FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

EU support to maritime activities

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Head of Unit

San Francisco, 10th September 2019

Fuel Cells & Hydrogen technologies in the context of the EU Climate and Energy Framework

Making energy more secure, affordable and sustainable

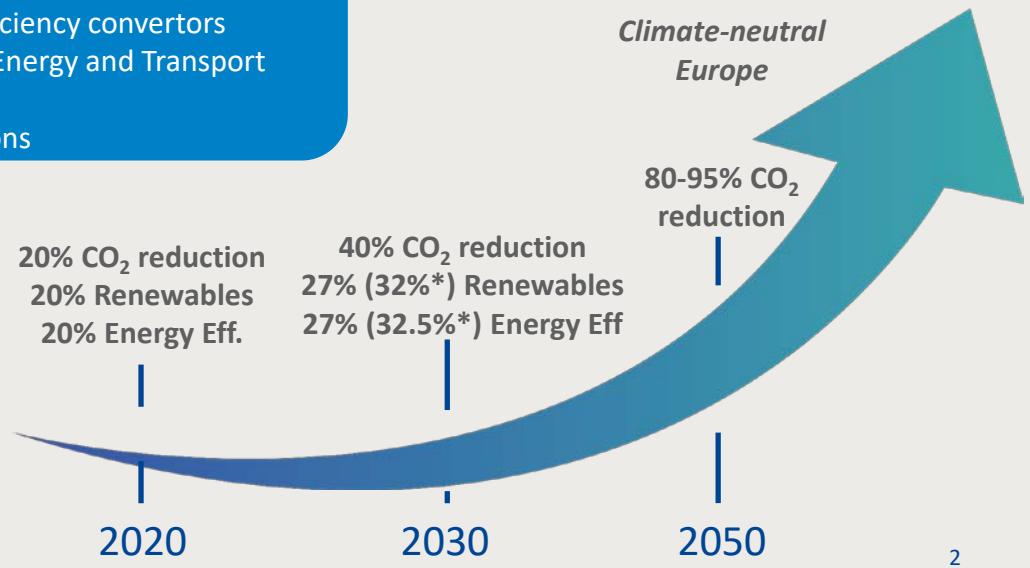
research excellence leading to industry innovation and growth

Increase independence from unstable outside regions

- H2 is a clean energy carrier
- Possibility for energy storage from renewable energy sources
- Fuel cells as very high efficiency convertors (electricity and heat) for Energy and Transport applications
- Reduction of CO2 emissions

Energy Union dimensions

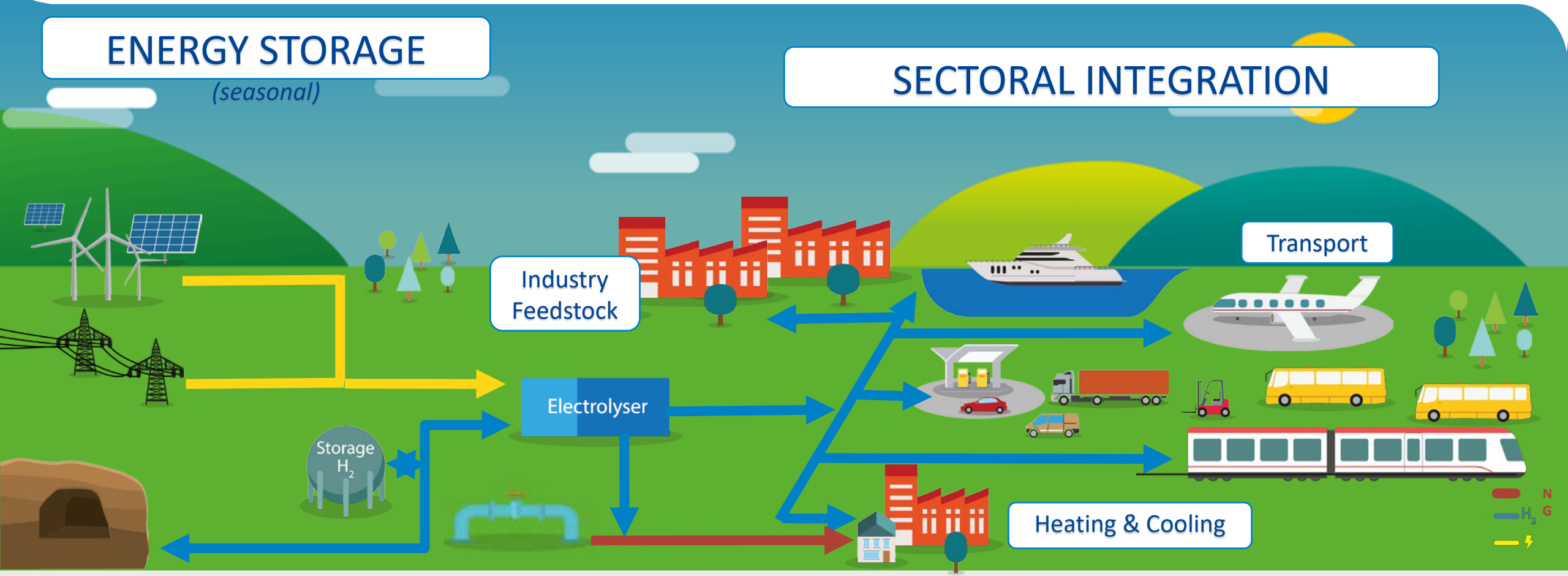
- ***Security, solidarity and trust***
- ***Fully-integrated Internal Energy Market***
- ***Energy Efficiency***
- ***Climate action - decarbonising the economy***
- ***Research, innovation and competitiveness***



* 14 June 2018: Commission, Parliament and Council Political Agreement (approved within Clean Energy Package, 19 Dec 2018)

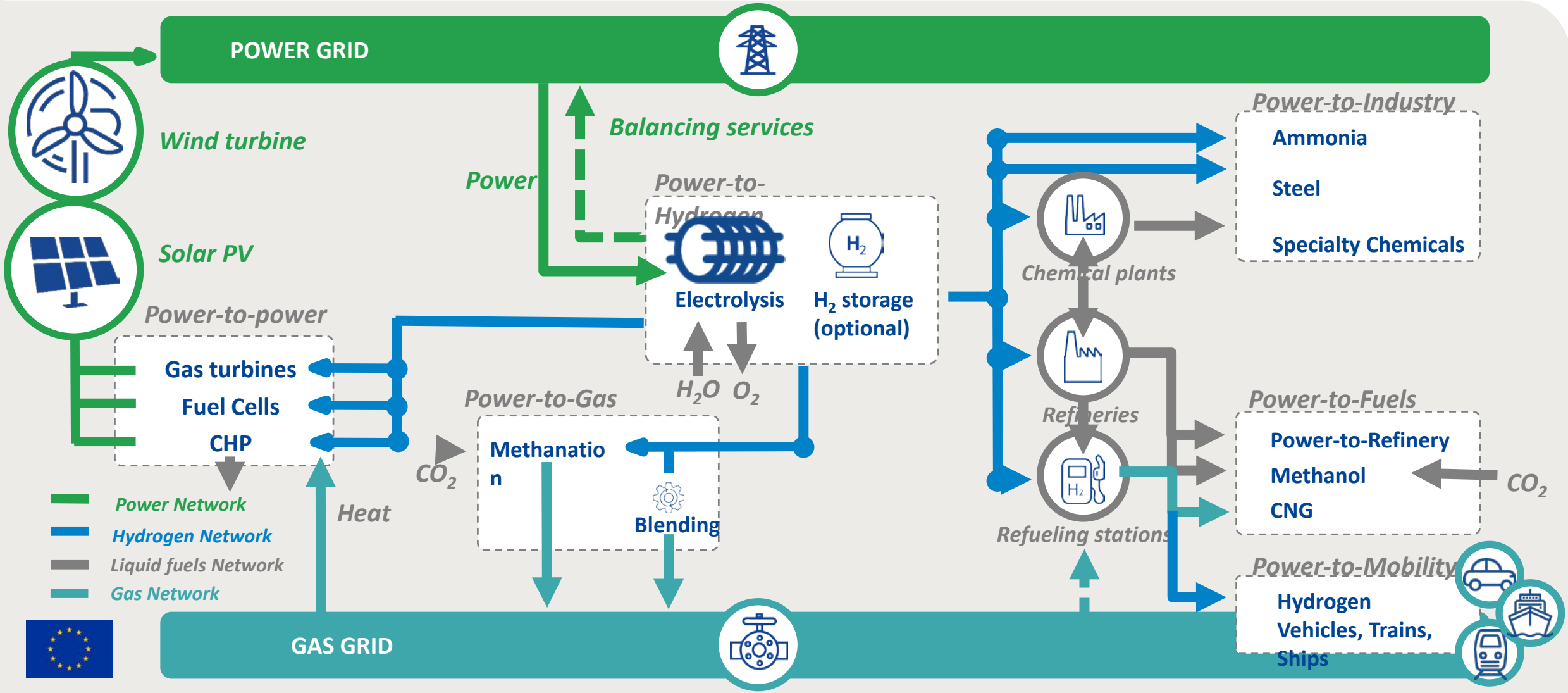
The role of hydrogen in our society & economy

Hydrogen allows more renewables in the energy system through storage and enables sectoral integration



Today's H_2 Production: enabler of Sectorial integration

H_2 is the best option for deep decarbonisation for a number of sectors



Besides CO_2 abatement, deployment of the hydrogen roadmap also cuts local emissions, creates new markets and secures sustainable employment in EU

2050 hydrogen vision

~24%

of final energy demand[1]

~560 Mt

annual CO_2 abatement[2]

~EUR 820bn

annual revenue (hydrogen and equipment)

~15%

reduction of local emissions (NO_x) relative to road transport

~5.4m

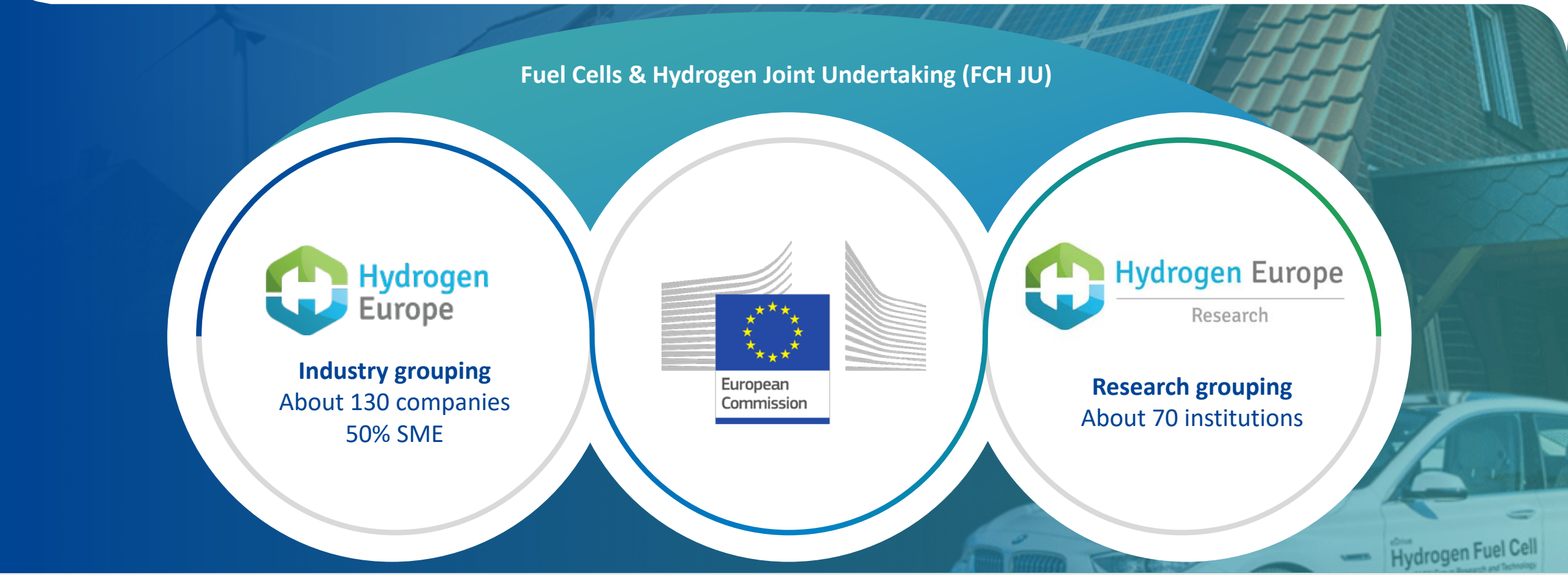
jobs (hydrogen, equipment, supplier industries)[3]

1 Including feedstock 2 Compared to the reference technology scenario 3 Excluding indirect effects

SOURCE: Hydrogen Roadmap Europe team

Strong public-private partnership with a focused objective

EU Institutional Public-Private Partnership (IPPP)



To implement an *optimal research and innovation programme* to bring FCH technologies to the point of market readiness by 2020

FCH 2 JU Programme structure

ENERGY

- Hydrogen production and distribution
- Hydrogen storage for renewable energy integration
- Fuel cells for power & combined heat & power generation

TRANSPORT

- Road vehicles
- Non-road vehicles and machinery
- Refuelling infrastructure
- Maritime, rail and aviation applications

CROSS-CUTTING

(e.g. standards, safety, education, consumer awareness, …)

FCH 2 JU*:

Total Budget: at least 1.3 bill.€

EU contribution: 665 mill.€

*Continuation to previous 2007-2013 programme (at least 1 bill. € total budget)

FCH JU programme(s) implementation (2008-2018)

Energy

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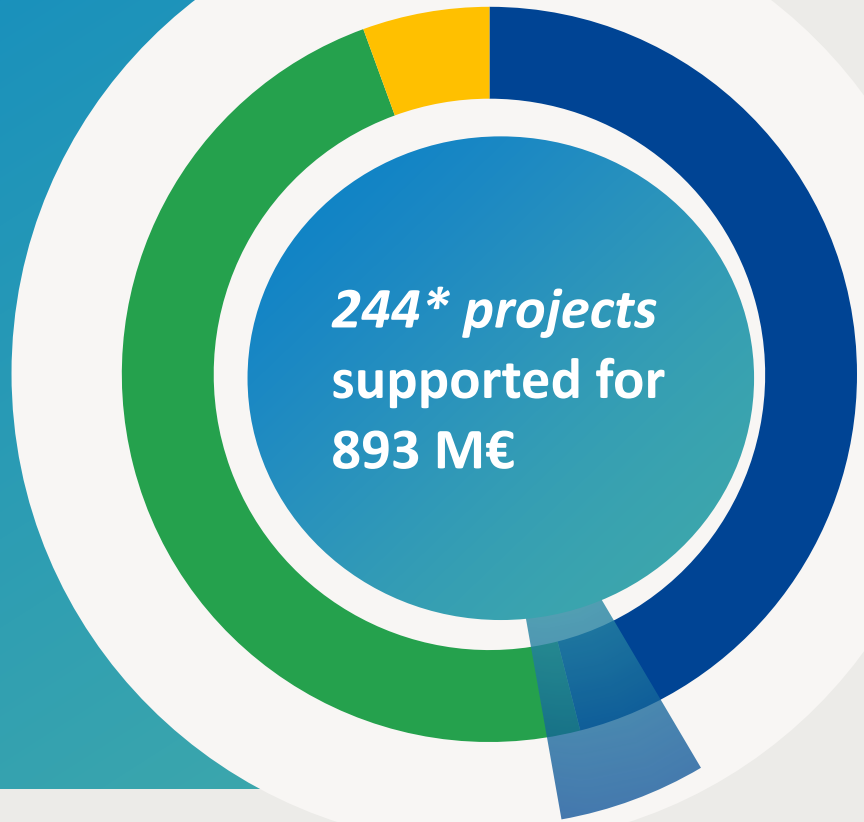


47 %

418 million euros

135 projects

42 %

376 million euros

65 projects

6 %

53 million euros

40 projects

5 %

46 million euros

4 projects

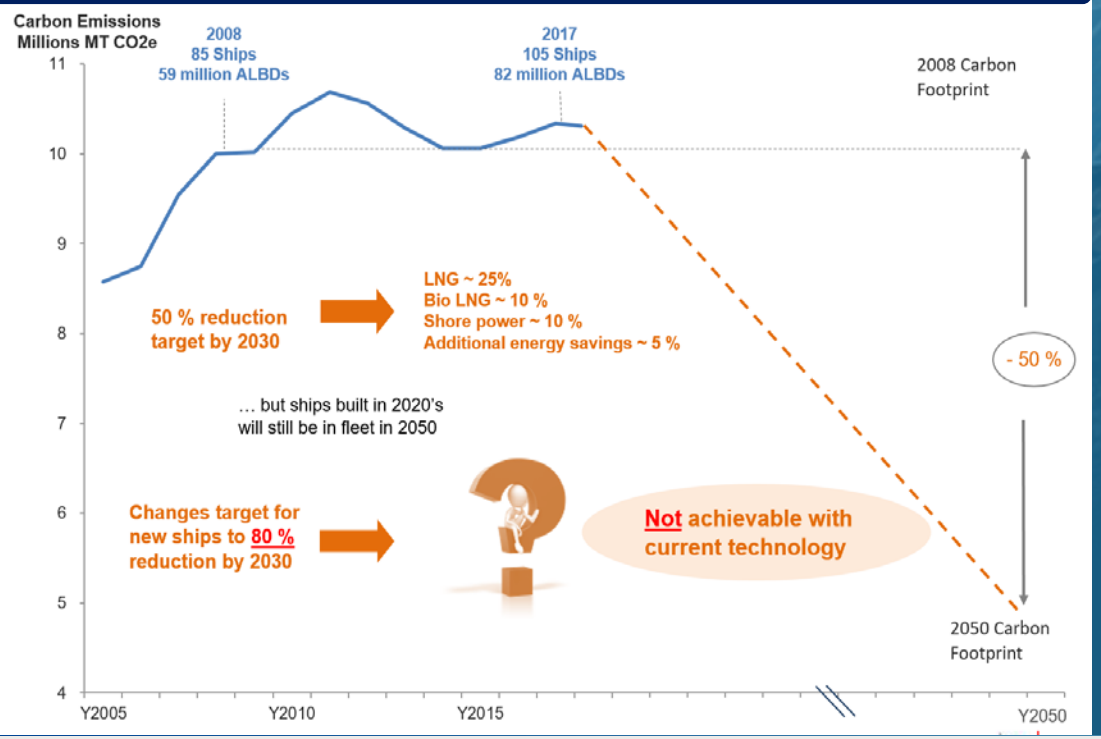
Similar leverage of other sources of funding: 892 m€

* Including recently signed 17 projects from call 2018

Maritime discovering Hydrogen and Fuel Cells

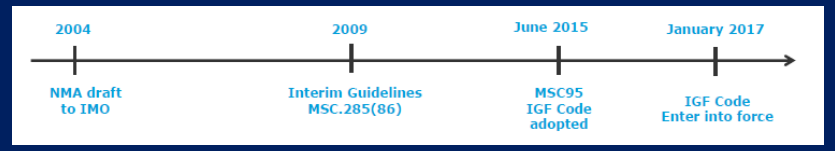
To accelerate the decarbonisation of Maritime, regulation for hydrogen need to be prepared

- IMO April 2018: “at least 50% of CO_2 reduction by 2050”



Reduction in emissions by fuel conversion (Petroleum oils → Natural gases)

NOx	SOx, PM	GHG
80%~90% reduction	Zero emission	20%~25% reduction



IMO targets are not achievable with current technologies, **converting the entire fleet to LNG will not be sufficient. Urgent need to regulate H2 for ships**

- Further R&D needed e.g. L H_2 storage, MW scale Fuel Cells,…

Overview of EU support: R&I on FC and H2 in maritime/port applications

MARANDA: hydrogen fueled PEMFC based hybrid powertrain system validated on board the research vessel Aranda

2017-2021

FCH JU Funding: ~3M€

BIGH2IT

A hydrogen territory in Scotland: hydrogen production, storage, transportation and utilization for heat, power and mobility.

2016-2021

FCH JU Funding: ~5M€

HySeas III: the world's first zero emission, sea-going ferry. Demonstrate a circular economy model for the local production of H2 fuel

2017-2021

H2020 Funding: ~9.3M€

New projects – started 2019

FLAGSHIPS

FLAGSHIPS: Fluvial push-boat, Lyon (FR) & RO-PAX ferry, Stavanger (NO)

2019-2022

FCH JU Funding: ~5M€

H2 PORTS

H2Ports: FC for port/harbor container terminal: Reach Stacker, Yard Tractor & Mobile HRS

2019-2022

FCH JU Funding: ~4M€

Call for proposals/applications 2019

H2020

- **Next Generation Propulsion for Waterborne >5MW on-board power**
- **Structuring R&I towards zero emission waterborne transport**

H2020 Funding: ~5-9M€

FCH JU

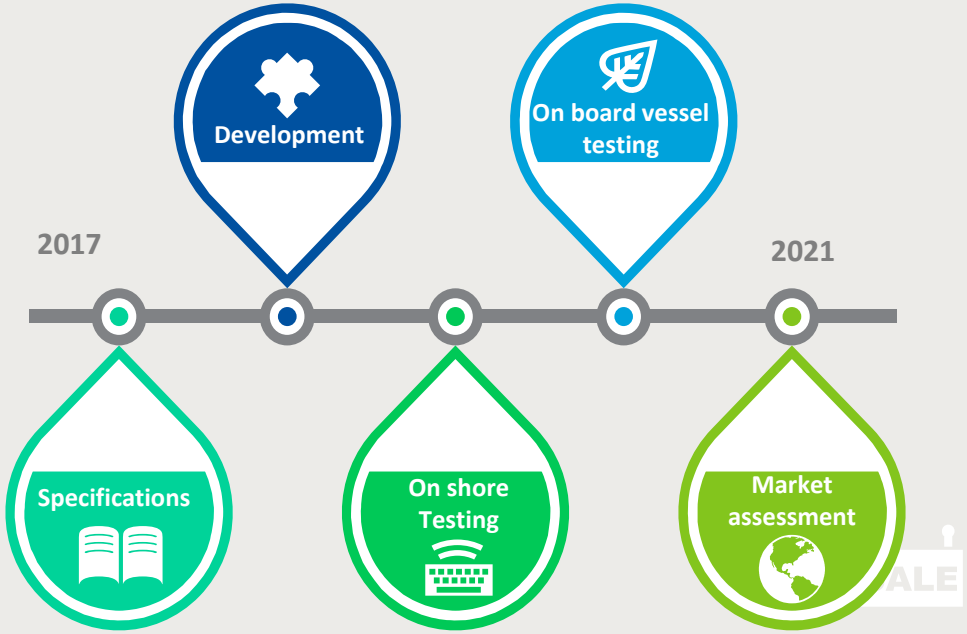
- **Scaling up and demonstration of a multi-MW Fuel Cell system for shipping**

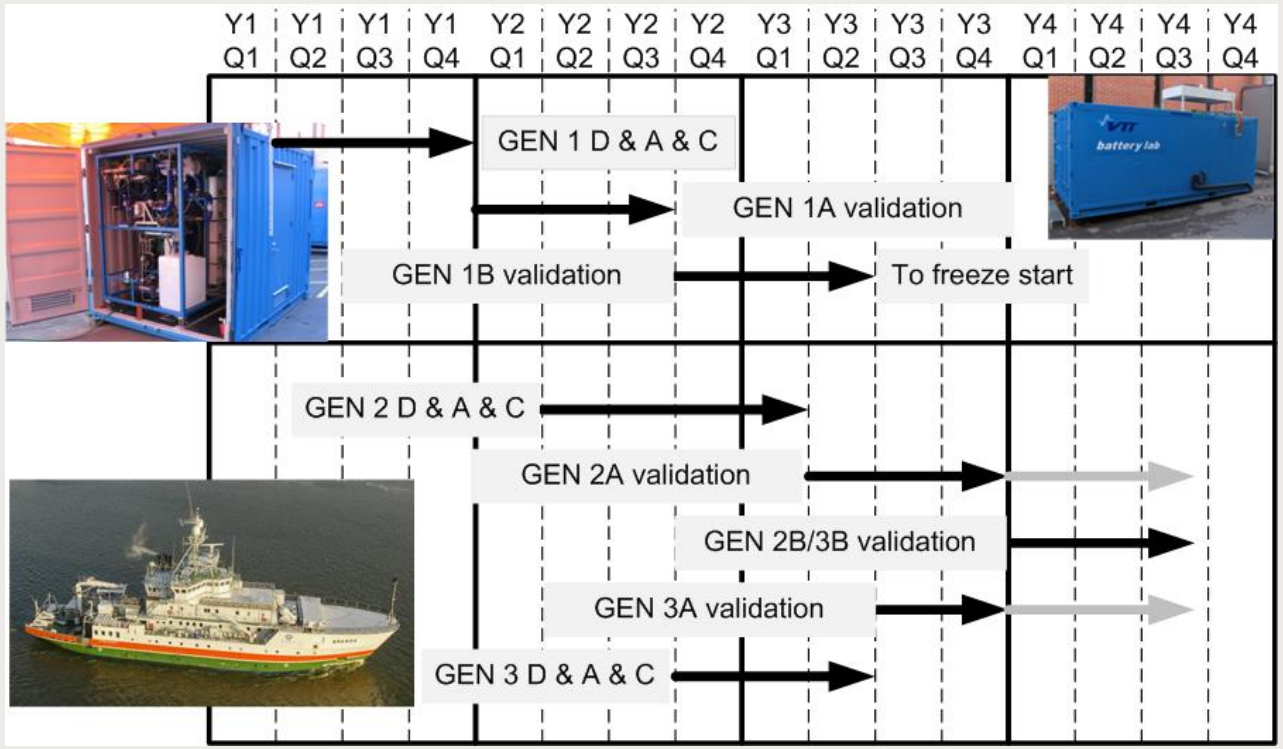
FCH JUFunding: ~10 M€

MARANDA: a research vessel in the Artic sea (1/3)

- **Duration:** 01/03/2017 to 28/02/2021
- **Participants: VTT (FI);** POWERCELL (SE); ABB (FI), OMB SALERI (IT); PERSEE (FR); SUOMEN YMPARISTOKESKUS (FI); Finnish Environment Institute; SWISS HYDROGEN (CH)
- **Project cost:** 3.7 M € (**EU/FCH JU contribution:** 2.9 M €)
- 165 kW fuel cell powertrain (hybridized with a battery) to fuel dynamic positioning activities of Aranda, a Finnish Research Vessel
- Gaseous mobile hydrogen storage container, refillable in any 350 bar hydrogen refueling station
- Special emphasis on air filtration and development of hydrogen ejector solutions, for both efficiency and durability reasons
- Liquid hydrogen considered in go-to-market strategy (scaling-up)
- https://cordis.europa.eu/project/rcn/207654_en.html

MARANDA: objectives and targets (2/3)





Fuel to electric efficiency
50%

System Cost
<1000€/kW*

*For 100 units / year

Fuel Cell stack life
15 000h

freeze start capabilities
from -35°C

operating temperature
[-32°;+50°]

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

MARANDA: issues already detected (3/3)

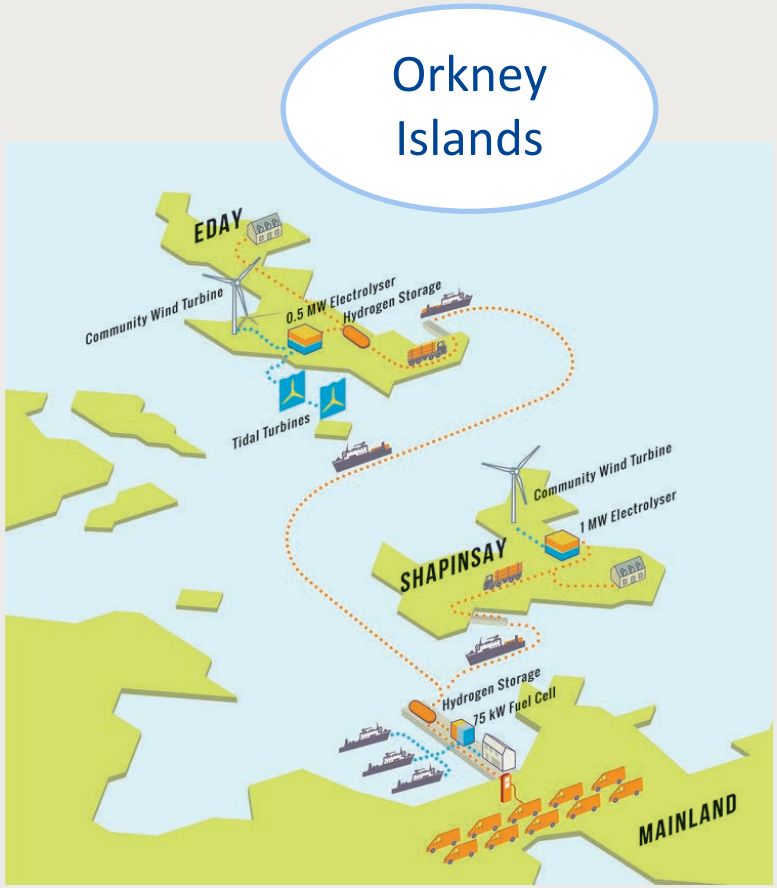
- Need to **improve fuel cell lifetime** beyond the 15,000 hours (2 years) [objective of Maranda]
- Need to **scale up fuel cell to multi-MWs** to satisfy all ship's power demand
- **Difficult regulatory compliance** due to:
  - Differences concerning hydrogen storage on board compared to other applications
  - Marine/Road Code compatibility: Swappable tanks
  - Definition of hazardous zones
  - Pressure to limit flamable materials onboard and use metals instead BUT PEM FC use plastic
  - Special fire detection & crew training needs

Fuel specific requirements for hydrogen as a marine fuel:

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

BIG-HIT Project - “Hydrogen Territory”

Building Innovative Green Hydrogen Systems in Isolated Territories



Use of renewable energy curtailment

In 2016 renewable electricity generation **produced 120% of the islands annual electricity demand**

Hydrogen from wind and wave

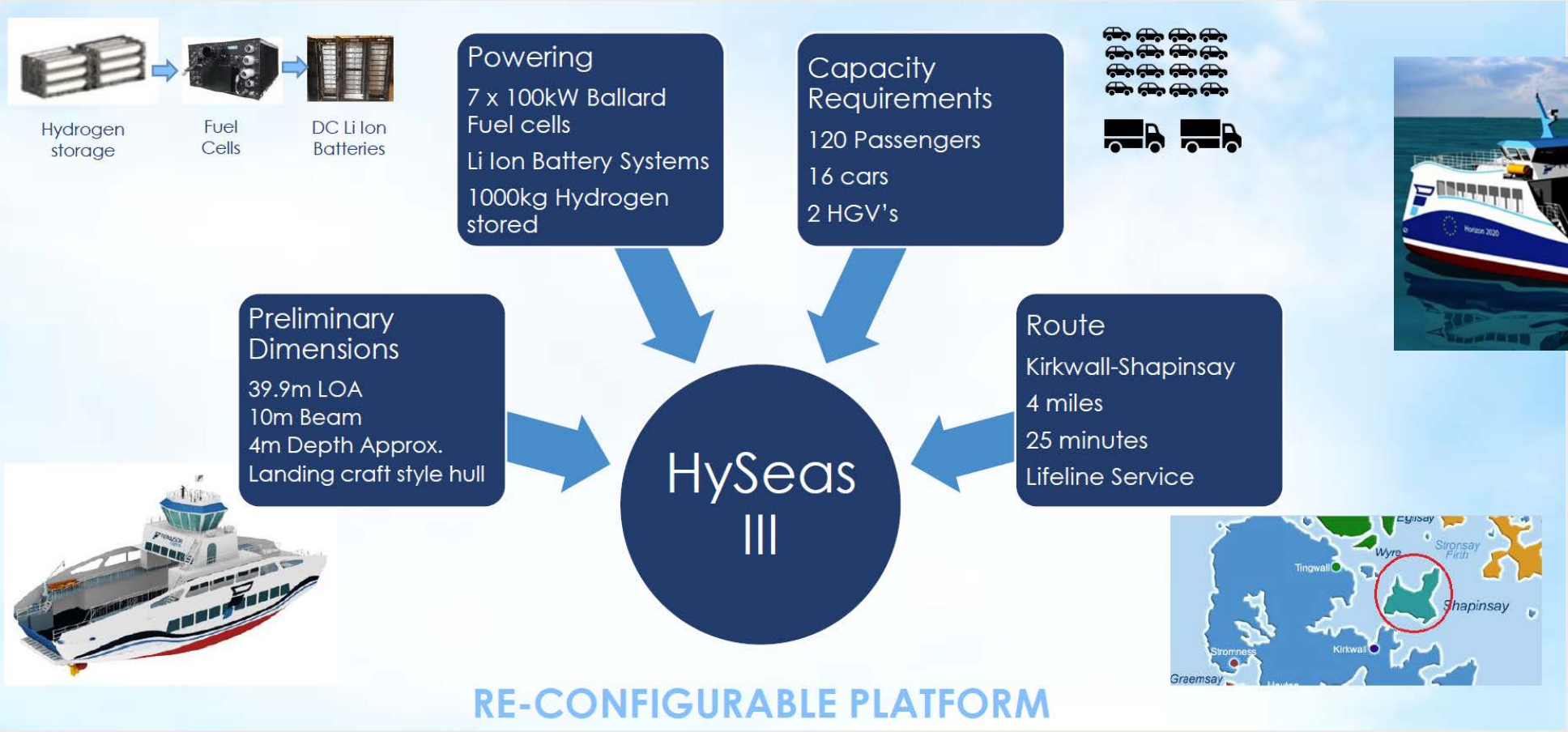
- Integration with wind and tidal turbines
- 2 PEM electrolysers (**1MW & 0.5MW capacity**) producing **~50tonnes/year of H**2

Port ecosystem

- 75kW PEM for cold ironing (3 ferries) and CHP at harbours offices and marina
- CHP for 2 schools, a HRS for 10 FCEvs

HySeas III

Develop and validate advanced ferry concepts for European waters



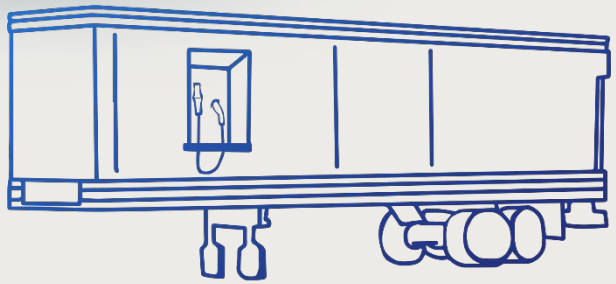
- 3 years project
- 9.3M€ funding
- Shipyard: Ferguson Marine

H2 PORTS

Implementing Fuel Cells and Hydrogen Technologies in Ports

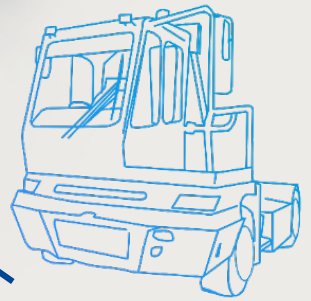
Reach Stacker in MSC Terminal

- FC: 90-120 kW
- 2 years / 5000 h of operation



Mobile HRS

- Hydrogen supply logistics at ports
- Port regulatory framework
- Safety procedures



Yard Tractor in Valencia Terminal Europa

- FC: 85 kW
- 2 years / 5000 h of operation

General features

- Total Budget: approx. 4 M€
- Duration (4 years): 2019-2023

First application of hydrogen technologies in port handling equipment in Europe

Partners: Fundación Valenciaport, valenciaport Autoridad Portuaria de Valencia, Grimaldi Group, msc Terminal Valencia S.A.U, Hyster-Yale Group, Ballard, Atena Future Technology, Centro Nacional del Hidrógeno, enagas

FLAGSHIPS
Clean waterborne transport in Europe

VESSEL 1:

LYON
GASEOUS HYDROGEN

A push-boat operating as an utility vessel on one of the most demanding rivers, the Rhône

~400 kW FC power

~600 kW FC power

VESSEL 2:

STAVANGER
LIQUIFIED HYDROGEN

A passenger and car ferry operating as part of the local public transport network

GENERAL FEATURES

Total Budget: 6.8 M€

Duration: 4 years (2019-2023)

A total of 1 MW installed on-board fuel cell power

On-site hydrogen production with electrolyzers powered by renewable electricity.

FCH JU call for applications 2019: Scaling up and demonstration of a multi-MW Fuel Cell system for shipping

Give a solution to the urgency of introducing ultra-low and zero-emission solutions for shipping

- Adapt, scale up and demonstrate a fuel cell system for shipping with a total **minimum nominal power output of 2 MW**
- Open to **all types of FC technologies** and **all types of fuels** but must **reach >70% CO2 reductions**
- Minimum power: **500 kW/fuel cell unit** ; Adapted for **maritime conditions** ; Assessment of **scalability to 20 MW**
- If H2 is the fuel, study on a **bunkering concept** with the potential **for scaling** up to the requirements for 20 MW
- Special focus on relevant **regulation and codes ongoing activities**, promoting **international collaboration** beyond EU
- Minimum 12 months and 3,000 h of operation

International cooperation strongly encouraged

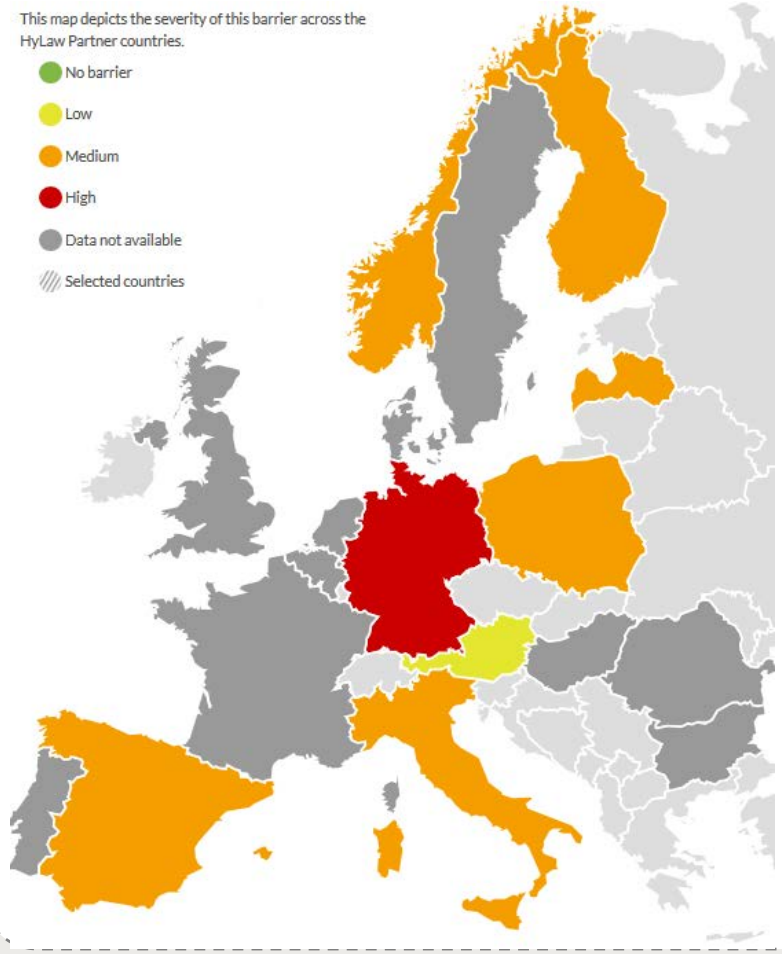
Up to 10 M€ funding

HyLaw: legal and regulatory barriers for maritime applications

- To enable investments, financial institutions, shipbuilders, shipowners and charterers **need comprehensive and predictable legal framework**
- This should include **removing existing regulatory gaps** and might include introduction of global carbon pricing mechanisms

www.hylaw.eu

Bunkering



Design / type approval

EU activities beyond R&I support

Readiness of the hydrogen industry and the shipping industry: What shall we do next?

Valencia, 2017: Workshop on FC and H_2 in maritime applications

- Awareness raising on FC and H_2 & technical State-of-the-Art
- Main conclusion: work needed on standards, protocols, permission framework for hydrogen handling in harbours or in boats (in addition to R&I support to technology)
  - ✓ All R&I maritime projects requested to have specific tasks on RCS gaps for FC and H_2 in maritime applications
  - ✓ Creation of a RCS Group
  - ✓ **There is a crucial need to adress RCS at international/IMO level !**

Brussels, 2018: Workshop with 50 industrial stakeholders including customers and technology providers

- Cruise and ferry operators:
  - ✓ Strong appetite to test and deploy the technology
- Ships & equipment providers:
  - ✓ Clear plans for FC and H2, trialed at various scale with different FC system providers
  - ✓ The market focus is towards multi-MW FC for oceangoing vessels
- FC system suppliers:
  - ✓ Many activities to develop dedicated heavy-duty/high power density FC

Equinor (STATOIL) - Platform Support Vessel pilot

Viking liquid hydrogen powered cruiseship (concept)

EC/FCH JU started discussions at IMO level

September 2018:

Meeting of Sub-Committee on Carriage of Cargoes and Containers (CCC)

EC/FCH JU invited presentation (lunch debate)

113 attendees, interest from many countries (FR, JP, DK, DE, etc.)

Main technical questions:

- "Physics" of H2, methanol and ammonia (weight, volume, production methods etc)
- Interest on e-fuels

May 2019:

Meeting of Marine Environment Protection Committee (MEPC)

Energy Observer presentation

Hydrogen Europe – Maritime Working Group

Roadmap needed for further EU funding (2020-2030)

Establish a Technology development roadmap

- Build consensus on fuels, technology, shipping segments, etc.

Regulatory aspects

- Identify regulatory challenges – www.hylaw.eu
- Map necessary changes
- Build an action plan

Working Groups created for broad overview in the short term

- Draft tool and roadmap under preparation
- Final version in October 2019

International cooperation on maritime/port applications

IEA-HIA Task 39 consists of four subtasks:

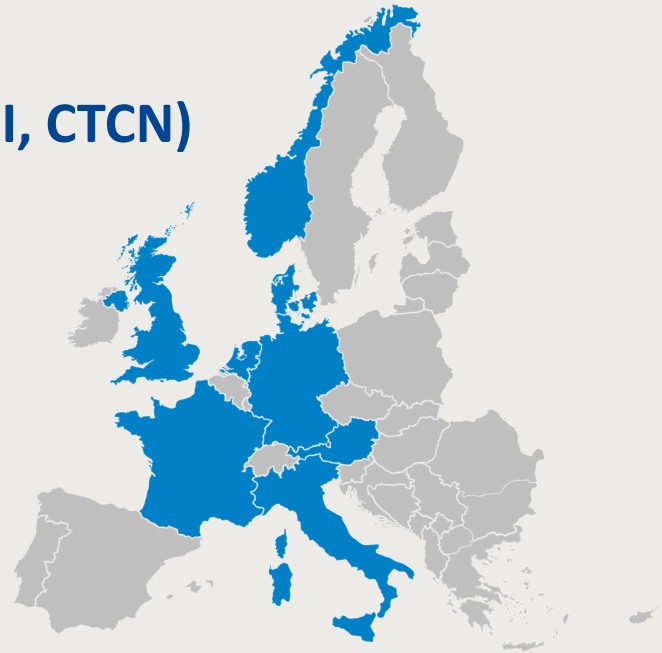
- Technology Overview
- New Concepts
- Safety and Regulations
- Demonstration

CEN/CENELEC SFEM WG Hydrogen

- Develop an appropriate PNR/standardisation roadmap/action plan to address PNR gaps in the maritime sector

FCH JU projects are open (in general) to international cooperation (IPHE, MI, CTCN)

While funding can cover participation of Mission Innovation members



Innovation Challenge Members: EU countries on the map and …

Australia
Canada
European Union
Chile
China
India
Japan
USA
Saudi Arabia

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