



SUNBORNE SYSTEMS

**WELCOME
TO THE
AMMONIA
AGE**



SUNBORNE SYSTEMS

WE BELONG TO THE AMMONIA AGE

BILL DAVID, Chief Scientific Officer

MARK PICCIANI, Principal Aerothermal and Combustion Engineer

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CARBON-FREE POWER IS IMPOSSIBLE

There are **two billion** internal combustion engines, **hundreds of thousands** of gas turbines and **gigawatts** of industrial burners.

But **there's no need to retire them**. We can re-fuel them – turning all this combustion into a **green and clean** climate solution.



UNRIVALLED CAPABILITIES

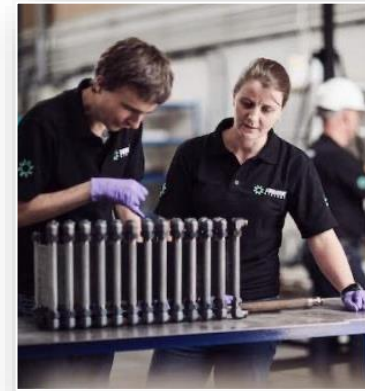
Our team has more than 30 years in collective experience in integrating complex thermal systems.

We have strong ties to our parent organisations:

- ✓ Reaction Engines
- ✓ The STFC Rutherford Appleton Laboratory

We access billion-dollar facilities and world-class experts to deliver value and insights others cannot.

This is how we deciphered the catalytic process, proving its uniqueness.

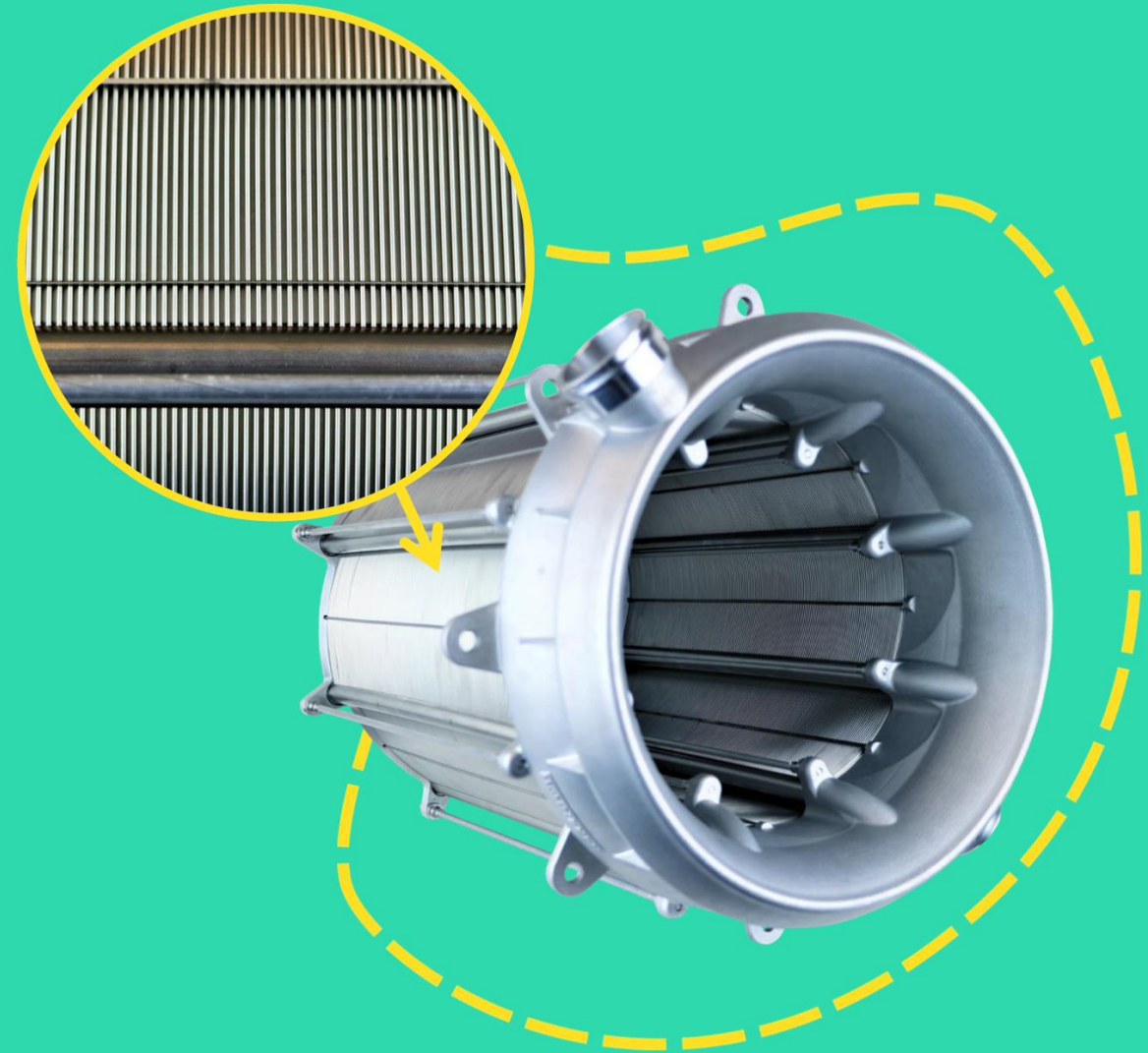


BETTER HEAT EXCHANGERS

We have an exclusive license to use Reaction Engines' world-class heat exchanger technology to build ammonia reactors.

This means we can put heat where we want it efficiently, in the smallest, lightest package possible.

Its inherently low pressure drop and latency means it can be retrofitted to existing power and propulsion systems, with minimal impact.



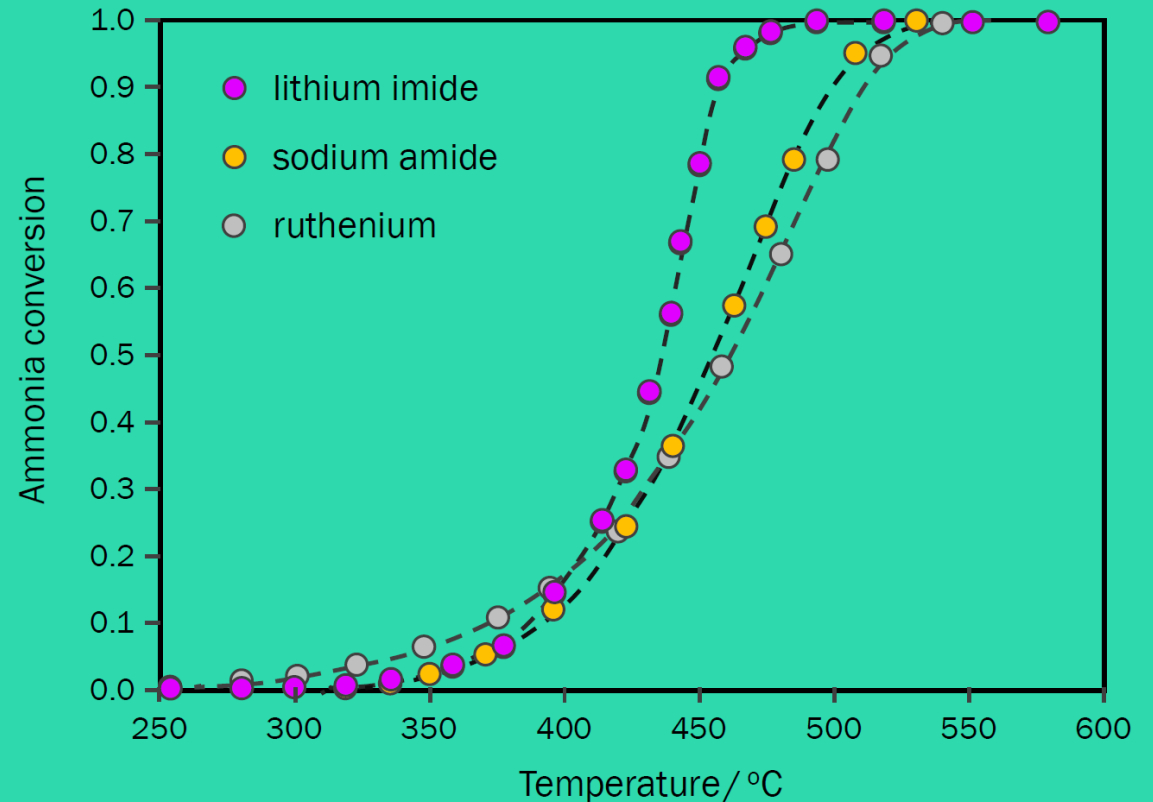
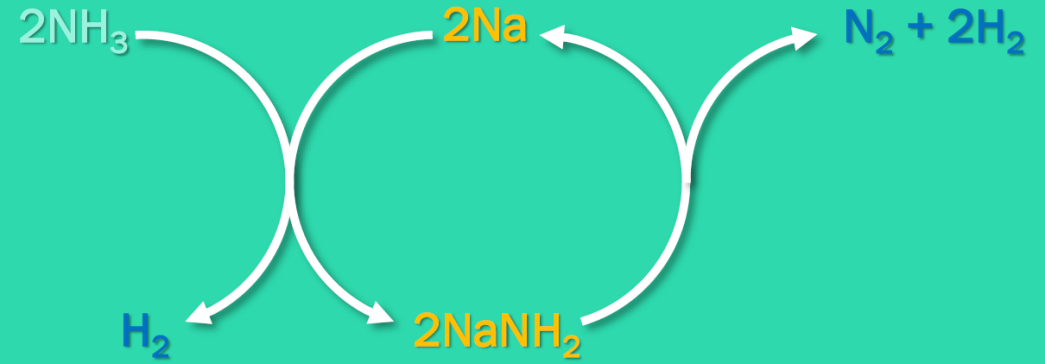
THE FUEL REVOLUTION IS HERE

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



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 $-70^\circ C$)

HEAT

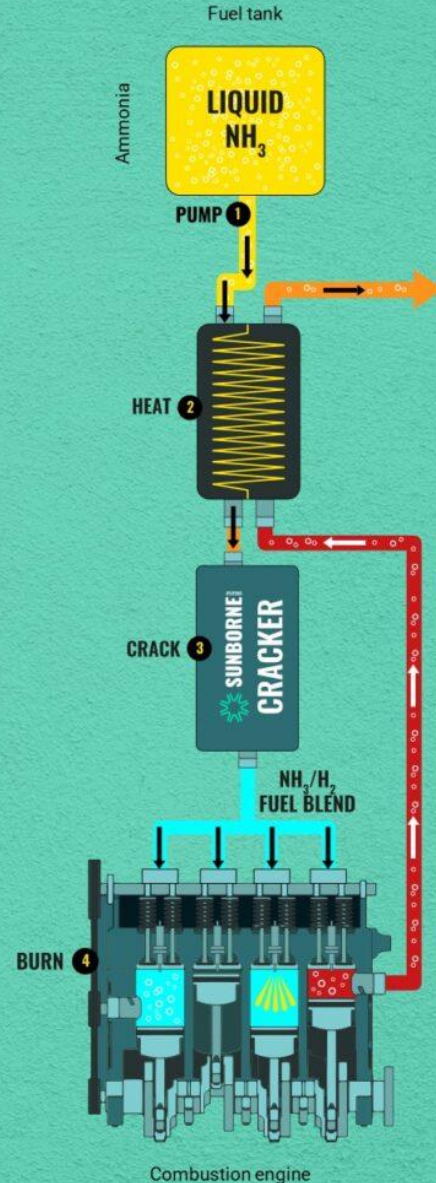
- Pumped NH_3 is warmed by system
- Waste/cooling heat recycled into the fuel
- Deep thermal integration drives up efficiency

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

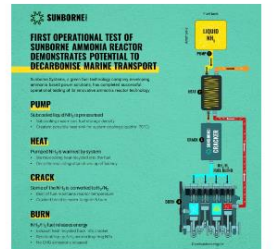


sunbornesystems.com/ammonia-reactor-exceeds-expectations/

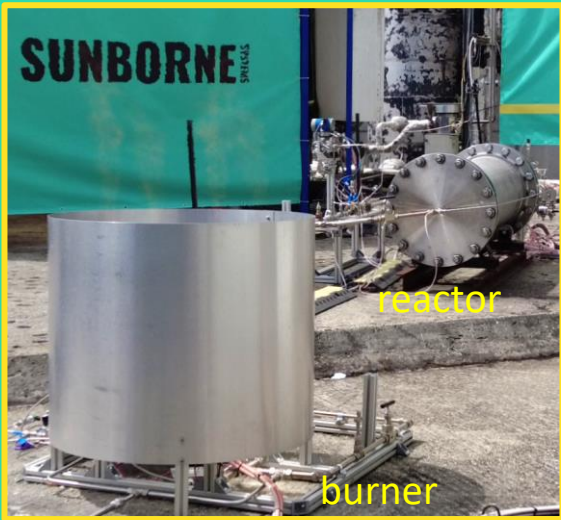
Sunborne Systems & AFC Energy: successful ammonia cracker demonstrations

By [Geoffrey Njovu](#) on October 29, 2023

Sunborne Systems is a green fuel technology company founded by Reaction Engines, the UK Science and Technology Facilities Council (STFC) and Kiko Ventures. The Oxfordshire-based company successfully demonstrated its ammonia cracking reactor's ability to **produce a fuel blend capable of powering a 56kW engine**.



www.ammoniaenergy.org/articles/sunborne-systems-afc-energy-successful-ammonia-cracker-demonstrations/



DECARBONISATION FOR LESS

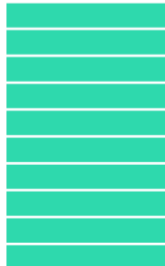
With ammonia, many 'hard to abate' sectors can start the transition to Net Zero before 2030.

With over a **billion vehicles** and **terawatts of heat and energy** to go **green and clean**, the opportunity is worth **billions of dollars** in reactor sales in the maritime sector and beyond.



Maritime

£30-50M



STANDARD
RETROFIT

£0.5M



SUNBORNE!
REACTOR

LOWER CAPITAL COST

- For a Panamax container ship, our reactor would represent 1% or less of a total retrofit cost – and realise significant savings in the process.
- That's because our single stored-fuel architecture means adding fewer parts to the system.
- The parts we do add are smaller and lighter, so they are easier and less costly to retrofit.

BIG BOLD AMBITIONS

Based upon **two already existing global industry infrastructures**, the worldwide ammonia market and the internal combustion engine, the potential impact of our technology could be remarkable.

> 5%

REDUCED EMISSIONS

Our technology can cut **global emissions** significantly by driving the adoption of ammonia as a combustion fuel for power and propulsion.

30% +

MARKET SHARE

The marine opportunity alone is worth billions per annum, with a **possible market share of over 30% (in partnership with major engine OEMs)**.

Adjacent opportunities of similar potential are there for the taking.

< 2030

PRODUCT LAUNCH

The market is moving fast – and so are we. **Our aim is to have our first product on the market in the second half of this decade.**

A TRANSITION STARTING NOW

With ammonia, many 'hard to abate' sectors can start the transition to Net Zero before 2030.

With over a **billion vehicles** and **terawatts of heat and energy** to go green and clean, the opportunity is worth **billions of dollars** in reactor sales in the maritime sector and beyond.

Power generation (remote places and seasonal storage)



Mining and other heavy vehicles



Retrofitting diesel trains



Maritime



Industrial heat
(fossil gas replacement)



Agricultural machines



Civil aviation

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

2023 – 2025

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

2025 – 2027

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