AMMONIA-TO-HYDROGEN DECOMPOSITION
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WHAT’S THE ISSUE?
Hydrogen’s inclusion in our energy economy is currently limited by its low volumetric energy density, & volatile reactivity. Current solutions are limited due to these properties, requiring energy intensive and expensive processes. Exploring the storage of hydrogen in other chemical forms has the potential to make the Canadian hydrogen economy a more achievable goal. Our project explores ammonia as a hydrogen carrier to be decomposed onsite. Ammonia has been chosen to be our hydrogen carrier due to its:
- High hydrogen weight percent (17.6 wt. %).
- Non-hydrocarbon-based resource.
- Competitive transportation costs.

1. Ammonia Storage Tank

\[ \log_{10}(0.86 \text{ bar}) = 3.18757 - \frac{506.713}{T - 80.78} \]

\[ T = 236.5^\circ K = -36.6^\circ C \]
- Storage for 10,000 cubic meters of ammonia at ~40°C.
- 3°C temperature buffer from boiling point for concerns regarding ammonia flashing from ambient pressure swings.

2. Fired Furnace Heater

- Fired furnace raises temperature to 500°C at validated 70% efficiency.
- Methane combustion with 10% excess air.
- Recycles all energy from reactor effluent.

3. Thermal Decomposition Reactor

- Multi-tubular PBR.
- Operating at 500°C & 1 bar.
- Single pass conversion of 85%.
- Nickel catalyst within tubes.
- 1252 tubes, with 5 cm ID.
- Heated length of 10 m.

4. Ammonia Separation and Recycle

- Absorption tower with 15 stages, utilizing a water solvent to strip ammonia from product mix.
- Subsequent 15 stage stripping tower to separate, recycle unreacted ammonia.

5. Hydrogen Separation

- Two PSA units, operating at 37°C and 10 bar.
- Adsorber bed material composed of activated carbon.
- Hydrogen purity of 99.98 wt. %.
- Purged with steam upon saturation.

FEASIBILITY
Economic Breakdown

<table>
<thead>
<tr>
<th>Total Capital Investment</th>
<th>Annual Operating Costs</th>
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<td>$154.9MM</td>
<td>$118.4MM</td>
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Net Present Value $84.5M
Discounted Payback Period 3.6 years
Project Return on Investment 54.6%

ACKNOWLEDGEMENTS
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HEALTH AND SAFETY CONSIDERATIONS
Safety Risks
- Equipment Malfunction
- Chemical Leakage
- Ammonia Flashing
- Hydrogen Explosion

Mitigations
- Fire Relief Valves
- Temperature Buffers
- Ventilation Strategies
- Advanced Control Strategies

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