Fuel cells: Addressing the key technical challenges

3 June 2020 • 09:00-09:45 BST

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Part of
Maritime Hybrid, Electric and Fuel Cells
Webinar Week

1-4 June 2020

marine propulsion & auxiliary machinery

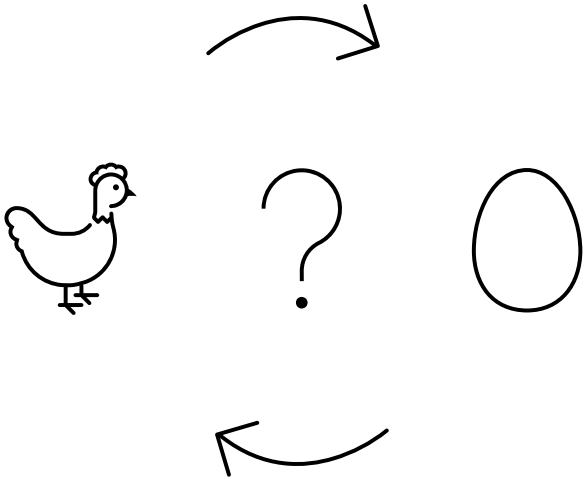
riviera

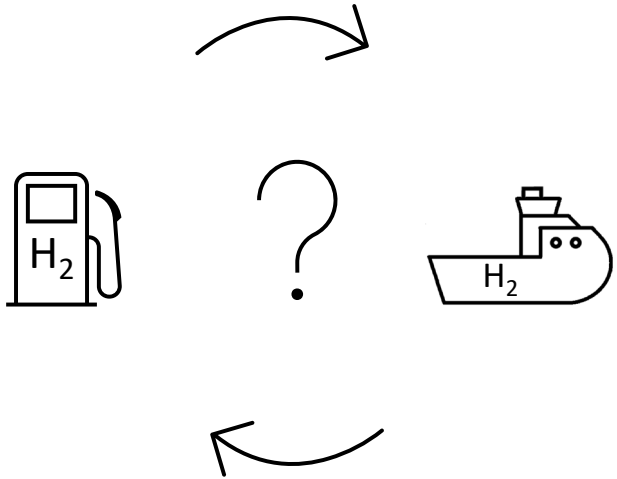
ROADMAP TO A HYDROGEN FUTURE

ULSTEIN SX190 ZERO-EMISSION

MARITIME HYBRID, ELECTRIC AND FUEL CELLS WEBINAR
KO STROO | ULSTEIN DESIGN & SOLUTIONS
3 JUNE 2020

WHICH CAME FIRST ?





ZERO-EMISSION SHIPS

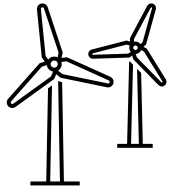
FOUR HYDROGEN CHALLENGES

Regulations

development and acceptance of regulations for bunkering and hydrogen power systems

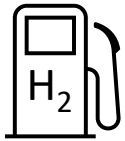
Green hydrogen

large scale production of hydrogen from renewable energy sources



Infrastructure

development of suitable transport, bunkering and storage technology



Cost

willingness to cover initial extra cost for hydrogen fuel and technology

ULSTEIN SX190

ZERO-EMISSION OFFSHORE SUPPORT

- Length 99.0 m
- Draught 3.5 - 6.0 m
- Deadweight 5000 ton
- Designed to IGF code
- Hydrogen system cost +25%
- Hydrogen fuel cost +50%

FUEL FLEXIBILITY

H_2 fuel cell room

2000kW

MDO engine room

5500kW

5x 40’ container

500bar H_2

90 POB

1000m^2 work deck

Electric power & DP system

HYDROGEN ROADMAP

2040

Full LH_2

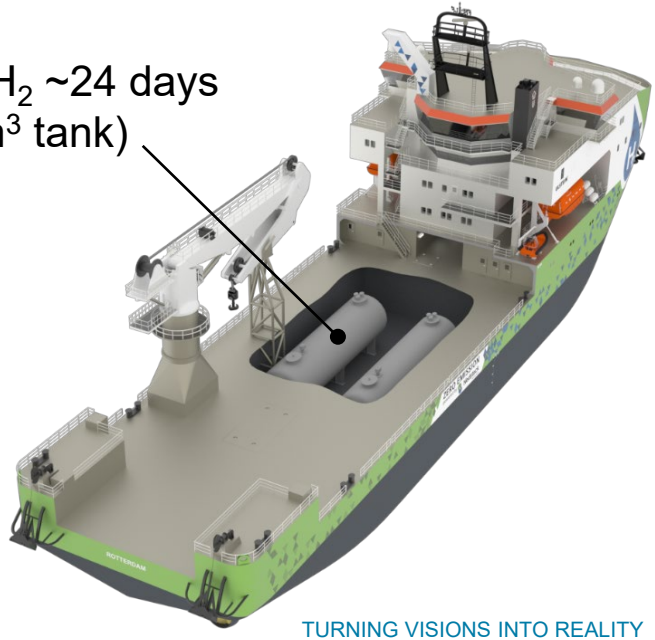
Liquid H_2 bunkering

Hybrid LH_2 ~24 days
(2x 300m^3 tank)

Hybrid LH_2 ~13 days
(5x 40ft)

Hybrid GH_2 ~4 days
(5x 40ft)

2020



Let’s Navigate Towards Zero-Emission Shipping

- Fuel cell power installations
- Megawatt applications

Fuel Cell Technology

Fuel cell power installation (FCPI)

FCPI
2MWe

GE POWER CONVERSION
PWM Drive / Transformer and Power Management

NEDSTACK
PEMGEN™ FC Power Systems

2 MW BoP Module Appearance

2 MW Stack Module Appearance

2 MWe End of Life

Vessel Layout
GE electric drive system

Sea-proven advanced power electronics

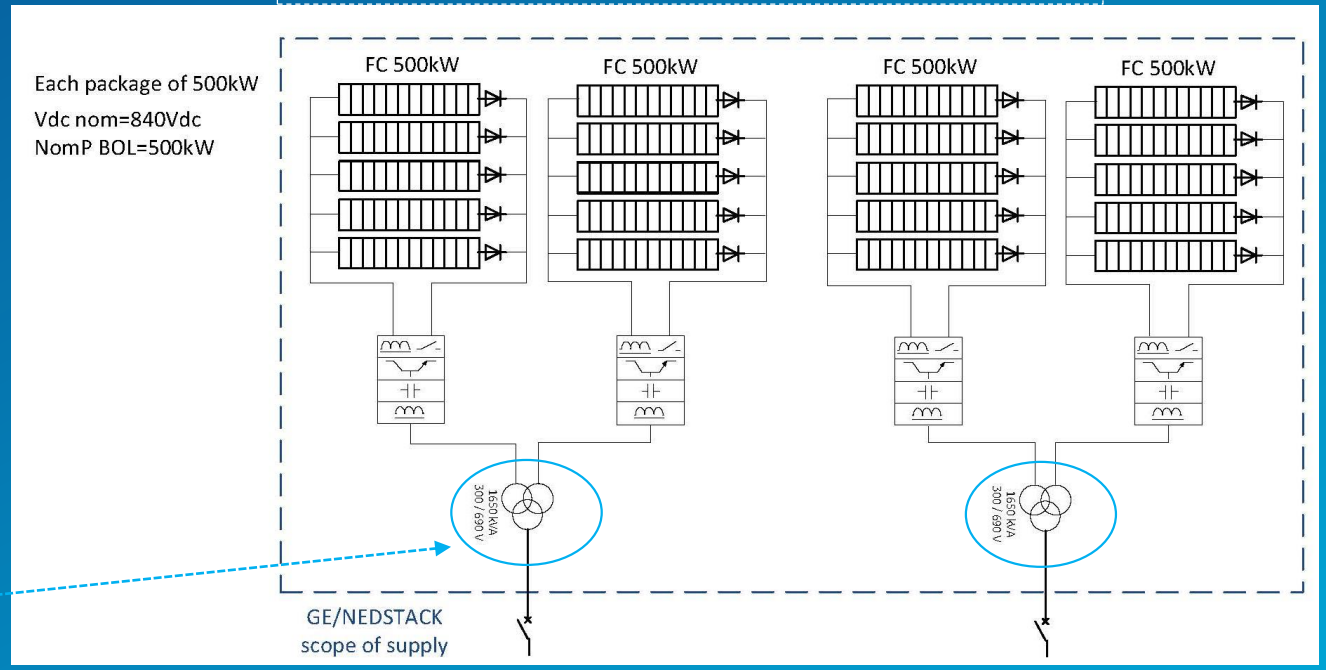
2 & 3 MWe EoL FCPI

- Meets maritime power density & redundancy
- Emphasis on fuel cells' protection & selectivity
- Solution protects against current ripple & short circuit

Galvanic Insulation

- Low common modes & high insulation needed
- Safe operation, no blackout – resilient under fault conditions

2 MWe FCPI
Single line diagram (SLD)



Compactness, Redundancy, Anti-Blackout

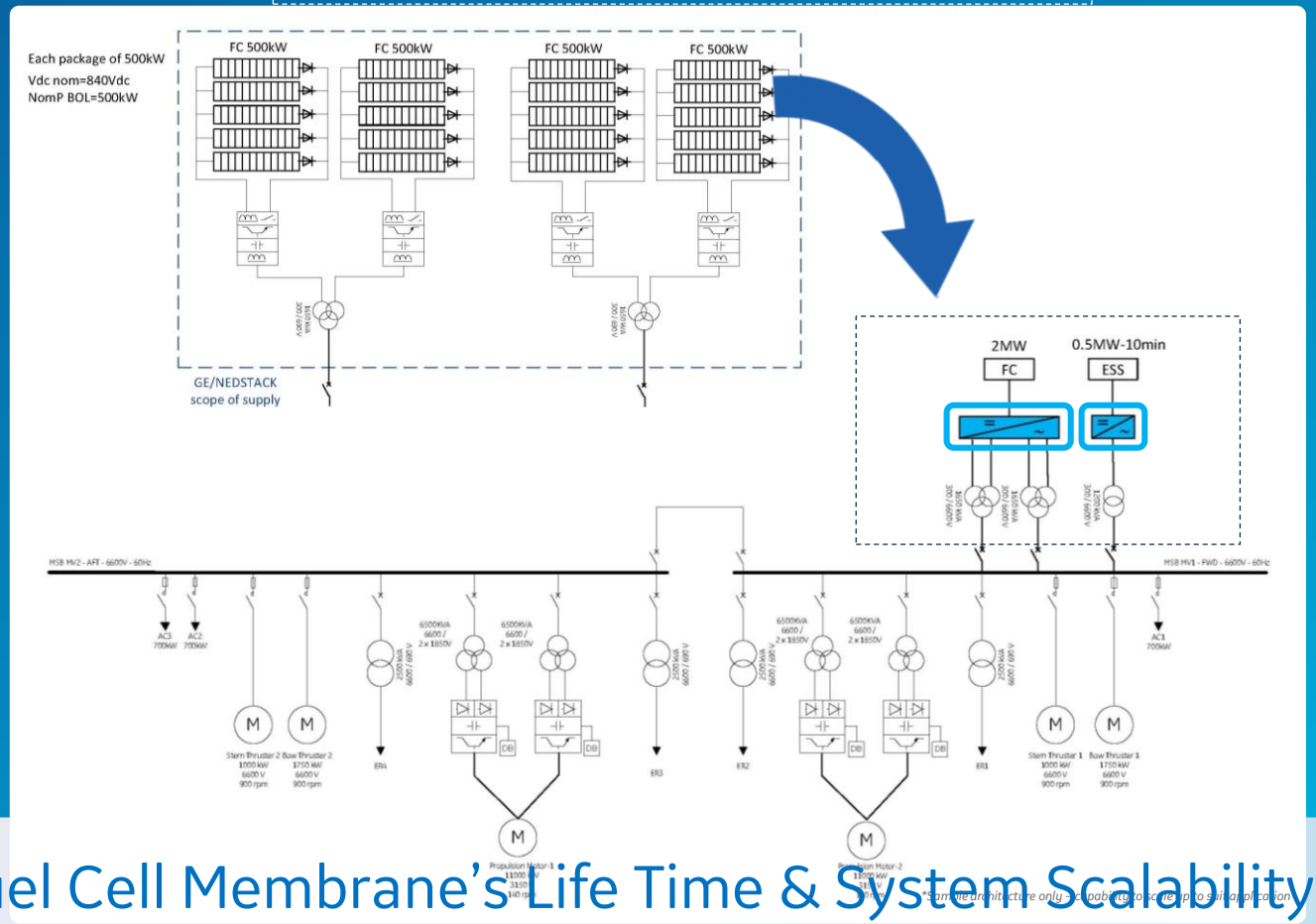
Fuel Cell Power Requirement
For different classes of ship

Fuel cells' life efficiency & expectancy

GE's fuel cell system architecture, variable frequency drive & dedicated Power Management System (PMS) are engineered to limit the switch-on and -off frequency of the fuel cells when sailing or in port.

- Hybrid power plant to fit any ship type & size
- Extends fuel cell total product life.
- Improves control & efficiency

2 MWe FCPI
System SLD

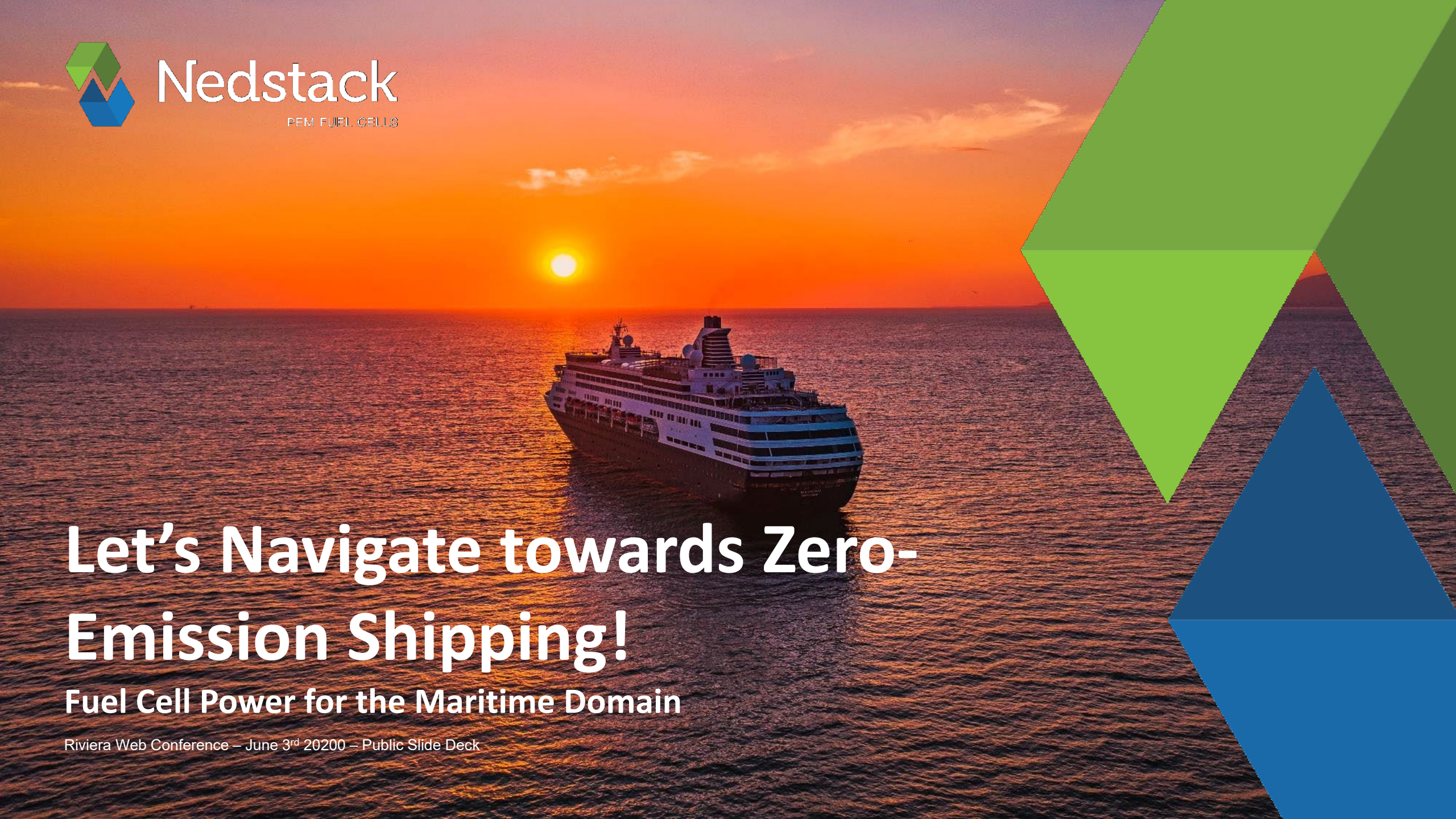


Fuel Cell Membrane's Life Time & System Scalability

*Same electric architecture only - capability to scale up to suit application

Nedstack

PEM FUEL CELLS



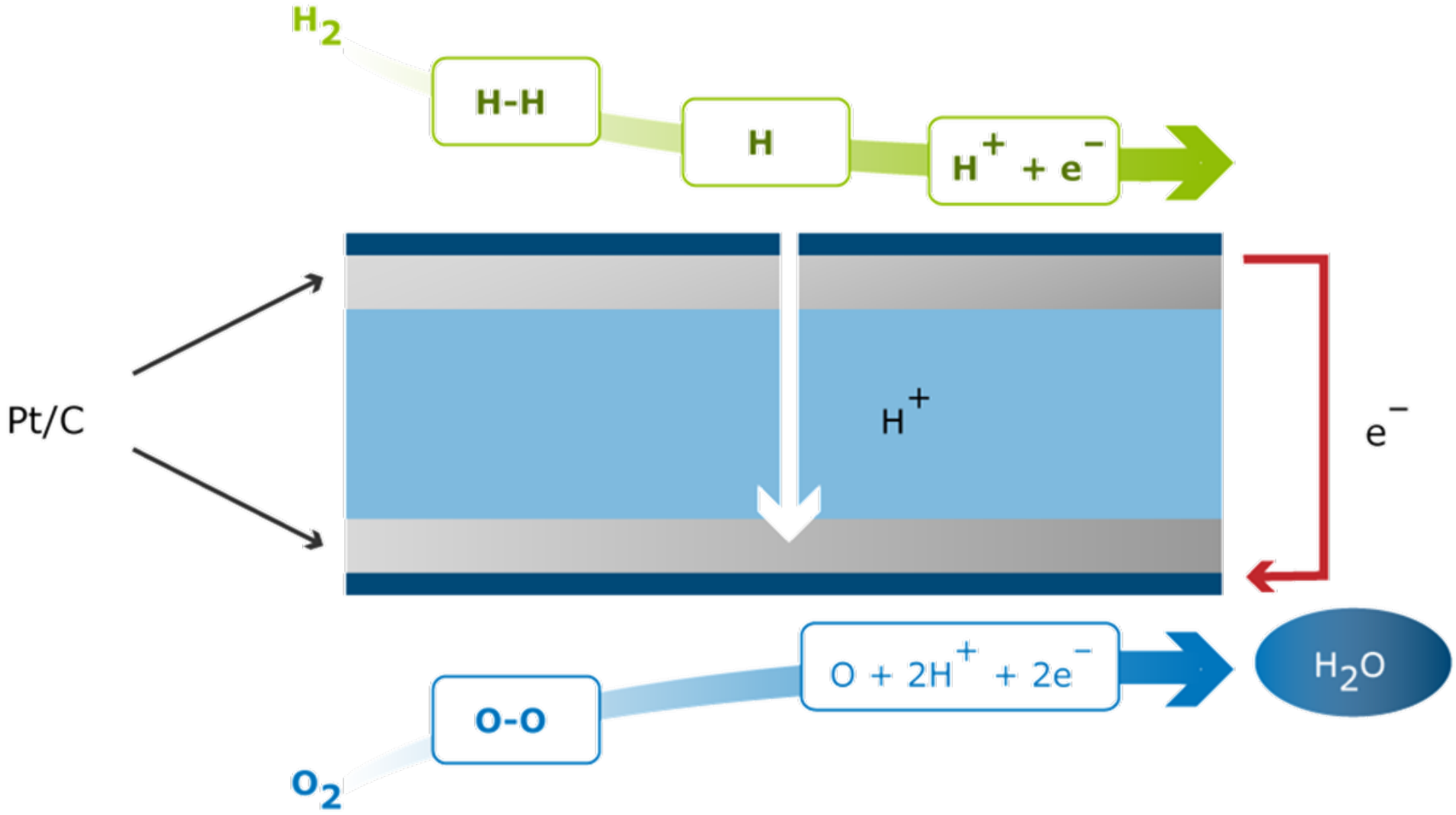
Let's Navigate towards Zero-Emission Shipping!

Fuel Cell Power for the Maritime Domain

Riviera Web Conference – June 3rd 20200 – Public Slide Deck

Fuel Cells are Electro-Chemical Reactors

As opposed to batteries they are not accumulators



What Makes a PEM Fuel Cells Maritime Fit?

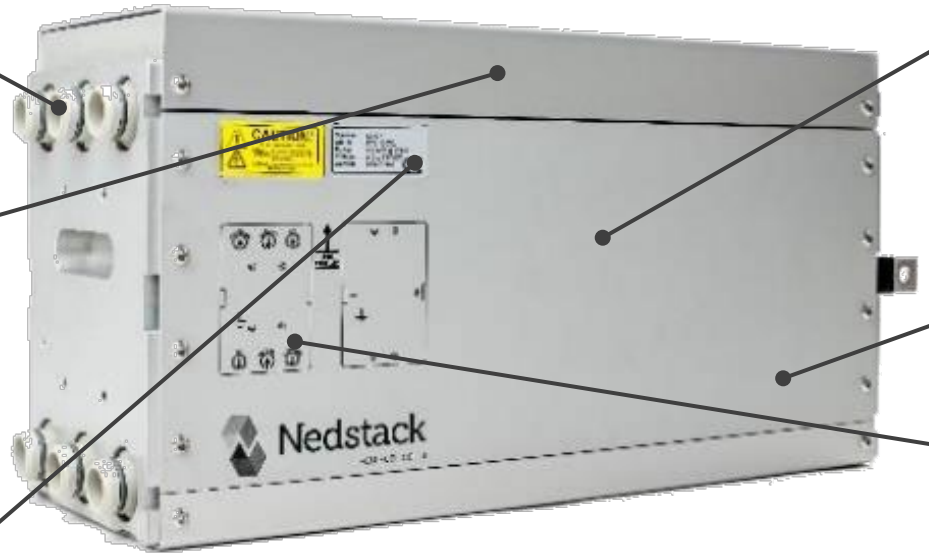
Robustness, XXL Lifetime and a Mature Safety Concept

Nedstack
PEM FUEL CELLS

Quick Connectors for easy servicing and refurbishment

Integrated State of Health Monitor

Designed and Tested to IEC 62282-2



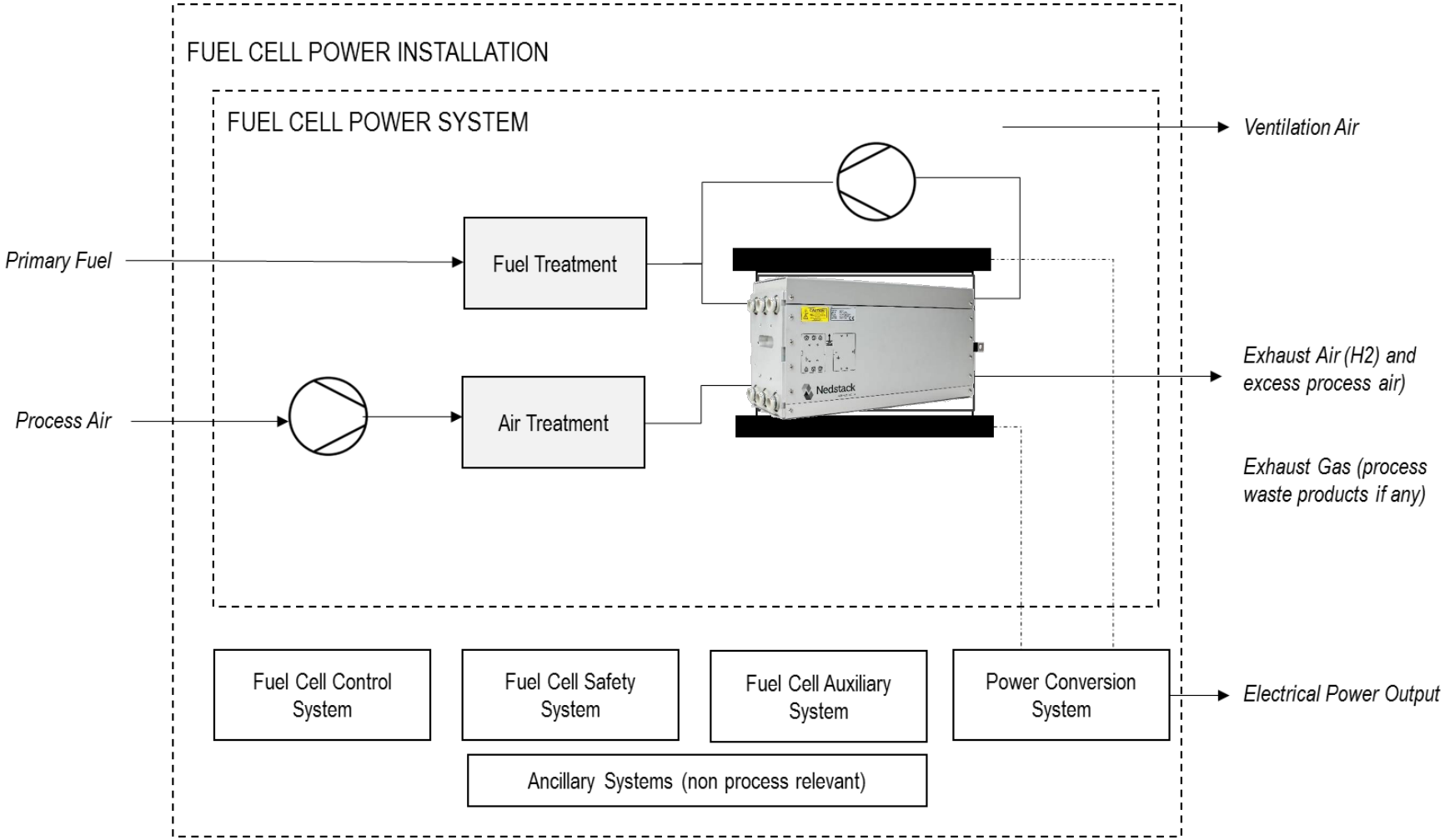
Robust Cassette Type design

XXL-Long Life MEA's
Fuel Tolerant (Grade 2.5)

Safety concept based on Low Pressure to reduce H2 volume

PemGen Maritime Fuel Cell Power Systems

IGF Code on Low Flashpoint Fuels Ch. E + Class Rules



1) IMO CCC-5-3 ANNEX 4 – relevant to the Pending IMO IGF Code on Low Flashpoint Fuels - Chapter E

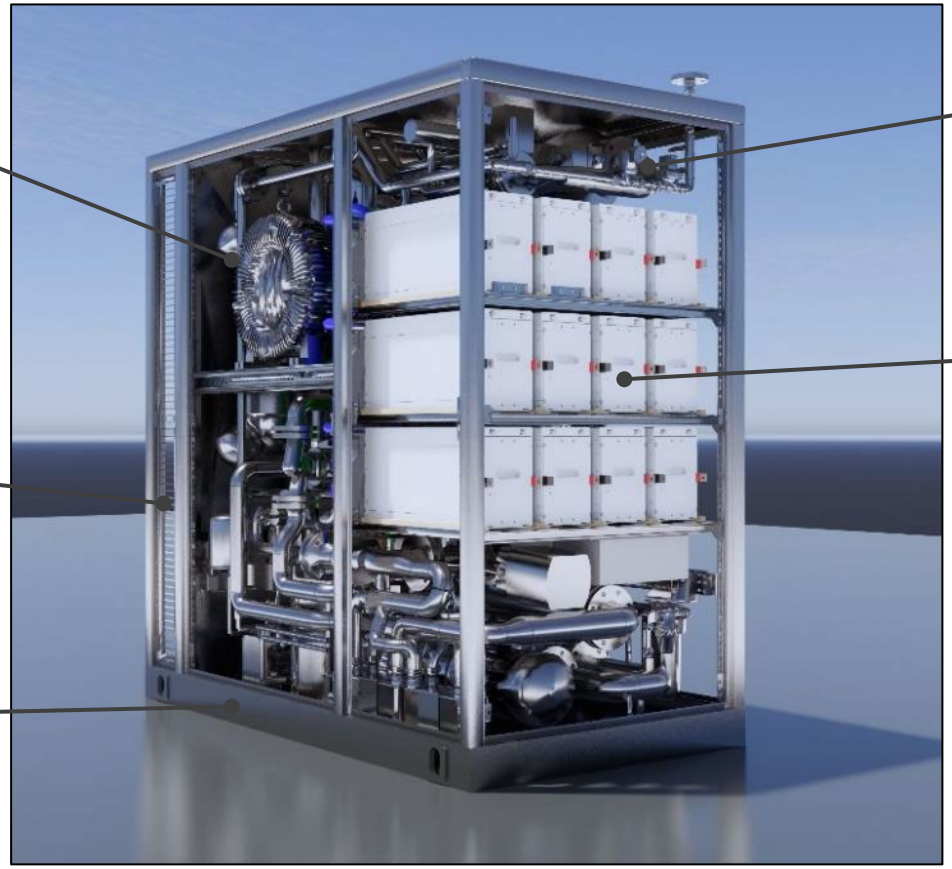
What Makes a Maritime PEM Fuel Cell Power Installation?
Supply Chains, Testing and Trade-Offs

Nedstack
PEM FUEL CELLS

Maritime / Industry Grade Balance of Plant

Electrically Optimized to integrated with maritime Power Conversion Systems

Robust and flexibly built level by Skid / Canopy



Quasi Atmospheric H2 system

Swappable XXL-Long Life PEM Stacks for short maintenance downtime

Alternative risk-based design in cooperation with Class Society for safety concept

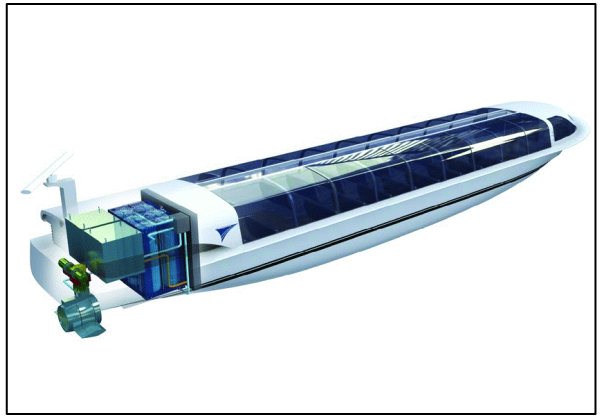
Are Maritime Fuel Cell Systems Ready for Deployment?

12 years of Ongoing Commitment. Time to Go

Nedstack
PEM FUEL CELLS

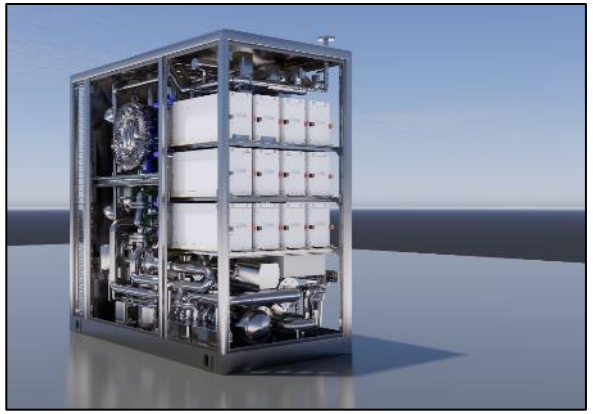
2008 **2020**

First Class Approval Experience



> DNV-GL Certified in 2012

Industrialization Program

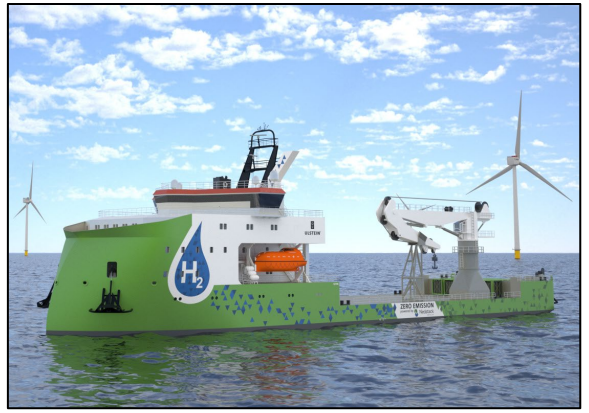


> PemGen® MT (Maritime Portfolio)

Sea Worthiness Verification

> MARIN Trials (2018-2020)

Ready for Demo and 1st deployment



> GE Power Alliance (2018- >)

ULSTEIN®

ULSTEIN SX190

ZERO-EMISSION DP2 CONSTRUCTION SUPPORT VESSEL

- Length 99.0 m
- Beam 23.8 m
- Hydrogen fuel cells
- Hydrogen/MDO hybrid
- 4+ days zero-emission endurance
- 60 - 90 POB
- Developed by Ulstein Design & Solutions B.V. and Powered by Nedstack

WWW.ULSTEIN.COM

GENERAL SPECIFICATIONS

Type	Construction support vessel
Design	ULSTEIN SX190 Zero-Emission
Designer	Ulstein Design & Solutions B.V.
Hydrogen fuel cells	Proton-Exchange Membrane (PEM) 2,000 kW (4 x 500 kW)
Main generator sets	2 x 2,000 kW 1 x 1,500 kW
Service speed	11.0 knots
Positioning system	DP2 4-point mooring
Propulsion thrusters	2 x 1,280 kW
Fwd azimuthing thrusters (retractable)	2 x 880 kW
Tunnel thrusters	2 x 750 kW
Deck area	1000-1200 m^2
Deck strength	10 t/m^2

MISSION EQUIPMENT

Main crane (optional)	50-100 mt
Cable carrousel (optional)	3000 t
Project store (below deck)	500 m^2

The ULSTEIN SX190 Zero Emission DP2 construction support vessel is Ulstein's first hydrogen powered offshore vessel featuring a Nedstack fuel cell power system. The design uses proven and available technology, enabling clean shipping operations to reduce the environmental footprint of offshore projects.

The PEM fuel cells used in the SX190 Zero-Emission design are fueled by hydrogen from containerized pressure vessels, a well proven and readily available technology. These hydrogen storage containers can be loaded and unloaded by normal container handling operations and equipment, eliminating the need for expensive bunkering infrastructure and providing worldwide operational flexibility.

With today's technology, the SX190 design is already capable to operate 4 days in zero-emission mode and to satisfy about 90% of all offshore support missions. However, with the rapid developments in hydrogen storage and fuel cell technologies, we are targeting a future zero-emission endurance of up to two weeks. For extended missions and capabilities, the vessel can fall back on its more conventional diesel-electric system using low sulfur marine diesel oil.

Designed to be a compact vessel supporting a wide variety of offshore operations, the ULSTEIN SX190 Zero-Emission offers a well-balanced combination of accommodation, payload capacity and a flush work deck area. Its operational flexibility is further enhanced by incorporating both a shallow water DP2 system and a 4-point mooring system.

THIS IS ULSTEIN

WE CHALLENGE THE OCEANS. ULSTEIN offers ship design packages and solutions for offshore support vessels, heavy offshore vessels and shortsea vessels. Since 1917, the Ulstein brand has been associated with quality and innovation in design and delivery.
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PRINCIPAL DIMENSIONS

Length overall	99.0 m
Beam	23.4 m
Depth to main deck (moulded)	8.4 m
Draught max	6.0 m
Draught design	4.5 m
Draught min (DP)	3.5 m
Deadweight	5000 t
Accommodation (1p cabins)	60 persons
Accommodation (1p/2p cabins)	90 persons

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11 November 2019 09:45

Hydrogen Fuel Cell Power Systems

For Merchant Marine Applications

Fuel Cell power systems eliminate vessel exhaust gases and by extension prevent harmful pollutants ending up in our atmosphere, our ecosystem and in vulnerable port communities. PEM fuel cells only produce electricity and the only bi-products are water and heat -making them an ideal solution for zero-emission cruise ships. GE's variable speed drive technology manages power generated to supply electricity to propulsion and onboard systems, as well extending fuel cell life.

GE AND NEDSTACK PARTNERSHIP

GE Power Conversion and Nedstack, a leading fuel cell manufacturer, are collaborating on developing hydrogen fuel cell systems for powering zero-emission cruise vessels.

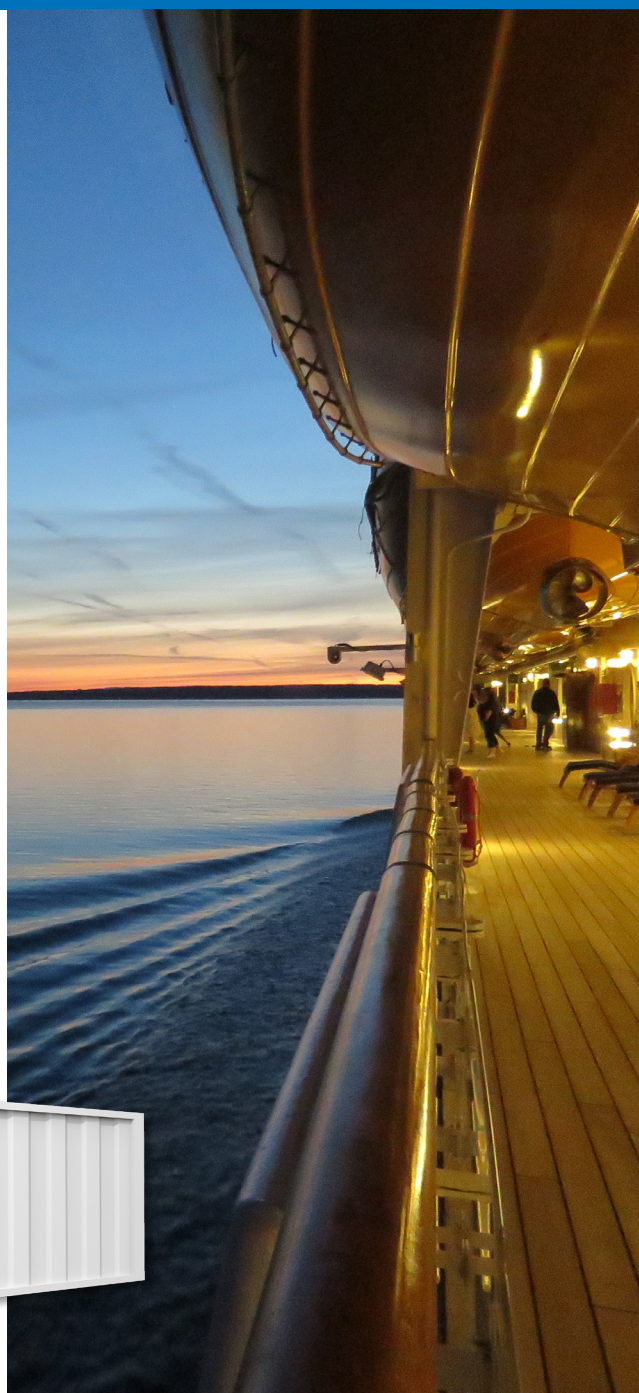
This partnership brings together GE's recognized expertise in cruise electrical power and propulsion solutions plus system integration capability, with Nedstack's extensive experience in megawatt-scale hydrogen fuel cell technology. The result will be highly efficient fuel cell solutions that enable a zero-emission cruise industry.

ZERO EMISSION CRUISING

The cruise industry shares a joint responsibility to eliminate the possible negative impacts it might have on port communities, the health of passengers and staff, and on the environment as a whole. Responsible zero-emission shipping is not only environmentally needed but will greatly contribute to the quality of the cruise experience itself.

Shipowners are already under pressure to comply with the reduced sulfur limit regulations coming into force in 2020. Both global International Maritime Organization (IMO) and regional regulations require marine vessels to reduce emissions or eliminate them altogether. GE and Nedstack have been working extensively on the 'marinization' of fuel cell technology to create a total zero-emission alternative that truly meets the needs of tomorrow's cruise industry.

This partnership brings together a rich pool of expertise that's spearheading much needed innovation. Given the marine transport and shipping sector's changing regulatory landscape, this innovation could not be more timely.



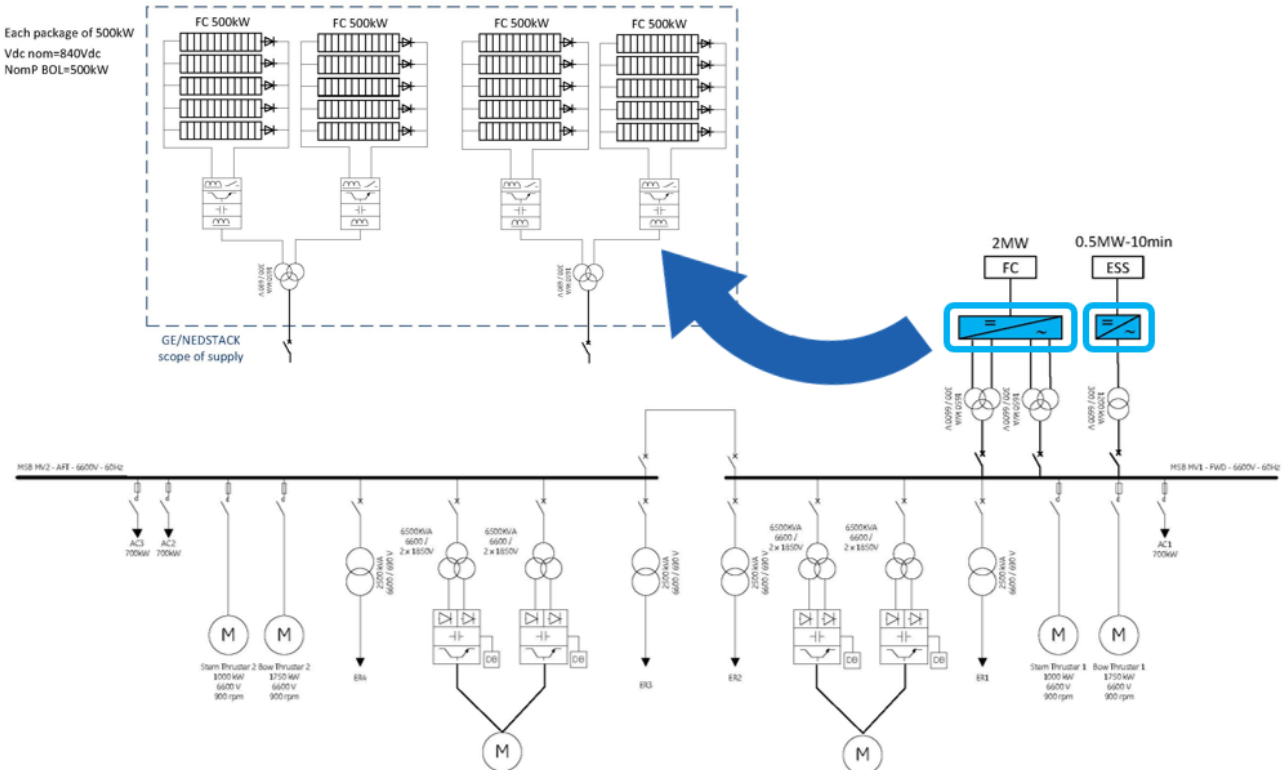
gepowerconversion.com

MARITIME FUEL CELL APPLICATIONS

GE and Nedstack envisage using this technology on passenger ships, replacing traditional diesel engines with fuel cells, and heavy fuel oil (HFO) with hydrogen. Together, GE and Nedstack have engineered the concept for a 2MW hydrogen fuelcell power plant on an expedition vessel.Initial results have been positive. Goal is a truly zero-emission system that will enable the world's first sustainable, clean cruise ships.

NEDSTACK'S FUEL CELL TECHNOLOGY

Proton Exchange Membrane (PEM) Fuel cells are electrochemical reactors in which a fuel and an oxidant are made to react in an electrochemical manner. Such reactors, as opposed to combustion reactions, do not produce any emissions other than pure water and can be scaled to multi-megawatt power ratings.



GE'S HYBRID ELECTRIC DRIVE SYSTEM

GE's variable speed electrical drive system is a crucial part of the system that optimizes control and efficiency by directing and managing the electricity produced by the hydrogen fuel cells. Frequently switching fuel cells on and off reduces their life expectancy – and this is a significant issue for vessels. To give some perspective, while a car's fuel cell is expected to operate for 7,000 hours, for a ship it needs to go over 20,000 hours. Machine longevity is essential. To overcome this, GE's variable drive, fuel cell system architecture and dedicated PMS are engineered to limit the switch on-and-off frequency of the fuel cells when sailing or in port. Indeed, optimizing the system and extending the fuel cells' lifespan is key to coping with the five-year dry dock intervals that cruise ships demand.

- **Improves control and efficiency**
- **Directly manages electricity produced by hydrogen fuel cells**
- **Extends fuel cell lifespan**

Nedstack and GE have designed a concept for a multi-megawatt hydrogen power plant for passenger vessels. The built-in redundancy and its scalability are promising. For more information please contact: marine@ge.com