DECEMBER 2021

COMMUNITY ENERGY PLAN

CORAL HARBOUR, NUNAVUT

Nunavut

NUNAVUT CLIMATE CHANGE SECRETARIAT
NUNAVUNMI HILAUP AALANNGUQTIRNINGA HAVAGVIAT
SECRÉTARIAT DU CHANGEMENT CLIMATIQUE DU NUNAVUT
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NORTHERN ENERGY CAPITAL

Sakku Investments Corporation

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EXECUTIVE SUMMARY

A Community Energy Plan (CEP) Team was assembled to conduct energy planning in the community of Salliq (Coral Harbour), Nunavut. This work was initiated in Spring of 2020 and this final report delivered in Fall of 2021. The CEP Team consists of the following parties.:

- Sakku Investments Corporation (Sakku), including Energy Champion Blaine Chislett. Sakku has led project management, building audits, and the self-install energy kits.
- GN Dept. of Environment, Climate Change Secretariat(CCS), CCS has led community engagement, as well as seeking information from other branches of the GN.
- Northern Energy Capital (NEC). NEC has led technical analyses and writing.

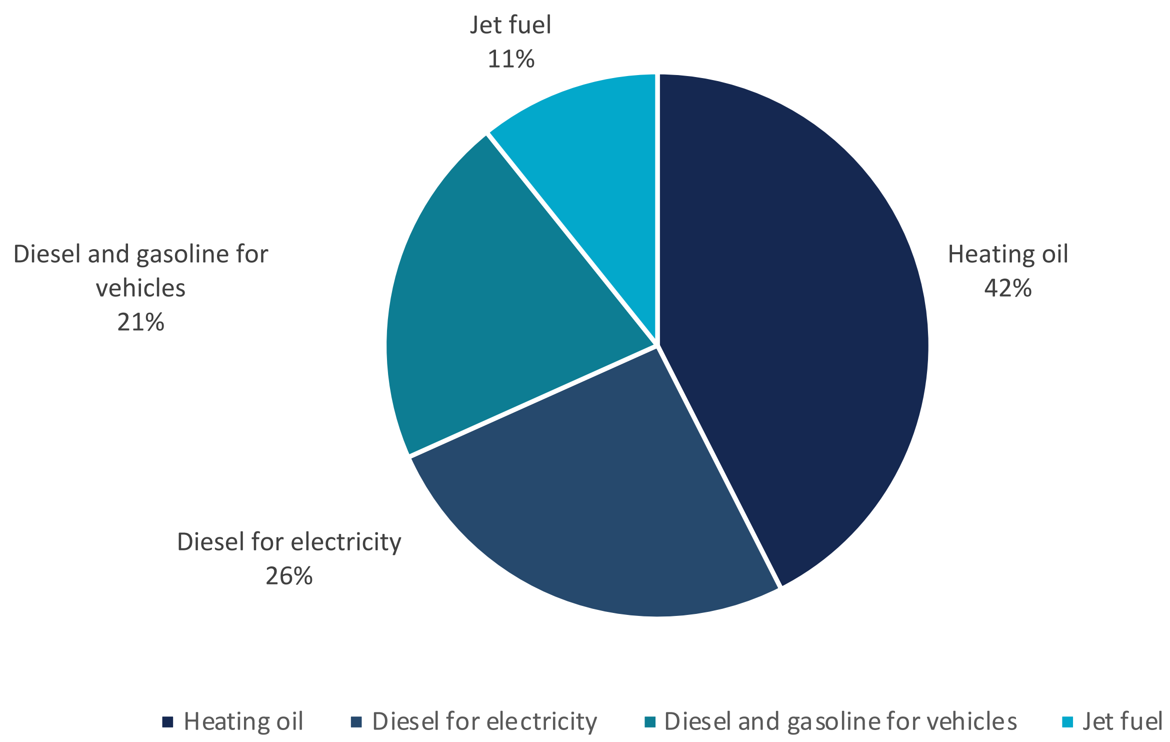
ENERGY BASELINE

Research was conducted into the energy sources, uses, costs, and greenhouse gas (GHG) emissions in Salliq and an Energy Baseline was established to measure these factors at the present time. This Energy Baseline serves as a starting point to help us see the results of future energy-related decisions in the community.

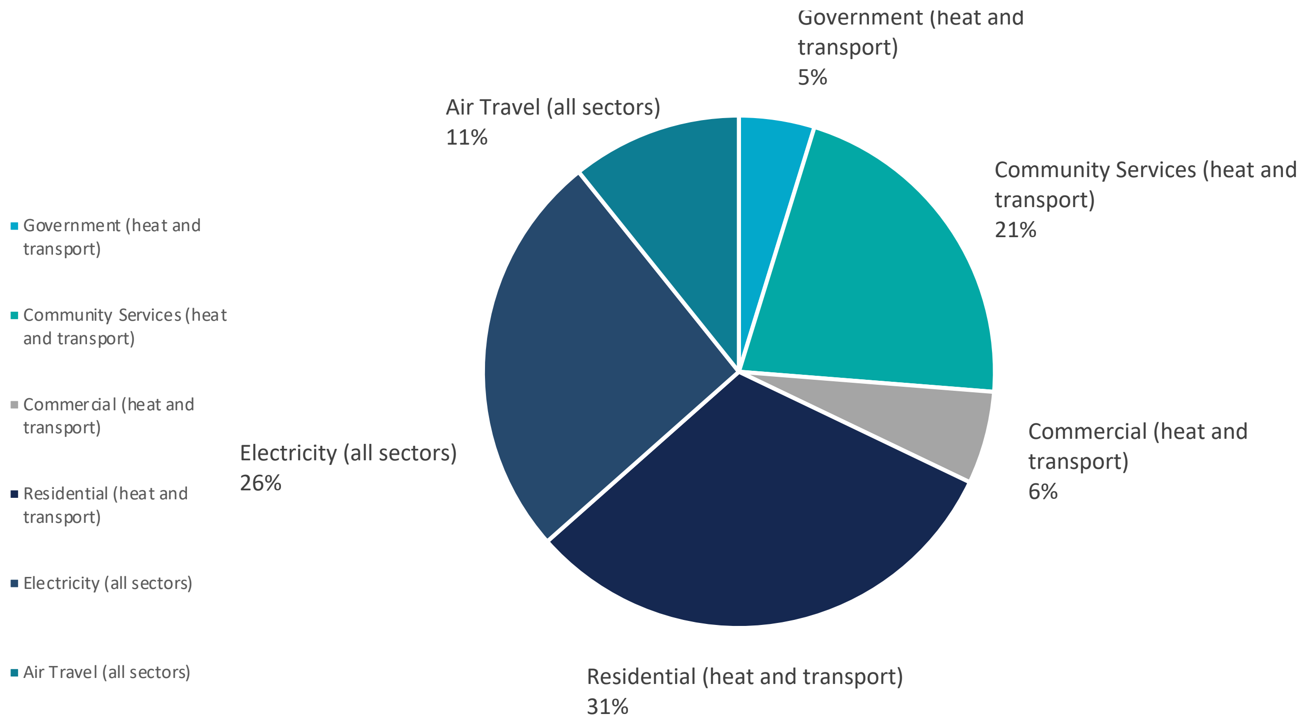
Energy in Salliq is nearly 100% derived from burning of fossil fuels, whether that be for electricity, heating, or transportation. The Petroleum Products Division of the GN reports a total of 3.96 million litres of annual fossil fuel sales in Salliq. Burning of these fuels produces GHG emissions totalling 10,900 tonnes CO_2e per year. Assuming a current population of 900 residents, this amounts to an average of 12.1 tonnes CO_2e /person /yr. The predominant demand for fuel is for heating, and the peak demand for heating occurs in winter.

Virtually all of the energy consumed in Salliq is derived from fossil fuels. This energy is used primarily for heating, electricity generation, and transportation.

FOSSIL FUEL CONSUMPTION BY FUEL TYPE



FOSSIL FUEL CONSUMPTION BY USER



COMMUNITY ENGAGEMENT

The CEP Team engaged with the community of Salliq in the following ways throughout performance of the CEP work:

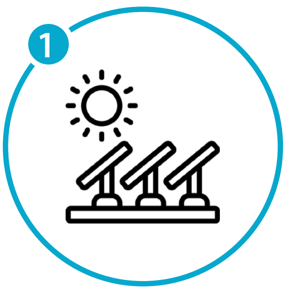
- A community energy survey was conducted, which yielded a total of 25 responses (11% of households).
- The CEP Team met with the Hamlet Council and staff in July 2021 to discuss potential clean energy projects and gather their input. The CEP Team announced their presence through local radio announcements and organized a prize draw for survey participants.
- The CEP Team is planning further community engagement, which has been delayed due to the Covid-19 pandemic. Planned activities include educational activities for kids, meeting with the Council and Hamlet staff to provide an update, and an open house to discuss the potential clean energy projects suggested in the CEP.
- Each household will also receive an Energy Efficiency Kit including a video (on a USB stick) with instructions for how to use each item in the kit.

Key insights from survey responses included the following:

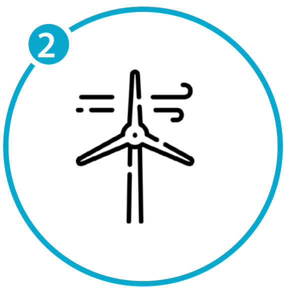
SURVEY RESPONDENTS EXPRESSED THE HIGHEST CONCERN FOR (IN ORDER)

1. the cost of electricity and fuel,
2. environmental impacts from fuels,
3. reducing imports,
4. reliability of energy sources
5. GHGs & climate change.

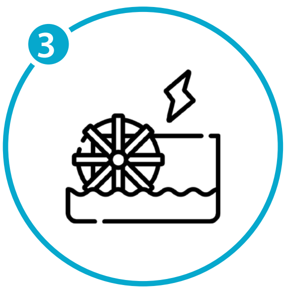
SURVEY RESPONDENTS EXPRESSED STRONG SUPPORT FOR (IN ORDER)



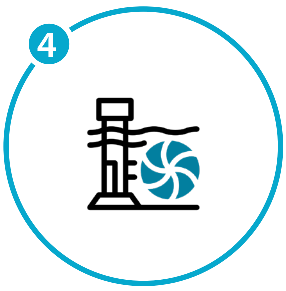
SOLAR ENERGY



WIND ENERGY



RUN-OF-RIVER HYDRO



TIDAL ENERGY

All survey respondents indicated they would be proud if Salliq pursued clean energy solutions.

OPTIONS FOR REDUCED RELIANCE ON FOSSIL FUELS

The CEP Team has examined a variety of potential options that could help lead Salliq away from reliance on fossil fuels - for example increased energy efficiency, clean energy generation, energy storage, or other projects. Analyses are based on best information available to the CEP Team. Factors considered in these analyses include:

- Financial cost, both capital cost and operating cost,
- Financial savings or revenues,
- Risks, and means of reducing risks,
- Complexity, and capacity of the community and its partners to implement the solution,
- Time horizon, whether the solution can be implemented today or requires further study,
- Eligibility for federal grant funding, to ensure that costs are not unfairly borne by Salliq residents.

Resulting from these analyses, the CEP Team recommends the following energy opportunities for Salliq that can be accomplished over the next 5 years. It is estimated that the implementation of these near-term projects would result in an overall reduction in diesel consumption (and associated GHGs) of approximately 19% - a substantial step that Salliq could be proud to accomplish.

NEAR TERM OPPORTUNITIES ARE:

1 SELF-INSTALL ENERGY KITS:

The CEP Team recommends that Self-Install Energy Kits be made available to all homes in Salliq by 2022. This project has been initiated by the CEP Team. Participating homes would save an estimated 200 kWh of electricity annually, and 462 L of heating oil, for an annual savings of approximately $538 per home.

2 BUILDING RENOVATIONS:

The CEP Team has conducted an energy efficiency audit (ASHRAE Level 2) of one commercial scale building: the 2-Bay Maintenance Garage. Potential energy conservation measures were identified in relation to building envelope upgrades, equipment maintenance and upgrades, controls, and lighting. In aggregate, these measures would result in energy savings of 5,500 L of heating oil and 6,300 kWh of electricity consumption annually, for a total annual savings of $8,200 and a reduction of 19.9 TCO_2eq of GHGs.

3 LED LIGHTS IN COMMERCIAL BUILDINGS:

The CEP Team recommends that all incandescent light bulbs in commercial buildings in Salliq be replaced with LED light bulbs by 2022. This would reduce electricity costs by an estimated $33,700 annually in commercial and community buildings.

4 MEDIUM-PENETRATION CLEAN ENERGY PROJECT:

Sakku and NEC, in consultation with the community, are currently investigating the feasibility of a wind and/or solar energy project in Salliq. Project capacity would likely be in the range of 200-500 kW (27 – 68% of peak electricity demand) and would include approximately one hour of battery storage. This project would have the largest impact on reducing diesel reliance. Depending on the timing of QEC's Independent Power Producer program, this project could be implemented within 3-4 years. The details of this project will be refined by further study work in the months to come.

5 ROOFTOP SOLAR ENERGY FOR UNSUBSIDIZED RATEPAYERS:

Under QEC's current Net Metering program, we estimate that approximately 42 kW of rooftop solar energy could be installed on homes (e.g. 8 homes with 5 kW each). Ideal candidates would be homeowners who have roofs in good condition, and who pay the unsubsidized electricity rate (i.e. homes that use a lot of electricity). Each 5 kW project would result in an estimated annual savings of $3,200 (assuming unsubsidized rates) for a financial payback of 8 years. The CEP Team would be happy to connect interested homeowners with parties who could assist with the Net Metering application and contractors who could implement the project.

6 BIOMASS HEATING PILOT PROJECT:

The CEP Team recommends that a biomass heating pilot project be installed and operated in Salliq by 2026, using dry wood pellets for fuel, and including an affordable storage facility (e.g. sea can). The condition of the wood pellets would be monitored to measure any effects of humidity, and to confirm that this technology is viable in Salliq.

The CEP Team has also identified the following longer-term opportunities. These are not demonstrably viable based on today's economic conditions, but could be expected to become viable 5+ years into the future. These projects should be studied further, and re-addressed upon fulfilment of the near-term goals listed above.

LONGER TERM OPPORTUNITIES ARE:

1 WASTE HEAT CAPTURE:

It is possible that waste heat from the QEC powerplant could be captured and routed to a new facility that would be constructed adjacent to the powerplant. Options include a new greenhouse, auto garage, or a swimming pool facility.

2 ELECTRIC THERMAL STORAGE:

Testing is underway now in other northern communities to see whether wind or solar energy can be stored in the form of heat, to be used upon demand. This could provide a cleaner way to heat buildings in Salliq.

3 ELECTRIC VEHICLES:

Electric vehicles don't make sense today because the electricity is generated (inefficiently) from diesel fuel. It's better to burn diesel directly in a vehicle. However, if in future the electricity grid is converted to predominantly clean sources, then electric vehicles may make sense in Salliq.

4 HEAT GENERATION RESEARCH PROJECT:

In the long run, Salliq should consider a cleaner solution for heat, which represents the largest component of the energy system. Leading options include 1) expansion of the electricity system and adoption of geo-exchange / heat pump technologies that can use electricity efficiently for heating, 2) expanded biomass, involving many hundreds of tons of wood pellets, to provide heat and hot water to most buildings in the community (if the biomass pilot project results in positive outcomes), or 3) a combination of the above two options. Other technologies may also become feasible in the future.

BARRIERS AND CHALLENGES IN THIS WORK INCLUDE:

- Affordability of energy in general, and particularly diesel fuel which is currently the cheapest way to heat homes. Alternatives can involve the construction of new infrastructure at a high cost. This can be addressed by applying for federal grant funding to reduce the financial impact on local residents.

- The reliability of diesel fuel, and familiarity among residents, compared to new solutions which may require more careful planning. This can partly be addressed by meaningful engagement with community members and efforts to address their questions, including with thorough pre-feasibility studies. This also calls for careful engineering of proposed solutions, and selection of equipment that is well suited to the local environment, to ensure reliability of new solutions.
- The need for specialized knowledge in designing new energy solutions.
- Subsidies for energy in Salliq (e.g. GN electricity subsidy) which makes energy appear cheaper than it is.

IF SOME OF THESE CHALLENGES CAN BE OVERCOME (THE CEP TEAM IS OPTIMISTIC THEY CAN), THEN RESIDENTS OF SALLIQ COULD ALSO POTENTIALLY EXPERIENCE THE FOLLOWING TYPES OF BENEFITS:

- Fewer diesel fuel spills,
- Lower GHG emissions which contribute to climate change.
- More local involvement in energy operations,
- Protection from global commodity markets and ever-increasing fuel prices.
- Potential improvements to buildings through various energy efficiency measures that could help to address related concerns such as mold and air quality.
- Opportunities for education and capacity building within the community.

ACKNOWLEDGEMENTS

The effort to produce this Community Energy Plan was led by a CEP Team consisting of:

HAMLET OF CORAL HARBOUR:

- Mayor and Council
- Leonie Pameolik, Senior Administrative Officer

SAKKU INVESTMENTS CORPORATION:

- Blaine Chislett, Energy Champion
- Cassandra Hargrave, Project Manager
- Jean Conrad, Director of Operations

GN DEPARTMENT OF ENVIRONMENT, CLIMATE CHANGE SECRETARIAT:

- Andreane Lussier, Climate Change Mitigation Manager
- Jordan Blake, Energy Policy Advisor
- Hyacinthe Djouaka, Climate Change Mitigation Specialist

NORTHERN ENERGY CAPITAL:

- Malek Tawashy, President & CEO
- James Griffiths, Lead CEP Author

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- Clean Energy for Rural and Remote Communities

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WWF:

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- Rinaldo MacDonald, Senior Financial Analyst

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- Ghanashyam Ranjitkar, Research Engineer, Marine Energy/BRG/CanmetENERGY
- Brian Perry, Research Engineer, Marine Energy

PEMBINA INSTITUE:

- Dave Lovekin, Director, Renewables in Remote Communities

ICE NETWORK:

- Eryn Stewart, Managing Director
- Bonnie Van Tassell, Program Manager

QEC:

- Gaurang Mukherjee, Director of Engineering
- Muhammad Nasir, Manager, Electrical Distribution
- Ahzar Mahmood, Manager, Mechanical Engineering
- Tilmon Comeau, Residual Heat Technician
- Sheila Papa, Director, Corporate Affairs
- Alex Brouse, Manager, Corporate Planning

GLOSSARY

AEA	Arctic Energy Alliance.
Biomass	Any biological matter that can be combusted for energy, eg. wood chips.
CanNor	Canadian Northern Economic Development Agency.
Capacity	The amount of electricity that a generator or grid can produce when it's running at full output, typically measured in MW or kW.
CCS	Climate Change Secretariat.
CEP	Community Energy Plan.
CIPP	Commercial and Industrial Power Producer.
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada.
CO2	Carbon dioxide, a greenhouse gas.
CO2e	Carbon dioxide equivalent: the number of metric tons of CO2 emissions of any gas with the same global warming potential as one metric ton of CO2.
CGS	Community Government Services.
Efficiency	The ratio of useful work performed to actual energy expended, usually in %.
Energy	The capacity to do work, such as moving or heating.
EPA	Electricity Purchase Agreement.
GHG	Greenhouse Gases: Gases that trap heat in the atmosphere.
GN	Government of Nunavut.
ICSP	Integrated Community Sustainability Plan.
IPP	Independent Power Producer.
IQ	Inuit Qaujimajatuqangit encompasses all aspects of traditional Inuit culture, including values, world-view, language, social organization, knowledge, life skills, perceptions and expectations.
Joules	The basic unit of energy, or work, used by the International System (SI) of units. However, the unit of kWh is more commonly used in the energy industry.
KHFL	Kivalliq Hydro Fibre Link.
KIA	Kivalliq Inuit Association.
KRLUP	Keewatin (aka Kivalliq) Regional Land Use Plan.

kWh	Kilowatt-hour, a unit of energy capable of generating 1 kW for 1 hr, equivalent to 3,600 kilojoules.
LED	Light Emitting Diode: a very efficient form of lighting.
MGIF	Municipal Green Infrastructure Fund.
NESP	Nunavut Energy Subsidy Program.
Net Metering	A billing mechanism where consumers can generate their own electricity to offset electricity purchased from the grid.
NHC	Nunavut Housing Corporation.
NIRB	Nunavut Impact Review Board.
NPC	Nunavut Planning Commission.
NRCan	Natural Resources Canada.
PPD	Petroleum Products Division, Government of Nunavut.
QEC	Qulliq Energy Corporation.
REA	Residential Energy Advisor.
Salliq	Traditional name for the community of Coral Harbour, NU.
Shugliaq Island	Traditional name for Southampton Island, NU.
Solar Irradiation	A measure of the power of sunlight per unit area that falls upon a surface.
Tonnes	A metric unit of measurement equal to 1,000 kg or approximately 2,200 lbs.
Utility	An organization that maintains infrastructure for a public service, like electricity, typically in a monopoly or quasi-monopoly arrangement.
URRC	Utility Rates Review Council.
Watts	A unit of power, or the rate at which energy is generated or used, equivalent to 1 Joule per second.

SECTION 01

1. Introduction

This section explains why and how Community Energy Planning is being conducted in Salliq (Coral Harbour), Nunavut.

1.1. OBJECTIVES OF THE CEP

Community Energy Planning is "a way to assess your community's current energy system and identify a path to reduce energy costs, reliance on fossil fuels, and greenhouse gas emissions".[1] This Community Energy Plan (CEP) has been researched and written specifically for the community of Salliq, to suit the community's own geography, resources, needs, and intentions for the future. This is the first CEP for Salliq.

This CEP outlines the energy-related challenges in Salliq, opportunities for energy transformation, and priorities of key stakeholders. This CEP is intended to bring focus on energy issues and to help accelerate the implementation of clean energy solutions in the community.

Specific objectives[2] of this CEP include:

- understanding Salliq's current energy uses and costs,
- collecting feedback from community members regarding energy,
- creating strategies to increase energy efficiency and conservation,

1 *Arctic Council (2019). Arctic Community Energy Planning and Implementation Toolkit [ACEPI].* *https://arcticenergytoolkit.com/resources*

2 *Adapted from Arctic Council (2019).*

- exploring renewable energy opportunities,
- exploring opportunities to reduce energy costs through specific recommended programs and activities, and
- increasing capacity in the community to address the opportunities and challenges ahead.

This CEP represents some of the first steps along the path of transition to a cleaner and more secure energy system in Salliq. Subsequent steps may involve the pursuit of specific projects, such as clean energy projects or energy efficiency projects. With careful planning, such projects can lead to the following types of community benefits, which will be explored in the CEP:

- economic development opportunities,
- modest jobs and training opportunities,
- increased self-reliance and less dependence on imported fuels,
- protection for the GN and QEC against increasing and fluctuating diesel fuel costs,
- increased recirculation of financial resources within the community,
- reduced pollution to soil and water due to diesel fuel spills,
- reduced GHGs and impact on climate change,
- education opportunities for youth,
- capacity building opportunities,
- increased community pride, and
- opportunities to share success stories with other communities.

1.2. GLOBAL AND LOCAL CONTEXT

The transition to a sustainable energy future is of global importance. The sustainable and ethical use of energy has been identified as a priority in international collaborative efforts such as:

- The United Nations (UN) Agenda 2030 Sustainable Development Goals.[3]
- The Paris Agreement under the UN Framework Convention on Climate Change, which commits participating nations to reducing greenhouse gas (GHG) emissions to 2005 levels by 2030. [4]
- The UN Declaration on the Rights of Indigenous Peoples, which includes "recognizing that respect for indigenous knowledge, cultures and traditional practices contributes to sustainable and equitable development and proper management of the environment." [5]

The transition to sustainable ways of using energy is also important at the national level:

- The Government of Canada has signed onto the Paris Agreement and its commitment of GHG reductions.
- The Government of Canada has resolved to formally support the United Nations Declaration on the Rights of Indigenous Peoples.[6]
- The Government of Canada has adopted the Pan-Canadian Framework on Clean Growth and Climate Change to help pave the way for this transition.[7]
- The strengthened climate plan entitled *A Healthy Environment and a Healthy Economy* was announced in 2020, and is currently under discussion.[8] This plan includes a commitment to "ensure rural, remote and Indigenous communities that currently rely on diesel have the opportunity to be powered by clean, reliable energy" by 2030.

The Government of Nunavut (GN) has also taken steps to address energy and climate change:

- The Ikummatiit Energy Strategy was approved by Cabinet in 2007, however no comprehensive implementation plan was put in place. [9]
- In 2013 the GN released a plan entitled Upagiaqtavut Setting the Course: Climate Change Impacts and Adaptation in Nunavut.[10]

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3 United Nations (2015). Transforming our world: the 2030 Agenda for Sustainable Development. https://sdgs.un.org/2030agenda
4 United Nations (2015). The Paris Agreement.
5 United Nations (2007). Declaration on the Rights of Indigenous Peoples [UNDRIP].
6 Government of Canada (2016). United Nations Declaration on the Rights of Indigenous Peoples. https://www.aadnc-aandc.gc.ca/eng/1309374407406/1309374458958
7 Government of Canada (2016). Pan-Canadian Framework on Clean Growth and Climate Change. https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html
8 Environment and Climate Change Canada (2020). A Healthy Environment and Healthy Economy. https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf
9 Government of Nunavut (2007). Ikummatiit: The Government of Nunavut Energy Strategy. https://gov.nu.ca/sites/default/files/ikummatiit_energy_strategy_english.pdf
10 Government of Nunavut (2013). Upagiaqtavut Setting the Course: Climate Change Impacts and Adaptation in Nunavut.

The GN has not yet set targets regarding clean energy or GHG emissions. An Auditor General of Canada report was delivered to the Legislative Assembly of Nunavut in 2018. The report gave recommendations, including setting GHG emission reduction targets for the territory.

Currently, Nunavut relies on imported fossil fuels for nearly all of its energy requirements, including nearly 100% of the power generated in Nunavut.[11] Nunavut imports 212 million litres of fuel annually for transportation, heating and electricity generation. The territory relies on air travel for goods and transportation, which represents approximately 72% of carbon emissions in the territory.[12] In 2018, Nunavut was responsible for roughly 702 kilotonnes of carbon dioxide equivalent (kt CO_2 eq), which is approximately 0.1% of Canada's emissions.

Nunavut's energy needs have been increasing over time. The price of energy in Nunavut is subsidized.[13] As the economy and population of the territory grows, so too does the demand for imported fuels as well as the need for alternative and renewable energy sources.

As climate change increases in the decades ahead, northern communities are expected to be amongst the most affected. Climate change is affecting residents of Salliq today, including the personal accounts provided in Section 4.5 in response to the CEP survey.

Therefore, this CEP is intended to highlight a path forward to a more sustainable and more resilient energy future for Salliq.

11 Qulliq Energy Corporation (no date). Power in Nunavut. https://www.qec.nu.ca/power-nunavut
12 Environment and Climate Change Canada. (2020). National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada. http://www.publications.gc.ca/site/eng/9.506002/publication.html
13 See Section 4.2 for a discussion of the electricity subsidy program provided by the GN.

1.3. THE CEP PROCESS

STEPS IN THE CEP PROCESS

This CEP effort was conducted according to the framework presented in the Arctic Community Energy Planning and Implementation (ACEPI) Toolkit[14]. See the CEP framework illustrated in Figure 1.

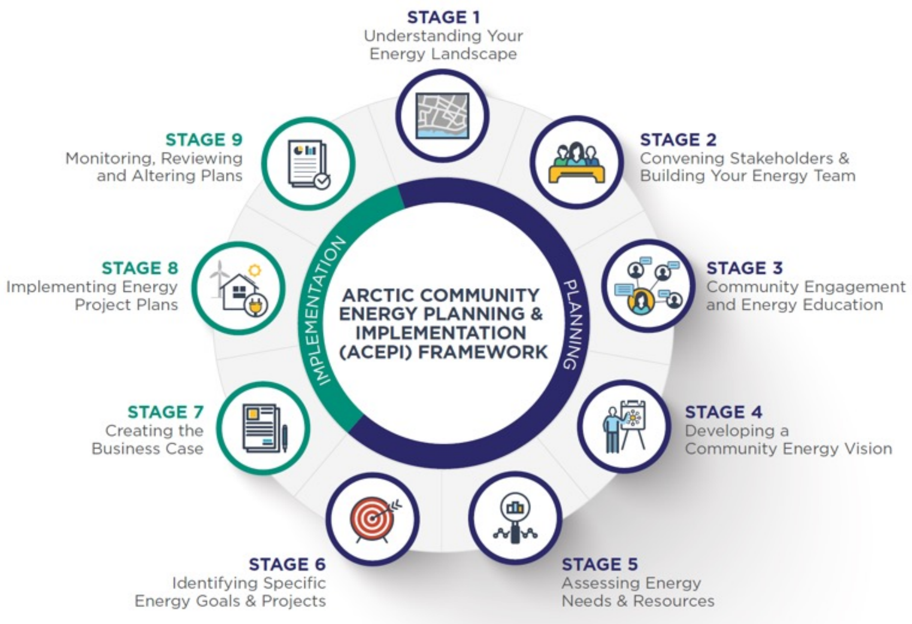

Figure 1: Framework developed for the ACEPI Toolkit (c)2019 Arctic Council.[15]

The CEP Team has worked with the community of Salliq with the intention of performing Stages 1 through 7 of this process.[16] The findings of this work are presented in this CEP as follows:

- **STAGE 1:** see Section 2 "Community Profile: Salliq".
- **STAGE 2:** see Section 3.2 "Energy Stakeholders in the Community".
- **STAGE 3:** see Section 3 "Community Engagement".
- **STAGE 4:** this work has not yet been performed.
- **STAGE 5:** see Section 4 "Energy Baseline".
- **STAGES 6 & 7:** see Section 5 "Energy Efficiency", Section 6 "Clean Energy", and Section 7 "Other Options for Energy Transformation".

A final section is provided to summarize the highest priority recommendations resulting from the CEP work - see Section 8 "Goals and Strategic Recommendations".

The community of Salliq is therefore, as of this date, ready to embark on Stage 7 of the ACEPI process: "Creating the Business Case". A high-level business analysis is presented in this CEP for certain recommended initiatives. These analyses could be further refined in pursuit of funding/ financing to move ideas to implementation. A description of the recommended process for further development (in ACEPI Stage 7) is provided in Section 9 of this CEP. The CEP team is

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14 Arctic Council, (2019).
15 Reproduced from Arctic Council (2019) with permission.
16 This CEP work was initiated in the midst of the global Covid-19 pandemic, which began in spring of 2020. Therefore the CEP Team's ability to conduct community engagement work was substantially delayed, and in some cases reduced. For this reason, the process of developing this CEP did not progress in linear fashion as depicted in Figure 1. Instead, the desktop analyses were drafted first (Stages 1, 2, 5, 6, 7), and work requiring substantial community engagement (Stage 3) was initiated subsequently.

prepared to continue supporting the Hamlet of Salliq in realizing its energy-related goals. Energy-related opportunities can take several years to fully develop - whether these be energy efficiency improvements, clean energy solutions, or changes to policies. The authors have established a time horizon of five years for planning purposes. It is the hope and intention of the CEP Team that, in five years' time, all of the near-term recommendations will have been implemented (ACEPI Stage 8), and some of the longer-term recommendations which are not currently viable may have become viable by then . The CEP Team also envisions an increased level of local capacity in Salliq once its residents, staff, and leadership will have increased their experience in initiating the energy transition.

The CEP process should be an iterative process (ACEPI Stage 9). The Hamlet of Salliq should revisit the CEP in future (e.g. 2027) to assess how effectively its recommendations have been pursued, and to update these recommendations based on the latest information at the time.

CHOOSING THE BEST PROJECT IDEAS

In order to focus the reader on recommendations which have the highest chance of success, the authors have also applied the framework of SMART Goals[17]. Ideas worthy of pursuit in this CEP should be:

S	M	A	R	T
SPECIFIC the idea should be clear and easy to understand,	**MEASUREABLE** people evaluating the idea's success in future should be able to measure something to determine whether success was achieved,	**ACHIEVABLE** it should be realistic that the idea could succeed if necessary resources are put to work toward it,	**RELEVANT** the idea should contribute to the objectives of this CEP, such as reducing pollution, increasing self-reliance, or creating local economic development,	**TIME BOUND** there should be a clear timeline by which the idea is expected to be implemented.

Recommendations in this CEP are also considered in two time categories:

- **Near-term opportunities:** which are viable today, and which could realistically be implemented within the next 5 years. This includes smaller, simpler projects with a high return ("low hanging fruit") as well as larger, more complex projects that are more impactful ("high impact projects").
- **Longer-term opportunities:** which are not viable based on today's economic conditions, but which could be expected to become viable 5+ years into the future (e.g. an emerging new technology that is currently too expensive), or projects which should not be pursued until an earlier step is completed (e.g. adding electric vehicles could become a project, but only after the electric grid has been largely converted to clean energy).

17 Doran, G. T. (1981). "There's a S.M.A.R.T. way to write management's goals and objectives". Management Review. 70 (11): 35–36.

The CEP Team also considered the following factors when evaluating project ideas:

- Costs including up-front capital costs and ongoing operating costs,
- Savings expected from the operation of the project,
- Reductions in pollution (e.g. fuel spills, air pollution) including GHG emissions,
- Financial pay-back period, i.e. how quickly the project savings can be used to repay the project costs,
- Level of complexity, with a preference for simpler projects where possible,
- Risk, including early-stage development risk and operational risk,
- Jobs and training that could potentially result from the project, and
- Eligibility for federal funding to help reduce the financial burden.

The final section of this CEP, Section 9 "Goals and Strategic Recommendations", considers all of the ideas identified in the CEP and analyzes them according to the criteria listed above. The best recommended projects are then summarized, with greatest attention and detail given to the near-term projects. In this way the Hamlet of Salliq is empowered with a set of SMART near-term goals that it could choose to pursue, as well as other good ideas for consideration in future.

1.4. CEP TEAM

This community energy planning effort was led by a CEP Team consisting of the following parties:

- **Sakku Investments Corporation:** Sakku Investments Corporation (Sakku) is the Development Corporation of the Kivalliq Inuit Association (KIA). Under the Nunavut Land Claim Agreement, KIA is a designated Inuit organization which represents the interests of all Inuit living in the Kivalliq Region. Sakku's vision is "a viable and healthy economy for the Inuit of the Kivalliq Region", and Sakku's mission is "to invest in viable business enterprises to the betterment of the Inuit of the Kivalliq Region".[18]

  Contact:
  Sakku Investments Corporation ᓵᒃᑯ ᐱᕈᐃᓭᖅᑎᓂ ᐊᐅᓚᑦᑎᔩᑦ
  Po Box 188, 32 Sivulliq Ave.,
  Rankin Inlet, NU, X0C 0G0
  Tel : 1-867-645-2805
  Eml: contact@sakku.ca
  Web: www.sakkuinvestments.ca

  Representatives on the CEP Team:
  - Blaine Chislett, Energy Champion
  - Cassandra Hargrave, Project Manager
  - Jean Conrad, Director of Operations

18 Sakku Investments Corporation (2019). About Sakku Investments Corporation. https://www.sakkuinvestments.ca/about-sakku/

- **Government of Nunavut, Department of Environment, Climate Change Secretariat:** The Climate Change Secretariat (CCS) is the Government of Nunavut's (GN) voice on climate change[19]. Housed within the Department of Environment, CCS coordinates climate change action across the GN and provides advice to departments and agencies on how to incorporate climate change initiatives into their work. The vision of the CCS is "to build a climate resilient Nunavut" and its mission is "to raise climate awareness in Nunavut while coordinating initiatives with communities and across the GN." CCS works collaboratively to coordinate initiatives that help Nunavut by planning for current and future climate change impacts, reducing our greenhouse gas emissions, and increasing climate change awareness amongst Nunavummiut.

  When it comes to Community Energy Planning, it is CCS's role to provide leadership and support the communities in developing energy plans. CCS is doing so by:

  - Connecting communities with key climate change partners and funding opportunities, and
  - Leading interagency development of exploratory options to reduce greenhouse gas emissions and lessen the territory's reliance on imported fossil fuels.[20]

  Contact:
  Government of Nunavut, Department of Environment, Climate Change Secretariat
  P.O. Box 1000, Stn. 1360
  Iqaluit, NU, X0A 0H0
  Tel: 1-867-975-7700
  Eml: climatechange@gov.nu.ca
  Web: www.climatechangenunavut.ca

  Representatives on the CEP Team:
  - Andreane Lussier, Climate Change Mitigation Manager
  - Jordan Blake, Energy Policy Advisor
  - Hyacinthe Djouaka, Climate Change Mitigation Specialist

19 Nunavut Climate Change Centre [NCCC] (no date). Climate Change Secretariat. https://www.gov.nu.ca/environment/information/climate-change-secretariat
20 NCCC (no date). Climate Change Secretariat

- ***Northern Energy Capital***: As a corporation, Northern Energy Capital exists to empower and enable community-owned renewable energy projects that transform the way energy is delivered in our northern communities, and in the process leave citizens with greater independence, resilience and economic opportunities. In realizing this purpose, NEC designs, develops and provides financial solutions for energy projects engineered for Canada's northern and remote communities.[21]

  Contact:
  Northern Energy Capital
  Suite 502 - 151 W. Hastings Street,
  Vancouver, BC, V6B 1H4
  Tel: 1-250-213 8185
  Eml: contact@northernenergycapital.com
  Web: www.northernenergycapital.com

  Representatives on the CEP Team:
  - Malek Tawashy, CEO, Northern Energy Capital
  - James Griffiths, Lead CEP Author, Northern Energy Capital

- ***The Hamlet of Coral Harbour (aka Salliq***): Key members of the community participated in the CEP work. A list of energy stakeholders in the community, who also participated in the CEP process, is provided in Section 4.2.[22]

  Contact:
  Hamlet of Coral Harbour
  P.O. Box 30,
  Coral Harbour, NU, X0C 0C0
  Tel: 1-867-925-8868
  Eml: coraledo@qiniq.com
  Web: www.coralharbour.ca

21 Northern Energy Capital (2021). About Us. http://www.northernenergycapital.com/
22 The Hamlet of Coral Harbour. (no date). Coral Harbour Community Website. https://coralharbour.ca/

2. Community Profile: Salliq

This section describes the community of Salliq, Nunavut.

2.1. GEOGRAPHIC SETTING

The coastal northern community of Salliq is located in a deep protected bay on the South side of Shugliaq Island (aka Southampton Island), which is at the northern end of Hudson Bay. Salliq lies within the territory of Nunavut at a latitude of 64°08’13”N and longitude of 83°09’51”W, just south of the Arctic Circle.

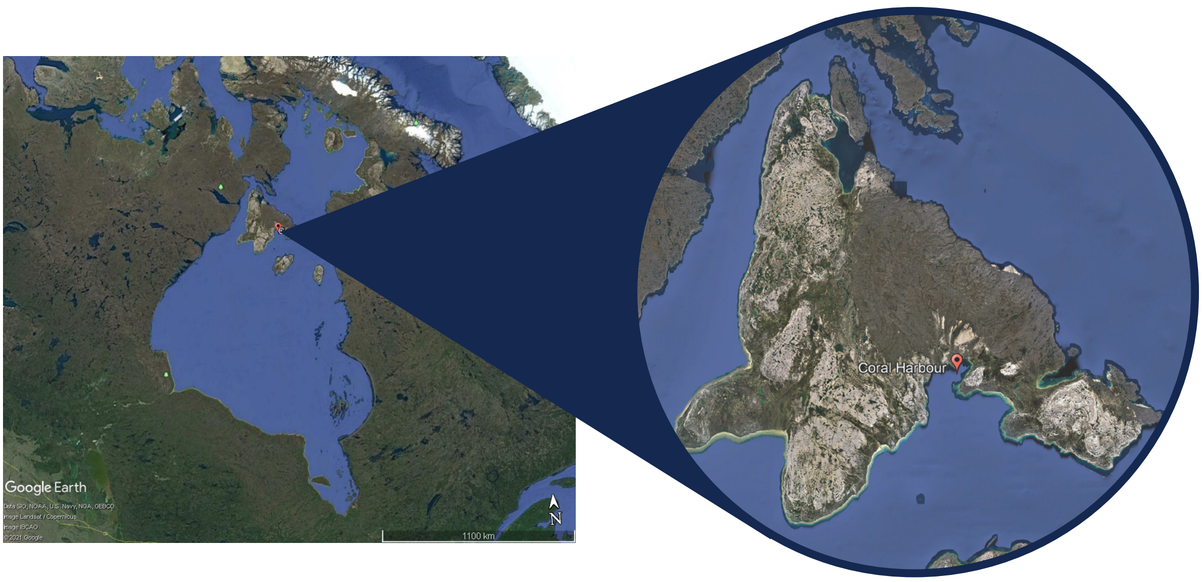

Figure 2: Location map for Salliq.

Salliq is remote, being over 300 km distant from the next nearest community. The terrain in the vicinity of the community is flat with frequent bedrock outcrops visible between regions of flat permafrost.

2.2. CLIMATE

Being near the Arctic Circle, Salliq experiences cold temperatures and long nights in the winter months, and mild temperatures with long sunny days in the summer months. The residents of Salliq are accustomed to this environment and the wide range in temperatures. Traditional activities in the region, as well as the behaviour of flora and fauna in the region, undergo seasonal cycles.

Temperature and precipitation are illustrated in Figure 3. Temperatures are regularly below freezing level for most of the year; average temperatures reach above freezing only from June through September.[23] In January, temperatures range from -26 °C during the day to -34 °C by night (the coldest ever recorded was -53 °C). July temperatures range from 15 °C by day to 5 °C by night (the hottest ever recorded was 28 °C). Temperatures can drop below freezing during all months of the year.

The temperature is generally less than 18 °C (a temperature that is commonly comfortable for humans) during all months of the year, with a total of 10,610 "degree days"[24] in a year. Therefore the residents of Salliq use heating in their buildings, but never cooling / air conditioning.
The climate is dry, with approximately 25mm of precipitation each month on average, most of this in the summer and fall. A few feet of snow covers the ground from October through June, with rain occurring during the summer months. The fall and spring seasons are times of great transition in the environment. Sea ice covers the ocean near Salliq from November through June (pers. comm. NRCan).

Salliq is relatively sunny during the summer months, with over 300 hours of bright sunshine on average in July (over 10 hours of bright sunshines per day on average). Average hours of sunshine are illustrated in Figure 4.

Wind speeds in town remain fairly consistent year-round, with monthly averages (at ground level) ranging from 16 km/h in July to 21 km/h in November. Winds typically blow from the North throughout the year. Wind speeds are also illustrated in Figure 4. A more detailed treatment of wind speeds and solar irradiation is provided in Section 6 in the context of renewable energy potential.

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23 Government of Canada (2020). Canadian Climate Normals 1981-2010 Station Data. https://climate.weather.gc.ca/climate_normals/

24 A "degree day below 18 °C" is a day where the temperature drops below 18 °C multiplied by the difference in this temperature from 18 °C. For example if a day's average temperature is 5 °C then this would be 18 - 5 = 13. "Degree days below 18 °C" for the year is the sum of each of these calculations for the entire year. It is a measure of how often a community is colder than 18 °C, and how much colder.

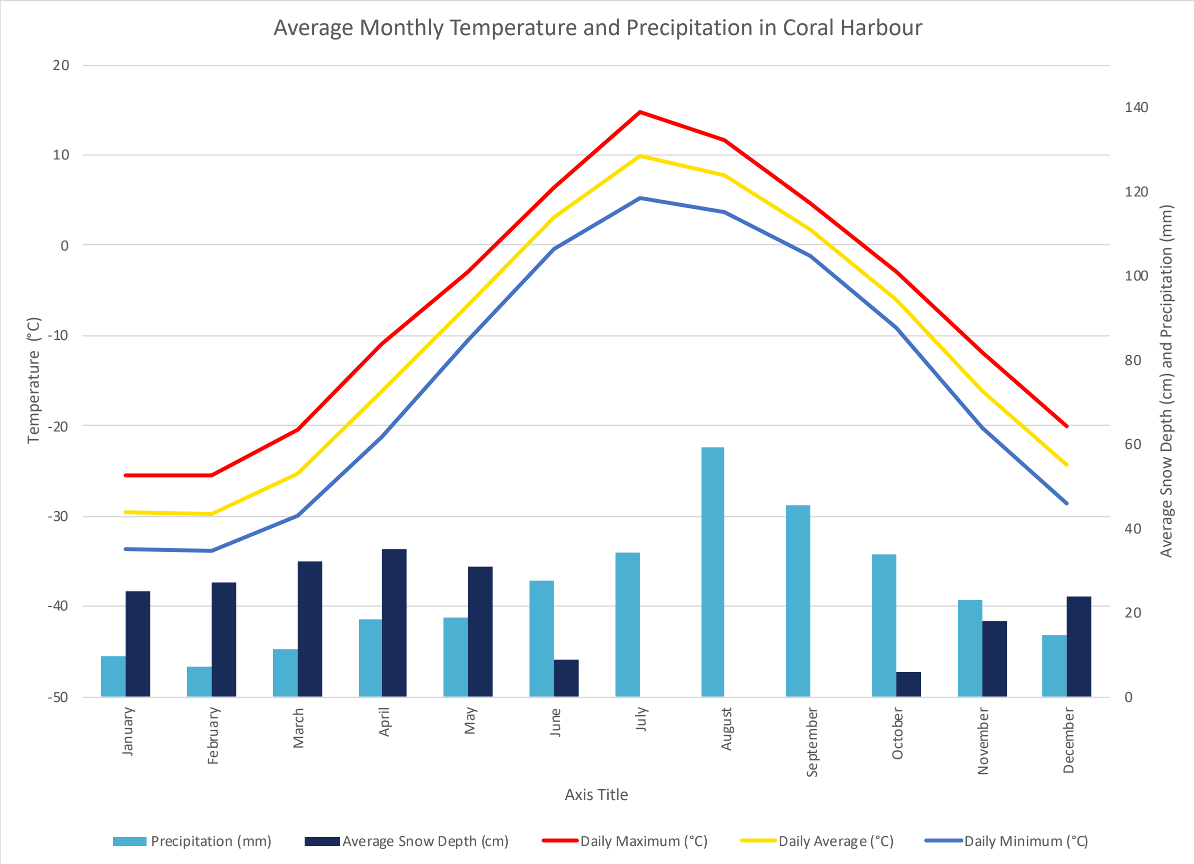

Figure 3: Average monthly temperature, precipitation, and snow depth in Salliq.

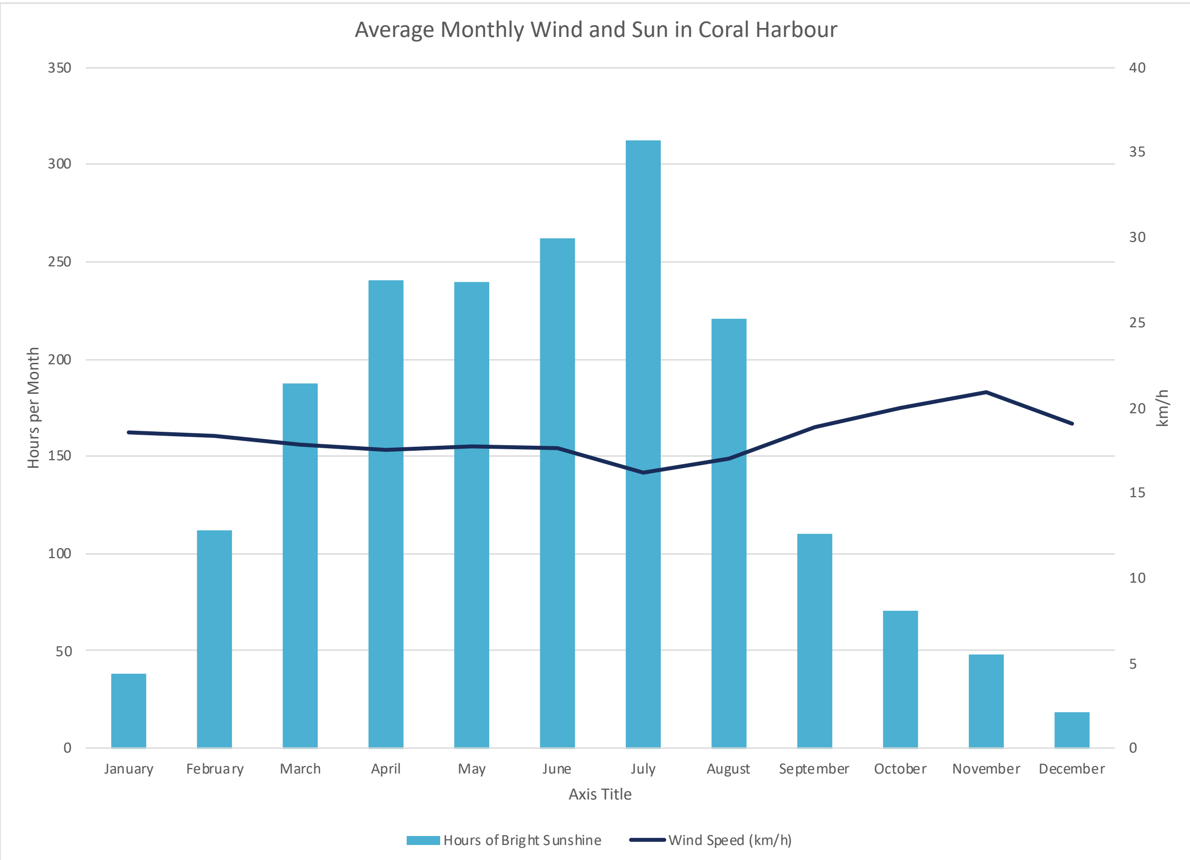

Figure 4: Average wind speeds and days of bright sunshine in Salliq.

2.3. CLIMATE CHANGE IN THE COMMUNITY

The Arctic is warming three times faster than the global average[25]. Climate change is causing significant changes to the stability of Nunavut's environment and the Inuit way of life. Inuit have been documenting these changes for generations, and these observations are now also supported by western science.

Inuit have observed the environmental impacts of climate change, including:

- changes to the length of the seasons,
- changes to the quality and extent of sea ice,
- impacts on vegetation, including berries, and
- thinning/deterioration of animal skins used for sewing[26].

Physical impacts from climate change are already affecting Nunavut in the following ways:

- record-breaking temperature and precipitation[27] [28]
- 40% of the Milne Ice Shelf collapsed off the western side of Ellesmere Island in 2020.[29]

Impacts from climate change are already affecting many aspects of the daily lives of Nunavummiut, including:

- damage to land infrastructure (buildings, roads, mines, and runways) from permafrost thaw and extreme weather events[30],
- damage to marine infrastructure (docks, wharves, and ports) from coastal erosion and extreme weather events[31],changes to hunting routes from sea ice loss, permafrost thaw, and snow melt[32],

25 Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. (2019): Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, pp 112-193.

26 Inuit Tapiriit Kanatami (2019). National Inuit Climate Change Strategy. https://www.itk.ca/wp-content/uploads/2019/06/ITK_Climate-Change-Strategy_English.pdf

27 MacDonald, M. (2020). Personal Communication, Health and Air Quality Program Meteorologist, Environment and Climate Change Canada.

28 ECCC. (2020). Almanac Averages and Extremes for July 6th, 14th, 16th, 23rd, 26th, 27th, 28th, 30th, 31st, Alert Climate Nunavut. https://climate.weather.gc.ca/climate_data/almanac_selection_e.html

29 Water and Ice Research Laboratory (2020). Milne Ice Shelf 2020, Press Release August 7, 2020. University of Carleton, Ottawa, Ontario.

30 Gregoire, L (2008). Grise Fiord: Climate Change – Slumping, sinkholes and thermosyphons. Canadian Geographic.https://www.canadiangeographic.ca/article/grise-fiord-climate-change-slumping-sinkholes-and-thermosyphons

31 Frizzell, S. (2017). Canada's northernmost community seeks PM's help to weather climate change. CBC News. https://www.cbc.ca/news/canada/north/grise-fiord-climate-change-budget-1.4036677

32 Nunavut Tunngavik Incorporated (2001). Elder's Conference on Climate Change: Final Report. March 29-31, 2021, Cambridge Bay Nunavut. https://www.tunngavik.com/documents/publications/2001-03-21-Elders-Report-on-Climate-Change-English.pdf

- changes in wildlife patterns and therefore hunting practices due to extreme weather events, changes in seasons, introduction of new species, and changes in sea ice patterns[33],
- changes to the tourism, the shipping industry and hunting routes due to sea ice loss[34],
- changes in water quality and quantity which are affecting drinking water and traditional fishing and hunting practices[35], and
- impacts for hunting and harvesting of certain species that are expanding their population and range with warmer temperatures[36].

In Salliq specifically, community members report the following direct observations which are believed to be affected by climate change:

- Warmer temperatures, with summers arriving earlier and lasting longer,
- Ocean ice is noticeably thinner,
- More extreme storms,
- Increased drought,
- Increased damage to animal skins,
- Increase in quantity and diversity of insects, and
- Flooding and erosion in coastal areas.

Nunavummiut are proud of their strong relationship to the land. Nunavut is rich in wildlife, fish and other natural resources. However, Nunavut's ecosystems are fragile and have long recovery times. Therefore, they need to be managed responsibly and sustainably, and treated with respect.

Because all infrastructure in Nunavut is built on permafrost, including a large portion that is slowly thawing, Nunavut communities will need to adapt to the effects of climate change.

Each Nunavut community has its own standalone energy grid. The harsh climate, remote locations, and high costs of living in Nunavut represent a significant challenge in implementing alternative energy sources and reducing GHG emissions. Implementing innovative technologies and solutions will be paramount to reducing dependence on fossil fuels and reducing the territory's GHG emissions.

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33 Government of Nunavut. (2019). Arctic and Northern Policy Framework, Nunavut's Vision.
34 Inuit Circumpolar Council Canada. (2014). The Sea Ice Never Stops: Circumpolar Inuit Reflections on Sea Ice Use and Shipping in Inuit Nunaat. Ottawa, Canada: ICC-Canada. https://secureserver-cdn.net/104.238.71.250/hh3.0e7.myftpupload.com/wp-content/uploads/Sea-Ice-Never-Stops-Final.pdf
35 P. Carlsson et al. (2016). Influence of Climate Change on Transport, Levels, and Effects of Contaminants in Northern Areas – Part 2. Oslo, Norway: AMAP. https://www.amap.no/documents/download/2917/inline
36 Inuit Tapiriit Kanatami (2019). National Inuit Climate Change Strategy.

2.4. COMMUNITY HISTORY

Salliq was historically the home of the Sallirmiut, people who are believed to have been the last of the Thule Inuit in the Arctic.[37] The Sallirmiut benefited from the abundant resources in the region, including Caribou, which served as an important food source. Sadly the majority of the Sallirmiut perished due to typhus disease contracted from European whalers in 1902.[38]

New people came to Salliq from other communities in the North, often associated with the whaling industry. In 1924 a trading post was established at Salliq by the Hudson's Bay Company. An airstrip was later built by a collaboration of the Canadian and US militaries, and the airstrip now serves the community. The Government of Canada built a school in 1955 and a nursing station in 1963, and other community buildings and publicly funded housing since then. Essential services, such as health care and education, have attracted many Inuit to move permanently to Salliq from the surrounding areas. Salliq was incorporated as a hamlet in 1972. The Nunavut Land Claims Agreement was signed in 1993[39], and the territory of Nunavut was formally founded in 1999.

Caribou were over-harvested in the 1950s until there were no more caribou left on Shugliaq Island. However, caribou were successfully reintroduced in the 1960s and according to the 2019 abundance survey have a population of approximately 12,000. Today ecotourism has thrived on Shugliaq Island with tourists seeking to glimpse caribou, polar bears, walrus, beluga whales, seals, sea birds, and other wildlife.[40]

Mineral explorations have been conducted on Shugliaq Island and have demonstrated potential for gold, diamonds, uranium, base metals, and nickel-copper platinum group elements.

37 *The Hamlet of Coal Harbour. (no date). Sallirmiut. https://coralharbour.ca/history-and-the-people/the-sallirmiut-people/*

38 *Struzik, E. (2012). Salliq. From: The Canadian Encyclopedia [online]. https://www.thecanadianencyclopedia.ca/en/article/coral-harbour*

39 *Nunavut Land Claims Agreement, The Inuit of the Nunavut Settlement Area-Canada, May 25, 1993, S.C. 1993 c. 29. https://www.gov.nu.ca/sites/default/files/Nunavut_Land_Claims_Agreement.pdf*

40 *Nunavut Planning Commission (2021). Salliq. https://www.nunavut.ca/coral-harbour*

2.5. COMMUNITY DEMOGRAPHICS

The most recent census in the community (2016) recorded a population of 890 people[41].

Population growth has been high, with a 6.8% increase between 2011 and 2016 (1.3% per year). Over 96% of the population identifies as having indigenous ancestry and a knowledge of the local language, Inuktitut. Approximately half the population speaks Inuktitut at home, with the other half speaking English at home. 13% of people speak Inuktitut in the workplace. An estimated 25 people are unilingual Inuktitut speakers.

The population of Salliq is young, with a median age of 21, and with only 5% of the population being over 65 years of age. For comparison the median age across Canada is 41. The population of Salliq is family based, with the majority of people over 15 years of age being either married or living as common-law. The majority of these families have children.

The average income, before taxes, for residents over the age of 15 is approximately $35,000 per year, with a median of $21,000. The average household income in Salliq is approximately $81,000, with a median of $59,000. Residents with full time employment earn on average $77,000 per year. 20% of income in Salliq comes in the form of government transfers.

There are approximately 35 households in the community with a total income below $20,000. A 2019 report on child and family poverty in Canada estimated that over 30% of children in Nunavut live below the poverty line.[42] Another study in 2018 estimated that approximately 7 out of 10 Inuit children live in food insecure households.[43]

According to Statistic's Canada, 42% of adults (anyone over 15 years old) in Salliq are employed, whereas 20% are unemployed, and 38% are not in the workforce. There are no statistics regarding the percentage of the population that engages in unpaid traditional activities, such as hunting and gathering. Of those recognized as working, 10% of are self-employed, with the remainder working as employees. The most common fields of occupation include "sales and service occupations", "education, law and social, community and government services", and "trades, transport and equipment operators and related occupations". The most common industries of employment include "public administration", "retail trade", "educational services", and "health care and social assistance". Many of these jobs are in the public sector.

Approximately 41% of adults in Salliq have completed high school, and 27% have continued with post-secondary education, either in trades or at a college/university. Approximately 4% have a bachelor degree. Approximately a third of college-educated residents completed their studies outside of Nunavut and then returned home.

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41 Statistics Canada (2016). Census Profile, 2016 Census: Salliq, Hamlet. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=6205014&Geo2=CD&Code2=6205&SearchText=coral%20harbour&SearchType=Begins&SearchPR=01&B1=All&TABID=1&type=0

42 Campaign 2000 (2020). 2019: Report Card on Child and Family Poverty in Canada. https://campaign2000.ca/wp-content/uploads/2020/01/campaign-2000-report-setting-the-stage-for-a-poverty-free-canada-january-14-2020.pdf

43 Dachner, N and Tarasuk, V. (2018) "Tackling household food insecurity: An essential goal of a national food policy". Canadian Food Studies. Vol. 5 No. 3, pp. 230–247.

2.6. COMMUNITY GOVERNANCE

The Hamlet of Salliq is represented by an elected municipal council consisting of a Mayor and eight Councilors. The last election occurred on October 28, 2019, in which all nine members of council were acclaimed without competition.[44] Elections occur every four years. At the time of writing this report, the Hamlet Council was made up of the following members:

- Mayor Willie Nakoolak
- Councilor Cindy Ningeongan
- Councilor Danny Pee
- Councilor Doris Bruce
- Councilor Jordan Emiktowt
- Councilor Kidlapik Nakoolak
- Councilor Leonie Duffy
- Councilor Noah Kadlak
- Councilor Troy Netser

The Hamlet government is mandated to deliver municipal services to the community. It is responsible for "snow clearing, water delivery, sewage pump-outs, garbage pick-up, and by-law enforcement, among other things".[45] The elected Hamlet Council makes the decisions on community needs and the hamlet staff administer those needs.

The senior staff person at the Hamlet is the Senior Administrative Officer (SAO), a position currently filled by Leonie Pameolik. Local departments under the SAO include "housing maintenance, water/sewage and garbage pickup, heavy equipment and garage maintenance, community economic development, community recreation, by-law enforcement, municipal building permits and various other community services". The Hamlet is a large employer in the community.

The Hamlet government is primarily funded by the GN under a formula based on population, need and other variables. These funds are provided to the GN by the Canadian Federal Government. Some services in Salliq are provided by the federal and territorial governments, as well as several private companies.

The Kivalliq Inuit Association (KIA) is the regional inuit organization, and their mission is "to represent, in a fair and democratic manner, Inuit of the Kivalliq Region in the development, protection, administration and advancement of their rights and benefits as an aboriginal people; as well as to promote their economic, social, political and cultural well-being through succeeding generations."

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44 Elections Nunavut. (2019). Election Results for October 28, 2019. https://www.elections.nu.ca/en/municipal-elections/municipal-council/results-municipal-council-election

45 The Hamlet of Coral Harbour. (no date). The Hamlet. https://coralharbour.ca/the-hamlet-and-news/

2.7. PLANNING

REGIONAL LAND USE PLANNING

The community of Salliq is in the planning region of the Keewatin[46] Regional Land Use Plan (KRLUP). The KRLUP was developed by the Nunavut Planning Commission (NPC)[47] and its partners over four years, and included consultation with people throughout the region.

The KRLUP was the first land use plan review to be conducted under the terms of the Nunavut Agreement[48]. The NPC was guided in its work by certain principles of the Nunavut Agreement including:

- "The primary purpose of land use planning in the Nunavut Settlement Area shall be to protect and promote the existing and future well being of those persons ordinarily resident and communities of the Nunavut Settlement Area taking into account the interests of all Canadians; special attention shall be devoted to protecting and promoting the existing and future well being of Inuit and Inuit Owned Lands...
- The purpose of a land use plan shall be (in addition to those stated above)...to protect, and where necessary, to restore the environmental integrity of the Nunavut Settlement Area...
- In the development of a regional land use plan, the NPC shall give great weight to the views and wishes of municipalities in the areas for which planning is being conducted...
- Land use plans shall take into account Inuit goals and objectives for Inuit Owned Lands..." [49]

Inuit Qaujimajatuqangit (IQ) is used throughout the KRLUP.

Land use planning on Inuit Owned Lands in Nunavut has the following objectives:

- "to promote, protect and enhance Inuit rights and interests on [Inuit Owned Lands] through the concept of sustainable development,
- to provide Inuit with rights in land that promote economic self-sufficiency of Inuit through time, in a manner consistent with Inuit social and cultural needs and aspirations,
- to identify the IOL that are of significant environmental, cultural or economic importance to Inuit,
- to ensure the incorporation of Inuit traditional knowledge in the [Inuit Owned Lands] land use planning process,
- to provide sufficient information and direction to KIA land managers when reviewing requests for land use activities, and
- to ensure the coordination of land use planning in Nunavut.

46 Keewatin is an outdated term for "Kivalliq".
47 Nunavut Planning Commission. (2000). Keewatin Regional Land Use Plan. https://www.nunavut.ca/land-use-plans/keewatin-regional-land-use-plan
48 Nunavut Land Claims Agreement, The Inuit of the Nunavut Settlement Area-Canada, May 25, 1993, S.C. 1993 c. 29. https://www.gov.nu.ca/sites/default/files/Nunavut_Land_Claims_Agreement.pdf
49 Nunavut Planning Commission (2000).

Sustainable development is the overriding principle guiding the preparation of the KRLUP, and the NPC defines it as follows: "Sustainable development is defined generally as the management of human relationships to the natural environment in such a way that economic, social and cultural needs are met, and ecological processes and natural diversity are maintained. Sustainable development considers the well-being of social, ecological and economic systems and recognizes that quality of life depends upon all these. This understanding leads to an integrated approach to planning, decision making and monitoring."[50] Sustainable development is a principle with longstanding roots in Inuit traditions, and Inuit have always adapted and found ways to survive in an ever-changing environment. The KRLUP seeks "a balance between industrial development and other human activities in order to guarantee the long-term preservation and conservation of the land, wildlife and wildlife habitat".

The KRLUP recognizes that much of the economy in the Kivalliq region is based on land and natural resources, most importantly tourism, mineral exploration, wildlife harvesting, construction services, and related regulatory activity. Kivalliq residents expressed a desire for a stronger local and regional economy that would provide more business and employment opportunities, particularly for young people. Kivalliq residents also expressed a desire to maintain the traditional Inuit lifestyle as much as possible, including ways to combine traditional elements with business/employment opportunities. The KRLUP also values public access to lands and resources.

The NCLA gives the NPC authority to review any project proposal within the planning region to ensure that it conforms to the KRLUP. Under the NCLA, municipalities remain responsible for developing municipal plans.

50 *Nunavut Planning Commission (2000).*

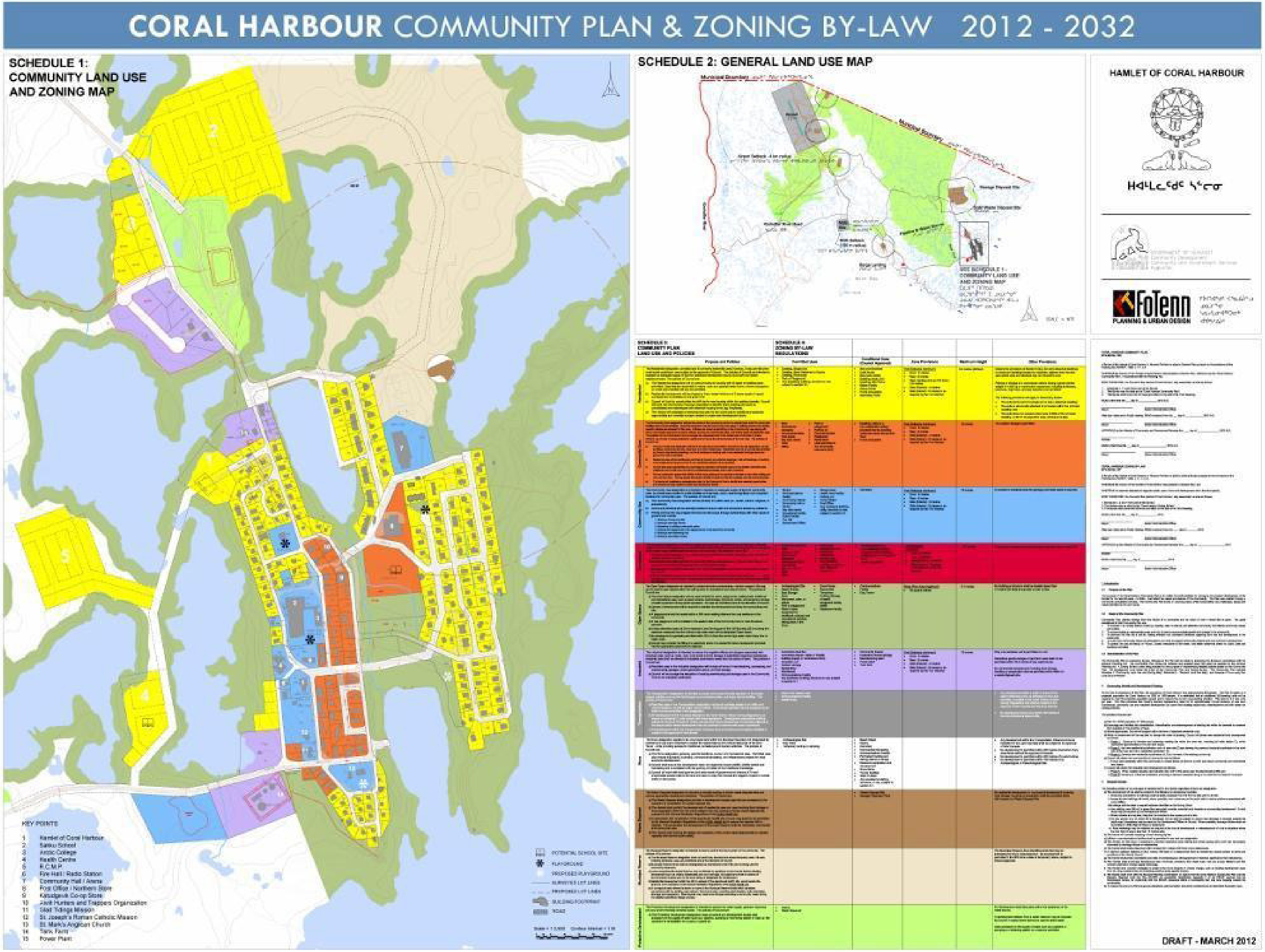

Figure 5: COMMUNITY PLAN MAP

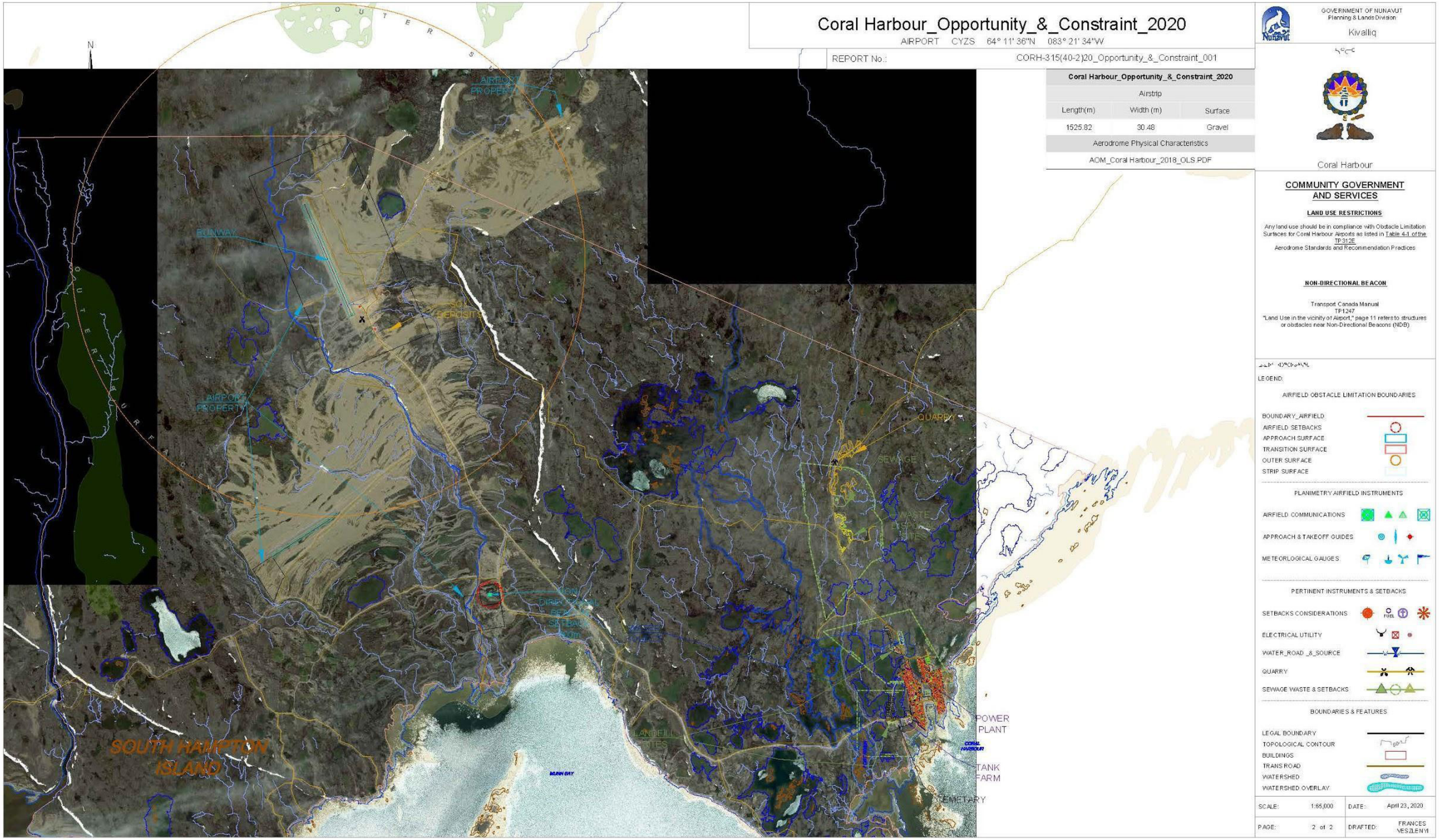

Figure 6: OPPORTUNITY AND CONSTRAINTS MAP

MUNICIPAL PLANNING

The Hamlet of Salliq has conducted various municipal planning initiatives, along with the GN department of Community Government Services (CGS) and other partners. Resulting documents and maps are housed on a CGS website: https://cgs-pals.ca/downloads/coral-harbour/

A Community Plan, Salliq By-law No. 236, was developed in 2012[51]. The purpose of the Community Plan is "to outline Council's policies for managing the physical development of the Hamlet for the next 20 years – to 2032."

The Community Plan has the following goals[52]:

1. To develop in an orderly fashion creating a safe, healthy, functional and attractive community that reflects community values and culture.

2. To accommodate an appropriate range and mix of uses to accommodate growth and change in the community.

3. To promote the Plan as a tool for making effective and consistent decisions regarding land use and development in the community.

4. To build upon community values of participation and unity to support community projects and local economic development.

5. To protect the natural beauty of "Nuna", protect viewpoints to the water, and retain waterfront areas for public uses and traditional activities.

Some notable elements in the plan that relate to energy include:

- An anticipated population in 2032 of 1,300 people,
- Concentration of development in the center of town and conservation of lands on the periphery of town,
- Development of new residential subdivisions with a preference for attached multi-unit residential building,
- A new industrial subdivision,
- Protection of archaeological sites,
- Encouragement of development that minimizes GHG emissions, is energy efficient, and that involves alternative energy,
- Adaptation to climate change, including set backs from coastal areas and erosion control,
- A commitment to present projects to the NPC for review as stipulated in the Nunavut Agreement and KRLUP.

51 *The Hamlet of Salliq [HCH]. By-law No. 236. Salliq Community Plan. Nov. 2, 2012.*
52 *HCH By-law 236 (2012).*

The Community Plan establishes 11 different land use designations, which are illustrated on the associated Community Plan Map in Figure 5. These land use designations are:

- Residential,
- Community Core,
- Community Use,
- Commercial,
- Open Space,
- Industrial,
- Transportation,
- Nuna (natural unsurveyed lands within the municipal boundary),
- Waste disposal,
- Municipal reserve, and
- Protective Development.

The Hamlet of Salliq and CGS collaborated to produce an Opportunities and Constraints Map, illustrated in Figure 6. This map can be used to identify lands that are free of conflicts with mapped features such as water sources, waste disposal sites, sewage areas, landfill sites, a tank farm, a cemetery, etc.

The Hamlet of Salliq has established the following:

- By-law No. 124 "Land Administration"
- By-law re "Quarry Administration"
- By-law No. 237 "Zoning By-law"

INTEGRATED COMMUNITY SUSTAINABILITY PLANNING

CGS and the Hamlet of Salliq, along with partners, collaborated to complete an Integrated Community Infrastructure Sustainability Plan in 2011[53]. This plan was produced according to the Integrated Community Sustainability Plan (ICSP) Toolkit, and intended to "reflect community goals and priorities identified by Hamlet Council and include the cultural, social, economic and environmental values associated with each community infrastructure priority." [54]

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53 Aarluk Consulting Inc. (2011). Infrastructure for a Sustainable Salliq. Vol 1, 2. Retrieved from: http://toolkit.buildingnunavut.com/en/Community/Old/5fd1ab6d-96b8-44f9-97fc-a1f700f2c2c9
54 Government of Nunavut (no date). Integrated Community Sustainability Plan Toolkit. http://www.buildingnunavut.com/en/index.asp

The general sustainability goals of the ICSP process are as follows[55]:

1. Meet basic human needs.
2. Achieve a sustainable economy and self-reliance.
3. Ensure equitable access for all residents and financial sustainability.
4. Promote individual and community health and well-being.
5. Use resources efficiently.
6. Reduce waste and hazardous waste.
7. Protect and promote Inuit culture, heritage and language.
8. Protect the environment and ecosystems."

During the 2011 ICSP process, residents of Salliq also identified the following goals in relation to municipal infrastructure[56]:

- "Connecting improvements to infrastructure and with economic development:
    - o **Timelines that are sustainable** – community would like capital projects to be planned with realistic and committed timelines.
    - o **Economic** – providing a plan for infrastructure development to support our current and future economic growth. Ensure that our infrastructure costs do not hamper our economic activity.
    - o **Education** – ensure education infrastructure and programs are a priority. Link education to economy. Building capacity in the community is key to future success.
    - o **Funding** – the impact of new infrastructure and the funding for programs needs to be linked.
- Long term goal is the community's Self-sufficiency:
    - o Accountability in the government and community are important for sustainable development, economy and infrastructure.
    - o Community voice in planning and implementation of infrastructure planning will be recognized at the government level."

Salliq has updated its annual ICSP summary, including the latest update for 2020/21[57] . The top 10 priorities identified in the 2020/21 ICSP for Salliq are:

1. construction of a new community hall,
2. construction of new public housing,
3. procurement of a new rock crusher,
4. renovations to a parking garage,
5. construction of new public housing for elders,
6. construction of a new small craft harbour,
7. drain the lake in town called Umajualuk Lake,
8. expansion or replacement of the health center,
9. add a new RCMP officer and jail cell,
10. construction of a new bridge at Murjangaat River.

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55 *Aarluk Consulting (2011)*

56 *Aarluk Consulting (2011)*

57 *HCH (2021). ICSP Community Profiles: Infrastructure Plan for Salliq, 2020/21. http://toolkit.buildingnunavut.com/en/Community/Plan/5fd1ab6d-96b8-44f9-97fc-a1f700f2c2c9*

Note that the top priority in the previous year's ICSP was to address the state of the community's Sakku school, however this project is now underway.

A 2008 consultation effort in Salliq revealed a desire to improve the efficiency of the local diesel-electric power plant. The 2011 ICSP consultations identified "Energy conservation and alternative energy production technology" as a lower long-term priority with the potential to support the community's environmental, economic, and social goals. Most recently, the 20/21 Salliq ICSP lists as priority #28 "Alternative Energy Sources" including solar PV projects.

It is clear that issues related to energy conservation, cost of energy, and environmental stewardship are important in Salliq. However they occur in a context of various other urgent priorities related to health, overcrowding, and public services, as highlighted in the ICSP process.

OTHER INFRASTRUCTURE RELATED LEGISLATION

Other legislation that is relevant to energy projects in Nunavut includes:

- **Building Code:** Consolidation of Building Code Act[58]
- **Electrical Code:** Canadian Electrical Code[59]

2.8. PAST INITIATIVES IN THE COMMUNITY

Salliq has a history of successful clean energy projects. A 10-kW solar PV project was constructed in 2018 on the roof of the Qaggivik Arena, marking a turning point in the community's ability to transition to locally-produced clean energy.[60] This project sells electricity to QEC under the utility's Net Metering program. This project was built by contractor Green Sun Rising, which reports annual production of approximately 10,000 kWh /yr, equal to approximately 30% of the Arena's electrical needs in the summer months (less in winter). This project is small compared to the overall energy needs of the community, however it demonstrates the viability of solar PV technologies in Salliq, and local residents benefit from becoming accustomed to the presence of solar PV in the landscape.

The potential for larger-scale renewable energy in Salliq has previously been studied by others. A 2019 study by Das and Canizares ranked 25 NU communities in terms of their estimated potential for renewable energy, and Salliq was ranked 9th out of 25.[61]

Another study was conducted by WWF-Canada and ITP Renewables in 2019.[62] This was a high-level examination of the potential for wind and solar energy, at different scales, including with battery storage. Educated guesses were made about wind and solar efficiency, installation costs, and

58 *Consolidation of Building Code Act. Statutes of Nunavut [2012, c. 15]. https://www.nunavutlegislation.ca/en/consolidated-law/current?title=B*

59 *Canadian Standards Association Standard, C22.1-15, Canadian Electrical Code Part I, 23rd Ed., Safety Standard for Electrical Installations*

60 *Green Sun Rising Inc. (no date). Diesel Reduction with Solar PV in Canadian Remote Communities. https://greensunrising.com/info/canadian-arctic/*

61 *Das & Canizares (2019). Renewable Energy Integration in Diesel-based Microgrids at the Canadian Arctic. URL: https://ieeexplore.ieee.org/document/8798665*

62 *WWF, ITP Renewables. (2019) Renewable Energy Can Power Nunavut's future: Report. https://wwf.ca/wp-content/uploads/2020/03/POWERING-NUNAVUT%E2%80%99S-FUTURE-with-habitat-friendly-renewable-energy.pdf*

operating costs. They studied how much battery storage would be needed to maintain stability of the electrical grid, for small and large projects. It was determined that certain combinations of technologies are likely to be economically viable in Salliq and could reduce diesel consumption by between 15 - 40%. The combinations that were studied included solar panels plus batteries, wind turbines plus batteries, or a combination of all three.[63] Solar energy performed slightly better than wind energy in this study. In fact Salliq was found to have the highest solar resource in this study, resulting in more cost-effective GHG reductions compared to most Nunavut communities. The study determined that wind and solar energy projects in Salliq could produce electricity at a price of approximately $0.51 - 0.58 /kWh with a 4% return on capital, or a higher return if grant money could be obtained. The study team concluded that Salliq warrants further detailed study.

The CEP team has reviewed this 2019 study and considers it to be reasonable. More detailed analysis of specific clean energy projects is presented in this CEP in section 6.

2.9. CURRENT INITIATIVES IN THE COMMUNITY

The following initiatives are currently underway in Salliq, which will contribute to energy efficiency in the community.

BUILDING RENOVATIONS AND REPLACEMENT

Planning is underway to arrange a renovation of the Sakku School building. There is likely a need to improve the school in relation to energy efficiency, but also other urgent issues such as mold, ventilation, structural issues, pedestrian traffic flow, fire safety, and overcrowding[64]. Mold and related health effects have been the subject of concern by local residents, with some families holding children back from school until the building is improved.[65] Current renovations include construction of a new gymnasium, conversion of the old gymnasium into educational trades/ shop space, improved acoustic insulation, internet connectivity throughout the school, improved accessibility, and in-floor heating for toddlers in daycare spaces.[66]

Other commercial-scale buildings in Salliq that are also in urgent need of renovation/replacement include the community hall, hamlet office, swimming pool, and health center. There is an opportunity to consider energy efficiency and lifecycle energy costs (and pollution) in the design of these new/renovated buildings.

NHC is also planning to conduct renovations to 50 Salliq households in 2021, primarily single-unit households that are oldest and in poorest condition.[67] Funding has been provided by the Low Carbon Emissions Fund to cover upgrades to heating systems, hot water systems, and building envelopes. It is anticipated that these renovations will improve energy efficiency to some extent.

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63 E.g. solar PV projects ranging from 460-kW to 2,000-kW and wind energy projects from 100-kW to 2,000-kW.

64 HCH (2021)

65 News article entitled “School in Coral Harbour reopens despite parents’ concerns about mould”. https://www.cbc.ca/news/canada/north/coral-harbour-school-1.4868792

66 News article entitled “Plans unveiled for Sakku School renovation and expansion in Coral Harbour”. https://www.nunavutnews.com/kivalliq-news/plans-unveiled-for-sakku-school-renovation-and-expansion-in-coral-harbour/

67 Pers. comm. with Jimmy Main of NHC.

LED STREETLIGHTS

The Hamlet of Salliq and QEC are collaborating to replace all streetlights in the community with Light Emitting Diode (LED) bulbs. This involves replacing both the bulb itself and the "head" of the streetlight. This work is scheduled to take place in 2021.[68]

Based on information from QEC, there are currently 91 streetlights in the community, which run for 4,000 hours per year, consuming 56 MWh of electricity or 16,400 L of diesel. After replacement with LEDs, these same streetlights will consume 23 MWh of electricity, or 6,700 L of diesel, for an estimated savings of nearly 60%. The new LED streetlights will also produce more light than before, with benefits for human safety and wellbeing.

The cost of the LED replacement program is approximately $1,000 per bulb, or $91,000 in total. It is estimated that the resulting diesel reduction associated with the switch to LED streetlights will produce an annual savings of approximately $9,000. The resulting financial payback for the program is estimated at approximately 10 years. The switch would also reduce local GHG emissions by approximately 26.7 tonnes CO_2e annually.

The opportunity to expand LEDs across Salliq is presented in Section 5.4.

KIVALLIQ HYDRO FIBRE LINK

The KIA and Sakku are working to develop a new electrical transmission and fibre-optic data line that would connect various communities in the Kivalliq region with the main North American electrical and data grids. The KHFL would span 1,200 km at a voltage of 230-kV, and would carry a capital cost of approximately $1.6 Billion. It is estimated that the KHFL would allow QEC to purchase energy from Manitoba at a cost savings of approximately 50%, resulting in $100 Million in diesel fuel cost savings for northern communities and mines, and GHG reductions of approximately 380,000 annually. The KHFL would make northern communities less dependent on fossil fuels to provide heat and electricity to homes and businesses.

The KHFL would connect five of the seven communities in the Kivalliq region, as well as mining facilities. However, Salliq is not one of the communities that would be connected to the KHFL, due to its geography. This makes Salliq an excellent candidate for developing local energy efficiency and clean energy solutions.

2.10. CAPACITY IN THE COMMUNITY

Clean energy projects are different from most historical construction projects that have occurred in Salliq. Implementing clean energy projects will require both experienced external experts combined with local knowledge, expertise and labour from Salliq.

Solar PV technologies including modules, mounting equipment, and wiring have become increasingly simplified in recent years, and semi-experienced crews can now quickly learn to install this equipment. Modern solar wiring, for example, is designed to be installed by non-electricians, and then inspected by the project electrician. A typical rooftop solar PV crew might involve one experienced foreman, one electrician, and several local hires/trainees. Ground-mounted solar PV installations can require more specialized expertise for the foundations. Project design can be conducted completely off-site, using inputs collected from the community.

68 *Pers. comm. with QEC.*

Wind energy projects typically require outside expertise (e.g. foundation design, heavy logistics) as well as specialized equipment from outside the community (e.g. cranes). Ideally wind energy installations can rely on local labourers as part of the crew. Civil and logistical works can often include local capacity.

Building renovations are not new to Salliq, even if some of the nuances of energy efficient buildings may be novel. Energy efficiency retrofits can be designed off-site, using information gathered within the community, and these renovations can be implemented using traditional forms of contracting and using local labour where possible.

For all energy projects, operational work represents the best opportunity to involve local people. Community members in Salliq could be identified and trained, as part of project delivery, so they can assume these operational roles - e.g. maintaining a solar PV array, a wind turbine, or battery storage system. Technical support can be provided remotely to ensure that issues are resolved locally whenever possible.

Salliq is home to a certified electrician named Emilia Netser, who has recently completed a solar PV installation course. Emilia could potentially serve as a valuable resource, to coordinate others in the community during the construction and operations of clean energy projects.

Our Energy Champion, Blaine Chislett, has been trained as a Residential Energy Advisor. Blaine lives in Rankin Inlet.

2.11. LOGISTICS IN THE COMMUNITY

Most human travel to and from Salliq is by scheduled flights several times per week, while most cargo arrives by barge.

Salliq does not have a deep water port to offload cargo from ships. Therefore, ships arriving in port must anchor in the harbour and tie up a barge alongside the ship. Cargo is transferred from ship to barge using the ship's crane. The barge is then brought to the port where cargo is offloaded using a fork loader.

There is a limit on the weight of cargo that can be safely transferred from ship to barge while at sea. Loads must be less than 11 tonnes, inclusive of the container weight. Therefore the contents of a 20' sea can are limited to approximately 9 tonnes, and a 40' sea can can contain 7 tonnes of contents.

The cost to ship a sea can to Salliq is approximately $6,500 for a 20' and $13,000 for a 40' sea can. Return trips cost $800.[69] Ships visit Salliq a few times per year, and they stay as long as needed to transfer cargo. If a project requires a dedicated visit from a ship, it is common practice to charge a $50,000 "diversion fee" to divert a ship from a nearby route.

Most projects considered in this CEP can be implemented using sea cans for transport. However, the wind energy projects discussed in Section 6.3 will likely require careful consideration of logistics and associated costs.

69 *pers. comm. Tara Tootoo Fotheringham of Arctic Buying Co.*

2.12. ENERGY MARKETS, PROGRAMS, AND POLICIES

There are few programs currently operating in Nunavut to support the sustainable energy transition, however several programs are in the works. Efforts to date by the GN have focused primarily on replacing aging infrastructure and maintaining safe and reliable service[70]. The GN does not have its own policy to put a price on GHG, however the territory elected to use the Federal Backstop carbon pricing instead. There are no diesel reduction targets.

Programs available today include:

- Government funding to support home renovations and equipment, including renovations to the NHC housing stock,
- NHC provides up to $15,000 to homeowners for energy efficiency measures as part of the Home Repair Program,
- CGS provides up to $500,000 to municipalities for climate change projects. This includes energy efficiency measures and the installation of solar panels, through the Municipal Green Infrastructure Fund (MGIF) program,
- Programs for QEC to purchase small amounts of clean energy, and
- The GN Department of Economic Development and Transportation offers funding that could potentially be used to advance the sustainable energy transition.

New and future QEC programs include mechanisms for QEC to purchase larger amounts of clean energy. These programs are described further below.

NET METERING

QEC currently operates a Net Metering program, which allows QEC customers to install and operate their own electricity generating equipment and thereby reduce the amount of electricity they purchase from QEC. For example a QEC customer (e.g. a house) could install a new rooftop solar PV system in order to generate their own electricity when the sun is shining. Whenever the solar PV panels generate more electricity than the house needs, QEC would consume the extra energy and give a credit to the customer. Likewise, at times when the solar PV system is producing less energy than the house needs, then electricity would be bought from QEC to serve the house as usual.

Net metering projects are typically small to medium in scale. They are installed behind a customer's electricity meter.

The QEC Net Metering program is currently limited as follows:

- QEC will not pay for any leftover energy credits at the end of each fiscal year (March 31), and so net metering projects should be sized smaller than the costumer's annual consumption,
- All net metering projects must be less than 10-kW nameplate capacity (approx. 20-40 PV panels),

70 Heerema, D., Lovekin, D. (2019). Power Shift in Remote Indigenous Communities. https://www.pembina.org/reports/power-shift-indigenous-communities.pdf

- QEC requires that "total generation to be connected to a distribution system circuit line section shall not exceed 7% of the annual feeder section average peak load" [71], and

- Each community may have only one net metering project on a municipal account.

Based on the peak electrical load in Salliq, we estimate that QEC's 7% limit is approximately 52-kW. Salliq already has one net metering project operating - the 10-kW solar project on the arena as described in Section 2.8. Therefore, approximately 42-kW of additional net metering projects could potentially be installed in Salliq - for example eight residential solar PV projects of 5-kW each, spread across the various electrical distribution lines. It is not clear whether this program will be expanded beyond the current 7% cap in the future.

QEC only allows one net metering project per community on a municipal account, which is the case for the existing solar PV project. Therefore, unless the program is expanded, net metering does not present an opportunity for buildings operated by the Hamlet to self-generate electricity. Future net metering projects would need to be associated with residential buildings.

Residential customers in Salliq could take advantage this program and install their own clean energy systems on their homes. A typical house rooftop might be able to host approximately 5-kW of solar PV panels.

There is no fee for a customer to apply to QEC's Net Metering program. Electricity delivered to QEC is valued at the same rate as electricity purchased from QEC. For most customers, this will be at the subsidized domestic rate of $0.293 /kWh.[72]

The customer is responsible for selecting the self-generating equipment, as well as purchasing, installing, and maintaining the equipment. The generating equipment must use an inverter to produce alternating current (AC) to match the grid voltage and frequency. QEC will cover the equipment cost for a new electric meter that can measure the flow of electricity in both directions.

The application process is described in a concise 8-step process on QEC's website. Applicants must prepare the following in support of an application for net metering:

- electrical single line diagram, stamped by an accredited professional engineer,

- site plan including the meter location,

- list of materials, which must carry CSA certification,

- product sheets for all equipment.

QEC advises that a typical timeline for processing a complete Net Metering Application is two weeks.[73] Upon approval, QEC intends to install its bi-directional meter within 2-3 weeks, depending on travel schedules. The meter itself is provided free of charge by QEC, however QEC's travel and installation labour may incur a cost of approximately $3 - 4,000 to be paid by the applicant.[74]

71 Qulliq Energy Corporation. (2018). Terms and Conditions of Service. https://www.qec.nu.ca/sites/default/files/terms_and_conditions_of_service_2018_-english_final.pdf

72 See section 4.2 for more detail regarding QEC rates and subsidies.

73 Pers. comm. with Qudsia Siddiqui of QEC.

74 Pers. comm. with Qudsia Siddiqui of QEC.

Once a project is accepted for net metering, then the applicant must also submit the following before the deadline stated by QEC in its acceptance letter:

- a Wiring Permit from an Electrical Inspector,
- an Inspection Report from an Electrical Inspector,
- a completed QEC Work Order Form,
- payment for all applicable fees.

The entire process of designing and implementing a net metering project should take at least 4 months. A business analysis of net metering opportunities in Salliq is presented in section 6.2.

CIPP PROGRAM

QEC has recently launched its program for Commercial and Institutional Power Producers (CIPPs).[75] This program is similar to the IPP program described further below, however the project owner must be an existing commercial or institutional customer of QEC (e.g. a company, or a hamlet government). Furthermore, CIPP projects must be installed on the property of the QEC account holder. These limitations mean that CIPP projects will likely be limited to small-to-medium scale solar PV installations on the rooftops of existing facilities. A project of substantial size does not appear possible under this program.

The CIPP program has the following pricing structure:

- Once per year QEC will determine an average avoided cost of fuel for the entire territory of Nunavut. This price is based on a 3-year rolling average. This would be the minimum price /kWh paid to the project owner throughout the project lifetime. At present the CIPP electricity price is slightly less than $0.25 /kWh.[76]
- This territory-wide average cost of fuel would be re-evaluated periodically. If this cost increases then the project owner would share in 50% of these increases. If the cost decreases then the project owner would experience a reduction by the full amount. The total increase in electricity price would be capped at 20% over the project lifetime, and would never decrease below the starting price.
- The Power Purchase Agreement between QEC and the project owner would last for 25 years.

75 QEC CIPP Program Webpage: https://www.qec.nu.ca/customer-care/generating-power/commercial-and-institutional-power-producer-program

76 QEC has set its electricity price at $0.2476 in its template Electricity Purchase Agreement under the CIPP Program. Source: QEC (2021). Power Purchase Agreement, Commercial and Institutional Power Producer (CIPP) Program. https://www.qec.nu.ca/sites/default/files/cipp_ppa_040321_0.pdf

The Nunavut Utility Rates Review Council (URRC) invited interested parties to submit comments on QEC's CIPP program in 2020. The URRC received written comments from elected officials, GN departments, Regional Inuit Organizations and NGOs. In no particular order, here are some of the concerns shared with URRC:

- The purchase price by QEC under the CIPP (including the limit on rate increases) is not attractive to incentivise the development and implementation of renewable energy systems in Nunavut. It makes the expected payback for a renewable project too long. The CIPP purchase price should also reflect the value that renewables and battery energy storage can provide to QEC operations and grid stability.
- Under the CIPP program as proposed, significant outside grant or incentive funding is needed in order for projects to be financially viable. Larger projects are typically more financially viable than smaller ones.
- Comparison of the CIPP to programs in other jurisdictions in Canada, unless facing the similar conditions and challenges, may not be useful (e.g. grid connection, road connectivity, availability of other sources of power, etc.).
- The Electricity Purchase Agreement (EPA) term should reflect the expected life of the equipment being installed, and a guaranteed minimum price in the EPA is essential.
- There is no definition of renewable energy, or limit on generating capacity included in the CIPP program.
- It would be ideal if the CIPP program were to outline the need for a grid impact study and clarify which party is responsible for completing the work (i.e., not all of the onus should be placed on the CIPP proponent).

There are local municipal buildings, organizations, and privately owned businesses in Salliq that might be interested in participating in QEC's CIPP program, including but not limited to the following:

Tuniq Lumber and Supplies
Owner: Bruce McKitrick
Tel: 867-925-8255 | Cell Phone: 807-620-2856
PO Box 98 Coral Harbour, Nunavut, X0C 0C0
Email: bruce_mckitrick@yahoo.com

Katudgevik Hotel Inns North
Tel: 867-925-8999 | Fax: 867-925-8309
Email: Katudgevik@innsnorth.coop

Katudgevik Coop Store
Tel: 867-925-9969 | 867-925-9909 | Fax: 867-925-8309
Coral Harbour, Nunavut X0C 0C0

Northern Store
Tel: 867-925-9920 | Fax: 867-925-8863
PO Box 90 Coral Harbour, Nunavut X0C 0C0

Sudliq Development Limited
Owner: Louis Bruce
Tel: 867-925-8119
Coral Harbour, Nunavut, X0C 0C0

Leonie's Place and Craft Shop
Owner: Leonie Duffy
Tel: 867-925-9751 or 867-925-8810 | Fax: 867-925-8606
PO Box 123 Coral Harbour, Nunavut, X0C 0C0

Aiviit Hunters and Trappers Organization
PO Box 108
Tel: 867-925-8622 | Fax: 867-925-8300

Health Center
Tel: 867-925-9916 | Fax: 867-925-8380

Hamlet of Coral Harbour
Box 30, Coral Harbour, Nunavut, X0C 0C0
Tel: 867-925-8867 | Fax: 867-925-8233

Human Rights Tribunal Office
Tel: 867-925-8447 | Fax: 867-925-8453

RCMP
Tel: 867-925-0123 | Fax: 867-925-8483

Sakku School
Tel: 867-925-9923 | Fax: 867-925-8410

Sivuniksavut Daycare
Tel: 867-925-8036 | Fax: 867-925-8066

Nunavut Arctic College
Tel: 867-925-9746 | Fax: 867-925-8301

IPP PROGRAM

QEC has been developing a program for purchasing electricity from Independent Power Producers (IPPs) for several years, however this program has not yet been launched. QEC's stated mandate behind this policy is the "need for a long-term approach that prioritizes and maximizes the benefits of moving to renewable energy and decreasing QEC's dependency on diesel fuel, all while still providing safe, reliable and affordable electricity." [77]

Today the IPP model is used by utilities globally to realize clean energy projects. Under an IPP program, QEC would divert some funds that are traditionally used to produce diesel-generated power, and use these funds instead to purchase clean electricity from the owners of a new project. The project owner could be a private company, or an indigenous organization, or a partnership, however priority will be given to projects owned by Inuit organizations, Inuit businesses and municipalities. QEC would not get involved in the complex process of deciding which technologies and which sites are best - they simply pay for the electricity produced by the projects that succeed.

The owner of the project would be responsible for:

- community consultation,
- designing the project, choosing the location, and obtaining land rights,
- satisfying QEC that the electrical interconnection will be safe and reliable,
- purchasing all equipment,
- building the project,
- operating the project throughout its lifetime (often 20-25 years), and
- decommissioning at the end of the project's lifecycle.

77 QEC (2020). Application for Commercial and Institutional Power Producers Pricing Structure. https://www.qec.nu.ca/sites/default/files/cipp_pricing_structure_application_050620_final_eng.pdf

Clean energy projects typically have a high capital cost. To pay for construction of the project, IPP owners might:

- invest some of their own money (equity),
- seek government grant funding, and
- borrow money from a bank (debt) to help pay for the full cost of the project.

During operations, the IPP owner delivers electricity to QEC each month and collects revenues from electricity sales. Some of this revenue is used to maintain the project (labour and parts), some to repay debt, and if the project runs smoothly then some is taken home by the owner as profit.

Some utilities run a competitive bid process to decide which projects they will buy electricity from. Others offer contracts to the first projects that are ready to build. It is not yet clear how QEC intends to choose successful projects under its IPP program. However, information from QEC to date suggests a type of "Standing Offer" model where a specific electricity price is set by QEC, and IPP owners can come forward if their project can deliver clean energy at that price.

A business analysis of IPP project opportunities in Salliq is presented in Section 6.2 and 6.3. The CEP Team at Salliq eagerly awaits the announcement of the rules, pricing structure, and application process for QEC's IPP program.

RENEWABLE ENERGY SUPPORT PROGRAM

This program aims to support the development and expansion of renewable energy in Nunavut. It incentivizes the installation of renewable energy systems on private homes and cabins, through financial support. The program is managed by the NU Department of Environment and delivered in part by NHC. The program launched in November, 2021.

HOME RENOVATION PROGRAM BY NHC

This program provides assistance to homeowners to pay for major repairs, renovations and additions to their home. [78] Funds can be used to pay for materials, freight, and labour, and the program also offers technical support before and during construction activities. This program offers funding on a sliding scale based on household income. Maximum funding is $65,000 including $15,000 specifically for energy efficiency improvements. In the past year NHC paid out approximately $711,000 via this program throughout the Kivalliq region (seven communities).

HEATING OIL TANK REPLACEMENT PROGRAM BY NHC

This program provides assistance to homeowners to replace their heating oil tank or associated components.[79] A grant of up to $7,500 is available for tanks deemed hazardous or outdated. Funds can also be used to clean up fuel spills up to 100 L. In the past year NHC paid out approximately $196,000 via this program throughout the Kivalliq region (seven communities). This program does not appear to be applicable for alternative fuel storage such as wood pellets.[80]

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78 NHC's Home Renovation Program webpage. http://www.nunavuthousing.ca/hrp

79 NHC's Heating Oil Tank Replacement Program webpage. http://www.nunavuthousing.ca/hotrp

80 NHC (2014). Heating Oil Tank Replacement Program Guidelines. http://www.nunavuthousing.ca/docs/hotrp-guidelines.pdf

ENERGY RETROFITS BY NHC

In 2018, the Government of Canada provided $6 Million in funding for NHC to improve energy efficiency in Nunavut communities through the Low Carbon Economy Fund (LCEF).[81] As discussed previously in Section 2.9, this fund is currently being used to renovate 50 homes in Salliq.

SMALL BUSINESS SUPPORT PROGRAM THROUGH THE DEPARTMENT OF ECONOMIC DEVELOPMENT AND TRANSPORTATION

The objective of this program is "to support small businesses and community-based economic development by providing assistance to new and existing small businesses through investment in new business attraction, retention and expansion".[82] The program includes three funds:

- Small Business Opportunities Fund,
- Entrepreneur Development Fund, and
- Sustainable Livelihood Fund.

Although this program is not specifically designed to support the sustainable energy transition, funds from this program could potentially be applied to projects that advance energy efficiency or clean energy solutions for small businesses.

STRATEGIC INVESTMENT PROGRAM THROUGH THE DEPARTMENT OF ECONOMIC DEVELOPMENT AND TRANSPORTATION

This program is intended "to assist Nunavut businesses and communities in two key strategic areas: investment for businesses and economic foundations for communities".[83] Under the business investment stream of the program, businesses or entrepreneurs can apply for funding assistance to build a financing package for a business venture. Under the economic foundations stream of the program, municipal governments, societies and not-for-profit corporations can apply for assistance to support various community economic development initiatives, including the development of local economic infrastructure.

Although this program is not specifically designed to support the sustainable energy transition, funds from this program could potentially be applied to projects that advance energy efficiency or clean energy solutions.

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81 Environment and Climate Change Canada [ECCC], (Sept. 10, 2018). "The governments of Canada and Nunavut announce investments in energy efficiency upgrades that help residents save energy and money," Media Release. https://www.newswire.ca/news-releases/the-governments-of-canada-and-nunavutannounce-investments-in-energy-efficiency-upgrades-that-help-residents-save-energy-and-money-692845531.html

82 Government of Nunavut [GN]. (no date). Small Business Support Program. https://gov.nu.ca/economic-development-and-transportation/programs-services/small-business-support-program

83 GN. (no date). Strategic Investments Program. https://gov.nu.ca/edt/programs-services/strategic-investments-program

COUNTRY FOOD DISTRIBUTION PROGRAM THROUGH THE DEPARTMENT OF ECONOMIC DEVELOPMENT AND TRANSPORTATION

This program is intended "to help Nunavummiut improve the local harvesting economy and country food distribution system".[84] Funding is available under this program to assist Nunavut municipalities, or Hunters & Trappers Organizations, with purchasing and distributing country foods, training, and infrastructure.

This fund could be used to install new energy-efficient freezers for storing local foods, as has been done in other Nunavut communities including Whale Cove, Taloyoak, Sanikiluaq, Qikiqtarjuaq, Pond Inlet, Kimmirut, Clyde River, Arviat, and Arctic Bay.

COMMUNITY CAPACITY BUILDING PROGRAM THROUGH THE DEPARTMENT OF ECONOMIC DEVELOPMENT AND TRANSPORTATION

This program provides funds for each Nunavut municipality to hire and maintain a Community Economic Development Officer within the community and to support community economic development projects and initiatives that support local development priorities, as determined by the local Council.[85]

Although this program is not specifically designed to support the sustainable energy transition, funds from this program could potentially be applied to advancing the community's capacity in relation to the energy transition.

FEDERAL FUNDING FOR ENERGY PROJECTS

Various funding programs are typically offered by Government of Canada agencies which can be used to support clean energy or energy efficiency projects. Funding agencies include Natural Resources Canada (NRCan)[86], Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC)[87], and the Canadian Northern Economic Development Agency (CanNor)[88]. These programs evolve over time, and projects should target the funding streams that are best suited at the time.

84 GN. (no date). Country Food Distribution Program. https://gov.nu.ca/edt/programs-services/country-food-distribution-program

85 GN. (no date). Community Capacity Building Program. https://gov.nu.ca/edt/programs-services/community-capacity-building-program

86 NRCan: https://www.nrcan.gc.ca

87 CIRNAC: https://www.canada.ca/en/crown-indigenous-relations-northern-affairs.html

88 CanNor: https://www.cannor.gc.ca

3. Community Engagement

Community engagement is an integral part of community energy planning. The community's needs and wants are a driving factor that shapes the direction of a CEP and play a factor in the recommendations that the CEP produces. CEPs allow communities to identify the real project opportunities that are best for them based on their interests, needs and resources. The most successful CEPs are done by the community, for the community with the support from government, utilities, and specialists. However, it has to be recognized that each community has a different level of capacity for completing a plan like this. They may choose to lead the process or have another stakeholder or partner facilitate it. In the case of this CEP, Sakku Investments Corporation approached the community, with their intention of completing a CEP. Sakku and the rest of the CEP Team sought community support early in the CEP process.

Engagement activities with community members from Salliq were delayed due to the COVID-19 pandemic which resulted in travel bans, school closures, the inability for some to work remotely, office closures, etc. With these ever-changing barriers and delays the entire engagement strategy had to be re-designed.

3.1. COMMUNITY ENERGY VISION & GOALS

Substantial modifications to the engagement process had to be made for this CEP due to the COVID-19 pandemic and subsequent restrictions. This limited in-person engagement with the community for the establishment of a clear Community Energy Vision and Goals. However, the CEP Team was able to modify their intended engagement strategy to meet COVID restrictions and continue with the development of the CEP. Here are the major modifications that occurred:

- Instead of having a community-wide visioning exercise at the very beginning of the CEP process (artic toolkit, step 4 of the Framework developed by ACEPI.), the CEP Team decided to complete various technical and financial analysis first (arctic toolkit, step 6 "Identifying specific energy projects") in order to determine the best clean energy project options for Salliq. This enabled us to move forward with the project, despite not being able to immediately travel to the community.
- The drafting and analysis conducted within the CEP document was completed before any community-wide in-person engagement. However, the process and text was informed by valuable input received from the CAO, the Mayor, and the Hamlet Council.
- The CEP Team was still able to launch and complete the community energy survey remotely, through online platforms.
- Since the community-wide in-person engagement was postponed until after the CEP was written, the focus of the in-person session will be shifted to explaining the CEP analysis results and the proposed clean energy projects.
- The in-person community-wide in-person engagement activities are planned to happen once the team is able to travel safely to the community. Due to previous restrictions this will occur at the end of the CEP drafting process. The engagement will consist of two different events. The first will be a community-wide engagement session in the form of an open-house for all community members to discuss clean energy projects with the CEP Team. The second will be a day of energy education activities for school aged children. The CEP Team will bring information and offer their expertise to discuss the clean energy projects that the CEP is recommending for Salliq.

The positive side of the shift in engagement activities, is that the CEP will be able to provide a completed cost-benefit analysis for the potential of a solar versus a wind project for the community discussion. This will add some weight to the conversation and may lead to discussion of a feasible project. Additionally, the design and contents of the energy kits and the suggested energy retrofit actions are supported by the on-the-ground energy audits and other observations by the CEP Team from their previous trip to Coral Harbour.

3.2. ENERGY STAKEHOLDERS IN THE COMMUNITY

In Salliq, energy issues are most relevant to the following list of stakeholders and decision makers. These parties should be involved in the work of identifying and implementing energy solutions. These parties have been invited to participate in the CEP work.

Leadership:

- Coral Harbour Mayor and Council
- GN, CCS

Implementers:

- SAO in Salliq, Leonie Pameolik
- QEC planners and program managers
- GN, Department of NHC & Local Housing Manager
- GN, Department of CGS
- Project developers

Enablers:

- Federal funding agencies
- GN, QEC
- GN, Department of Housing
- GN, Department of CGS
- Environmental advocacy groups:
- Nunavut Impact Review Board, and
- Arctic Renewables Society

End Users:

- The Hamlet of Coral Harbour
- CGS local operations
- NHC local operations and its housing tenants
- Homeowners
- Business Owners
- School and health facilities
- Public buildings (recreation hall, etc.)

Members of the core CEP Team are listed further above in section 1.4.

3.3. KEY ROLES IN THE CEP

The key members of the CEP are outlined in Section 1.4 CEP Team; however, it is important to highlight that the partnership with the local community Energy Champion, Blaine Chislett from Sakku Investments Corporation, has been invaluable. Blaine has been an incredible asset in connecting the CEP Team with community members, both due to his expertise in the field of energy and asset maintenance in Nunavut, but also because of his great ability to connect and communicate in Inuktitut with local community members. Having Blaine opened many doors for the CEP Team.

3.4. METHODS OF COMMUNITY ENGAGEMENT

Despite COVID driven limitations, one of the early engagement activities that the CEP Team was able to complete was an online survey. Responses to the Community Energy Survey are summarized throughout this CEP Report, and are also included in Appendix A. The CEP Team deemed this activity a success, considering the difficult context. To meet safety requirements, the CEP Team reduced the scope of early community-wide engagement activities and decided instead to target specific community members, such as Hamlet staff, the CAO, the Mayor, the local HTO and Council members. The selected subset of community members were consulted from the start to make sure the priorities of the community were well understood and taken into consideration throughout the CEP process. Communication with the mayor and the CAO was established via email and a few conference calls, several months before the CEP Team's first travel to the community, where the team met with the Hamlet and Council members. Their valuable input, questions and feedback were integrated into the CEP draft and the clean energy projects analysis.

In order to continue work during the travel-ban, the CEP Team attempted to hire a local liaison. This task proved to be harder than expected, since working remotely without having in-person meetings limited the scope of what could be accomplished. The local liaison was hired to conduct the energy audits under instructions from Blaine. However, before this work was started, the travel ban was lifted, and Blaine was able to perform the energy audits himself with the support of the Climate Change Secretariat.

The CEP Team is planning to return to the community, as soon as possible, to lead a community-wide in-person engagement session. This session will be open to all members of the community, with the intent of gathering valuable input from those who would like to contribute to this community energy plan and the overarching energy conversation. The input gathered at this session may influence the implementation plan and any future clean energy projects that will result from this process.

Planned activities for the final community engagement trip include:

- Educational activities for school aged children that CCS developed with ICE enterprise over the past two years. An activity was made for each grade. This was done using the funds CCS received from NRCan's CERRC capacity building stream to work on CEP in Nunavut. While the activities were not designed specifically for Salliq's CEP, they were made for Nunavut and will be able to be used for other projects and audiences.

- Meeting with the Council and Hamlet staff to provide an update on the CEP analysis results and discuss clean energy project options specific for the community's needs.

- Host an open-house event in order to provide all community members with the opportunity to interact with the CEP Team in-person and receive detailed information on the CEP text. This will include discussing the energy baseline of the community and the recommendations proposed by this CEP. The open-house will allow community members to ask questions, provide feedback and learn more about possible clean energy projects.

- Distribute the self-install Energy Efficiency Kits which include an instruction video (on a USB stick) to each household. The instruction video shows how to install and use each item in the kit (see section 5.2 for more details on the energy kits that will be distributed).

The CEP Team also plans to continue community engagement efforts in relation to specific projects being advanced after completion of the CEP.

3.5. COMMUNITY SURVEY

As part of the CEP work, the CEP Team conducted a Community Energy Survey (aka "the survey") of Salliq residents. The survey was hosted online using the Google Survey service, in both English and Inuktitut. Printed copies were also distributed, and results entered into the online survey by the CEP Team.

The survey was launched in mid-March of 2021 and remained open for approximately 2-½ months, closing on June 4th, 2021. Promotion of the survey was through online means (Facebook group), radio ads, and by placing printed surveys prominently at the hamlet office. Valuable prizes were offered in order to incentivize participation.[89]

In total 25 households responded to the survey, which represents approximately 11% of the 220 households in Salliq. Note that 23 of the 25 respondents (92%) live in single-family houses, whereas across the community only 55% of households live in single-family houses. Therefore, the results should be seen as useful information, but not an accurate statistical representation of Salliq residents.

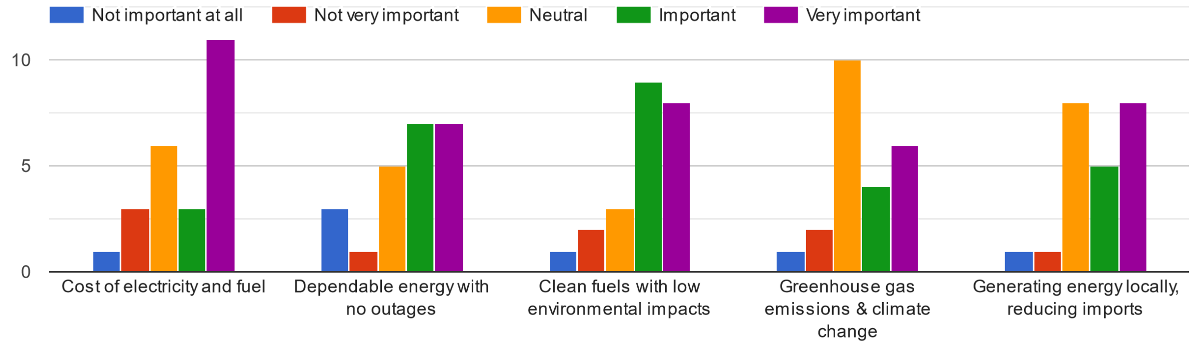
A summary of key survey results is provided below, and complete survey data is provided in Appendix A.

Question: "Which energy issues are most important to you?"

All of the listed issues were considered to be important by survey respondents. They indicated the following, ranked in order of strongest support:

1. Cost of electricity and fuel
2. Clean fuels with low environmental impacts
3. Generating energy locally, reducing imports
4. Dependable energy with no outages
5. Greenhouse gas emissions & climate change

89 In Salliq it is not culturally appropriate to go door-to-door for promotional reasons, and even less so during the Covid-19 pandemic. Initial plans to promote the survey at a public gathering had to be canceled due to the Covid-19 pandemic.



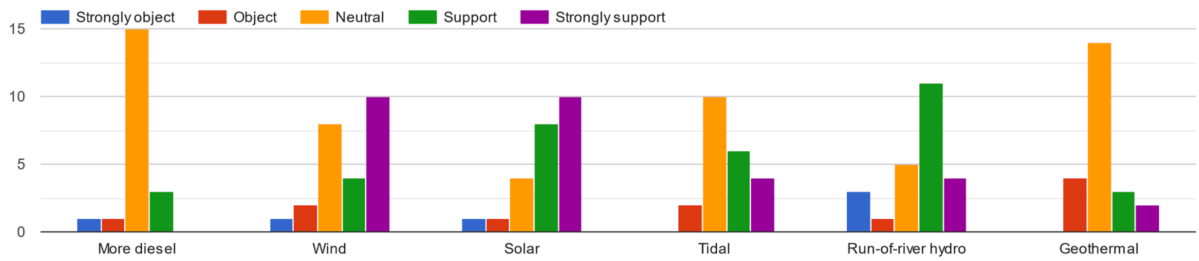
Question: "We are studying various types of energy to see whether they could be possible in Coral Harbour. IF they are possible, which types would you like to see built?" Survey respondents indicated the strongest support for the following, ranked in order of strongest support:

1. Solar
2. Wind
3. Run-of-river hydro
4. Tidal

Survey respondents were generally neutral with regard to the following:

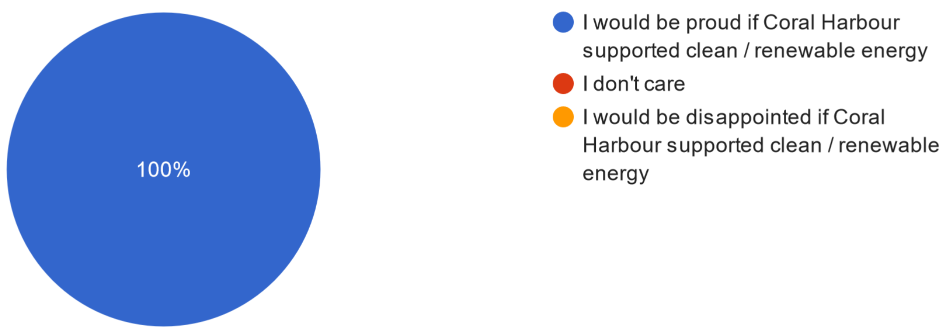
1. Geothermal
2. Continued use of diesel

Survey respondents did not object strongly to any of these options, including continued use of diesel.



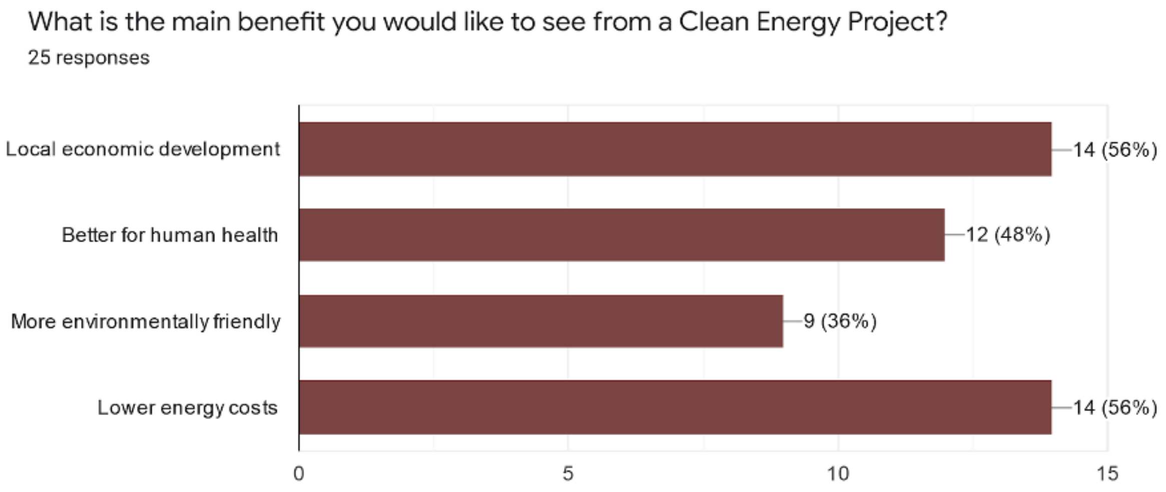
Question: "How would you feel if Coral Harbour supported clean / renewable energy?"

100% of survey respondents indicated that they would feel proud if Coral Harbour supported clean / renewable energy.



Question: "What is the main benefit you would like to see from a Clean Energy Project?" Survey respondents indicated the following, ranked in order of strongest interest:

1. Lower energy costs (tied)
2. Local economic development (tied)
3. Better for human health
4. More environmentally friendly



Question: "What actions do you think Coral Harbour should take in relation to energy?" Notable answers included:

1. General support for energy conservation and efficiency
2. Find lower-cost sources of energy
3. General support for solar, wind, and hydro energy
4. Upgrade the transmissions lines as they are past their lifespan
5. Become energy independent
6. Unplug what isn't being used
7. Go green
8. Upgrades to housing
9. Convert to LED light bulbs

In general, from survey responses as well as conversations in Salliq, the strongest concerns from residents appear to be consistently related to energy costs and affordability. Environmental concerns appear to rank second, with more concern given to local environmental quality than global climate change, although these two concepts overlap. Local sources of energy are preferred, with a strong preference for renewable energy sources including solar, wind, tidal, and hydro.

Other survey responses are referenced throughout this CEP, in the appropriate section (e.g. energy baseline, building stock, energy efficiency upgrades, clean energy project siting).

3.6. UTILITY INVOLVEMENT

In Nunavut, the Qulliq Energy Corporation (QEC) is the sole, arms-reach, utility company that provides electricity for the community of Coral Harbour. The CEP team informed QEC of their intent to complete a CEP for Coral Harbour and acquired data from the utility to complete the energy baseline. QEC has also been invited to attend the in-person community engagement sessions, including the open-house.

3.7. GOVERNMENT INVOLVEMENT

The CEP development process has had significant government involvement, at the territorial level. Staff from CCS, at the Department of Environment are part of the CEP team. CCS's specific role within the CEP process is outlined in Section 1.4. In addition to this major involvement, the CEP team also reached out to the Department of Economic Development and Transportation to discuss the Department's stance on alternative energy solutions and learn of any programs that may support opportunities reflected within the CEP. Details on the programs can be found in Section 2.12.

4. Energy Baseline

This section describes the current state of affairs in Salliq with regard to energy, thus establishing an "energy baseline" for the community.

This energy baseline provides a snapshot of the community's energy sources, uses, costs, and GHG emissions as of 2019/20. An energy baseline provides a "before" picture, which can be compared to the "after" picture as the community implements energy solutions in future.

Therefore the energy baseline allows the community to measure progress on key goals such as energy efficiency and diesel reduction. The energy baseline also allows comparison to other similar communities.

The CEP Team developed a visual summary of Salliq's energy baseline as a poster entitled "Coral Harbour Energy Use Profile", which can be used to illustrate this energy baseline for community members. This poster is included in Appendix D .[90]

90 *Poster produced by CCS.*

4.1. METHODOLOGY

The energy baseline for Salliq includes a measure of the following factors:

- Sources of energy,
- Uses of energy,
- Costs of energy,
- GHG emissions associated with energy,
- Buildings in the community,
- Waste in the community.

Data sources referenced in compiling this energy baseline include the following:

- Fuel usage data for Salliq was provided directly by correspondence with PPD.
- Information regarding PPD and fuel specification: https://www.gov.nu.ca/petroleum-products-division.
- Retail fuel price list from the Government of Nunavut effective April 1, 2020[91]
- Electricity production and consumption data was provided by correspondence with QEC.
- Residential electricity rates from QEC: https://www.qec.nu.ca/customer-care/accounts-and-billing/customer-rates.
- Building data as collected by Statistics Canada in 2016.[92]
- NU housing survey conducted in 2011 by the Nunavut Statistics Bureau on behalf on NHC: https://www.gov.nu.ca/eia/information/nu-housing-survey.
- Municipal waste data was taken from the report by Arktis Solutions entitled "Report on Current State of Solid Waste Management and Facilities in Nunavut and Cost-Benefit Analysis of Selected Solid Waste Management Approaches" and dated March 30, 2011[93].

Each data source may differ slightly in its time period, however all data is considered relatively accurate for 2019/20.

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91 GN (2020). Retail Fuel Price List. https://www.gov.nu.ca/sites/default/files/2020-01_draft_fuel_price_list_-_apr_1_2020_0.pdf

92 Statistics Canada (2016). Census Profile, 2016 Census: salliq, Hamlet. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=6205014&Geo2=CD&Code2=6205&SearchText=coral%20harbour&SearchType=Begins&SearchPR=01&B1=All&TABID=1&type=0

93 Arktis Solutions (2011). Report on Current State of Solid Waste Management and Facilities in Nunavut and Cost-Benefit Analysis of Selected Solid Waste Management Approaches. https://assembly.nu.ca/library/GNedocs/2011/000359-e.pdf

4.2. ENERGY SOURCES AND COSTS

Salliq is almost completely reliant on fossil fuels for its energy: oil for heat, diesel for electricity, and diesel and gasoline for transportation. These fuels need to be imported from southern Canada and cause high amounts of air pollution and GHGs.

Virtually all of these fuels are provided to Salliq by the GN Petroleum Products Division (PPD).[94] PPD does not subsidize fuels - they are sold at a price that reflects part of their costs. However the GN does subsidize electricity derived from diesel, as discussed in section 4.2.

PPD sold a total of 3.96 Million L of fuels in Salliq in 2018/19, and these are broken down by fuel type in Figure 7. The predominant fuel type is heating oil (42% of all fuel purchases), followed by diesel for electricity production (26%), and diesel and gasoline for vehicles (21%). A final 11% of fuel purchases in Salliq was for jet fuel.[95] Each fuel type is discussed in further detail below.

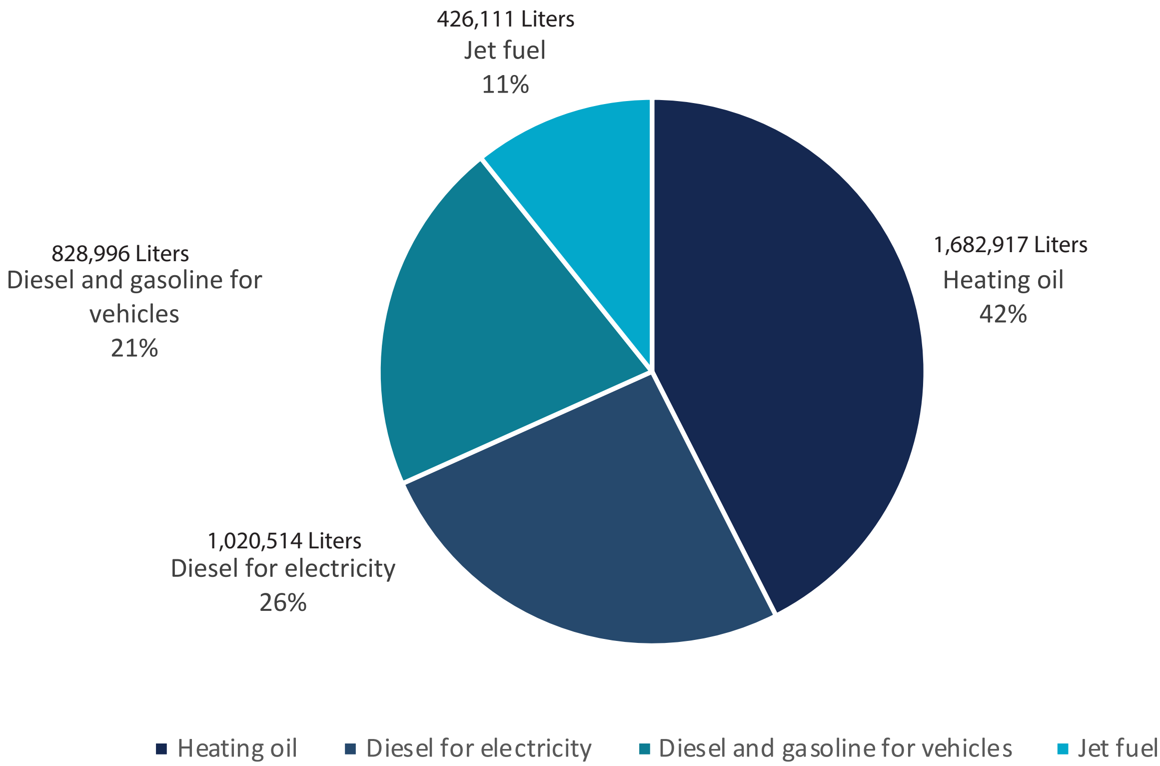

Figure 7: Breakdown of fuel consumption in Salliq in 2018/2019 by fuel type.[96]

Although heating oil makes up 42% of all fuel purchases, it is likely that heating makes up more than 50% of the total energy consumption in Salliq. This is due to heating oil furnaces being higher in efficiency, typically between 80-90%, than other uses, such as electricity production and vehicles, which operate between 20-40% efficiency.

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94 GN (no date). Petroleum Products Division. https://www.gov.nu.ca/petroleum-products-division
95 This may not represent the full amount of jet fuel used for transportation to/from Salliq as aircraft also re-fuel in the South.
96 Source: PPD

HEATING OIL

PPD provides approximately 1,683,000 L of P50 heating oil to various customers in Salliq throughout the year. It was assumed that all of this is used for space heating and hot water heating in buildings. Using a typical efficiency of 85% for oil heaters, this would result in a total of approximately 56,000 GJ of heat, or 64 GJ per resident.

The retail price for heating oil in Salliq is currently $1.0372 /L, for a total annual cost to the community of approximately $1.75 Million or nearly $1,950 per resident. Fossil fuel prices have been forecast to increase by an estimated 1.5% per year.[97] [98] The majority of survey respondents (61%) indicated that they pay their own heating bill, whereas a minority (39%) indicated that someone else pays (we assume NHC).

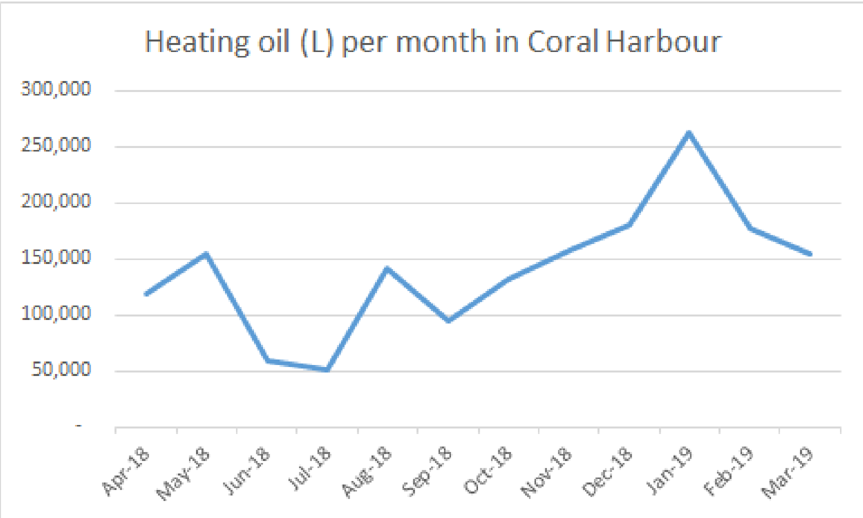

Figure 8 shows the monthly variation in heating oil sales in Salliq. As expected, the majority of heating oil is sold during the winter months, and it is assumed that the majority is also consumed over this time. Heating oil purchases in July are only 20% of the winter peak.

Figure 8: Heating oil purchases by month in 2018/19 in Salliq.[99]

DIESEL FUEL FOR ELECTRICITY

The electric grid in Salliq is owned and operated by QEC, and is powered by diesel fuel. QEC's powerplant includes three CAT D 3508 diesel generators rated for 1,200 RPM: two with a maximum generating capacity of 420 kW and one with a capacity of 480 kW, for a total of 1,320 kW of peak electrical generating capacity.

QEC produces a total 3,609 MWh of electrical energy in Salliq throughout the year. This is an average demand of 406 kW, with a peak of 731 kW during the moment of greatest electrical demand. QEC forecasts that by 2025 demand will increase to 3,915 MWh annually, with a peak demand of 780 kW.[100]

Diesel generators are not efficient at converting fuel energy into electrical energy, as most energy is wasted as heat. QEC reports a conversion efficiency of 3.39 kWh/L in Salliq.

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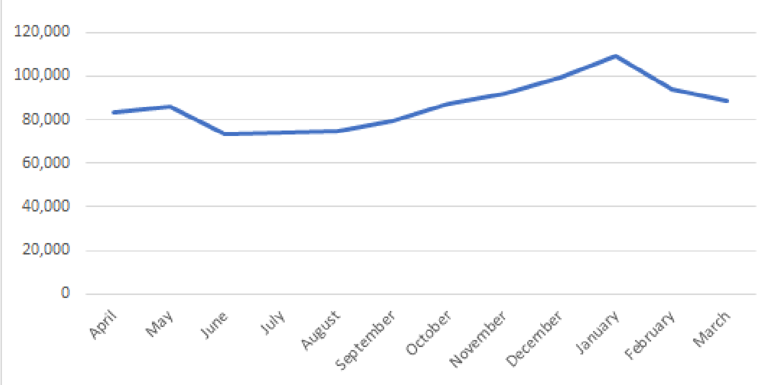
97 GN PPD. (2020). PPD Retail Price List. https://www.gov.nu.ca/sites/default/files/2020-01_draft_fuel_price_list_-_apr_1_2020_0.pdf
98 WWF, ITP (2019).
99 Source: PPD
100 Note: this forecasted 2025 peak is still far below the maximum generating capacity.

This is equivalent to an energy efficiency of approximately 32%, meaning that 68% of QEC's diesel energy is lost as heat. QEC consumed approximately 1.04 million L of diesel fuel (P50 non-motive) in Salliq in 2018.



The monthly profile in Figure 9 shows that electricity consumption peaks in winter, however it is more steady throughout the year compared to heating oil. Summer electrical consumption is approximately 2/3 of winter consumption.

Figure 9: Diesel fuel consumption by QEC per month in 2018/19 in Salliq.[101]

QEC pays a bulk rate of $0.94 /L for diesel fuel from PPD in Salliq (about 10% cheaper than retail heating oil).[102] After accounting for lubricants, QEC paid $1,032,000 for diesel fuel in 2018/19. QEC sells electricity to local customers in three rate categories: [103] [104]

- domestic (aka residential),
- commercial, and
- streetlights.

In recent years QEC has sold 44% of its electricity to its 262 domestic customers at a posted rate of $0.9524 /kWh. QEC sells 54% of its electricity to its 81 commercial customers at a posted rate of $0.8718 /kWh. The final 2% of QEC's electricity was sold to the Hamlet for streetlights. QEC's total revenues in Salliq were $3.1 Million for the year. 100% of survey respondents indicated that they pay their own electrical bills.[105]

The GN heavily subsidizes electricity for both residential and commercial customers, in order to help people and businesses with high monthly bills. This subsidy, delivered through the Nunavut Energy Subsidy Program (NESP), works to equalize electricity rates across the territory, and is calculated as 50% of the base electricity rate in Iqaluit.[106] Residential customers pay this lower rate for the first 700 kWh per month in summer, and the first 1,000 kWh per month in winter, while small commercial enterprises are eligible for the subsidy for the first 1,000 kWh per month.

Due to this subsidy, most Salliq residents will pay $0.293 /kWh for the bulk of their electricity, while commercial customers pay $0.242 /kWh. Residential customers receive electrical bills with the

101 Source: PPD
102 QEC (2017). General Rate Application 2018-19. https://www.qec.nu.ca/sites/default/files/2018-2019_qec_general_rate_application.pdf
103 Note that the QEC rate categories don't align perfectly with the traditional concept of residential and commercial end users.
104 Current QEC rates: https://www.qec.nu.ca/customer-care/accounts-and-billing/customer-rates
105 QEC (2017). General Rate Application 2018-19. https://www.qec.nu.ca/sites/default/files/2018-2019_qec_general_rate_application.pdf
106 Government of Nunavut. (2005). Nunavut Electricity Subsidy Program: Contribution Policy. https://www.gov.nu.ca/sites/default/files/files/NU%20Electricity%20Subsidy%20Program%20Contribution%20Policy.pdf

subsidy already removed, whereas commercial customers must apply for a rebate. Across Nunavut, NHC administers the majority of electricity subsidies for residents in public housing.[107] This subsidy helps Salliq residents with affordability, however it can also present a challenge for energy conservation because energy is artificially cheap.

QEC was founded in 2001 and took over the assets of the Northwest Territories Power Corporation[108]. At this time QEC's rates were adopted from its predecessor, which had set different rates in each NU community. In 2017, QEC proposed a transition to a new rate structure that would see all NU communities pay the same territory-wide rate, however the proposal was turned down. If the change in rate structure would have taken place, Salliq would have experienced a decrease in rates over a 5-year transition period. The next general rate structure is due to be released soon, however any changes proposed by QEC will require approval by Cabinet and the Utility Rates Review Council (URRC).

DIESEL AND GASOLINE FOR VEHICLES

PPD reports sales of 216,000 L of diesel (P50 motive-grade) and 613,000 L of gasoline (Grade 3/ Class D) in Salliq, for a total of 829,000 L of motor vehicle fuel. We assume all of this is to power local vehicles.

PPD sells motive diesel for $1.1829 /L and gasoline at $1.0876 /L, for a total annual cost to the community of approximately $922,000.

PPD aims to keep fuel prices as steady as possible because fuels are used in Nunavut primarily to meet basic needs, and cannot simply be reduced when prices are high (i.e. not elastic demand). It is worth noting that the cost of gasoline is cheaper in Salliq than many places on Earth.

JET FUEL

PPD reports annual sales of 426,000 L of type A-1 jet fuel in Salliq, for a total cost of $639,762. We assume that this fuel is used predominantly to refuel aircraft for flights out of Salliq, to other Nunavut communities. The authors are unsure what share of total round-trips this fuel represents, and so we estimate 50%. Although jet fuels are burned predominantly outside of the community, they do cause GHG emissions and they should not be ignored.

SOLAR PV

As reported previously in section 2.8, there is one 10-kW solar PV project operating in Salliq, which is reported to provide approximately 10,000 kWh per year of renewable electricity for QEC. This represents 0.28% of QEC's annual electricity production, and so the Salliq electricity grid remains 99.7% powered by fossil fuels.

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107 WWF (2017). Tracking Fuel Subsidies in Nunavut. https://wwf.ca/wp-content/uploads/2020/03/Tracking-Diesel-Fuel-Subsidies_April-2017.pdf

108 Wikipedia page re QEC. https://en.wikipedia.org/wiki/Qulliq_Energy

BIOMASS / WOOD

No survey respondents reported using biomass for heating. Given the lack of trees in the northern community of Salliq, no biomass is available locally. However, various forms of biomass are used in other northern Canadian communities, and so biomass opportunities are discussed further in Section 6.4.

AREAS OF CONCERN

As noted above, the primary challenge is that Salliq is nearly completely reliant on imported fossil fuels for its energy needs.

Survey respondents in Salliq voiced the following concerns with regard to energy supply, in order of highest importance:

- High energy costs,
- Environmental impacts (e.g. fossil fuel spills),
- Energy security, considering that fuels need to be imported from southern Canada,
- Reliability of the energy supply and frequency of outages,
- GHGs and air pollution.

In relation to fuel/oil spills, as recently as April of 2021 a fuel spill was reported by PPD in the community of Baker Lake, NU, which resulted in approximately 10,000 L of gasoline being spilled near the community's tank farm.[109] This spill left residents understandably concerned regarding environmental and human health impacts, including drinking water supply. Adoption of clean energy sources can reduce the need for fossil fuels and decrease risk of spills.

Finally, it is important to emphasize the value of heating oil to the average Salliq resident as a reliable and affordable heating source, especially in winter. As noted above, the average Salliq resident may pay approximately $1,950 per year in heating oil purchases; this value includes both residential and commercial consumption.

Heating oil is converted to heat energy at a typical furnace efficiency of 85%, producing on average approximately 64 GJ of heat (approximately 17,800 kWh of heat). If the average Salliq resident wanted to convert to electricity for heating, and assuming a 100% efficiency for electric heaters, the amount of electricity needed to meet the same heating demand would cost approximately $5,200 per year at the subsidized rate.

The resulting increased electricity consumption would put the resident well above the threshold for the GN electricity subsidy, and so the resident might realistically pay $16,900 per year in electricity for heating.

Therefore, under current pricing, the average Salliq resident would pay approximately 8-9 times more to heat using electricity compared to heating oil. This makes heating electrification a non-viable option to pursue at this time.

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109 Article entitled "Fuel spill poses risks to Baker Lake's water supply: Nunavut government". https://nunatsiaq.com/stories/article/fuel-spill-poses-risks-to-baker-lakes-water-supply-nunavut-government/

4.3. ENERGY USES

Figure 10 presents a breakdown of fossil fuel purchases according to the type of end user.

Approximately 31% of fuels are purchased for residential use (homes and personal vehicles), 21% by community services (hamlet operations and public facilities), 6% by commercial users, and 5% for government operations (GN and federal government). A further 26% of all fuel purchases in Salliq are by QEC to generate electricity, which is then used by QEC's residential, community, and government customers.[110] Air travel is also treated as its own category.

It is clear that residential users and community services account for the majority of diesel fuel used in Salliq.

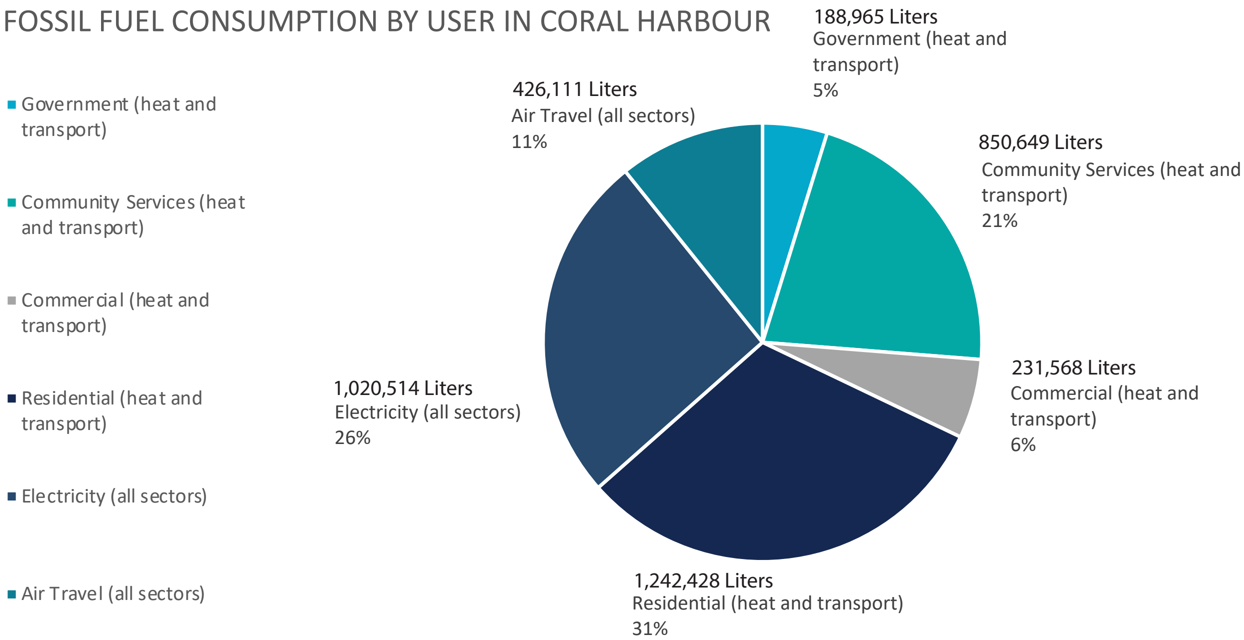

Figure 10: Breakdown of fuel consumption in Salliq in 2018/2019 by end user.[111]

It is understood that most Salliq residents use heating oil as the primary fuel for heating in the home. 80% of survey respondents indicated that they use heating oil (diesel), with 20% indicating that they use electricity for heating.

In relation to fueling vehicles, survey responses in Salliq suggest that each household may own, on average: 2.0 snowmobiles, 1.9 ATVs, 1.9 bicycles, 1.7 trucks, 1.7 boats, 1.1 cars, 0.5 RVs, and 0.5 motorcycles. Survey respondents report spending approximately $1,150 per month on fuel purchases in summer and $1,900 per month in winter. 2016 Census data estimates that approximately 45% of Salliq residents commute on foot, 45% in a vehicle (driving or passenger), and 10% by other means.[112]

110 Unfortunately a breakdown of electricity by end user was not available, and so a more granular breakdown of total energy use by residential, commercial, and government users is not possible at this time.

111 Source: PPD

112 Statistics Canada (2016). Census Profile, 2016 Census: Salliq, Hamlet. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=6205014&Geo2=CD&Code2=6205&SearchText=coral%20harbour&SearchType=Begins&SearchPR=01&B1=All&TABID=1&type=0

4.4. GREENHOUSE GASES AND POLLUTION IN THE COMMUNITY

A calculation of the GHG emissions in Salliq is made simple by the fact that >99% of all energy is derived from combustion of fossil fuels - be it for heating, transportation, or electricity. The authors assume a GHG intensity of 2,753 g/L based on the federal government's latest nationwide GHG report.[113] This means that for every litre of diesel fuel burned, 2,753 g of CO^2 and equivalent GHGs are produced.[114] However, it should be noted that this is the most basic way to calculate GHG emissions.

In total, Salliq recorded fossil fuel purchases of 3.96 Million L in 2018/19. Combustion of these fuels produces GHG emissions totalling 10,900 tonnes CO_2e per year. Assuming a current population of 900 residents, this amounts to an average of 12.1 tonnes CO_2e /person /yr.

Factors that cause an upward trend (increase) in GHG emissions in Salliq include:

- the majority of energy is derived from diesel fuels,
- fuels must be transported from faraway,
- cold wintertime temperatures,
- fairly low population density,
- poor energy performance in much of the housing stock, and

At the same time, factors that cause a downward trend (decrease) in GHG emissions in Salliq include:

- low levels of consumption,
- local ingenuity as residents find creative ways to conserve energy and live within their means.

The per capita emissions in Salliq are typical of northern/remote communities. For example, Faro, YT and Tulita, NWT both reported an intensity of 11-12 tonnes CO_2e /person /yr in recent CEPs.[115] [116]

As a further comparison, the Canadian national average is approximately 21 tonnes CO_2e /person / yr. Per capita emissions in some provinces (BC, ON, PEI) are as low as 12-13 tonnes CO_2e /person /yr, while other provinces (AB, SK) are as high as 67 tonnes CO_2e /person /yr.[117] Per capita emissions in Salliq are lower than the national average, primarily due to the lack of industry in the community. In addition to GHG emissions, combustion of fossil fuels in Salliq also produces local air pollution (particulates, NOx, SOx) as well as noise pollution, both of which can have an impact on local

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113 ECCC. (2020). National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada. http://publications.gc.ca/collections/collection_2020/eccc/En81-4-1-2018-eng.pdf

114 1 tonne = 1,000 kg = 1,000,000 g

115 Frappé-Sénéclauze et al (2013). Community Energy Plan, Town of Faro, YT. https://www.pembina.org/reports/faro-community-energy-plan-final-rc.pdf

116 Arctic Energy Alliance (2020). Tulita Energy Profile 2018. https://aea.nt.ca/document/4347/

117 The Conference Board of Canada. (2016). Provincial and Territorial Ranking: Greenhouse Gas Emissions. https://www.conferenceboard.ca/hcp/provincial/environment/ghg-emissions.aspx?AspxAutoDetectCookieSupport=1 people and ecosystems. Non-GHG pollution associated with municipal waste is also discussed in section 4.6.

4.5. BUILDING STOCK

Information regarding buildings in Salliq is taken from 2016 Census data as well as information provided by NHC, and supplemented by the CEP Team's survey results.

Housing in Salliq is chronically in great demand. Out of a population of approximately 900, 130 are on a waiting list for public housing.[118] A reported 43 people are currently homeless in Salliq. Homes in Salliq are generally crowded. Census data reports 3.9 people per home on average. Of the 220 recorded family dwellings, 75 of them house five people or more.[119] The majority of energy survey respondents in Salliq reported more than 5 people living in the home. A GN survey in 2010 found that more than one third of families regularly used the living room for sleeping.[120]

Many homes in Salliq are in poor condition. Statistics Canada categorizes 95 of Salliq's housing units as "not suitable" and 65 of them are in need of "major repairs". The GN survey found that more than half of households were unsatisfied with the condition of their dwelling, especially amongst families in public housing.

Approximately half of the homes (120 of 220) are single-family detached houses and the remainder (100 of 220) are attached dwellings. The majority of homes in Salliq (175 of 220) are owned and managed by NHC, and rented by the inhabitants. These are a mix of bungalow houses and multi-unit buildings including duplexes, 4- and 5-plexes, and one 10-plex building.[121] A minority of homes (45 of 220) are privately owned, and most of these are single-family detached houses.

NHC estimates that approximately 30% of homes under NHC's management were built before 1980, 40% between 1980 and 2000, and 30% since 2000. In recent years, more multiplexes have been built than private homes. The newest homes are the multiplexes, including the 10-plex in 2015. No new housing has been built since 2015, despite the very high demand. Census data reports the following estimated age distribution[122] for all private dwellings, as illustrated in Table 1.

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118 News article entitled "Ottawa's 'neglect' of Nunavut housing is 'beyond measure,' Qaqqaq says as she releases new report" https://www.nunavutnews.com/nunavut-news/ottawas-neglect-of-nunavut-housing-is-beyond-measure-qaqqaq-says-as-she-releases-new-report/

119 Statistics Canada (2016). Census Profile, 2016 Census: Salliq, Hamlet. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=6205014&-Geo2=CD&Code2=6205&SearchText=coral%20harbour&SearchType=Begins&Search-PR=01&B1=All&TABID=1&type=0

120 Government of Nunavut (2011). Nunavut Housing Needs Survey, Fact Sheet: Coral Harbour.

121 pers. comm. Jimmy Main at NHC.

122 This age distribution is an estimate based on a 25% sample in the 2016 census, and therefore subject to some uncertainty.

Year of Construction	No. of Homes
1960 or before	0
1961 to 1980	35
1981 to 1990	60
1991 to 2000	60
2001 to 2005	10
2006 to 2010	30
2011 to 2016	20
TOTAL	220

Table 1: Estimated age distribution of all private dwellings in Salliq.

The vast majority of homes are wood frame construction. A small number of newer homes were built using structured insulated panels (SIPs) and these are likely more energy efficient. 48% of survey respondents in Salliq reported insulation above the ceiling in their home, with another 40% being unsure.

Survey respondents in Salliq were asked to list the steps they have taken to improve energy efficiency in the home. The majority (60%) of respondents reported purchasing LED or CFL light bulbs, a substantial portion had installed energy efficient appliances (28%) or window coverings (28%) or weather stripping (24%), and a minority had upgraded insulation (16%). Several survey respondents reported taking other steps to conserve energy (see full survey results in Appendix A). However it should be noted that the majority of survey respondents live in single-family detached homes, and most pay their own electrical bill (NHC doesn't pay). These results may not be representative of those living in NHC housing.

Salliq also hosts the following community buildings[123]:

- Hamlet Office,
- Health Centre with Residences,
- Trade / Maintenance Garages,
- Community Freezer Building,
- Airport Terminal Building,
- Community Hall,
- Human Rights Tribunal,
- Wildlife Office,
- CGS Trade Shop,
- Sakku School,
- Sivuniksavut Daycare,
- Atiqtait Preschool,
- Kaajuuq Youth Centre, and
- Swimming Pool.

No energy audits had been conducted in Salliq prior to this CEP, and so little information is known about the overall state of energy efficiency in the community. However, since little dedicated energy efficiency work has been performed to date, we can estimate that energy efficiency is likely typical of other remote Nunavut communities prior to energy-specific interventions. AEA (2017)[124] conducted assessment of buildings in other NU communities (Iqaluit, Rankin Inlet, Cambridge Bay, Kugluktuk and Arviat) between 2013 and 2017, totalling 52 residential houses and seven commercial buildings. These results may be typical in Salliq as well.

123 pers. comm. SAO Leonie Pameolik, and data from CGS.
124 Arctic Energy Alliance (2017). Community Energy Services Summary Report.

4.6. WASTE IN THE COMMUNITY

Information on municipal waste is available from the 2011 report by Arktis Solutions[125], based on data from 2010. Note that the population has grown by an estimated 14% since 2010.

Municipal waste in Salliq is stored by each household in a metal drum for collection approximately every 5 days. The average household produces approximately 4-5 bags of waste per day, for an average of 7.5 m^3 per person per year of solid waste. The community as a whole produced approximately 6,400 m^3 of solid waste annually in 2010, and this will likely have increased to approximately 7,300 m^3 due to population growth.

Fees are collected from residents to pay for waste collection, to the tune of approximately $160,000 per year for the community. There are no known recycling operations in Salliq, however we understand that used batteries are being stored in a dedicated sea can.

Salliq lists in its 2020/21 ICSP the following priorities related to waste:

- #13: Installation of a new oil incinerator to eliminate the growing quantity of used motor oil in the community which is currently stored in drums,
- #25: Remediation of the old landfill site,
- #36: Remediation of a contaminated site near the airport, where spilled diesel fuel is seeping into the ocean,
- #49: Establishment of a new solid waste site.[126]

The CEP Team has examined options for incineration of used oil as a means of energy production. One challenge is that incinerators should be located far from town, due to the resulting air pollution. However it is expensive to transport small amounts of heat or electricity from the outskirts of town to end users. Therefore we understand why Salliq is pursuing oil incineration as a means of waste reduction, not energy generation.

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125 Arktis Solutions (2011). Report on Current State of Solid Waste Management and Facilities in Nunavut and Cost-Benefit Analysis of Selected Solid Waste Management Approaches. https://assembly.nu.ca/library/GNedocs/2011/000359-e.pdf

126 Note that current GN funding for new landfills in Nunavut does not include Salliq.

5. Energy Efficiency Opportunities

This section outlines opportunities to improve energy efficiency in Salliq. Topics considered in this section include:

- Energy efficiency in buildings,
- Building code standards,
- LED lighting,
- Self-install energy kits,
- Heat pumps & geoexchange, and
- Tiny homes.

5.1. ENERGY EFFICIENCY IMPROVEMENT IN BUILDINGS

Detailed information is not currently available regarding the energy efficiency of buildings in Salliq, nor regarding specific opportunities for improvement. Therefore, we first examine findings from other similar communities in Nunavut.

AEA ASSESSMENT FINDINGS

When AEA (2017)[127] conducted energy assessment of buildings in other Nunavut communities, (52 houses and 7 commercial buildings) they arrived at the following conclusions:

- "A large potential for the implementation of energy efficiency and conservation measures exists in the buildings assessed."
- "In residential housing, the 52 houses assessed could save a total of 19% of their energy use (47,000 litres of oil & 70,000 kWh of electricity) and reduce annual greenhouse gas (GHG) emissions by 17% (175 tonnes)."
- "Commercial buildings, on average, could save 20% of their annual energy bills ($140,000 total for the seven buildings assessed) and 230 tonnes of GHG emissions annually by implementing the recommended measures, which have a payback of less than 5 years."
- "In general, Nunavummiut seem energy-conscious and conserve energy where possible; about 25% of the homes assessed had supplemental biomass heating systems."
- "There is a lack of easily accessible funding for homeowners, businesses and community governments to implement energy efficiency and renewable energy upgrades and people seemed unsure of where to go to get answers to their energy-related questions."
- "The local stores, for the most part, do not carry many energy efficient products such as window insulation kits, weather stripping, LED bulbs and ENERGY STAR® appliances."
- "Most local Housing maintenance staff have a general lack of comfort with higher-efficiency heating equipment."

The five most common recommendations from the AEA (2017) assessments were related to:

- Ventilation and indoor air quality,
- LED light bulbs,
- Higher wall insulation levels, with 40-50% of the total on the exterior,
- High-efficiency oil heating equipment (and no electric hot water tanks), and
- Programmable thermostats.

127 *Arctic Energy Alliance (2017). Community Energy Services Summary Report.*

The CEP Team expects that most of these recommendations will apply well to Salliq. It is likely that many buildings in Salliq would benefit from upgrades to ventilation, lighting, insulation, furnaces, and thermostats with a payback often in the range of 5 years, similar to the AEA findings. Until more detailed audit/assessment information is available, we estimate that these upgrades might result in diesel savings on the order of 20%, similar to the AEA findings.

With any building upgrades, it will be important to also consider maintenance needs associated with any new equipment. Some upgrades (e.g. weather stripping, window coverings) need to be replaced regularly for energy savings to persist.

BUILDING AUDITS IN SALLIQ

The CEP Team has conducted one energy audit of a community-scale building to the standard of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Level 2. The site inspections were performed by Energy Champion Blaine Chislett (Sakku) and Hyacinthe Djouaka (CCS) in spring/summer of 2021. Guidance and analysis was provided by SES Consulting[128].

The following building was audited:

- 2-Bay Maintenance Garage

A second building was inspected at the request of the Hamlet – the Waste Water Treatment Plant – however this building was found to be in good condition with a reasonably high level of building energy efficiency. Therefore, a full audit was not conducted on this building.

A photograph of the 2-Bay Maintenance Garage is provided below in Figure 11. The resulting Energy Audit Report is attached as Appendix B.

Figure 11: 2-Bay Maintenance Garage in Salliq.

128 Due to travel restrictions related to the Covid-19 pandemic, staff at SES Consulting could not travel to site, and therefore they provided guidance to the local team, analysis, and reporting.

This building consumes both heating oil and electricity, however energy consumption in the building is dominated by heating oil. Because no historical billing data was available from the Hamlet, energy consumption was modelled based on professional experience and energy use intensity values from the Building Performance Database for commercial buildings in the same climatic region, and also with reference to other commercial buildings in Salliq for which billing data was available. If billing data (heating oil and electricity) becomes available for this building in future, then the financial analysis can be refined.

Various energy conservation measures were examined including building envelope upgrades, equipment maintenance and upgrades, controls, and lighting. Those that are deemed worthwhile are summarized in Table 2.

Item	Description	Total Cost	Effective Payback	NPV	Annual Savings			
					$	L	kWh	GHG
3.1.1	Programmable Stats	$1,000	2.9	$2,300	$350	261	100	0.8
3.1.2	Heating OS/Override Buttons	$1,000	2.1	$5,100	$470	522	100	1.5
3.2.1	Equipment Repair and Servicing	$1,500	0.4	$39,500	$3,500	2,873	600	8.4
3.2.2	Door and Window Sealing	$3,500	1.8	$20,500	$1,900	1,828		5.0
3.3.1	LED Upgrade	$15,000	9.4	$5,800	$1,600		4,500	3.4
3.3.2	Lighting Controls	$3,500	10.0	$1,100	$350		1,000	0.8
Total	**Total**	**$25,500**	**3.1**		**$8,170**	**5,484**	**6,300**	**19.9**

TABLE 2: Energy conservation measures identified for the 2-Bay Maintenance Garage in Salliq.

All of the measures analysed above were found to have a short payback period: less than 10 years, and some even less than 2 years. Taken in aggregate, the total payback period estimated for these measures is 3.1 years.

The CEP team offers the following high-level financial analysis for the above-referenced building upgrades, taken in aggregate. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

Project:	Building Energy Efficiency Upgrades
Buildings:	2-Bay Maintenance Garage
Capital cost:	$ 25,500
Project lifetime:	These upgrades will have a lifetime of 15 – 20 years
Annual savings:	5,500 L of heating oil 6,300 kWh of electricity $ 8,200 in annual savings
GHG savings:	19.9 tonnes CO_2e
Return on investment:	approx. 32 %

TABLE 3: Energy conservation measures identified for the 2-Bay Maintenance Garage in Salliq.

The CEP Team intends to lead the effort to implement the above-referenced measures at this building, in collaboration with the Hamlet. Government grant funding will be sought to cover the cost of the entire bundle of measures, for example from the Municipal Green Infrastructure Fund (described in Section 2.12).

ADDITIONAL BUILDING AUDITS IN SALLIQ

If the community wishes to conduct further assessment of buildings, additional ASHRAE audits could be performed on commercial-scale buildings. This could be accomplished by flying in a certified Energy Advisor from southern Canada, or pairing a qualified local person with an outside energy auditor working remotely. There is no certified Energy Advisor in the Territory at the moment.

Another potential resource for benchmarking energy performance for commercial buildings is the EPA Energy Star Portfolio Manager. For residential-scale buildings, EnerGuide audits (or similar) could be performed[129]. Another option is to use thermal imaging as a way to estimate the energy efficiency of many homes, at a high level, in one effort.

Survey respondents, when asked whether their home had ever had an energy audit, all indicated "no" or "unsure". The vast majority (84%) of survey respondents indicated that they would be interested in any free energy audits or free energy efficiency upgrades to the home, if these were made available.

The CEP Team is also aware of a potential upcoming program to train residential energy auditors in Nunavut. A small group (less than 10) of Nunavummiut were trained in 2020, however none of the trainees has yet passed all of the NRCan exams to become fully certified (as of Summer 2021). The Arctic Renewables Society is currently seeking federal funding to get a new cohort trained as soon as possible.

5.2. SELF-INSTALL ENERGY KITS

There are simple modifications that can be made by the resident of any home to improve energy efficiency. To promote these home improvements, a community can initiate an organized program to provide materials to each resident, and to support them in making the necessary modifications.

The CEP Team has worked with IODI and supplier Ecofitt to purchase 220 "self-install energy kits" (one for each home, including homeowners and renters) which are tailored to the needs of a typical Nunavut home.[130] The contents of each kit are as follows:

- Two dimmable LED light bulbs to reduce electricity used for lighting,
- One pluggable LED nightlight,
- One power bar including USB charging ports,
- Clear plastic glazing to make windows more efficient,
- 12 gaskets to prevent air leakage at wall outlets,
- One low-flow sink faucet and one low-flow showerhead to reduce water consumption and associated heating needs, and
- One "Ecofitt" coloring book and box of 4 crayons.

129 An upcoming federal funding program is intended for EnerGuide home energy audits: https://www.nrcan.gc.ca/science-and-data/funding-partnerships/funding-opportunities/funding-grants-incentives/our-action-starts-home-home-energy-retrofit-initiative/23230
130 Ecofitt. (2021). Ecofitt Website. https://ecofitt.ca/

Results of self-install programs vary from community to community, however a typical result has been annual electricity savings of approximately 200 kWh and heating savings of 15,000 MJ per year. In addition to energy savings, the installation of low-flow faucets in the kitchen, bathroom, and shower can also bring water savings of 30,000 L per year.

In order for these kits to be successful in reducing energy consumption, the items must be installed. Also, as noted further above, some upgrades (e.g. weather stripping, window coverings) need to be replaced regularly for energy savings to persist. Experience from other communities has shown that kit recipients typically install more of the easiest items to install (e.g. light bulbs) and fewer of the harder items to install (e.g. faucets).[131]

One option is for the community to engage a person to visit each home and offer to install the kits. Experience from other communities has shown that this approach can increase uptake and results. However, during the Covid-19 pandemic (ongoing at the time of writing), this is not a viable option.

Our analysis indicates that the distribution and installation of self-install energy kits would have a very high return on investment in terms of financial savings (to the utility payer) and GHG reductions. This is a relatively small project, but well worth the effort. The CEP team has purchased and packaged 220 kits as described above. These kits are scheduled for distribution during the February open-house activities in Salliq.

To assist with promotion, and to provide guidance on proper installation, the CEP Team has commissioned a series of videos that will be distributed along with the kits. The videos includes demonstrations by Energy Champion Blaine Chislett, along with a rationale for installing the kits. Screenshots from these videos are included in Figure 12.

Figure 12: Screenshots from the instructional video to accompany Self-Install Energy Kits in Salliq.

The videos can be viewed on Youtube at the following links:
https://www.youtube.com/watch?v=lpHdjou6mqk&t=3s
https://www.youtube.com/watch?v=Q0Nh8Gacjgk
https://www.youtube.com/watch?v=voyDjXA8UcA
https://www.youtube.com/watch?v=zmD__oVkzW0
https://www.youtube.com/watch?v=3BDhJ3QqNYI
https://www.youtube.com/watch?v=xsIMCVc0XBM&t=1s

We offer the following high-level financial analysis. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

131 Illume Advising (2015). Overview of Energy Savings "Kit" Programs: Background, Challenges, and Opportunities. White Paper. https://illumeadvising.com/files/2016/08/KitsWhitePaper_Final.pdf

Project:	Self-Install Energy Kits
Volume:	220 kits have been purchased as part of the CEP work
Capital cost:	\$16,700 for 220x kits \$1,500 for shipping and distribution \$4,000 to produce an instructional video to accompany each kit. Total: \$22,200
Project lifetime:	Some materials will need to be replaced each year (e.g. window glazing) Other materials may last up 5-10 years (e.g. LEDs) or longer (e.g. faucets)
Annual savings:	We assume that 50% of kits are actually installed in homes. 200 kWh of electricity at each home = \$59 (at subsidized rate) 15 GJ of heat at each home = 462 L of heating oil (assuming 85% efficiency) = \$480 (at current rates) Total = \$538 /yr for each home = \$59,200 for 110 homes
Annual GHG savings:	1.2 tonnes CO_2e per home 132 tonnes CO_2e for 110 homes (50%)
Financial payback:	0.5 years
Return on investment:	250%

TABLE 4: Financial analysis for Self-Install Energy Kits in Salliq.

Finally, if these energy savings are to persist, additional kits (particularly soft materials such as weather stripping and window coverings) will need to be provided to Salliq residents in future.

5.3. BUILDING CODE & STANDARDS

Legislation was put in place in 2012 which requires adherence to relevant sections of the National Building Code for all new construction in Nunavut.[132] We understand that compliance with this new legislation has been lacking. Therefore, the GN is leading a new effort to increase enforcement, led by the Office of the Chief Building Official. Increased enforcement/compliance is expected to lead to moderate improvements to energy efficiency in newly constructed buildings going forward.

Beyond the National Building Code, regulators could consider additional policies to enforce a higher standard of energy efficiency in new buildings. Additionally, building standards could specify optimal roof angles for new buildings, which would enable optimal orientations of solar PV systems in future.

132 *Building Code Act (2012). https://www.nunavutlegislation.ca/en/download/file/fid/7444*

5.4. LED LIGHTING

Traditional incandescent light bulbs are approximately 20% efficient - they turn 20% of the electricity they consume into light, and the remaining 80% is "lost" as heat. Modern LED light bulbs are typically 80% efficient, losing only 20% as heat. Therefore they are approximately 4 times more efficient, making LEDs an obvious choice for lighting needs in northern remote communities where there are fewer accessible energy sources. Modern LEDs produce high-quality lighting of any desired colour or brightness, and dimmable LEDs are also available. LED bulbs also last longer than traditional bulbs, thereby saving time and money in the long run. LED bulbs currently cost about twice as much as traditional incandescent bulbs, however the price is quickly decreasing as LEDs become mass produced globally.

As previously mentioned in section 5.2, LEDs are included in the Self-Install Energy Kits for homes. When it comes to streetlights, Salliq is already underway with the roll-out of LEDs as discussed in section 2.9. With regard to commercial-scale buildings (offices, school, health center, etc.), there is an opportunity to replace traditional bulbs with LEDs. This would require some manual labour by maintenance staff. LED bulbs could be rolled out in one big effort, or they could replace traditional bulbs gradually as they expire.

Commercial-scale buildings typically use approximately 8% of their electricity for lighting.[133] In Salliq, 54% of all electricity, or 1,900 MWh each year, is sold to customers in the "commercial" category. We estimate that 8% of this, or 154 MWh might be attributable to lighting. Therefore, replacing all light bulbs in commercial-scale buildings has the potential to save 115 MWh per year, or 33,900 L of diesel, for a financial savings of $109,000 (true cost) or $33,700 (subsidized QEC rates).

The CEP Team presents the following high-level financial analysis of LED lighting in commercial buildings. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

Project:	LED Light Bulbs in Commercial-Scale Buildings
Volume:	We estimate approximately 500 traditional incandescent light bulbs in ~14 commercial-scale buildings
Capital cost:	Equipment: $3-4 per bulb $1,500 - 2,000 total Labour: Estimated at $10,000 for one month of work Total: $12,000
Project lifetime:	Most LED bulbs are expected to last 5-10 years
Annual savings:	$109,000 /yr (true cost) $33,700 (subsidized rates)
Annual GHG savings:	93 tonnes CO_2eq
Financial payback:	0.1 years (true cost) or 830% return 0.5 years (subsidized rates) or 230% return

TABLE 5: Financial analysis for Self-Install Energy Kits in Salliq.

133 US Energy Information Administration. (2021). How much electricity is used for lighting in the United States? https://www.eia.gov/tools/faqs/faq.php?id=99&t=3

Replacement of all commercial-scale light bulbs with LED bulbs appears to be a very worthwhile effort in terms of saving money and reducing GHG emissions. Other Nunavut communities have recently installed LEDs with mixed results (some equipment failure problems).[134] Lessons learned from these experiences should inform equipment selection in Salliq.

It is also possible that some commercial-sector lighting may be more challenging to replace with LEDs - for example fluorescent lights that might require replacement of the electrical ballast and the assistance of an electrical engineer, who would need to be flown into the community. The business case for replacing these systems with LEDs may be weaker.

5.5. GEO-EXCHANGE & HEAT PUMPS

Unlike geothermal energy, which captures heat from a hot source underground, a geo-exchange system takes advantage of two bodies that are different temperatures, and uses a heat pump to concentrate heat into buildings. For example, if the ground temperature is slightly higher than the air temperature, then a heat pump could take advantage of this difference to heat buildings. The result is a form of electric heating that is very efficient. In fact, heat pumps can have efficiencies above 100%, that is they produce more usable heat than the electrical energy consumed.

Geo-exchange systems operate cleanly and don't produce any substantial pollution or GHG emissions. In the case of Salliq, however, the electrical grid is currently powered almost entirely by diesel fuel, with an efficiency of approximately 32% (that means that 68% of the diesel energy is converted to heat or sound before it reaches the user). This low efficiency would eliminate any advantage created by a geoexchange system.

Geo-exchange is also challenging in cold climates, especially below freezing temperatures. The CEP Team is uncertain whether geo-exchange systems could be technically feasible in Salliq. Few examples have been identified in similar communities.

In the long run, however, there are no easy alternatives for heating in Salliq, and heating is responsible for the largest GHG emissions. Therefore, as the local electrical grid begins to convert to clean sources, geo-exchange should be examined in greater detail to determine its feasibility in Salliq.

5.6. TINY HOMES

Salliq has expressed a need for new housing. "Tiny homes" are small homes, usually built for a single family, that can be mostly manufactured off-site and assembled onsite. Tiny homes are often designed to be very energy efficient.

Considering that many homes in Salliq are overcrowded, tiny homes do not appear to be a solution to the broad housing needs of the community. However, tiny homes could potentially be workable for specific needs such as transitional housing for homeless people, or for young families wanting to live separately from extended family.
A tiny home was constructed in the community of Arviat as a pilot project, for the purpose of

134 News article entitled "QEC moving ahead with $500,000 in LED street lights in 2021-22; questions arise over longevity". https://www.nunavutnews.com/nunavut-news/qec-moving-ahead-with-500000-in-led-street-lights-in-2021-22-questions-arise-over-longevity/

studying its energy performance. A case study by the Canada Mortgage and Housing Corporation examined the successes of this tiny home[135]. The home, named the "E/2 Northern Sustainable House" is a single-storey, 3 bedroom, residential dwelling with a heated area of 128 m^3. Insulation in this home was to a very high standard - R-46 in the walls, R-52 in the floor, and R-66 on the roof. Heating is delivered via an oil-fired boiler and a heat recovery ventilator (heat exchanger).

The study concluded that this tiny home consumed 14% less energy compared to a similarly-sized home based on 1997 standards. This was a smaller energy savings than the authors had anticipated, however lessons were learned that can inform the design of future tiny homes. The CEP Team is not aware of the cost of the tiny home constructed in Arviat and how this compares to typical housing construction.

135 Canada Mortgage and Housing Corporation (2016). Research Highlight: Arviat E/2 Northern Sustainable House Energy Consumption Performance Assessment. https://assets.cmhc-schl.gc.ca/sf/project/cmhc/pubsandreports/pdf/68530.pdf?rev=6cad19ff-b624-4d55-ba5b-3ffa4b03c439

6. Clean Energy Opportunities

An obvious way that Salliq can improve its energy system is to implement clean energy technologies, which can deliver heat and/or electricity without causing substantial GHG emissions. Energy provided by clean technologies reduces the need to import and burn diesel fuel.

Many clean energy projects have been deployed across northern Canada in recent years, thanks in part to the maturing of various technologies. Between 2015-2020 the number of clean energy projects nearly doubled in remote Canadian communities, including an 11-fold increase in the number of solar energy projects.[136] These projects resulted in a combined reduction of 12 million litres of diesel combustion per year. Nevertheless, the roll-out of clean energy projects in the North is still in its early stages, with the vast majority of energy in northern communities still coming from diesel fuel. A substantial increase in clean energy deployment would be required to transition communities such as Salliq away from diesel fuel.

Clean energy development requires a combination of technical knowledge, vision and courage, sustained hard work, stakeholder engagement, and a willingness to design solutions that are workable for all key stakeholders. In the sub-sections to follow, various clean energy technologies will be evaluated for their suitability in Salliq.

136 Lovekin D. et al. (2020). Diesel Reduction Progress in Remote Communities. Pembina Institute. https://www.pembina.org/pub/diesel-reduction-progress-remote-communities

Candidate clean energy technologies that the CEP has considered in Salliq include:

- solar photovoltaic energy,
- wind energy,
- biomass energy,
- run-of-river hydro-electric energy,
- ocean energy,
- geothermal energy, and
- energy storage.

The following technologies are not evaluated in this CEP:

- hydro-electric energy with storage, as the Canadian Energy Atlas shows no mapped potential in the region,

6.1. METHODOLOGY

The CEP Team took the following steps in conducting the assessment of clean energy project options.

Basic criteria are established to guide the identification of a viable clean energy project. These criteria can be specific to each technology, but should always include the following:

- **Authorization from QEC.** Technologies should be capable of demonstrating through technical studies their compatibility with the continued reliable operation of the local electrical grid, resulting in authorization from QEC to interconnect.
- **Alignment with federal funding programs.** Due to the high costs of building infrastructure in Nunavut, federal funding is commonly used to cover some or all of the capital cost of new projects. Even in the upcoming IPP program, grant funding will likely be required to create a viable business. Therefore alignment with federal funding programs is critical. At present, projects that demonstrate a high rate of diesel reduction per dollar of grant funding are generally well received by funding decision makers.
- **Energy resource.** The strength and quality of the wind resource, solar irradiation, hydrological flow, tidal exchange, geothermal gradient, etc. This can be estimated based on computer modeling, and then verified using field measurements.
- **Distance from grid.** Projects that are farther afield will require longer transmission lines to connect with the Salliq electrical grid, with resulting costs and environmental impacts.
- **Road access.** Sites with good road access will be more affordable to build.
- **Logistics.** Heavy equipment is typically transported by large transport ships to Salliq and then transferred to a barge for unloading.[137] There is no deep water port in the community, nor cranes for unloading heavy or specialized equipment. Therefore solutions that are logistically simpler may be more affordable.

137 *pers. comm. Tara Tootoo Fotheringham of Arctic Buying Co.*

- **Appropriate size for demand/market.** Projects should be appropriate in size and nature to supply a local energy need, or to align with utility procurement programs. This includes ensuring that projects will not cause unmanageable instability in the Salliq electrical grid as generation rises and falls.

- **Interconnection cost.** Cost of safely and reliably interconnecting with an end user or the Salliq electrical grid. Small projects might interconnect cheaply behind the meter of an existing electricity user. Larger projects might require stepping up the voltage to connect to distribution lines, along with protections and controls to protect the generator and the grid.

- **Environmental impact.** Consultation with the Hamlet government and government regulators can reveal environmental factors that should be avoided by a clean energy project.

- **Human use.** Some of the lands surrounding Salliq are used by residents for recreation, hunting, trapping, gathering, harvesting, or spiritual use. Additionally, larger generators such as large wind turbines can make sound and are not appropriate within ~500m of a residence. Medium-sized turbines can be placed up to approximately 200m from a residence.

- **Alignment with planning.** Consistency with existing community planning objectives and land use designations. Avoidance of any areas legally designated as off limits to energy generation projects.

- **Alignment with community feedback.** A preference for fuel types or locations that received strong public support in the community energy survey.

Resource mapping was reviewed to examine the predicted strength of the energy resources (e.g. wind, solar, tidal, geothermal) based on computer modeling and satellite imagery. Other relevant spatial factors were included in mapping where appropriate.

Candidate projects were identified with the aim of satisfying the established criteria.

A project shortlist was established in consultation with Mayor and Council.

Pre-feasibility analysis was performed for shortlisted projects, and the results presented in this CEP. This includes screening a project for potential critical flaws, assessing key risks, analyzing the expected costs and revenues, and describing a path forward toward establishing feasibility and eventual implementation. The CEP Team performed financial modeling based on industry best practices to examine the financial performance of the proposed investment.

A Risk Assessment is presented to highlight various key risks and recommended risk reduction measures.

The CEP Team's recommendations for next steps in development of a clean energy project are discussed in section 8.7.

6.2. SOLAR ENERGY

Solar photovoltaic (PV) technologies use silicone membranes to capture energy from sunlight and convert it to electricity. Solar PV systems can be installed on buildings (smaller systems) or deployed on ground-mounted racks (larger systems). Solar PV systems have matured to the point of being cost-competitive with traditional energy sources in many parts of the world. Solar PV can be viable at any scale, from very small to very large, however larger projects generally have a higher financial performance.

A typical solar energy project is comprised of three main components:

- **Solar panels:** Delicate silicon membranes, usually called cells, are assembled into larger modules or panels that are robust and can be exposed to the elements.
- **Mounting or racking system:** For a building installation the racking will be fixed to the roof of the building. For a ground-mounted system the frames or racks will be mounted on supporting structures which are pile driven into the ground or attached to concrete footings.
- **Inverters:** These electrical devices convert direct current (DC) electricity to alternating current (AC) which is typical of the local grid.
- **Mounting systems** for ground-mounted arrays can either be fixed tilt (i.e. the panels will be fixed at a specific angle), or a tracker system (i.e. the mounting system tilts throughout the day to track the sun). Both arrangements are shown in figure 13.

Figure 13: Fixed mounting system (left) and single-axis tracker mounting system (right).[138]
An electrical gathering system gathers DC power from the solar panels and connects to one or multiple inverters, which convert the power from DC to AC to match the electrical grid.

In a ground-mounted system near populated areas, security and safety are primary considerations. Solar arrays are often enclosed by a security fence around the site perimeter.

Figure 14: Inverter unit typical of a large ground-mounted solar PV array.[139]

138 Reproduced with permission from Green Cat Renewables.
139 Reproduced with permission from Green Cat Renewables.

 

Figure 15: Wooden pole and mesh fencing (left) and metal fencing (right).[140]

Decision makers in Salliq should consider the following pros and cons of solar PV energy.

PROS:

- Mature technology with decades of operational experience.
- Cost competitive due to significant recent reductions in technology costs.
- No greenhouse gas emissions or pollution during operations, thus reducing emissions typically caused by burning diesel.
- Reliable energy from dawn until dusk. Available in the daytime when grid load is typically at its peak.
- No reliance on fuel imports.
- Can be installed using primarily local labour and does not require specialist machinery.
- Creates local job opportunities for year-round maintenance (e.g. snow and ice clearing, panel cleaning).
- Long operational lifetime.
- Highly scalable and can be sized optimally.

CONS:

- Large solar projects can require a large land footprint per kW installed.
- Only available during daylight hours with reduced production in cloud cover.
- Strongest production in summer, less (or none) in winter.
- Toxic waste is commonly produced in the manufacturing of PV panels.
- Can be susceptible to vandalism.
- Can cause glare effects to nearby residents or aircraft.
- At the end of the project lifetime, any waste produced by the project would need to be transported offsite as there are no recycling facilities in the community.

SITE SELECTION CRITERIA

140 *Reproduced with permission from Green Cat Renewables.*

The following factors should be considered when selecting a site for a solar PV project.

- **Solar resource.** Computer modeling can predict the solar irradiance level based on geographic latitude and cloud cover statistics with a high degree of accuracy. No direct measurement of the solar resource is needed.
- **Ground conditions.** Much of the installation cost of a solar PV installation depends on the local ground conditions. Flat, solid ground will allow for easy movement of the construction crew, as well as affordable racking and anchoring equipment. Ground that is uneven, rocky, or permafrost (like in Nunavut) can lead to higher equipment and labour costs. A small PV system can make use of existing rooftops (if roofs are suitable), however a larger system should be mounted on the ground.
- **Road access.** A site that lies closer to existing, usable roads will have lower costs than a site requiring construction or upgrades of roads.
- **Interconnection costs.** A site that lies closer to a suitable interconnection point on the electrical grid will be cheapest. For a small PV project this interconnection point could be the electrical meter in a local building. However, a larger project would likely need to build new electrical lines to interconnect at the QEC diesel power plant, which results in higher costs and higher electrical losses.
- **Visual impact.** Visual impacts are very subjective. Roof mounted arrays will generally be difficult to distinguish from the roof of the host building. Ground-mounted arrays will introduce a new structure into the landscape, which is typically low-lying and not visible from a distance. If the Hamlet believes that visual impacts may be a factor for local residents, then more information is needed regarding any geographic constraints to minimize potential visual impacts.
- **Footprint.** Large solar PV projects take up a lot of land compared to most other energy technologies (when not on roofs or walls). In order to maximize efficiency, it is important for the design engineers to lay out the rows of PV panels so that they are optimally oriented toward the path of the sun. In northern communities these panels are often oriented close to vertical so that they capture as much winter sun as possible, when the sun is low in the sky. This requires spacing between long rows of panels. Once geographic constraints are understood, then our design team can help to identify all potential suitable sites for the community's consideration.
- **Noise.** Solar panels themselves do not generate any noise, however the electrical components (e.g. inverter, transformer) can create noise. In small solar arrays the noise generated is minimal and would be difficult to detect over a normal background noise level. For a larger solar PV system, noise should be considered when selecting a site.
- **Glare.** Solar PV technology is specifically designed to absorb as much sunlight as possible, however occasionally reflected light can cause a glare effect. Solar arrays should therefore be designed and sited to ensure there are no adverse glare impacts.
- **Environmental Impacts.** Environmental impacts from solar PV projects are typically very

low. Nevertheless, sites with the potential to cause unacceptable environmental impacts should be identified and avoided. This includes ensuring that the chosen site is not an important habitat or travel route for wildlife.

- **Security.** We are open to a discussion with the hamlet regarding risk of vandalism and any related siting considerations or precautions that should be taken.
- **Community Values.** The chosen site should reflect existing community planning, community preferences, and cultural values.

Implementation of a solar energy project would require review and approval by the Nunavut Impact Review Board (NIRB), and this could require further study of some of the topics listed above.

SOLAR RESOURCE

Salliq was assessed to have the highest solar resource of all the Nunavut communities studied by WWF and ITP[141]. The solar resource will benefit from the generally clear skies that are common in Salliq, especially in summer.

Average solar radiation values can be estimated for each month using the American online tool PV Watts, and these values are listed below in Table 6.[142] PV Watts estimates an annual average of 3.02 kWh/m^2/day, whereas WWF/ITP relied on an estimate of 2.9 kWh/m^2/day.

Month	Solar Radiation (kWh / m^2 / day)
January	0.94
February	1.71
March	3.31
April	3.94
May	4.12
June	6.35
July	6.00
August	4.39
September	2.70
October	1.24
November	0.57
December	0.92
Annual	3.02

TABLE 6: Solar irradiance per month in Salliq as estimated by PV Watts.

As expected, the data illustrates a strong solar resource in summer, however the solar radiation

141 WWF, ITP. (2019)

142 National Renewable Energy Laboratory. (no date). PV Watts Calculator. https://pvwatts.nrel.gov/pvwatts.php is expected to drop below 2 kWh/m^2/day for five winter months of the year. Unfortunately solar energy is weakest during the winter months, when the community's energy needs are highest. This is a common challenge with solar energy in the North. While solar energy cannot provide all of Salliq's energy needs, it can make a substantial contribution, especially in summer months. The solar resource will be consistent across the community, subject to any human-made structures that may cause shadows. This is apparent in the mapping published by the Canadian Energy Atlas in Figure 16, which shows an equal solar resource across Shugliaq Island.

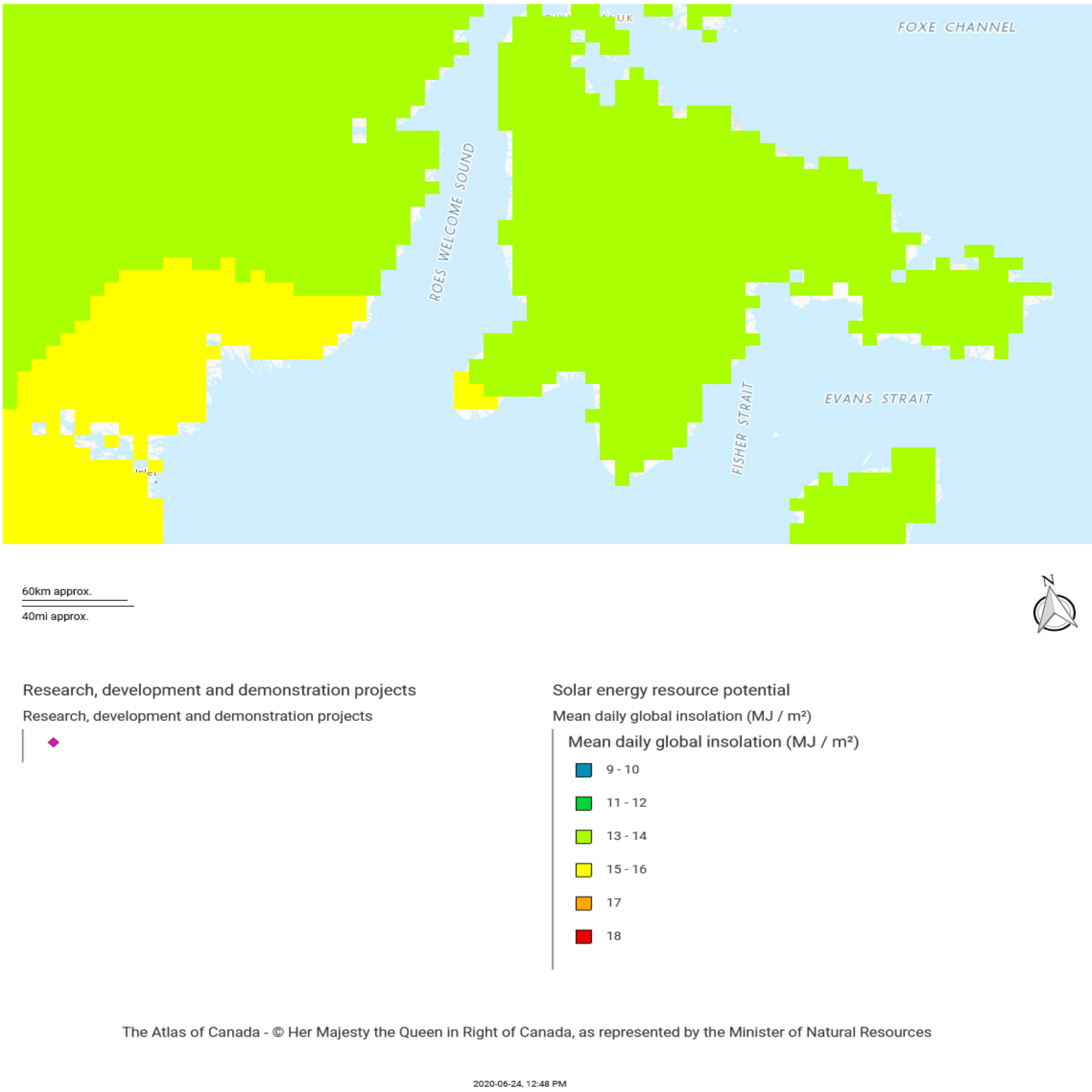

Figure 16: Solar resource estimated by the Canadian Energy Atlas, which is consistent across Shugliaq Island.[143]

Before implementing a solar PV project, it is common practice to purchase a commercial-quality solar resource estimate from a computer model, as these are considered to be more accurate. Further recommendations for developing a solar PV project are provided in section 8.7.

CANDIDATE SITES & TECHNOLOGIES

143 *Units in the map are in MJ/m2/day. Note that 13 MJ/m2/day = 3.6 kWh/m2/day.*

Due to the consistent solar resource across the community, solar PV projects could be located anywhere that satisfies the criteria discussed above. I.e. sites that are close to the electrical grid, affordable to construct, and which don't overly disturb human and animal uses of the area.

Small-scale solar PV:
It is often affordable to install solar PV panels on roofs of existing buildings. Solar PV systems could be mounted on the rooftops of single family homes or multi-unit residential complexes.

The optimal rooftop would have the following qualities:

- newly built or in good condition so that its lifetime will be long,
- oriented toward the south for peak daytime production, or split east-and-west for good production in morning and evening,
- some metal roofs have ribs that can aid in attaching the solar PV mounting brackets, and otherwise roofs can be penetrated and sealed,
- ideally the host building would have an electrical demand large enough to consume most energy locally (e.g. net metering),
- risk of glare on neighbouring people should be considered.

Large-scale solar PV:
Previous analysis by WWF and ITP examined solar PV projects ranging in capacity from 650 - 2250 kW, and concluded that solar PV was the optimal next step in Salliq.[144] A project of this scale would represent a substantial step in the transition to clean energy. A solar PV system would also require an energy storage component (e.g. large battery) in order to ensure stability of the electrical grid. Energy storage is discussed in more detail in section 6.8.

It would be necessary to identify a suitable piece of land in/near the community where a ground-mounted solar PV array, and associated battery system, could be built. The chosen site would need to satisfy the criteria listed further above.

The CEP Team has examined available community mapping and identified several candidate sites for a large-scale solar PV array. These candidate sites are depicted in Figure 17, and are constrained to within 3km of town. Such a map can serve as a focal point for consultation with community members and stakeholders to help identify the optimal site.

The CEP Team has also learned that the Hamlet has expressed a desire for clean energy projects to be located close to the airport. Final site selection wlll be conducted in consultation with the Hamlet to ensure an appropriate site is selected.

144 WWF, ITP (2019).

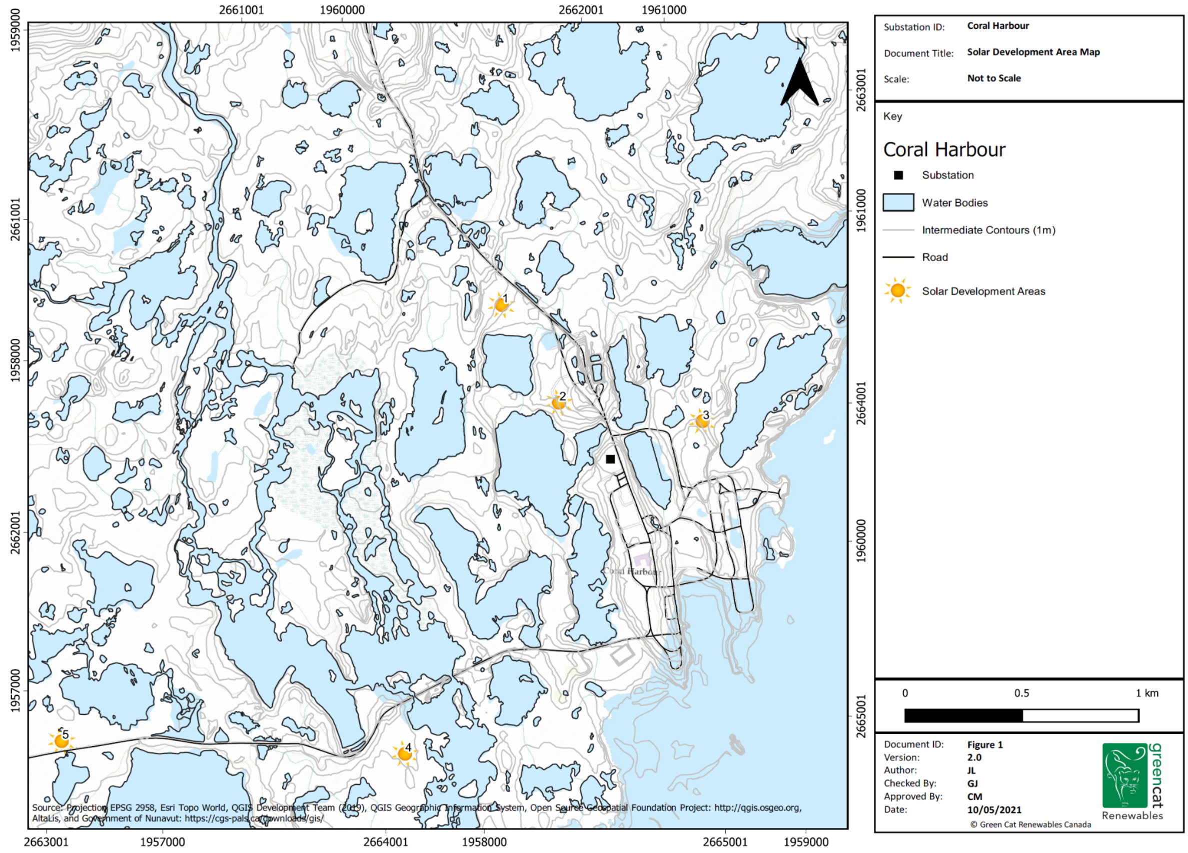

Figure 17: Map of candidate ground-mounted solar PV sites. These are sites which are within 3km of the center of town, have sufficient land area, and avoid known constraints.

The CEP Team has also conducted a site visit to leading candidate solar sites in order to collect information related to project feasibility. Select photos are depicted in Figures 18-20 below.

Figure 18: Solar PV Site #1, looking southeast towards the community. Note that this was historically a landfill site.

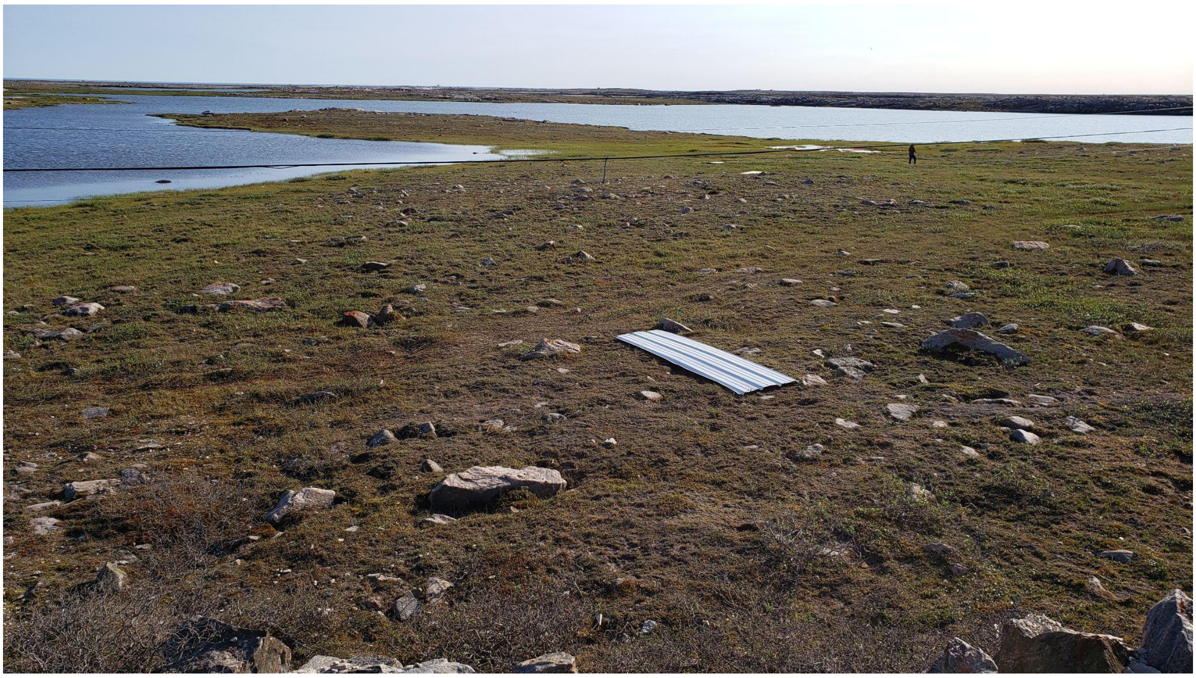
Figure 19: Solar PV Site #2, looking south towards the large body of water.


Figure 20: Solar PV Site #3, looking east towards the bay.

SHORTLISTED PROJECTS

Small-scale solar PV:
Although solar PV systems should be cheaper than diesel-derived electricity from a holistic perspective, the GN's electricity rate subsidy makes it hard for residential-scale projects to compete with the subsidized QEC rate of $0.293 /kWh. However, there could be an opportunity for small scale solar PV projects on the rooftops of homes that use a lot of electricity. If monthly QEC electricity bills are commonly above the 700/1,000 kWh threshold for the GN rate subsidy, then these homes could be paying the full $0.9524 /kWh for electricity on the margin. At these high-consumption homes, homeowners could invest in a rooftop solar PV system and apply under QEC's Net Metering program to reduce their electricity bills going forward.

We have chosen the following case for study:

- a 5-kW solar PV system,
- on a residential rooftop, optimized as the rooftop allows,
- selling electricity to QEC under the Net Metering program,
- for greater pricing, a group of homeowners could collaborate with a contractor to install several small-scale solar PV systems with a total capacity less than 42-kW, as allowed under QEC's Net Metering program.

Large-scale solar PV:
The CEP Team envisions a large-scale solar PV project to substantially reduce the consumption of diesel fuel in Salliq. Our preliminary examination of available technologies for this application has revealed a configuration that we believe is optimal.

We have chosen the following case for study:

- a 500-kW solar PV system,
- ground-mounted on metal racking,
- bifacial modules to maximize electricity production,
- fixed axis with a tilt angle between 45° - 55°,
- 20m spacing between rows of PV modules,
- approximately 1 km from the QEC powerplant,
- approximately 100m from existing roads,
- selling electricity to QEC under the CIPP or IPP program.

Note that the details of this project, including its scale (kW), will be refined by further study work in the months to come.

FINANCIAL ANALYSIS

Small-scale solar PV:
The CEP Team has sought quotes from various contractors who design and install residential-scale solar PV systems in northern communities. We offer the following high-level financial analysis of this proposed solution. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

Project:	5-kW rooftop solar PV on each of 8 homes
Nameplate capacity:	5-kW per home 40-kW total[145]
Capital cost:	$25,000 per home (based on $5 /W)[146] = $200,000 total
Annual operating cost:	$100 per home (minimal) = $800 total
Annual electricity production:	3,400 kWh/yr per home, after electrical losses = 27,200 kWh total
Annual savings:	$1,000 per home at subsidized rates, or $3,200 per home at unsubsidize
Project lifetime:	40+ years (Inverters may need replacement after 10-25 years)
Financial payback:	25 years at subsidized rates or
Return on investment:	1% at subsidized rates or 12% at unsubsidized rates

TABLE 7: Financial analysis for residential-scale solar PV in Salliq.

It is apparent from this analysis that residential-scale solar PV is viable for customers who purchase unsubsidized electricity from QEC. For customers with primarily subsidized rates (most customers) the return on investment from small-scale solar PV will be minimal.

Large-scale solar PV:
The CEP Team has worked with a candidate solar PV contractor to arrive at a conceptual large-scale ground-mounted solar PV project for Salliq. We offer the following high-level financial analysis of this proposed solution. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

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145 Recall that we estimate QEC's limit for net metering in Salliq to be approximately 50-kW, and Salliq already has a 10-kW net metering project operating. Therefore the remaining allowable net metering capacity is approximately 40-kW.

146 Approximate pricing informed by input from Kuby Renewable Energy Ltd. and NWT Solar Solutions.

Project:	300-kW ground-mounted solar PV array plus battery storage
Nameplate capacity:	300-kW (AC) 390 kW (DC) 400 kWh (battery storage system)
Capital cost:	=$3,120,000 Estimate including development costs [147]
Annual operating cost:	= $101,000 Including a reserve account to fund replacement of inverters and batteries after approx. 20 years.
Annual electricity production:	532 MWh/yr after electrical losses
Annual revenues:	$133,000 at QEC's proposed $0.25 /kWh CIPP rate
Project lifetime:	40 years+ Inverters and batteries may need replacement after approx. 20 years.
Financial payback: Return on investment:	Project revenues are modeled to be in excess of operating costs. However, financial performance of this project would not support repayment of a capital investment.

TABLE 8: Financial analysis for residential-scale solar PV in Salliq.

This project would require grant funding in order to be viable at the assumed QEC electricity price of $0.25 /kWh.

One scenario is for the project to seek grant funding to cover the entire capital costs, estimated at $3.12 million. Subject to more refined study, we suspect that operational revenues would be sufficient to cover operating costs.

If QEC were to pay more for electricity in future (e.g. the true cost of diesel-fueled electricity), then revenues might exceed operating costs. In this event, partial grant funding might allow the project to proceed under an IPP model. The IPP would receive grant funding, finance the remainder of capital costs through private equity and/or debt, and then use revenues to pay a return on this investment throughout the project's operational life.

GHG ANALYSIS

Small-scale solar PV:
Installation of 40-kW of residential solar PV across eight homes in Salliq would generate approximately 27,200 kWh of clean electricity each year. If all of this clean energy resulted in displacement of diesel fuel, then it would displace approximately 8,000 L of diesel each year and would reduce GHG emissions by approximately 22.0 tonnes CO_2e each year.

147 *Cost assumptions for the Tesla powerpack battery system are adopted from ITP (2019).*

In practice, QEC may need to keep some diesel generators running on standby while clean energy systems are running (as a backup) and so GHG savings may be lower than stated above. This will depend on the choice of battery system, as well as the chosen grid control strategy by QEC. Further clarity on GHG reductions should arise from continued development and study work.

Large-scale solar PV:
Installation of a 300-kW ground-mounted solar PV system in Salliq, with associated battery storage, would generate approximately 532 MWh of clean electricity each year. If all of this clean energy resulted in displacement of diesel fuel, then it would displace approximately 155,300 L of diesel each year and would reduce GHG emissions by approximately 427 tonnes CO_2e each year. In practice, QEC may need to keep some diesel generators running on standby while clean energy systems are running (as a backup) and so GHG savings may be lower than stated above. This will depend on the choice of battery system, as well as the chosen grid control strategy by QEC. Further clarity on GHG reductions should arise from continued development and study work.

JOBS ANALYSIS

Small-scale solar PV:
Installation of 40-kW of residential solar PV across eight homes in Salliq would require a construction crew of approximately 5-8 people. Typically most labour can be hired locally. Salliq also has at least one person trained in solar PV installation, and so perhaps some of the technical/ supervising roles could also be filled locally.

Solar PV projects are known for having very low maintenance needs. During operations, one individual in Salliq should be trained to assist residents with any questions or issues that may arise.

Large-scale solar PV:
Installation of a 300-kW ground-mounted solar PV system in Salliq, with associated battery storage, would require a construction crew of approximately 20 - 30 people. Some of this labour can be hired locally. During operations, two individuals in Salliq should be trained to conduct regular monitoring and maintenance, with outside services brought in as required.

RISK ASSESSMENT

The following risks should be considered when pursuing a solar PV energy project in Salliq:

Small-scale solar PV:

- Cold climate: All equipment would need to be rated for cold climate.
- Structural integrity: Structural suitability of selected rooftops would need to be verified by a structural engineer, as is common practice in the design and delivery of rooftop systems. This structural engineer would need to be flown in to the community. Roofs on selected homes would need to be in good condition with a long expected lifetime before replacement (e.g. 25+ years).
- Transportation timing: All equipment needed for this project would need to be procured off-site for shipping to the community during the seasonal shipping window.
- Overall this is considered a very low-risk project.

Large-scale solar PV:

- Cold climate: All equipment would need to be rated for cold climate.
- Geotechnical conditions: Ground-mounting equipment needs to be appropriate for the local ground conditions, which have not yet been inspected.
- Site selection: Appropriate siting should be finalized in consultation with affected stakeholders.
- Public support: Survey respondents in Salliq indicated strong support for solar energy. Expanded and focused community engagement should be conducted during project development.
- Transportation timing: All equipment needed for this project would need to be procured off-site for shipping to the community during the seasonal shipping window.

Overall this is considered a low-risk project.

RECOMMENDATION

The CEP Team has identified a large-scale ground-mounted solar PV opportunity that would represent a substantial step for Salliq's transition away from diesel fueled electricity. Furthermore, in consideration of other projects evaluated in this CEP, <u>we believe that this solar PV (plus battery storage) project represents a substantial opportunity for Salliq to significantly displace diesel on its electrical grid</u>.

Recommendations for developing a clean energy project in Salliq are provided in section 8.7.

6.3. WIND ENERGY ASSESSMENT

Wind energy technologies use large rotating blades to capture energy from the wind and convert it to electricity.

Community-scale wind energy projects typically include the following components:

- One or several wind turbines (see Figure 21), which can range in size from small scale (e.g. 5m blades on a 15m tower) to large scale (e.g. 30m blades on a 50m tower),
- Roads to access each turbine site,
- A foundation for each turbine that is suitable for local ground conditions,
- A transformer to convert the voltage of electricity coming from the turbine to match the local grid voltage,
- Electrical lines/cables to collect electricity from each turbine and deliver it to the grid,
- Switchgear/substation as needed to ensure safe operation of the wind energy project without causing problems on the local grid.

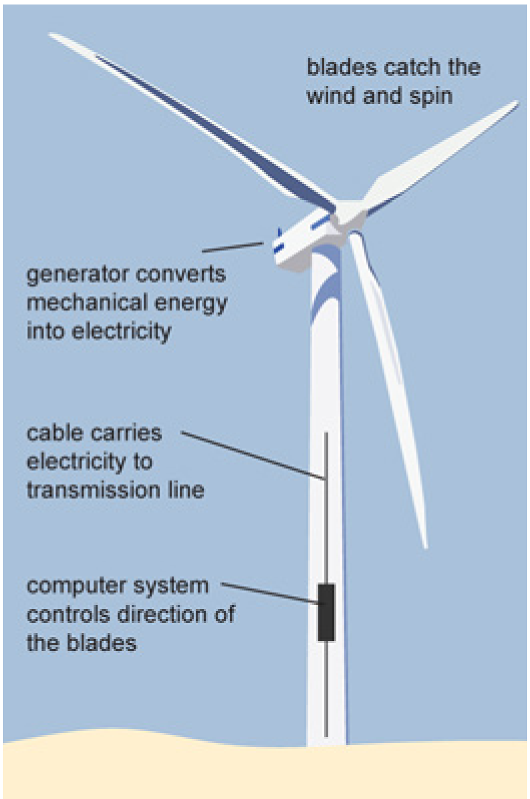

Figure 21: Schematic showing a typical modern wind turbine.[149]

Although wind turbines of various sizes can be purchased, the most affordable wind energy comes from large-scale wind turbines which reach high up into the atmosphere where winds flow fast and steadily, and with large rotors that can capture energy from a large area. However, large wind turbines require large cranes to construct, and in a remote community crane rentals can be expensive. Large wind turbines can also exceed local barging limitations for size and weight, as discussed previously in 2.11. Therefore we expect that a medium-scale wind turbine (one or several) will be the optimal choice for Salliq.

149 Source: National Energy Education Development Project.

Decision makers in Salliq should consider the following pros and cons of wind energy.

PROS:

- Mature technology with decades of operational experience.
- Cost competitive due to recent reductions in technology costs.
- A large amount of energy can be produced by a single turbine (e.g. 100 kilowatts to 2 megawatts).
- No greenhouse gas emissions or pollution during operations, thus reducing emissions typically caused by burning diesel.
- No reliance on fuel imports.
- Typically more energy is produced in winter, when it is needed most.
- No health impacts to humans found during a large study by Health Canada.
- Modern technologies allow for heated components (e.g. nacelles, blades) on some models to combat the effects of cold climate and the potential for icing losses.

CONS:

- Only available when the wind is blowing, and this can change from minute to minute; therefore proper system balancing is vital.
- Sound can be a nuisance to humans if located within ~500m (medium scale) or ~1km (large scale) from residences.
- Not suitable close to airports or telecommunications towers (e.g. 1km)
- Can impact bird populations if not sited carefully (location dependent), and may require further study.
- Visible from far away; this can also be a pro, as a tall tower can serve as a beacon to return home in low visibility.
- High quality roads are required to access the site.

SITE SELECTION CRITERIA

The following factors should be considered when selecting a site for a wind energy project.

- **Wind resource.** Computer models can predict the wind resource with a medium degree of accuracy. Typically a viable wind energy project requires an annual average wind speed of at least 6 m/s measured at a specific height above ground (~20-50m for a small community project). For a large wind energy investment, it is often worthwhile to measure wind speeds directly using a tall meteorological tower for at least 12 months. Climate factors (e.g. cold temperatures, icing) will also affect wind energy production.
- **Road access.** Wind turbines involve large components that must be transported on good roads with no extreme turns or slopes. Therefore sites that have a clear path from the point of delivery (e.g. port) to site will be most affordable.

- **Ground conditions.** Wind energy projects involve a lot of civil construction work (e.g. foundation, crane pad) and therefore the construction cost is sensitive to the local ground conditions. Information related to local geology, terrain, and soils should be reviewed during the siting exercise to help identify appropriate sites. In Nunavut, permafrost mapping should also be reviewed to inform site selection.

- **Interconnection cost.** A site that lies closer to a suitable interconnection point on the electrical grid will be cheapest. A medium-to-large wind project would likely need to include new electrical lines to interconnect at the QEC diesel power plant. Buried cables are more expensive than overhead lines on poles, however they can be more reliable especially in icy conditions. Longer electrical lines also result in higher electrical losses during operations.

- **Distance to homes.** Wind turbines create some sound when they operate, and some of these sounds can cause an annoyance to nearby residents. Computer modeling can be used to predict sound levels at any location, once a specific wind turbine model has been chosen. Note that a large study by Health Canada found no evidence of human health effects due to wind turbines.[148]

  The moving blades can also create moving shadows that can cause a distraction to nearby people (the "flicker" effect). The flicker effect can be especially pronounced when the observer is indoors. This can also be modeled using computers.

  A good rule of thumb is to locate medium-to-large wind turbines at least 500-1000m away from homes.

- **Distance to airport.** A wind turbine located within 4km of an airport that is more than 45m above the published elevation of the airport can lead to complications for NavCan / Transport Canada with regard to safe approaches for incoming aircraft.[149]

- **Visual impact.** Wind turbines are very tall (e.g. 50-100m to the top blade tip) and often visible from afar. Many people don't mind looking at wind turbines, and some people even find them pleasant as a symbol of a new way of producing energy. However, some people do find wind turbines unpleasant to look at.

- **Flora and fauna.** Wind turbines generally cause very low environmental impacts. However if siting is not done carefully, then they can have unacceptable impacts on plants (e.g. rare plants) or animals (e.g. birds, fish, caribou calving grounds or migratory routes). Much scientific study is available on this topic from the literature. It is important to consider any available environmental information before finalizing the site of a wind energy project. Typically a wind energy project should be set back from known environmental constraints (e.g. streams, key habitats).

Implementation of a wind energy project would require review and approval by NIRB, and this could require further study of some of the topics listed above.

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148 Health Canada (2014). Wind Turbine Noise and Health Study: Summary of Key Findings. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/noise-bruit/turbine-eoliennes/pamphlet-brochure-eng.pdf

149 Pers. comm. with John McFee at Transport Canada.

WIND RESOURCE

The experience of the CEP Team is that the online wind energy modeling available from AWS TruePower is among the most accurate tools available for predicting the wind resource at a new site.[150] More confidence can be gained in the future by installing a wind meteorological tower (met tower), or other device, and taking direct measurements over 12 months.

The AWS wind mapping uses a colour scheme to denote areas according to their average annual wind speed. Wind speeds are modeled at a specific height above ground level ("agl").

Salliq is expected to be less windy than the surrounding regions on Shugliaq Island, as depicted in Figure 22. The zoomed-in wind map in Figure 23 illustrates the predicted wind speeds in the vicinity of Salliq, showing an estimated average speed of 6.28 m/s at 60m agl at a specific site just outside of town. Other sites near town were predicted to have similar wind speeds (see Appendix C) which includes wind speed predictions at various sites and various heights). Based on these estimates, it appears that Salliq has a low-to-moderate wind resource consistent with IEC Class III or IV.[151] Wind turbines models exist today which are optimized for performance at these lower wind speeds.

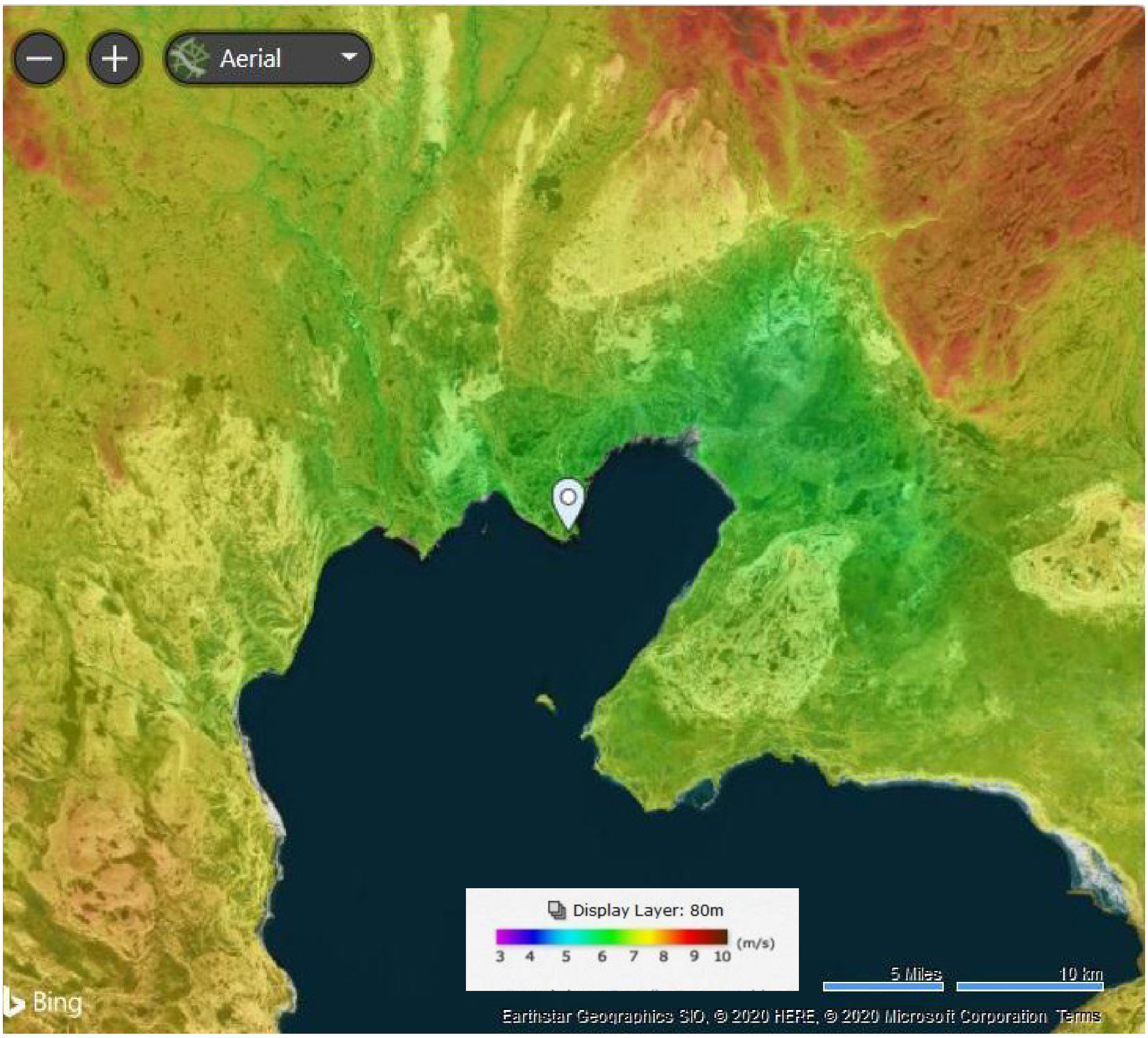

Figure 22: Predicted wind resource across southern Shugliaq Island, at 80m agl, from the AWS Dashboard online tool.

150 UL (2021). AWS Dashboard Online Tool: https://dashboards.awstruepower.com/

151 Wind classification is defined in IEC Standard 61400.

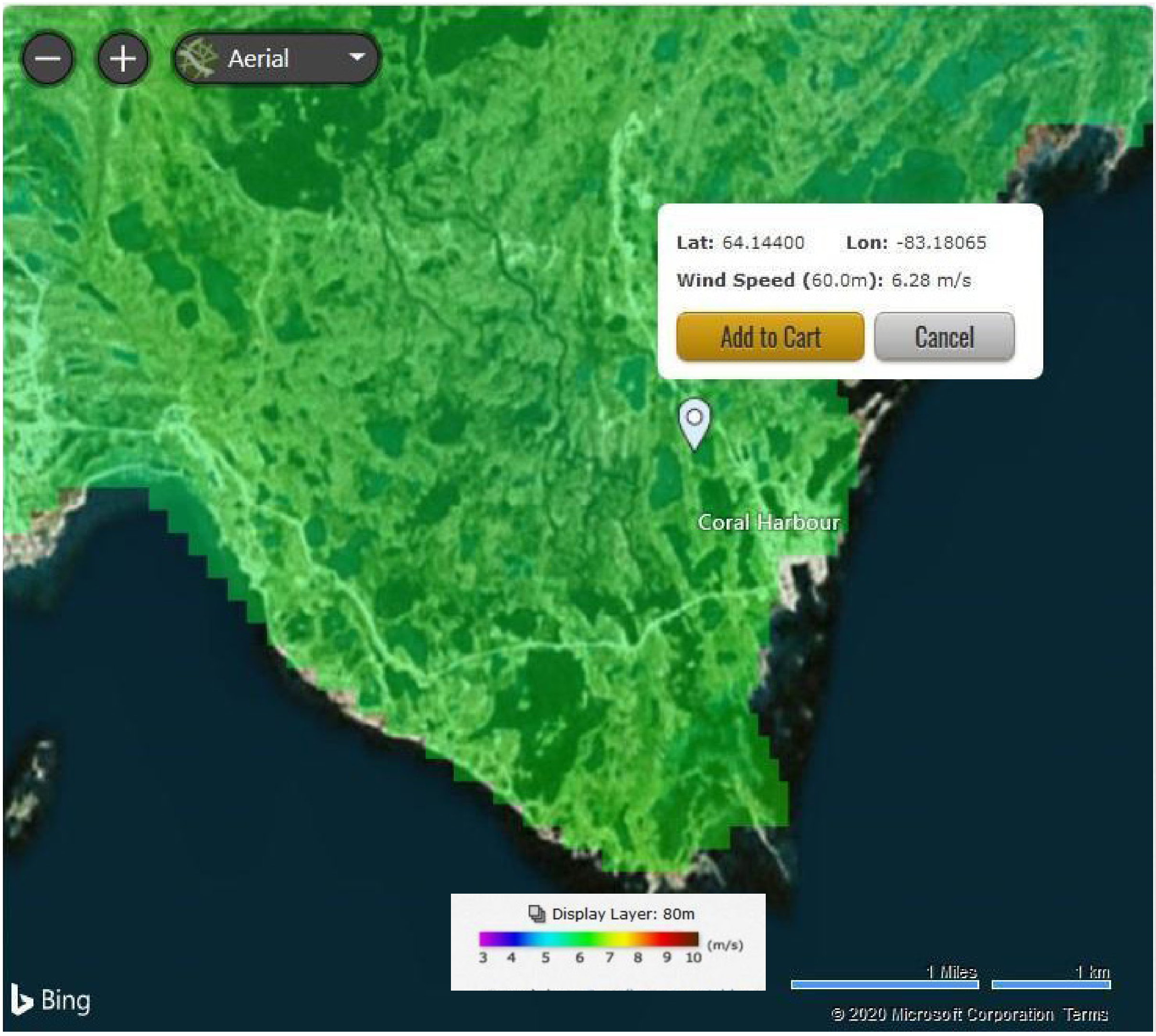

Figure 23: Predicted wind resource in the vicinity of Salliq, at 60m agl, from the AWS Dashboard online tool.

The AWS Dashboard provides additional statistics to help describe the predicted wind resource. Figure 24 illustrates the predicted monthly pattern of wind speeds, as well as a "wind rose" which shows which directions the incoming winds are expected to come from.

Unlike the solar resource, the wind resource is predicted to be fairly consistent throughout the year, with variations of only ~30% from winter to summer. A strength of wind energy in northern Canada is that it typically peaks in winter when a community's energy needs are highest, and this is the case in Salliq.

The wind rose in Figure 24 shows that winds are expected to come primarily from the North, Northwest, and Northeast, with little wind energy coming from the South. Winds are predominantly blowing from the land to the sea. This information can help to inform site selection and layout design for wind energy.

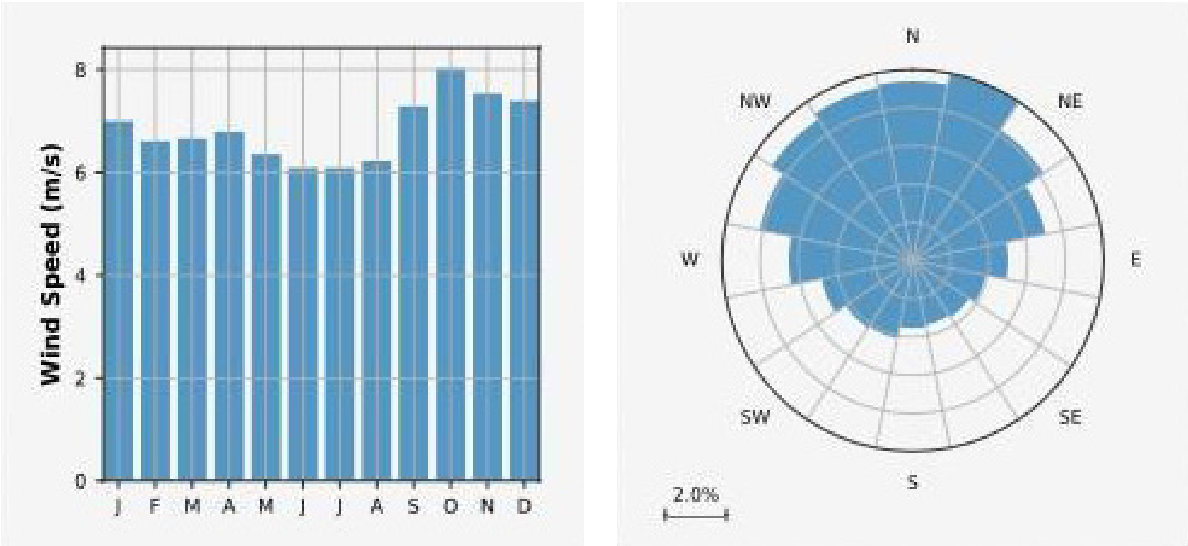

Figure 24: Monthly wind profile (left) and wind rose (right) from the AWS Dashboard online tool.

The wind resource will vary throughout the Salliq region according to the local terrain. Elevated areas (ridges, plateaus) will cause the incoming winds to accelerate as they pass by, resulting in higher wind speeds, whereas lower-lying areas will have less exposure to the winds. Similarly, areas with smooth terrain (e.g. tundra, water, gravel/grass) will have higher wind speeds, whereas "rougher" areas (e.g. buildings, vegetation, bluffs) will cause more turbulence and lower wind speeds. For this reason, the areas closer to the waterfront to the South of Salliq are predicted by AWS to have the best wind resource.

CANDIDATE TECHNOLOGIES

Previous analysis by WWF and ITP examined wind energy projects ranging in capacity from 100 kW to 2,300 kW, and concluded that a 200 kW wind energy project was expected to be nearly as affordable as solar PV in Salliq.[152] A project of this scale would represent a substantial step in the transition to clean energy. Such a project would also require an energy storage component (e.g. large battery) in order to ensure stability of the electrical grid. Energy storage is discussed in more detail in section 6.8

There are dozens of wind turbine models available globally that have a proven track record. However, only a small subset of these should be considered for implementation in a northern climate such as in Salliq. Wind turbines that perform well in cold climates are typically direct drive (no gearbox), include blade heating systems to combat icing, and are well engineered and ideally supported by the manufacturer during operations. A 2016 study entitled "Potential for Wind Energy in Nunavut Communities" concluded that only two manufacturers had a sufficiently proven record in the North: Enercon and Northern Power Systems; unfortunately Northern Power Systems is no longer in business.[153] Another study entitled "Rankin Inlet Energy Assessment Report" considered Enercon and EWT wind turbines, due to the track record of these manufacturers in northern and cold sites.[154]

152 WWF, ITP (2019).
153 Pinard, J. et al. (2016). Potential for Wind Energy in Nunavut Communities. https://www.qec.nu.ca/sites/default/files/potential_for_wind_energy_in_nunavut_communities_2016_report_0.pdf
154 Western Colorado University and Alaska Center for Energy and Power (2018). Rankin Inlet Energy Assessment Report.

In addition to Enercon and EWT, the authors recommend two additional wind turbine manufacturers worthy of consideration, including one that is pre-commercial at this time.

Therefore we can recommend the following list of potentially suitable wind turbine suppliers:

- Enercon: Enercon has installed over 26,300 wind turbines globally since its inception in 1984. Most turbines are large-scale, > 1MW. Considered to be the most robust of the major large-scale wind turbine manufacturers and best suited for northern climates. Industry leader in ice detection and anti-icing technologies. Enercon turbines are currently operating successfully in cold climates at the Diavik Mine in NWT and the Raglan Mine in northern Quebec.[155]

- EWT: EWT has installed more than 600 wind turbines since its inception in 2004. Most turbines are medium-scale, < 1 MW. EWT is currently commercializing its first anti-icing systems. EWT turbines are currently operating successfully in cold climates in Alaska and Northern Europe.[156]

- Xant: The innovation offered by Xant is a wind turbine model that can be tilted up without the need of a crane. Turbine components can also be transported in traditional shipping containers. This would offer a clear price advantage in remote communities. Xant is in the process of establishing a track record with its cold climate wind turbines, currently offered up to 95 kW.[157]

- Frontier Power Systems: A modern wind turbine designed in Canada for remote/northern communities. Frontier is currently installing its 100 kW turbines at 10 sites in Alaska, and has plans for expanded deployment in northern Canada in 2022.[158]

The Canadian Wind Energy Association (CanWEA) offers guidance on best practices for cold climate considerations.[159]

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155 Enercon. (no date). Enercon Wesbite. www.enercon.de
156 EWT. (no date). EWT Website. www.ewtdirectwind.com
157 Xant. (2021). Xant Website. https://xant.com
158 Frontier Power Systems. (no date). Frontier Website. https://frontierpowersystems.ca/products/
159 CanWEA 2017. Best Practices for Wind Farm Icing and Cold Climate Health and Safety. https://canwea.ca/wp-content/uploads/2017/12/canwea-best-practices-for-wind-farm-icing-and-cold-climate-health-and-safety.pdf

CANDIDATE SITES

Five potential wind energy sites were identified by the CEP Team, as depicted in Figure 25. The ideal wind energy site in Salliq should be close to the QEC powerplant, sufficiently far from residents, and accessible by existing roads. Note that wind site #1 is less than 500m from residents, and should only be considered for a smaller wind turbine model (e.g. Xant). Sites closer to the ocean are expected to have a slightly stronger wind resource.

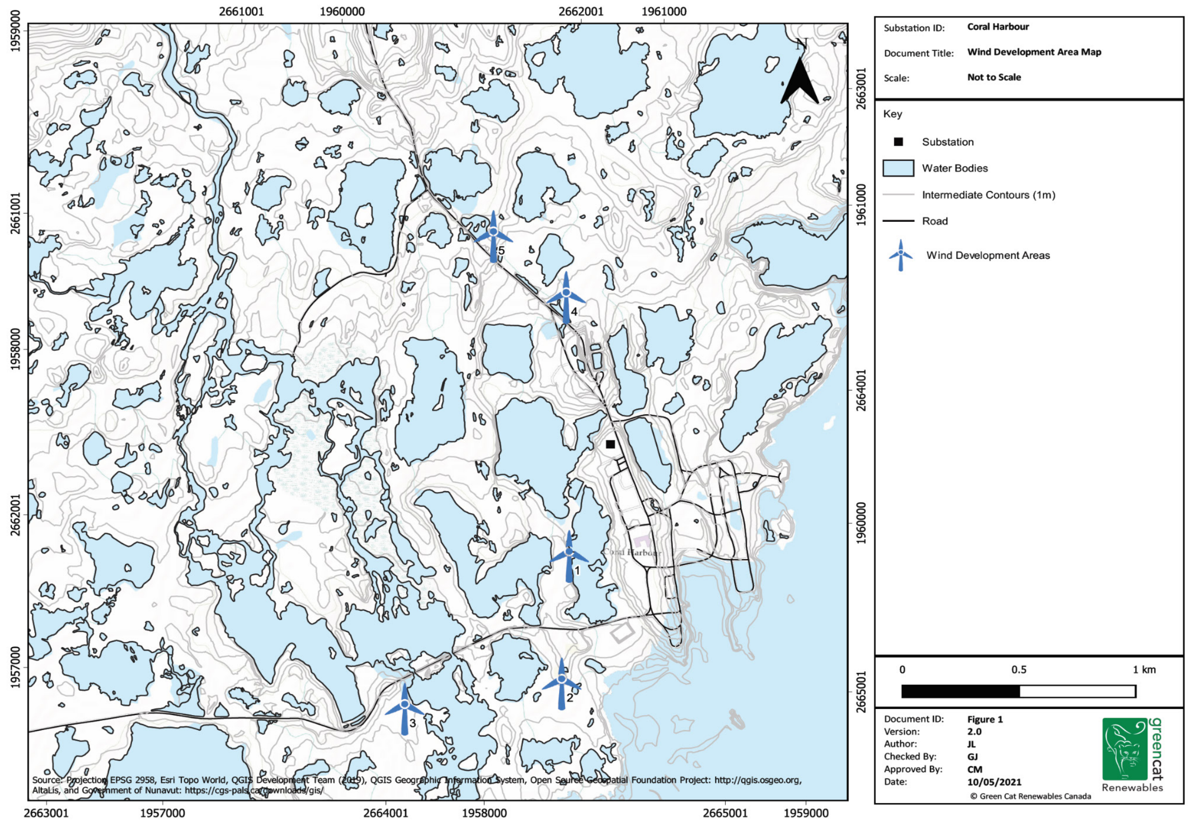

Figure 25: Candidate wind energy sites in Salliq.

This map has been used in conversations with Mayor and Council.

The CEP Team has also conducted a site visit to leading candidate wind sites in order to collect information related to project feasibility. Select photos are depicted in the Figures 26-28 below.

Site #1 was not visited.

Site #2 was rejected due to the presence of grave sites. All candidate sites may also host breeding and/or migratory birds. No environmental or cultural factors have been identified to date which should affect wind turbine siting. Community consultation should continue in order to reveal any other factors that should affect the choice of wind energy site.

The CEP Team has also learned that the Hamlet has expressed a desire for clean energy projects to be located close to the airport. Final site selection wlll be conducted in consultation with the Hamlet to ensure an appropriate site is selected.


Figure 26: Wind candidate site #3.


Figure 27: Wind candidate site #4.


Figure 28: Wind candidate site #5.

SHORTLISTED PROJECTS

Site #3 has been identified by the CEP Team as the leading candidate wind energy site. The site is centred at 64°7′46.39″N x 83°11′18.16″W. The site is:

- Exposed to good wind speeds near the shoreline,
- Approximately 1,000m from the nearest residences,
- Approximately 120m from the nearest roads,
- Approximately 900m from the QEC diesel powerplant, and
- Approximately 10km from the airport.

Figure 29 illustrates this candidate site in the context of local features. Ground conditions have not yet been inspected by the CEP Team.

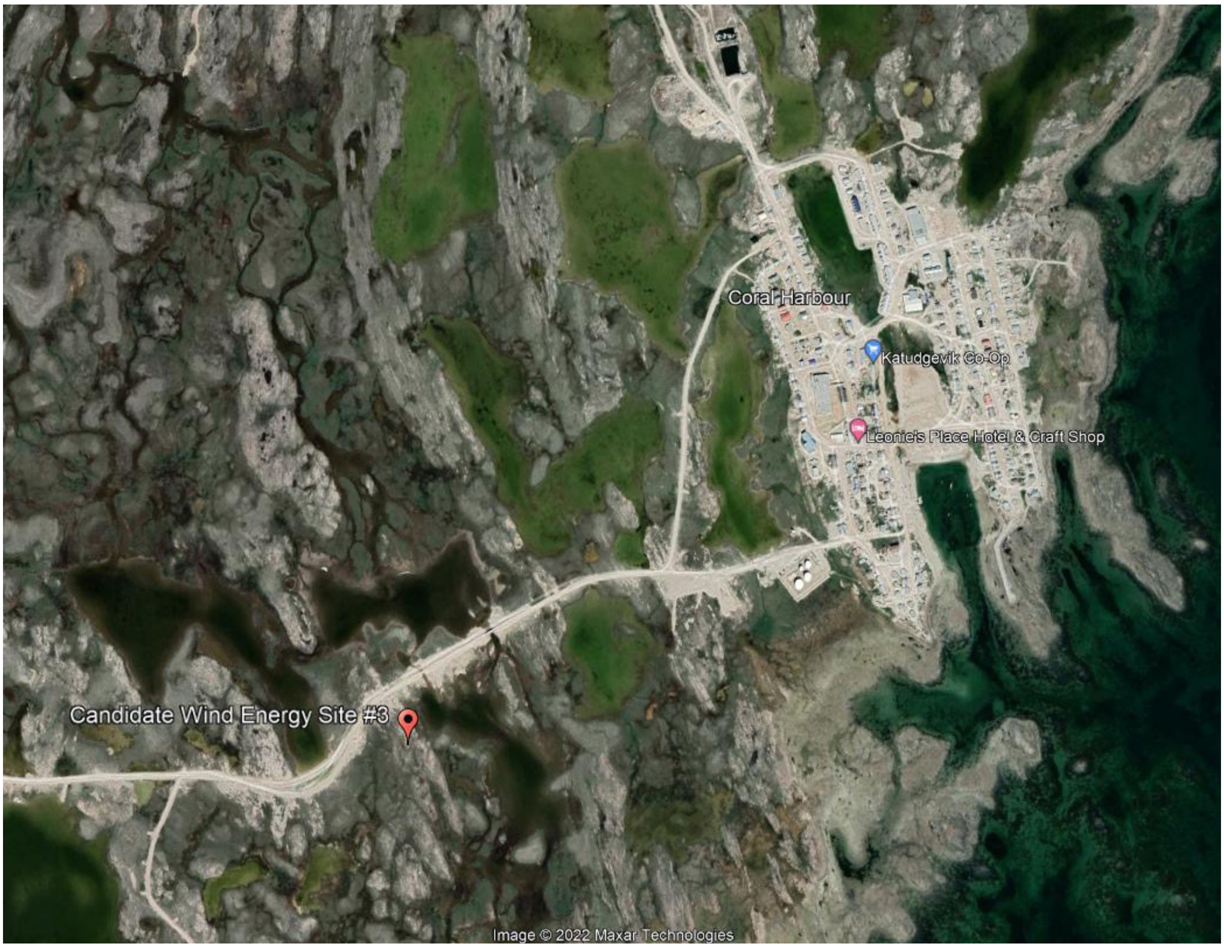

Figure 29: Map of leading candidate wind energy site to the Southwest of Salliq.

The CEP Team has identified two case studies for analysis:[160]

285 KW WIND FARM:

- 3 x Xant M26 wind turbines with 95 kW capacity each.
- Rotor diameter of 24m.
- Hub height of 23m (tallest tilt-up option).
- Estimated wind speed of 5.7 m/s at 23m agl.
- Estimated gross energy production of 275 MWh /yr /turbine, or 825 MWh /yr for the project.
- Estimated net energy production of 660 MWh /yr for the project assuming 20% losses.

1 MW WIND FARM, INITIALLY DE-RATED TO 500 KW:

- In order to ensure stability of the electrical grid, the project would begin operations at 500 kW. If in future the grid can integrate more renewables (e.g. more storage or smart loads come online) then this capacity ceiling could be raised.
- 1 x EWT DW61 wind turbine with 1.0 MW capacity, initially restricted to 500 kW maximum output.
- Rotor diameter of 61m.
- Hub height of 46m (requires a crane to install).
- Estimated wind speed of 6.33 m/s at 46m agl.
- Estimated gross energy production of 1,985 MWh /yr
(or 2,710 MWh at full output).
- Estimated net energy production of 1,588 MWh /yr assuming 20% losses
(or 2,168 MWh at full output).

160 The CEP Team has received proposals directly from both EWT and Xant to inform this analysis. Logistics advice was also provided by Arctic Buying Co.

FINANCIAL ANALYSIS

285KW WIND ENERGY PROJECT:

We offer the following high-level financial analysis of this proposed solution. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

Project:	285 kW wind energy project with battery storage
Technology:	3x Xant M26 wind turbines with nameplate capacity of 95-kW each, or 285-kW total 1x Tesla PowerPack2 2hr battery 200-kWh storage capacity [161]
Capital cost:	$4.73 million Estimate including development costs [162]
Annual operating cost:	$160,000 Including a reserve account to fund replacement of inverters and batteries after approx. 20 years.
Annual electricity prod	660 MWh/yr after 20% losses
Annual revenues:	$165,000 at QEC's proposed $0.25 /kWh CIPP rate
Project lifetime:	20 years+ Batteries may need replacement after approx. 20 years.
Financial payback: Return on investment:	Project revenues should be sufficient to cover operating costs. However, financial performance of this project would not support repayment of a capital investment.

TABLE 9: Financial analysis for 285 kW wind energy project in Salliq.

This project would require grant funding in order to be viable at the assumed QEC electricity price of $0.25 /kWh.

One scenario is for the project to seek grant funding to cover the entire capital costs, estimated at $4.68 million. Subject to more refined study, we suspect that operational revenues would be sufficient to cover operating costs.

If QEC were to pay more for electricity in future (e.g. the true cost of diesel-fueled electricity), then revenues might exceed operating costs. In this event, partial grant funding might allow the project to proceed under an IPP model. The IPP would receive grant funding, finance the remainder of capital costs through private equity and/or debt, and then use revenues to pay a return on this investment throughout the project's operational life.

500KW - 1MW WIND ENERGY PROJECT:

161 *Informed by WWF, ITP (2019).*
162 *Cost assumptions for the Tesla powerpack battery system are adopted from ITP (2019).*

We offer the following high-level financial analysis of this proposed solution. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

Note also that we assume that 5% of the energy generated by this larger project must be "spilled" (i.e. wasted) in order to maintain stability of the electrical grid. This is consistent with the CEP Team's preliminary grid integration studies for a wind project of this scale.

Project:	500 kW wind energy project with battery storage (with potential to ramp up to 1 MW in future)
Technology:	1x EWT DW-61 wind turbine with nameplate capacity of 1.0-MW, initially de-rated to 500-kW 3x Tesla PowerPack2 2hr battery with combined 600-kWh storage capacity [163]
Capital cost:	$9.73 Million Estimate including development costs [164]
Annual operating cost:	$279,000 Including a reserve account to fund replacement of inverters and batteries after approx. 20 years.
Annual electricity production:	De-rated to 500-kW: 1,588 MWh/yr after 20% estimated losses assume another 5% is "spilled" to maintain grid stability = 1,509 MWh /yr At full 1MW capacity: 2,168 MWh/yr after 20% estimated losses assume another 5% is "spilled" to maintain grid stability = 2,060 MWh /yr
Annual revenues:	De-rated to 500-kW: $377,000 at QEC's proposed $0.25 /kWh IPP rate At full 1MW capacity: $515,000 at QEC's proposed $0.25 /kWh IPP rate
Project lifetime:	25 years+ Batteries may need replacement after approx. 20 years.
Financial payback: Return on investment:	Project revenues are modeled to be in excess of operating costs. However, financial performance of this project would not support repayment of a capital investment.

TABLE 10: Financial analysis for 500 kW to 1.0 MW wind energy project in Salliq.

This project would require grant funding in order to be viable at the assumed QEC electricity price of $0.25 /kWh.

One scenario is for the project to seek grant funding to cover the entire capital costs, estimated at $9.73 million. Subject to more refined study, we suspect that operational revenues would be

163 Informed by WWF-ITP (2019).
164 Cost assumptions for the Tesla powerpack battery system are adopted from ITP (2019).

sufficient to cover project costs, including a healthy contingency allowance. Because EWT wind turbine require a crane to perform some major repairs, it is good to retain some cash flow within the operating company to manage any such maintenance needs.

If QEC were to pay more for electricity in future (e.g. the true cost of diesel-fueled electricity), then revenues might exceed operating costs by a sufficient margin. In this event, partial grant funding might allow the project to proceed under an IPP model. The IPP would receive grant funding, finance the remainder of capital costs through private equity and/or debt, and then use revenues to pay a return on this investment throughout the project's operational life.

This larger project has the advantage that its output can be increased in future if the electrical grid grows to accommodate more variable clean energy. Modifying the output limit on an EWT wind turbine can be done easily once it is already operational, with little cost.[165] However, increasing the wind energy capacity beyond 500 kW would likely require increased battery storage, a detailed control strategy with QEC, and perhaps more spilled energy as well.

GHG ANALYSIS

If all of the wind energy produced in Salliq resulted in displacement of diesel fuel, then the projects under consideration are estimated to result in diesel and GHGs savings as follows.

285 KW WIND FARM:

- 178,800 L /yr avoided diesel,
- 490 Tonnes CO_2e /yr avoided GHGs.

500 KW WIND FARM:

- 408,000 L /yr avoided diesel,
- 1,122 Tonnes CO_2e /yr avoided GHGs.

In practice, QEC may need to keep some diesel generators running on standby while clean energy systems are running (as a backup) and so GHG savings may be lower than stated above. This will depend on the choice of battery system, as well as the chosen grid control strategy by QEC. Further clarity on GHG reductions should arise from continued development and study work.

JOBS ANALYSIS

The CEP Team has reviewed job creation statistics from various other wind energy projects across Canada. We predict the following job creation numbers for the wind energy projects under consideration for Salliq:

285 KW WIND FARM:

- 30 jobs during construction (1-2 years)
- 2 jobs during operations (20-25 years)

165 *pers. comm. with EWT.*

500 KW - 1.0 MW WIND FARM:

- 40 jobs during construction (1-2 years)
- 3 jobs during operations (20-25 years)

During construction a portion of the labour can be sourced from local people, with specialized labour and equipment coming from outside of Nunavut . During operations, local people can be trained for regular maintenance and monitoring work, with support for major maintenance activities coming from southern Canada. Early planning can help to maximize local hiring opportunities, but the CEP Team anticipates that some specialized labour would also need to be flown in.

RISK ASSESSMENT

The following risks should be considered when pursuing a wind energy project in Salliq:

- **Wind resource:** If a wind project is implemented based only on computer modeling, then a moderate degree of uncertainty should be ascribed to the wind resource, as the project may produce less (or more) energy than predicted. This risk can be addressed by installing a meteorological tower at the chosen site, however this is an expensive undertaking.
- **Ground conditions:** Foundation costs are sensitive to geotechnical conditions. These should be studied in more detail at the chosen site to ensure an efficient foundation design. The effects of permafrost should be considered during detailed design.
- **Public support:** Survey respondents in Salliq indicated strong support for wind energy in the community. Expanded and focused community engagement should be conducted during project development.
- **Technology selection:** As discussed in the candiate technologies section for wind energy assessment above, only a handful of wind turbine vendors produce machines that are considered suitable for northern climates. A wind project in Salliq should employ a wind turbine model that is suited to cold conditions, ideally with no gearbox, and that can operate throughout most of the year without external support.
- **Operational support:** This project should employ a wind turbine from a vendor that will offer ongoing support. This means training a local person to handle most day-to-day wind turbine issues, as well as flying technicians to site when needed to remedy technical issues. Some suppliers will guarantee that a wind turbine will remain operational for a minimum number of hours in a year. Wind turbine vendors should also be asked to place technical information in "escrow" so that they can be accessed in the event of insolvency of the company during the project lifetime.
- **Icing losses:** Even the most suitable turbines, with blade heating, will experience energy losses and downtime due to ice buildup at the most extreme times. These losses should be estimated in financial modeling. The CEP Team does not have site specific icing data for Salliq, however data collected from Rankin Inlet suggests a moderate degree of icing. At present the CEP Team recommends total losses of 20%, inclusive of icing losses.

- **Logistics:** A wind energy project will involve heavy equipment transport and logistics including wind turbine components and potentially a crane. Many aspects of this logistical effort will involve costs, which the CEP Team has been studying. For a smaller wind turbine (e.g. Xant) components will be shipped in sea cans, which are handled regularly in Salliq. For a larger wind turbine (e.g. EWT) this will require identifying innovative means of offloading barges, as Salliq has no facilities for offloading a deep water ship. Logistics planning should be informed by existing wind energy projects in NWT, northern Quebec, and Alaska. Figures 30-32 below illustrate logistics solutions implemented by EWT at recent projects in Alaska. Solutions involved hoisting tower sections and blades from a barge onto shore using a mobile crane mounted on the beach at the shoreline. Other components were transported by barge with a ramp to allow trucks to roll directly onto the beach. Reinforcements were made to the road and ramp on the beach to accommodate heavy loads.

Figure 30: EWT tower sections being lifted from barge to beach using a mobile crane.

Figure 31: EWT blades being lifted from barge to beach using a mobile crane. Sets of three blades are held in a custom-made cradle for safe transport.

Figure 32: EWT turbine components being transported from barge to beach using a temporary ramp.

RECOMMENDATION

The CEP Team has studied two wind energy cases, at 285 kW and 500 kW. Either one would represent a substantial step for Salliq's transition away from diesel fueled electricity.

Wind energy (winter peaking) could also be combined with solar PV energy (summer peaking) and battery storage to form the foundation of a new clean energy based microgrid, backed up by the existing diesel generators.

The CEP Team is currently undertaking a more detailed technical study to determine the optimal mix of wind vs. solar energy in Salliq. Recommended steps for developing a wind energy project in Salliq are provided in section 8.7.

6.4. BIOMASS ENERGY ASSESSMENT

There are no forests in the vicinity of Salliq, and therefore no opportunities to sustainably harvest large amounts of biomass locally. However, the notion of shipping biomass to the community is worth considering.

Biomass can be used to generate heat, electricity, or both. However, the most logical application in Salliq would be for heat. Biomass heating systems can provide space heating as well as hot water.

Renewable heat projects are currently delivering more energy across northern Canada than renewable electricity projects.[166] There are six documented projects in Nunavut, six in the Yukon, and 53 in the Northwest Territories, accounting for 20% of the total heat demand in northern Canada. Communities with prominent biomass heating projects include:

- Northern Lights College Dawson Creek, BC
- Tetlit Gwich'in District Heat. Fort Mac Pherson, NT
- Whitehorse Correctional Centre, YT
- Dawson Infrastructure Heating Project, YT
- Chief T'Selehye School, Fort Good Hope, NT

No survey respondents in Salliq reported using wood for heating at home.

FUEL SOURCE

Forms of biomass include the following:

- **Wood chips:** these are often a byproduct of the forestry industry and can come in various sizes, wood types, and moisture levels,
- **Wood pellets:** these are manufactured to a precise specification in an industrial process, and shipped globally as a commodity,
- **Agricultural waste:** such as animal manure and plant waste,
- **Bio-gas:** which can be harvested from the breakdown of biological materials, or
- **Liquid bio-fuels:** such as alcohol, waste vegetable oil, or bio-diesel.

The most suitable form of biomass for Salliq is likely manufactured wood pellets. These are energy dense, they are light as the moisture has been removed, they are consistent in quality (easy on the machinery), and they can be purchased from various Canadian suppliers. Several suppliers also offer wood pellets that are certified to come from sustainable sources.

166 Lovekin D. et al. (2020). Diesel Reduction Progress in Remote Communities. Pembina Institute. https://www.pembina.org/pub/diesel-reduction-progress-remote-communities

BIOMASS TECHNOLOGY

The components of a typical biomass heating system include:

- A boiler where biomass fuel is burned to produce hot air and/or hot water,
- Small storage bin adjacent to the boiler to store small volumes of biomass fuel,
- Larger storage bin to store large volumes of biomass fuel to replenish the small bin,
- Feed system to automatically inject fuel from the small storage bin into the boiler,
- Pipes, valves, electrical wiring, and connections between the boiler and the hot air and/or hot water systems in a building, or in multiple buildings,
- Foundations and trenching for the new structures and connections,
- Exhaust system to vent exhaust into the atmosphere,
- Ash depository where ash can be periodically cleaned from the boiler.

A small biomass system can be sized for a single home, or a larger system can even feed multiple buildings from a single boiler unit. Larger systems are typically more affordable. However, the cold winter conditions in Salliq may make it unfeasible to transport heat over long distances.

CANDIDATE SITES

Based on available data from CGS, there are several buildings in Salliq that consume large amounts of heating oil each year, and could therefore be good candidates for biomass heating. These are listed in Table 11 below. No data was available on hamlet-operated buildings at the time of writing.

Building	Litres of heating oil consumed /yr	Heating oil cost $/yr
Sakku School (renovations underway)	97,000 L/yr (prior to renovations)	$101,000 /yr (prior to renovations)
10-plex residence (there is one in town)	24,000 L/yr	$25,000 /yr
5-plex residences (there are six in town)	15,000 - 20,000 L/yr	$16,000 - 21,000 /yr
Health Center	20,000 L/yr	$21,000 /yr
Trade Shop	15,000 L/yr	$16,000 /yr
Human Rights Tribunal Office	3,500 L/yr	$3,600 /yr

TABLE 11: Heating oil consumption at large-scale buildings in Salliq.

The Sakku School is the largest consumer of heating oil by far. This building has been in need of repair for some time, and the hamlet has documented concerns related to mold, ventilation, structural issues, pedestrian traffic flow, fire safety, and overcrowding at the school. As a place for children, air quality and safety issues are of critical importance. Fortunately this building is currently undergoing renovation at the time of writing. The expected energy efficiency of the school after renovations is not known.

Salliq also contains nine other buildings that each consume heating oil in the range of 15,000 - 24,000 L/yr, and which could be targeted for renewable heat projects.

While this CEP will focus on larger applications, wood pellets can also be used by individual families. AEA has developed a useful guidance document for such families.[167]

SHORTLISTED PROJECT

The CEP Team has chosen a project for analysis based on the common case of 15,000 - 24,000 L/yr of heating oil consumption. If such a project can be successful in Salliq, then it could be replicated at each of the nine buildings of this scale.

The project under consideration would involve the installation of a new biomass heating system adjacent to one of these buildings. This system would provide hot air and hot water to the building. The existing oil burner could be decommissioned, or perhaps left in place as a backup source.

Wood pellets would be transported to the community once per year to provide sufficient fuel. This building would require approximately 37 tonnes of dry wood pellets each year, which would be transported in four 10' sea cans and stored adjacent to the target building. A 10' sea can full of dry wood pellets would weigh approximately 11 tonnes, approaching the weight limit for barge transportation to Salliq.[168]

Capital costs for this project would include a second set of four sea cans to allow for shipping of new pellets during the short barging season. Each barging season, empty sea cans in Salliq would be replaced with sea cans full of wood pellets. Sea cans may need to be modified to ensure compatibility with the boiler system.

Wood pellets need to be kept dry year-round, as humidity can spoil the fuel. Today, other northern communities are using and storing wood pellets.[169] However, most of these communities are served by road[170], and the CEP Team is unclear whether any of these communities are storing an entire year's supply of pellets at a time. Road accessible communities may refresh their supply throughout the winter. Therefore we perceive some risk associated with the winter-long storage of wood pellets, with regard to humidity. We understand that humidity during ocean transport is also a concern.

Provided that dry storage can be achieved, operating costs would be slightly higher than existing heating systems. Biomass boilers require slightly more regular maintenance, including removing ash and clearing occasional jams.

The GN currently offers a subsidy for replacement of heating oil tanks[171], however the CEP Team is not aware of a similar subsidy for biomass infrastructure.

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167 AEA (2012). Residential Wood Pellet Heating A Practical Guide for Homeowners. https://aea.nt.ca/document/3121/

168 pers. comm. Tara Tootoo Fotheringham of Arctic Buying Co.

169 pers. comm. John Carr of AEA.

170 AEA (2009). NWT Community Wood Pellet Study: Supply and Transport Options for Wood Pellets.

171 Nunavut Housing Corporation (2014). Heating Oil Tank Replacement Program. http://www.nunavuthousing.ca/docs/hotrp-guidelines.pdf

FINANCIAL ANALYSIS

We offer the following high-level financial analysis for this project. Note that all financial analyses in this CEP, including cost and revenue estimates, are preliminary and should be refined in future through continued development work, study, and consultation.

Project:	50-kW biomass heating system
Nameplate capacity:	50-kW of space heating and hot water
Heat production:	190 MWh /yr (assuming 90% efficiency)
Avoided heating oil:	20,000 L/yr $21,000 /yr (assume 85% efficiency)
Capital cost:	$400,000 (rough approximation)
Annual operating cost:	$7,800 wood pellets supply $16,500 barge transportation $5,000 other operating costs = $29,300
Project lifetime:	20+ years
Financial payback: Return on investment:	This project is not financially viable without grant funding, as the revenues (avoided heating oil) are lower than the estimated operating costs.

TABLE 12: Financial analysis for biomass heating in Salliq.

Capital costs for this analysis are considered very approximate, and have been estimated using contractor proposals in southern Canada and adjusted for northern transportation and installation. Wood pellet prices are based on purchase in southern Canada, and barge transportation costs were informed by Arctic Buying Co. The estimate of "other operating costs" is also very preliminary, and could be refined in conversation with contractors.

Note that the proposed fuel costs ($24,300) are not too far above the current fuel costs ($21,000). Therefore, <u>if grant funding could be accessed to pay for the capital cost of a new biomass furnace and storage solution, then this project could potentially be operated within existing budget constraints</u>.

Heating with biomass can bring additional benefits that are not captured in the narrow analysis above. Biomass fuel is not toxic, in comparison with heating oil which is notorious for toxic spills, resulting in pollution of soils, water, and air for local residents. Survey respondents in Salliq generally indicated strong support for "clean fuels with low environmental impacts". It is unknown what financial burden is caused by fuel spills in Salliq, however we understand that both QEC and the GN Department of Environment regularly experience costs related to fuel spill remediation. A second benefit associated with biomass heating is the potential for forestry jobs; however, in the case of Salliq, these jobs would be in southern Canada where the wood is harvested.

GHG ANALYSIS

The carbon intensity of biomass heating is approximately 0.007 tonnes CO_2e/MWh[172], whereas burning heating oil has a carbon intensity of approximately 0.269 tonnes CO_2e/MWh. Replacing 20,000 L of heating oil with biomass heat would produce a GHG savings of approximately 50 tonnes CO_2e/yr. Additional GHG emissions would be associated with transportation of the wood pellets to Salliq, which has not been captured in the above analysis.

The burning of biomass in the community would also result in local air pollution, including particulates. This is likely not a large concern at small scales, and this could partly be offset by reduced burning of diesel. However this should be considered carefully if Salliq intends to burn large amounts of biomass in close proximity to buildings.

JOBS ANALYSIS

This project would produce minimal employment opportunities. Existing maintenance staff in Salliq would need to be trained in how to operate and maintain the biomass system, with technical support from the South.

RISK ASSESSMENT

The following risks should be considered when pursuing a biomass heat project in Salliq:

- **Dry transportation and storage:** As noted further above, the CEP Team perceives some risk associated with the ocean transportation and storage of wood pellets in a sea can in Salliq without the ingress of humidity. If other satisfactory examples cannot be identified from other communities, then an effort may be required in Salliq to determine whether or not humidity is a problem.
- **Fuel supply:** Before investing in new equipment, the project should have an agreement with a reputable supplier of sustainably harvested wood pellets for the next 20 years, in addition to a back-up plan in case the contracted supplier becomes unavailable.
- **Technology selection:** The selected biomass heating system should be designed to operate at cold temperatures, and should come with a strong warranty from the manufacturer.
- **Operational support:** An installer should be selected that will offer ongoing technical support during operations. Local people should be trained in operations at the time of commissioning. Spare parts should be kept in the community to cover the most common replacement needs.
- **Logistics:** Transport of all equipment for this project would need to be arranged by barge. A biomass heating system, as well as the wood pellets needed each year, can all be transported in sea cans.

172 Assuming that biomass is harvested sustainably.

RECOMMENDATION

Biomass heating could have benefits in Salliq including reduced diesel consumption, reduced fuel spills, and reduced GHG emissions. Biomass is likely to cost a bit more than diesel fuel, however this cost difference may disappear at large scales.

Due to the perceived risk associated with dry transport and winter-long storage of wood pellets in Salliq, the CEP Team recommends a demonstration project of medium scale to prove the feasibility of biomass for heating in Salliq. As this project would achieve reductions in heating oil consumption, it would be a good candidate for federal funding.

Aspirations for larger scale biomass in Salliq should wait until a demonstration project is operating.

6.5. RIVER ENERGY ASSESSMENT

The CEP Team has concluded that river energy is unlikely to be cost-competitive in Salliq compared to other available clean energy technologies. An explanation of this reasoning will follow.

Run-of-river hydro-electric systems harvest energy from flowing water as it runs downstream. Unlike large-scale hydro-electric dams which typically create a large reservoir, run-of-river systems only generate electricity when the water is flowing. They are considered to have lower environmental impacts compared to large-scale projects because they don't flood land to create a new reservoir.

Run-of-river hydro projects typically have the following components:

- a weir (a type of very small dam) which creates a small headpond where some water is diverted from the river into the penstock,
- a penstock is a long pipe that carries water downhill to the powerhouse,
- a powerhouse where this water forces a generator to turn, creating electricity,
- a tailrace where the water is returned to the river, and
- a transmission line to carry the electricity to the user or grid.

For streams that host fish, or which serve as navigation routes for watercraft, it is important to leave enough water in the stream. Therefore only a portion is typically diverted into the penstock and powerhouse. Run-of-river hydro projects can come in any size, from several kW to over 100 MW, however most are between 25-kW and 25 MW.

Run-of-river hydro projects have been installed throughout Canada, including some projects in the Yukon (40 MW), Northwest Territories (ranging from 4 - 10 MW), and in Nunavik in Quebec (up to 4 MW). See the map of hydro projects in Figure 33. While some of these are at similar latitudes to Salliq, no hydro-electric projects have yet been installed in Nunavut.

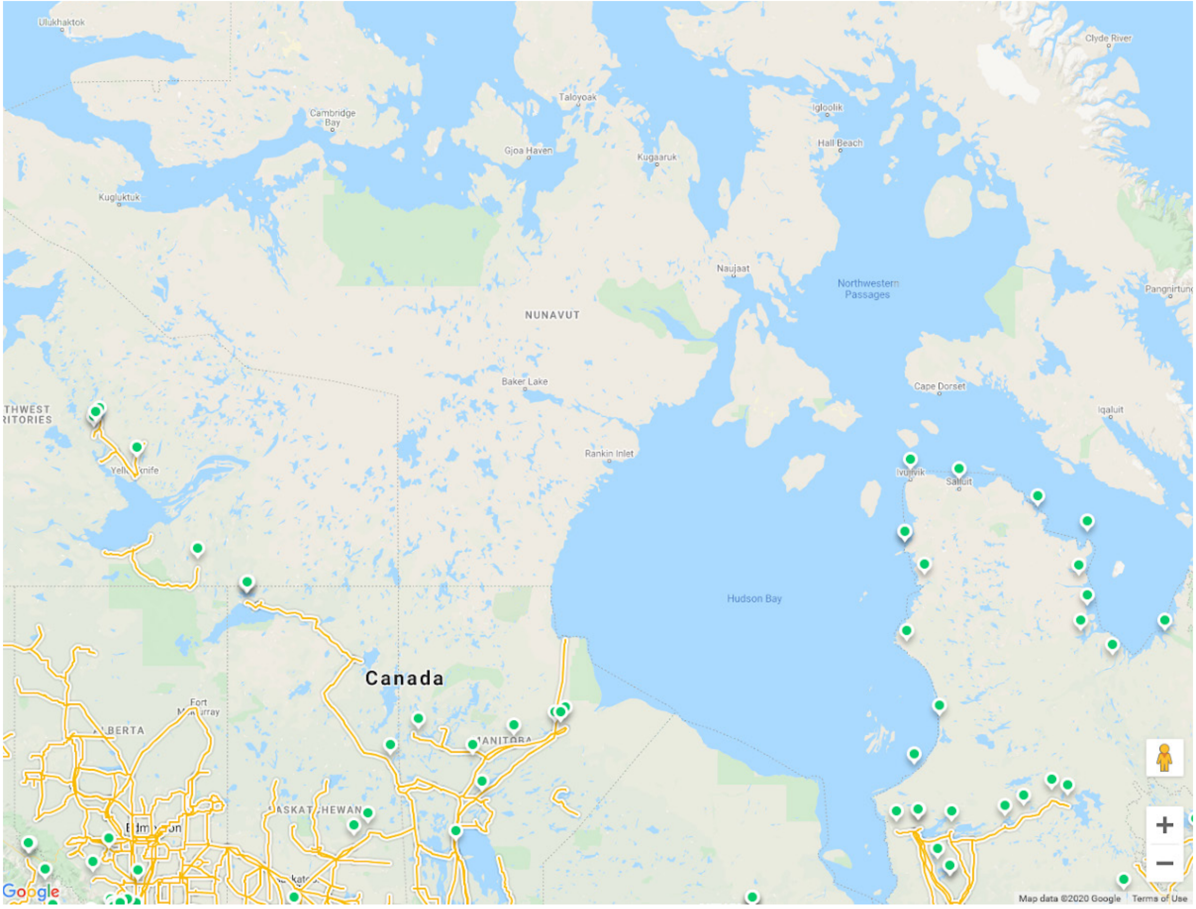


Figure 33: Map of existing hydro-electric generating stations in north/central Canada.[173]

A second technology can be considered alongside run-of-river hydro, and that is "river hydro-kinetic" technology. River hydro-kinetic systems involve placing a turbine directly into the river, which is forced to turn by the passing water. These systems can function with very low stream flow (>1 m^3/s) and the turbines can be removed during the freezing season to preserve the equipment. Hydro-kinetic turbines are often several meters wide and require several meters of stream depth to function.

A hydro-kinetic energy system is currently operating on a river on the Kvichak River near Igiugig, Alaska and providing power to the community.[174] This river flows year-round, however ice flows in the river in spring. Similar systems are also being tested at the Canadian Hydrokinetic Turbine Test Centre on the Winnipeg River in Manitoba.[175] Other northern communities may benefit from the lessons learned with these pilot projects.

173 Adapted from: Canadian Geographic (2016). Canadian Hydropower Interactive Map. https://hydro.canadiangeographic.ca/

174 News article entitled "Alaska village to test river-generated hydropower next winter". https://www.ktoo.org/2019/01/23/alaska-village-to-test-river-generated-hydropower-next-winter/

175 Canadian Hydrokinetic Turbine Test Centre website. http://www.chttc.ca/

SITE SELECTION CRITERIA

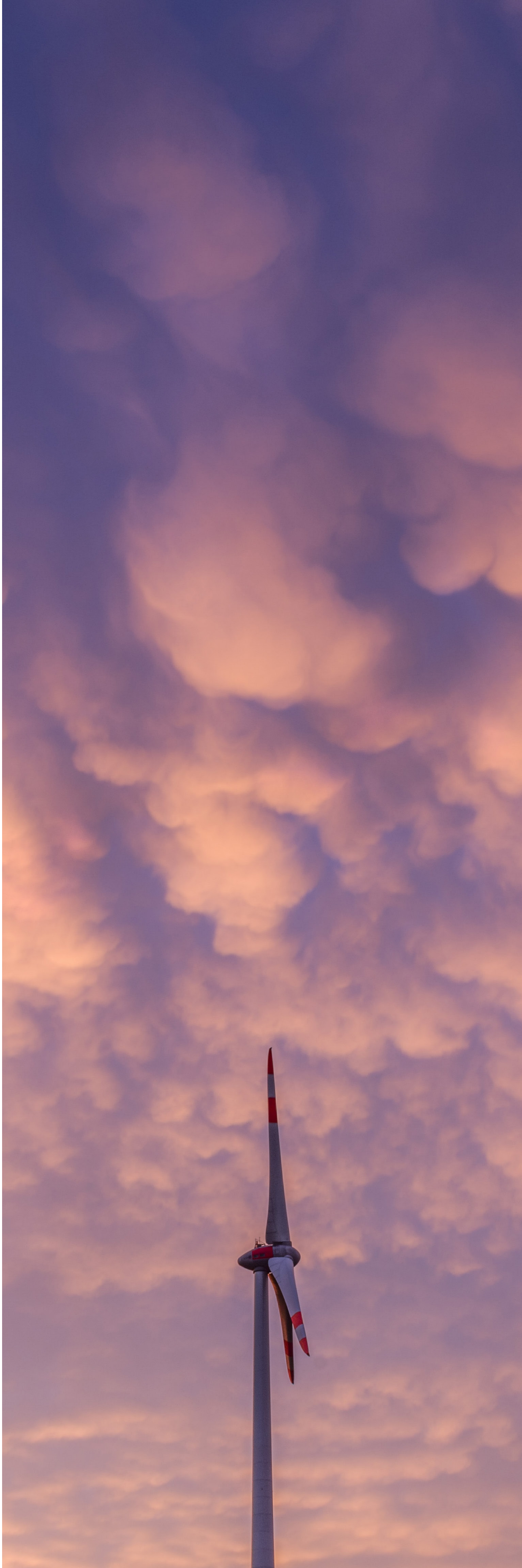
The following factors should be considered when selecting a site for a run-of-river energy project.

- **Stream flow:** This is typically measured by the average stream flow throughout the year. This can be estimated based on hydrology mapping, and it can also be measured directly in a stream.
- **Elevation drop:** The best run-of-river hydro projects are installed in a section of the river where the elevation drops steeply over a short distance.
- **Road access:** Heavy components need to be transported to site during construction.
- **Interconnection cost:** A site that lies closer to a suitable interconnection point on the electrical grid will be cheapest.
- **Environmental impacts:** Rivers that host fish, or that are used by watercraft, will be more vulnerable to environmental impacts. Likewise the areas needed for the powerhouse, penstock, access roads, and transmission line also need to be considered for environmental sensitivity.

Note that the same criteria apply for river hydro-kinetic systems, except that a vertical elevation drop is not required. Rivers with water velocity faster than 1m/s, with a minimum of 2m depth, could be suitable for hydrokinetic systems.

CANDIDATE SITES

The CEP Team noted three mapped streams in the vicinity of Salliq that are worthy of consideration. On the Canadian Energy Atlas these are named Kirchoffer River (13km to the West of Salliq), Post River (1km to the West) and Ford River (10km to the East). These are depicted in the map in Figure 34.



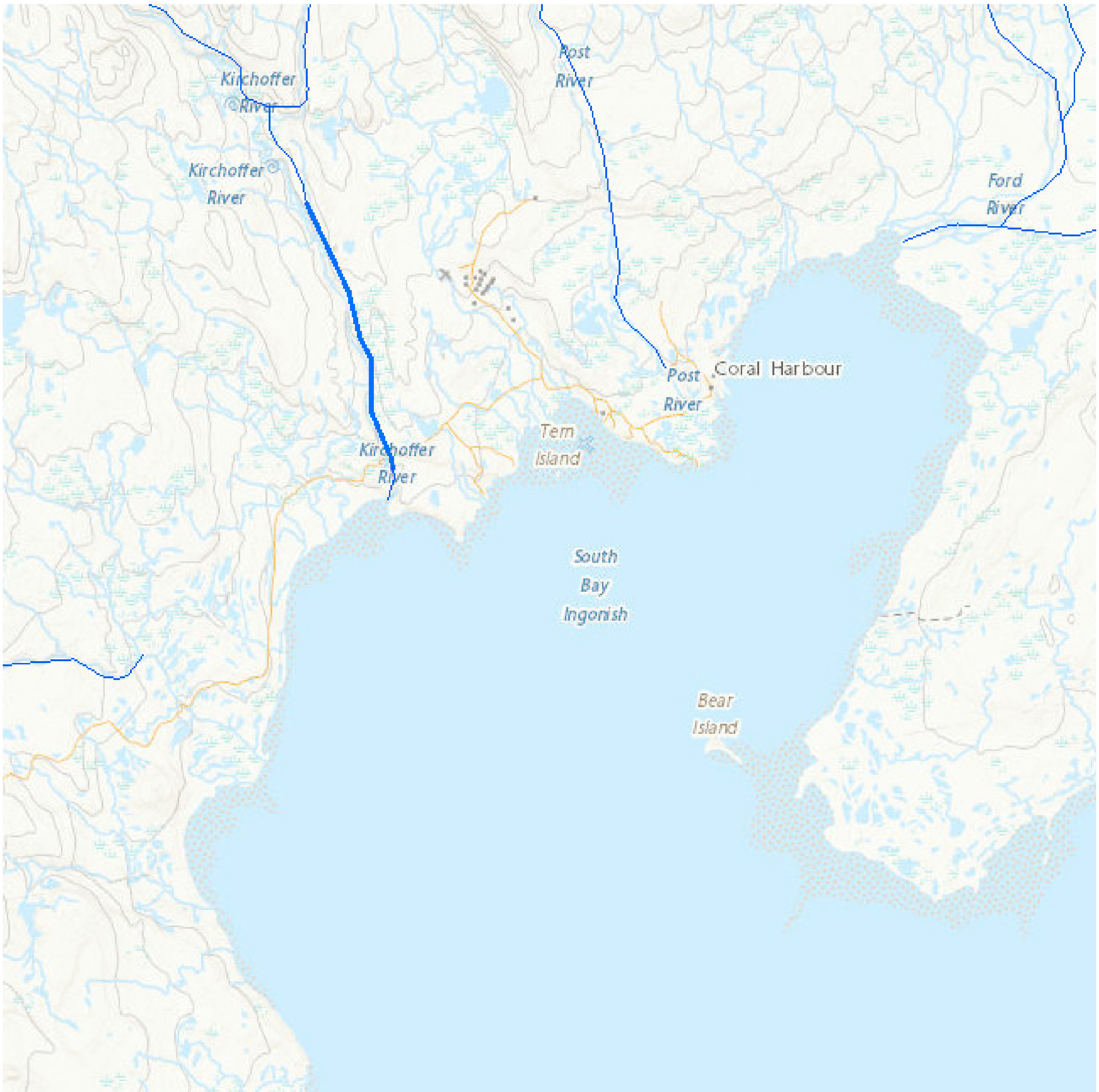


Figure 34: Mapped streams near Salliq.[176]

The CEP Team identified sections of each stream which were found to have the highest vertical elevation drop over a short section. Elevation profiles for Kirchoffer River and Post River are depicted in Figures 35- 36. However in both cases these elevation drops are very modest (1 - 1.5% slope).

176 Source: Government of Canada (2018). The Atlas of Canada: Clean Energy Resources and Projects [CERP]. https://atlas.gc.ca/cerp-rpep/en/

Figure 35: Elevation profile for a section of Post River.

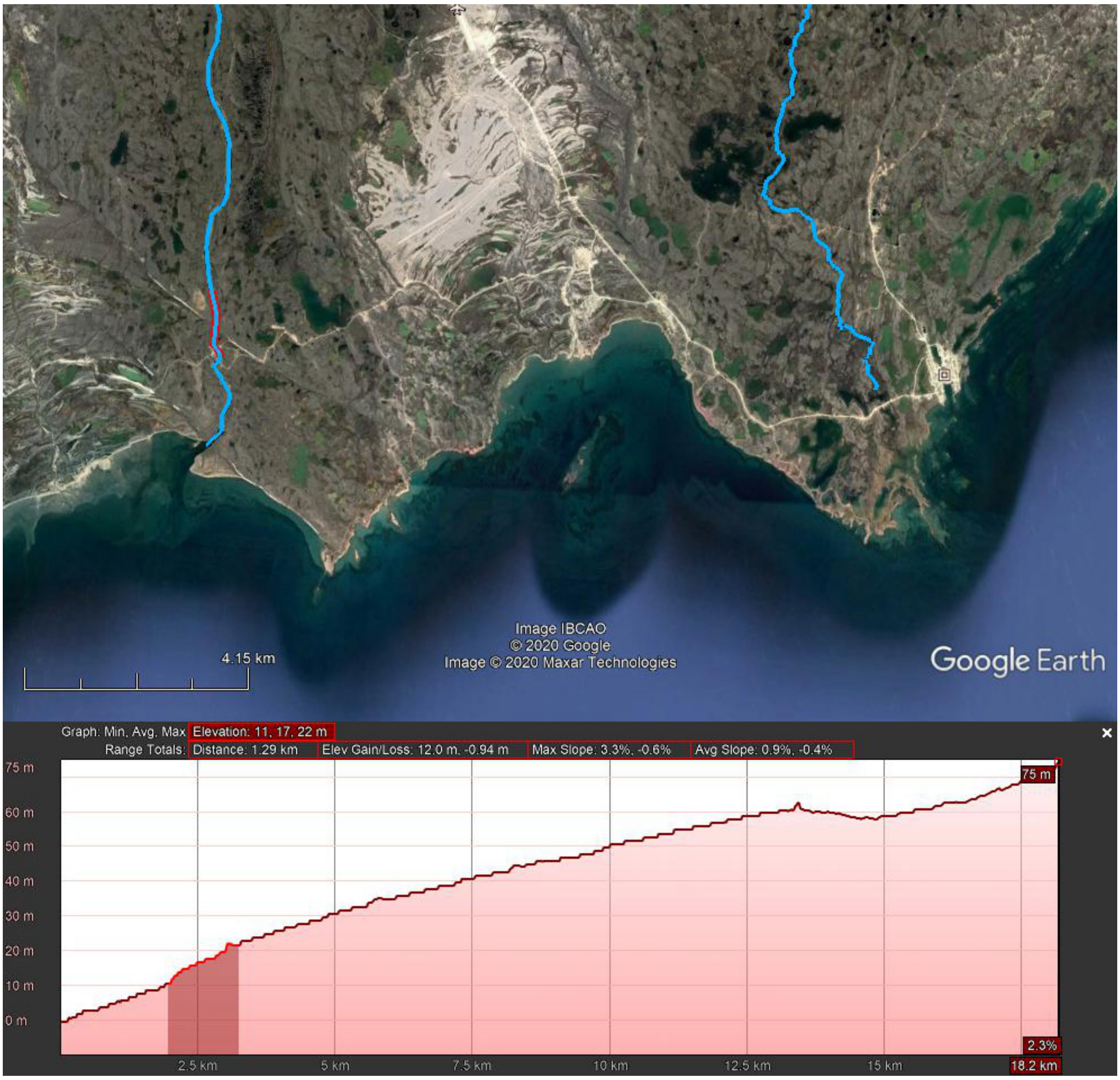


Figure 36: Elevation profile for a section of Kirchoffer River.

The Post River, which flows very close to town, is used as the source of drinking water in Salliq, and therefore any disturbances upstream of the drinking water intake should be very carefully considered.

The Ford River is known to be a source of fish for local people, and its ongoing use for fishing should be protected.

RIVER ENERGY RESOURCE

The federal government has conducted computer modeling to estimate the hydro-electric potential across Canada. A broad study was conducted by Natural Resources Canada (NRCan), which relied on stream measurements where available and hydrology mapping elsewhere.[177] More importantly, this initial study did not incorporate the effects of freezing on rivers, and

177 Jenkinson & Bomhof (2012). Assessment of Canada's Hydrokinetic Power Potential, Phase II Report: Methodology Validation. Prepared for NRCan.
Jenkinson & Cornett (2014). Assessment of Canada's Hydrokinetic Energy Resources.

was therefore not applicable to the North. However, NRCan is currently conducting a more detailed study of northern rivers, and the results are expected to be published imminently. This new study will incorporate satellite imagery to estimate the effects of freezing in rivers.

The research team at NRCan was generous in sharing information from this ongoing study with the CEP Team.[178] Based on best available modeling, including freezing effects, NRCan provided an estimate of stream flow along Kirchoffer River, as depicted in Table 13. This river was chosen as a first study case as it is expected to have the highest energy potential.

Month	Flow (m3/s)
Jan	0
Feb	0
March	0
April	0
May	0.01
June	164
July	100
Aug	38
Sept	29
Oct	0.9
Nov	0.002
Dec	0
Average	**27.7**

TABLE 13: Estimated stream flow on Kirchoffer River.

178 Pers. comm. with Ghanashyam Ranjitkar and Brian Perry of NRCan.

NRCan's modeling gives an estimate of 27.7 m^3/s for the average annual flow on Kirchoffer River. However, this flow is all occurring in the summer months (June through September), when the energy needs of Salliq are lower. Satellite imagery examined by NRCan suggests that all three candidate rivers appear frozen between approximately October through May. These satellite images are depicted in Figure 37.

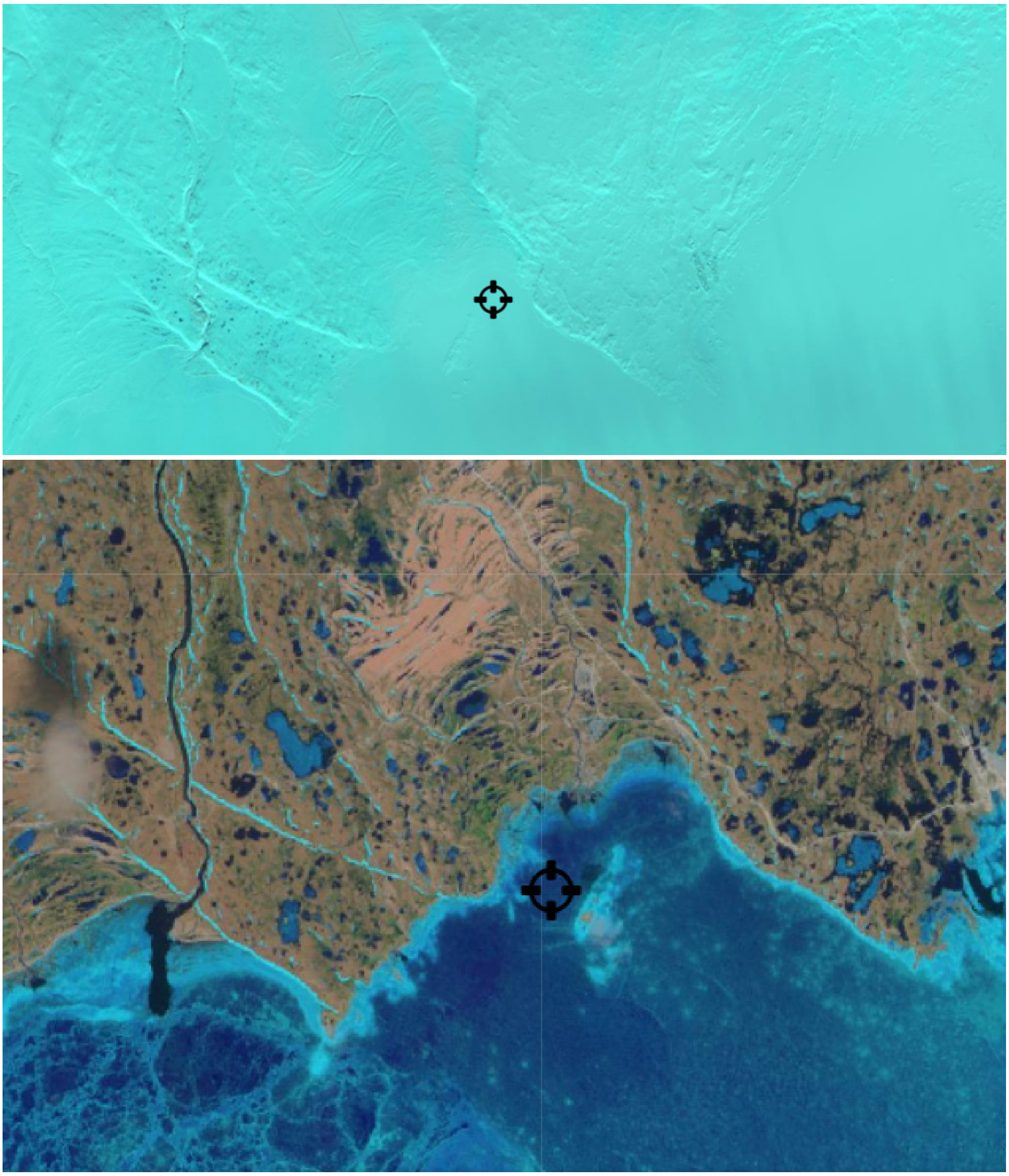


Figure 37: Satellite imagery showing a frozen landscape in mid-February (top) and thawing rivers in late June.[179]

179 Source: Natural Resources Canada.

RECOMMENDATION

It is likely that river energy - either run-of-river or hydro-kinetic - could be technically feasible at Salliq. A system of several kW could potentially be installed on the Kirchoffer river near where it meets the ocean, near to where the existing road crosses the river. A transmission line could be run alongside the road to town, approximately 15km in length.

However, when considering clean energy solutions for summer months, solar PV presents many advantages over hydro-electric energy. Solar PV is generally cost competitive with run-of-river energy today, and unlike run-of-river technology, solar PV pricing continues to decrease each year. Solar PV systems are also very flexible in their siting, so they can often avoid long transmission lines.

Because of the competitiveness of solar PV energy in summer (and wind in winter), the CEP Team does not recommend that river energy be explored further as a solution in Salliq.

6.6. OCEAN ENERGY ASSESSMENT

Several types of ocean energy technologies are currently under development, including various pilot projects and commercialization efforts around the world.

- Tidal energy technologies capture energy from ocean waters as they move in and out of a bay or marine channel, back and forth twice per day as the tides rise and fall. Tidal energy is very predictable, as substantial energy can be generated four times per day throughout the year. Due to the amount of energy in the ocean, a challenge is to protect equipment from the high forces of moving water, as well as the corrosive effects of salt. Tidal technologies are the most mature of the ocean energy technologies, and some equipment suppliers are making efforts to commercialize their systems.

- Wave energy technologies capture energy from the rising and falling surface of the ocean as waves pass by. Wave energy is driven by storms, and therefore typically higher in winter months. However wave technologies are still pre-commercialization and therefore not suitable for energy solutions in remote communities in the short term.

Mapping from the Canadian Energy Atlas shows two sites in the vicinity of Shugliaq Island which are deemed to have potential for tidal energy, as depicted in Figure 38. These sites are both far from the community - one is approximately 150km to the East, and the other is approximately 250km to the West.

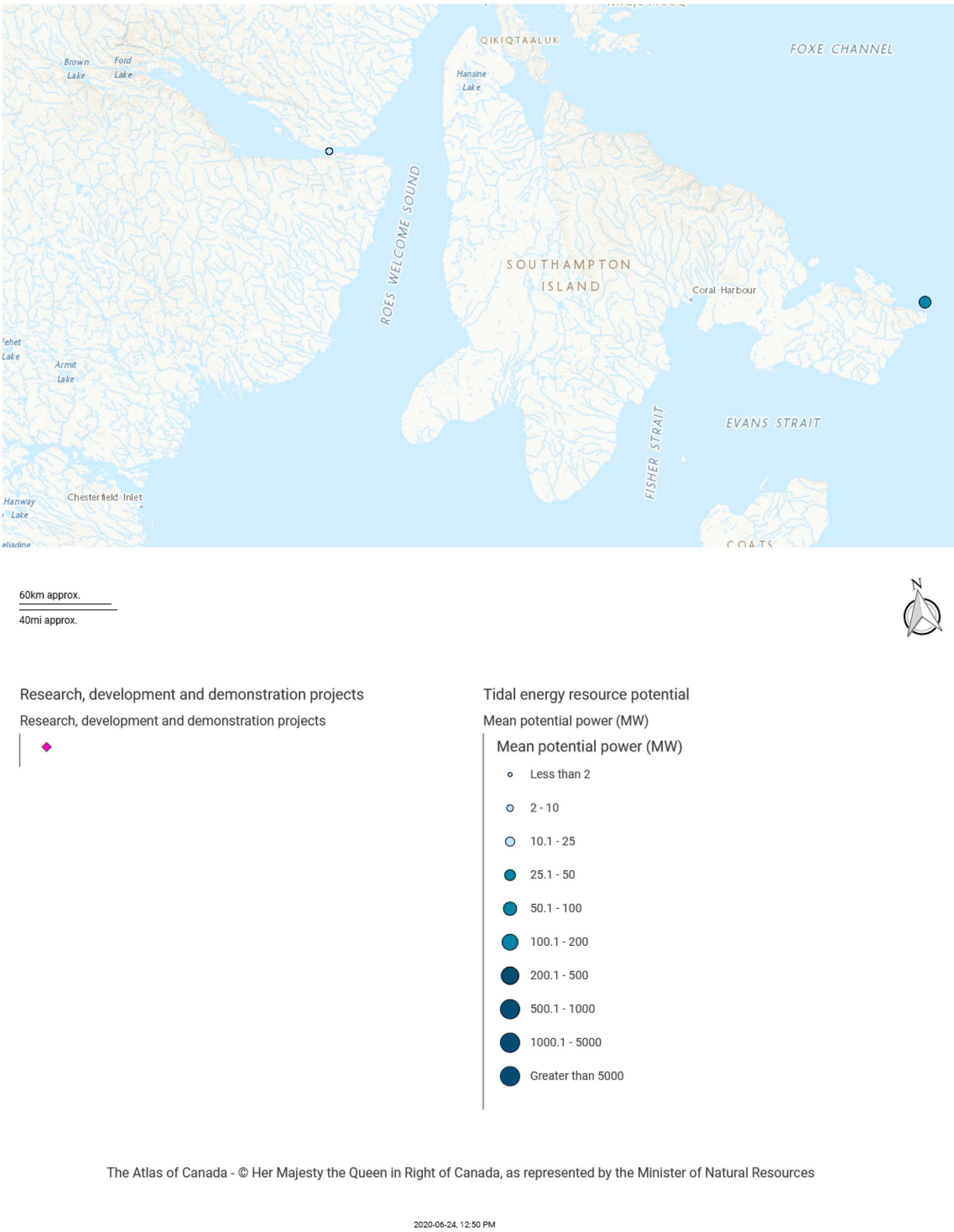


Figure 38: Two mapped sites with tidal energy potential in the vicinity of Shugliaq Island.[180]

180 Source: Government of Canada (2018). The Atlas of Canada: CERP. https://atlas.gc.ca/cerp-rpep/en/

A further complicating factor in northern Canada is the effect of sea ice, and the spring ice floes, on human-built systems. As noted further above, the surface of the ocean surrounding Salliq is typically frozen from October through June.

Because remote communities need to rely on their energy systems to meet basic human safety needs, and help is often far away, the CEP Team does not consider ocean energy systems to be sufficiently proven at this time. Ocean energy systems should be refined and proven in easier southern sites over the years to come. Only then should they be considered for application in a cold-climate site like Salliq.

6.7. GEOTHERMAL ENERGY ASSESSMENT

The CEP Team has reviewed available information regarding geothermal energy.

In 2018, QEC commissioned a study of geothermal resources across Nunavut.[181] This study aimed to gather existing data, identify data gaps, and conduct a geothermal resource assessment according to the guidelines set by the Canadian Geothermal Energy Association. Resulting geothermal potential mapping is depicted in Figure 39. Additional independent mapping is provided by the Canadian Energy Atlas in Figure 40.

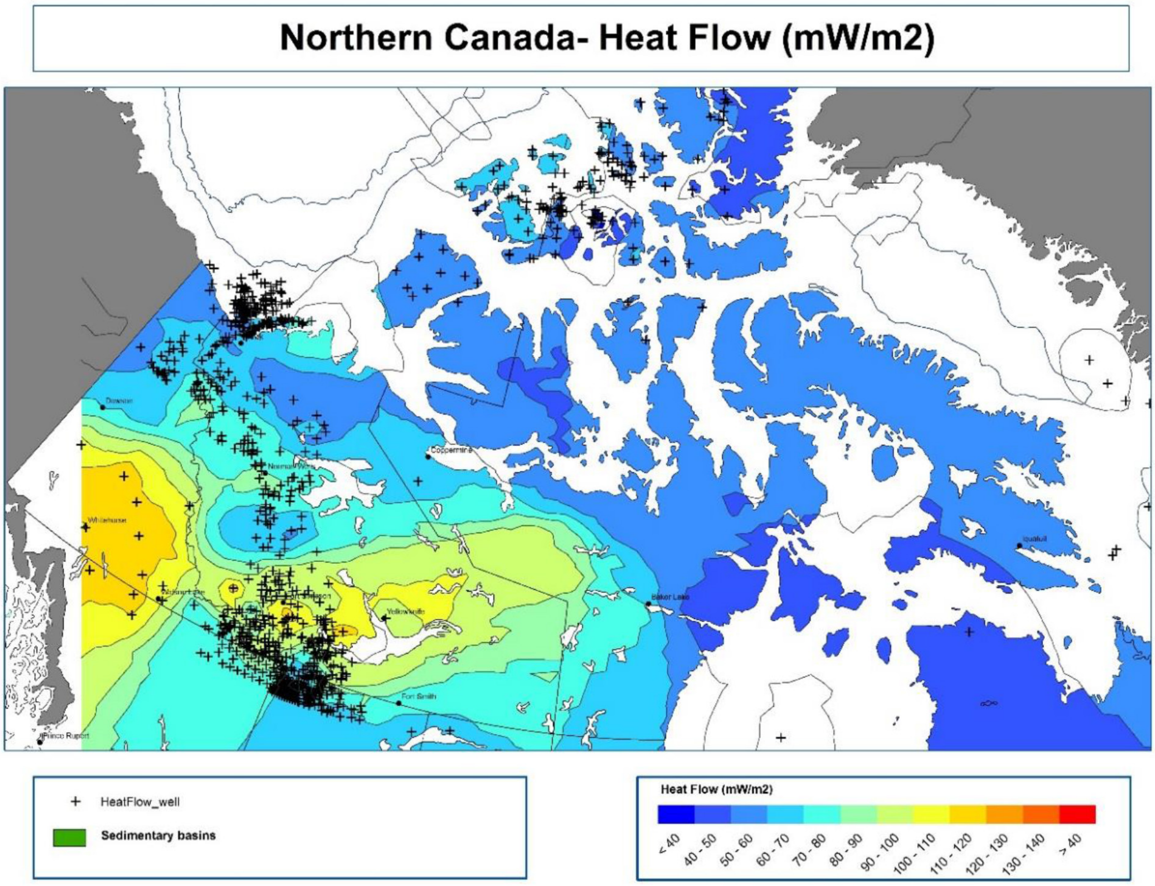


Figure 39: Heat flow mapping for northern Canada by RESPEC (2018), produced for QEC.

181 RESPEC (2018). NUNAVUT GEOTHERMAL FEASIBILITY STUDY, TOPICAL REPORT RSI-2828. Prepared for QEC. June, 2018. URL: https://www.cangea.ca/nunavutgeothermal.html

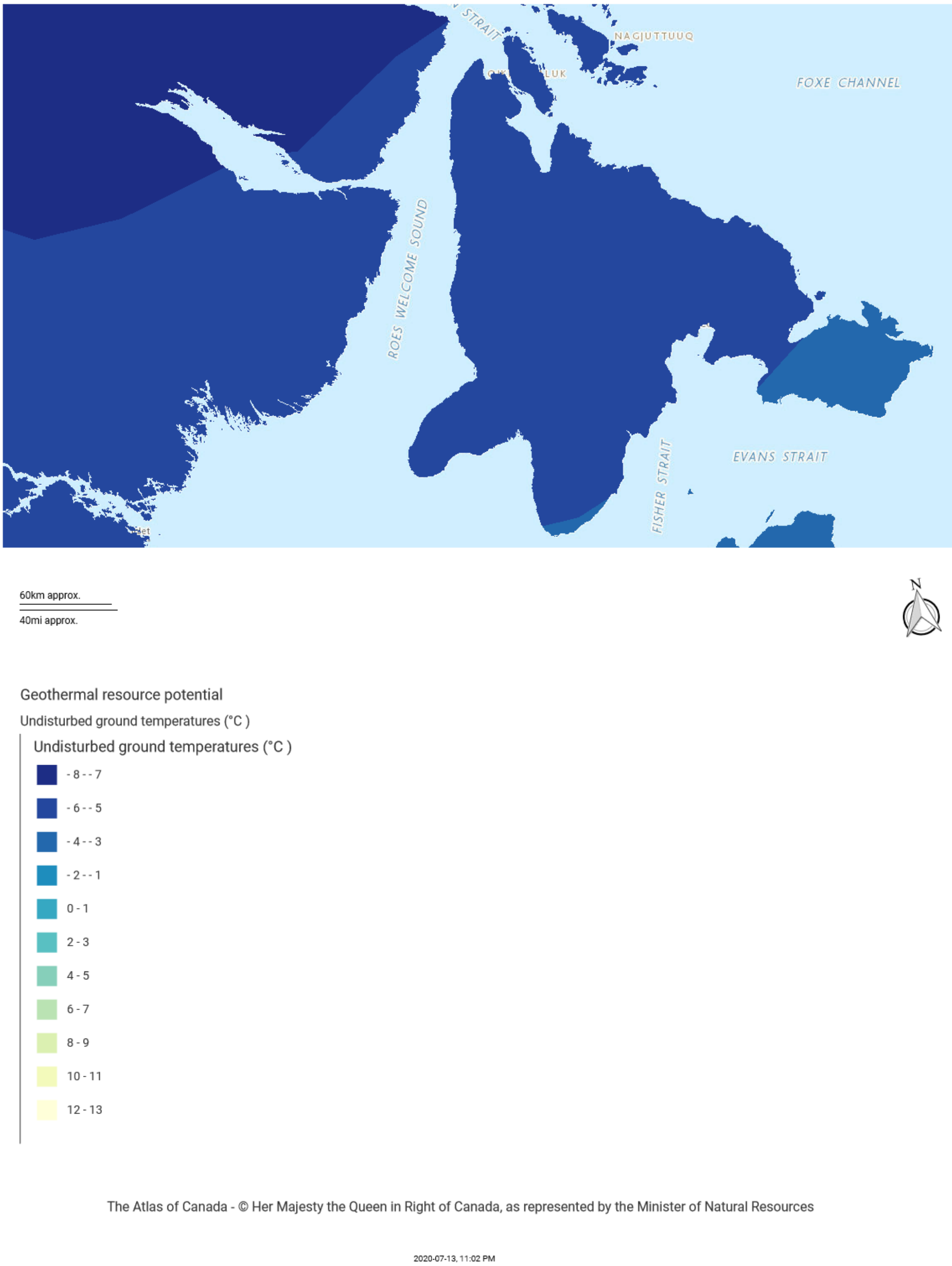


Figure 40: Low geothermal potential predicted by the Canadian Energy Atlas.

Based on both of these mapping sources, most of Nunavut is modeled to have low geothermal potential, especially around Salliq. It is apparent that the heat flow wells that inform the geothermal modeling (Figure 39) are primarily concentrated in the Yukon and NWT, often associated with oil and gas exploration/extraction.

Survey respondents were asked whether they are aware of any water springs in the vicinity of the community, as these can be signs of geothermal potential nearby. Survey responses included:

- "No"
- "I am not aware of geothermal springs for the area"
- "Some but not sufficient"
- "Yes about 75 miles southwest"
- "Only 100 miles from town"
- "There is an area on this island, not sure where"

Additional testing could potentially reveal a stronger geothermal resource in Salliq than is currently predicted. The RESPEC study[182] recommends such testing adjacent to Nunavut communities. However, compared to other forms of clean energy, testing a geothermal resource is very expensive. Holes must be drilled to a sufficient depth, often hundreds of meters, and this testing can cost in the millions of dollars.

Salliq would be better served by spending these dollars on realizing more suitable clean energy solutions today, using available means. Therefore, unless funding from government is earmarked for this purpose, the CEP Team does not recommend further exploration of geothermal energy solutions for Salliq.

182 RESPEC (2018).

6.8. ENERGY STORAGE ASSESSMENT

Electricity demand on a microgrid like Salliq is always fluctuating as people turn electrical devices on and off. Diesel generators are able to follow these fluctuations by ramping up and down to match demand. However large-scale clean energy projects can cause fluctuations that are too large for a microgrid, for example when a cloud passes in front of the sun, or the wind stops blowing, or vice versa. Forcing a traditional diesel generator to follow such extreme fluctuations can cause damage to the generators, or a power outage across the grid.

Therefore it is generally accepted that large-scale clean energy projects on a microgrid must also incorporate energy storage. An energy storage device can absorb energy at times (e.g. too much wind), and release it at times (e.g. no wind), in order to deliver energy that is smoother and more grid-friendly. Battery storage can also reduce the amount of energy from a clean energy project that is wasted.

Various energy storage technologies exist today, including mechanical flywheels, compressed air, and pumped water. Many of these have been tested in northern Canada at medium-to-large scale.[183] However chemical batteries are generally considered to be the optimal choice today, and some battery technologies have recently become commercially competitive. An energy storage system is typically characterized by its maximum output capacity (in kW) and by how long a period it can supply this output (in hours).

Small-scale clean energy projects typically don't require energy storage,[184] however larger clean energy projects do (e.g. projects with a clean energy penetration of over 20%). Battery systems are expensive, and they don't deliver any new energy - they just store it. Therefore, batteries should be sized to the minimum required to keep the grid safe and stable.

Battery systems typically require replacement every 10-20 years. It would be important to ensure that used battery fluids are transported offsite during battery replacements, as there are no recycling facilities in the community.

The question of how much clean energy, and how much storage, is optimal - is a complex question. This was studied previously by WWF and ITP using HOMER software, which is the industry standard for this purpose.[185] The WWF/ITP study identified various combinations of clean energy and battery storage that were predicted to be feasible and safe for the grid.

Examples of a clean energy system with 14% diesel reduction for QEC in Salliq:

- **Wind + Battery:** 200 kW of generation, plus 1x Tesla Powerpack2 2hr battery, or
- **Solar + Battery:** 460 kW of generation, plus 2x Tesla Powerpack2 4hr batteries.
- **Wind + Solar + Battery:** 120 kW of solar PV generation, 100 kW of wind generation, plus 2x Tesla Powerpack2 4hr batteries.

Examples of a clean energy system with 20% diesel reduction for QEC in Salliq:

183 News article entitled "Compressed air, flywheels and more: Energy storage solutions being tested in Canada". https://www.cbc.ca/amp/1.5945923
184 Typically little storage is needed for clean energy projects with a capacity < 20% of the community's peak capacity in any season. These are considered small scale, or "low-penetration", projects.
185 WWF, ITP (2019).

- **Wind + Battery:** 300 kW of generation, plus 1x Tesla Powerpack2 2hr battery, or
- **Solar + Battery:** 660 kW of generation, plus 4x Tesla Powerpack2 4hr batteries, or
- **Wind + Solar + Battery:** 400 kW of solar PV generation, 100 kW of wind generation, plus 1x Tesla Powerpack2 4hr batteries.

Examples of a clean energy system with <u>40% diesel reduction</u> for QEC in Salliq:

- **Wind + Battery:** 600 kW of generation, plus 4x Powerpack2 2hr batteries, or
- **Solar + Battery:** 1,350 kW of generation, plus 14x Powerpack2 4hr batteries, or
- **Wind + Solar + Battery:** 1,000 kW of solar PV generation, 100 kW of wind generation, plus 12x Powerpack2 4hr batteries,

Examples of a clean energy system with <u>60% diesel reduction</u> for QEC in Salliq:

- **Wind + Battery:** 900 kW of generation, plus 11x Powerpack2 4hr batteries, or
- **Solar + Battery:** 2,250 kW of generation, plus 31x Powerpack2 4hr batteries.

The above solutions were all modeled by WWF/ITP to have an electricity cost in the range of $0.50 - 0.63 /kWh, with the larger systems generally having a higher cost. The WFF/ITP study found that solar PV projects were slightly cheaper than wind projects - however the difference between the two is likely within the margin of error of that study.

This range of electricity price is much higher than the $0.25 /kWh that QEC is currently proposing under its CIPP program. However WWF/ITP found that wind+solar+battery projects should be competitive with the true avoided cost of diesel in Salliq. Therefore these solutions make sense from an overall cost and GHG perspective, and should be paid for by a combination of government grant funding and higher prices paid by QEC.

Going forward, technology improvements in solar PV technology (e.g. more efficient and cheaper panels), wind energy (e.g. tilt-up towers), and energy storage (cheaper batteries) are expected to further drive down the cost of clean energy solutions. Meanwhile QEC's cost to deliver diesel-fed electricity is only expected to increase in the long run.[186] Therefore the business case for clean energy is expected to improve over time.

As it relates to the analyses in this CEP, we will assume battery storage with capacity (kW) approximately equal to the clean energy generating capacity. The CEP Team's ongoing technical studies suggest that this approach will allow for all clean energy generated by the project to be used on the QEC grid - except for the case of a larger wind energy project where preliminary study results suggest that approximately 5% of clean energy might need to be "spilled" to maintain stability of the electrical grid. A proper understanding of QEC's response to clean energy plus storage - how they will operate their diesel generators - will require further study.

186 U.S. Energy Information Administration, Annual Energy Outlook 2021. https://www.eia.gov/outlooks/aeo/

7. Other Opportunities for Energy Transformation

This section explores other projects and programs that could be implemented in Salliq to assist with the sustainable energy transition. For options that appear to be technically feasible, further community consultation should take place to determine their suitability in Salliq.

7.1. WASTE-TO-ENERGY

The CEP Team has reviewed information available from the literature, as well as conversations within the GN, to investigate the feasibility of converting waste in Salliq to energy.

A study on community waste led by Arktis Solutions[187] included 3 participants from Salliq. Concerns voiced by these participants included smoke and odours, the location of the landfill, health and safety, and fencing and litter. This study estimated that 6,435 m^3 of waste is produced each year in Salliq (based on the 2010 population of 854 residents) and an annual budget of approximately $79,000. Assuming a current population of 900 residents, and an average mass of compacted municipal solid waste of approximately 325kg/m3 we can estimate the mass of total municipal solid waste in Salliq at approximately 2,200 metric tonnes per year, or 6.0 metric tonnes per day.[188]

187 Arktis Solutions (2011).
188 US EPA. (2016). Volume-to-Weight Conversion Factors for Solid Waste. https://www.epa.gov/smm/volume-weight-conversion-factors-solid-waste

The primary landfill in Salliq is approximately 2.5 km from residences, and some burning of waste also occurs. Converting waste to energy can help to alleviate the challenges associated with municipal waste, as well as producing a useable product (heat and/or electricity).

Methods of converting waste to energy include:

- **Incineration:** burning waste to produce heat in a boiler, and
- **Gasification:** extracting gases from waste and running a generator to create electricity and/or heat.

Types of waste available in Salliq include:

- landfill waste (garbage)
- human waste (sewage)
- industrial waste
- waste oil

Gasification is typically a cleaner option, producing less air pollution, however it involves more complex technology. Gasification can result in electricity production. Incineration is often the cheapest option. Incineration can provide a source of heat, however incinerators typically need to be located away from town, and therefore far from heat loads.

The GN is currently working on a waste strategy, and this strategy would not preclude incineration or discourage communities from pursuing incineration provided they have good feasibility studies to support.

Some companies that produce waste-to-energy technologies include:

- Enexor
- Eco Solutions
- Verdo

Waste-to-energy facilities are typically more efficient at a larger scale. Verdo produces standard sized waste-to-heat boilers with a minimum size of 4MWt, which has the capacity to consume 1.3 metric tonnes per hour, or 11,400 metric tonnes per year.[189] Therefore the amount of waste produced in Salliq is small compared to this minimum standard size of waste-to-energy incinerator from Verdo. Gasification unit from Eco Waste Solutions are available in the 1 - 10 metric tonnes/day range[190]. Enexor offers waste gasification units in the 75 kW range.[191]

Based on the information reviewed, we expect that Salliq on its own does not produce enough waste to support a cost-efficient waste-to-energy facility.

189 Verdo. (no date). Waste to Energy. https://www.verdo.com/int/energy-plants/waste-to-energy/
190 Eco Waste Solutions. (no date). Eco Model. http://ecosolutions.com/wp-content/uploads/2016/10/ECO-Model-REV-B.pdf
191 Enexor. (no date). Enexor Website. https://www.enexor.com/our-product/

Other northern Canadian communities have considered implementing waste-to-energy using only locally produced waste, including Iqaluit, NU and Old Crow, YT. However, we understand that these projects have been either not implemented or unsuccessful.

QEC also reports some experimentation with converting used motor oil to heat, however these experiments have had limited success.

The CEP Team has also benefited from speaking with experts from the community of Nuuk, Greenland. GN representatives were able to visit facilities in Greenland. Greenland includes six communities that use incinerators to eliminate municipal waste, with annual waste volumes ranging from 2,000 to 10,000 tons/yr.[192] [193] The larger communities also capture heat for local use. Issues of ongoing concern in Greenland include transport of waste, longevity of equipment, cleaning and maintenance, disposal of ash, landfilling, and air quality.

One success story in Greenland has resulted from various smaller communities compacting their waste and shipping it to the larger community of Nuuk.[194] This solves the waste program in these smaller communities. In Nuuk there is a large incinerator which converts the waste to heat and thereby provides district heating for nearby homes and municipal buildings.

We believe that a regional approach could be worth investigating, which could include various coastal communities in the region. A central community could be selected which is optimal from a logistics standpoint, and which also produces a moderate amount of waste locally. Costs and benefits from such a program could be shared across the participating communities, including the cost and GHG emissions associated with transporting waste between communities.

7.2. WASTE HEAT CAPTURE

In some cases, waste heat from existing industrial operations can be captured and redirected to another nearby heating need. Such projects are typically viable in northern communities only if the source of heat is very large, and if the distance to the end user is very small (e.g. hundreds of meters). Heat is typically transported in underground pipes filled with fluid or steam, and long distances lead to high energy losses.

QEC reports that waste heat at the site of the QEC powerplant in Salliq could potentially be an asset.[195] In fact, all QEC powerplants capture some waste heat from the diesel generators to heat local QEC operations buildings, and additional heat is radiated into the atmosphere to help keep the diesel generators sufficiently cool.

QEC conducted feasibility analyses in 1999 for the implementation of such a system in Salliq specifically, and QEC staff have re-examined the results of these analyses at a high level based on current pricing. QEC advises that the business case remains poor (projected payback period > 20 years) if the intent is to transport heat to another existing facility in Salliq.

192 Eisted & Christensen (2011). Waste management in Greenland: Current situation and challenges. https://www.researchgate.net/publication/50304022_Waste_management_in_Greenland_Current_situation_and_challenges
193 Journal of the Northern Territories Water and Waste Association (2017). https://issuu.com/cryofront/docs/ntwwa_2017_p6
194 WWF (2017). Renewable Energy Across the Arctic: Greenland Report. https://www.google.com/search?client=firefox-b-d&q=+WWF+2017.++Renewable+Energy+Across+the+Arctic%3A+Greenland+Report.
195 pers. comm. with Tilmon Comeau and Azhar Mahmood at QEC.

Alternatively, as the closest existing heat loads are too far away, it could also be possible to develop new uses for heat in the immediate vicinity of the QEC powerplant. For example a new greenhouse, swimming pool, or another community asset that requires heating. Such a project could be explored further with QEC and the hamlet government.

Government funding could also help to improve the business case. QEC has sometimes partnered with hamlets in seeking government funding to realize waste heat projects, however QEC needs to be directly involved in project implementation as it concerns their diesel generators.

7.3. ELECTRIC THERMAL STORAGE

Electric Thermal Storage (ETS) units are electric heaters encased in ceramic bricks. The electric heating element heats up the bricks during off-peak hours, when electricity is cheapest or in excess, and the bricks store this heat. When space heating is needed, this heat is diffused from the bricks into the home. ETS systems can be designed to replace a space heater, baseboard heater, forced air furnace, or hydronic furnace. The lifespan of all of these systems is 20-25 years.

Thermal storage is a type of "controllable load", which can help an electrical grid operator to deal with the intermittent nature of clean energy technologies. If controllable loads can be programmed to turn on when power generation is spiking (i.e. a windy or sunny period) then they can help to smooth out the load and make the grid more stable. Controllable loads can help to integrate more clean energy on a microgrid, because excess energy can be stored when it might have otherwise been wasted. They can also provide heating that is powered by clean energy. ETS systems have been employed in the following cases:

- The Yukon Conservation Society is in the process of a pilot project involving 42 homes in Whitehorse, YT. As of the date of writing, 32 of these ETS installations had been completed. The Society will monitor these systems over the next two winters to determine the suitability of using ETS systems in northern Canadian communities.
- Summerside, PEI's "Heat Now For Less" program offers ETS systems to homeowners at a discounted rate.[196]
- Nova Scotia Power has made ETS systems available to residential customers. Options include a furnace replacement and an in-floor radiant heating system for concrete floors.[197]

ETS has also been used in urban settings in Germany, Sweden, and Denmark, and in rural settings in three communities in southeast Alaska[198].

The pilot project in Whitehorse has experienced installed costs in the range of $20,000 - 30,000 for a system capable of storing 180 kWh of energy.[199] Suitable homes are those in decent condition, with adequate air ducting, and adequate electrical service to power the heating elements.

Telecommunications equipment is also needed so that the electrical utility can program the timing of the loads and monitor their condition. Maintenance costs for ETS systems are expected to be similar to traditional heating systems. The CEP Team looks forward to learning the results of this pilot project.

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196 https://summerside.ca/residents/electricity/conserving_energy/heat_for_less_now
197 https://www.nspower.ca/your-home/energy-products/electric-thermal-storage
198 https://www.energy.gov/sites/prod/files/2015/12/f27/chaninik_final_report_ee00002497_july_2013.pdf
199 Pers. comm. J.P. Pinard.

An estimated 49 homes in Salliq currently have forced air ducting.[200] If each of these 49 homes had an ETS unit similar to those being deployed in Whitehorse, the result would be 8,800 kWh in energy storage. This is more than enough storage needed to integrate high-penetration renewables into the grid. Therefore, we expect that much of Salliq's energy storage needs could be met through ETS, if this technology proves viable in the North. At an average cost of $25,000 for 180 kWh of storage, ETS would be cheaper than batteries today.

The CEP Team sees ETS as a promising option for enabling more renewables on the grid. Since the benefits of ETS systems are primarily experienced by the electrical utility, QEC's involvement would be critical for such an undertaking.

7.4. ELECTRIC VEHICLES

Electric vehicles run on battery power and do not consume any fossil fuel. These vehicles produce no emissions or pollution when they operate. Electric vehicles can include cars, trucks, busses, motorcycles, scooters, boats, and recently even ATVs and snowmobiles.

Electric vehicles cost more to purchase than traditional vehicles. However, if these vehicles are heavily used, then this purchase price can be worthwhile as monthly costs are low. Similarly, the environmental impacts of electric vehicles can be justified if the vehicles are heavily used. Therefore the first vehicles in a community to convert to electric are typically the most-used vehicles, such as delivery vehicles, taxis, or a maintenance staff vehicles.

Hybrid-electric models also exist, which use a combination of electricity and fossil fuels. Benefits of electric or hybrid-electric include:

- low operating costs,
- no emissions,
- quieter operation,
- instant heated seats (the engine doesn't need to heat up), and
- funding can sometimes be accessed to reduce purchase costs.

And challenges include:

- higher capital costs,
- limited range on a single battery charge,
- availability of charging stations, and
- lack of local maintenance expertise (may have to transport a vehicle to the South for repairs).

Electric vehicles can only be justified if they are run on clean energy. Electric vehicles use their energy efficiently, with 60% of charging energy typically being used to move the vehicle (40% is lost as heat or sound).[201]

200 Pers. comm. Jimmy Main at NHC.
201 https://cleantechnica.com/2018/03/10/electric-car-myth-buster-efficiency/

In the case of Salliq, however, the electrical grid is currently powered almost entirely by diesel fuel, with an efficiency of approximately 32% (that means that 68% of the diesel energy is converted to heat or sound before it reaches the user). When these losses are combined with the electric vehicle losses, the result is that electric vehicles would be only 19% efficient in converting QEC's diesel fuel into motion. This is similar to the efficiency of existing gasoline or diesel powered vehicles in Salliq today.[202]

For this reason, electric vehicles should not be considered in Salliq until the QEC grid has been sufficiently converted to clean energy sources. Once the grid is sufficiently clean, then electric vehicles could be a useful tool to further electrify the energy system in Salliq. In the long run, electric vehicles could cause Salliq to use more electricity (which can be generated from clean sources) and less diesel fuel (which cannot currently be substituted).

7.5. GREENHOUSES

Most food in Salliq must be imported from southern Canada. Traditional foods make up a significant portion of the local diet, which are hunted or gathered from the surrounding region. However agriculture is challenging to accomplish in this northern climate. For this reason, a greenhouse can be a welcome contribution to local food stocks.

Greenhouses use glass or thin plastic walls to trap heat inside. This design can help to achieve a higher growing temperature during sunny periods, and can also extend the growing season slightly in spring and fall. However to grow crops year-round, greenhouses require heat. In Salliq, heat is scarce and expensive. Greenhouses also require high quality soil and an ample supply of clean water.

The CEP Team has been investigating whether sources of waste heat may exist in Salliq that could be captured for use. A case study is presented in section 7.2 based on waste heat at QEC's generating station.

202 https://www.fueleconomy.gov/feg/atv.shtml

8. Goals and Strategic Recommendations

Various potential projects and programs have been identified and examined in this CEP. These are summarized below, in the following categories:

- ***Lowest Hanging Fruit:*** These projects are relatively simple, affordable, and could be implemented quickly with high bang-for-buck.
- ***High Impact Projects:*** These projects are larger, more expensive, and more complex. They would require a dedicated project development effort. Costs and revenues would need to be further refined in support of a business case.
- ***Future Possibilities:*** These projects are not viable in Salliq today, however they should be re-examined in future as conditions and technologies change.
- ***Rejected Projects:*** These projects appear to be un-viable and not worth further consideration.

It will take years to transition Salliq completely away from fossil fuels. However, with the successful implementation of the projects identified in this CEP, GHG emissions in Salliq would be reduced by approximately 17%. With adequate effort, human resources, and funding, this result could be achieved within 5 years. See the breakdown of potential GHG savings in Figure 41.

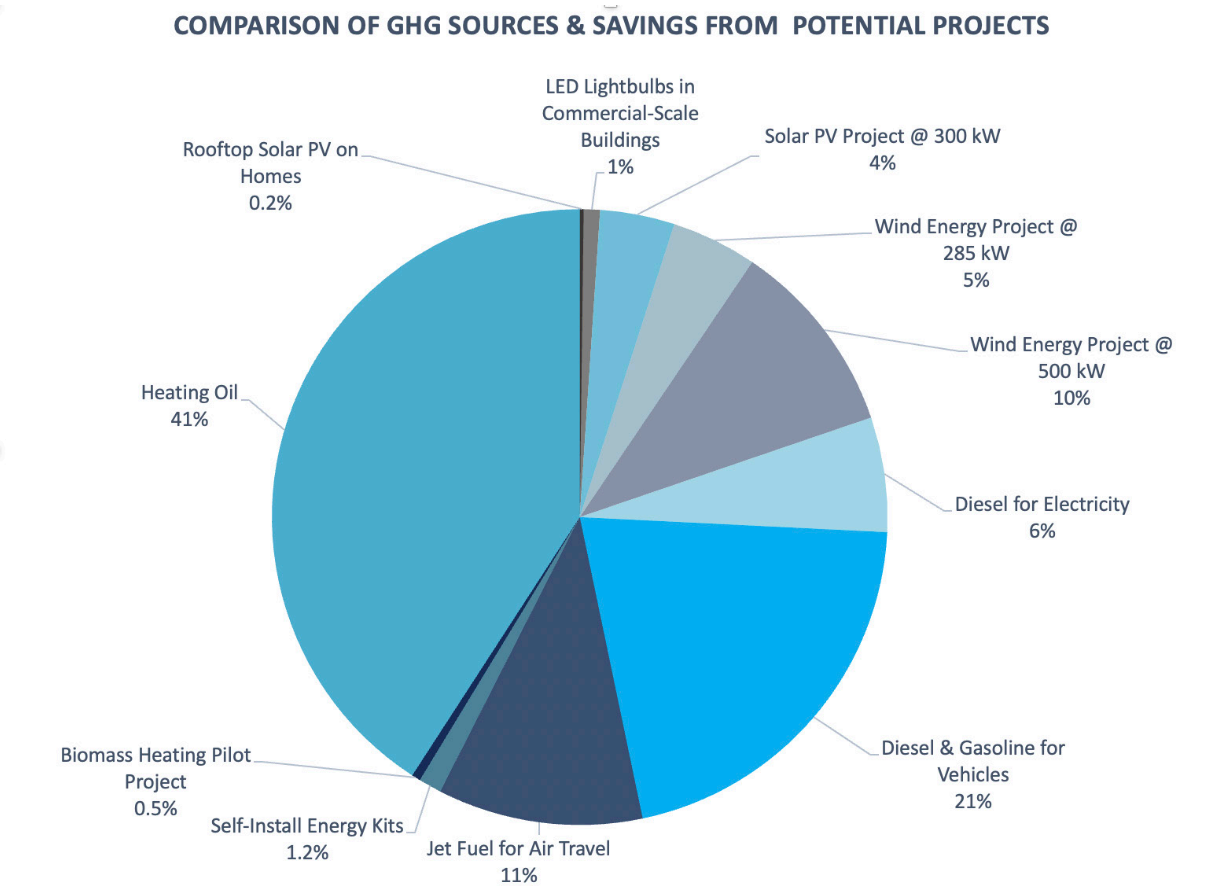


Figure 41: Comparison of Estimated GHG Savings from Various Potential Projects in Salliq.

The near-term solutions recommended in this CEP are mostly intended to convert diesel-fueled electricity to clean electricity, as these solutions are less complex. Only the Self-Install Energy Kits are expected to have a small impact on displacing heating oil.

Table 14 below also provides the estimated GHG savings over the lifetime of each project, as well as the estimated GHG savings per million dollars of capital expenditure, based on best available information.

Project	Estimated Capital Cost	Estimated Lifetime	Estimated Lifetime GHG Savings (TCO_2e)	Lifetime GHGs / $1million of CAPEX ($TCO_2e$)
LED Lightbulbs in Commercial-Scale Buildings	$ 12,000	5	465	38,750
Self-Install Energy Kits	$ 22,200	5	660	29,730
Building Upgrade x1	$ 25,500	15-20	348	13,657
Solar PV Project @ 300 kW	$ 3,120,000	25	10,675	3,421
Rooftop Solar PV on Homes	$ 200,000	25	550	2,750
Biomass Heating Pilot Project	$ 400,000	20	1,000	2,500
Wind Energy Project @ 500 kW	$ 9,730,000	20	22,440	2,306
Wind Energy Project @ 285 kW	$ 4,730,000	20	9,800	2,072

TABLE 14: Estimated GHG savings compared to estimated project costs.

LOWEST HANGING FRUIT

These projects have the highest return on investment. They are easy to undertake, low in capital cost, low complexity, low risk, and could be implemented immediately. These are smaller projects that have a modest impact on reducing energy costs and GHG emissions.

LED LIGHTBULBS IN COMMERCIAL-SCALE BUILDINGS

LED lightbulbs could replace all existing incandescent bulbs in all commercial buildings.

Cost:	$12,000 for all 11 buildings. Maintenance costs should be slightly lower than the status quo.
Impact:	93 tonnes CO_2e/yr in GHG savings, or a 1% reduction in Salliq's emissions. 0.5-year payback on investment. 230% return on investment, assuming QEC's subsidized commercial rates.
Risk:	Low. LED light bulbs are commonplace, inexpensive, and can be directly substituted for existing bulbs. Some buildings might currently use fluorescent bulbs, and in this case replacement with LEDs might be more complex and expensive.
Status:	This project has not been initiated.
Lead Actors:	Hamlet of Salliq, CGS, GN, NHC

SELF-INSTALL ENERGY KITS

Self-Install Energy Kits could be installed in all 220 homes in Salliq. We include the cost of an instructional video.

Cost:	$22,200 for all 220 homes. Repeat every 5-10 years.
Impact:	132 tonnes CO_2e/yr in GHG savings, or a 1% reduction in Salliq's emissions 0.5-year payback on investment. 250% return on investment.
Risk:	Moderate. It is unclear how effectively the contents of these kits will be used by residents in Salliq.
Status:	The CEP Team has initiated the purchase and installation of 220 kits.
Lead Actor:	CEP Team, ICE, along with NHC for rental housing.

ROOFTOP SOLAR PV ON HOMES (UNSUBSIDIZED RATEPAYERS)

Solar PV systems could be installed on approximately 8 homes across Salliq and operate under QEC's Net Metering program. This project is financially viable if the participating homes have high levels of electricity consumption, commonly buying unsubsidized electricity from QEC.

Cost:	$200,000 for a 5-kV solar PV system at each of 8 homes. Very little maintenance over 40 years, or as long as the rooftops last.
Impact:	22 tonnes CO_2e/yr in GHG savings, or a 0.2% reduction in Salliq's emissions. 8-year payback on investment, assuming unsubsidized QEC rates. 12% return on investment.
Risk:	Moderate. It is unclear whether there are willing participants in this program.
Status:	This project has not been initiated.
Lead Actor:	The CEP Team will connect any interested homeowners with contractors who could perform such a project

BUILDING UPGRADE: 2-BAY MAINTENANCE GARAGE

Upgrades could be made to this building including building envelope upgrades, equipment maintenance and upgrades, controls, and lighting. The CEP Team intends to lead the effort to implement upgrades at this building, in collaboration with the Hamlet. Government grant funding will be sought to cover the capital cost.

Cost:	$25,500 capital cost. $8,200 reduction in annual operating cost. Lifetime of 15 -20 years.
Impact:	3.1-year payback on investment. 32% return on investment. 19.9 tonnes CO_2e/yr in GHG savings, or a 0.2% reduction in Salliq's emissions.
Risk:	Low. Similar building improvements have been documented throughout northern communities, with predictable positive results.
Status:	This project has not been initiated.
Lead Actor:	The CEP Team intends to lead this effort by seeking government grant funding and coordinating with the Hamlet regarding its implementation.

8.1. HIGH IMPACT PROJECTS

These are larger projects that would have a higher impact on reducing electricity costs and GHG emissions in Salliq. They are more complex, more expensive, take longer to research and develop, and involve more risks to manage. These projects require expensive studies to properly estimate their costs and benefits. These projects also have longer lifetimes, so their benefits are spread out over time.

SOLAR PV PROJECT @ 300 KW

A solar PV system could be implemented with nameplate capacity of 300 kW under QEC's future IPP program. This system would include 400 kWh of battery storage to help balance the grid.

Cost:	$3.12 million capital cost. Very little maintenance over 40+ years, aside from replacing inverters every 10-25 years.
Impact:	427 tonnes CO_2e/yr in GHG savings, or a 4.5% reduction in Salliq's overall emissions. Financial return not sufficient to repay a capital investment; requires grant funding.
Risk:	Low. Solar PV systems are well suited to northern climates.
Status:	Sakku and NEC are currently investigating a clean energy project for Salliq.
Lead Actor:	Sakku and NEC

WIND ENERGY PROJECT @ 285 KW

Three medium-scale Xant M26 wind turbines could be installed with a nameplate capacity of 95 kW each. These wind turbines would be tilted up, without the need for a crane. This system would include 200 kWh of battery storage to balance the grid.

Cost:	$4,730,000 capital cost. $160,000 annual operating cost. Lifetime of 20+ years.
Impact:	At the proposed IPP rate of $0.25 /kWh, the revenues from this project would pay for its operations cost, however the project would not return a profit on the investment. Therefore this project would require either grant funding to proceed, or a higher electricity price from QEC to justify a private sector project. 490 tonnes CO_2e/yr in GHG savings, or a 4.5% reduction in Salliq's overall emissions.
Risk:	Medium. Wind turbines have evolved to become much better suited to northern climates. However, icing losses and mechanical issues can still affect performance.

Status: Sakku and NEC are currently investigating a clean energy project for Salliq.

Lead Actor: Sakku and NEC

WIND ENERGY PROJECT @ 500 - 1,000 KW

One large-scale EWT DW-61 wind turbine could be installed with a nameplate capacity of 1.0 MW. This wind turbine would initially be de-rated to a maximum output of 500-kW in order to ensure grid stability. This project would initially include 600 kWh of battery storage to balance the grid. In future, as additional storage is brought online, the maximum output of this turbine could be increased (un-de-rating).

Cost: $9,730,000 capital cost.
$279,000 annual operating cost.
Lifetime of 25+ years.

Impact: 1,122 tonnes CO_2e/yr in GHG savings, or a 10.3% reduction in Salliq's overall emissions.
Financial return not sufficient to repay a capital investment; requires grant funding.

Risk: Low/Medium.
Wind turbines have evolved to become much better suited to northern climates. However, icing losses and mechanical issues can still affect performance. EWT wind turbines have an operational track record at northern sites. Logistics for this project would be very complex.

Status: Sakku and NEC are currently investigating a clean energy project for Salliq.

Lead Actor: Sakku and NEC

BIOMASS PILOT PROJECT

Due to the concern regarding year-long storage of wood pellets in a dry environment, the CEP Team recommends a pilot project to confirm the feasibility of this approach. We recommend a commercial/community-scale building for this pilot project.

Cost: $400,000 capital cost (very approximate).
$8,000 increase in annual operating cost (very approximate).
Lifetime of 20+ years.

Impact: This project is not economically profitable as modeled.
50 tonnes CO_2e/yr in GHG savings, or a 0.5% reduction in Salliq's emissions.

Risk:	Moderate. We perceive some risk associated with storage of wood pellets. This project would help to quantify that risk.
Status:	This project has not been initiated.
Lead Actor:	Implementation should be led by a GN entity such as CGS, with maintenance managed by the Hamlet

8.2. FUTURE POSSIBILITIES

These projects appear promising, however they should not be implemented immediately. These projects either involve technology that is not yet fully mature, or they should be implemented following certain initial steps. The viability of these projects should be re-examined in 5 years' time.

WASTE HEAT CAPTURE

The CEP Team suspects that a viable project could be pursued that involves capturing waste heat from the QEC diesel generators and building a new facility adjacent to the QEC powerplant that would make use of this heat. Possibilities discussed thus far include a greenhouse, auto garage, or swimming pool facility. The CEP Team intends to work with research center Nergica to conduct this analysis, with input from the hamlet government and QEC.

ELECTRIC THERMAL STORAGE

ETS units have been deployed in southern communities, and a pilot project is underway to test their effectiveness in Whitehorse, YT. If this pilot is successful, then ETS should be investigated for Salliq. ETS systems are cheaper than battery systems, and could be an affordable part of the solution to integrating renewables on the grid. A large portion of the community's long-term energy storage needs could potentially be met by ETS.

ELECTRIC VEHICLES

Electric vehicles will not represent a solution to GHG emissions until the electricity grid in Salliq is substantially converted to clean energy sources. The viability of electric vehicles should be re-examined in 5 years' time.

GREENHOUSES

Greenhouses are a potential local use for heat that would otherwise be wasted. If sources of waste heat can be identified in Salliq, then a greenhouse project should be considered.

GEO-EXCHANGE / HEAT PUMPS

The technical feasibility of geo-exchange systems in Salliq is uncertain. Such systems perform less efficiently in cold climates, and these projects are also complex and expensive. More information should be gathered from experiences in other northern, less remote communities.

8.3. REJECTED PROJECTS

These projects were examined but deemed to be unviable in Salliq.

- **Tiny Homes:** Prefabricated energy-efficient tiny homes have proven successful in southern urban settings. A tiny home pilot project in the North was less successful than planned. Housing in Salliq is crowded, more living space is needed. Therefore, we don't currently recommend a focus on tiny homes in Salliq.
- **River Energy:** Because local rivers are frozen throughout the winter when Salliq has the highest energy needs, they are not a competitive energy source compared to wind and solar energy.
- **Ocean Energy:** Because ocean energy technologies are not yet mature, they should not be employed at remote northern sites.
- **Geothermal Energy:** Because mapped geothermal potential in the region is low, we don't recommend a focus on geothermal energy. Testing for geothermal potential is also very expensive.
- **Waste-to-Energy:** Because of the small scale of the Salliq community, we don't recommend converting waste to energy.

8.4. SHORT-TERM (5YR) GOALS

After careful consideration and analysis of the various alternatives, and consultation with stakeholders, the CEP Team recommends the following "SMART" goals for Salliq over the next five years. In order of increased complexity:

- **Self-Install Energy Kits:** The The CEP Team recommends that Self-Install Energy Kits be made available to all homes in Salliq by 2022. This project has been initiated by the CEP Team. 220 kits have been purchased and will be distributed to both homeowners and renters, and an instructional video has been developed to assist with uptake. Coordination with the hamlet office will be required to ensure adequate human resources and funding to allow renewal of kit materials over time.
- **Building Renovations:** The CEP Team recommends that upgrades be performed to the 2-Bay Maintenance Garage as outlined in this CEP within the next 5 years. The CEP Team intends to lead this effort by seeking government grant funding and coordinating with the Hamlet regarding its implementation. The CEP Team also recommends that the Hamlet pursue further building audits for both community-scale and residential-scale buildings in order to continue on the path of improved energy efficiency within the building stock. The Hamlet would need to work with GN entities such as CGS and NHC to implement these improvements.
- **LED Lights in Commercial Buildings:** The CEP Team recommends that LED light bulbs be used exclusively in commercial buildings in Salliq by 2022. This project should be led by a GN entity such as CGS. LEDs are also being installed in some Nunavut communities by the GN's Nunavut Energy Management Project.

- **Medium-Penetration Clean Energy Project:** Sakku and NEC are currently investigating the feasibility of a wind and/or solar energy project for Salliq, including battery storage. Project capacity would likely be in the range of 200-500 kW. Funding will be sought to cover the costs of further project development, as described in Section 8.7. The details of this project, including its scale (kW), will be refined by further study work in the months to come.

- **Rooftop Solar for Unsubsidized Ratepayers:** If candidate residents exist in Salliq (homeowners who are interested in rooftop solar PV, have roofs in good condition, and pay unsubsidized electricity rate), then the CEP Team would be happy to connect them with contractors who could perform such a project. Local solar installer Emilia Netser could potentially assist in realizing these projects.

- **Biomass Heating Pilot Project:** The CEP Team recommends that a biomass heating pilot project be installed and operated in Salliq by 2026, including an affordable storage facility (e.g. sea can). The condition of the wood pellets will be monitored to measure any effects of humidity. Implementation of this project should be led by a GN entity such as CGS, with maintenance managed by the Hamlet. Federal funding should be sought to cover the cost of this project.

The CEP Team is in the process of discussing the above near-term project recommendations with the Hamlet of Salliq and relevant GN departments. As noted in Section 3, community engagement work in Salliq has been substantially delayed due to the Covid-19 pandemic. The CEP Team will continue this engagement in order to confirm whether each of the above-noted projects will have support from the Hamlet council and the community, and to assist in passing off these projects to the parties noted above who are best suited to lead each project. With regard to the self-install energy kits (#1 above) the commercial-scale building renovations (#2) and the clean energy projects (#4) the CEP Team intends to remain intimately involved in planning the implementation of these projects.

Below is a summary of key tasks that should be undertaken in Years 1 through 5 (2022 through 2026) in order to accomplish the near-term goals set out above, as well as preparing the Hamlet for a successful revisitation of the CEP in 2026:

YEAR 1 - 2022

- Completion of the community engagement work that was delayed during the CEP. Community engagement work will continue through year 1 and beyond.
- Distribute self-install energy kits and associated videos.
- Inform local homeowners regarding the potential for rooftop solar under net metering.
- Develop and hire a "Regional Energy Manager", to assist with coordination of energy planning and act as a liaison on projects.
- Seek funding to implement energy efficiency upgrades to buildings that have been audited, and to audit additional buildings.
- Seek funding (IODI Phase 3) to complete development work on a clean energy project (wind or solar plus battery).
- Initiate environmental permitting, design, and engineering work to progress clean energy project.
- Engage with QEC to conduct a grid impact study for clean energy project.
- Work with the GN and Hamlet to ensure that LEDs are installed in commercial/community buildings.

YEAR 2 - 2023

- Continued community engagement work towards one or more clean energy project.
- Final stages of development work to progress selected clean energy project (solar+battery) to "shovel-ready".
- Work with the GN to advance a biomass heating pilot project, including pursuit of funding.
- Implement energy efficiency upgrades to buildings that have been audited.
- Conduct energy efficiency audits on additional buildings.
- Work with NHC and homeowners to encourage energy efficiency solutions in residential buildings.
- Develop a longer-term plan for maintenance and updates to the self install energy kit program.

YEAR 3 - 2024

- Construction of selected clean energy project (solar) under QECs IPP program.
- Continued implementation of energy efficiency upgrades to buildings.
- Revisit planning for additional clean energy projects, such as wind, and begin planning for wind resource assessment.
- Continued work with GN to advance biomass heating pilot project.

YEAR 4 - 2025

- Completion of construction on clean energy project (solar) and beginning of project operations.
- Target date for implementation of the biomass heating pilot projects.
- Hiring/training for maintenance work to support the new clean energy project.

YEAR 5 - 2026

- Review of literature to learn the current status of emerging technologies including waste heat capture, electric thermal storage, electric vehicles, greenhouses, and geo-exchange / heat pumps.
- Hamlet to organize a team to revisit the CEP, to review progress to date, and to set new goals for the next 5 years.
- Begin collecting data from the biomass heating pilot project, solar project, and wind resource.

8.5. LONG-TERM PATHWAY TO DIESEL REDUCTION

- **Electricity System:** The conversion of the electricity system in Salliq to predominantly clean sources should be the long-term objective as means of reducing diesel consumption in the community. Beginning with the 5-yr goals listed above, and subsequently by incorporating the lessons learned along with QEC, clean energy penetration should be increased using a combination of clean generation sources, energy storage, and intelligent control strategies that enable QEC to eventually reduce its reliance on its large diesel generators. This is the easiest part of the energy system to clean up.

- **Transportation:** Once the electricity grid has been sufficiently converted to clean energy, electric vehicles should be reexamined to determine their potential to reduce GHG emissions in Salliq. This will also cause an increase in the overall size of the electricity system. Air travel will likely be the most challenging component in terms of emissions reductions, with no proven safe and commercially available alternatives today.

- **Heating:** The heating system is perhaps the most interesting component of Salliq's diesel reduction challenge. The best practice is to begin with heat energy conservation, and the CEP Team has already initiated efforts to improve energy efficiency in the home (self-install energy kits) and workplace (building audits and improvements). Waste heat capture may in future serve a small demand for heat. Nevertheless, heating will continue to be a dominant component of the energy needs in Salliq, and the greatest opportunity for diesel reduction. Options for large-scale production of heat without emissions in Salliq include biomass (pilot project proposed), electric thermal storage (testing underway in other northern communities) and potentially geo-exchange / heat pumps.

The path forward in the next 5 years is fairly clear, as described further above. By the end of this period, the community of Salliq may need to make a choice regarding its continued path forward. At this future fork in the road, the choice may likely be between:

- **Heating with biomass,** specifically sustainably harvested wood pellets from southern Canada, including dry storage of large volumes (many hundreds of tons) over many months. This would allow the electricity system to continue growing at its usual pace.

OR

- **Heating with electricity,** potentially including electric thermal storage and geo-exchange / heat pumps. This would require a substantial enlargement of the electricity system, literally by several times its current size. This could, for example, improve the business case for larger-scale wind energy.

OR

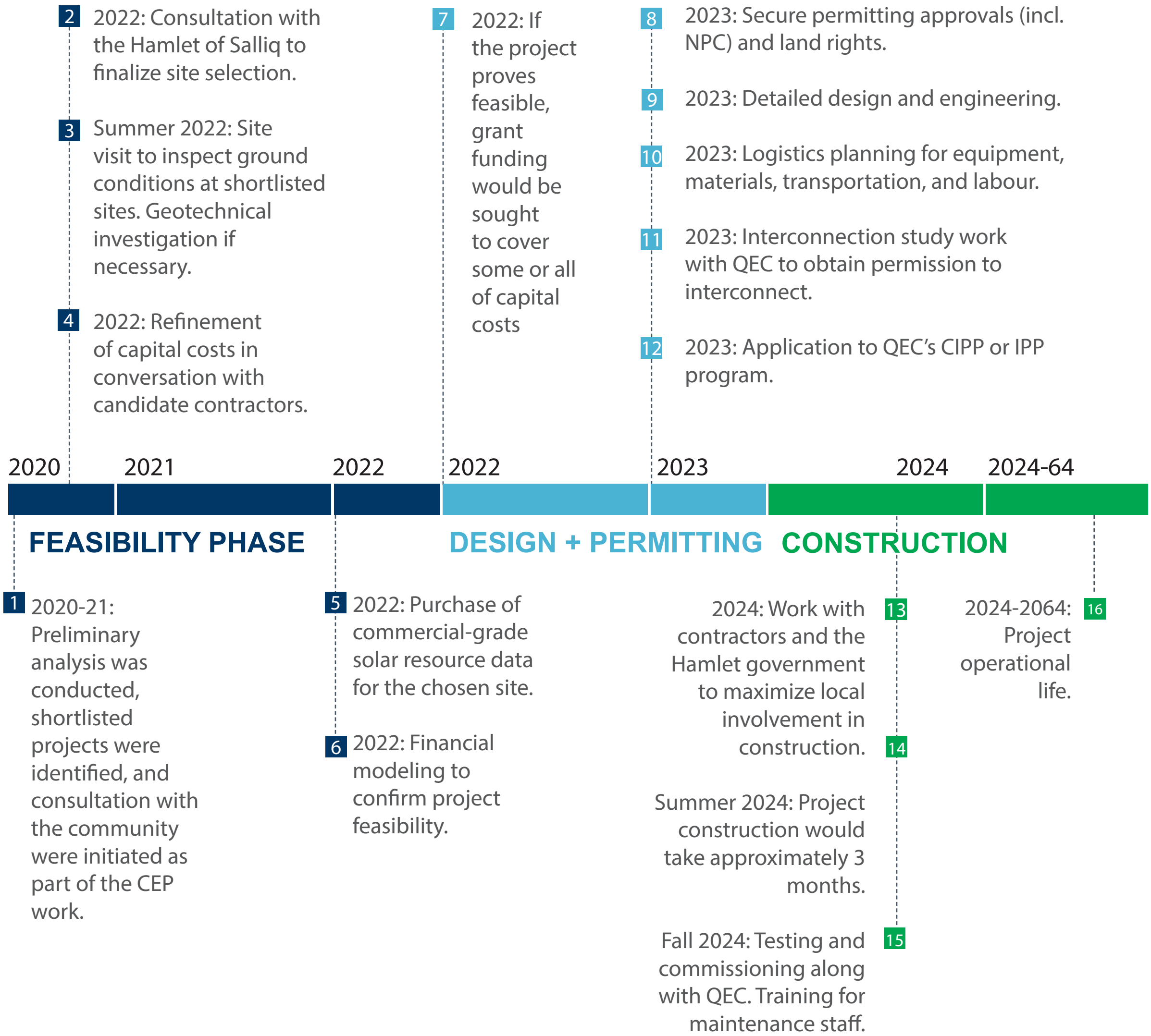
- **A combination of (1) and (2) above.**

Fortunately the community does not have to make this choice today. Efforts can be focused on the goals identified for the next 5-year period, which will require all of the community's available capacity and focus. As lessons are learned, as familiarity is gained with clean energy technologies, and as increased government funding is available - then conversations can turn to the question of how to address heating in the long run.

8.6. NEXT STEPS IN CLEAN ENERGY PROJECT DEVELOPMENT

Sakku and NEC are prepared to work with the community to investigate the feasibility of a wind and/or solar energy project in Salliq. The following timeline illustrates the steps involved in this process, including a realistic timeline.

SOLAR PV PROJECT DEVELOPMENT TIMELINE:



WIND PROJECT DEVELOPMENT TIMELINE:

2021 | 2022 | 2023 | 2023 | 2024 | 2025 | 2025-45+

FEASIBILITY PHASE

1. 2020-21: Preliminary analysis was conducted, shortlisted projects were identified, and consultation with the community were initiated as part of the CEP work.
2. Spring 2022: Consultation with the Hamlet of Salliq to finalize site selection.
3. Spring 2022: Site visit and geotechnical investigation at shortlisted sites.
4. Summer 2022: Installation of a meteorological tower to measure the wind resource for 12 months.
5. 2023: Refinement of project revenues and costs in conversation with candidate contractors.
6. 2023: Financial modeling to confirm project feasibility.

DESIGN + PERMITTING

7. 2023: If the project proves feasible, grant funding would be sought to cover some or all of capital costs.
8. 2024: Secure permitting approvals (incl. NPC) and land rights.
9. 2024: Detailed design and engineering.
10. 2024: Logistics planning for equipment, materials, transportation, and labour.
11. 2024: Interconnection study work with QEC to obtain permission to interconnect.
12. 2024: Application to QEC's CIPP or IPP program.

CONSTRUCTION

13. 2025: Work with contractors and the Hamlet government to maximize local involvement in construction.
14. Summer 2025: Project construction would take approximately 3 months.
15. Fall 2024: Testing and commissioning along with QEC. Training for maintenance staff.
16. 2025-45+: Project operational life.

Appendix A: Results of the Community Energy Survey

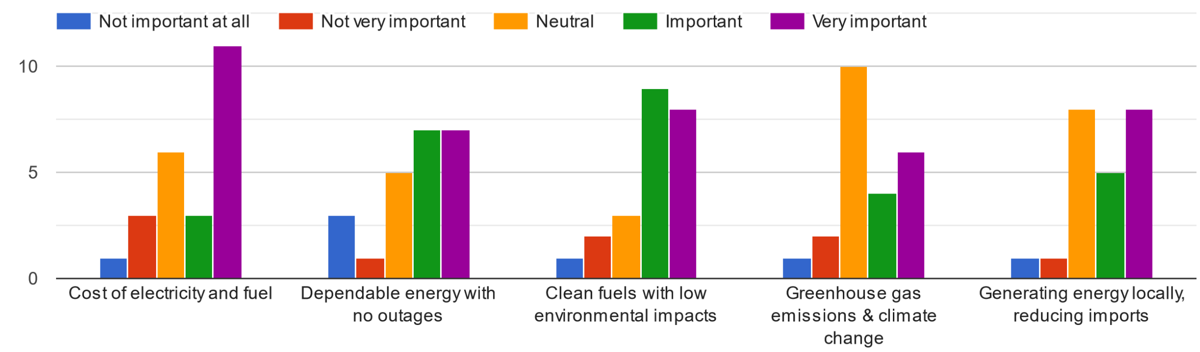
Q1 - Name:
(25 responses are confidential)

Q2 - Email address:
(25 responses are confidential)

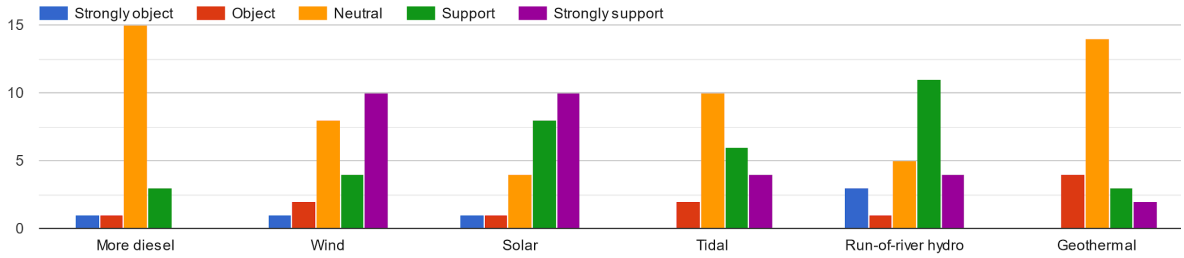
Q3 - If willing, please give us your address. We won't share it with anyone else.
(19 responses are confidential)

Q4 - What changes have you noticed because of climate change?
21 responses:
1. Polynia closer to the town, early spring than usual, fast snow melt
2. Sea ice conditions
3. Nothing yet
4. Ice condition
5. This winter has been more cold that means we used alot of fuel over the winter, this could change of how we would get heat without using fuel as much as it should. Therefore housing has been doing hard work for changing the maintenance of the main heater. This leads to many houses in a year and damage health and it's own place many more than it should have gone wrong. Like
6. More storms
7. Mining industries/pollution
8. More extreme storms
9. earlier and longer summers
10. Less snow
11. Sea ice is thinner then usual
12. More snow but faster melt
13. Increased heat, drought and insect outbreaks, all linked to climate change, have increased wildfires. Declining water supplies, reduced agricultural yields, health impacts in cities due to heat, and flooding and erosion in coastal areas are additional concerns.
14. The ocean ice is melting from the bottom
15. Not much
16. The sun usually hot on a clean day
17. It's warmer
18. This year, water on the bottom of the ice.
19. The environment in general
20. Animals skins seemed to be damaged
21. Melting faster/warmer winter

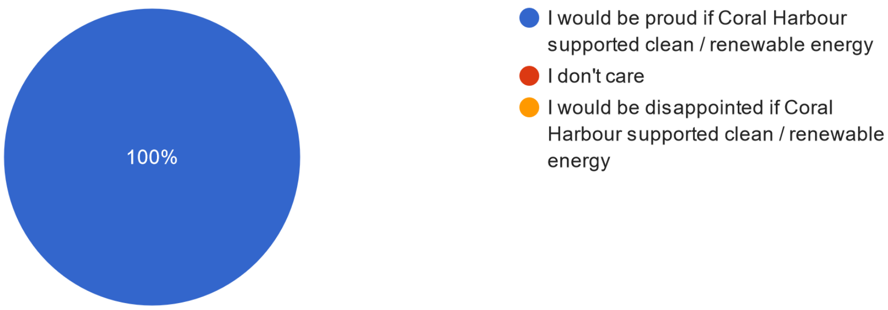
Q5 - Which energy issues are most important to you?



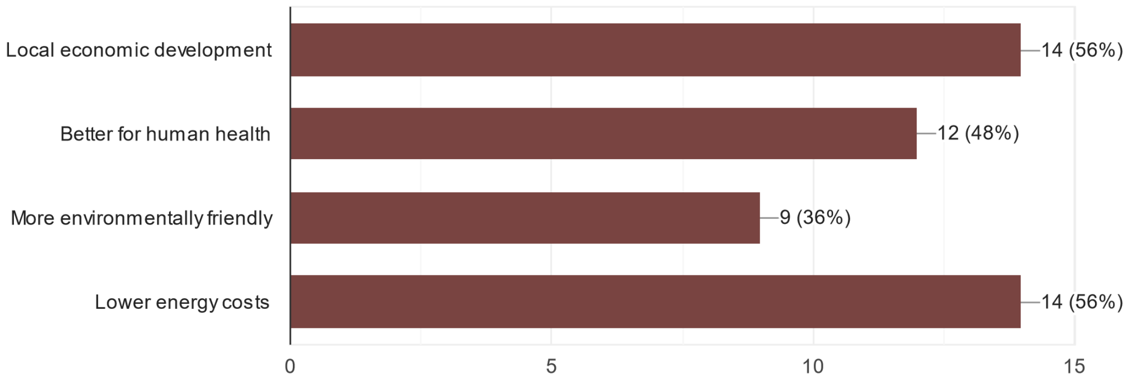
Q6 - We are studying various types of energy to see whether they could be possible in Coral Harbour. IF they are possible, which types would you like to see built?



Q7 - Which statement fits your views best?
25 responses:



Q8 - What is the main benefit you would like to see from a Clean Energy Project?
25 responses:



Q9 - What environmental factors should be considered when choosing a site for a clean energy project? Please write below. You may also add your environmental knowledge directly to this interactive map at the link below. Please click "Add Marker" and then add text to explain what is there on the map that should be protected. https://www.google.com/maps/d/drive?state=%7B%22ids%22%3A%5B%221q7XdRk8_eJHo-D2FOVSLanpVQmaY8M1c%22%5D%2C%22action%22%3A%22open%22%2C%22userId%22%3A%2211544134 8429800040592%22%7D&usp=sharing

11 responses:

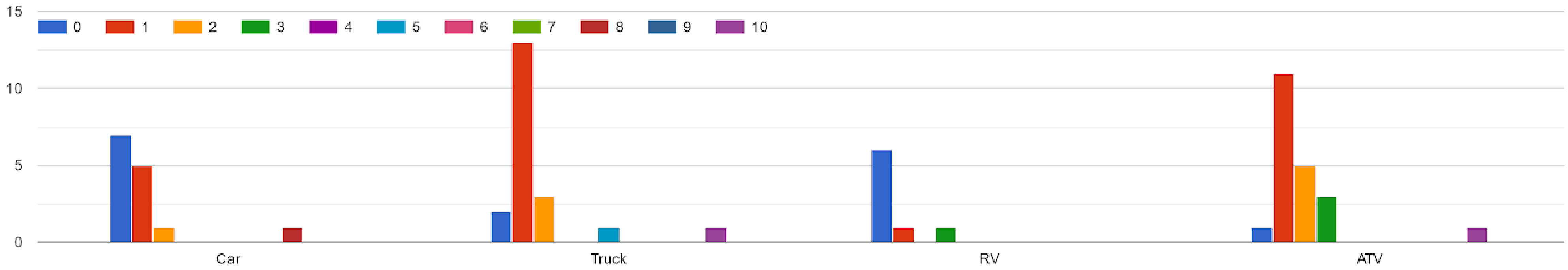
1. Local travel routes should be considered, wildlife abundance and restricted areas
2. Don't know
3. At this point any anywhere would be great cause it's our first solar system going on.
4. Be mindful of the hunting grounds.
5. I don't like the site that's mark. would consider different site @ old airport dump. Reason eye sore & raven heaven site which would be no good for water reservoir close by.
6. Otherside
7. It doesnt show on my device
8. I don't know
9. That animals are not harmed or thought of before going ahead with the projects
10. Micro dust
11. Qurluqtuuq River for hydro power
12. No spatial features were added to the interactive map.

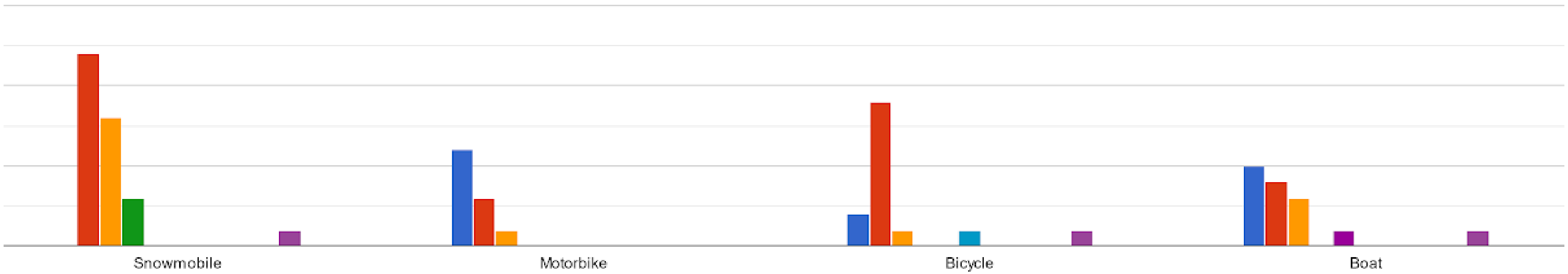
Q10 - Are you aware of any "springs" (sources of water flowing out of the ground during winter) around Coral Harbour? This can help us to develop a geothermal model for the area.

19 responses:

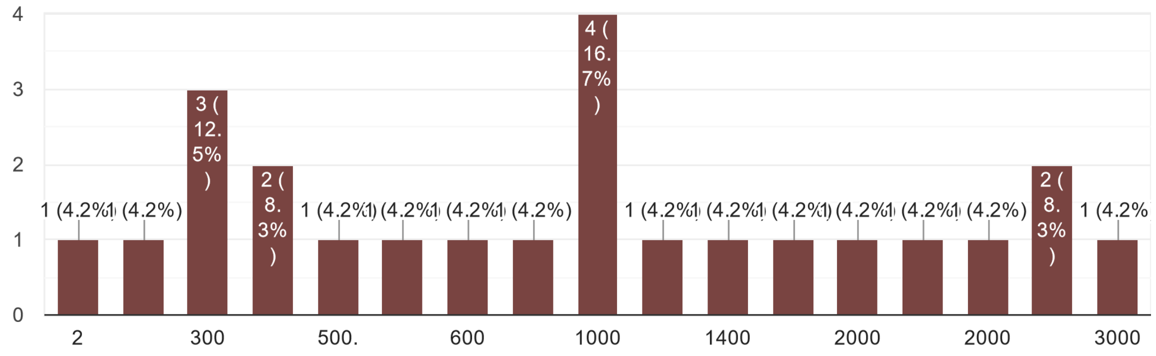
1. No
2. Not sure
3. Yes about 75 miles south.west
4. Yea
5. Some but not sufficient
6. Don't know
7. Yes
8. The local dumping ground is affecting our clean water support. The main water pump needs to get higher level after the dumping ground that's combination of two trackings of very bad bacteria, garbage and sewage lagoon.
9. I am not aware of geothermal springs for the area
10. None that i know of.
11. no
12. Kirchner Falls
13. Not aware
14. Yes
15. Only 100 miles from town
16. There is an area on this island, not sure where.
17. Nothing

Q11 - How many vehicles are there in your household?

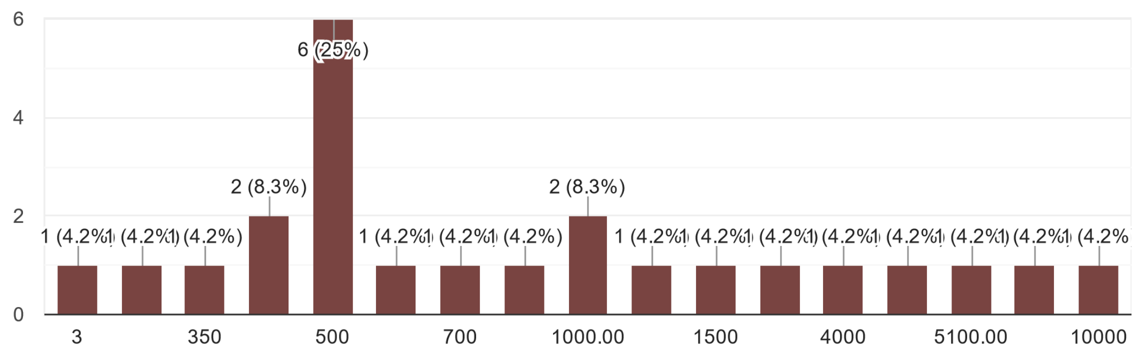




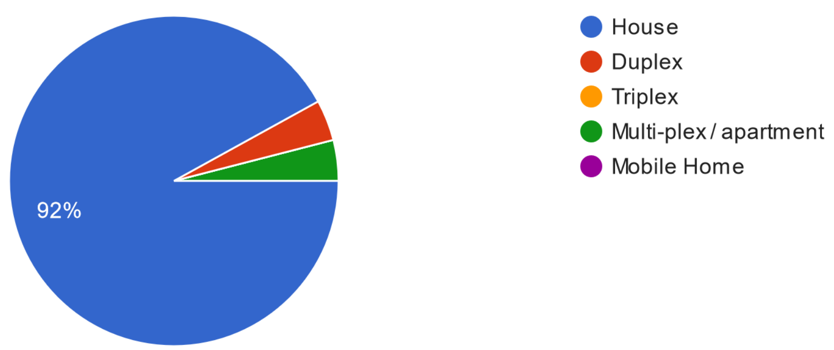
Q12 - How much ($) does your household spend per month on fuel for vehicles in SUMMER?
24 responses:



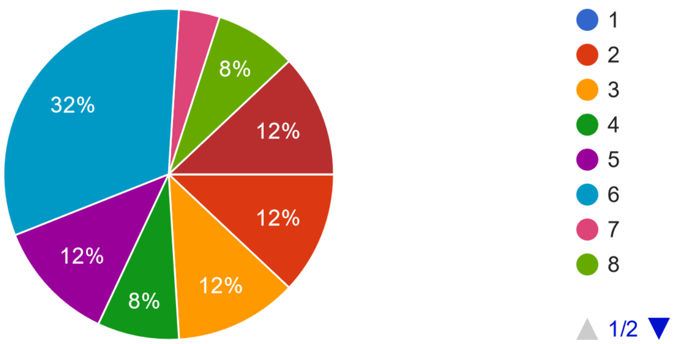
Q13 - How much ($) does your household spend per month on fuel for vehicles in WINTER?
24 responses:



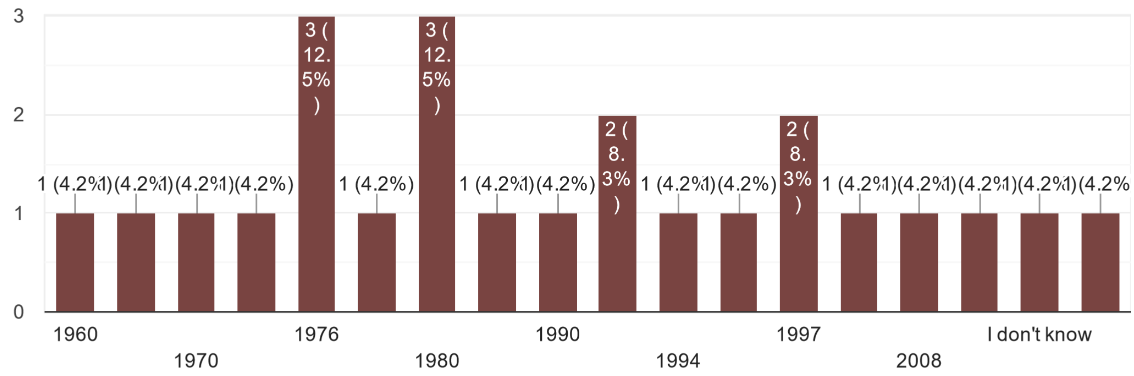
Q14 - What kind of home do you live in?
25 responses:



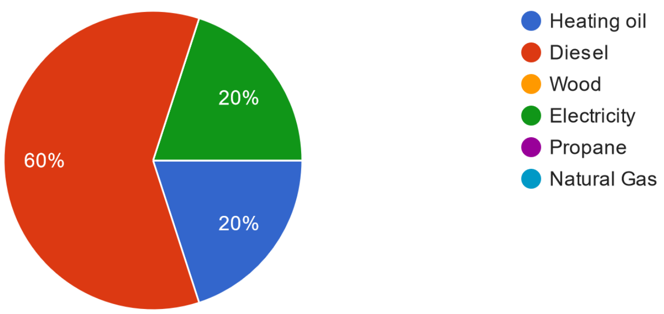
Q15 - How many people live in your home?
25 responses:



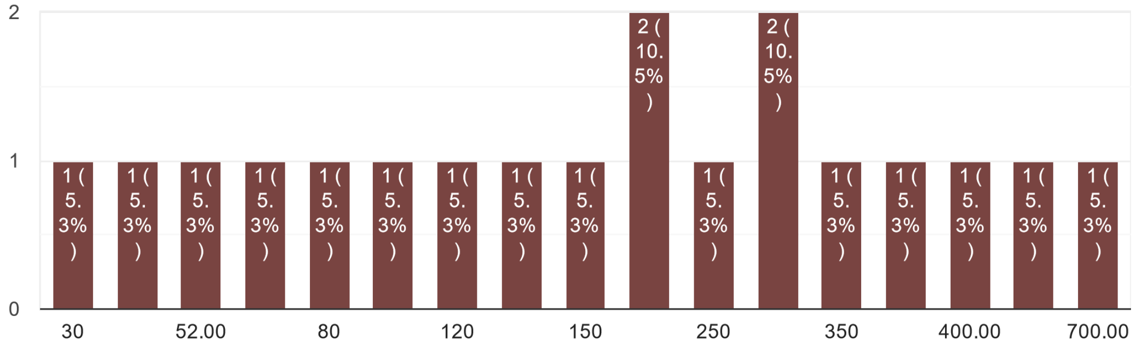
Q16 - If you know, please tell us what year your home was built.
24 responses:



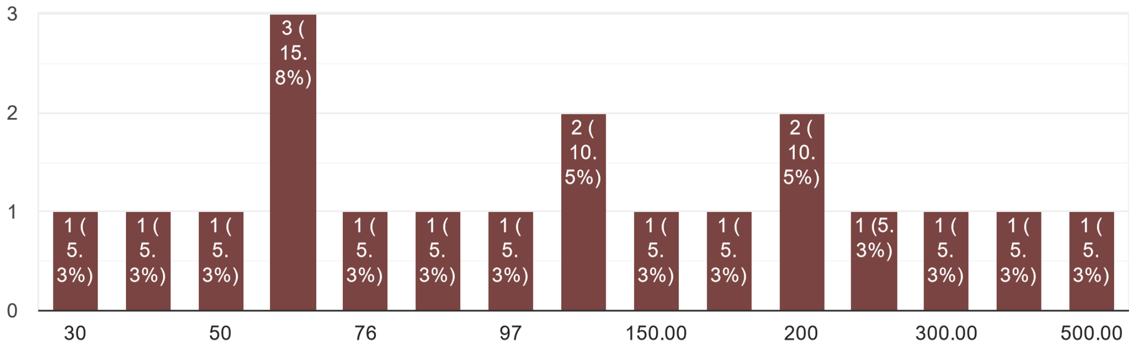
Q17 - What are the main sources of energy used in your home for heating?
25 responses:



Q18 - Electricity bill: January
19 responses:



Q19 - Electricity bill: July
19 responses:

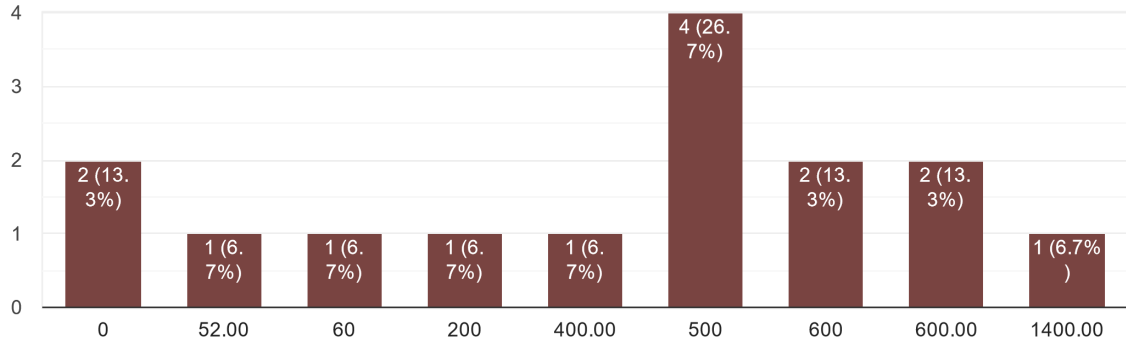


Q20 - Electricity bill: Annual total
20 responses:

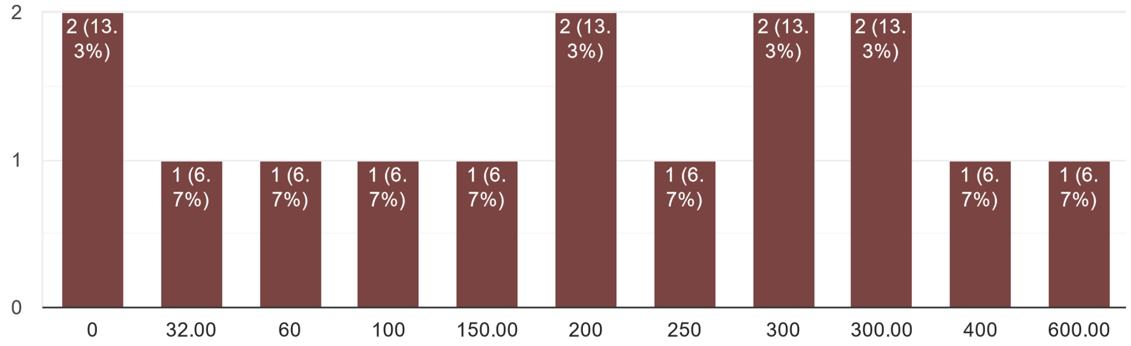
1. 360
2. 400
3. 1500
4. 120
5. 2200
6. 3000.00
7. 2500
8. 3300
9. 500.00
10. 70
11. 3500
12. 900
13. 12000.00
14. 400.00
15. 000
16. 200
17. 4900.00
18. 720
19. 100
20. 258.60

Q21 - Who pays the electricity bill in your household?
23 responses:

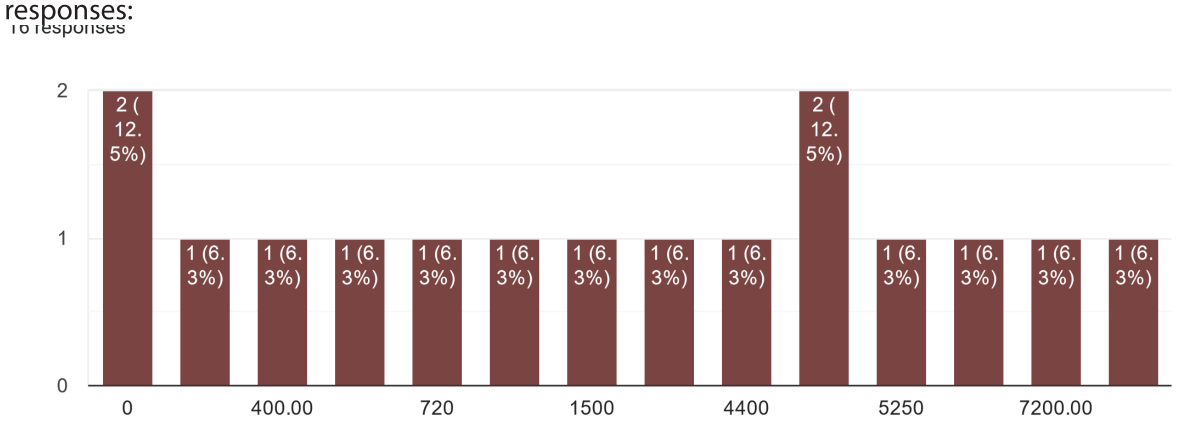
Q22 - Heating bill: January
15 responses:



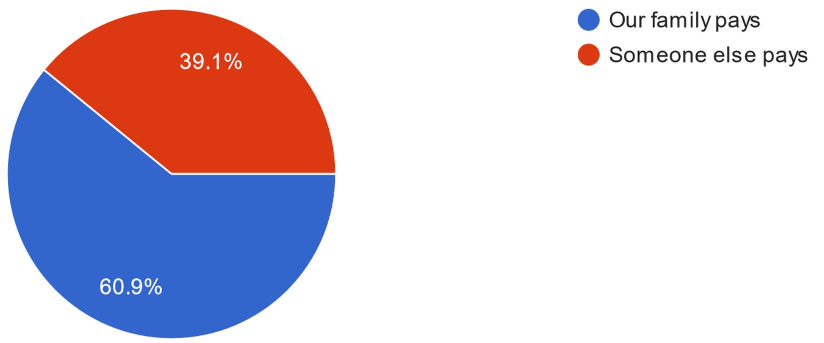
Q23 - Heating bill: July
15 responses:



Q24 - Heating bill: Annual total
16 responses:



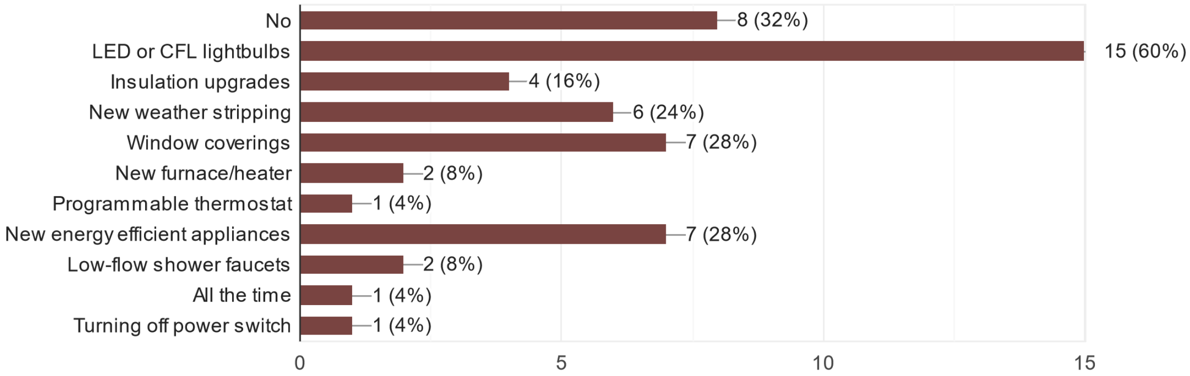
Q25 - Who pays the heating bill in your household?
23 responses:



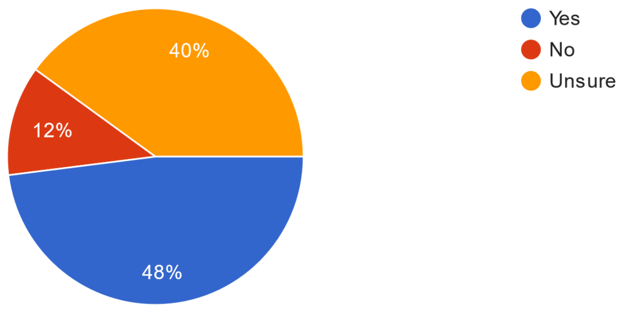
Q26 - Does your family regularly consider the costs of energy when making purchasing decisions? (e.g. LED light bulbs, energy efficient appliances, fuel efficient vehicles). If so please provide an example.
13 responses:

1. Yes
2. No comment
3. Yes we buy LED lights, we don't buy the big trucks, and yes to energy efficient appliances
4. Toaster microwave
5. Yes, led light fixtures
6. Led lights
7. No
8. not sure
9. Yes energy saving etc
10. Us

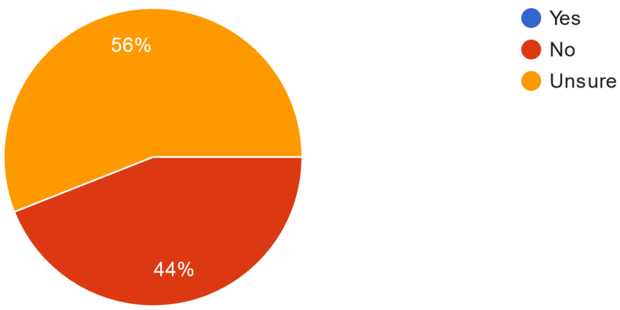
Q27 - Has your family made any improvements to your home to help reduce energy costs?
25 responses:



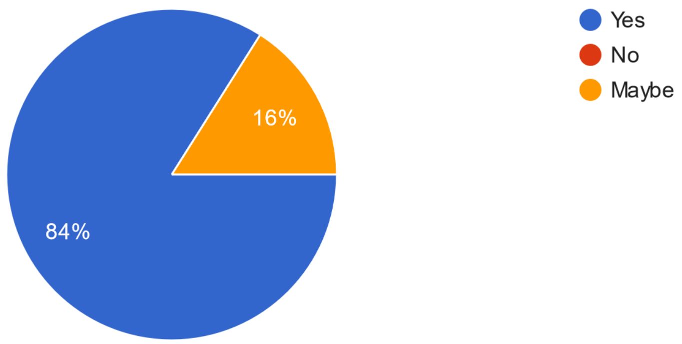
Q28 - Do you know whether your home has insulation above the entire ceiling?
25 responses:



Q29 - Have you ever had an "energy audit" to measure the energy efficiency of your home and suggest improvements?
25 responses:



Q30 - IF a free energy audit, or free home energy upgrades, were offered in future to help you reduce bills, would you participate?
25 responses:



Q31 - What actions do you think Coral Harbour should take in relation to energy?
21 responses:

1. Switch to a more eco-friendly source
2. Unsure
3. Don't know
4. Personal
5. Find energy saving system for the community
6. The power station would need a windmill for power outage over the winter.
7. Upgrade the energy lines as they are past their lifespan
8. Get windmills lol
9. somehow become energy independent
10. Hamlet of coral Harbour
11. Try save energy
12. Create more jobs for that criteria
13. Get hydro
14. Use more LEDs lights
15. Unplug what isn't being used
16. Lower the cost of power
17. Go green
18. Do solar and hydro power.
19. Housing
20. Wind turbine
21. The community council should look at windmill and see the differences fuel and power prices

Q32 - Is there anything else you would like to tell us?
13 responses (some duplicates):

1. No
2. Do pilot project on energy saving systems
3. I would like to add if you guys are surveying please assure that make this heard and the water supply needs to get higher level period, windmill is the answer for the community much cleaner and more safe not serving fuel spills all over community
4. I would consider wind power rather then solar.
5. no
6. To expensive
7. Wish me lucky
8. No going green programs

Appendix B: Building Energy Audit - Automotive Garage, Salliq

Hamlet Garage
Coral Harbour
Energy Study

Energy Study for:

Northern Energy Capital

Attention:
James Griffiths
Development Manager

Prepared by:

SES Consulting Inc.

Suite 410 – 55 Water Street
Vancouver, BC V6B 1A1
Tel: 604.568.1800
www.sesconsulting.com

January 10, 2022

Executive Summary

I. Background of the Project

SES Consulting Inc. was engaged to provide an Energy Study to analyse the present operation of Hamlet Garage located in Coral Harbour, Nunavut. The 523 m^2 5,600 ft^2) garage was constructed in 2009 and is used for storage and maintenance of the Hamlet's heavy vehicles. The Garage is open between 8:30 AM to 5:00 PM, Monday through Friday.

The building is steel framed with batt insulation (R20, 9" to 12" thick). Exterior and interior cladding is metal. The trussed roof is insulated at R50 with sheet metal cladding while the flooring is 6" concrete slab on grade with thermosiphon.

Heating for the garage is provided by an oil-fired 185,000 BTU Modine unit heater controlled by a manual Honeywell thermostat. An oil-fired Olsen 143,000 BTU/hr furnace provides ducted heating for the partial second floor and is controlled by a manual thermostat located on the second floor. Ventilation is limited to two ceiling fans and there is no mechanical cooling at this facility. Domestic hot water is provided by an oil-fired water heater and storage tank. Interior lighting is predominantly provided by T12 fluorescent fixtures while exterior lighting is comprised of five LED wall packs, both controlled by wall switches.

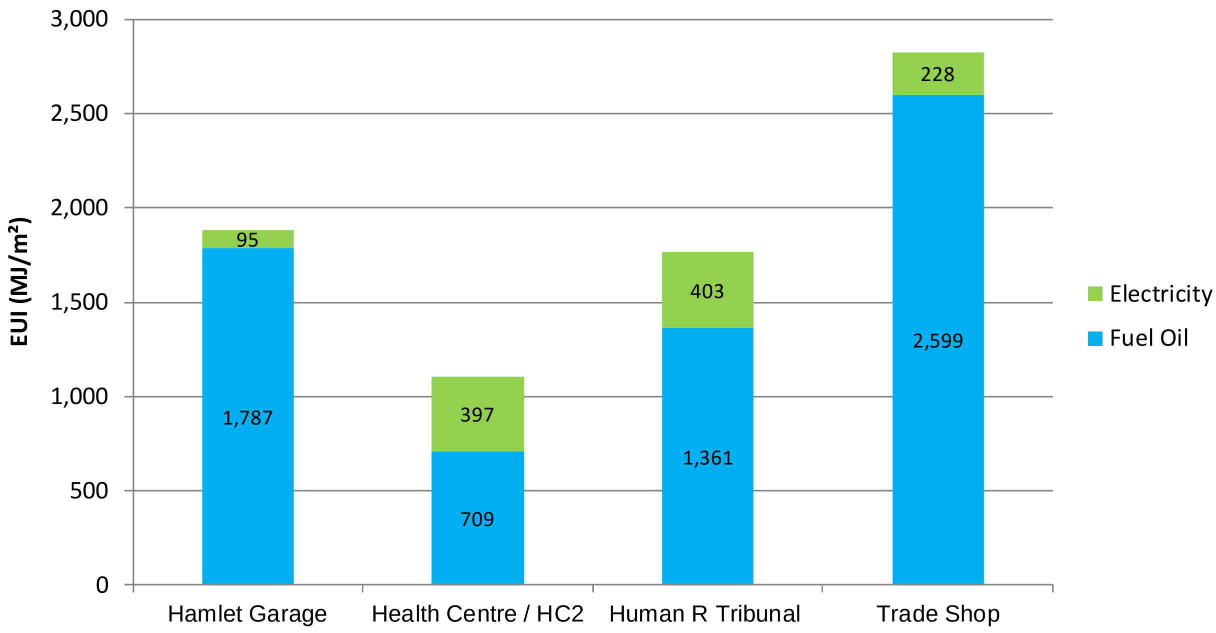
II. Consumption and Benchmarking

The facility currently produces **82** tonnes of Annual CO_2 emissions based on the following energy consumption data.

Annual Utility Costs (Inc taxes) and Consumption for the Hamlet Garage are:

Utility	Energy Use (GJ)	EUI (MJ/m^2)	Cost ($)	Cost ($/m^2)
Fuel Oil	987	1,787	$28,527	$54.54
Electricity	52	95	$5,067	$9.69
Total	**1,039**	**1,882**	**$33,593**	**$64.23**

A baseline energy consumption of 1,900 MJ/m^2 was estimated using database values of commercial buildings in the same climatic region, as well as comparing to other commercial buildings in the community that had energy data available.



III. Recommended Projects

We have identified a number of excellent opportunities to reduce electricity and fuel oil consumption in the facility and recommend the implementation of the following projects:

1. Programable Thermostats
2. Heating Occupancy Sensors/Override Buttons
3. Equipment Repair and Servicing
4. Garage Door and Window Sealing
5. LED Upgrades
6. Lighting Controls

IV. Business Case

The business case associated with each of these projects is summarized below:

Item	Description	Total Cost	Effective Payback	NPV	Annual Savings			
					$	L	kWh	GHG
3.1.1	Programmable Stats	$1,000	2.9	$2,300	$350	261	100	0.8
3.1.2	Heating OS/Override Buttons	$1,000	2.1	$5,100	$470	522	100	1.5
3.2.1	Equipment Repair and Servicing	$1,500	0.4	$39,500	$3,500	2,873	600	8.4
3.2.2	Door and Window Sealing	$3,500	1.8	$20,500	$1,900	1,828		5.0
3.3.1	LED Upgrade	$15,000	9.4	$5,800	$1,600		4,500	3.4
3.3.2	Lighting Controls	$3,500	10.0	$1,100	$350		1,000	0.8
Total	**Total**	**$25,500**	**3.1**		**$8,170**	**5,484**	**6,300**	**19.9**

V. Outcomes and Co-Benefits

These projects have the potential to produce the following outcomes:

Energy footprint	Electricity	Fuel Oil	Greenhouse gases
22%	44%	21%	24%

The projects that are evaluated in this study provide a vision for the Hamlet to reduce their environmental impact while improving reliability and redundancy. Control Measures including installing programmable thermostats, occupancy controls and photocells for the heating, ventilation and lighting can be easily implemented and provide energy savings with minimal upfront costs. Capital measures including maintaining and repairing existing HVAC equipment will provide significant energy savings and extend the life of the existing equipment. Capital infrastructure upgrades including redoing the seals on the doors and windows GHG savings and operating costs. Upgrading the lighting system to new LED fixtures would greatly reduce the electrical consumption of the facility.

We feel that these projects provide the Hamlet a great opportunity to reduce the environmental impact, energy consumption and cost of operating the Garage. If all of the recommended projects are implemented, we estimate electrical consumption will be reduced by 44%, fuel oil by 21%, and the building's greenhouse gas footprint reduced by 24%.

Hamlet Garage
- Energy Study -

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Appendices

A. Acknowledgements A1

1. Energy Study Methodology

Timing of Work: This study started in August 2020 and involved a review of potential community buildings to determine an appropriate site to audit. A site visit was then conducted by Sakku Properties' staff to gather inventory information and investigate site conditions. This included a review of the building HVAC systems and building condition. The study was completed in December 2021.

Reference Material: The following documents were provided to us to be referenced in this work:

- Description of building and equipment including condition of envelope and mechanical equipment.
- Photos of building and major equipment.

Methodology: The primary purpose of this study was to identify and evaluate opportunities to reduce energy consumption at this facility. To do this we have gathered site inventory information of all mechanical and electrical systems that consume significant amounts of energy. We then estimated the utility billing history for the site, and performed an energy balance to understand the breakdown of usage for each of the systems in the facility. Beyond that we created a list of potential conservation projects and evaluated the business case associated with these ideas. Project Costs are estimated, and the energy savings are projected using a combination of reasonable assumptions and spreadsheet-based modelling.

Consulting Team: Sean Crowley, P. Eng. – Lead Consultant
Scott Sinclair, P.Eng. – Engineering Support

2. Background Description of Facility, Hardware and Systems

2.1 Overview

The Hamlet Garage, located in Coral Harbour, Nunavut, is one and a half story building with a total conditioned area of approximately 520 m^2 and was constructed in 2009. The main floor contains the garage used for truck storage and repair, a warehouse where for truck repair items is stored, and the boiler room (furnace, domestic hot water). There are two manually controlled garage doors and entrance door. The second floor contains an office room, a rest room, a storage room, and the washroom. Generally, it is open between 8:30 AM to 5:00 PM, Monday through Friday.

This energy audit was requested by the Hamlet of Coral Harbour to be able to assess potential energy efficiency renovations and to access additional funding sources.

Facility details are presented in Table 1.

Table 1: Facility Details

Description	Details
Fuel Type	Fuel Oil
Facility type	Parking Garage
Year of construction	2009
Building age	12 years
Total conditioned floor space (m^2)	523
Number of floors	1.5
Percent glazing	0%

2.1.1 Physical Condition and Building Envelope

The building is steel framed with batt insulation (R20, 9" to 12" thick). Exterior and interior cladding is metal. The truss roof is insulated at R50 with sheet metal cladding. The flooring is 6" concrete slab on grade with thermosiphon.

Figure 1: Building Exterior

2.2 Mechanical Systems

2.2.1 Heating

Heating for the building is provided by fuel oil. The garage is heated by a 185,000 BTU Modine unit heater controlled by a manual Honeywell thermostat. An oil-fired Olsen 143,000 BTU/hr furnace provides ducted heating for the partial second floor and is controlled by a manual thermostat located on the second floor. Two 1,000 L oil tanks are located beside the garage.

Figure 2: Modine Unit Heater (left), Honeywell Thermostat (right)

2.2.2 Cooling

There is no mechanical cooling equipment at this facility.

2.2.3 Ventilation

There are 2 ceiling fans in the garage, which are used to circulate the heat. Fans are controlled by line switches.

Figure 3: Ceiling Fan (left) and switches (right)

2.2.4 Domestic Hot Water

Domestic hot water is supplied by an oil-fired 150,000 BTU/hr water heater with storage tank. A small pump provides water recirculation.

2.2.5 Mechanical Equipment Service Life

A brief overview of theoretical average service life of the mechanical equipment described in this section is presented in Table 2. Detailed inventories of all mechanical equipment and oil-fired equipment, including their simulated energy use, are attached in Appendix C and Appendix D, respectively.

Table 2: Service Life Remaining

Equipment	Age	ASHRAE Service Life*	Service Life Remaining
Modine Unit Heater	12	13	1
Olsen Oil Furnace	12	18	6
DHW Heater	12	15	3

* Based on 2007 ASHRAE HVAC Applications Manual Chapter 36, Table 4.

2.3 Electrical System

The garage is fed with a 100 A – 120/240 V service.

2.4 Lighting System

Interior lighting is provided by 50 T12 fluorescent bulbs (34 watts) with magnetic ballasts, which are switched on at the beginning of each workday and turned off at the end of the day. Exterior lighting is provided by 5 LED wall packs (80 watts) controlled by manual switches. This facility also has 10 incandescent emergency exit lights (30 watts each) which run 24/7.

Figure 4: T12 Fluorescent (top), Exterior Wall Pack (left), and Emergency (right)

2.5 Control Equipment

The oil-fired unit heater and furnace are controlled by separate Honeywell wall mounted analog thermostats. Ceiling fans and interior/exterior lighting is controlled by wall-mounted switches.

2.6 Energy Analysis

Utility data (electrical consumption / demand and fuel oil consumption) was not available for this building. Energy consumption was estimated using energy intensity benchmark data for commercial buildings for the same climatic region. Benchmark data from climatic zone 8 was obtained from the Building Performance Database and used to create the a monthly electrical and fuel oil consumption profile. This facility has limited electrical equipment so it was assumed that electricity would only account for 5% of the total building energy. Energy intensities were then compared to other community buildings that did have energy history to confirm that the estimates were reasonable. Finally, monthly equipment consumption (electricity and fuel oil) based on nameplate data and estimated run times was balanced to match the estimated annual consumption.

2.6.1 Energy Intensity Analysis

Benchmark consumption data for commercial buildings in climatic zone 8 was obtained from the Building Performance Database and is shown in Figure 5 (the figure has been reproduced to match the energy units in Figure 6).

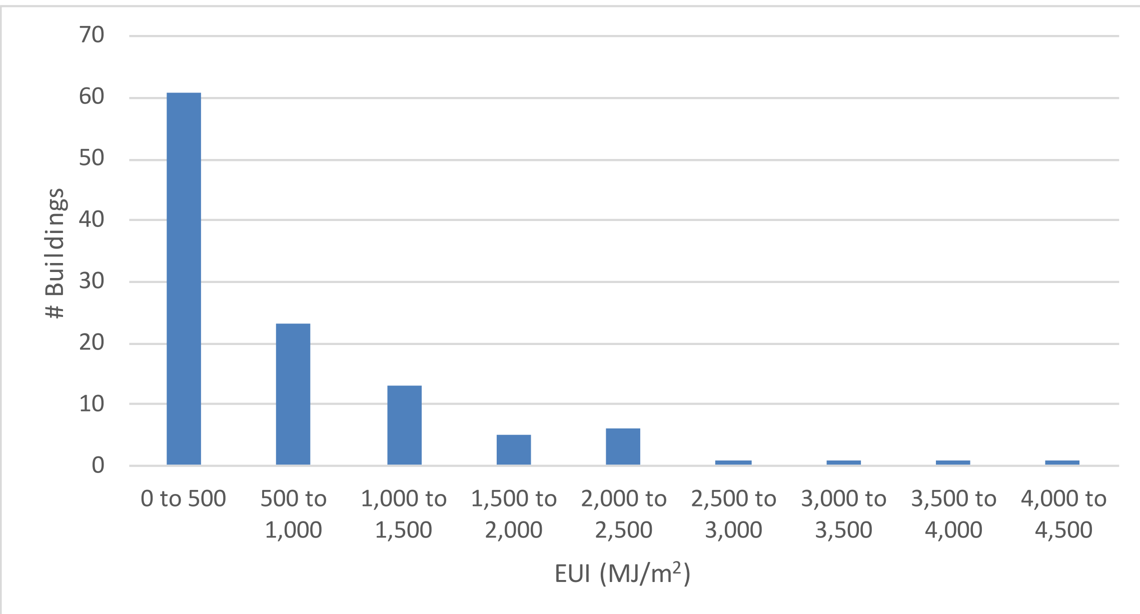


Figure 5: Building Performance Database Climatic Zone Commercial Building EUI's

Based on the description of the buildings current condition, as well as the fact that this type of facility will inherently have a high level of heat loss due to the garage doors being opened and closed, an EUI was chosen at the middle to high end of the scale. The Hamlet Garage had an estimated EUI of 1,900 MJ/m^2. This estimate was then compared with the metered EUI of other commercial buildings in the community to ensure that the value was reasonable. Figure 6 presents the comparison of estimated energy use intensity (EUI) of the Hamlet Garage and metered EUI of other commercial community buildings

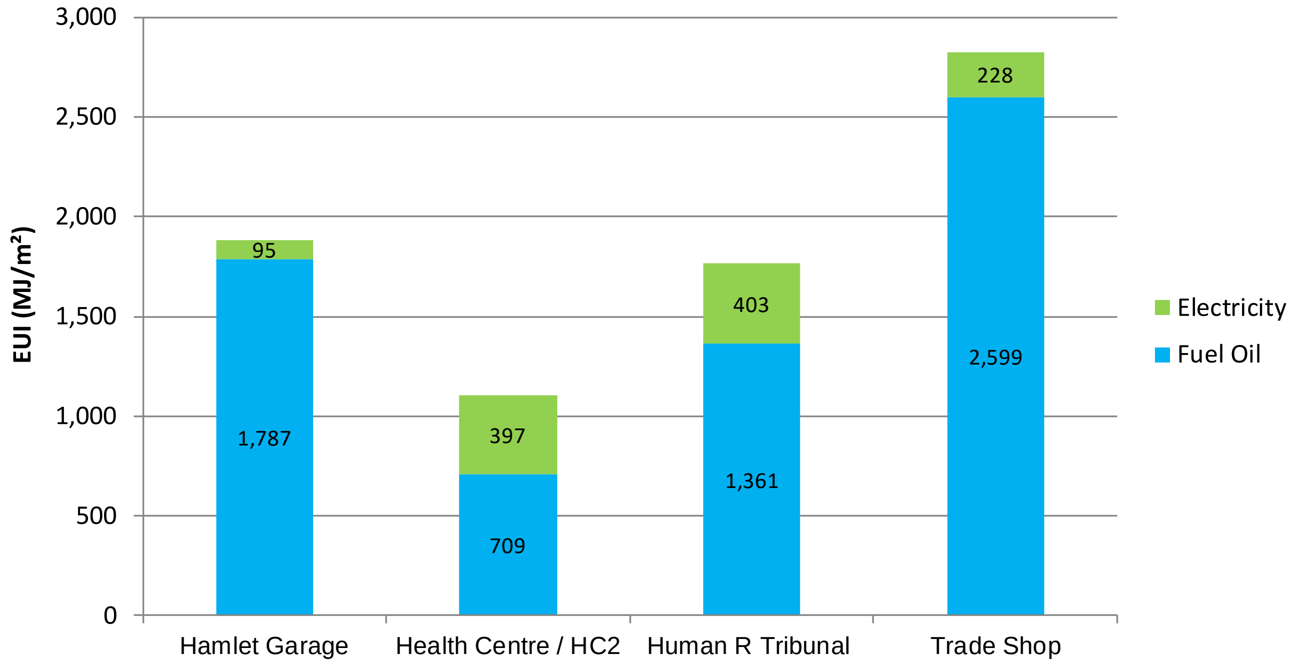


Figure 6: Energy Use Intensity Comparison

Estimated annual energy consumption and the corresponding costs and energy intensity for the Hamlet Garage are presented in Table 3.

Table 3: Annual Energy Consumption and Energy Intensity

Utility	Energy Use (GJ)	EUI (MJ/m^2)	Cost ($)	Cost ($\$/m^2$)
Fuel Oil	987	1,787	$28,527	$54.54
Electricity	52	95	$5,067	$9.69
Total	**1,039**	**1,882**	**$33,593**	**$64.23**

2.6.3 Energy Use Profiles

Figure 7 presents the estimated annual fuel oil consumption. Space heating is the primary energy use at this facility and is estimated to account for 95% of total facility energy consumption. The consumption follows a seasonal heating profile with highest consumption in January and December. During the summer months, domestic hot water accounts for the majority of oil heating.

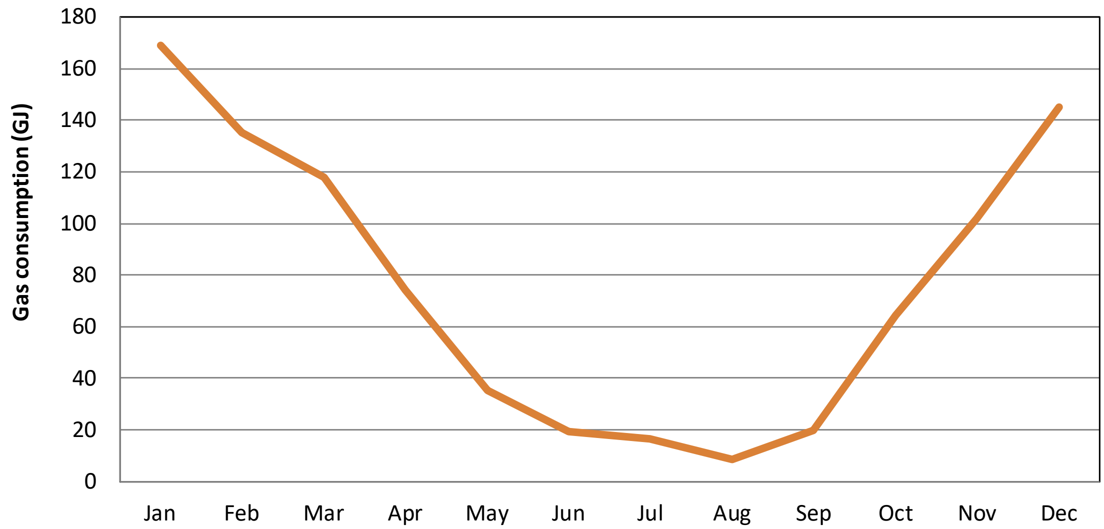


Figure 7: Monthly Fuel Oil Consumption Profile

Figure 8 presents the building's estimated electrical consumption. As this building has limited electrical equipment, it is estimated at approximately 5% of total energy consumption, with lighting accounting for the majority of the electrical consumption, with pumps and fans associated with the oil-fired unit heaters and furnace accounting for the remaining. Higher consumption in the winter and shoulder season months is a result of longer run times for lighting and heating fuel oil pumps.

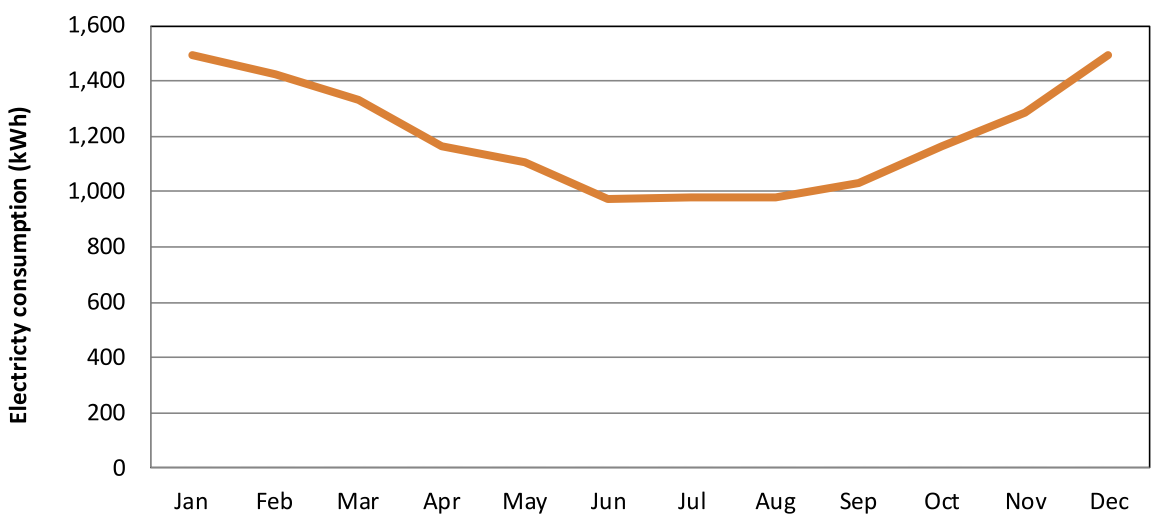


Figure 8: Electrical Consumption

2.6.4 End Use Breakdown

The percentage of energy consumption by building system is presented in Figure 9. With limited electrical equipment at this facility, lighting accounts for the majority of the consumption with pumps and fans associated with the oil-fired unit heaters and furnace the next largest consumer.

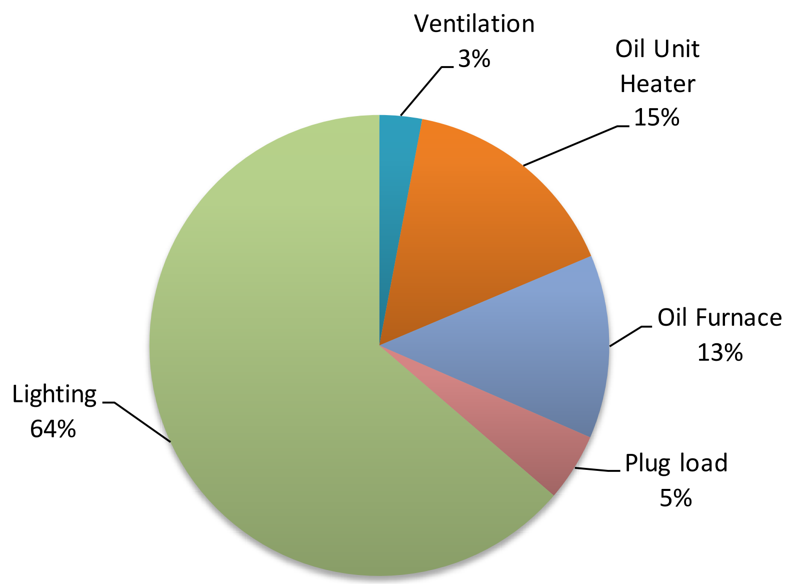


Figure 9: Electricity Consumption

Electrical and fuel oil consumption, in equivalent units of energy, is presented in Figure 10. Fuel oil consumption accounts for the vast majority of the energy consumption at this facility. We have identified several opportunities to reduce fuel oil consumption, which will be discussed in Section 3.

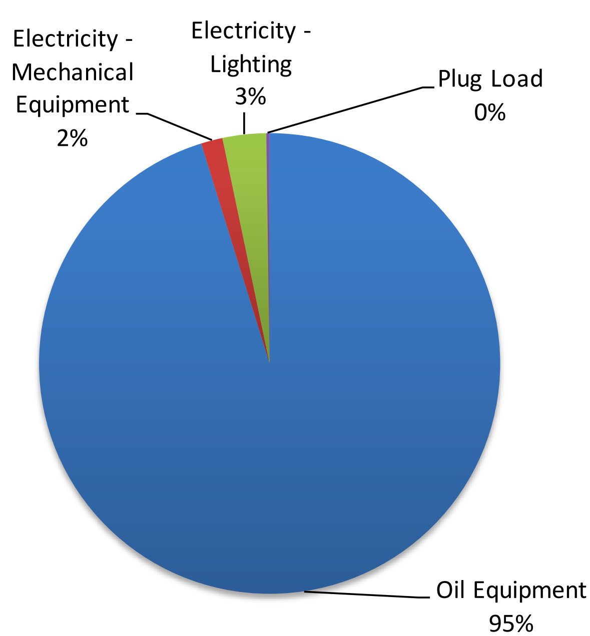


Figure 10: Fuel Oil and Electricity

3. Energy Conservation Opportunities

The primary objective of this study was to identify and analyse energy conservation opportunities at the Hamlet Garage. Electricity in the Hamlet is subsidised by the Government of Nunavut. Commercial customers are eligible for a reduced rate on the first 1,000 kWh each month, with any subsequent use charged at the full rate. Rate schedules for fuel oil was not available for this facility, therefore, prices used in this analysis for financial savings estimates were based on average rates from other commercial buildings in the community. Electricity and fuel oil prices and are presented in Table 4. For Greenhouse Gas estimates, we have used emissions factors of 0.00076 tonne CO_2e / kWh of electricity, and 0.072 tonne CO_2e / GJ for fuel oil.

Table 4: Rate Schedules

Utility	Rate
Electricity	
Standard Rate	$0.7458 / kWh (inc taxes)
Subsidised Rate	$0.242 / kWh (inc taxes)
Average Rate	$0.351 / kWh (inc taxes)
Fuel Oil	
Recent Fuel Oil Rate	$0.994 / L (inc taxes)
Recent Fuel Oil Rate	$28.89 / GJ (inc taxes)

A number of potential conservation opportunities have been analyzed and are broken down in this section between control upgrades, capital upgrades and lighting upgrades. A detailed explanation as well as an estimated cost and energy saving potential are summarized for these projects.

3.1 Control Measures

A summary of the analysis for the recommended control upgrades is presented in Table 5. Detailed descriptions for each project are presented below.

Table 5: Control Measures Summary

Item	Description	Total Cost	Simple Payback	Annual Savings			
				$	L	kWh	GHG
3.1.1	Programmable Stats	$ 1,000	2.9	$ 350	261	100	1
3.1.2	Heating OS/Override Buttons	$ 1,000	2.1	$ 470	522	100	2
Total		$ 2,000	**2.4**	$ 820	**783**	**200**	**2.3**

3.1.1 Programmable Thermostats

The oil-fired unit heater and furnace are currently controlled by manual thermostats. This type of limited control often leads to unnecessary heating during unoccupied periods since it relies on occupants to manually setback the space temperature setpoint. We recommend replacing the wall mounted non-programmable thermostats with programmable thermostats that have 7-day scheduling and setback capabilities. This will allow separate occupied and unoccupied heating setpoints, resulting in fuel oil savings. In order to optimize savings associated with this measure we also recommend that the occupants be trained to use the new thermostats effectively.

3.1.2 Heating Occupancy Sensors / Timers

The programmable thermostats outlined in Section 3.1.1 are able to setback space temperature setpoints during known unoccupied times (typically evening and weekends). However, they are not able to setback setpoints when the building is unoccupied during the occupied schedule.

To further reduce space heating energy requirements during the occupied schedule, we recommend adding occupancy sensors or timers to setback the space heating setpoint during the occupied schedule when the building is unoccupied. This will ensure that the space is not overly heated when people are not present.

3.2 Capital Measures

A summary of the analysis for the recommended capital upgrades is presented in Table 6. Detailed descriptions for each project are presented below.

Table 6: Capital Measures Summary

Item	Description	Total Cost	Simple Payback	Annual Savings			
				$	L	kWh	GHG
3.2.1	Equipment Repair and Servicing	$ 1,500	0.4	$ 3,500	2,873	600	8.4
3.2.2	Door and Window Sealing	$ 3,500	1.8	$ 1,900	1,828		5.0
Total		$ 5,000	**0.9**	$ 5,400	**4,701**	**600**	**13.4**

3.2.1 Equipment Repair and Servicing

The heating equipment is relatively new and in good working order, however it is unknown when the units were last serviced. We recommend that the furnace, unit heater and DHW heater have their combustion efficiency checked and that the unit be serviced if they are not performing to expected levels. Typically, this type of servicing would be performed during regular maintenance checks, but due to the remoteness of the community there may not be a technician available and is likely that the units are not performing up to nameplate standards.

3.2.2 Door and Envelope Sealing

We recommend that targeted air sealing projects be implemented around the garage doors, entrance door and windows to reduce any air inflation, which can be a major source of heat loss.

3.3 Lighting Opportunities

Lighting conservation projects are presented in Table 7. Detailed descriptions for each project are presented below.

Table 7: Lighting Upgrades Summary

Item	Description	Total Cost	Simple Payback	Annual Savings		
				$	kWh	GHG
3.3.1	LED Upgrade	$ 15,000	9.4	$ 1,600	4,500	3.4
3.3.2	Lighting Controls	$ 3,500	10.0	$ 350	1,000	.8
Total		$ 18,500	**9.5**	$ 1,950	**5,500**	**4.2**

3.3.1 LED Lighting Upgrades

The facility currently has approximately 50 T12 fluorescent luminaires (34 watts each) as well as 10 incandescent emergency lights that run 24/7. This form of lighting is outdated and quite inefficient compared to modern technology. We recommend upgrading to LED versions of luminaires, which can typically be installed in place of traditional bulbs (if the lights currently have magnetic ballasts, they must first be disconnected by an electrician prior to installing the LED bulbs).

3.3.2 Photocell and Lighting Timers

As with the occupancy controls/timers discussed for the heating system in Section 3.1.2, we recommend installing a photocell for exterior lights and timers on the interior lights to ensure that they are not left on when no one is in the space. A digital timer would allow the occupants to set the duration of the lights, and not have to worry about turning the lights off at the end of the day.

3.4 Projects Analysed by not Recommended

The following project presented in Table 8 was evaluated but have been excluded from the recommended projects due to the high payback as well as the existing unit's current condition. We still feel that this project would be a worthwhile upgrade when the units are required to be replaced, however it does not have a good payback based on energy savings alone.

Table 8: Projects Analysed but Not Recommended

Item	Description	Total Cost	Simple Payback	Annual Savings			
				$	L	kWh	GHG
3.4.1	High Efficiency Equipment	$ 60,000	33	$ 1,800	1,567	200	4.5
Total		$ 60,000	**33**	$ 1,800	**1,567**	**200**	**4.5**

3.4.1 High Efficiency Equipment

The current UH and furnace have a combustion efficiency of approximately 80%. Both units are fairly new and do not need to be replaced at this time. However, when these units are required to be replaced due to maintenance reasons, we recommend that higher efficiency (up to 87%) units be installed.

4. Financial Analysis

Table 9 presents a financial analysis of the energy conservation measures presented above.

Table 9: Financial Analysis

Item	Description	Project Cost	Savings		Simple Payback	First Year Savings	Life Expectancy	NPV	IRR
			L	kWh					
	Control ECMs								
3.1.1	Programmable Stats	$1,000	261	100	2.9	$350	15	$2,300	33%
3.1.2	Heating OS/Override Buttons	$1,000	522	100	2.1	$470	15	$5,100	61%
	Capital ECMs								
3.2.1	Equipment Repair and Servicing	$1,500	2,873	600	0.4	$3,500	20	$39,500	216%
3.2.2	Door and Window Sealing	$3,500	1,828		1.8	$1,900	20	$20,500	57%
	Lighting ECMs								
3.3.1	LED Upgrade	$15,000		4,500	9.4	$1,600	15	$5,800	13%
3.3.2	Lighting Controls	$3,500		1,000	10.0	$350	15	$1,100	12%
	Total Recommendations	**$25,500**	5,484	6,300	**3.1**	**$8,170**	**16.0**	**$74,300**	**35%**

Our financial analysis is based on an annual fuel cost escalation rate of 2.1%, and a discount rate of 7.5%. Carbon pricing has been fixed at 2021 rates. Please note that a weighted average life expectancy has been used to analyze the 'Total' NPV of these projects.

5. Conclusion

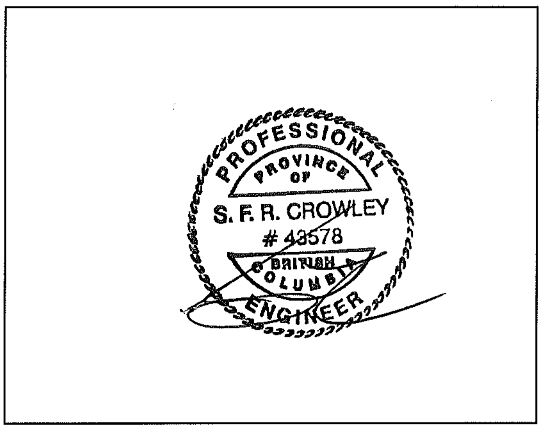
The Hamlet Garage is an excellent candidate for efficiency upgrades. We have identified a number of low-cost control and lighting energy saving opportunities, including programmable thermostats, occupancy control/timers and photocells for the heating, ventilation and lighting systems, and upgrading to LED lights, which can be easily implemented at a minimal cost. As well, repairing and servicing existing equipment will increase efficiency without needing a high capital investment.

Capital measures such as upgrading the sealing on the doors and windows reduce the energy consumption of the building as well as GHG savings.

If all of the recommended projects are implemented, we estimate electrical consumption will be reduced by 44%, fuel oil by 21%, and the building's greenhouse gas footprint reduced by 24%.

PROJECT ENGINEER'S APPROVAL

The calculations contained in this document have been reviewed for accuracy and completeness by:
Sean Crowley, P.Eng.



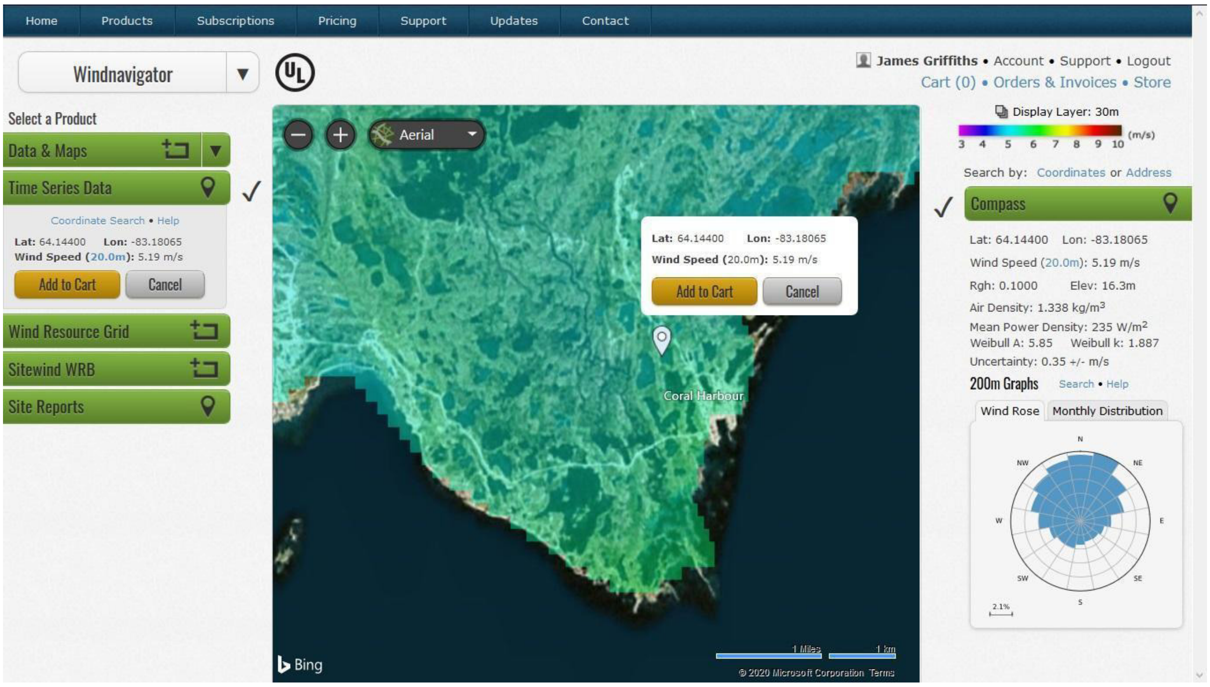
Signature: ____________ Date: Jan 10, 2022

Appendix A - Acknowledgments

SES Consulting Inc. would like to acknowledge the valuable assistance of the following personnel in providing the necessary information for this report.

This report was created and written by Sean Crowley. In addition, this report was prepared with the assistance of Blaine Chislett from Sakku Properties and Hyacinthe Djouaka from the Nunavut Department of Environment, Climate Change Secretariat, who conducted the site visit and coordinated with the Hamlet. Their cooperation and contributions to the project are greatly appreciated.

Appendix C: Predicted Wind Resource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Wind Speed (20.0m): 5.19 m/s
Rgh: 0.1000 Elev: 16.3m
Air Density: 1.338 kg/m³
Mean Power Density: 235 W/m²
Weibull A: 5.85 Weibull k: 1.887
Uncertainty: 0.35 +/- m/s
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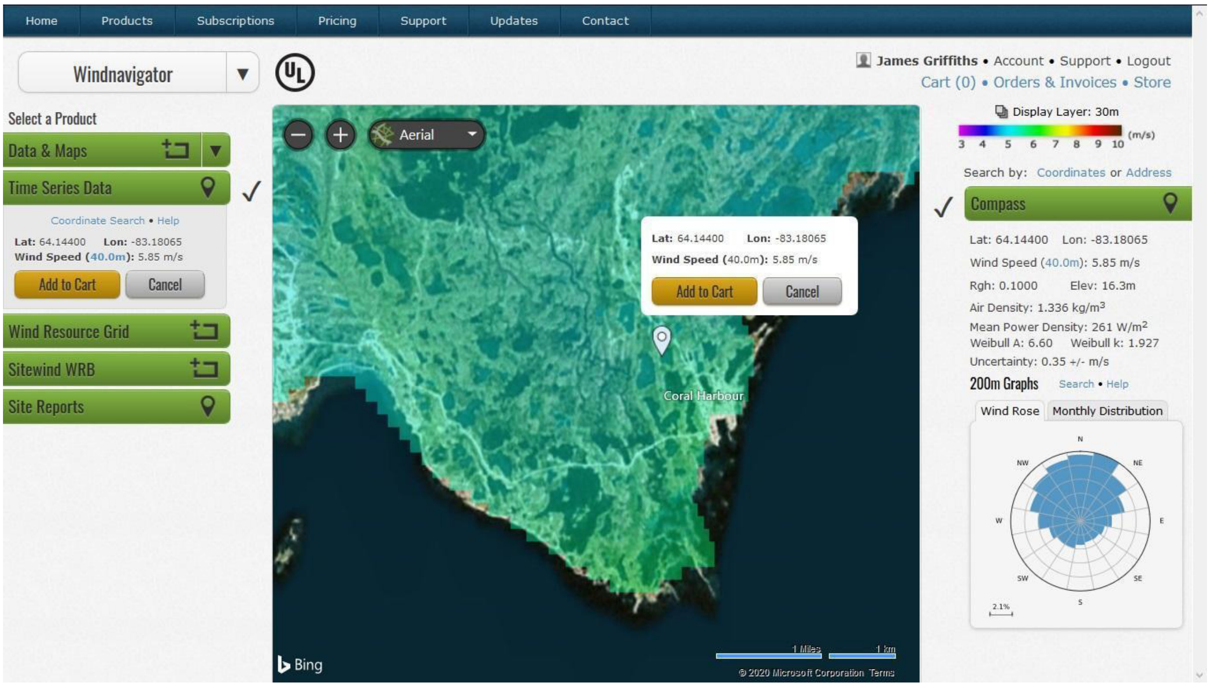
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Wind Speed (40.0m): 5.85 m/s
Rgh: 0.1000 Elev: 16.3m
Air Density: 1.336 kg/m³
Mean Power Density: 261 W/m²
Weibull A: 6.60 Weibull k: 1.927
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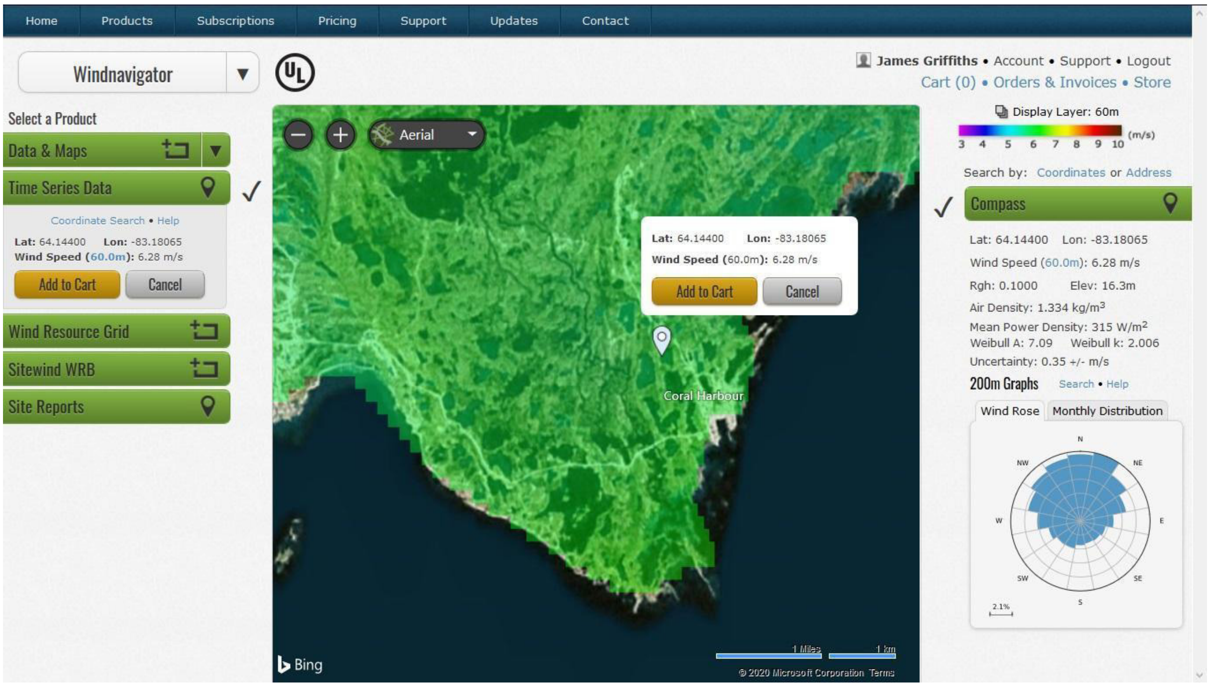
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Air Density: 1.334 kg/m3
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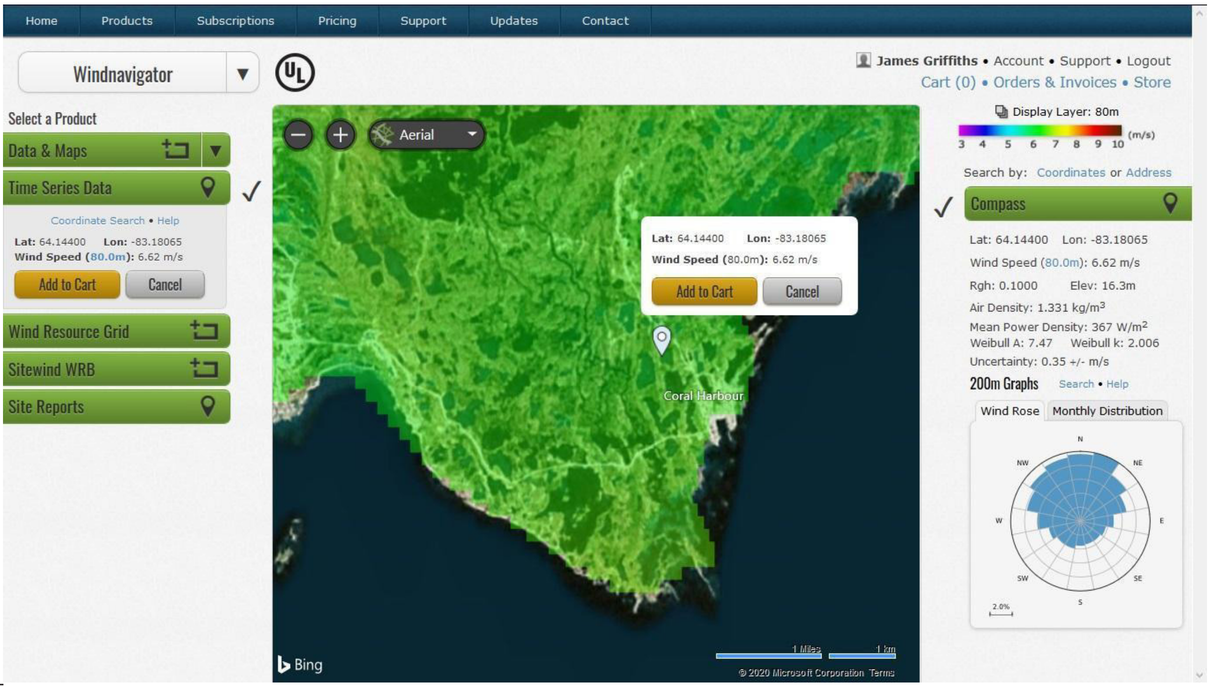
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Mean Power Density: 367 W/m2
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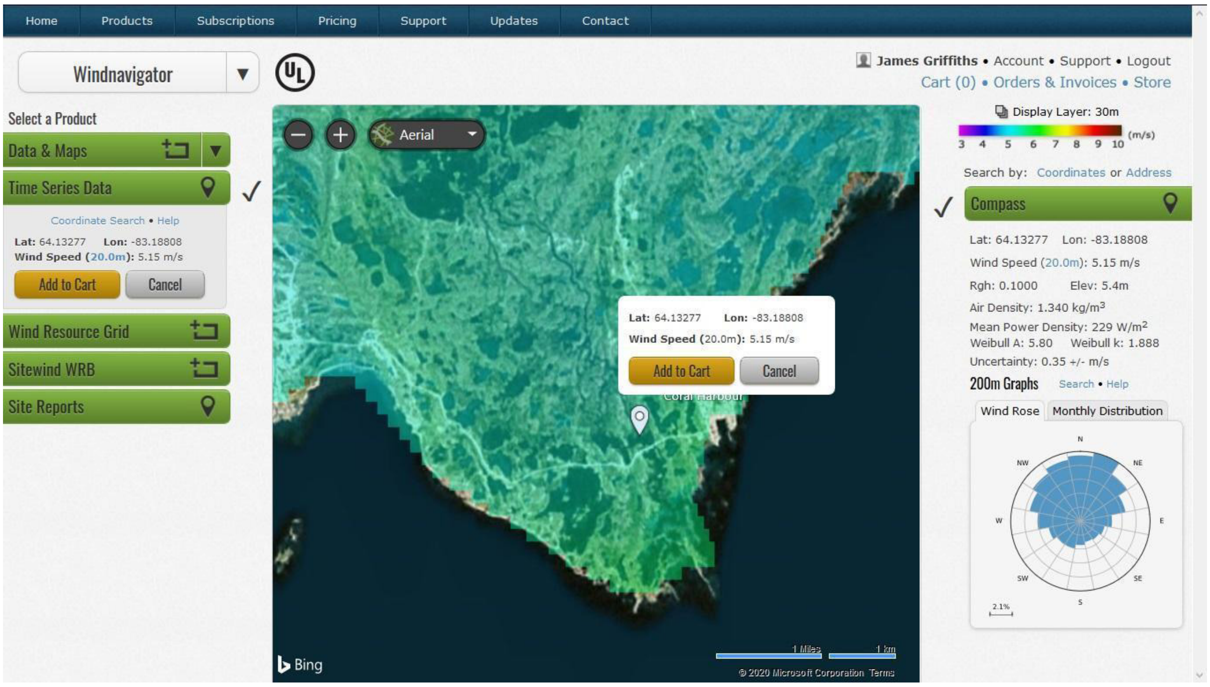
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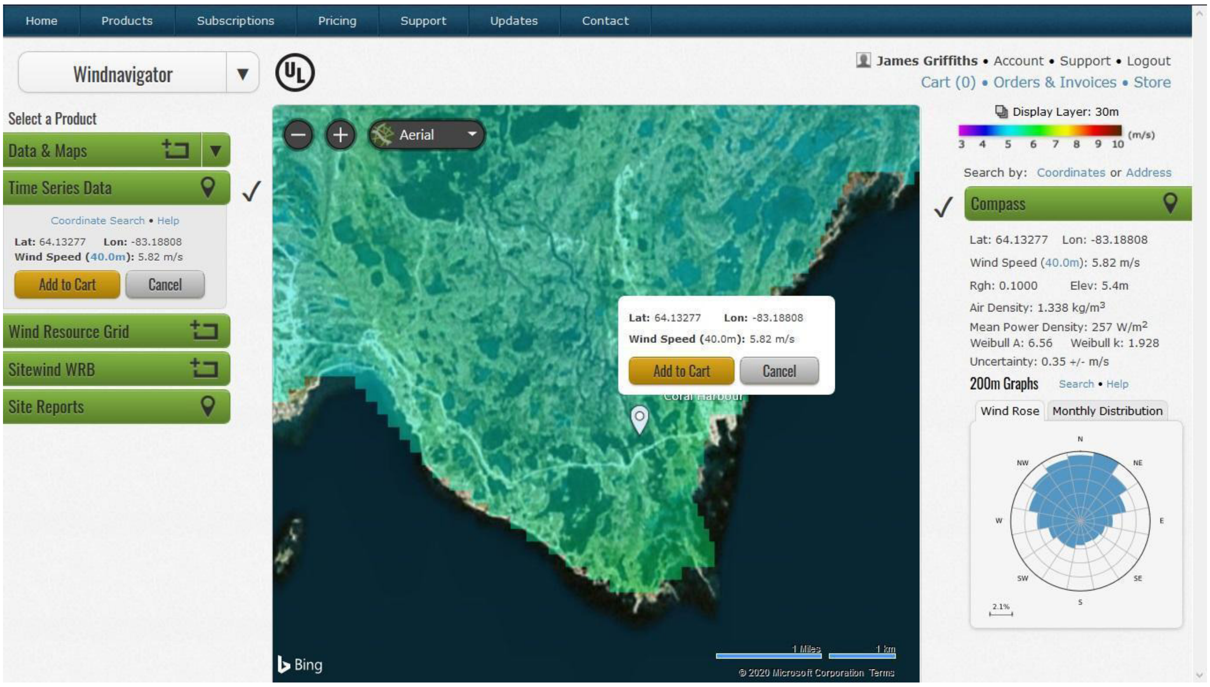
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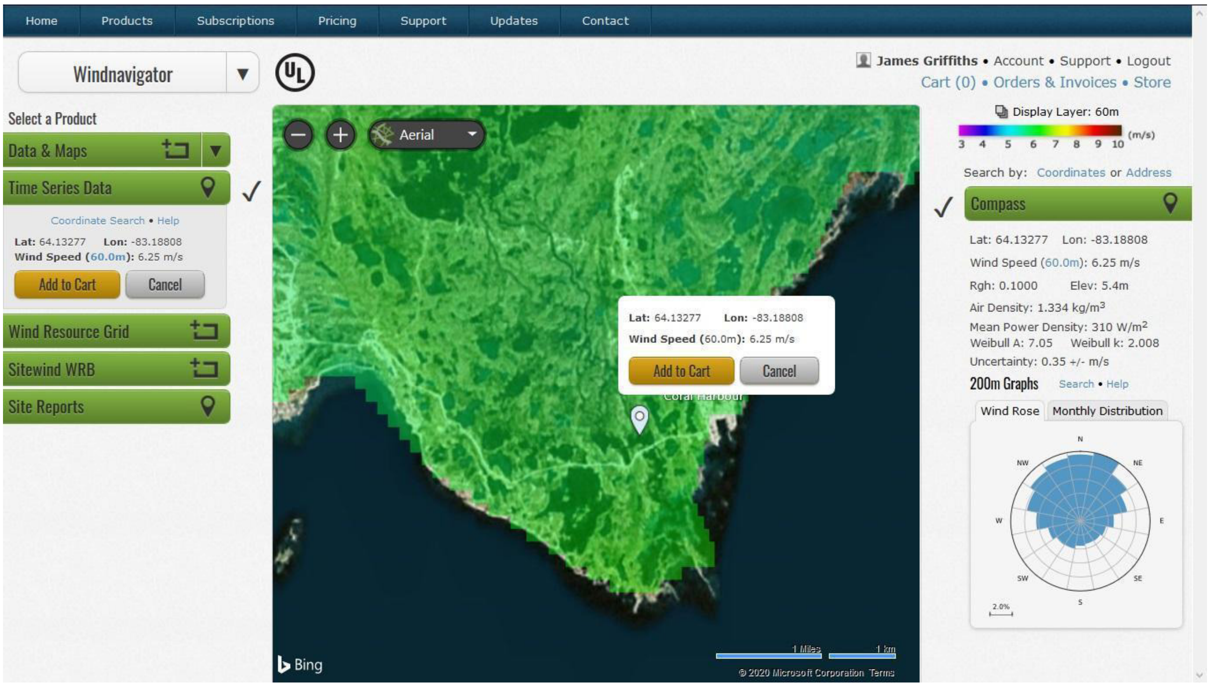

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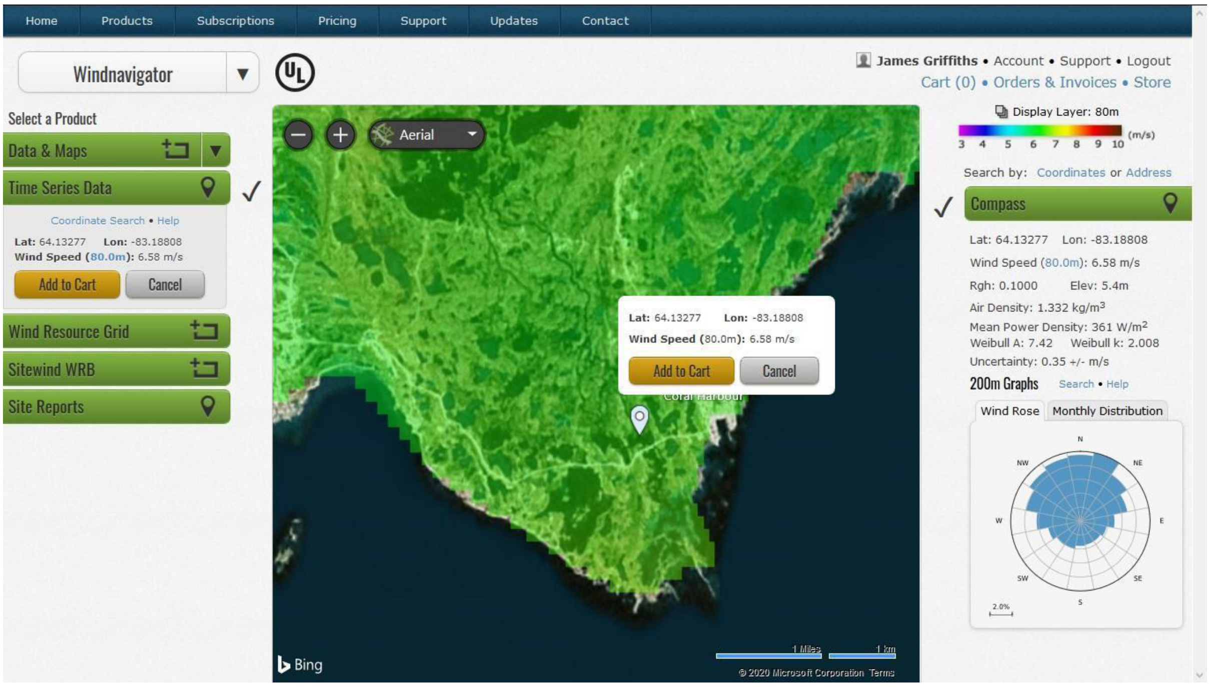

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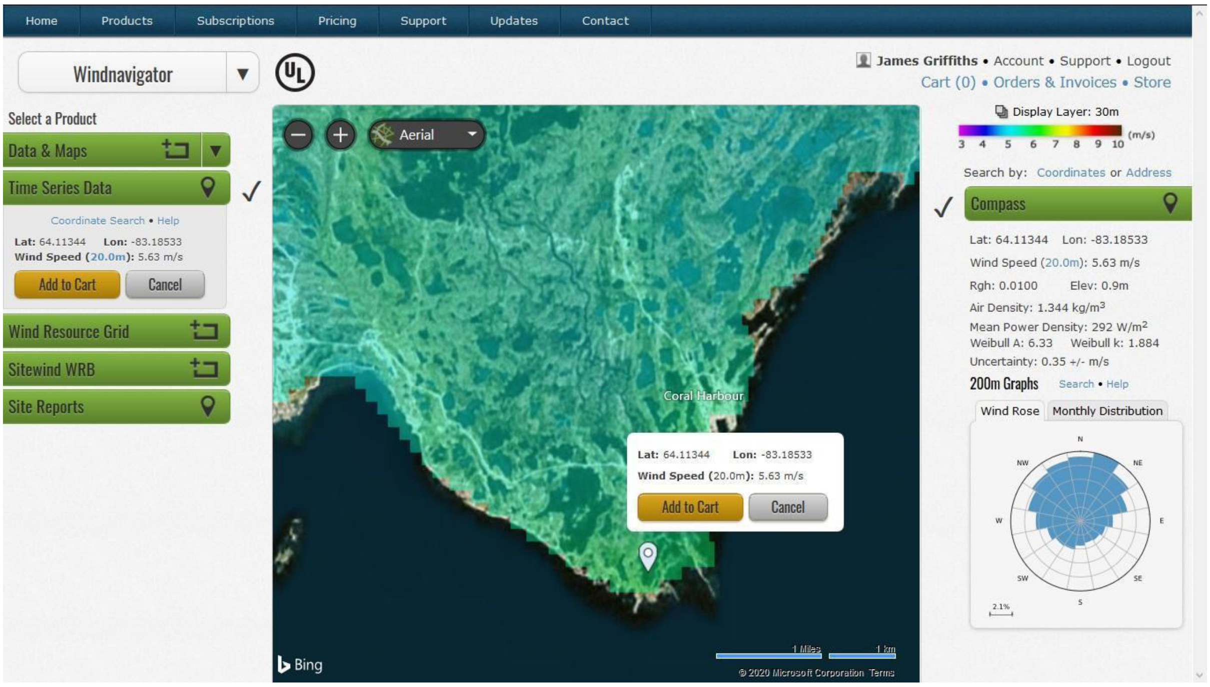

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Uncertainty: 0.35 +/- m/s
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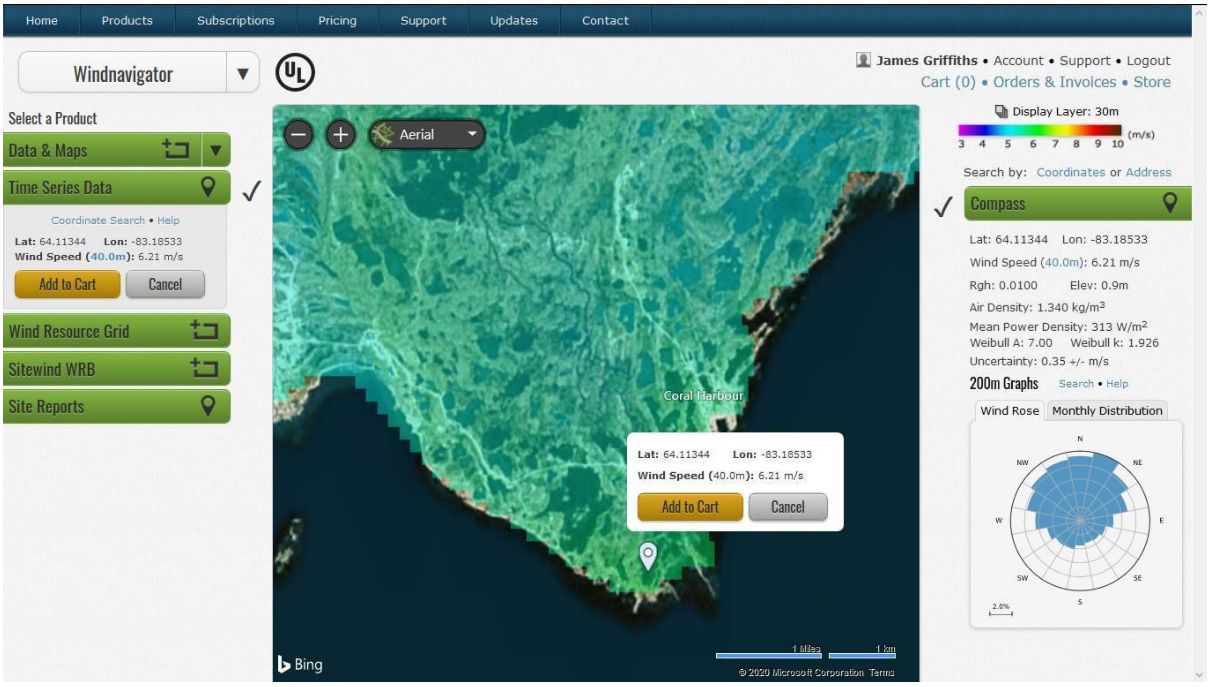

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Lat: 64.11344 Lon: -83.18533
Wind Speed (40.0m): 6.21 m/s
Rgh: 0.0100 Elev: 0.9m
Air Density: 1.340 kg/m³
Mean Power Density: 313 W/m²
Weibull A: 7.00 Weibull k: 1.926
Uncertainty: 0.35 +/- m/s
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Wind Rose Monthly Distribution
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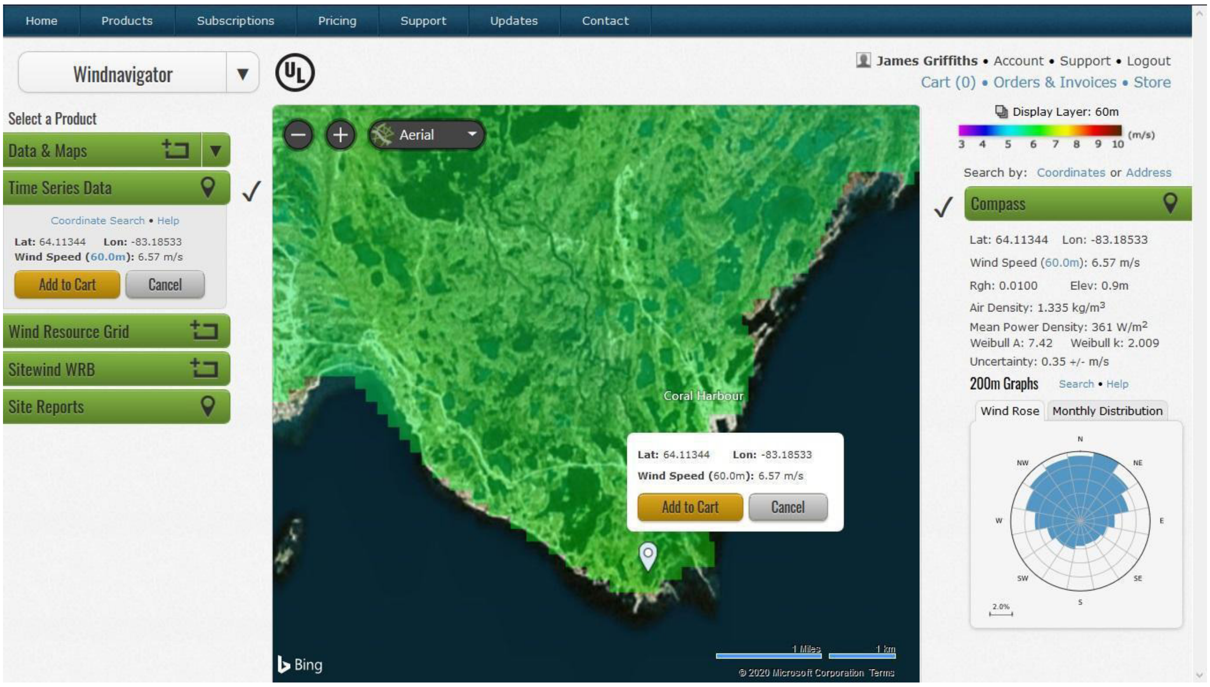
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Wind Speed (60.0m): 6.57 m/s
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Display Layer: 60m
Search by: Coordinates or Address
Compass
Lat: 64.11344 Lon: -83.18533
Wind Speed (60.0m): 6.57 m/s
Rgh: 0.0100 Elev: 0.9m
Air Density: 1.335 kg/m3
Mean Power Density: 361 W/m2
Weibull A: 7.42 Weibull k: 2.009
Uncertainty: 0.35 +/- m/s
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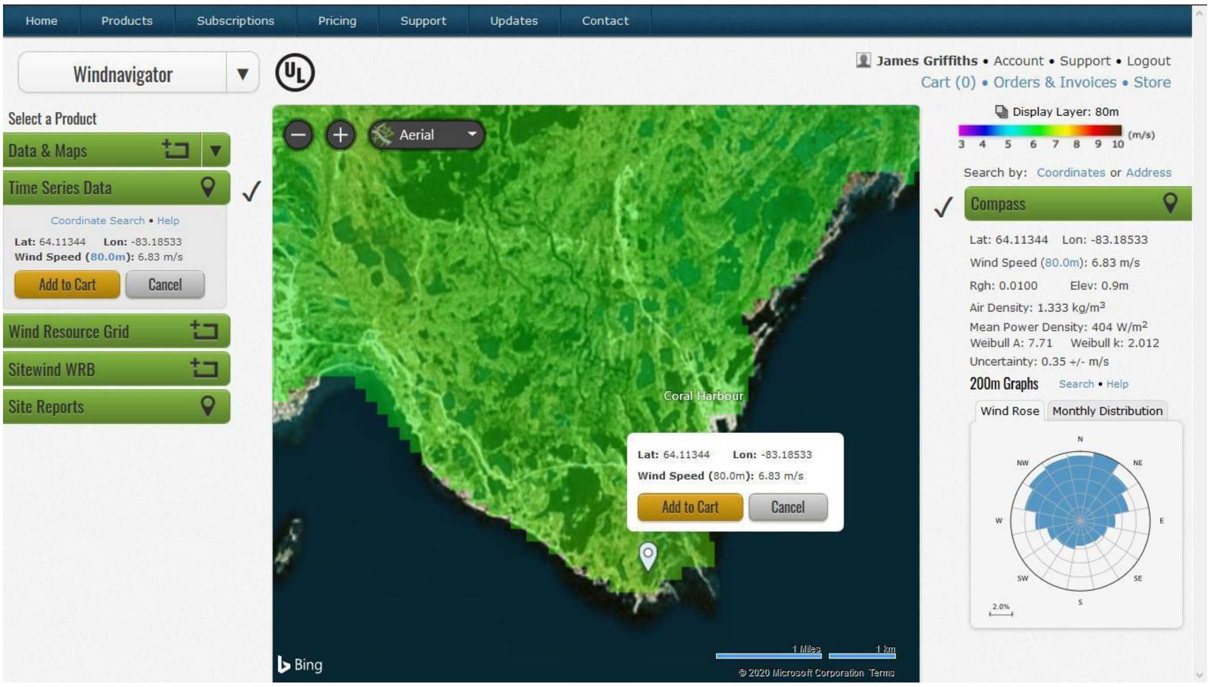
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Lat: 64.11344 Lon: -83.18533
Wind Speed (80.0m): 6.83 m/s
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Display Layer: 80m
Search by: Coordinates or Address
Compass
Lat: 64.11344 Lon: -83.18533
Wind Speed (80.0m): 6.83 m/s
Rgh: 0.0100 Elev: 0.9m
Air Density: 1.333 kg/m3
Mean Power Density: 404 W/m2
Weibull A: 7.71 Weibull k: 2.012
Uncertainty: 0.35 +/- m/s
200m Graphs
Wind Rose
Monthly Distribution

Appendix D: Specifications for candidate wind turbines

Xant / EOCycle M-26 Wind Turbine:

eocycle

	CHARACTERISTIC	SPECIFICATION
Main Data	Model	EOX M-26
	Design class	IEC Class IIIA wind turbine
	Design life	30 years without major component replacement
	Rated power	90 kW
	Rated wind speed	Average annual wind speed: 7.5 m/s (27 km/h) (17 mph)
	Cut-in | Cut-out wind speed	2.75 m/s (9.9 km/h) (6 mph) | 20 m/s (72 km/h) (45 mph)
	Extreme wind speed	52.5 m/s (189 km/h) (118 mph), 3-second average
	Operating temperature	-20 °C to 40 °C (-4 °F to 104 °F)
	Lightning protection	Lightning rod, surge protection devices, grounding system
Rotor	Rotor diameter	26 m (86 ft)
	Swept area	530m² (5700 ft²)
	Rotor speed	Variable, up to 55 rpm
Generator	Type	PM Generator
	Model	3-phase
	Generator	90 kW, 400 V, 42.4 Hz, 1.25 service factor
	Drivetrain	Direct drive (no gearbox)
	Generator enclosure and insulation	Totally enclosed, weather-proof, class F insulation, IP55, maintenance free
Power Converter	Type	Grid-tied / utility-interactive
	Converter output	3-phase, 380 V to 500 V
Control System	Controller model	Siemens PLC
	Advanced features	Data logging and direct integration with safety system
	SCADA/Monitoring system	EOX SCADA, web and mobile application
	Control strategy	Maintenance free active stall-regulated
	Weather sensors	Wind speed, wind direction, temperature
Yaw System	Type	Electric auto-yaw
Materials	Steel components	High quality, as per ASTM standards
	Corrosion protection	Hot-dip galvanized or zinc-coated, as per ASTM standards
Braking System	Normal operation	Combination: 1) generator 2) stall blade design 3) yaw-assist
	Emergency rotor brake	Fail-safe hydraulic disk brake
Blade	Model	Eocycle
	Design	Fixed-pitch (no moving parts)
	Length	12.5 m (41 ft)
Tower	Tower - hub height	32 m and 38 m (100 ft and 125 ft) free-standing
	Finish	White paint

AVERAGE WIND SPEED (M/S)	GROSS OUTPUT (MWH/YEAR)
4.0	126.2
4.5	170.3
5.0	216.4
5.5	262.1

AVERAGE WIND SPEED (M/S)	GROSS OUTPUT (MWH/YEAR)
6.0	305.9
6.5	346.7
7.0	383.9
7.5	417.0

eocycle.com

EWT DW-61 Wind Turbine:

With its 61-metre rotor and advanced control features, the DIRECTWIND 61 maximizes your energy output from low-wind (class IIIA) sites. This pitch-controlled, variable-speed wind turbine is optimized for distributed energy generation. Thanks to EWT's continuous market-driven innovation, it combines high yields with outstanding reliability. Our direct drive technology means fewer moving parts, so less maintenance and more availability. Meanwhile the aerodynamic rotor design ensures high efficiency and reduces noise.

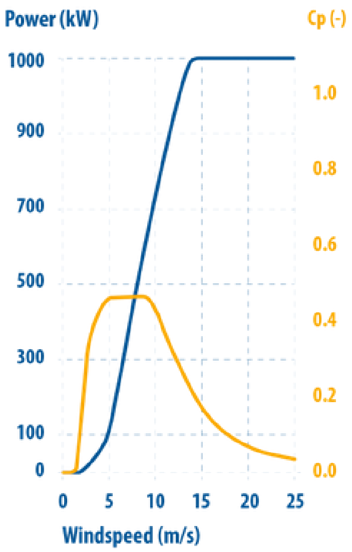
Standard power output options

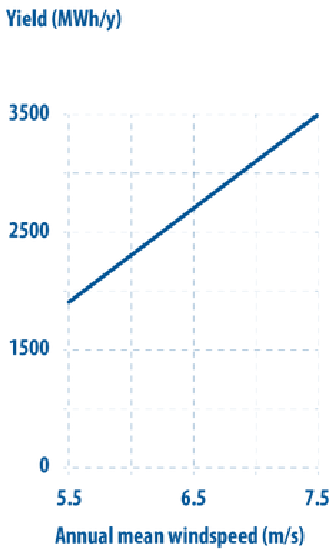
- 500 kW
- 750 kW
- 900 kW
- 1 MW

Other output ratings are available on request.

Specifications

Rotor diameter (metres)	**60.9**
Variable rotor speed: min (rpm)	**9**
Variable rotor speed: rated (rpm)	**22 (500 kW), 23 (750 kW), 24 (900 kW & 1 MW)**
Hub heights (metres)	**46 and 69**
IEC wind class	**IIIA (up to 7.5 m/s average at hub height)**
Cut-in wind speed (m/s)	**3**
Cut-out wind speed (m/s 10-min average)	**25**
Survival wind speed (m/s)	**52.5 m/s**





Power Curve DW61-1000kW