MariNH$_3$

Clean, green ammonia
engines for maritime

2025 MariNH$_3$ Conference

Ammonia to Hydrogen: Hydrides in Action

Materials-based solutions for maritime

Sponsored by: CIMAC INTERNATIONAL COUNCIL Power | Drives | Propulsion

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The University of Nottingham and
ISIS Facility, Rutherford Appleton Laboratory, UK

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The partnership: University of Nottingham UK | CHINA | MALAYSIA; UKRI Science and Technology Facilities Council; University of Birmingham; University of Brighton; Cardiff University Prifysgol Caerdydd

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Outline

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Clean, green ammonia engines for maritime

1. MariNH$_3$
2. Ammonia in combustion engines
3. Onboard H_2 storage options
4. Cracking at sea and buffering
5. The opportunity

Our role

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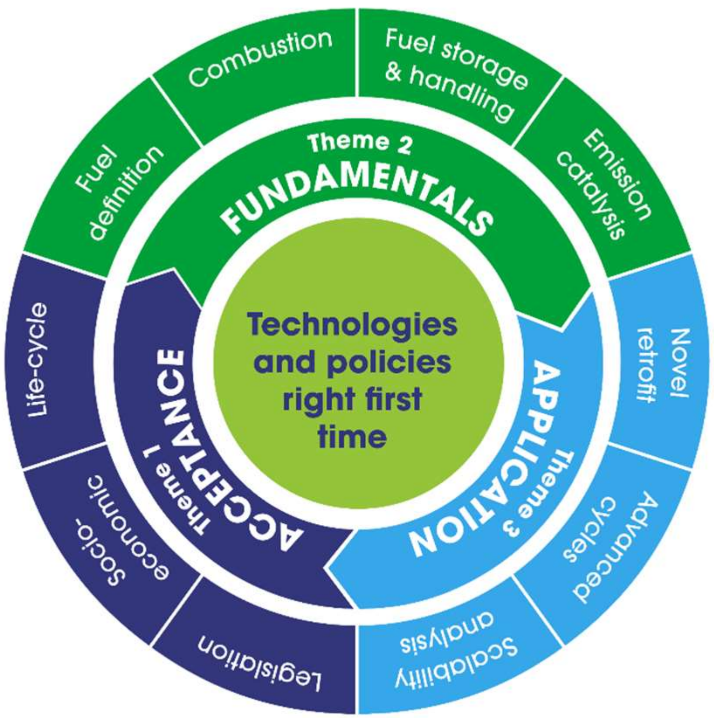

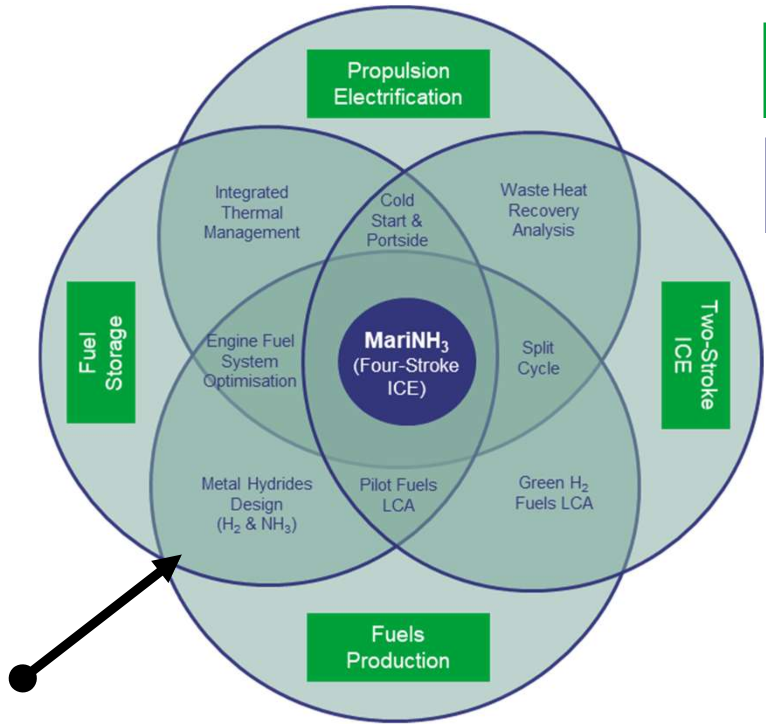

Peripheral research areas

Navy text denotes specific overlaps with peripheral areas

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Facilities

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Hydrogen and energy storage labs Research Acceleration & Demonstration (RAD) building, University of Nottingham

GC

Rig

Capabilities:
Ammonia storage
Ammonia cracking
Ammonia synthesis

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Ammonia: can this magic fuel clean up the shipping industry?

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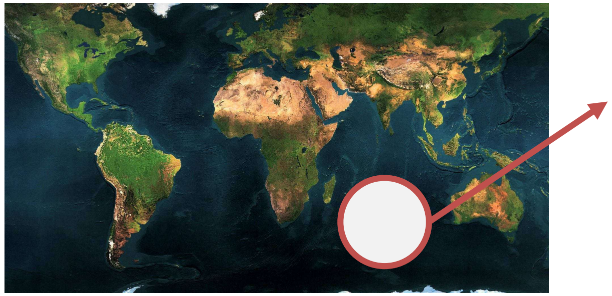

"Shipping"
3% GHGs ➔ **6^{th} largest emitter > Germany!**

Ammonia in engines (30-45% less)

- Zero-carbon emissions
- Storage and handling
- Toxicity
- Lower energy density then conventional fuels (diesel etc.).
- Alternative combustion characteristics: NH_3 combustion generates harmful NO_x (global warming potential ~300x)

- Hydrogen has already powered cars, planes and trains.
- Hydrogen is harder to transport, requiring large volumes even when compressed or as a liquid at 20 K.
- Ammonia is convenient to transport as liquid.

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What have we learned so far from ammonia in combustion engines?

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- A small amount of H_2 (e.g. 20%) supports stable combustion and with less NO_x emissions.
- The addition of H_2 may also reduce the NH_3 slip by 50%.
- The H_2 assisted operation may be suitable for warm up and for very low load operations (near ports).

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Onboard hydrogen storage options

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- Ammonia as a hydrogen store.
- Separate compressed gas store in addition to ammonia store.
- Extracting hydrogen from ammonia store via cracking (requires high temperatures).
- Extracting hydrogen from hydride stores (utilize ammonia and low-grade waste heat).

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Is compressed H_2 the right fit?

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1250 gal
265 psi
534 kg H_2

53% more H_2

5800 gal
3200 psi
350 kg H_2

LiH-NH_3 system: a closed-loop H_2 store

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Parameter	H_2-350bar	LiH-NH_3
Engine power	500 kW	500 kW
H_2 required for 1 h operation (30% share)	11.25 kg	11.25 kg
System mass (kg)	400-650 kg (tank + H2)	~150 kg
Efficiency (%)	>90	~85 (reactor heat losses)
Safety	High pressure leak risk	1-5bar (toxic)
Cost (£)	High	Low
NH_3 utilisation	No	Yes
Waste heat usage	No	Yes (100-400°C)

LiH-NH_3 system

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LiH-NH_3 system: a closed-loop H_2 store

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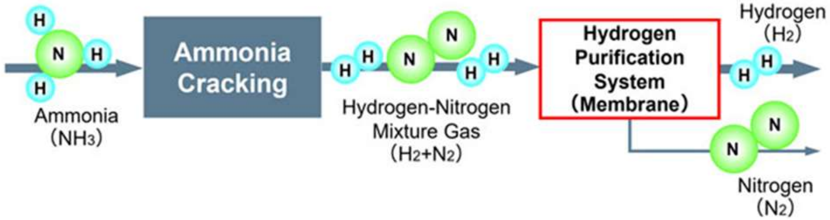
Parameter	LiH-NH_3	Cracking
Operating temperature	100-300 °C	>500°C
Waste heat utilisation	Perfect for marine engine	May require supplemental heating
Energy for H_2 Prod.	Exothermic	Endothermic
Main product	H_2 (unreacted NH_3 is a fuel)	H_2/N_2
Byproducts	$LiNH_2/Li_2NH$	N_2
Space	Potentially compact solid storage	Cracker + separator + gas buffer
Cost	Lower (no precious catalysts)	High



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For onboard H_2 release, LiH-NH_3 is the "Just-In-Time" solution

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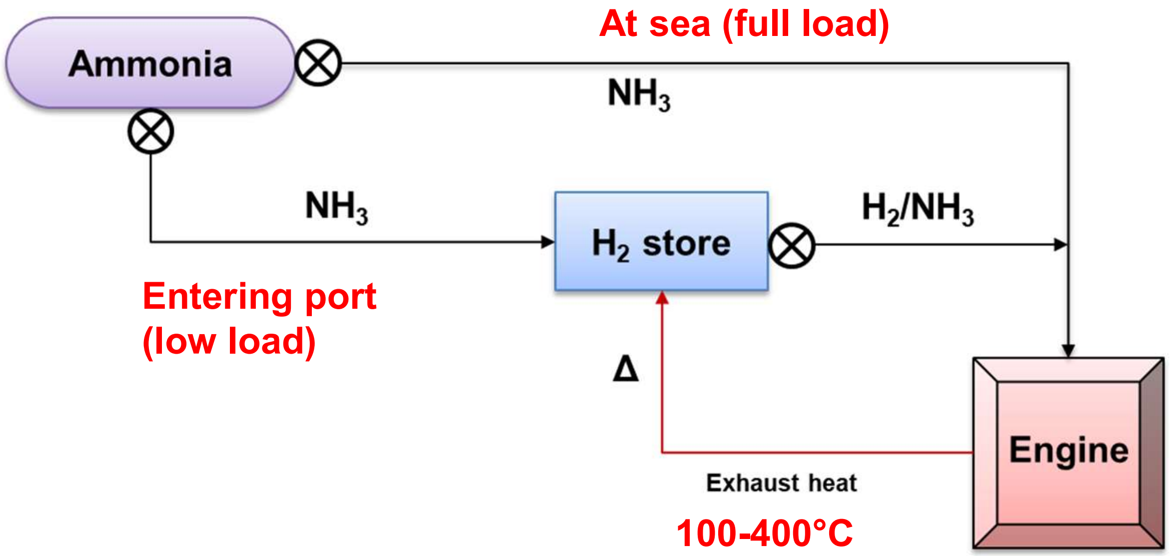

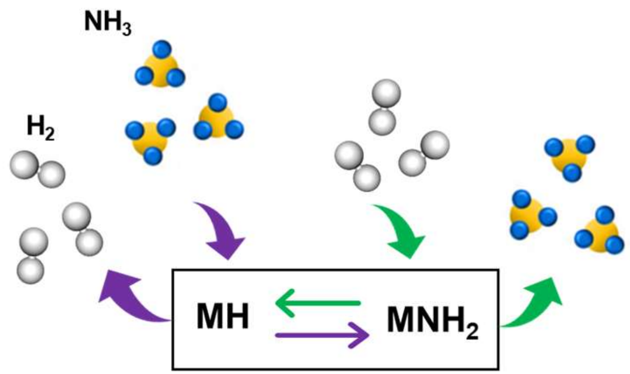

$$LiH + NH_3 \overset{\Delta}{\leftrightarrow} LiNH_2 + H_2$$

(~8.1 mass% H_2)

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The chemistry is proven. The opportunity is now.

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Key takeaways

- Ammonia in marine engines needs hydrogen.
- Lightweight metal hydrides utilising engine’s waste heat may provide on-demand hydrogen near ports.
- Maritime demands high energy density – can this method really compete with traditional H_2 storage?
- Ammonia cracking is not new, but how do we ensure robust buffering and compliance with existing safety measures and regulatory framework?

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Thank you!

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