



LH2 SHIPPING

Advancing from LH2-fuelled car passenger ferry,
M/F Hydra, to shortsea cargo ship

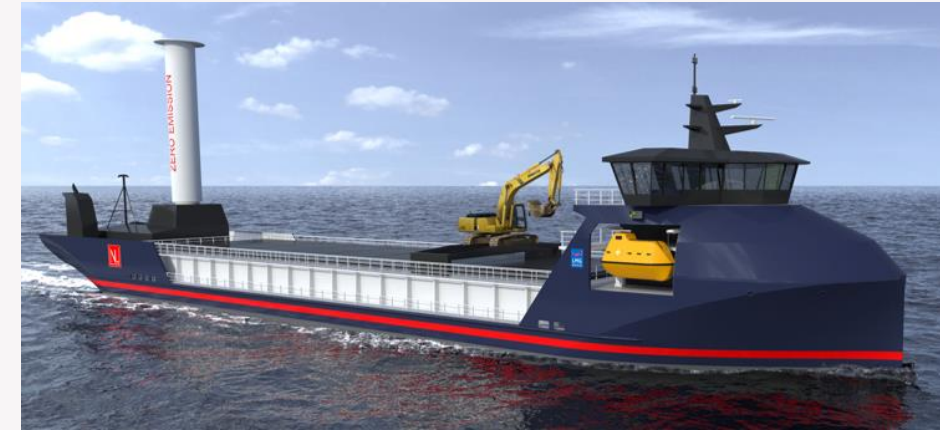
Dr. Ivan Østvik, CEO LH2 Shipping
ZESTA, London 11-12 September 2023

Company mission

Develop and build LH₂ driven ships



LH2 SHIPPING



Pictures: Westcon Yard/Norled/LMG Marin

Development, construction and commissioning of LH₂ driven ships towards:

- Cargo owners, cargo traders, ship brokers, ship operators, ship owners

Ensure technical and commercial viability of ship projects:

- Detailed technical and operational analysis of LH₂ ship operations
- Cooperation with energy producers for LH₂ supply chain and bunkering solutions

Ensure safe operation of the LH₂ onboard ship systems:

- Crew training, certification, alternative design, risk assessment and operational support

Background

Regulatory outlook



Shortsea fleet consists of older tonnage where 80% is built before 2010.

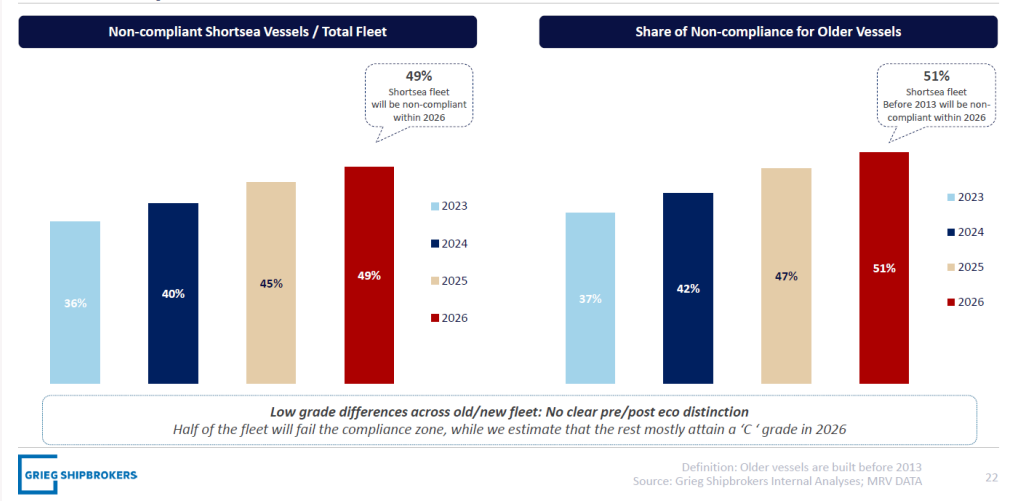
Grieg Shipbrokers analysis' shows that more than half the fleet will be in non-compliance with stricter emission regulations from the EU.

This will result in added OPEX costs.

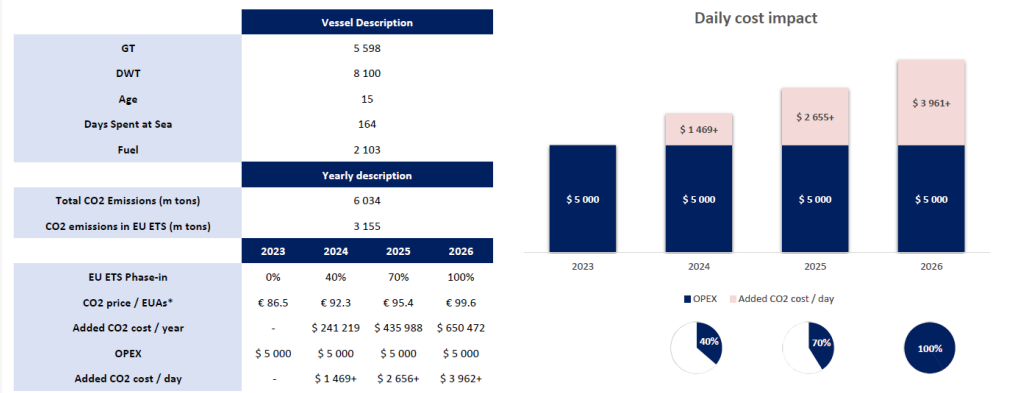
LH₂ fuelled vessels will be timely by 2026 and represent an opportunity for ship owners.

M/F Hydra, world's first ship sailing on LH₂ fuel, is in operation in Norway since March 2023 with DNV certified technology and good operational performance.

Non-Compliance Alert: Shortsea Fleet at Risk



Case Study: Shortsea and EU ETS Cost Implications



Introduction



LH2 Shipping, with partners LMG Marin and Seam, are developing LH₂ driven shortsea cargo ships.

LH₂ as fuel offers zero-emission operation with certified ship technology ready for commercial use.

Car and passenger ferry M/F Hydra has been in operation since March 2023 and sails with very good performance.

CEO of LH2 Shipping was project manager for M/F Hydra.

LH2 Shipping is targeting several shipping segments.

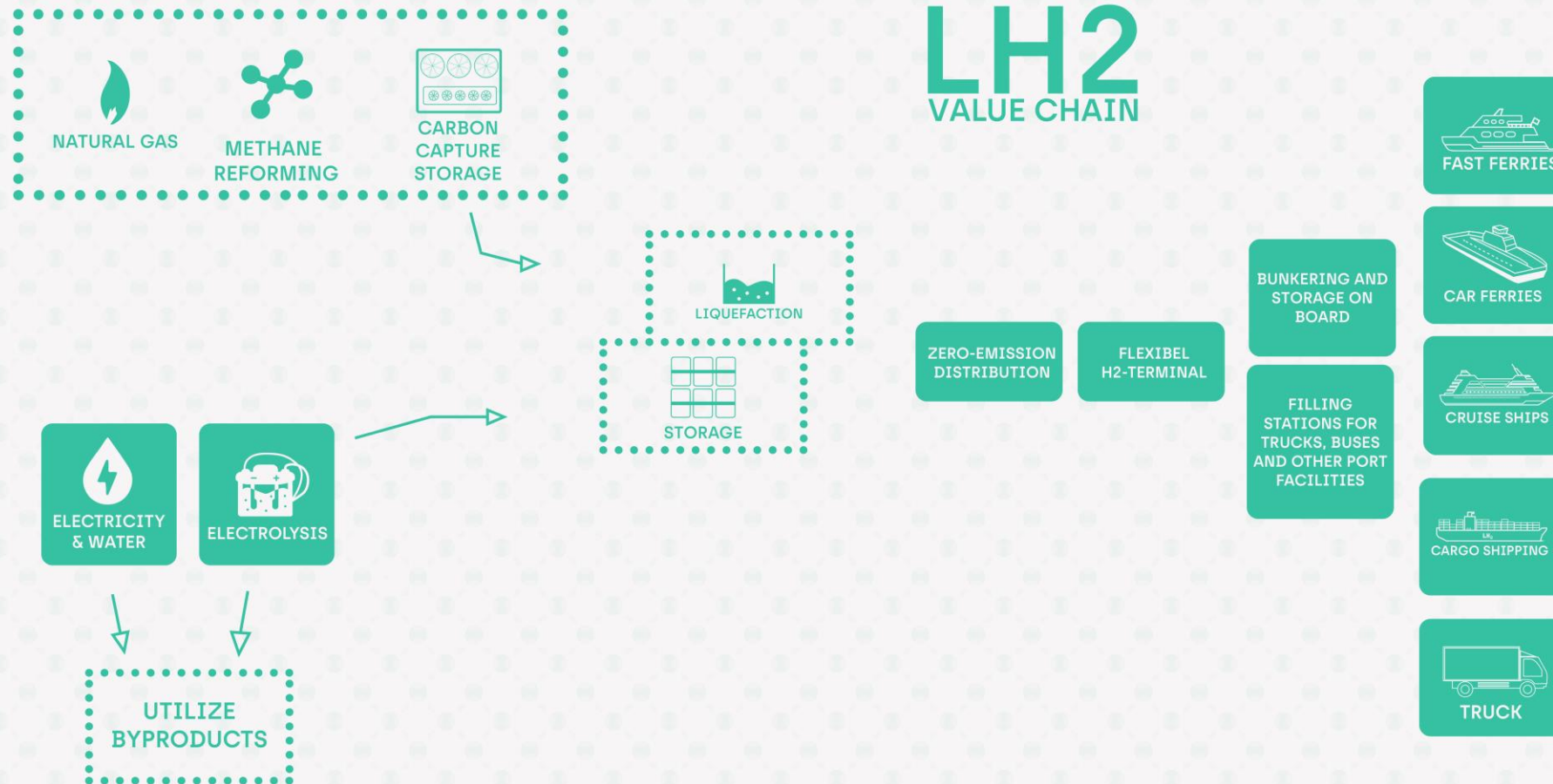
The LH₂ solutions shown in this presentation can be implemented for all three targeted ZESTA shipowner cases/challenges with modifications to storage and fuel cell capacities.



M/F Hydra, world's first ship sailing with LH₂ as fuel. Ship and technology certified by DNV (class) and NMA (Flag). Picture: Norled



LH₂ supply chain



Picture: LH2 Shipping

LH₂ bunkering operations

LH₂ fuel is transported from production sites for blue/green hydrogen to dedicated LH₂ bunkering sites.

M/F Hydra is bunkering 3 tons per hour from LH₂ delivery trucks/containers.

Future solutions will see a mix of trucks, containers and bunker vessels delivering LH₂ to ship bunkering sites.



LH₂ bunkering of M/F Hydra using LH₂ transport containers.
Method to be scaled for future projects.
Picture: Østvik

LH₂ ship systems



Certified LH₂ ship system can be developed, installed and commissioned for cargo ships.

New development projects use learnings from M/F Hydra, world's first LH₂ driven ship.

The LH₂ system are designed to meet roundtrip requirements for North, Baltic and Irish Sea operations:

- LH₂ storage capacity 10-20 tons (ops profile related)
- Fuel Cell installation 1,5-2,5 MW @ 50% load
- Battery capacity 2,0-4,0 MWh

Alternative design/risk assessment for storage system, whereas FC/FC room is moving towards rules-based design.

Certification and training required for crew.



M/F Hydra's onboard LH₂ system with 4-ton storage tank, processing area and fuel cell room with 400 kW PEM FCs.

LH₂ storage and fuel cell systems certified by DNV.

Picture: Westcon Yard

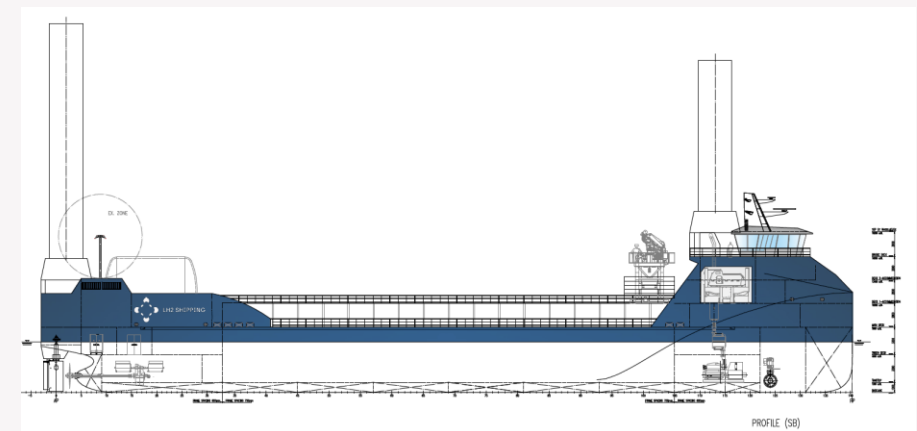
Ship design and operations

Detailed voyage analysis are conducted to:

- Define energy requirements for all voyage elements
- Define fuel costs and other OPEX
- Assess energy reduction equipment (sails, etc.)
- Optimise the onboard LH₂ system
- Develop bunkering schedules as part of voyage
- Plan port stays with shore power and/or FC operations

Resulting in cargo ship designs, such as:

Length over all:	95m
Molded depth:	8m
Beam:	16m
Fully loaded draught:	6m
Deadweight capacity:	5000t
LH ₂ storage capacity	15 tons
FC system	2MW



Pictures: LMG Marin

Veer Voyage challenge

Veer Voyage sailing ship to operate in North Atlantic with container transport. A hydrogen fuel consumption of 3,9 kg/nm @ 10 knots and 4,9 kg/nm @ 11 knots is provided by Veer Voyage.

LH₂ ship storage and fuel cell operations onboard is available for zero emission operation. This is proven by M/F Hydra, sailing with DNV certified solutions.

An example fixed, relatively small onboard LH₂ tank, 10m long og 4m diameter, located at stern, can provide app. 5 tons of LH₂. This provides an energy content of up to 165 MWh and a nautical range (sailing without sails) of 1280nm/1020nm. Note that a larger tank with 10 tons capacity has only a marginal higher CAPEX costs and will thus provide double range.

Fuel cells to be located under deck in a FC room with required 1,5-2,0 MW capacity.

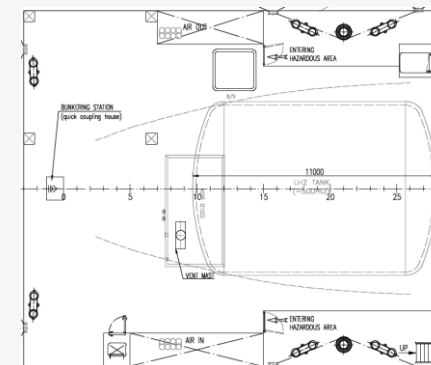
Main challenge is currently LH₂ supply in ports. LH₂ supply issue is improving and by 2027 is should be available in US and Europe, thus contracts for LH₂ supply can be made.

Bunkering times will be 2 hrs. based on current technology. Small safety area in port for bunkering operations, 25m radius, with limited influence on ship container operations.

Operational support, certification and crew training can be provided.



Picture: Veer Voyage



Picture: LH2 Shipping. Stern location of LH₂ tank, FCs located on deck below.

Wah Kwong challenge

Ships are operating world-wide and represents a set of ship types; gas tankers, oil tankers, bulk carriers, container vessels and LNG. The example is utilising the lower ship segment: 8MW engine, energy consumption of 4MW/hr and a 20-day voyage. This vessel uses 1920 MWh per journey.

A potential LH₂ ship storage and fuel cell solution for this vessel is:

- A fuel cell efficiency of 50% requires LH₂ onboard storage of 3840 MWh.
- The vessel deck is large, and crew is experienced with ex-zones. Retrofit may be possible, check deck strength, ex-zones.
- With six -6- fixed, onboard LH₂ tank, 12m long og 8m diameter, located on top deck at dedicated positions, each storing 20 tons of LH₂ (660 MWh each) provides sufficient energy content for such a journey. Larger tanks can also be made.
- 8-10 MW fuel cells can be divided into 6 smaller parts and located at each tank location in a FC room with required app 1,5 MW capacity.

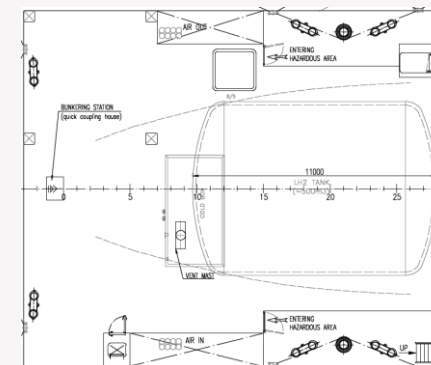
Main challenge is currently LH₂ supply in ports. LH₂ supply issue is improving and by 2027 is should be available in US and Europe, thus contracts for LH₂ supply can be made.

Bunkering times will be 6-7 hrs. per storage tank based on current technology. Small safety area in port for bunkering operations, 25m radius, with limited influence on other ship operations. Several bunkering stations can be made available for ship.

Operational support, certification and crew training can be provided.



Picture: Wah Kwong



Picture: LH2 Shipping



LH2 SHIPPING

Enabling safe, sustainable and cost-competitive sea transport using LH₂ as fuel