AMOGY

# Ammonia – a renewable fuel for carbon-free power

May 2024

ABOUT AMOGY

# Company Profile

**180+ Employees**

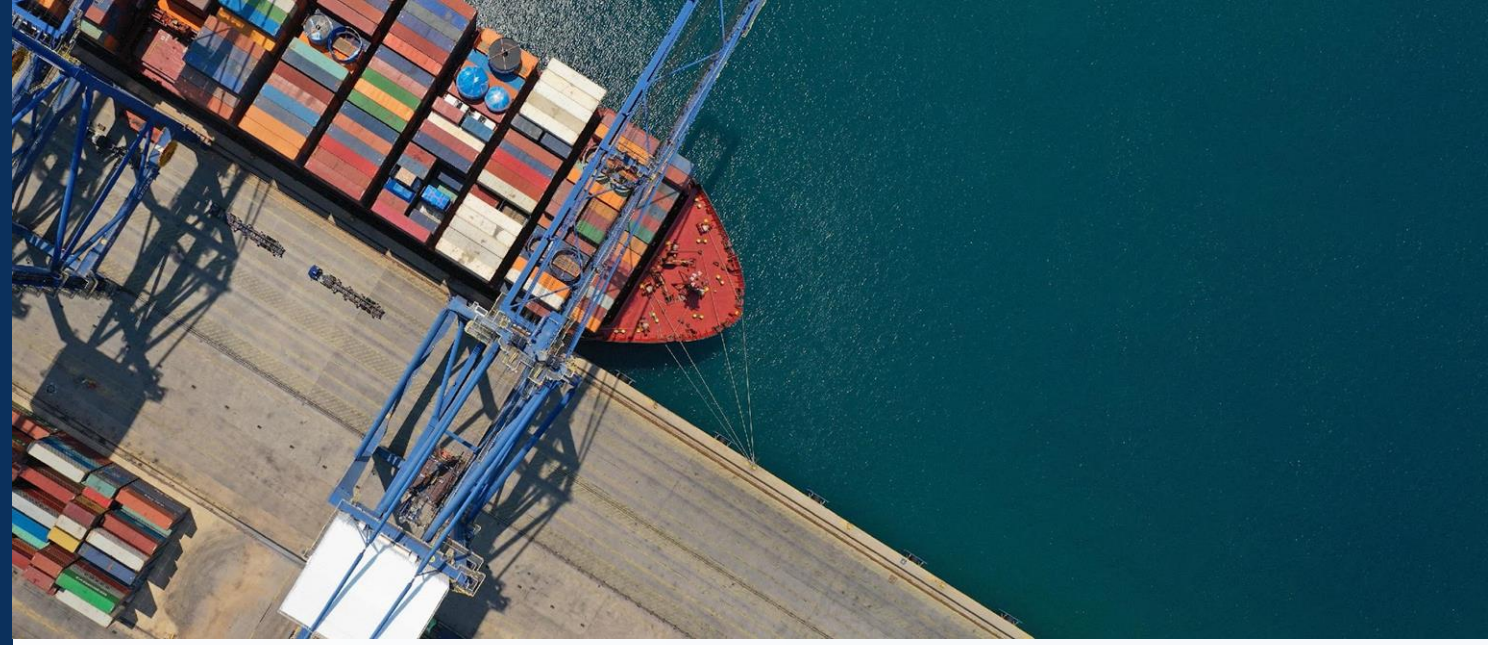
**Founded: Nov. 2020**

**Funding to date: $220M**

**Headquarter Brooklyn, NY**

**Other Locations**
Houston, Stavanger, Stord, Singapore

# Our Investors



**Funding raised to date: $220M**

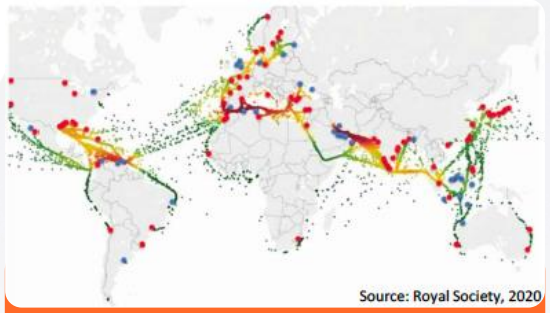
- Seed: $3M | Mar 2021
- Series A: $20M | Nov 2021
- Bridge: (uncapped note): $46M | Jun 2022
- Series B: $150M | Mar 2023

aramco ventures | Climate Pledge Fund | amazon | TEMASEK | SK

MOL Mitsui O.S.K. Lines | APVentures ADVANCE & PIONEER | Mitsubishi Corporation | YANMAR | DCVC Data Collective

ZEON | Korea Zinc | MITSUBISHI HEAVY INDUSTRIES | Marunouchi Innovation Partners

# Ammonia Infrastructure Today




**190** MTA of production

**200** ports store ammonia

**4,000** km+ of pipelines in U.S

**20** MTA of waterborne trading


**500** vessels capable of carrying ammonia

- 100+ years of scaled industrial use of ammonia
- No ammonia-to-power technology available to date

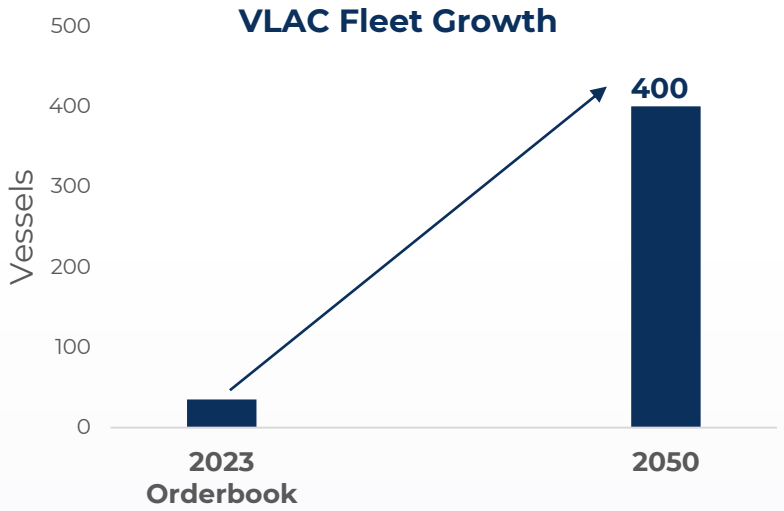
MTA: Million Metric Tons Annually  Sources: DNV, IRENA

# Ammonia in Maritime

## The interest in ammonia has been growing

### Over 15 Ammonia Bunkering Projects Announced


★ = key announced bunkering projects




**Major shipyards accumulated 30+ Very Large Ammonia Carriers (VLACs) on order in 2023**

Hanwha Ocean · Eastern Pacific Shipping · HD Hyundai Heavy Industries · Maersk

Sources: Clarksons, press releases, and company websites.
VLAC: Very Large Ammonia Carrier; VLAC market 2050 fleet from Maritime Strategies International (link), 2023 orders based on announced orders for VLACs.

# ENOVA – Norway

## Ammonia fueled vessels program

### HIGHLIGHTS OF THE PROGRAM

- This program targets ship owners, offering up to **80% soft funding for additional CAPEX-costs** when transitioning to ammonia and hydrogen technologies. (New build and retrofit)
- Include systems, batteries, integration, and yard, **up to 300M NOK (or 30M €) per project** for one or more vessels.
- Ship owners must be registered in Norway as a Norwegian company and must be under Norwegian flag.
- Evaluation criteria: **cost-effectiveness** (weighted at 70%) and **project maturity** (weighted at 30%)*.

*Cost-effectiveness being **support funds** [NOK]**/installed power of main engine(s)**[kW].
Maturity being **Technology TRL**, **Comprehensive safety level**, **financial feasibility**.

### Ammonia in Vessels

The program can support projects involving investment in one or more ammonia vessels. The investment can be in new vessels, the conversion of existing vessels, or a combination of these.

Received applications:

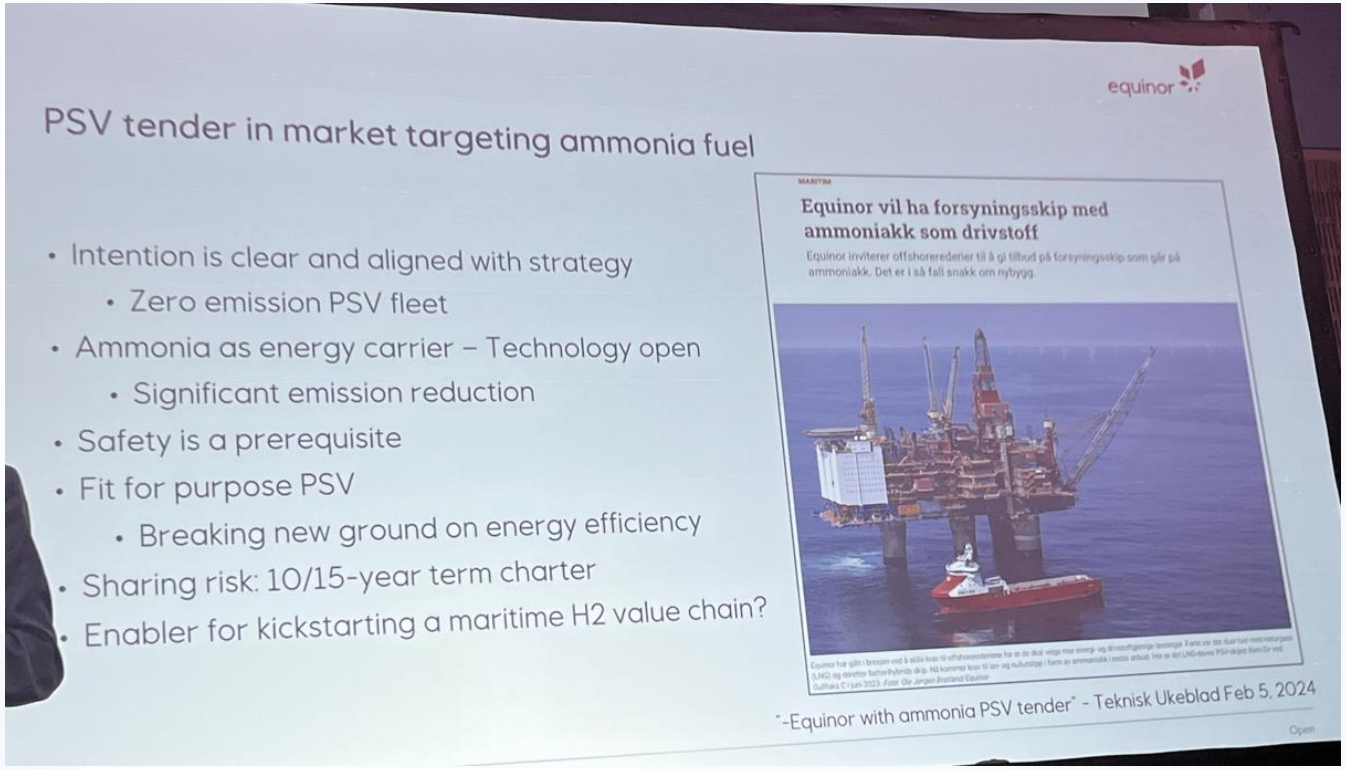
- **32** vessels
- **11** companies/shipping lines
- Total requested amount: **3.3 billion NOK**

Approximately 50% of the applications are for offshore vessels, where key customers have begun to request such solutions.

Sources: Clarksons, press releases, and company websites.
VLAC: Very Large Ammonia Carrier; VLAC market 2050 fleet from Maritime Strategies International (link), 2023 orders based on announced orders for VLACs.

# EQUINOR dual fuel - AMMONIA New Build Offshore vessel tender

- **Issued**: 23 Jan 2024
- **Due date**: 14 May 2024
- **Commencement**: 2026-2027
- **Duration**: **10- or 15-years** firm + 5 x 1-year
- **Deck size**: Min 950m2
- **Fuel**: Dual fuel - MGO-Bio Diesel/Ammonia
- **Battery notation**: Battery/Shore-power
- **ENOVA**: Owner must apply for ENOVA “NH3 to vessel” grant
- **Evaluation Criteria**:
  - Cost and commercial aspects including offered rates
  - Fuel consumption and emissions
  - Technical solution
  - Health, Safety and Security (HSE), including human rights and cyber security
  - Execution plan and Organization of the work
  - Capacity and availability



AMOGY

# Our Technology

# Most Advanced Ammonia Cracking

## Technology

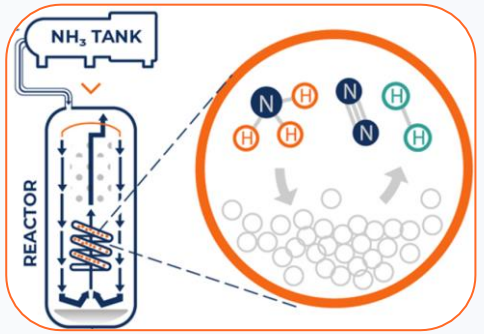
- Most efficient ammonia cracker on the market
- High energy density
- Zero carbon emissions

## Demonstrated Ability

- Scale up via successful demonstrations
- Extensive and expanding IP
- Strong industry partnerships

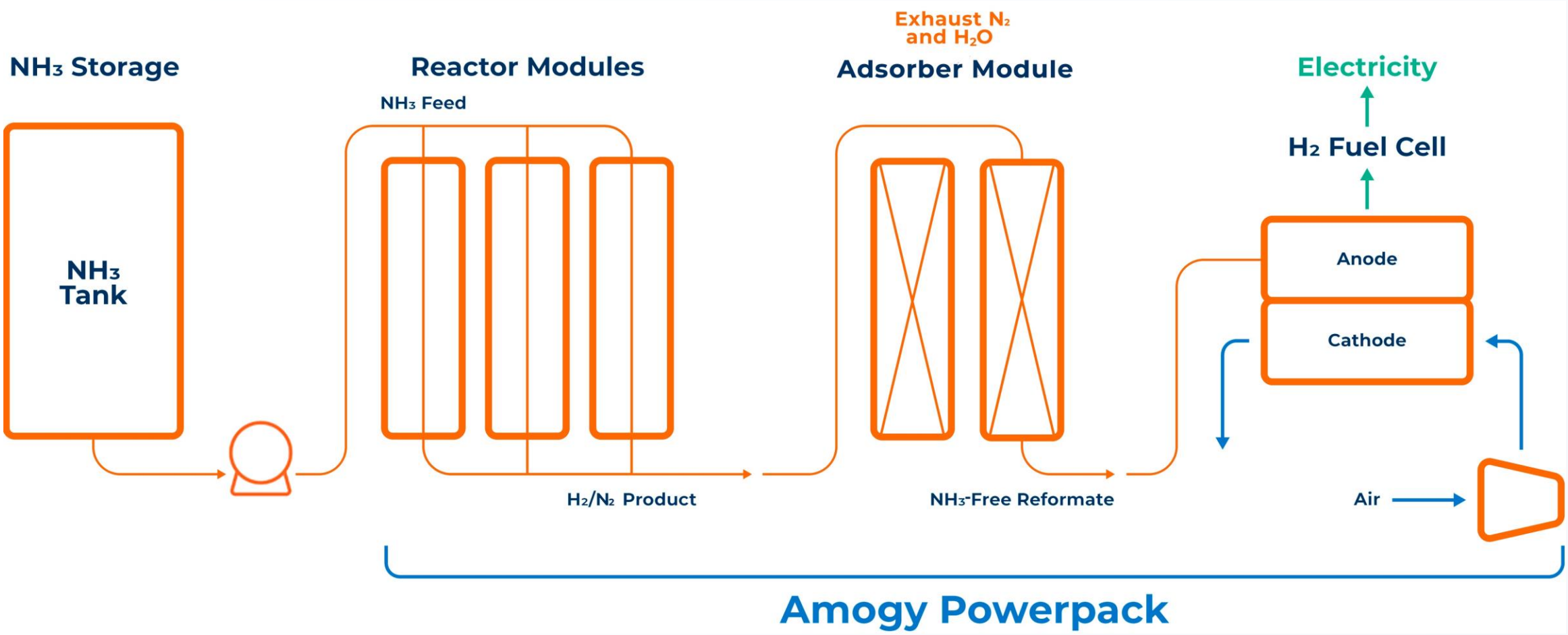
**200 kW**
**Cracking Module**

- **40-70%**
  **more efficient ammonia cracking catalyst***
- **Up to 35%**
  **higher reforming efficiency****
- **>80%**
  **higher reformer power density*****




*At typical operating temperatures.
**Compared to other reforming technologies (SMR, $NH_3$ cracking, photocatalytic reactors); ***Compared to Steam Methane Reforming (SMR) technologies.

# Amogy's Ammonia-to-Power Technology



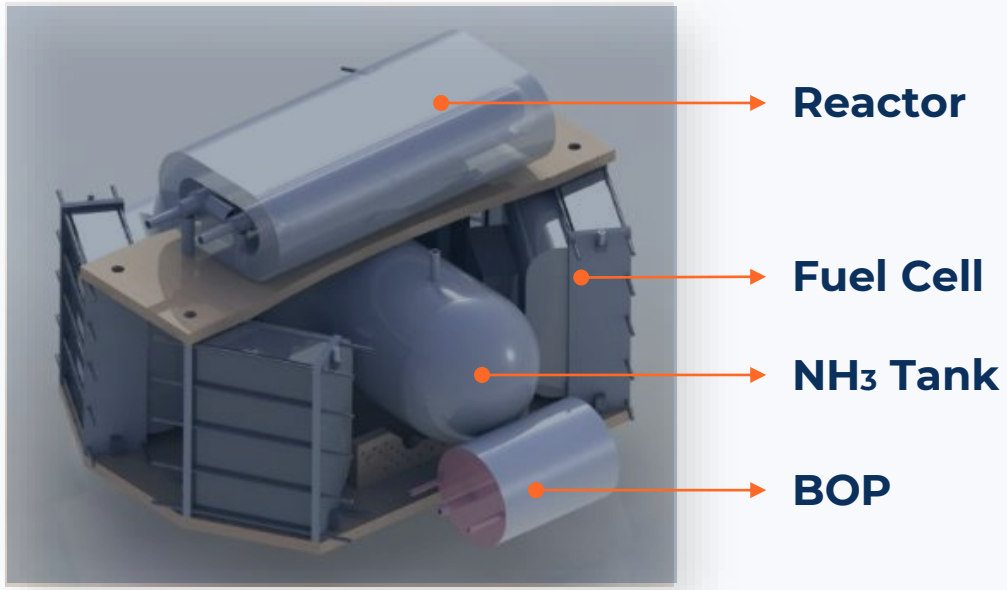

AMOGY
Our Demonstrations

# 5 kW Ammonia Powered Drone

(Watch demo)

World’s first zero-emission ammonia-powered drone

- Power: 5 kW
- Ammonia-to-power efficiency: 38%
- Demo date: July 2021

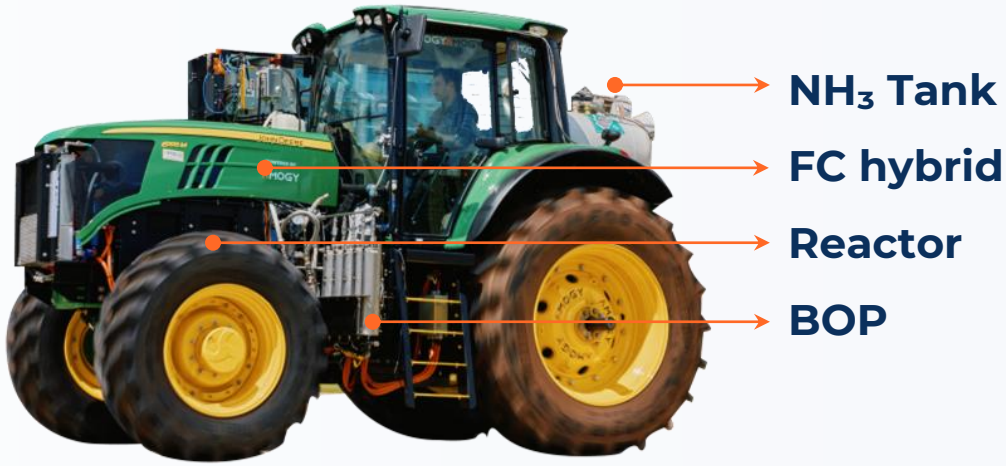


# 100 kW Ammonia Powered Tractor

(Watch demo)

World's first zero-emission ammonia-powered tractor

- Power: 100 kW
- Ammonia-to-power efficiency: 40%
- Demo date: May 2022



# 300 kW Ammonia Powered Semi-Truck

(Watch demo)


World's first zero-emission ammonia-powered class 8 truck

- Power: 300 kW
- Ammonia-to-power efficiency: 40%
- Demo date: Jan. 2023

# Past Demonstrations

**Rapid technology scale-up and commercial readiness with the world's-first ammonia-powered mobility applications**

**DRONE**

**TRACTOR**


**CLASS 8 TRUCK**

| | Jul 2021 | May 2022 | Jan 2023 |
|---|---|---|---|
| | **5 kW** | **100 kW** | **300 kW** |
| **Technology Readiness Level (TRL)** | **4** | **5** | **6** |
| **Control System** | Manual control | Automated at steady state | Parallel Fuel Cell system integration |
| **Reaction System** | Lab scale | 10 kW modules, 3 in parallel | 10 kW module, 12 in parallel Fast startup |
| **Test Environment** | Hovering in test field | Test drive & implements corn field | Highway-speed test drive closed course track |

## Upcoming Demonstration:

# Tugboat

World's first carbon-free, ammonia-powered tugboat vessel

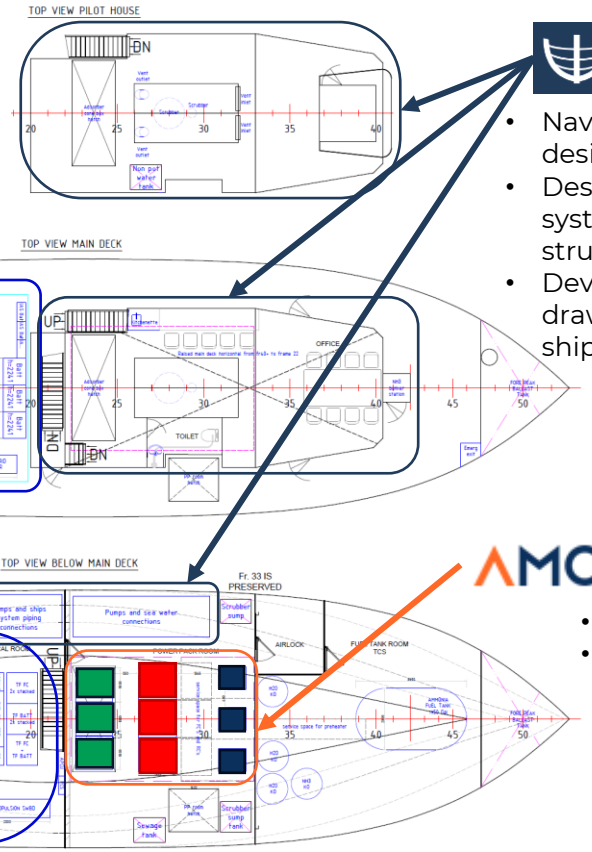
- Vessel dimension: 100 ft.
- Stored energy: >5 $MWh_e$
- Demo date: 3Q 2024
- Vetted design from key regulatory bodies to ensure full safety compliance


| Vessel procurement Safety and regulatory assessment & procurement | Vessel construction & System installation | First $NH_3$-powered tugboat! |
|---|---|---|
| ***Q2 2022 - 2023*** | ***Today*** | ***3Q 2024*** |

NH3 Kraken

# Project Breakdown

- Shipyard with subcontracted pipefitters, electricians, etc.
- Legacy equipment removal & full retrofit construction
- Provides practical guidance on vessel construction & operation




- Naval architect & vessel designer
- Designs vessel auxiliary systems & overall structures
- Develops construction drawings for the shipyard to execute

- Power provider
- 200kW powerpacks systems

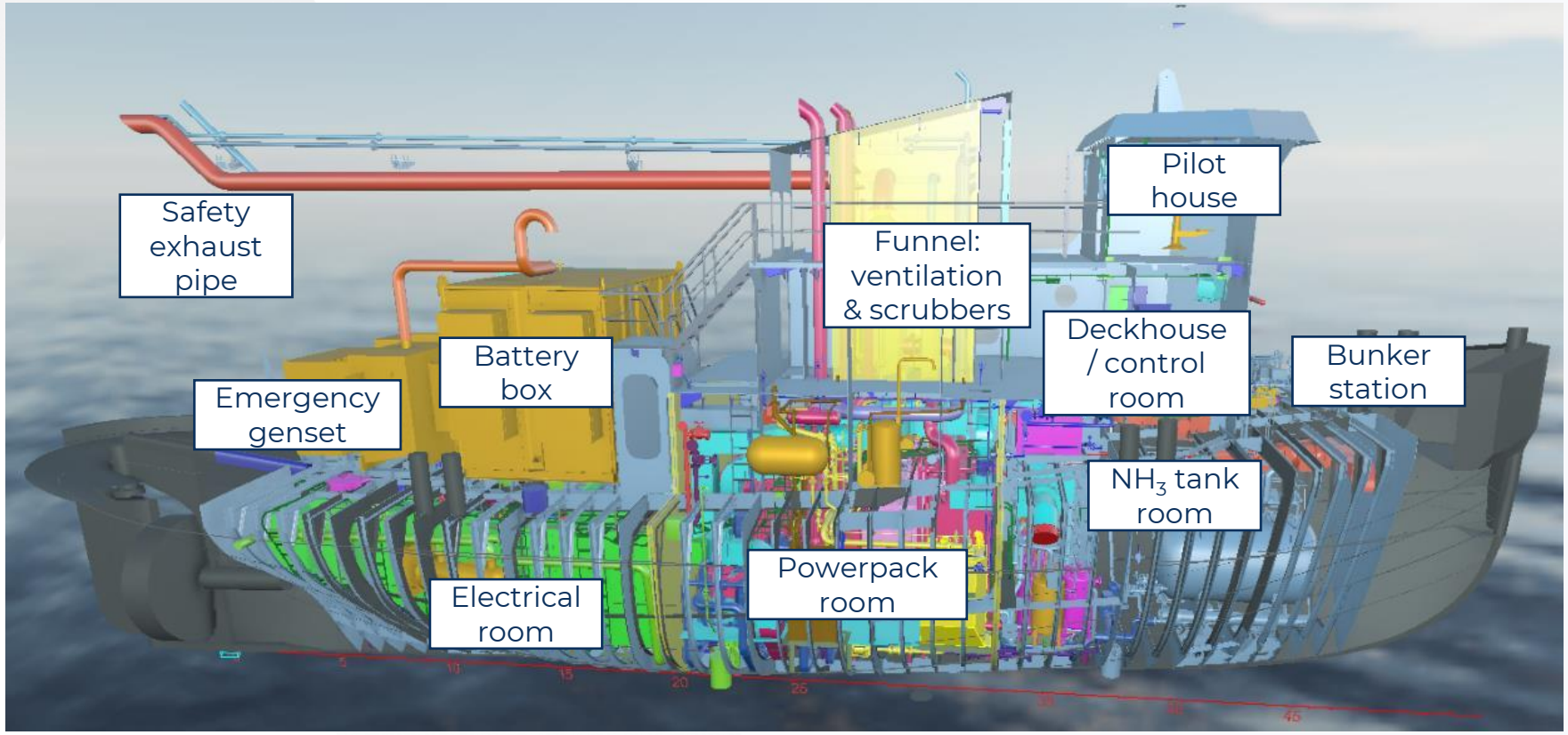
Received Statement of Feasibility and Technology Qualification Plan (TQP) approval from Lloyd's Register

- DNV – ship classification society
- USCG – regulatory agency
- Provides risk-based guidance on design & operating requirements

- VSI – tank & feed system vendor
- Macrotek – scrubber vendor
- Other vendors for subsystems, nitrogen, etc.

# Tugboat Demonstration Scope

**Demonstration scope covers the entire vessel construction, generating important learnings for product development**




- Vetted design from key regulatory bodies to ensure full safety compliance
- Continued involvement to ensure future Amogy systems adhere to future regulations

# Stord, NO – Test Facility

- Amogy engineering and buildout started in March 2023
- Phase 1 finished in October 2023
- Phase 2 currently in commissioning
- 1 MW test capacity on DC/DC hub
- 1,2 MW capacity on cooling system
- Possibility for testing with ammonia, hydrogen, and hydrogen/nitrogen mix

SUSTAINABLE ENERGY | NORSK KATAPULT SENTER
siva

ALLEC
SMART ENERGY SERVICES

AMOGY

# Our Product

# Amogy Powerpack (200 kW)

Our technology converts ammonia into electrical power with zero onsite $CO_2$ emissions.



Reactor module

Adsorber module

Fuel cell module

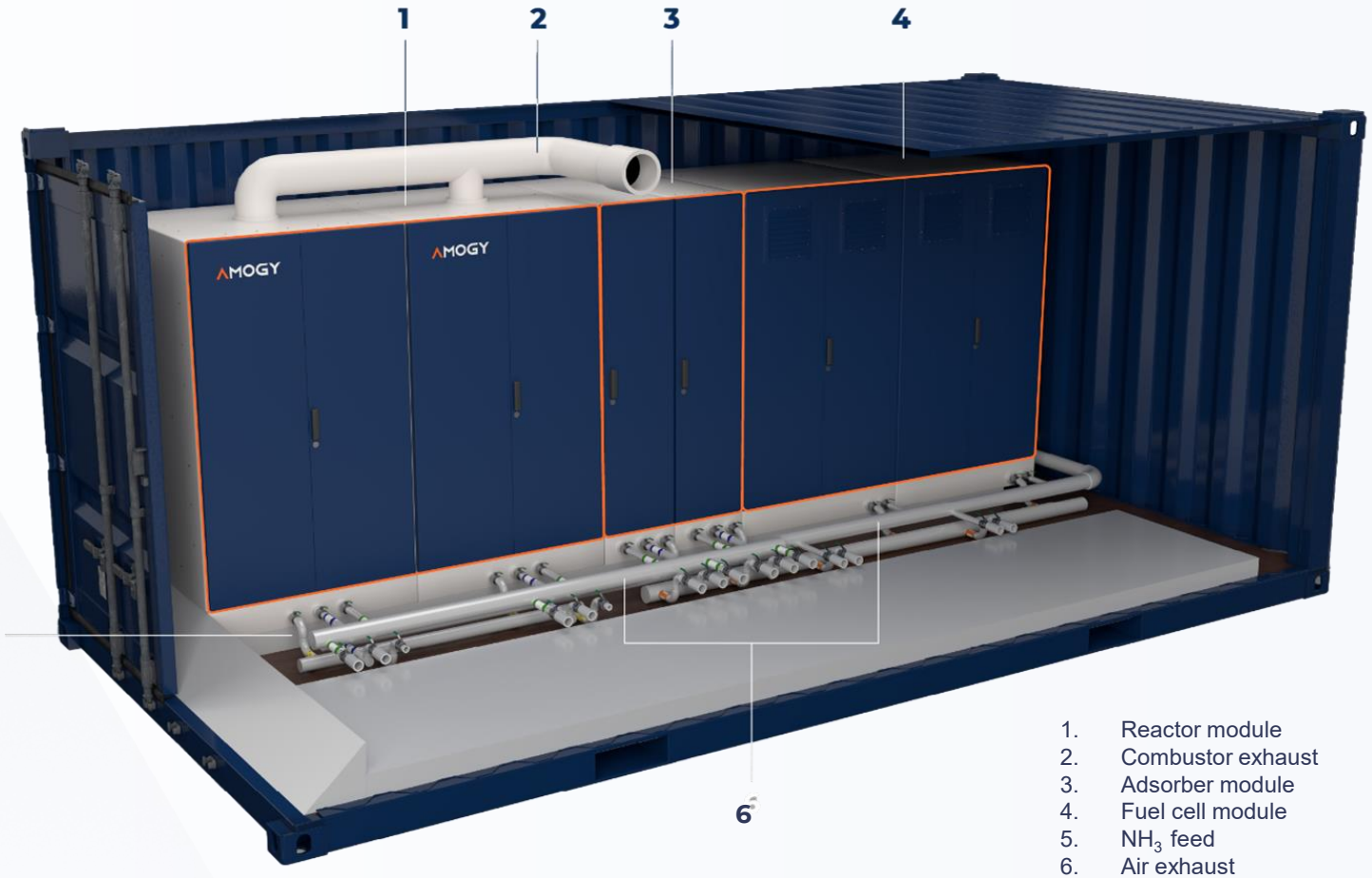
## AMOGY POWERPACK

More information

# Amogy Containerized Powerpack (400 kW)

**Complete ammonia-to-electrical power solution**

- 20 ft containerized system containing 2 modular 200 kW units
- Containerized 400 kW option for on-deck/ outdoor installation
- Zero onsite $CO_2$ emissions



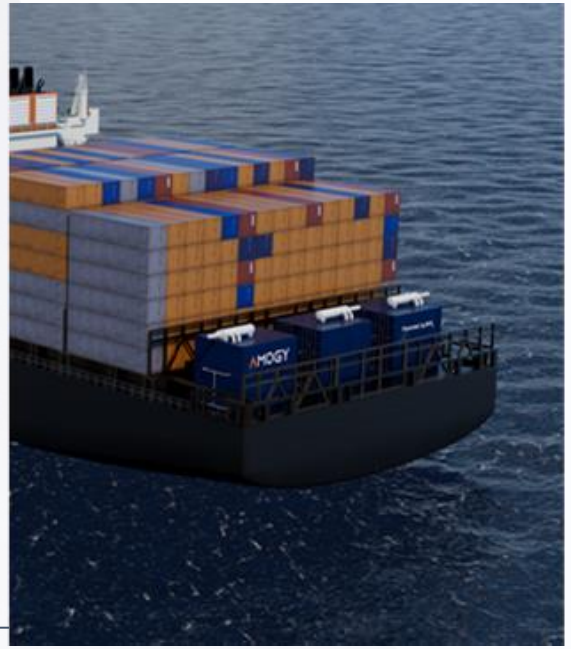

1. Reactor module
2. Combustor exhaust
3. Adsorber module
4. Fuel cell module
5. $NH_3$ feed
6. Air exhaust

More information

# Target Applications

## Maritime Shipping

- Propulsion: offshore supply, short-sea cargo, other hybrid vessels
- Auxiliary power: deep sea cargo, inland and bunker barges




> APRIL 23, 2024

**Hanwha Ocean, Amogy and Hanwha Aerospace Forge Partnership to Decarbonize Maritime Sector with Ammonia as a Zero-Emission Fuel**

Hanwha


> APRIL 17, 2024

**Amogy Receives Order from Terox to Enable Carbon-free Charging on Construction Sites**

TEROX

## Power Generation

- Shore power
- Remove EV charging
- Diesel generator displacement

## Example Contracts

# Hanwha

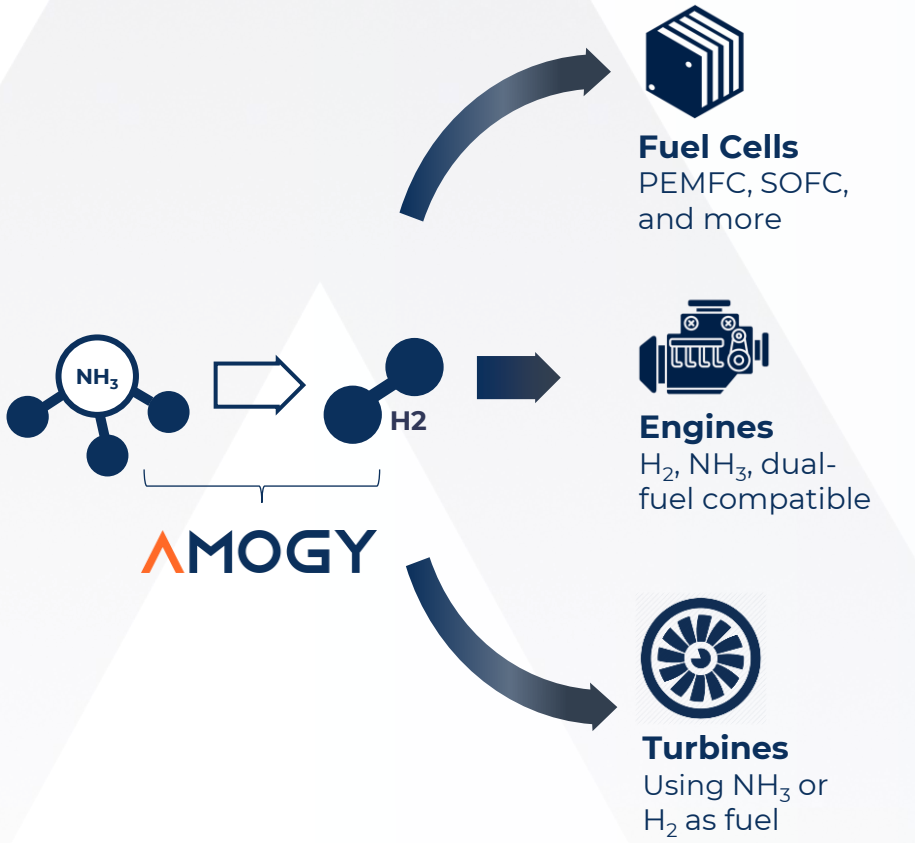

- Hanwha Ocean signed a contract to purchase Amogy's ammonia-to-electrical power system including Hanwha Aerospace's hydrogen fuel cell system

# Terox


- Terox to deploy Amogy's ammonia-to-electrical power system to generate electricity on construction sites.
- The pilot project aims to demonstrate the feasibility of ammonia-based power systems for stationary power generation at construction sites, which have historically relied on heavy-polluting diesel generators or grid connections.


AMOGY
Our Possibilities

# Enabler of Ammonia-to-Power for Many End-Uses




| Power Scale | Market Entry | Amogy Advantage |
|---|---|---|
| Today: 0.2 – 5 MW<br>Future: 50+ MW | PEMFC – 2025+<br>SOFC – 2030+ | • Zero emission<br>• Significantly higher energy density and lower cost compared to Liquid or Compressed Hydrogen |
| 3 – 10+ MW | 2027+ | • Zero carbon-based pilot fuel<br>• GHG / $NO_X$ reduction<br>• Single fuel feed system<br>• High cracking efficiency utilizing waste heat |
| 100+ MW | 2027+ | |

**Ammonia cracking enables the integration of low-cost fuel with multiple power generation options.**

# Thank You

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