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# Zero Emissions Vessels are Electric Vessels

Electrical Vessel System Integration

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# ABB Marine and Ports

## Overview

Global leader in **electric propulsion** and **container terminal automation**



~ **2000** employees



~ **1BUSD** business



**1500+** vessels electrified



Footprint in **30**  
countries



**100+ years**  
experience



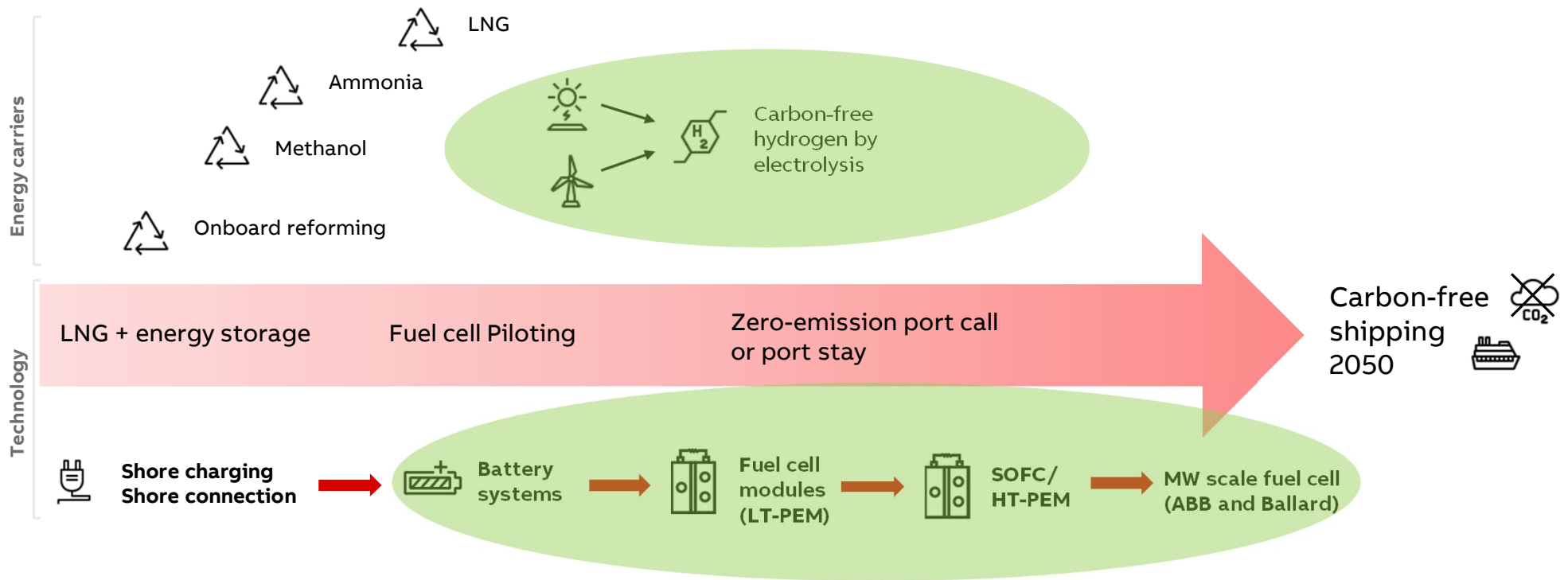
**1300+** container cranes  
automated



**2000+** vessels and terminals  
digitally connected

# Pathway to carbon-free shipping

Transitions in **fuel** and **technology**

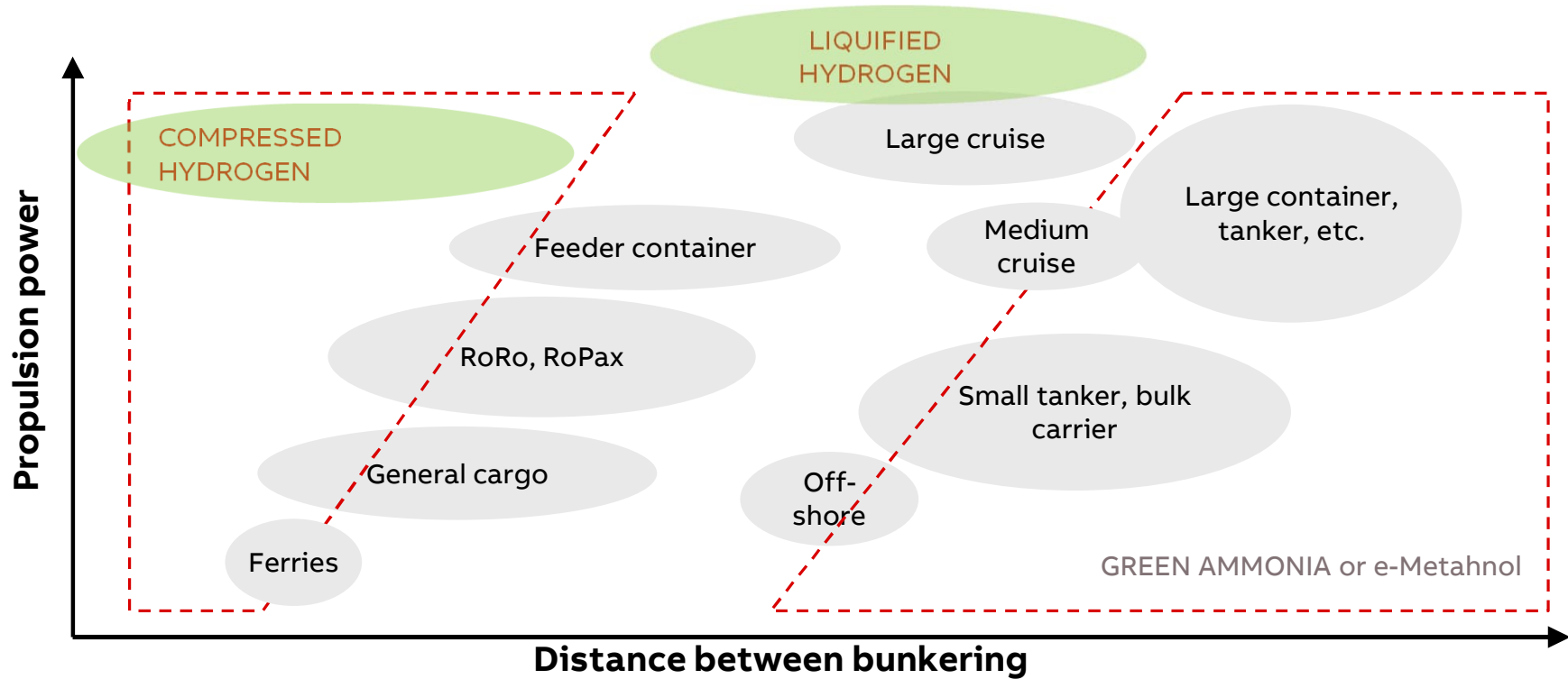


# Energy sources - comparison

Consumption 2MW – 24hrs

	<b>Energy converter - Efficiency</b>	<b>Power Distribution</b>	<b>Volume of energy – 40f Cont.</b>
<b>Electrical energy in Battery banks</b>	Charging from shore (DC or AC) direct to DC switchboard – 93%	<b>DC Switchboard</b>	<b>4MWh – 2 hrs (78)</b>
<b>Hydrogen Compressed</b>	Fuel Cells – LT PEM – 40-50% ICE – Otto – 40%	<b>DC Switchboard / (in combo with ICE hybrid)</b>	<b>33MWh – 8 hrs (21)</b> <b>80MWh – 1 day (7)</b>
<b>Hydrogen Liquid</b>			
<b>Ammonia</b>	Fuel Cells – SOFC – 60-70% ICE – 2 str or 4 str - 40%	<b>DC Switchboards / (in compo with ICE hybrid)</b>	<b>120MWh – 1,5 days (5)</b>

## Carbon-free fuels and ship types



# Energy efficiency – the key!

## Energy Source

Select the energy type with the best total efficiency.

- Battery when frequent charging points are available – High efficiency – large size
- Hydrogen shorter sailing distances, and possible with regular bunkering – Less volume but low efficiency

## Energy flow

Use of DC distribution for low loss connection of the various energy converters as DC outputs.

Can easily combine all types of energy converters, inclusive ICE's.

## Ship operation

Operate the ship optimized with low as possible energy usage;

- Digital tools to select speed and course depending of weather and operation.
- Efficient hull shape
- Use of rotating sails or sails.

## Propulsion system

Select a propeller with optimal efficiency.

- New types are coming into the market with 15-25% improved efficiency.

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# Zero emission operation

The solution is electric

## Charging technology

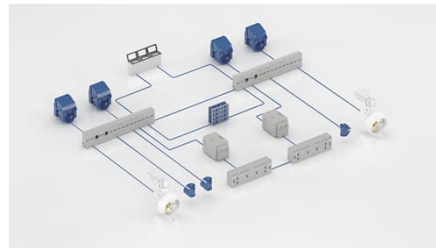
Electric charging



## Onboard DC Grid™

Electric power solution

- Modular system



## Batteries

Clean, flexible

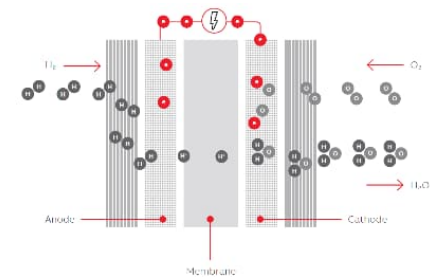
- Energy storage functions



## Fuel cells (or ICE)

Clean and flexible

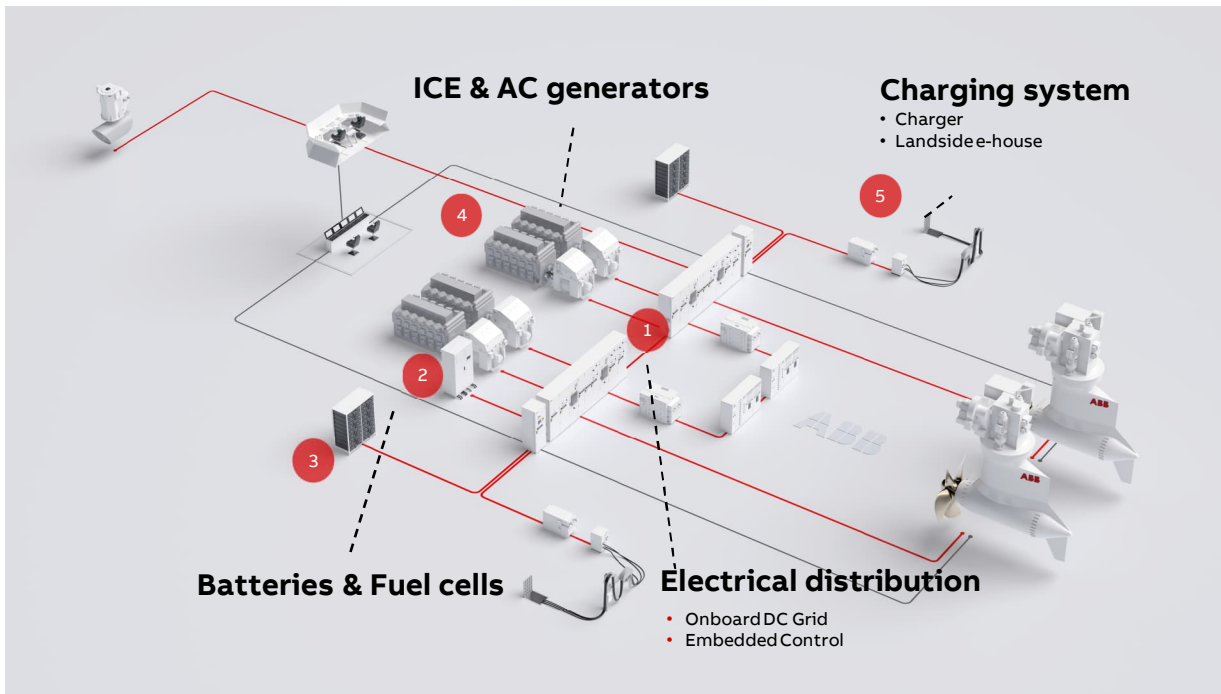
- Energy production function



# Electric and hybrid vessels

System integration of main power components

## Electrical solution



## The main objects

**1 - Fixed** integration of the complete system around the **electrical distribution system, common point for all energy converters and main consumers.**

**2 - Container - Fuel Cells: Intergartion of Fuel cell technologies; LT PEM, HT PEM and SOFC.**

**3 - Container - Batteries:** Integration of various Lithium chemistries; NMC – LFP and LTO battery types.

**4 - Container - ICE & AC Generators:** for green fuels

**5 - Fixed - Charging system:** Based on DC charging S-MCS or AC charging IEC standard 8005-1 or 2



# Marine LT PEM fuel cell solutions

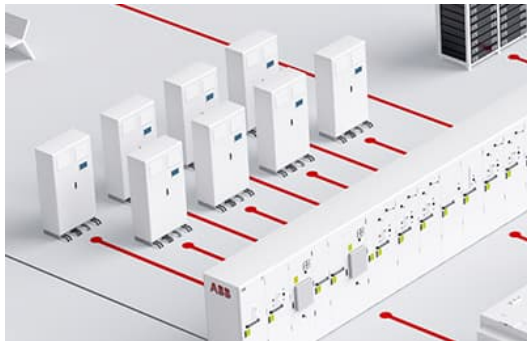
Hydrogen project examples



## Integration of fuel cells

- Scalable and flexible installation with marine certified fuel cell modules
- Integrated in hull space

**0,2 MW - Pilots**  
**Carnival - Viking Cruises**



## E-house installation of fuel cells

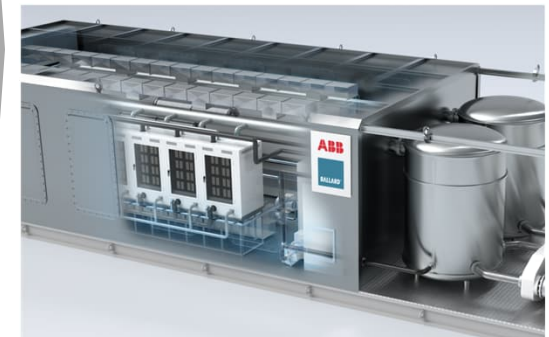
- Integration of fuel cell modules with total 1,4 MW per high-cube 40” container
- Suitable for on-deck installation



## High-power marine fuel cell concept

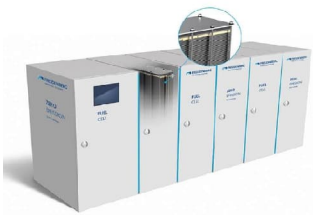
- 3 MW fuel cell unit
- Larger units with common balancing plant.

**6 - 12 MW**  
**Carnival - Viking Cruises - MSC Cruises**



# High-temperature fuel cells with heat recovery for larger ships

Fuel Cell and reformer solutions for Methanol & Natural Gas with improved efficiency



**Royal Caribbean & Carnival**

## Methanol & Natural Gas – 0,2 - 4 MW

- Operate on various other fuels than hydrogen with internal reforming capability to H<sub>2</sub>
- With modular Heavy Duty FC Stack



**Royal Caribbean**

## Methanol & Natural Gas 1- 2 MW

- Operate on various other fuels than hydrogen with internal reforming capability to H<sub>2</sub>
- Solid oxide fuel cells (SOFC) and high-temperature PEM fuel cells (HT-PEMFC)



IMAGES: Bloom Energy, Blue World Technologies

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## Modular design - example

### ZeroCoaster - Coastal cargo vessel – «Green Coastal Program»

#### DESIGNING MODULAR ENERGY SYSTEM READY FOR BATTERY, HYDROGEN, AMMONIA, METHANOL

The consortium includes:

Vard Design, AFC Energy, ABB, DNV, Sintef Ocean

Modularity:

- Use of module based energy converters and energy storage
- Enable various types of energy carriers.

Saved energy consumption:

- Efficient hull shape
- Use of rotating sails



## Hydrogen project - examples



5000 DWT Bulk Carrier with rotating sails, 800kW FC, batteries, Hydrogen ICE and Bio diesels

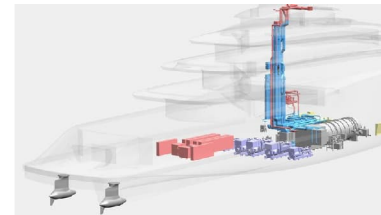


200kW fuel cell system from Freudenberg. Powered by hydrogen derived from methanol.

Ongoing concept design for 12 MW fuel cells.



400 kW fuel cell system on hydrogen powered river container vessel



Yacht with Onboard DC Grid and 3 MW fuel cell system



Electric propulsion and power plant with integrated of fuel cells

● Heidelberg – Felleskjøpet Agri

● Carnival - Pa-X-ell2 program

● FLAGSHIPS project CFT river container vessel

● NN Yacht owner

● Samskip Hydrogen fuel cell Shuttle Container vessel

**We believe the future of shipping is Electric. Digital. Connected.**

