Integrating Renewable Energy, Heat, and Water Quality and Quantity in Sustainable Energy and Water Projects for the Circum-Arctic and Northern and Remote Regions of Canada

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Introduction

Integrating renewable energy, heat, and water assists sustainable energy and water projects. Illustrative projects in northern and remote regions of Canada and the circum-Arctic are examined, and lessons extracted. Renewable energy can have multiple benefits for northern and remote communities, which in Canada primarily rely on hydrocarbons for electricity, heating and water services.

All northern communities share common difficulties with treating waste water due to the extreme cold and long winters. For example, the use of renewable energy, heat and water is more advanced in Scandinavia communities, offering insights and models for northern Canada. Sustainable energy and water development can also assist all northern communities in mitigating and adapting to climate change.

Norden Experience

The Nordic countries (Denmark, Iceland, Finland, Norway and Sweden), and the self governing regions of the Faroe Islands and Greenland (Denmark), and Aland (Finland), are collectively known as the Norden region. The Norden region is subject to European Union directives and policies, and the European framework for climate adaptation and mitigation, renewable energy, energy efficiency, and water.

This European regulatory framework includes the Energy Roadmap 2050, the 2020 Energy Strategy, the Renewable Energy Directive, the proposal for Energy Efficiency Directive, the Water Framework Directive, and the 2009 White Paper: Adapting to Climate Change: Towards a European Framework for Action. European policies and the regulatory framework for carbon, energy and water are more developed than Canada, and greater integration of these components.

Each Norden country implements European requirements through national legislation in the ways that are most appropriate for that country. Even within a country, there can be

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significant variation in the implementation. For example, Denmark, the Faroe Islands and Greenland are all members of the Kingdom of Denmark, but place varying emphasis on energy, cooling and heat, and water, given differences in geography, industry, population, and weather.

Long term European, regional and national funding is available for the research and implementation of sustainable energy projects at the European, regional and national level, which in turn encourages the development and implementation of pilot and full scale projects. For example, the Nordic Council of Ministers sponsors analysis, and encourages the joint implementation of energy, heat and water initiatives across Nordic countries, including the Action Programme for Nordic Cooperation on Energy Policy for 2010 to 2013.

The Nordic Investment Bank's mandate includes sustainable energy and climate. The Bank has invested extensively in sustainable energy projects in the region including: offshore wind development, hydroelectric projects that substitute for diesel generation, projects to increase energy efficiency, and combined power, heat and water projects. This funding has led to successful implementation and operation of projects, which in turn encourages investments in other projects.

The Norden region is also farther along on the path to sustainable energy and water development than northern and remote areas of Canada. District heating is important and prevalent in all Nordic countries except Norway; which however now leads annual growth in district heating.

Greenland has the most similar environment and populations to northern Canada, but a more sustainable approach to energy and water. Greenland is switching from diesel to hydroelectricity, with funding for dams from Nordic Investment Bank, and significantly lower hydro construction costs than Canada. Other energy technologies are also being explored in Greenland.

For example, a pilot plant in Nuuk uses hydroelectricity to electrolyze water into hydrogen and oxygen. Hydrogen is then stored for conversion into electricity, and on-demand heat in a fuel cell. Excess heat from hydrogen production and fuel cells heats Nuuk, while electricity is used by building or enters the grid. Qaanaaq in northwestern Greenland has a compact settlement, and above ground pipelines that combine multiple services heat, water and sanitation services. High efficiency diesel engines and district heating ensure that energy is completely used. Qaanaaq is also considering decentralized wastewater treatment due to the costs of centralized systems.

Denmark is known its exploitation wind resources. Community wind systems in Denmark have family tax exemptions if electricity is generated in the community, resulting in the use of cooperatives for most wind farms, and the broad social acceptance of wind generation throughout the country.

In Iceland, all electricity is renewable. Seven tenths is hydroelectricity, and the remainder is geothermal. The main use of geothermal energy is for heating, with heated water and heat being distributed through extensive district heating systems. Eight tenths of the overall energy supply is derived from renewable energy. Hydrogen is increasingly being used for vehicle and marine transport.

Sweden is shifting to a renewable economy by 2020, aided by tradable green certificates. Hydro resources provide half of the electricity. Other sources are bio-wastes, biomass, offshore wind and photovoltaic. Around a fifth of total heat is provided by biomass and bio-wastes. District heating is two fifths of the heating market in Sweden, with biomass supplying two thirds of fuel, supplemented by garbage and geothermal sources.

Canadian Arctic Experiences

Energy use in the Canadian Arctic differs from more southern regions of Canada. Almost three-quarters of northern fuel consumption is imported refined hydrocarbons. This may be fuel oil or propane for heating, and diesel for transport and electricity. Despite abundant natural gas in some areas, it is currently exploited only in Inuvik and Norman Wells.

The climate, geography, and small population of northern Canada encourages a unique de-centralized pattern of energy use with limited number of high industrial energy requirements. Overall, industrial demand can vary significantly with the opening and closing of remote hydrocarbon and mining operations. Though industrial load has traditionally been met by imported hydrocarbons, renewable energy is being considered. The high cost for imported hydrocarbons in all locations encourages the consideration of renewable energy, with hydro being one of the preferred options.

Water sanitation and treatment is complex in northern Canada. Natural or constructed wetlands are used for water treatment, but the prolonged periods of freezing in winter require that wastewater be stored until in ponds till summer. Treated waste water may be discharged into wetlands or marine waters. Discharges of untreated waste water may occur, but impacts tend to be limited in scope due to the smaller sizes of the communities. Iqualuit is an exception to this due to its size and population. For example, Iqualuit has a history of wastewater discharges due to breaches of the sewage lagoon, but recently embarked on a new waste water system.

The Canadian Council of Ministers of the Environment developed the Municipal Wastewater Effluent Strategy of 2009 which harmonized a national framework for wastewater. The Wastewater Systems Effluent Regulations SOR/2012-139 were issued in June 2012 under the Fisheries Act. These regulations do not yet apply to the Northwest or Nunavut Territories, northern Quebec, Newfoundland and Labrador, as these regions were given additional time to develop standards and approaches.

Research is underway to enhance the capacity of northern communities to develop and implement plans for water protection and waste water management, including integrating scientific and indigenous knowledge.

Manitoba

The Churchill Northern Studies Centre illustrates the innovative integration of energy, heat, water and wastes in the construction of its new building. The centre is located 23 kilometres east of the town of Churchill, Manitoba. It is supplied with hydroelectricity by a Manitoba Hydro transmission line. Due to the remote location and rocky landscape where the Centre is situated, there are no pipelines from Churchill for gas or water service, or wastewater removal. Instead, the centre is instead designed to as autonomous as possible for water and wastes, and to decrease carbon emissions.

Measures for water at the Churchill Northern Studies Centre include large composting systems for waterless toilets and urinals. Wastewater is treated in biofiltration tanks indoors, and sandbed dispersal fields outdoors. In the summer, nearby lake water is pumped in and treated to drinking water quality. During the winter, large tanks store trucked-in water. Untreated lake water is distributed to a separate system to flush toilets. Drain water heat exchangers recover heat from the showers and toilets, using it to pre-heat hot water.

Northwest Territories

Electricity is generated from hydro, diesel and natural gas in the territory. Strategy documents describe future energy development, including encouraging hydroelectric research and funding. For Yellowknife, hydroelectricity is generated at the Snare-Yellowknife power system, with the Jackfish diesel plant as a standby. Yellowknife's carbon emissions are high due to use of diesel for heating buildings.

Yellowknife is conducting feasibility studies for upgrading the sewer and water systems. The water and sewer systems surpassed their 25-year life expectancy with significant water loss. The proposed upgrade will reduce water consumption, and reduce carbon emissions related to water heating by approximately 10 tonnes CO2e per year.

Preliminary studies have been conducted on the potential of the closed Con Gold Mine as a geothermal heat source for Yellowknife. Water in deep levels of the mine could be accessed for heat. Smaller projects could use the mine waters in some shafts as an open loop or closed loop geothermal resource. The mine heat system would supply heat with a lower life cycle cost than hydrocarbons. However, there is a long payback for the investment to connect the city to the mine, which could be barrier to its use.

Existing mines in the territories contribute to sustainable energy and carbon reductions, and, in certain circumstances, could be a source of energy and heat for communities. The Diavik Diamond Mine located 300 kilometres northeast of Yellowknife has built a state of the art wind farm with 9.2 megawatts of installed wind capacity at a cost of $30C million that is the largest remote wind-diesel hybrid installation globally.

The Diavik wind farm generates an average wind power ranging from 2.1 to 6 megawatts, and provide tens per cent of Diavik's power load; thus, eliminating four million litres of fuel a year, and saving the company approximately $6C million per year on diesel. Through use of the wind farm, Diavik can reduce its CO2 e emissions by 12,000 tonnes a year, which is about six per cent of its carbon emission. To put this reduction in perspective, Diavik produced 198,084 tonnes of CO2e in 2009, and was 16 per cent of the carbon emissions of the territory.

Another interesting initiative in the Northwest Territories is the Fort Simpson Solar Energy Project. This is the largest solar photovoltaic system in northern Canada, displacing diesel generation, and reducing carbon emissions. The Northwest Territories Power Corporation (NTPC) owns and operates the system which was built by a Canadian company, SkyFire Energy Solar. Funding was provided through the territorial government's Energy Priorities Framework, with $700,000C contributed under the framework, and $60,000C from NTPC. The solar array contains 258 panels rated at 235 watts each for a total of 60.6 kW. The system is connected to the Fort Simpson grid and provides enough energy for up to 10 houses or up to 8.5% of the minimum power requirements in the summer.

Last, the Arctic Energy Alliance is a non-profit society promoting efficient, renewable and carbon neutral energy practices. In 2011, they issued the Guide to Best Energy Practices for Remote Facilities, which contains best practices for remote facilities producing energy, such as lodges, and exploration and traditional camps. However, water and heat are not considered these best practices.

Nunavut Territories

All of Nunavut's electricity, heating and transportation needs are met by diesel. Natural gas exists in Arctic islands but is not currently produced. Qulliq, formerly the Nunavut Power Corporation, relies on older diesel plants to generate electricity for communities. Diesel prices vary and must be shipped thousands of kilometres under marine transport, resulting in Canada's most expensive electricity. District heating has been recently implemented in Arviat, Baker Lake, Iqaluit, and Rankin Inlet by Qilliq using federal funding under the ecoENERGY program.

Qulliq is considering developing hydroelectricity near Iqaluit. As a result of the natural lake and the high head, a small dam at Jaynes Inlet (Qikiqgijaarvik) will create water storage. Run-of-river hydro projects could be used with dam to supply Iqaluit with electricity year around. Qulliq wants use a public-private partnership to raise the money to build the plant, and there have been suggestions to use companies that built dams in Greenland due to lower construction costs.

Nunavut has wind resources, but it has not been cost effective to develop them. Windmill projects in Kugluktuk, Cambridge Bay and Rankin Inlet produce little energy and were expensive to develop. The technology is sensitive to cold weather, high maintenance, and onsite technicians are not always available. As a result, there are high costs to maintain and repair the windmills, and power bills have not been reduced.

Qulliq is considering using wind power to supply heat; and a project in Cape Dorset may use wind turbines to heat water, and provide heat for buildings.

In 2010, Dalhousie University contracted with territorial government to investigate wastewater treatment: determining performance of current wastewater systems, characterizing risk to environment and human health, assessing technological and management solutions to improve treatment, and proposing regulation performance standards. In all but four Nunavut communities, wastewater is trucked to stabilization ponds and wetlands for treatment. In some instances, the treated water is discharged in the ocean.

Mining companies also import diesel and build own power plants, providing future incentive for them to also consider renewable energy applications similar to the Diavik Diamond Mine. For example, the Agnico-Eagle's Meadowbank gold mine near Baker Lake has a diesel generator that produces 26 megawatts. Newmont Mining Corporation previously shipped 24 million litres of diesel every year to the recently closed Hope Bay mine near Cambridge Bay.

Yukon Territories

Yukon's energy strategies include improving energy efficiency and conservation, producing more renewable energy, responsibly developing oil and gas and making good energy choices. Proposed territorial actions include wood-fuelled home heating systems, increasing energy efficiency and renewable energy. With most electricity generated by diesel, the territory is seeking to replace diesel with local hydrocarbons and renewable energy.

Yukon Energy Corporation's 20-Year Resource Plan addresses generation and transmission priorities. The isolation of Yukon's electrical system requires flexibility due to: seasonal variations in loads and hydro generation; variations in hydro power as water conditions change; development and loss of major mine loads; and possible uses of natural gas. Generation includes hydroelectricity on the integrated grid, and diesel generation in five off-grid communities. Near term options include hydro, biomass, liquefied natural gas from British Columbia, and wind. Longer-term options are hydro, geothermal, nuclear, solar, natural gas, and improving grid interties to British Columbia and Alaska.

Off-grid mine loads relying on diesel for generation are expected to grow within the next ten years for new mines projects of Casino, Selwyn and Northern Dancer. The Minto copper-gold mine located 240 kilometres north of Whitehorse constructed a water treatment plant that treated water containing dissolved metals and suspended solids, producing up to four million litres of water daily that complies with water quality requirements for discharge into the environment.

The Champagne and Aishihik First Nations, Dakwakada Development Corporation, Village of Haines Junction and the Yukon Cold Climate Innovation Centre are developing a small-scale (two to three megawatts) wood biomass pilot project, potentially with existing forestry at Haines Junction.

Conclusions

There are interesting lessons and approaches between Canada and the Norden region for community-based renewable energy uses, distributed heat, and water treatment, and private sector approaches.

A policy and legal frameworks which encourages a more integrated approach to sustainable energy development is place in Europe and for the Nordic region. Elements of the European framework are:

- National regulations with requirements for increased renewable energy participation and carbon reductions that contain mechanisms and structures for requirements to be operationalized.

- National regulations that provides consistent and implemented environmental standards for water quality and waste water treatment.

- Academic and government funding for research and pilot projects for renewable technologies and wastewater treatment.

- Innovative government and private sector financing for sustainable energy, heat and water projects.

Canada may experiences difficulties in proceeding with integrated energy, heat and water projects in the absence of this consistent legal and policy framework. With limited exceptions, Canadian northern and remote communities are not connected to an electricity grid. Sustainable energy projects in Canada are characterized by investment difficulties and limited use of district heat.

There have been innovative wind and solar applications for Canadian industries and communities. Electricity generation, heat and water in these northern and remote communities could be assisted by industrial projects in the hydrocarbon, mining and forestry sectors. Water resources could be used further for dams and run-of-river hydro projects. Interestingly, warmer waters from the depths of mines have been proposed for distributed heat applications. All these examples, and proposed future resources developments across northern and remote Canada suggest that it could be useful to explore combining large scale resource projects with electricity, heat and water services for communities.

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