NAMEPA Safety at Sea Seminar 2023
The Mechanics of Safety

Rich Delpizzo, ABS Global Government Services

TECHNOLOGY TRENDS

Exploring the Future of Maritime Innovation

> "Innovation in the maritime industry is cyclical, and we're on the verge of a new wave of technologies and change."

Elemental power

LMG MARIN
FERRY AND DREDGER VESSELS

Headquartered in Bergen, Norway, LMG Marin has an extensive portfolio of naval architectural design, engineering and technology development as well as numerous design patents. Recent hydrogen vessel projects include a fuel cell ferry for Norled. Producing onboard energy with hydrogen and fuel cell technology, the project started around four years ago. Hydrogen tanks with 80m³ of volume are installed on the Hydra craft's roof, for safety and practicality.

A contract with the Piriou shipyard has also seen the company design a 70m hopper dredger, which will be the first in the world to employ a fuel cell to provide some of the energy required for the ship's propulsion. Delivery of the €32m (US$34m) HydroMer ship is planned for the third quarter of 2023. It will be based at ports on the French Mediterranean coast.

"The HydroMer dredger tender was granted to us two years ago and concept development took around one year," says Alexandre Bellot, LMG Marin research project coordinator. "The vessel was built this year and the hull is now at Piriou shipyard for outfitting. Certification is still underway."

Both the dredger and the 82.4m Norled ferry project have needed additional time for development and approval, due to their pioneering nature.

The HydroMer and the Hydra are fitted with electric propulsion powertrains. Fuel cells are used to boost power production on the dredger – onboard power totals 2,500kW – and contribute more than 20% of the vessel's

"The Hydra ferry relies on fuel cell electric production for 50% of its propulsion, [with] the auxiliary systems and Li-ion batteries charged by shore power," explains Bellot. The HydroMer is refuelled around once a week by exchanging four compressed (500 bar) hydrogen storage containers. "The Norled ferry uses a fixed liquid hydrogen tank, which is refilled at port from a bunkering tower that has been specifically designed for this application and to interface with liquid hydrogen bunkering trucks every three weeks," he says.

The more widespread type approval and certification of current fuel cell technologies makes vessel integration simpler, but Bellot says that a new-build craft installation is the safer option. "Fuel cells need to be integrated in vessel design to guarantee design and operational safety. System integration for hydrogen propulsion also requires arrangements for storage, specification of safety systems including remote hydrogen safety automation, and design for the venting of accidental release of gas.

"Hydrogen propulsion systems are also best integrated on board for new-builds, where all specifics can be targeted with design adaptations. Retrofits can also be considered, but in such cases more specific analysis is required. As shown by the number of hydrogen ships coming to realization, hydrogen is being proved as a viable source of energy for maritime applications."

Other hydrogen projects the company is involved with include the design of the liquid hydrogen-fueled Energy Observer 2. The 120m vessel has 4MW of electric propulsion, with fuel cell power of 2.5MW, 1,000m³ of hydrogen storage and a proposed range of up to 4,000 nautical miles. The Zero Emission Fast Ferry project is designed for local Norwegian coastal sailing, with LMG Marin one of four naval architect offices tasked with design. Its proposal is based on its full flight ZeFF hydrofoil concept.

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14
2023_05

American Bureau of Shipping signs MoU with Korea to study near-shore green hydrogen production

Author:

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May 16, 2023 | News, Offshore Wind

Vard wins contract for two battery-hybrid, methanol-ready CSOVs

Written by Nick Blenkey

Order for battery-hybrid,methanol-ready VARD 4 19 design CSOVs includes option for two more vessels.

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Elemental power

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AMOGY

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> WHERE WE'RE GOING

A carbon-free transportation industry by 2050.

November – Amogy's founders officially launched the company with the goal of converting ammonia into a sustainable power source to decarbonize transportation.

2020

March – Closed a $3M Seed funding round led by AP Ventures.

July – Successfully engineered the first-ever ammonia-powered emission-free drone flight at a 5kW scale.

November – Closed a $20M Series A funding round led by AP Ventures and Amazon's Climate Pledge Fund and Saudi Aramco Energy Ventures.

2021

May – Successfully demonstrated a 100kW powerpack in a tractor, scaling 20x in less than a year.

June – Closed a $46M Bridge funding round led by SK, AP Ventures, Amazon's Climate Pledge Fund and Saudi Aramco Energy Ventures.

2022

2023 Q1 – Presented the world's first ammonia-powered semi-truck by scaling the powerpack to 300kW.

2023 – Planning to scale to 1MW in a boat demonstration, beginning the commercialization of Amogy technology.

2024-25 – Planning to scale to 10+MW, powering container ships on transoceanic voyages.

2023-25

What We Do

The Coalition acts to accelerate the U.S. and Canada maritime value chain's pathway to net zero greenhouse gas (GHG) emissions by jointly developing and executing a roadmap to a commercially viable net-zero emission logistics value chain. Cross-functional collaboration will be utilized to enable swift mobilization and tangible, sustainable results.

MEASUREMENT & OPERATIONAL EFFICIENCIES

Learn More >

FINANCE, COMMERCIAL & CHARTERING

Learn More >

POLICY, REGULATORY & INCENTIVES

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TECHNOLOGY, INFRASTRUCTURE & FUELS

Learn More >

Through focused Workstreams, the Coalition:

- Facilitates collaboration among industry stakeholders regionally and globally
- Identifies, evaluates, encourages, and engages in commercial and technical pathways and projects that deliver significant near-term reductions in GHG emissions and lead to commercially viable net-zero emissions

Technology works a lot like History…

“History Doesn't Repeat Itself, but It Often Rhymes”

- Mark Twain

LNG Progress

- Transporting Liquid Methane
  - 1915 – Godfrey Cabot receives a patent for transporting LNG by river barge
  - 1951 – William Wood Prince (Chairman, Union Stock Yards, Chicago) begins to put the concept into use:
    - Load LNG in Louisiana & Barge LNG up the Mississippi
    - Unload, re-gasify and use at Union Stock Yards
    - Fails to yield a successful design
  - 1950's – US and European interests combine to develop a safe concept to economically transport gas over long distances
    - French and British interest originated from a need to convert customers from 'town gas' to natural gas

LNG Progress

- Transporting Liquid Methane (1958-1959)
  - Conversion of *Normati* (built in 1945)
  - Renamed *Methane Pioneer*
  - Owners were Conch International Methane Limited:
    - Conoco, Union Stock Yards, Shell
  - 5,000 m^3 LNG tanker
  - 5 Aluminum self-supporting prismatic cargo tanks
    - Balsa insulation
  - 27 day trip – Lake Charles, LA to Canvey Island, UK

Source: LNG: A Nontechnical Guide (Tusiani & Shearr)

LNG Progress

- 1965 – Purpose Built Ships
  - *Methane Princess* and *Methane Progress*
    - Conch International
    - 9 prismatic cargo tanks
    - 27,400 m^3 capacity per tanker

LNG Progress

- 1965 – *Jules Verne*
  - Société Gaz-Marine
  - Cylindrical cargo containment
  - 25,840 m^3 tanker

- Late 70s – *Moss Tanks*
  - ETC/General Dynamics
  - 125,000 m^3

- 1971 – *Descartes*
  - Gazocean
  - Membrane tank concept
  - 50,000 m^3 tanker

- 2007 – Q Series (165 to 266,000 m3 tankers)

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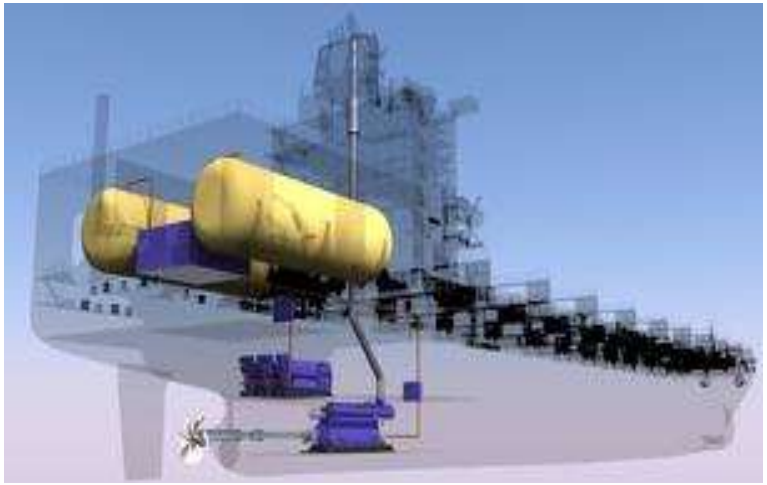
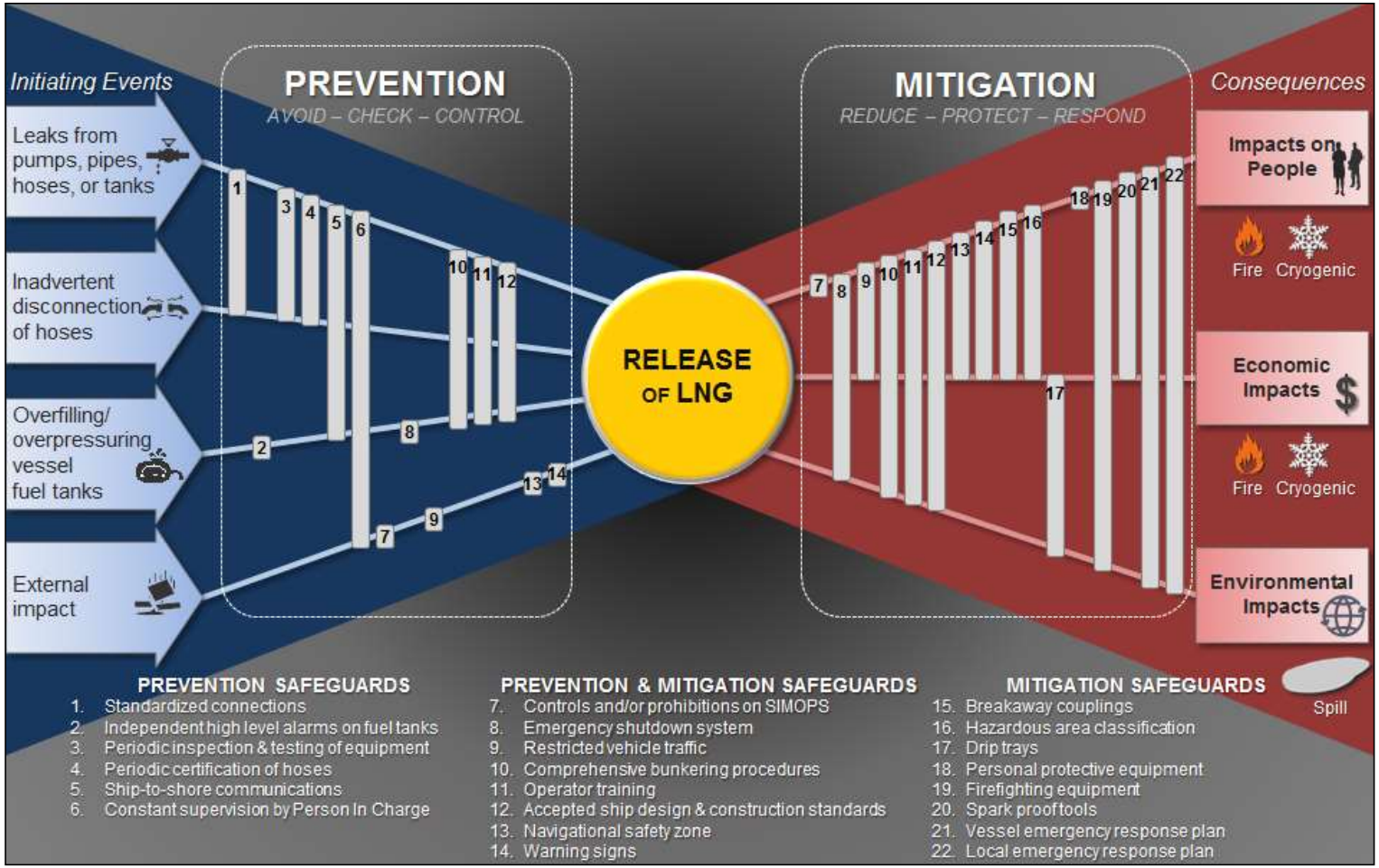
LNG as Fuel

- Harvey Energy

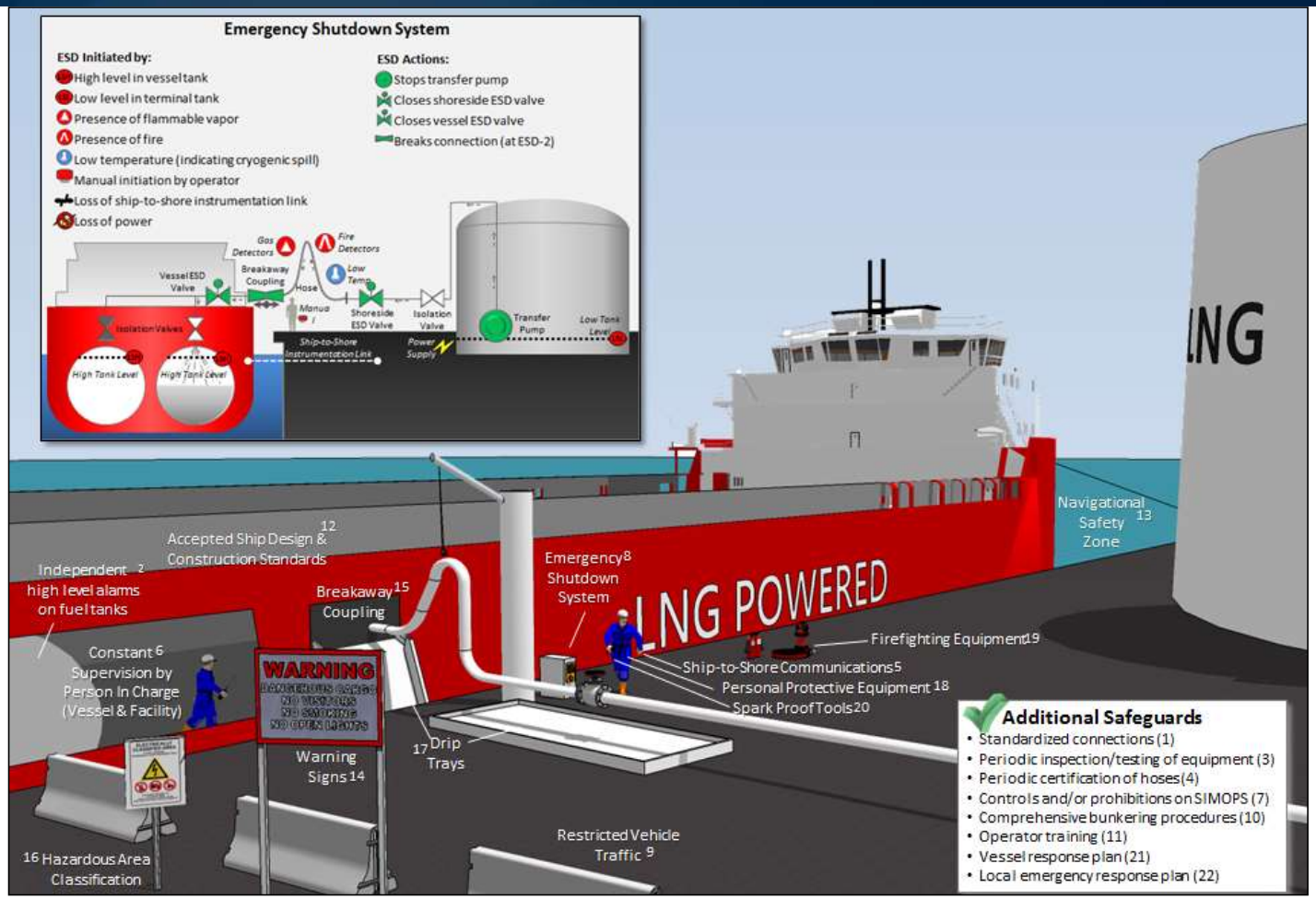
- TOTE Marlin Class



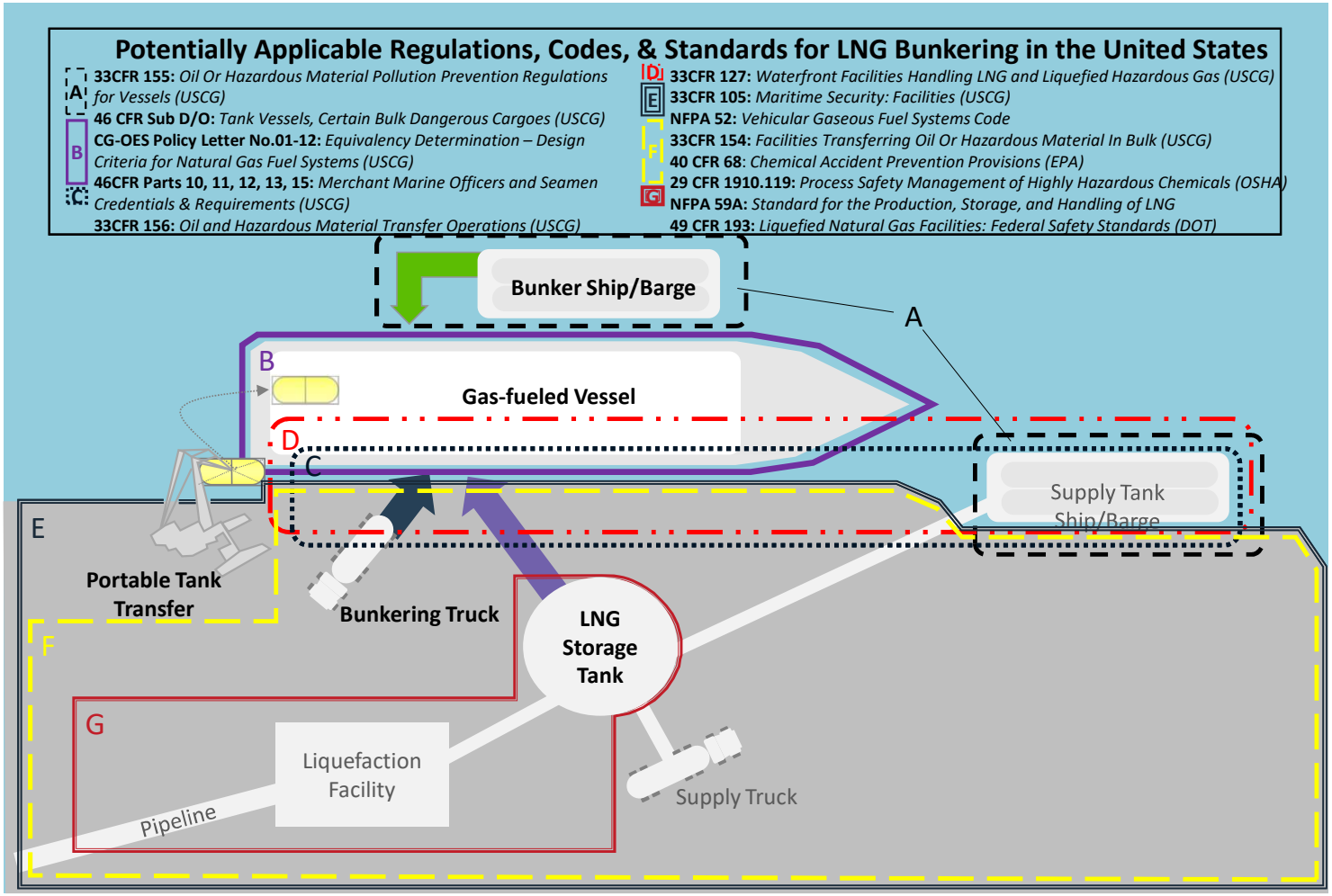
Bow Tie Diagram – LNG Bunkering



Safeguarding LNG Bunkering



Bunkering Regulatory Framework

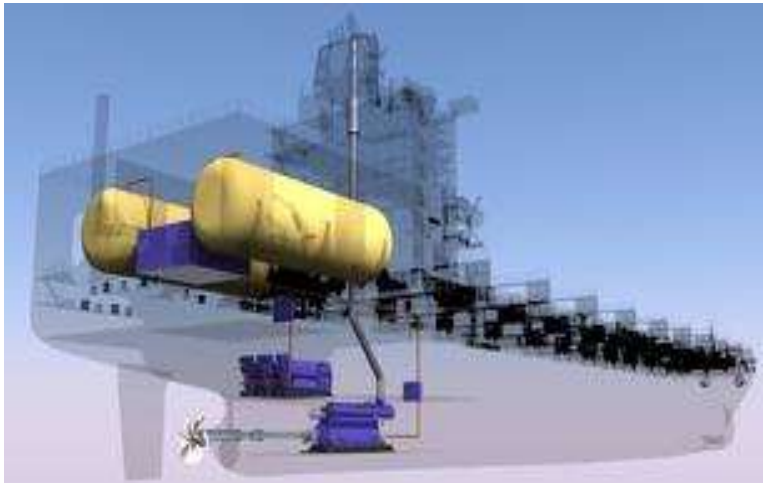


LNG as Fuel

- Harvey Energy

Today, over 80% of alternative fuel ships on order use LNG

- TOTE Marlin Class



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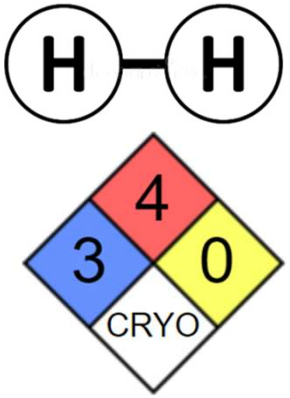
Hydrogen

Hydrogen

- Properties:
  - Most common element in the universe
  - Colorless, odorless, tasteless, non-toxic gas
  - Low-density gas
  - Highly flammable
  - Liquefies at -253°C (-423.4°F)
  - High heating value, low volumetric energy density

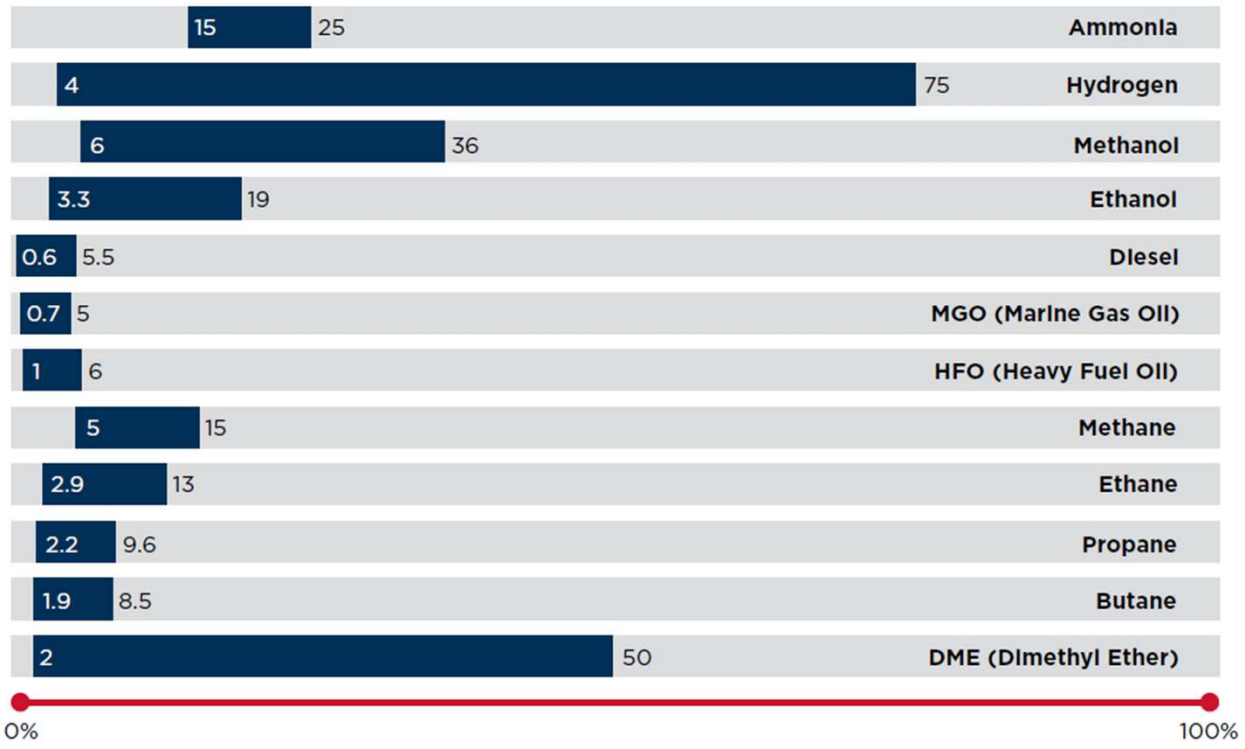


	Hydrogen	Ammonia	Methane (LNG)	MGO
Boiling Point (°C)	**-253**	-33	-161	180 – 360
Density (kg/m^3)	**70.8 (LH_2)**	696	430	900
Lower Heating Value (MJ/kg)	**120.2**	22.5	48	42.7
Auto Ignition Temp. (°C)	**585**	630	537	250
Flashpoint (°C)	-	132	-188	> 60
Liquid Energy Density (MJ/L)	**8.51**	15.7	20.6	38.4
Lower Flammability Limit (% v/v)	**4**	15	5.3	0.7
Upper Flammability Limit (% v/v)	**75**	25	17	5

Hazards

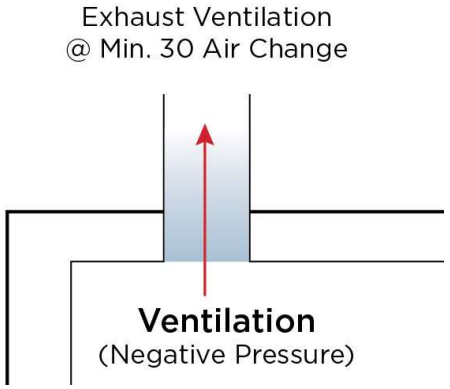
1. Cryogenic Hazard
2. Molecular Behavior
3. Flammable Concentrations

Risk Mitigation - Flammability

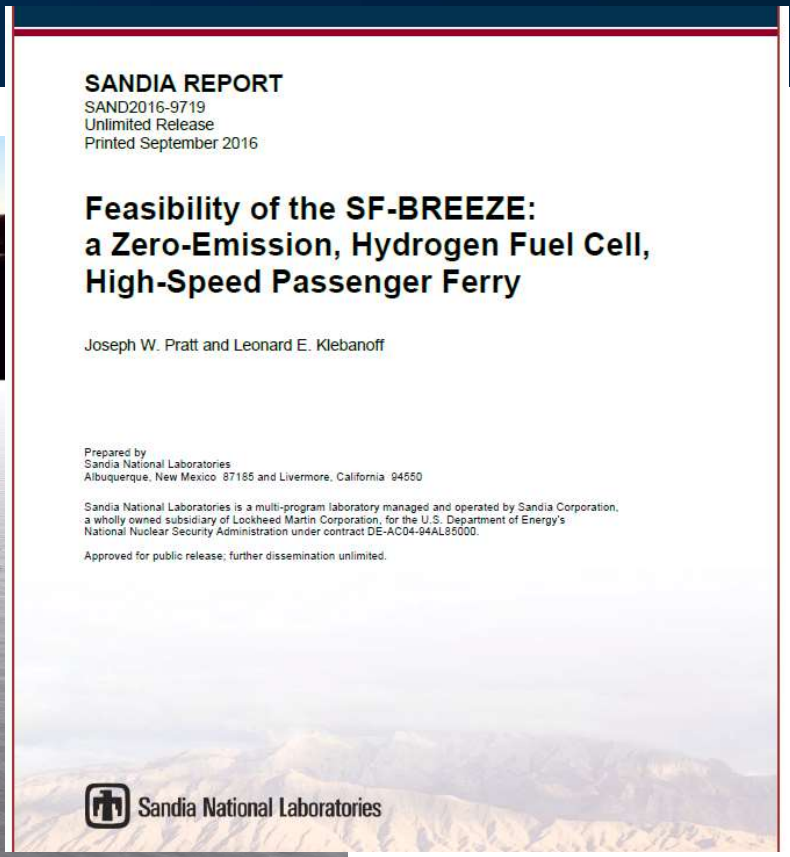


Hazard Mitigation

- Ventilation
- Leak Detection
- Zone & Area Classification



Feasibility Studies



SANDIA REPORT
SAND2016-9719
Unlimited Release
Printed September 2016

Feasibility of the SF-BREEZE: a Zero-Emission, Hydrogen Fuel Cell, High-Speed Passenger Ferry

Joseph W. Pratt and Leonard E. Klebanoff

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Sandia National Laboratories

San Francisco Bay Renewable Energy Electric Vessel with Zero Emissions (SF-BREEZE)

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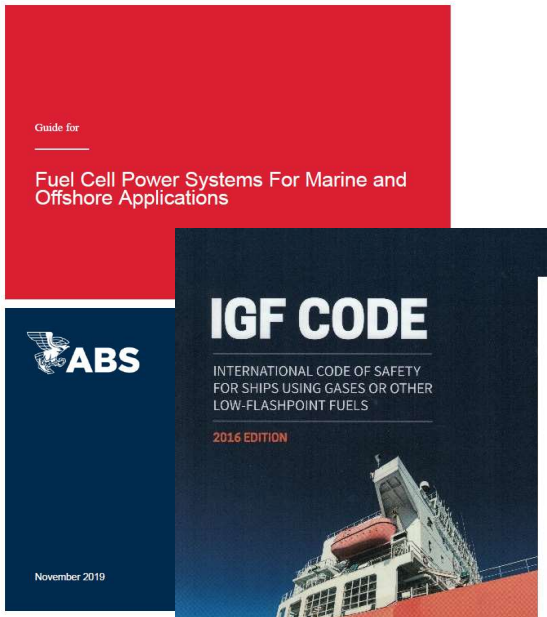
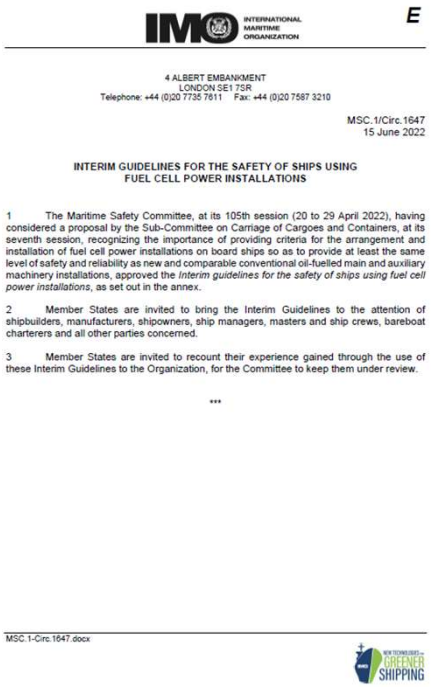
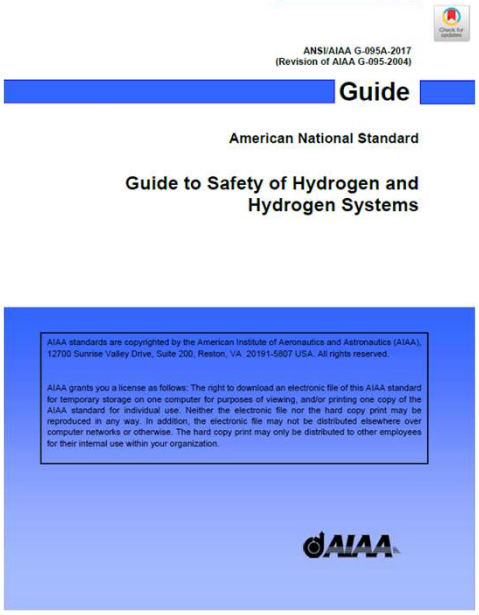
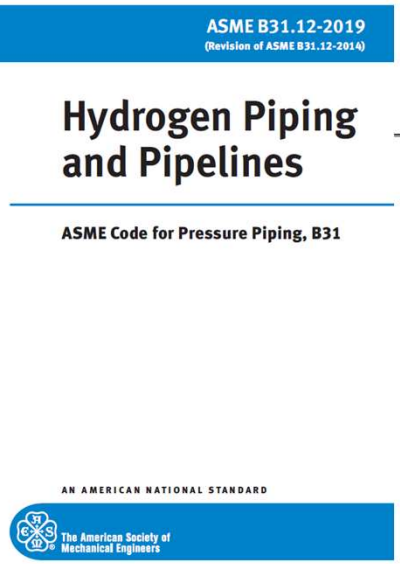
Existing Guidance for Hydrogen

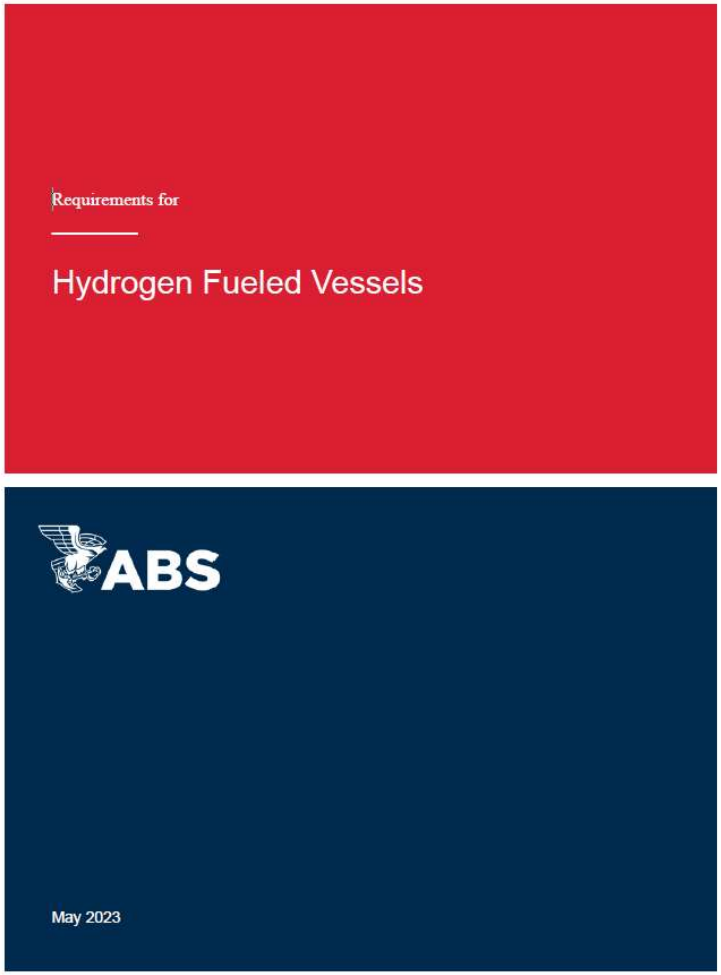








Existing Guidance for Hydrogen



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Scripps Institution - Hydrogen Fuel Cell Vessel

Hydrogen-Fueled Research Vessel to be Built to ABS Class

TUE, FEB 14, 2023 21:00 CET

Image courtesy of Glosten

University of California San Diego Scripps Institution of Oceanography

- Designed by Glosten
- Hydrogen-hybrid propulsion system
  - H2 fuel cells
  - Conventional diesel-electric plant
- Operating profile includes day-trips and longer coastal research voyages
- To replace existing RV *Robert Gordon Sproul*

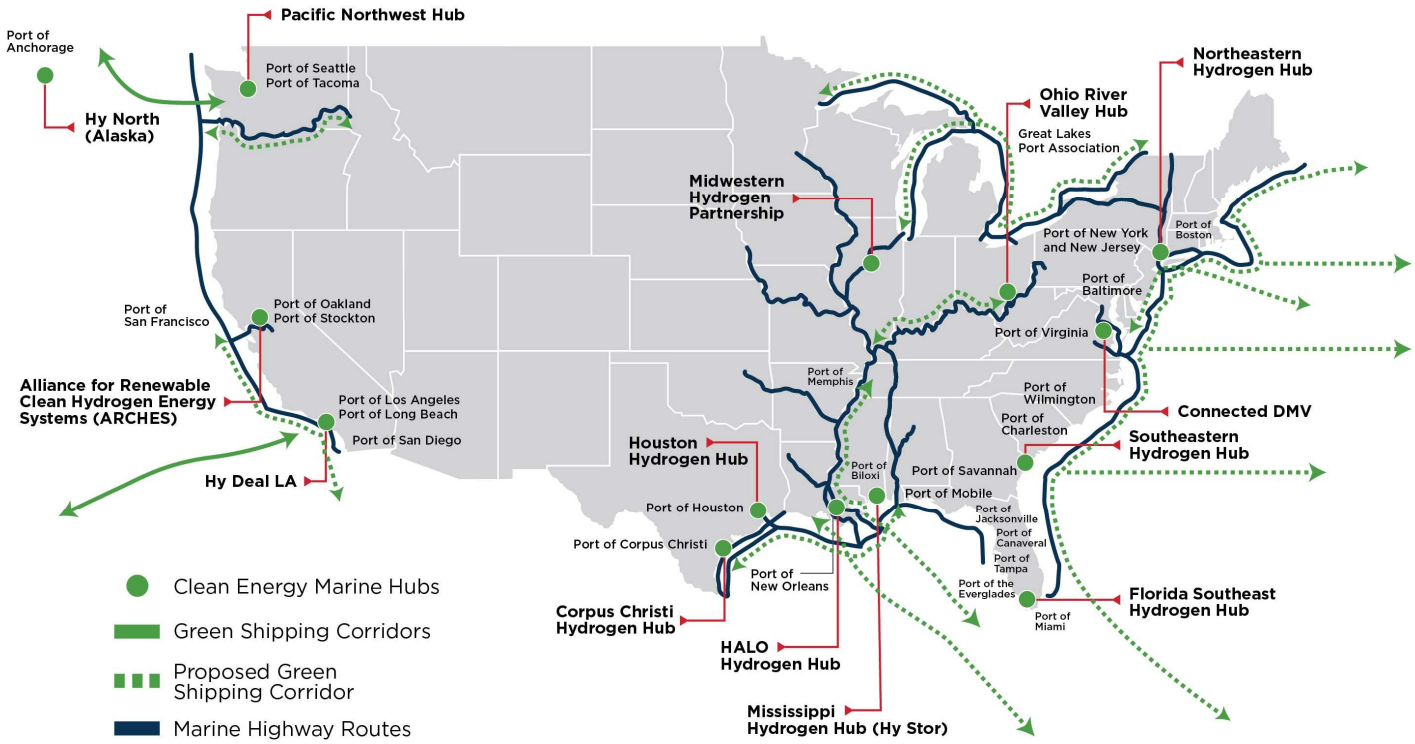
Regulatory Framework

USCG Design Basis Agreement / ABS Classification / Engineering Rigor:

- Approval in Principle (AIP)
- Vessel Design Philosophy
- Gas Related Systems Design Philosophy
  - Bunkering. Storage
- Lithium-Ion Batteries Design Philosophy
- Hydrogen Dispersion & Explosion Analyses
- Fire Risk Assessment
- HAZID Studies (Transiting/Bunkering)
- Gas System Risk & Probabilistic Damage Assessment
- Failure Modes and Effects Analysis
- Etc.

Major Initiatives and Opportunities

- **Agency/Office Grant Programs and Support Roles:**
  - DOE
  - MARAD
  - EPA
  - USCG
  - DOC/DOS
  - Transport Canada
  - State/Province/Local
- **Regional Initiatives:**
  - H_2 Hubs
  - Green Shipping Corridors
  - NSF Innovation Engines
- **National Maritime Innovation Center**



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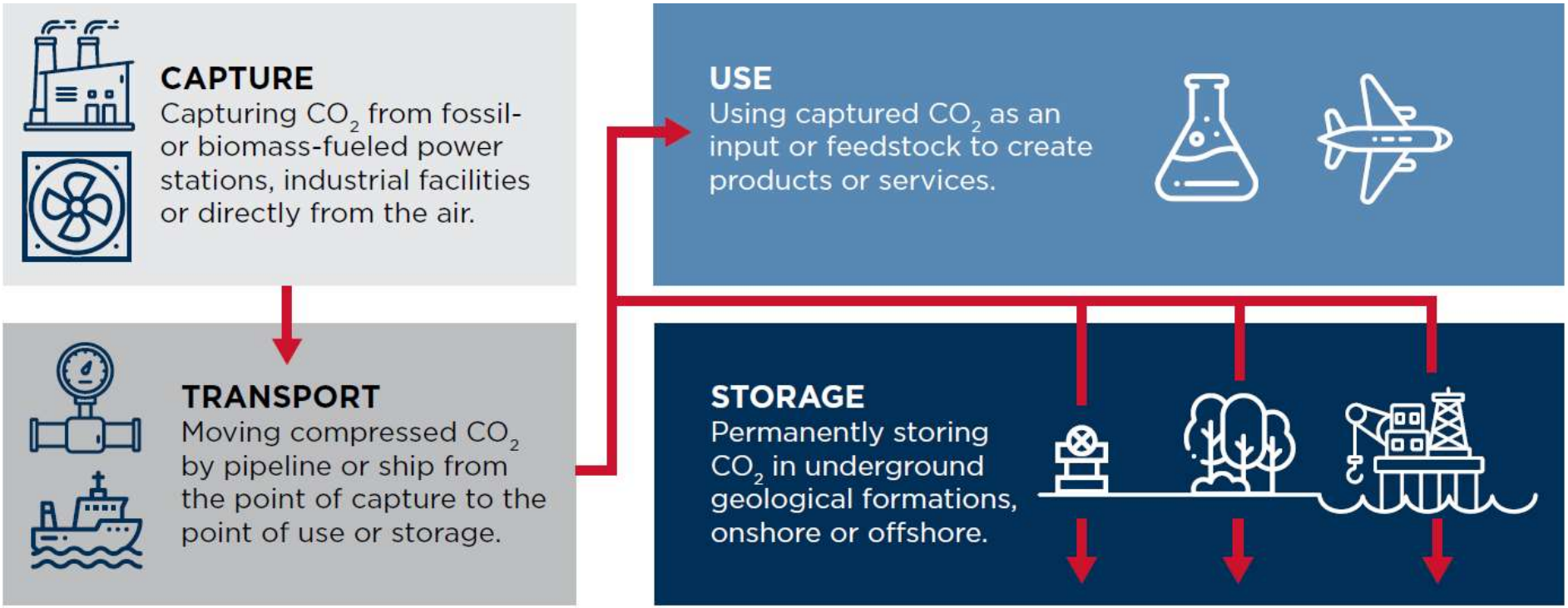
Carbon Capture

Carbon Capture, Utilization and Storage Value Chain



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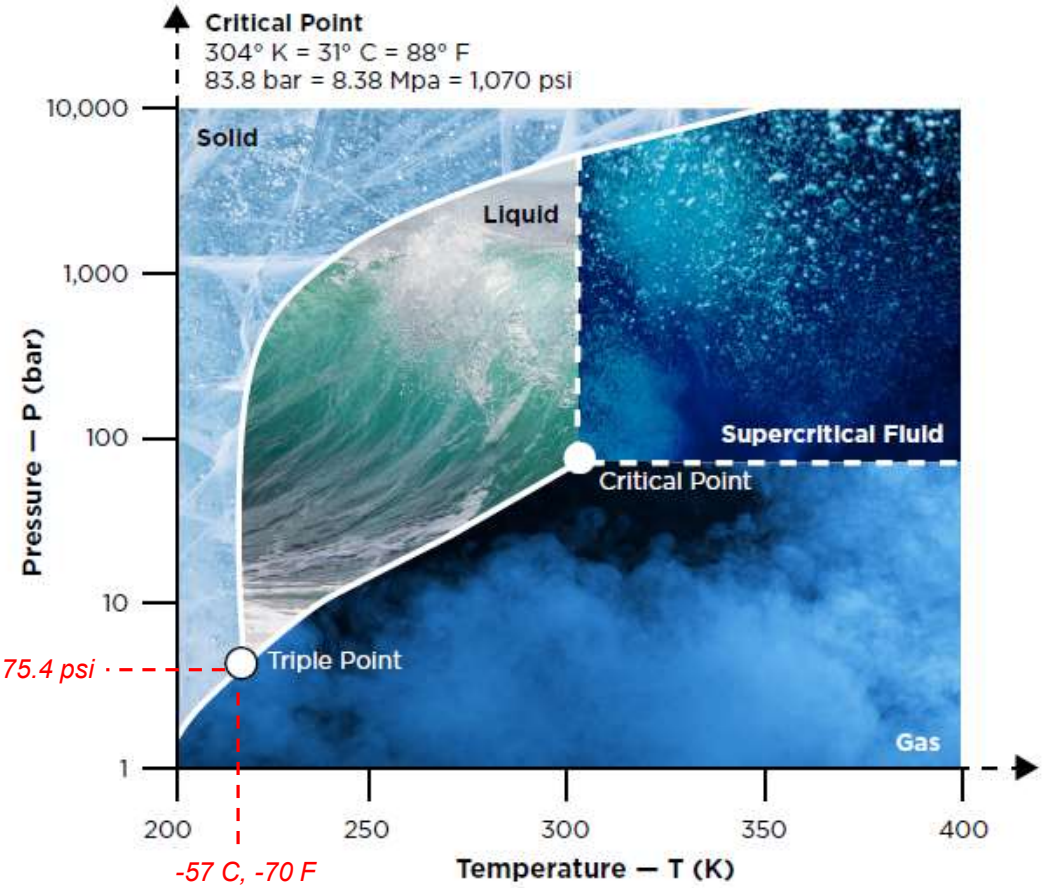
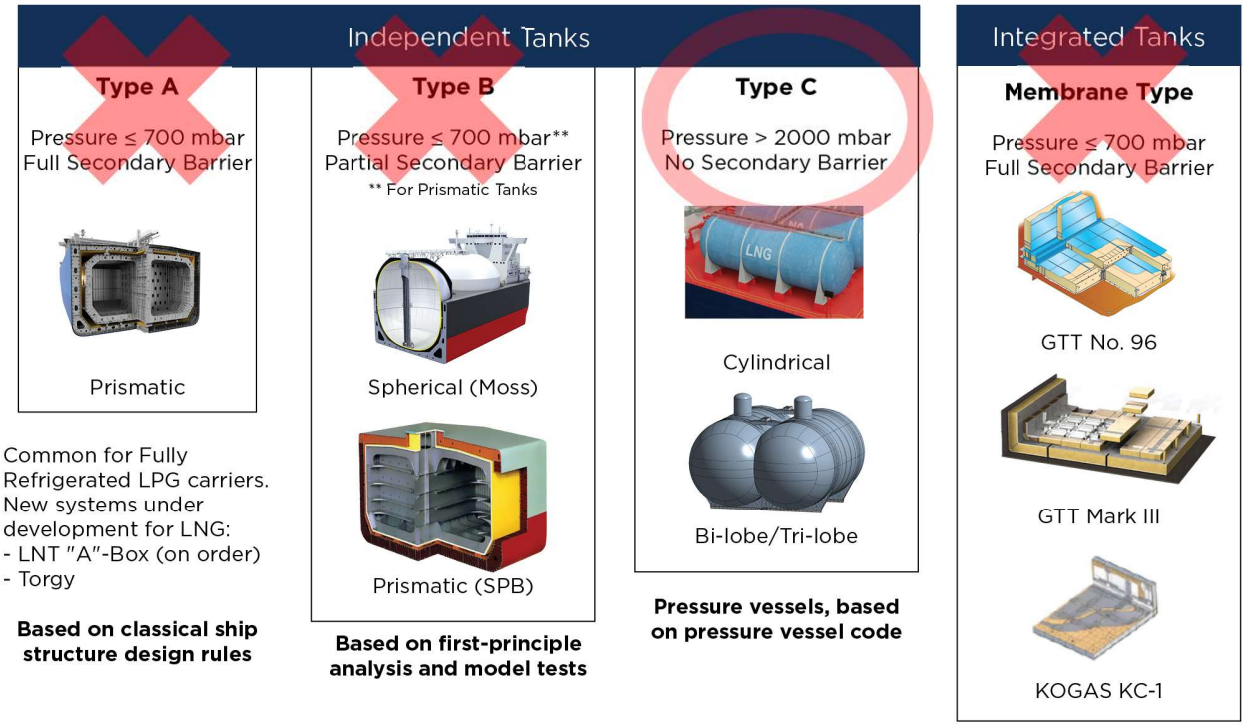
CO2 Characteristics and Phase Diagram

- CO2:
  - Cryogenic Hazard
    - Need proper PPE
  - Not flammable
  - Asphyxiant
  - Heavier than air
    - Adequate ventilation
    - Similar safeguards to CO2 fire suppression systems
- Liquid CO2 cannot exist at pressures below triple point
- Triple Point Depends on CO2 purity (-57°C, 5.2 bar for pure CO2)



IMO Classification of Gas Carriers



Cargo to be maintained above triple point => Pressure Vessel

Example of Low-Pressure Storage

Conceptual image of Mitsubishi Shipbuilding Co.'s liquefied CO2 demonstration test ship
Source: Mitsubishi Shipbuilding Co.

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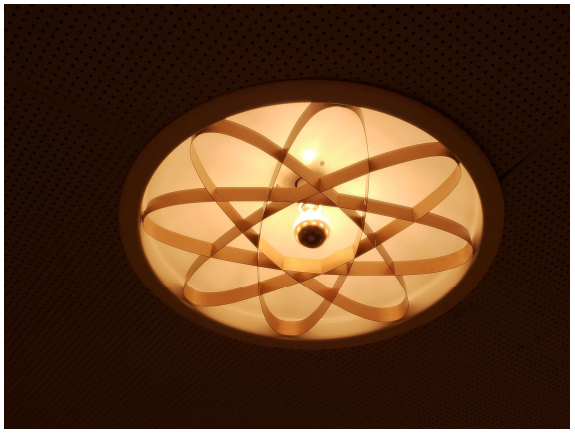
Nuclear

Been there, Done that…

- NSS Savannah



Source: Me

Commercial Nuclear Challenges

Safety

- Risk Management
- Safety Considerations

Regulatory

- International (IAEA, IMO)
- Flag State
- Coastal State

Operational

- Nuclear Maintenance at Shipyards
- Terminal Considerations
- Crew Training Requirements
- End of Life Considerations

Commercial / Social

- CAPEX requirements for construction
- Trade location limitations
- Public perception and acceptance

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Alternative Energy: Nuclear


© Seaborg

TECHNOLOGY

Industry Guidance for Novel Concepts

- NTQs for Marine Modular Reactors
- Intro to Advanced Commercial Nuclear for Maritime

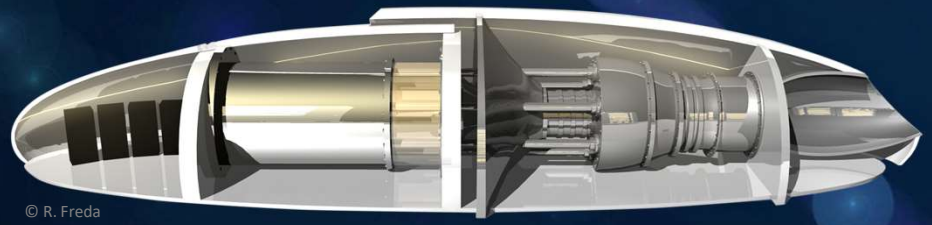

© Core Power

RESEARCH

THE UNIVERSITY OF TEXAS AT DALLAS

Industry Research Engagements

- ABS-Herbert Concept Design Study
- US DOE Nuclear Energy University Program
- Advanced Nuclear Maritime Demonstration Project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SNAME Nuclear Initiatives

- SNAME AHP 10
  - International Reactor Innovative and Secure (IRIS)
    - Westinghouse
  - High Temp Reactor-Gas Turbine (HTR-GT)
    - General Atomics
- SNAME Panel M-48
  - Atomic Batteries

MIT News
ON CAMPUS AND AROUND THE WORLD
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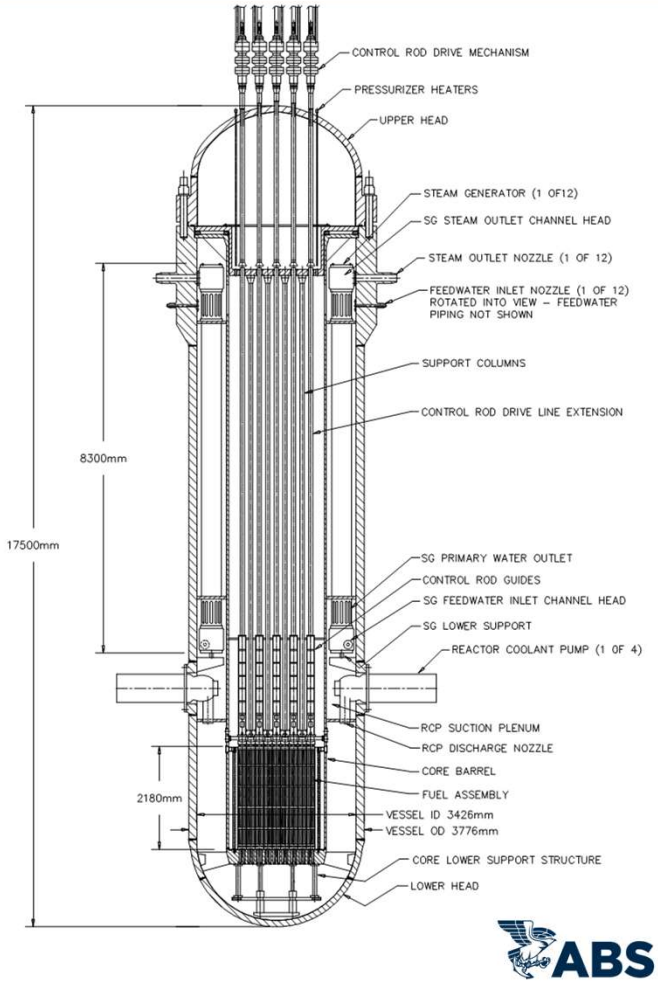
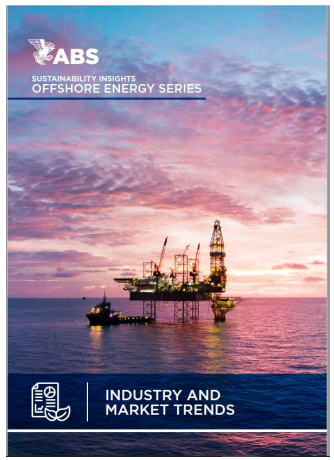
3Q: Why "nuclear batteries" offer a new approach to carbon-free energy

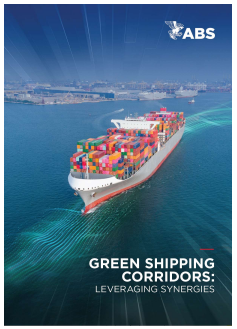
Jacopo Buongiorno and others say factory-built microreactors trucked to usage sites could be a safe, efficient option for decarbonizing electricity systems.

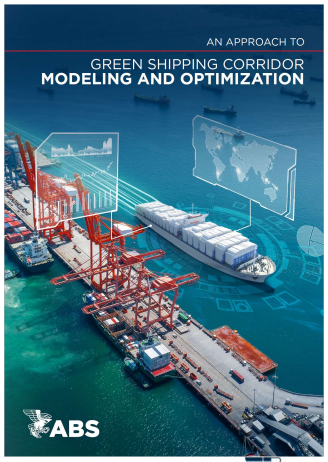
David L. Chandler | MIT News Office
June 25, 2021



ABS Sustainability Related Publications







Please visit: www.eagle.org/sustainability

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In Summary…

“Those who say it can't be done are usually interrupted by others doing it.”

- James Baldwin
(Writer, Playwright, Poet, Activist)

Thank You

www.eagle.org