Investigating the Feasibility of Hydrogen to Reduce Diesel Reliance in Remote Communities

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Abstract

As Canada looks to reduce greenhouse gas (GHG) emissions, hydrogen is considered to be a viable replacement for fossil fuels. Hydrogen is a zero-emission fuel source when produced through electrolysis from renewable energy and utilized in a fuel-cell to create electricity [1]. This study explored wind energy to generate hydrogen for remote communities in Nunavut, where aging-diesel generators are the principal source of electricity generated power. The results of this study indicate that communities with high wind potential and water accessibility are favourable locations to implement a wind-hydrogen alternative to fulfill daily electricity demands. To expedite alternative clean energy projects, the Government of Nunavut should incentivize independent power purchase (IPP) agreements to provide a fair and equitable electricity generation rate [2, 3].

Introduction

As remote communities look to reduce their reliance on diesel to offset adverse health and environmental impacts, clean energy projects are recommended. Locally-produced hydrogen has the ability to encourage the uptake of renewable energy (e.g., wind) since it provides grid stabilization, long-term storage, as well as potentially reduce the cost of electricity [4].

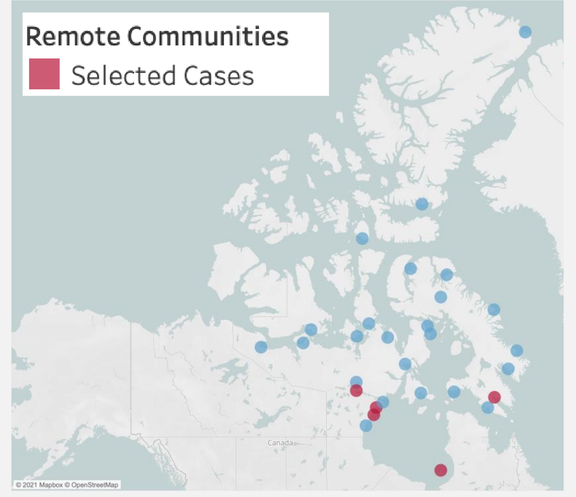

Figure 1. Nunavut remote communities. Modified from Canada Energy Regulator (2021) [5].

Nunavut Overview

- Limited seasonal delivery of diesel results in higher energy costs [5, 6].
- The electricity rate for communities is between \$0.59 to \$1.16 CAD/kWh [7] and subsidized to an average electricity cost of \$0.32 CAD/kWh [6], which is above the Canadian average (\$0.17 CAD/kWh [8]).

Alternative Energy Solution: Wind-Hydrogen Energy

- The variability of wind energy can be overcome using energy storage options.
- Batteries provide short-term energy storage, but are not a viable option for long-term power generation [4].
- Hydrogen is able to discharge power over a long-time period, which makes it a viable low-carbon energy alternative [4].
- Wind energy can be used to produce hydrogen via an electrolyzer that uses wind electricity to split water into oxygen and hydrogen.
- Hydrogen fuel cells are used to produce electricity and stabilize the grid with the byproducts being heat and water.

Objectives

- The primary objective was to find an alternative low-carbon energy solution to reduce the cost of electricity in Nunavut communities.
- This study investigated the feasibility of a locally-produced wind-hydrogen coupled project in Nunavut communities to replace diesel electricity generators.
- A comparison of the future of electricity generated from hydrogen versus diesel-fired electricity generation was explored in further detail.

Results and Discussion

- Rankin Inlet, Iqaluit, Baker Lake, Whale Cove, and Sanikiluaq were chosen due to their proximity to water, potential wind energy, and annual electricity generation [9].
- A techno-economic analysis was performed for these communities. The results of Rankin Inlet are presented here as an example.
- The potential daily wind energy was calculated based on the daily wind speed and power capacity of an Enercon 2.3 MW E-82 arctic-rated wind turbine.
- Figure 2 shows the amount of electricity that hydrogen can provide to fulfill the demand.

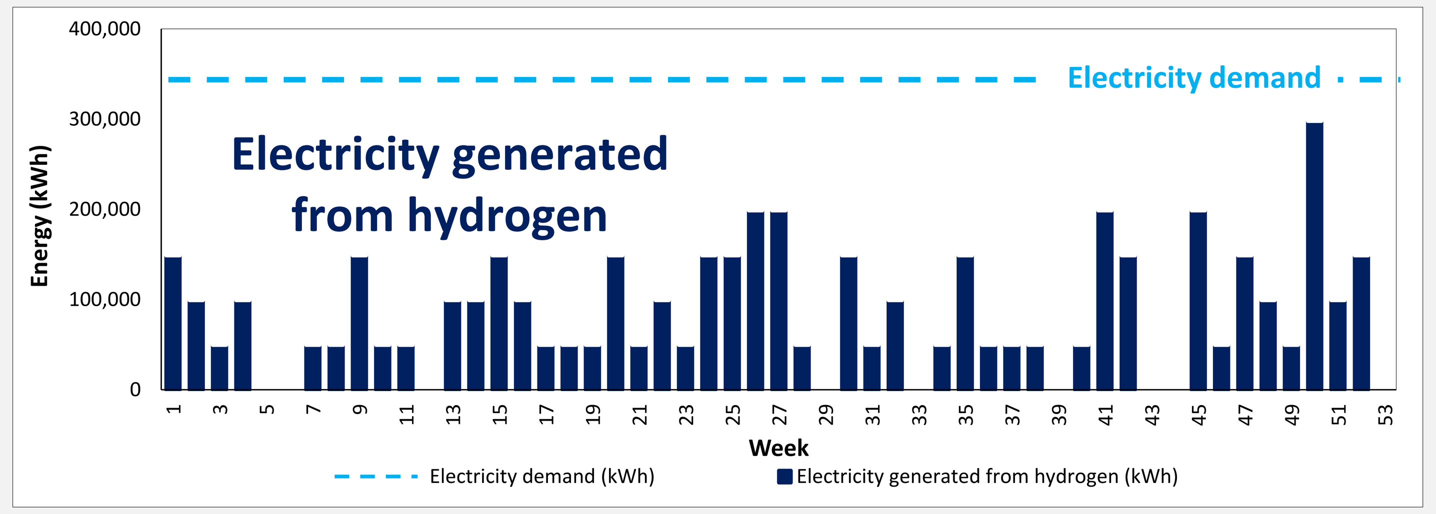

Figure 2. Electricity generated from hydrogen for Rankin Inlet

- A model was developed to minimize the levelized cost of electricity (LCOE). The capacity of the wind farm, electrolyzer, hydrogen storage and fuel cell were considered as hyper-parameters of optimization.
- LCOEs were calculated based on the benchmark data for initial, operational and maintenance costs [10, 11].
- The LCOE for Rankin Inlet is \$0.26 CAD/kWh with a payback period of 5 years (Figure 3).
- LCOEs were calculated for a worst-case scenario where the initial costs of the project were doubled.
- Worst-case LCOE for Rankin Inlet is \$0.36 CAD/kWh with a payback period of 9 years (Figure 3).

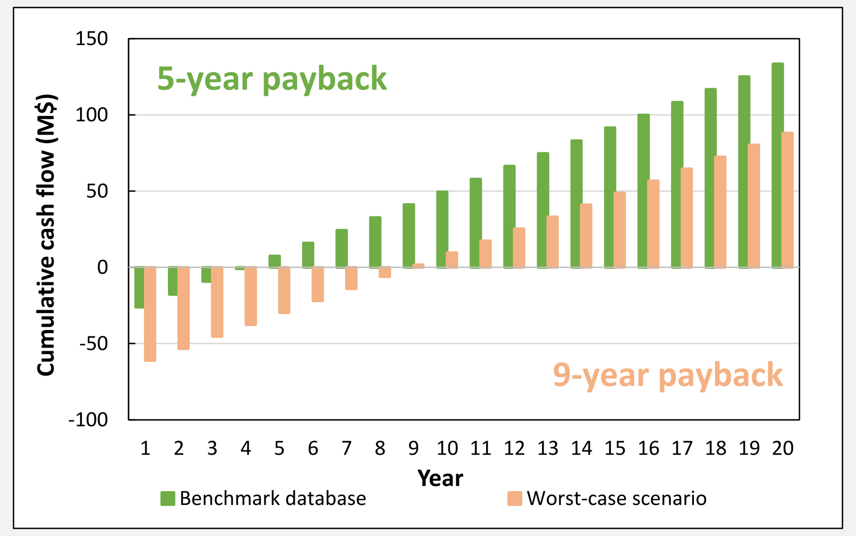

Figure 3. Rankin Inlet payback period calculated based on the simplified model.

- Due to aging diesel generators with decreasing efficiencies, the electricity rate increased significantly in the last few years [12].
- Estimates show that the cost of wind turbines, electrolyzers, fuel cells and hydrogen tanks are projected to decline significantly by 2030 [4, 13].
- Consequently, this would lead to the LCOE generated from hydrogen to decline to approximately \$0.11-0.15 CAD/kWh for Rankin Inlet (Figure 4).

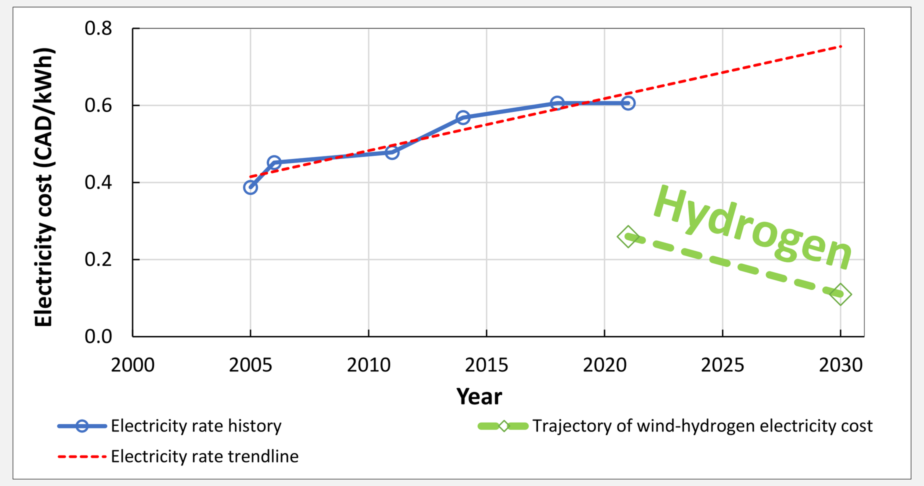

Figure 4. Trajectory of hydrogen electricity cost (THEC) for Rankin Inlet

- Implementing a wind-hydrogen facility would eliminate 13,309 tonnes of CO_2, which is equal to the annual emissions from diesel-fired generators [9].
- Potential carbon offset credits were calculated for Rankin Inlet up until 2030 (Figure 5).

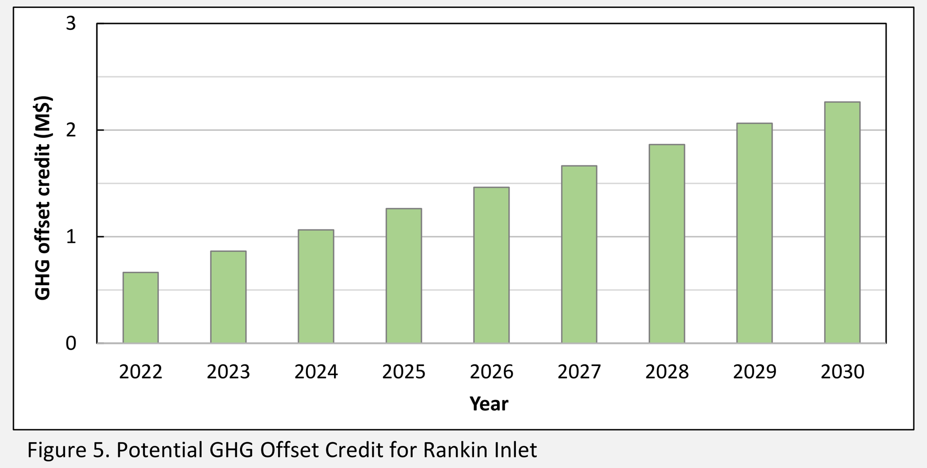

Figure 5. Potential GHG Offset Credit for Rankin Inlet

- Figure 6 presents the summary results of Rankin Inlet, Iqaluit, Baker Lake, Whale Cove, and Sanikiluaq, which shows that a wind-hydrogen coupled project is economically feasible in comparison to diesel electricity generation.

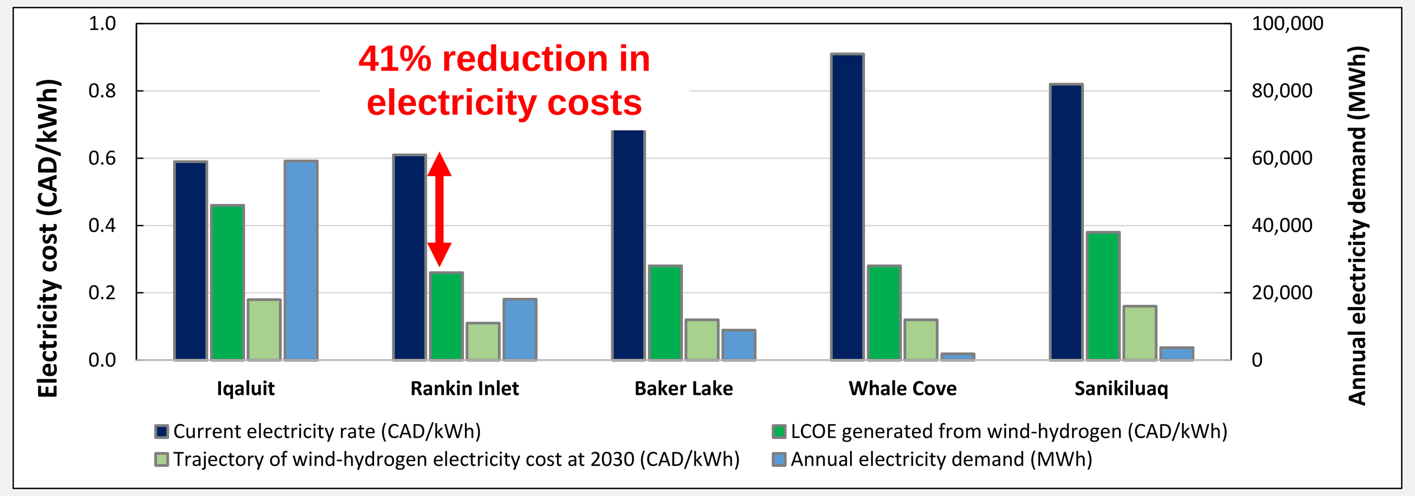

Figure 6. Summary results for selected communities

Conclusion

- Based on this study, a wind-hydrogen coupled facility is economically feasible.
- This project has the potential to provide less expensive electricity than current diesel-fired generators.
- A blueprint model was developed that can be used by Canadian communities to transition off of diesel fuel electricity power generation.
- Currently, there is limited available local wind speed data for communities. If communities are interested in integrating a wind-hydrogen coupled project, there needs to be accessible and reliable wind speed data to conduct a feasibility assessment.
- A wind-hydrogen coupled project can lower GHG emissions currently being generated by diesel electricity. Consequently, if this project was implemented in these communities, they could generate carbon offset credits in the future.
- Locally-produced hydrogen can reduce Nunavut communities' reliance on imported diesel by increasing their energy independence. Hydrogen offers the opportunity of strengthening energy security in remote communities [1].

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