AMMONIA-TO-HYDROGEN DECOMPOSITION

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Cracked
Clean Energy Solutions

SCHULICH School of Engineering
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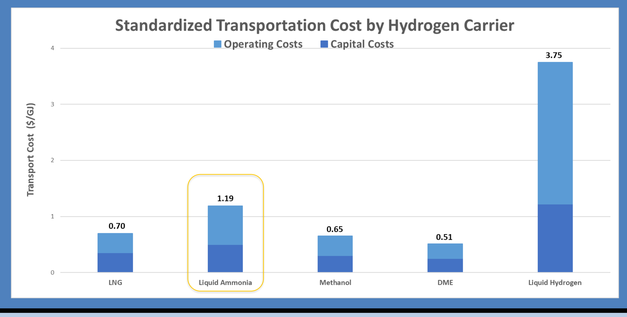
WHAT'S THE ISSUE?

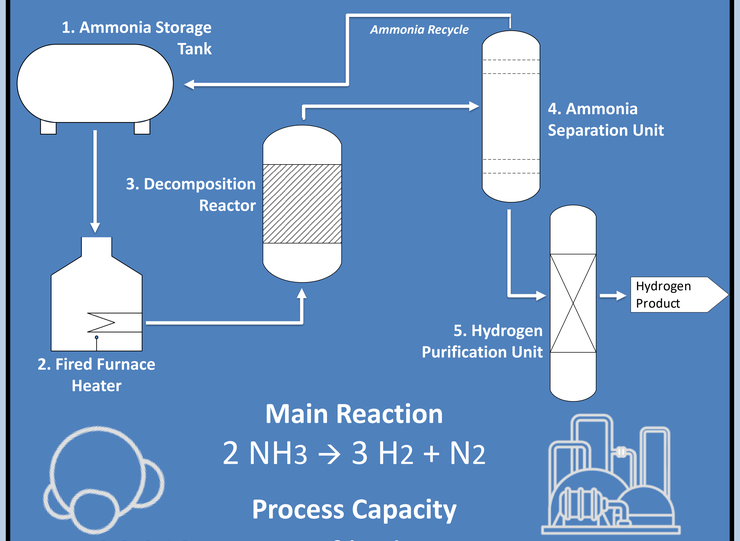
Hydrogen's inclusion in our energy economy is currently limited by its **low volumetric energy density**, & **volatile reactivity**. Current solutions are limited due to these properties, requiring **energy intensive** and **expensive processes**. Exploring the storage of hydrogen in **other chemical 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.



PROCESS HIGHLIGHTS



Main Reaction

$2\ NH_3 \rightarrow 3\ H_2 + N_2$

Process Capacity

26 240 tonnes of hydrogen per year

HEALTH AND SAFETY CONSIDERATIONS

Safety Risks

- Equipment Malfunction
- Ammonia Flashing
- Chemical Leakage
- Hydrogen Explosion

Mitigations

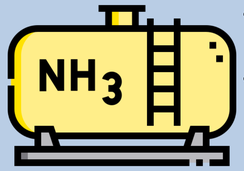
- Fire Relief Valves
- Temperature Buffers
- Ventilation Strategies
- Advanced Control Strategies

DESIGN DESCRIPTION

1. Ammonia Storage Tank

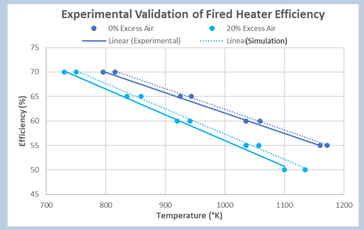
$$log_{10}(0.86\ bar) = 3.18757 - \frac{506.713}{T - 80.78}$$

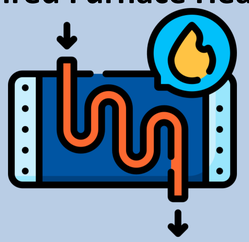
$$T = 236.5°K = \mathbf{-36.6°C}$$



- 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.

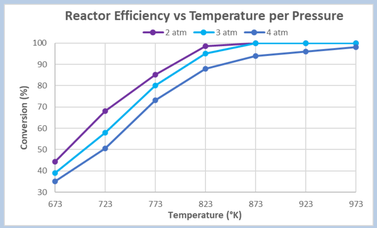
2. Fired Furnace Heater

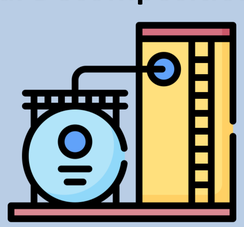




- Fired furnace raises temperature to 500°C at validated 70% efficiency.
- Methane combustion with 10% excess air.
- Recycles all energy from reactor effluent.

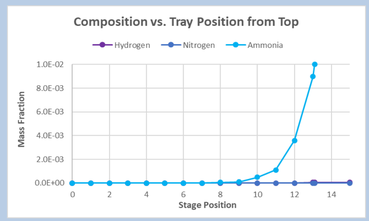
3. Thermal Decomposition Reactor





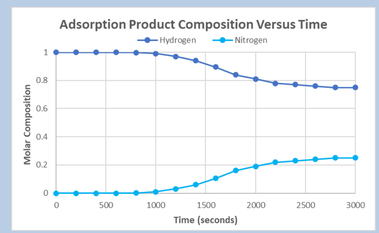
- Multi-tubular PBR.
- Operating at 500°C & 1 bar.
- Single pass conversion of 85%.
- Nickel catalyst within tubes.
- 1252 tubes, with ID 5cm.
- Heated length of 10m.

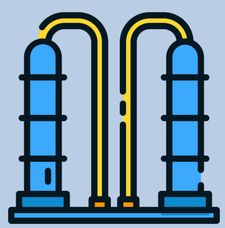
4. Ammonia Separation and Recycle



- 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





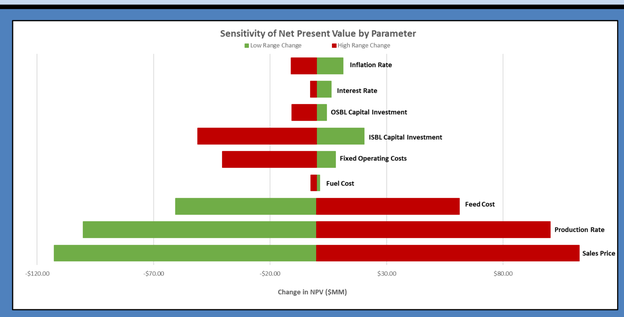
- Two PSA units, operating at 37°C and 10 bar.
- Adsorber bed material composed of activated carbon.
- Hydrogen purity of 99.98 wt. %.
- Purged with steam upon saturation.

FEASIBILITY

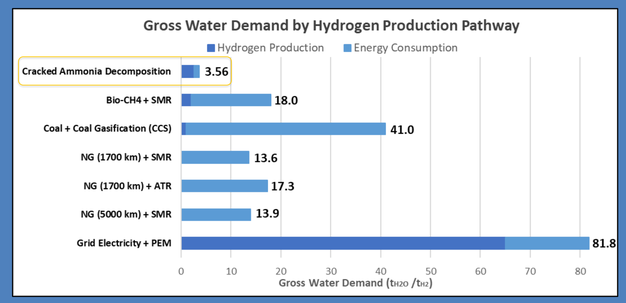
Economic Breakdown

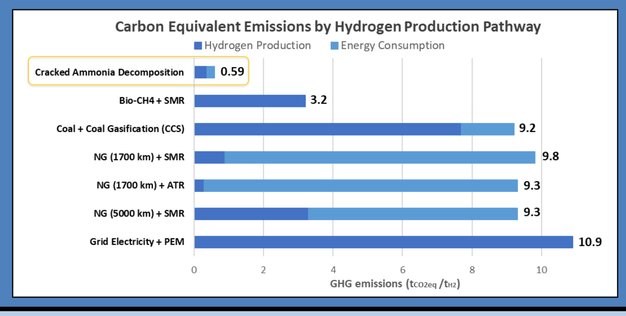
Total Capital Investment	Annual Operating Costs
$154.9MM	$118.4MM

Net Present Value	Discounted Payback Period	Project Return on Investment
$84.5M	3.6 years	54.6%



Environmental Breakdown





ACKNOWLEDGEMENTS

The Cracked team extends heartfelt thanks **to Dr. Nader Mahinpey** for his invaluable support and guidance, and to **Babak Labbaf** and **Dr. Amr Abdalla** for their support under **Dr. Mahinpey**'s leadership.

We extend our gratitude to **Dr. Hector De La Hoz Siegler** for organizing an enriching semester that has deepened our understanding of team dynamics and rigorous engineering design.