Fuel cells:
Key operational challenges

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Part of
Maritime Hybrid, Electric and Fuel Cells
Webinar Week

1-4 June 2020

Presentation documents

Page 2: Kristina Fløche Juelsgaard, Ballard Power Systems Europe
Page 6: Joseph Pratt, Golden Gate ZERO Emission Marine
Page 11:Tjalve Magnusson Svendsen, Prototech

marine propulsion & auxiliary machinery
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Fuel cells: Key operational challenges

- service & maintenance

Kristina Fløche Juelsgaard
Director of Business Development

Maritime Hybrid, Electric & Fuel Cells,
Webinar June 4th, 2020

Power to change the world®

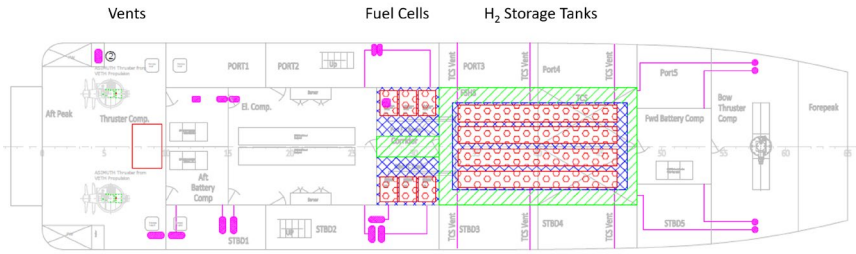
Operational Challenges

- How to go from combustion engines to fuel cells

New Technology – new operational challenges:

- New skills required (electrical, mechanical, gas)
- Different operational behaviour (less noise, vibration)
- Different safety measures and perception of safety
- Different service and maintenance routines
- Different indicators of technical issues

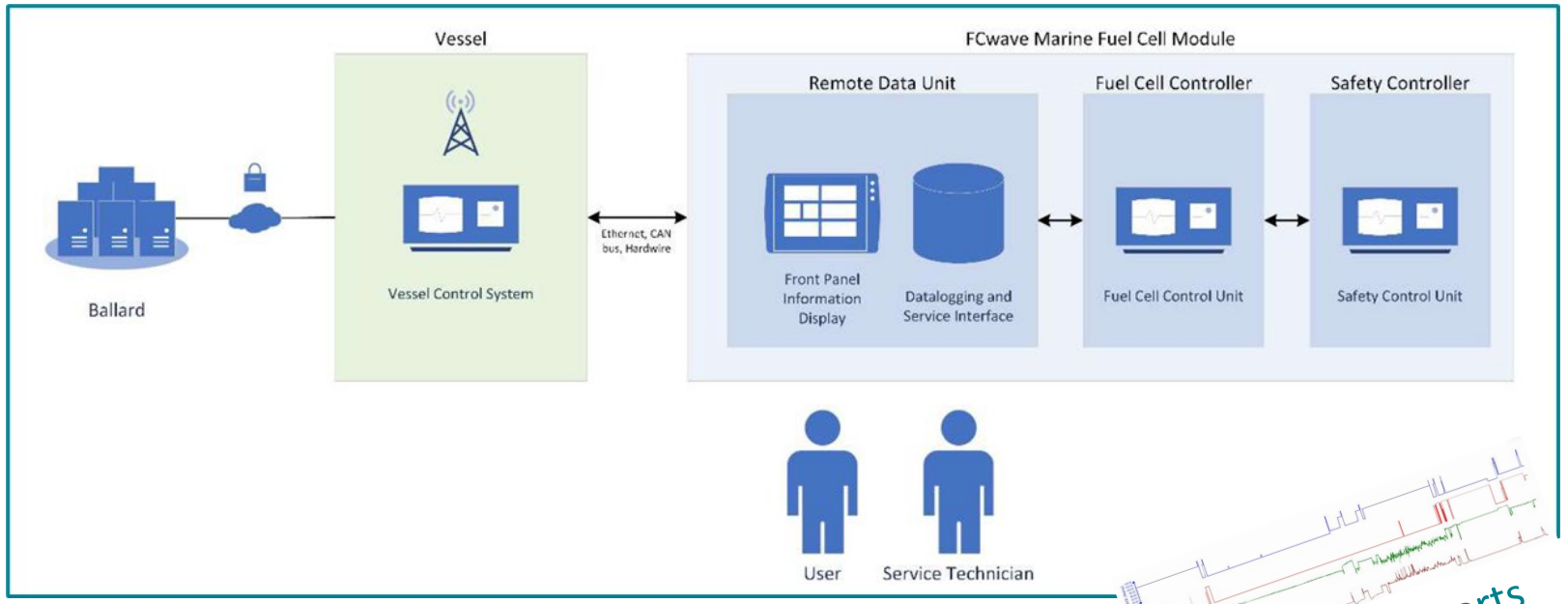
→ Risk

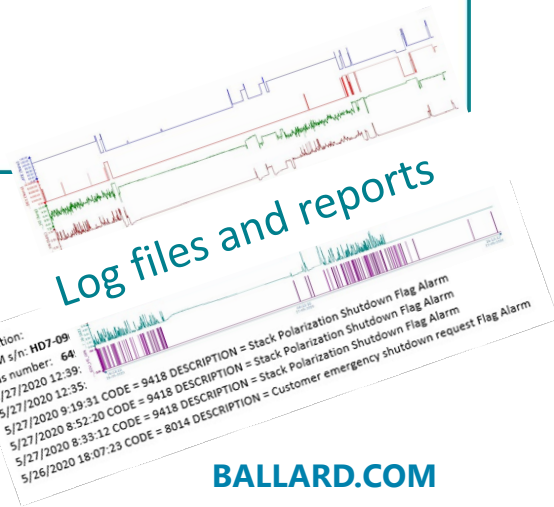


Service & Support Supply Chain

- When reliability, availability and efficiency are key!

- Service Setup
- Training Package
- Spare Parts Logistics
- Repair Options
- Monitoring and Control





3 Key take aways for successful operation:

- Full coverage Service Agreement

- Training and early involvement of staff

- Good Data collection and reporting

Thank you!

Kristina F. Juelsgaard
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We deliver fuel cell power
for a sustainable planet
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Fuel Cells: Key Operational Challenges

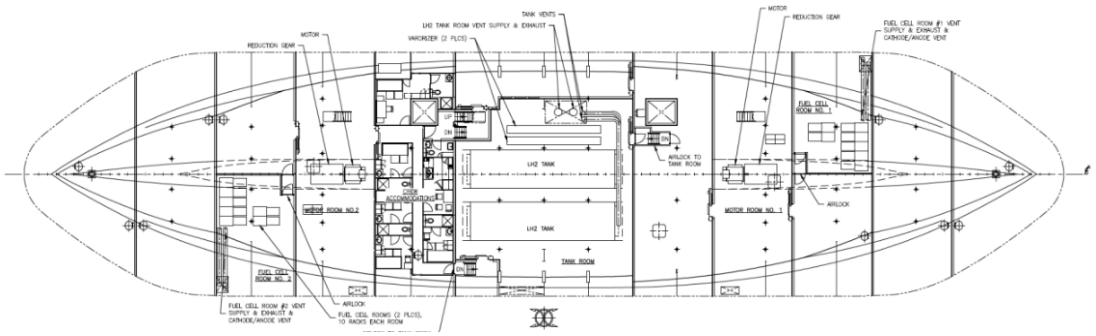
Joseph Pratt, CEO & CTO

GOLDEN GATE ZERO EMISSION MARINE

Maritime Hybrid, Electric and Fuel Cells Webinar Week
Riviera Maritime Media
June 1-4, 2020

Criteria for Adoption

1. Does the technology work?
2. Can it meet my performance requirements and arrangement limitations?
3. How much does it cost?
4. Where do I get the hydrogen?



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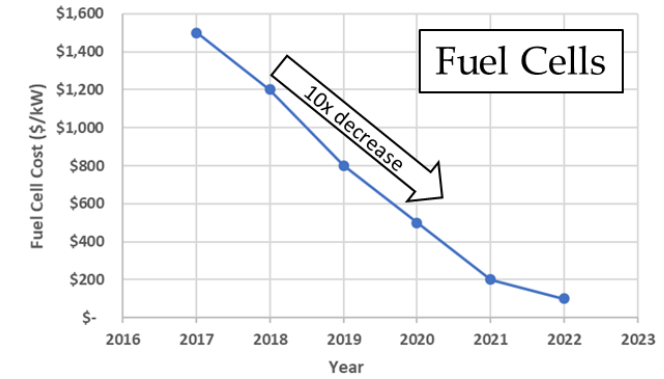
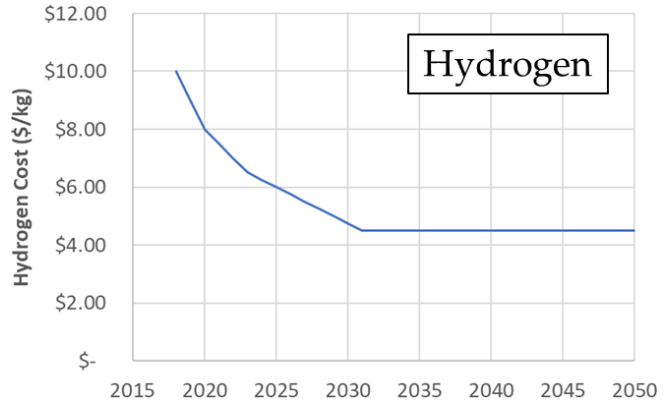
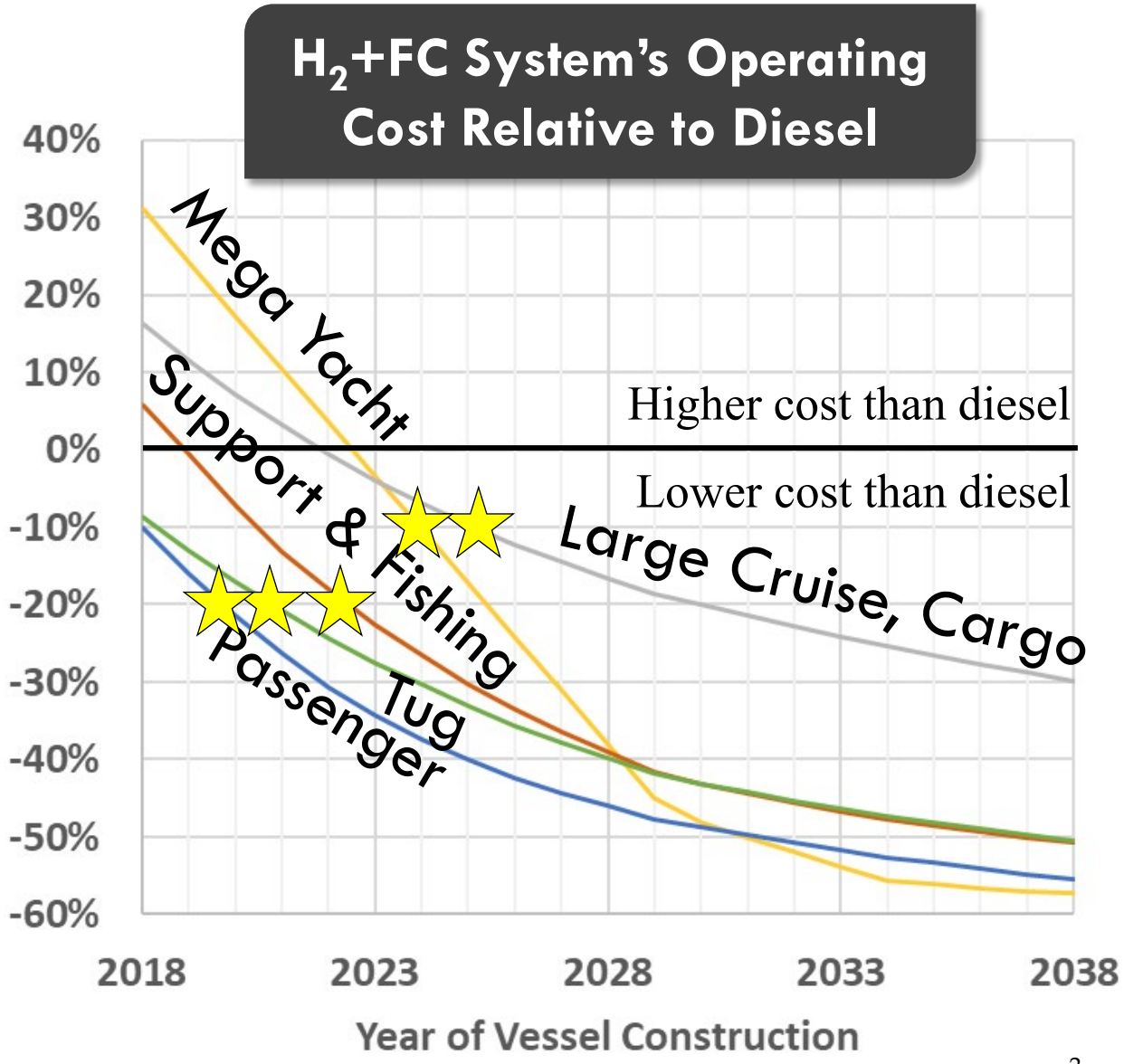
Hydrogen fuel cell systems have a lower lifetime operating cost than diesel.







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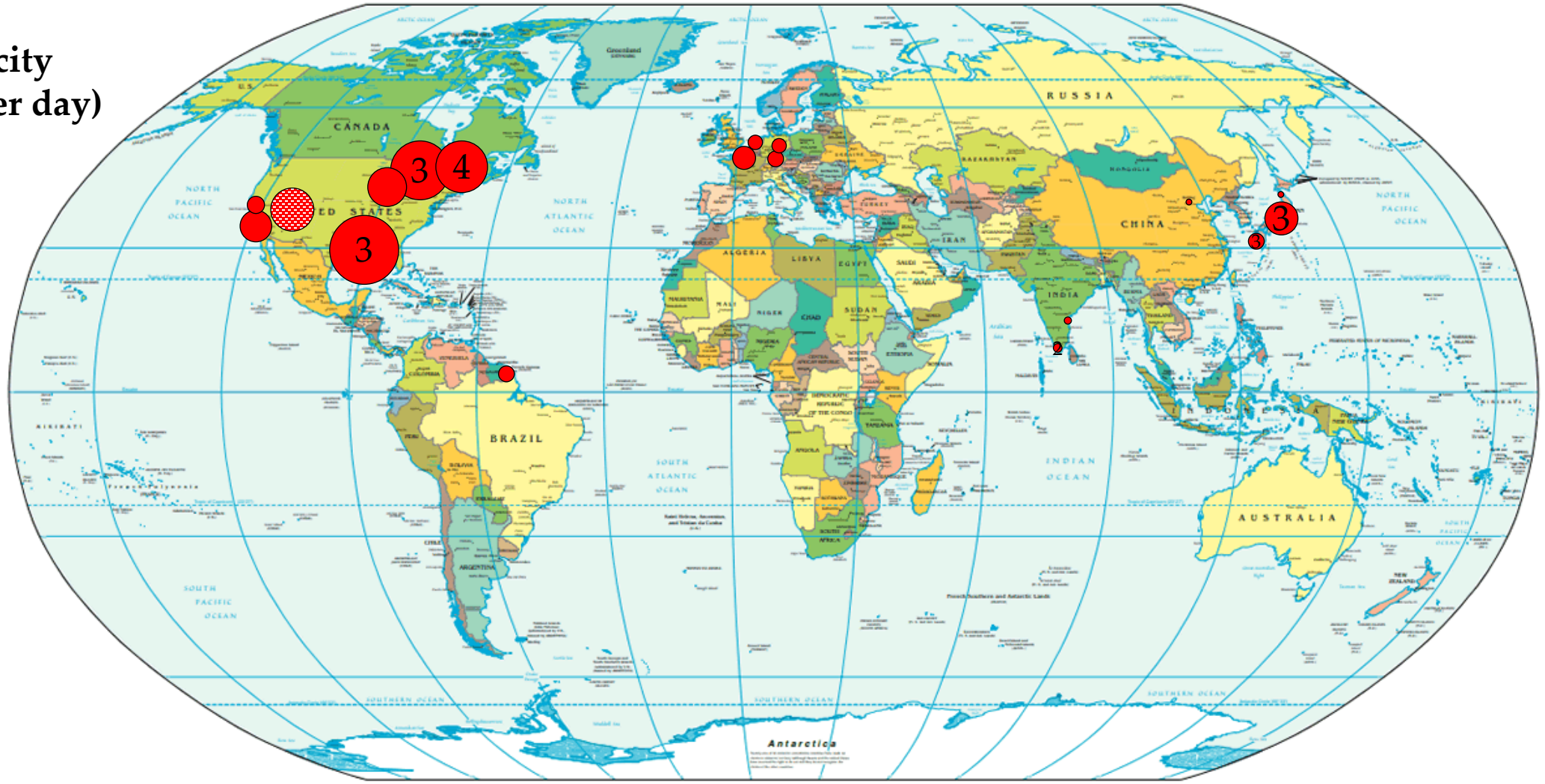
85% of the world's LH_2 production is in North America

Plant Capacity (metric tons per day)

- <1
- 5
- 20
- # 75

Number of clustered facilities



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Reference: S. Krasae-in et. al *Development of large-scale hydrogen liquefaction processes from 1898 to 2009*, IJHE 35 (2010) 4524-4533

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- Design
- Engineering
- Technology Solutions
- Markets

Pioneers of the
Marine Hydrogen Fuel Cell
Business

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EXTRAORDINARY STORIES

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Maritime Hybrid, Electric and Fuel Cells Webinar Week

04.06.2020

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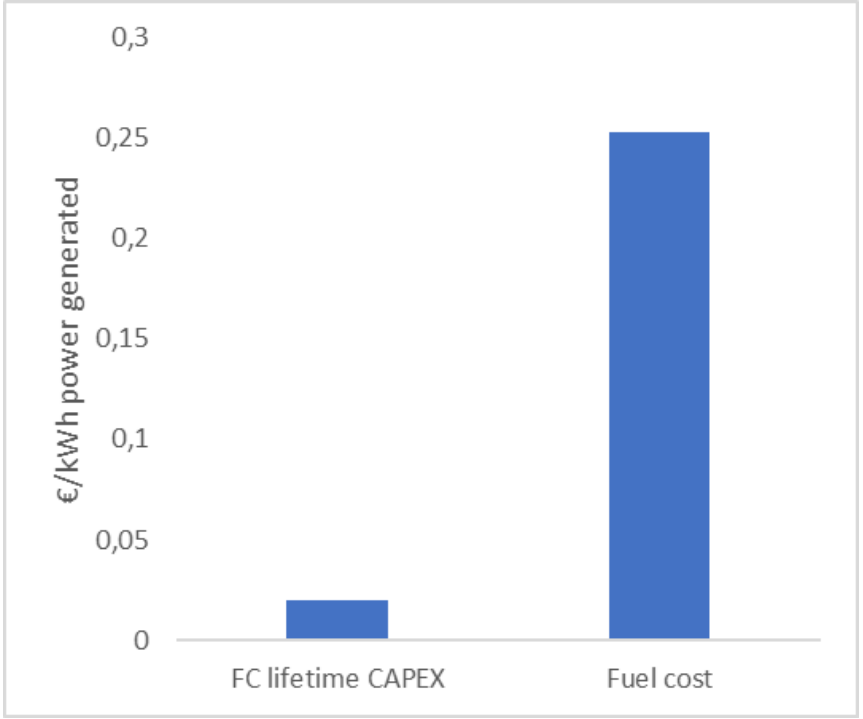
cmr Prototech

Fuel cells: key operational challenges

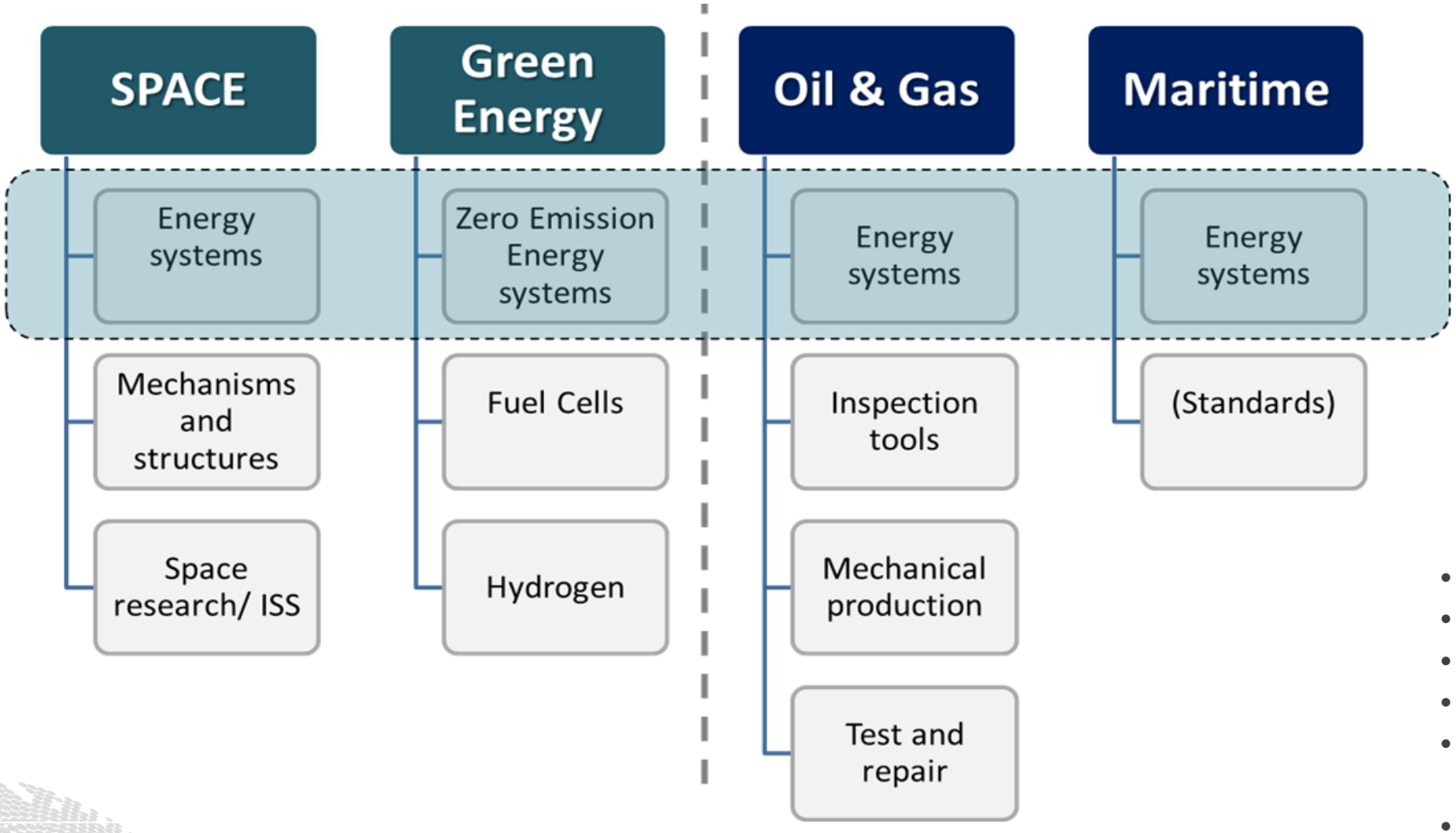
- Fuel availability and cost most critical barrier
  - Fuel cost very often dominant part of total cost of ownership
  - Development of fuel value chain and bunkering logistics takes time
  - A variety of zero-emission solutions probably required to meet emission targets
    - Hydrogen PEM
    - Ammonia SOFC
    - LNG/LBG/methanol/ethanol SOFC with CCS
- Other aspects
  - Size/weight, durability, efficiency, approvals, CAPEX



Assuming:

- 5 €/kgH2
- 1000 €/kW Fuel Cell CAPEX
- 50,000 hours of operation

cmr Prototech - in short



- Dates back to CMI/ Odd Dahl
- Established as legal entity in 1988
- Part of NORCE
- 40 employees from 7 countries
- Prototype development – from idea to product
- Highly skilled workforce and spectacular projects from space to the seven seas

Close to 30 years experience with research, development and testing of hydrogen, fuel cell and electrolyser technologies

- SOFC, PEMFC, HTPEMFC, SOEC, HPPEM ELY, RFCS
- Compact reformer systems, system integration

Mjøllner - 10 kW SOFC Statoil, 1991-1997

H2 fueled 12,5 kW FC system incl batteries and electric propulsion installed on MF Vågen (2009-2011)

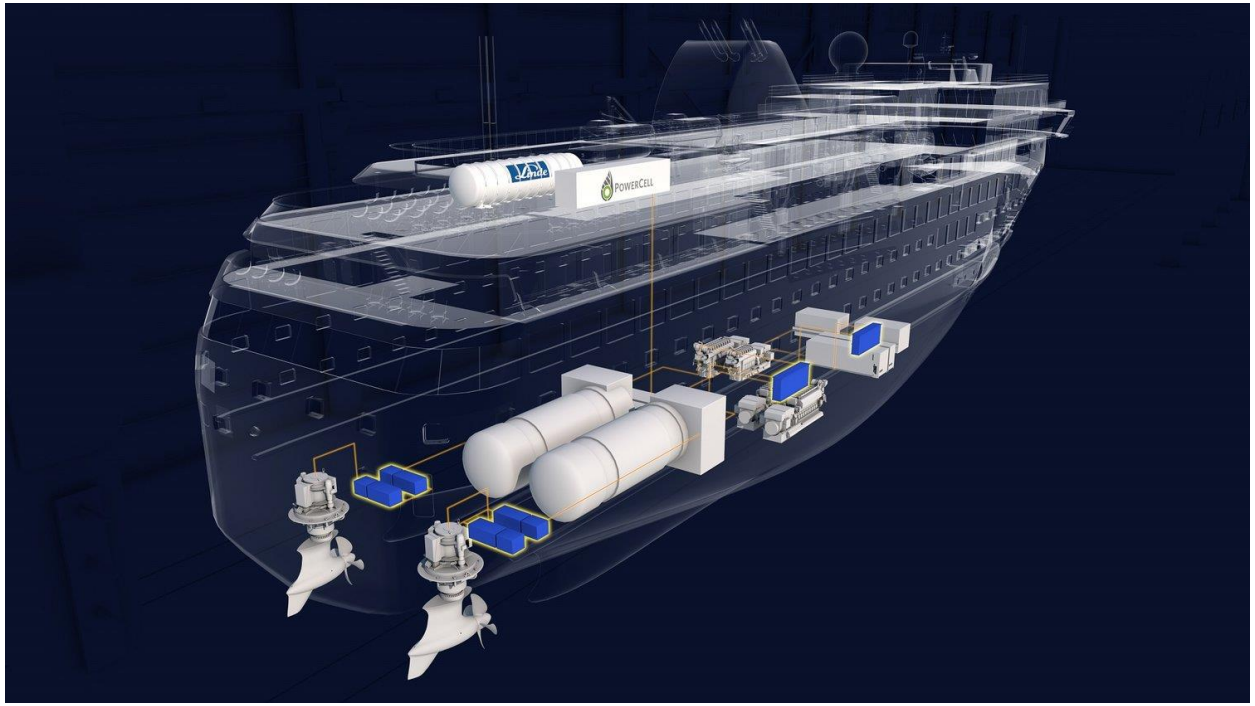
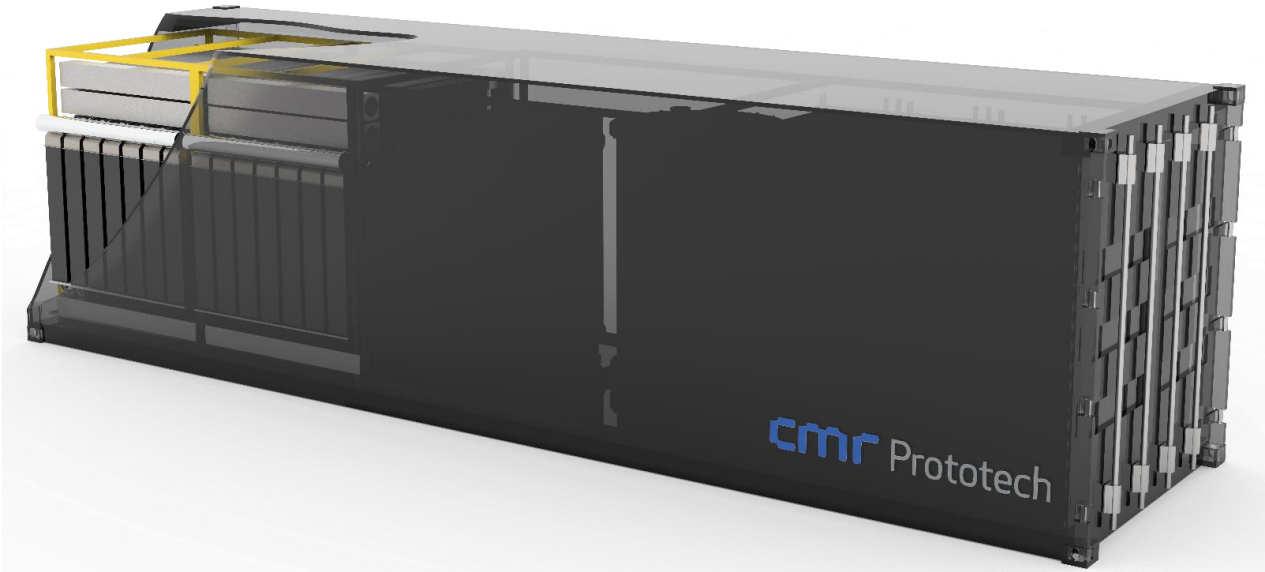


Photo: Havyard

Prototech R&D partner in ongoing maritime projects related to hydrogen fuel cells and LH2 value chain

Prototech currently develops *flexifuel* power solutions to minimise shipowner risk of selecting the one *fuel of the future*



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SHIPFC

GREEN AMMONIA ENERGY SYSTEM

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