Hydrogen Liquefaction Facility in Kitimat to Supplement Hydrogen Injection into Natural Gas Pipeline

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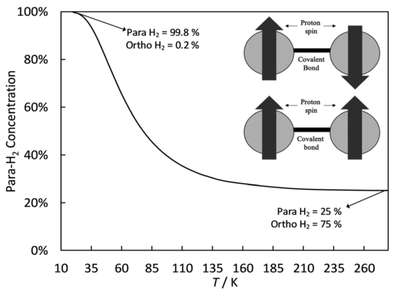
Background

- Hydrogen (H_2) identified as a valuable energy currency for a low-carbon future [1]
- Hydrogen at atmospheric pressure has low energy per volume
- Liquefying hydrogen by cooling to around 20 K (-253 °C) decreases its volume – easier to store and transport [2]
  - Hydrogen liquefaction is complicated – cold temperatures and phenomena such as ortho-para conversion



[2]

- Injecting hydrogen into a natural gas pipeline allows for transport with existing infrastructure [3]
  - As hydrogen technology matures and global demand shifts away from natural gas, can increase ratio of hydrogen to natural gas in pipeline
  - May need to separate hydrogen from natural gas mix at destination
- Coastal Gaslink pipeline designed to transport 2.1 billion $\frac{ft^3}{day}$ of natural gas from interior BC to coast for export [4]
  - Can also process and export hydrogen that is added to this pipeline

[4]

Goal

- Study the economic benefits of injecting hydrogen into Coastal Gaslink pipeline based on modern hydrogen and natural gas liquefaction technologies

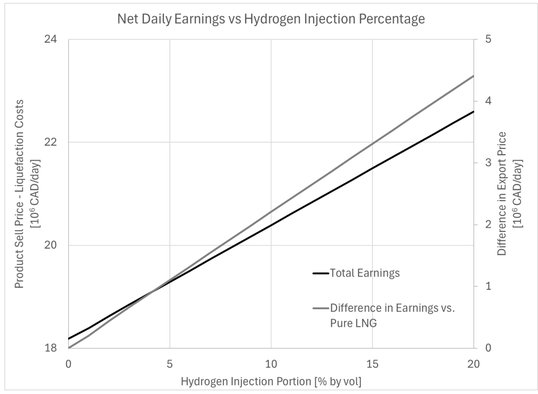
Methods

- Investigate methods of separating natural gas and hydrogen at processing plant
- Research modern hydrogen and natural gas liquefaction processes
  - Estimate specific energy consumption (SEC) for the liquefaction process
    - ❑ Energy input required per unit of product
  - Estimate the specific liquefaction costs (SLC) at the facility for both hydrogen and natural gas
    - ❑ Levelized cost per unit of product including all operational costs and capital investment costs
- Estimate the export earnings for natural gas/hydrogen mixes (up to 20% hydrogen by volume) with market prices

Results

- Separate natural gas and hydrogen by sending stream into LNG process – result is LNG and cold, low pressure mix of hydrogen and impurities
  - Can then purify hydrogen with cooling and distillation tower [5]
- U. Cardella's LH_2 process starts at 303 K, 2.5 MPa and ends at 200 kPa, 22.9 K (LH_2 conditions) [6]
  - Exergy change is 2.08 $\frac{kWh}{kg}$ - minimum possible energy input to liquefy H_2
- Kitimat LH_2 process would start at ~ 112 K, 120 kPa (LNG conditions) and ends at LH_2
  - Exergy change is 2.75 $\frac{kWh}{kg}$
  - SEC would be 9.17 $\frac{kWh}{kg\ LH^2}$ for a typical exergy efficiency of 30% [2]
- From 2018 EUR-CAD exchange rates, inflation, and electricity costs, SLCs of 2.185 $\frac{CAD}{kg\ LH^2}$ (50 TPD) 1.821 $\frac{CAD}{kg\ LH^2}$ (>50 TPD) chosen for Kitimat LH_2 plant [6] [7] [8] [9]
- SLC for LNG is 0.321 $\frac{CAD}{kg\ LNG}$ [8] [10] [11]
- LNG and LH_2 prices are 0.83 and 9.90 $\frac{CAD}{kg}$ respectively [12] [13]
- 1% by volume H_2 injection corresponds to 50 $\frac{tonnes}{day}$ [4]

Discussion



- 5% H_2 injection: \$1.1 million $\frac{CAD}{day}$ increase in earnings compared to pure LNG export (6.1% increase)
- 20% H_2 injection: \$4.4 million $\frac{CAD}{day}$ increase (24.3%)

Recommendations

- Injecting hydrogen into Coastal Gaslink pipeline can increase revenues and assist global transition to low-carbon energy
- Further design:
  - Operation of pipeline with mixed gas
  - Detailed liquefaction plant for more accurate cost estimates
  - Calculate costs for feedstocks and transport fees

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