Green Hydrogen as an Additive to Natural Gas Pipelines

Green Hydrogen Solutions Ltd.

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What's the Opportunity?

- The province of Alberta has shown promising capabilities to harness renewable energy. However, renewable power faces issues regarding intermittency and power storage. Therefore, the concept of storing renewable energy in the form of hydrogen has been explored by energy producers.
- Green Hydrogen Solutions Ltd. wishes to assess the feasibility of green hydrogen in Alberta in order to align energy generation with net-zero goals, while incorporating a heat recovery strategy to repurpose waste heat from the process.
- **Could a project like this be profitable, and ideally cheaper to produce, per kg H_2 than blue hydrogen?**

Why Blend Green Hydrogen with Natural Gas?

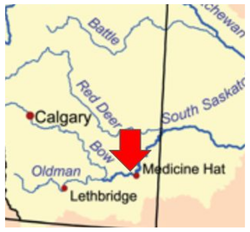
- Green hydrogen, defined as hydrogen produced by the electrolysis of water, using renewable electricity, produces zero CO_2e emissions compared to its alternatives: natural gas (NG) and blue hydrogen [1].
- Oxygen by-product can be purified and sold, or vented to the atmosphere with no negative impacts to the environment.
- Alberta's existing NG infrastructure is designed for an H_2 gas blend of up to 15% by volume [2]. This in turn:
  - Provides opportunities for long-duration hydrogen/energy storage and transportation.
  - Reduces CO_2e emissions by 5% from burning gas blend vs. non-blended natural gas [3].
- The province already has a skilled workforce, technical capacity, and also has experience in industrial-scale hydrogen production, transportation, and use [4].
- **By producing green hydrogen, Alberta can diversify its energy portfolio and boost the economy while contributing to a low-carbon future.**

Social, Health, Safety, & Environment

Concerns	Mitigations
Hydrogen Leaks	H_2 Detection & Ventilation [5]
Hydrogen Embrittlement	X52 steel pipes [6] with Al_2O_3, Ti_3AlN or TiC barrier coatings [7]
Electrical Hazards (Electrolyzer)	Grounding, Adherence to CSA [8]
Public Land Authorization	Consult Treaty 7 Indigenous communities [9] and AER [10]
Environmental Assessment	AER and AEP assessment [10]

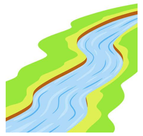
Our Process

Medicine Hat was chosen as our location for this project due to its proximity to a large river, nearby wind energy producers, and hydrogen-capable pipelines.

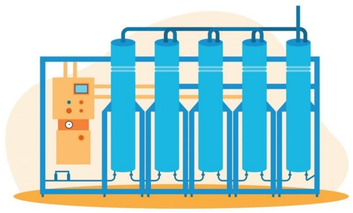


30 MW of power from grid, renewably sourced from a power purchase agreement.

The South Saskatchewan River acts as a water source for our process. Its initial conductivity and total organic carbon content are much too high for electrolysis, so purification is required.



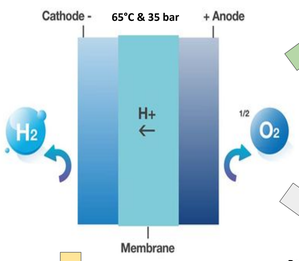
The river water undergoes a multi-step treatment process (ultrafiltration, reverse osmosis, electrodeionization) to meet ASTM Type 1 water standards for electrolysis, after which its TOC content will be <50 ppb and its conductivity will be <0.056 µS/cm [11].



The purified water is pumped to our PEM electrolysis unit, where it will be split into hydrogen and oxygen through an endothermic reaction:

$$H_2O_{(l)} + \text{energy} = \tfrac{1}{2}O_{2(g)} + H_{2(g)}$$

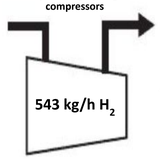
PEM ELECTROLYZER



Electrolyzer power consumption [13]: 51 kWh/kg H_2

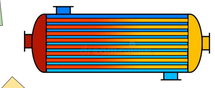
Produced oxygen is vented to the atmosphere.

Reciprocating hydrogen compressors

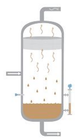


The produced hydrogen, initially at 30 bar, passes through the compression unit to increase its pressure to 150 bar, enough to be able to inject into the pipeline which operates at a maximum pressure of 140 bar [12].

Shell and tube heat exchangers are incorporated into the process to remove heat of compression and cool the hydrogen to a final temperature of 60°C, cool enough to prevent damages to pipeline coating for corrosion prevention [14].

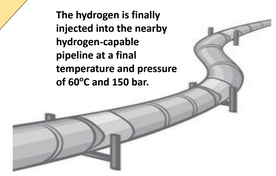


The cooled hydrogen passes through two-phase separators to remove any compressor oil that may have made its way into the stream.

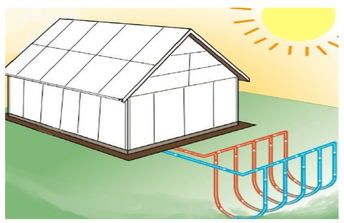


Waste heat is captured from electrolysis and post-compression heat exchange via a glycol loop using 103 t/h of 60/40 water/glycol mix. Heated glycol is pumped to a greenhouse 1 km away and chilled to -15°C before re-entering the system.

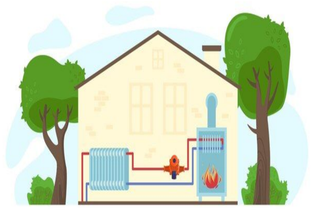
The hydrogen is finally injected into the nearby hydrogen-capable pipeline at a final temperature and pressure of 60°C and 150 bar.



Heated glycol is used for greenhouse heating during the colder months of the year. Backup diesel generators are included for heating during plant downtime.

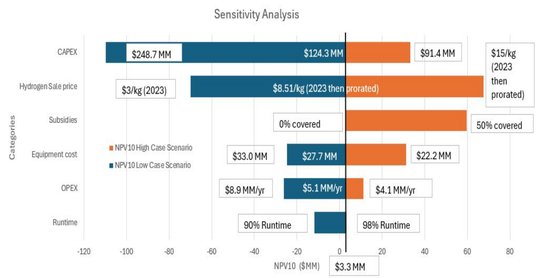


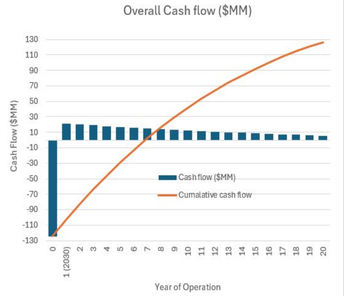
The final 85/15 by volume percent natural gas/H_2 blend goes to a variety of end users, including (but not limited to) homes, where it can be used for domestic heating. This blend reduces CO_2e emissions from burning natural gas by 5%.



Economic Feasibility

- Net Present Value (NPV10) of $3.3 million under the base case scenario:
  - (CAPEX = $124.3 MM, Hydrogen Sale Price $8.51/kg then prorated to $3.00/kg by 2050, annual OPEX at 5.1 MM/yr).
- Capital expenditures (CAPEX) represent the most significant financial variable, with a base estimate of **$124.3 MM**. However, the sensitivity of our CAPEX ranges from $91.4 MM to $248.7 MM due to variation in costs for the PEM electrolyzer, electrical installation, piping, and construction. This correlates to a wide NPV10 fluctuation from $33.3 MM to - $109.7 MM.
- Federal and provincial subsidies covering 50% of CAPEX may improve NPV10 to $59.8 MM, thus offering a more secure investment option.
- Payback period is 7 years (not discounted) or 19 years for the discounted payback period.
- Minimum selling price of Hydrogen should be $8.25/kg today, or **$6.11/kg in 2031** with a depreciation rate in sale price by 3.7% annually up until 2050 to result in a positive NPV10 [15].
- The project is currently **not advisable** due to high uncertainty in CAPEX, hydrogen sale price and risk of negative returns.





Conclusion & Recommendations

- GHS proposes a green hydrogen facility in Southeast Alberta using renewable power for PEM electrolysis and membrane technology for water purification, aligning with environmental goals and government initiatives.
- **This project could be economically viable if supportive regulatory framework approves subsidies for our green hydrogen project.**
  - Cost to produce 1 kg of blue hydrogen in Alberta [16]: ~ $2.00
  - Cost to produce 1 kg of green hydrogen with our project: $1.80 – $4.40
  - Our lowest possible **selling price to be profitable**: $6.11/kg H_2 in 2031.
- **Although blue hydrogen currently holds the financial advantage in Alberta, a more favorable regulatory environment could make green hydrogen more economically attractive than blue hydrogen!**

Acknowledgment

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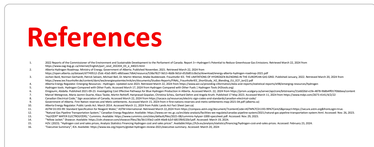
References



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