10
Avalon Resources	Nechalacho (Thor Lake)	Rare Earth	North Slave	Mine Development	2013	14 years after open	EA - Public Hearings	10
	Nechalacho (Pine Point)		South Slave	Processing Plant	2013			22
Tyhee	Yellowknife Gold	Gold	North Slave	Mine Development	2013	8 years after open	EA - DAR submitted	10

New mines provide the best opportunity for connecting to and expanding the NWT transmission system because new mines have not already committed the capital needed to build the infrastructure to self-supply their electrical needs. Therefore, the competitor to connecting a mine to the NWT transmission system is the capital cost of installing new diesel generation plus the ongoing cost savings associated with lower priced transmission grid energy over the operating life of the mine.

Once mine infrastructure is built, the capital required to build a transmission line between the NWT grid and a mine must be justified purely on the ongoing operational savings of lower priced grid-power versus diesel-generated power.

Besides pure economics, another challenge for connecting new mines to the grid is coordinating the commitments of both the mine and the transmission line proponents. Both the mine and transmission line are long lead time projects with technical, permitting and financing complexities that often cannot be synchronized to the point that the involved parties commit to the necessary capital investment at the same time.

3 Please see the map in Section 3 showing the regions of the NWT.
4 In the process of a starting a mine, Mine Development comes after Advanced Exploration.
5 In the environmental review process, some of the main steps are Preliminary screening; Terms of Reference; Developer's Assessment Report (DAR) submitted; Public Hearings; Report of Environmental Assessment / Impact Review; Minister's Decision

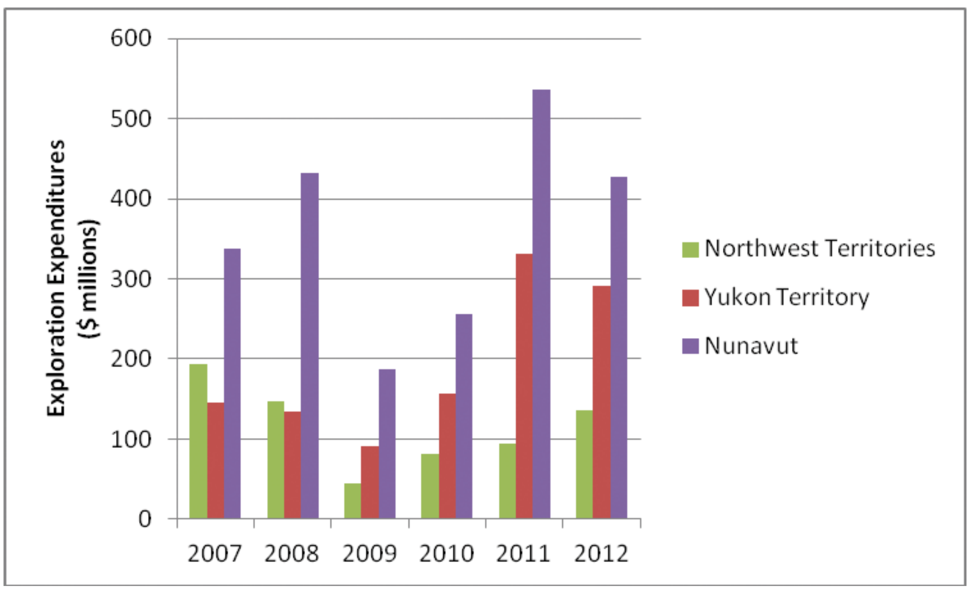
1.3 Future Mining Trends in the NWT

NWT is resource rich and has experienced much growth because of mining since the turn of the millennium. Diamond mining has been instrumental in this growth and NWT is now the 4th largest producer of diamonds worldwide. Mining in the NWT is directly responsible for 29% of the NWT Gross Domestic Product; more than any other private sector activity.

Factors driving mining in the NWT include the commodity prices, barriers to entry and resource availability. Forecasting commodity prices is outside the scope of this report, however providing lower cost energy can reduce the cost of production and reduce or remove a barrier to entry. Section 3 gives an example of a mine benefiting from grid power.

Figure 1 shows the dollars spent in exploration and mine development in the Yukon, Nunavut and NWT. Exploration activity is an indication of future mining activity, and while NWT has not seen the same exploration dollars as either the Yukon or Nunavut since 2009, the trend is increasing which should indicate continued growth.

Figure 1 – Exploration Expenditures in the Yukon, Nunavut and NWT[6]



6 Source http://mmsd.mms.nrcan.gc.ca/stat-stat/expl-expl/1-eng.aspx accessed Feb 4, 2013

2 Mining Case Study: Viability of Grid Power

2.1 Background

The goal of providing grid power to mines is to be a catalyst for economic growth by enabling new mines to start-up and to extend the life of existing mines.

For planning purposes, economically viable mines must have a cost of production that is lower than the current and forecast market price of the commodity. Calculation of the cost of production takes into account initial capital investment and the operation costs. However, once a mine is in operation, the decision to continue operations is based upon the marginal cost of production (which does not include recovering the initial capital cost investment).

Mines in the NWT require significant initial capital investments to establish and are costly to operate because they are located in remote locations with expensive transportation links for moving supplies, staff, and shipping product to market. In addition, mines have significant energy requirements needed for transportation, materials handling, material processing, heating and other ancillary services.

Currently, mining operations in the NWT are powered by on-site diesel electric generation which creates greenhouse gases (GHGs), and are subject to changes in diesel fuel prices, high fuel transportation costs, and high maintenance costs. Diesel electric generation is currently the most suitable option to electrify mine sites because diesel generation is a flexible and robust technology that is well understood, reliable in isolated locations and can be salvaged after a mine closure.

For a diesel electric powered mine, capital costs include the diesel generators, fuel handling, and fuel storage, and these costs make up 10% to 30% of the capital costs of a new mine.
The Operation and Maintenance costs consist of items such as diesel fuel, system monitoring and maintenance required to maintain reliable operations. Ongoing electricity generation (fuel & maintenance) makes up 20% to 30% of the production (marginal) costs of a mine[7].

2.2 Diesel Alternatives

Providing power at a lower cost than diesel can improve the business case for a mine under development or extend the life of an operating mine.

A typical mine in NWT has an electrical load averaging 10 MW. Diesel electric generation for such a site can have an initial capital cost of $60M and after accounting for both capital and O&M costs electricity costs can be 30¢/kWh to 40¢/kWh. Industrial rates for similar 10MW loads connected to the continental electrical power grid in southern Canada range from 3.5 to 10.5 ¢/kWh[8] and are currently 14.5 ¢/kWh in the NWT (forecast from GRA schedules)

7 http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/miners-turn-to-renewable-energy-to-cut-costs/article1359140/ and http://www05.abb.com/global/scot/scot216.nsf/veritydisplay/2205e72865c2c747c1257a620026d001/$file/Mining%20brochure_EN_lowres.pdf accessed Jan 30, 2013

8 http://www.hydro.mb.ca/regulatory_affairs/energy_rates/electricity/utility_rate_comp.shtml#general_large_industrial (accessed Jan 30, 2013)

Alternative energy sources which are less costly than diesel will give benefits for the mine – reduced marginal cost of production – and for the utility – new source of revenue and potential legacy assets.

Renewable energy options such as wind, hydroelectricity and solar are alternatives for supplying energy to mines, but are not analyzed in detail here because they typically have drawbacks that make them unsuitable as the primary energy source for mines. For example, although solar and wind generation have zero fuel costs (e.g. wind and sun are renewable); their generation is intermittent and undependable because the presence of wind and sun cannot be guaranteed for every hour of the year. While this intermittency prevents them from being used as the primary power source, solar and wind can be useful to supplement diesel generation up to about 20%[9] without any significant operational challenges. Hydropower on the other hand can be designed as a consistent source of reliable electrical energy but the locations suitable for hydroelectric generation are rarely located in close proximity to mines and thus require transmission lines to move the power from the generation site to the mine load which results in a case-by-case financial evaluation for each mine.

2.3 Grid Power via a Transmission Line

Building a transmission line from the mine to the existing NWT power system and accessing grid power can have economic advantages in some instances. Table 3 shows the economic characteristics of a typical mine with an average electrical load of 10 MW, a 15 year planned lifespan located 110 km from existing transmission system.

9 Presentation: Peter Bubik (Feb 24, 2012), Hatch Renewable Power Symposium (Vancouver), "Wind Power For Mines and Remote Communities"

Table 3 – Mine Economics – Diesel Power versus Grid Power

Costs To Serve a Typical Mine with Diesel Power	Amount ($2012)	Costs To Serve a Typical Mine with Hydro Power from the Existing System via a Transmission Line	Amount ($2012)
Capital Cost (Diesel Generators & Fuel Storage)	$60M	Capital Cost (Back-Up Diesel Generators & Fuel Storage)	$30M
Annual Operating & Maintenance Costs	$5.3M	Capital Cost (110 km Transmission Line and Substations)	$50M
Annual Fuel Costs	$27M	Annual Operating & Maintenance Costs	$4M
Levelized Cost of Energy (LCOE) for Life of Mine	39¢/kWh	Annual Electricity Purchase Costs	$12.2M
Present Value of Energy Costs (Capital and Energy)	$346.0M	Levelized Cost of Energy for Life of Mine	32¢/kWh
		Present Value of Energy Costs (Capital and Energy)	$225.3M

From the table we can see there are number of benefits to providing electricity to a mine from the existing power system via transmission line:

- Lower cost of operations
- Annual electricity purchase costs less than half the cost of diesel fuel costs
- Lower Levelized Cost of Energy LCOE,
- On a present value basis >$100M savings in electricity related costs over the 15 year mine life

However, the challenges that must be considered include:

- Stranded capital assets: Higher capital cost can lead to a longer payback period which introduces financial payback risks which must be compensated for by lower operational costs
- Increased Capital costs: Transmission Lines and Substations are capital intensive assets and backup diesel generation is still required at the mine site.

Table 4 shows how diesel generation and grid power delivered via a transmission line rank using the evaluation criteria.

Table 4 – Criteria Dashboard – Mining Case Study

Criteria Dashboard – Mining Case Study				
Resource	Economic Impact	Technical Viability	Environmental Performance	Social Benefits
Diesel	**NIL** *Status quo*	**HIGH** *Universally viable*	**LOW** *GHG emissions, air quality*	**LOW** *Imported fuel; local health*
Grid Power via Transmission Line	**NIL** *Typically break even v. diesel*	**HIGH** *Universally viable*	**HIGH** *Offset isolated diesel with hydro*	**HIGH** *Reliability; econ. growth*

3 Viability of Providing Grid Power to Mines

The default electricity source for most isolated resource extraction projects is on-site diesel fired generation. The case study above shows that it is possible for a grid power solution to be economically attractive. A key barrier to the implementation of such an alternative is the long distances and resulting high costs of a new transmission line between the established centralized grid and the mine sites.

A transmission project must be evaluated as a significant capital investment (building a transmission line to connect to the grid), which is then recouped over the operating life of the mine. Depending upon the relative cost savings of grid-supplied electricity versus self-supply (from diesel generators) and the operating life of the project, a greater (or lesser) amount of the transmission line capital costs can be economically borne by the mine.

From this point of view, operational cost savings obtained from having access to transmission grid energy support a maximum capital investment. In some cases such a transmission line may have other benefits, such as interconnecting remote communities, which opens the door to sharing the capital costs amongst multiple beneficiaries, but these capital cost sharing arrangements must be evaluated on a case by case basis.

To investigate the issue of maximum capital investment support by operational cost savings, two cost models were developed; one for a mine served with diesel-generation and the other for a mine served with grid power via a transmission line. The key questions are:

- How long a transmission line can be economically supported by a mine?
- What are the effects of the diesel fuel price and grid power rates on the length of that line?

The diesel-based electric generation cost model:

- Included capital costs for redundant diesel fired generation.
- Included ongoing operation and maintenance (O&M) costs.
- Derived the levelized cost of electricity (LCOE): All-in unit cost of energy for multiple diesel fuel prices were calculated by dividing the present value of the capital and operational costs by the present value of the energy generated .

The cost model for a mine served with grid power via a transmission line:

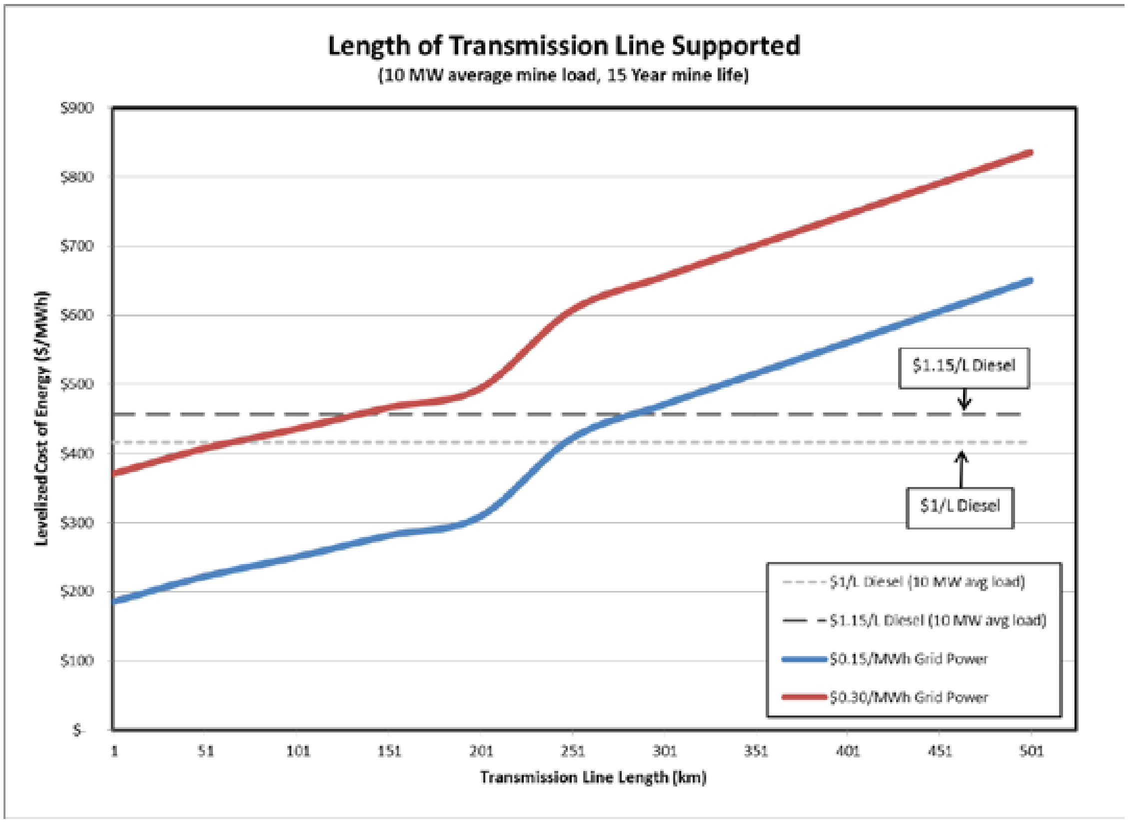
- Included the capital cost of transmission line, substations, and back-up diesel generation.
- Included ongoing O&M costs.
- Derived the LCOE by dividing the present value of the capital and operational costs by the present value of the energy purchased for increasingly longer transmission lines.

The results of the modeling are plotted in Figure 2 to show unit energy cost relationship between diesel-powered mine and a grid-powered mine.

Some of the key parameters in the modeling included:

- A 10 MW average mine load was used as a representative value based on the list of proposed mines in Table 2
- A 15 year mine life was used as a representative value based on the list of proposed mines in Table 2
- Two power price points
  - $0.15/MWh because that is the forecast industrial rate in the North Slave (Snare) region from the NTPC General Rate Application (GRA) for 2013/14.
  - $0.30/MWh which is a rough approximation of the unit cost of energy from Taltson expansion if built with a transmission line running from Twin Gorges to Yellowknife with this particular customer purchasing a portion of the power
- Two diesel price points
  - $1/L is the sum of the current bulk rate in Edmonton ($0.86/L) and an estimated transportation cost to mines in the North Slave Region of $0.15/L
  - $1.15/L is the price forecast for 2013/14 for Thermal Zone diesel in the NTPC General Rate Application (GRA).
- The price of power and diesel were escalated at 2% as an estimate of CPI
- A discount rate of 8% was used which reflects a modest level of risk and return expectation associated with mine projects

Figure 2 – Economic Transmission Line Lengths for Mines [10,11]



A number of observations can be made from Figure 2:

- The key sensitivities in line length are the price of diesel and grid-based electricity.
- A 250 km transmission line could be built for the same life cycle energy costs (capital, O&M) when purchasing $0.15/MWh power and offsetting power generated with $1/L diesel.
- The supported line length is reduced to 70 km if the price of power is $0.30/MWh and diesel remains at $1/L.

Reducing the capital cost of a transmission line using new transmission technology could extend the distances.

10 Source: Mining Case Study Analysis Tool MG02.xlsx
11 The ramp up in levelized cost of grid power between 200 km and 250 km is due to the increase in transmission line voltage from 115kV to 161kV

4 Mining Conclusions & Recommendations

Table 5 gives a list of prospective mines, their estimated electric load and distance from the existing grid. For a transmission line length threshold of 250 km, a number of mines should be considered for grid connection because they could realize savings from connecting to the grid and purchasing power.

Table 5 – Proposed Mines – Distance From Grid and Electric Load Size

Company Name	Project	Region	Load (MW)	Distance to Grid (km)	Project Life (years)
Avalon Resources	Nechalacho (Thor Lake)	North Slave	10	95	14
Canadian Zinc	Prairie Creek	Dehcho	5	480	14
De Beers	Gahcho Kue	South Slave	10	270	15
Fortune Minerals	Nico	North Slave	12	30	15
Seabridge	Courageous Lake	North Slave	45	260	15 (Est.)
Selwyn Resources	Howards Pass	Sahtu	Unknown	700	15 (Est.)
Tamerlane	Pine Point	South Slave	6	Connected	2.5
Tyhee	Yellowknife Gold	North Slave	10	60	8
Diamond North Resources (Snowfield)	Drybones Bay	North Slave	Unknown	45	15 (Est.)

Setting aside the regulatory and economic factors that largely define the viability of a prospective mine project, Table 5 shows the mines that are the most likely candidates for interconnection to the grid. Nico, Tyhee, and Avalon are the closest mines to the North Slave Grid that could be largely served by the existing hydro capacity. However, additional generation would be required to serve 100% of the annual power requirement from any one of these potential customers, particularly in low water years.

There are other potential customers such as Courageous Lake and Drybones Bay but these mines have much larger loads. A centralized LNG facility that relies on minimal LNG storage would likely provide the most cost effective and timely generation option. In addition, a LNG facility would generate lower GHG emissions than the diesel base case. The business case for LNG and other options such as hydro expansion and diesel generation need to be examined further.

The remaining mines are further from the grid than the basic economic threshold of 250 km as identified in the analysis. However Gahcho Kue is only 20 km past and warrants closer review for viability should it approach a commitment to be constructed. Further mining opportunities exist in Nunavut, however the mines are located at a distance in excess of 400 km from the established grid, which is too far to be considered economically viable.

Figure 3 – Map of Proposed Mines to Be Investigated For Grid Power

It is important to note that the above analysis was done comparing the diesel-based generation and grid power via a transmission line on a break even basis for LCOE. Simply having the same cost structure provides an operational incentive to a mine developer to make the decision to grid connect by reducing the need for fuel storage and reducing the amount of fuel that has to be transported.

The analysis was also done on a generic basis and must be adapted to each individual case considering the following:

- Consider the 250 km line length to be a maximum, shorter transmission lines will cost less and provide greater savings which could be shared with the mine proponent to give them an incentive to connect to transmission.
- Surplus available energy on the North Slave (Snare) system is not large and triggering the construction of new generation will impair the economics. (see Section 6 for details)
- Including a transmission line as part of a mine project increases the environmental footprint and investment complexity, and will introduce schedule & permitting risk. Depending on the scale of development, transmission lines can take 5 to 10 years to permit and build and this must be coordinated with mine development lead times and investment decisions.
- The grid power alternative will always require a larger initial capital expenditure which may be unattractive to a mine developer who is subject to fluctuating commodity prices and likely wishes to recover the capital investment as quickly as possible after operations commence.

The remaining challenge is to assess the available energy to serve mines, as there is not a large surplus on the Snare System (See Section 6). Grid capacity on the Snare System (the area where mines are located) is annually constrained during the winter period (6 months).

To make grid power an attractive option for a mine, the development schedule for electrical infrastructure must be within the mines timeline for power. Please refer to Section 6 for more detailed actions. The information available from the Chamber of Mines[12] indicates that most of the proposed mines are scheduled to be operating by 2015. This timeline is too short to include a new transmission line as a project component. However, projects experience which delays prior to becoming operational could become candidates for grid power.

In conclusion, an economic case can be made for connecting new mines to the grid when they are within about 250 km of the existing system, and there is sufficient surplus energy available. Potential customers must be examined on an independent basis, based on their unique circumstances and schedule.

12 Presentation: Tom Hoefer, Chamber of Mines (Nov 22, 2012), "NWT Energy: A Mining Industry Viewpoint"

Appendix B: Oil & Gas Market Assessment

Other than in the Sahtu region of the NWT, it is not expected that there will be any substantive oil and gas development in the NWT. The oil and gas industry is currently exploring for shale oil in the Sahtu region around Norman Wells which could lead to an increase in electrical load associated with extraction activities. Natural gas prices in North America are currently at historic lows and are not expected to increase substantially for the foreseeable future, as a result the best use for natural gas extracted as a byproduct of oil extraction is self-supplying oil extraction electricity. In the event that natural gas byproducts are insufficient to self-supply the electrical demand of the oil extraction efforts, additional natural gas and/or diesel can be imported to bridge the gap.

The purpose of this oil and gas market assessment is to consider the market forces and factors that will influence oil and gas development within the Northwest Territories ("NWT") over the next 20 years. Oil and gas development is an important factor in planning the NT Power System Plan because it is a potential source of significant new electrical loads. Additionally, revenue from new loads can be used to fund and/or justify new infrastructure.

In recent years, the stalling of the Mackenzie Valley pipeline and dwindling conventional oil production and reserves at Normal Wells have diminished the hydrocarbon industry in the Northwest Territories, but there is some hope that recent shale oil exploration around Norman Wells could reinvigorate the industry and lead to new electrical loads in that area.

1 North American Context

Unconventional shale gas discoveries and exploitation within the continental United States and the Western Canadian Sedimentary Basin have created a supply glut of natural gas and historic highs for proven reserves in North America (See Figure 1). This increase in shale gas production (see Figure 2 for US shale gas production) has contributed to significant decreases in natural gas prices that are expected to persist for the foreseeable future, as shown in Figure 3. Consequently, production of the once promising NWT natural gas industry is currently languishing (see Figure 4) with no relief in sight because NWT natural gas is uneconomic compared to inexpensive unconventional shale gas supplies in southern Canada and the United States. Additionally, with the Mackenzie Gas Pipeline ("MGP") stalled, there is no cost effective method to transport NWT natural gas to market. Exports of Liquefied Natural Gas ("LNG") to overseas markets is a potential outlet for excess natural gas supplies in North America, but this market only benefits the NWT if a pipeline to move product to southern Canada is constructed.

Natural gas prices in North America are currently at historic lows, thus making LNG a potentially attractive imported fuel source. LNG as a fuel source needs evaluation on a community specific basis to assess the specific costs associated with diesel to "bi-fuel" generator conversions and LNG transportation.

Figure 1 - Proven Gas Reserves[1]

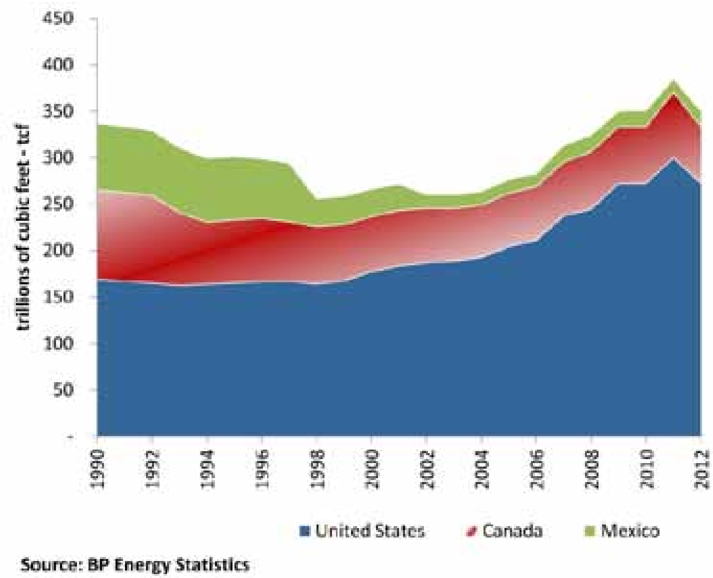
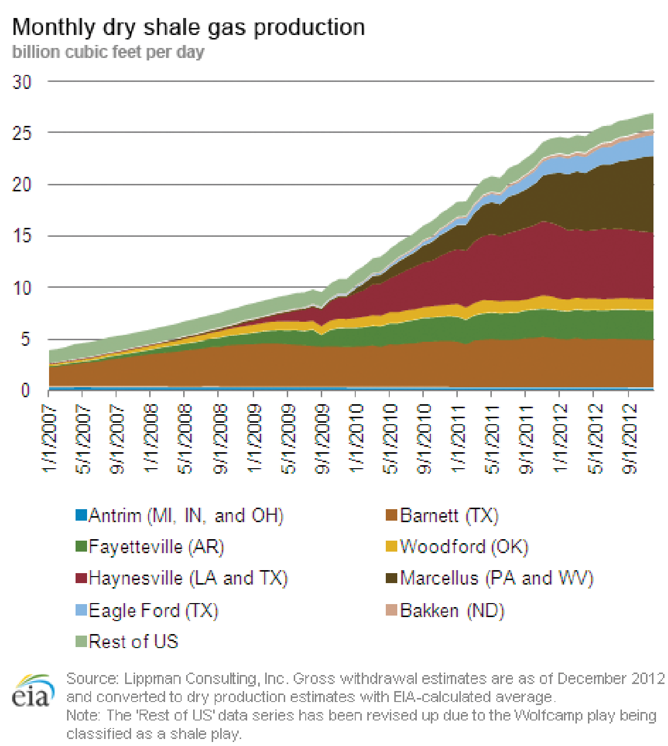


Figure 2 – US Shale Gas Production[2]



1 Source: Canadian Gas Association, "Proven Reserves of Natural Gas - North America," 2012. [Online]. Available: http://www.cga.ca/wp-content/uploads/2011/02/Chart-10-Proven-Reserves-of-Natural-Gas2.pdf.

2 Source: Energy Information Administration, "Natural Gas - U.S. Energy Information Administration (EIA) - U.S. Energy Information Administration (EIA)," 2012. [Online]. Available: http://www.eia.gov/naturalgas/weekly/

Figure 3 – Actual and Forecast delivery prices (AECO C) to Nov-11 for delivery of gas within Alberta[3]

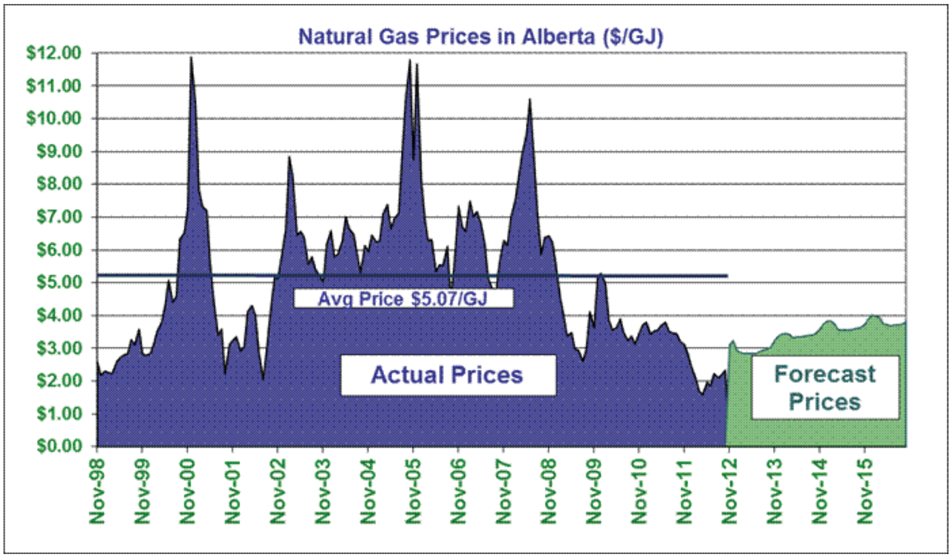
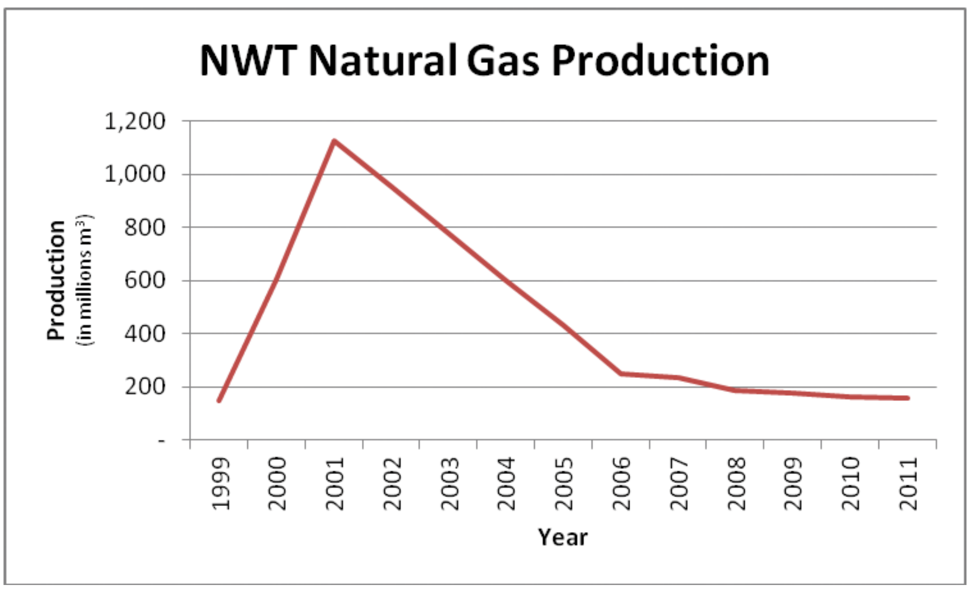


Figure 4 - NWT Natural Gas Production[4]

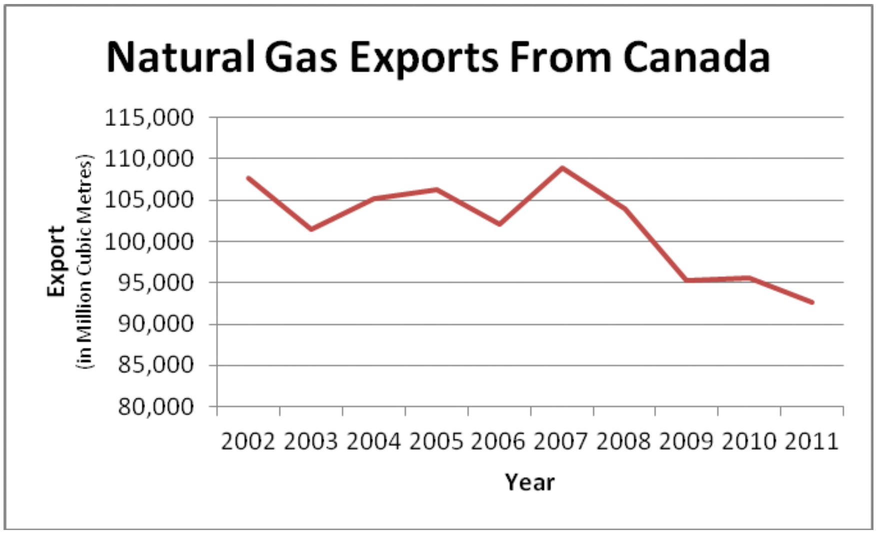


Further evidence of downward market pressures on the Canadian price for natural gas is that with such large supplies of gas in the US, the US is reducing its imports of natural gas from Canada. Figure 5 shows that natural gas exports from Canada have been dropping steadily since 2007.

3 Source: Gas Alberta, "Market Prices," 2012. [Online]. Available: http://www.gasalberta.com/pricing-market.htm

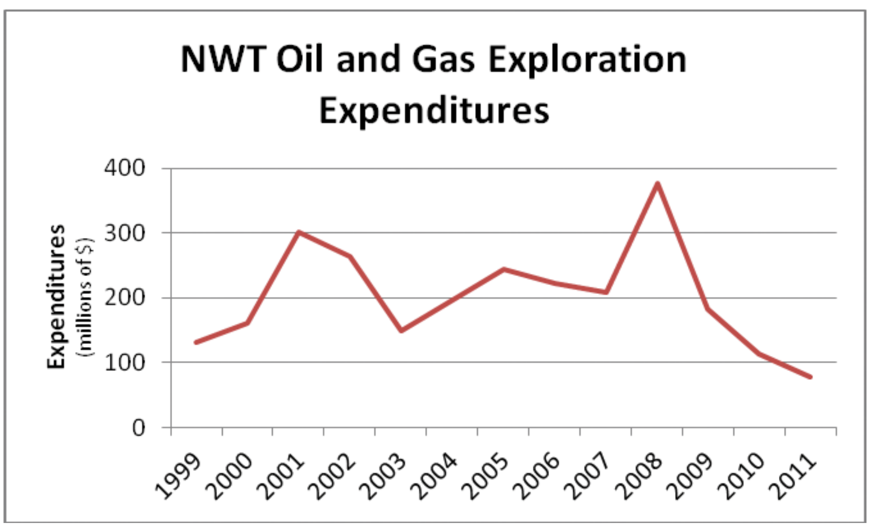
4 Source: NWT Bureau of Statistics, "Annual Volume of Mineral Production by Commodity – Northwest Territories, 1999 to 2011," 2012. [Online]. Available: http://www.statsnwt.ca/economy/minerals/Annual%20Mineral%20Production.xlsx

Figure 5 - Natural Gas Exports from Canada[5,6]



Not surprisingly, the reduction in natural gas prices has also led to a reduction in natural gas exploration in the NWT since 2008, as shown in Figure 6. It is reasonable to conclude that as long as natural gas prices remain at historic lows, exploration expenditures in the NWT will also remain low. Therefore, without a recovery in exploration and drilling in the NWT, natural gas production in the NWT cannot recover and accordingly the electrical loads associated with natural gas production will also not grow.

Figure 6 - NWT Oil & Gas Exploration Expenditures[7]



5 Source: Canadian Association of Petroleum Producers, "Exports from Canada, 1952 - 2008," 2012. [Online]. Available: http://membernet.capp.ca/SHB/Sheet.asp?SectionID=9&SheetID=224

6 Source: Canadian Association of Petroleum Producers, "Exports from Canada, 2009-2012," 2012. [Online]. Available: http://membernet.capp.ca/SHB/Sheet.asp?SectionID=9&SheetID=314

7 Source: NWT Bureau of Statistics, "Value of Oil and Gas Expenditures & Development Northwest Territories 1999 to 2011," 2012. [Online]. Available: http://www.statsnwt.ca/economy/oil-gas/Oil%20and%20Gas%20Exploration.xlsx

1.2 Mackenzie River Delta

First proposed in the 1970's, active development on the Mackenzie Gas Pipeline ("MGP") has effectively ceased. To make the construction decision by December 2013 as required by the National Energy Board ("NEB"), the project team would need to be dramatically increased to be large enough to support engineering, field investigations and financing.

The exact natural gas price at which the MGP project is viable is not known, but it was revived in 2005 when prices were peaking at $15/GJ. After receiving Federal approval in March 2011, active development was halted because prices had dropped to $4.50/GJ – and gas prices have declined since then. Therefore the project is not expected to proceed within the 20 year planning horizon.

Without a pipeline to transport gas to market and low natural gas prices and no pipeline, gas exploration in the Mackenzie Delta will remain depressed and offshore exploration in hibernation.

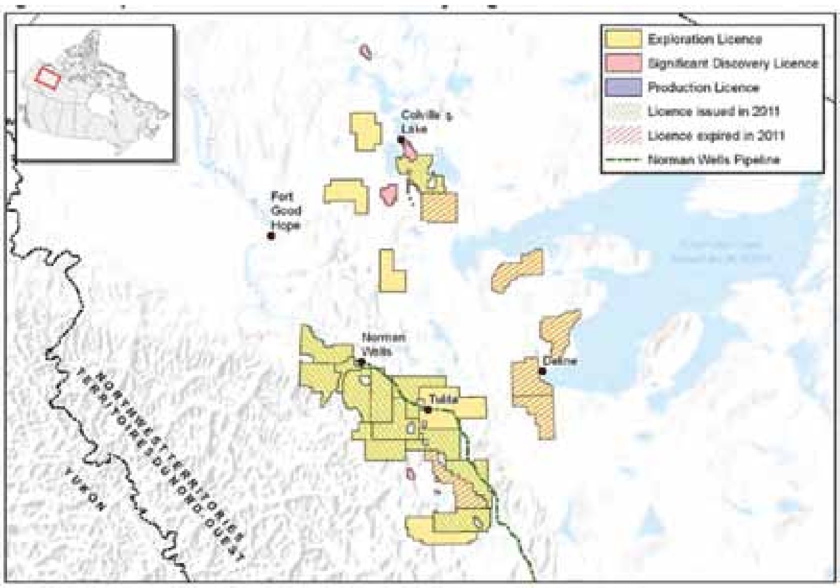
1.3 Sahtu Region

The same drilling technologies that have facilitated the shale gas boom in the United States and southern Canada are facilitating the exploration and development of shale oil resources in the NWT. The primary area of potential is the Canol shale in the Sahtu region which has seen active exploration in 2011 and 2012, and has existing production infrastructure including spare capacity on the existing pipeline from Norman Wells to Alberta. More exploration is planned over the next two years which will help to determine what reserves are present in the region. From an electrical perspective, new demand could emerge if industry transitions from exploration to production and takes advantage of existing capacity within the Norman Wells Pipeline, but the increase in electrical load will initially be incremental and the industry could self-supply energy using fuel byproducts from the drilling activities.

1.3.1 Exploration

A land rights auction in 2011 and 2012 attracted major oil and gas players (Shell, Imperial Oil, Husky, ExxonMobil and ConocoPhillips) who secured land parcels in the vicinity of Norman Wells and Tulita. Figure 7 shows the licenses issued in 2011 around Norman Wells and Tulita. Additional licenses were issued in 2012. The parcels secured in 2011 & 2012 included commitments to spend more than $600M in exploration.

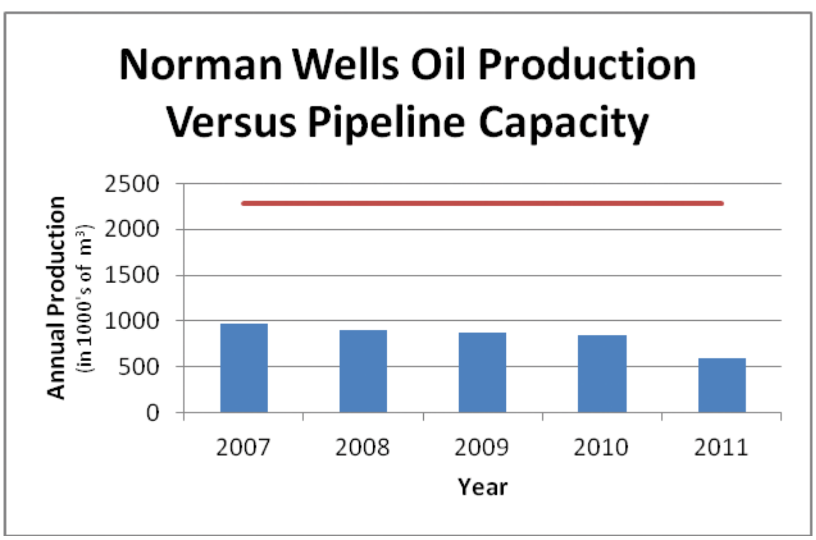
Figure 7 - Land Licenses[8]



1.3.2 Oil Pipeline Capacity

As Figure 8 below shows, declining production from existing Norman Wells facilities leaves more than half of the capacity on the pipeline to Zama Lake, Alberta unused.

Figure 8 - Norman Wells Oil Production Versus Pipeline Capacity[9]



8 Source: Aboriginal Affairs and Northern Development Canada, "Northen Oil and Gas Annual Report 2011," 2011. [Online]. Available: http://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-HQ/STAGING/texte-text/nog_ann2011_pdf_1335968796614_eng.pdf

9 Source: Aboriginal Affairs and Northern Development Canada, "Northen Oil and Gas Annual Report 2011," 2011. [Online]. Available: http://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-HQ/STAGING/texte-text/nog_ann2011_pdf_1335968796614_eng.pdf

2 Electricity Sources for Oil & Gas

In southern Canada, oil extraction has been a source of electricity demand, but natural gas extraction does not produce the same net electrical requirements because natural gas can be used for self-supplied onsite power generation. The needs of the oil and gas projects would very likely be met in a manner similar to how the Norman Wells complex currently supplies its own electricity needs, using natural gas from drilling activities.

Oil and gas extraction activity tends to be dispersed over a larger area and developed in stages when compared to a mine which is a single concentrated point of electrical load. If natural gas is available as a by-product of the extraction process, it will likely be the preferred source of fuel for electrical generation because it is reliable, dispatchable and requires very little electrical transmission infrastructure. Additionally, natural gas generation can also be scaled to match any size of required load. If natural gas is not available and the total electrical load is small, imported diesel and/or Liquefied ("LNG") will likely be an economical choice for supplying energy.

3 Findings

In southern Canada, oil extraction has been a source of electricity demand, but natural gas extraction does not produce the same net electrical requirements because natural gas can be used for self-supplied onsite power generation. The needs of the oil and gas projects would very likely be met in a manner similar to how the Norman Wells complex currently supplies its own electricity needs, using natural gas from drilling activities.

Oil and gas extraction activity tends to be dispersed over a larger area and developed in stages when compared to a mine which is a single concentrated point electrical load. If natural gas is available as a by-product of the extraction process, it will likely be the preferred source of fuel for electrical generation because it is reliable, dispatchable and requires very little electrical transmission infrastructure. Additionally, natural gas generation can also be scaled to match any size of required load. If natural gas is not available and the total electrical load is small, imported diesel and/or Liquefied ("LNG") will likely be an economical choice for supplying energy.

Appendix C: Benefits of Southern Interties

The purpose of this 20-year electrical market assessment is to consider the market forces and factors that will influence the development of the electric supply system within the Northwest Territories ("NWT"). The expansion of the electric transmission system connecting remote communities, the development of new generation resources, and possible interties with continental electric grids will be the largest moving pieces that determine the outlook over this 20 year timeframe.

Interties to larger existing grids in southern Canadian provinces could provide the NWT grid with electricity to drive proposed resource extraction investment. However, this idea requires extremely long transmission lines to connect both the Taltson grid to the North Slave region, and to connect the Taltson grid to one of the Western Canadian Provinces.

1 Benefits of Intertie

An important option for the Northwest Territories Power Corporation's (NTPC) system planning goals (improving electricity affordability, ensuring reliable electrical supply, spurring economic development and job creation, diversifying energy supplies) is interconnecting with a neighboring provincial electricity grid to the south. Connecting to the continental grid would open to the door to several benefits and opportunities for the NWT. However, connecting to the continental grid would be technically, environmentally, and economically challenging.

Interconnection of the NWT grid with either Saskatchewan, Alberta or British Columbia electric systems would require the construction of a transmission line from part of the NWT grid (practically speaking, this will mean the Taltson grid) to a nearby portion of one of the provincial grids.

The benefits that this would provide to the NWT include:

Revenue Opportunities: The ability to trade electricity with other utilities would provide revenue opportunities to NTPC. The ability to buy electricity when prices are low and re-sell it when prices are high (enabled by the water storage capabilities of the Taltson hydro project) would provide revenue opportunities. Additionally, NTPC could sell excess energy/capacity and ancillary services from the Taltson facility into the free market.

Supply Opportunities: Access to electricity supply from neighboring provinces could accommodate future mining load growth, possibly more economically than could be accomplished by NTPC building its own new generation. Since mines use electricity 24/7, the average cost of importing electricity (which would include both low-cost times of day and high-cost times of day) would be reasonable.

Electric System Benefits: Interconnection to southern grids increases the redundancy of the NWT's electric supply. A failure of a current NWT generation resource could be addressed by increasing electricity import levels from the south. This ability to import energy would improve service to customers and increase the reliability of the NWT energy system, while helping NTPC avoid underutilized and costly backup generators and associated fuel inventories.

Right Sizing of New Generation: With the flexibility of both importing and exporting to the continental grid, new generation projects stand a greater chance of being optimized on a cost per megawatt basis, rather than being restricted to the size of the new load's requirement. Moreover, the potential diversification of revenue sources for the generation project further diminishes the credit risk profile of the new project.

Social Benefits: A transmission line built to interconnect to a southern grid could be built to pass by remote communities along the desired route. This provides benefits to small communities along transmission routes, including decreased electricity rates, local air and noise quality improvements (due to the replacement of diesel generation with grid power), and the possibility of installing telecommunications lines alongside (and concurrent with) the transmission routes.

Despite all these benefits, interconnection faces significant barriers. Purely technical and regulatory challenges such as the transmission line length issues and learning to manage an altered NWT system under the WECC requirements exist, but should not present a fundamental barrier. Much more challenging will be the economics (e.g. cost and cost recovery) for these transmission lines. Transmission line costs for such an interconnection project are examined in detail in Sections 2.1, 2.2, 2.3.

2 List of Intertie Options

The three potential interties for NWT are to Saskatchewan, Alberta or British Columbia. The red lines in the figure below indicate potential transmission routes for these different intertie options.

An intertie with the Yukon was not explored, as this was seen as having limited benefits and being prohibitively expensive (and challenging) because of the mountain range that separates the Yukon from the NWT. An intertie with Nunavut was also not explored, due to the lack of grid infrastructure in Nunavut.