



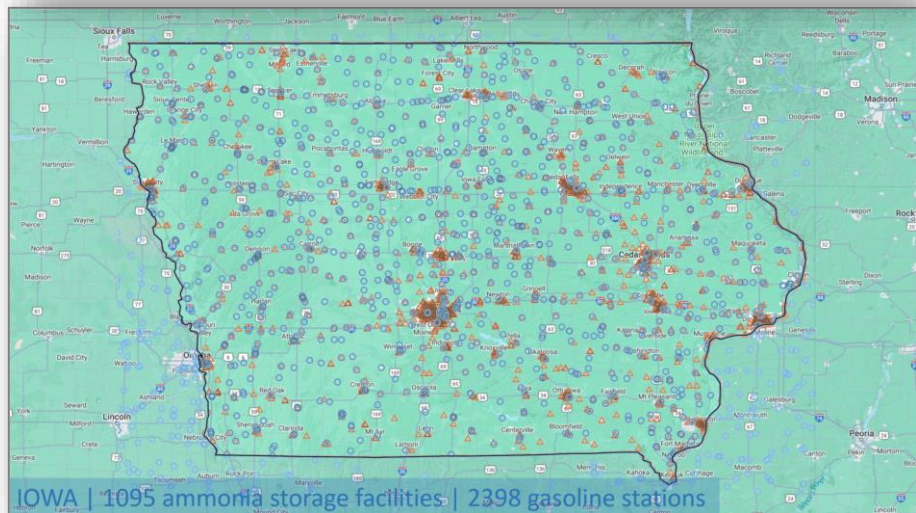
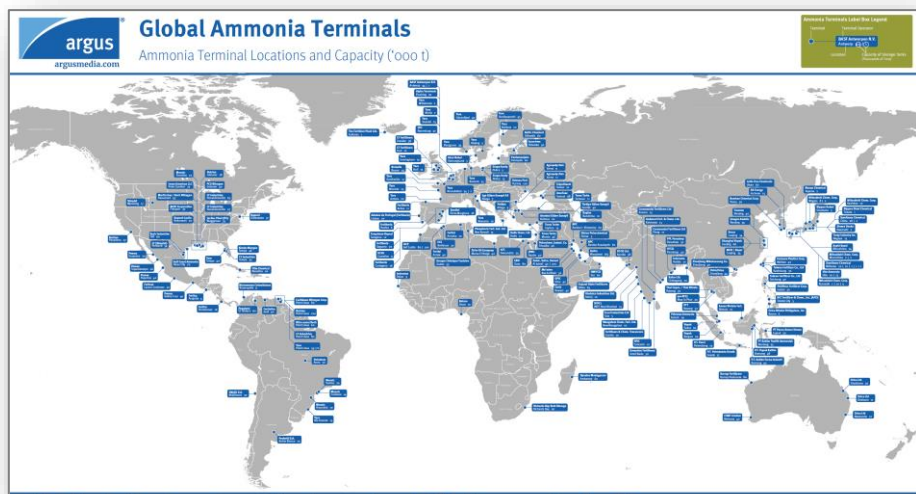
SUNBORNE SYSTEMS

**From carbon-free energy storage to carbon-free power
building on existing global infrastructures**



From carbon-free energy storage to carbon-free power building on existing global infrastructures

CARBON-FREE ENERGY STORAGE



Maritime



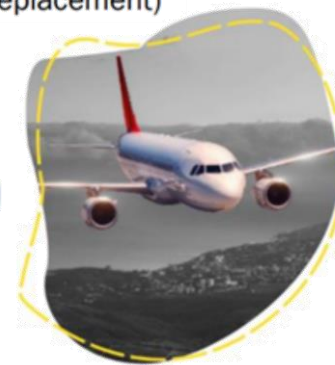
Industrial heat
(fossil gas replacement)



Mining and other
heavy vehicles



Power generation
in energy importing
regions & sectors

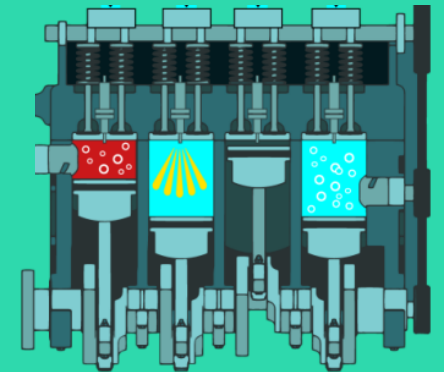


Civil aviation

CARBON-FREE POWER

WE ENABLE ZERO-CARBON ENGINES

- ✔ Allows existing engine architectures to convert to ammonia fuel.
- ✔ No second (pilot) fuel system required: we enable a 'real zero' engine system.
- ✔ Recovered heat is used to crack ammonia into a self-igniting fuel blend.
- ✔ Our catalysts crack ammonia at lower temperatures than anyone else's.
- ✔ Engines using our reactors are more efficient as a result, lowering OPEX.



THE FUEL REVOLUTION IS HERE



FIRST OPERATIONAL TEST OF SUNBORNE AMMONIA REACTOR DEMONSTRATES POTENTIAL TO DECARBONISE MARINE TRANSPORT

Sunborne Systems, a green fuel technology company developing ammonia based power solutions, has completed successful operational testing of its innovative ammonia reactor technology

PUMP

Subcooled liquid NH_3 is pressurised

- Subcooling maximises fuel storage density
- Greatest possible heat sink for system cooling (liquid is -70°C)

HEAT

Pumped NH_3 is warmed by system

- Waste/cooling heat recycled into the fuel
- Deep thermal integration drives up efficiency

CRACK

Some of the NH_3 is converted to H_2/N_2

- Rest of fuel maintains reactor temperature
- Cracked blend is easier to ignite & burn

BURN

NH_3/H_2 fuel releases energy

- Exhaust heat recycled back into cracker
- Residual/top-up NH_3 scrubs lingering NO_x
- No GHG emissions released

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www.youtube.com/watch?v=TudHSr6tQPc

NH_3 flow: $\sim 8\text{gm/s}$ | power: $\sim 56\text{kW}$ | 25 minutes

LOOKING FORWARD

2021 – 2023

PROTOTYPE DEVELOPMENT

- Clean sheet to full prototype
- Reactor and system design work to show performance in target applications.
- Technology development and Customer Engagement
- Successful demonstration: sunbornesystems.com/ammonia-reactor-exceeds-expectations/

SYSTEM FEASIBILITY STUDY

- Maritime reciprocating engine system integration study
- Joint with Cummins and Ocean Infinity: UK government grant

EXPLORING PARTNERSHIPS

- Finding and engaging engine OEMs



COMPLETED

2025 – 2026

TECHNOLOGY DEVELOPMENT

Enabling core products and demonstrators:

- Catalysts & coating processes product-ready
- Reactor design and manufacture maturation
- NH₃/H₂ combustion and emissions mitigation
- System design/optimisation tools

ENGINE SYSTEM DEMONSTRATION

- Series of system demonstrators ending in a capstone 1MW (1340hp) engine
- Conversion done in partnership with / support from engine OEM
- Full NH₃ fuel system demonstrated



GROWING PARTNERSHIPS

- Working directly with OEM(s)

NEXT STEPS 1

2027 – 2028

SHIP-BASED DEMONSTRATOR

- Reactor and system design operating in target applications
- Naturally follows from earlier projects

PRODUCT READINESS

- First products through full design cycle
- Manufacture and assembly set up

TURBINE (GENSET) DEMONSTRATOR

- The other major combustion engine
- Free turbine gensets available
- Could be done as parallel stream with larger funding

EXPANDING PARTNERSHIPS

- Getting more OEMs on-board for product launch



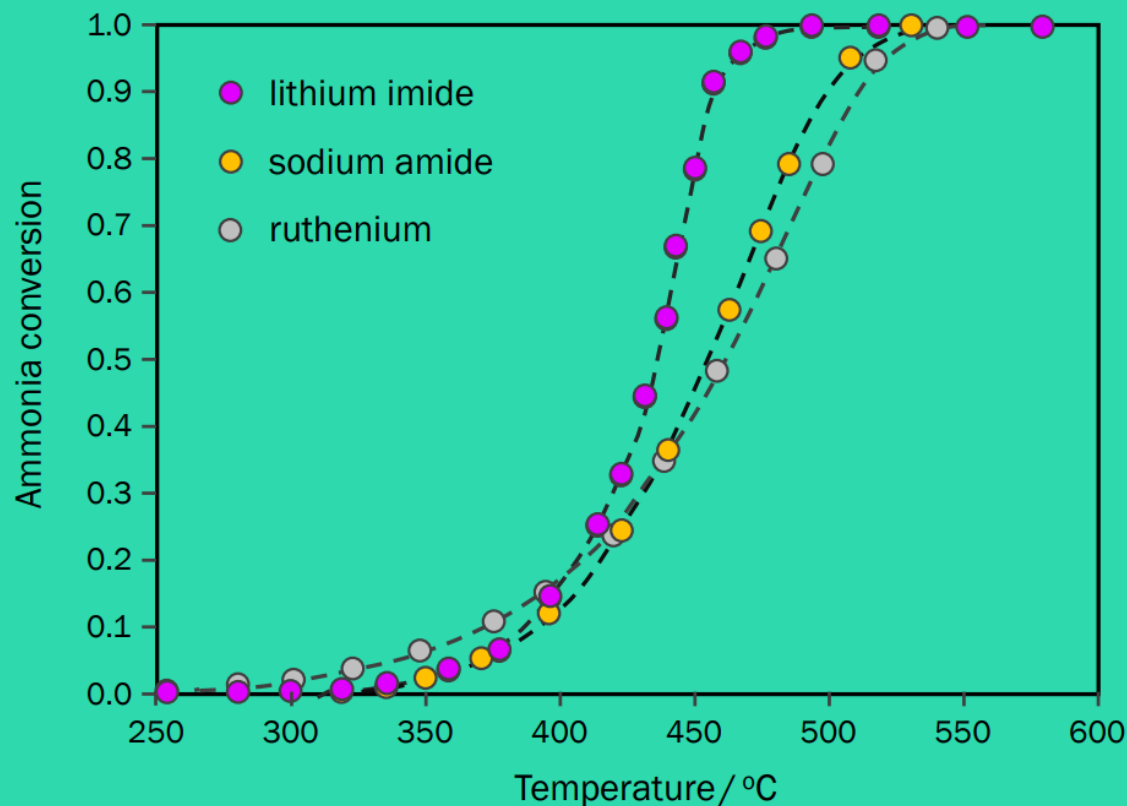
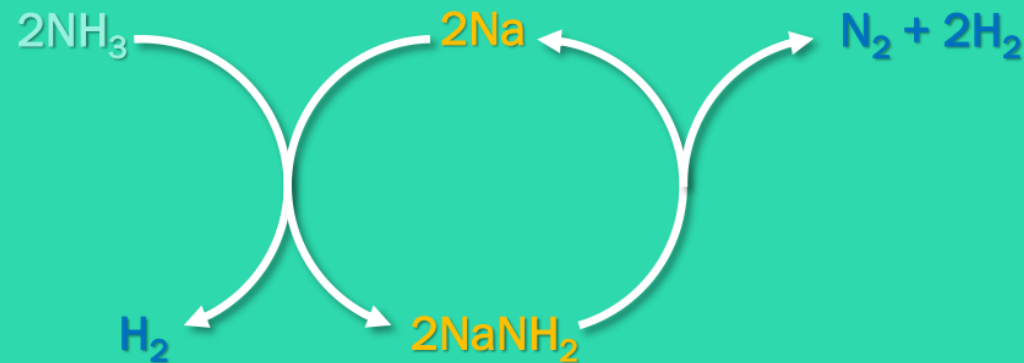
NEXT STEPS 2

BETTER CATALYSTS

We use a novel chemical looping mechanism that doesn't follow the same rules as traditional transition metal (ruthenium) surface catalysts.

This means:

- ✓ Lower temperature cracking
- ✓ Higher operating pressures
- ✓ Lower operating costs



THE FUEL REVOLUTION IS HERE

CATALYST PROJECT: TECHNICAL DE-RISKING BY TECHNOLOGY DEMONSTRATION

- Catalysis mechanisms are well-understood; science aspect at TRL 2–3
- Dry and wet catalyst coating technologies are currently at TRL 1–2.
- Project Objectives (TRL 4-5)
 - construct a demonstrator operating at grid-backup power scale (1-5kW) for (e.g. remote locations, phone masts)
 - Achieve catalyst performance at (1-5kW) with >1000h duration

Catalyst
(TRL 2-3)

Dry
coating
(TRL 2)

Wet
coating
(TRL 1-2)

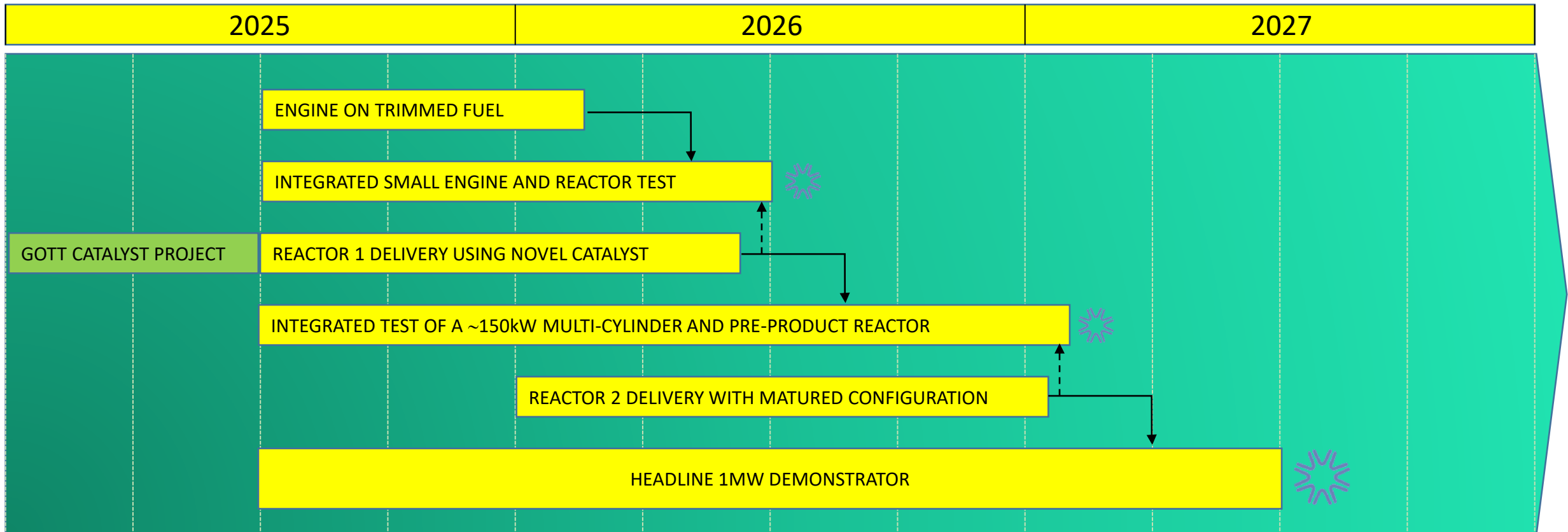
GOTT funding unlocks
commercial
opportunities by
bumping up the TRL

Industrially
relevant-scale
catalyst
demonstrator
(TRL 4–5)

- STFC/UKRI (Energy Materials Group, ISIS)
- University of Birmingham

LOOKING FORWARD

DEMONSTRATORS



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STFC / Oxford

Tom Wood

Matthew Cummings

Emma Perry-McLean

Jonny Betteridge

Geofrey Njovu





Charlotte Kirk

Phill Marks

Caitlin Brooker-Davis

ROADMAP • OPEN ACCESS

2023 roadmap on ammonia as a carbon-free fuel

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