Clean Hydrogen Partnership

R&I on hydrogen as a powerful leverage to decarbonise shipping

Lionel BOILLOT, CleanH2 JU

6 November 2025 – Paris (IEA)

Structure

Overview

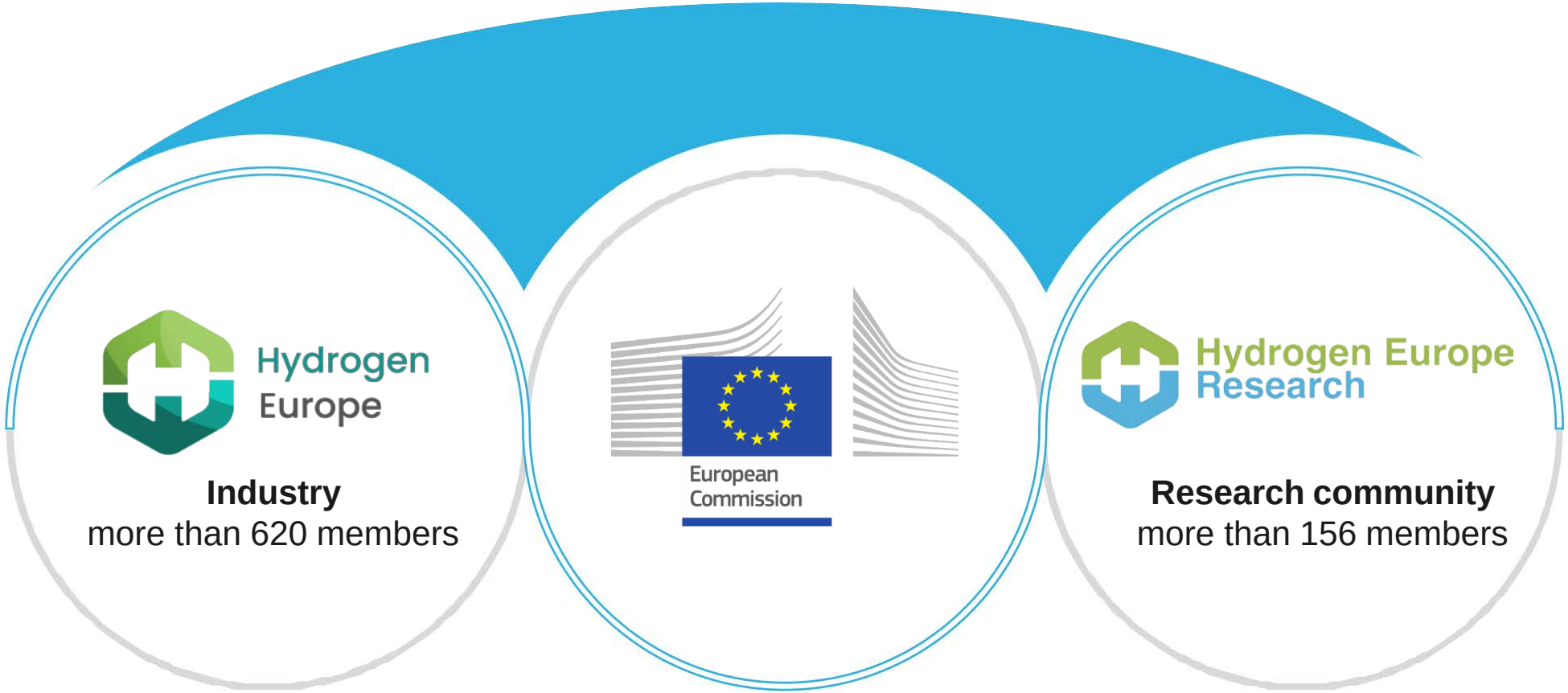
- Clean Hydrogen JU intro
- Overview JU supported projects – shipping and ports

Shipping

- Evolving context 2017 to 2025
- Fuel Cells projects and demonstrators
- Hydrogen distribution and storage
- Regulation
- Cooperation

Clean Hydrogen Joint Undertaking – Introduction

Institutionalised European Public-Private Partnership



1 billion EURO from Horizon Europe* to implement R&I activities and facilitate the transition to a greener EU society through the development of hydrogen technologies

**** additional 200 million EURO for Hydrogen valleys (under RePowerEU)***

Co-funded by the European Union

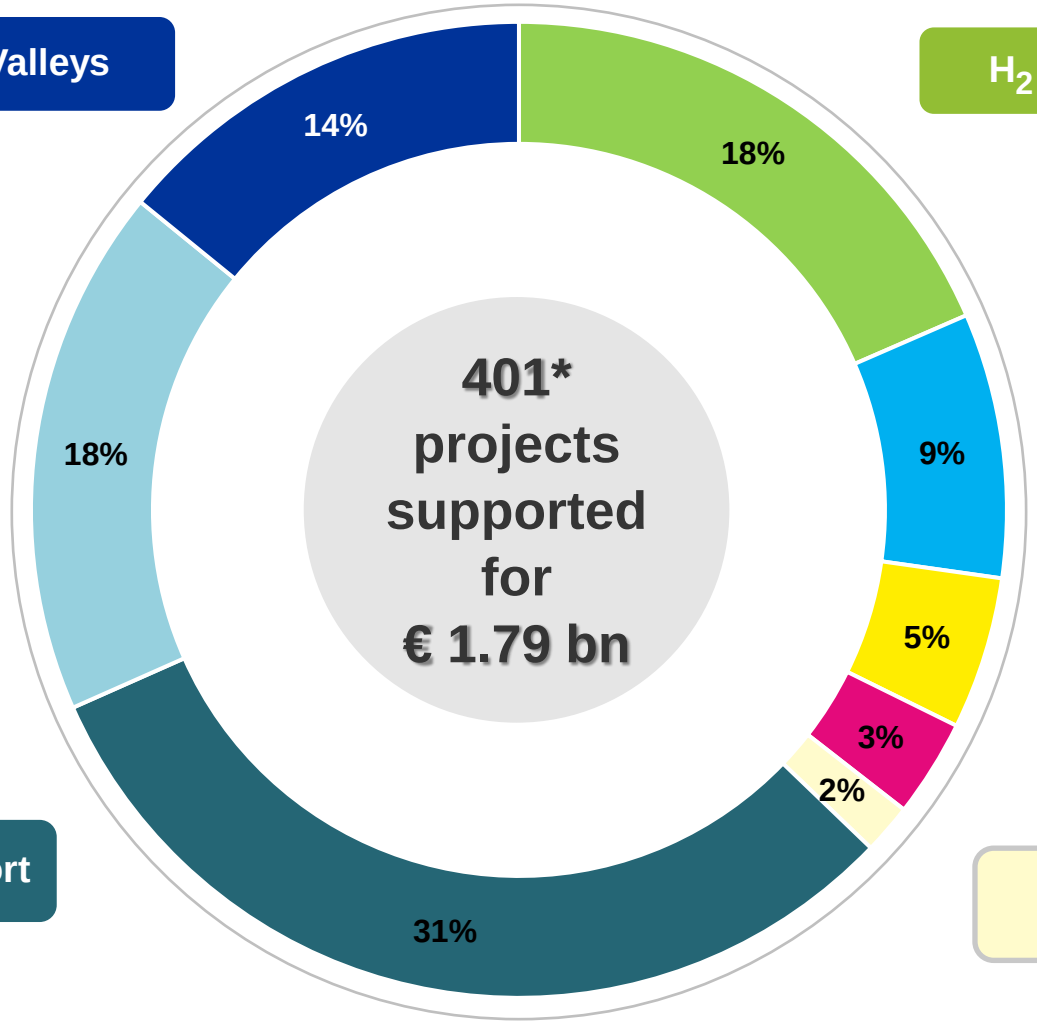
Clean Hydrogen JU Programme

Clean Hydrogen Partnership

H_2 Valleys

21 Projects

€ 253.4 million



H_2 Production

Electrolysis & Other routes

88 Projects

€ 331.2 million

H_2 Storage & Distribution

41 Projects

€ 157.3 million

Cross-cutting

58 Projects

€ 90.6 million

Supply Chain

18 Projects

€ 58 million

Strategic Research Challenge

3 Projects

€ 29.6 million

H_2 End Use: Clean Heat and Power

90 Projects

€ 314 million

H_2 End Use: Transport

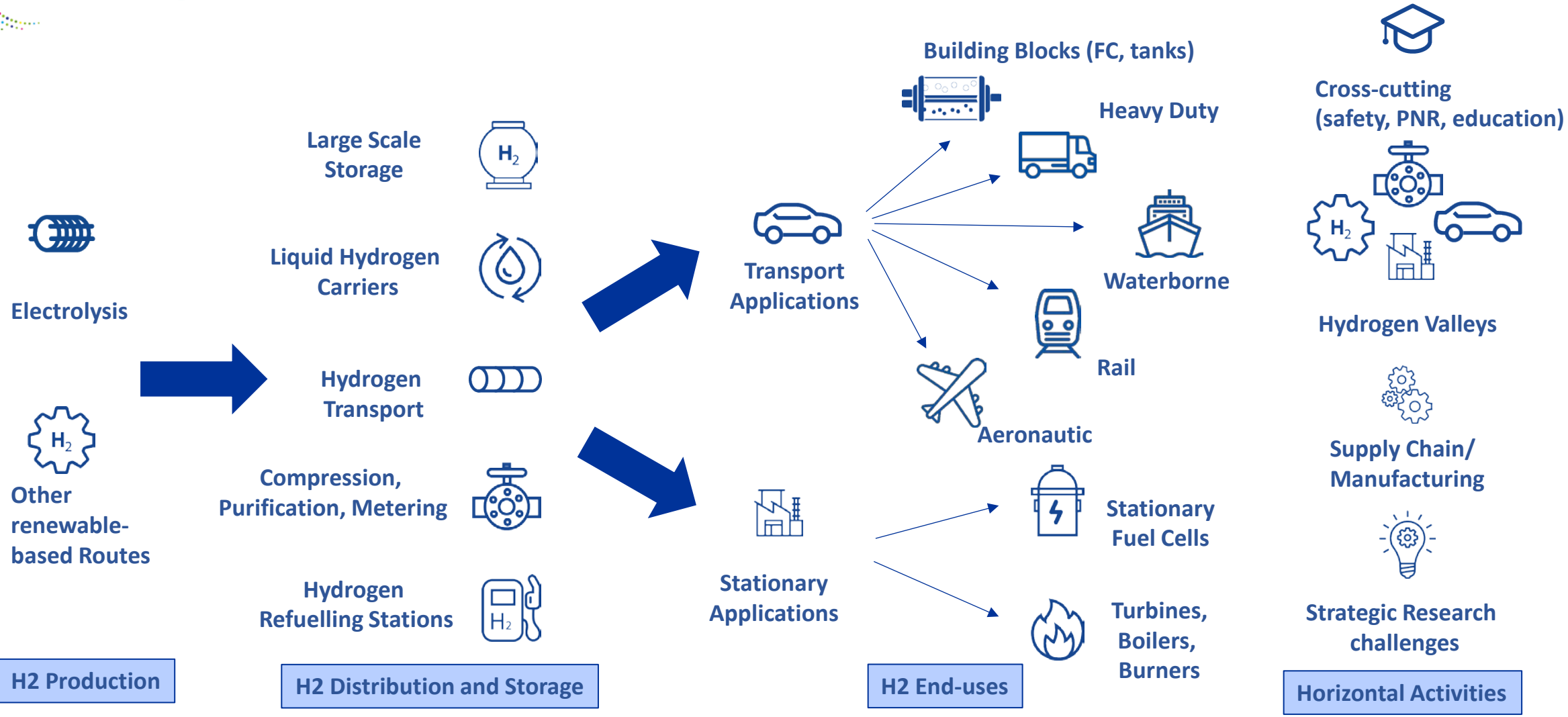
82 Projects

€ 559.1 million

* Not all projects from Call 2024 are included as they are still under preparation

Co-funded by the European Union

Clean Hydrogen Partnership **Strategic Research & Innovation Agenda** (2021 – 2027)



Clean Hydrogen JU SRIA 2021-2027

Co-funded by the European Union

Hydrogen solutions for shipping and ports

Clean Hydrogen Partnership

H2 MARINE

+ New

Multi-MW stacks and **fuel cells** systems

NICOLHy

LHe CRAFT

NavHyS

Tanks for hydrogen « bulk » and on-board storage

DelHyVEHR

LVHYS

Liquid hydrogen bunkering

Demonstration of short sea and fluvial vessels

MARANDA

HEAVENN

RH2IWER

HyShip

FLAGSHIPS

SHIPFC

CleanH2Shipping

EUROPEAN PARTNERSHIP

Hydrogen **ports ecosystems**

NAHV

CONVEY

BalticSeaH2

TRIĒRĒS

Regulations, codes and standards

HyLAW

eSHyIPS

ON THE WAVE OF HYDROGEN

+ New study

Heavy machinery for container handling

H2 PORTS

+ New

Heat and **on-shore power** for ferry terminals

BIGHIT

GREEN HYSLAND

EVERYWH2ERE

BalticSeaH2

amon

Co-funded by the European Union

Challenges

- H_2 price
- SOFC supply chains

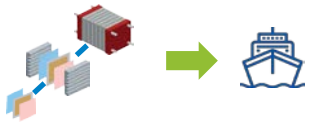
Hydrogen in shipping: context evolution 2017 to 2025

- **Regulations**
- **Cooperation**
- **R&I (incl. failures)**

	2017-18	2025
Ships / Vessels	Concept & 1st demonstrator(s) 	10+ sailing (≠ type and size), ~50 on order 
Certified equipment (FC and H2 storage)	Ø	~10 type-approved and ~20 AiP
Sum PEM FC power inst.	~ 200kW	~ 22 MW (i.e. x100)
Technical approach	« Marinize »	Maritime specific
IMO rules	Ø – alternative design approval	Interim guidelines for H2 and ammonia as fuel, FC and bulk H2 carriers
Class societies guidance	Ø	RINA, ABS, DNV, BV, LR, ClassNK, KR, CCS
Stakeholders	Institutional, EU and global levels (IEA, EMSA, CEN/CENELEC, etc.), pioneering countries (JP, NO)	Institutional, national and regional levels and market players

Research on Fuel Cells for maritime and other HD applications

Maritime



Large PEMstack development

- **250+kW PEM stack** for maritime
- **40.000h lifetime** on-line diagnostic and prognostic
- Accelerated test procedure
- Resistant to maritime environment (titling, vibration, air filter, etc.)
- Scale-up to multi-MW FC system

MW PEMFC System development

New

- Scale-up to **multi-MW FC system**

Targets PEM FCS for maritime

- FCS Power rating: 3MW for 2024, 10 MW for 2030
- FCS lifetime: 40.000 h for 2024, 80.000 h for 2030
- PEMFC system CAPEX: <1,500 EUR/kW for 2024,1,000 EUR/kW for 2030

Spill over from other HD applications

MEA/Stack performance

- Focus on charge, mass and heat transports phenomena
- Optimisation of stacks for High Power Range Application

Focus on durability

- Development of durable and high-power density MEAs for HD, with reduced Pg loading
- Target = 20.000h at system level

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Demonstrators: towards larger vessels

Building the pilots and experiments to speed up standards for waterborne applications

Maritime

R&D vessel
CH_2 PEM

MARANDA / 0,16 MW

Platform vessel
NH_3 SOFC

SHIPFC / 2 MW

Ro-Ro vessel
LH_2 PEM

HyShip / 3 MW

Challenges

- H2 supply and price
- Large SOFC supply chain
- Lengthy authorisation process

IMO INTERNATIONAL MARITIME ORGANIZATION

CESNI

2017 | 2018 | 2019 | 2020 | 2022 | 2024

Fluvial

FLAGSHIPS > 1 MW

2 cargo vessels
CH_2 PEM

HEAVENN / 0,38 MW

Barge vessel
CH_2 PEM

RH_2IWER / 7.5MW

6 inland vessels
CH_2 PEM

/ 0.6MW

1 inland vessel
CH_2 PEM

Co-funded by the European Union

Synergies at EU level – Programmes and Projects

Clean Hydrogen Partnership

Co-funded by the European Union

Horizon Europe, incl. Clean Hydrogen JU

Proof of Concept → Pilot → Demonstration → Scale up

Innovation Fund (EU ETS money)

INNOVATION FUND

Alternative Fuels - powertrains

Internal Combustion Engines

H2

CH3OH

FASTWATER

Market available

NH3

AMMONIA 2-4

4-strocke APOLO 125kW

APOLLO

Fuel Cells

LT PEM

GAMMA FUEL CELLS

1MW

HT PEM

HyEkoTank

2,4MW

SOFC

NAUTILUS

60kWe SOFC+battery

HELENUS

500kW

SHIP-AH2OY

1MW-LOHC

Alternative Fuels - storage

NH3 CRAFT

sH2YpS

LH2 in container

Demonstrators with PEM FC

H2ydroShuttle
Short sea container MWs PEMFC on **LH2** – SAMSKIP - 47M€ funding

EO2 Energy Observer 2
Cargo ship - MWs PEMFC on **LH2** - AssetCo EO2 – 40M€ funding

Swap2Zero
Hybrid passenger cruise ship with wind, **LH2,** bio-LNG – ARVAG - 40M€ funding

Bunkering liquid hydrogen and hydrogen derivative-fuels

LH2 distribution

Safety and efficiency of LH2 transfer technologies (tank to tank) in public areas for mobile applications (trucks, **ships**, stationary tanks)

Delivery of Liquid Hydrogen for Various Environment at **High Rate** (including maritime)

LH2 tank storage

Novel **large size LH2** on-board **storage**

LH2 on-board tank

- Below deck storage
- Materials, engineering, tests bench + in SOV
- **LH2 bunkering operations** (delivery, cryo-pumps, etc.)

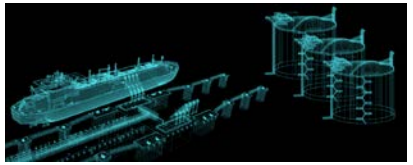
LH2 « bulk » storage

Large **LH2 tanks for bulk vessels**:

- Long-term storage and long-distance transport
- 180m3 ⇔ 10t LH2 demo
- Material research

Insulation concept for LH2 storage:

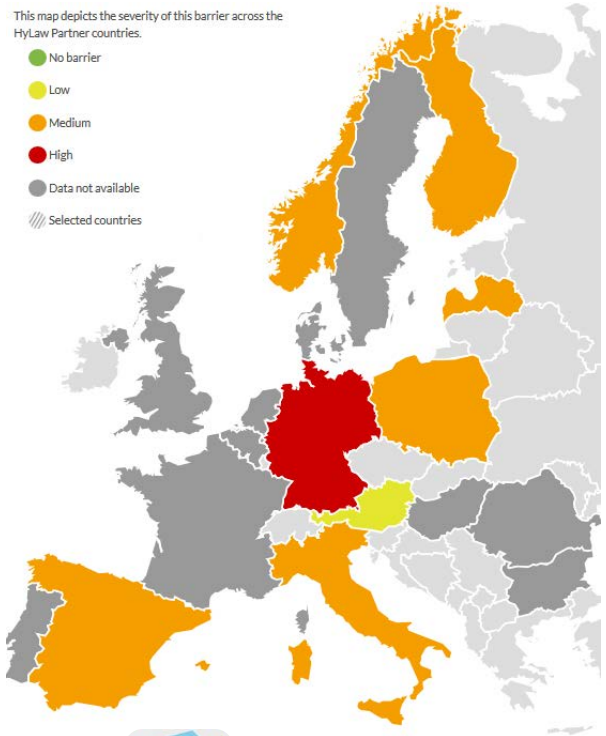
- Large on-ground tanks 40.000 – 200.000 m³ LH2
- Spill over to maritime
- Material research



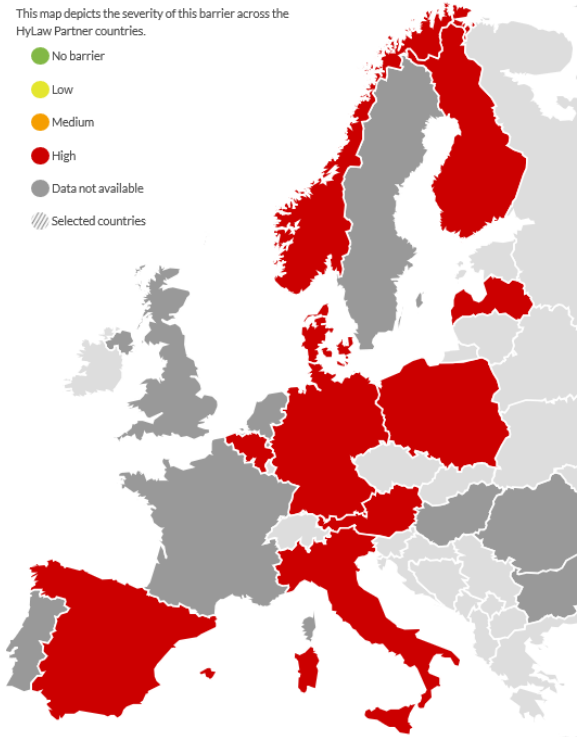
Regulations, codes and standards for hydrogen ships

Enable investments, financial institutions, shipbuilders, shipowners and charterers need comprehensive and predictable legal framework

Bunkering



Design / type approval



Overview of legal frameworks for hydrogen in maritime (2019)

A follow-up study should be launched in **S1 2026**

Pre-Normative Research, codes and standards

Hydrogen for passenger vessels

- Experimental data
- Guidelines for safe design for

the new IGF chapter on hydrogen

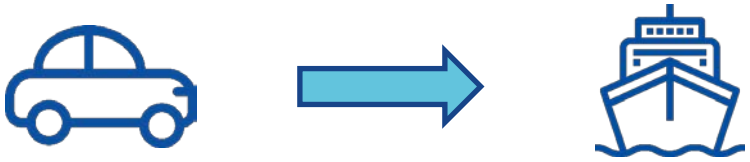
CEN/CENELEC SFEM WG Hydrogen

- Develop an appropriate PNR/standardisation roadmap/action plan to address PNR gaps in the maritime sector
- CEN Agreement Workshop in July 2024 with e-SHyIPS

Regulatory issues, example of H2 storage in MARANDA

Derive maritime solutions from the automotive applications

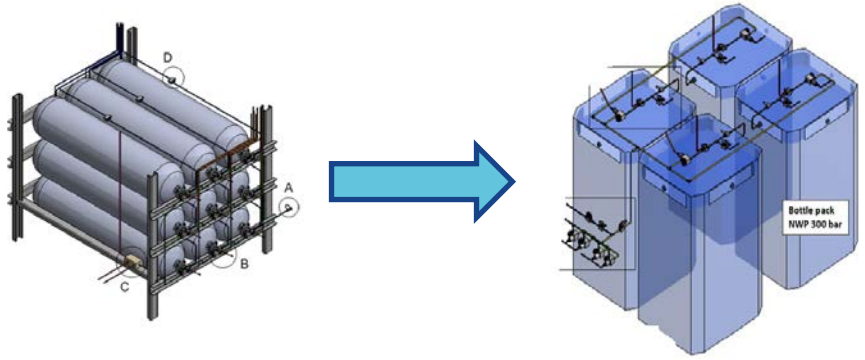
Marinisation approach



Conceptually simple:

- Quick, lower costs and risks
- Bring to maritime requirements
- “Only” maritime regulation compliance

Issues for H2 storage…



… and yes — researching the hard way!

Issue 1:

On-road transport of H2 requires equipment to be certified by the transportable pressure equipment directive (TPED)

→ Destructive tests of the entire storage system

Issue 2:

On-road transport of compressed H2 requires a ventilated container, with openings…

→ But maritime transport of H2 requires: gas tightness and fire safety

Issue 3:

Eventually new TPED storage system is available only on pre-order basis

→ Delays

Issue 4: 300 bar bundles…

→ Not matching required ship autonomy

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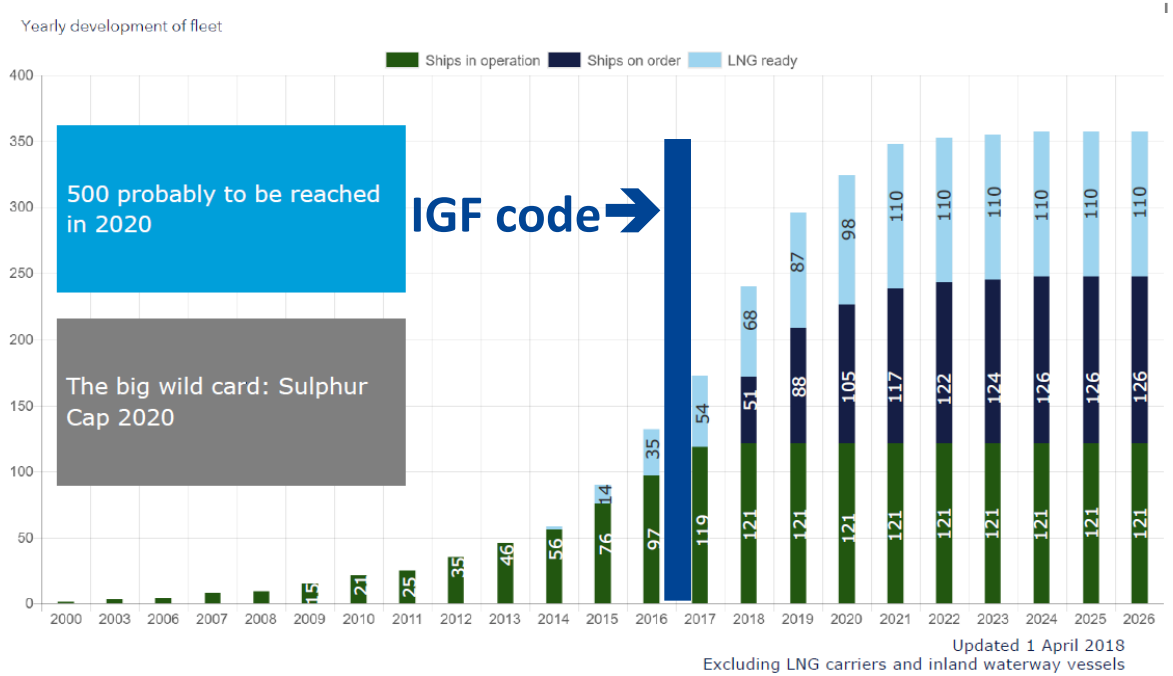
Why regulation matters? LNG learning

LNG as a blue print

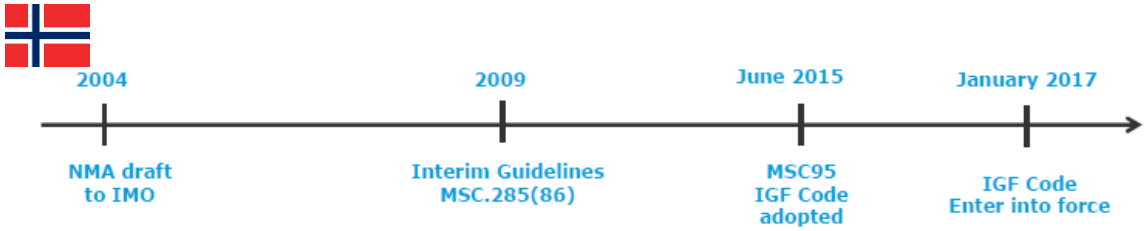
Impact of IMO rules on market



Explicit international rules are instrumental to the emergence of alternative fuels in maritime applications

H2 = Alternative design process, or…

Chronology for an IMO rule development (LNG)



- The process to develop international codes and rules is particularly long and requires national sponsorship(s)

Status at IMO for H2 (2025)

- Interim guidelines for ships using **fuel cells** (MSC 2022)
- Interim safety guidelines for ships using **ammonia** cargo as fuel (CCC11 2025)
- Interim safety guidelines for **hydrogen-fuelled ships** (CCC11 2025)
- Amendments to the Interim Recommendations for carriage of **liquefied hydrogen in bulk** (CCC11 2025)

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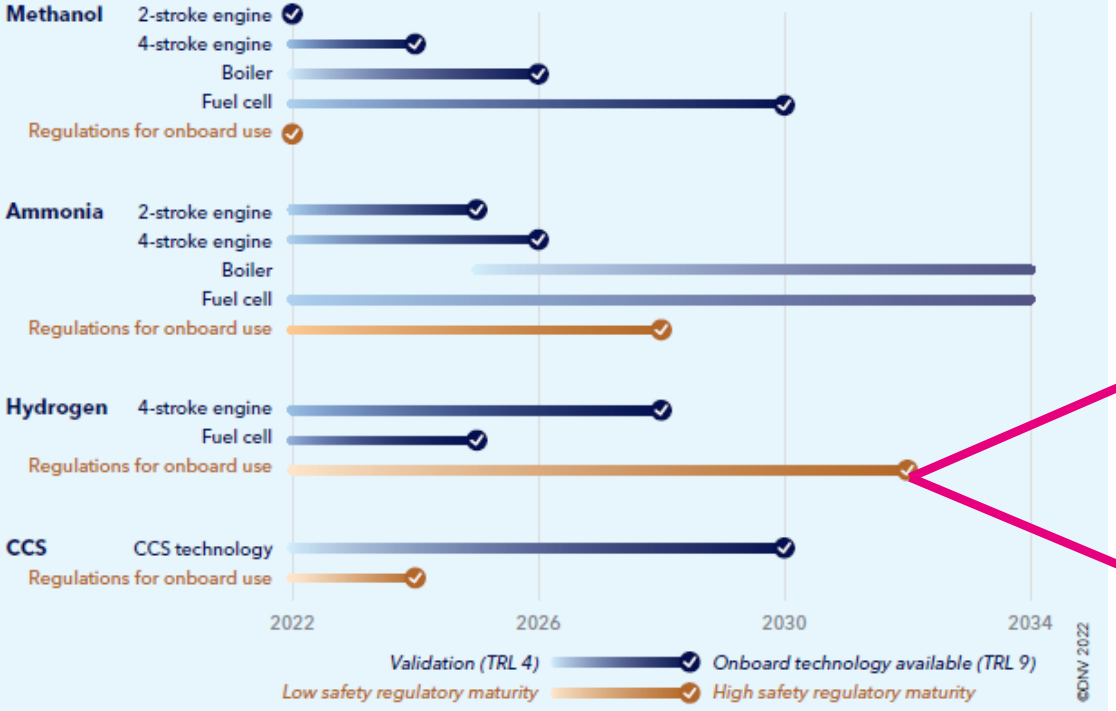
Explicit international rules are instrumental to the emergence of alternative fuels in maritime applications

Last in rules...

Figure 3.3

Estimated maturation timelines for energy converters, onboard CCS technologies, and corresponding safety regulations for onboard use



MARITIME FORECAST TO 2050 – DNV (2022)

Transport in the European Union – DG MOVE (2024)

Last in market !

Alternative fuel uptake in the world fleet by number of ships and gross tonnage

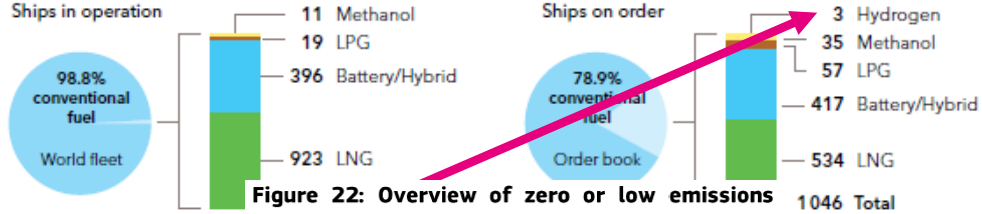
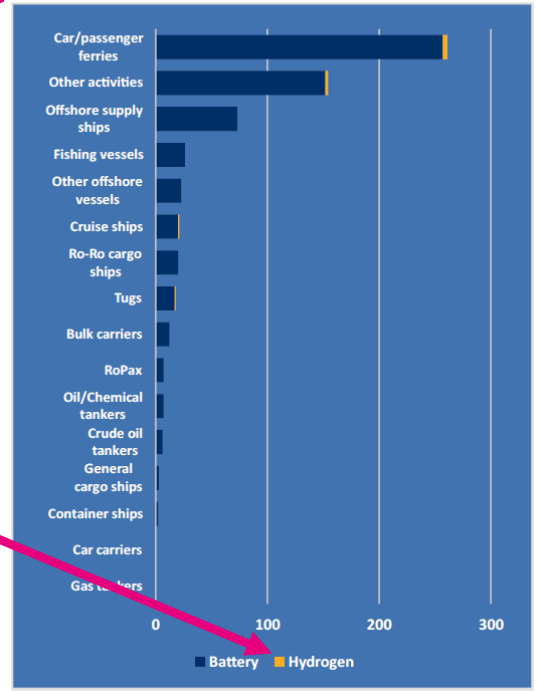


Figure 22: Overview of zero or low emissions vessels in operation or on order in 2022



Source: European Alternative Fuels Observatory.

Workshops, and Regulation, Codes and Standards (RCS)

European and international cooperation is key to foster introduction of H2 ships

IEA-HIA Task 39

Four subtasks:

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

RCS work and Cooperation

- JU **RCS Group**
- Projects with **class societies** as partners or AB
- Projects with specific tasks on RCS ➔ **IMO groups**
- **Collaboration** with CEN/CENELEC, ESSF, HE WG maritime, AWP European standardisation, JRC

Workshops

Workshops FC and H_2 in maritime applications (June 2017, May 2018)

- Awareness raising on FC and H_2, technical State-of-the-Art
- Work needed on standards, protocols, permission framework for hydrogen handling in harbours or in boats

IMO

IMO - Sub-Committee on Carriage of Cargoes and Containers (CCC5 - 2018)

Hydrogen Power for ships EU co-funded research developments and identified issues

Hydrogen solutions for shipping and ports

Clean Hydrogen Partnership

H2 MARINE

+ New

Multi-MW stacks and **fuel cells** systems

NICOLHy

LHe CRAFT

NavHyS

Tanks for hydrogen « bulk » and on-board storage

DelHyVEHR

ELVHYS

Liquid hydrogen bunkering

Demonstration of short sea and fluvial vessels

MARANDA

HEAVENN

RH2IWER

HyShip

FLAGSHIPS

SHIPFC

CleanH2Shipping

EUROPEAN PARTNERSHIP

Hydrogen **ports ecosystems**

NAHV

CONVEY

BalticSeaH2

TRIĒRĒS

Regulations, codes and standards

HyLAW

eSHyIPS ON THE WAVE OF HYDROGEN

+ New study

Heavy machinery for container handling

H2 PORTS

+ New

Heat and **on-shore power** for ferry terminals

BIGHIT

GREEN HYSLAND

EVERYWH2ERE

BalticSeaH2

amon

Co-funded by the European Union

Challenges

- H_2 price
- SOFC supply chains

Ports as deployment sites for projects

Pilots for clean port operations in container and ferry terminals

Heat and on-shore power for ferry terminals

- Port of Palma = 100kW PEM
- Port of Orkney = 75kW PEM
- Port of Tenerife = 100kW PEM
- Port of Helsinki = 600kW PEM
- Port End Use = 8kW SO on NH3

Heavy machinery for container handling

- Port of Valencia

+ New

Hydrogen valleys in ports

Studies and pilots on:

- Infrastructure for H_2/NH_3 bunkering
- NH_3 and synthetic fuels for maritime
- Retrofit of port vessels fleet
- Passenger ferries

Integrated H2 ecosystem = port of Hirtshals

- H2 production and end-uses
- Aquaculture, food industry and logistics (trucks)
- Synergy with REGEAR (CEF)

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Overview Hydrogen valleys with ports component

BalticSea H2 (2022, 25M€)

- Studies and pilots on:
  - Infrastructure for H_2/NH_3 bunkering
  - NH_3 and synthetic fuels for maritime
  - Retrofit of port vessels fleet
  - Passenger ferries

BIG-HIT(2015, 5M€)

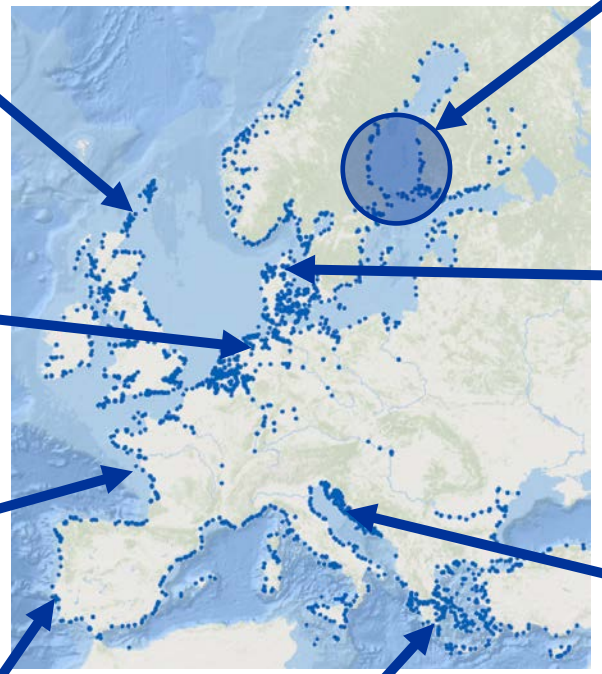
- H2 production and end-uses in port of Orkney (UK)

CONVEY (2023, 9M€)

- H2 production and end-uses in port of Hirtshals (DK)
- Aquaculture, food industry and logistics
- Synergy with REGEAR (CEF)

HEAVENN (2019, 20M€)

- H2 pipeline in Groningen port (NL)
- A H2 fluvial barge



NAHV (2022, 25M€)

- H2 hubs in marinas (application case in marina of Cres island, HR)
- Ship and ferry

AdvancedH2Valley (2023, 9M€)

- Ro-Ro tractors in port of Nantes (FR)
- Fluvial barge

H2tALENT (2023, 9M€)

- H2 production and storage in the port of Sines (PT)

TRIERES (2022, 8M€)

- H2 bunkering system in Port of Piraeus (GR) for a ferry
- Replication in Port of Larnaca (GR)

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Synergies at EU level - Projects

Clean Hydrogen Partnership

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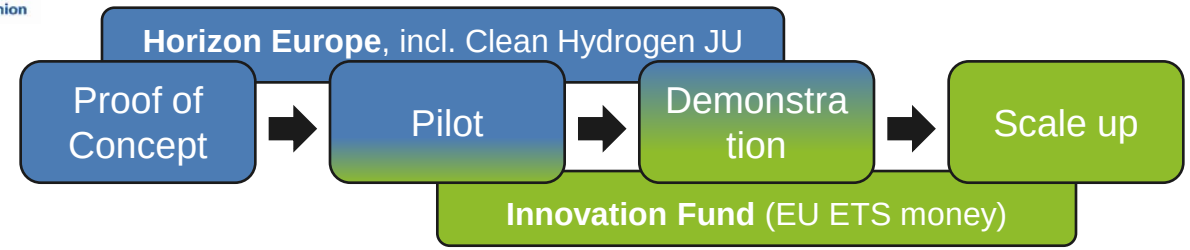

INNOVATION FUND

Ports – H2020

Antwerp

PIONEERS will work on the implementation of green port innovation demonstrations on clean energy production and supply, the deployment of electric, hydrogen and methanol vehicles, sustainable port design, modal shift and flows optimisation, and digital transformation through AI- and 5Gbased digital platforms.

HAVEN VAN ANTWERPEN-BRUGGE
pioneers-ports.eu
€ 24 999 997 #101037564

Start date	End date
1 October 2021	30 September 2026

Rotterdam

Green Deal port projects with the following demonstrated elements: On-site BioLNG production; Shore power peak shaving; Port digital twin (GHG tooling and energy matching); Ammonia bunkering; Offshore charging buoy; Autonomous e-barge; Green energy container for inland shipping; Hybrid shunting locomotive; Green connected trucking; Spreading of road traffic.
HAVENBEDRIJF ROTTERDAM NV
magpie-ports.eu
€ 24 964 564 #10103659

Start date	End date
1 October 2021	30 September 2026

Studies and infrastructures in ports

CEF

- PONTIS – CORES – CICERONE – studies
- ENHANCE – LH2 and NH3
- GreenH2Atlantic – 100MW H2
- H2Sines.Rotterdam – 400MW H2

H2bank

- RjukanH2 - Norway – 19MW
- Gen2-LH2 - Norway – 82MW
- HammerfestH2 - Norway – 7,5MW

esa **"Space4Maritime Decarbonisation**

Other programmes: ENOVA, etc.

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Study on ports as hydrogen « coastal hubs »

Ports as global hydrogen « coastal hubs »

- Creating / Serving H_2 demand locally for energy intensive industry (steel, chemicals, refineries, etc)
- Integration of renewable electricity
- International trading routes for H_2
- Multimodal transport node

Study on hydrogen in European ports and industrial coastal areas

Study timeline

- Project start: Nov 2021
- Project end: Nov 2023
- **Advisory Board Meetings**: Feb 2022; Apr 2022; Sept 2022; Nov 2022
- **Ports Network event**: May 2022; Nov 2022

Reports

Available here: https://www.clean-hydrogen.europa.eu/media/publications/study-hydrogen-ports-and-industrial-coastal-areas-reports_en

- March 2023 — *Report 1: Hydrogen demand and supply, and business models*
- September 2023 — *Report 2: Recommendations on the areas of priority for R&I projects, safety regulations, codes and standards and non-technical enablers*
- November 2023 — *Report 3: Case studies, and release of the final study and associated data pack*

CEM Global Ports Hydrogen Coalition

Report 1: Hydrogen demand & supply, business models

Report 2: R&I, safety and governance gaps

Report 3: case studies with techno-economic feasibility

A follow-up study should be launched in S2 2025

Co-funded by the European Union

Thank you

Lionel BOILLOT
Project Manager
Clean Hydrogen Joint Undertaking
Lionel.BOILLOT@clean-hydrogen.europa.eu

For further information
https://www.clean-hydrogen.europa.eu/

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