Zero Emission
Fuel Cell Power
and Hydrogen
Fueling Systems

National Shipbuilding Research Program
Business Technologies and Ship Design & Material
Technologies Joint Panel Meeting
September 14-15, 2021
The *Sea Change*: Realization of a long effort...
Vessel Overview

- Aluminum catamaran
- 72’-7” LOA
- 24’-6” beam
- 78 passengers + 2 crew
- 22 knot top speed
- 2x 300 kW electric motors
- 360 kW PEM fuel cell
- 100 kWh Li-ion battery
- \( \text{H}_2 \): 242 kg @ 250 bar (3,600 psi)
Vessel Features

- Fuel cell room
  - 3 x 120 kW racks

- Boarding from sides and bow for maximum flexibility

- 300 kW (400 hp) shaft motors (1 in each hull)

- Bow observation deck

- H₂ tank array
  - 242 kg, 250 bar compressed gas,
  - 1-3 days operation

- 2x49.7 kWh batteries in hulls provide boost power to achieve 22 knots
The fueling will look like today’s operation with diesel

California’s Office of Spill Prevention and Response (OSPR) has exempted hydrogen fueling from the insurance requirements imposed on diesel fueling.
ZEI’s role in the project: Everything Hydrogen

- Integrated hydrogen and fuel cell system
- Hydrogen fueling system
- Hydrogen safety systems
- Hydrogen system controls
- Regulatory approvals for the hydrogen portions
### Key Milestones

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
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<tbody>
<tr>
<td>Project Began</td>
<td>June 11, 2018</td>
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<tr>
<td>Ferry Design Complete</td>
<td>Oct. 2018</td>
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<tr>
<td>Keel Laying Ceremony</td>
<td>Nov. 8, 2018</td>
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<tr>
<td>Ferry Build Began</td>
<td>Feb. 2019</td>
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<tr>
<td>Vessel Moved to All-American Marine</td>
<td>March 2020</td>
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<tr>
<td>Launched for Commissioning</td>
<td>August 12, 2021</td>
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<tr>
<td>Begin Operation in SF Bay (est.)</td>
<td>Nov. 2021</td>
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The *Sea Change* is

**North America’s first hydrogen fuel cell vessel**

and the

**First commercial hydrogen fuel cell ferry in the world**
Lessons Learned

• Shipyards do not typically have the expertise needed
  • $H_2$ piping installation, inspection, and testing
  • Hazardous area electrical installations
  • High pressure or cryogenic temperatures
  • High voltage DC power
  • Integration of all of the above

• The regulations lag far behind the technology and regulators do not have the knowledge needed to fill in the gaps

• (...and various technical improvements)
Our Solution: Turnkey Fuel Cell Power System

A hydrogen fuel cell power system that is designed and factory-built to enable shipyards to easily deliver hydrogen powered vessels

Turn-key
Complete
Easy to integrate
Better performing
Above best-in-class technology
Provides fastest path to market

**Power Output:** 250kw (335hp) system

Scalable / stackable to meet a range of power requirements for multiple use cases

**Built with the USCG in mind**
Our Solution: The World’s Easiest Hydrogen Fueler

THE ZEI FUEL BOX

*The World’s First Man Portable Hydrogen Dispenser*

*Launching 2022*

*Patent Pending*

Lowest Cost H2 Fueling Solution

Reduces operational costs and significantly lowers time to market

Can be installed on the vessel

Works for fueling 95%+ of all hydrogen mobility types
First Implementation: Small fast boats

Vessel planned specifications
- 25’ x 8.5’
- 40 knots top speed
- 300 hp

- 4+ hour endurance
- 700-bar compatible
- Harbor patrol, tourism

Small Fast Hydrogen Fuel Cell Passenger/Patrol Vessel
Emergency Fuel Tank
H2 Fueler
Mobile Fuel Source

Our Partners
A wide variety of immediate use cases

Single Screw (250 kW) and Twin Screw (500 kW)

- Law Enforcement
- Fire
- Military
- Fishing
- Pilot
- Tour

- Autonomous
- Watersports
- Leisure
- Ferry
- Research

Also scalable to multi-MW for commercial, defense, and private vessels
The advantages of fuel cells go far beyond environmental.

**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.
Hydrogen provides a solution where batteries do not work.

Our team has over 100 years’ experience innovating hydrogen tech, all focused on making hydrogen simple for you. Drop us a line with any questions or inquiries:

info@zeroei.com

Hydrogen Simplified.