Current Status of the San Francisco Bay Renewable Energy Electric Vessel with Zero Emissions (SF-BREEZE) Feasibility Study

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Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2016-XXXX.

Project Concept

High-speed H_2 Ferry

- Zero-emission Hydrogen Fuel Cell Power
- 150 passenger, 35 kts

SF-Breeze Technical Design

Dockside H_2 Station

- Serving vessels, cars, buses and trucks
- 2,500 kg/day capacity & 80% base utilization

Example existing dockside hydrogen station in Hamburg, Germany

Goal of the Feasibility Study

Primary question:

Is it technically possible and commercially viable to build a high-speed, zero-emission passenger ferry and associated fueling facility, both of which satisfy all applicable codes and regulations?

Project Funding from the US DOT / Maritime Administration (MARAD)

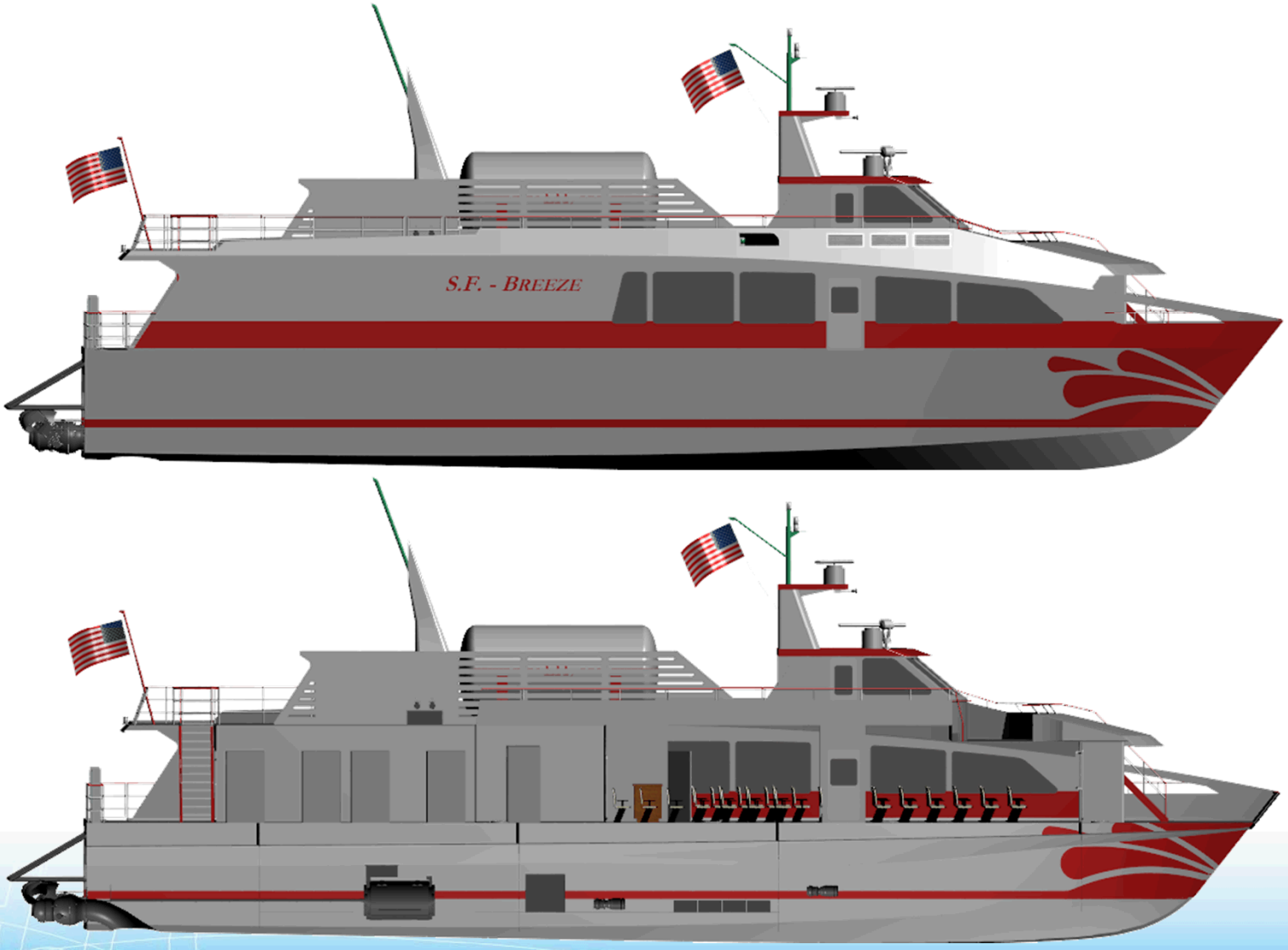
Near Term and Long Term Benefits of the SF-BREEZE

- Eliminates diesel emissions and fuel spills.
- Dramatically decreases noise from the vessel, providing health benefits for operators, a better experience for the public and protects marine life from noise injury.
- Extends U.S., California, and San Francisco leadership in hydrogen fuel-cell technology into the maritime application.
- Enables low-cost, multi-use hydrogen infrastructure for fuel-cell vehicles and vessels.
- Potential to grow U.S. shipbuilding capability through clean tech
- Reduced vessel emissions may help ports meet expansion needs

Ferry Operating Logistics

- 23 nm one-way, 35 kts top speed
- Each round trip uses about 500 kg LH_2
- Daily logistics:
  - Two morning round trips
  - Refuel in less than 1 hr.
  - Two afternoon round trips
- Designing the ferry to meet the long distance of the Vallejo-SF route gives it maximum flexibility in eventual route choice, including a SF-South Bay route.

SF-BREEZE Current Design

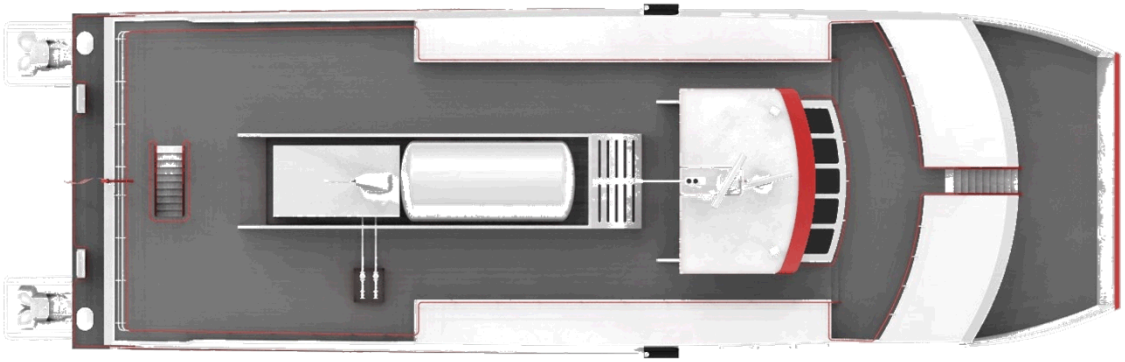


Elliott Bay Design Group

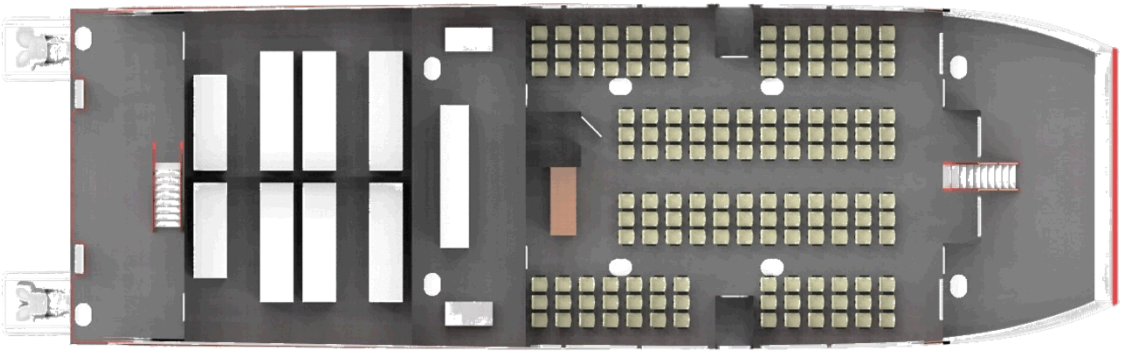
Design generated by Elliott Bay Design Group

Current Design

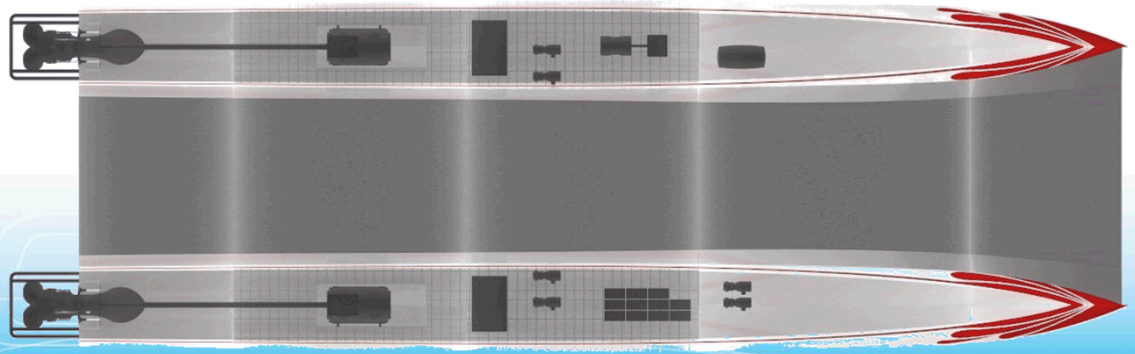
Upper Deck



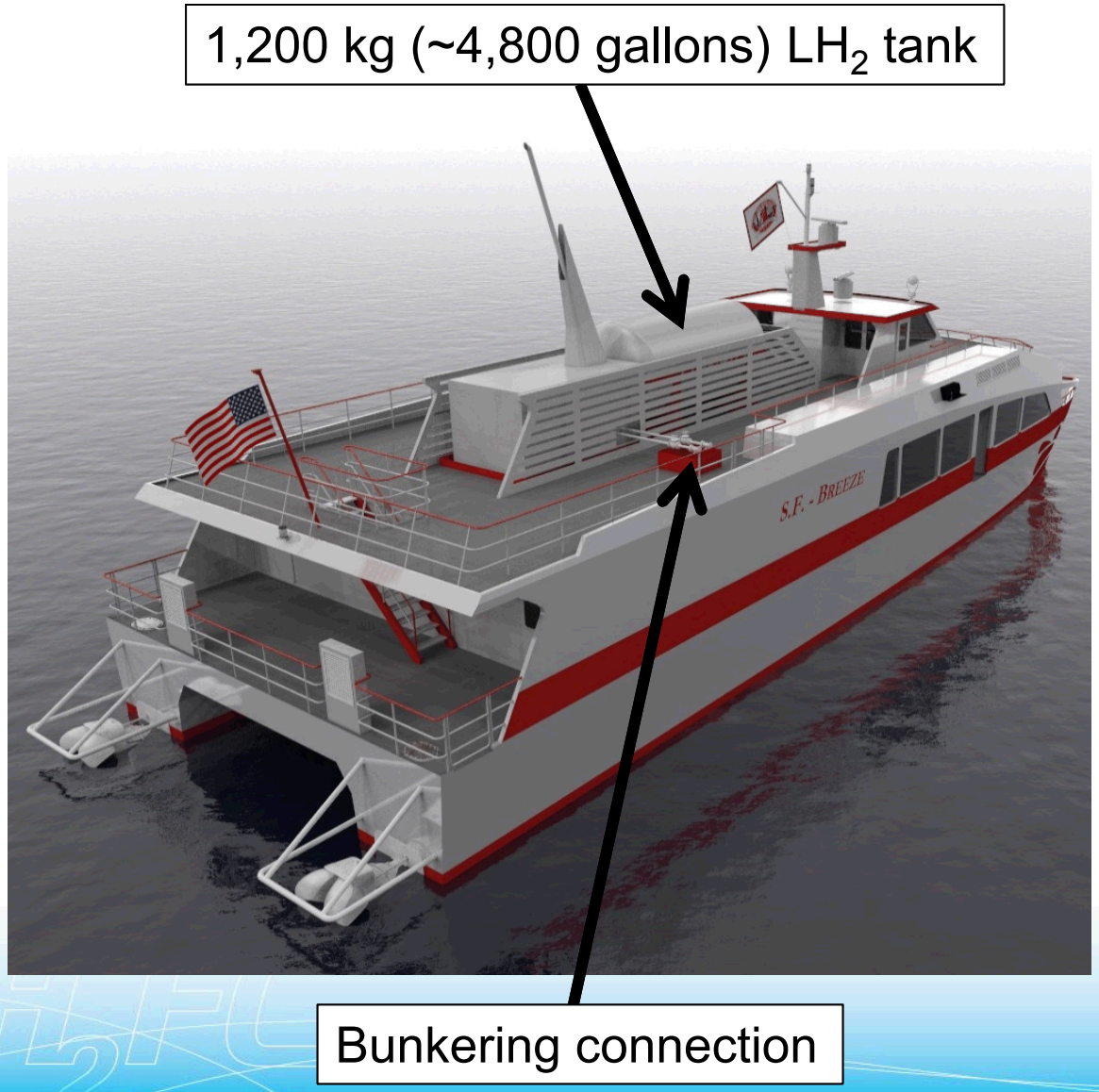
Main Deck



Hulls



Ferry Fueling Characteristics



*The ferry uses **liquid** hydrogen (LH_2) because it is currently the lightest and most compact method to store hydrogen, and operates at low pressure*

LH_2 is a cryogenic fuel similar to LNG

LH_2 refueling at A.C. Transit Emeryville CA hydrogen station

LH_2 has been handled routinely for decades

Process will be similar to LNG bunkering

(1) Shoreside storage tank (or refuel directly from truck).

(3) Transferring the fuel

(4) Underway

(2) Piping and connecting the fueling arm

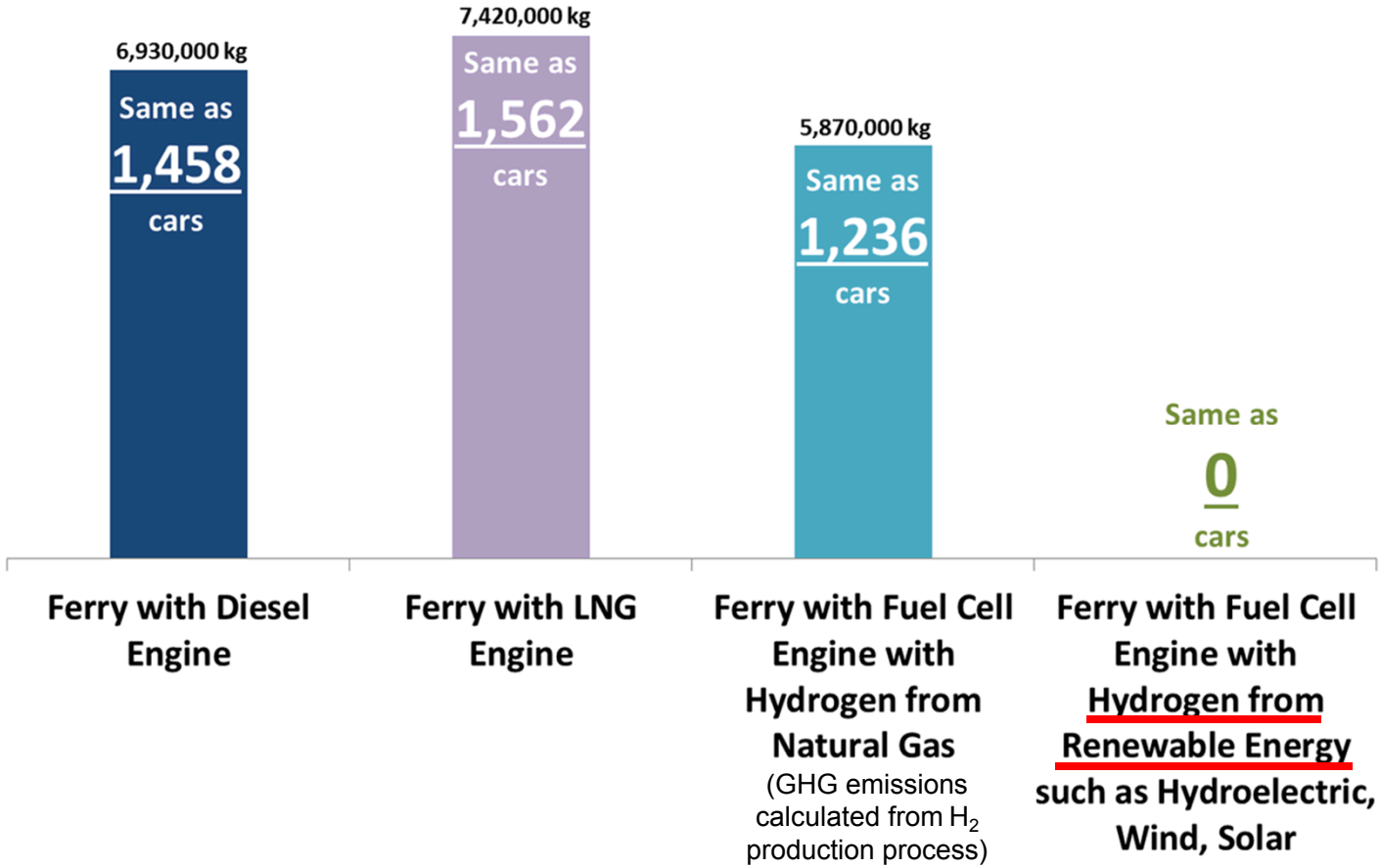
Images from "*Step by step LNG Bunkering by DNV*" by Lars Petter Blikom (available at: youtu.be/oZWuTWtp5Rs)

Important difference between LH_2 and LNG:

Hydrogen is non-toxic and is not a greenhouse gas. If vented or spilled it quickly and completely evaporates with no harm to personnel or the environment.

Use of *renewable* hydrogen can completely eliminate the greenhouse gas emissions from vessels

Yearly Stack Greenhouse Gas Emissions from one ferry with the same power and energy use as the SF-BREEZE, operating 300 days/year



A ferry with a Fuel Cell Engine also has zero pollutant emissions
(NOx (smog), SOx (sulfur/acid rain), particulate matter (soot), carbon monoxide)

Renewable liquid hydrogen is available. The cost is higher than non-renewable hydrogen.

Renewable methane

→ Reformation

H_2 ↓

Liquefaction → Renewable liquid hydrogen

↑ H_2

Renewable electricity

→ Electrolysis

Recent developments in LNG shipping are helping – In general, LNG and liquid hydrogen (LH_2) are similar

IMO INTERNATIONAL MARITIME ORGANIZATION

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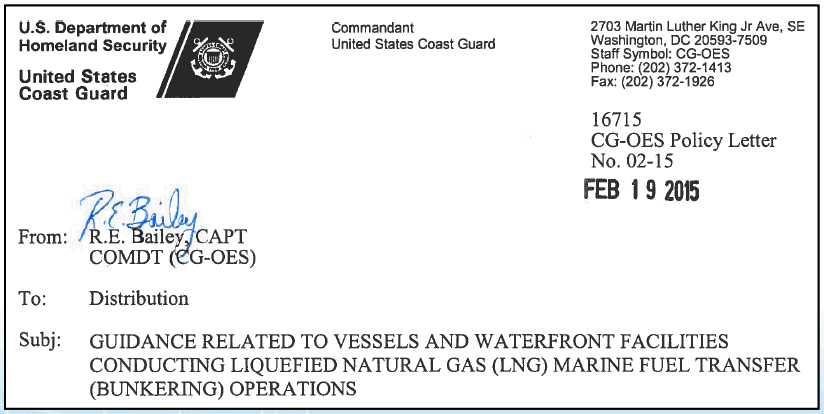
MARITIME SAFETY COMMITTEE
95th session
Agenda item 22

MSC 95/22/Add.1
19 June 2015
Original: ENGLISH

REPORT OF THE MARITIME SAFETY COMMITTEE ON ITS NINETY-FIFTH SESSION

Attached is annex 1 (Resolution MSC.391(95) – Adoption of the International Code of Safety for Ships Using Gases or other Low-Flashpoint Fuels (IGF Code)) to the report of the Maritime Safety Committee on its ninety-fifth session (MSC 95/22).

IMO IGF Code



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

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United States Coast Guard

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Washington, DC 20593-7509
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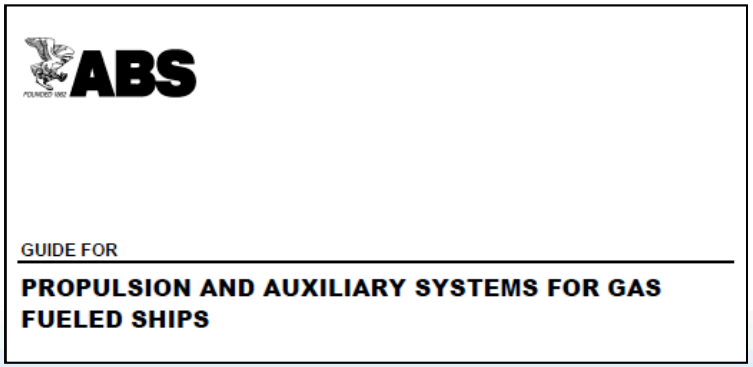
16715
CG-OES Policy Letter
No. 02-15
FEB 19 2015

From: R.E. Bailey, CAPT
COMDT (CG-OES)

To: Distribution

Subj: GUIDANCE RELATED TO VESSELS AND WATERFRONT FACILITIES CONDUCTING LIQUEFIED NATURAL GAS (LNG) MARINE FUEL TRANSFER (BUNKERING) OPERATIONS

USCG Policy Letters



ABS

GUIDE FOR

PROPULSION AND AUXILIARY SYSTEMS FOR GAS FUELED SHIPS

ABS Guidance

… and many others!

The project team includes designers, regulators, national experts, and class society working together.

USCG MSC and Design and Eng. Stds.

USCG Sector San Francisco

USCG Liquid Gas Carrier NCOE

American Bureau of Shipping

The goal of everyone involved is *to establish what makes sense* for this and future LH_2 vessels

Conclusions (as of January, 2016)

- Both the SF-BREEZE and fueling facility are technically feasible.
- There have been no identified regulatory roadblocks to implementation to-date. Final review by USCG and ABS is pending.
- Cost and economic assessment is in-progress and will include a description of the various grant and financing opportunities available.

Next Step:

- The completed feasibility study can be used by a potential owner to make an informed decision on proceeding with build and operation.

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