Hydrogen and Ammonia Pathways Towards Net-Zero in the Northwest Territories

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1. Introduction

- The Northwest Territories (NWT) imports 89.3% of its energy in the form of fossil fuels (mainly diesel) to meet the demands of 45,132 people living in 33 communities. Fossil fuel importation occurs despite the NWT having tremendous untapped hydroelectric potential and a year-round excess available on the Taltson hydro grid.
- This high demand for fossil fuels means that the NWT has per capita emissions of 35.0 metric tons CO2e/year or ~1.8x the Canadian average of 19.6 metric tons CO2e/year. Fossil fuels account for 94% of the NWT’s total greenhouse gas emissions.
- For the NWT to become net zero by 2050, drastic action must be taken in all sectors to reduce reliance on fossil fuels. Meaningful action will require the adoption of non-carbon energy carriers, such as hydrogen and ammonia, that can be produced using hydroelectricity.
- This research aimed to understand what a hydrogen and ammonia-based net-zero energy system would look like in the NWT.

2. Methods

- This project used 2019 NIR data, literature review, and Government of NWT fuel tax data to characterize the NWT energy system.
- Based on literature, various efficiencies were assumed for each sector, and useful/lost energy totals were ascertained for each category.
- Estimates of technology adoption were made based on technology readiness level and practicalities of operations in the north.
- To model demand, net-zero technology efficiencies were used from literature to understand the total amount of hydrogen, ammonia, biofuels, and electricity needed to power the energy system that would provide the same useful energy currently required.
- The total additional hydroelectric capacity required was calculated based on literature values for hydrogen and ammonia production, and a carbon reduction potential was calculated based on direct CO2 emissions.

3. Existing NWT Energy System

Overall, the NWT energy system in 2019 used 21,478 Tj of energy with the following observations:
- Fossil fuels make up 19,186 Tj or 89.3% of the total primary energy demand.
- Diesel fuel is the most combusted fuel and provides 67.7% of total energy.
- The most energy intensive end-use sector was freight (combined off-road and on-road heavy hauling which accounted for 39.3% of energy used in the NWT.
- Energy efficiencies vary widely between end-use sectors, with the lowest being internal combustion engines, and the highest efficiencies were found in the building sector.
- Overall, the NWT energy system was found to be 52.4% efficient.

4. Hydrogen-Based Net-Zero NWT Energy System

In a hydrogen and ammonia-based net-zero energy system, the total primary energy demand is 24,139 Tj with the following observations:
- Fossil fuels do not play a role in a hydrogen-based energy system; however, drop-in biofuels make up 17.0% of energy demand in this scenario, with the largest user being the aviation sector.
- Hydroelectricity is the largest primary energy source, providing 15,967 Tj of energy or 66.1% of total demand, an overall increase of ~16.4x compared to current production.
- Ammonia production is the largest user of energy, being 38% of primary energy demand.
- A decrease in overall system efficiency was observed due to the conversion losses of generating hydrogen and ammonia.

5. Carbon Reduction Potential

- To demonstrate this, the excess hydro production potential was graphed against the largest hydrogen end-use sector - freight.

6. Hydrogen Production Potential

It was clear early in the project that the current NWT excess hydro capacity was inadequate to provide enough electricity to produce hydrogen on a system scale.

7. Biofuel Makeup

Annual Biofuel Makeup of Net-Zero Scenario

References