Industry PROFILE

An integrated approach to nurturing industry development and NWT Wealth

Energy Generation

Energy is a fundamental ingredient for any economy, and in the Northwest Territories, our climate and our isolation make energy an even greater concern for our economic health. While we are poised to become a major exporter of natural gas, we still rely heavily on imports to fulfill domestic needs.

The production and sale of energy is a significant component of the Northwest Territories (NWT) economy. This profile examines the investment and economic impacts of energy generation for domestic use and export. It does not, however, address the economics of oil and gas activity which are examined within a separate industry profile.

Nor does this paper deal with issues of energy conservation, which are examined in detail within the NWT Energy Strategy; copies of this strategy are available from the Resources Wildlife and Economic Development (RWED) web site.

The NWT is in a contradictory position regarding energy. Currently poised to become one the largest exporters of natural gas in Canada, the cost of fuel in many of our communities remains prohibitively expensive and requires government subsidies. The NWT also possesses abundant freshwater resources, however our topography limits opportunities to develop hydroelectricity. The diamond mines import over 100 million litres of fuel annually, most of which runs their diesel-electric plants, while the Talston hydro dam to south is running under-capacity.

Hydro Turbines (Microsoft)

The high cost of energy affects almost all aspects of living and doing business in the NWT. Energy generation offers opportunities for innovation in meeting the NWT's own needs, exporting the surplus and subsequently creating significant employment and business opportunities.

Background

Canadian Energy Generation

In Canada the two basic methods of producing electrical power are hydroelectric generation and thermal generation. Hydroelectric generation is based on the energy contained in flowing water, and thermal generation, based on the production of steam. Thermal generation may be conventional, using coal and petroleum products like gas or diesel, or nuclear, using uranium in thermonuclear fission. Canada and the NWT have an abundant supply of freshwater resources from which electric power can be generated, and Canadians are among the world's highest per capita producers and consumers of electricity.

Actual production depends on the amount of time particular generators are running and on load (appliances, motors, etc) placed on the system; it is normal to have 10-25% extra capacity. In 1994, total actual production in Canada was 533,508 GWh (GW = 10^9 watts). Of this, 61% was hydroelectric, 19% nuclear, 15% coal, 3% natural gas, 1% oil and 1% other sources.

NWT Energy Generation

The table below provides an overview of the quantity and type of electricity generation in the NWT. The Taltson and Snare-Bluefish hydroelectricity systems are supplying more than half of the total utility needs in the South and North Slave areas. Diesel fuel is burned to supply all other communities and about one third of industrial supply. Gas turbine generation is the largest source for industrial use, and accounts for a fifth of the total. Gas turbines are used to supply the communities of Inuvik and Norman Wells. Electricity generated from non-hydro renewable sources (solar and wind) is extremely small and is not displayed in the chart.

Whereas Canada depends on oil for 7% of its electrical generation, the NWT uses oil for 31% of its needs.

The Taltson hydro system south of Great Slave Lake currently supplies, on average, 56 GWh or 19% of NWT "community" (excludes major industrial) consumption per year. However, the system has existing capacity to generate an additional 100 GWh, which has not been used since the Pine Point mine shut down. In contrast, the hydro system to the north of Great Slave Lake, Snare-Bluefish, cannot quite meet the demand of the North Slave communities, necessitating approximately 10% of the 185 GWh annual demand to be supplied by diesel generators.

NWT 2003 Electricity Generation (MWh)

Generation	Utility Generation		Industrial Generation		Total	
Hydro	220,197	67%	50,664	20%	270,861	46%
Internal Combustion	89,235	27%	95,465	37%	184,700	31%
Gas Turbine	21,689	7%	111,164	43%	132,853	23%
Total	331,121		257,293		588,414	

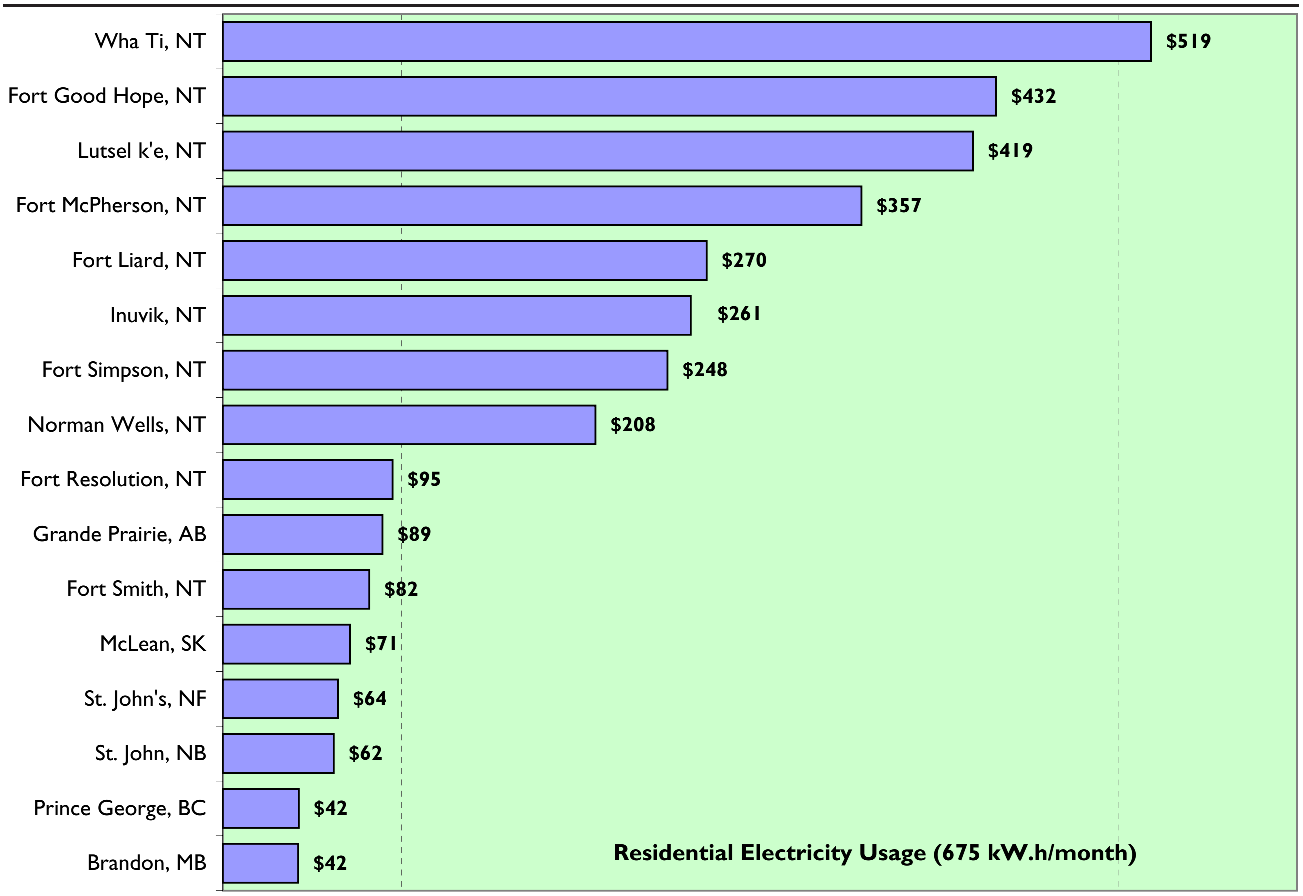
Data From: NWT Statistice Quarterly, Vol.26 No.2, June 2004

NWT Electrical Costs

For a modern economy, a reliable supply of electricity is essential. NWT residents enjoy electricity services that are equivalent to the levels of service provided in southern Canada. Unfortunately, the delivery of high-quality electric service to NWT communities does not come cheaply. Electricity rates in most NWT communities rank among the highest in Canada. With the exception of communities on hydro, such as Fort Smith, Fort Providence, Yellowknife and Hay River, electrical costs can be 300 to 500 percent higher than southern towns and cities. The chart below highlights costs in a few select communities, based on average household consumption of 675 kWh per month. In McLean, Saskatchewan, for example a household would be paying $71 per month compared to $270 in Fort Liard.

The Domestic Power Subsidy program provides a discount, for the first 700 kWh of consumption per month, to all NWT residential power consumers outside of Yellowknife whose power rates are higher than the Yellowknife area. Businesses must apply for the Commercial Power Subsidy Program – the uptake is very limited. The total costs of this program have risen dramatically in recent years (due to rising electricity costs and increased private home ownership) and are now in the range of $6 to $7 million per year. Part of this is covered by a dividend to the Government from the NWT Power Corporation.

Electrical Power Costs in Select NWT and Other Communities 2004

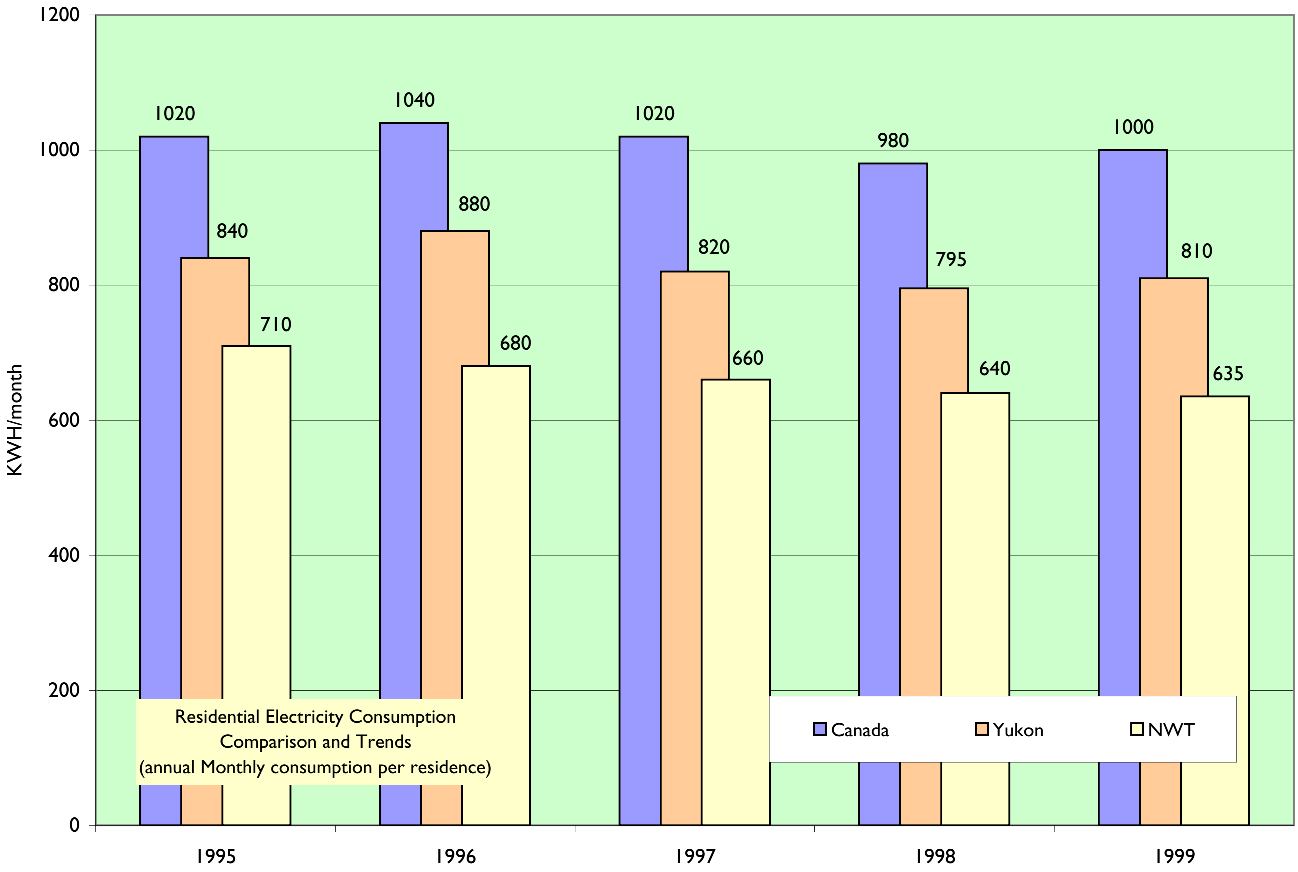


Source: RWED review of NCPC and Saskatchewan Rate Applications

NWT Households Conserve

The NWT is a cold climate region of Canada; Yellowknife is the only capital city in Canada where the average annual temperature is below freezing. The NWT also has long periods of darkness in the winter. Even so, NWT energy consumers are very frugal energy consumers. As shown in the chart below, electrical consumption by NWT households, on average, is only 64% of the typical Canadian family. What is more, the consumption of electricity by NWT consumers has been declining in relation to national trends. In 1995 NWT households consumed 70% of the national average; this has since declined to 64%.

Electrical Power Costs in Select NWT and Other Communities 2004



Source: Energy Strategy Discussion Paper

NWT Gas Generation Potential

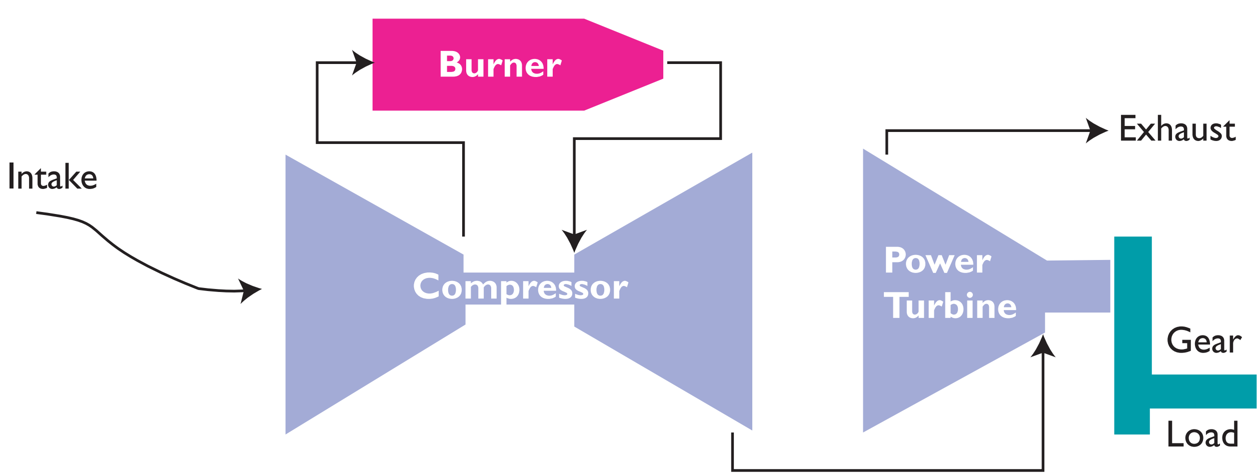
An exciting project for NWT communities is using local gas for local heating and electrical generation. This works to reduce imports, adds value to the local economy, creates opportunities for employment and could significantly reduce costs. Communities with access to local gas or those along the proposed Mackenzie Valley pipeline route can take advantage of these opportunities. One model is Inuvik Gas Ltd. local natural gas distribution system serving Inuvik. The project was designed by North of 60 Engineering, and is owned jointly by the Inuvialuit Petroleum Corporation, Enbridge Inc. and Alta Gas Services. In that instance, NWT Power Corp. replaced their old diesel-powered generation with two new natural gas powered reciprocating engines in the station, while retaining some diesel capacity as standby backup. Cogeneration, however, is not featured.

Significant new drilling for and discovery of natural gas has already occurred in the Liard River valley area. Fort Liard's electrical power, however, is still generated by diesel powered gen-sets. Because of the terrain and separation of residences, local natural gas distribution may not be as widespread as it is in Inuvik. It may be economically-limited to more centrally-located major energy consumers in Ft. Liard proper. A smaller-diameter spur line lateral from the mainline pipeline should be run into a "town gate" custody transfer point for each of the designated communities within 50 miles of the proposed Mackenzie Valley natural gas pipeline route.

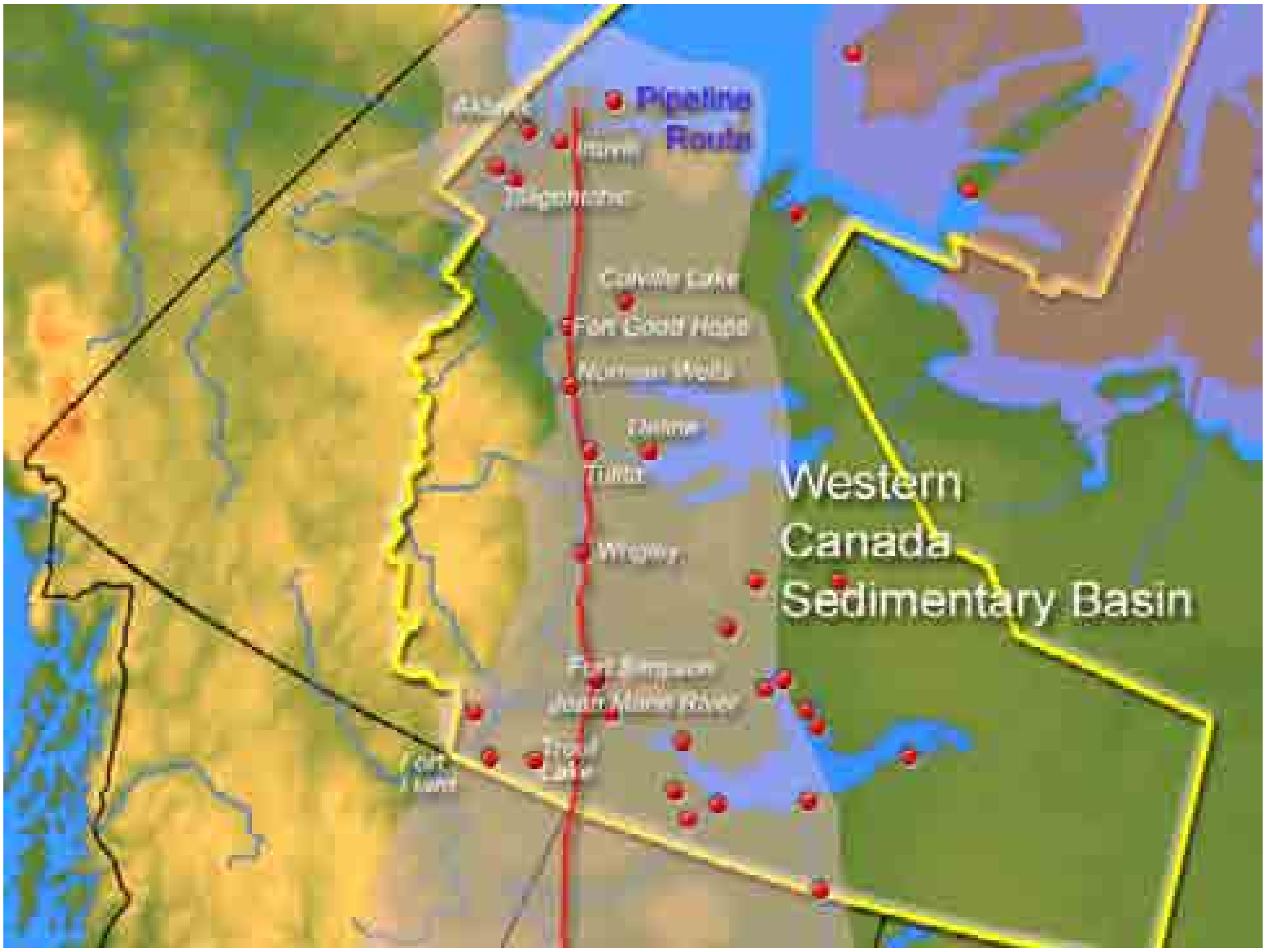
Suggested spur line laterals to communities within an 50 mile (<85 km) radius of the likely mainline pipeline route would be: Aklavik, Deline, Fort Good Hope (K'asho Got'ine), Tsiigehtchic, Tulita, Fort Simpson, Jean Marie River, Trout Lake (Sambaa K'ee) and Wrigley. Inuvik, Colville Lake, Norman Wells and Ft. Liard are special cases that have local access to indigenous natural gas. Tuktoyaktuk and Fort McPherson would require laterals of 130 km and 100 km respectively and may warrant further examination. It should be noted that for a household in Colville Lake, the cost of consuming 675 kWh per month is $1,800, 18 times the cost of the same consumption in Fort Smith.

One issue may be Natural Gas Liquids (NGL's) in the main line because of the expected dense-phase gas composition design of the mainline. Small scale distributed microturbine power generation, which is able to effectively generate electrical power from rich or lean natural gas or liquid by-products of natural gas production may help solve this dilemma. Distributed generation based on natural gas, or liquid by-products of natural gas production, and in

Workings of a Gas Turbine



Communities With Significant Micro Turbine Potential



particular, small scale on-site power generation may assist Northern communities and local commercial enterprises to lower their energy costs significantly. This can be done by reducing the need for duplication of infrastructure. Instead of gas pipelines and electrical transmission and distribution systems being built, one infrastructure network, a gas pipeline, combined with small scale and readily transportable, scalable microturbine electrical generation equipment, can effectively serve both functions. Gas Microturbine power generation and cogeneration represent a significant opportunity for small communities.

Microturbines are unique, small gas turbines being pursued in the under 300 kW size range. Leading manufacturers include Allied Signal, Capstone, Elliott, and NREC. The NREC microturbine is different since it is a split-shaft design that uses a power turbine rotating at 3600 rpm and a conventional generator.

Microturbines are capable of operating either in stand-alone mode without an electrical utility, or in parallel with the electrical utility grid. Microturbines have the benefit of being fuel flexible with only minor hardware and software modifications to adjust for a wide variety of hydrocarbon fuels. They can operate on liquid fuels including natural gas liquids, diesel, kerosene, naphtha or bum gaseous fuels ranging from low-btu landfill and digester gas to high btu fuels such as propane and raw solution gas. Natural gas fired units produce significantly lower emissions than other fossil fuel fired electrical generators. These easily transportable generators are designed to be "plug and play".

Installation is also simple, often consisting of little more than hooking up the gas or liquid fuel supply and wiring the power into a suitable power connection point. The engine is a high-speed turbine, operating at speeds in the 50, 000 - 120,000 rpm range. The construction is a single shaft with the compressor, expander turbine and a generator rotor supported by journal and thrust air bearings. Two of the microturbine product lines utilize air bearings thus eliminating the need for oil lubrication, which is an added benefit in cold climates. In Mercury Electric's Honeywell microturbine, a closed oil loop is used only for cooling the power electronics and the generator stator. Microturbines achieve a relatively high electrical conversion efficiency of close to 30% by employing recuperation. This entails feeding the hot exhaust gases through a heat exchanger and passing this energy on to the compressed combustion air. The Honeywell product has the ability to operate with either a diffusion flame that can burn gas with a wide range of specific gravities and heating values, or with a mixer flame that is designed to burn cooler and produces significantly less NOx using pipeline specification natural gas. The whole turbine engine core is an easily field removable single sealed unit.

Source: Putt Report

Capstone 30 kw Microturbine

The Economics of Micro Turbines

Field servicing consists of removing the old core and exchanging it for a factory rebuilt unit. The combustor is external with a replaceable liner to reduce maintenance costs. The turbine engine is operated by a dedicated computer that can start the turbine, monitor and protect it. The onboard computer also matches the power output load to the most efficient engine speed.

When evaluating remote generation costs, the opportunity for savings occurs when the need for redundancy is taken into account. Assuming a typical load of 300 kilowatts at peak, a facility which depends on on-site generation would normally have two complete 350kW or 400 kilowatt generating units. With microturbines, that same facility could place five or six units totaling 375 - 450 kilowatts and maintain the level of reliability and redundancy of the two larger units.

Finally, multiple microturbine units can be programmed to optimize operation based on load demands. Specifically, they can be set up to always run near their peak level of efficiency, by turning additional units on and off in response to load demands. With a larger reciprocating engine, a smaller load demand will be met by reducing the power of the engine. Below about 60 - 70 % of full output, however, reciprocating engines begin to lose efficiency, and below 50% the efficiency loss is significant.

Given the wide range of possible applications and needs in the North, it is difficult to make blanket generalizations about the economics of microturbines for power generation. It is fair to say that under a variety of conditions, microturbines offer numerous advantages over conventional reciprocating generators, and some of these advantages can be stated in economic terms. For example, Mercury's microturbines can be installed in Southern locations for as little as $1000 - $1200 per kilowatt or around $75,000 - $90,000 per 75 kW unit. Due to higher transportation costs, it is assumed that this cost could be 15 -20% higher for remote Northern locations. In addition to the premium for installation, it is necessary to assume higher maintenance expenses to take higher shipping and handling expenses. For the purposes of the sample economics below, we have conservatively assumed a maintenance cost of $0.035/kWh vs. a typical cost in the South of $0.014/kWh.

RENEWABLE ENERGY

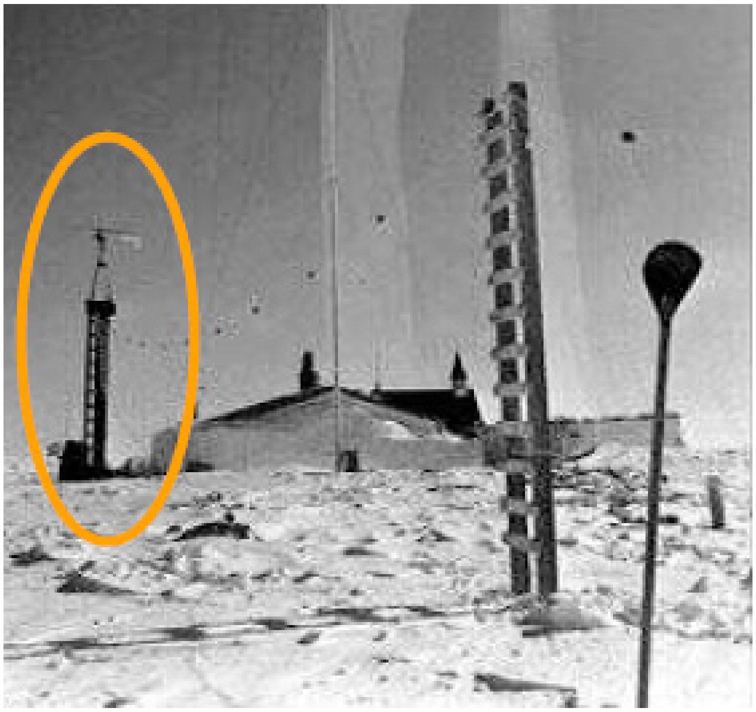
The NWT is blessed with an abundance of renewable energy sources, including biomass, solar, wind and water. Although biomass (wood) will continue to be important fuel sources for space heating, solar, wind and water have great potential for electrical energy generation.

Solar photovoltaic systems are currently being used in many remote and off-grid locations in the NWT. The two-year Renewable Energy Technology Conversion Assistance Program demonstrated that renewable energy systems are economical and dependable sources of energy for year round dwellings that are not connected to community electricity grids. Users have found that hybrid wind and solar energy systems, backed up with conventional generators, are dependable, easy to use and affordable. These renewable energy systems work most effectively when combined with battery storage capacity, which stores energy when the sun shines and the wind blows.

Assessments of wind resources are underway in several locations in the Northwest Territories with the goal of eventually testing integrated wind - diesel energy systems in several communities and remote sites.

Renewable energy can have significant positive economic benefit - reduced imports, local employment, new skills, reduced costs plus environmental savings.

Solar Array for a Local Home Owner - RWED Photo



The photo at left shows the early application of wind technology of the Hudson Bay Company. Below is a photo of a modern Vestas turbine being installed near Whitehorse; this unit can generate 1,300,000 kWh of power per year.

Source: GNWT Archives and the Yukon Energy Corporation.

NWT HYDRO

Source: NWT Power Corporation; NWT and Towards and Energy Strategy for the NWT (GNWT Publication).

The NWT hydroelectric generation potential has been known for years, and is documented in reports dating back to 1972. With as much as 11,000 megawatts in undeveloped sites, this potential is world class. The Report on Electrical Generation, Distribution, Regulation and Subsidization in the NWT, known as the Robertson Report, highlighted this potential in 2001 and laid the initial framework for how this potential might be developed for the benefit of all Northerners. Copies of this report can be found on the main Government of the NWT website (www.gov.nt.ca) Recent events and developments also seem to indicate that there is a potential market for hydroelectric power in North America:

- The recent US focus on developing a continental energy market;
- Deregulation trends and the desire to ensure energy can be transmitted across jurisdictions without undue impediments; and,
- Canada's ratification of the Kyoto Protocol will lead to a demand for clean, emission-free power.

During the summer of 2001, a hydro presentation was made in most NWT communities that provided an overview of the hydro potential available in the NWT and how that potential might be developed in an environmentally responsible manner. Key aspects of this presentation included the provision of revenues to GNWT and Aboriginal governments and the potential to reduce energy costs to NWT consumers. After this initial round of consultation, the GNWT committed that any additional research with regard to the impacts and benefits of NWT hydro development must be done in partnership with Aboriginal governments.

Transmission Lines will be critical to hydro development Source: Microsoft

Sites with Short Term Hydro Potential

As identified by NCPC

The NWT Power Corporation (NWTPC) has identified three projects with short term development potential (possible within 10 years).

Site 7 - Upper Snare River Hydro

This project involves the construction of a 12.5 MW hydro site on the upper Snare River and the construction of 75 km transmission line to connect the site to the existing Snare hydro sites. This project will provide power to the City of Yellowknife and will offset the need to provide diesel generation to serve the growing load in Yellowknife. This project is similar to the Snare Cascades project the Corporation did in 1994-1996 with the Dogrib Power Corporation. It will require more expenditures to receive regulatory approval than occurred in 1994 as the Snare Cascades site was located between 2 existing hydro sites. As this project has NTPC as a customer with Yellowknife being the primary market, the project is minimal risk and will be able to secure financing at reasonable interest rates.

When it is constructed the need to transport and store diesel in Yellowknife will be reduced as will the need to run the Jackfish diesel plant. Preliminary estimates are for the hydro facility to cost $71 million and the transmission line $19 million. Construction time is estimated at 30-36 months and will provide both skilled and unskilled jobs.

Taltson

This project involves the construction of a new 36 MW hydro site and a 550 km transmission line to connect the site to the proposed Snap Lake diamond mine and the 2 existing diamond mines. This project would provide power to the mines reducing their diesel consumption by 75 million litres.

However, there are a number of challenges to the development. The project requires a significant investment approximating $300 million (hydro facility $150m and T-line $150m).

NWTPC has indicated project financing will require an extension to the projected life of the mines or the development of new properties. Further, development of this project will require approval by the Mackenzie Valley Land and Water Board (MVLWB). After environmental approval, which is expected to take 2 years, the construction time is 30-36 months.

Great Bear River

This project involves the construction of a new hydro facility of 126 MW and a 600 km transmission line. This project would provide power to the proposed pipe line compression stations north of Tulita (3). It would also provide hydro power to up to 10 communities along the line. This project would be easier to finance than the Taltson project as the power purchase contract would be for a longer period (25 years) and the contract would be with either the gas suppliers directly or the pipeline. As the market perceives an on-going need for gas the contract to supply power will be more marketable. The estimated cost of the project is $480 m (hydro facility $300 M and T-line $180 M) and would take 30-36 months to construct after approval by the Mackenzie Valley Land and Water Board (MVLWB).

Existing and Possible Hydro Generation Sites - See facing page
Communities are shown as red dots, possible hydro developments are larger blue dots.

NWT Hydro Export Markets

In recent years there has been growing interest in development of an export market for NWT hydro electricity. The capacity of the Taltson system alone can be increased by 10 times with little or no environmental impact. Furthermore, there is little chance the demand for energy will drop considering that energy demand is expected to rise in both the developed and developing world. Couple that fact with the political or societal instability of many regions which supply energy resources and the economic, environmental and social concerns associated with use of nonrenewable energy sources, and the NWT becomes a prime location to capitalize on the long term, clean energy potential of hydro power.

Before the potential of NWT hydro production can be achieved, significant infrastructure investment is needed to ensure the NWT can meet the opportunity to supply energy to the North American market. The NTPC does not currently have the financial capability nor the flexibility to develop the potential of large-scale hydro projects on its own. As part of its long-term strategic plan the NTPC is endeavouring to create that legal and corporate capacity through the establishment of its non-regulated subsidiary, the NWT Energy Corporation (03) Ltd. (NTEC). NTEC was created specifically to pursue the development of hydro power. The Corporation is under the leadership of the Hon. Richard Nerysoo, Chairman of NTPC. NTEC is working specifically on several potential NWT hydroelectric developments, and is seen by the NTPC as the appropriate partner for investors seeking to capitalize on the NWT's hydro potential.

As NTPC Chairman Nerysoo puts it in the company's 2003 Annual Report:

> "A key initiative of the Board this year has been to re-focus the activities of the NWT Energy Corporation Ltd. This Corporation is being managed out of the Chairman's office and is working specifically on several potential NWT hydroelectricity developments. The future of the Northwest Territories Power Corporation and the NWT Energy Corporation are bright."

A number of projects are already underway. The NTEC notes in a review of its activities:

> "One development is the expansion of the Taltson hydro generation facility that is being progressed in partnership with the Akaitcho Regional Investment Corporation and the South Slave Metis Economic Corporation. The second major development that NTEC is working on is the development of hydro generation on the Great Bear River. In this project NTEC is working with the Deline Land Corporation and the Tulita Yamouria Secretariat."

Source: Northern Powerhouse - the Untapped Energy of Northern Rivers By Cambridge Strategies Incorporated

Energy from Mine Waters

A low-temperature geothermal resource associated with abandoned coal mines at Springhill, Nova Scotia continues to provide direct use geothermal energy for space heating in an industrial development in that community. A similar project has been proposed for Nanaimo, B.C. where there is an abundance of warm water in extensive underground mine workings beneath the city. The mines at Springhill, which ceased operations in 1958, are flooded and contain about 4,000,000 m3 of water. Since 1989, this water has been recovered at the surface at a temperature of about 18 C. The heat in the water is derived from the normal heat of the host rocks, and the temperature is controlled by natural convective mixing of the water. Water is pumped from the mines to act as the primary input to heat pumps for both heating and cooling of commercial buildings (Jessop et al., 1995).

The water in the mine workings acts as a large reservoir of heat that is drawn on and replenished seasonally, rather than being depleted. In addition to a short payback period (approximately one year, Jessop (1998)), there are nonmonetary benefits: the extraction of energy from the mine produces no combustion gas and leaves no chemical residue on the surface. Jessop et al. (1995) estimated that in the winter heating season carbon dioxide emissions from a conventional oil-based heating system that supplies 890 GJ would release about 500 tonnes of carbon dioxide. In the summer, an air conditioning system driven by electricity produced from coal, as is most electricity in Nova Scotia, implies the release of 240 tonnes of carbon dioxide (for a total of 740 tonnes). The emissions necessary to produce the same benefits of heating and cooling from the geothermal source (electrical energy needed to drive the heat pumps and water pumps) total 370 tonnes. This results in a net reduction in carbon dioxide emissions to the atmosphere of 50%.

Source: THE CURRENT STATUS OF GEOTHERMAL EXPLORATION AND

DEVELOPMENT IN CANADA

D.M. Allen; M.M. Ghomshei and T.L. Sadler-Brown, A. Dakin, D. Holtz

Canadian Geothermal Energy Association
(Department of Earth Sciences), Simon Fraser University, 8888 University Drive,
Burnaby, British Columbia, Canada V5A 1S6

The Con Mine in Yellowknife could provide a source for mine water heating. (Photo RWED)

Challenges

Human Resources

The energy industry is very technical, and ongoing operations require a high proportion of skilled positions, often highly specialized. Demand for human resources can be categorized in two distinct areas: construction of generating capacity, and maintenance. Construction of generating capacity, such as hydro projects, generally requires a large workforce with specialized skills unavailable in the NWT, requiring importing workers. This is also the case with the proposed Mackenzie Valley gas pipeline, which will require thousands of workers over a two to three year period.

Maintenance of operations requires a smaller workforce relative to construction, but engineering, specialized technical skills and qualified tradesmen are required. The workforce does not shrink or expand continuously, but rather it changes in pulses relative to the establishment or decommissioning of generating capacity.

Skilled tradesmen are in short supply in the NWT, as are homegrown engineers and technicians in energy related fields.

Capital

Investment is an issue. On one hand, large-scale hydro development will require hundreds of millions of dollars, and guarantees of a market. The economics of potential investments will have to be examined on an individual basis.

With regard to micro turbine development, the investment is significantly lower, both for transmission and resource access. However, the investment may be quite large in relation to market size.

Defining Green Power

Green Power is electricity, generated from renewable sources, that mitigates climate change by producing few or no greenhouse gas emissions. It is generally further defined as having minimal effect on:

- local and regional air quality (hazardous air pollutants, particulate matter, and precursors to the production of ground level ozone/smog, and acid rain);
- water quality;
- watersheds, river systems, and fisheries;
- flora and fauna;
- geophysical features;
- noise;
- visual esthetics; and
- any additional build-up of hazardous or toxic waste.

Most definitions of Green Power identify generation technologies that minimize these impacts relative to conventional electricity supply systems. Examples of specific technologies and resources include:

- Solar: photovoltaics, thermal electric generators (e.g., including solar water and air heating, specific building designs).
- Wind: individual turbines and wind farms.
- Environmentally-desirable and/or small hydroelectricity (various definitions): run-of-the-river hydroelectric facilities of less than 20MW that do not require a dam for storage and the electricity output relies on the seasonal flows of water in the river; 12 and small hydoelectric facilities of less than 30 MW or meeting the definition of Low-Impact Hydropower.

Source: The Pembina Institute Green Power Guidelines for Canada, 2000

Regulations and Taxation

There are 3 natural gas distribution systems in NWT communities; Norman Wells, Inuvik and Hay River. No single agency regulates prices for gas within the NWT.

The Public Utilities Board (PUB) is an independent agency of the GNWT. One of the PUB's main responsibilities is regulating the rates charged to customers by the electric and natural gas utility companies in the NWT. In order to change their rates, utility companies must first file a General Rate Application with the PUB. After evaluating the application and holding public hearings to obtain the comments of customers and other interested parties, the PUB will use the information collected to issue a written decision either approving or rejecting the application. In accordance with the Public Utilities Act, no public utility may collect charge or enforce rates other than the rates approved by the PUB. The rate application process is very costly for the utility.

The National Energy Board (NEB) regulates the tolls and tariffs charged by pipeline owners to move petroleum products. The NEB also has regulatory powers over electrical transmission lines over a certain distance, and those which cross interprovincial and international borders.

The federal government implemented the *Mackenzie Valley Resource Management Act* with the intention of providing Northerners decision-making participation and responsibility in environmental and natural-resource matters.

The legislation establishes co-management boards for the Sahtu and Gwich'in settlement areas with responsibilities for land use planning and for issuing land use permits and water use licences.

In the rest of the Mackenzie Valley, an umbrella board, the Mackenzie Valley Land and Water Board, was established in April 2000. This body issues land use permits and water licences in those areas of the Mackenzie Valley where comprehensive claims have not been settled.

The MVRMA also establishes a Valley-wide public board to undertake environmental assessments and panel reviews. This is the Mackenzie Valley Environmental Impact Review Board. The *Canadian Environmental Assessment Act* no longer applies in the Mackenzie Valley except under very specific situations.

Fuel Cells - Future Technology

Fuel cells are unique electrochemical devices that convert fuel into electricity in ways completely different from the thermodynamics of the Carnot cycle and prime mover technology. In fuel cells, hydrogen and oxygen (typically) are separated by an electrolyte – inducing an electrochemical potential that is converted into direct current electricity by hydrogen protons moving through the electrolyte (to combine with oxygen and form water) and electrons flowing through a separate electrical circuit. This is the basic fuel cell concept, but a practical operational fuel cell system for the stationary power generation market that uses economic fuels such as natural gas is still under development.

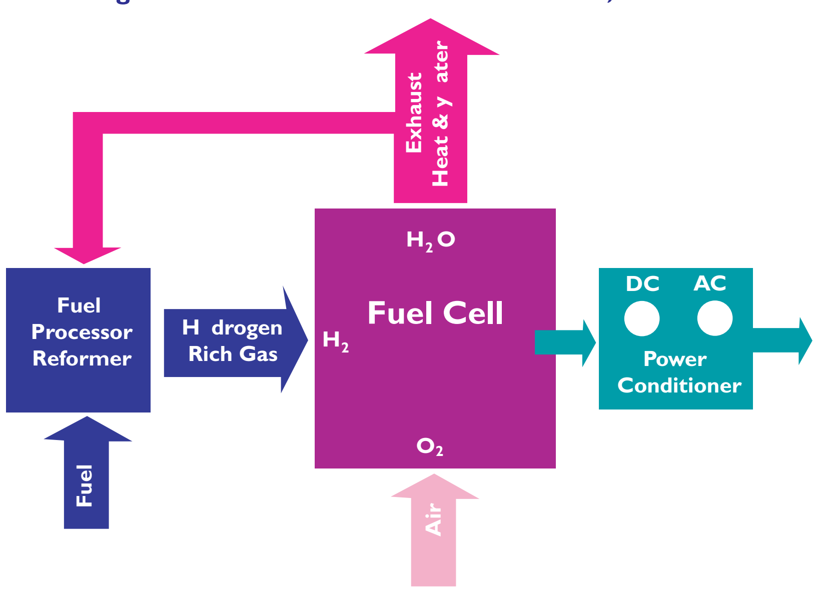
The figure below illustrates this basic system composed of a fuel processing and conditioning subsystem, the fuel cell, a heat and water recovery subsystem, and a power conditioning subsystem to convert DC into usable AC power. These subsystems may include an array of pumps and compressors to move fuel, air, and water.

Fuel cells have long been a highly attractive power generation concept. Fuel cells feature the potential for high efficiency (35-60 percent), low (to zero) emissions, low noise emissions, and high reliability due to (theoretically) limited moving parts. However, the sobering fact remains that existing engine and turbine technology were actually invented after fuel cells. That is, the rate of technology development and market acceptance for prime movers has been considerably greater than fuel cells. Prime mover technologies have moved far down the price-volume curve, with equipment readily available at prices of $200-400/kW. The only commercially available fuel cell, the ONSI PAFC introduced in 1991, is priced 10-20 times higher. The fuel cell area is rich with opportunity – and risk.

GRI's focus has been on pursuit of solid oxide fuel cells due to their potential for low first cost and high efficiency. Low first cost is achieved by a simplified balance-of-plant system – including use of internal reforming and reduced need for fuel clean-up (e.g., SOFC are more tolerant to CO). Manufacturing cost studies indicate the potential for system prices of $700/kW. Until fuel cell prices decrease, their market application is likely to be focused on unique or niche markets where customers are willing to pay a premium for quality power or reliability. Major pushes to commercialize PEM fuel cells over the next five years will demonstrate the ability of companies to simultaneously address technical, market, and business challenges.

Source: NATURAL GAS POWER SYSTEMS FOR THE DISTRIBUTED GENERATION MARKET by William E. Liss, GRI

Workings of a Fuel Cell Source:William E. Liss, GRI



CONCLUSIONS

The NWT has an abundance of hydrocarbon, hydro and renewable energy resources. In fact, the Western Canada sedimentary basin extends through much of the western NWT. The hydro potential of many rivers is world class and well documented.

While the NWT is poised to become one the largest exporters of natural gas in Canada, the cost of fuel in many communities would be prohibitively expensive without government subsidies.

While most communities were constructed along river routes, there has been very limited hydro development.

Grids connecting communities within the North are limited. While diamond mines import over 100 million litres of fuel annually, most of which runs their diesel-electric plants, the Talston hydro dam to south is running under-capacity.

1. Opportunities need to be examined for micro turbine electrical generation, especially in those communities with access to local resources. This would include Fort Liard, Colville Lake and perhaps, Fort Simpson. For example, electrical costs in Fort Liard are three times that of Yellowknife even though the community has ready access to gas resources.

2. To avoid economic rents or monopoly profits, it may be necessary to regulate local gas prices at a fair market return.

3. Opportunities exist to expand existing hydro production in the NWT. These need to be examined on a case-by-case basis.

4. At the same time, opportunities may exist to develop the electrical transmission grid in the NWT and displace imported fuels with local hydro energy. Significant opportunities need to be examined in relation to supplying the needs of the diamond mining industry and the North Slave.

5. The NWT has opportunities to export hydroelectricity to southern markets. Significant investments would be required in production and transmission infrastructure. Overall these projects have significant potential to promote NWT economic growth and development. As the primary market is export, these investments are similar to natural gas or hydrocarbon exports and should be treated in the same manner.

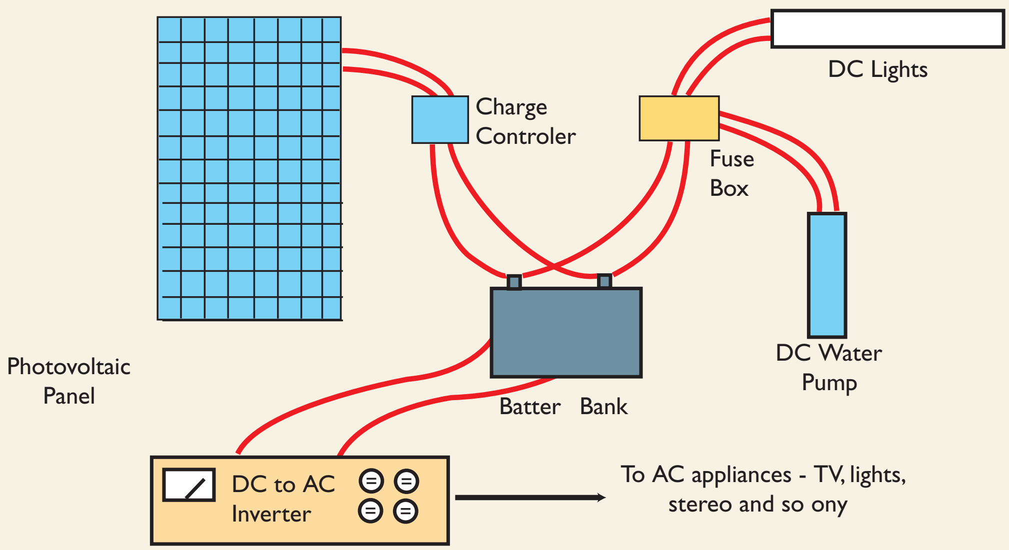
6. Where there exists surplus capacity within the hydro system, consideration should be given to encouraging residents to utilize the resource for auxiliary heat. This would act to reduce imports and overall costs.

7. Utilization of geothermal resources for heat recovery may provide an opportunity for heat recovery in several locations, including Yellowknife.

8. The use of renewable energy sources including solar, wind and biomass needs to be encouraged especially in remote communities and at facilities that are not connected to community energy grids.

Solar Array for a Local Home Owner - RWED Photo

Typical Solar System



Solar Electric or Photovoltaic Systems convert some of the energy in sunlight directly into electricity. Photovoltaic (PV) cells are made primarily of silicon, the second most abundant element in the earth's crust, and the same semiconductor material used for computers. When the silicon is combined with one or more other materials, it exhibits unique electrical properties in the presence of sunlight. Electrons are excited by the light and move through the silicon. This is known as the photovoltaic effect and results in direct current (DC) electricity. PV modules have no moving parts, are virtually maintenance-free, and have a working life of 20 - 30 years.