



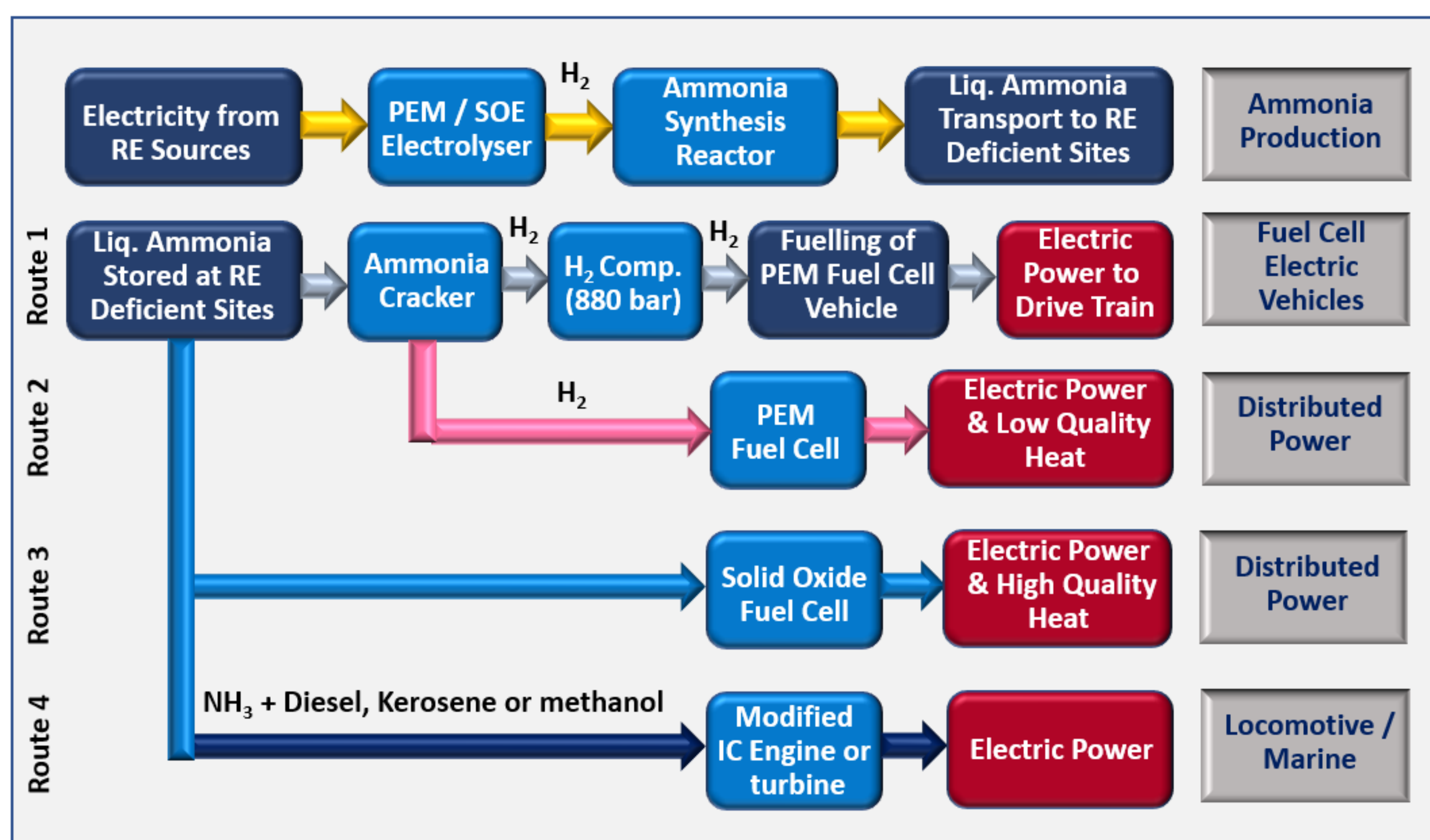
# Low pressure green ammonia production for distributed scale applications

Mandar Risbud, Gary Paul, Sarbjit Giddey, Nawshad Haque, Tara Hosseini, Tim Lai

## Background

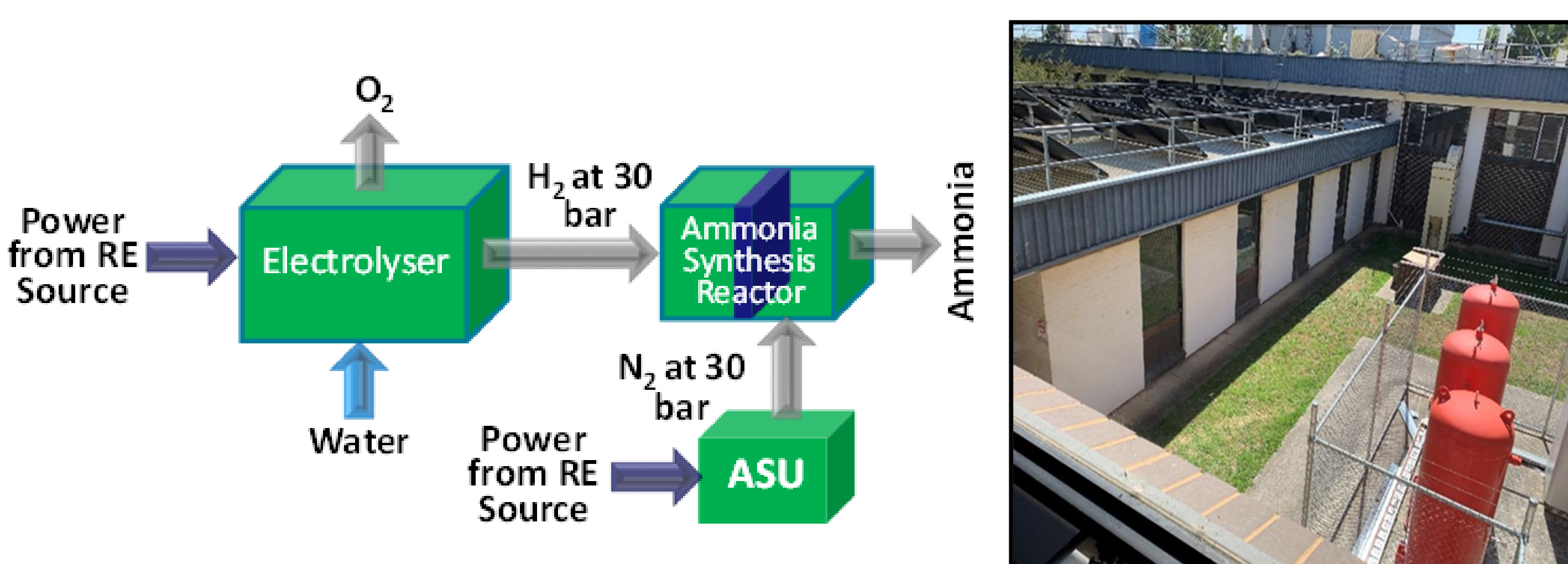
- Global Ammonia Production  $\approx$  200 Mt/yr mostly from coal, natural gas and fuel oil; mainly used as a fertiliser. Responsible for nearly 2% global CO<sub>2</sub> emissions
- Conventional Haber-Bosch process is capital and energy intensive (high temperature, high pressure) involving multiple steps.
- Ammonia can play a major role in renewable energy storage and as a H<sub>2</sub> carrier.

## Ammonia as a renewable energy storage and H<sub>2</sub> carrier



Our group is working on technology development shown in blue boxes

## CSIRO Technology concept and demonstration rig

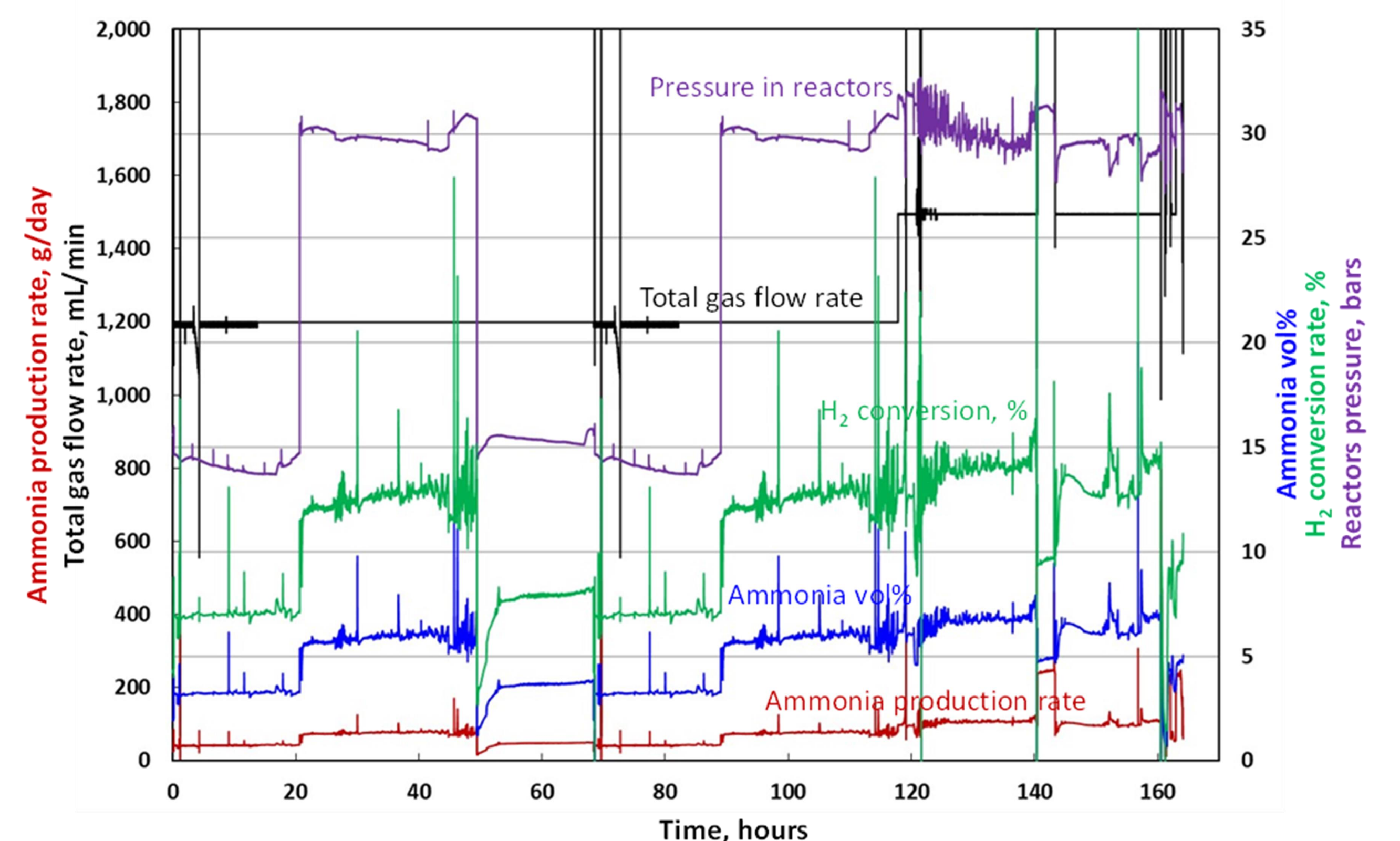


## CSIRO technology

- Patented technology based on hybrid membrane reactor approach.
- Technology allows ammonia production above equilibrium contents, with hydrogen to ammonia conversion rates approaching 15%.

## Technology advantages

- **Energy Savings:** Low pressure operation (1/5<sup>th</sup> of pressure compared to Haber-Bosch)
- **Decentralised NH<sub>3</sub> / fertiliser production:** Direct coupling of RE electrolyser and ASU to ammonia synthesis reactor: lesser system/BOP components.
- **Capital savings:** No high pressure (>150 bar) reactors / equipment. Low pressure membrane based reactor offers substantially reduced synthesis reactor costs.



Ammonia production rates and hydrogen to ammonia conversion rates achieved at 450°C / 30 bar pressure.

## Major Achievements

- Successful demonstration of green ammonia production at kg/day scale using hydrogen from an electrolyser operated by grid supported solar PV at CHES, CSIRO Clayton.
- Technology allows the use of low cost materials for the reactors.

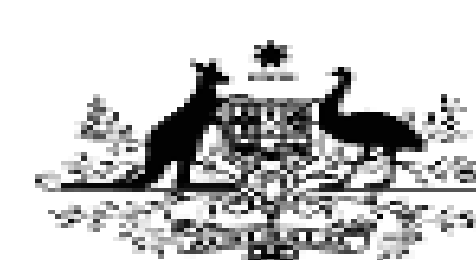
## Drivers and Future opportunities

- Use of intermittent RE sources and the modular technology allows for distributed production of ammonia.
- The detailed techno-economic analysis on CSIRO's technology and conventional Haber-Bosch process demonstrates a significant savings on the CAPEX and OPEX
- Currently CSIRO team working on technology commercialisation, with support from industry.

As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.  
CSIRO. Unlocking a better future for everyone.

FOR FURTHER INFORMATION  
Mandar Risbud  
ENERGY  
Mandar.Risbud@csiro.au  
csiro.au/energy

ACKNOWLEDGEMENTS  
Authors would like to acknowledge ARENA and GRDC for funding of the project and ORICA for their help and support



Australian Government  
Australian Renewable  
Energy Agency

ARENA

