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Powering Canada's Territories: Governing Critical Infrastructure Assets (2015-2021)

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Critical Infrastructure in Canada's Arctic Territories

Introduction

Power generation infrastructure is critical both for residents and businesses in the Canadian Territories. Reliable power enables the operation of mechanical systems, such as water pumps and communications infrastructure, and light during long periods of darkness. In 2015, the Standing Senate Committee on Energy, the Environment and Natural Resources published *Powering Canada's Territories.*[1] This policy primer revisits the findings of the report six years later, highlighting recent developments and new or emerging challenges.

Efforts to maintain or improve these critical infrastructure assets are impacted by the regulatory and financial systems governing them. Presently, the reliability and resiliency of energy generating utilities is being tested by the effects of climate change. Climate change is being experienced at three times the global average in the Arctic.[2] The increasing intensity of storms, floods, droughts, and seasonally irregular weather will continue to augment pressures upon the planning, design, implementation, and operation of infrastructure. This policy primer will argue that infrastructure governance and regulatory regimes directly impact public safety in the Canadian Territories.

Background

Many of the generation facilities operating today were once owned and operated by the federal government, through the Northern Canada Power Commission (NCPC). This commission was transferred to the territories in the 1980s. Today, territorial governments own and operate many of the most significant energy generation stations in the territories. The supply of electricity is predicated upon ongoing infrastructure planning and asset maintenance at the territorial level. In the 1980s, some distribution and generation would be further devolved to private companies owned by ATCO group—a Calgary based firm.

When the Senate Standing Committee released research and testimony concerning power generation issues in 2015, an inventory of assets was undertaken. The report did not recommend the downloading or privatization of assets under territorial jurisdiction. The emphasis was placed upon the need for an augmentation of federal support to fund infrastructure, supply expertise, and bolster conservation programs.[3] Between 2015 and 2021, the federal government has pursued several efforts to support territorial infrastructure needs. However, trends towards jurisdictional delegation have not been reversed.

Overview of Assets in 2021

Yukon remains a national leader in clean energy production. Since 2015, the proportion of clean electricity produced has varied depending on the annual precipitation. In 2020—a low precipitation year—hydroelectricity accounted for 86 percent of electricity generated.[4] In 2018—a more historically typical precipitation year—hydroelectricity accounted for over 94 percent of the territory's total power generation. The advancement of climate change will continue to impact the rainfall upon which Yukon relies to generate electricity.

Yukon has four hydro plants with a total capacity of nearly 95MW. Notably, the Whitehorse and Aishihik hydroelectric facilities can produce up to 40 and 37MW respectively. However, seasonal freezing impacts the flow of water and, by extension, hydroelectric output. While the Whitehorse hydro facility can produce 40MW of power in the summer, it can only produce about 25MW in the winter, when the flow of the Yukon river is reduced.[5] Since 2015, a backup facility in Whitehorse was upgraded from diesel to natural gas (LNG). Commissioned in 2015, the project site now includes two modular LNG fueled reciprocating generators, replacing the aging diesel generating equipment previously used as its backup.[6]

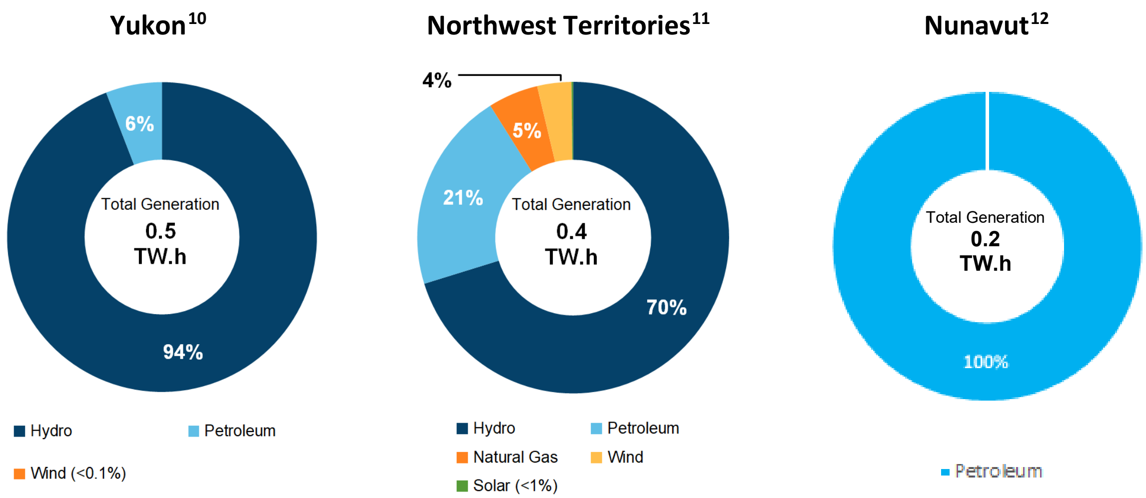
In the Northwest Territories (NWT), hydroelectricity accounts for approximately 75 percent of electricity production in normal precipitation years. Snare Hydro, which generates 68MW, and Bluefish Hydro, which generates 7.5MW, both operate in proximity to Yellowknife. Taltson Hydro produces 18MW on a separate grid serving the Fort Smith area. By 2019, work was underway to develop a 60MW run-of-the-river expansion of Taltson. The expansion of hydroelectric capacity will help reduce the reliance on fossil fuels. NWT, like Yukon, uses fossil fuels for backup capacity. For example, 2018 was a low precipitation year for NWT with 5 percent less hydroelectricity produced than in a typical precipitation year.

Precipitation is not a factor for Nunavut, which has no hydroelectric capacity. In 2021, Nunavut remains dependent upon diesel power plants to generate 100 percent of its electricity needs. The liquid fuel used by these plants is not sourced or refined in the territory, making all twenty-five of Nunavut's communities dependent on fuel imports. From environmental, risk management, and operational standpoints this lack of diversification is problematic. All fuel used must be imported to each community during a short summer sealift season, then stored in tanks for the duration of the year. There are no transmission lines between communities. Ongoing efforts to develop alternatives to diesel generation include the study of geothermal, and hybrid solar technologies.

In 2005, the Iqaluit Hydroelectric Project was initiated, driven by the ratepayers calls for stabilized electricity rates. Jaynes Inlet and Armshow South were identified as sites which could produce electricity year-round if reservoir dams were constructed. Studies totalling 10 million dollars were undertaken between 2005-2014, but the prospective hydro projects were abandoned in 2017. Although the hydroelectric assets would likely pay for themselves over the course of their lives, estimates that the facilities would cost “well over $300 million, even approaching $500 million” to construct stymied momentum for their development.[7]

Where hydro power generation and distribution infrastructure exists, climactic change may affect power systems. Modeling developed to track and compare estimated to actual hydro power generation suggest that climate change may result in an increase in hydroelectric energy production in Quebec, Ontario, and Yukon. However, British Columbia, Alberta, and the Northwest Territories may experience production decreases as steep as 10 percent[8]. Such changes to capabilities for hydroelectric production “delineates a critical energy security concern, especially in places such as Canada”[9] where recent changes in the climate are substantial and hydropower productions for both domestic uses and exportation are affected.

Figure 1-Power Generation Capacity (2018)



Source: Adapted from Canada Energy Regulator (2020) Provincial and Territorial Energy Profiles

In 2021, the regional transmission lines in Yukon and NWT remain disconnected from the North American Grid. Of these two Territories, Yukon has the most developed power generation system and transmission grid. In December 2020, Yukon Energy published a *10-year Renewable Electricity Plan.*[13] The report highlighted summer production as higher than territorial consumption and recommended the construction of transmission lines connecting Yukon to Alaska. The construction of this transmission link would allow Yukon to sell surplus hydroelectric power to the state of Alaska.

The NWT has two isolated electric power transmission grids which serve the North slave (Snare Grid) and South Slave (Taltson Grid) regions. In 2015, testimony to the Senate's standing committee articulated risks and inefficiencies associated with the lack of connectivity between these two grids. It was estimated that 30-50 percent of the water available to existing NWT turbines goes unused, due to the lack of transmission and storage infrastructure. Recognizing these issues, approximately 2 million dollars in federal funding was secured to review and update the feasibility for transmission infrastructure in late 2018. In the 2019 federal budget, a further 18 million dollars was committed over three years, to improve the facilities at Talson and connect the two grids.[14] That same year, private investors would express interest in funding the design and construction of a 270km link to connect the two grids.[15] Mines operate in proximity to Talson, and investors likely sensed an opportunity to leverage private profits from transmission infrastructure in their vicinity.

The geographic isolation of Nunavut's communities is generally not conducive to a territorial transmission network. The geographic expanse of Nunavut is four times that of Yukon, with a smaller population. Nunavut's lack of regional interconnectivity underscores the dangers of aging assets without redundancies or backup sources of power. When compared to other parts of Canada, Nunavut has the second lowest power generation per capita[16]. While Prince Edward Island has a lower jurisdictional generating capacity, they can import power from New Brunswick[17]. Opportunities to connect to the grids of other provinces or territories are not evident in Nunavut. From a public safety perspective, the lack of connectivity between generation stations augments the need to invest in backup generation technologies.

In 2020, Nunavut's *Alternative Energy Report* identified a proposal for a 1,200 km transmission line linking Arviat, Baker Lake, Chesterfield Inlet, Rankin Inlet, Whale Cove and two mines operating in this region to Manitoba. The estimated cost of the Manitoba-Kivalliq Hydro Project is 1.6 billion. To date, the federal government has supplied 1.6 million for the study of this proposal.[18]

Infrastructure State of Repair Risks

Like all infrastructure assets, electricity generation and transmission infrastructure assets have a lifecycle. The reliable supply of electricity is predicated upon anticipating when assets will need to be refurbished or decommissioned. Ongoing infrastructure planning to maintain, extend, or decommission outdated portions of major utilities is critical for system-wide reliability and resiliency.

Yukon has demonstrated excellence in the planning, maintenance, upkeep, and expansion of its power generation facilities. Above and beyond achieving a state of good repair, Yukon Energy Corporation (YEC) has demonstrated consistency in their management of asset aging. Through deliberative planning and design, the corporation has achieved progressive expansions of their hydroelectric generation facilities. For example, the Whitehorse hydro plant was built with two turbines in 1958, a third was added in 1969, and a fourth in 1985.[19]

Similarly, in 1975, Aishihik hydro plan was built with two 15MW turbines and a third 7MW turbine was added in 2011. The site continues to be enhanced to be able to use more water from the lake. The oldest facility in Yukon, Fish Lake, was originally built in the 1940s and undertook a four-year rebuild in 2016. These projects illustrate a proactive and effective infrastructure management regime in Yukon Territory. Over the course of many decades, Yukon has anticipated lifecycle aging constraints and advanced investments to improve the territory's critical infrastructure. The examples provided are characteristic of an institutional culture where the technical parameters inform the vision, planning, approval, design, and delivery of a coordinated power generation system. In short, Yukon has matched supply to meet the needs of the Territory by replacing, improving, and modernizing sites ahead of asset aging and regional growth demand curves.

The achievement of ongoing upgrades is also noted for some core assets in the Northwest Territories. The Snare Hydro System, which provides power to Yellowknife, Benchoko, and Dettah has been progressively expanded with new facilities to meet growing demand. The facility now has four separate hydro pants: Snare Rapids, Snare Falls, Snare Cascades (leased from the Dogrib Power Corporation), and Snare Forks. Bluefish Hydro, first established in the 1940s, underwent a significant dam replacement in 2012. It is anticipated that the new Taltson generating station will replace existing diesel power generation and increase system reliability. However, despite these efforts some more remote communities can be characterized as underserved.

With respect to lifecycle and overall quality considerations, the quality of Nunavut's power generation facilities can be characterized as an infrastructure deficit. In 2020 Nunavut Tungavik published *Nunavut's Infrastructure Gap,*[20] identifying infrastructure issues in multiple sectors, including electricity generation. Nunavut produces less than half the Terawatt-hours of Yukon (see **Figure 1**), for a population estimated to be 6 percent smaller. Nunavut also has the lowest electricity consumption per capita, coupled with the highest prices. In 2015, *Powering Canada's Territories* found that seventeen of Qulliq Energy Corporation's (QEC) twenty-five power plants were operating far beyond their useful life span. Plants dating back to the 1930s-1970s were so old that they "posed a potential risk to public safety"[21] and urgently needed to be replaced.

Since 2015, six of these seventeen power plants have been replaced. The Qikiqtarjuaq and Taloyoak power plants, built in 1936 and 1972 respectively were replaced in 2016. Pangnirtung, built in 1971 was replaced in 2017. Grise Fiord, built in 1963, and Kinngait, built in 1964, were replaced in 2018 and 2019. The QEC is presently working on replacements in Kugluktuk and Cambridge Bay. Applications are being reviewed for Igloolik and Gjoa Haven. Without putting a negative slant on this progress, the deficit remains a substantive threat to public safety. As each year passes, all the power plants continue to age. Power plants which have exceeded their operation life are summarized in **Table 1**.

Table 1-Nunavut Power Plants Beyond their 40-year Operational Life

Plant Name	Year Constructed	Years Past Operational Life (2021)	Plant Name	Year Constructed	Years Past Operational Life (2021)
Cambridge Bay	1967	14	Hall Beach	1974	7
Kugluktuk	1968	13	Igloolik	1974	7
Arviat	1971	10	Kugaaruk	1974	7
Resolute Bay	1971	10	Chesterfield Inlet	1975	6
Rankin Inlet	1973	8	Goja Haven	1977	4
Arctic Bay	1974	7			

Source: Calculations by Author. Data: Senate of Canada[22], *Nunatsiaq News*[23]

Assuming a regular lifespan of forty years for power generation facilities of this type, eleven of Nunavut's twenty-five power generation plants have exceeded their operational life in 2021. The rate of replacement must keep up with the aging of both older assets and more recent installations dating to the 1990s.

Table 2 - Nunavut Power Plants Within their 40-year Operational Life

Plant Name	Year Constructed	Years Remaining (2021)	Plant Name	Year Constructed	Years Remaining (2021)
Coral Harbour	1988	7	Baker Lake	2003	22
Whale Cove	1991	10	Iqaluit	2014	33
Kimmirut	1992	11	Qikiqtarjuaq	2016	35
Pond Inlet	1992	11	Taloyoak	2016	35
Clyde River	1999	18	Pangnirtung	2017	36
Naujaat	2000	19	Kinngait	2018	37
Sanikiluaq	2001	20	Grise Fiord	2019	38

Source: Calculations by Author. Data: Senate of Canada[24], *Nunatsiaq News*[25]

In 2014, Kinngait's then forty-seven-year-old diesel plant experienced four power failures. In 2015, a fire in Pangnirtung's then forty-four-year-old power plant left residents without power for weeks in freezing cold conditions. Beyond failing to generate power, there are other safety risks. In 2016, four fuel facilities were issued Environment Canada compliance orders for not safely storing fuel.[26] It is clear that the ongoing efforts to overhaul Nunavut's aging power plant infrastructure are necessary to ensure the safety and security of the power supply in the territory.

Fuel Transportation Risks

The reliance upon diesel fuel for electricity production in some of Canada's most remote territorial communities invites ongoing risks. Diesel power relies on liquid fuel transportation over long distances. In Nunavut, spillages are declining, but still account for approximately 100,000 litres of fuel spilled into the local environment each year.[27] Fuel spills remain frequent when fuel is being offloaded to communities during the sealift. The lack of port infrastructure in Nunavut results in the use of small barges to offload shipping containers from large ocean-going vessels. Poor weather and rough water can delay the delivery of essential goods, including the fossil fuels needed to power entire communities.

The transportation of liquid fuels from southern Canada may also lead to leaks and spills during maritime crashes. The Canadian North is warming at about three times the global average rate.[28] Ice loss has led to increasing maritime traffic in Canada's Arctic waters. For these vessels, storms, unpredictable weather, and ice calving continue to present challenges for the delivery of fuel. In 2017, QEC reported their annual imports of diesel fuel to be approximately fifty-five million litres annually, costing the public utility 54 million dollars[29].

On land, the advancement of climate change will result in less predictable seasonal temperatures and precipitation. Warming has already result in shortened seasons or closures of seasonal ice roads used to transport fuel[30]. In some areas it is anticipated that new community resupply strategies will be needed to ensure the viability of power systems in remote communities, which currently use ice roads to deliver diesel.

Federal Funding Streams

Strategies to reduce the amount of liquid fuel needed to power communities, including the introduction of back-up systems are important strategies to increase self-sufficiency and resiliency. *Powering Canada's Territories* (2015) recommended, "That the federal government significantly increase funding…with the objective of reducing the consumption of carbon-intensive fuels, increasing energy efficiency, and enhancing community economic viability."[31] Since 2015, the spirit of this recommendation has been addressed by a variety of federal funding streams.

Since 2018, Natural Resources Canada has administered the *Indigenous Off-Diesel Initiative.*[32] The goal of the initiative is to bolster the development of community-driven energy plans. The federal government has committed to over 700 million dollars to help rural and remote communities get off diesel power, pledging that all remote communities will be off diesel by 2030. The *Clean Energy for Rural and Remote Communities*[33] program funds a mandate to reduce the reliance of rural and remote communities on diesel fuel for heat and power with 220 million dollars being pledged over six years. A parallel *Impact Canada* Initiative has been budgeted 75 million dollars over four years.

The *Northern Responsible Energy Approach for Community Heat and Electricity* [34] program (*Northern REACHE)* continues to be administered by Crown-Indigenous Relations and Northern Affairs. This program funds renewable energy projects, energy efficiency projects, and related capacity building and planning in Yukon, NWT, Nunavut, Nunavik, and Nunatsiavut. In 2018, 53.5 million dollars was allocated for ten years.

Infrastructure Canada administers project funding dispensed through bilateral agreements with the provinces and territories. In 2018, the *Arctic Energy Fund*[35] was earmarked 400 million dollars over eleven years for the territories exclusively. The *Green Infrastructure Stream* was allocated 9.2 billion dollars in 2018 for projects across Canada for ten years[36]. That same year, the *Rural and Northern Communities Stream*[37] was allocated 2 billion dollars for eleven years[38]. Environment and Climate Change Canada also administers project funding dispensed through bilateral agreements with the provinces and territories. In 2017, the *Low Carbon Economy Fund* was budgeted 1.9 billion dollars for a five-year period[39].

Emerging Technologies

In 2016, Yukon published its *Biomass Strategy*, concluding that "(b)iomass energy for heat is a cost-effective and environmentally sustainable solution for heating in the territory. Expanding biomass energy use helps to support numerous Yukon commitments and objectives, including promoting local economic opportunities in the forest and heating industries and enhancing local energy security and self-sufficiency."[40] Numerous jurisdictions in Yukon are now pursuing biomass to address power generation needs including Carcross, Burwash Landing, and Teslin First Nation. Biomass heating systems are also being advanced by the NWT communities of Aklavik, Inuvik and Tulita.[41]

Technologies to capture energy losses or decrease fuel consumption are essential strategies for the resiliency of energy production systems. In Nunavut, the QEC has successfully deployed District Heating Systems (DHS) in Iqaluit, Rankin Inlet, Arviat, Kugluktuk, Sanikiluaq, and Taloyoak. These DHS systems consists of insulated pipes between buildings proximate to the power generation stations, allowing for the distribution of heat. Thermal energy from the power plants is captured and circulated to customers. The QEC estimates that across Nunavut, the use of DHS for space heating saves over three million litres of heating fuel annually.[42]

In the Northwest Territories, new Variable Speed Generation (VSG) Technologies are being deployed. Diesel generators can usually only convert 25-30 percent of the diesel's energy to electricity, while 65-75 percent is released as heat. High efficiency and "smart generation" technologies can help to reduce the amount of fuel required to sustain a community.[43]In 2017, Aklavik became the first location to install variable speed generation technology [44] Aklavik's generator can now operate at its most efficient speed for any load, increasing efficiency by up to 40 percent. The platform also allows for renewable penetration up to 90 percent without the added complexity and cost of storage normally required for gird stabilization. This has ultimately reduced fuel consumption by close to half of previous levels.

The diversification of generation resources is an important strategy for bolstering the overall resiliency of the electricity infrastructure systems in Canada's territories. The twenty-four-hour sunlight experienced at northern latitudes offers unique opportunities for solar power collection to increase capacity. In August 2019, it was announced that the new power plant in Kugluktuk Nunavut would be a hybrid facility, including a 500-kilowatt solar array and battery storage facilities. The installation of battery storage in Kugluktuk will be the first of its kind in Nunavut.[45]

Solar generation technologies have improved substantially since the 2012 installation of a 100-kilowatt array in Fort Simpson. The 2016 installation of a diesel hybrid system in Colville Lake has demonstrated the benefits hybrid solar array and battery systems for northern communities. Between April 2017 and March 2018, the community reported that 134.4 kilowatt hours had been generated, reducing the community's diesel fuel consumption by 38,337 litres. During the summertime, the solar installation and batteries can supply approximately 53 percent of the community's power needs. New solar power facilities were also installed in Fort Liard and Wrigley in 2016, and in Aklavik in 2017. In 2021, Old Crow's diesel generators were turned off for the first time in 50 years. It is estimated that the Old Crow solar farm will displace 190,000 litres of diesel annually[46]. The federal government has also invested 3.3 million in the indigenous-owned Nihtat Corporation for the construction of a combined solar-battery systems in Inuvik and Iqaluit. The arrays will generate 1.25MW reducing local diesel consumption by 380,00 litres annually[47].

Reliance upon backup systems which use liquid fuels can also be reduced in hydroelectric systems, by pumping water into reservoirs during times of surplus. As previously discussed, Yukon's energy needs are predominantly met by the hydroelectric resources available in that territory. In Yukon's *10-year Renewable Electricity Plan,*[48] a new pump storage reservoir was proposed at Moon Lake in northern British Columbia. During the summer, surplus hydro capacity would be used to pump water up from a lower reservoir to an upper reservoir. The water would then be run downhill to produce power when needed. The seasonal mismatch between potential production from hydro generation and the timing of maximum customer demand is a key planning constraint for YEC.[49]

Yukon installed a 0.15MW wind turbine on Haeckel Hill, and a second 0.66MW turbine in 2000. When these turbines reached the end of their 20-year life in 2018, the project was positioned as a success. However, given the efficacy of Yukon's hydroelectric assets the wind turbines were not recommissioned.[50] The utility of wind power is highly context-specific and that same year, the Government of the Northwest Territories and Infrastructure Canada announced 40 million dollars for the Inuvik Wind Project, anticipated for 2022.[51] The federal government has invested 2 million dollars towards a 0.3MW wind installation in Destruction Bay Yukon. An important dimension of the project, owned by Kluane First Nation, is the 0.25MW battery and energy management system[52]. In Nunavut, QEC has undertaken a study to rank the potential for wind generation in all 25 of Nunavut's communities.[53]

Efforts to address climate change will shift various sectors away from the use of fossil fuels, increasing electricity reliance. Since 2015, it has become more evident that electricity generated from hydro or other renewable sources will be a preferred substitute for fossil fuels. Yukon Territory's *Strategy for climate change* (2020) targets the electrification of large segments of the economy.[54] For example, the territory plans to introduce infrastructure which will enable 6,000 electric buses and cars by 2030. Such efforts will increase the overall significance of electricity generation and transmission facilities.

Net Metering and Independent Power Production

NWT was the first territory to legislate net energy metering. Since 2014, residents of NWT may install up to 15kW of renewable electrical generation to offset their power use. Customers receive credit for excess power fed back to their utility. The NWT further encourages community-owned renewable generation as a means for the local governments of individual communities to sell power to their utility.[55] The objectives of these policies are to bolster investments in renewables by individuals, decreasing the load born by utilities and displacing the reliance upon diesel. In 2016, Łı́ı́dlı̨ı̨ Kų́ę́ Dene First Nation, in partnership with Bullfrog Power became the territory's first Independent Power Producer (IPP). The first nation repurposed a site previously used for diesel fuel tank storage, installing a 35kW solar array[56].

Closely following the publication of *Powering Canada's Territories*, Yukon adopted an Independent Power Production Policy (IPP) in late 2015. The IPP provides a framework for Yukon's Standing Offer, allowing businesses to generate and sell renewable electricity to their utility. Under the Standing Offer Program, the project's capacity must be between 30 kilowatts and 2,000 kilowatts. There is an annual limit of electricity purchased by the utilities from independent power producers. By 2019, the Territory had achieved agreements with the Vuntut Gwitchin First nation to build a solar farm in Old Crow and with Kluane First Nation to build a wind project in Destruction Bay[57].

In 2018, Nunavut would similarly amend the QEC Act, enabling the Corporation to purchase power from third parties[58]. A net metering program was achieved shortly thereafter. In 2021, Nunavut did not yet have enabling legislation or policies to guide independent power producers, however the QEC has asserted that it is in the process of developing an IPP program[59].

Since its adoption, uptake by prospective independent energy generators has hinged upon the availability of government subsidies. When considering the operation of power medium to large scale generation and transmission utilities, we may reflect upon their use in textbooks as exemplifications of 'natural monopolies'. Power utilities frequently exhibit high design and construction costs, presenting a barrier to entry for smaller actors. Market competition may be particularly dampened where electricity transmission occurs over very large areas to a small consumer base. Although to date local independent energy production has been predominantly taken up by community associations, these policies should be recognized for their industrial potential. Extractive industries can command power needs exceeding those of civilian populations. Enabling policies that help mining or industrial sites to use sustainable technologies may reduce their reliance on fossil fuels and lessen their draw upon public utilities.

Devolution of Governance to the Territories

Presently, the vast geography of the Canadian territories is served by three territorially owned electricity utilities and two regulated private companies. Public utilities operated by the territories are largely responsible for the supply of electricity, setting electricity rates, and electricity consumption. Territorial governments also play a leading role in guiding systems planning for expansions and upkeep. The founding of these public utilities can be traced back to the rapid expansion of the mining sector near Yellowknife. In 1948, the federal government recognized the need for an integrated utility industry in the North. An Act of Parliament established the Northwest Territories Power Commission. In 1956, operations were expanded to include Yukon, and the utility was renamed the Northern Canada Power Commission (NCPC).[60]

In 1987, the YEC was established to take over the Yukon assets of the NCPC and devolve operations to the territory. The YEC is structured as a crown corporation, organised as a subsidiary of the Yukon Development Corporation. YEC directly serves residents in and around Dawson City, Mayo, and Faro. The territorially managed utility generates most of the electricity produced for its jurisdiction, operating the Aisihik and Mayo hydroelectric generation stations in proximity to Whitehorse.

The Northwest Territories Power Corporation (NTPC) was similarly established as a Crown corporation in 1988. At the time of its creation, assets owned by the NTPC were devolved for the areas today known today as the Northwest Territories and Nunavut. Since 2007, NTPC has been organised as a subsidiary of the Northwest Territories Hydro Corporation and is owned by the Government of the Northwest Territories. The NTPC operate the jurisdiction’s larger hydro generating stations, including Snare, Bluefish, and Taltson. It produces and distributes electricity to consumers in twenty-six of the territories’ thirty-three communities.

In both Yukon and NWT, ATCO Group serves as a transmission agent, delivering power purchased from the territories’ public utilities. ATCO Group is a publicly traded Calgary-based company which distributes power in Alberta, Yukon, and the Northwest Territories. ATCO purchases power for distribution to nineteen communities in Yukon. ATCO also generates diesel electricity for six small off-grid communities in Yukon. In NWT, ATCO Group distributes power as Northland Utilities NWT and Northland Utilities Yellowknife. These companies purchase electricity on a wholesale basis for delivery to consumers. This ATCO group company also generates power in four NWT communities: Hay River, Sambaa K’e, Fort Providence, and Wekweeti. Since the 1980s, Northland Utilities has been part owned by Denendeh Investments Incorporated (DII). DII invests in indigenous initiatives such as job shadowing and indigenous placement in the company. In late 2015, DII’s ownership of Northland increased from 14 percent to 50 percent.

In Nunavut, the electricity utility QEC was created during the establishment of Nunavut. The passage of the *Nunavut Power Utilities Act* (1999), and the *Qulliq Energy Corporation Act* in (2001) transferred control of generation assets, which the NTPC had inherited from the NPCP in 1988. Nunavut now operates stand-alone diesel power plants for each of the territories’ twenty-five communities. Aside from its public governance structure, the QEC is also notable for incorporating Inuit social values as the guiding principles for QEC operations. In line with Article 23 of the *Nunavut Agreement* (1993),[61] QEC observes an Inuit employment plan to develop a workforce that is demographically representative of the territory.

Financing Infrastructure in Canada's Territories

When studying public management, the balance of powers between levels of government is an important dimension. A distinct difference can be noted between the governing authority exercised by Canadian provinces, as compared to in the territories. The Canadian constitution allows provinces to exercise powers *in their own right*. The territories may only exercise *delegated* powers under the authority of the Parliament of Canada. While many operational and regulatory functions have been devolved to territorial governments, a significant portion of the territories' financial resources continue to come from the federal government.

To support extractive activities, and associated territorial settlement, the federal government administers a transfer program known as Territorial Formal Financing (TFF). The purpose of the TFF is to ensure that public services are available at comparable levels to other parts of Canada, despite the small population sizes of the territories. The federal government also contributes significant funds to infrastructure in the territories.

The high costs of building major capital infrastructure projects are not directly financed from revenues at either the federal or territorial level—they are debt financed. The debt-financing of new infrastructure assets is typically structured according to the life of the asset. The bulk of debts in all three territories is associated with the construction of major infrastructure projects. The federal government has the capability to create federal debt and control the maximum amounts that may be borrowed for each territory. The debt which a territory may leverage is commonly referred to as a territory's debt cap. Territorial debt caps are legislated by the federal government through the Governor in Council.

Since the publication of *Powering Canada's Territories* in 2015, the federal government undertook a review of all three territorial borrowing limits and debt-carrying capacity. The Federal government then increased the borrowing capacity for all three territories in 2020. Yukon's borrowing limit was increased from 400 million dollars to 800 million dollars.[62] The debt caps for the Northwest Territories and Nunavut were increased from 1.3 to 1.8 billion dollars[63] and 650 to 750 million dollars respectively.[64] Nunavut's 2021-2022 operating budget reported 446.6 million dollars in long-term debt "for power stations, housing and the Iqaluit airport."[65] While debt caps are established by the federal government, the federal government does not guarantee borrowing by territorial governments. Territorial governments are responsible for the debts they incur.

Aside from these elevated territorial debt caps, another significant development since 2015 is the establishment of the Canadian Infrastructure Bank (CIB). The Canadian Infrastructure Bank is not a bank in the conventional sense of the word, nor is it a federal ministry. The CIB was legislated into existence as a Crown Corporation in 2017. The CIB has been allotted 35 billion dollars in public funds, to try and attract the involvement of private sector investors to projects deemed to be "in the public interest." The determination of whether a project is in the interest of the public is made independently by an unelected board of directors.

The mandate of the CIB to blend public spending and public needs with private profits has generated controversy. The ongoing Taltson Hydroelectric Project—to expand the existing generating station and connect the NWT's hydroelectric girds—would seem to afford a case study. In 2018, 2 million dollars in federal funding was secured for the project, with an additional 18 million pledged in 2019. Shortly after this three-year federal spending commitment was announced, the CIB announced it had identified private investors for the project.[66] While there are undoubtably opportunities to make money from mining activities and associated infrastructure in the Slave area, the disconnection of NWT's power grids has been identified as a public safety issue. The CIB has also signed a memorandum of understanding to advise Kivalliq Inuit Association and its partners on this proposed Manitoba-Kivalliq transmission line project[67].

The CIB has been critiqued as "a solution looking for a problem"[68] and as a model trying to "push water up a hill."[69] At this time, it is not clear that the activities of the CIB will have a positive effect on the infrastructure delivery process. Turnover on the CIB board has been disruptive, and in January 2020 the House of Commons commissioned an audit. Administrative and economic critiques of the CIB have raised important questions concerning the basis for its mandate, transparency, austerity, and the process used to dispense public funds in support of private interests.[70] This policy primer will contribute by pointing to delays to the provision of critical infrastructure as having the potential to exacerbate existing threats to public safety.

Conclusions

In 2015, the Standing Senate Committee on Energy, the Environment and Natural Resources published *Powering Canada's Territories.*[71] Six years later, several substantive efforts have been undertaken to address the public safety concerns identified in this report. Technologies for power efficiency and conservation opportunities have seen significant investment from both federal and territorial governments. The Senate Standing Committee noted that it is "possible to consume less energy while maintaining the same level of energy services."[72] Describing this prospect as "low hanging fruit" when compared to available energy generation options.

Since 2015, hybrid generation technologies have continued to advance. The successful introduction of hybrid generation technologies within the energy mix of many communities has demonstrated their ability to decrease the dependence upon imported liquid fuels. As investments to update and modernize systems continue, careful planning must be undertaken to assure the effective mobilization of emerging technologies. Solar and wind provide a power supply that is *intermittent*—they generate electricity while the sun is shining, or the wind is blowing.[73] Energy storage and variable speed generation technologies promise a way forward to help integrate intermittent sources of power into stable, reliable, and modern electricity generation systems.

While costly in the short run, such investments in technologies to diversify critical electricity generating and transmission infrastructure are necessary to face the climate change effects being experienced in Canada's Arctic. In Yukon and the Northwest Territories, growing evidence suggests that climate change will affect precipitation patterns, impacting hydroelectric production. While hydro remains the preferred technology to generate most of the energy in these territories, redundancies and backups are important to guard against shortfalls. New technologies enabling hybrid energy systems will play an important role where climate change disrupts the fuel imports to isolated communities.

Nunavut remains the territory facing the greatest risks and power generation shortfalls on a per-capita basis. While plant replacements move forward, the territory continues to play catch up from a deficit position. In Nunavut, the ongoing reliance on fossil fuel energy presents a 'double bind' of high per capita emissions and severe climate impacts. The reliance upon fuel imports is untenable, underlying the importance of the upcoming deployment of hybrid technologies in Kugluktuk.

In both Nunavut and NWT, the high cost of diesel-generated electricity has a compounding effect across other infrastructure systems, which require power for their operation. High power costs make water, wastewater treatment, and communication facilities more expensive to run and maintain. In recognition of these issues, the federal government has launched several funding streams since 2015, including the *Indigenous Off-Diesel Initiative,*[74] the *Clean Energy for Rural and Remote Communities,*[75] the Northern REACHE program,[76] and the *Arctic Energy Fund.*[77] Infrastructure Canada dispenses substantial funds through bilateral funding agreements with the territories for *Green Infrastructure* and *Rural and Northern Communities*.

These funding efforts align with *Powering Canada's Territories* recommendation that Canada increase federal support for territorial energy provision. Territorial governments, while tasked with front-line operations, still govern with only delegated authority from Parliament. Recognizing the history of Canada's federal-territorial dynamics is useful when analyzing the lifecycle of individual infrastructure assets. Over the past seventy years, but particularly since the 1980s, power generation assets have been subject to devolutions of jurisdictional authority. This policy primer has discussed the devolution of jurisdictional authority and multi-level funding arrangements, to highlight linkages between governance and public safety. Since 2015, the federal government has directly funded a variety of energy-centered programs, while continuing to enlarge the financial responsibilities of the territories. The elevation of territorial borrowing capacities in 2020 can be characterized as a form of jurisdictional autonomy.

The adoption of net metering in all three territories, Yukon's IPP, and the inception of the CIB in 2017, mark three new efforts to increase the involvement of the private sector activities in the generation of electricity in Canada's territories. While the premise of the IPP is on stable footing, uptake has predominantly been the result of public, as opposed to private investments. The CIB has become involved in the Northwest Territory's expansion at Taltson and the Manitoba-Kivalliq proposal. The extent to which this new Crown corporation will help or hinder the socially responsible delivery of infrastructure promises opportunities for ongoing scholarship.

In conclusion, in the harsh conditions of Canada's Arctic, energy generation infrastructure is critical to assure public safety. Governance regimes which enable the expedient delivery of assets while assuring transparency and accountability are desirable. The advent of climate change will continue to augment pressures upon the planning, design, implementation, and operation of northern infrastructure assets.

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