PersEE Innovation

# Current and Future Hydrogen and Fuel Cell Activities in Shipping

Lessons learnt from MARANDA, a FCH JU funded project

# MARANDA

## Introduction

# MARANDA, a FCH JU funded project*, will accelerate the introduction of Fuel Cell and Hydrogen in the Marine sector

This project will contribute to meeting marine regulations and greening marine activities

## *MARANDA project aims to:*

**DEVELOP an emissions-free fuel cell hybrid based marine powertrain system**

**ENSURE suitability for a broad spectrum of marine applications**

**PROVE the technical performance of the system in a target marine vessel**

**DEMONSTRATE the economic feasibility of hydrogen and fuel cells in marine sector**

*This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735717.
This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY

# Aranda, MARANDA's demonstration vessel

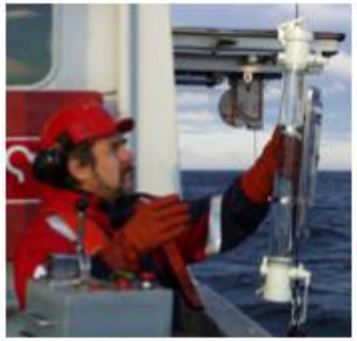
Aranda is a flagship Finnish research vessel, operating in arctic conditions

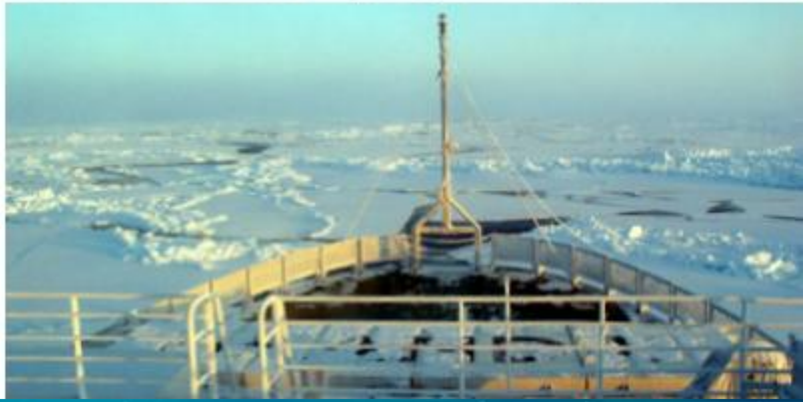
| | |
|---|---|
| **Owner/TC-Owner** | SYKE (Finnish Environment Institute) |
| **Call sign** | OIRY |
| **IMO** | 8802076 |
| **Built** | 1989 Helsinki, Wärtsilä Marine |
| **Classification** | FMA |
| **Flag** | Finnish |
| **Crew** | Finnish |
| **GT / NT** | 1734 / 521 |
| **Lenght (LoA)** | 59,24 m |
| **Breadth** | 13,80 m |
| **Draught** | 5,0 m |
| **Engine** | 1300 + 1700 kW (4 x Wärtsilä-Vasa 8R22 + W-V 12V22) |

## Well-equipped for challenging work

Aranda can conduct a wide range of biological, physical, chemical and geological research. The vessel's well-equipped laboratories and advanced computer system enable prompt onboard sample analysis and data processing.

Research facilities are mainly located in the central and aft part of the ship. Comfortable cabins and well-equipped common rooms make working aboard a pleasant experience, even on long expeditions. A floating floor has been installed in the research area to minimise vibrations and noise. The ship has special facilities for handling and storing samples, including a clean container, thermostatically adjustable acclimated rooms, cold storage, and freezer facilities housing a super freezer. Chemical research is facilitated by permanently fixed pipes between Aranda's bottled gas store and laboratories.

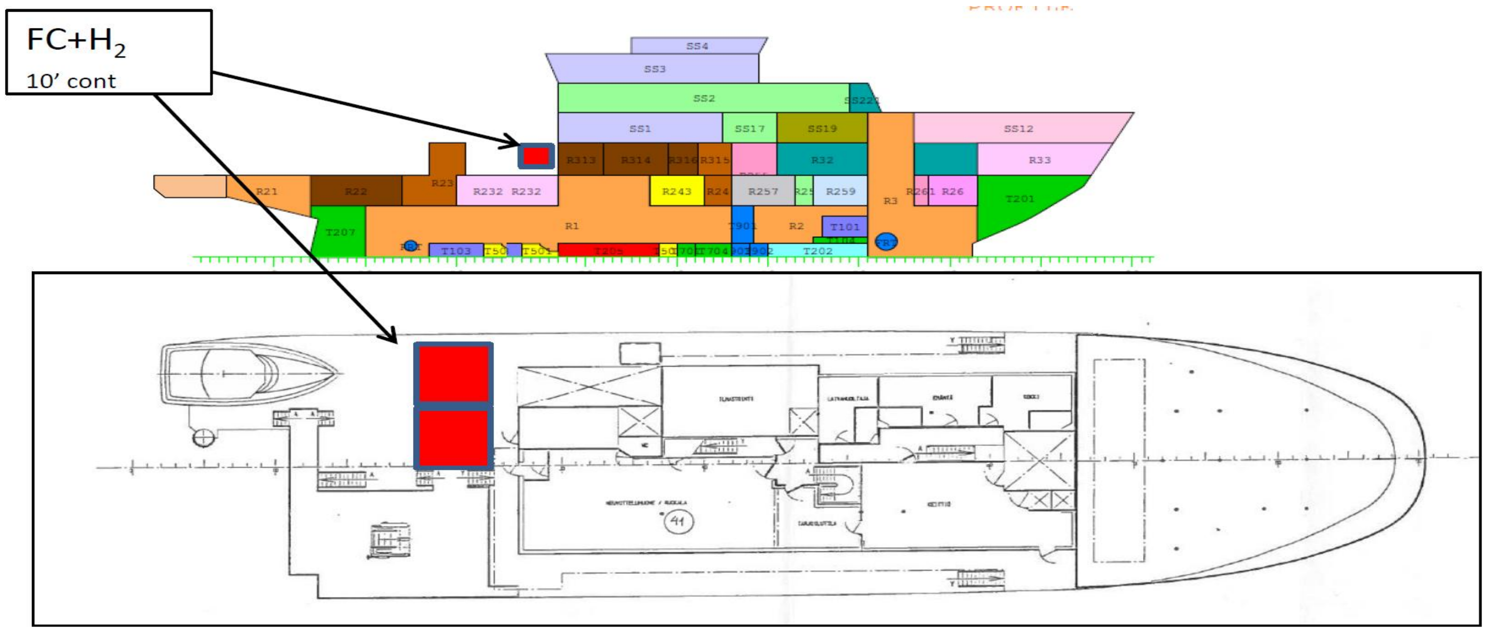




# Planned fuel cell and hydrogen installation in Aranda

A 165 kW (2 x 82.5 kW AC) fuel cell powertrain (hybridized with a battery) will provide power to the vessel's electrical equipment as well as the dynamic positioning during measurements, free from vibration, noise and air pollution.

Special emphasis is placed on air filtration and development of hydrogen ejector solutions, for both efficiency and durability reasons.





A mobile hydrogen storage container, refillable in any 350 bar hydrogen refueling station will be developed in this project.
Liquid hydrogen, more suited to larger fuel cells, will be taken into consideration in the business cases and go-to-market strategy.

# MARANDA Basic details

http://www.fch.europa.eu/project/marine-application-new-fuel-cell-powertrain-validated-demanding-arctic-conditions

## Time

- Start date:
March 1, 2017

- End date:
February 28, 2021

- Duration: 48 months

## Coordinator

- Coordinator:
Teknologian tutkimuskeskus VTT Oy, Finland
http://www.vtt.fi/

- Contact: Jari Ihonen (jari.ihonen@vtt.fi)

## Reference

- Project reference: 735717
- Topic: FCH-01-5-2016 Develop new complementary technologies for achieving competitive solutions for marine applications
- Contract type: RIA

## €

- Project cost:
3,704,757.50 €

- Project funding:
2,939,457.50 €

## Participating companies

POWERCELL SWEDEN AB (SE); ABB OY (FI), OMB SALERI SPA (IT); PERSEE (FR); SUOMEN YMPARISTOKESKUS (FI); The Finnish Environment Institute; SWISS HYDROGEN SA (CH)

# MARANDA KPIs

Both technical and economical

**Fuel to electric efficiency**
50%

**freeze start capabilities**
from -35°C

**operating temperature**
[-32°;+50°]

**system cost**
< 1000€/kW*

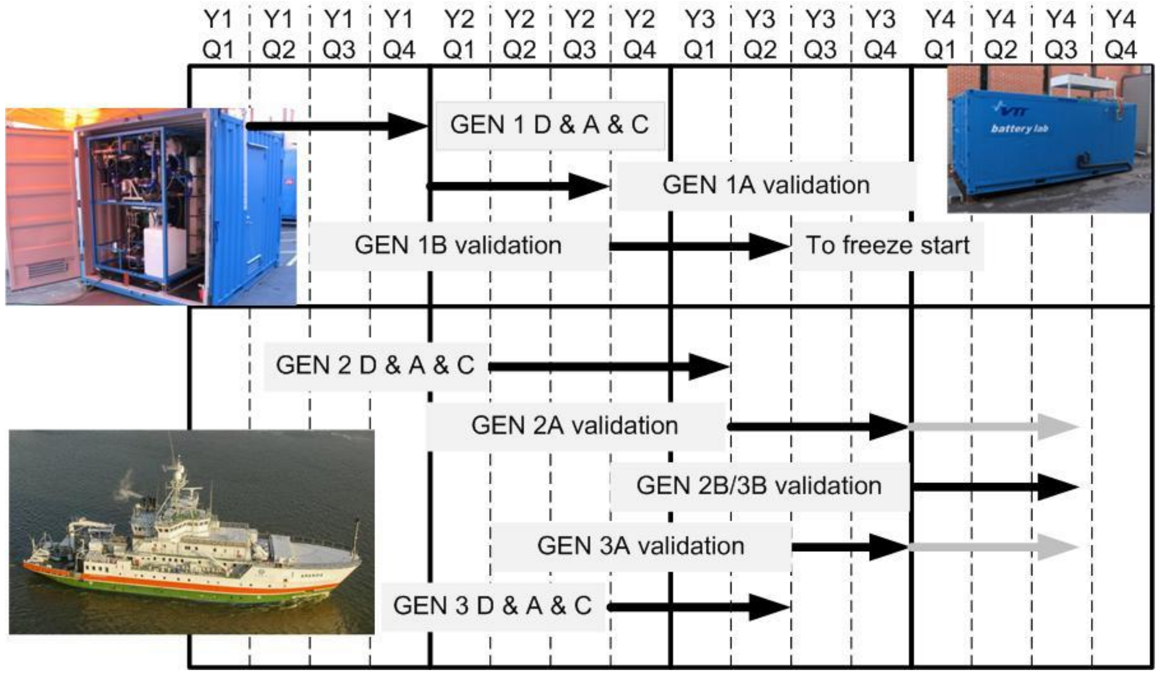
**Fuel cell stack life**
15 000h

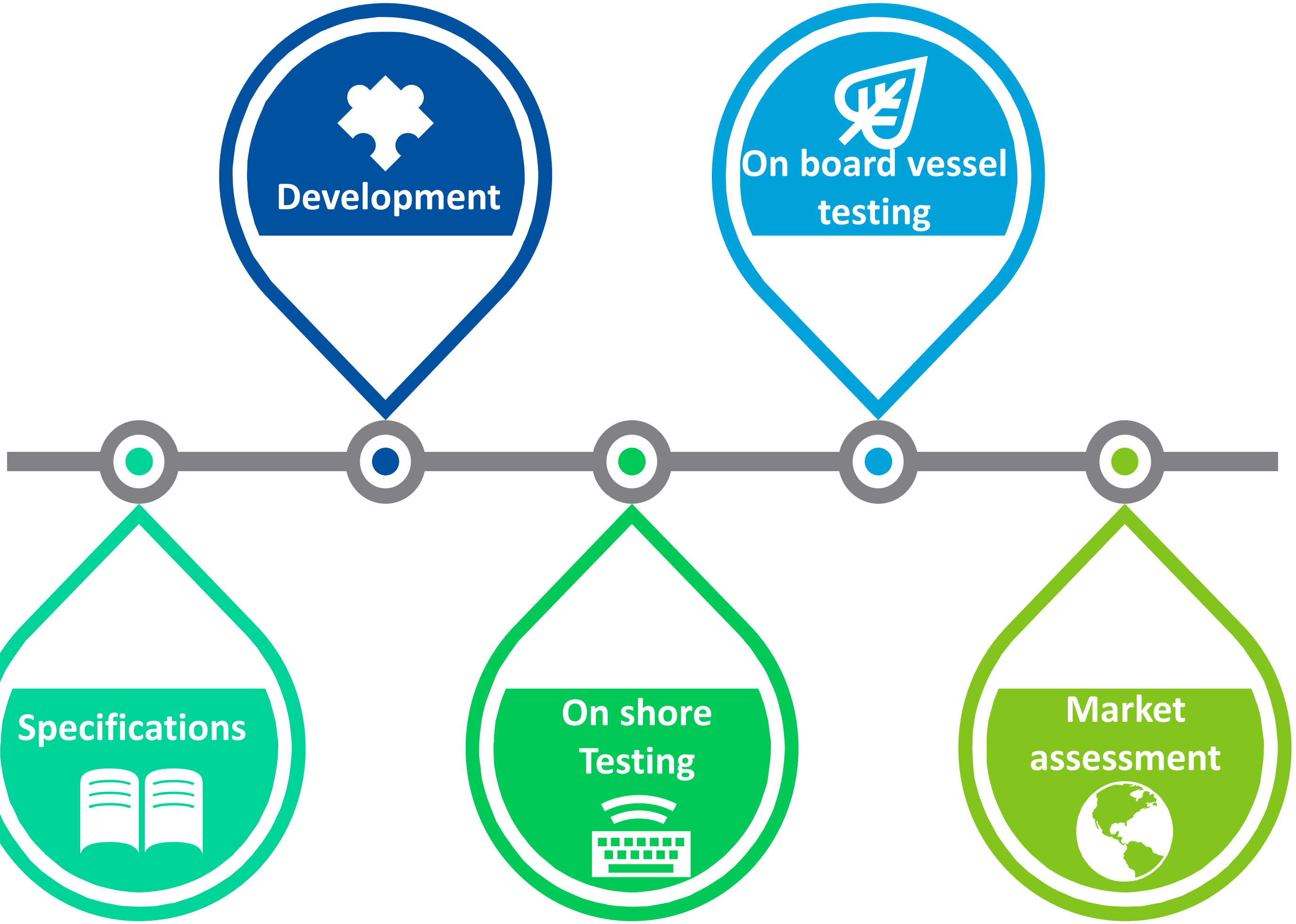
**Fuel cell systems conditions**
able to withstand the shocks, vibrations, saline environment and ship motions

*For 100 units / year

# MARANDA timeline

A four year project including onshore and on board vessel validations




The fuel cell system will be tested in conditions similar to arctic marine conditions before implementation to the target vessel. In addition, long-term durability testing (6 months, 4380 operating hours) of the system will be conducted at an industrial site.

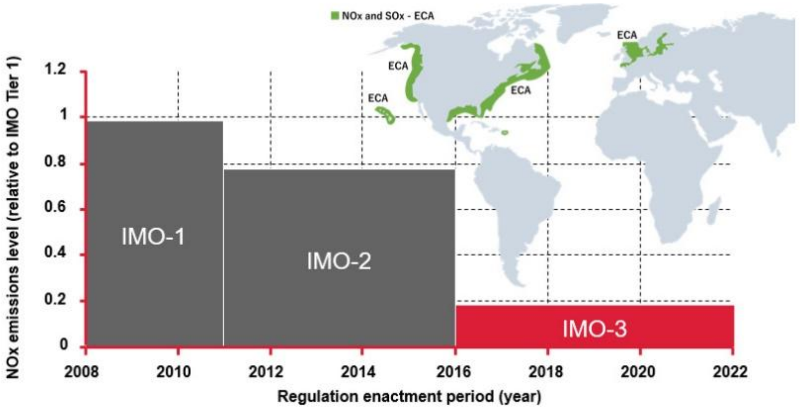
# FCH in Shipping

It’s coming!

# Marine applications must go green

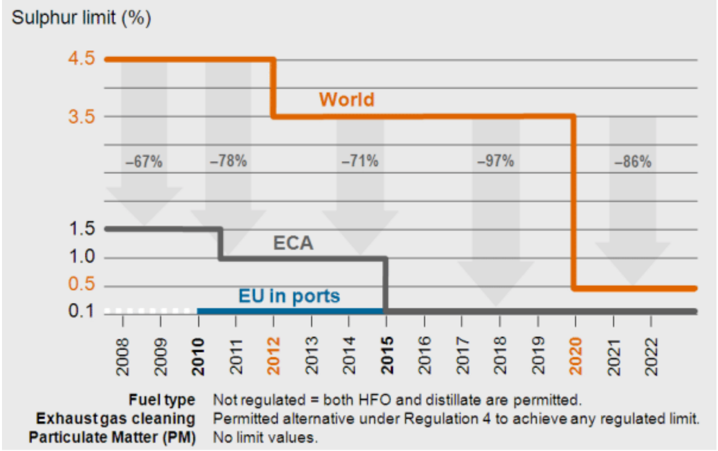
International regulation now imposes emission reduction of both air pollutants and GHG

## $NO_X$





## $SO_X$




Applies to new keels

## $CO_2$

Reduction of the total annual GHG emissions by at least **70%** in 2050 compared to 2008

IMO INTERNATIONAL MARITIME ORGANIZATION

**Reduction** of the total annual GHG emissions **by at least 50% in 2050** compared to 2008

Applies to entire fleet

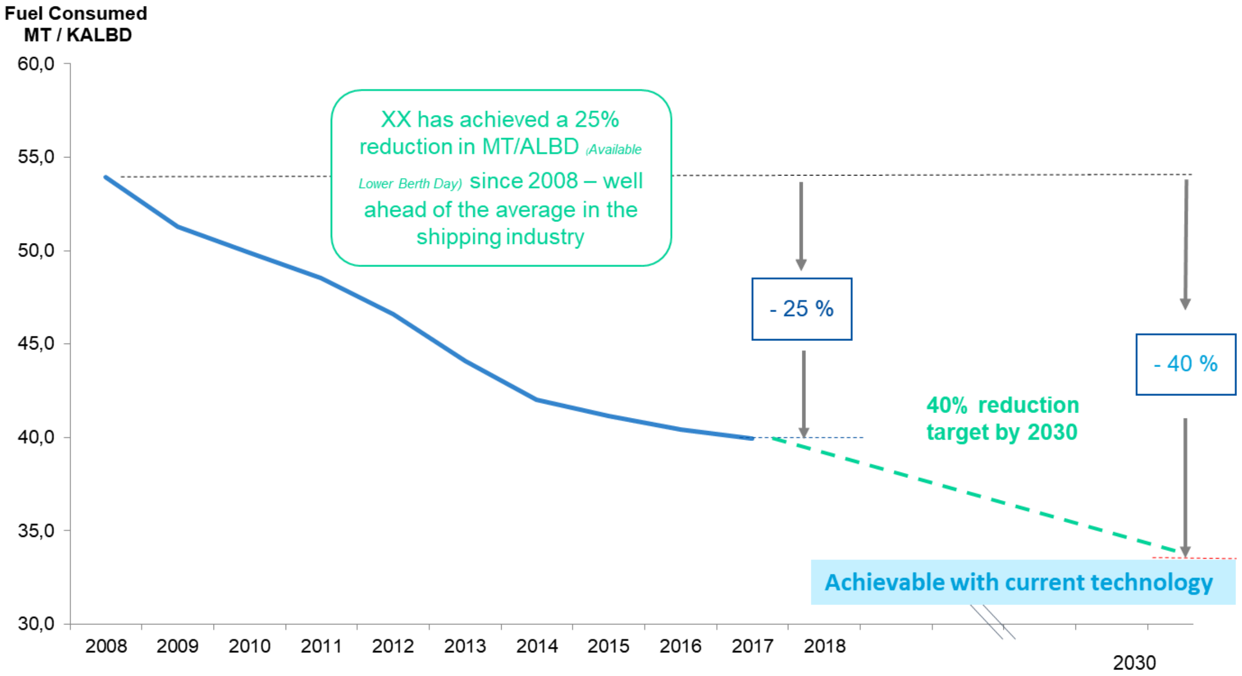
With 30 year ship ownership, actions towards GHG emission reduction should start **now**!

# Existing technologies, when combined, won't suffice to achieve CO2 targets



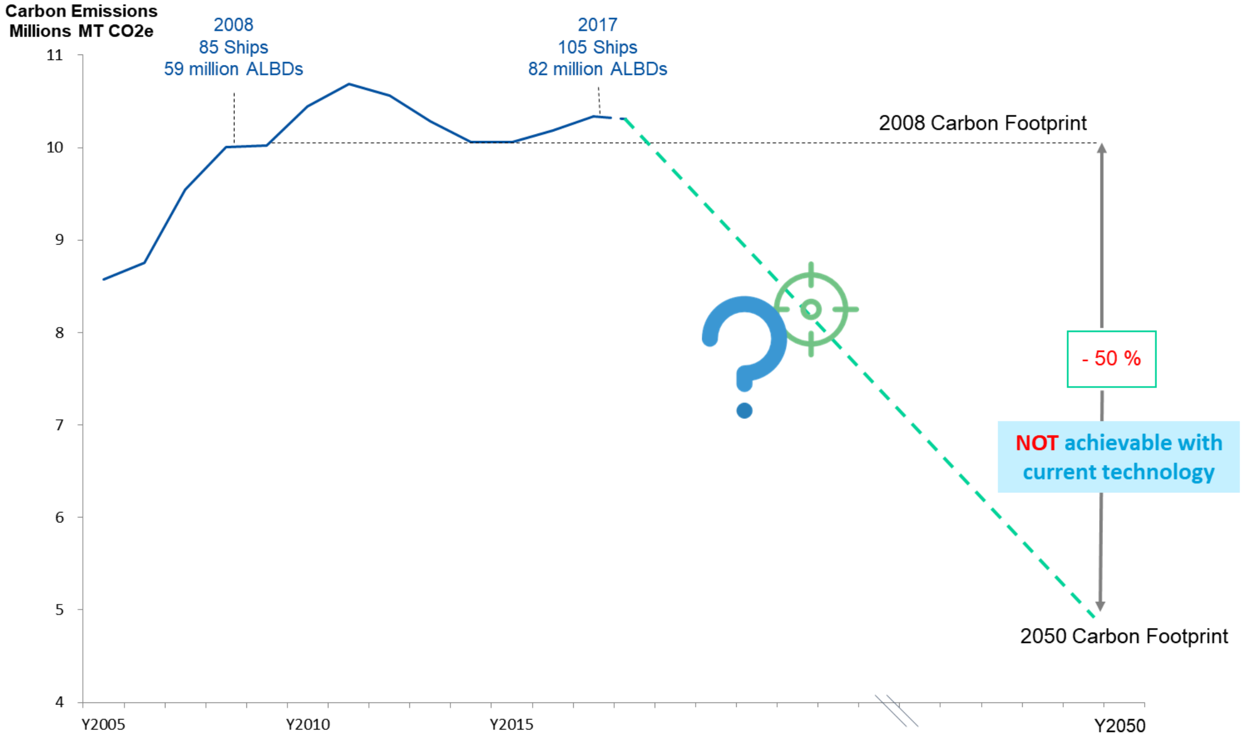
Using real data from ship owner "XX"

## Reduction of average unit $CO_2$ emissions (per transport work) by at least 40% by 2030 is achievable




- LNG ~ 25%
- Bio LNG ~ 10 %
- Shore power ~ 10 %
- Additional energy savings ~ 5 %

## Reduction of absolute GHG by at least 50% in 2050 is not achievable with existing technologies



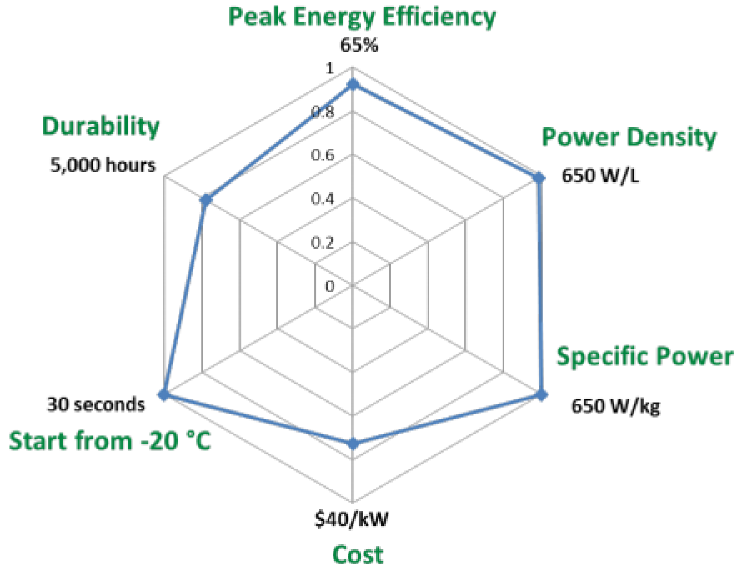

*LNG has proved efficient to address particulate emissions, but fails contributing significantly to $CO_2$ reductions*

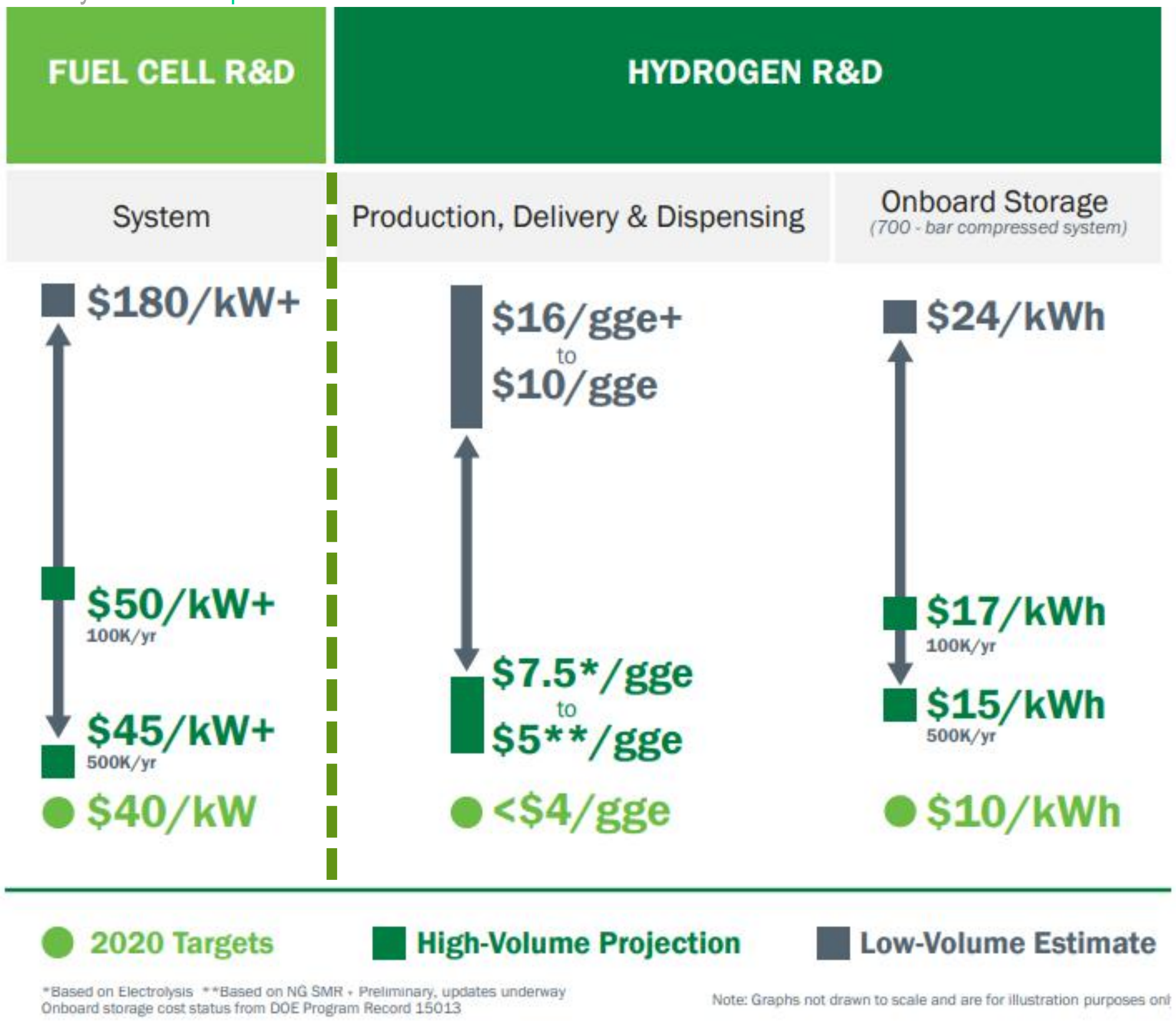
# HFC technologies are expected to be ready for the marine sector post 2020



Both technically fit and competitive

## FC Power system 2020 targets vs 2015 status (blue)




*LNG has proved efficient to address particulate emissions, but fails contributing significantly to $CO_2$ reductions*

# HFC propelled vessels are lining up for implementation

Individual willingness to go green is massive but plans might be pushed back due …

**Present**

Concept boats

**Race for Water** (2017)

**Energy Observer** (2017)

**2019**

FCH JU - Maranda


**Water-Go-Round**

**2020**

HYSEAS III

**HYBRIDship**

**2021**

NPRA

GKP7H2

**2023**

# FCH in Shipping

IMO doublespeak

# The regulatory environment for Hydrogen & Fuel cells is lagging behind

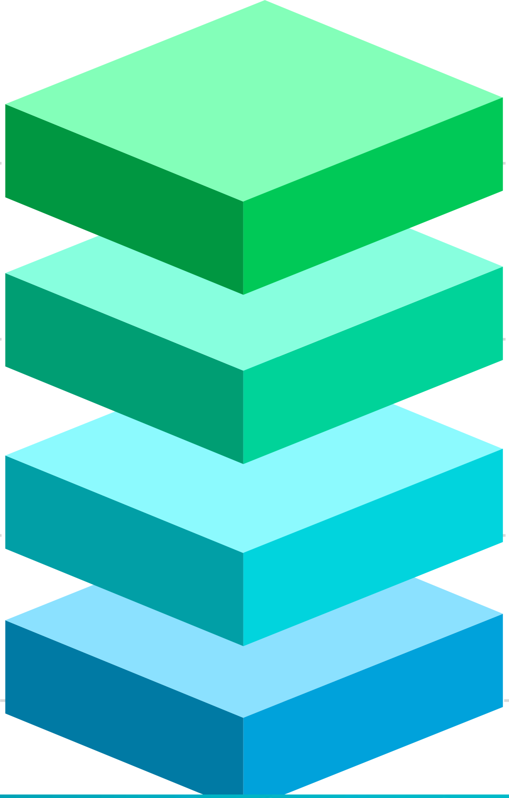
RCS (Regulations Codes and Standards) for deploying FCH ships are extremely limited

## Fuel specific requirements (Hydrogen)

- No prescriptive requirements available today
- The applicable part of the IGF Code (A) requires that an 'Alternative design' approach is followed

## Fuel consumers (FCs)

- The IGF Code's prescriptive requirements is limited for consumption by internal combustion engines, boilers and turbines
- Existing class rules can ease the alternative design process if the rules are acknowledged by the Administration

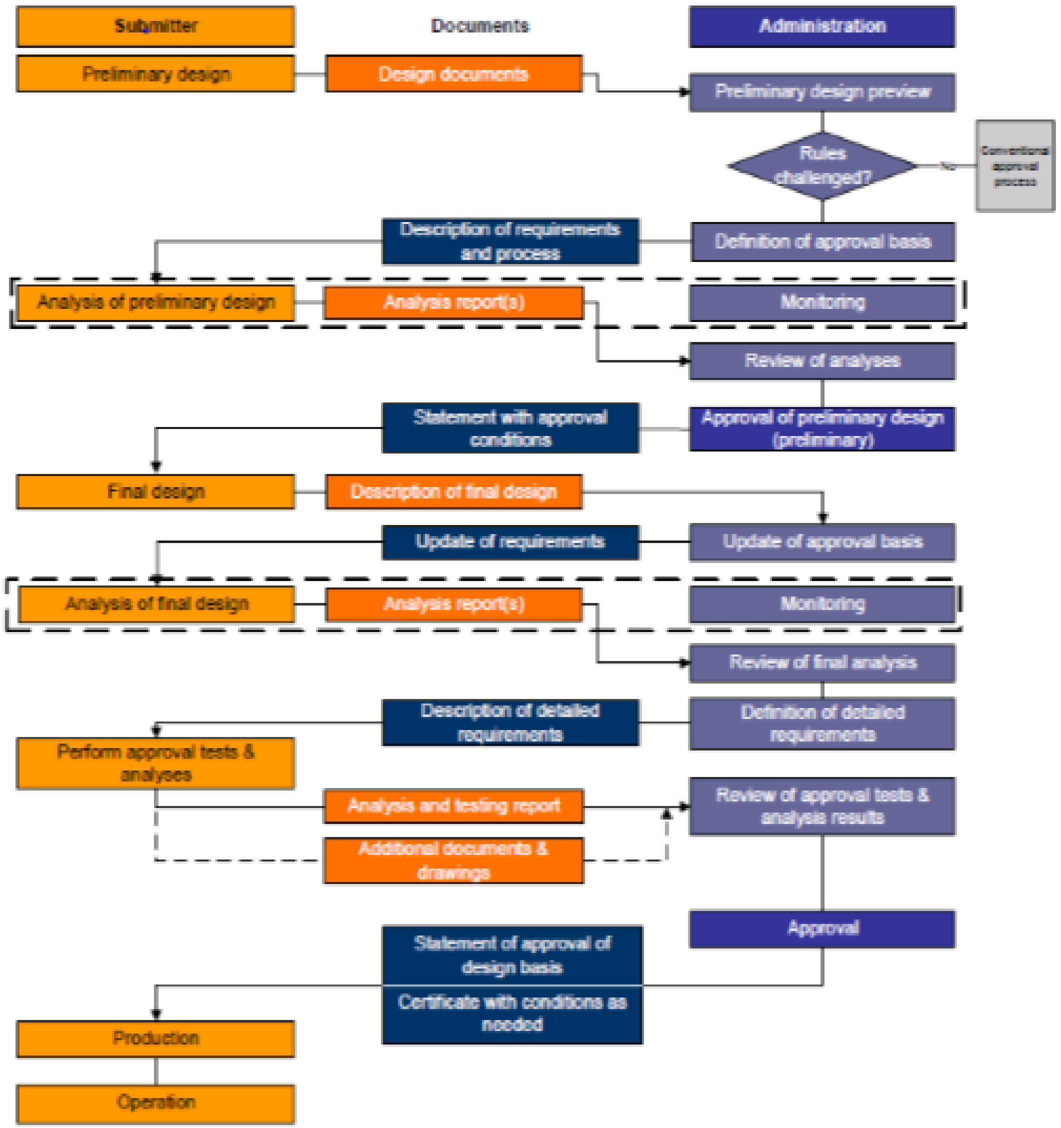


| | Now | In the next 4 years / BAU |
|---|---|---|
| IGF CODE Main | Only for LNG | No changes |
| IGF CODE Part E | Only for non $H_2$-FC | No changes |
| IGC CODE | Not covering $LH_2$ | Progressing under the impetus of Japan & Australia |
| Guidelines | Limited contributions, from DNV GL essentially | Ad hoc efforts connected to FCH JU & nationally funded demo project |

# All projects will go through the 'alternative design' process although not suited for mass deployment



The ship owner is alone taking the regulatory risk, while serving a global environmental cause




## Procedure for approval of alternative design

*The alternative design is the process by which it must be demonstrated that safety, reliability and dependability of the systems is equivalent to that achieved with new and comparable conventional oil-fueled main and auxiliary machinery.*

**Lengthy**

**Costly**

**Unpredictable**

**Subjective to individual interpretation**

# Addressing these gaps require a coordinated approach

At national, regional as well as international level

In Norway, NMA has launched a few workshops in partnership with DNV GL to support local projects

In Europe, the FCH JU is leading a project to support the upcoming ships to be funded this year

In the US, DOE has launched a call for expression of RCS related gaps

At IMO level....

## What can we do?

# FCH in shipping

The next LH2 sources?

# With 1MW calling for 1tpd of LH2, capacities in Europe are not sufficient

## < 20 TPD

?

**Leuna, Germany**
Operated by: **Linde**
Capacity (TPD): **5**
Commissioned in: **2008**
Still in operation: **YES**

**Rosenburg, Netherlands**
Operated by: **Air Products**
Capacity (TPD): **5**
Commissioned in: **1987**
Still in operation: **YES**

**Lille, France**
Operated by: **Air Liquide**
Capacity (TPD): **10**
Commissioned in: **1987**
Still in operation: **YES**


Let's release the
$CO_2$ emission reduction
potential of
Hydrogen and Fuel Cells

Contact us at maranda@pers-ee.com

## Acknowledgments

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