Efficient, scalable and modular ammonia to hydrogen/electricity conversion system development and demonstration

Cavendish Renewable Technology, Australian National University, Royal Melbourne Institute of Technology, Northwestern University and Emerson Process Management Australia

15 March 2024

The ultimate objective of this project is to revolutionise the conversion of liquid ammonia to electricity or hydrogen by optimizing catalytic converter integration with fuel cells. This will ensure maximum conversion efficiency under normal operating conditions, while reducing costs by avoiding the use of expensive critical materials such as Palladium. This system will be a significant contribution to making green ammonia a viable energy vector.

Introduction

Ammonia offers significant advantages as a carrier of renewable energy because of its high hydrogen content, it's a liquid at room temperature and is already a commonly transported commodity. Current challenges in converting liquid ammonia back into electricity or hydrogen include energy-intensive conversion processes and downstream separation complexities, consuming more than one-third of hydrogen's energy content (as shown in Figure 1 below).

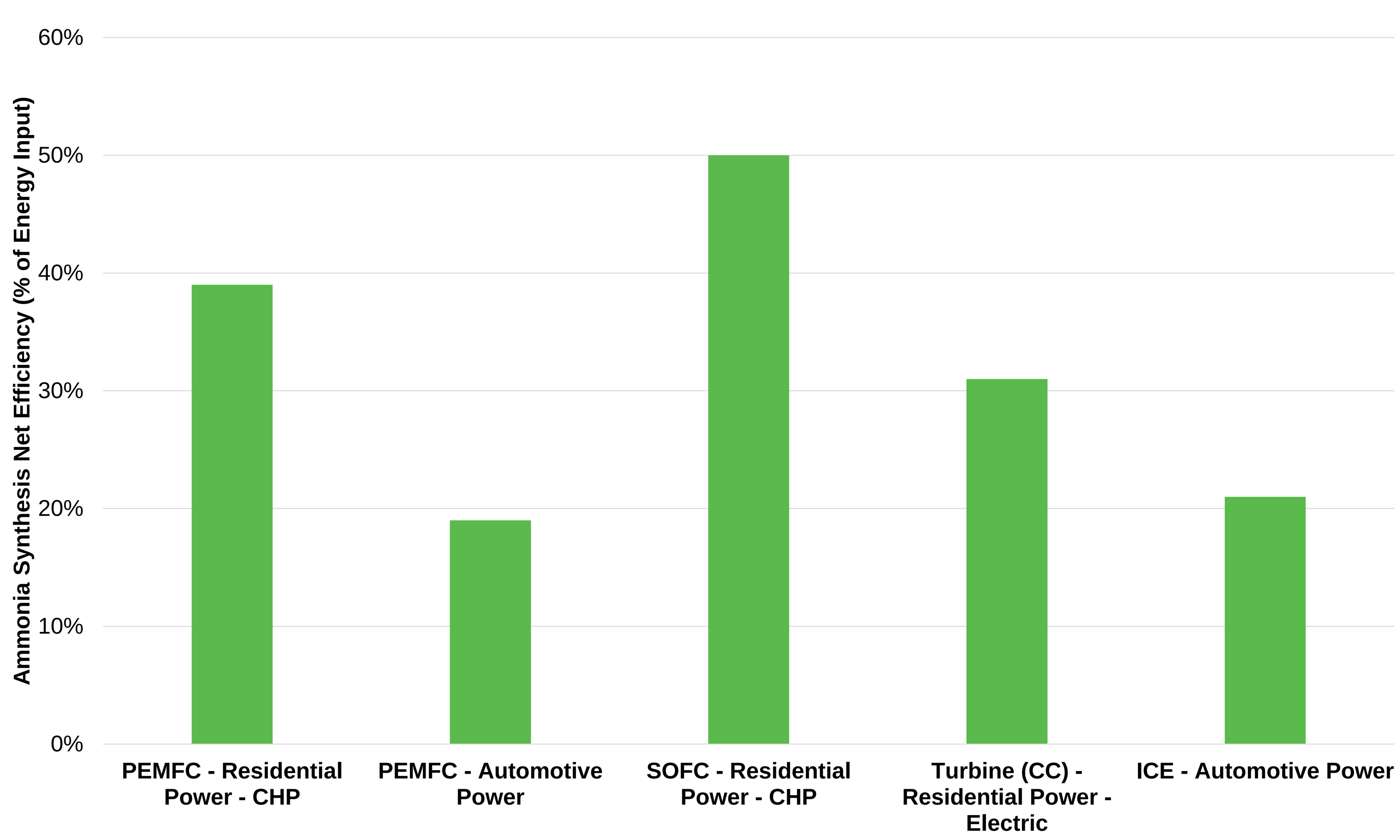

Figure 1: Comparison of efficiency for different end-use applications of ammonia[1]

Note: PEMFC – Polymer electrolyte membrane fuel cell, CHP – Combined heat and power, SOFC – Solid oxide fuel cell, CC – Combined cycle, ICE – Internal combustion engine

Methodology

The proposed solution involves a catalytic reactor (Ammonia cracker), directly integrated with a Solid Oxide Fuel Cell (SOFC) or as a standalone unit utilizing SOFC exhaust heat, the novel integrated ammonia cracker (NIAC). Based on the end use of the proposed ammonia cracker, the output would be either electricity, hydrogen, or a combination of hydrogen and electricity. The catalytic cracker does not require additional downstream separation and operates at significantly lower temperatures than traditional ammonia crackers. Thereby, the proposed cracker can also be used with well established Polymer Electrolyte Membrane (PEM) fuel cell technology.

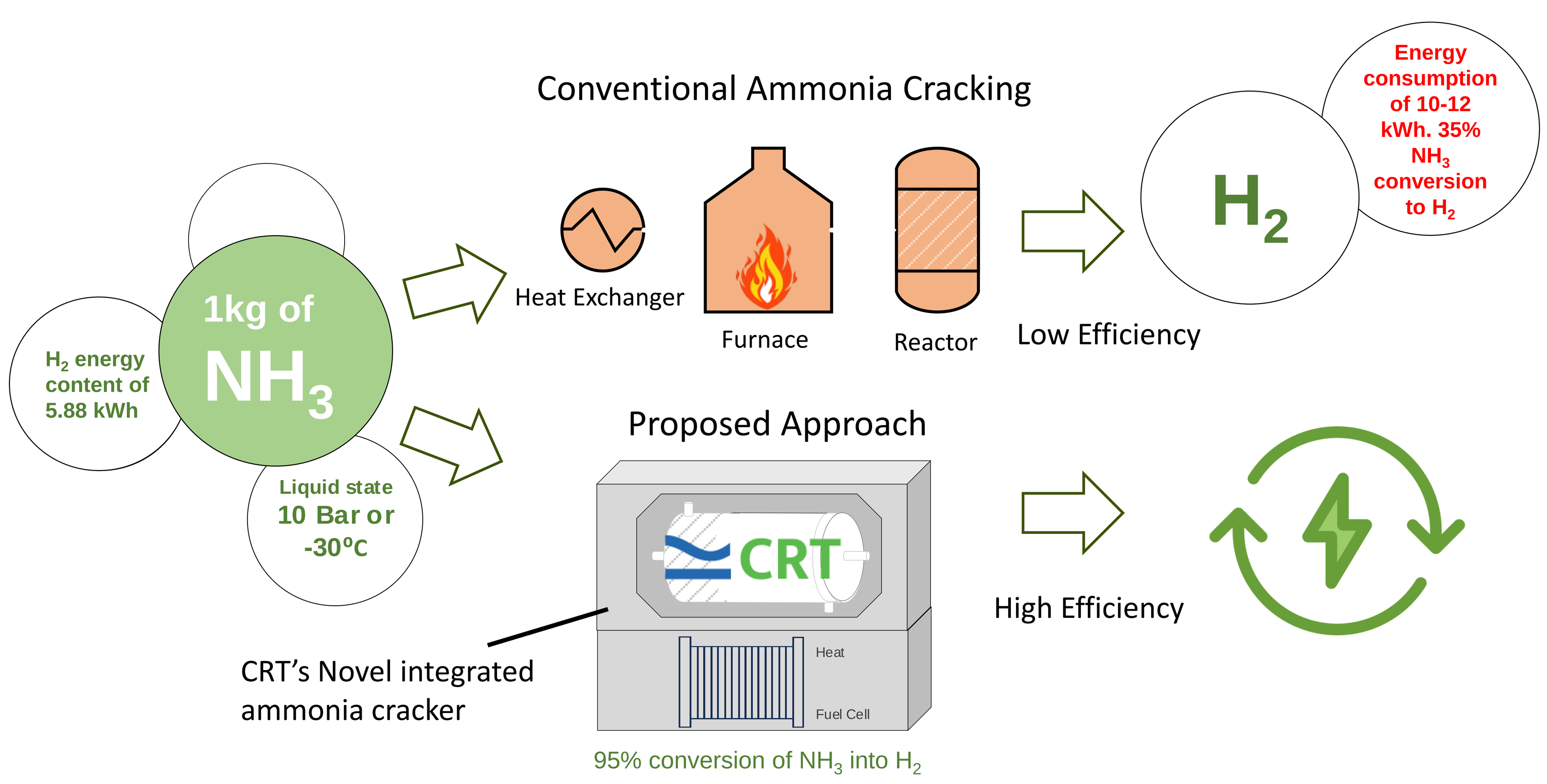

Figure 2: Conventional cracking versus proposed approach

Converting Ammonia to Electricity

The novel integrated ammonia cracker (NIAC) is a versatile device which can be used either inside or external (below) to a fuel cell. In the integrated configuration, the catalytic reactor would be placed in way to allow lossless integration with the fuel cell system and simpler balance of system design. Our technology provides an integrated approach bypassing the need for expensive palladium membranes used in conventional ammonia crackers and enabling more efficient conversion at high temperatures.

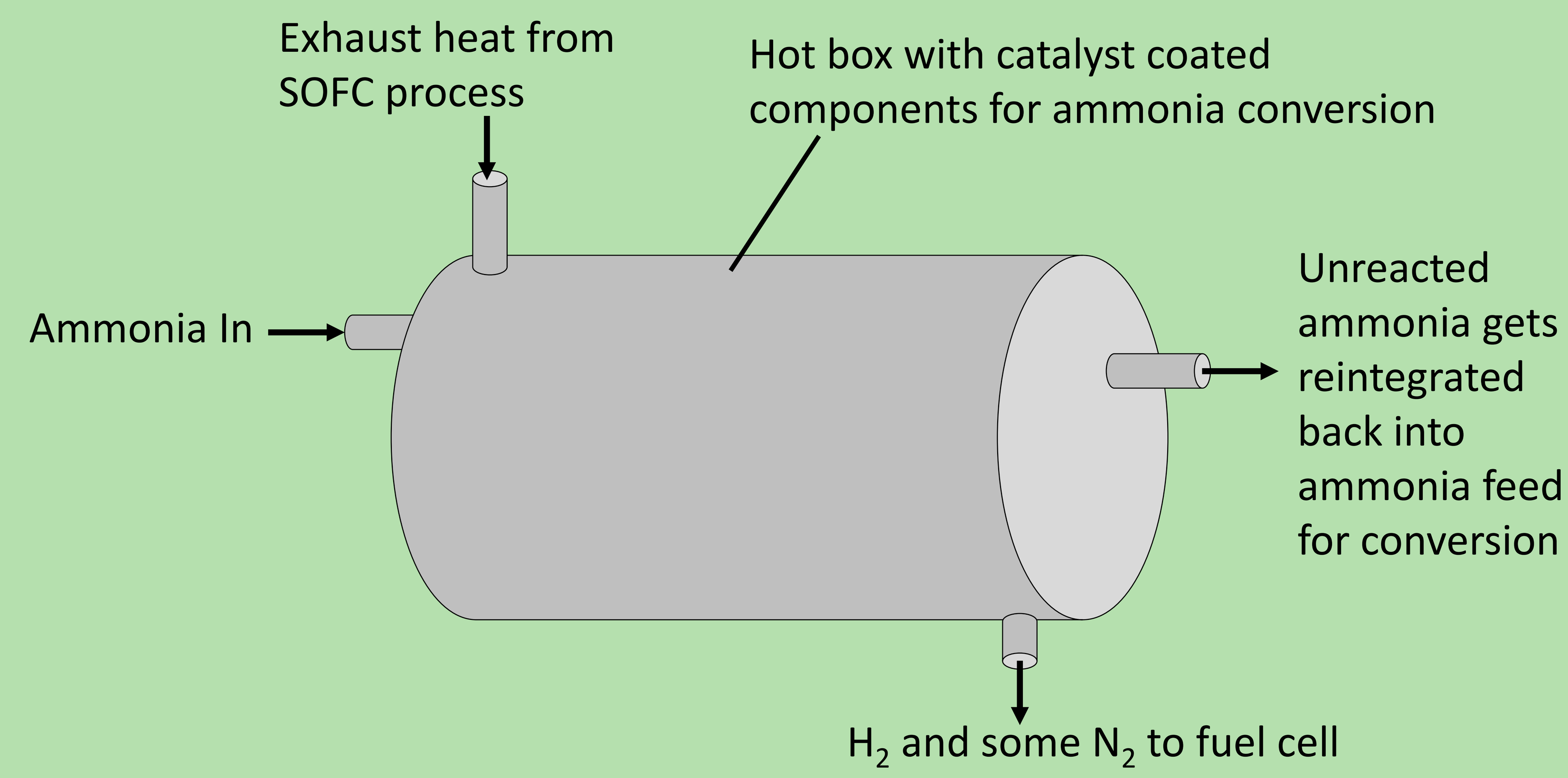

Figure 3: Simplified diagram of lab scale NIAC

Project Timeline

2024 -Stage 1
- Optimizing the Chemical Composition of Catalysts
- Optimization of Ammonia Cracker Design
- Optimization of catalyst coating methods

2025 - Stage 2
- Material Freeze: After optimization of catalyst composition and cracker optimisation
- Modelling and integration studies
- Building small fuel cell stacks
- Building prototype

2026 - Stage 3
- Demonstration and performance evaluation
- Producing a commercialisation roadmap and funding strategy for technology commercialisation.
- Develop go to market strategy

Future Directions

The future directions for the proposed technology will involve:

- Staying at the forefront of technology advancements
- Contributing to a green ammonia-based energy transition
- Showcasing benefits for applications in power, transportation and industry
- Adapting and standardising technology to suit diverse regional needs
- Focusing on commercialisation through licensing agreements with energy and chemical industry partners, supported by the market analysis and viability studies, while evaluating potential spin-offs or startups based on market demand and technology readiness.
- Continuous innovation and ongoing investment in R&D optimization

For further information

Name: Aniruddha Kulkarni
Email: engineering@cavendishrenewable.com.au
Address: 2/27 Laser Drive, Rowville VIC 3178
Website: https://cavendishrenewable.com.au/

References

1. ACS Sustainable Chem. Eng. 2017, 5, 10231–10239

Acknowledgement

This Project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Transformative Research Accelerating Commercialisation Program