



The #H2IQ Hour

Today's Topic: *Sea Change*, the First Hydrogen-Powered Passenger Ferry in the U.S.

December 12, 2024



This presentation is part of the monthly H2IQ hour to highlight hydrogen and fuel cell research, development, and demonstration (RD&D) activities including projects funded by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

HOUSEKEEPING

The webinar is being recorded and will be available in the **H2IQ Webinar Archives**

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Questions?

- There will be a Q&A session at the end of the presentation
- To submit a question, please type it into the Q&A box; **do not** add questions to the Chat


This webinar is being recorded.

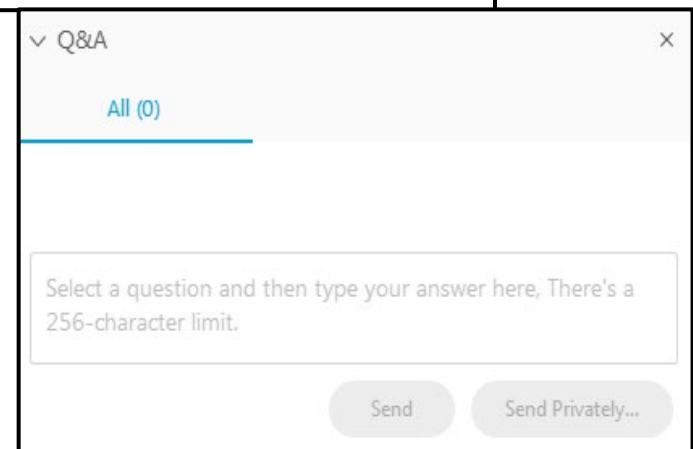


THE H2IQ HOUR Q&A PROCESS

Please type your questions in the Q&A Box

Open the Q&A panel

- 1 To open the Q&A panel, click Panel options (Windows) or More options (Mac)  and select **Q&A**



Q&A

All (0)

Select a question and then type your answer here, There's a 256-character limit.

Send Send Privately...

SWITCH Maritime

Bringing to market the first zero-emissions hydrogen fuel cell powered ferry in the U.S.



SWITCH

Executive Summary

- 1 **SWITCH Maritime:** Mission and Business Model
- 2 **Sea Change:** Project Narrative, Regulatory Approval Process, and Lessons Learned
- 3 **Next Steps:** Leveraging a Strong Foundation to Scale

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SWITCH Maritime:

**Offering Comprehensive Zero-Emissions
Vessel Solutions for Operators**

Change is hard but inevitable

Operator Comfort Zone

- Vessel operators are focused on their core business – providing safe, reliable, and effective service
- Many years of experience with diesel ICE technology
- Well established operations, regulations, and maintenance processes

**Business as usual;
risks are low and well managed.**

Energy Transition



Uncharted Waters

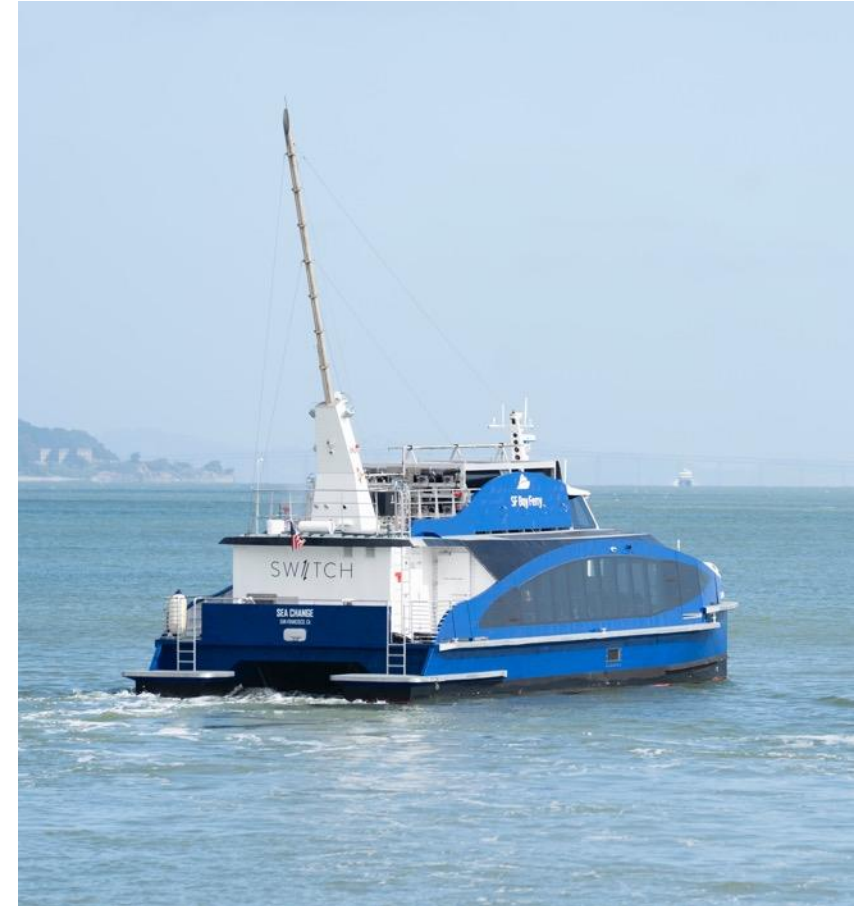
- Vessel operators are faced with the challenge of adapting to changing needs and pressures
- Less experience with novel technologies
- Lack of internal knowledge on regulations, maintenance and operations best practices

**Risks are not well managed;
scope of risk is unknown.**

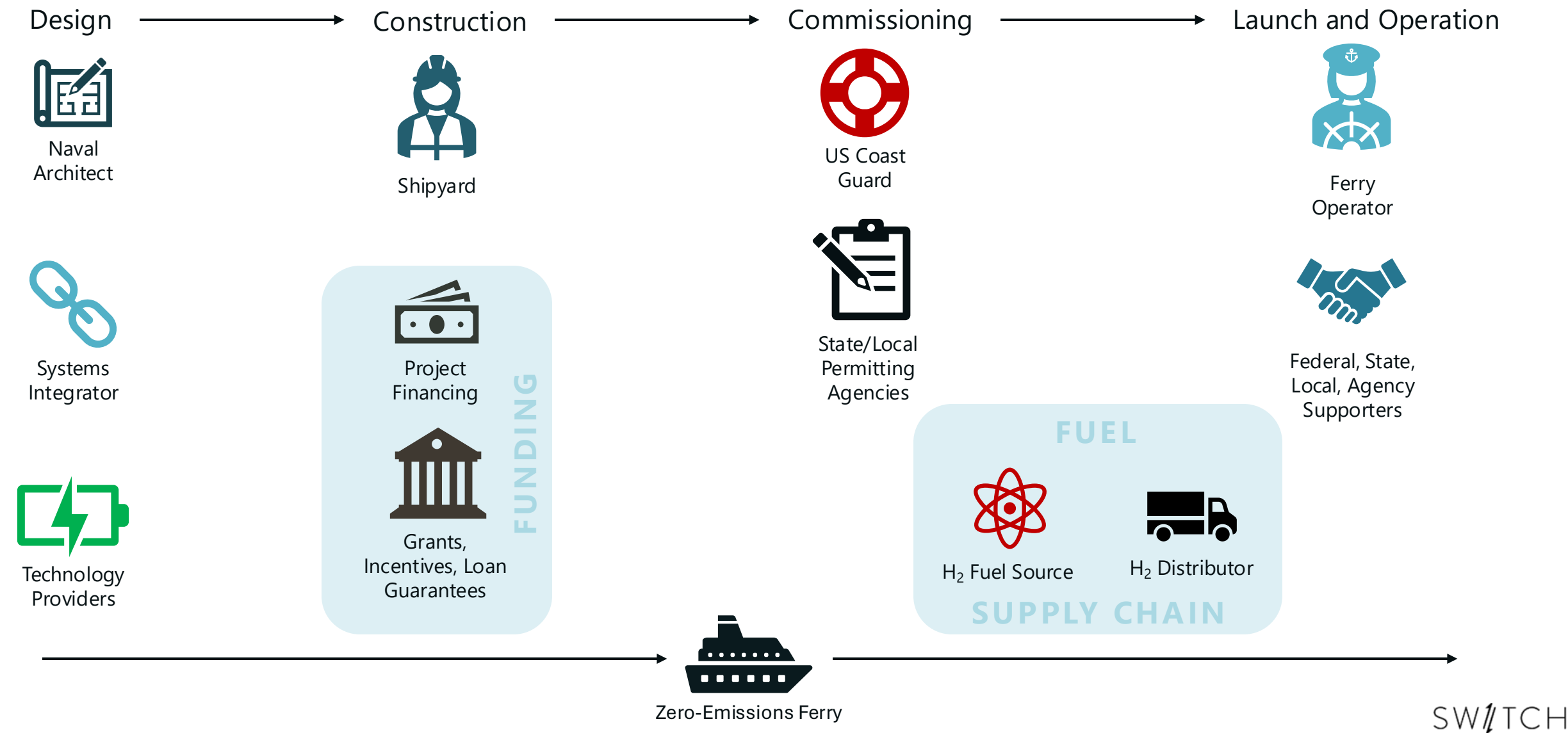
SWITCH simplifies and de-risks the energy transition for operators

SWITCH Model Benefits To Operators

- 1 **Decarbonization:** Operator realizes tangible emissions reduction, reducing gallons of diesel consumed
- 2 **Risk mitigation:** SWITCH manages development, construction, and regulatory risk associated with ZEF deployment
- 3 **Increased optionality:** SWITCH lease model ensures operators can make a 5-year technology deployment decision, rather than a 25-year decision
- 4 **Integrated fueling solution:** SWITCH authors development of hydrogen fuel supply chain
- 5 **Comparable specifications:** Operator receives a zero-emissions vessel with operational and performance specifications that parallel diesel-powered vessel(s)



SWITCH leverages expert resources to deliver turnkey package



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The Sea Change:

**First Zero-Emissions Hydrogen Fuel Cell
Ferry in the United States**

Sea Change establishes proof-point for tech, regulatory, & commercialization

The *Sea Change* carries 75 passengers, has a service speed of ~12 knots, and a range of 300 nm on a single fueling.



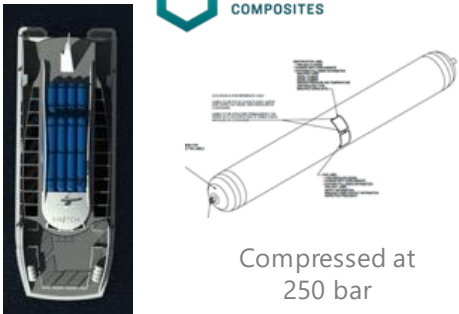
Technology Overview

Fuel Cell



360 kW PEM fuel cell

H2 Storage



246 kg gaseous hydrogen storage

Battery



100 kWh energy storage

Electric Propulsion

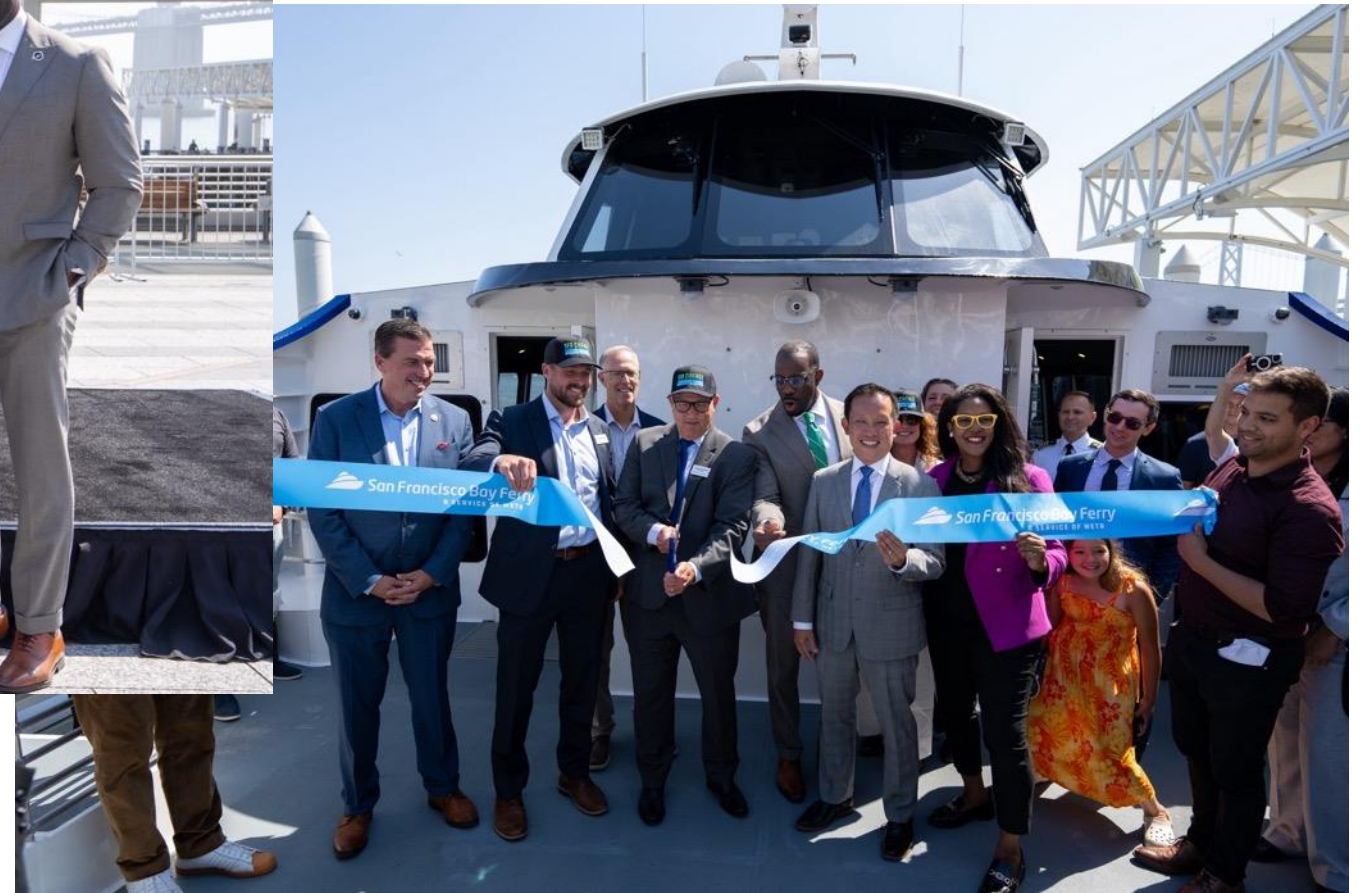


2 x 300 kW electric traction motors

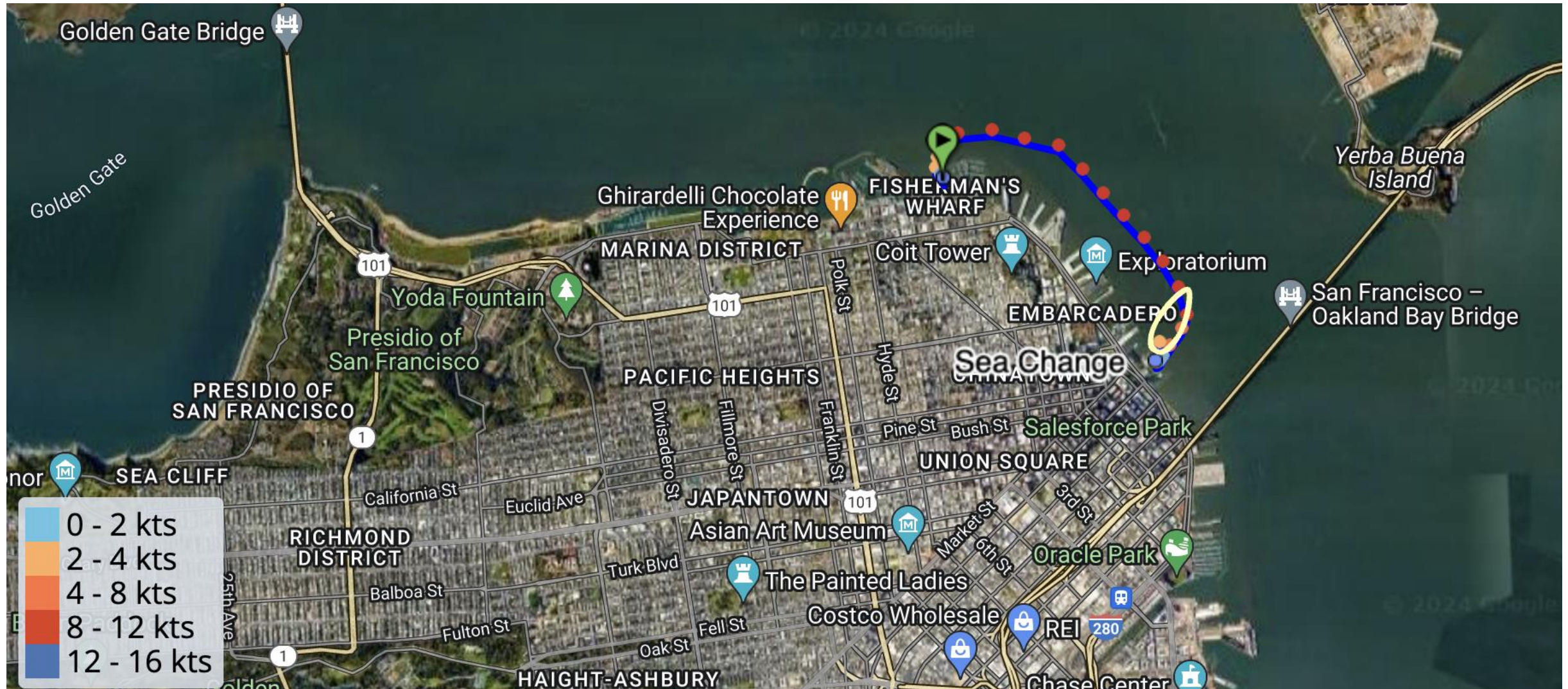
May 2024 - Sea Change receives COI from the U.S. Coast Guard



July 2024 - Sea Change enters public passenger ferry service in San Francisco



Service Route: SF Ferry Building \leftrightarrow Pier 41



August 2024 – Governor Newsom visits Sea Change, launch of CA ARCHES H2 hub



Project Structure - SWITCH ZEF-75 #1



SWITCH Maritime LLC
(Platform DevCo)

SWITCH MARITIME

Equity (100%)

SWITCH Fleet LLC (DE)
(FleetCo SPV)



UNITED



Ferry Service Sponsors

Sponsorship Funds

CARB / CEC
(Grantor)

Grant Funds



CALIFORNIA ENERGY COMMISSION

Water Emergency Transit Authority
(SF Public Ferry Agency)

WETA
WATER EMERGENCY
TRANSPORTATION AUTHORITY

San Francisco Bay Ferry
A SERVICE OF WETA

Service Contract

Service Payments

Blue & Gold Fleet
(SF Ferry Operator)



Bareboat Lease

Bareboat Payments

SWITCH ZEF-75 Ferry #1 LLC
(VesselCo SPV)

100% Ownership

Equity Funds

Guarantor
Loan Payments

Key Bank
(Construction & Term Lender)



Vessel Construction & Term Loan
Debt Funds (\$5m gross)
BAAQMD/NorCal FDC Loan Guarantee

CARB (Grantor)

BAAQMD (Grantee)

NorCal FDC (Loan Guarantor)



Grant Funds

Remaining Grant Disbursements

Loan Guarantee

Sub-contractor Agreements
Sub-contractor Fees

H2 System (ZEI)
Naval Arch (Incat)
Propulsion (BAE)
Fuel Cell (Hydrogenics)

Technical / Sub-Contractor Oversight

Hornblower Construction Management / Engineering



Construction Supervision Agreement
Shipyard Payments

All American Marine Shipyard



SWITCH

FOAK project capital stack

Project funding for the *Sea Change* came from a variety of public and private sources, incorporating a **blend of financial instruments** to bring the vessel across the finish line.

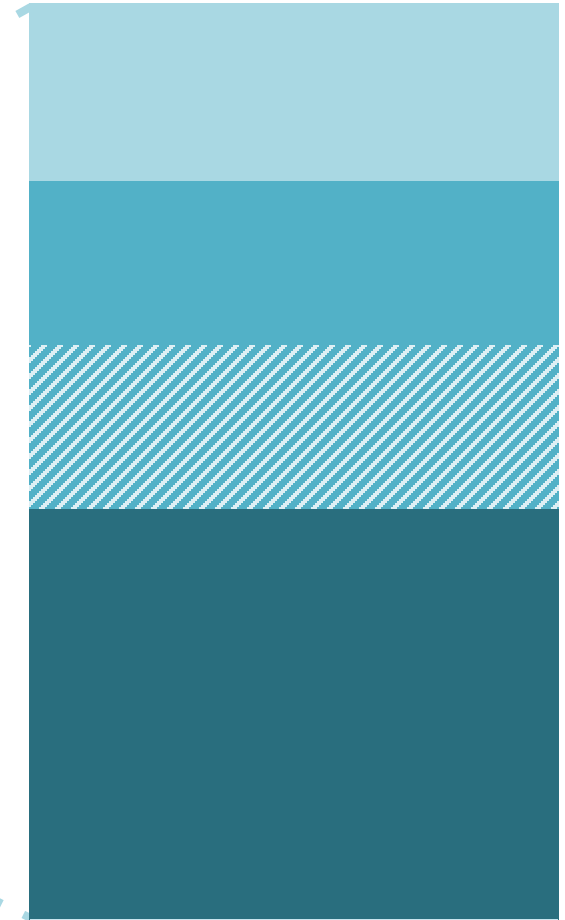
● **\$3M grant** from the California Air Resources Board (CARB), facilitated by the Bay Area Air Quality Management District (BAAQMD)

● **\$5M commercial loan** from Key Bank

● **50% loan guarantee** from the California Infrastructure and Economic Development Bank (IBank) and the Northern California Financial Development Corporation (NorCal FDC), guaranteeing \$2.5M in project debt

● **\$6.3M project equity** contributed by SWITCH Maritime

● **\$14.3M total project cost***

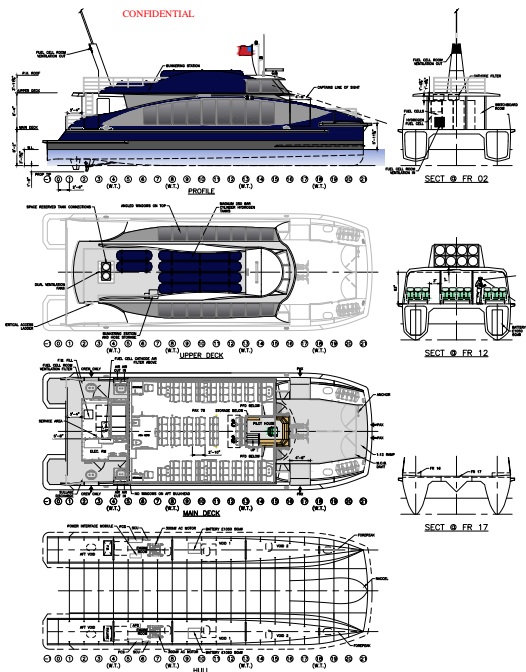
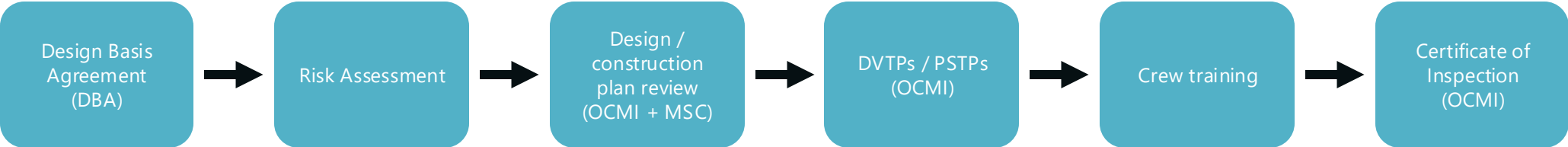


Project Financing

**50% of total project costs incurred were first-time and circumstantial costs that need not be considered for development of future vessels.*

Close collaboration with the USCG, establishing framework for future H2 vessels

Since no unified regulatory set of codes and standards existed for hydrogen powered vessel under USCG, a patchwork of existing regulations were applied to establish equivalent level of safety: USCG 46 CFR Subchapter T, IGF Code, DNVGL, IEC



H₂ Fueling – Pier 68 (permitted site)



H₂ Fueling – Supply chain development and implementation

A maritime hydrogen fuel supply chain did not exist in San Francisco, necessitating that **SWITCH manage development and permitting process to ensure safe, dependable, and compliant fueling** operation for the Sea Change.

Fuel supply chain design

Regulatory approvals

Crew fueling training

Mobile truck-to-ship fueling
GTM 1500 Trailer(s)
Transfer rate: ~ 85 kg / hr
Leverage existing supply



Operations Manual

+ Appendices:

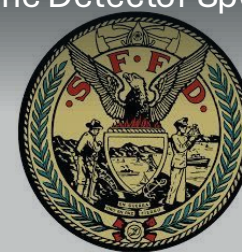
- Site Plan
- Transfer System
- P&ID
- Breakaway Coupling
- DOI
- Responsible Personnel
- Bunkering Procedure
- Truck / Trailer Ops Manual



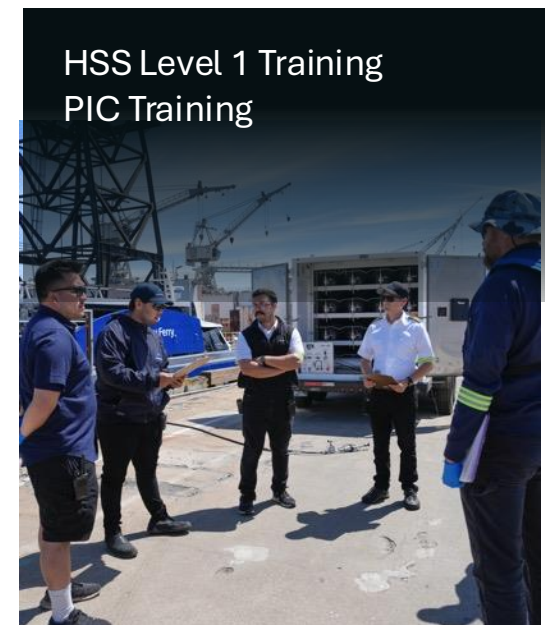
Emergency Manual

+ Appendices:

- Safety Data Sheet
- Evacuation / Rally Point
- Gas Detector Specs
- Gas Monitor Specs
- Thermal Camera Specs
- Flame Detector Specs



HSS Level 1 Training
PIC Training



H₂ Fueling – Process overview

Bunkering Process:

1. Establish Permitted Transfer Area
2. DOI + Safety Briefing (PIC duties, etc.)
3. Manual Pre-Bunkering Checklist
4. Pre-Fill Inert
5. High Pressure Leak Check
6. Cascade Fill
7. Post Fill Inert
8. Post-Fill Cleanup



Lessons learned (just to name a few)

- 1 **KISS:** minimize complexity = minimize potential failure points (e.g. reduce FC & HSS system cycling)
- 2 **Diagnostic visibility:** streamline and consolidate all diagnostic systems for operator awareness & root cause analysis
- 3 **Local support / equipment:** prioritize vendors with strong local maintenance support and minimize equipment sourced from far flung areas.
- 4 **Power management system:** FCs like steady, consistent load at optimal efficiency. Batteries should complement with ramping. Maintain ability for operator to tune power management system as duty cycle expectations can change / account for some degradation from BOL to EOL.
- 5 **H2 pressure regulation:** FCs like steady, consistent pressure. Regulator needs to provide stable output pressure and be able to adapt to changing fill states / minimize pressure swings when power ramps up.
- 6 **Education:** Baseline education of crew, regulators, etc. is important and time consuming. Plan accordingly.
- 7 **H2 Cost:** H2 still costs too much. While \$1/kg price targets aren't realistic, cost can come down significantly by taking increase ownership over means of production and co-locating supply and demand.
- 8 **And many more...**

3

Next steps:

Leveraging a Strong Foundation to Scale

Next-Gen designs in development

SWITCH is actively **advancing larger and faster hydrogen fuel cell ferry designs** to expand range of applicable routes and operational profiles, with target start of construction in mid-2025. These designs build on the Sea Change experience and will be ready to meet industry standards for reliable commercial service from day one.

ZEF-150



CH_2

23-26 knots

ZEF-300



LH_2

30-35 knots

RoPax



LH_2

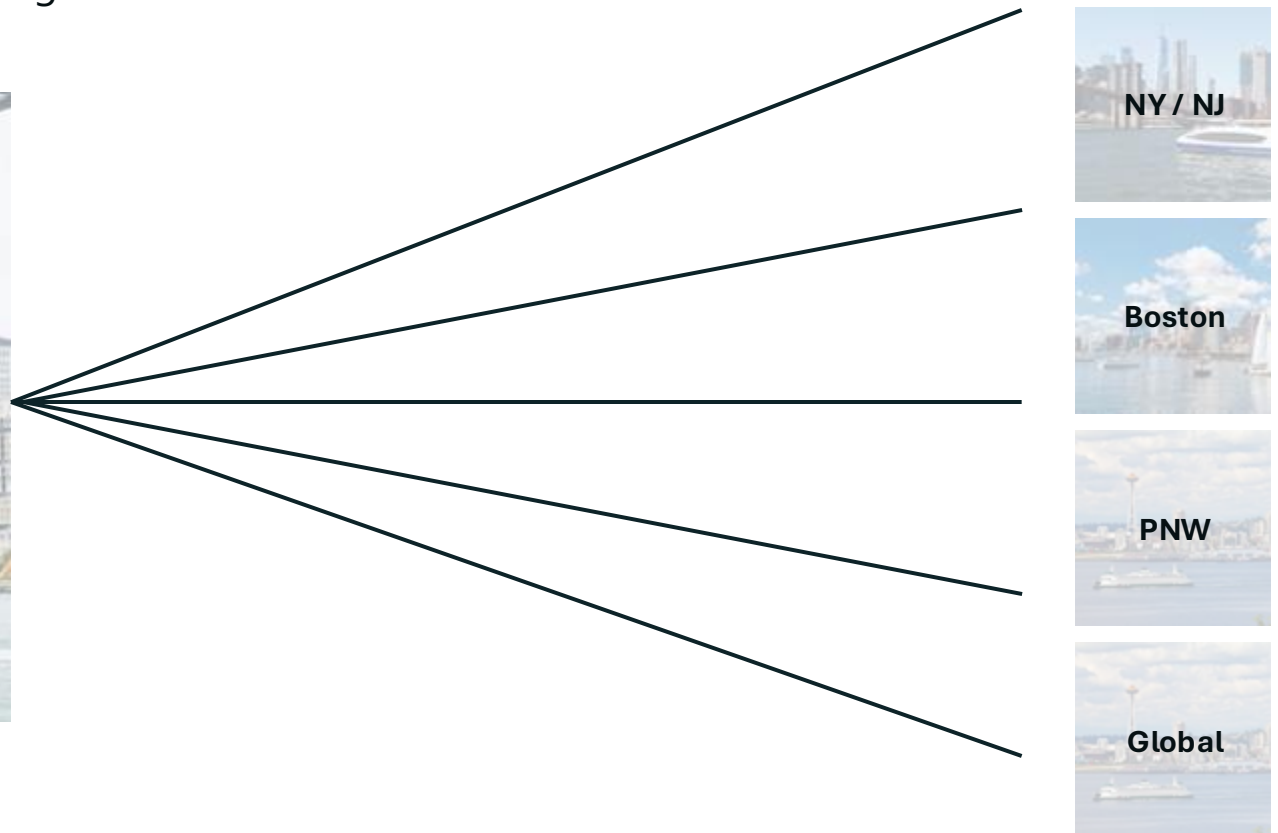
13-14 knots

Expanding aperture to new markets

California's leadership on decarbonization (e.g. CARB's Commercial Harbor Craft Regs) and **WETA's industry-leading energy transition strategy** in San Francisco have solidified the Bay Area as the first focus market and strong foundation for SWITCH.



SWITCH is **poised to work with operators in key markets across the U.S. and internationally** to help navigate the changing landscape and achieve sustainability objectives.



Thank you

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