Hydrogen-powered ferries: unlocking the potential

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Premier partner

Panellist documents

Page 2: Ryan Sookhoo, Cummins Inc, Fuel Cell and Hydrogen Technologies
Page 10: Joseph W. Pratt, Golden Gate ZERO Emission Marine
Changing Tides of Energy

Ryan Sookhoo

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A TECHNOLOGY LEADER
WITH A BROAD PORTFOLIO
OF POWER SOLUTIONS

- Diesel powertrain
- Natural gas powertrain
- Hybrid electric
- Battery electric
- Fuel Cell electric
Feasibility of Fuel Cell Systems

*Fuel cells operate at high efficiency and their life cycle cost is getting closer to combustion engines*

- Life cycle costs are decreasing due to commercial volume and improved stack durability
- Greater predictability in maintenance and operational costs
- Improved hydrogen fuel infrastructure and distribution
- Increased harnessing of renewable energy for fuel (P2G) and incentives for carbon free fuel
- Fuel cells have a high efficiency at a wider operating range, translating to greater operational flexibility
- Favourable operating range for fuel cells is between 30% and 80%
- Efficiency of fuel cells decrease moderately towards the end of life
Hydrogen Marine Applications

Zero/V
- Review design, identify potential barriers for technology adoption
- DNV-GL Conditional Approval
- Funded by the MARAD

MarFC
- Lower the technology risk
- Estimated Costs – CapEx, OpEx
- Permitting and acceptance
- Engage potential adopters/end users

SINTEF and ABB
- Determine technicalities of scaling-up
- Control of fuel cell plant in combination with energy storage
- Optimize efficiency, reliability and the lifetime of fuel cell stacks

Water-Go-Round
- Commercial operation (2020), 84 passenger (reconfigurable), 22 knot top speed
- 2x 300 kW electric motors, 360 kW PEM fuel cell
- 100 kWh Li-ion battery, H2: 242 kg @ 250 bar
ABB and SINTEF
Test main propulsion fuel cell potential

SINTEF Ocean Laboratory, Trondheim

- Viability testing for main ship propulsion
- MW + power ranges
- Key objectives:
  - Model the operation and control of a complete marine power system in a megawatt-scale propulsion plant
  - How to enhance the control of fuel cell plant in combination with energy storage
  - How to optimize efficiency, reliability and the lifetime of fuel cell stacks

Hydrogen Infrastructure

- Hydrogenics has supplied zero-emission solutions to over 60 fueling stations – more than any other hydrogen fueling company.
  - Largest H2 station in EU (780kg/Day) - 2012
  - Refuels busses and passenger cars – future boats?

- Synergy of Ports
  - The success of one enables another – Land and water fuel cell applications are connected
  - Ports are unique - Maximize H2 refueling infrastructure to support both land and water refuel
  - New but proven – Leverage existing H2 safety protocols & standards. Unknowns still exist
  - Renewable fuel generation and supply –Leveraging the distribution network
  - Scale – The larger the H2 capacity, the lower the $/kg
Port H2 Ecosystem

- Energy Storage
- Power Electronics
- Switch gear
- Backup/balance Power E2P - Micro-grid
- AC/DC
- Electrolyser
- P2G - Electrolyser
- Co-located / Remote
- Power Electronics
- Port / Community / House power
- G2P - FC Prime Power
- G2V - H2 Fueling Station
- Fuel Cell
- Power Electronics
- Battery
- In Port Aux Power
- Port H2 Ecosystem
- Vessel Electrification
  - Diesel hybrid
  - BEV
  - FC Hybrid
- Cummins - Serving marine power needs
  - Extensive knowledge and proven experience in all areas
  - Offer total turnkey power solution(s) including: Vessel electrification, Fuelling and or Charging, stations, Microgrid, H2 production, System control, Digital – prognostic, diagnostics, real time comms & optimisation
Hydrogen-powered ferries: unlocking the potential
Joseph Pratt, CEO & CTO
Golden Gate Zero Emission Marine

Passenger Shipping Webinar Week
Riviera Maritime Media
September 21-25, 2020
Implementation Aspects

1. Code and Safety Requirements

2. Arrangement Impacts

3. Business Impacts
**Required Rules, Regulations, Codes, and Standards**

- **Flag State**
  - Ultimate authority
  - Method for determining Equivalent Risk described by IMO MSC.1/Circ.1212

- **International**
  - IMO’s 2015 *International Code of Safety for Ships using Gases or other Low-flashpoint Fuels* ("IGF Code") was adopted by USCG
    - Written with natural gas / LNG in mind, not hydrogen
    - SOLAS-class vessels, not local vessels in inland/protected waters

- **Class**
  - DNV-GL: Rules for Classification: Ship, part 6, chapter 2, section 3
  - ABS: Fuel Cell Power Systems for Marine and Offshore Applications

- **Industry Standards**
  - IEC, ISO, EN, SAE, ASME, ANSI, CGA, etc.
Fuel cells offer flexibility in arrangement…
...but come with constraints to meet safety regulations

External hazardous zones

Internal considerations

Download the SF-BREEZE II report from maritime.sandia.gov
Example: Implementation of fuel cells on the Water-Go-Round

- **Fuel cell room**: 3 x 120 kW racks
- **H₂ tank array**: 242 kg, 250 bar compressed gas, 1-2 days operation
- **10 m H₂ vent**
- **300 kW (400 hp) shaft motors** (1 in each hull)
- **50 kWh batteries** in each hull

This project is supported by the “California Climate Investments” (CCI) program.
Business Benefits of Hydrogen Fuel Cells

- Higher revenue and lower total cost of ownership
- Fuel price certainty
- Less complicated on-board systems with less frequent and simpler maintenance
- No noise or exhaust = happier customers
- Green marketing = more customers
- Win public contracts

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