Fuel cells: Addressing the key technical challenges

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Premier Partners

Panellist & partner documents

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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?

[Diagram showing a chicken and an egg on the left side, and a hydrogen fuel pump and a ship on the right side, with arrows indicating the sequence or relationship between them.]
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

- H₂ fuel cell room: 2000kW
- MDO engine room: 5500kW
- 5x 40’ container
- 500bar H₂
- Electric power & DP system
- 90 POB
- 1000m² work deck
HYDROGEN ROADMAP

2020

- Hybrid GH₂ ~4 days (5x 40ft)

2040

- Hybrid LH₂ ~24 days (2x 300m³ tank)
- Liquid H₂ bunkering
- Full LH₂

- Hybrid LH₂ ~13 days (5x 40ft)
Let’s Navigate Towards Zero-Emission Shipping

- Fuel cell power installations
- Megawatt applications
Fuel Cell Technology
Fuel cell power installation (FCPI)

GE POWER CONVERSION
PWM Drive / Transformer and Power Management

NEDSTACK PEMGEN™ FC Power Systems

FCPI
2 MWe

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

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
Let’s Navigate towards Zero-Emission Shipping!
Fuel Cell Power for the Maritime Domain
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

- Quick Connectors for easy servicing and refurbishment
- Robust Cassette Type design
- XXL-Long Life MEA's Fuel Tolerant (Grade 2.5)
- Safety concept based on Low Pressure to reduce H2 volume
- Integrated State of Health Monitor
- Designed and Tested to IEC 62282-2
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

- 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

2008

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-)

2020
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 DESCRIPTION

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. WWW.ULSTEIN.COM

GENERAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Type</th>
<th>Construction support vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>ULSTEIN SX190 Zero-Emission</td>
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<tr>
<td>Designer</td>
<td>Ulstein Design &amp; Solutions B.V.</td>
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<tr>
<td>Hydrogen fuel cells</td>
<td>Proton-Exchange Membrane (PEM)</td>
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<tr>
<td></td>
<td>2,000 kW (4 x 500 kW)</td>
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<tr>
<td>Main generator sets</td>
<td>2 x 2,000 kW</td>
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<tr>
<td></td>
<td>1 x 1,500 kW</td>
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<tr>
<td>Service speed</td>
<td>11.0 knots</td>
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<tr>
<td>Positioning system</td>
<td>DP2</td>
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<tr>
<td>Propulsion thrusters</td>
<td>2 x 1,280 kW</td>
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<tr>
<td>Fwd azimuthing thrusters</td>
<td>2 x 880 kW</td>
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<tr>
<td>Tunnel thrusters</td>
<td>2 x 750 kW</td>
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<tr>
<td>Deck area</td>
<td>1000-1200 m²</td>
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<tr>
<td>Deck strength</td>
<td>10 t/m²</td>
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MISSION EQUIPMENT

| Main crane (optional)       | 50-100 mt                   |
| Cable carrousel (optional) | 3000 t                       |
| Project store (below deck) | 500 m²                       |

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.

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 |

CONTACT

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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.

gerpowerconversion.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 fuel cell 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