MariNH$_3$

Clean, green ammonia
engines for maritime

# AMBURN & MariNH$_3$: Ammonia energy delivery

Supported by: CIMAC INTERNATIONAL COUNCIL Power | Drives | Propulsion; Cambustion


Professor Agustin Valera-Medina

CEAT Centre of Excellence on Ammonia Technologies



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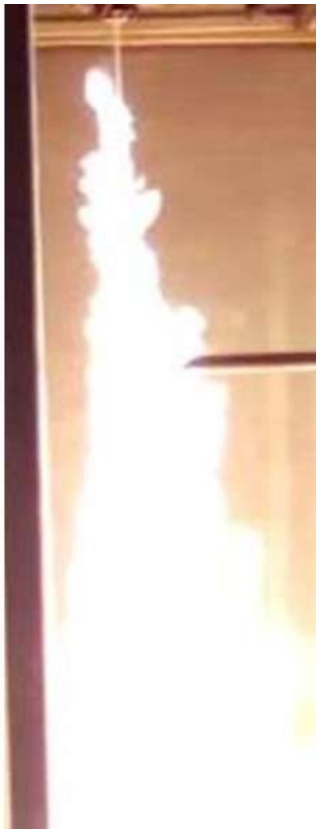

Cardiff University Press | Gwasg Prifysgol Caerdydd

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# Introduction

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**Exhibit 11: Distribution of global hydrogen resources and demand centers**

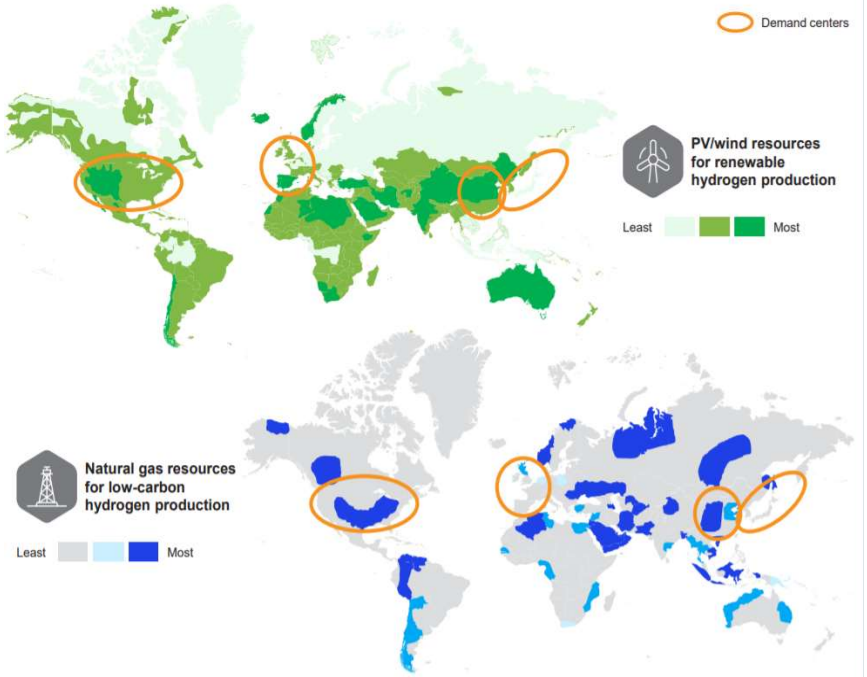
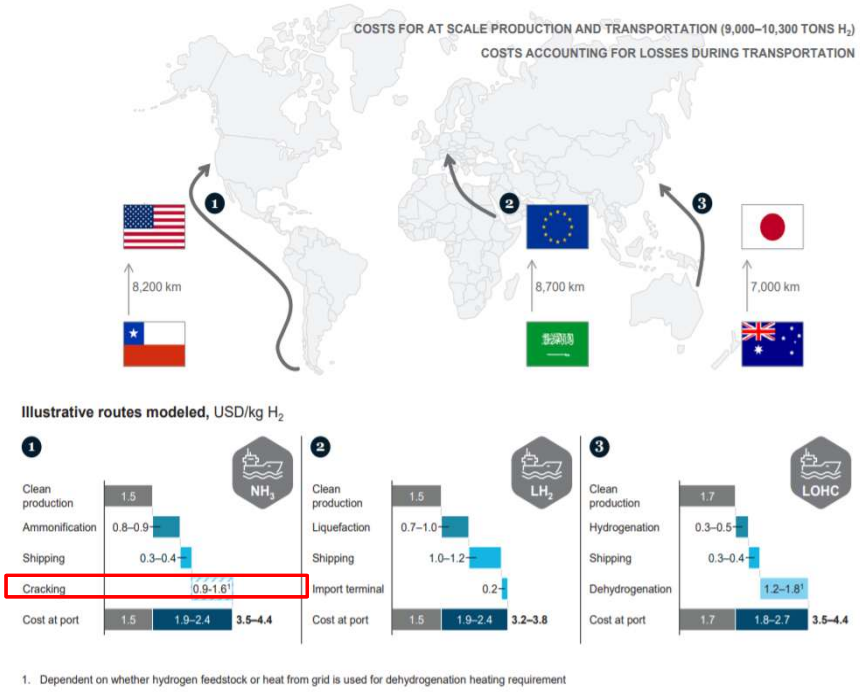



**Exhibit 16: Landed costs of hydrogen at port for selected global transport routes**




Hydrogen distribution and comparison between vectors.
Ammonia is superior if used raw [Hydrogen Council 2021]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# Opportunities

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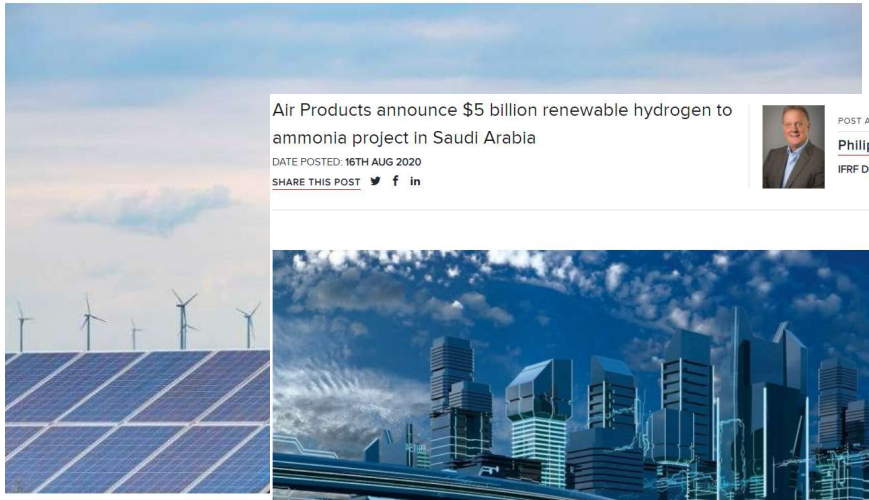
## World's largest renewable energy project proposed for north-west Australia ditches electricity in favour of ammonia exports

ABC Kimberley / By Ben Collins and Vanessa Mills

Posted Yesterday at 3:29am, updated Yesterday at 3:59am



The proposal is to use large-scale wind ar

Air Products announce $5 billion renewable hydrogen to ammonia project in Saudi Arabia

DATE POSTED: 16TH AUG 2020

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POST AUTHOR

Philip Sharman

IFRF DIRECTOR

HYDROGEN POWER

## CF plans green ammonia plant in Louisiana

The company believes it can make more money in hydrogen than it does in fertilizer

By Alexander H. Tullo

NOVEMBER 5, 2020 | APPEARED IN VOLUME 98, ISSUE 43

CF Industries' fertilizer plant in Donaldsonville, Louisiana

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Resources, Energy & Environment

### IHI and JERA Complete Fuel Ammonia Substitution Demonstration Testing at Hekinan Thermal Power Station

Demonstration Testing at Hekinan Thermal Power Station

IHI

IHI Corporation ("IHI") today announces the completion of pioneering fuel ammonia substitution demonstration testing at Unit 4 of the Hekinan Thermal Power Station of JERA Co., Inc ("JERA").

PRESS RELEASE

## GE and IHI Sign Agreement to Develop Ammonia Fuels Roadmap across Asia

June 22, 2021

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# Opportunities

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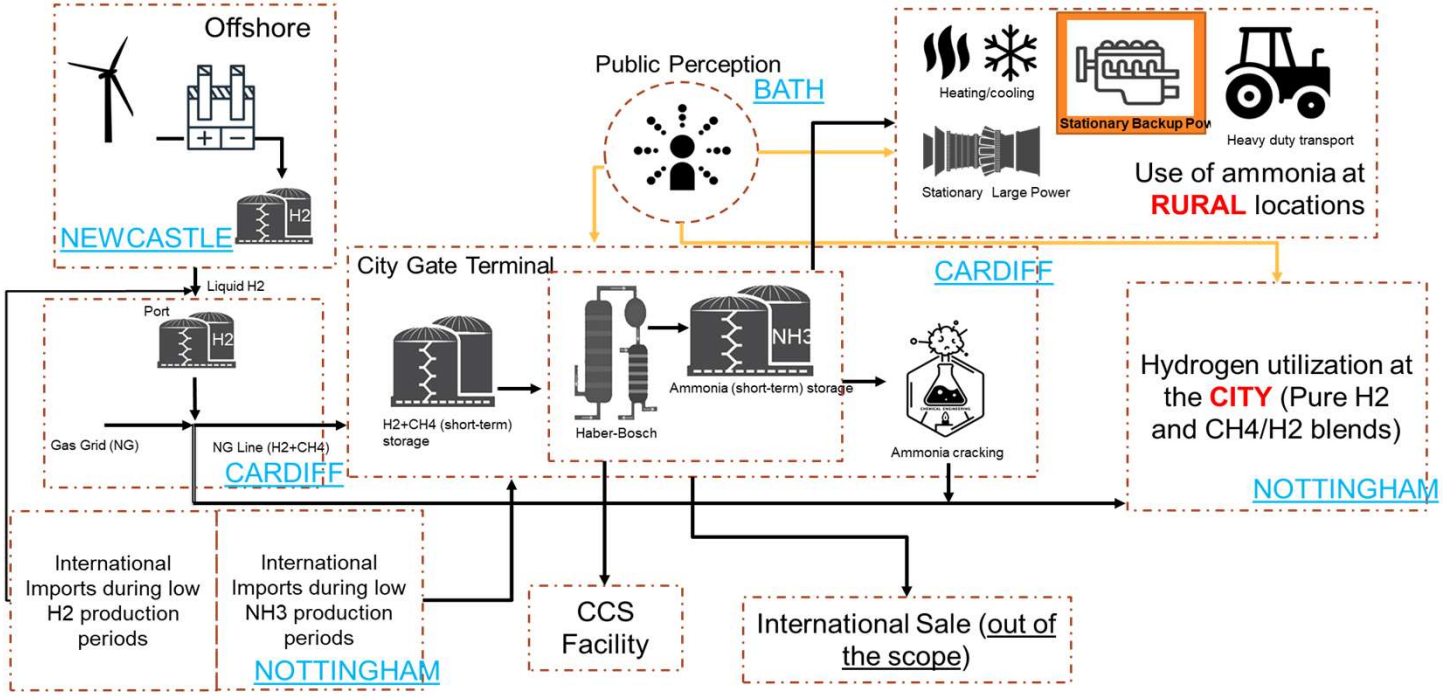
- Cheaper distribution, higher hydrogen content and easier operation will change the position of $NH_3$ in the energy arena.





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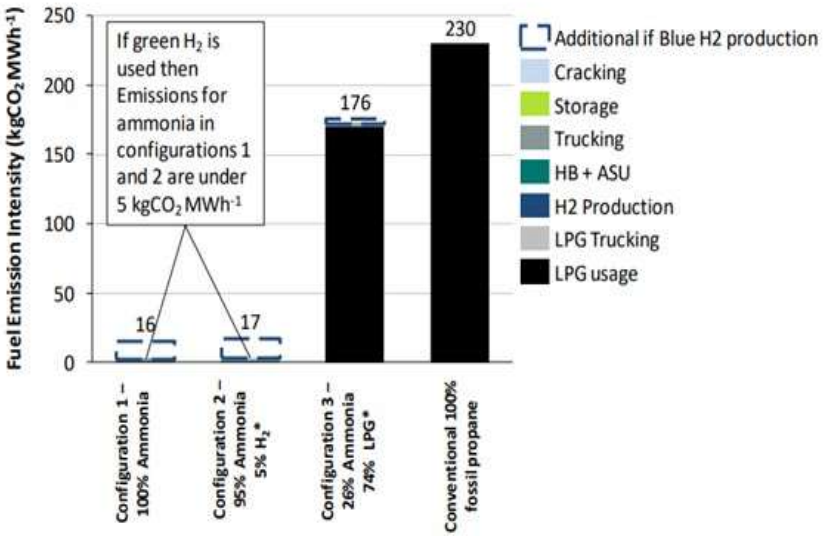
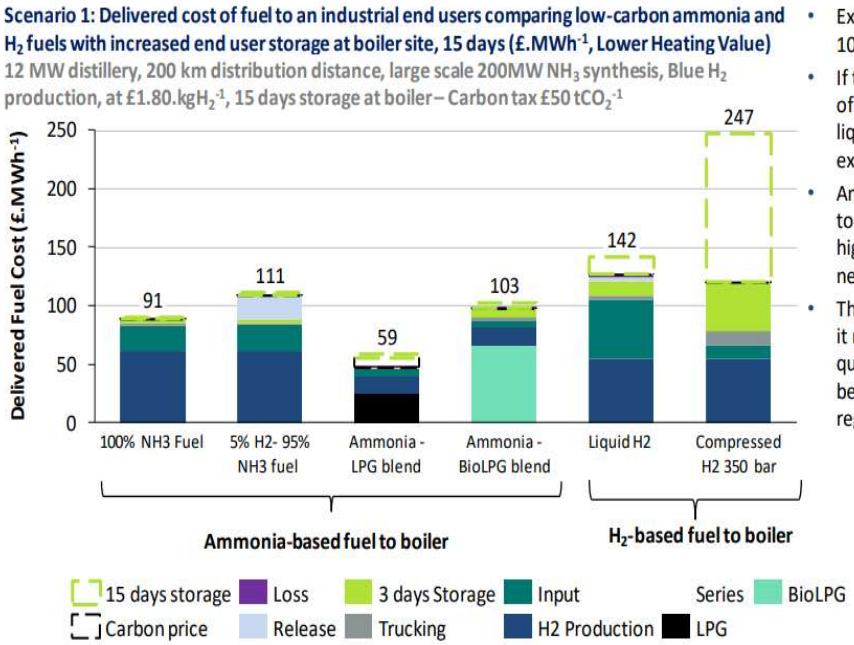
# Developments – boilers / furnaces

MariNH3
Clean, green ammonia engines for maritime




- Existing off-gas grid boiler sites have between 10 and 15 days of storage.
- If this higher storage is needed Ammonia offers a comparative cost improvement over liquid and compressed hydrogen which are expensive to store.
- Ammonia can be stored at similar conditions to LPG whilst compressed hydrogen needs high pressures (350 bar), or liquid hydrogen needs extremely low temperatures (-253°C).
- Though this gives an advantage to ammonia, it may be that for new technologies lower quantities of storage are used due to storage being more expensive and possible regulatory/safety constraints.

Emissions and delivery fuel cost of various options. Ammonia with LPG is the most cost effective, with the potential reduction of 95% CO2 emissions (report 2023, 145 pages).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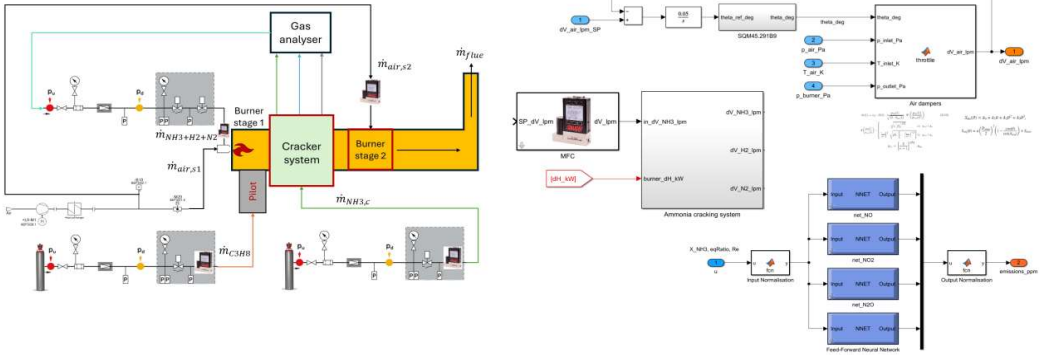
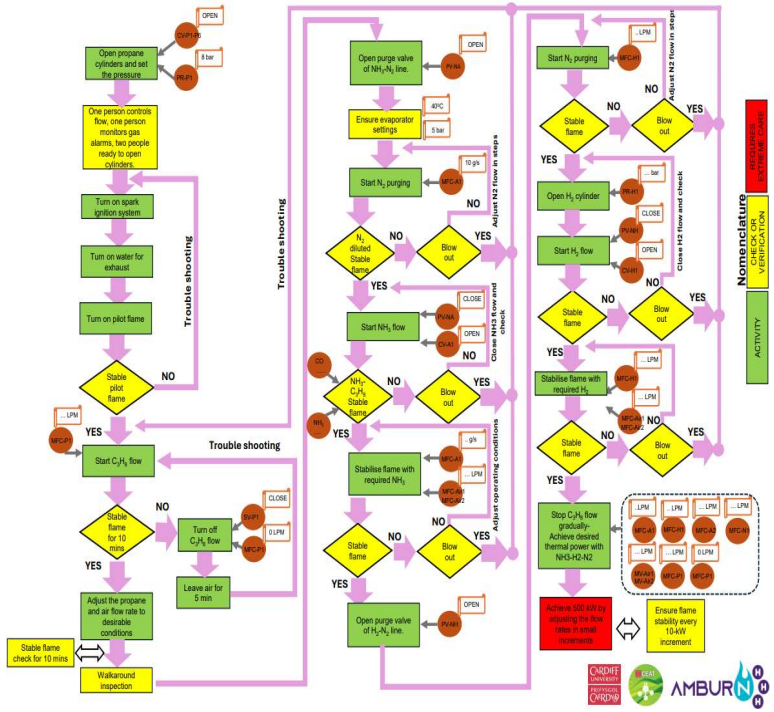
Automatic ammonia-hydrogen ($NH_3$/ $H_2$) combustion system










Commissioning, Control Design using AI, Bespoke Protocols, HAZID/HAZOP, Dispersion analyses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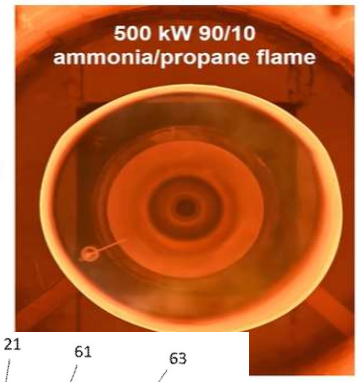
#ammonia, #netzero, #zerocarbonfuels, #industrialimplementation

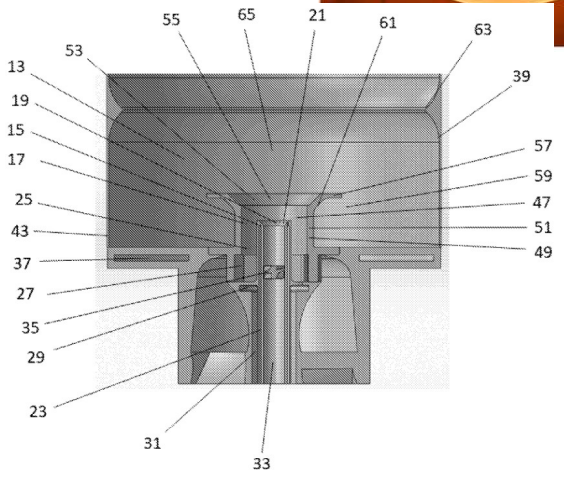
**WP6: Stage 1 Combustion Testing**

Lead Partner: Cardiff University

- Lab scale burner scaled up to 3MW √
- Commissioned the burner √
- Tested up to 500kW thermal power √

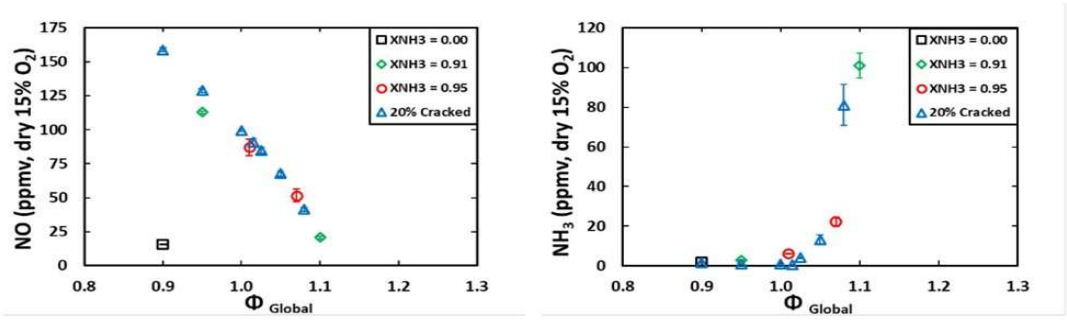



AMBURN




Emissions: $NH_3/C_3H_8$ and Cracked $NH_3$ – Air Staging

500 kW, $\Phi_P$ = 1.2




* Negligible $N_2O$, $NO_2$ and $H_2$ measured

Patent US20240060645A1 (Valera-Medina). Proved at 0.5MW power with 95-5% $NH_3$/LPG and 100% $NH_3$ (using cracked ammonia). Negligible emissions of NO and $NH_3$.

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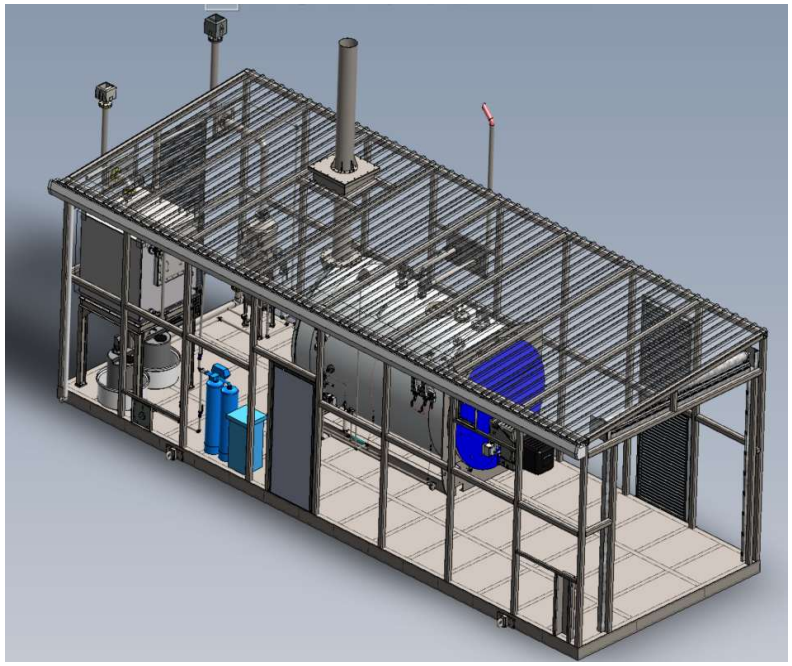
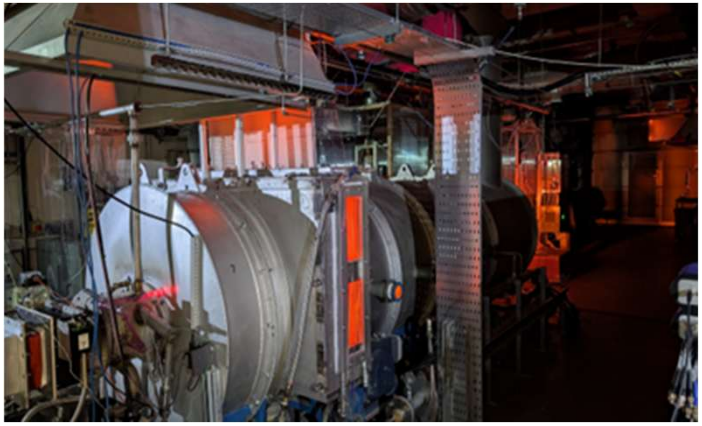
The unit will be used for demonstration in a poultry farm. The system has currently been operated using 97% ammonia and 3% LPG, reducing ~80% $CO_2$ at 900kW.





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The unit has been tested at 980 kW (Spadeadams). Further developments are expected for the deployment of ammonia to isolated regions.

# Developments – boilers / furnaces

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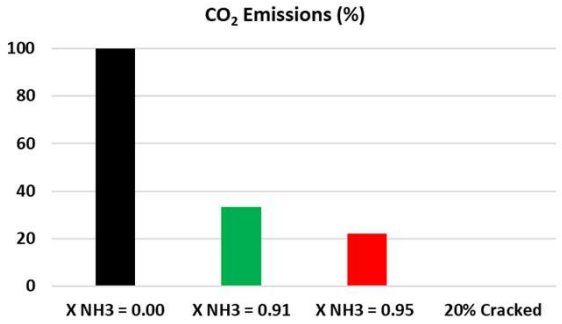
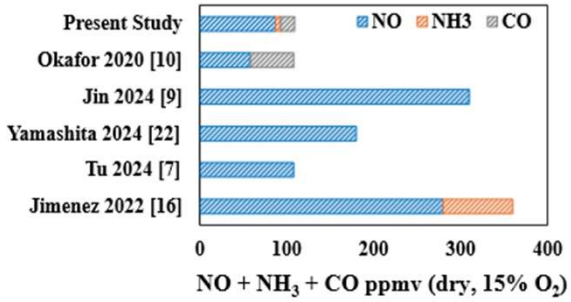
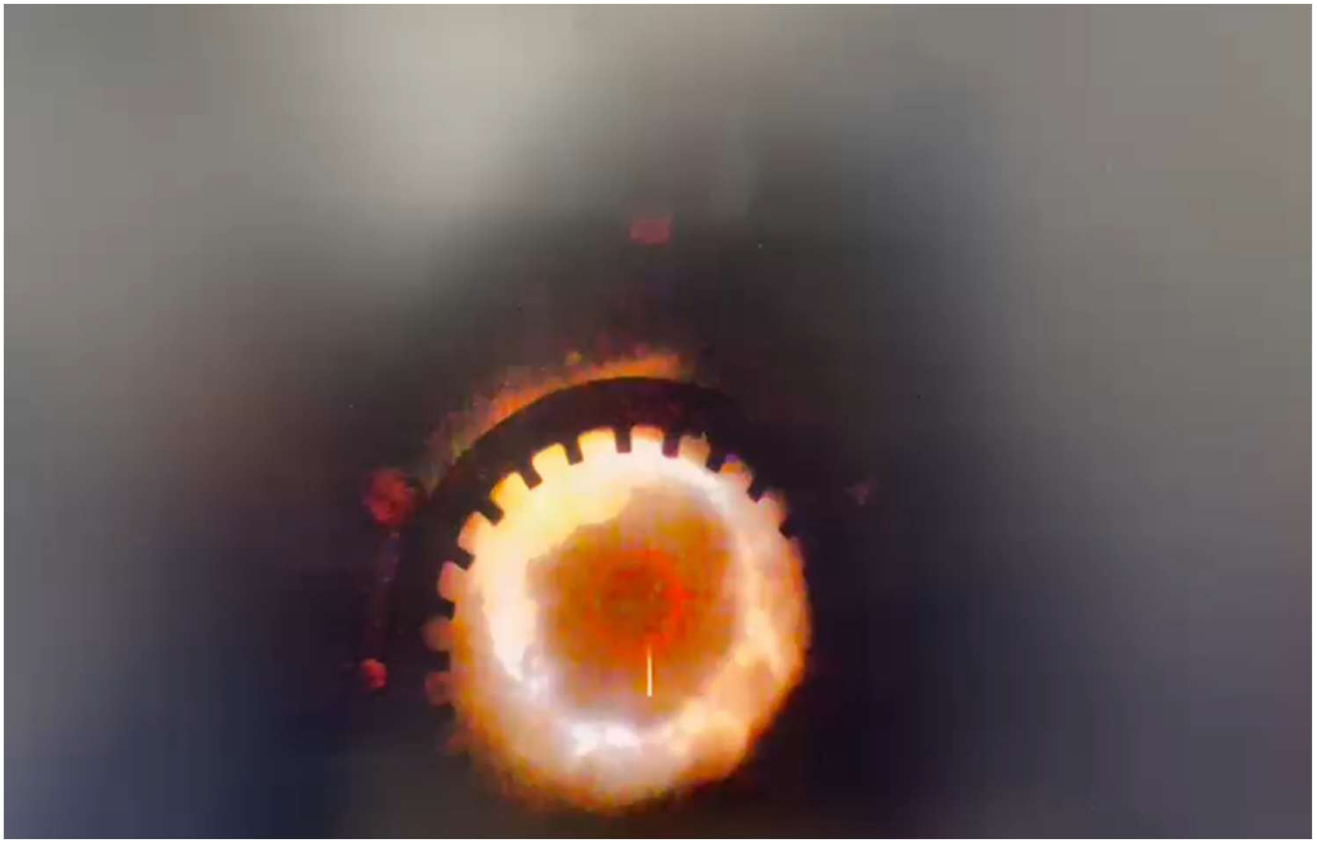



Emissions abatement compared to other studies (low power) with steam generated (5 bar, 1.3 tons/hr).



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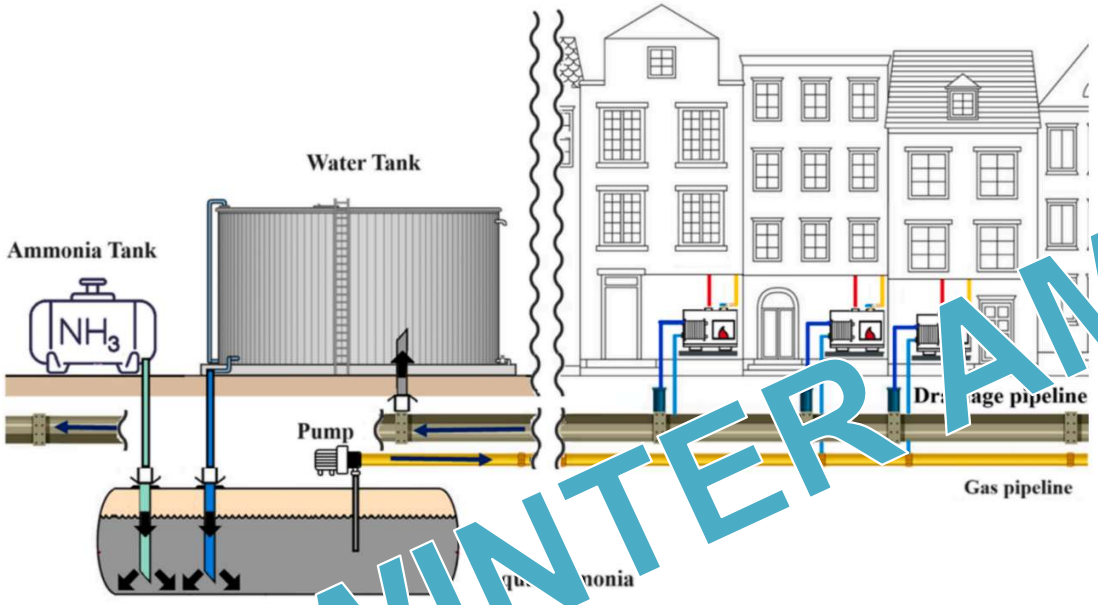


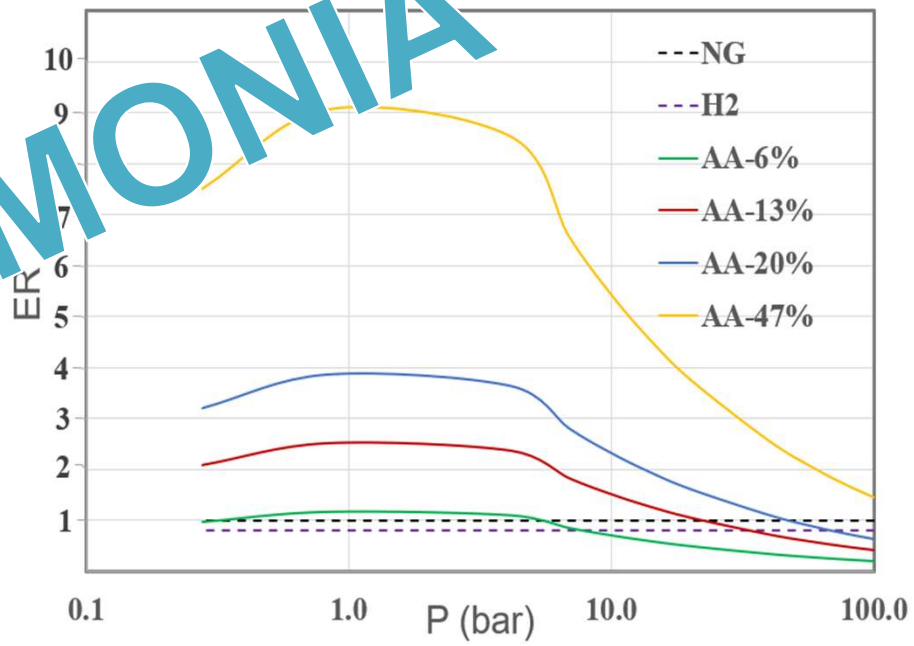


WINTER AMMONIA

Aqueous Ammonia Concept [Mehdipour et al, 2025]

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# Developments – boilers / furnaces

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**Concluded**
- HAZOP and Dispersion Analyses
- 500 kW facility at Cardiff University
- Ultra-low emissions at 25 kW
- Commission of bespoke cracker unit
- 1,000 kW facility at Spadeadams

**Ongoing**
- Preparation of proposal for AMBURN Phase III (implementation)
- Integration of novel fuelling control
- Discussions for a new Technical Specification (ISO)
- Evaluation of novel methods for emissions control

**Next Steps**
- Integration of systems using ML and Digital Twining
- Technical Specification
- Demonstration 5 weeks continuous running 1MW
- Leaning out components manufacturing for cost reduction

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## Final outcomes

- Design of a burner/cracker concept for medium heating scale heating applications
- Techno-economic analysis for national/international implementation
- Demonstration of super-low emissions burner

## Acknowledgements


- Staff/PDRAs/Technicians – High level of skills.
- Industrial steering – fast TRL progression
- DESNZ support has enabled the transition of lab to demonstration scale in months rather than years (total funding £3.6M)


AMBURN H2


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# Thank you for your attention

For further information:
valeramedinaa1@cardiff.ac.uk



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