ABL

LONGITUDE
An ABL Group Company

Hydrogen Fuel Cell Ferry Design (HySeas III)

Dr Julius Partridge

Contents

The ABL Group Family

The **ABL Group** are a comprehensive family of branded energy and marine consultancy companies offering services that are both complementary and interconnected. This allows our business lines, branded service companies, and expertise to focus closely on delivering technical excellence in engineering and consultancy, loss prevention and loss management.

ABL Group

ABL Group is a leading global independent energy and marine consultancy working in energy and oceans to de-risk and drive the energy transition across renewables, maritime and oil and gas sectors.

OWC
An ABL Group Company

OWC

Project development services, owner's engineering and technical due diligence to the offshore renewables industry.

LONGITUDE
An ABL Group Company

Longitude Engineering

Independent engineering, design and analysis services for the marine, renewables, oil and gas, defence and offshore infrastructure industries.

EAST POINT GEO
An ABL Group Company

East Point Geo

Expert Geoconsulting organization supporting all sectors; providing efficient client-focused deliverables including data assurance, ground models and quantitative risk assessment.

OSD-IMT
Part of Longitude

OSD-IMT

Established in 1989, a specialist ship design house focused on offshore support vessels and clean shipping technology.

INNOSEA
An ABL Group Company

INNOSEA

Engineering advisory, verification, research and development, concept development and consultancy for marine renewable energy.

ABL YACHTS
An ABL Group Company

ABL Yachts

Superyacht surveyors and consultants.

ADD ENERGY
An ABL Group Company

Add Energy

Asset integrity management, well engineering and management, and operations consultants.

Global Partner, Local Expert

62
Offices

38
Countries

303**
Locations

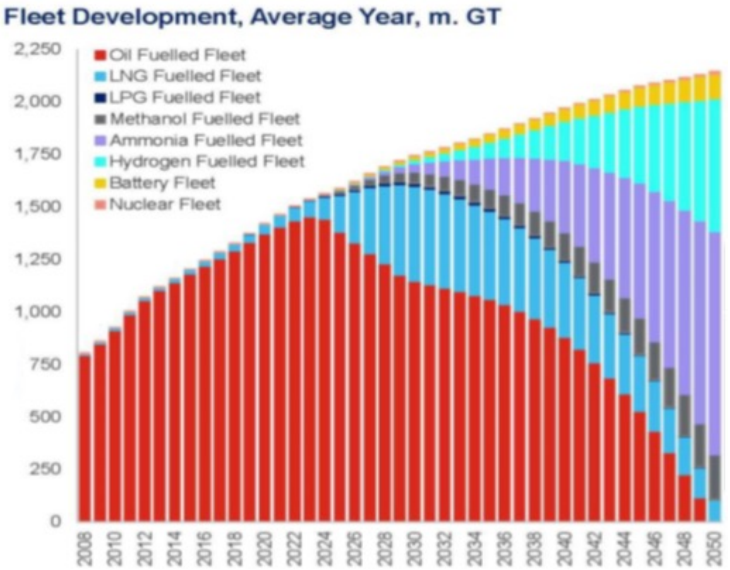
+1000
People

* Includes subcontractors on 100% utilisation basis. Calculated as an average during Q4 2021.
** ABL locate many staff strategically at maritime and offshore hubs to be able to serve clients locally
Additional note: the 38 countries number is driven by our offices, in terms of locations where we have surveyors etc we cover 71 countries, a truly global footprint

Contents

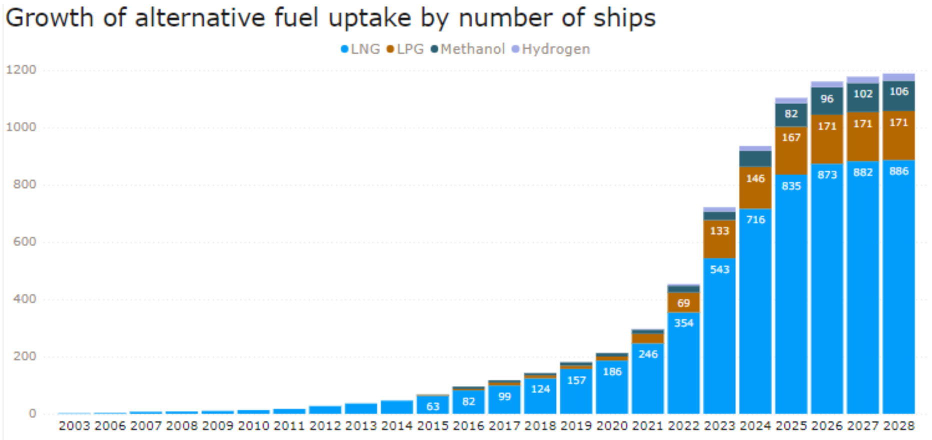
Hydrogen in the Marine Industry

- Predicted growth in alternative fuels
  - LNG large initial growth but already tailing-off.
  - Methanol starting to enter market.
  - Ammonia expected to dominate for larger vessels.
  - Hydrogen expected to dominate for small vessels.



Courtesy of Clarksons

- Hydrogen.
  - 3 in operation, 1 under testing.
  - 21 on order.
  - 25 vessels by 2028 (8 ICE, 17 Fuel Cell).
  - Expected to grow significantly especially for smaller vessels (CTVs, Ferries, Tugs).



Courtesy of DNV

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Project Overview

HySeas Project

- Part of European Union Horizon 2020 program
- Three phases:
  - Hyseas I – theory of hydrogen powered vessels (2013)
  - Hyseas II – initial design of hydrogen fuelled vessel (2014-2015)
  - Hyseas III – Concept design. ABL/Longitude involvement

HySeasIII

Specific Project Objective

- Concept design to a level of maturity to achieve independent 3rd party approval (e.g. Approval in Principle).
- Design which can be developed to Basic Design level with low risk

DNV

APPROVAL IN PRINCIPLE

Broader objectives

- A design (or template design) that can be applied to a number of different coastal / island communities for Caledonian Maritime Assets Ltd.

Current Vessel

Current Ship

- Single ended, ramped, vehicle and passenger ferry.
- Twin screw direct drive diesel propulsion.
- Built 1989 and lengthened 2011.
- Capacity for
  - 91 Passengers,
  - 15 Cars, or
  - 1 Heavy Goods Vehicle (HGV).
- 37 round trips per week
- Average Annual CO_2 emissions of 458 tonnes.

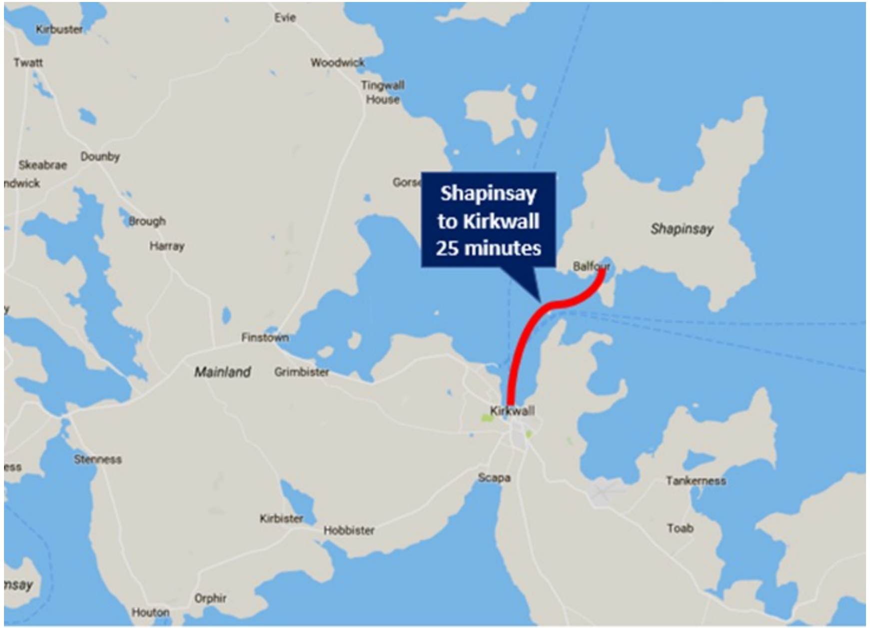
MV Shapinsay

Route and Vessel Requirements

Basic requirements

- Double ended ferry designed for the Kirkwall to Shapinsay route
- Up to 6 Round trips per day.
- Capacity for
  - 120 Passengers, plus
  - 16 Cars, or
  - 2 Heavy Goods Vehicles (HGVs), or
  - Combination of cars, HGVs or motorhomes.
- Electric propulsion
  - Hydrogen Fuel Cells
  - Batteries

Route



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Concept Design

Dimensions

- Length: LOA = 40.00m LBP = 37.20m
- Breadth:11.50m
- Depth: 2.50m

Compressed Hydrogen Fuel

- 10 tanks (32 kg of H_2 @ 250 bar).
- Bunkered from pier to two locations onto ship

Fuel Cells

- Two LT-PEM. Space for a third
- Power for propulsion and auxiliaries at 9.5 knots, 15% sea margin

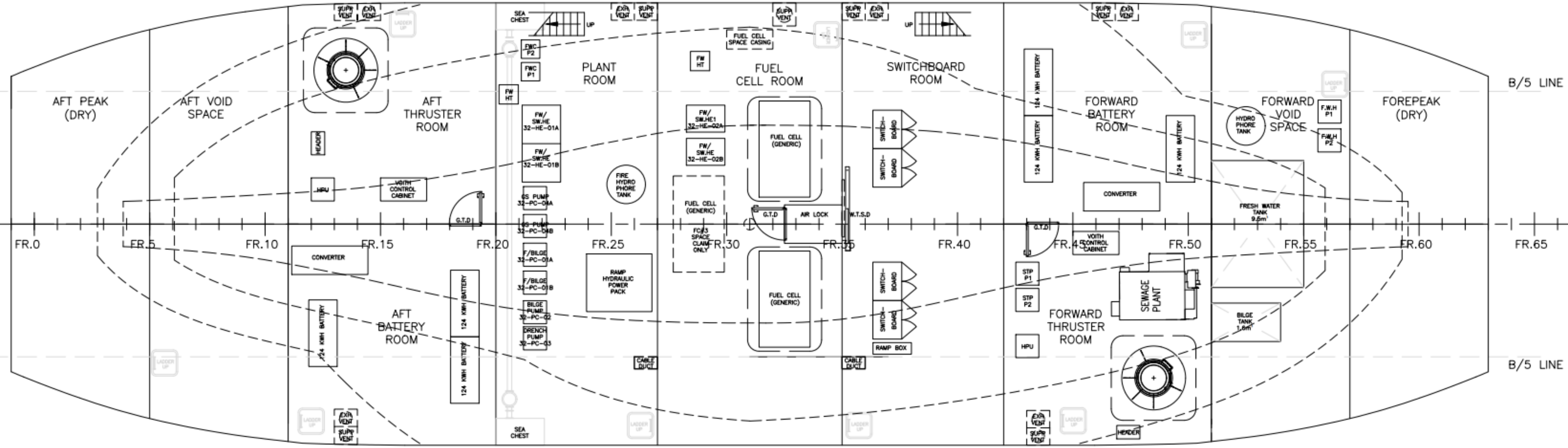
Batteries

- Peak load shaving, propulsion assistance, range extension and return to port facility. Located in two separate spaces.

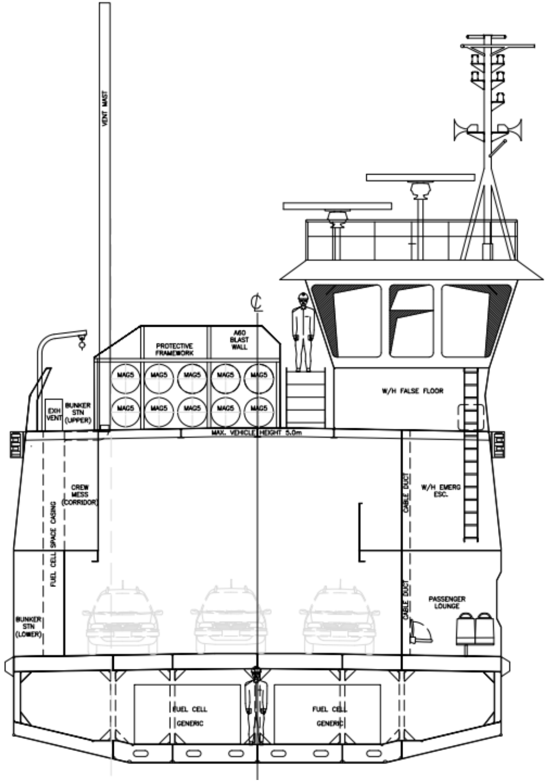
Twin Electric Voith Schneider Propulsion.

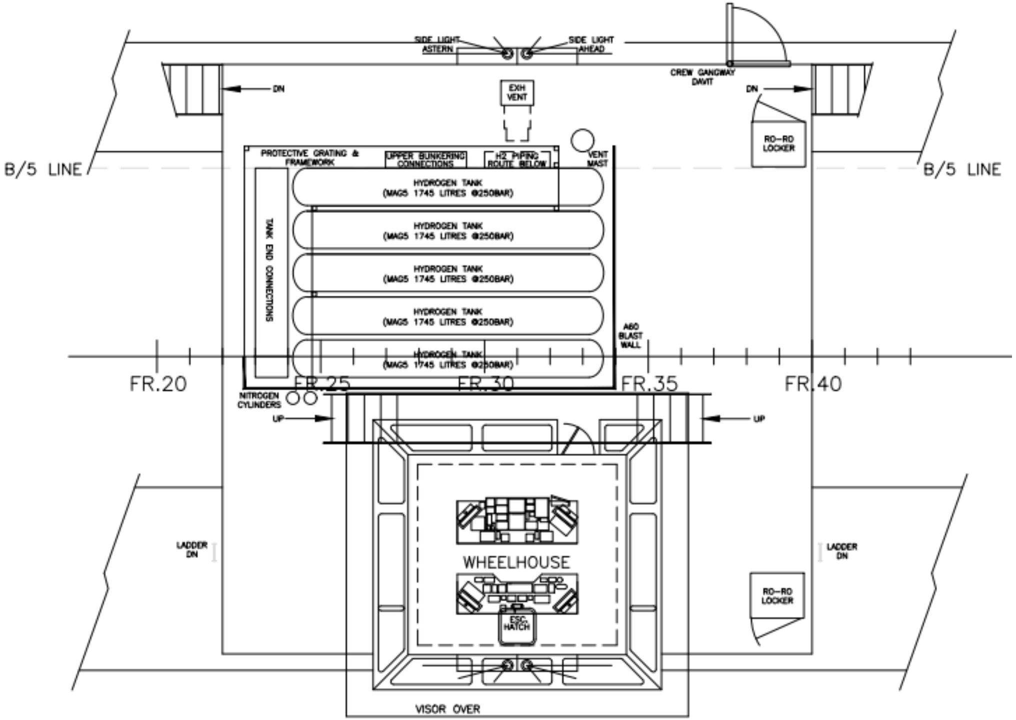
Concept Design Rendering

Vessel GA – below Main Deck



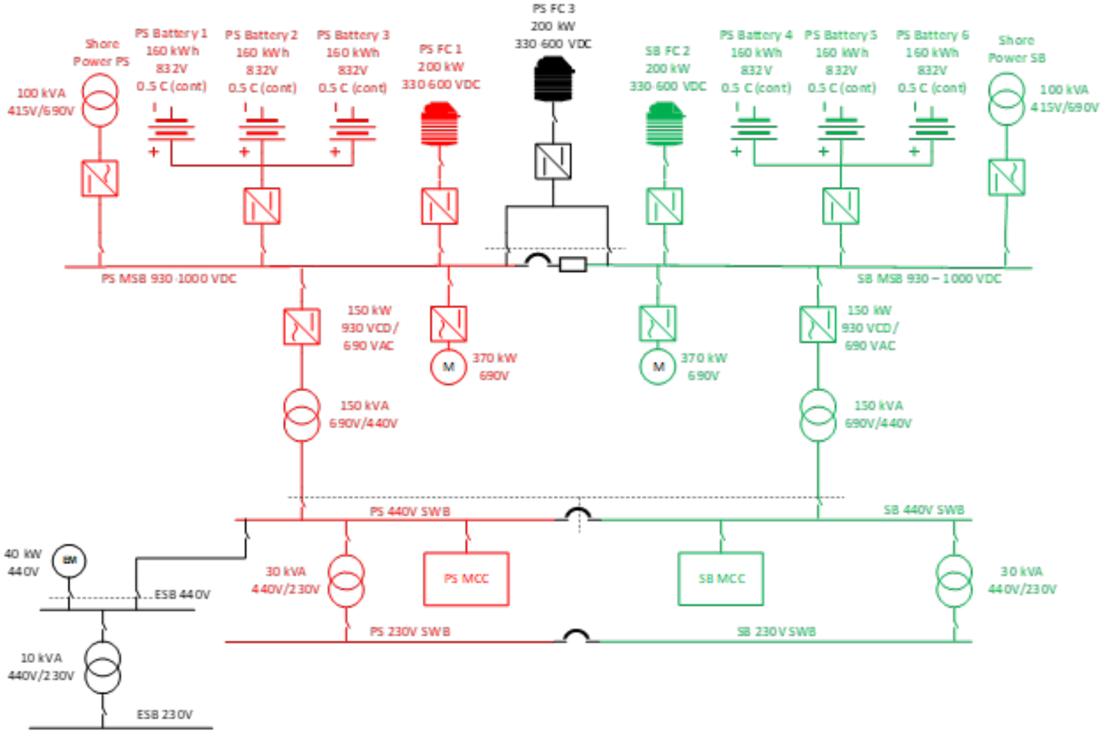
Vessel GA – Bridge Deck





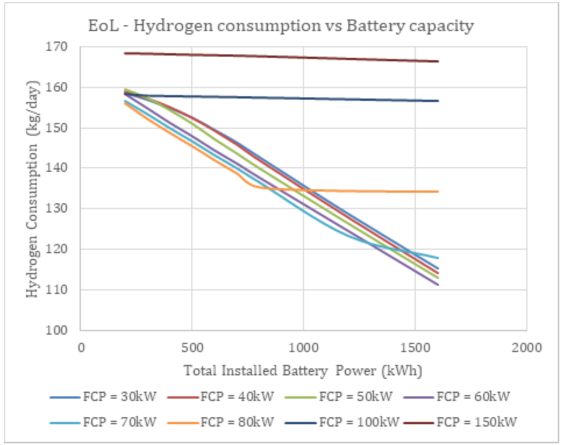
Electrical SLD

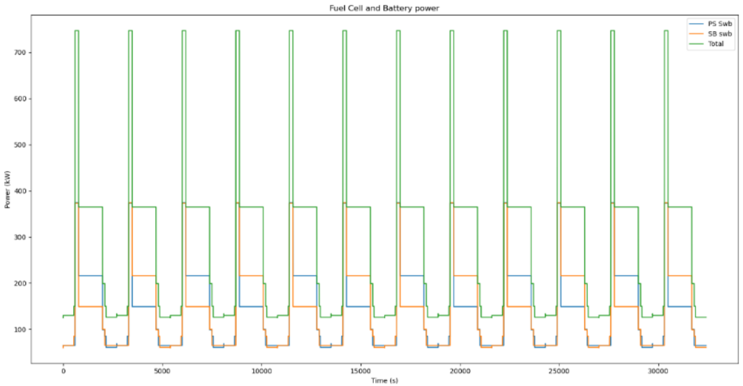
- DC distribution system (930 - 1,000 VDC).
- Operated closed bus.
- 6 x 160 kWh battery strings arranged in 2 groups (832V).
- 2 or 3 x 200 kW LT PEM FC (330-600 VDC).
- 2 shore power connection points for battery charging (3 phase 415 VAC).
- 2 x 370 kW Voith propulsion units (690 VAC).
- 440VAC and 230VAC switchboards for auxiliaries.
- Emergency switchboards and generator (40kW).

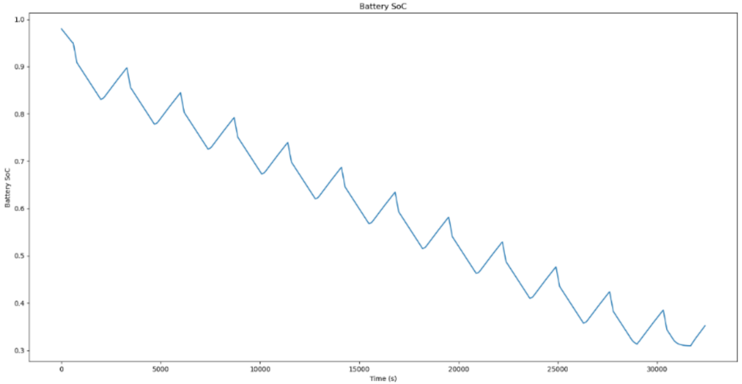


Modelling for hydrogen sizing

- Need to determine hydrogen consumption based on vessel operation.
- Load profile based on vessel hydrodynamics and expected operating profile. Hotel loads based on load analysis.
- Beginning-of-Life and End-of-Life characteristics considered for fuel cell and batteries.
- Python code to model system built and Power Management System (PMS) to simulate system performance.
- Hydrogen consumption determined for various configurations.







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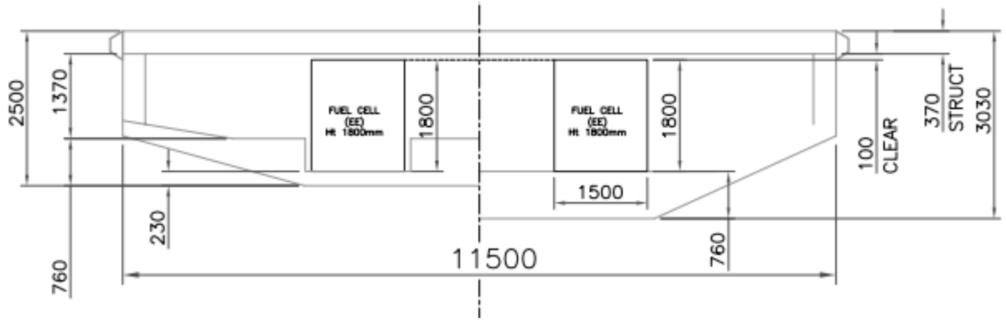
Design Constraints and Challenges

Project / Design challenges

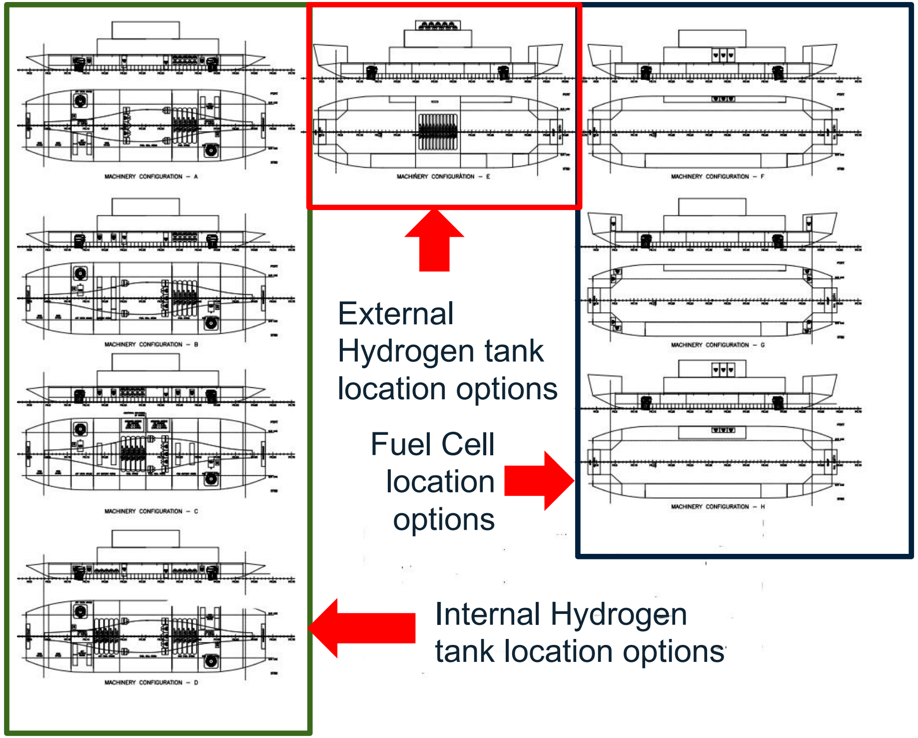
1. Absence of specific marine hydrogen fuel regulations.
2. Unclear route to approval
3. Equipment selection – procurement rules, vendor engagement, lack of vendors with fully developed products.
4. Spatial constraints – equipment, hazardous zones.



Guidance

Design Constraints and Challenges II

Tank location options



Restrictions

Options limited by ships function and IGF code.

- Below Main deck – insufficient space.
- Main deck - encroachment of vehicle capacity.
- Upper deck – all possible locations prohibited by IGF code.
- Bridge deck – only credible location.

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Conclusions

- Hydrogen as a marine fuel is in it's infancy but beginning to make a breakthrough.
- Short sea ferries are a viable vessel type for hydrogen powered vessels.
- Numerous challenges from both vessel design and infancy of hydrogen vessels.
- Vessel design constraints limited,
  - Hydrogen storage location and volume.
  - Height restrictions in machinery spaces.
  - Hazardous zones and safety equipment location.
- Industry barriers,
  - Lack of approved equipment options was a problem.
  - No clear design process due to lack of regulations and approval process.
- Overall conclusion is that hydrogen powered vessel market will begin expanding quite rapidly, however barriers still exist.

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