

RENEWABLE ENERGY ATLAS AND MICROGRID FIELD TESTING IN THE ARCTIC



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The Renewable Energy Atlas and Microgrid Field Testing in the Arctic project is being led by National Resources Canada CanmetENERGY–Varenes. It is supported logistically by Polar Knowledge Canada, with the study area comprising several Inuit-owned business sites and Government of Nunavut sites. The study area is located in Cambridge Bay, Nunavut.

Abstract

In order to increase the contribution of renewable energy to local electricity generation mix in remote communities, more information about renewable energy resources in the Arctic (wind speed and solar irradiance) and the electrical load profiles of communities needs to be acquired so that renewable energy systems can be appropriately sized to meet demand. With that in mind, Natural Resources Canada (NRCAN) CanmetENERGY, in collaboration with Polar Knowledge Canada (POLAR), developed a project proposal for ecoENERGY Innovation Initiative (ECO-EII) funding with the following objectives:

1. Development of a pan-Arctic Renewable Energy Atlas. This project has been proposed by the Arctic Council and is being supported by the Government of Canada, predominantly through NRCAN CanmetENERGY–Ottawa;

2. Field testing of a renewable energy microgrid with intelligent load management in Cambridge Bay, with POLAR conducting the fieldwork under the guidance of NRCAN CanmetENERGY–Varenes; and
3. A techno-economic assessment of renewable microgrid design to include a comparative study of optimal storage methods.

The cumulative efforts of these three phases will play a major role in helping to reduce dependence on high-cost, imported diesel fuel as a means of energy generation in remote northern communities. This proposal was accepted for full project funding through the ECO-EII program; . This report primarily focuses on the work conducted to date on Phase 2, field testing of a renewable energy microgrid with intelligent load management in Cambridge Bay.

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Résumé

Afin d'accroître la contribution de l'énergie renouvelable à la production locale d'électricité dans les collectivités éloignées, il faut acquérir plus d'information sur les ressources d'énergie renouvelables dans l'Arctique (vitesse du vent et irradiation solaire) et les profils de charge électrique des collectivités afin que les systèmes d'énergie renouvelable puissent être adéquatement dimensionnés pour répondre à la demande. Dans cette optique, Ressources naturelles Canada (RNCAN) – CanmetÉNERGIE, en collaboration avec Savoir polaire Canada (POLAIRE), a élaboré une proposition de projet pour le financement de l'Initiative écoÉNERGIE sur l'innovation (écolIE) avec les objectifs suivants :

1. Élaboration d'un atlas des énergies renouvelables dans l'ensemble de l'Arctique. Ce projet a été proposé par le Conseil de l'Arctique et est appuyé par le gouvernement du Canada, principalement par l'entremise de RNCAN – CanmetÉNERGIE d'Ottawa;
2. Mise à l'essai d'un microréseau d'énergie renouvelable avec gestion intelligente de la charge à Cambridge Bay, POLAIRE effectuant le travail sur le terrain sous la direction de RNCAN – CanmetÉNERGIE de Varenes;
3. Une évaluation techno-économique de la conception de microréseaux d'énergie renouvelables comprenant une étude comparative des méthodes de stockage optimales.

Les efforts cumulatifs de ces trois phases contribueront grandement à réduire la dépendance à l'égard du carburant diesel importé et coûteux comme moyen de production d'énergie dans les collectivités éloignées du Nord. Cette proposition a été acceptée pour le financement intégral du projet dans le cadre du programme écolIE. Ce rapport porte principalement sur les travaux réalisés à ce jour dans le cadre de la phase 2, soit la mise à l'essai d'un microréseau d'énergie renouvelable avec gestion intelligente de la charge à Cambridge Bay.

Introduction

Canada's northern regions of Yukon Territory, the Northwest Territories, Nunavut, Nunatsiavut, and Nunavik are home to a population of 119,000

inhabitants who are scattered among 65 remote, rural communities. Many of these communities are highly dependent on diesel-based electricity generation, which ties a community like Cambridge Bay to electricity generation costs considerably higher than the Canadian average on a per-kilowatt-hour (kWh)¹ basis, with unsubsidized rates as high as \$1.14 per kWh, compared with \$0.132 in Ontario.² The logistics of routing diesel to such communities constitute one of the main reasons for the high cost of fuel. In addition, infrastructure for trucking and for fuel storage must be in place, increasing considerably the environmental impact of electricity generation in remote communities.

Ambient and climatic conditions such as extended solar irradiance in spring and summer months, colder winter temperatures that increase conductivity, and stronger, more frequent winds, particularly during winter months, provide the potential for increased use of clean, renewable energy from wind and photovoltaic (PV) systems. This would allow greater energy independence for many remote, off-grid communities such as Cambridge Bay, with a significant reduction in fossil-fuel usage.

It is not, however, a simple matter of replacing diesel generation with a renewable source. It is necessary to know what the energy loads are in a community — when energy demand peaks, when troughs occur, how those peaks and troughs correlate to renewable energy resource availability, and what the maximum amount of renewable energy that can be placed onto a microgrid is before that renewable resource has an impact on grid stability. Through the ECO-EII, NRCAN CanmetENERGY–Varenes in partnership with NRCAN CanmetENERGY–Ottawa and POLAR developed a three-phase project proposal to determine the potential for reducing diesel dependence for energy generation in remote northern communities. The overall project is entitled Renewable Energy Atlas and Microgrid Field Testing in the Arctic (REMFTA). The project will achieve its stated objectives by (1) improving access to renewable energy information by populating a pan-Arctic renewable energy atlas; (2) community monitoring, managing, and field testing of a renewable energy microgrid with intelligent load management in Cambridge Bay; and (3) collaborating with CanmetENERGY experts to study renewable energy integration with secondary storage methods.

¹ https://www.qec.nu.ca/sites/default/files/qec_energy_framework_-_generation_-_april_18_eng.pdf

² <https://www.oeb.ca/rates-and-your-bill/electricity-rates>

This combined approach will offer insight into properly sizing wind and PV systems to accommodate common demand-side and ambient-based variability. This project aligns with two of POLAR's science and technology priorities; in particular, reducing diesel dependency for energy generation through greater uptake of Alternative and Renewable Energy and Improving the Design of Northern Build Infrastructure by identifying better building design, construction techniques, maintenance practices, technologies, and energy efficiencies for northern climates. As a co-lead on the ECO-EII project, POLAR is providing in-community advice and support, community liaison, project execution, and data collection.

REMFTA proposal

The original project proposal that was approved for NRCAN ECO-EII funding has three distinct phases:

Arctic Renewable Energy Atlas: In collaboration with the Arctic Council's Sustainable Development Working Group (SDWG), CanmetENERGY–Ottawa is assisting in the development and population of the online Arctic Renewable Energy Atlas, a comprehensive toolkit that will include maps, renewable energy resources, and case studies of renewable energy projects across all eight Arctic member states. This toolkit will act as a database for renewable energy projects across the Arctic and provide researchers and potential project practitioners with access to resource knowledge and best practice. POLAR has served in an advisory role as needed.

Techno-economic assessment of renewables microgrid design and operation with load management in Alaska and Nunavut: A collaborative partnership between CanmetENERGY, POLAR, and Intelligent Energy Systems (IES) to develop a comparative study of renewable energy integration, coupled with secondary energy storage, through demand management and lithium-ion storage systems for remote microgrids in Alaska and Canada. This activity will gather and process data from Alaska's Chaninik Wind–Electric Thermal Storage (ETS) project, build ETS and battery system models using data from Alaska-based systems, and conduct a comparative techno-economic analysis of batteries and ETS for microgrid services for systems in Alaska and Canada. POLAR's role will be in managing the installation and monitoring the techno-economic assessment of the community's load usage and energy efficiency, and

upon completion, sharing load-usage, energy-efficiency, and renewable energy findings with current and future community, government, and industry partners. This project will build on the work done under the community monitoring phase of the REMFTA proposal.

Community monitoring, managing, and testing of a renewable energy microgrid with intelligent load management in Cambridge Bay: This phase develops a coordinated approach to energy solutions (peak shaving, renewable energy integration), including the monitoring of renewable resources and community electrical demand. POLAR is managing the implementation of renewable energy monitoring and load-monitoring instrumentation in Cambridge Bay, collaborating with CanmetENERGY experts to study renewable energy integration with secondary storage methods through intelligent demand management, and developing open-source information sets and energy modelling. As this phase forms the main basis for this report, it will now be discussed in greater detail.

In order to ensure that the most representative data was obtained for this project, CanmetENERGY in collaboration with Nunavut's sole electrical energy utility, Qulliq Energy Corporation (QEC), developed a list of the top 21 high-energy-usage units in Cambridge Bay. Providing a community liaison function on behalf of the project, POLAR personnel visited the owners/occupiers of the aforementioned high-energy-usage locations to describe the purpose of the project, set out the potential benefits, and request their participation. This included providing project information to potential collaborating businesses, local government departments, and schools through a written summary that was prepared by NRCAN CanmetENERGY–Varenes. The summary identified the goals of the project, the collaborating partners, the instrumentation that would need to be installed at each location, and any associated costs. POLAR personnel also conducted in-person discussions that centred on the value for the customer in attaining load profiles for daily, seasonal, and peak use operation. These benefits included how to make structural changes for greater energy efficiency as well as better overall methods for energy usage.

Following the initial in-person briefings, partnerships were established with ten commercial, public, and government locations in Cambridge Bay, including the elementary and secondary schools, the Canadian

High Arctic Research Station (CHARS) main research building, the water treatment plant, and the northern store (a full list of locations is available upon request). Load-usage and energy-efficiency measures were then determined for each building within the set of collaborating partners by utilizing site surveys, reaching a better understanding of building function, and conducting qualitative load profiles based on hours of operation and equipment use as well as normal and peak load levels. Using this information, opportunities were evaluated to improve energy efficiency within the building envelope, and subsequently, internal equipment and current usage profiles. Using these energy audits, POLAR then developed seven distinct energy-efficient sets based on common building types found in remote, northern communities, including mechanical/construction garages, ice arenas, schools, meat packing facilities, grocery stores, medical centres, and office buildings. Each audit set provided energy-efficient improvements by building type, proposed changes to building operation to shift energy peak loads, equipment enhancements for improved efficiencies, and/or energy-efficiency modifications to the building envelope. Included within the recommendations were, where possible, descriptions of the benefits of each improvement, including the cost, payback period, and recommendations for suitable equipment models and vendors. This set of energy-efficient briefing materials was subsequently shared with municipal and business contacts throughout the Kitikmeot Region.

After initial discussions with building owners, and prior to installation of energy-monitoring equipment, POLAR sought the advice and guidance of the Government of Nunavut's Director of Safety Services and Chief Electrical Inspector as well as the Electrical Inspector for the Kitikmeot Region regarding compliance with the electrical code of Nunavut and safety inspection protocols that needed to be in place (pre-installation, installation, and post-installation) for the load-monitoring instrumentation. This advice informed CanmetENERGY's selection of the AccuEnergy AcuPanel 9100 series plug-and-play meters for this project.

Upon receiving ten AcuPanel meters in Cambridge Bay, POLAR initiated contract negotiations with local electrical contractors for up to ten community-based installations. Based around CanmetENERGY's installation guidelines, and conducting a risk assessment for both installing and operating the meters, a sequential installation plan was

developed. The first units selected for installation were the two schools, as these would benefit from frequent daily building checks by the building manager, and so ascertain early if there would be need for changes to the operation and installation methodology, which would affect future locations. Once a successful proof of concept has been completed at both schools, the next eight installations will be scheduled and conducted. From there, NRCAN CanmetENERGY and POLAR will monitor installations and results over the course of the 2018–2019 winter.

Community considerations

Energy efficiency is one of the key reasons for diesel reduction, and greenhouse gas emissions will be cut significantly in remote communities. Identifying how energy can be better used and saved can lead to great economic benefits for individuals, communities, and utilities, as well as improved living conditions for occupants of residential units. By better understanding how energy is being used in remote communities (commercially, residentially, and on a municipal scale), it will be possible to identify where energy efficiency measures can be best targeted and propose changes to operating procedures to reduce peak loading. As part of this project, both NRCAN and POLAR have committed to work with project participants in the community of Cambridge Bay to help identify how energy is being used in individual units and propose energy efficiency measures that can reduce costs. By better understanding energy usage on a community scale, it will also be possible to greatly reduce community diesel consumption for both heat and electricity generation. This will not only reduce overall costs to the community, but will ultimately lead to cleaner air and a healthier environment. This project will also help pave the way for future clean energy integration into the Cambridge Bay microgrid, thereby further reducing overall diesel dependency. This information will also, in part, be transferable to other remote communities, thereby allowing similar communities to benefit from energy efficiency improvements and diesel reduction opportunities identified by this project.

Conclusions and next steps

Although well underway, project progress was initially slower than anticipated, hampered by contracting and regulatory issues, both of which required considerable effort on the part of the POLAR engineer based in

Cambridge Bay to help resolve. Initial installations have now been completed and monitoring work is underway. CanmetEnergy and POLAR are now moving forward with the next batch of installations with a view to having a minimum of ten high-energy-usage units under a monitoring protocol before the end of the 2018-2019 financial year. A lot of the work that has been done to date under the auspices of Phase 2 will greatly aid in the execution of Phase 3, the techno-economic assessment of the renewable energy microgrid design and operation with load management in Alaska and Nunavut, thereby allowing that phase to move forward more quickly than initially planned.

Combined, all three phases of this project have a great deal of potential to greatly reduce fossil-fuel usage by encouraging and aiding the uptake of appropriate renewable resources as a replacement for diesel and by identifying and shaping energy loads and efficiency, thereby reducing the overall need for energy generation.

Finally, this project has proved to be highly beneficial in establishing a collaborative working partnership between NRCan CanmetENERGY and POLAR, and is another step towards POLAR's goal of testing and demonstrating technologies at CHARS and in Cambridge Bay, thereby reducing the risk for future energy generation projects in Canada's remote Arctic communities.

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References

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