AN INTRODUCTION TO

NEXT GENERATION HYDRO

Technical Workshop #1

Participant Package

November 26, 2014

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YUKON DEVELOPMENT CORPORATION

NEXT GENERATION HYDRO powering our future

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BACKGROUND

EDUCATIONAL CONCEPTS

YUKON DEVELOPMENT CORPORATION ACT

HYDROELECTRIC POWER PLANNING DIRECTIVE

Corporation to plan Project

1(1) The Yukon Development Corporation is directed to plan one or more hydroelectric projects (referred to in this Directive as the "Project") as further described in this Directive.

(2) The goal of the Project is to ensure, together with supporting renewable and, to the minimum extent feasible, non-renewable sources of electrical power, an adequate and affordable supply of reliable and sustainable electrical power in Yukon.

(3) In planning the Project the corporation must

(a) evaluate the expected growth in residential, commercial, and industrial demand for electrical power in Yukon;

(b) plan for scalability, so as to allow for the increase of energy supply over time to meet that projected demand growth;

(c) assess the Project's financial needs and risks, and evaluate options for Project financing and financial risk mitigation;

(d) determine the anticipated positive and negative socio-economic and environmental effects of the Project, and develop specific means of maximizing its benefits, minimizing its adverse effects and mitigating any unavoidable negative impacts;

(e) in respect of the effects referred to in paragraph (d), have particular regard to the impacts on, and opportunities for, the First Nation or First Nations in whose traditional

LOI SUR LA SOCIÉTÉ DE DÉVELOPPEMENT DU YUKON

DIRECTIVE PORTANT SUR LA PLANIFICATION DE LA PRODUCTION DE L'ÉNERGIE HYDROÉLECTRIQUE

Planification d'un projet par la Société

1(1) Il est ordonné à la Société de développement du Yukon de procéder à la planification de projets hydroélectriques (ci-après appelés le « projet »), tels que décrits dans la présente directive.

(2) Le projet a pour objet d'assurer au Yukon un approvisionnement adéquat et abordable en énergie électrique fiable et durable, de même que des sources d'énergie électrique renouvelables et, si elles sont non renouvelables, que dans la mesure minimale nécessaire.

(3) Lors de la planification du projet, la Société doit :

a) évaluer la croissance projetée de la demande pour l'énergie électrique au Yukon dans les secteurs résidentiel, commercial et industriel;

b) planifier pour la variabilité d'échelle de manière à permettre une augmentation de l'approvisionnement en énergie au fil du temps et répondre ainsi à la croissance projetée de la demande;

c) évaluer les besoins et les risques financiers, ainsi que les possibilités pour le financement du projet et l'atténuation des risques financiers;

d) déterminer les effets socioéconomiques et environnementaux prévus du projet, tant positifs que négatifs, et développer des moyens concrets pour optimiser leurs avantages, réduire leurs effets indésirables et atténuer les impacts négatifs inévitables;

e) quant aux effets mentionnés à l'alinéa d), tenir compte en particulier des impacts sur les Premières nations lorsque le projet est situé sur leur territoire traditionnel et des possibilités qui territory the Project may be located;

(f) engage with First Nations to explore options for Project location as well as opportunities for partnership in Project planning and execution; and

(g) consider one or more specific possible locations for the Project, taking into consideration the above criteria as well as proximity to the existing and expected future customer base.

(4) The corporation must deliver its plan for the Project as a written report to the Minister at a date to be agreed upon by the Minister and the corporation, and include as a component of that report the business case for the Project.

Planning resources and communication

2 Within 90 days after the date of this Directive, the corporation must submit to the Minister a written work plan for the planning of the Project, including

(a) a description of the financial, human and other resources that the corporation expects to require in order to execute this Directive;

(b) a schedule of planning stages and, if the Minister and the corporation agree, interim deliverables, including a proposed date for the submission of the written report, to be amended as required; and

(c) plans for communication between the corporation and the Minister and communication with the public.

Minister may change deadlines

3 The Minister may extend or waive any time limit described in this Directive.

leur sont offertes;

f) collaborer avec les Premières nations pour évaluer les options portant sur l'emplacement du projet ainsi que des possibilités de partenariat pour la planification et l'exécution d'un projet;

g) examiner un ou plusieurs emplacements possibles pour le projet, en tenant compte des critères ci-dessus, ainsi que de la proximité de la clientèle actuelle et à venir.

(4) La Société doit remettre au ministre son plan du projet consigné dans un rapport écrit à une date convenue par le ministre et la Société. L'analyse de rentabilité du projet est un élément faisant partie du rapport écrit.

Planifications des ressources et des communications

2 La Société doit remettre au ministre, dans les 90 jours suivant la date de la présente directive, un plan de travail écrit portant sur la planification du projet, notamment :

a) une description des ressources financières, humaines et autres que la Société prévoit avoir besoin pour réaliser la présente directive;

b) un calendrier des diverses étapes de la planification qui peut être modifié au besoin et, si le ministre et la Société s'entendent, des éléments livrables de projet par intérim, notamment une date suggérée pour la remise du rapport écrit;

c) des plans pour la communication entre la Société et le ministre ainsi qu'avec le public.

Le ministre peut modifier les délais

3 Le ministre peut renoncer à tout délai décrit dans la présente directive ou le prolonger.

NEXT GENERATION HYDRO - ENGAGEMENT AND TECHNICAL PROCESS OVERVIEW

Two teams, engagement and technical, are working together to achieve the work identified in the Next Generation Hydro Work Plan.

The chart below demonstrates the key activities in each stream of work over the course of 2015.

The **Technical Team** will work to the end of 2015 to narrow the number of potential hydro sites based on the criteria identified in the Yukon Hydroelectric Power Planning Directive. The team will draft a number of technical reports that will assess the feasibility of the short listed potential hydro projects against the Directive criteria.

The **Engagement Team** will work along-side the technical team to inform and receive input from First Nations, as well as stakeholders and the public, as technical papers are produced. Engagement feedback will be collected and reported in the Next Generation Hydro Discussion Paper and will be considered in the development of the Next Generation Hydro and Transmission Viability Study.

NEXT GENERATION HYDRO - ENGAGEMENT AND TECHNICAL PROCESS

OCTOBER 2014 – DECEMBER 2015

Technical

OCTOBER – DECEMBER, 2014

- Review and analysis of all potential hydro sites in the Yukon against Directive and Screening Criteria
- Research and analysis of Technical Paper #0: Site Screening Inventory Report
- Research and analysis of Technical Paper #1: Economic Growth Scenarios & Energy Demand Forecasts

JANUARY – FEBRUARY, 2015

- Technical Paper #0 - Site Screening Inventory report completed and short list of potential hydroelectric projects announced
- Release of Technical Paper #1 - Economic Growth Scenarios & Energy Demand Forecasts

MARCH – MAY, 2015

- Research and technical analysis of Technical Papers #2–#6

JUNE, 2015

- Release of Draft Technical Papers #2–#6

JULY – SEPTEMBER, 2015

- Development of Next Generation Hydro and Transmission Viability Study based on the results of the Technical Papers #0–#6
- YDC Board reviews Viability Study and Next Generation Hydro Discussion Paper and makes recommendations for Business Case development

END OF 2015

- Development of Next Generation Hydro Business Case
- YDC Board presents Next Generation Hydro Business Case to Minster Responsible for YDC

Engagement

OCTOBER – DECEMBER, 2014

- Letters and calls to First Nations to introduce the project
- Calls and interviews with key stake-holder groups to record interests and concerns
- Technical Workshop #1 – Introduction to Next Generation Hydro Phase 1 Project Identification. The process and rationale are explained, input received and concerns are identified.
- Public Speaker Event #1 – (video to be placed on website)
- Public information household flyer

JANUARY – FEBRUARY, 2015

- Technical Workshop #2 – January, 29-30:

  Day 1: Presentation of the Short List Report

  Day 2: Presentation and input sought on the Draft Technical Paper — Economic Growth Scenarios & Energy Demand Forecasts
- Public Speaker Event #2 - Jan 29 – Presentation of the Site Screening Inventory & Draft Technical Paper – Economic Growth Scenarios & Energy Demand Forecasts
- Public Information household flyer
- On going meetings with affected First Nations and communities

MARCH – MAY, 2015

- Yukon First Nations Energy Forum Part 2 – Energy Investment Opportunities and Best Practices
- Public Speaker Event #3 – First Nation Energy Investment (video to be placed on website)
- On going meetings with affected First Nations and communities

JUNE, 2015

- Technical Workshop (2 day) – Presentation and feedback on Draft Technical Papers #2–#6
- Public Speaker Event #4 – Towards a Next Generation Hydro and Transmission Viability Study (video to be placed on website)
- On going meetings with affected First Nations and communities

JULY – SEPTEMBER, 2015

- Release of Next Generation Hydro Engagement Discussion Paper (summary of engagement feedback received)
- "What we heard" communications to the public from the Discussion Paper
- Release of Next Generation Hydro and Transmission Viability Study
- Public information household flyer
- On going meetings with affected First Nations and communities

END OF 2015

- Next Generation Hydro Business Case Announcement

Technical Papers:

(#0) Site Screening Inventory
(#1) Updated Economic Growth Scenarios & Energy Demand Forecasts
(#2) Scalability of Next Generation Hydro Project Options
(#3) Jurisdictional Transmission Line Technical Logistics Analysis
(#4) Jurisdictional Transmission Connection Market Assessment
(#5) Project Cost per Hydro Development Phase
(#6) Positive and Negative Socio-economic and Environmental Effects

YUKON DEVELOPMENT CORPORATION

NEXT GENERATION HYDRO powering our future

GLOSSARY OF TERMS

Energy Basics

Capacity (Demand): The supply (or consumption) of electrical power at a given instant in time. Usually measured in watts (W), kilowatts (kW) or megawatts (MW) depending on context. The annual peak demand is a key factor in sizing power lines and generators.

Kilowatt (kW) – 1000 watts

Megawatt (MW) –1000 kW

Energy: The supply (or consumption) of electrical power over a period of time. Usually measured in kilowatt-hours (kWh) for residential usage or gigawatt-hours (GWh) for regional/territorial usage. The annual energy supply must at least cover the annual energy consumption.

Kilowatt hour (kWh) – amount of energy used or produced in an hour

Example: Energy is power x time (1 MW or 1000 kW x 8760 hours per year = 8.76 GWh)

Example: a 100 watt light bulb I 10 hours consumes one kWh of electricity (100 watts x 10 hours = 1000 watts per hour (Wh) or 1 kWh)

Dispatcheable Generation: Refers to sources of electricity that can be dispatched at the request of power grid operators; that is, generating plants that can be turned on or off, or can adjust their power output on demand.

Generation Resource: The primary energy source that is converted to electrical power. Commons generation resources include hydro, wind, solar, or thermal (e.g. natural gas, coal or diesel).

Intermittent Energy: Any source of energy that is not continuously available due to some factor outside direct control (i.e wind blowing, or sun shinning).

Load: The electrical energy required to power homes, businesses and industrial processes. Sometimes referred to as demand.

Load Profile: A visualization of load (energy demand) over time).

Demand Side Management (DSM): The attempt to reduce overall electrical consumption at customer sites via initiatives, rate structures and or codes/standards. Demand side management, when used during peak demand periods, is useful to delay or avoid upgrading power lines.

Electrical Grid or "The Grid": The connected network of transmission lines, substations and distribution lines that brings power from sources (e.g hydro plants, wind turbines, diesel generators) to users (homes, businesses and industrial projects).

Transmission Lines: Conductors strung on overhead structures (wood pole or lattice steel towers) or placed underground that deliver electric power over long distances from power plants to substations and are typically energized at 69 kV or higher.

Distribution Lines: Conductors strung on overhead structures or placed underground that deliver electric power from substations to user sites (e.g. homes, shopping centres, mines).

Resource Capacity: The quantity of a particular energy resource. It is usually reported on a site-by-site; regional or territorial basis in both capacity (MW) and energy (GWh) terms

Geothermal: The use of heat from the earth to generate electricity or provide space heating and cooling (Energy Strategy).

Biomass: Energy resources from organic matter, including wood, agriculture waste, and other living material that can be burned to produce electricity and heat (from the Energy Strategy).

Climate Change: A change in the average weather that a given region experiences. Climate change on a global scale includes changes to temperature, shifts in wind patterns, and changes to precipitation (from Climate Change Action Plan).

Independent Power Producer (IPP): An energy producer who generates electricity for sale to utilities or consumers such as the general public, businesses or industries (Energy Strategy).

Net Metering: When electricity consumers who own small, renewable energy generators such as wind or solar can receive a credit for a portion of the electricity they generate (Energy Strategy).

Renewable Energy: Energy that comes from sources renewed on an ongoing basis through natural processes. Examples include sun, wind, wood, flowing water, or relatively warm ground, air or water temperatures (from Climate Change Action Plan).

Sustainable Electricity: Is about pursing innovative business strategies and operating activities that meet the needs of members, stakeholders and the communities in which we operate, while protecting and enhancing the legacy we leave for future generations (Canadian Electricity Association)

The Public Utilities Act: Among other things defines a public utility as producing, generating, storing, transmitting, selling, delivering or furnishing electricity or gas to or for the public or a corporation for compensation. The act also defines the role of the Yukon

Utilities Board (YUB) and the regulation of public utilities via a franchise. There are several Orders in Council that direct the YUB as well. One is the Rate Policy Directive (1995) O.I.C. 1995/090 that ensures ATCO Electric Yukon and Yukon Energy Corporation cannot charge customers different rates and all Yukon residential customers who use 1000 kWh or less per month are charged the same no matter their location in Yukon.

Hydro Basics

Hydropower: A form of electrical power generated by converting the kinetic energy of moving water to electricity using a turbine. The capacity of the resource is influenced by the flow and elevation drop (head).

Storage Hydro: Is a type of hydroelectric generation where a storage reservoir is created to store water to accommodate fluctuating river flows.

Run of River Hydro: Is a type of hydroelectric generation where little or no water storage is used.

Micro Hydro: A category of very small hydropower generation that typically has a peak capacity of less than 100 kW and uses the natural flow of water.

Small Hydro: A category of hydropower generation that typically has a peak capacity of less than 10 MW and requires some form of weir in the stream or river.

Medium Hydro: A category of hydropower generation that typically has a peak capacity between 10 MW and 100 MW

Generation: The source of electrical power be it hydro, wind, solar, or thermal (fossil fuel).

Yukon Hydroelectric Power Planning Directive: Yukon government issued 'The Directive' to Yukon Development Corporation (YDC) in 2013. It Directs YDC to "plan one or more hydroelectric projects, together with supporting renewables and transmission. The directive has seven criteria for project selection.

Other

Sustainable Development: Beneficial socio-economic change that does not undermine the ecological and social systems upon which communities and societies are dependent (Umbrella Final Agreement).

YESAB: Yukon Environmental and Socio-Economic Assessment Board

YESAA: Yukon Environmental and Socio-Economic Assessment Act

YUKON'S ENERGY PARTNERS

Dawson City, as a result of the 1898 Gold Rush, was one of the first cities in North America to be electrified using hydro. Yukon's energy grid has come a long way from those humble beginnings. A number of hydro plants and transmission lines have been added to meet the needs of Yukon's emerging economy and today Yukoners benefit from a legacy of hydropower. Several key players have a role in ensuring that Yukon's electricity supply remains abundant, reliable, and cost effective for generations to come. Read more about each key player and the role they play below.

Yukon Government (YG)

Yukon government plays a leadership role in planning for Yukon's energy future by setting policy direction. The Yukon Energy Strategy and Climate Change Action Plan are two such policy documents. The government also runs the Energy Solutions Centre (ESC), which works on energy policy and provides Yukoners with energy information and programs. As well, ESC provides support for the government's Micro-Generation Policy and program and, when approved, the Independent Power Producer Policy.

Yukon Development Corporation (YDC)

YDC is a crown corporation tasked to ensure there is enough energy to meet Yukon's future needs for sustainable development that contributes to healthy communities and the creation of jobs and business opportunities.

By legislation, YDC is charged with looking at the role of energy to promote the development of Yukon resources on an economical and efficient basis; promoting employment and business opportunities for Yukon residents; assuring a continuing and adequate supply of energy in a manner consistent with sustainable development; and carrying out development directives issued to it by the Yukon government.

Yukon Development Corporation has been tasked by Yukon government to lead the Next Generation Hydro project.

Yukon Energy Corporation (YEC)

YEC is a public utility wholly owned by Yukon Development Corporation. YEC generates the majority of Yukon's renewable electricity for customers connected to the transmission grid. Renewable energy comes from three hydro facilities, and a small wind facility. Fossil fuel generators are used for back-up supply. Yukon Energy also distributes electrical energy to Dawson and Mayo.

ATCO Electric Yukon (AEY)

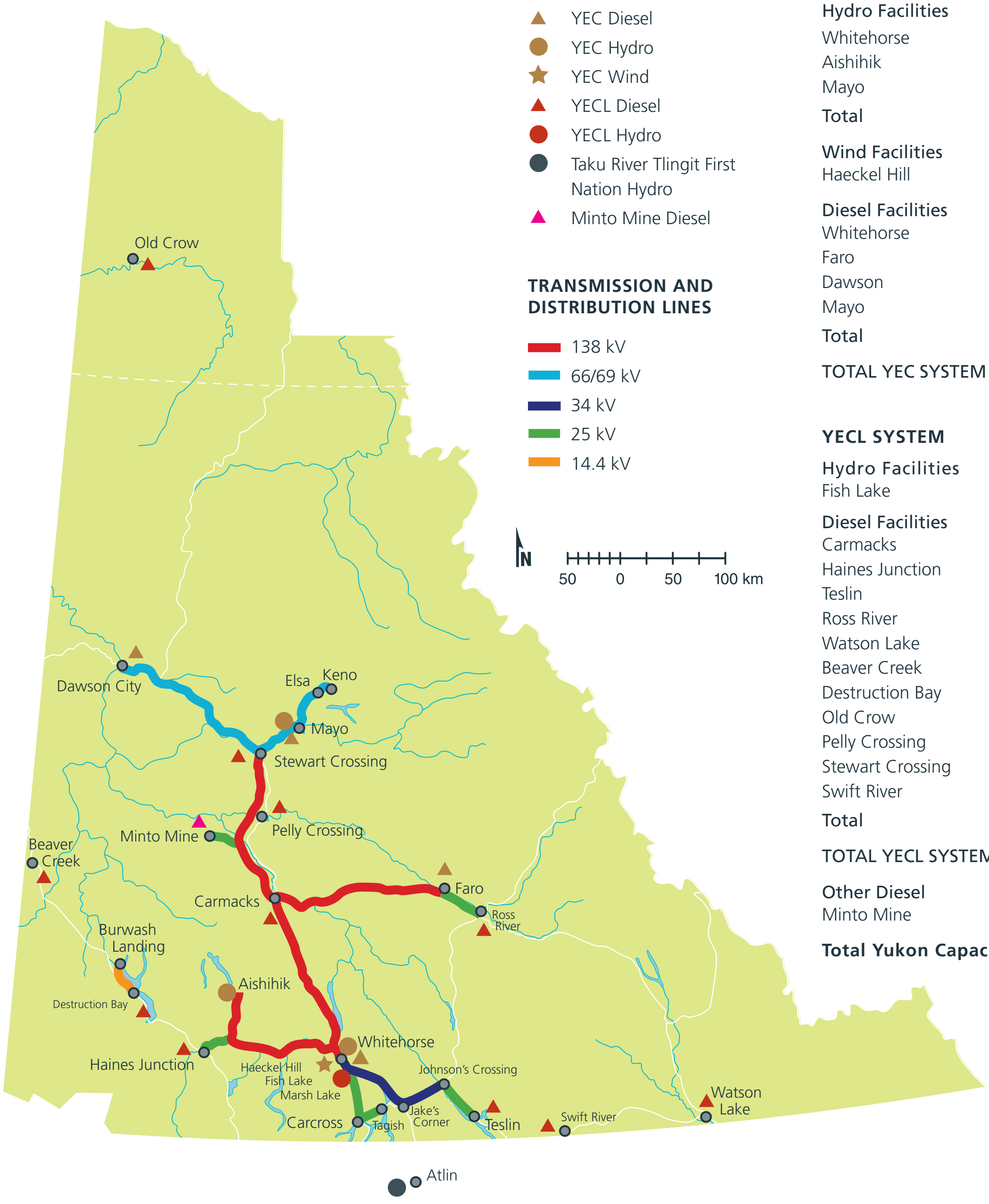
ATCO Electric Yukon (formerly Yukon Electrical Company Ltd.) is a private utility. Most of us get our electric bills from ATCO because they distribute power or connect our homes and businesses to the transmission grid. AEY generates electricity from fossil fuels for the communities of Old Crow, Watson Lake, Beaver Creek Burwash, and Destruction Bay. AEY also operates a small hydro plant at Fish Lake near Whitehorse.

Yukon Utility Board:

The Yukon Utilities Board is a regulatory board whose mandate is received by the Public Utilities Act. Their mandate is to review utility activities to ensure that rates charged to customers (rate payers) are fair and reasonable. The board consists of three to five members that are appointed by the Government of Yukon. The Board regulates Yukon's two electrical utilities: the Yukon Energy Corporation (YEC) and ATCO Electric Yukon (AEY).

Yukon's Transmission and Generation Facilities

2014



GENERATING STATIONS

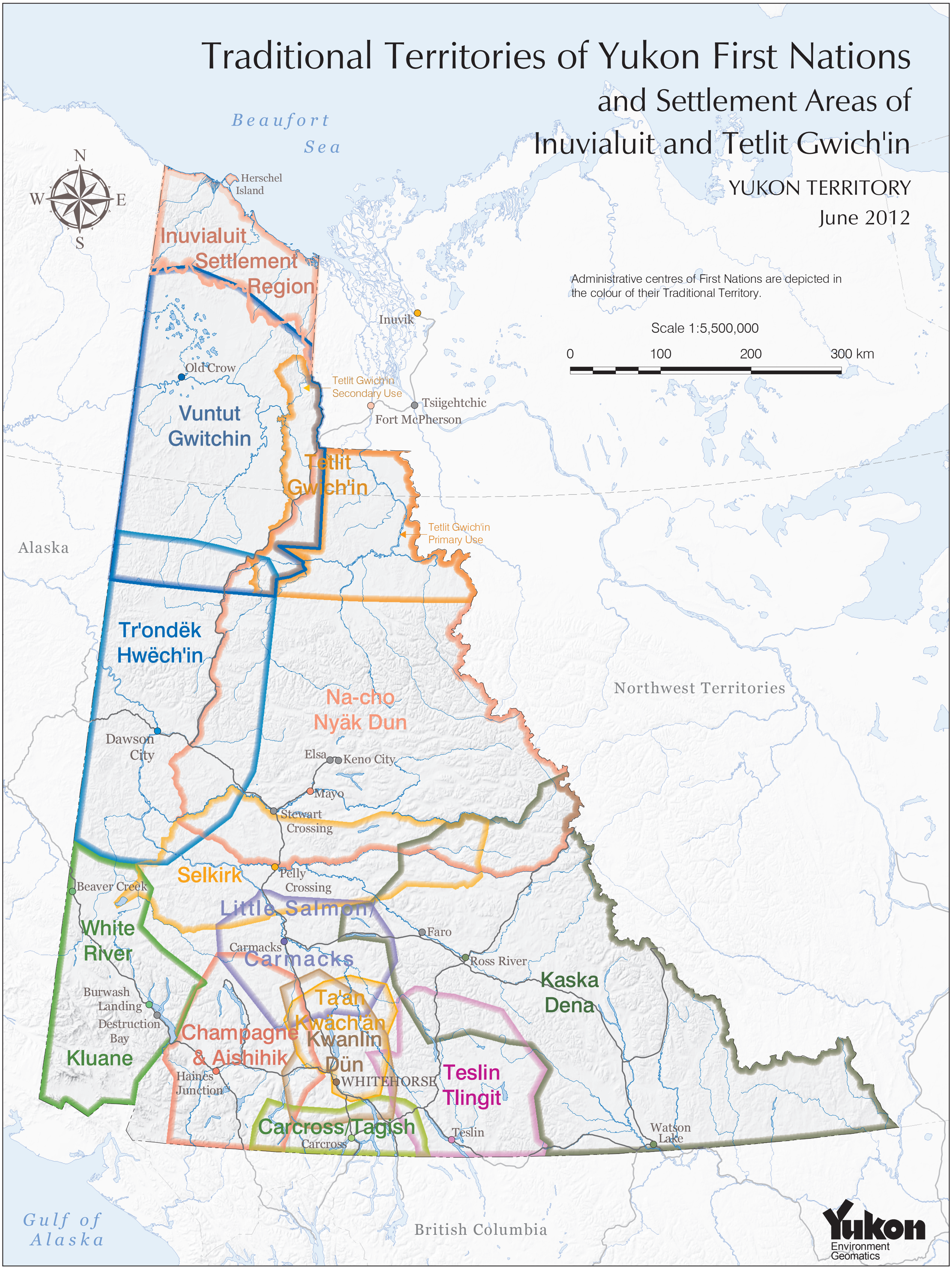
- YEC Diesel
- YEC Hydro
- YEC Wind
- YECL Diesel
- YECL Hydro
- Taku River Tlingit First Nation Hydro
- Minto Mine Diesel

TRANSMISSION AND DISTRIBUTION LINES

- 138 kV
- 66/69 kV
- 34 kV
- 25 kV
- 14.4 kV

YEC SYSTEM	(in MW)
Hydro Facilities	
Whitehorse	40.0
Aishihik	37.0
Mayo	15.1
Total	**92.1**
Wind Facilities	
Haeckel Hill	0.8
Diesel Facilities	
Whitehorse	23.0
Faro	8.5
Dawson	5.1
Mayo	2.5
Total	**39.1**
TOTAL YEC SYSTEM	132.0

YECL SYSTEM	(in MW)
Hydro Facilities	
Fish Lake	1.3
Diesel Facilities	
Carmacks	1.5
Haines Junction	1.5
Teslin	1.5
Ross River	1.0
Watson Lake	5.0
Beaver Creek	0.9
Destruction Bay	0.9
Old Crow	0.7
Pelly Crossing	1.2
Stewart Crossing	0.1
Swift River	0.3
Total	**14.6**
TOTAL YECL SYSTEM	15.9
Other Diesel	
Minto Mine	8.0
Total Yukon Capacity	**155.9**



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HISTORY OF HYDRO IN THE YUKON

Since the Klondike gold rush, hydro electricity has played a crucial role in powering the growth and development of our territory. Throughout this time hydro energy has supported many mines, who, as customers, have helped to pay for the hydro legacy that provides electricity to this day. Planning Next Generation Hydro can be informed by insights and lessons learned from our past.

1907 – 1920 A.N.C. Treadgold builds first hydro plant to supply power to the gold dredges. It was a 1.2 MW plant on the Twelve-Mile River.

1911 – 1966 North Fork Plant is built on the Klondike River to power the gold dredges.

1948 The Canadian Government forms North West Territories Power Commission (NWTPC) for the purpose of facilitating power development for mining and other interests

1949 Fish Lake #1 Power House is built near Whitehorse.

1952 NWTPC builds Mayo Lake and Wareham Lake control structures to serve needs of United Keno Hill Mine and Elsa, near Mayo.

1952 Fish Lake #2 Power House is built on McIntyre Creek near Whitehorse.

1954 NWTPC (NCPC) begins planning hydropower options in the Whitehorse area. At the time it was recognized that the Whitehorse Rapids project exceeded the present need and therefore would be an expense that would take time to recover.

1956 – 1958 Construction begins on Whitehorse Rapids project and timber is cleared to create Schwatka Lake. The Whitehorse Rapids project started small but was built to grow over time. When it opened in 1958 only two turbines were installed. The Whitehorse Hydro facility was initially built for 11 MW capacity, expanded to 19.5 MW in 1966, and then 40 MW in 1985. A fish ladder was put in place for the salmon migration as required by the Department of Fisheries. The project served Yukon Electric and National Defense Department customers.

1957 A second generating unit is added to the Wareham Lake hydro facility in Mayo. It is 5,150 KW or 5.1 MW. Records indicate care was taken to ensure the cost of the power plant didn't put ratepayers on the Mayo transmission system at risk if the mines were to close. At the time environmental assessment wasn't required and as a consequence an existing salmon run was cut off. Work has since been done to improve salmon spawning habitat.

1969 NCPC installs a third turbine at the Whitehorse facility and a transmission line to Faro is built to supply the town and the new Cyprus Anvil lead-zinc mine. To aid water storage for the Whitehorse Rapids dam, the Lewes control structure is re-built to regulate the water levels on Marsh Lake.

1970 – 1974 In the early 1970's NCPC began looking at Aishihik Lake as a site for a new hydro facility to meet demands as Yukon grew and the Faro mine operated. Environmental impact work was required for this project as the regulatory regimes were changing at this time (pending Inland Waters Act). For the first time there was a formal project forum held by the Water Board and a number of public interest groups called for more studies to be conducted before licensing. First Nation leaders argued for the settlement of land claims before the project could be approved. The Water Board eventually approved the project with a six-foot storage limit. With some controversy the underground power house and penstocks were built. In 1974, two 15 MW generators were installed.

1979 - 1985 Fuel prices were rising, which affected electrical cost with the burning of diesel, at peak periods when hydropower was not sufficient. In 1980 NCPC decided to add a fourth wheel (generator) to the Whitehorse Rapids facility. It was completed in 1985 bringing the capacity to 40 MW in summer and 20 MW in winter when flows decrease.

1987 NCPC is devolved and Yukon Energy Corporation is created as an arms length public utility.

1998 Throughout the 70's to the late 90's with some stops and starts along the way, the Faro Mine consumed this hydropower and helped to pay for the infrastructure as a rate-payer. Yukon government agreed to help Cyprus Anvil (later Curragh Resources Inc.) with infrastructure costs (road and energy). An investment that wasn't fully paid for by the time the mine closed its doors in 1998. The ripple effect - Yukon's population fell from 33,519 in 1997 to 29,960 in 2002, representing a decline of about 10 per cent. The loss of the mining customer and decrease in population put rate-payers (users of electricity) at risk, so a subsidy (rate relief) was given to customers until recently when the debt was fully paid.

2011 Additional powerhouse is added to the Mayo facility (Mayo B). This third turbine added another 10 MW of capacity. Water continues to be spilled from the Wareham spillway to maintain fish habitat.

2011 Mayo-Dawson Transmission line is connected to the Ashihik Transmission system — creating one connected grid in the Yukon. Minto mine assists in the development of this project.

2011 A third turbine is installed at Aishihik bringing capacity to 37 MW.

ELEMENTS OF THE ELECTRICAL GRID

The electrical grid is a system that connects where the electricity is generated (generation) to the point where the electricity is used (load). Electrical generators can be located hundreds of kilometers from the load that they supply. It is therefore necessary to move large quantities of electricity over long distances.

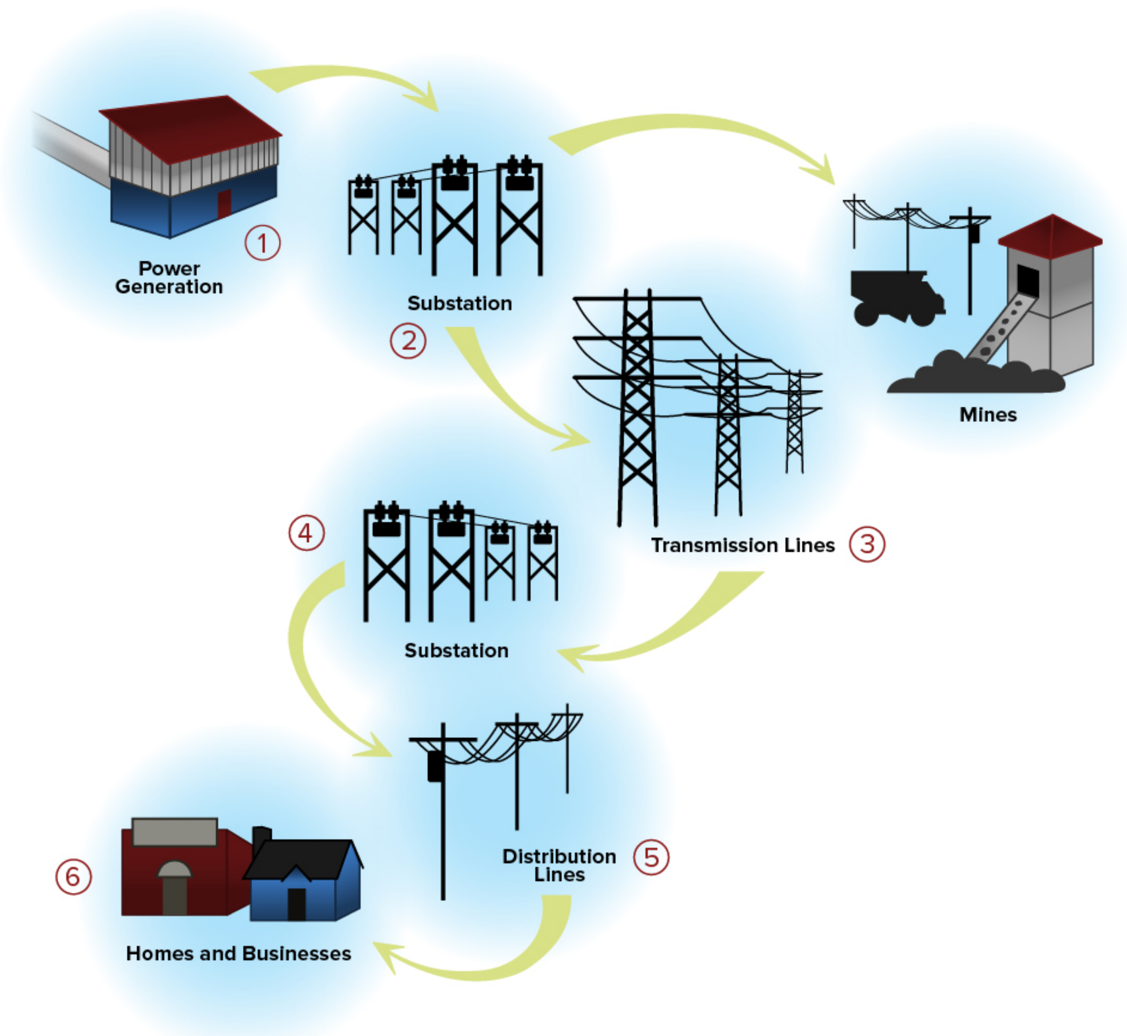


Figure 1 above illustrates how electricity is transmitted from generator to loads in six steps.

The steps can be summarized as:

1. **Power Generator:** Electricity is generated at a power plant (e.g. hydroelectric plant, wind turbine, diesel generator, natural gas generator, solar panels)
2. **Substation:** After the electricity is generated it is transformed from lower voltages to higher voltages for long distance transmission. In the Yukon, mines connect directly to the transmission system via a substation.
3. **Transmission:** The substation feeds the electricity onto transmission lines for long distance transport. Transmission lines transport the electricity most of the distance from the generator to the load.
4. **Substation:** Close to the loads (i.e. electricity user), substations convert the electricity from a high transmission voltage to a lower distribution voltage.
5. **Distribution:** The electricity is transported along distribution lines for the final delivery to the load (i.e. end user). Distribution lines are much smaller and operate at a lower voltage than transmission lines but higher voltages than your home. Distribution systems are the networks of wooden poles found in cities and towns that run down residential roads and ultimately connect electricity to homes and businesses. On the power pole closest to the end user, the electricity is converted to an even lower voltage (i.e. 120 volts AC) for use in homes and small businesses.
6. **Load:** The end user (e.g. homes, businesses, mines, etc.) receives electricity from the distribution system and uses the electricity to supply their electricity

MATCHING ENERGY NEED TO ENERGY AVAILABILITY

Electrical systems are built to continuously match the supply of electricity to customer demand. On a minute-by-minute, daily and seasonal basis our demand for electrical **energy** goes up and down depending on demand changes such as turning off and on lights, TVs, baseboard heating, stoves etc. To meet these changes in demand, the electrical system must have enough **capacity** to supply **energy** exactly when it is needed. As well, there needs to be enough stored energy to meet upcoming needs for future demand.

Energy and Capacity:

Electricity generation is measured via two related but different measures: **energy** and **capacity.**

Energy is a measure of power used over time and represents the "work" that could be done. For example, a 1 MW plant that operates for 1 hour is said to have produced 1 megawatt-hour ("MWh") of energy.

Capacity is a measure of the ability of a given power source to produce power, typically measured in watts ("W"), kilowatts ("kW"), or megawatts ("MW").

The difference between **energy** and **capacity** is important to understand and key to thinking about the requirements of an electrical generation source. Put simply, **energy** is what we consume to do work (e.g. cook food, light & heat our homes) and **capacity** is the assurance that the energy we want to use is instantly available when energy is required.

Dispatchable and Intermittent Energy sources:

Electric generation sources (hydroelectricity, wind, solar, diesel, natural gas) can be thought of in terms of their ability to supply energy on a longer-term basis, and their capacity to provide energy when the energy is needed.

Generation sources that can be called upon at any time to generate electricity are said to be **dispatchable**. These **dispatchable** generation sources have dependable capacity and deliver what is called firm energy because energy is consistently available when required. Examples of **dispatchable** generation sources that provide larger quantities of "firm" energy are hydroelectric projects with water storage, natural gas generation and diesel generation.

Generation sources that generate electricity only when their fuel supply is available, and not necessarily when the energy is needed, are called intermittent generators. Examples of intermittent generators are wind, solar power and some run of river hydro projects.

	Dispatchable Generation Hydro with Storage natural gas, and diesel)	**Intermittent Generation (Wind, Solar)**
Energy Source	Good	Good
Capacity Source	Good	Poor

*Table 1. Shows how well **dispatchable** generation and **intermittent** generation meet energy and capacity needs.*

Turning Electricity On and Off

Another important characteristic to consider when comparing different generation options is the speed at which various power sources are able to turn on and off and to change generation levels (e.g. ramp up and ramp down).

For example, coal and nuclear plants need days or weeks to start-up and shut-down. These power sources are run to meet “base loads” or the constant amount of power needed on any given day.

Other generation options, such as hydro-with- storage, simple cycle gas turbines, and natural gas reciprocating engines, can be dispatched quickly to meet short-term changes in demand for power. For example, they can be ramped up to provide lots of power in the morning when everyone wakes up, and ramped down once everyone goes to work. These variable types of generators have the ability to change the amount of energy supplied frequently in response to short term (e.g. hourly, daily) changes in demand.

LOAD - HOW WE USE ENERGY

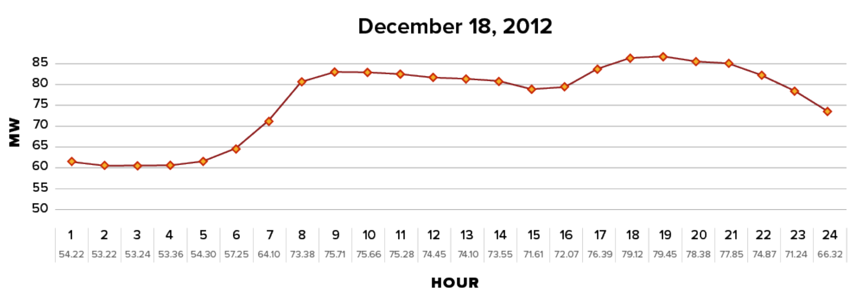
Although there are many different types of electricity users in the Yukon, they can be divided into three main groups:

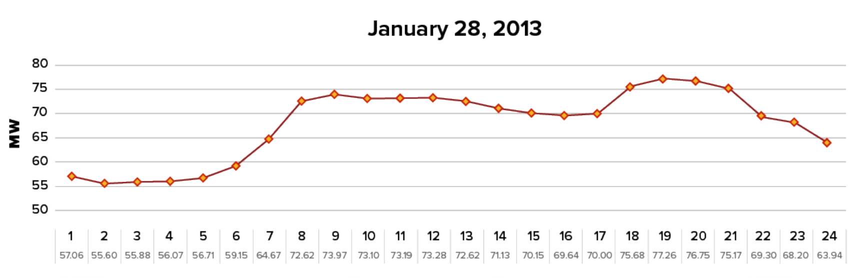
- Residential users
- Commercial users
- Industrial users

These three groups use energy differently and place different demands on the energy system depending on the time of the day, season, and as a result of specific events. For example, in a typical daily pattern, we use less energy when we are asleep with the lights off, and more energy when we get home from work at night and turn on the lights, begin cooking, watch TV and start a load of laundry. Similarly, on a seasonal basis Yukoners use more energy in the winter when it is dark (e.g. more lighting) and colder (e.g. more heating and time indoors) compared to the summer months. We must consider both seasonal and daily load profiles for the Yukon when considering our energy options.

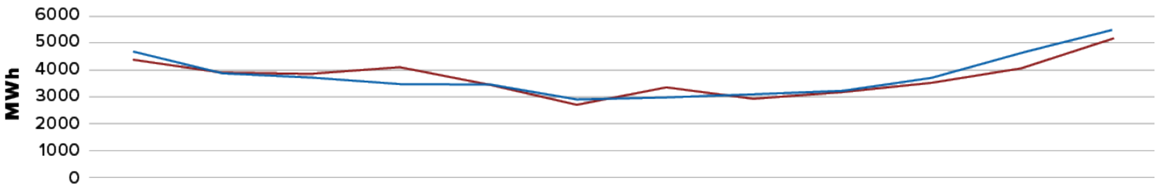
Figure 1 shows daily load profile for two different years.

DAILY ENERGY USE (LOAD)





MONTHLY ENERGY GENERATION
2012 AND 2013



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	46850	38803	37204	34837	34565	29120	29913	30993	32166	37290	46306	454617
2013	43801	39095	38622	41031	34694	27008	33711	29315	31893	35445	40829	51266

MONTH

Figure 2 shows seasonal load profile for 2012 and 2013.

HYDRO BASICS

Hydroelectric generation is the primary source of electrical energy across Canada and has been used in the Yukon since the Gold Rush. Hydroelectricity is a clean, renewable energy source that provides reliable power throughout the year.

Hydro electricity is created when water is used to rotate a turbine and generator. The force of the water spins the turbine, which then turns the generator to create electrical energy. Hydroelectric facilities can be run of river systems or storage reservoir systems. Run of river systems temporarily divert water from the river as it moves and requires no (or minimal) water storage.

Rivers naturally have flow that fluctuates. For example, in the Yukon the spring and summer water flows are higher when precipitation falls primarily as rain and when snow and glaciers are melting. In the winter flows are low due to freezing conditions. Water is stored from the summer in reservoirs to make up for low water flows in winter.

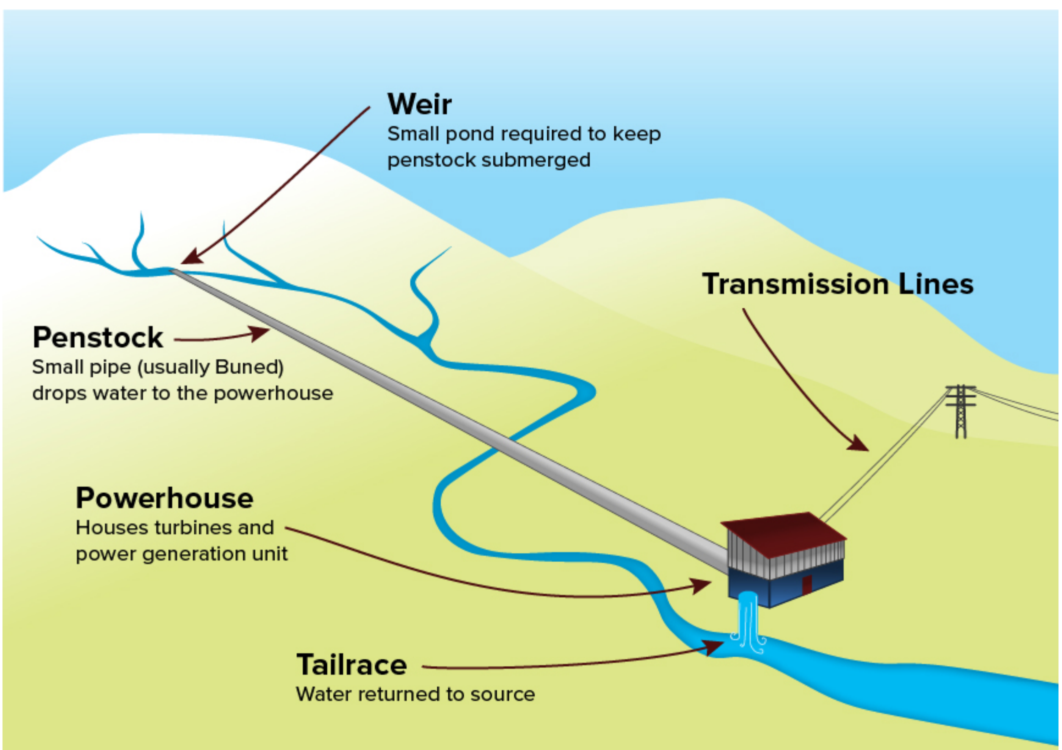
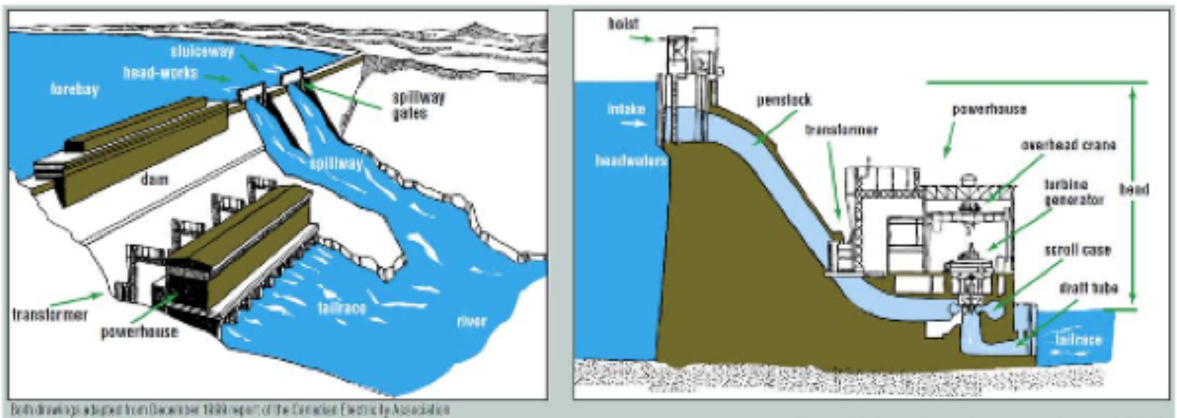
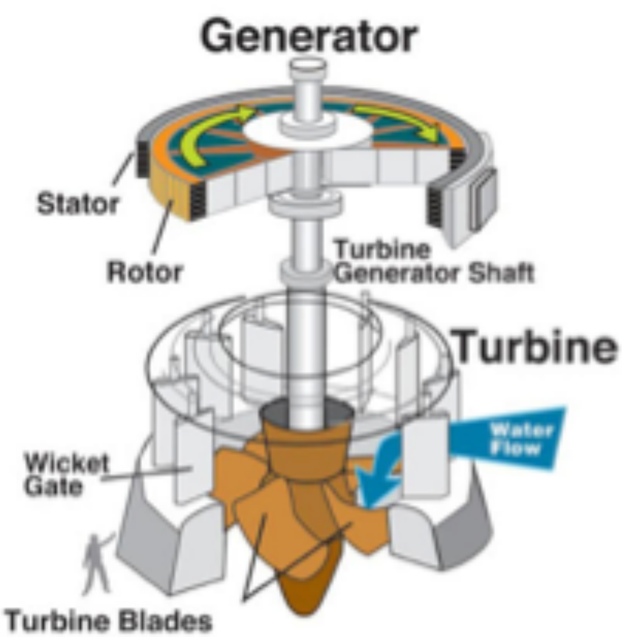


Figure 1 above shows a typical run of river hydro project. Water is diverted from the river through a penstock to a powerhouse and generating unit where it goes through the turbines and produces power.

Figure 2 and 3 below shows storage hydro. Hydro reservoirs store water throughout the year. The water is channeled into a penstock (a large pipe) that then flows into the turbines to generate power. Water is discharged back into the river or waterway at the end of the powerhouse.



(from Yukon Development Corp. 2001)



HYDRO PROJECT DEVELOPMENT TIMELINE

A hydro facility is a large undertaking. It can take a minimum of 10-15 years to select, plan and build a hydro project. The chart below shows a typical development timeline for a hydro project. The timeline can shift when considering the development and exploration of several options at the same time.

Phase	Timeline
Project Identification Review of potential hydro sites and the development of a business case for one or more projects.	1-2 years
Pre-Feasibility Study Further explore selected options and refine technical analysis for decision-making.	2-3 years
Project Selection and Confirmation Select on a project to move forward with.	1-2 years
Feasibility Study Further refine the technical analysis, examine business model options and partnerships.	2-3 years
Site Design and Planning Create a site plan and design for the hydro facility.	1-3 years
Assessment and Permitting Submit site plans to YESAA, affected First Nations and others for stakeholder consultation, assessment and permitting.	2-3 years
Construction & Commissioning Construct and commission the facility.	2-3 years
Operation	70+ years

TYPES OF HYDRO DEVELOPMENT STUDIES

Many hydro sites in the Yukon have been the subject of engineering studies with various level of detail, ranging from desktop-only studies to complete pre-feasibility studies supported by a field investigation program. An overview of the level of detail of each stage of engineering studies related to the development of a hydroelectric project is presented below. An overview of the associated environmental studies and permitting process for each step is also included.

1) Desktop study: Simple office calculations and layout determination completed based on existing topographical maps (1:50,000), available flow data (from Water Survey of Canada gauging stations, from the same river if possible, or nearby rivers otherwise), and available geological maps. No site visit is conducted. A site layout drawing may or may not be produced.

2) Reconnaissance/Conceptual engineering study: Study that involved first a reconnaissance site visit to observe the site main components, including river layout and abutments, geological features, and may include simple measurements (head drop). Complemented with simple office calculations to determine power benefits. A project layout is proposed based on existing topographical maps and observations from the site visit. A site layout drawing will be produced. An order-of-magnitude cost estimate (+-50-100%) is produced. A scoping level of assessment and regulatory approvals is usually completed to identify the main development issues, and provide recommendations.

3) Pre-feasibility engineering study: Detailed conceptual engineering study determines the viable layout and long-term power benefit based on a realistic operation scheme. Preliminary engineering is based on site mapping and site hydrology. The study is initiated by a detailed site visit with a team of experts including a geologist and hydro technical engineer. For larger project, a preliminary field investigation program will be completed, including preliminary topographical survey and geophysical investigations on site. The investigation program will only include a few boreholes at key locations (i.e. control structure site) and seismic lines for example. Planning of detailed geotechnical investigations for the feasibility study is usually conducted. A set of design criteria is established for the project, including a hydrological study. Preliminary design of main works is conducted to define key dimensions. A set of drawings is produced to cover all main works of the project. A cost estimate based on a bill of quantities is prepared at a +-30 to 50% is produced. The site visit will usually also involve an environmental specialist. The environmental and socio economic components for the effects assessment are defined. Baseline study may be conducted at the same time. Consultation and preliminary agreements with First Nation and other governments are usually put in place. Approvals and permits for geotechnical site investigations for feasibility study are obtained.

4) Feasibility engineering study: The study is initiated by a complete intrusive geotechnical investigations program and detailed topographic survey. It is conducted for the main works for the project, but also potential construction material sources, access roads and transmission lines. The engineering level of detail is upgraded based on the results of the investigation program. The design criteria are updated and expanded if necessary. Alternative layouts are considered and project optimization is conducted, which can include cost comparison analysis. Works are designed in more details and all components are now assessed. Continuous flow monitoring should continue and will allow updating power estimates. The operation scheme will be optimized. Detailed hydraulic studies (computer or scale modelling) will be conducted to optimize the main works and minimize construction costs. At the end of the study, the proposed layout, design basis and criteria will all be freeze to continue with detailed engineering phase. Detailedproject planning is conducted to determine viable construction methods and the associated optimal schedule. A detailed set of drawings is produced; including work and associated components, and construction layout. A cost estimate at a +-15-20% level is prepared.

The environmental effects assessment is conducted at the same time as the pre-feasibility study (may have started before). The environmental effects assessment review process is launched in parallel with the study with a project application to YESAB. Final agreements with First Nation and Governments are established. A formal decision to proceed with the project to construction is usually taken at the end of the feasibility study. Funding for the process must be secured.

5) Detailed design: Complete detail design drawings and technical specifications are prepared with the short goal to proceed to construction. Project optimization is completed especially regarding hydraulic studies are finalized. A complete set of drawings for construction (to be formally released during procurement) is produced. A final cost estimate at +-10-15% is prepared. Procurement of long-lead items and prequalification of contractors is conducted. Procurement is subsequent to this phase and can be done simultaneously. Engineering support is provided during procurement to review questions, addendum and for proposal review. Regulatory approvals are obtained during this process and funding is made available. Acquisition of land has to be finalized and construction preparation starts. Environmental and regulatory commitments and mitigations have to start to be implemented, if applicable.

SOCIO-ECONOMIC AND ENVIRONMENTAL EFFECTS OF HYDRO

A Next Generation Hydro Project will require a suite of governmental approvals including: First Nations approvals, environmental assessment, permits, authorizations and licenses. Some socio-economic and environmental considerations, as described in the Directive, will be used to assess the viability of potential hydro sites in the first phase of the Next Generation Hydro Project – Project Identification. The Yukon Hydroelectric Power Planning Directive states that socio-economic and environmental effects must be considered in the project identification process. The technical team is performing a high level review of different hydro sites taking into account environmental and socio-economic criteria and constraints that will have to be considered once hydro sites are selected for potential development.

All sizable energy projects have both positive and negative effects at different project phases (from construction to operation) and the various project elements will have different socio-economic and environmental implications. These include impacts and benefits to lands and resource use and development, economic inputs, heritage resources and community structure and dynamics.

YESAA defines socio-economic and environmental effects as "the effect of any change [to the environment] on health and socio-economic conditions, physical and cultural heritage, the current use of lands and resources for traditional purposes by Aboriginal persons, or any structure, site or thing that is of historical, archaeological, paleontological or architectural significance".

Post phase 1 a more comprehensive socio-economic, environmental, traditional knowledge and engagement process will kick in for future Next Generation Hydro phases from pre-feasibility to the end of assessment and permitting (see Hydro Project Development Timeline Fact Sheet).

In particular, a hydro project will undergo assessment under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA), will require a license under the Yukon *Waters Act*, and will also likely require a Fish Habitat Offset Plan pursuant to the *Fisheries Act and Fish Habitat Policy (2013)*. A number of other project authorizations not listed will also be required. These regulatory processes will only begin once a final project or projects are selected. This is one of the reasons it takes 10 to 15 years to build a medium to large hydro project. *The tables below show some socio-economic and environmental* *characteristics. Any potential hydro project will have to consider these effects before approval.*

Sample list of socio-economic effect considerations:

Land and Resource Use - First Nations Settlement and Interim Protected Land - First Nations cultural and traditional practices (i.e. hunting, traditional knowledge, cultural sustainability) - Land Tenure - Hunting, fishing, eco-tourism and outfitting - Trapping - Recreation - Tourism - Exploration and Mining activities
Economic Resources - Employment opportunities - Goods and services - First Nations economic opportunities - Project sustainability
Heritage Resources - Historic/archeological sites or objects
Community Structure and Dynamics - Health, well-being and vitality - Cultural well-being - Community stability - Services and infrastructure - Education and training

Sample list of environmental effect considerations:

Atmospheric Environment	
Atmospheric Environment	• Climate and meteorology • Ambient air quality • Ambient Noise level
Aquatic Environment	
Hydrology	Description of all lakes, streams, rivers within study area, watershed boundaries, river hydraulics/hydrology, bathymetry, Ordinary High Water Mark (OHWM), flood zones, ice formation, dynamics and melt patterns;
Geomorphology	Erosion, sedimentation, channel dynamics and sediment supply and quality
Water quality and quantity	Surface and groundwater sources
Delineation and Description of riparian habitat	Shoreline, flood zones, back channels, wetlands
Vegetation	Aquatic and Riparian
Aquatic Fauna	Composition, abundance, distribution, population dynamics and habitat utilization
Species of special interest (flora and fauna)	Rare, vulnerable or endangered with consideration for any listed within the Endangered species act or species at risk act.
Terrestrial Environment	
Land Features	• Geology (bedrock and surficial) • Geo-chemical characterization of rock types, sediments that may be disturbed • Terrain and Soil • Seismicity • Mercury levels in proposed inundated areas • Identification and characterization of erosional areas or areas subject to instability, slumping or landslides • Groundwater movement, aquifer recharge zones • Permafrost conditions
Fauna	Composition, abundance and distribution, population dynamics and habitat utilization
Flora	Composition, abundance and distribution, forest inventory, ecological land classification. Special consideration for medicinal herbs, berries harvested by First Nation communities.
Wetlands	Delineation, characterization and classification
Mercury	Concentrations, mobility and fate within the riparian ecosystem

Species of special interest (flora and fauna)	Rare, vulnerable or endangered with consideration for any listed within the Endangered species act or species at risk act.
Human-Wildlife Interaction	

*Additional Valued Components will be identified as project and Baseline collection programs advance.