We start at 4 PM,

please mute your microphone upon entry

Waterstof Industrie Cluster **March 25 2021**

WIC Seminar

“Current status and planned initiatives for H_2 in Europe”

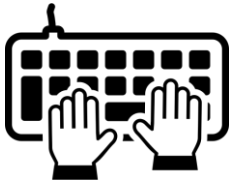
“Nedstack PEM fuel cell products, solutions and applications”

“CertifHy: A Tracing and Tracking system for renewable and non renewable hydrogen”

WaterstofNet

WATERSTOF INDUSTRIE CLUSTER

Few game rules

- Please mute your microphone 
- You can use your camera if desired 
- Questions are reserved for the Q&A after the presentations 
  - Please use the raise hand function if you want to ask a question, the moderator will give you the word 
  - You can use the chat for questions at any time 

Status WIC

- 80 members
- New since last meeting:

SEA-Tank Terminal

inovyn
An INEOS company

AIR PRODUCTS

WDP
WAREHOUSES WITH BRAINS

WIC webinar March 25

- 4 - 4.30 PM: Bart Biebuyck, director FCHJU,

"Current status and planned initiatives for H2 in Europe"

- 4.30 - 5.00 PM: Jogchum Bruinsma, Application Manager Maritime

at Nedstack, "PEM fuel cell products, solutions and applications"

- 5.00 - 5.30 PM: Wouter Vanhoudt, Director Europe & Asia at Hinicio,
- "CertifHy: A Tracing and Tracking system for renewable

and non renewable hydrogen"

Upcoming activities

- “Speed dating” April 22
- Next webinar May 20
- Next cluster meeting: June 2 (and September and December 8)
- Conference + working visit in fall

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

Current status and planned initiatives for H2 in Europe!

Bart Biebuyck

25 / 03 /2021 Virtual

Strong public-private partnership with a focused objective

A combined private-public of more than 2 billion Euro has been invested to bring products to market readiness by 2020

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Hydrogen Europe
Industry grouping
>185 members
50% SME

European Commission

Hydrogen Europe Research
Research grouping
83 members

285 projects supported for 1.07 B €

Energy
H_2 production and distribution
H_2 storage
F/C for CHP

Transport
Road vehicles
Non-road vehicles
Refueling infra
Maritime, rail and aviation applications

Cross-cutting
standards, safety, education, consumer awareness, …

45 %
481 million euros
153 projects

41.4 %
443 million euros
77 projects

6.3 %
67 million euros
48 projects

7.3 %
79 million euros
7 projects

Similar leverage of other sources of funding: 1.08 B €

EU Hydrogen Strategy of 8th July 2020

Objectives in 3 phases with the Hydrogen Alliance to support the investment agenda

Phase 1: 2020-2024

- **6GW** of renewable H_2 electrolysers
- 1 million tonnes renewable H_2
- Replace **existing** H_2 **production**
- Regulation for liquid H_2 markets
- Planning H_2 infrastructure

Phase 2: 2025-2030

- **40GW** renewable H_2 electrolyser
- 10 million tonnes renewable H_2
- New applications in steel & transport
- H2 for electricity balancing purposes
- Creation of "Hydrogen Valleys"
- Cross-border logistical infrastructure

Phase 3: 2030-2050

- H_2 technologies matured and deployed at large scale in hard to abate sectors.
- Expansion of hydrogen-derived synthetic fuels
- EU-wide infrastructure network
- An open international market

Clean Hydrogen Alliance to support the EU investment agenda

European Clean Hydrogen Alliance
https://www.ech2a.eu

What is it?

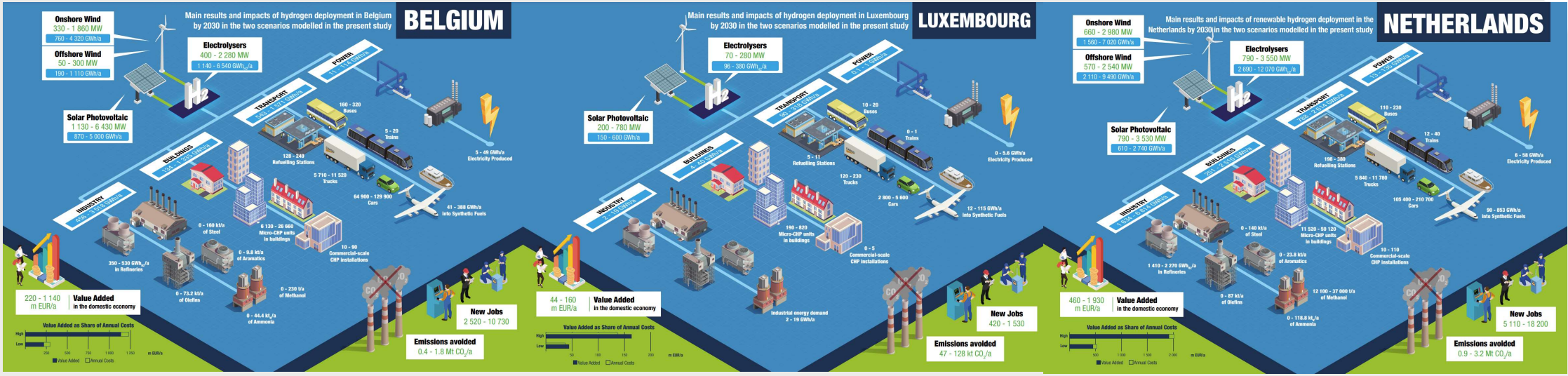
- Launch on 8th July 2020
- Mission to create a project pipeline for a massive role-out of EU Clean Hydrogen technology
- Involving all active stakeholders in the clean hydrogen ecosystem, bringing together supply and demand

The blueprint estimates investments of €430 billion by 2030

- Hydrogen Production
- Transmission & Distribution
- Mobility Applications
- Industrial Applications
- Energy Applications
- Residential Applications

Opportunities from the inclusion of Hydrogen in NECPs

The Benelux countries NECPs were analyzed on the national opportunities for H_2 deployment by 2030



https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

~2030
ambitious scenario

~ 6.1 GW
electrolysis

~ 5.1 Mt CO_2/a
avoidance

~ 3.2 b EUR/a
added value in domestic economy

~ 30.000
jobs

BENELUX - on the road to deployment

BELGIUM

48 Belgian beneficiaries Participating in **69*** projects FCH JU contribution **37.9** Mil € (3.6 % of total FCH JU funding)

National Policy Framework:
Target to reach **22** Public H2 refuelling stations by 2020

Planned
- **60** planned FC cars
- **3** planned HRS
- **10** planned FC buses (JIVE)
- **6** planned FC garbage trucks
- **172** planned m-CHP

Antwerp:
- **5** deployed buses
- **1** deployed HRS (High V.LO.City)

Brussels:
- **2** deployed cars (SWARM)
- **1** deployed HRS

Halle:
- **2** deployed MHVs (Hylift-DEMO)
- **1** deployed HRS (Hylift-DEMO)
- **2** deployed Electrolysers (Don Quichote)

Various locations (BE):
- **605** m-CHP installations (ene.field & PACE)

Rotterdam:
- **6** buses active (3EMOTION)

Groningen:
- **2** buses active (High V.LO.city)
- **1** HRS active (High V.LO.city)

The Hague:
- **1** HRS active (H2ME 2)

Various locations (NL):
- **40** FC cars
- **31** m-CHP installations (ene.field & PACE)

LUXEMBOURG

1 beneficiary Participating in **2** project FCH JU contribution **1.5** Mil €

- **1** planned HRS**

THE NETHERLANDS

93 beneficiaries Participating in **92** projects FCH JU contribution **71.3** Mil € (**6.7** % of total FCH JU funding)

National Policy Framework:
Target to reach **20** Public H2 refuelling stations by 2020

Planned
- **8** planned HRS (H2ME 2, JIVE 2, REVIVE)
- **12** planned FC cars
- **60** planned FC buses (JIVE2)
- **67** planned m-CHP
- **11** FC garbage trucks
- **2** planned Electrolyser

**Excluding Joint Research Centre Participations*
** Not directly related to FCH JU activities

FCH-JU region initiative was key to boost the hydrogen awareness in EU

The regions initiative led to the H2 Valley partnership, PDA and a call topic on H2 Valleys

https://www.fch.europa.eu/page/about-initiative

Supporting regions and cities in assessing various FCH applications

European Hydrogen Valleys Partnership

launched May '19 at EVS 32 in Lyon

Partnership led by:
North of Netherlands (NL)
Auvergne-Rhône Alpes (FR)
Le Normandy (FR)
Aragon (ES)
40 regions joined

http://s3platform.jrc.ec.europa.eu/hydrogen-valleys

HYDROGEN VALLEY

"I want NextGenerationEU to create newEuropean Hydrogen Valleys to modernise our industries, power our vehicles and bring new life to rural areas."

Project Development Assistance (PDA)

launched Jan '20 (38 applications / 19 countries)

Great opportunity to bring on-board and share learnings with 'less FCH ready' but higly interested EU13regions

https://www.fch-regions.eu/

End of 2021 another PDA will be launched focus on EU13!

Examples of Hydrogen valleys in Europe today

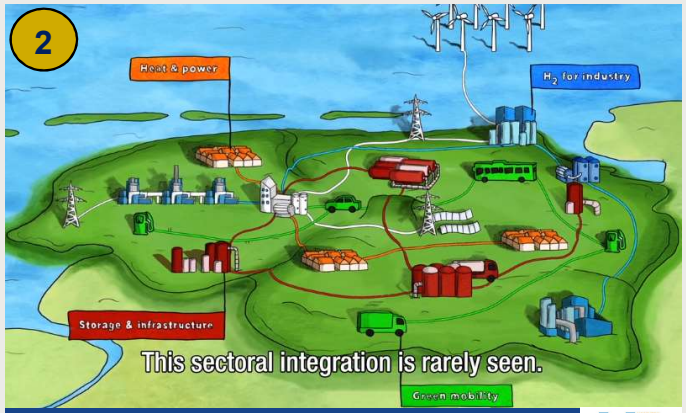
Its scope is system integration: Production of renewable H2, storage, distribution and end use (transport, stationary & industry)

1

Orkney's Island (Scotland):

- H2 production by wind on Islands
- Storage and transportation by truck
- Use: heat (school), power (ferries) & mobility (municipality cars)

2



North Netherlands (Groningen):

- 31 partners (public + private)
- Electrolysis for green H2 production,
- H2 Mobility: buses, passenger cars and trucks
- H2 Refueling stations
- E-Kerosene for aviation
- H2 for an inland water transport barge
- Domestic Heat applications
- Underground H2 storage (Hystock)

3

Hydrogen Island (Spain)*

- H2 production from solar
- H2 injection in gas-grid
- Use: heat (hotel, municipality buildings), power (port of Palma), mobility (buses)

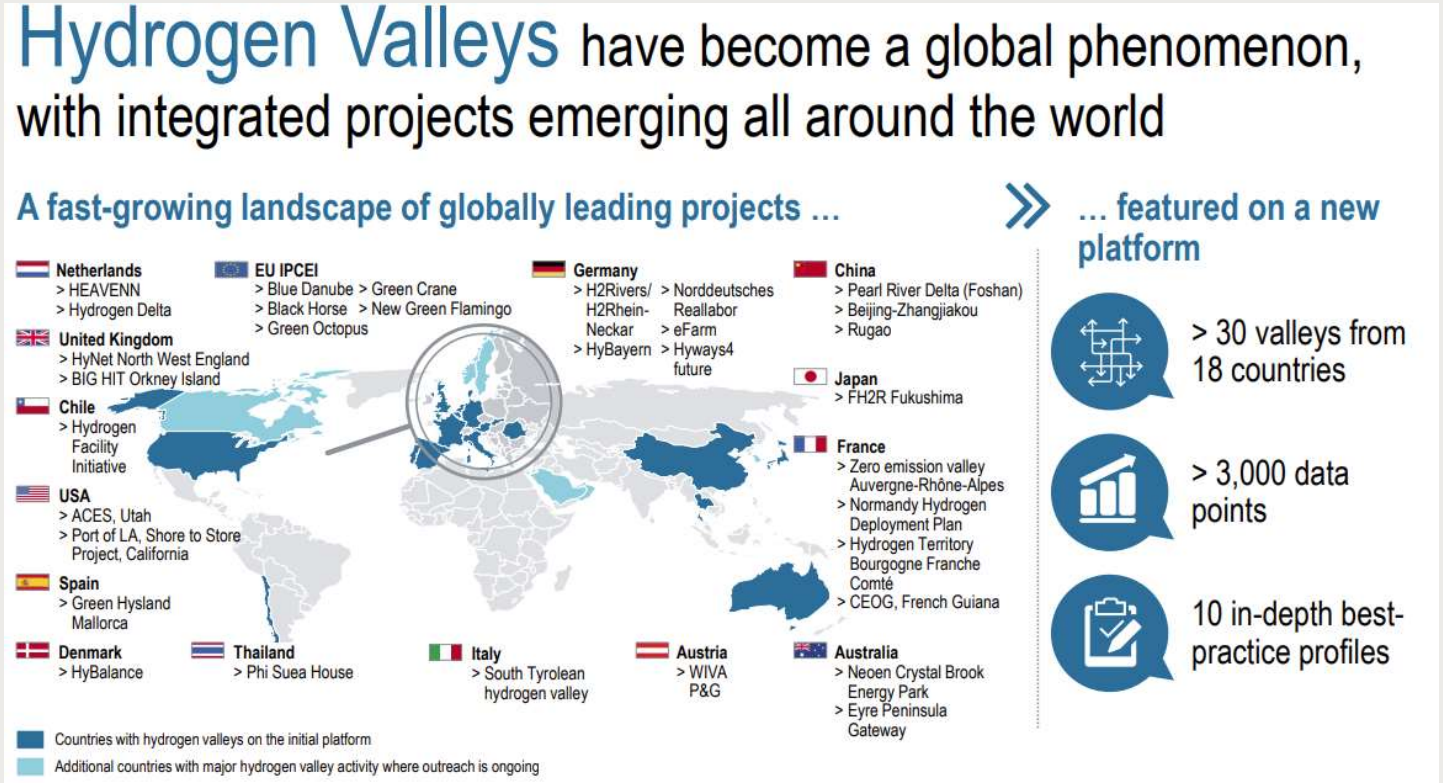
(*) Subject of successful signing the grant by Dec 2020

Future Possible (cross boarder) H2 valleys: Ports, Airports, Industrial hubs, Logistical hubs, A H2 city (or area)

Hydrogen Valleys to accelerate the energy transition

Renewable and Clean Hydrogen Challenge (IC8) under MISSION INNOVATION

Mission Innovation



- ✓ **Peer-to-peer exchange** among H2 valleys
- ✓ **Raise awareness** among policy makers
- ✓ **Advance clean energy transition**
- ✓ **EU (EC+FCH JU) in the lead also in terms of gathering and sharing lessons learnt**

https://www.h2v.eu/

(2) Electrolysis projects: increase capacity & lowering cost

Europe is world-leader in electrolysis systems (EU has the most patents and publications vs other parts of the world)

Project: Don Quichot
Place: Belgium
Date: 2011
Electrolyser: Hydrogenics (PEM)
Funding: 5.0 m€

Project: Haeolus
Place: Norway
Date: 2017
Electrolyser: Hydrogenics (PEM)
Funding: 5.0 m€

Project: H2future
Place: Austria
Date: 2016
Electrolyser: Siemens (PEM)
Funding: 12 m€

Project: Djewels
Place: The Netherlands
Date: 2018
Electrolyser: McPhy (ALK)
Funding: 11 m€

Djewels → Scale-up → HYDROGEN VALLEY

NEXT:

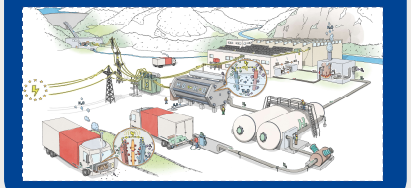
~2025: several 100 MW's

~2030: GW scale

0.15 MW → 1.2 MW → 2.5 MW → 3.4 MW → 6.0 MW → 10 MW → 20 MW → 60MW → 100 MW

Project: Hybalance
Place: Denmark
Date: 2014
Electrolyser: Hydrogenics (PEM)
Funding: 8.0 m€

Project: Demo4grid
Place: Austria
Date: 2016
Electrolyser: IHT (ALK)
Funding: 2.9 m€



Project: Refhyne
Place: Germany
Date: 2017
Electrolyser: ITM (PEM)
Funding: 10 m€

The European Green Deal call for proposals includes a topic to install a 100MW Electrolyser.

Call closed:

16 proposals received

Developing an EU wide Guarantees of Origin (GO) Scheme for Hydrogen

Two definitions: one for Green and one for Low-Carbon Hydrogen – more than 70,000 GOs issued already

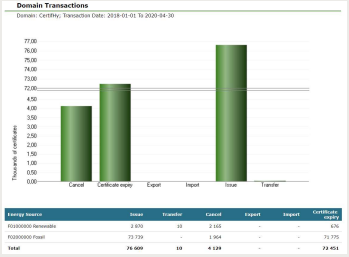
Four production plants included in the pilot scheme which have been already audited

Air Liquide, Port Jerome (SMR +CCS)

Colruyt Group, Halle (Electrolysis +RE)

Air Products, Rotterdam (by product H2 from Chlor-alkali process)

Uniper, Flakenhagen (Electrolysis + RE and methanation



https://cmo.grexel.com/Lists/PublicPages/Statistics.aspx

On-going actions:

(1) Certifhy3: Setup of a platform for piloting a GO scheme for hydrogen across Europe. https://www.certifhy.eu/

(2) IPHE taskforce on Hydrogen Production Analysis methodology.

=> important to unlock future cross boarder trading.

FCH-JU has projects related to many different modes of transport

Heavy duty transportation is looking seriously to hydrogen due to the huge performance improvements of fuel cells

12

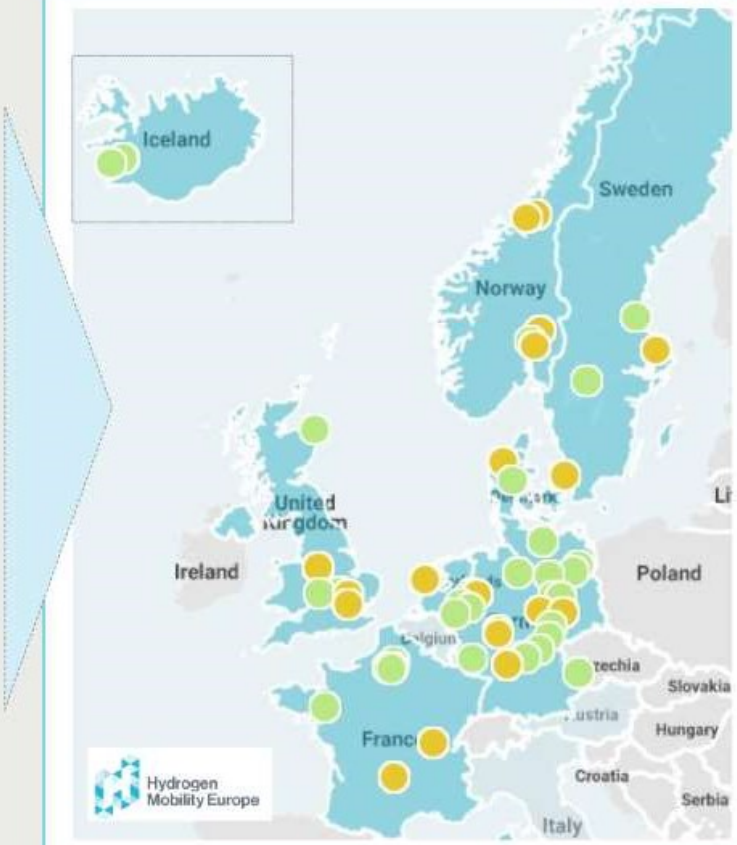
Bringing H2 mobility initiatives into one framework

H2ME Project overview (2015 – 2022)

HRS: Hydrogen Refuelling Station
FCEV: Fuel Cell Electric Vehicle
RE-EV : Range-Extended Electric Vehicle
OEM: Original Equipment Manufacturer

Endorsers:

- Mobilité Hydrogène France
- H_2 Mobility
- UK H_2 Mobility
- Scandinavian Hydrogen Highway Partnership
- Hydrogen mobility grouping in Benelux
- Hydrogen mobility grouping in Austria
- Hydrogen mobility grouping in Italy



Concept:

- Joint initiative from the **most ambitious European hydrogen mobility initiatives**
- **One 'working framework'** linking these initiatives, which provide the opportunity to:
  1) identify **optimal commercialisation strategies** and **synergies between countries**
  2) develop **European strategies for commercialisation**

New hydrogen refuelling stations:

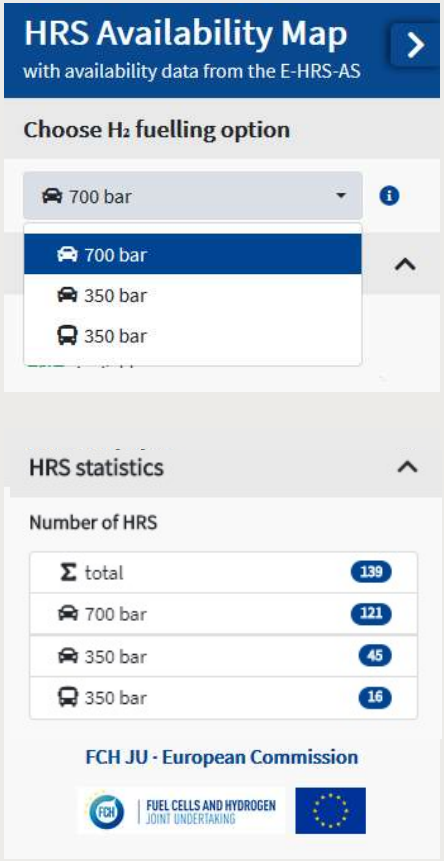
- **20** - 700bar HRS in Germany
- **12** - 700bar HRS in Scandinavia
- **11** - 350bar and 700bar HRS in France
- **6** – 350bar and 700bar HRS in the UK
- **1** - 700bar HRS in NL

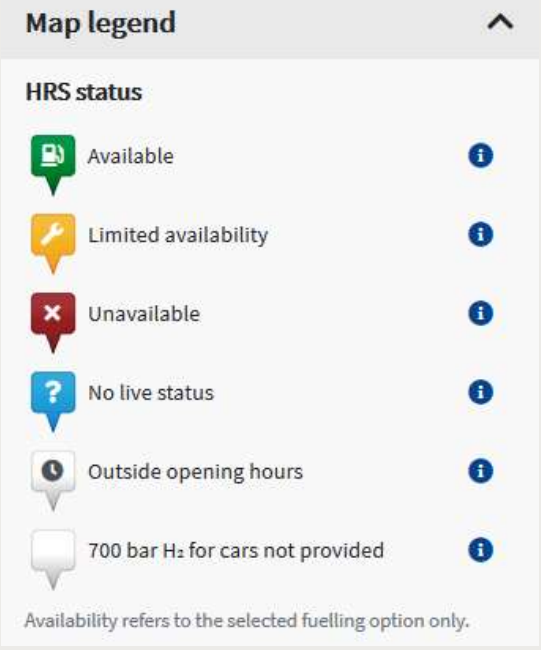
Fuel cell vehicles:

- **500** OEM FCEVs
- **900** fuel cell RE-EV vans

Visualization of the data: Real-time availability information

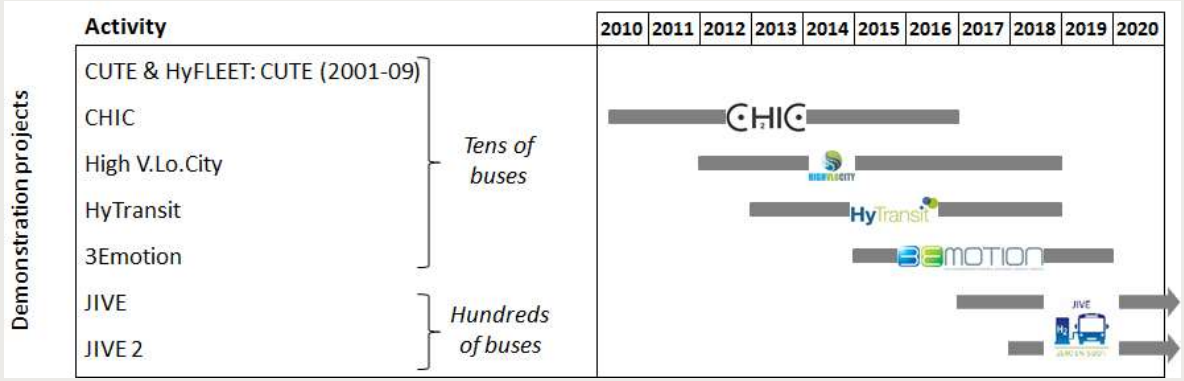
https://h2-map.eu/

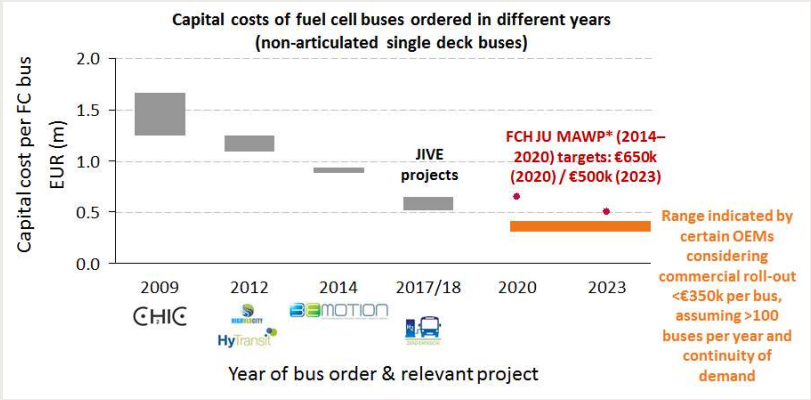




FCH-JU funded FCB projects and studies since 2009

7 projects will put in total about 360 FCB's on the road





Van Hool hydrogen bus for PAU (France) crowned as best bus of the world 2019!

JIVE/JIVE2

- **Orders placed for 230/295 buses (78%)** with 5 suppliers Van Hool (80), Solaris (57), Wrightbus (65), SAFRA (10), and Caetano (18).
- **Delivery of the first 50 buses** in Cologne (35), Wuppertal (10), and Pau (5) and start of full route operation.
  All buses on the road by end 2021
- Increased **interest from other European OEMs**, with JIVE-compliant offers received from: Optare, Rampini, and SOL and continued interest from ADL, Daimler, VDL, and interest from 2 other major European OEMs.

Next: Coaches

Project Information

CoachHyfied

Grant agreement ID: 101006774

Status
Ongoing project

Start date
1 January 2021

End date
31 December 2025

Funded under
H2020-EU.3.4.6.

Overall budget
€ 7 329 180,25

EU contribution
€ 4 999 441,75

Coordinated by
FEV EUROPE GMBH
Germany

Heavy duty trucks demonstration projects to validate the technology

Long haul and urban applications

15 Long haul trucks

- At least 400 km autonomy;
- Tractor and rigid configurations;
- Integration in the daily operations of end users with different operations(Air Liquide, BMW, Carrefour, Colruyt)
- 2021/2022 deployment of the trucks;

30 trucks
13 demonstration sites
7 countries

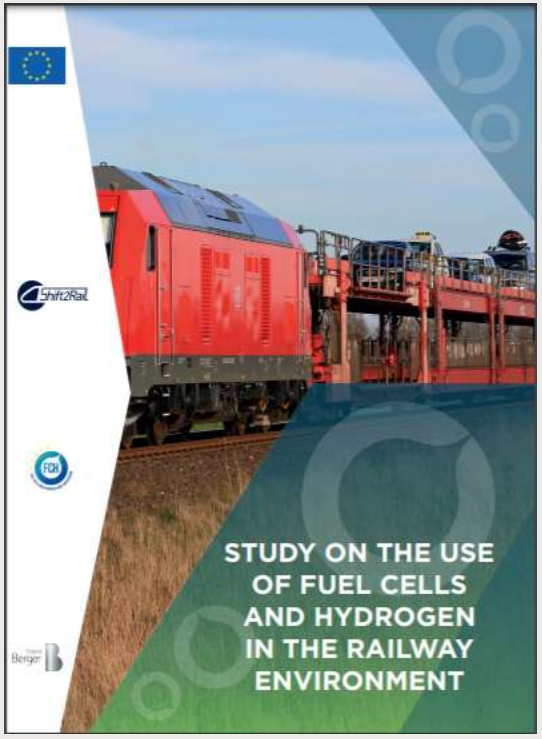
15 Refuse trucks

- Daily back-to-base missions;
- Standardization of the design towards mass production;
- Fleet operation: 120.000 hours;
- First truck already deployed in Breda;

23/11/2020: Industry commitment for 100.000 trucks and 1500 HRS by 2030 in the EU

Rail accelerates Hydrogen and Fuel Cells technology

The first business models are appearing



- FCH trains make economic sense above all on longer non-electrified routes >100 km
- FCH trains esp. for last mile delivery & main routes with very low utilisation (<10 trains/day)
- Low electricity costs (<EUR 50 /MWh) & high infra utilisation (HRS…) favour FCH technology;
- FCH trains has downtimes <20 minutes (due to fast refuelling) and withstand long operating hours >18 hours w/o refuelling;
- FCH trains are economically feasible clean alternative to diesel trains in many cases;
- In some cases, battery trains may appear as more cost-effective option but come with operational constraints resulting from highly route-specific tailored battery configurations.

FCH2RAIL

The European Commission's Fuel Cells and Hydrogen Joint Undertaking (FCH JU) has selected a CAF-led project for a €10m grant to support the development of a hydrogen-powered train prototype.

The €14m FCH2RAIL project seeks to design and develop a zero-emission vehicle with competitive operating performance compared with diesel engine-powered trains.

The European Union (EU) funding was awarded under the Horizon 2020 programme.

Besides CAF, the FCH2RAIL project involves DLR, Renfe, Toyota Motor Europe, Adif, IP, CNH2 and Faiveley Stemmann Technik.

https://fch.europa.eu/publications/use-fuel-cells-and-hydrogen-railway-environment

FCH2 JU is supporting the growing sector of maritime

Continuum of funding in the best fit for business case

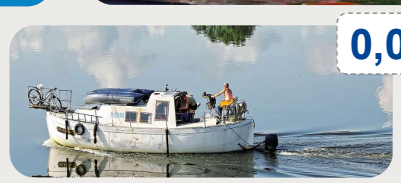
2020 – LH2 vessel

2019 – sea-going vessel

2018 – ferry + barge pusher

2017 – research vessel

2013 - APU for yachts



No « one size fits all »

- Different vessels segments
- Different power and autonomy
- Various fuels (H_2, NH_3, LOHC)
- FC technologies (PEM, SOFC)

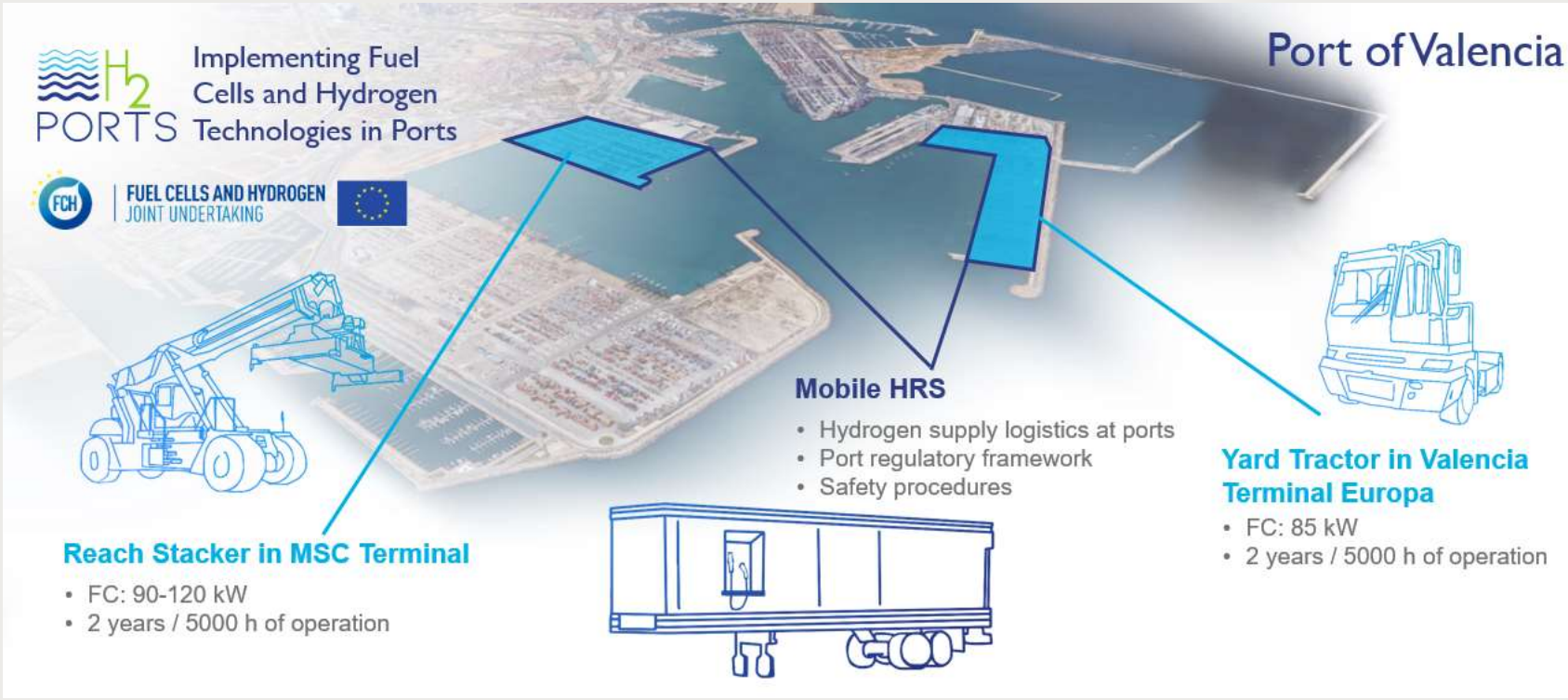
Key considerations

- Crucial need for international cooperation
- Importance of regulatory aspects (IMO and CESNI)
- Ports as hydrogen « coastal hubs »
- FC for hotel load at port or propulsion at sea

Challenges: R&D in the area's of LH_2 storage (bunkering), MW scale Fuel Cells, carriers,…

H2Ports project aims to implement Fuel Cells and Hydrogen in Ports

First application of hydrogen technologies in port handling equipment in Europe



H2PORTS project in the port of Valencia

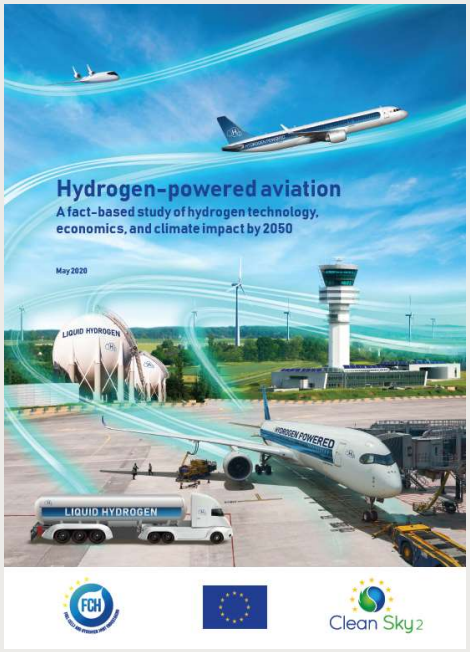
- Reach stackers and yard tractors will be demonstrated in the port
- A mobile hydrogen refueling station will be operated inside the port

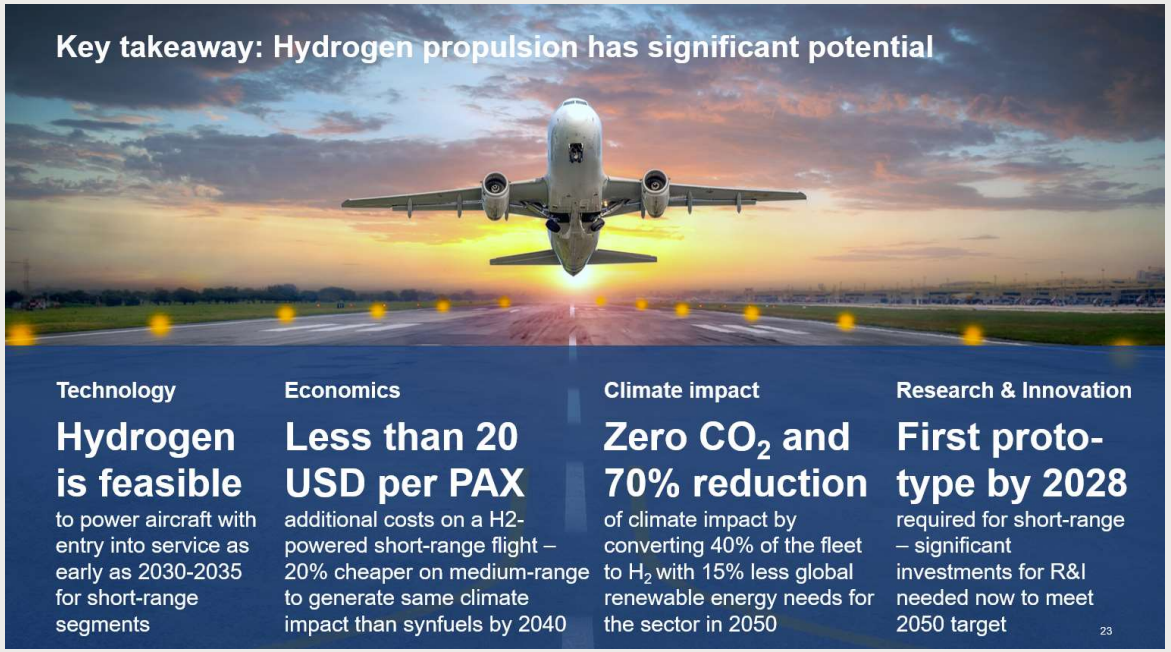
DURATION:
2019-2022; project 4.1 M€ (4 M€ by FCH-JU)

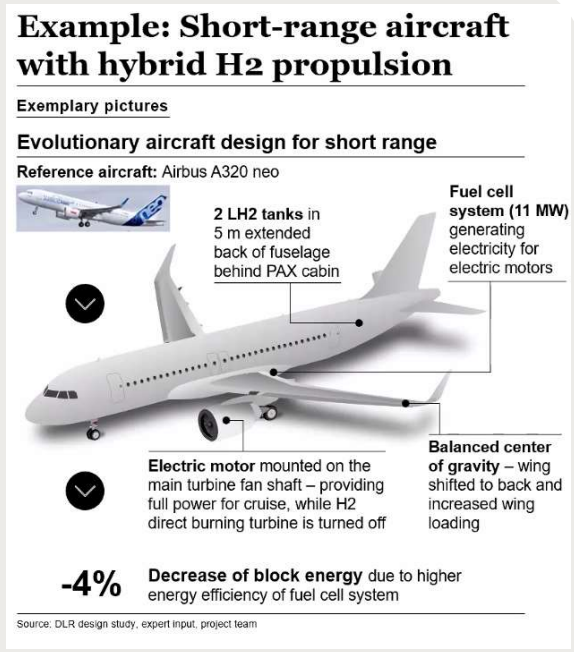
Next: Building a worldwide hydrogen ports coalition under CEM

Hydrogen powered Aviation study (joint study with Clean Sky2 JU)

Hydrogen propulsion has significant potential







https://www.fch.europa.eu/news/new-study-hydrogen-powered-aviation-preparing-take

Next: Close collaboration with all stakeholders to realize the demonstrator by 2028!

La France veut lancer un avion « zéro émission de CO2 » dès 2035

Au-delà des mesures d'urgence, le plan de soutien à l'aéronautique française du gouvernement, chiffré à 15 milliards d'euros par Bruno Le Maire, vise à placer l'aéronautique française en pointe dans la transition énergétique. Avec un objectif ambitieux : lancer un avion vert à l'hydrogène dès 2035.

Educational Activities – Overview

Preparing the European workforce is crucial for scaling up the industry.

15 projects

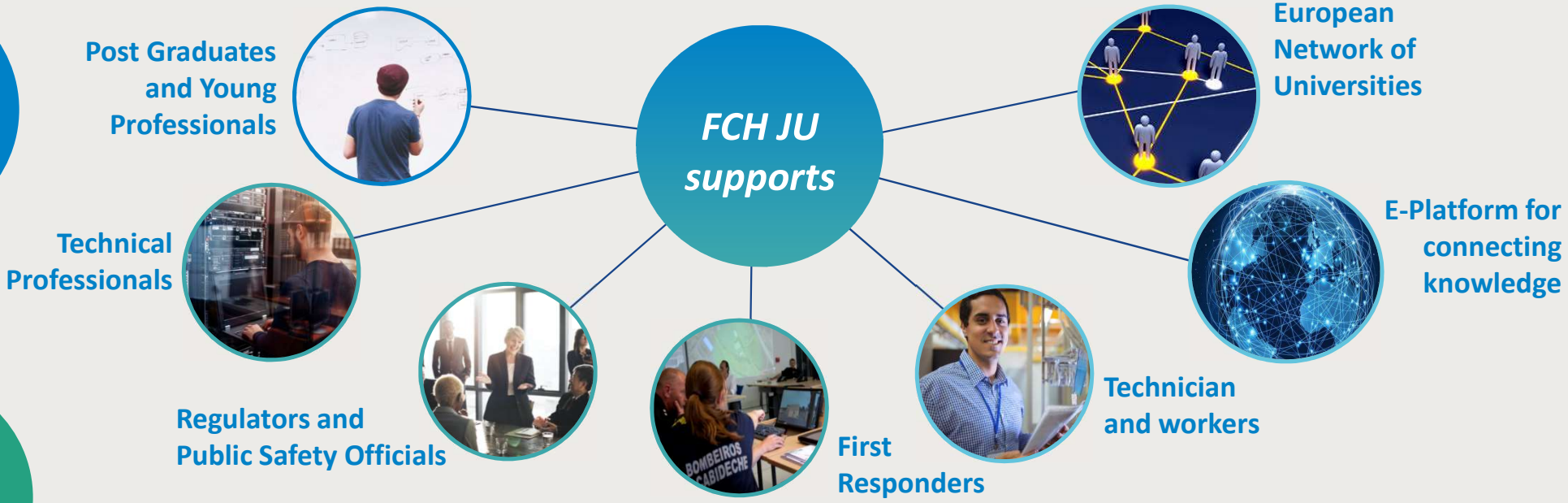
10 – FP7
5 – H2020
+ complementary initiatives & studies

Budget

Overall
18,6 M€

FCH 2 JU Funding
14,7 M€

Educational and training programs tailored to multiple target groups



Multiple levels and types of education, learning formats, features…

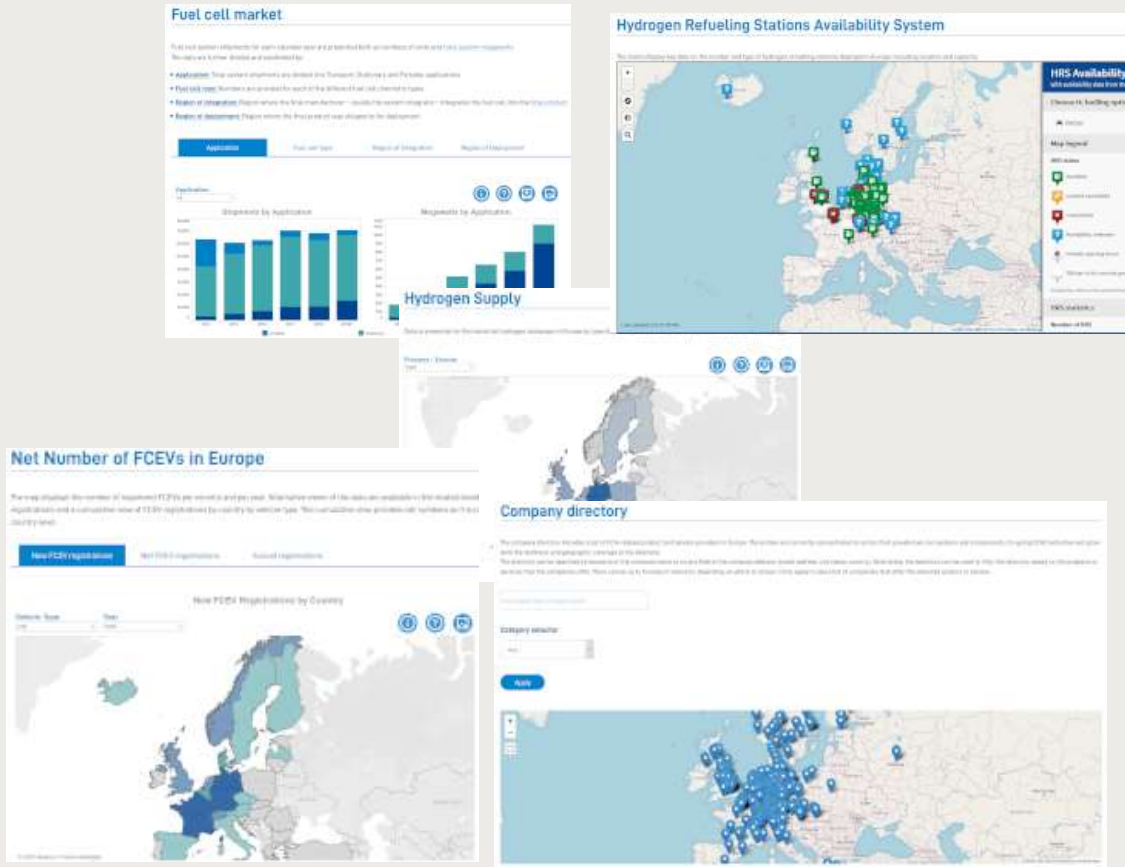
Graduate *Undergraduate* … *In person training* … *Serious games* *Mock-up installations*
Vocational *Compulsory* … *e-learning* *blended* … *Virtual reality*

Happy to share best practices, learnings and material.

Fuel Cells and Hydrogen Observatory (Launched 15 Sept '20)

One stop shop to understand where the FCH sector is at and how it is evolving

- **Go to resource for all things on fuel cells and hydrogen**
- **User friendly and reliable output**
  - charts, graphs and data downloads
  - reports
- **It covers**
  - Technology & Market
  - Policies & regulation
  - Codes & Standards
  - Patents & Publications
  - Funding
  - Education & Training
- **Global resource**
- **www.fchobservatory.eu**
  info@fchobservatory.eu



@FCHObservatory

The Fuel Cells and Hydrogen Observatory has been prepared for the FCH 2 JU under a public procurement contract

European Hydrogen Safety Panel (EHSP) initiative

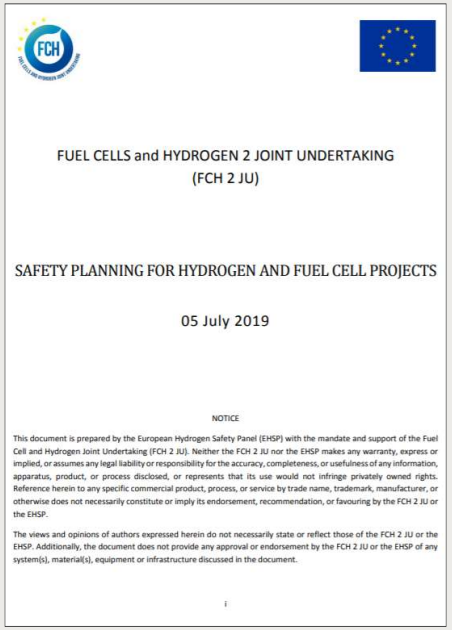
Expert group on hydrogen safety assisting the FCH 2 JU at project and programme level

EHSP Launched and running!

16 experts from industry & research

Assuring that H2 safety is adequately handled
Promoting and disseminating H2 safety culture

The EHSP released the first 2 reports on:
- Safety planning in FCH projects
- Lessons learnt from HIAD



FUEL CELLS and HYDROGEN 2 JOINT UNDERTAKING
(FCH 2 JU)

SAFETY PLANNING FOR HYDROGEN AND FUEL CELL PROJECTS

05 July 2019

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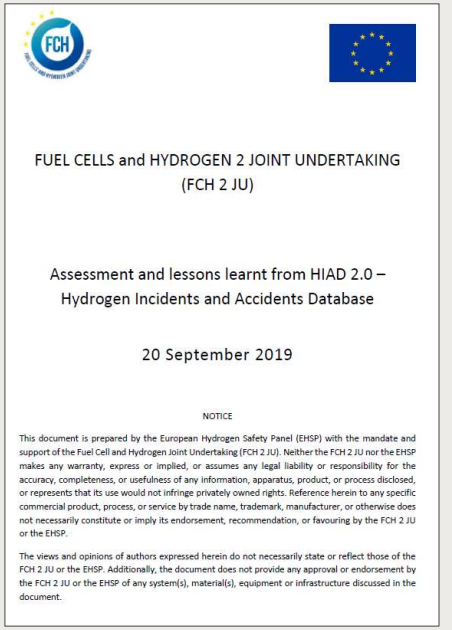

FUEL CELLS and HYDROGEN 2 JOINT UNDERTAKING
(FCH 2 JU)

Assessment and lessons learnt from HIAD 2.0 –
Hydrogen Incidents and Accidents Database

20 September 2019

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Funding instruments at EU level

Future European Funding opportunities for hydrogen

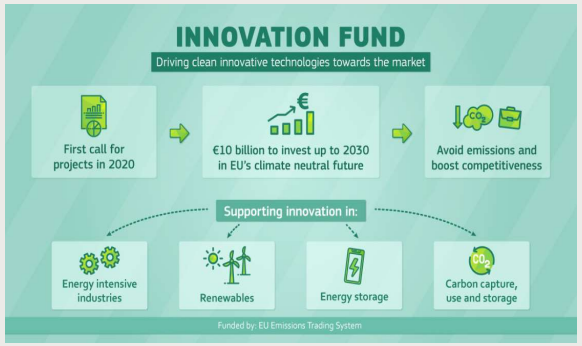
Depending on the project seize and goal, the right funding instrument should be chosen, FCH can help you

New partnership: CLEAN HYDROGEN

H2 is split in 7 partnerships in EU:

- Clean Hydrogen
- Processes4Planet
- 2ZERO
- Waterborn
- Clean Steel
- Clean Sky
- EU Rail

Start expected by end 2021 with an increased budget

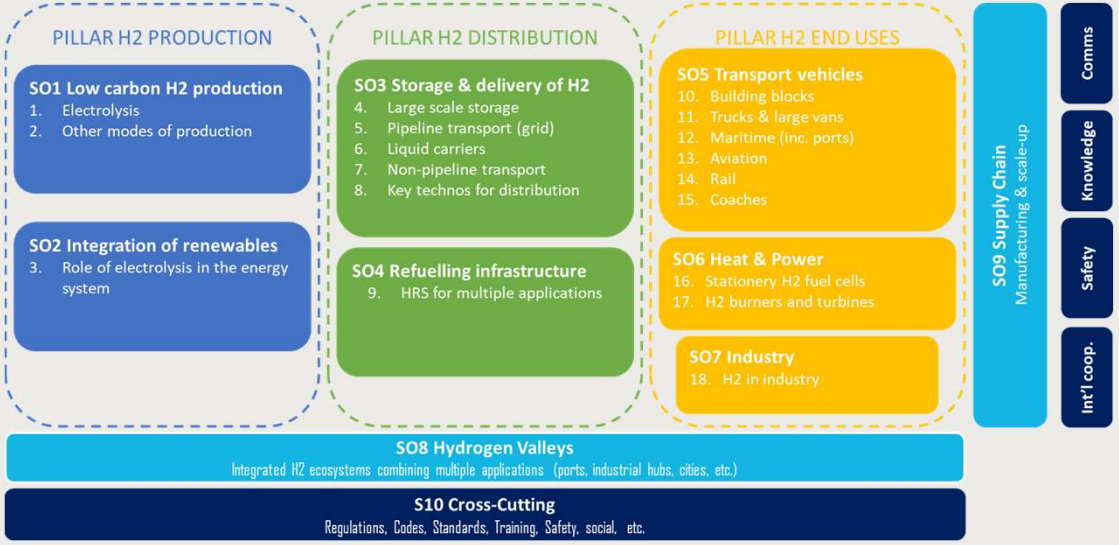


Hydrogen – Research and innovation

Partnership under Horizon Europe Programme

Maintain and strengthen **EU's global leadership role** through support:

- Establish Clean Hydrogen Partnership (successor of FCH-JU) by end 2021 with a budget of **1 billion EUR**
- Targeted research and innovation in Horizon Europe
- ETS Innovation Fund
- Interregional Innovation Investment Instrument with pilot action on hydrogen technologies

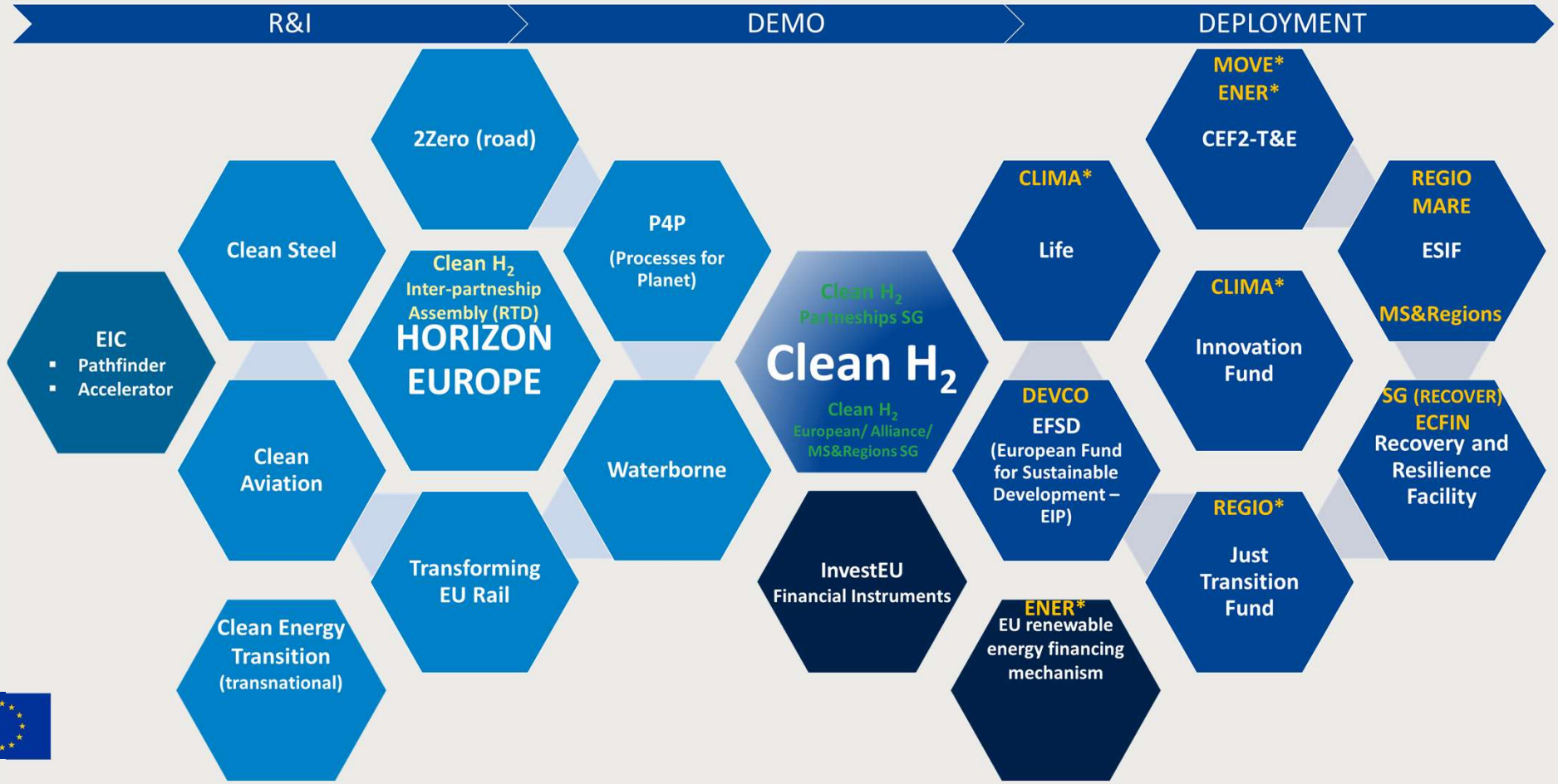


H2 is split in 7 partnerships in EU:

- Clean Hydrogen
- Processes4Planet
- 2ZERO
- Waterborn
- Clean Steel
- Clean Sky
- EU Rail

SYNERGIES: Strong cooperation is Key to deal with bigger yet fragmented EU Funds

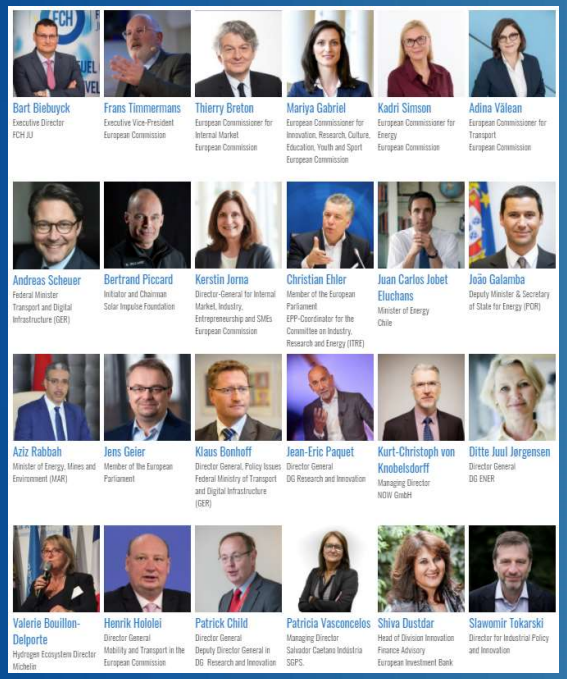
H2 evolving and growing: from R&D&I to large Demos and full Market Deployment



The 1st European Hydrogen Week

A huge success with many high level speakers

More than 10.000 people from 63 countries joined



The 2nd European Hydrogen Week + Launch of Clean H_2 JU

29th Nov. – 3rd Dec. 2021

Brussels, Belgium

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

Bart Biebuyck
Executive Director
Bart.Biebuyck@fch.europa.eu
@bart.biebuyck
Bart Biebuyck

For further information

www.fch.europa.eu
www.hydrogeneurope.eu
www.hydrogeneurope.eu/research

@fch_ju
Fch-ju@fch.europa.eu
FCH JU

Nedstack
PEM FUEL CELLS

PEM fuel cell products, solutions and applications

Waterstof Industrie Cluster - March 25th, 2021 – Arnhem (NL)

Nedstack | Personal Introduction

Name	Jogchum Bruinsma
Position	Application Manager Maritime Systems
Group	Power Systems
Location	Arnhem – The Netherlands

Role and Background

Role at Nedstack

- Responsible for Customer Application Studies in the maritime domain.
- Responsible for Maritime Systems Project Management;
- Responsible for Pursuing and Administering Class Approvals;

Other functions

- Board member of Zero Emission Shipping Technology Association
- Roadmap Leader for Maritime at Hydrogen Europe;
- Member of STEERER Green Shipping Expert Group;
- Member of IEA-HIA Maritime task expert group

Background and Education

- 2 years at Huisman as Lead Engineer;
- 8 years at Boskalis as Senior Lead Engineer;
- First FC-Boat Application Project in 2010 at Alewijnse
- MEng in Control Systems Engineering – HAN University
- BEng in Industrial Automation Studies – HAN University

Nedstack

PEM FUEL CELLS

A Company

Nedstack fuel cell technology BV

Nedstack | Company Profile

Name	**Nedstack Fuel Cell Technology BV**
Location	Westervoortsedijk 73, Arnhem, the Netherlands
Founded	1999
Ownership	Privately

Website	www.nedstack.com
Industry	PEM Fuel Cells
Logo	Nedstack PEM FUEL CELLS

High lights

- Independent Company since 1999;
- Leading Global Player in PEM-FC R&D;
- In-house Cell plate production and Stack Assembly;
- > 700 FC Systems installed-base as per 2017;
- > 23.000 Hours in-use Lifetime demonstrated;
- Highly competent Application Support team in-house;
- Strong footprint in EU and China

WE SUPPORT UN GLOBAL COMPACT

TÜVRheinland CERTIFIED Management System ISO 9001:2015 www.tuv.com ID 9000004557

Specialized in Containerized Power Plants

Nedstack main location

Nedstack

PEM FUEL CELLS

B

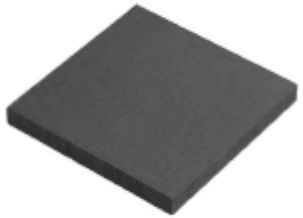
Capabilities

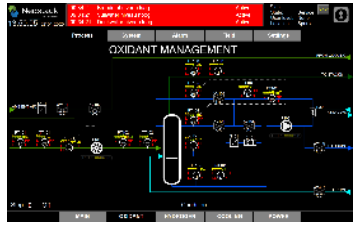
From Powder to Power

Nedstack | Services Portfolio

Signature PEM Fuel Cell Technology Portfolio

Fuel Cell Parts			Fuel Cell Solutions		
BMC's	BPP's	CVM	PEM Stacks	Power Plants	FC Control





Application Engineering & Project Management Services

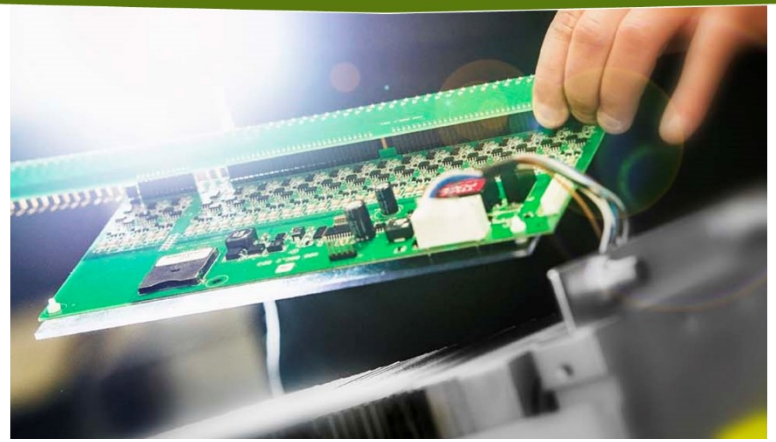
Field Engineering Services (Commissioning / Inspection)

Maintenance & Support Services

■ By Co-Maker

Nedstack | Fuel Cell Centre of Expertise

Fuel Cell Development



Fuel Cell Verification

Fuel Cell Application

Fuel Cell Manufacturing

Nedstack

PEM FUEL CELLS

C

Technology

Low Temperature PEM Stacks & Systems

Nedstack | LT-PEM Fuel Cell Principle

PEM FC's use Hydrogen as a Fuel and a PEM Membrane as Electrolyte

	Operating temp (°C)	Fuel	Electrolyte
PEMFC	40-90	H_2	Proton Exchange Membrane
AFC	40-200	H2	KOH
DMFC	60-130	Methanol	Proton Exchange Membrane
PAFC	200	H_2	Phosphoric Acid
MCFC	650	CH_4, H_2	Molten Carbonate
SOFC	600-950	CH_4, H_2	Solid Oxide

- Noble metals
- Noble metals/ non-noble metals
- Non-noble metals

Nedstack | Market Offering – PEMFC

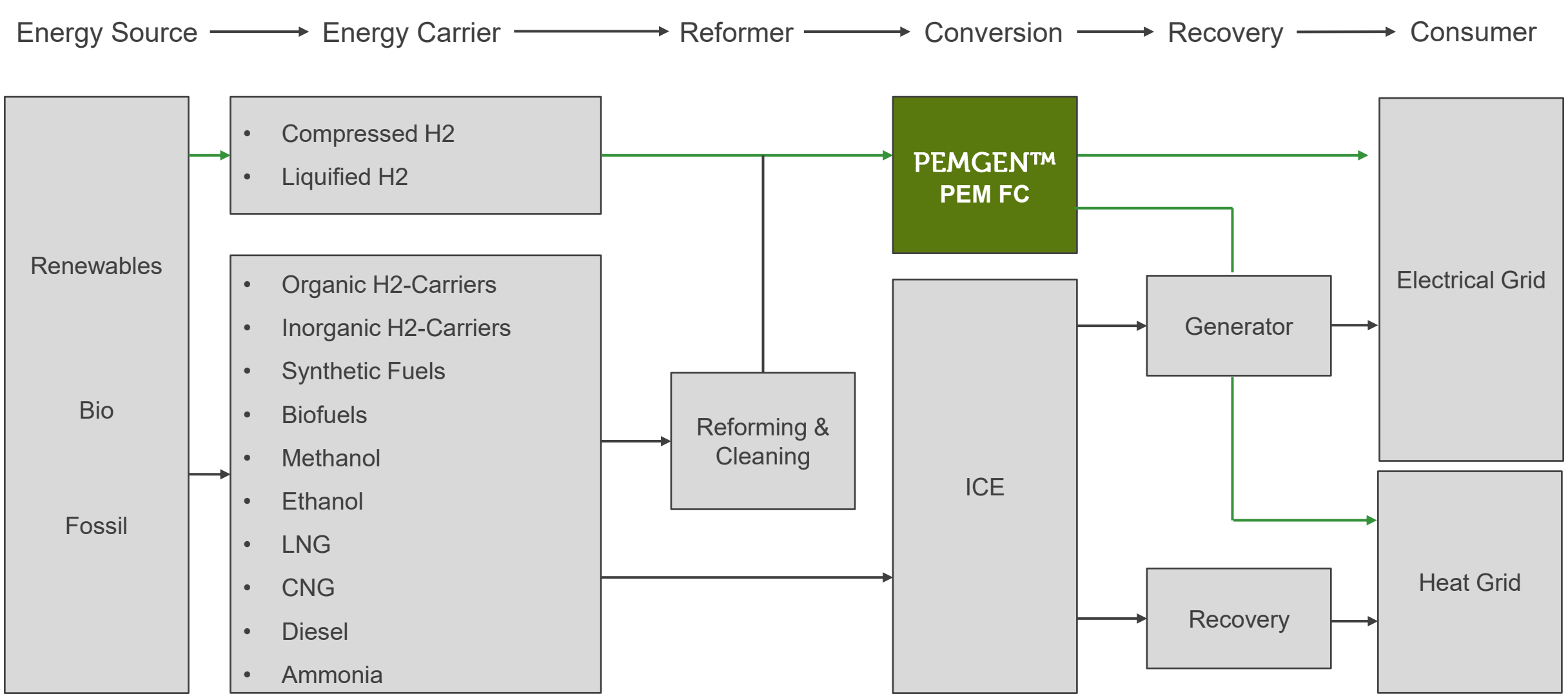
System Name	Nedstack FCT 13 XXL Extended Life
FC Type	Long Life - Proton Exchange Membrane Fuel Cell (PEMFC)
Intended Use	Multi-purpose: Commercial Vehicles, Marine, Stationary

Performance Specifications		
Operating Power Range (per Stack)	min-max kW	0 – 13.3
Rated Power Voltage range (per Stack)	min-max VDC	54 – 98
Stack Peak Voltage (at OCV)	VDC max	100
Cell Voltage	VDC	0.5 – 1.0
Minimum Cell Voltage	VDC	0.3
Current Range (per Stack)	Amps	0 – 230
Maximum Available Current	Amps	230
Operating Pressure	barg	Ambient – 0.45
Nominal Efficiency (@80% load)	%	50
Peak Efficiency	%	60
Nominal Operating Temperature	ºC	65
Peak Operational Temperature	ºC	70
Lifetime (till stack refurbishment)	Hrs / years	20.000 / 12

Dimensional and Environmental Specifications		
System Size (l x w x h)	mm	590 * 189 * 288
System Weight	Kg	38
Water Production	l/ hour	1.2 – 6.9
Altitude	Min – max (m)	Sea level – 3000
Ambient Temperature	min-max ºC	-20 - +60
Relative Humidity	RH	0 – 100%
Noise Emission	dB(A)	0

Standardization and Regulatory Compliancy		
Hydrogen Safety Regulations	EC	2007/46/EC
Electric Safety	ECE	R-100 Rev.2
Electro Magnetic Compatibility	ECE	R-10 Rev.5
Fuel Cell System Safety	IEC-EN	62282-2

Nedstack | Process flows block diagram



Nedstack

PEM FUEL CELLS

Solutions & Markets

Mission Critical High Power PEM solutions and applications

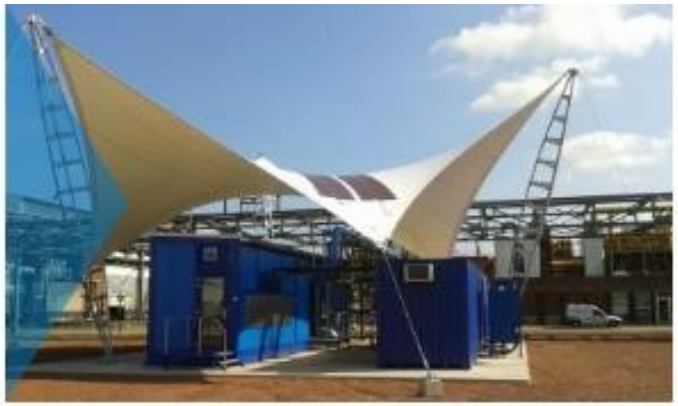
Nedstack Focus Markets

Maritime & Ports

- Ferries
- Cruise Vessels
- Dredging
- Inland navigation
- Fish farming
- Tug boats
- Canal boats

Built Environment

- District heating
- Holiday parks
- Hotels / Conference
- University campuses
- Industry parks;
- Hospitals;
- Shopping malls;



Industry

- Chlor-Alkali industry
- Sodium-Chlorate Ind.
- Semi-conductor

Nedstack Port & Maritime References

75 kWe

1 MWe

2 MWe

Nedstack Port & Maritime References

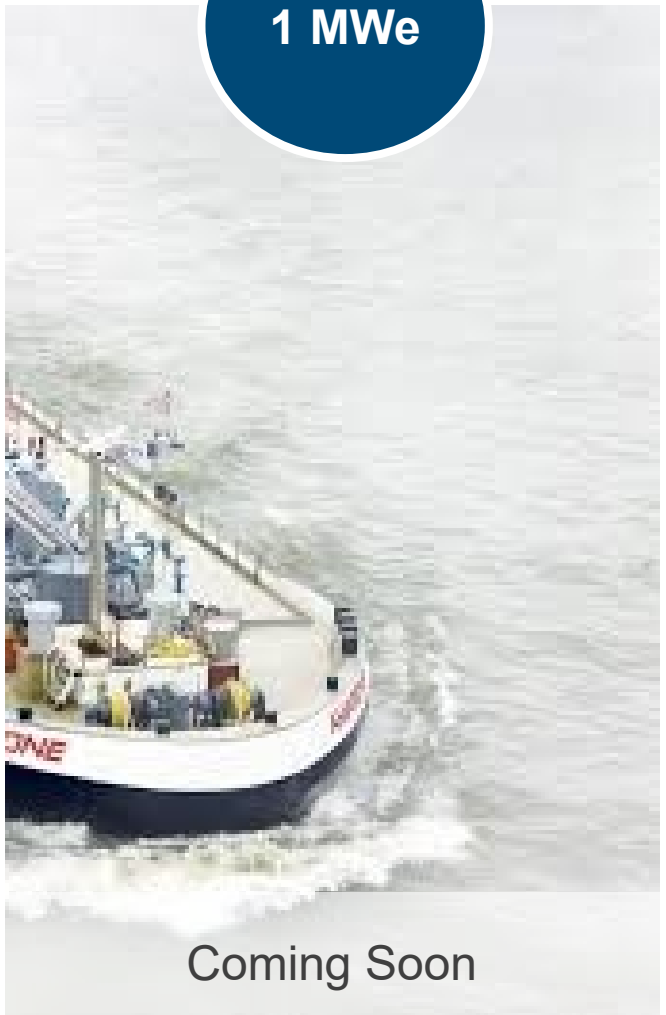
10 kWe

IHC

80 kWe

THEOLA STUDEWES
SHIPYARDS

1 MWe



Coming Soon

Nedstack

PEM FUEL CELLS

E

Maritime application

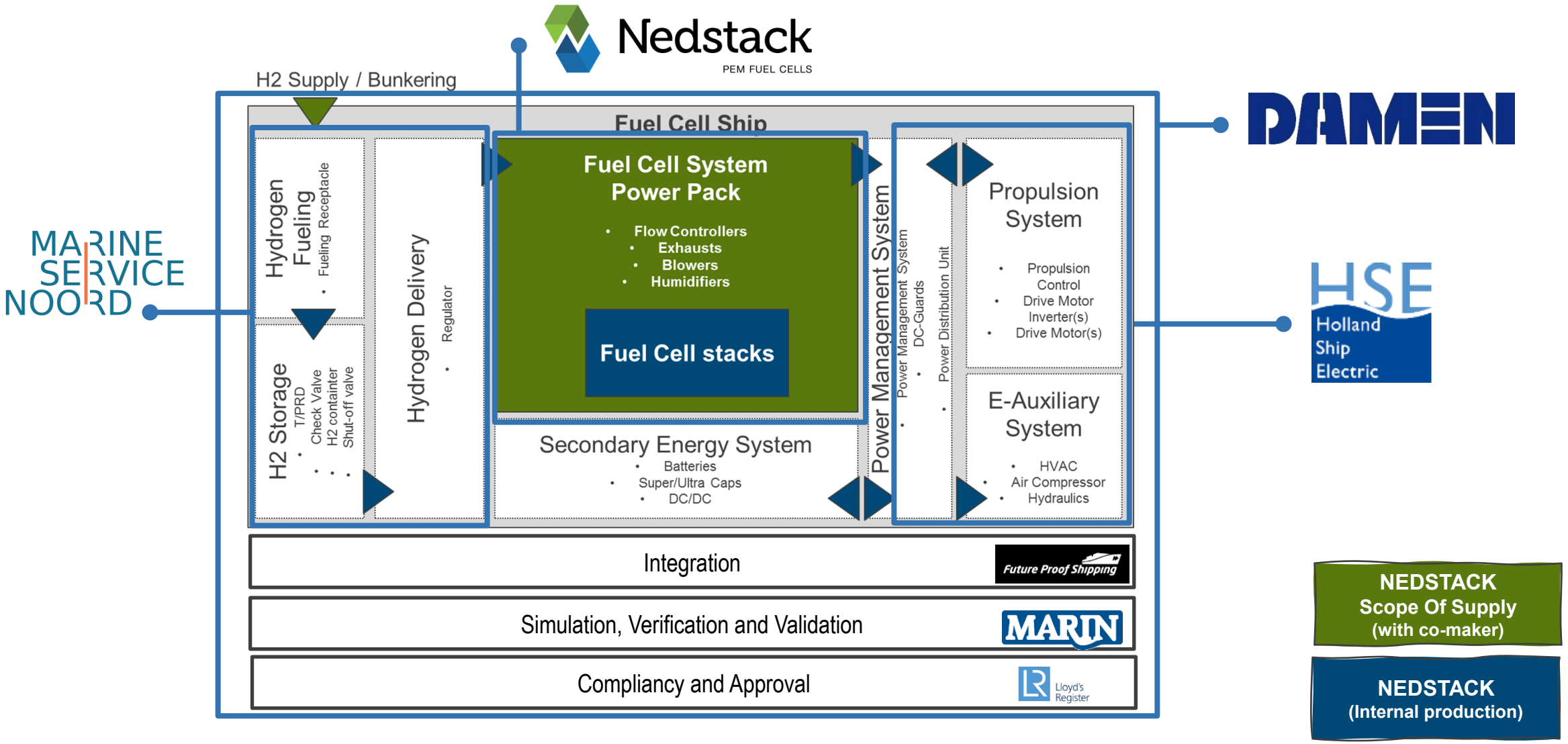
Installing PEMFC systems in inland and oceangoing vessels

Nedstack | Maritime Market Solutions

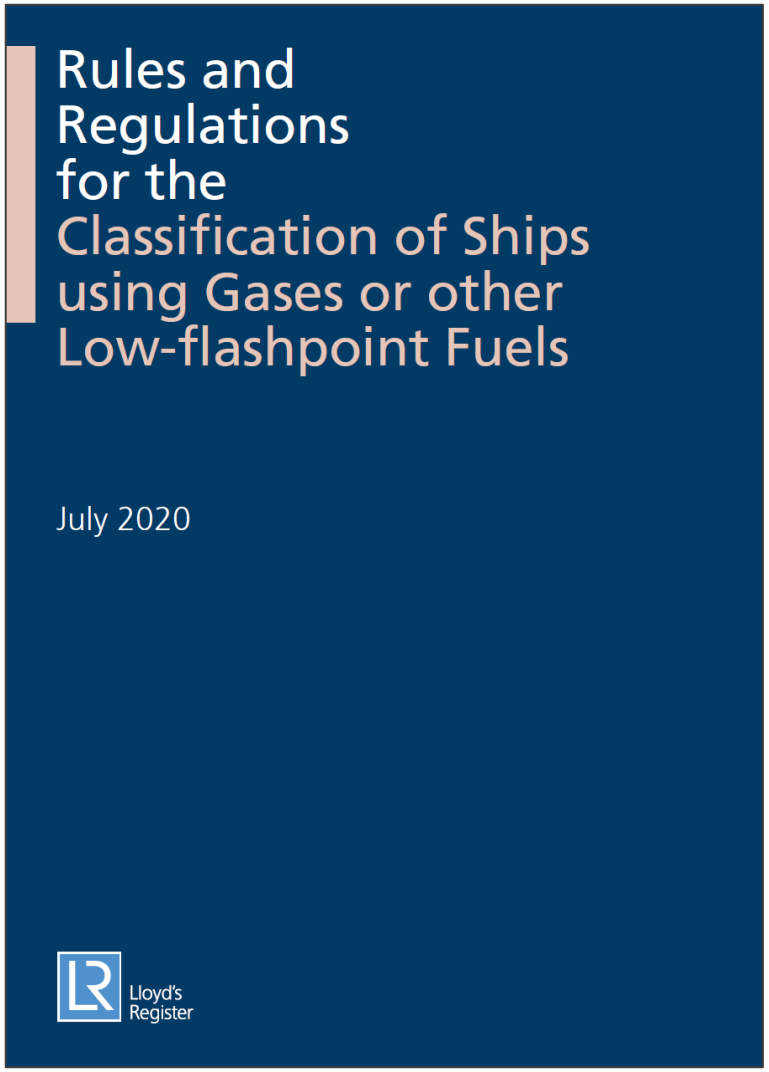
Nedstack | The Next Generation: Binnenvaart

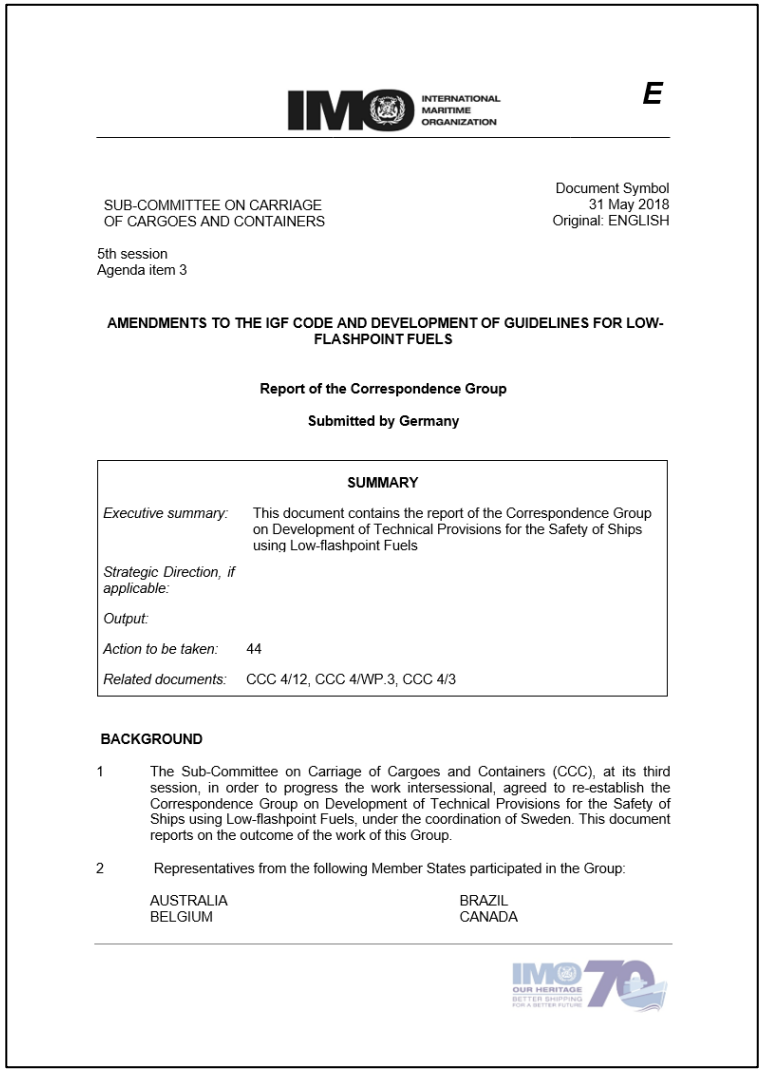
Supported by: Rijksdienst voor Ondernemend Nederland, Lloyd's Register

Nedstack | FELMAR Consortium Structure

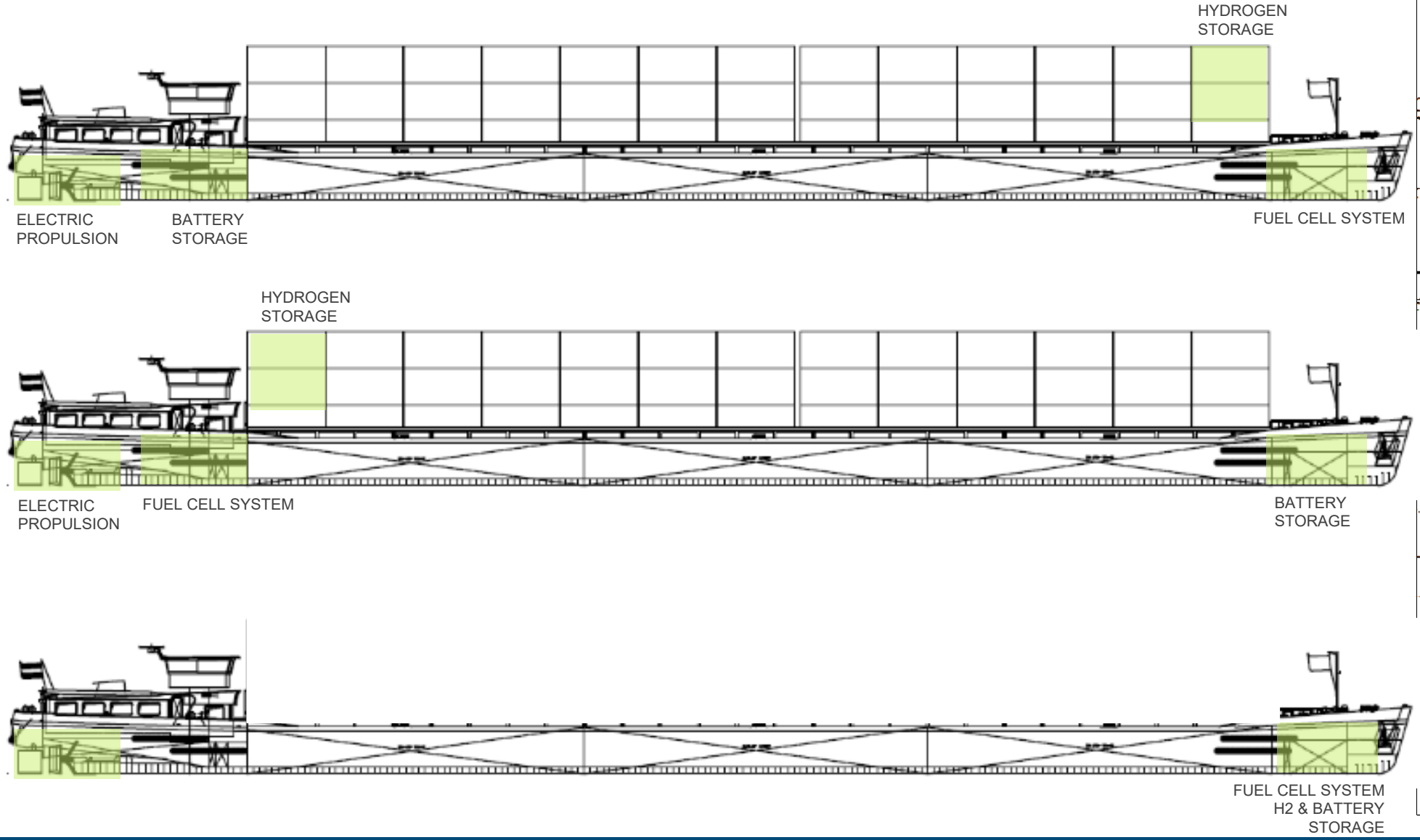


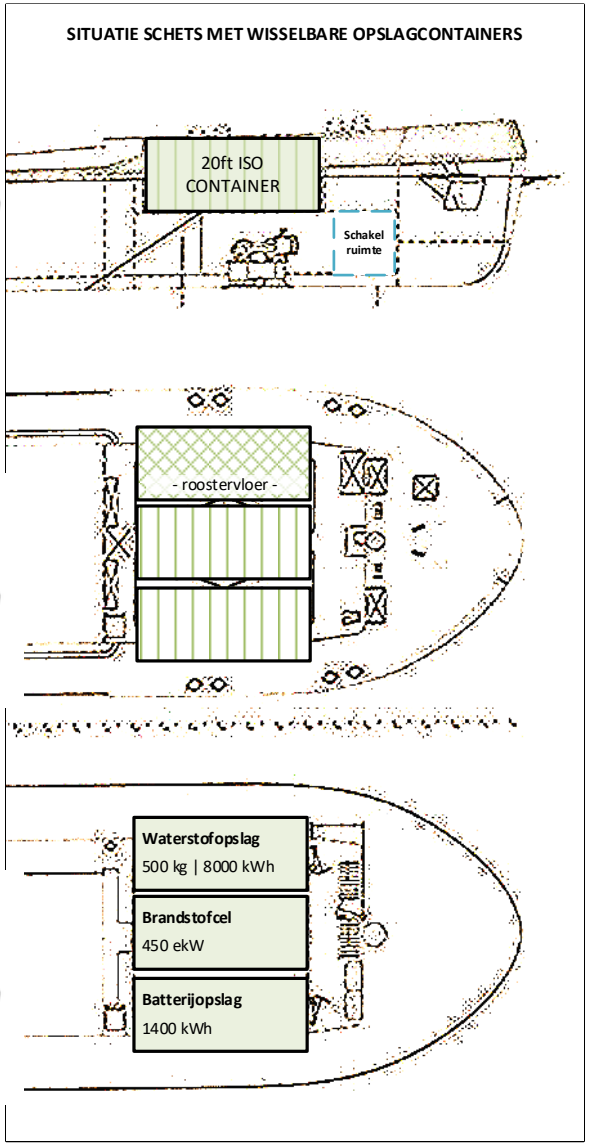
Regulations are in progress



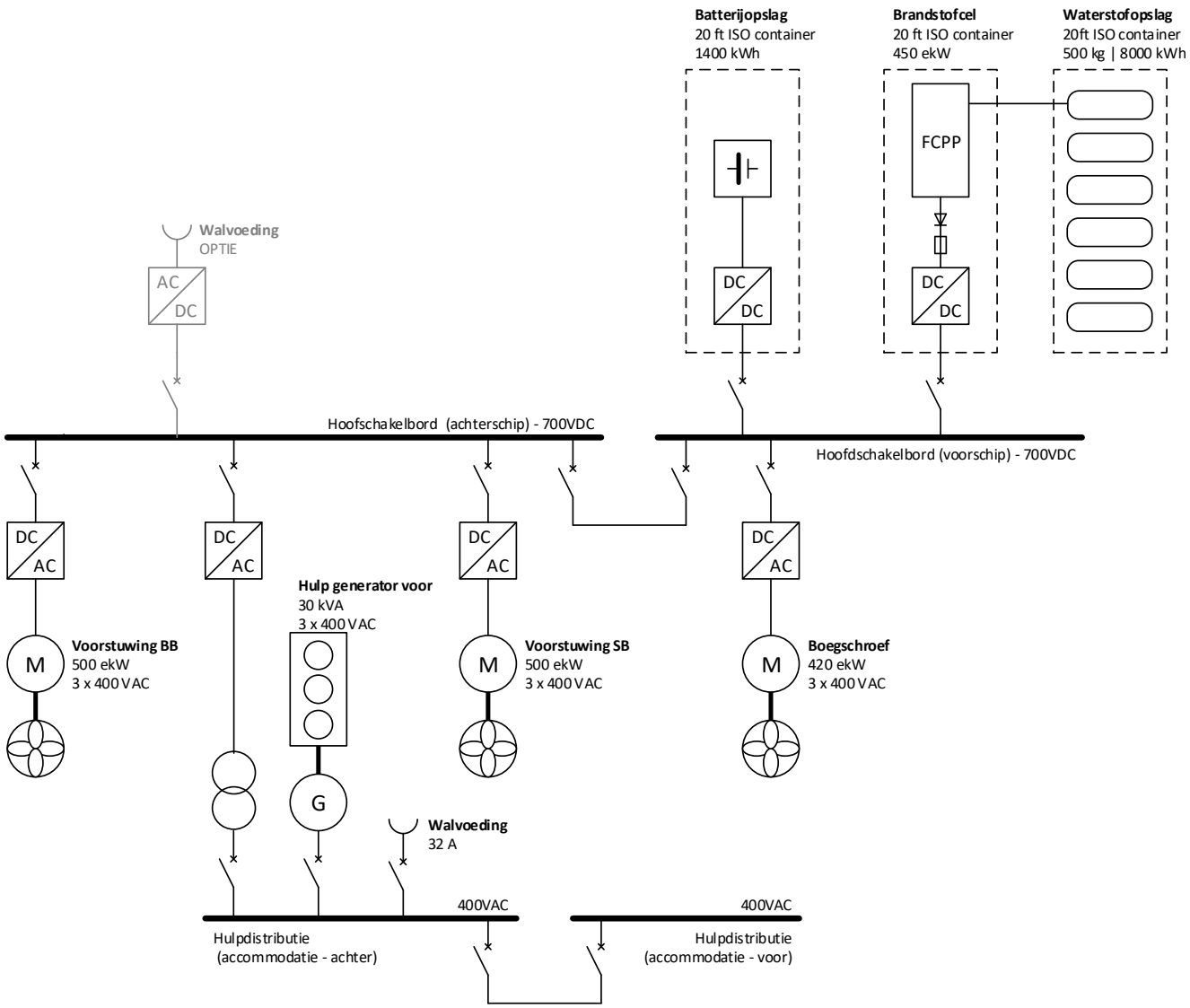


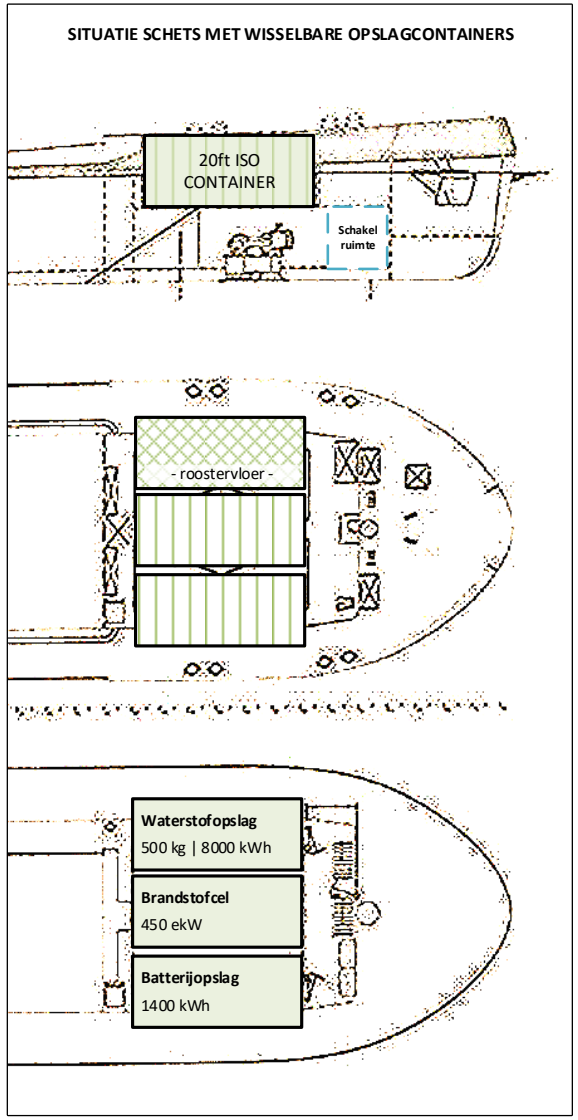
Nedstack | **Fuel cell integration**





Nedstack | Inland ship propulsion: FCE – MEC*



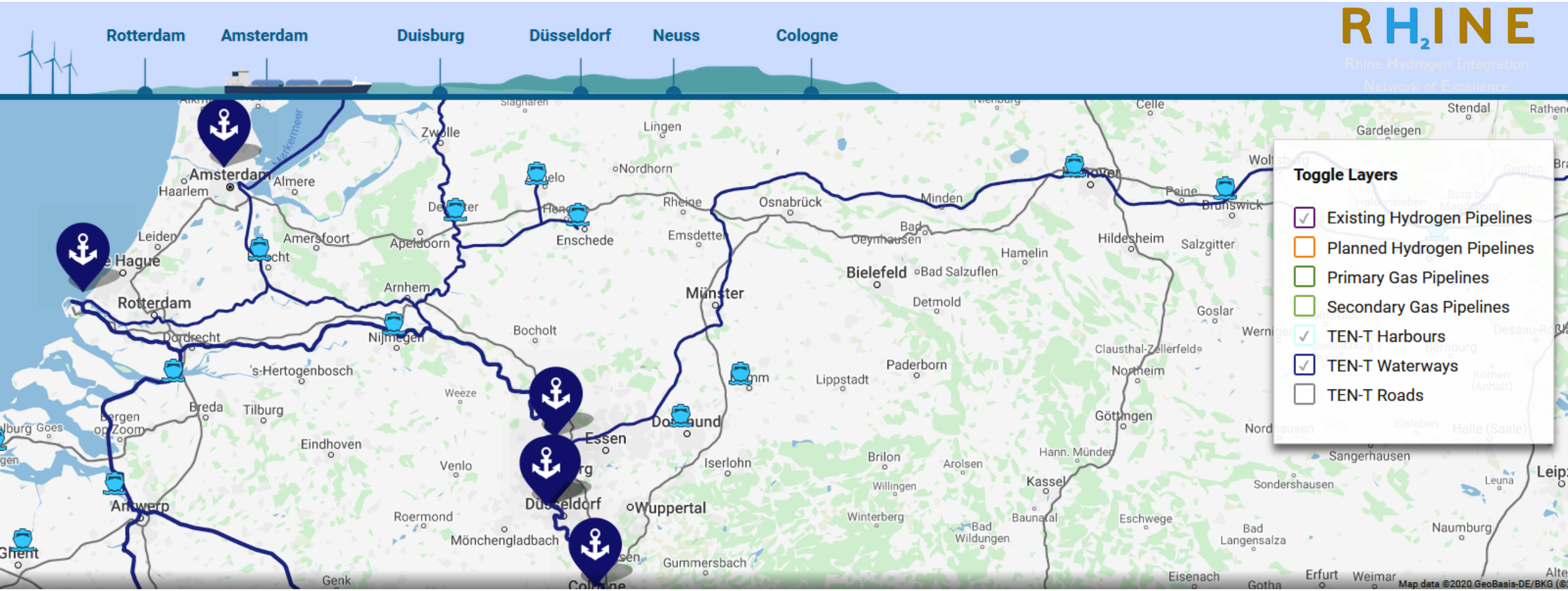


1) *MEC: Modulair Energie Container

Projects

Pilot projects and developments in maritime & ports

Nedstack | Zero emission corridor – RH2INE



RH2INE
Rhine Hydrogen Integration Network of Excellence

* Source: www.rh2ine.eu

Nedstack | Inland shipping projects

MAAS

- Container vessel
- ARA area
- 800 kW fuel cell propulsion

ANTONIE

- Dry bulk
- Delfzijl – Rotterdam
- 300 kW fuel cell propulsion

ISHY

- Multiple inland & sea going vessels
- Fuel cell & ICE technology

Future Proof Shipping

Lenten Scheepvaart

NPRC Sinds 1935

Interreg 2 Seas Mers Zeeën

Nedstack | High power maritime applications

H – TUG

- Zero emission port tug
- 60T Bollard Pull
- 4 MW propulsion
- 2MW PEMFC power generation

SX190

- Hybrid fuel cell drive Offshore Support Vessel
- Dynamic positioning class 2
- 2MW PEMFC
- 3-5 days zero emission DP2 operation with CH2

H2 POWER BARGE

- Multi MW shore connection
- Mobile deployment
- No infrastructure required
- Flexible configuration

OSD IMT SHIP DESIGN & MARINE CONSULTANCY

ULSTEIN

DAMEN

eekels | TBI

Nedstack | Partnerships

ZERO-EMISSION WATERBORNE TRANSPORT - PARTNERSHIP

WATERBORNE

EUROPEAN CLEAN HYDROGEN ALLIANCE - PARTNERSHIP

European Clean Hydrogen Alliance

ZERO EMISSION SHIPPING TECHNOLOGY ASSOCIATION

ZESTAs.

Nedstack

PEM FUEL CELLS

Temporary power units

Providing clean and sustainable power to off-grid locations

Nedstack | Temporary Power Market References

Nedstack | Market potential

Construction

Public Works

Mines & Quarries

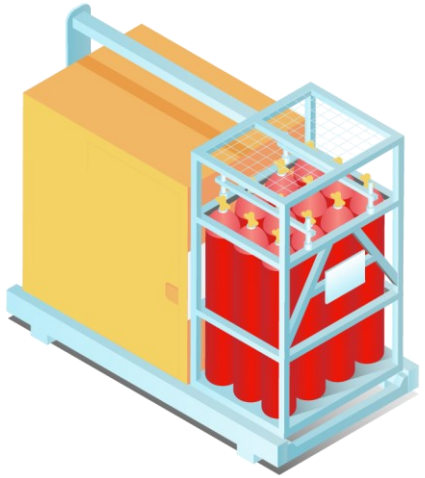
Concerts / Festivals

Fairs

Sports Events

Nedstack | Endurance extender

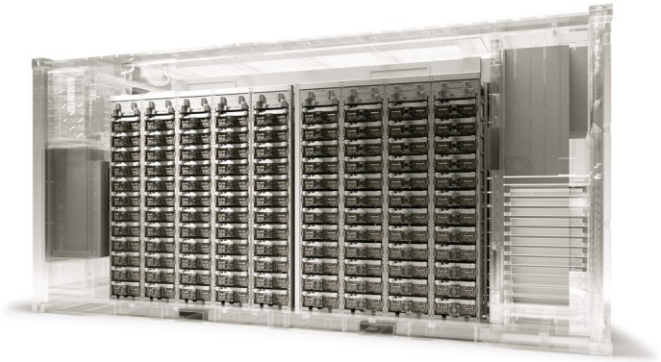
FC MPU



- Provides enduring power at nominal
- Uses compressed hydrogen as a fuel
- H2 storages modules can be swapped

✓ **Endurance**

Battery-Box



- Provides high peak power capability
- Is flexible enough to meet high C-rates
- Has limited capacity for endurance.

✓ **Flexibility**

Power User

- **Has enduring fluctuating power demands**
- **Increasingly desires zero-emissions**
- **Is not willing to compromise on operations**

✓ **Zero-Emission**

Nedstack | The Promise of Endurance

H2-Fuel Feed Strategy

Bottle Rack
20 Mpa
~ 8 kg

Tube Trailer
30 Mpa
~ 300 kg

MPED Container
50 MPa 40’ MPED
~1050 kg

Cryogenic Trailer
Cryogenic
~ 3000 kg

PemGen MPU
Assuming Ƞ=50%

Power Endurance Per Unit

Endurance
133kWhe

Endurance
5 MWhe

Endurance
17 MWhe

Endurance
50 MWhe

1) *1 kgH2 = 33.33 kWh LHV*

Nedstack

PEM FUEL CELLS

Power-to-Power

Mission Critical High Power PEM solutions and applications

Nedstack | Concepts for Offshore Wind P2P

Nedstack | Concepts for PV-Solar P2P

Nedstack | Concepts for Residential Heat & Power

Nedstack | Please be in touch!

Point of Contact

Nedstack
PEM FUEL CELLS

www.nedstack.com

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Application Manager Maritime Systems
Nedstack Fuel Cell Technology BV
Westervoortsedijk 73, NL-6827 AV, Arnhem

Phone: +31 630 03 23 19
E-Mail: Jogchum.bruinsma@Nedstack.com

A Tracing and Tracking system for renewable and non-renewable hydrogen

An initiative funded by the FCH 2 JU

WaterstofNet - Webinar WIC

March 26th, 2021

A WORLD CLASS EXPERTISE IN HYDROGEN AND FUEL CELLS

Unmatched experience **at every step of the value chain on all aspects**

Our clients in a 360° view on the entire hydrogen industry

- ✓ Technology
- ✓ Economy
- ✓ Business Cases
- ✓ Markets
- ✓ Strategy
- ✓ Public policies and regulation
- ✓ Social acceptance, etc.

PRODUCTION

ENGIE, TOTAL, Shell, ENEDIS, VENTS DU NORD, EDF, AREVA H2Gen, NUON, AkzoNobel, Nouryon, RWE, AGFA, equinor, HYDROGENICS, McPhy, ecoPETROL, enel

T&D & STORAGE

Air Liquide, HDF, THE LINDE GROUP, MAHYTEC, AREVA, gasunie, HySA Catalysis, CEA, nel, ABB, ENGIE

FUEL CELL APPLICATIONS

RENAULT, MICHELIN, VOLVO, Autogermana, Fuel Cell Europe, FiA, DEME, POWERCELL, CIRCUIT DE SPA FRANCORCHAMPS, PLASTIC OMNIUM, Chemours

END-USER CLIENTS

LA POSTE, colruyt, NHS SCOTLAND, ArcelorMittal, SNCF, FiA, CIRCUIT DE SPA FRANCORCHAMPS

PUBLIC SECTOR

FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING, European Commission, UNDP, Agentschap NL Ministerie van Economische Zaken, RhôneAlpes, LA MANCHE, ZERO WASTE SCOTLAND, CCI VAR, SIPPEREC, ADEME, Pas-de-Calais Conseil Général, MAIRIE DE PARIS

INVESTORS AND DONORS

AFD, giz, sojitz, COCASD, IDB, Fouriertransform, CAF, THE WORLD BANK, VOLVO Volvo Group Venture Capital, FONDATION TUCK The Future of Energy

Introducing myself

Wouter VANHOUDT
Director EMEA

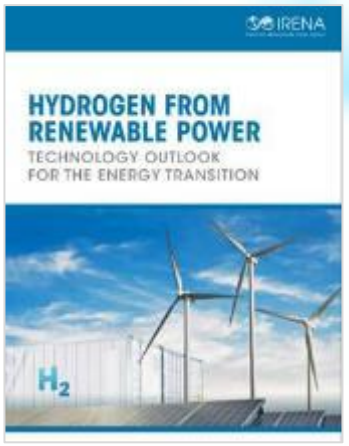
Master in Commercial Engineering Business Informatics & Master of Finance Vlerick Management School.
Project Coordinator for European Commission supported Standard on Green H2 Certification.
Chair and Board of AIB Gas Scheme Group.
Prince Albert Funds Alumnus, Professional career: 17 year, of which 1 year in China and **3 years in Middle East.**
Belgian native. Trilingual: Dutch-English-French. Based in Brussels

CEN CENELEC – JTC 6 liaison

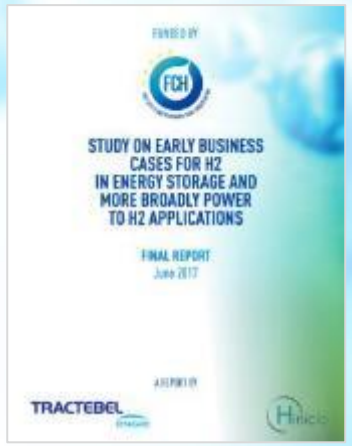
Coordinator since 2014

Chair Gas Scheme Group & Board Member

2019



2018

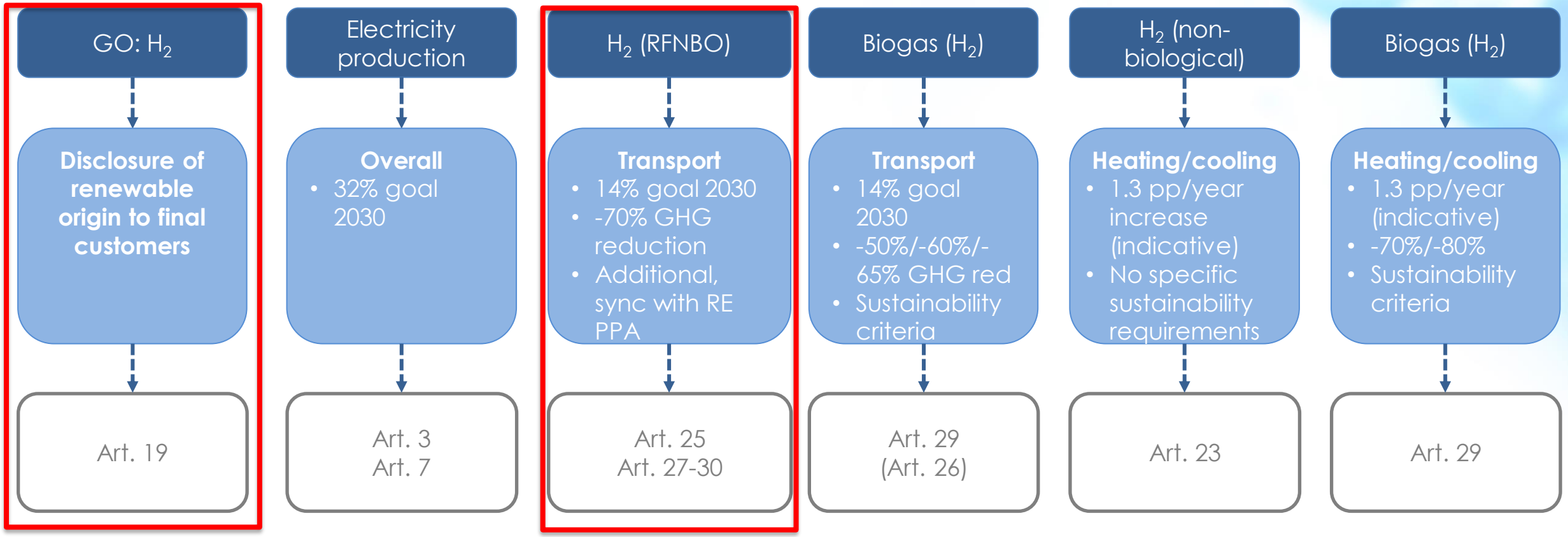


2017

FaStGO
Facilitating Standards for Guarantees of Origin

2020

The Renewable Energy Recast (RED 2 : 2021-2030) already supports Hydrogen, the main business driver being on customer disclosure & transport (RFNBOs)



We need a “data sheet” for Hydrogen to enable customer choice, just like car industry has standardised data sheets..

Criteria	Car X	Car Y
#Seats	4	5
CO2	95 gr CO2 / 100 km	110 gr CO2 / 100 km
Color	Green	Green (RAL 6002)
Consumption	4 l / 100 km	30 miles / gallon

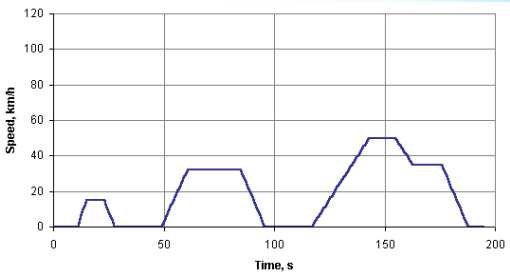


Figure 1. ECE 15 Cycle

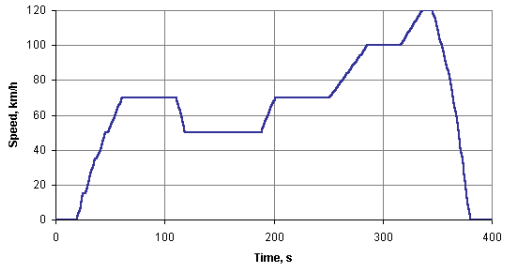
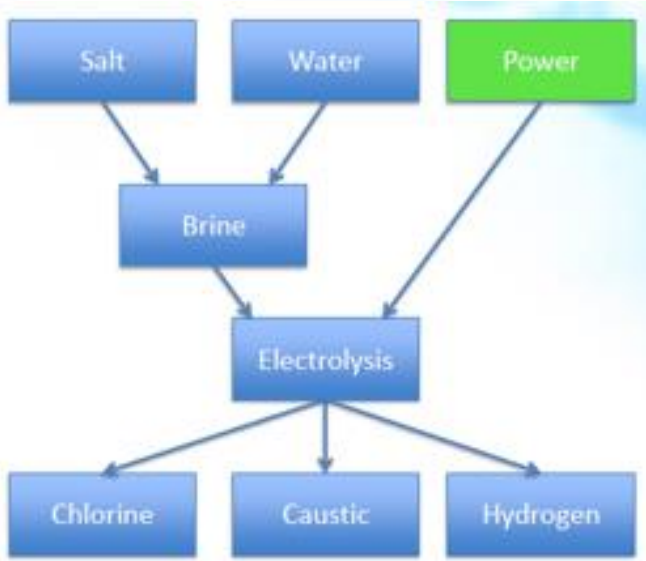


Figure 2. EUDC Cycle

Source: Hinicio analysis, drivemag.com, dieselnet.com

CertifHy developed a datasheet for hydrogen and CO2 allocation methods for different production pathways

PART 1: Factual information	Comments
• Account number	
• Identity of the Production Device o Production device identifier o Name o Location country o Location city o Commissioning date o Installed production capacity	
• Date and time of hydrogen production: beginning and end of the production batch	dd.mm.yyyy
• Fuel (or heat source) and Technology o Fuel (or heat source) code(s) (see Annex A) for up to ten fuels including respective share of total fuel input o Technology code (see Annex B); including main/by-product	
• Financial support to hydrogen production or input fuel production o investment supported, and/or o production supported, and/or o supported scientific/demo/pilot project, or o unsupported, or o no information available	
• Share of renewable energy for each input energy carrier for producing the hydrogen	%
• GHG balance: o GHG emissions intensity	g $CO2_{eq}$ /MJ_{H2}
• GO identity o Identifier (the unique number which has been assigned to the GO)	ID dd.mm.yyyy
o Issuing date o Cancellation/Expiry date	
• Certification Body	Name



Example: coal based electricity: x GHG / MWh

Allocation method	% of GHG from Power allocated to H2	% of GHG from Power allocated to Cl	% ...to Caustic
Mass based allocation			
Energy based allocation			
Value based allocation (EUROSTAT prices averaged)			
Mole based allocation			
Bench mark based (against ODC process, producing Clorine but no H2)			

Guarantee of Origin - What are we talking about ?

It is

- **Made for the sole purpose of informing the user about the production attributes of a product**
  - Renewable Origin
  - GHG footprint
  - Production technology
  - Geographic Origin,
  - …
- **Providing the guarantee that the quantities supplied have been produced within the perimeter of the system**
- **Made to avoid double counting**
- **Agnostic regarding the usage of the product**

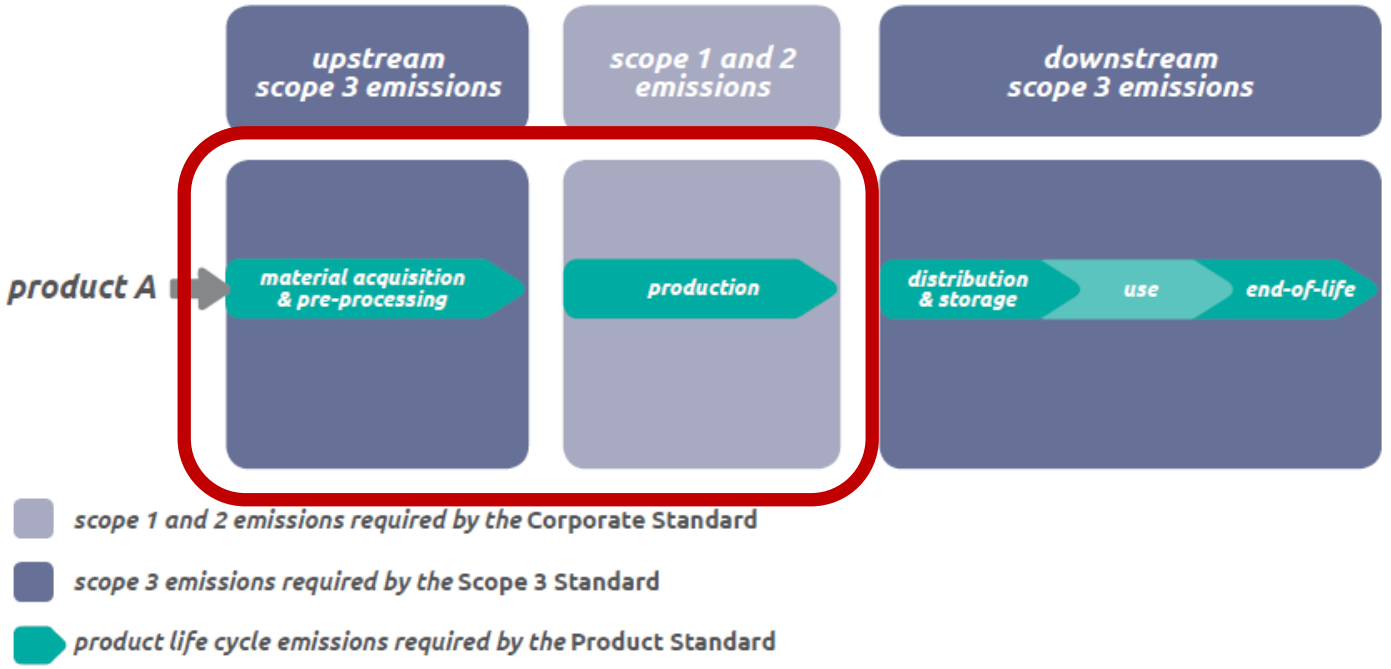
It is Not

- **A GHG reporting system (a way to account for a country or a corporation GHG emissions)**
- **Providing information about distribution or delivery**
- **A certificate giving right to incentives**
- **Meant to explicitly support investment in specific production technology**
- **Making a physical link between the production facility and the delivered product**
- **A full Life Cycle Assessment**

Guarantee of Origin - What are we talking about ?

- **Product LCA from Well to Gate**
  - Excludes:
    - usage phase, distribution
    - Construction and material needed to manufacture production plant and other equipment.
  - Includes:
    - upstream emissions related to Energy and raw material extraction, production and transport
    - Direct emissions within the battery limit of the production plant

Figure [1.1] The relationship between the *Corporate, Scope 3, and Product Standards* for a company manufacturing product A



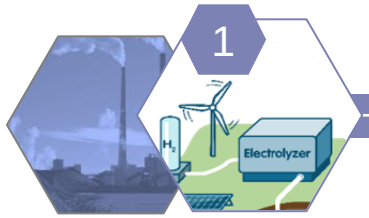
Source: Green House Gas Protocol: Product life Cycle Accounting and Reporting Standard - WBCSD, WRI

- **According to International Standards:**
  - **EN ISO 14044: Life Cycle Assessment, ISO 14067**: Green house Gases – Carbon footprint of products – Requirements and guidelines for quantification
  - **Green House Gas Protocol** – Product Life Cycle Accounting and Reporting Standard

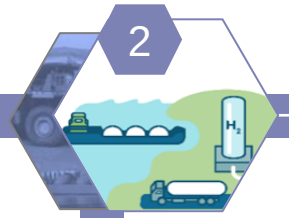
Hydrogen GO a prerequisite for Hydrogen as an enabler of the Energy Transition

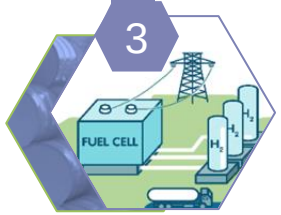
Enable the renewable energy system → Decarbonize end uses

Enable **large-scale renewables integration** and **power generation**

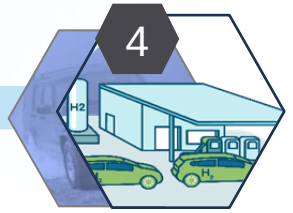


Distribute energy across sectors and regions

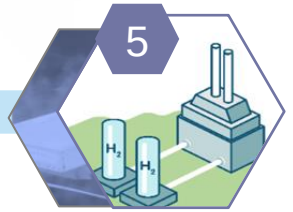




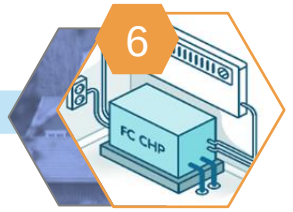
Act as a **buffer** to increase system resilience



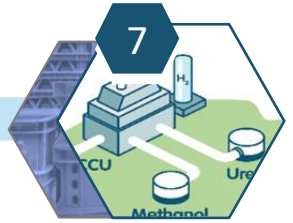
Decarbonize **transportation**



Decarbonize **industrial energy** use



Help decarbonize **building heat and power**



Serve as **feedstock**, using captured carbon

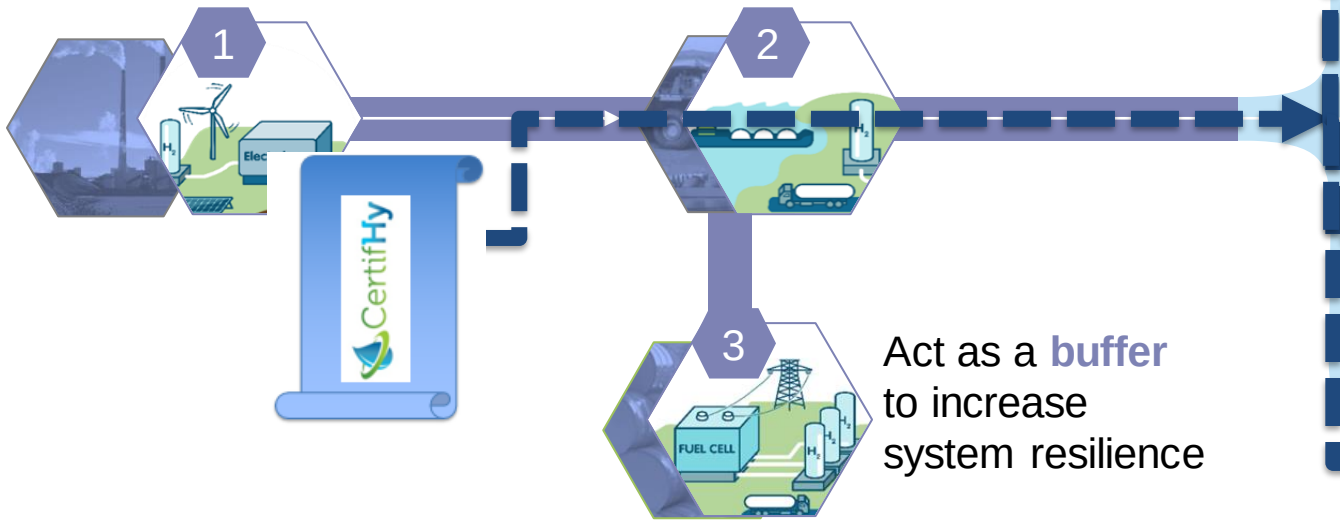
Source:
Hydrogen Council, McKinsey study 2017

Hydrogen GO - propagating environmental attributes along industrial chains

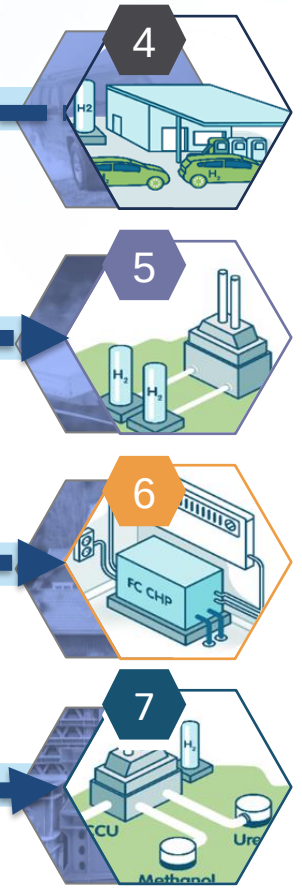
Enable the renewable energy system → Decarbonize end uses

Enable **large-scale renewables integration** and **power generation**

Distribute energy across sectors and regions



Act as a **buffer** to increase system resilience



Decarbonize **transportation** — g CO2/km

Decarbonize **industrial energy** use — g CO2/kWh

Help decarbonize **building heat and power** — g CO2/kWh

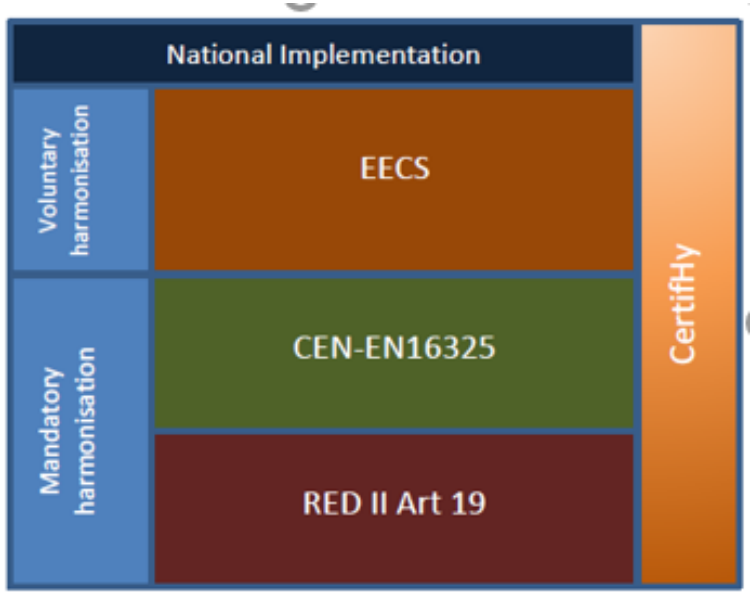
Serve as **feedstock**, using captured carbon — g CO2/kg

Source:
Hydrogen Council, McKinsey study 2017

Development of a harmonized market: increasing level of details from RED2 -> CEN Standard -> EECS -> CertifHy

CertifHy has a stakeholder platform of +100 organizations that can define the CertifHy scheme:

- **Definition of GHG allocation methods for specific pathways**
- Define data fields which might not be required by RED2 / implemented in MS
- Define labels (which could be used to add data fields to National Gos)



Steering Group

- Takes decisions regarding platform governance and organization
- Endorses the important scheme decisions
- Convenes plenary sessions
- Working group chairs and co-chair
- Various DG's of the EC will be re-invited as in CertifHy 2 to become Observer

	Stakeholder Platform	WG1: GO scheme and procedures	WG2: GO issuing (Producers)	WG3: GO commercialization and use (Users)	WG4: Regulatory Framework	WG5: Issuing Bodies (IBs)
Role	• Act as a discussion forum for stakeholders • Endorse the overall scheme	• Define the scheme • Provide input to and interface with standardization with regards to structure and content	• Define the requirements that will apply to the H2 production sites	• Specify the features that are needs to address market needs in terms of GO product and commercialization	• Ensure alignment between GO scheme and the pertinent regulation, especially at EU level	• WG in process of being created
Composition	• All pertinent stakeholders	• GO Scheme experts (including industry) • Standardization experts	• Operators of H2 production sites	• All actors involved with the distribution and the use of GOs (fleet operators, industrials from the automotive, steel, glass, etc. sectors, industrial gas companies,..)	• Public affairs experts of the stakeholder group • Representatives of the Commission	• Competent Issuing Bodies from Member States

Next to a robust tracing and tracking system for hydrogen production, CertifHy developed two labels: "CertifHy Green" and "CertifHy Low Carbon" together with Policy makers, Civil Society, and Industry.

CertifHy developed

Factual data fields on GO Scheme …

Data on Origin Production Batch	Units
• Date and time of hydrogen production (beginning and end) • Facility (identity, location, date of start of operation, process and capacity) • Energy sources (including GoO information if applicable) • Raw material sources (including sustainability information if applicable)	
• GHG emissions intensity of hydrogen produced	g $CO2_{eq}$ /MJ_{H2}

• Information on any support scheme (e.g. investment support, feed-in tariff, …)
• For hydrogen produced as a by-product:
  ○ Main product
  ○ Basis of GHG emissions allocation (e.g. input energy share)	

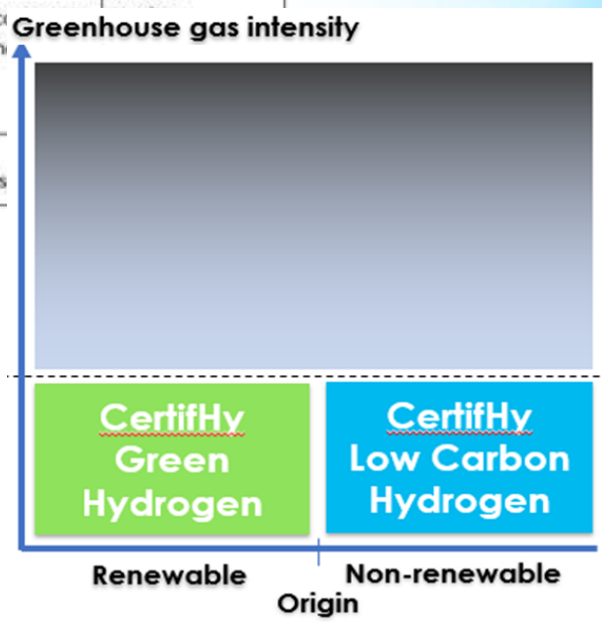
• Average GHG emissions intensity of all H_2 produced by the facility during the 12 months preceding date of production	g $CO2_{eq}$ /MJ_{H2}
• Share of renewable energy in total energy input* for producing the hydrogen	%
• Average GHG emissions intensity of the renewable share	g $CO2_{eq}$ /MJ_{H2}
• Average GHG emissions intensity of the non-renewable share	g $CO2_{eq}$ /MJ_{H2}
*excluding ancillary energy consumption	

A robust tracking system for **objective characteristics of hydrogen production**: production technology, place of production, energy sources used, financial support received, GHG allocation methods, etc.

… and two labels

Eligibility for *CertifHy Green Hydrogen* Guarantee of Origin	
CertifHy Green share of production [options]	%
Allocated GHG emissions intensity [options]	g $CO2_{eq}$ /MJ_{H2}
CHG emissions offsetting	Yes/No
Criteria:	
Does the unit quantity of hydrogen covered by this document belong to the CertifHy Green share of production?	Yes/No
Is the emissions intensity of the unit quantity of hydrogen covered by this document lower or equal to the CertifHy Low-GHG threshold (36,4 $gCO2_{eq}$)?	Yes/No
***CertifHy Green Hydrogen* Guarantee of Origin**	**Yes/No**
Eligibility for *CertifHy Low-GHG Hydrogen* Guarantee of Origin	
Allocated GHG emissions intensity	g $CO2_{eq}$ /MJ_{H2}
CHG emissions offsetting applied	Yes/No
Criterion: Is the emissions intensity of the unit quantity of hydrogen c… this document lower or equal to the CertifHy Low-GHG thresh… $gCO2_{eq}$)?	
***Low GHG Hydrogen* Guarantee of Origin**	
Issuing Number :	
(At least one of the above criteria must be satisfied for a GoO to be iss…	

Subjective appreciation



Labels are additionnal data which follow the GO to give specific information to the customer: they provide extra info on top of the national GO

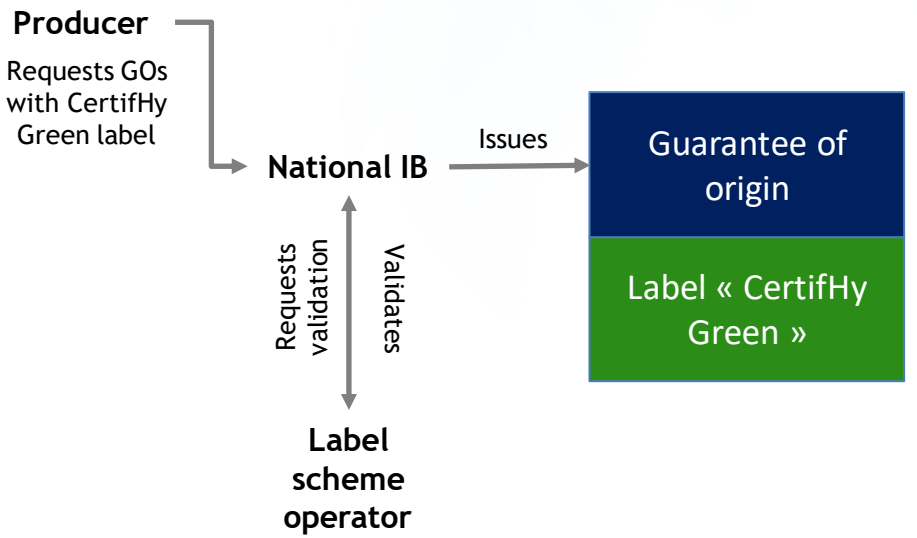
DESCRIPTION

CertifHy (Blue / Green) label for each production batch upon National IB's request.

How does it work for the producer?

- The production device is registered in the relevant production registrar
- National IB must request validation from CertifHy during the issuance of GO when the producers asks for a CertifHy (Green / Blue) label

Use case



Certificate content

GO and labels are **different.**

A GO is the identity card of the molecule, a label is a « flag » added on the GO and refers to different criteria.

CertifHy aims to develop the 1st European-wide Green and Low Carbon hydrogen GO scheme

2014 — 2016 — 2017 — 2018/9 — 2020s..

Phase 1

1. Define a **widely acceptable definition of green hydrogen**
2. Determine **how to design and implement** a robust **EU wide GO scheme**

Affiliated partners:

TOTAL, MACHIELS, AkzoNobel, colruyt, Shell, AIR PRODUCTS, AREVA H_2Gen, BMW, EDF, AIR LIQUIDE, THE LINDE GROUP, HYDROGENICS, uniper, OMV

Phase 2

1. Set-up a **hydrogen GO Stakeholder platform**
2. **Finalise the scheme design** ensuring it can be the **main route to guarantee the origin of green & low carbon hydrogen across EU Member States**
3. **Run a pilot scheme** to test the proposed design
4. **Identify actions** which need to be undertaken after the completion of the study **to achieve an EU wide deployment of the scheme**

Phase 3

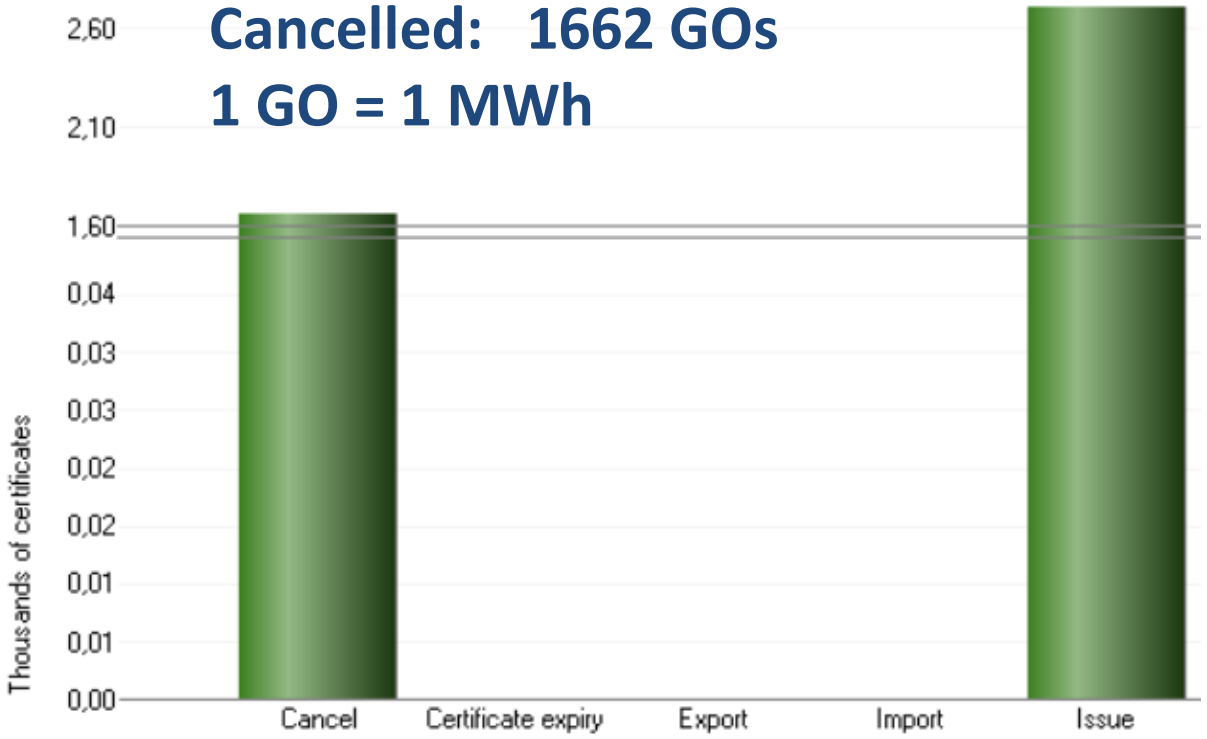
1. **Prepare EU wide deployment:**
   Implement Scheme:
   - Gas Scheme Group of AIB
   - Voluntary Issuing Body
   - Expand Stakeholder Forum with WG on Issuing Bodies
2. **Expand from GOs to RFNBO certification**

The first commercial transactions already took place, i.e. issuance and use ('Cancellation') of first green H2 GOs: H2 Mobility Deutschland & Transport for London

Domain Transactions

Domain: CertifHy; Transaction Date: 2019-01-01 To 2019-02-28

Issued: 2714 GOs
Cancelled: 1662 GOs
1 GO = 1 MWh



Energy Source	Issue	Transfer	Cancel	Ex
F01000000 Renewable	2 714	-	1 662	

News Release

Air Products launches European project to certify renewable hydrogen

One of the first to receive Guarantees of Origin under CertifHY; renewable hydrogen will support vehicle fuelling stations

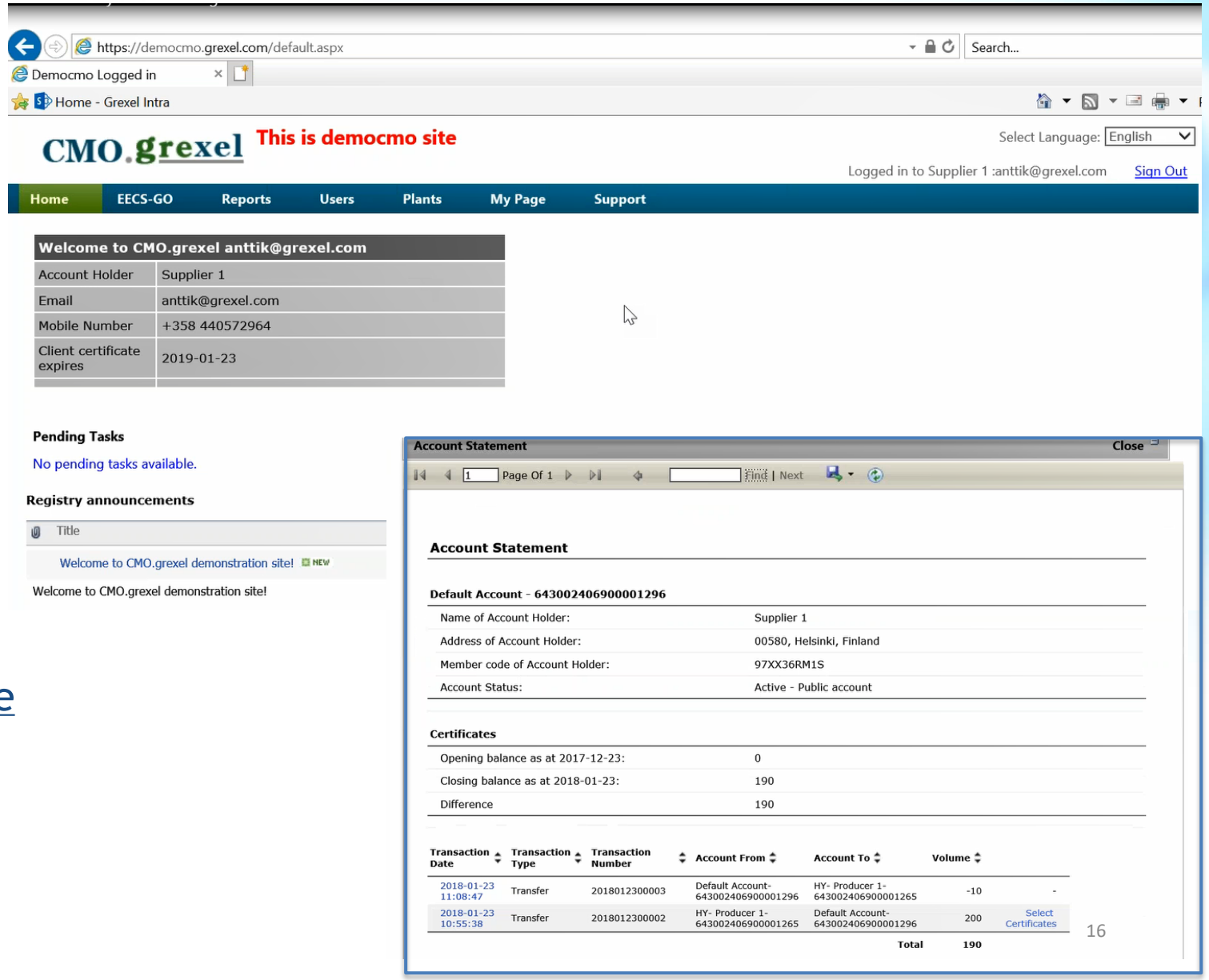
07/02/2019 Rotterdam, The Netherlands

As part of the pilot project, two of Air Products' hydrogen customers in the mobility sector will receive GOs for renewable hydrogen. The first is H2 MOBLITY Deutschland, an organisation operating a network of hydrogen fuelling stations in Germany. The second is London's integrated transport authority, Transport for London, which operates hydrogen buses across the United Kingdom's capital.

http://www.airproducts.co.uk/Company/news-center/2019/02/0207-air-products-launches-european-project-to-certify-renewable-hydrogen-uk.aspx

CertifHy puts both a Guarantee of Origin (GO) "scheme" as well as a "system" at the disposal of Member States (MS): https://cmo.grexel.com/Lists/PublicPages/Statistics.aspx

- Member States are free to choose whether they only adopt the "scheme" (i.e. the data fields on the GO, all procedures, etc.), which is important for cross border trade
- or (part of) the "system" that CertifHy developed (Notification Body, GO Issuing Body, GO registry, etc.);
yet MS are also free to develop their own Registry: cfr https://cmo.grexel.com/Lists/PublicPages/Statistics.aspx



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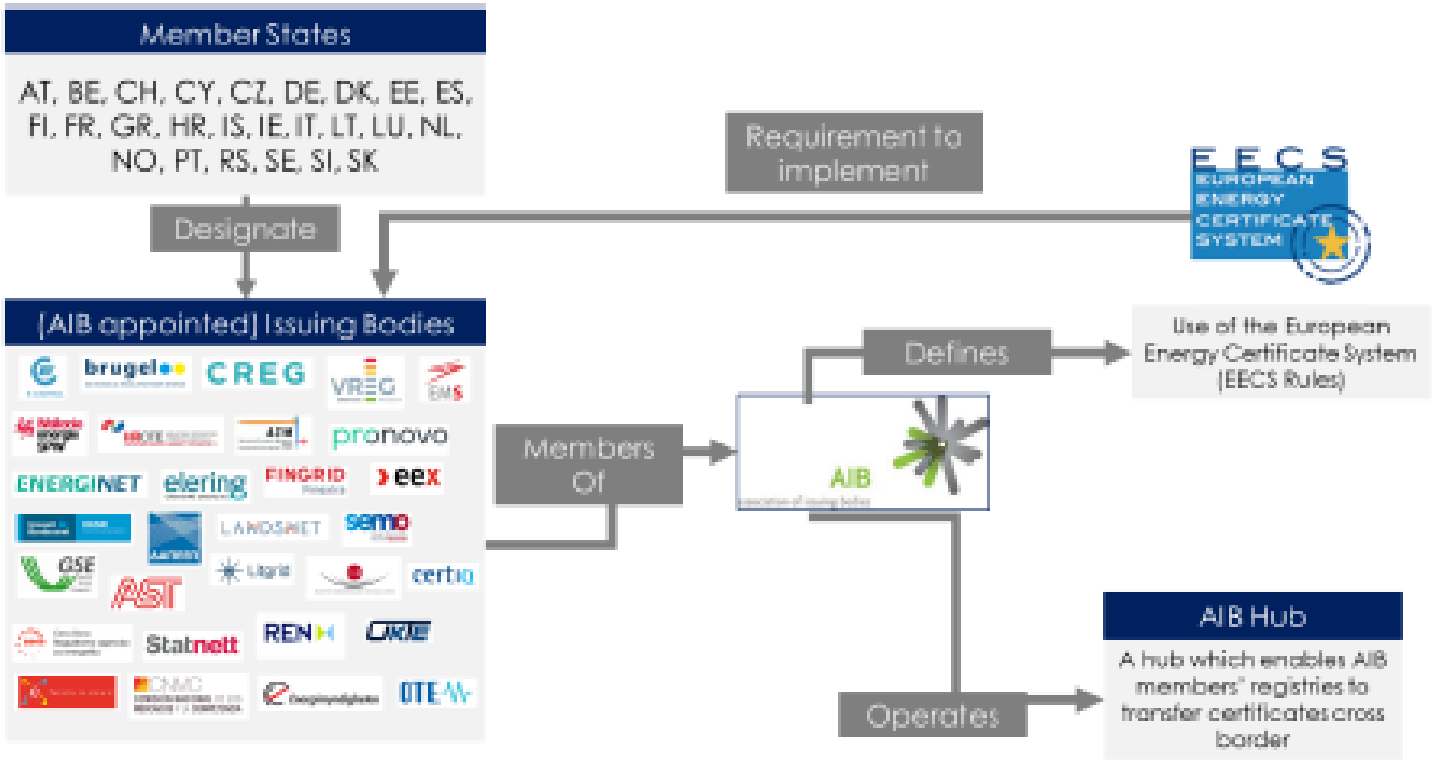
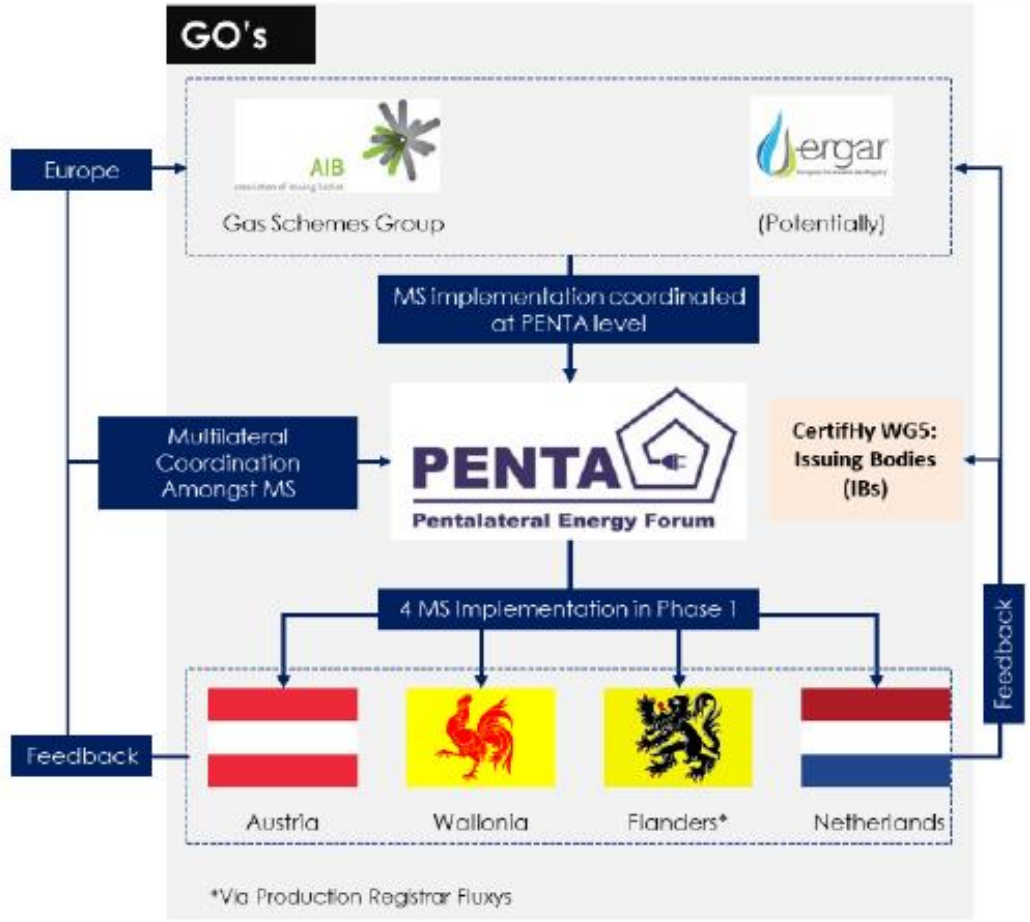
CertifHy Phase 1 (2021 - 2022) : Focus on Guarantees of Origin through work with AIB

RED2, CEN Standard and AIB (though its governance) maximises harmonized GO implementation



CertifHy Phase 1 (2021 - 2022) : assist 4 MS to implement the Gas Scheme which will act as pilots with feedback loops foreseen.



Beyond Europe, CertifHy will also provide input to international Clean Energy Ministerial and IPHE's Task Force on hydrogen certification

Beyond implementation with 4 EU MS, 1st level capacity building with Morocco for import/export of GOs with the European Union is foreseen

Phase 2: from GO towards RFNBO certification

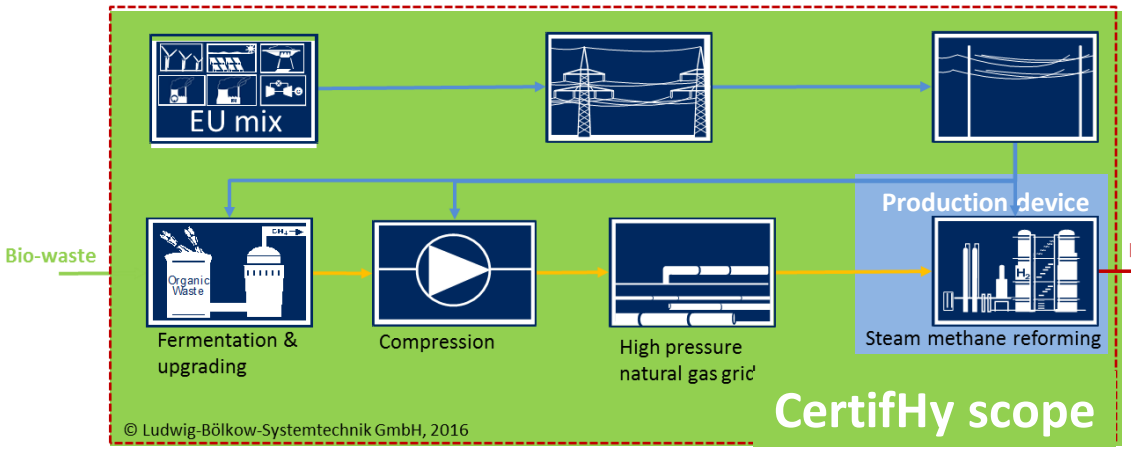
RFNBO scope:
Sustainability criteria for elec:
Additionality & "in-sync" with RE

Out of scope

Construction material (e.g. steel)

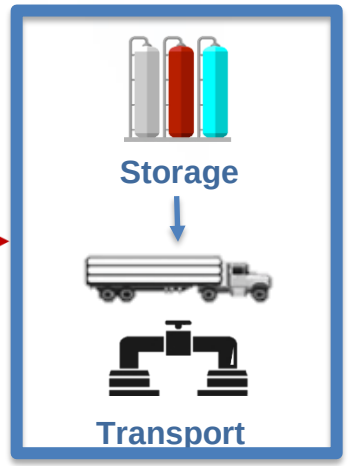
Manufacture

GO scope



RFNBO scope

+ mass balance



Application	Labelling: consumer disclosure	Transport sector	
Legal background	Labelling RED II Art 19	RED II - Art 25	Mass Balance (RED I Art 18 and RED II Art 30)
Mode of delivery	Book & claim	Mass Balancing	
Organization	Issuing Bodies by Government mandate	Voluntary Scheme recognized by EC	**RFNBO: non-existent (yet)**
Applied scheme	**CertifHy GO Scheme (in process)**	**RFNBO: non-existent (yet)**	**RFNBO: non-existent (yet)**
Document type	GoO Guarantee of Origin	PoS Proof of Sustainability	PoO Proof of Origin
Value	End Consumer disclosure: i.e. CSR/ Marketing	RED II: 14% Renewable Fuel in Transport obligation on Fuel Suppliers	

CertifHy will continuously work on understanding market needs & investigate downstream H2 uses (e.g. PtL) as well as other uses of GOs

Figure 8: Policy landscape of potential other uses of H_2 GOs

CertifHy

An initiative funded by the FCH 2 JU

For questions, please contact

certifhy@hinicio.com