KLUANE RH2

Feasibility Study Executive Summary

September 2023

Report submitted to:

The Arctic Institute of North America

Government of Yukon

Natural Resources Canada

by

High Latitude Energy Consulting

THOR Hydrogen

HIGH LATITUDE ENERGY CONSULTING

THOR HYDROGEN

Executive Summary

Introduction

The Kluane Lake area is the traditional territory of the *Lù'àn Män Ku Dän*, the Kluane Lake People. The Kluane Lake Research Station (KLRS) is located on the south shore of *Lù'àn Män* - adjacent to the community of Silver City, approximately 220 km northwest of Whitehorse.

The Arctic Institute of North America (AINA) operates the KLRS under the auspices of the University of Calgary. The station, founded in 1961, supports a range of natural science research activities and cultural, artistic, and educational outreach programs in the environs of Kluane National Park and within the traditional territories of the Kluane, White River, and Champagne-Aishihik First Nations.

As a central focus of their decarbonization targets, AINA explored strategies for reducing and eventually eliminating the use of diesel at the station. Although the KLRS has historically only operated between March and September, AINA wished to consider a scenario in which the station operates across the entire year, confirming whether it would be possible to use renewables alone. AINA's aspiration for the Kluane Lake Research Station is aligned with the Yukon government's decarbonization strategy to substantially reduce greenhouse gas emissions caused by the territory's reliance on energy from fossil fuels.

This common ambition to decarbonize is the main driver for implementing the Kluane RH2 project, which received funding from the Yukon Development Corporation (YDC), Natural Resources Canada (NRCan), and the Energy Solutions Centre (ESC). This Feasibility Study Report provides a foundation for developing microgrid systems in the north. The study has looked beyond technical issues into how this could benefit communities in the north, for example, enabling self-sufficiency, localizing energy production, building capacity, and ultimately realizing energy sovereignty for First Nations.

This feasibility study has demonstrated that a microgrid system based entirely on renewable energy and utilizing long-duration energy storage in hydrogen has the ability to reliably power energy users in the north – from research stations to communities to remote industry.

Embracing the introduction of new technologies while developing the skills and support mechanisms to safely and effectively operate such systems unlocks the potential to shift the energy mindset – from dependency to self-sufficiency, from constraint to abundance, and from limited horizons to a world of opportunity for the north.

Challenge and Opportunity

Global average temperatures are increasing due to human emission of greenhouse gases. However, temperature changes are not uniform across the planet. Northern Canada is warming at three times the global mean, creating significant uncertainty around future outcomes for the northern climate, society & culture, and natural ecology[1]. Climate and economic resilience are critical to mitigation and adaptation planning in this time of rapid change. But how we respond to this challenge can cause us to think about energy in new ways - how to harness locally available energy sources and how to utilize these sources in ways that re-imagine the opportunities.

The central opportunity driving this study is the desire to achieve decarbonization and energy resilience across Northern Canada. By demonstrating that it is technically feasible for a research station to operate entirely on renewables, it is possible to conclude that communities and industries can reduce and ultimately eliminate the use of fossil fuel energy by adopting similar technology.

Beyond decarbonization, this technology can support a vision for northern First Nations communities to become self-sufficient in renewable energy generation, bringing communities closer to the ideal of full energy sovereignty with abundant discretionary energy that enables new opportunities for commerce to be unlocked.

The challenge is developing new energy systems that can be introduced gradually into facilities or communities, scalable systems to meet growing needs, and expanding populations. It is essential to build familiarity with technology and trust that it can operate safely and reliably.

A key learning from community engagement is that successful integration of technology into a community begins at the outset of a project, through local participation in the design, execution, and operation of energy facilities.

---

[1] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

The Feasibility Study

The core study team is from partners HiLat (Whitehorse, YK) and Thor Hydrogen (Kimberley, BC). Associate Ensol and sister company Solaris, located in Surrey, BC, provided design support on the modular hydrogen system. The project team focused from the outset on the premise that the proposed method had to be beneficial not only to the KLRS but also suitable for broader adoption across the north.

The *Kluane RH2 Feasibility Study Report* includes energy analysis using industry-standard software, in-depth technical research and evaluation, best practices for risk and safety review, and preliminary design integration (for modular systems) to create layouts and renderings of the proposed system. The study also involved community consultation, and the project team participated in community engagement to share and gather knowledge.

Internal framing and planning of the study anticipated questions from a broad audience including stakeholders, decision-makers, community members, regulators. The numerous issues covered in the reports are essential to creating a foundational understanding of issues such as the current technology landscape, the interaction of system components, and how modularity can help to incrementally scale capacity. The team has been successful in covering this range of objectives which, in the first instance, were focused on the KLRS facility but were also strongly connected to the desire to ensure that this technology is broadly applicable to northern communities.

Summary of Study Outcomes

Feasibility encompasses more than the availability of technology, and the following aspects qualify the statement of general feasibility.

Reliability	The feasibility study does not include a definitive assessment of probable operational uptime. Reliability of the proposed microgrid system is defined by the combined reliabilities of key components and ancillary plant. Assessment of reliability is based on data from equipment manufacturers and operational statistics. The combination of electrochemical systems (electrolyzer, fuel cell) and rotating equipment (e.g., compressor, pumps) added to the novelty and operational context of systems introduces uncertainties that will be resolved in the FEED stage through appropriate equipment selection, monitoring, and maintenance protocols.

Costs and Economics	Currently there is no return on investment for this project without grant funding of at least 80% to assist with capital costs. The economics were evaluated based specifically on the offset cost of diesel without other benefits being considered – such as GHG reduction credits, improved climate resilience, and the potential for enhancement of local capacity and energy autonomy. **Further study is required to optimize the economics of this system and assess the benefits of scaling and additional revenue streams.**
Safety	The feasibility study includes an in-depth treatment of the safety in design philosophy and how this can be effectively managed.
Scalability & Applicability	A modular design is proposed that is containerized for ease of transportation and handling. This is designed to be internally scalable (i.e., expanding capacity within the container) and scalable through replication of the units themselves.
Standardization	We have adopted the philosophy of '*design one, build many*', the idea that if a system is well designed for function, safety, ease of manufacture and upgrade, deployment, then it can be effectively replicated and scaled with a reduced design and regulatory burden.
Regulatory Status	The lack of a clear regulatory pathway for sanction of the proposed system upgrade is the most significant impediment to the project. **Further development of systems, especially in proximity to the aerodrome, are unlikely to proceed before pre-existing and longstanding regulatory issues have been resolved.**
Hydrogen	This study recommends that compressed hydrogen be used as the energy storage medium for long duration energy storage. Alternatives to hydrogen (such as batteries) and alternatives within the hydrogen space (such as ammonia) have been assessed but are either not practical or sufficiently mature for application in this instance.
Complexity	The systems proposed are a combination of technology: Known technology (solar photovoltaics and battery); Novel but simple technology (electrolysis and fuel cells); Complex new technology (hydrogen compressor). **Training and expertise will be required to operate the combined microgrid.**
Novelty	Hydrogen generation facilities have significant novelty and technical challenge, along with more limited operational experience and smaller

	incident databases. External engagement with third parties will be key to calibrating risk-centred decision-making processes.
Capacity	The ability to operate a facility with a degree of technical complexity requires training. The remoteness of facilities and perceived lack of qualified individuals must be recognized as a potential impediment to the feasibility of the project. Accordingly, early measures must be taken to address capacity – in part by hiring possible operators into the project team and the FEED and detailed design stages, well before start-up.
Community	Engagement with members of the community around the KLRS is important to building understanding and acceptance. This is key, since it is community members who give the social license to develop and operate new energy systems. The success of any project in northern Canada needs committed and creative community outreach that is informative and inspiring, and which in return is inspired by the contributions and values of the people that such systems serve.
Backup Energy	It is likely that a hybrid microgrid would initially cover only a portion of the energy demand during a proving phase and therefore a backup electricity source would be available for the full duration of a transition to renewables. It is recommended that the diesel generator is maintained in standby mode for at least two seasons.
Value Streams	When water is split into hydrogen and oxygen in the electrolysis process, the intent is to utilize only the hydrogen stream, compressing it and storing this in high pressure tanks. Although the oxygen produced by electrolysis is effectively 'medical grade' no evaluation of a business case has been made given the low volume produced.
Heat Output	The electrochemical reaction created from combining hydrogen and oxygen in the fuel cell creates both electrical energy and thermal energy. The electrical energy is used to power the station in the winter, but no design effort has been directed to using thermal energy for heating buildings. Although produced thermal energy may be used in containerized systems, it is recommended that some focus is applied in the next phase to harnessing this heat output in a community context.

=====

This study demonstrates that a microgrid system based entirely on renewable energy and utilizing long duration energy storage in the form of hydrogen has the ability to reliably power energy users across the North – from research stations to communities to industry. Although the economics do not in themselves make a strong case for change there are several complementary justifications for advancing the concept to implementation, including GHG reduction, energy self-sufficiency, economic and climate resilience, capacity growth and job creation.

It is important that the next phase brings the project closer to a practical demonstration of the technology. This can be moved forward by undertaking a Front-End Engineering Design of the system, during which the design is developed to a level that enables a final investment decision to be taken. In terms of required funding for the FEED phase, a firm budget has not been established. We recommend that this is developed in a Pre-FEED study that bridges this feasibility study and a FEED study.

In terms of a candidate for first application, it is clear that there are significant regulatory impediments to developing the system at Kluane Lake Research Station to the extent that the probable timeframe excludes this location from short-term consideration. In view of this, we strongly recommend that an alternative location be identified for application of this renewables plus energy storage technology. Although a standardized and modular approach remains feasible, a brief 'Pre-FEED' phase is required to gather location specific knowledge and calibrate the system and processes to this different application, perhaps in a community setting.

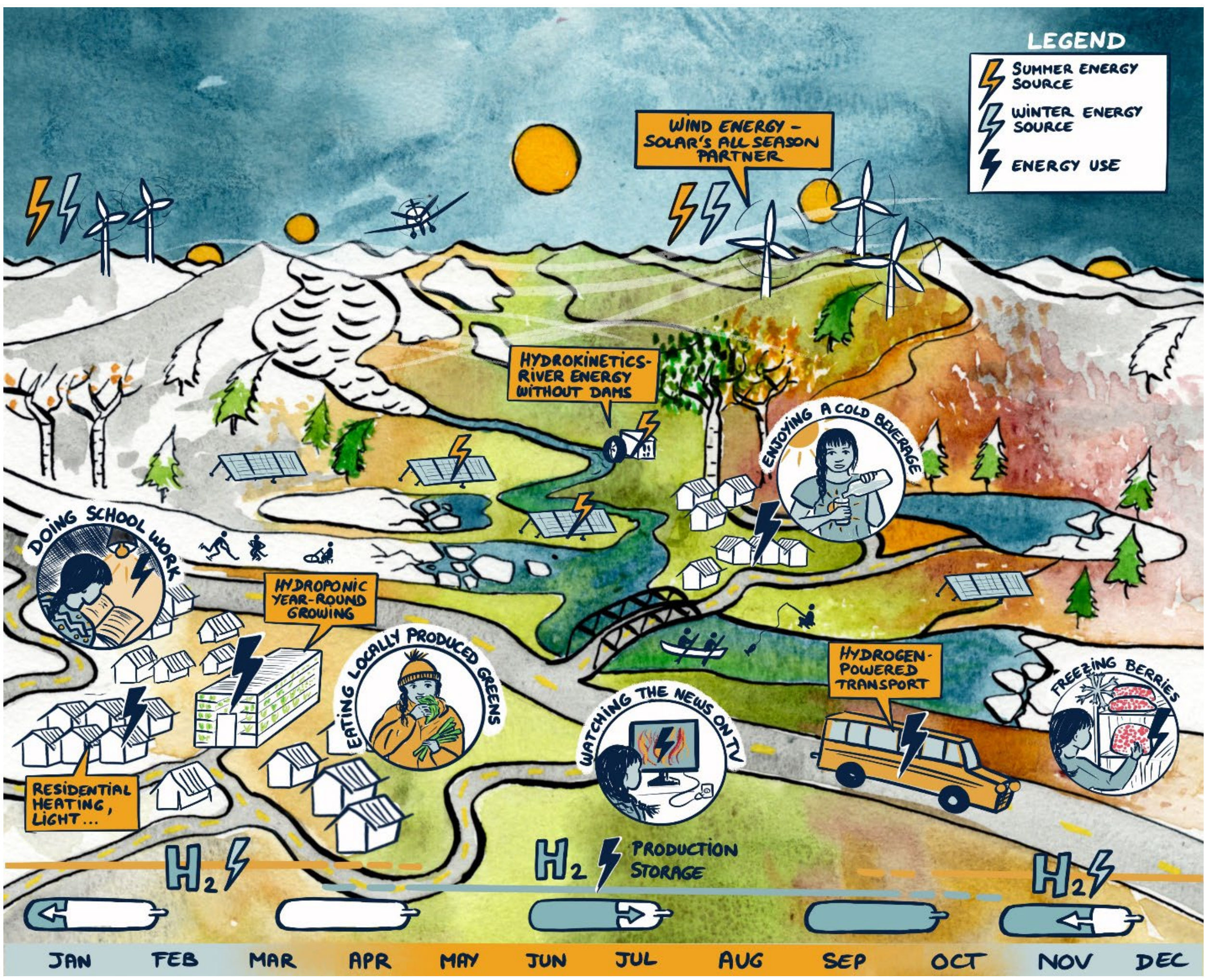
Beyond decarbonization, this technology supports a vision for northern First Nations communities to become self-sufficient in renewable energy generation bringing communities closer to the ideal of full energy sovereignty. Capacity is one of the greatest challenges to the feasibility of operating hybrid microgrids in the north. Capacity building must begin at the outset of the project.

HIGH LATITUDE
ENERGY CONSULTING

THØR
HYDROGEN

Community Scene, Renewable Energy Microgrid

from storyboarding narrative by local Yukon artist Esther Bordet



Yukon Territory - Nunavut   Info@hilat.ca