

CHBC BRIEFING: MARITIME

APRIL 27, 2021

HOUSEKEEPING

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 - Streaming Audio/Computer Speakers (Default)
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- Question & Answers
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- Recording & Slides
 - The recording of the webinar and the slides will be available after the event. Registrants will be notified by email.
- Troubleshooting
 - Contact Peter Thompson | <u>pthompson@californiahydrogen.org</u>



BRIEFING SERIES SPONSORS





WEBINAR SPEAKERS













Emanuel Wagner
Deputy Director
California Hydrogen
Business Council

Cory Shumaker
Development Specialist
California Hydrogen
Business Council

Tim Sasseen

Market Development

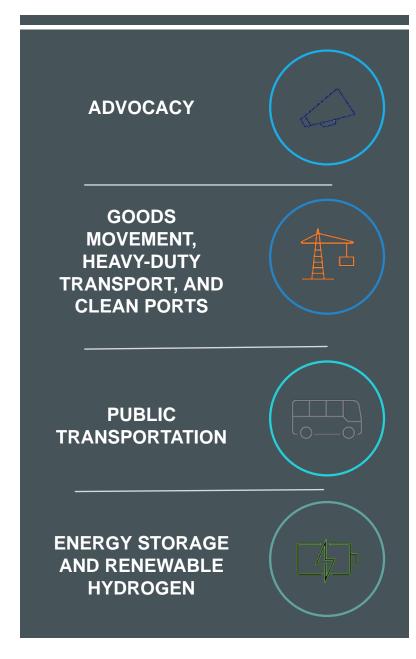
Manager, US

Ballard Power Systems

Joe Pratt
CEO & CTO
Golden Gate Zero
Emission Marine

Kristian Jokinen
Program Manager
CALSTART

Narendra Pal
Director of Hydrogen
Technology
Hornblower Yachts





Our Vision:

 CHBC is committed to advancing the commercialization of hydrogen in the energy and transportation sectors to achieve California's climate, air quality, and decarbonization goals.

Our Mission:

 Provide clear value to our members and serve as an indispensable and leading voice in promoting the use of hydrogen in the utility and transportation sectors in California and beyond.

Our Principals:

Leadership, Integrity, Teamwork and Inclusion.

Our Objectives:

- Enhance market commercialization through effective advocacy and education of policymakers and policy influencers
- Be "the" trusted "go to" resource on Hydrogen and Fuel Cell technology for policymakers and policy influencers
- Accelerate market growth via networking opportunities and information exchange for the industry and its customers

OUR MEMBERS

Platinum





















Gold





































Silver





















energy independence now











































































Innovator



































































MRS **Enterprises**

Planet Hydrogen Sheldon Research and Consulting

Starworks

Terrella Energy Systems Ltd.

Versallis Tech Services LLC

Zero Carbon Energy Solutions

VALUE IN MEMBERSHIP

- Active representation in all relevant California policy making venues
- A trusted and knowledgeable industry resource
- Access to policymakers, policy influencers and industry
- Track record of success
- Platform for industry collaboration
- Learn more: www.californiahydrogen.org



BECOME A MEMBER AND MAKE A DIFFERENCE
TOGETHER WE CAN INFLUENCE PUBLIC POLICY AND GROW YOUR BOTTOM LINE

NEXT UP:



Cory Shumaker

Development Specialist

California Hydrogen

Business Council

Zero Emissions Ship Technology Association

THE ROAR OF THE TIDE OF CHANGE ZESTAS.org

ZESTAs.

H2 vessels under construction









H2 EXAMPLES OF VESSEL PROJECTS 2020 2023





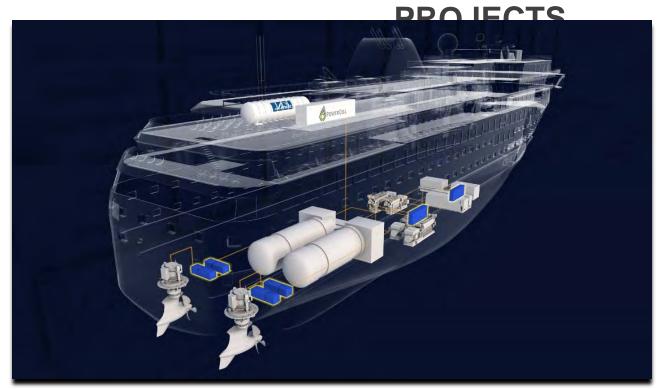








SOME OF THE ONGOING MARITIME HYDROGEN





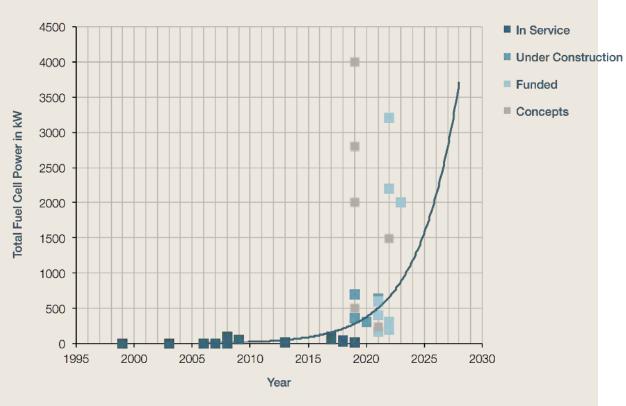






HYDROGEN VESSELS EXPONENTIAL TREND CURVE

Hydrogen Powered Vessels





Industry Partners



ZESTAs.





NEXT UP:



Tim Sasseen

Market Development

Manager, US

Ballard Power Systems

Introducing



The future of zero-emission marine propulsion



On a global scale, the shipping industry contributes a significant share of GHG emissions



2.2%

CO₂ per year

15%

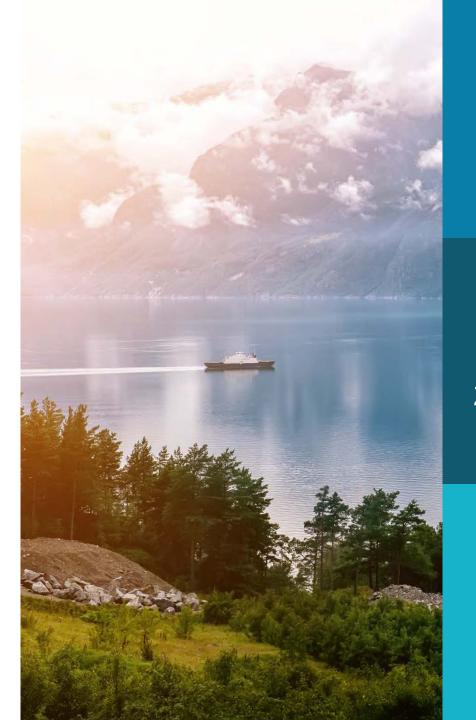
NO_x per year

13%

SO_x per year



Zero-emission requirements are coming to the marine industry



IMO phasing-out GHG:

↓ 50% by 2050

Norway protecting fjords:

100% zero-emission by 2026

Europe EMSA to cut CO₂

50% by 2050



Hydrogen fuel cells for zero-emission vessels

Fuel cells will play a key role in helping the marine industry address GHG emissions on the water, and in ports.



Longer Range

Fuel cell powered vessels can run longer, and travel farther, before refueling.



Fast, Flexible Refueling

Rapid refueling of liquid hydrogen in just minutes



Scalability & Modularity

Deployed in parallel, dispatchable configurations to meet variable power requirements. Flexible configurations adapt to vessel space constraints.

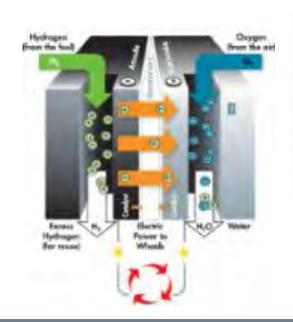


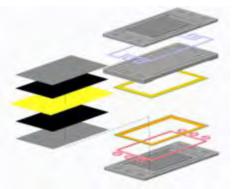
Stable, Reliable Power

Require very little maintenance, have low maintenance costs and an extremely long service life



We continuously invest in our technology and product development





Unit cell components

MEA, bipolar plates

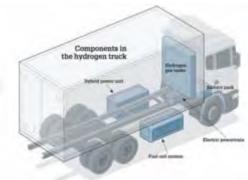


Fuel cell stacks

14th generation



Fuel cell modules
8th generation



Fuel cell vehicle integration application engineering/ after sales service



Humidified and pressurized system



Freeze-start from -30°C



IP67 protection



>30,000 hours

Ballard's current fuel cell module offering for HD mobility





Power Level

30, 85 & 100kW Legacy Mobility Platform

(7th generation)

Features

- >1,500 modules produced
- 15,000hrs
- IP 55
- Air and cooling kits









70 & 100 kW HD Mobility Engines (8th generation)

- >25,000hrs
- Freeze start (-25°C)
- Engine bay and roof top
- IP6K9K







200kW HD Power System

ID Power System Marine & Rail

- >25,000hrs
- Marine certified
- Cabinet configuration
- Stand alone or containerized
- Multiple modules to MWs





Introducing



The future of zero-emission marine vessels





Designed for Ease of Integration

- Module integrated into a clean-lined cabinet with easy access doors
- All interfaces accessible from the front for service and maintenance
- All connections are situated at the bottom of the system
- It is possible to make the module connections below floor level
- The flexible and modular design minimizes the space required in a ship



Product Features

the marine environment.

Ballard's FCwave™ was designed hand-in-

hand with industry to withstand the rigors of



Scalable from 200kW

Power from 200kW to megawatts to suit a broad range of marine vessels



Low Lifecycle Cost

Powered by Ballard's latest FCgen®-LCS fuel cell stack which offers significantly lower life cycle cost



Meets Stringent Safety Standards

Designed hand-in-hand with industry to withstand the rigors of the marine environment



Ease of Integration

Modular design minimizes the space required in a vessel



Exceptional Reliability

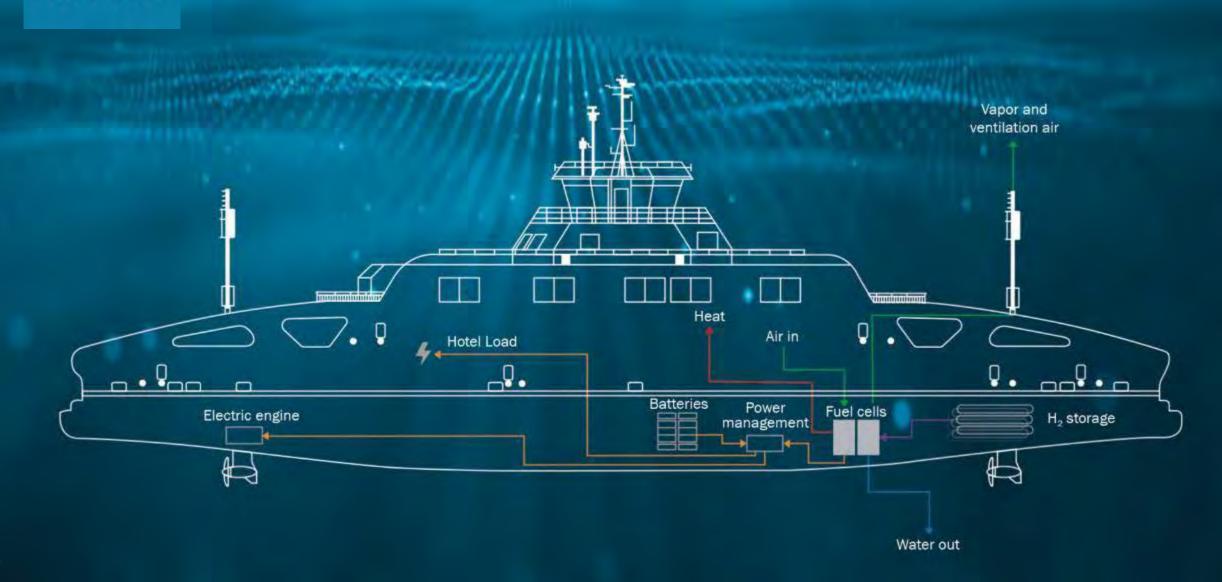
Uses proven components from Ballard's heavy duty module portfolio to deliver reliable performance



FCwave[™] Modular Installation Layout



Vessel Integration





Ballard Marine Projects in Europe

- HySeas III, the world's first sea-going renewables-powered ferry
- Hjelmeland ferry in Norway
- FLAGSHIPS project to power:
 - Norled ferry in Norway
 - River barge in France (ABB)
- ELEKTRA fuel cell river barges in Germany
- MW scale aux power for cruise ship with ABB



HyZET Tug Study - California

- CEC funded design of fuel cell powered harbor work boat
- PoLA, PoLB operation
- One week of operation between fueling
- 90' tug vessel, 6700HP electric drive
- 1.2MW fuel cell (6x FCwave) + 3.6MW ESS power
- Liquid hydrogen fuel storage and bunkering

















Leveraging Ballard's heavy-duty vehicle experience and expertise

- 8 generations of fuel cell module products
- Over 3,000 trucks and buses deployed are powered by Ballard
- Over 80 million kilometers in service
- > 30,000 hours fuel cell stack life demonstrated



Industry-leading technology



More than \$1.5B invested in our proprietary proton exchange membrane (PEM) technology

BALLARD'S TECHNICAL ACHIEVEMENTS:

STACK POWER

POWER DENSITY

PLATE THICKNESS











Strong intellectual capital and IP with over 1,400 patents and applications



Thank you

Please contact Tim Sasseen for more information

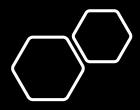
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Ballard.com

NEXT UP:



Joe Pratt
CEO & CTO
Golden Gate Zero
Emission Marine

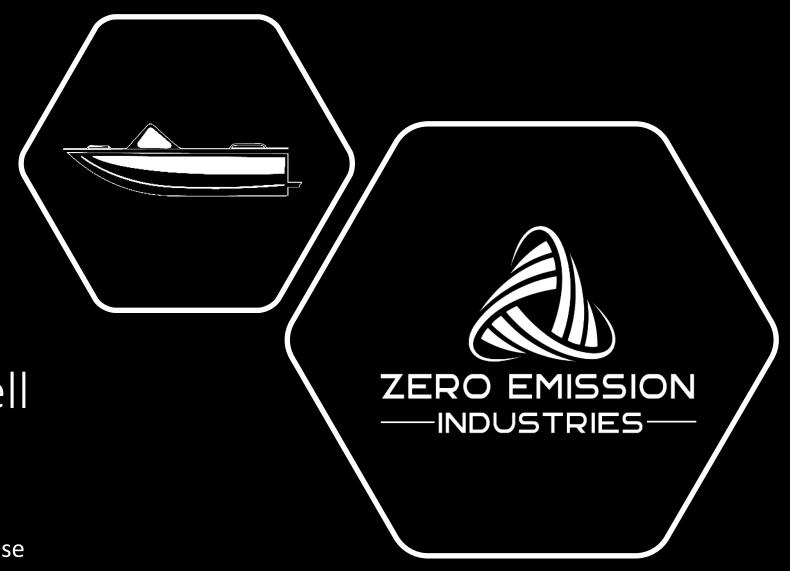


Small Fast Multi-Use Hydrogen Fuel Cell Harbor Craft

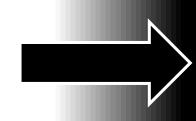
CHBC Briefing Series

Marine Hydrogen Projects Showcase

April 27, 2021











The Water-Go-Round (Sea Change)

Hydrogen Simplified

Why Hydrogen Fuel Cells for Marine

Fuel Cell Diesel and LNG **Battery Electric** Best of Both Flexible Flexible Flexible Zero Emission Zero Emission Zero Emission Simple Maintenance Simple Maintenance Simple Maintenance



Operating advantages of on-board hydrogen fuel cell systems



Reliable

Fuel Cells are solid state, and the rest of the power train has few moving parts



Scalable

Power can be scaled up/down depending on vessel type and operating needs



Modular

No more "engine room", power train can be distributed across the vessel



Flexible

Maintain current operational flexibility



Low Maintenance

Reduce operation and maintenance cost by 20% to 50%



Connected

Remote monitoring and real time operational intelligence.



Development and Technology Challenges

Today the technology is there for each of these vessel types and more*









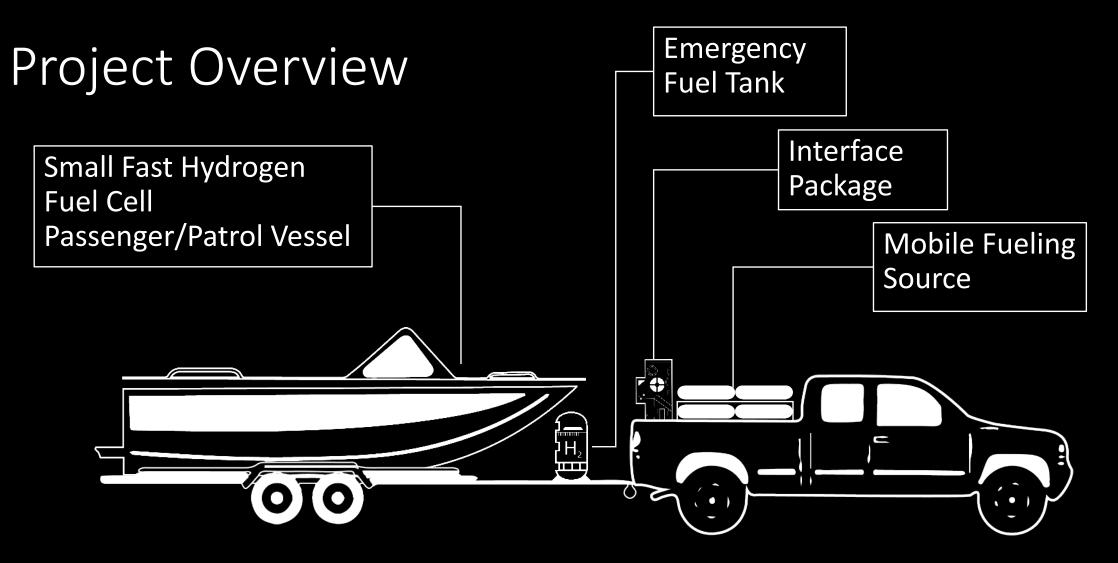


(The most difficult vessel to power is <u>small and fast</u>*)

What is needed to achieve wide adoption:

- Innovations to help lower the cost of H₂ implementation and improve efficiencies
- Widely available hydrogen fueling infrastructure, or awareness of existing hydrogen infrastructure
- Operational and public education





Vessel planned specifications

- 25' x 8.5'
- 40 knots top speed
- 300 hp

- 4 hour endurance
- 700-bar compatible
- Harbor and beach tours and patrols



Benefits

- Low cost, high performance marine fuel cell system
- Easy-to-use, portable fueling system
- Path to mass adoption through connection to recreational boats
- Potential for widespread air quality improvements and H₂ cost reductions

	Commercial Harbor Craft
Vessels in California	3,300
Potential GHG Avoided (MT/yr)	100,000
Potential Pollutants Avoided (MT/yr)	900
Potential H ₂ Demand (MT/yr)	4,500



Recreational Boats					
600,000					
2,600,000					
22,000					
110,000					



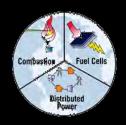
Team



California Energy Commission



Zero Emission Industries



Advanced Power and Energy Program



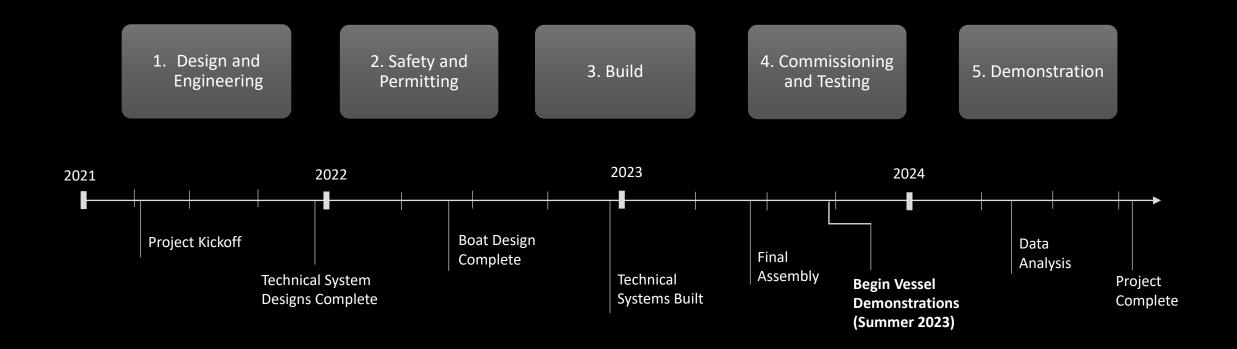
Ocean5 Naval Architects



Watershed Innovation / Correct Craft



Major Tasks and Schedule





Thank You!

For Questions or Comments please reach out:

Joe Pratt
jpratt@ggzeromarine.com
(510) 788-5101



zeroei.com

NEXT UP:



Kristian Jokinen
Program Manager
CALSTART





HyZET – Hydrogen Zero Emission Tug

CHBC - 4/27/2021











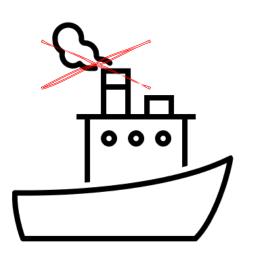














Project Objectives

- Develop a baseline harbor craft design including detailed specs and costs. These detailed specifications will be used to inform future deployment.
- Evaluate the costs of constructing, operating, and maintaining the fuel cell-powered harbor craft when compared to the baseline vessel.
- Develop a cost-benefit analysis estimating emissions and comparing to other solutions.
- Identify technology and regulatory barriers to hydrogen fuel cell systems.
- Develop supporting plans for refueling infrastructure, including analysis of hydrogen production and delivery pathways (H2 production to port)

NEXT UP:



Narendra Pal
Director of Hydrogen
Technology
Hornblower Yachts

Marine Hydrogen Demonstration

Dr. Narendra Pal,
Director of Hydrogen Technology

Maritime Hydrogen Projects Showcase, California Hydrogen Business Council

April 27, 2021



Marine Hydrogen Demonstration

Outline

- Hornblower Group
- IMO's Vision for 2050 and Challenges to meet the targets
- Options for Maritime
- Hornblower Maritime Hydrogen Projects



About Hornblower Group

Hornblower Group is a global leader in world-class experiences. The corporate entity of Hornblower Group is comprised of American Queen™ Steamboat Company and City Experiences. Seaward Services, Inc., a marine services company specializing in the operation, maintenance and repair of government and privately owned vessels, is also a subsidiary of Hornblower Group, operating and maintaining U.S. Navy Ranges and port facilities, including local oil spill response. Today, Hornblower's footprint spans 111 countries and territories, and 125 U.S. cities, with offerings including water-based experiences, land-based experiences, overnight cruise experiences, and ferry and transportation services. Hornblower Group is headquartered in San Francisco, California, with additional corporate offices in Boston, Massachusetts; Chicago, Illinois; London, United Kingdom; New Albany, Indiana; New York, New York; and across Ontario, Canada.



About City Experiences

City Experiences represents Hornblower Group's expansive portfolio of water- and land-based experience companies and includes two sub-brands: City Cruises and City Ferry. City Cruises companies operate dining, sightseeing and private events across 22 destinations in the U.S., Canada and the UK. City Cruises companies also operate cruises on behalf of the National Park Service and the Niagara Parks Commission and currently hold service contracts to provide ferry service to the Statue of Liberty National Monument and the Ellis Island National Museum of Immigration, Alcatraz Island and Niagara Falls. City Ferry companies offer specialized knowledge and expertise required to transport passengers, vehicles and other cargo safely across inland and coastal waterways, serving as operator of NYC Ferry and Puerto Rico ferry system, among others. City Experiences' portfolio of companies also offers a range of land-based experiences including shore excursions, partner-offered experiences, multi-port packages, with companies including Cruising Excursions, ShoreTrips and Walks products. For more information visit **cityexperiences.com**.



HORNBLOWER

Hornblower Group A family of companies

\$450 M+

In Government Funds Managed in 5 years

220 +

Vessels Managed

42

Vessels Built over the past 4 years

30 M+

Passenger trips in 2019

3000+

Crew Members







Turnkey Marine Services Provider

Hornblower drives client efficiencies by providing turnkey additional support opportunities in the maritime trade.

Hornblower's portfolio of client service offerings will include planning and consulting, design and shipbuilding, vessel operations, marketing and technology integration, and cargo management.

Consulting & Planning

Groundwork needed to validate new opportunities (e.g. operational feasibility studies, economic impact and transportation needs).

Design

Design new vessels or adapt existing design to meet requirement identified during planning phase.

Shipbuilding/ Construction Oversight

Construction execution and/or oversight to specification with delivery to internal or external owner/operator entity.

Technology

Integrate Information
Technology for
capturing data,
external
communications and
reporting.

Operations & Oversight

Day-to-day operations and associated functions (e.g. vessel maintenance, engineering, customer support, reporting.



Construction & Alternative Propulsion

Alternative propulsion systems is a Hornblower Group core competency.

Alternative Propulsion



Hydrogen Production and fueling station

California, Bay Area

\$16,000,000 project receiving \$8,000,000 from the department of energy

3-year project commences in 2021



First hydrogen ferry in the United States

California, Bay Area

Hornblower is managing the construction of the vessel at All American Shipyard in Washington State



Hornblower Discover Zero

California, Bay Area

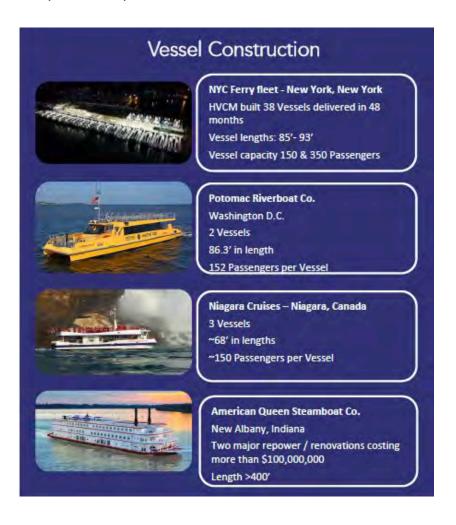
Zero-emission hydrogen + lithium-ion passenger vessel.



Gee's Bend

Camden, Alabama

Hornblower managed the repower of the Country's first all-electric passenger / car ferry. In operation since 2018





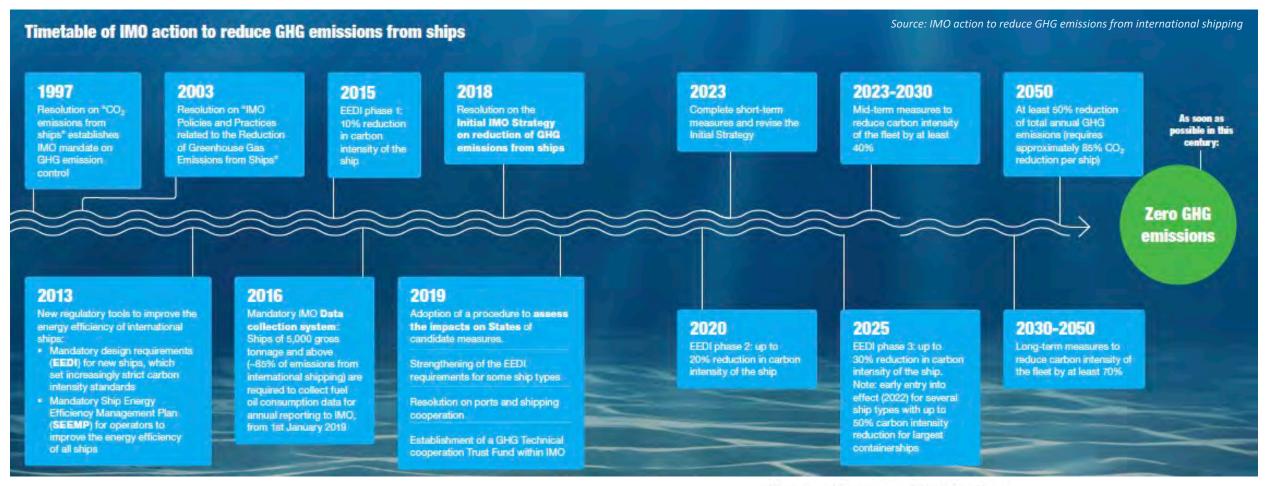
Marine Hydrogen Demonstration

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- Hornblower Maritime Hydrogen Projects



IMO adapts plan for 50% cuts to shipping GHG emissions by 2050



Regulations are Global but may be driven by Regional

Norway Mandates World's First Zero-Emission ECA for No Later Than 2026

by Ship & Bunker News Team Friday May 4, 2018









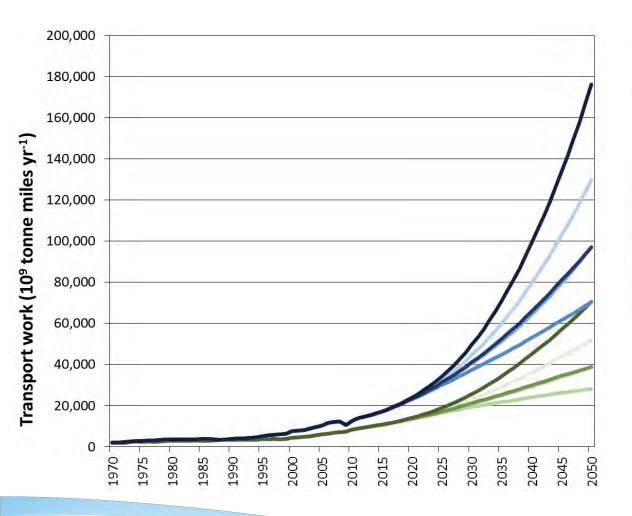


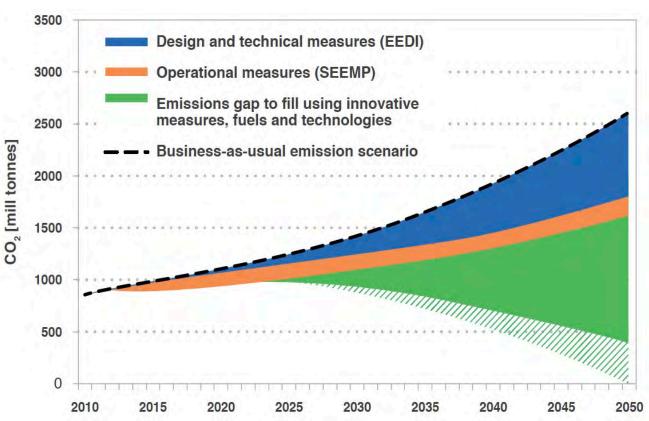






GHG reduction pathway to achieve IMO's ambitious goals









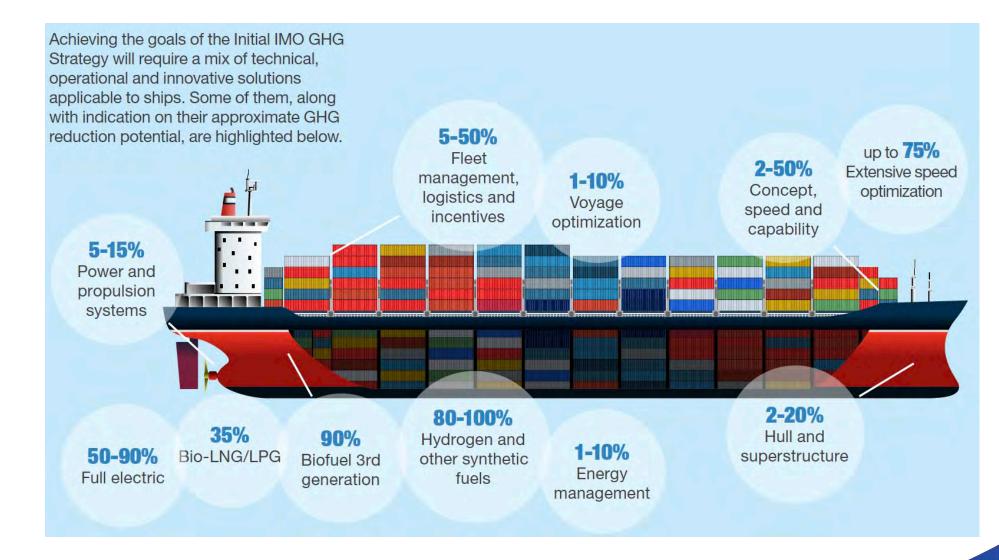
Marine Hydrogen Demonstration

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A wide variety of solutions

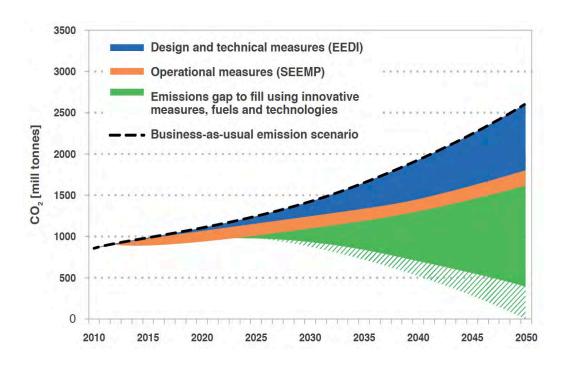




Emission Reduction Technology Options

Parameter	Tier 4 Diesel	Electric Hybrid	LNG	Battery or H ₂ Fuel Cell
NOx	Low	Low	Low	0
SOx	Low	Low	0	0
CO ₂	no change	10%-40%	+/- 10%	0
	(0 if biofuel)	lower		

Die	esel and LNG	Ва	ttery	Fu	el Cell
✓	Flexible		Flexible	✓	Flexible
	Zero Emission	✓	Zero Emission	✓	Zero Emission
	Simple Maintenance	✓	Simple Maintenance	✓	Simple Maintenance





Marine Hydrogen Demonstration

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1st USA 100% Hydrogen Fuel-Cell Powered Ferry

Driven by our passion for innovation, Hornblower has developed a collaborative partnership with SWITCH Maritime, whose mission is to build the first fleet of zero-emissions vessels in North America.

The first such vessel, in the final stages of construction at All American Marine shipyard, is a 75-passenger hydrogen-powered, zero-emissions ferry (ZEF-75 Class), named the Sea Change. As part of the Hornblower/SWITCH partnership, Hornblower has acted as the exclusive owner's representative in the construction of this first-of-kind ferry, which will be ready for commercial operations in Q2 of this year.





Fuel Cell-Battery Hybrid Ferry : Nautilus Project (Hornblower Discover Zero)

Project funded by US Department of Transportation (MARAD)

Salient Features

Fuel Cell: 120 kW (4 x 30 kW modules)

• Hydrogen Storage: 170 kg @ 250 bar

Bunkering: Tube Trailer and Hydrogen Barge

Battery Storage: 1.6 MWh

Work Plan

Phase 1: Detailed Design

Produce approved build-ready designs for the on-board hydrogen storage and fuel cell system, Li-ion battery energy storage system, and associated filling equipment.

Phase 1 Go/No-Go Decision: Independent analysis of the technical, regulatory, and business aspects of the detailed design will be done by Sandia to inform a Go/No-Go decision by all partners.

Phase 2: Installation; Phase 3: Operation



VESSEL STATISTICS

Length: 149 feet*

Beam: 36 feet

Draft: 7.5 feet

Maximum speed: 12 knots

Passenger Capacity: 600

Propulsion System: Battery Electric

Energy Storage Capacity: 2,532 kilowatt-hours**

Onboard Renewables:

- 11.2 kW Solar Electric
- 1 kW Wind
- Solar Hot Water
- Surge Generator
- Rainwater Capture

Partners













Hydrogen Barge

With support from the US Department of Energy, Hornblower Energy is leading the country's first barge-based hydrogen production, bunkering, and refueling infrastructure project for maritime and landside applications.

Salient Features

Green Hydrogen Production: 530 kg/day

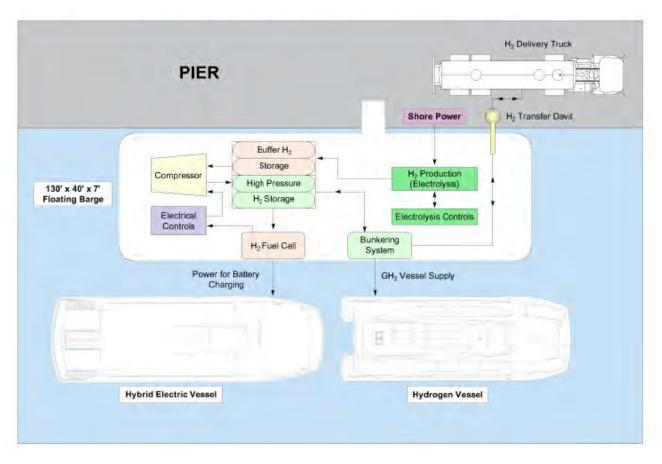
Onboard Hydrogen Storage: 500 kg @ 500 bar

Dispensing / Bunkering: Vessels & Tube Trailer

Recharging: Hybrid vessels

Budget

Total Project Budget: \$16 M Total DOE Share: \$8 M Total Cost Share: \$8 M





























We Create Amazing Experiences

Q&A

Submit your question in the Q&A Panel on your right.











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UPCOMING CHBC AND PARTNER EVENTS

- May 5, 2021
 - CaFCP Webinar Energy Observer
 - <u>cafcp.org/content/energy-observer-visits-california-maritime-perspective-global-hydrogen-revolution</u>
- May 19, 2021
 - CHBC Briefing: Innovations in Hydrogen Rail Project Showcase
 - Register: https://register.gotowebinar.com/register/2015531671823417613

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CONTACT

Emanuel Wagner

Deputy Director

California Hydrogen Business Council

ewagner@californiahydrogen.org

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