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Fuel Cell Solutions for Zero-Emissions Marine Applications

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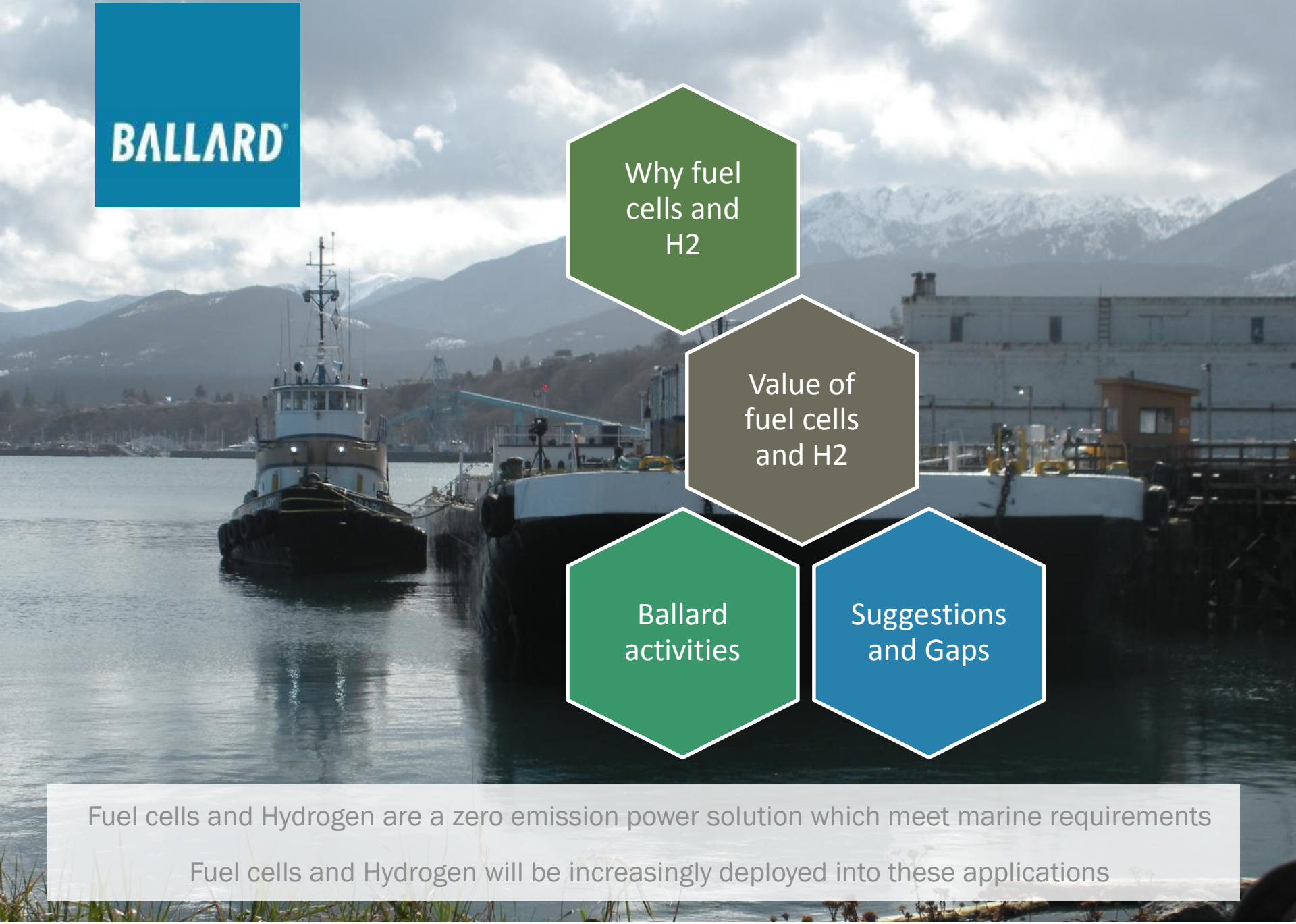
H2@Scale℠
U.S. Department of Energy

Fuel cells and Hydrogen are a zero emission power solution which meet marine requirements

Fuel cells and Hydrogen will be increasingly deployed into marine sector



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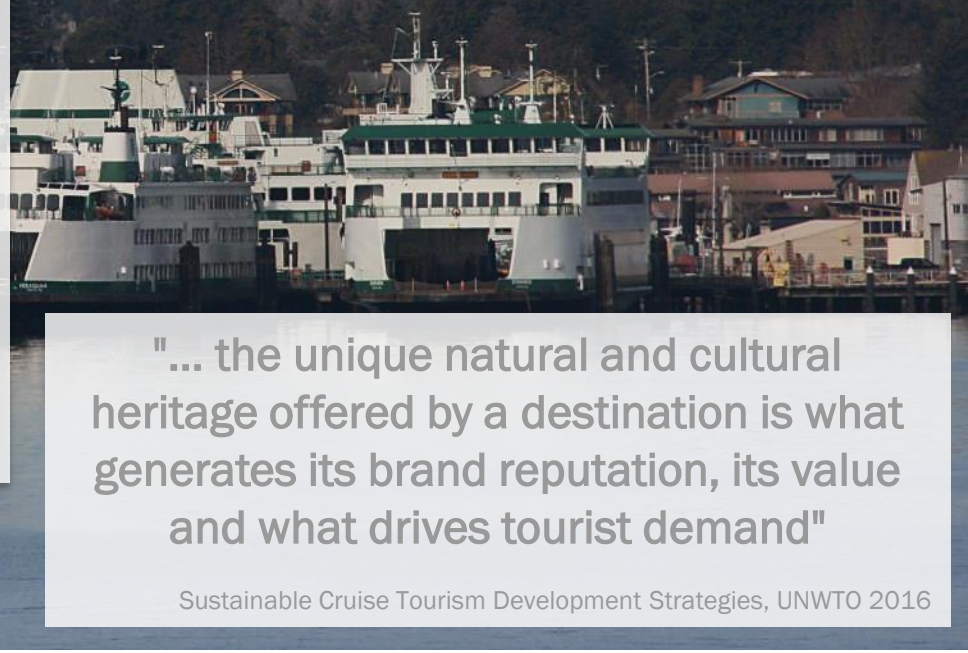
Why are fuel cells needed for Marine?

- Marine activities are already significant contributors to air pollution and GHGs
- Emissions are expected to increase with increased globalization
- Zero emission requirements are coming
- Customers want zero emission solutions



"... the unique natural and cultural heritage offered by a destination is what generates its brand reputation, its value and what drives tourist demand"

Sustainable Cruise Tourism Development Strategies, UNWTO 2016

Value of fuel cells and hydrogen in Marine applications

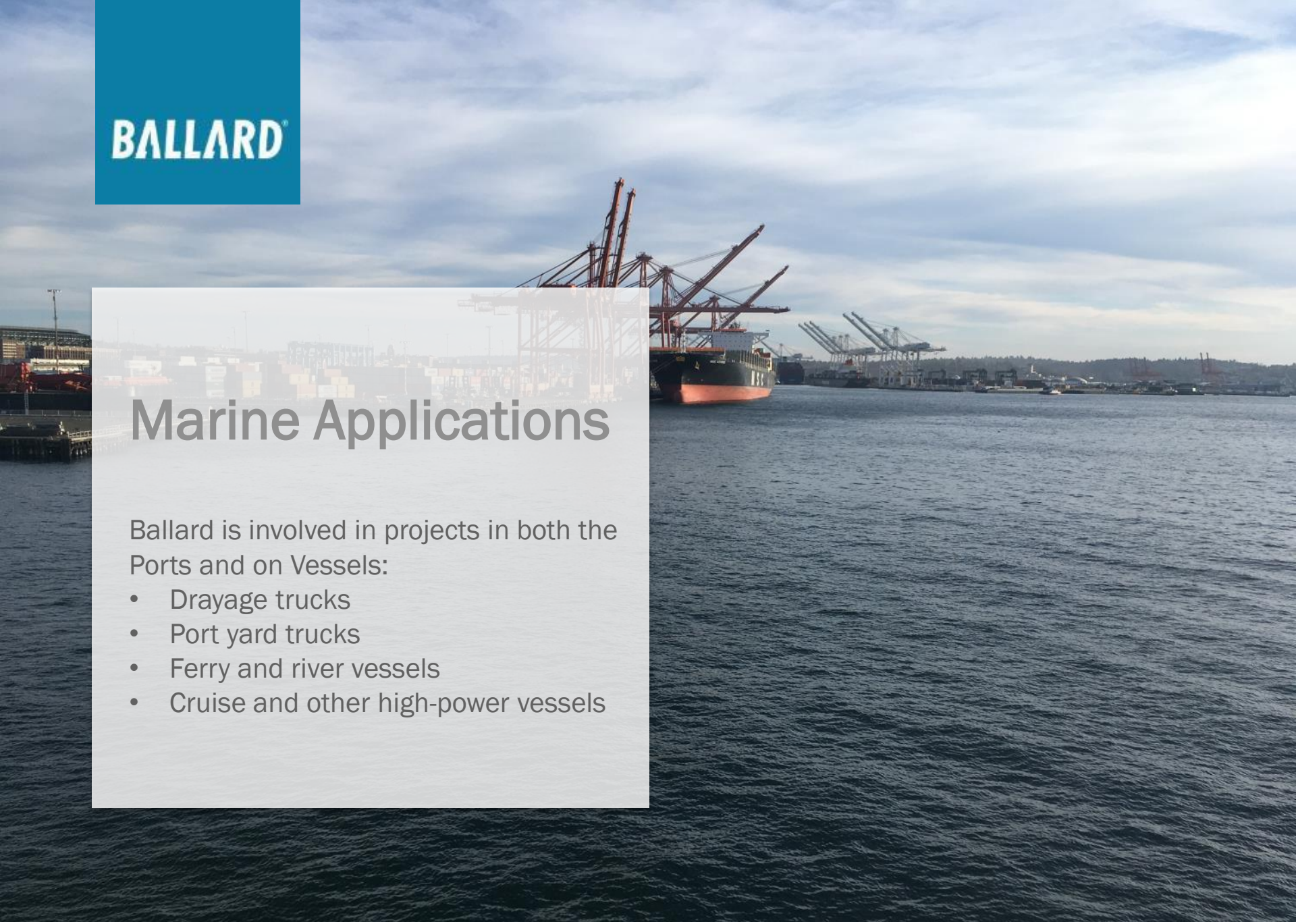
- Scalable from 100kW to MWs
- Distributed, dispatchable power solution
- Reliable, high efficiency DC power generator
- Low maintenance, long life, refurbishable
- Long range, quick refueling, heavy payloads
- High volume liquid hydrogen storage

Value of fuel cells and hydrogen in Marine applications

- Propulsion for ferries, barges and fishing vessels
- Hotel and auxiliary loads (heat and power) for cruise ships
- Cold ironing / shore power
- Port operations

Centralized hydrogen infrastructure at ports can fuel many applications

- Vessels
- Onshore power
- Cargo handling equipment
- Drayage trucks



Marine Applications

Ballard is involved in projects in both the Ports and on Vessels:

- Drayage trucks
- Port yard trucks
- Ferry and river vessels
- Cruise and other high-power vessels

Developing partnerships with marine industry leaders

Through active participation to a number of marine demonstration projects, Ballard is developing a unique expertise and strong partnerships with industry leaders and stakeholders.

Ballard Marine Center of Excellence

- Marine customization / codes and standards compliance
- Engineering, verification, and manufacturing
- Applications engineering, commissioning support and after-market service solutions

Port Applications – Yard Tractors

- H2Ports project at Port of Valencia

H2 PORTS | FCH | FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

- ZECAP project at Port of Los Angeles

CALIFORNIA AIR RESOURCES BOARD

Port Applications – Drayage Trucks

- ZECT project at Port of Los Angeles – one drayage truck

CALIFORNIA AIR RESOURCES BOARD

- AZETEC project in Alberta – two regional haul trucks

EMISSIONS REDUCTION ALBERTA

Vessel Applications

- Smaller ferry boats: HySeasIII, Flagships, Norled
- Inland vessels: Flagships, Elektra
- Coastal vessels
- Cruise vessels – MW scale power system co-developed with ABB

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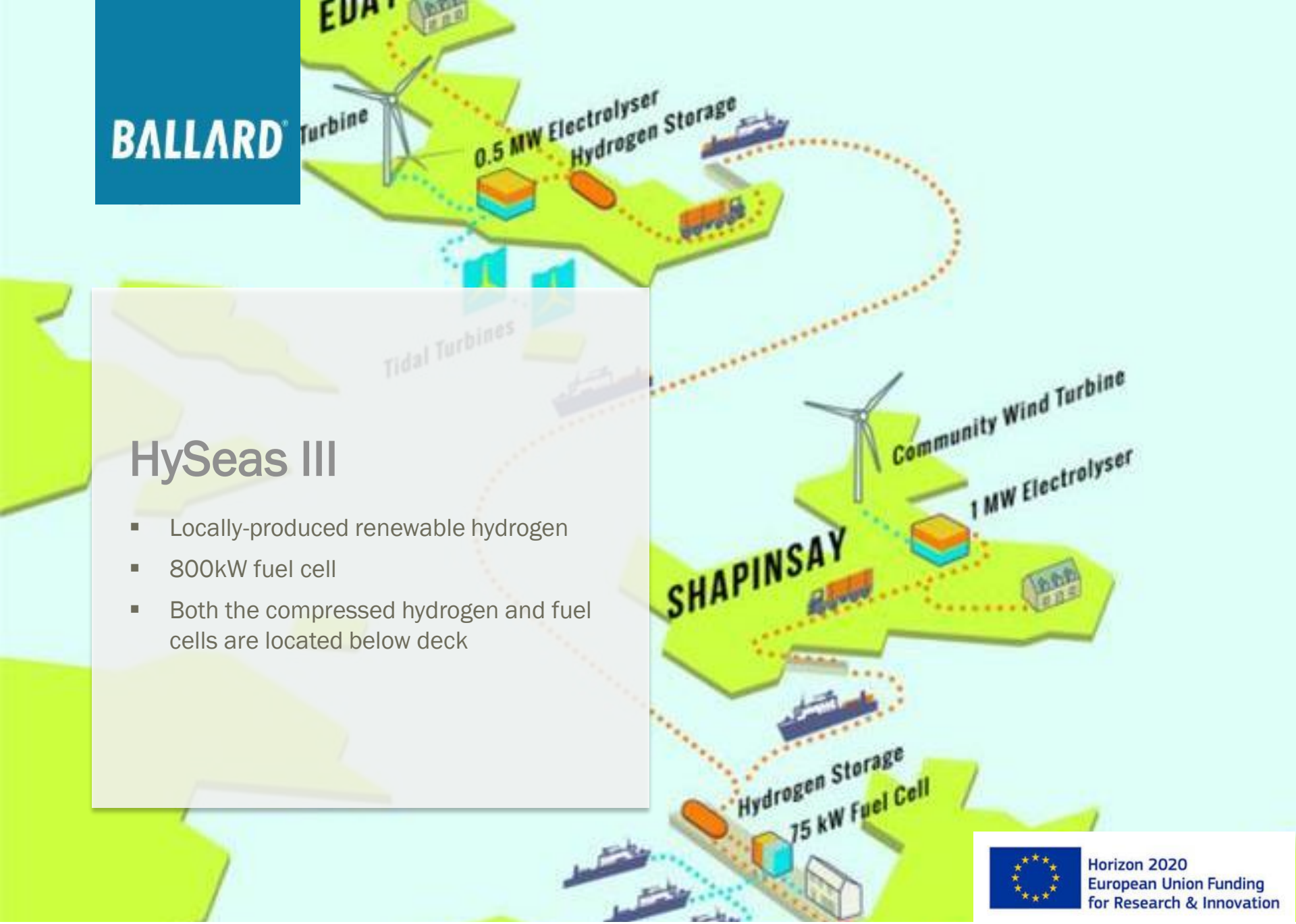

HySeas III

- Locally-produced renewable hydrogen
- 800kW fuel cell
- Both the compressed hydrogen and fuel cells are located below deck

Horizon 2020
European Union Funding
for Research & Innovation

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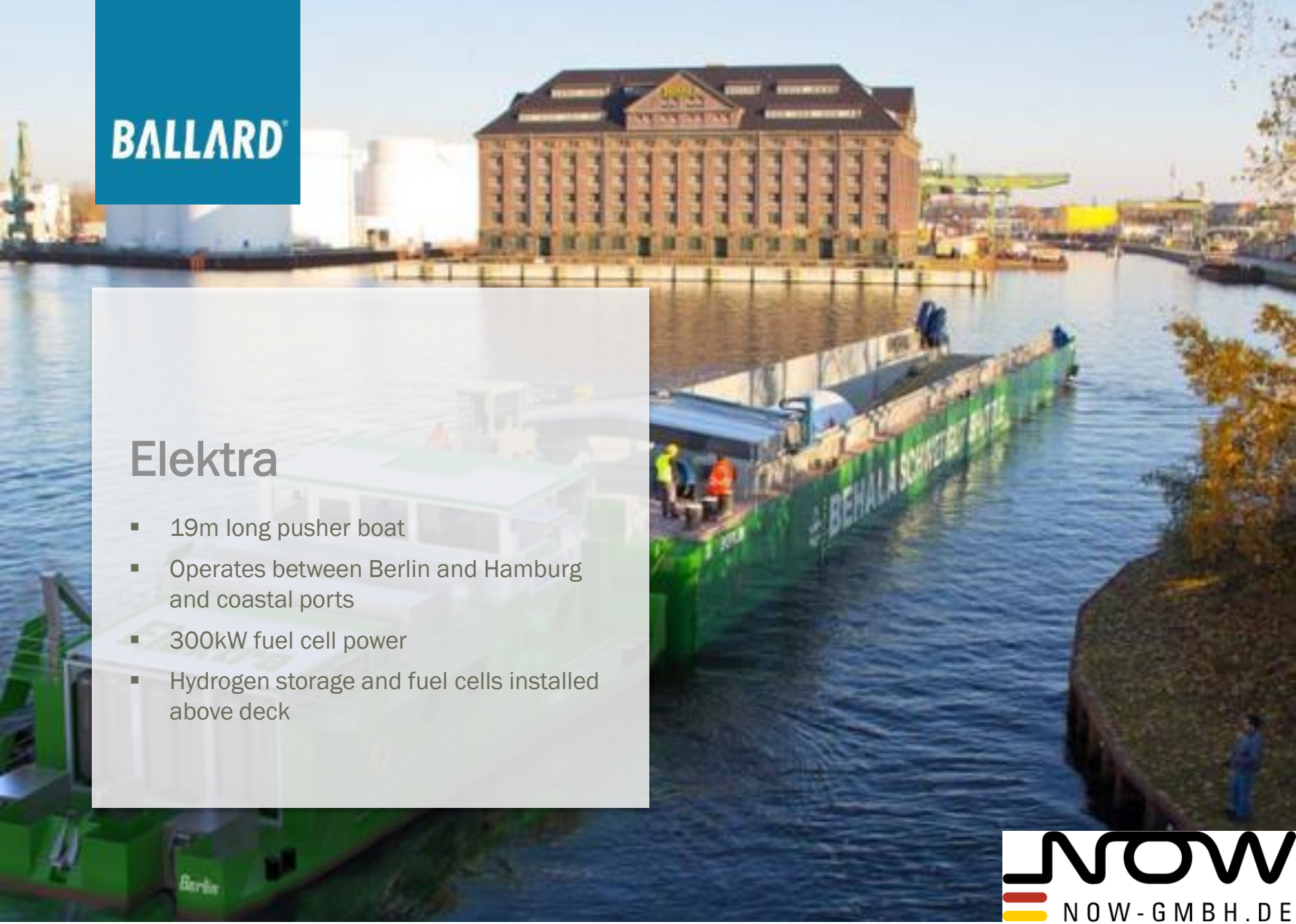
Flagships

- A river push boat on the Rhone River in France and a passenger ferry operating in Norway
- Renewable hydrogen for both vessels
- A total of 1MW fuel cell power
- Hydrogen storage and fuel cells installed above deck

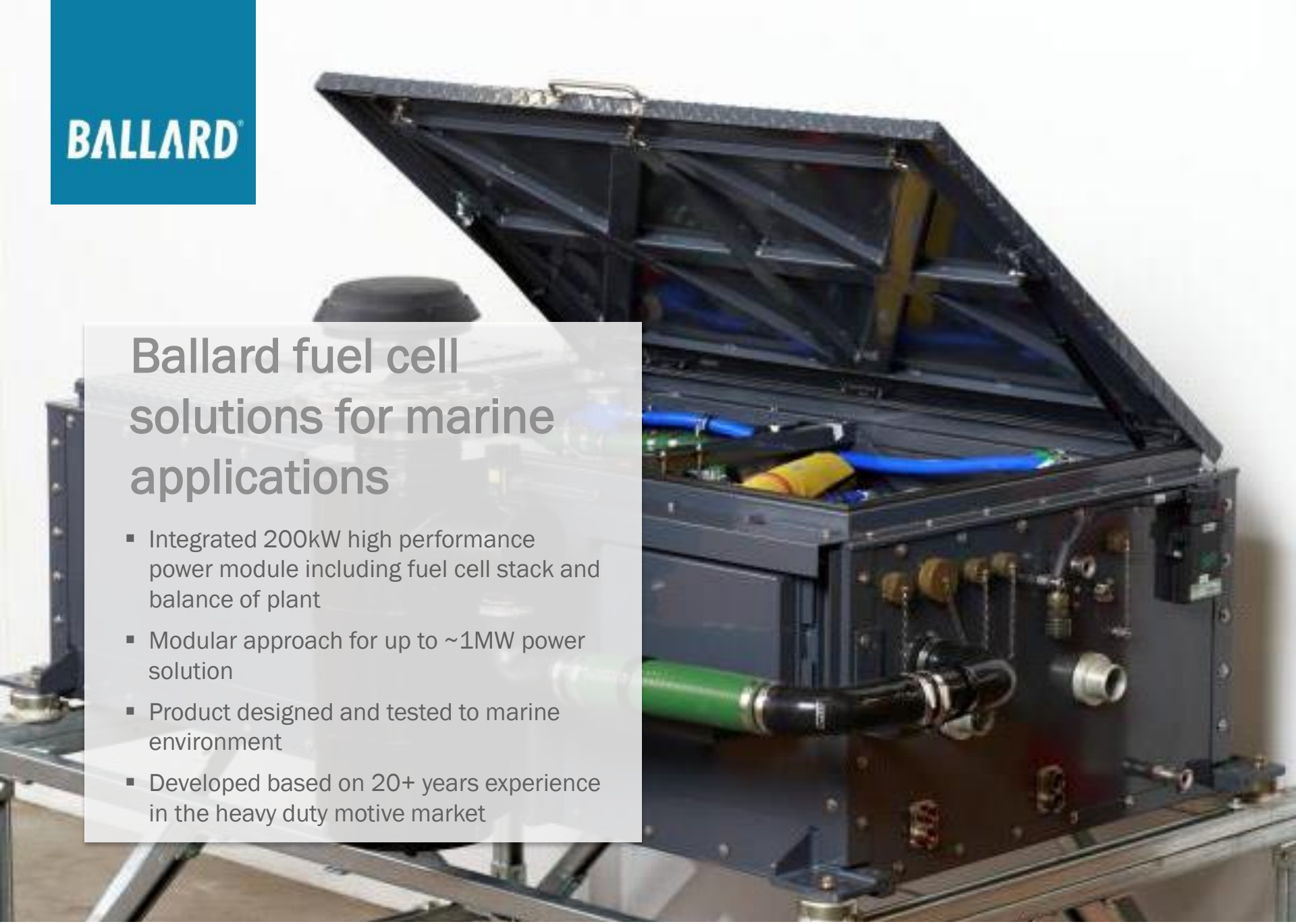
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING



Elektra

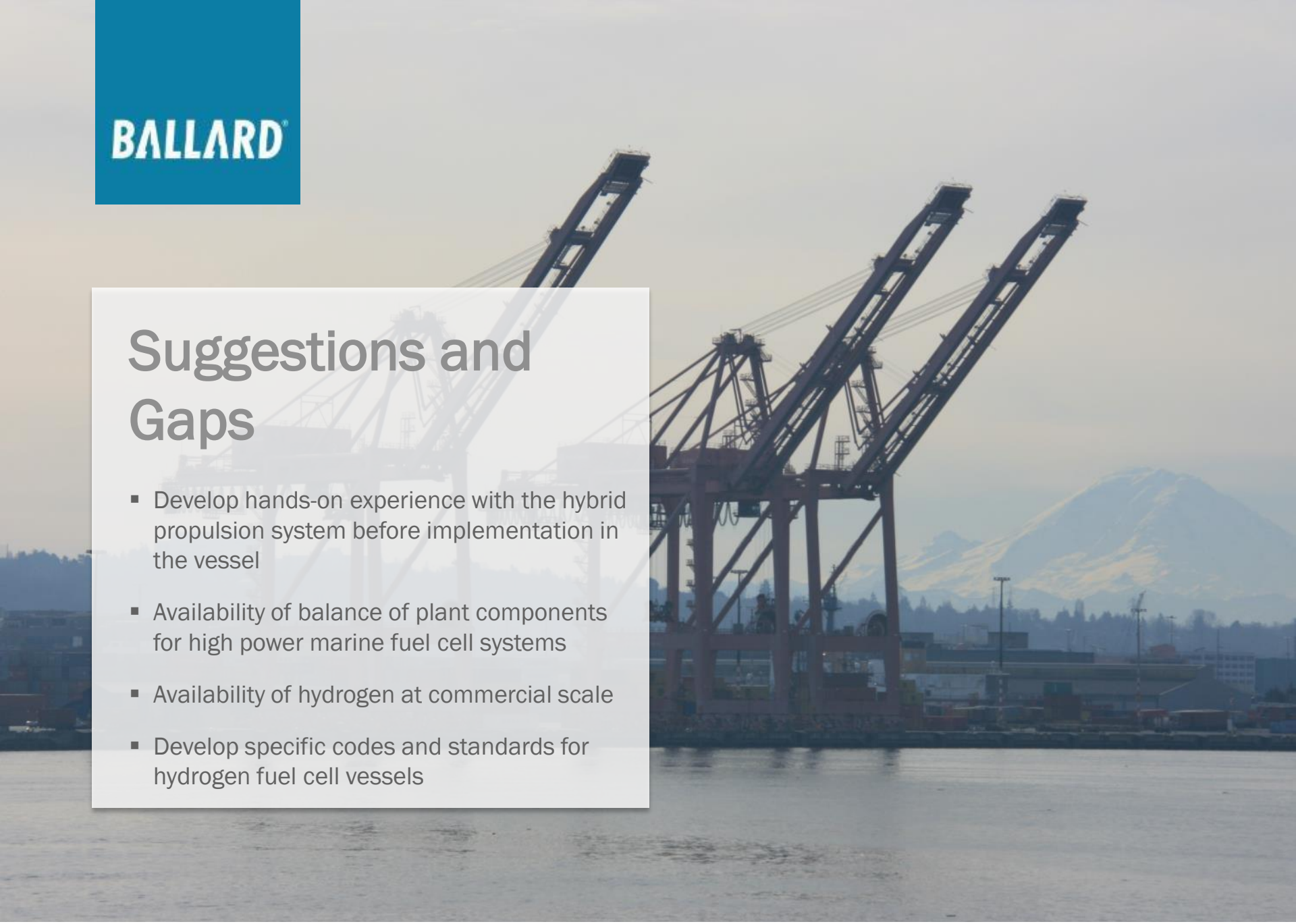
- 19m long pusher boat
- Operates between Berlin and Hamburg and coastal ports
- 300kW fuel cell power
- Hydrogen storage and fuel cells installed above deck

NOW-GMBH.DE



Ballard fuel cell solutions for marine applications

- Integrated 200kW high performance power module including fuel cell stack and balance of plant
- Modular approach for up to ~1MW power solution
- Product designed and tested to marine environment
- Developed based on 20+ years experience in the heavy duty motive market



Suggestions and Gaps

- Develop hands-on experience with the hybrid propulsion system before implementation in the vessel
- Availability of balance of plant components for high power marine fuel cell systems
- Availability of hydrogen at commercial scale
- Develop specific codes and standards for hydrogen fuel cell vessels

Ballard by the Numbers

Celebrating 40 years
1979-2019

700
Employees

1,500
Patents & Applications

Publicly listed Company
24 years Nasdaq
26 years TSX

4 Strategic shareholders
WEICHAI
大洋电机 BROAD-OCEAN
AngloAmerican
NISSHINBO

239 (888*)
transit **buses** in service

571 (1,449*)
trucks delivering goods

4 train projects on track

5 ships in development

12,000
Forklifts in operation

$80M
automobile stack development program

Delivered
850MW
of **fuel cell** products

Produced
5 million
MEAs

KM
>16M km
of service for modules operating in buses

>30,000hrs
Operation of fuel cell stack in London **BUSES**

* Currently in construction or commissioning phase

Ballard is a Global Company

Hobro, Denmark: Ballard Marine Center of Excellence dedicated to fuel cell marine applications

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We deliver fuel cell power for a sustainable planet