AMOGY

Unleashing the NH_3 Kraken: Pioneering Carbon-Free Ammonia Power

Jatinder Sampathkumar

Ammonia Energy Association - November 2024

ABOUT AMOGY

Company Profile

130+ Employees

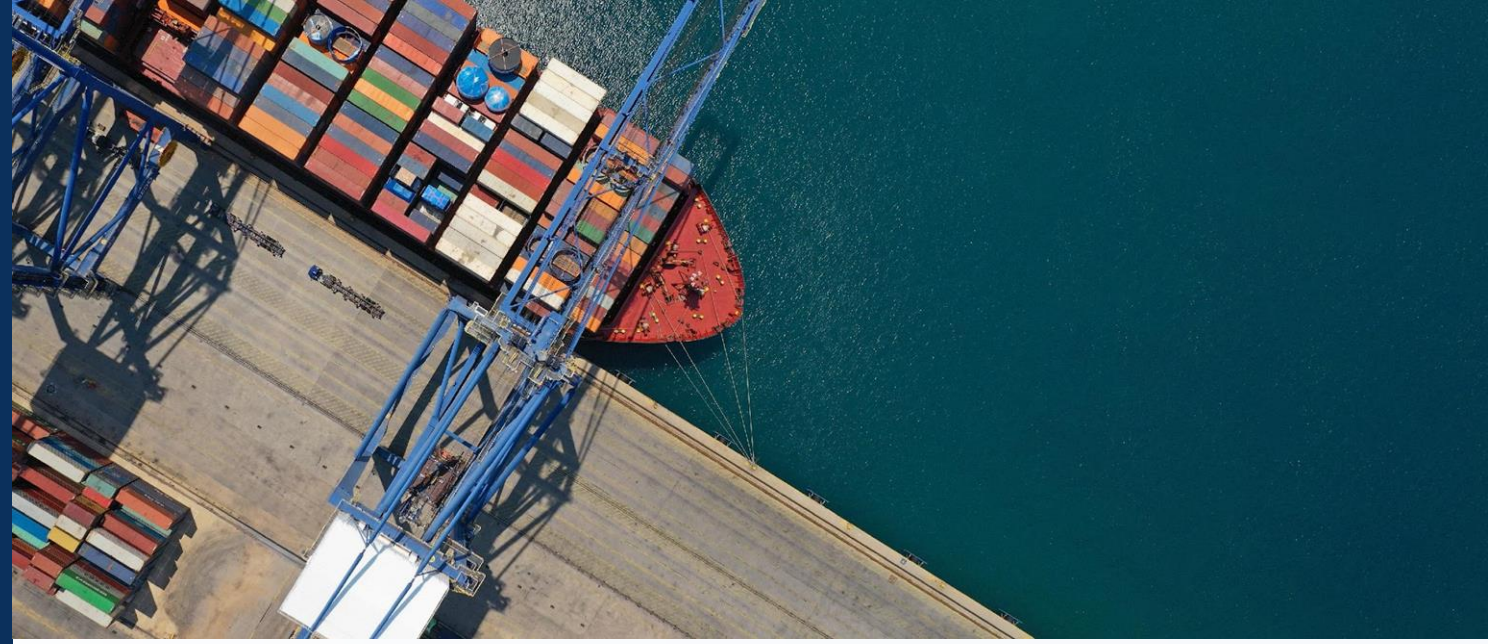
Founded: Nov. 2020

Funding to date: $220M

Headquarters: Brooklyn, NY

Other Locations: Houston, Norway, Singapore, Korea

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

AMOGY

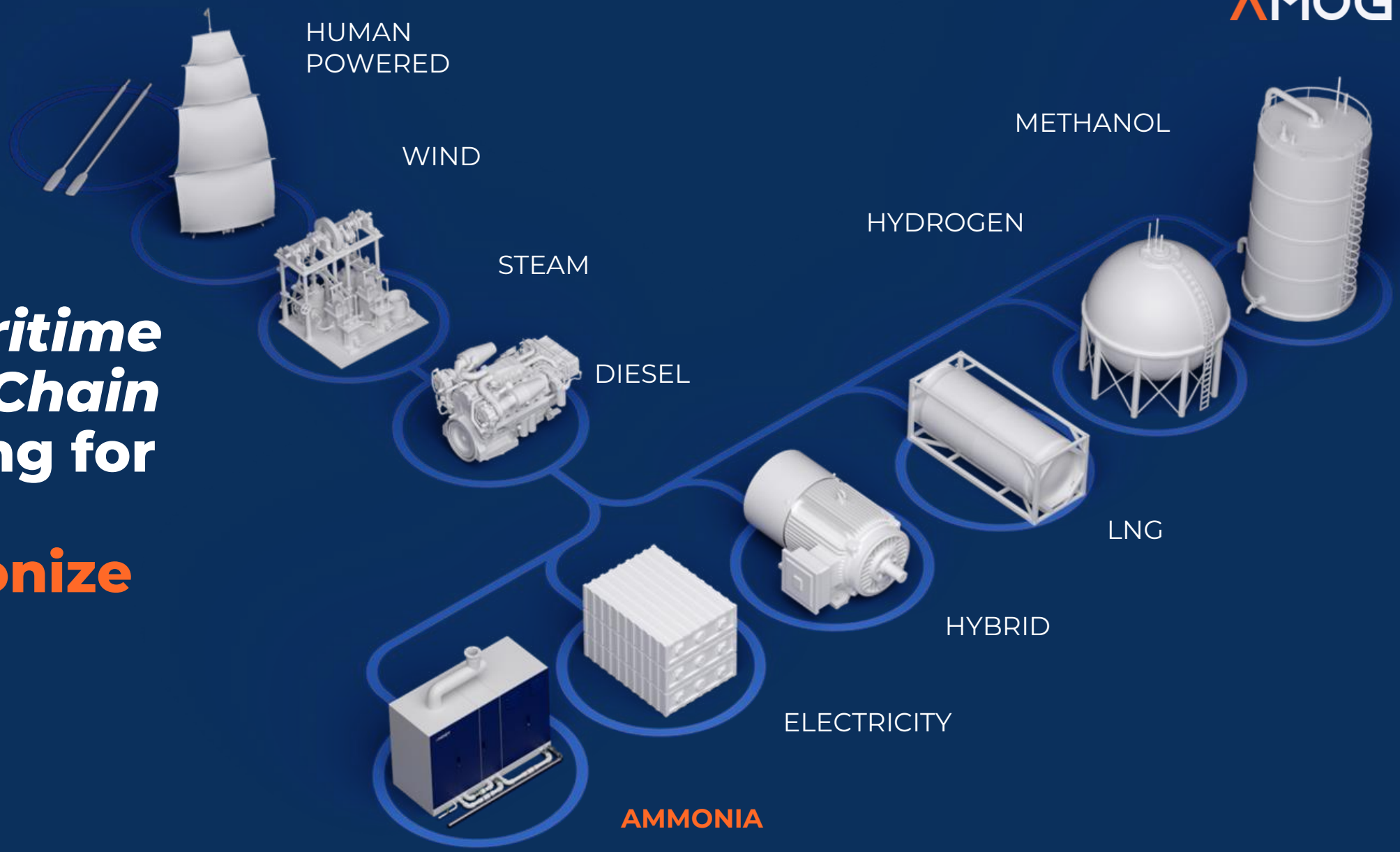
“The maritime sector accounts for up to 3% of global GHG emissions.”

If the maritime industry were its own country, it would be the sixth-largest GHG emitter in the world.

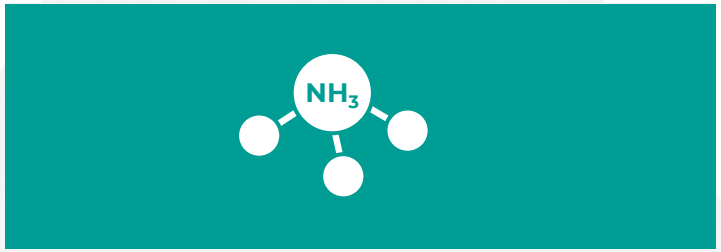
Sources: EU & Global energy, climate change and environment.

AMOGY

The *Maritime Supply Chain* is looking for ways to decarbonize



Ammonia



Green

– No Carbon

- Abundant and cheap
- 100+ yrs. scaled industrial use

Liquid

– High Energy Density

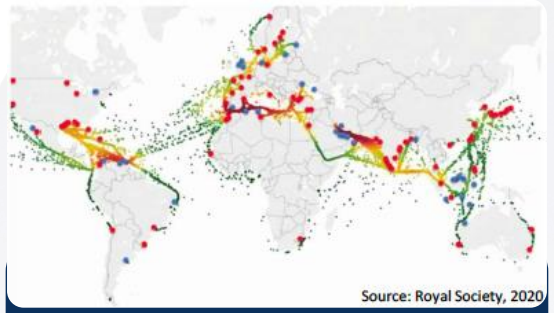
- Material: 10x battery & 4x H_2 350 bar
- System: > 2x battery & H_2 350 bar
- Easy to store, deliver and use

High Power

– Scalable Solution

- Miniaturized NH_3 power system
- Efficient conversion to electricity
- Zero GHG emissions

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, however,

no ammonia-to-power technology available yet

MTA: Million Metric Tons Annually Sources: DNV, IRENA

Ammonia Chosen by Major Shipowners

DNV: "Ammonia-fueled ships expected to represent almost 100% of new vessels (by fuel consumption) from 2044 onwards"

2023

MOL receives AiP for ammonia FSRU design from ClassNK

2024

First Ammonia-Ready Containership Delivered to CMB

EXMAR Selects Ammonia-Dual Fuel Engines for First Ocean-Going Ammonia Ships

2025

Yara announces world's first clean ammonia-powered container ship

Hanwha Ocean bags $498 million order for world's largest ammonia carriers

2026

Hanwha Ocean, Amogy, and Hanwha Aerospace Forge Partnership

Maersk Tankers orders up to ten very large ammonia carriers

The tanker major orders up to ten Very Large Ammonia Carriers together with a Japanese partner. The ships are expected delivered from late 2026.

2027

Capital Gas Ship Management Orders Two Very Large Ammonia Carriers

Moving the Maritime Industry Closer to Clean Energy, Amogy is Building the World's First Ammonia-Powered, Zero-Emission Ship

NYK Proceeds with Designs for Ammonia Bunker Vessel

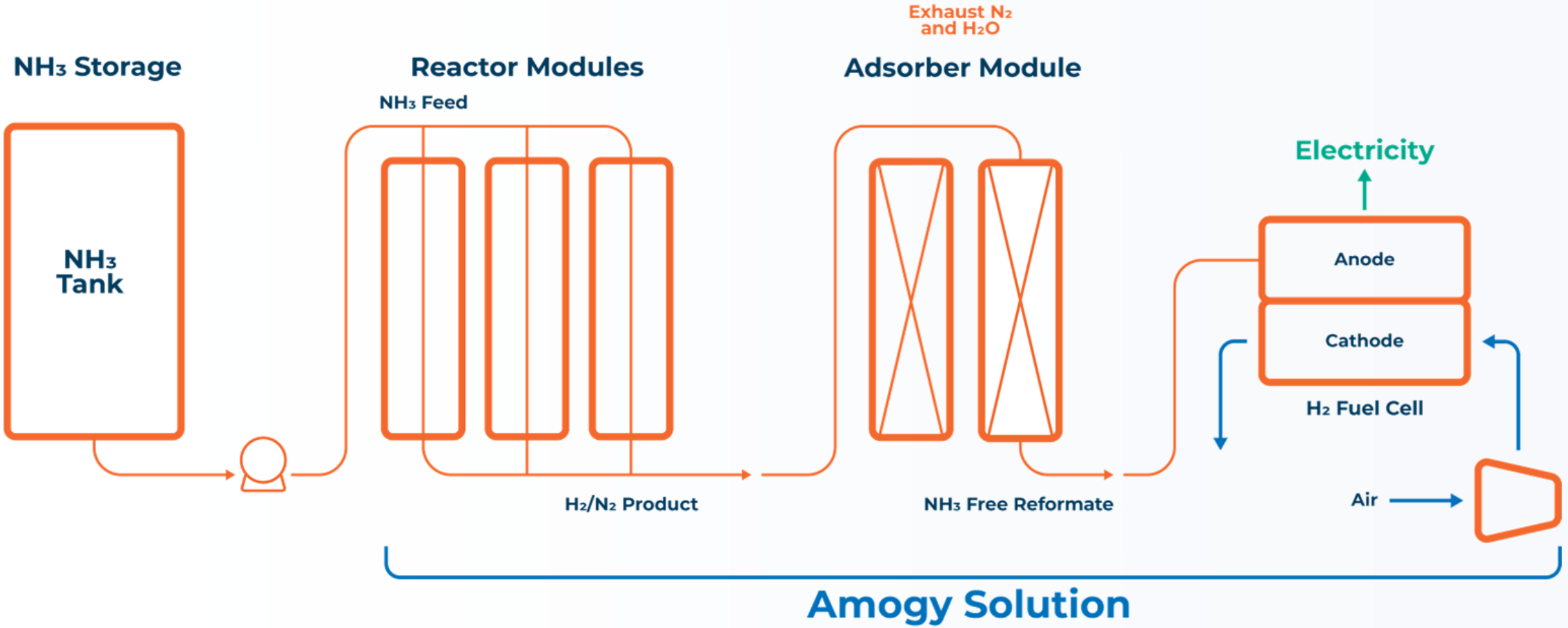
YARA INTERNATIONAL PRE-ORDERS 15 AMMONIA BUNKERING BARGES FROM AZANE FUEL SOLUTIONS TO LAUNCH WORLD'S FIRST CARBON-FREE BUNKERING NETWORK

Singapore's MPA Expects Ammonia Bunkering From 2026: Report

Höegh Autoliners and Sumitomo Corporation forge alliance on ammonia bunkering in Singapore and Jacksonville ports

Sources: The Maritime Executive, Ammonia Energy Association, Company-specific websites.

Amogy's Ammonia-to-Power Technology



Amogy's Ammonia-Powered Milestones

Drone

July 2021

$3M | Seed

(Feb. '21)

Tractor

May 2022

$20M | Series A

(Oct. '21)

Class 8 Truck

Jan. 2023

$46M | Bridge

(Jun. '22)

Tugboat

Sept. 2024

$150M Series B for commercialization

(Mar. '23)

2026

Ammonia-to-power commercial products

Maritime

Power Generation

Hydrogen Carrier

Full Commercialization

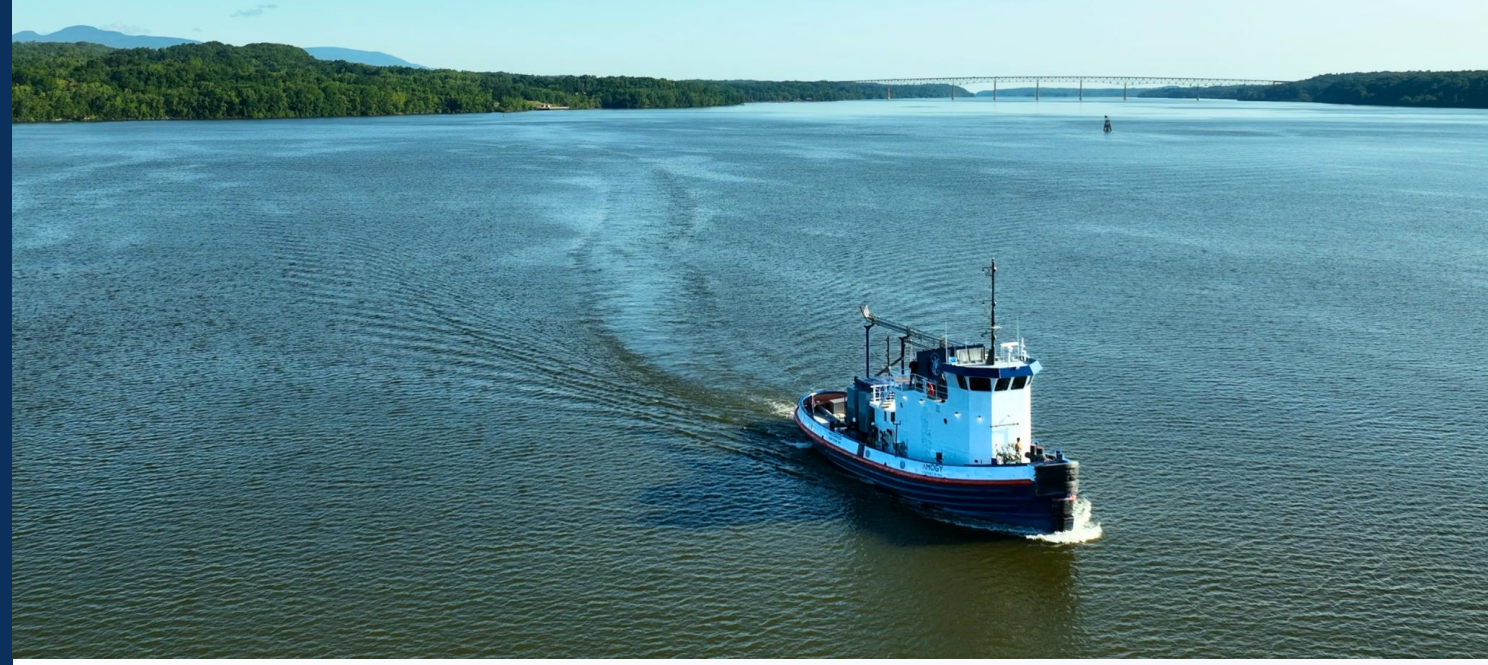
— DEMONSTRATIONS

Ammonia Powered Tugboat

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

- Stored energy: >5 MWh_e
- Vetted design from regulatory bodies to ensure full safety compliance
- Demo date: September 2024

Watch Demo

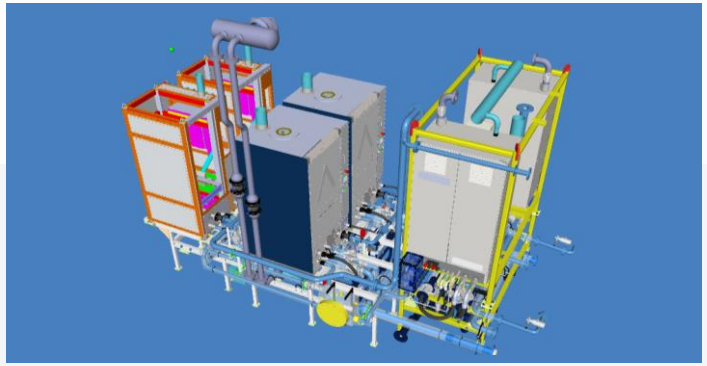


Partners:

NH_3 Kraken Conversion

Tugboat Details

- 1957 ABS Classed Single Screw Icebreaker Tugboat
- First Diesel Electric Power Tug in Norfolk Harbor
- 32 m LOA



Retrofit and Conversion

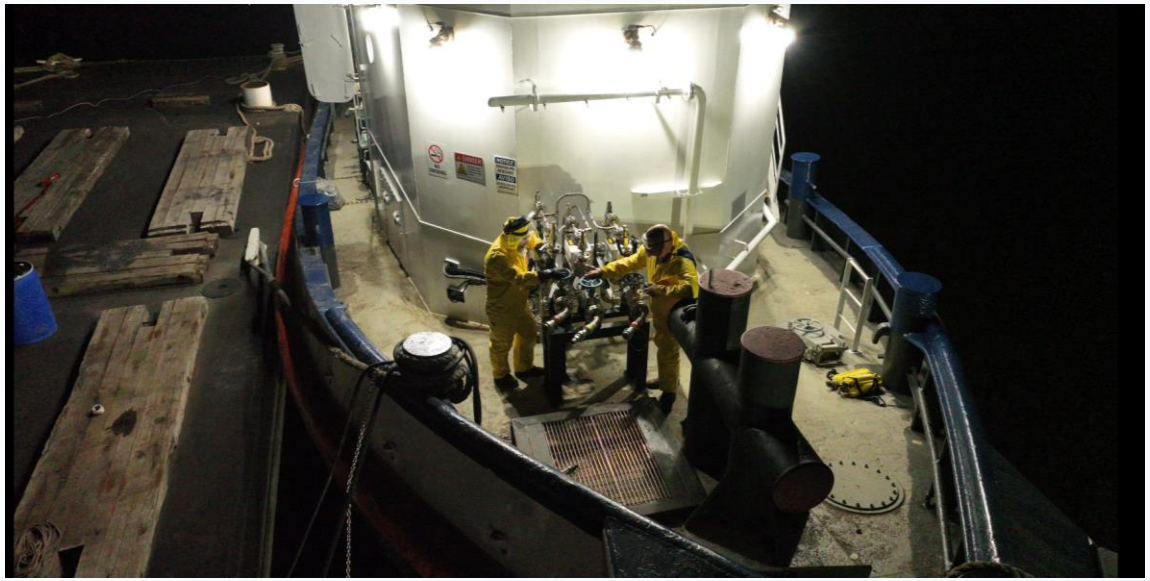
- Hybrid Electric Conversion
- Integration of Amogy Technology
- Fuel Preparation System
- Safety (Flammability, Combustibility, Toxicity)

Guidance from Class and Industry Standards

- IMO Standards
  - SOLAS/IGC Code/FFS Code
- Title 46 US Code of Federal Regulations (CFR): Shipping
- Class Requirements on Ammonia Fueled and Hydrogen Fueled Vessels

Ammonia Bunkering

- First ammonia bunkering in USA.
- Collaborated with multiple regulatory bodies
  - USCG provided guidelines on the use of ammonia cargo as fuel – a first for this demonstration.
- ***Safe*** and ***Swift*** bunkering
- Created the regulatory infrastructure enabling future ammonia fueling

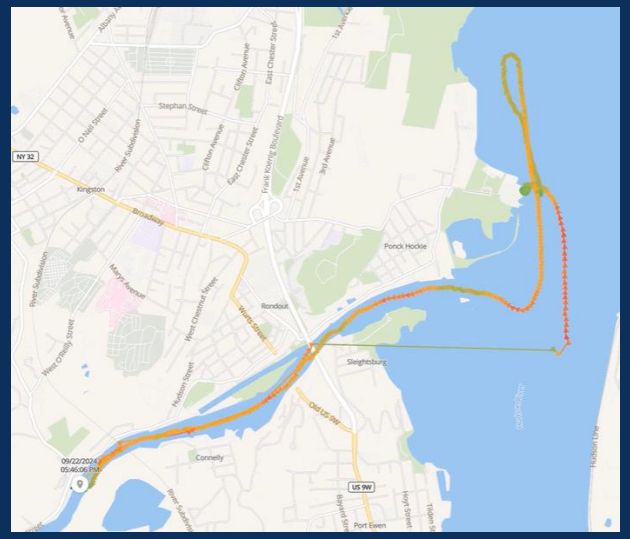


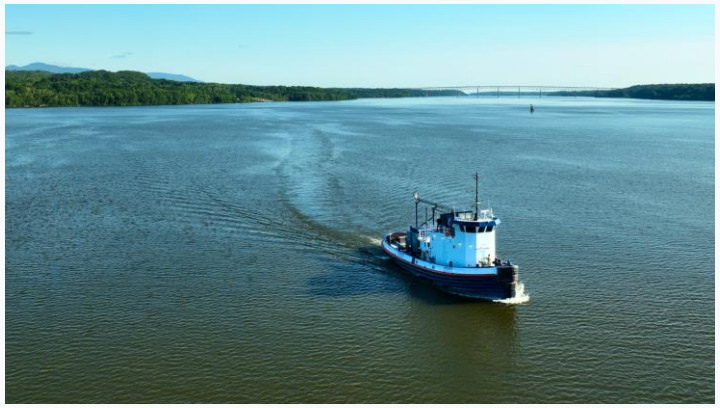
— COMISSIONING AND OPERATION

Ammonia Sailing

- World’s first carbon-free, ammonia-powered vessel
- Vessel dimension: 100 ft
- Sailing location: Hudson River

NH3 KRAKEN

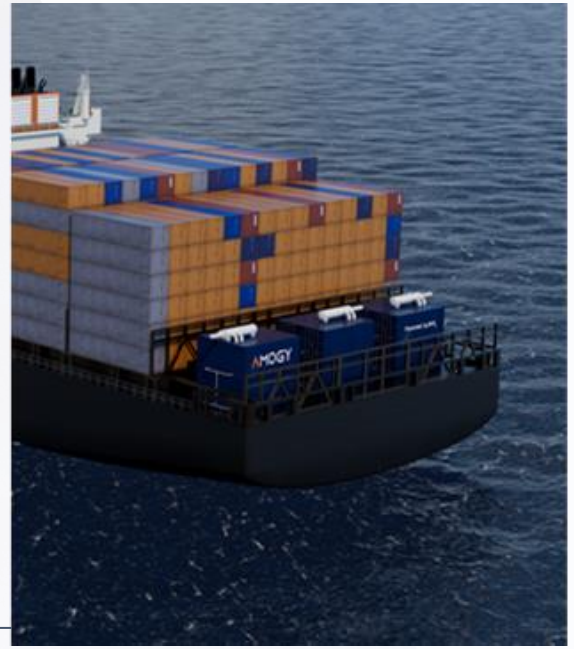




Applications

Maritime Shipping

- Ammonia carriers
- Container ships
- Tankers
- General cargo
- Offshore vessels



> 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

- Distributed power generation
- Shore power
- Microgrids
- Utilities

AMOGY

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

Amogy 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.

Thank You

Jatinder Sampathkumar

Senior Systems Engineer

amogy.co

contact@amogy.co

AMOGY

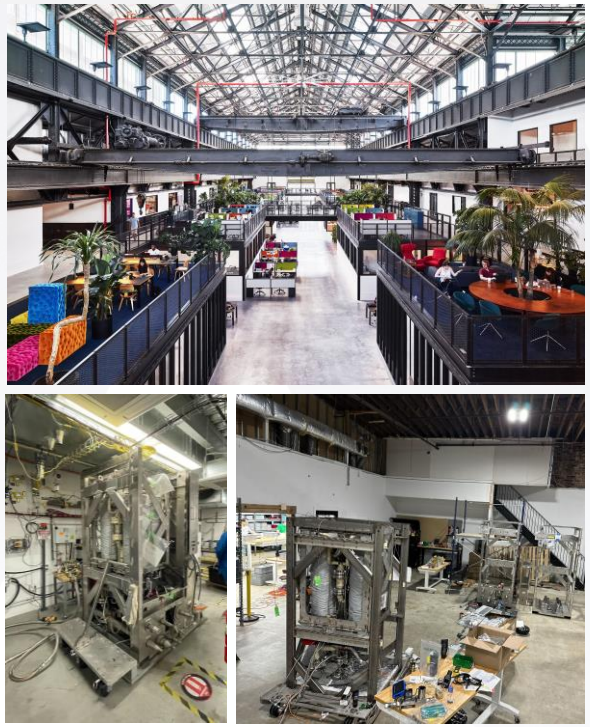
Additional Reference Slides

AMOGY

Global Footprint

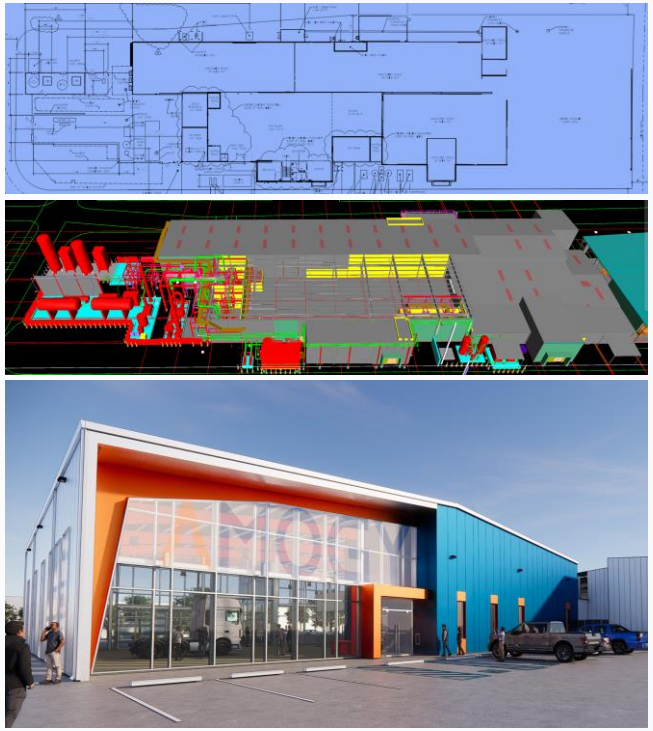
Amogy Facilities

Facility overview (NYC, Stord, Houston)



Brooklyn, NY
Amogy HQ, R&D lab

Stord, Norway
Scale-up test, module test



Houston, TX (Opening Q1 2025)
Product development, manufacturing

Ammonia Can Be Handled Safely

Safe handling of ammonia is not new

- Second most produced chemical in the world
- 20 MTA actively transported across ~200 shipping ports

- Robust safety standards from key organizations

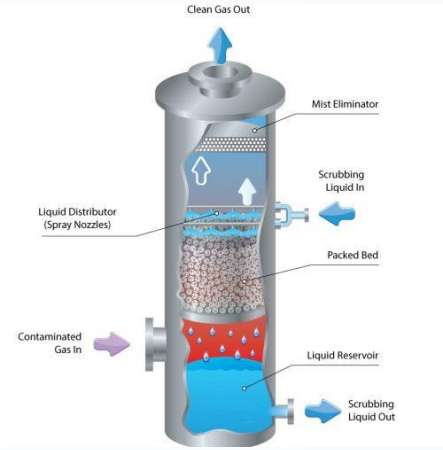
EPA OSHA® IMO INTERNATIONAL MARITIME ORGANIZATION

Risk can be mitigated

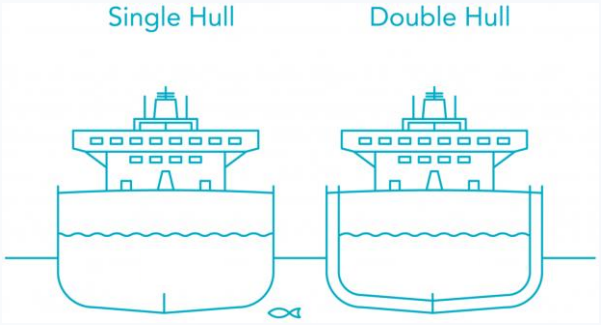
Odor threshold
5 PPM

OSHA PEL*
50 PPM

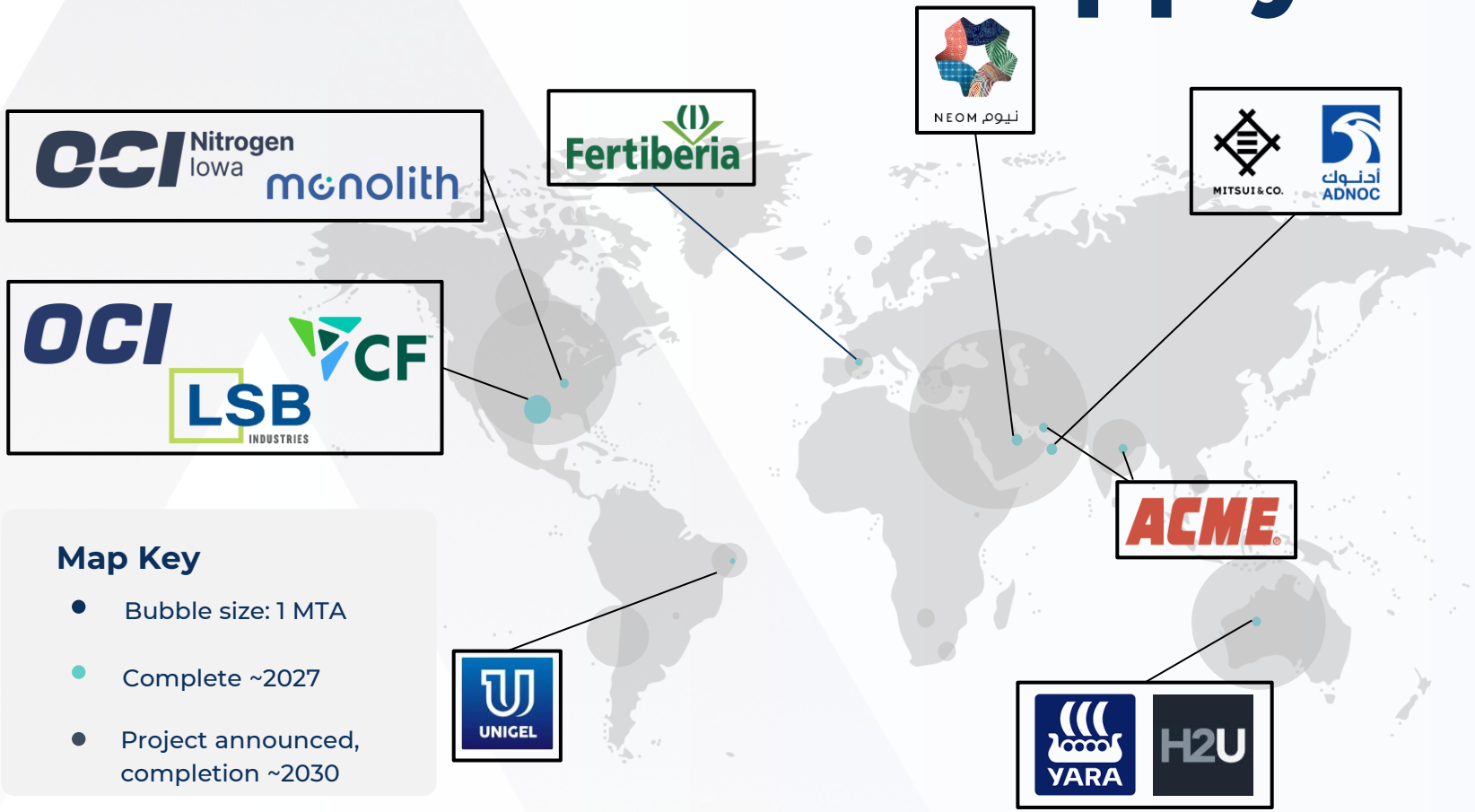
NH_3 scrubbers absorb trace ammonia



Double hull vessels prevents spills



Clean Ammonia Supply



Map Key

- Bubble size: 1 MTA
- Complete ~2027
- Project announced, completion ~2030

8 **MTA** projects by 2027

200+ **MTA** projects announced

25 projects FID announced

- Growing number of ~0.5 to 1 MTA blue and <0.1 MTA green NH_3 projects mitigates supply constraints
- Combination of 45Q and 45V incentives de-risks US supply

Note: 8 MTA by 2027 are projects deemed probable and possible by Argus; 13 additional projects are partially-financed.
Source: Argus Ammonia Analytics Q2 2024.

Our Demonstrations

AMOGY

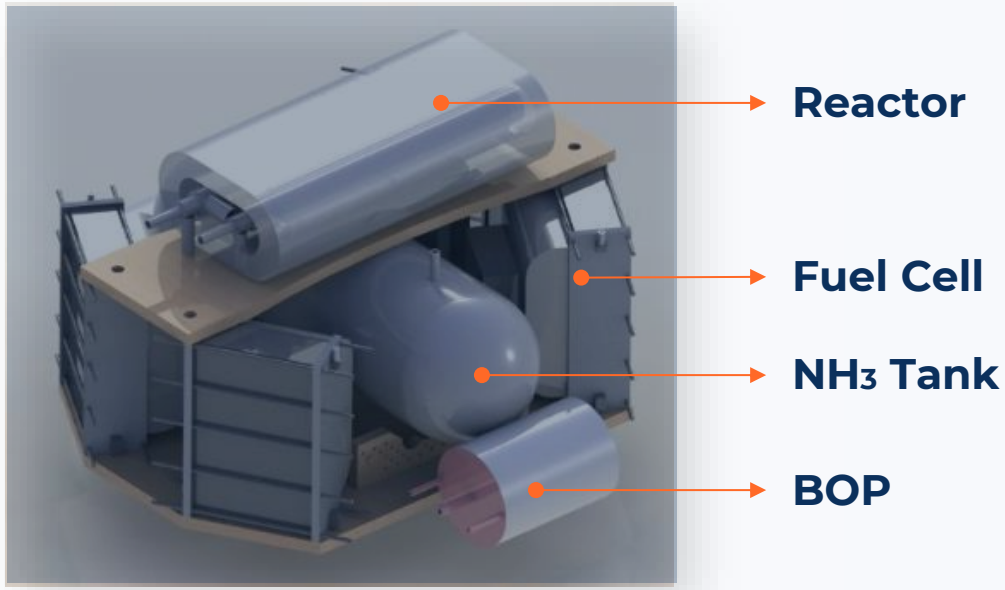
— DEMONSTRATIONS

Ammonia Powered Drone

World's first carbon-free, ammonia-powered drone:

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

Watch Demo



— DEMONSTRATIONS

Ammonia Powered Tractor

World's first carbon-free, ammonia-powered tractor:

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

Watch Demo

— DEMONSTRATIONS

Ammonia Powered Truck

World's first carbon-free, ammonia-powered class 8 semi-truck:

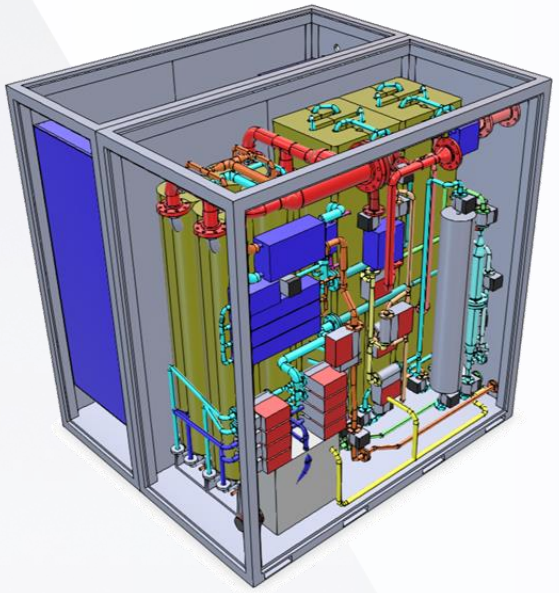
- Power: 300 kW
- Ammonia-to-power efficiency: 40%
- Demo date: January 2023

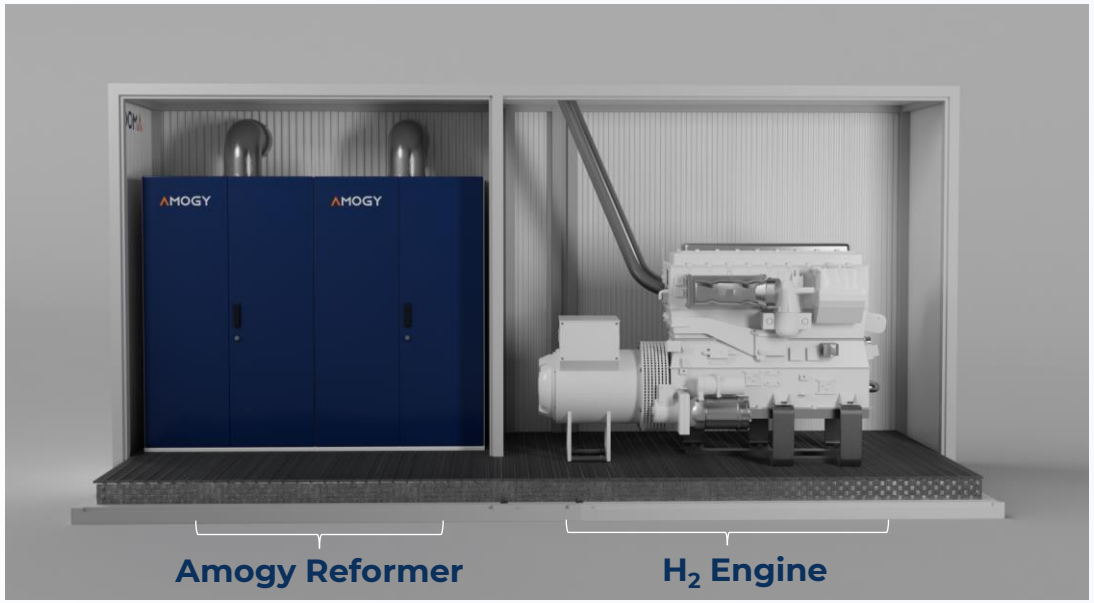
Watch Demo

Our Technology

AMOGY

Ammonia-to-Power Solutions





Amogy Reformer + Fuel Cell

- **Zero carbon emissions:** 100% carbon-free electrical power.
- **High efficiency:** approx. 40%.
- **Modular and scalable:** adaptable to various power needs, up to multi-MW.
- **Versatile applications:** maritime, stationary power, and others.

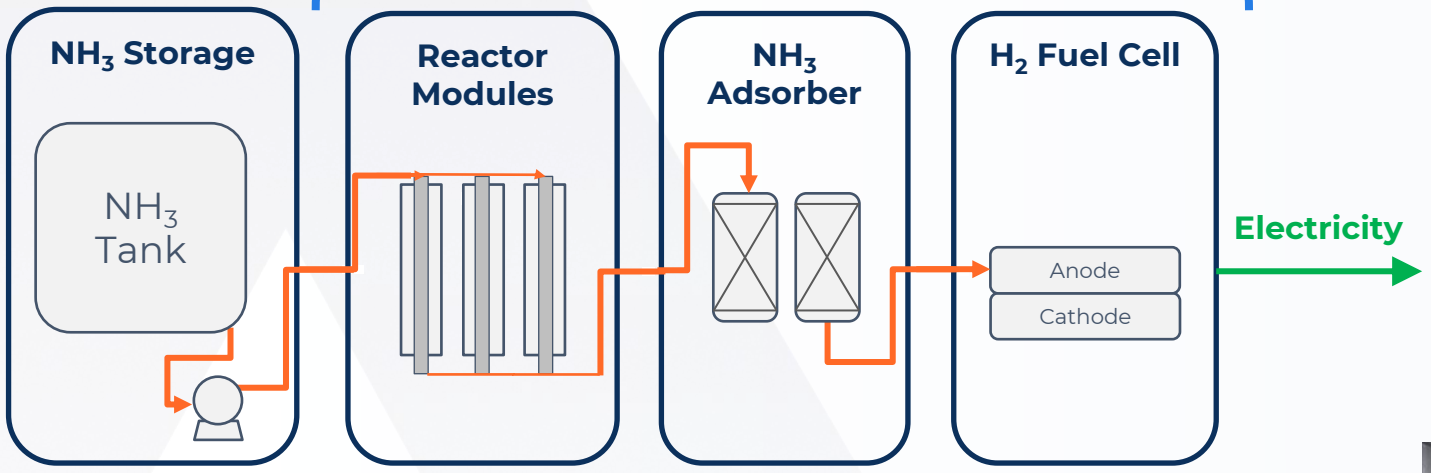
Amogy Reformer + H_2 Engine

- **Combined heat and power:** generates electricity & high-quality heat.
- **Climate resilient:** tolerant to high ambient temperatures.
- **Reduced cost:** reduced upfront costs with a small efficiency penalty.
- **Well established:** using well proven engine technology.

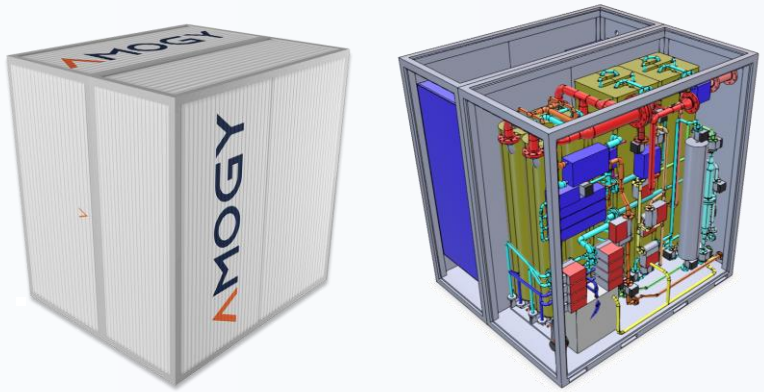
Efficiency is defined as gross electrical power produced by the fuel cell divided by the Lower Heating Value (LHV) of ammonia fuel.

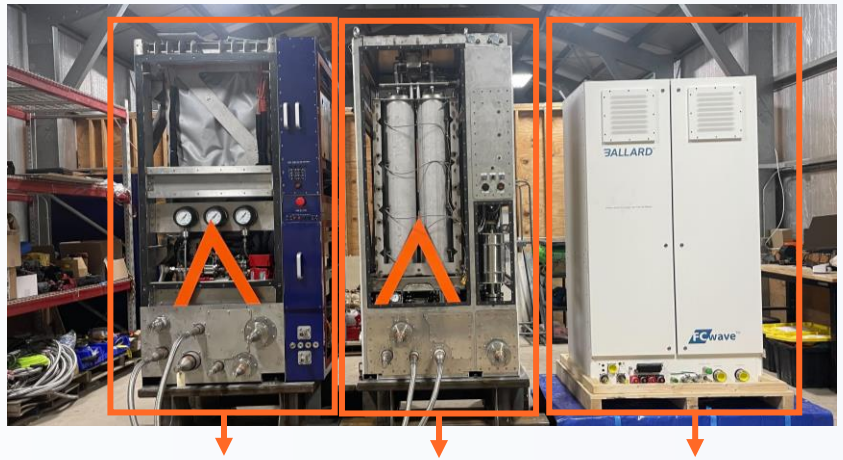
Amogy's Technology

Ammonia-to-power: Fuel Cell Solution



Fuel Cell Solution

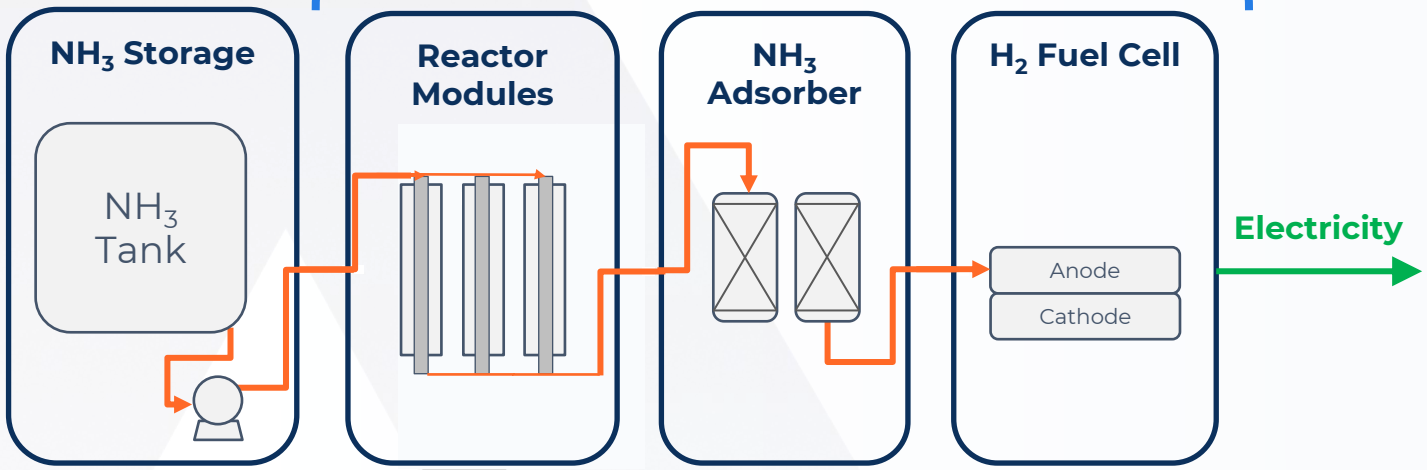




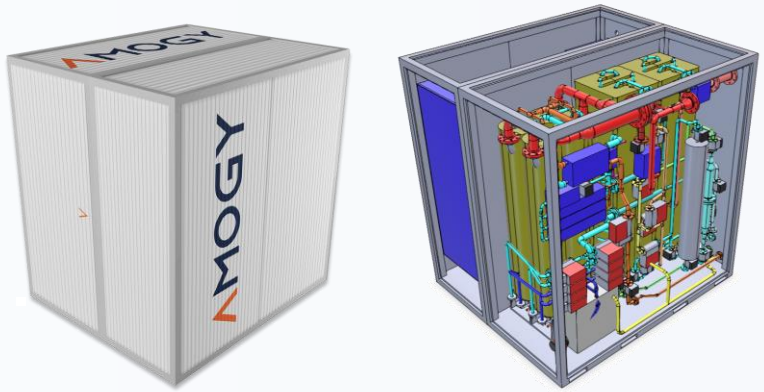
Reactor Adsorber Fuel Cell

Amogy's Technology

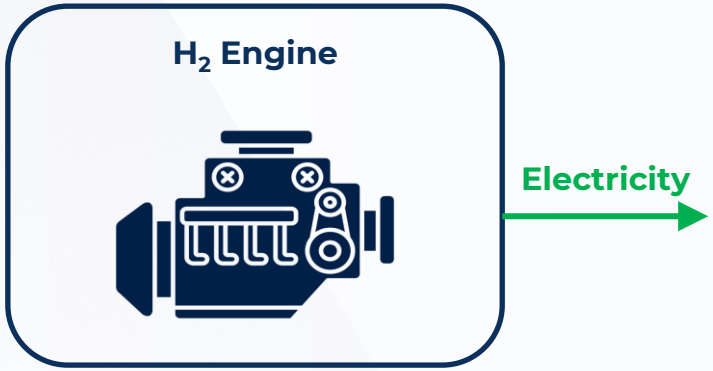
Ammonia-to-Power: Fuel Cell Solution

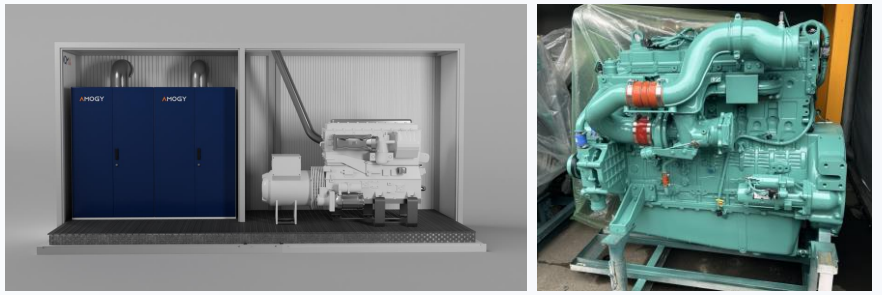


Fuel Cell Solution



H_2 Engine Solution



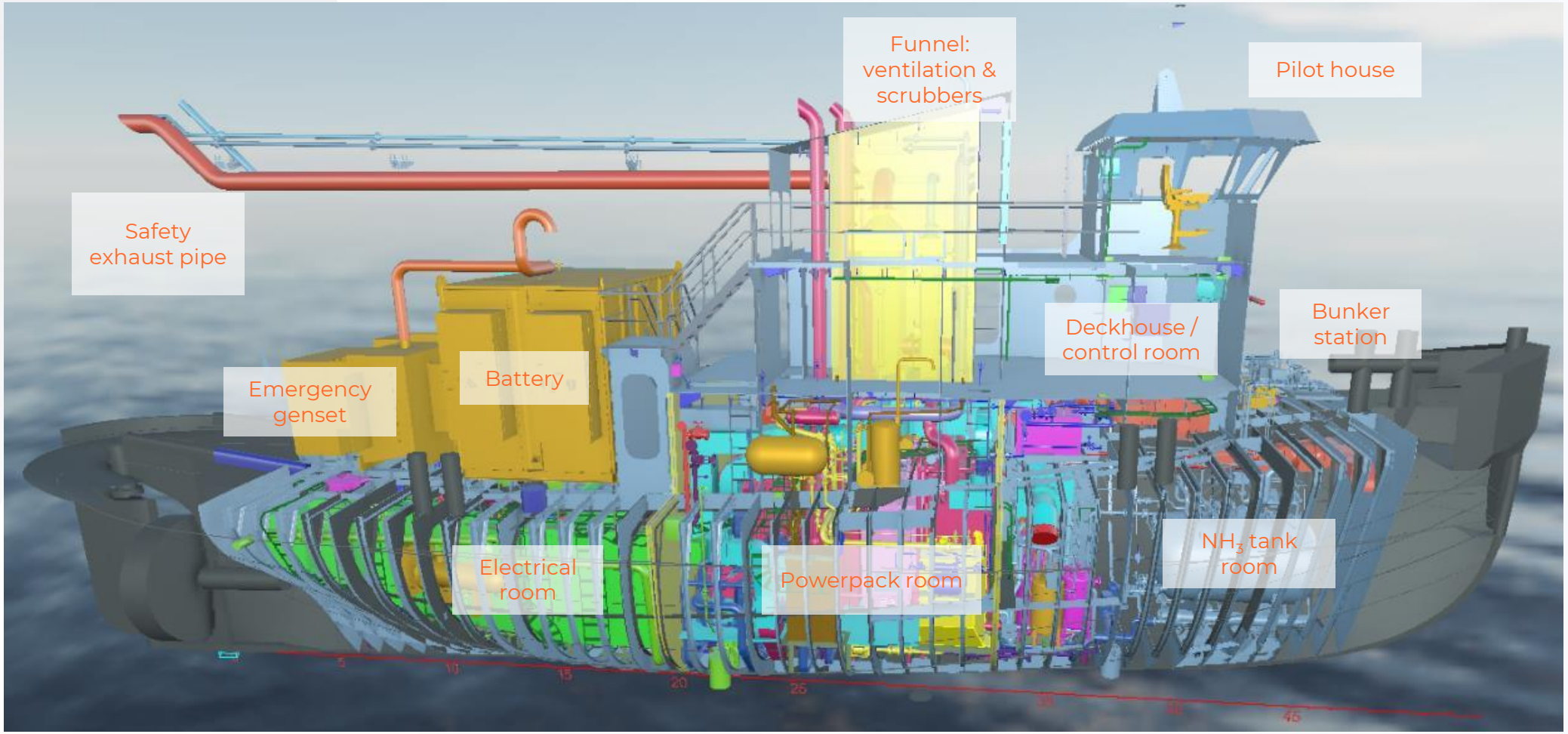


Ammonia-to-Power: Engine Solution

Vessel Design & Construction

AMOGY

Vessel Design



General Arrangement & Vendors

Regulatory

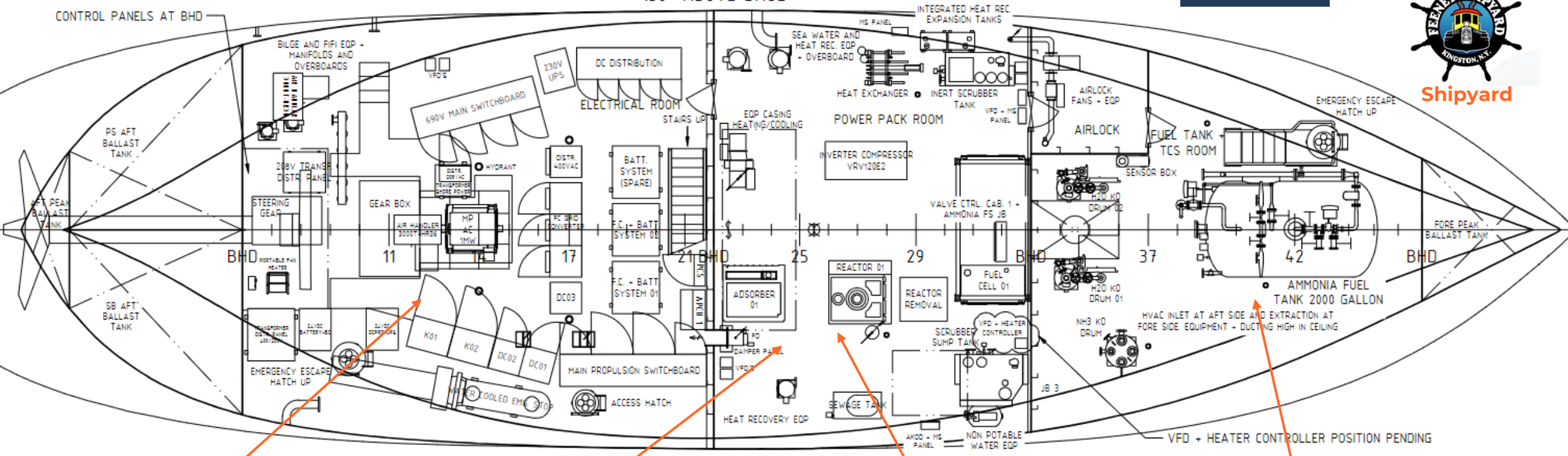
DNV

Naval Architect

C-JOB

Shipyard

FEENEY SHIPYARD KINGSTON, N.Y.



SEAM

Electrical Integrator

W-INDUSTRIES

Powerpack skid foundations & piping

AMOGY

Powerpack

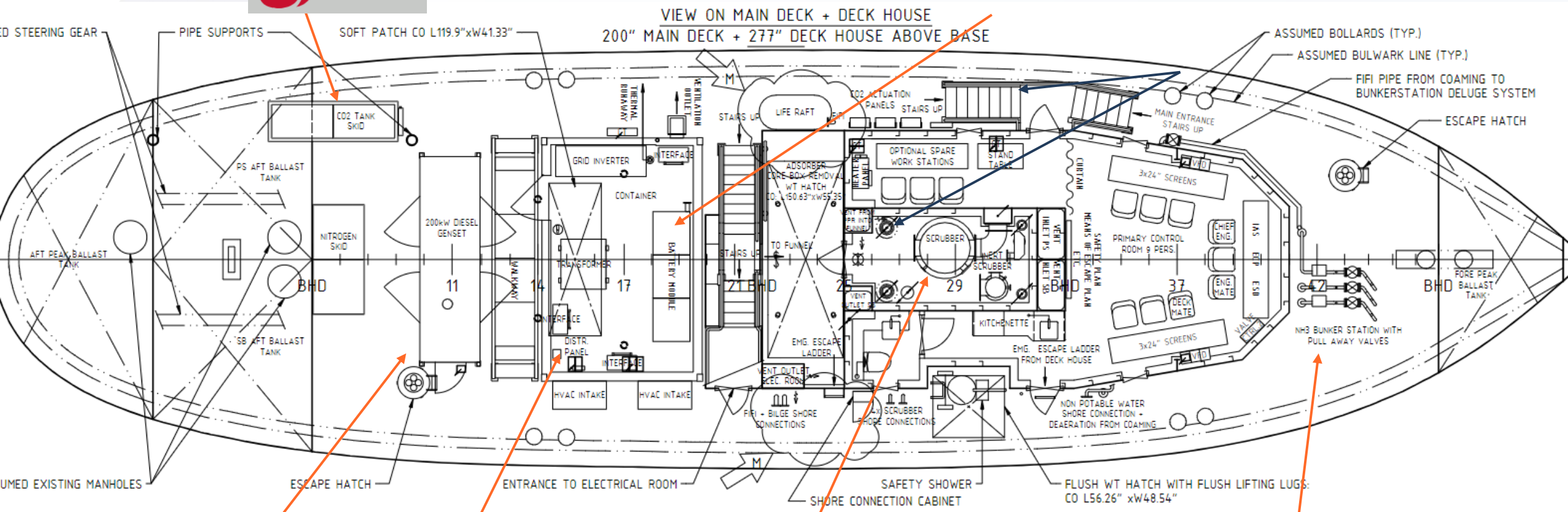
NH_3 Storage and Vaporization System

VECTOR SYSTEMS, INC.

General Arrangement & Vendors

CO2 Firefighting — Hiller

Batteries — Corvus Energy



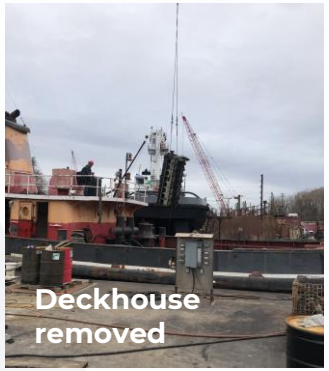
Emergency Generator — aggreko

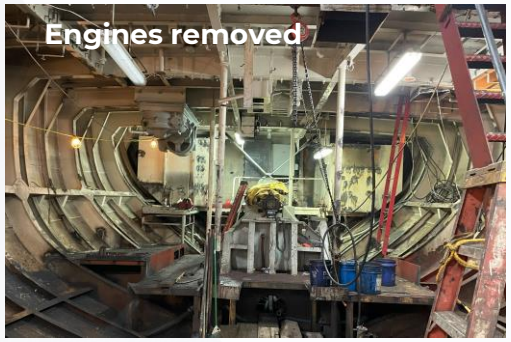
W-INDUSTRIES — Battery Box

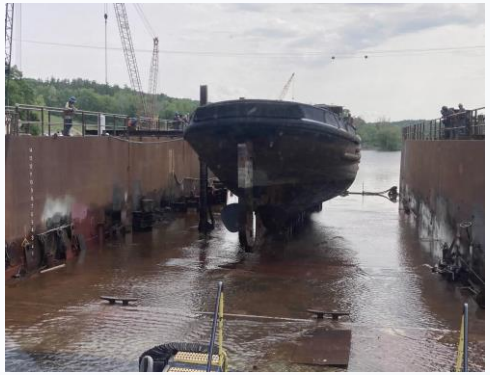
macrotek — Scrubber System

YARA / Tanner Industries, Inc. — Bunkering

Construction Progress







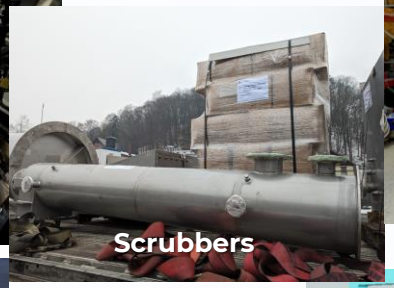
Initial Design & Demolition

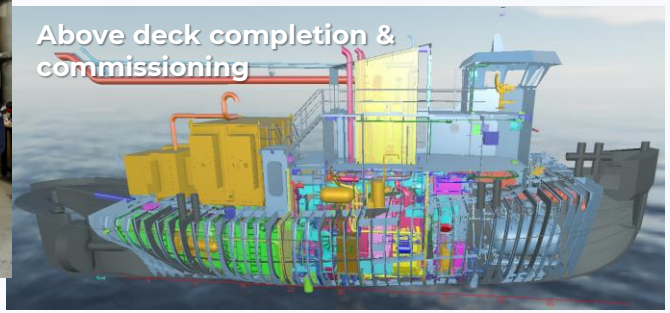
Legacy Equipment Removal

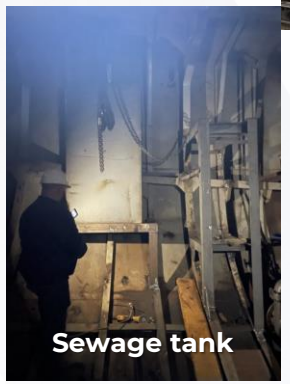
Drydock & Initial Construction

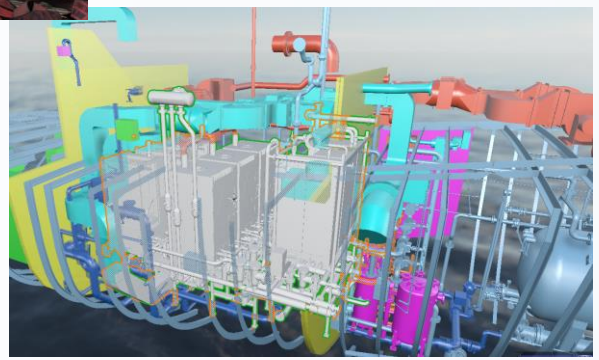
3Q22 4Q22 1Q23 2Q23 3Q23

Construction Progress









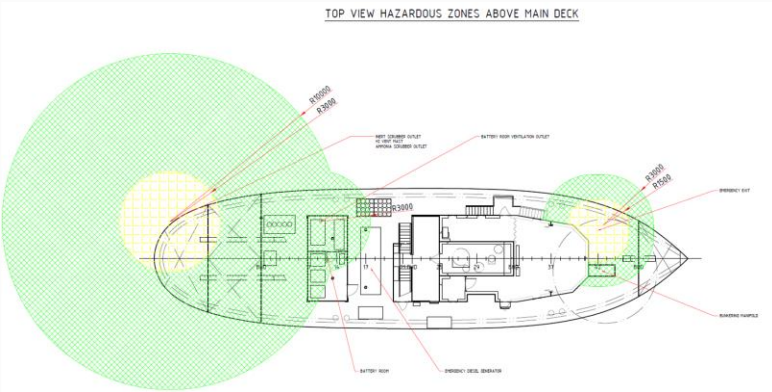
4Q23 | Jan 24 | Mar 24 | May 24 | July 24 | Sep 24

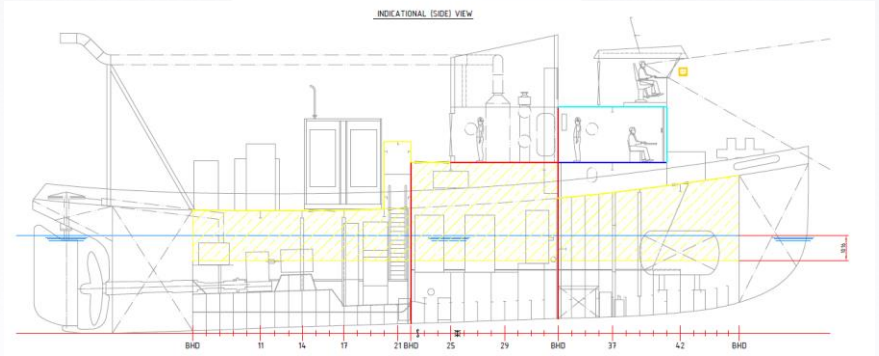
Safety in Design

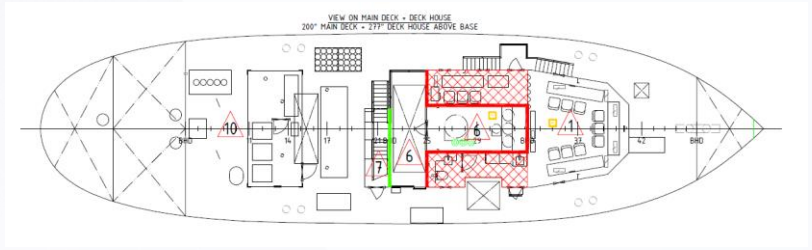
AMOGY

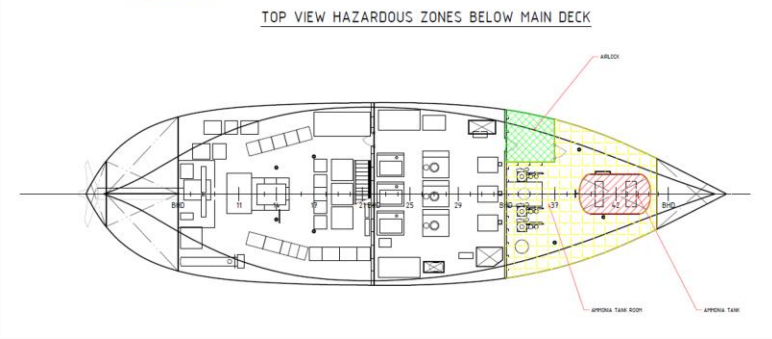
Safety Philosophy

- **Safety in Design**
  - Safeguards for potential NH3 & H2 releases
  - Hazardous zone plan per IMO and Class Standards
  - Double Containment Systems
  - Structural Fire Protection
- **3rd Party Support**
  - Emergency diesel genset onboard
  - Escort vessel to maintain safety zone during operation
  - Multiple HAZID and HAZOPS conducted
    - Jan 2023 HAZOP moderated by DNV



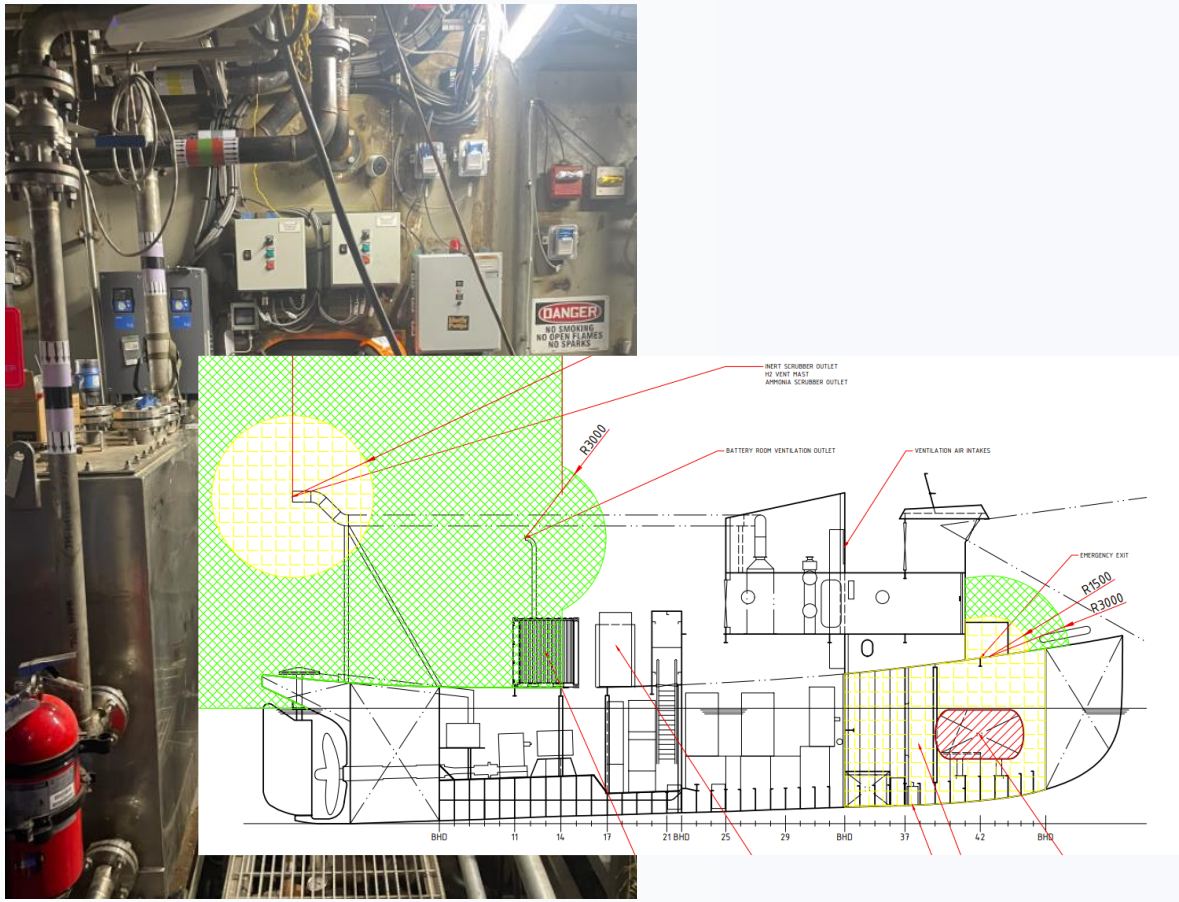






Gas Leakage & Detection

- Engineering safeguards
  - Entire tank room considered to be the tank connection space
  - Ventilation design ensured negative pressure in tank room to contain leaks
  - Redundant gas detectors with automated ventilation responses and audiovisual indicators
  - Double-walled piping in manned spaces
- Personnel safeguards
  - Defined operator responses to gas alarms
  - Personal gas monitors & other appropriate PPE required for entry
  - 24hr onboard alarm monitoring



Bunkering

- Risk-based design led to USCG approval
  - Completed a dispersion analysis for several ammonia release scenarios
  - Submitted multiple revisions of bunkering logistics & personnel safety plans
- Automated process controls to keep the tank room unmanned
- First responders onsite in case of emergency
- Operations:
  - Pre-transfer safety discussion w/all parties
  - Pre-transfer procedure review w/all parties
  - Radio communications across boat, truck, and onshore control station

Regulatory Engagement

AMOGY

Regulatory Purpose & Need

Why Amogy needed USCG

- Regulatory oversight required since Amogy would be fueling over the water.
- Quantity and type of fuel being used.
- Project on public waterway

Why USCG needed Amogy

- IMO “Net zero GHG shipping emissions by or around 2050”
- USCG recognizes NH3 is one of the future fuels.
- USCG recognized Amogy as an opportunity to learn about NH3 as a fuel.

IMO CCC 10 Ammonia as Fuel

- Guidelines for int’l standard for the safety of ships using NH3 as fuel. (Dec 2024)
- The deletion of the prohibition of use of toxic cargo as fuel from the IGC Code (July 2026)
- Guidelines on the use of ammonia cargo as fuel on ships (CCC 11/Spring 2026)

Main Challenges and Key Solutions

USCG and Amogy together faced two main challenges:

- **Lack of regulatory guidance for NH3 as a bunker fuel**
- **Lack of streamlined approach to execute innovative technology demonstrations.**

USCG and Amogy Used Existing Regulations as Model as solution:

- **Bunkering –**
  - **USCG used existing LNG/LHG regulations and handling of NH3 as a cargo as foundation.**
- **Safety –**
  - **Utilized existing regulations for the safe handling and transport of NH3 (USDOT, OSHA, EPA, DHS)**
- **Waivers –**
  - **USCG allowed for waivers and exemptions when demonstrated appropriate**

Path to US Coast Guard Approval

CHALLENGE: Lack of regulatory guidance for NH3 as a bunker fuel and no streamlined approach to execute innovative technology demonstrations

SOLUTION: Use existing regulations for LNG and NH3 with waivers when appropriate

PROCESS: Regulatory body and industry lead collaborative process

Nov 2022:
LOI/WSA submitted to SECNY

March 2023:
In-person presentation to USCG NatioCenter of Expertisenal

May 2023:
In-person meeting at USCG SECNY.

June 2023:
Presentation to Maritime Association of the Hudson River and PANYNJ Harbor Safety Exec Steering Committee.

Sept 2023:
In-person meeting at NewLab with USCG SECNY.

April 2024:
Virtual meeting with USCG SECNY.

May 2024:
Supplemental LOI/WSA submitted.

July 2024

33 CFR 105 Final Waiver and Sea Trial approval by USCG HQ.

Sept 2024

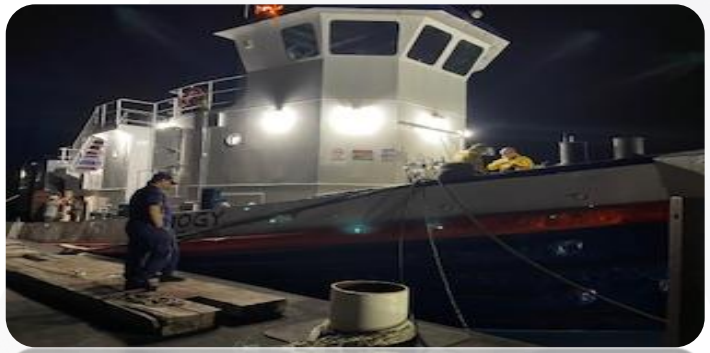
Final USCG approval for bunkering and sea trial by USCG SECNY

***Initial contact made to Sector NY August 2022**

NH3 Kraken Demo Collaborators

Regulatory Approval

USCG Sector NY
USCG HQ

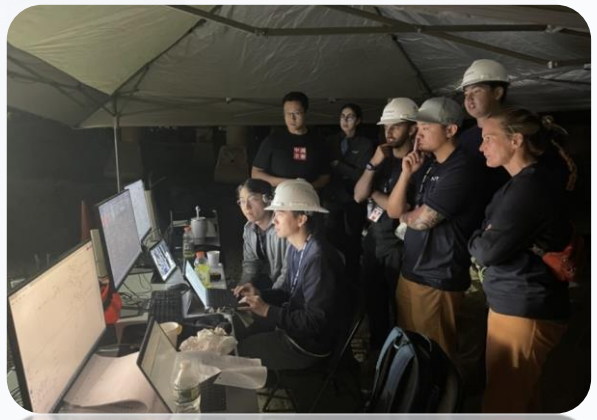


Ammonia Supplier

Tanner Industries

Safety Compliance

Kingston FD
Port Ewen FD
Ulster County Sheriff's Office

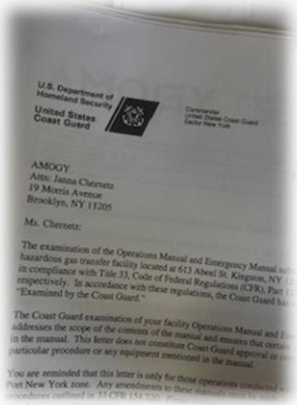


Shipyard & Infrastructure Support

Feeney Shipyard

IMPACT

USCG Approved Process NH3 Fuel Sea Trial + **Proved Truck-to-Ship Bunkering Could be Done Safely** + **FOUNDATION for Future Use of NH3 as a Fuel** = **Collaboration Between Regulatory Bodies and Industry Leads to Success**


U.S. Department of Homeland Security
United States Coast Guard

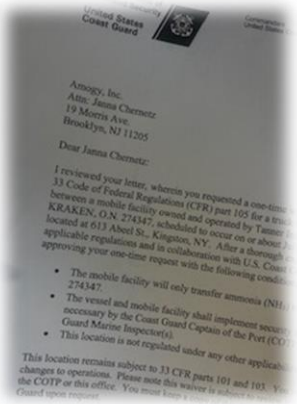
AMOGY
Attn: Janna Chernetz
19 Morris Avenue
Brooklyn, NY 11205

Ms. Chernetz:

The examination of the Operations Manual and Emergency Manual
hazardous gas transfer facility located at 613 Abeel St. Kingston, NY
in compliance with Title 33, Code of Federal Regulations (CFR), Part
respectively. In accordance with these regulations, the Coast Guard
"Examined by the Coast Guard."

The Coast Guard examination of your facility Operations Manual and
addresses the scope of the contents of the manual and ensures that
in the manual. This letter does not constitute Coast Guard approval
particular procedure or any equipment mentioned in the manual.

You are reminded that this letter is only for these operations conducted
Port New York zone. Any amendments to these


United States Coast Guard

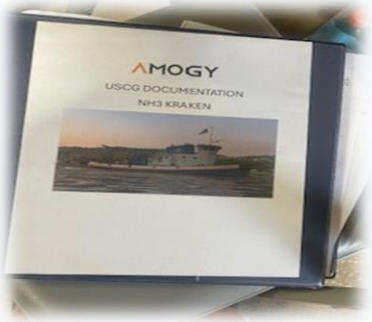
Amogy, Inc.
Attn: Janna Chernetz
19 Morris Ave.
Brooklyn, NJ 11205

Dear Janna Chernetz:

I reviewed your letter, wherein you requested a one-time
33 Code of Federal Regulations (CFR) part 105 for a tr
between a mobile facility owned and operated by Tamn
KRAKEN, O.N. 274347, scheduled to occur on or about
located at 613 Abeel St., Kingston, NY. After a thorough
applicable regulations and in collaboration with U.S. Coa
approving your one-time request with the following condi

- The mobile facility will only transfer ammonia (NH
274347.
- The vessel and mobile facility shall implement secu
necessary by the Coast Guard Captain of the Port (CO
Guard Marine Inspector(s).
- This location is not regulated under any other applica

This location remains subject to 33 CFR parts 101 and 105. Y
changes to operations. Please note this waiver is
the COTP or this office. You must



— Regulatory Engagement

Regulatory Guidance for the World's First Carbon-Free, Ammonia Powered Vessel

NH3 TTS Bunkering, Sea Trial & Vessel Design

- Vessel dimension: 100 ft.
- Demo date: September 2024
- Vetted design for vessel and bunkering from key regulatory bodies to ensure full safety compliance

DNV

OSHA Occupational Safety and Health Administration

Regulatory Readiness, Safety & Security

Key existing regulatory guidance and standards used for NH_3 Kraken sea trial:

Bunkering:

- ✓ United States Coast Guard - 33 CFR Parts 105 & 127 as it pertains to LNG
- ✓ Environmental Protection Agency - 40 CFR Part 68, Clean Air Act
- ✓ U.S. Department of Transportation - 49 CFR Parts 171 – 180 as it pertains to the transport of NH3
- ✓ Occupational Safety Health Administration - 29 CFR 1910.111
- ✓ Department of Homeland Security - 6 CFR Part 27

Selected Vessel Design/Engineering Standards for demo project:

- ✓ Tank – ASME BPVC Section VIII-1
- ✓ Piping (reformate stream): Spec DWA (H2) /DWC (NH3), 316/316L Stainless Steel Double Wall Piping
- ✓ Fire system: USCG approved
- ✓ Hazardous zone plan for the vessel based on ABS regulations for ammonia, hydrogen, and batteries on bulk carrier
- ✓ Vessel structural fire protection plan based on requirements from SOLAS, BV, and IGF codes relevant to this application
- ✓ HAZard Identification & HAZard and Operability facilitated by DNV
- ✓ AiP and Technology Approval by LR

Note: not an exhaustive list