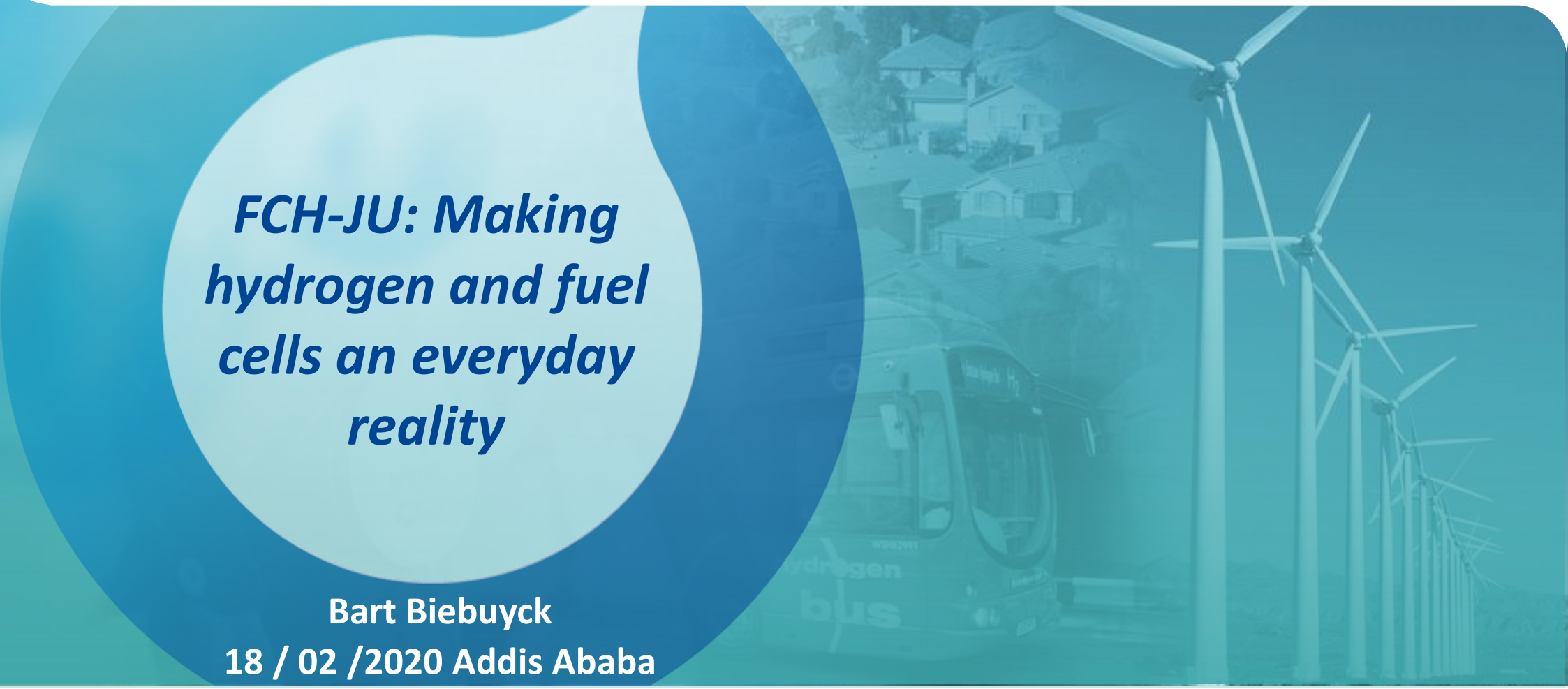
FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING



FCH-JU: Making hydrogen and fuel cells an everyday reality

Bart Biebuyck

18 / 02 /2020 Addis Ababa

Strong public-private partnership with a focused objective

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

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Hydrogen Europe
Industry grouping
>150 members
50% SME

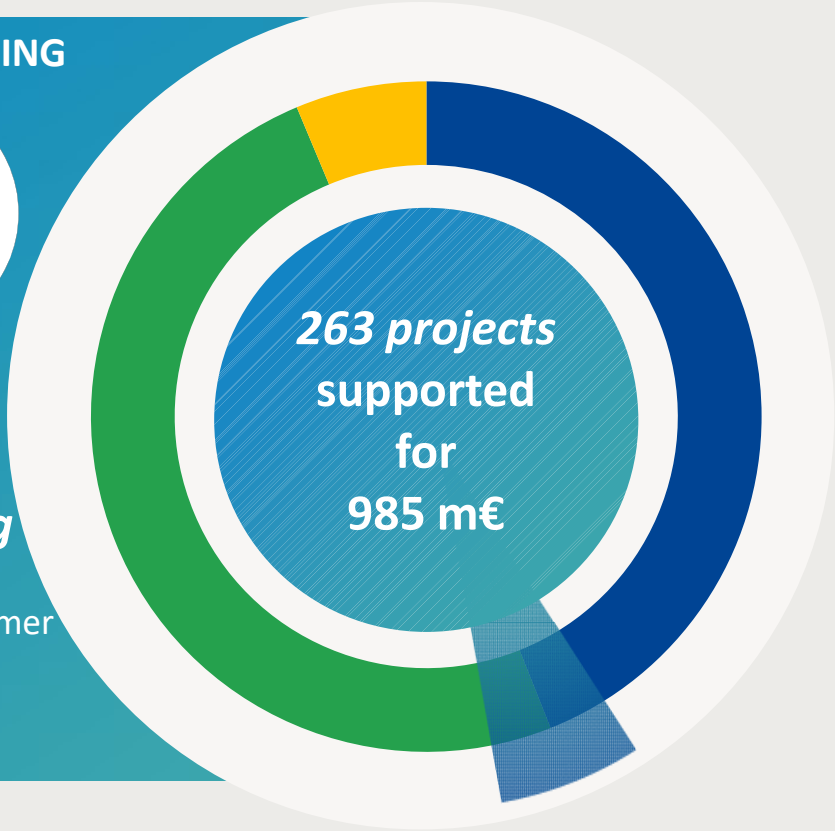
European Commission

Hydrogen Europe Research
Research grouping
78 members

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, …



46 %
457 million euros
145 projects

41 %
404 million euros
70 projects

6 %
58 million euros
43 projects

7 %
66 million euros
5 projects

Similar leverage of other sources of funding: 1.005 b€

The Hydrogen roadmap for Europe

2030 - 2050 hydrogen vision

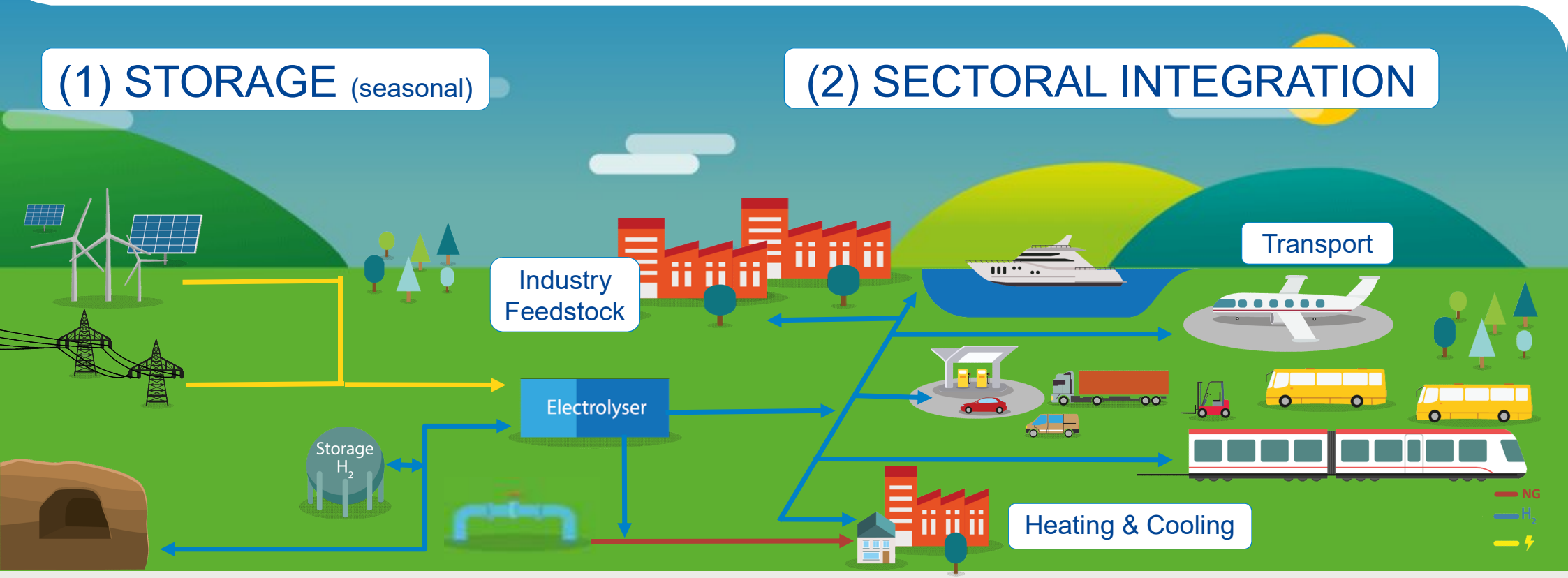
2030	~6%	~37 Mt	~EUR 150bn	n.a.	~1.0m
2050	**~24%**	**~560 Mt**	**~EUR 820bn**	**~15%**	**~5.4m**
of final energy demand[1]		annual CO_2 abatement[2]	annual revenue (H2 & equipment)	reduction of local emissions (NO_x) relative to road transport	jobs (H2, equipment, supplier industries)[3]

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

SOURCE: Hydrogen Roadmap Europe team

The role of hydrogen in our society & economy

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



Orkney Islands: Europe's first Hydrogen territory

Blueprint for other territories which consider hydrogen to decarbonise

BIG HIT

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

2016-2021

FCH 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€

FINANCIAL TIMES

US COMPANIES MARKETS OPINION WORK & CAREERS LIFE & ARTS

Ideas to Change the World

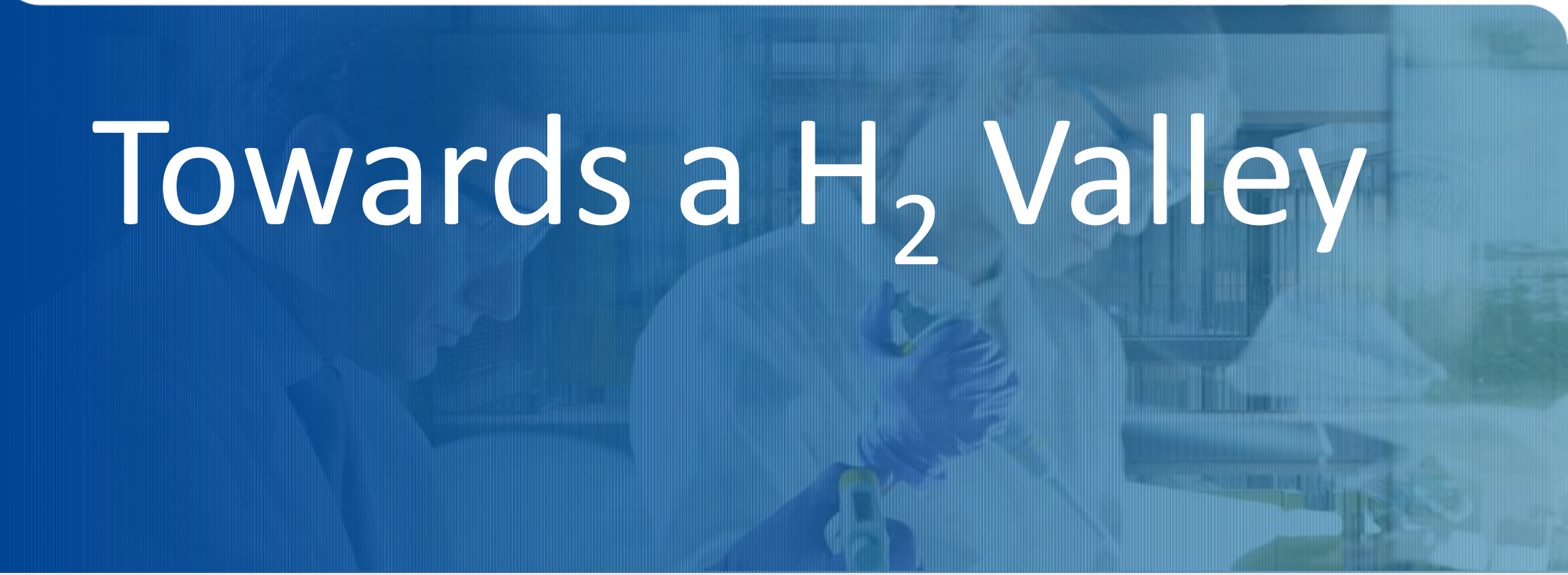
Renewable Energy + Add to myFT

Orkney project shows potential of hydrogen as a fuel source

The gas may be best option for heavy transport such as trucks, ships and trains

Scotrenewables' prototype tidal energy converter - the SR2000 was used for the conversion of tidal energy to hydrogen gas © Scotrenewables

Towards a H_2 Valley



FCH-JU initiative: 92 Regions/Cities from 22 countries (about 25% of EU) study to:

(1) assess FCH applications,

(2) identifying financing/funding options

(3) develop roadmaps,

(4) engage their stakeholders

Belgium
>Flanders
>Pom West-Vlaanderen

United Kingdom
>Swindon and Wiltshire
>Aberdeen
>Birmingham
>Cornwall
>Dundee
>Fife
>Leeds
>London (Greater London Authority)
>Newcastle
>Orkney Islands
>Oxfordshire
>Perth and Kinross
>Manchester
>Tees Valley

Norway
>Akershus
>Møre og Romsdal
>Oppland County Municipal
>Sogn og Fjordane

Iceland
>Reykjavik

Sweden
>Gavleborg
>Mariestad

Finland
>Kokkola

Germany
>Baden-Württemberg
>Bremerhaven
>Hamburg
>HyCologne-Hydrogen Region Rhineland
>Kreis Steinfurt
>North Rhine-Westphalia
>Heide region
>HYPOS (East Germany)
>Recklinghausen
>Saxony-Anhalt

France
>Auvergne Rhone-Alpes
>Bourgogne-Franche-Comté
>Centre-Val de Loire
>Grenoble
>Grand Dole
>La Roche sur Yon
>Normandie
>Occitanie-Phyrenees
>Orléans
>Pays de la Loire
>Pays de St Gilles

Spain
>Aragon
>Barcelona
>Cantabria
>Castilla – La Mancha
>Murcia
>Port of Valencia
>Puertollano
>Valladolid

Netherlands
>Assen
>Drenthe
>Emmen
>Groningen
>Helmond

Estonia
>Tallinn

Denmark
>Guldborgsund
>Lolland

Latvia
>Riga

Czech Republic
>Trutnov

Slovenia
>Velenje

Croatia
>Split
>Split-Dalmatia County

Italy
>Lazio
>South Tyrol
>Favignana
>Torino
>Venice
>Toscana

Austria
>Tirol

Portugal
>Torres Vedras
>Médio Tejo

Romania
> Constanța

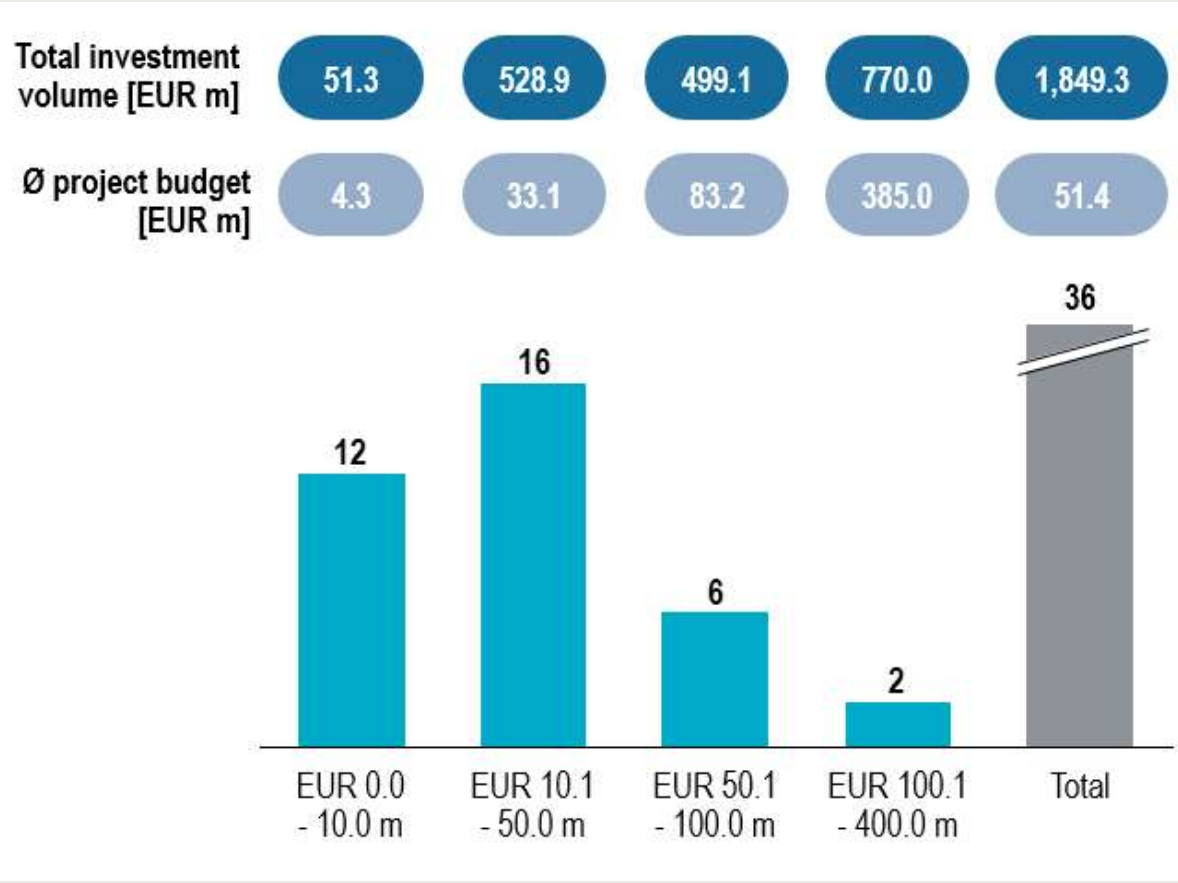
Bulgaria
>Bulgarian Ports
>Sofia

Greece
>Alimos
>Agia Paraskevi
>Ierapetra
>Kozani
>Milos
>Vrilissia
>Kalymnos
>Heraklion
>Western Macedonia
>Papagoou-Halargos
>Region of Crete

Signing ceremony 23 Nov. 2016 with CoR President Markku Markkula + FCH-JU and 40 regions

Planned deployments result in total investments of >EUR 1.8bn in the next 5 years – Majority small to medium sized projects

Envisaged investment volumes for next implementation projects



High future FCH investment volumes

> Participants indicate significant investments in FCH projects in the next 5 years and beyond

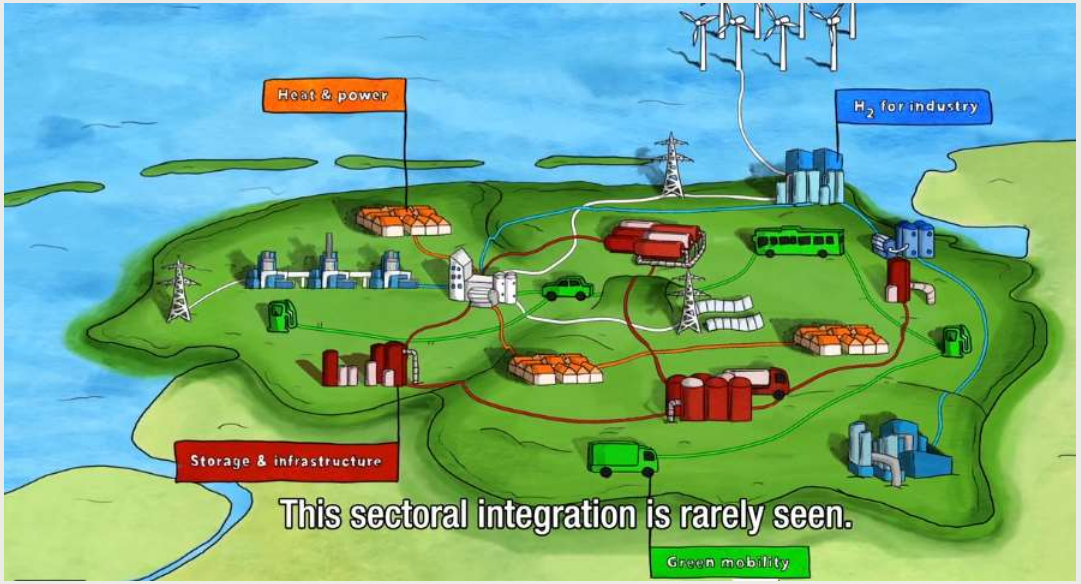
> Typically, regions with no FCH experience so far start with smaller projects and investments

> Nevertheless, some newcomer regions intend to make significant investments of up to EUR 50 m as well

> Overall investment volume is driven by a few very large projects which aim at realising very ambitious investment plans

H_2 Valley Support for 20 Million Euro (Call Jan. 2019)

6 proposals received and 1 selected to start the grant preparation



https://www.youtube.com/watch?v=L27dkYyg04g

HEAVENN KEY FACTS:

- North Netherlands (Gronningen / Delfzijl / Emmen)
- Total project circa 90 million Euro
- 31 partners (public + private)
- Project supported by 65 parties (Nat. + Int.)
- 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)

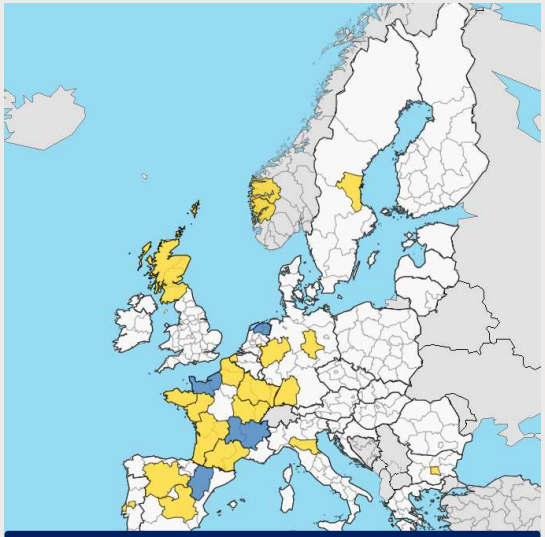
Hydrogen Valleys Partnership (European + Worldwide)

Established under the EC smart specialization platform for Industrial Modernization

European Hydrogen Valleys Partnership launched May ‘19 at EVS 32 in Lyon

EUROPEAN HYDROGEN VALLEYS PARTNERSHIP

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



Partnership led by:

- North of Netherlands (NL)
- Auvergne-Rhône Alpes (FR)
- Le Normandy (FR)
- Aragon (ES)

32 regions joined and more will follow.

Tender: Platform for Exchanges Between Worldwide Initiatives on Hydrogen Valleys:

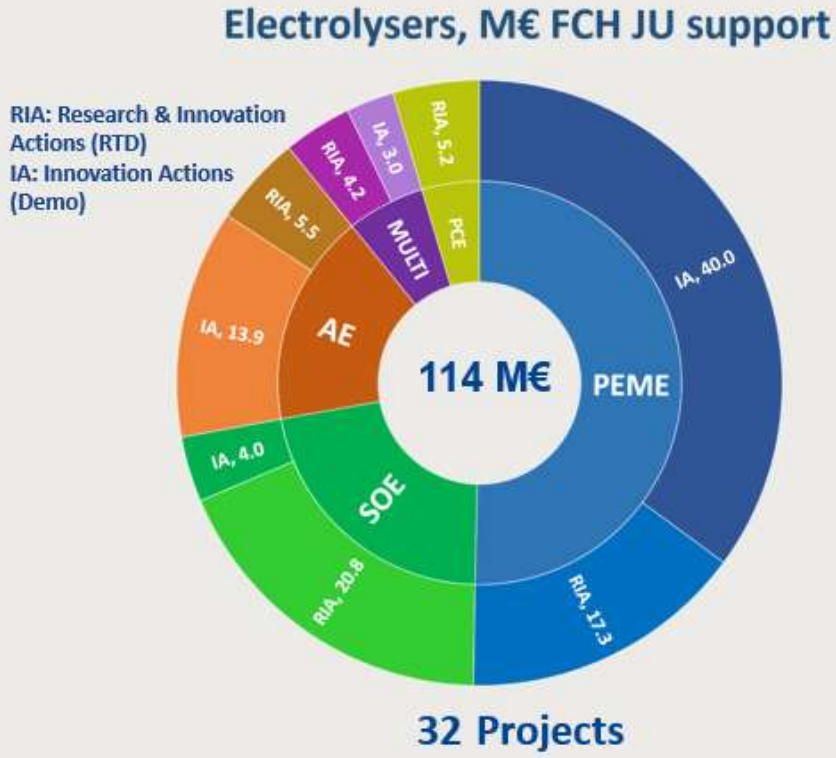
To set-up a global Information Sharing Platform within MI-IC8, to facilitate the emergence and implementation of large-scale hydrogen projects and leveraging the knowledge where IPR issues are less sensitive.

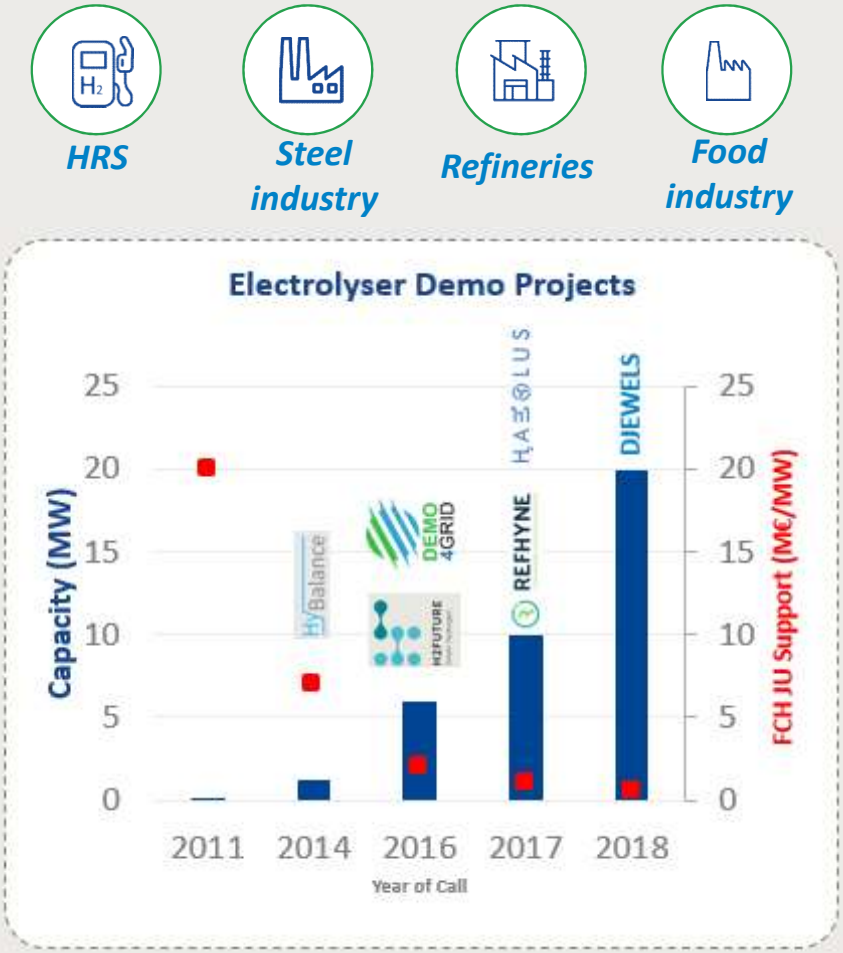
STATUS: Kick-off mtg. with consultant held

Green H_2 production and industry

Electrolysis demonstrations for energy storage and greening of Industry

Continues support to develop higher capacity electrolysers led to cost reduction and increased interest by industry





FCH electrolysis projects over time

Europe is world-leader in electrolysis systems and is happy to support Africa to provide electrolysis for H2 production

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€

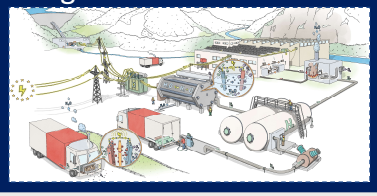
Project: Djewels
Place: The Netherlands
Date: 2018
Electrolyser: McPhy (ALK)
Funding: 11 m€

Djewels

0.15 MW → 1.2 MW → 2.5 MW → 4.0 MW → 6.0 MW → 10 MW → 20 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€

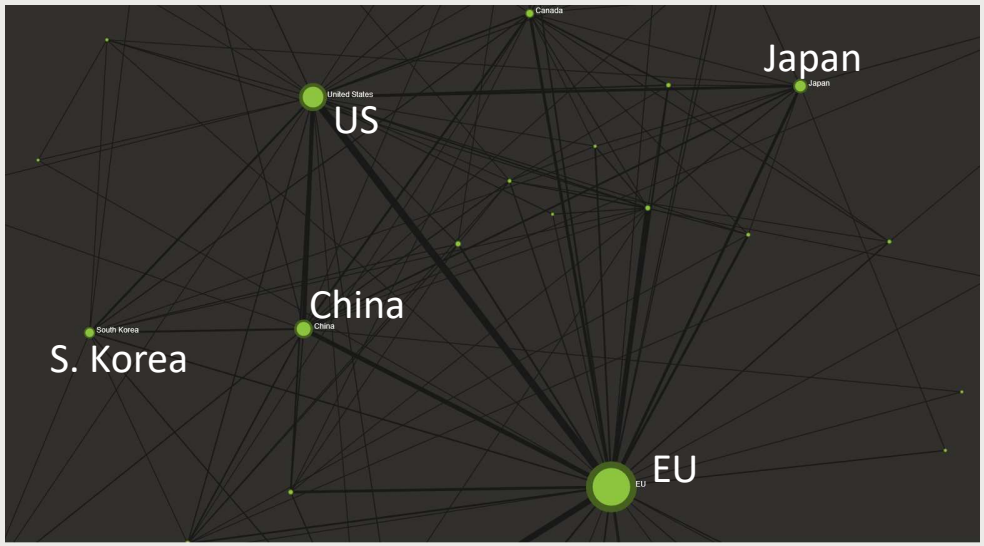


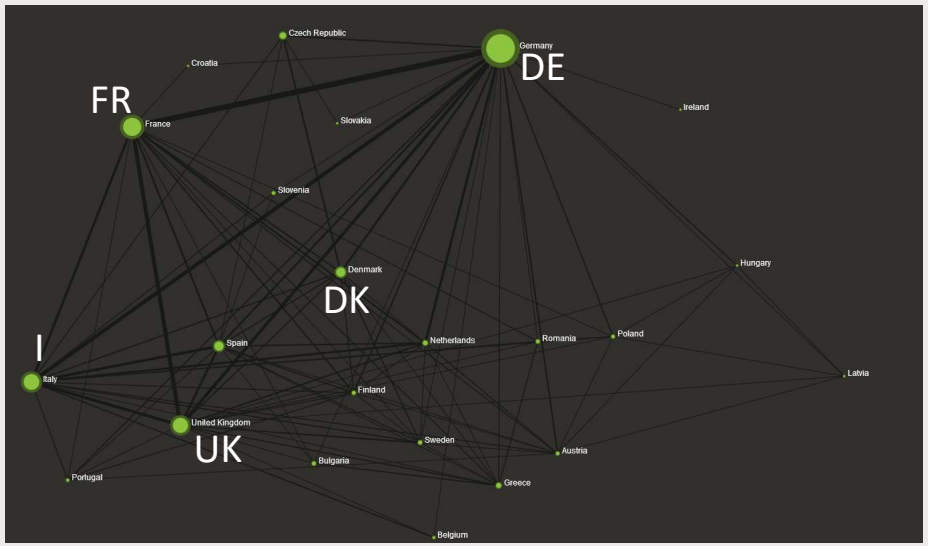
Project: Refhyne
Place: Germany
Date: 2017
Electrolyser: ITM (PEM)
Funding: 10 m€

Preparing >100 MW and GW scale

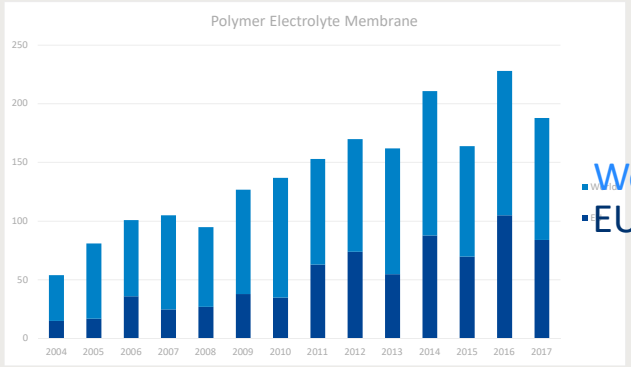
PEM electrolysis: Number of publications, patents, etc. 2004 - 2017

https://fch.europa.eu/page/tools-innovation-monitoring-tim





EU 823, US 430, China 270, JPN 193, S. Korea 143



DE 224, FR 136, I 116, UK 111, DK 62

Developing an EU wide Guarantees of Origin 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

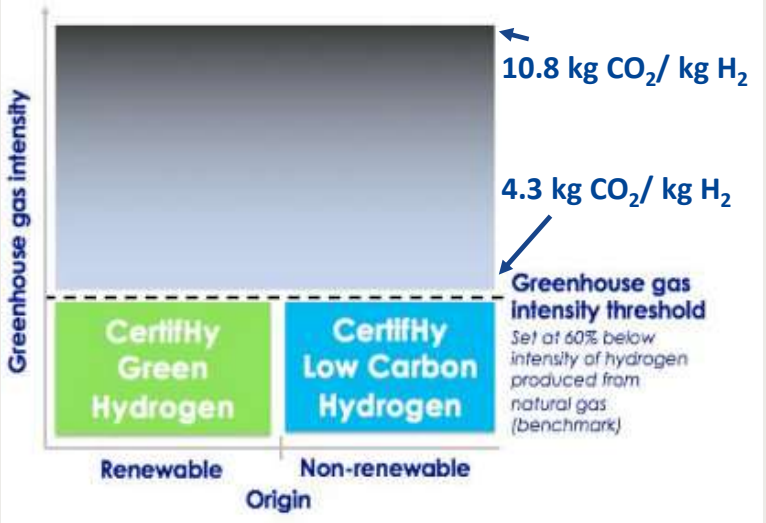
Air Liquide, Port Jerome (SMR +CCS)

Colruyt Group, Halle (Electrolysis +RE)

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

Uniper, Flakenhagen (Electrolysis + RE and methanation

Two labels are defined for hydrogen



Name	GSRN	Installed Capacity (MW) (MW)	Commissioning Date	Domain	Fuel	Technology
Eoly H2 Production Plant	643002406971000037	8,50	2017-10-23	CertifHy	F01000000 - Renewable	W010101 - Hydrogen/Water electrolysis/Low temperature/Main-product
MEB Rotterdam	643002406971000068	2 000,00	1983-01-01	CertifHy	F01000000 - Renewable	W020001 - Hydrogen/Chlor-alkali electrolysis/By-product
Port Jerome	643002406971000051	4 200,00	2007-07-01	CertifHy	F02000000 - Fossil, F01000000 - Renewable	W030201 - Hydrogen/Steam methane reforming/With CCS or CCU/Main-product
WindGas Falkenhagen	643002406971000044	32,13	2013-08-01	CertifHy	F01000000 - Renewable	W010101 - Hydrogen/Water electrolysis/Low temperature/Main-product

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

Next:

Expanding the GO scheme to all Member States and establish one central GO scheme.

TRANSPORT

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

Heavy duty transportation is discovering hydrogen thanks to the huge performance improvements of fuel cells

17

Simultaneously roll-out of vehicles and infrastructure in Europe

Europe supports FC vehicles and Hydrogen Refuelling Stations thanks to EU programs (FCH-JU & CEF) & national programs.

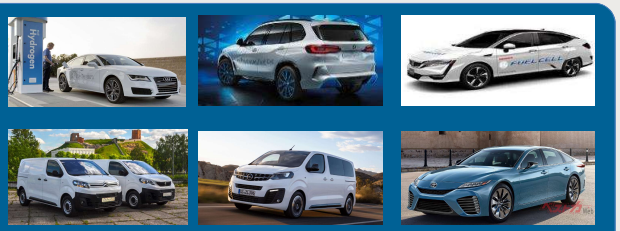
Fuel Cell vehicles

~2020

- '13 Hyundai IX35
- '15 Renault Hykangoo
- '15 Toyota Mirai
- '16 Honda Clarity
- '18 Mercedes GLC
- '18 Hyundai NEXO

~2025

- AUDI model
- BMW X5 Small series
- PSA Expert & Jumpy
- Opel Zafira Life
- New Toyota Mirai
- Lexus model
- New Honda Clarity

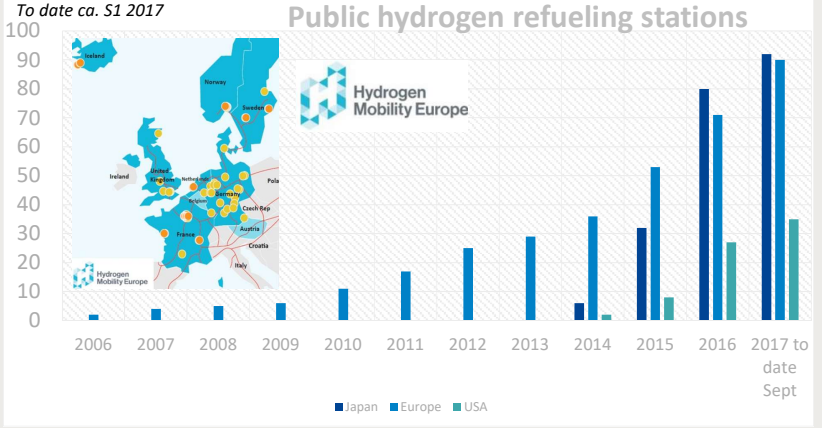


	S1 '19	2020	2022	2025	2030
Europe	1731	-	-	(0.9 -1 mill)*	1.2 million **
China	112	5000	-	50.000	1 million
Japan	3219	40.000	-	200.000	800.000
USA	7450	-	-	-	-
S-Korea	2353	-	67.000	-	-

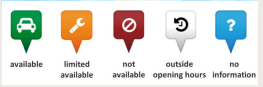
- EU OEM's: small demo's ~2025, mass production 2025~
- FIA: In 2024 a H_2 class @ Le Mans
- California & Japan sales higher due to strong policy support

Hydrogen Refuelling Stations

Source: FCH JU KM data collection file, 20/09/2017, public stations
USA-DoE & CaFCP, Japan-HySUT
To date ca. S1 2017



https://h2-map.eu/



"H2 live" App

H2 mobility Deutschland

	S1 '19	2020	2022	2025	2030
Europe	134	-	-	(820~842)*	3750 **
China	12	100	-	350	1000
Japan	108	160	-	320	(900)
USA	41	100	-	200~225	-
S-Korea	27	-	310	-	-

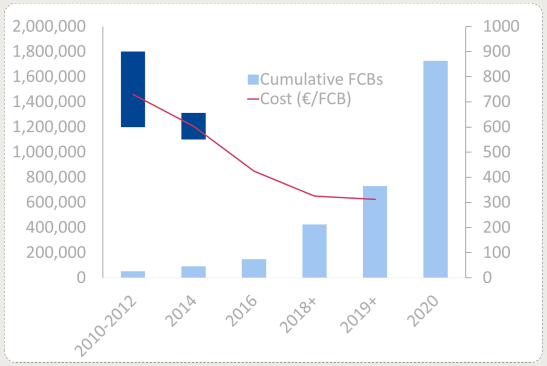
* According to the action plan of Alternative Fuel Directive
** McKinsey study H2: Europe roadmap (ambitious scenario).

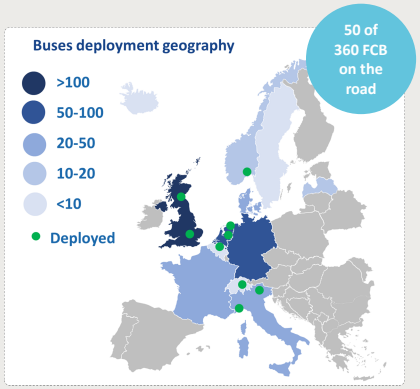
Japan: Air Liquide opens a hydrogen station in Shichinomiya, Kobe

Nel ASA: Awarded frame contract for multiple hydrogen fueling stations in California by Royal Dutch Shell Plc

Roll-out of FC buses accelerates and become commercial

EU is supporting totally 360 Hydrogen buses deployment that lead to a price reduction of 66% vs 2010 and a new initiative of 1000 buses in EU create scale and get cheaper than other zero-emission buses.





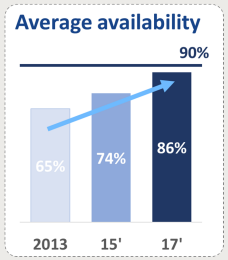
Van Hool hydrogen bus for PAU crowned as best bus of the world 2019!

12 European OEM's are developing H_2 buses: www.fuelcellbuses.eu

88% *green hydrogen*

Achieved

- **> 6,000,000 km driven since projects started**
- **> 92 t of H_2 consumed only in 2017**
- **> 25,000 h lifetime reached**
- **625,000 €/bus offered**
- From order to operation, 18m delivery time



H2Bus Europe
UK - Denmark - Latvia

Single Deck - 12 m
Price < €375k
Range >450 km* Extended >675 km*
*Dependent on duty cycle calculated at 10°C

Double Deck - 10.9 m
Price < €410k
Range >310 km* Extended >420 km*
*Dependent on duty cycle calculated at 10°C

Articulated - 18 m
Price < €465k
Range >520 km* Extended >750 km*
*Dependent on duty cycle calculated at 10°C

Single Deck - 12 m
Price < €375k
Range >450 km* Extended >675 km*
*Dependent on duty cycle calculated at 10°C

Everfuel, Wrightbus, Ballard Power Systems, Hexagon Composites, Nel Hydrogen and Ryse Hydrogen, leading players in the hydrogen fuel cell electric value chain, are joining forces to form the H2Bus Consortium. The members are committed to deploying 1,000 hydrogen fuel cell electric buses, along with supporting infrastructure, in European cities at commercially competitive rates.

First H2 trucks appearing on the EU roads and more are to come

Worldwide there is a clear traction towards Hydrogen for trucks due to the limited range of batteries.

FCH-JU H2ME project Batt+RE

REVIVE: H2 Garbage Trucks in 8 EU cities

H2HAUL: 15 Heavy Duty trucks in 4 countries

CNH Industrial takes $250 million lead in Nikola's Series D round

Fuel cell startup gets access to Iveco European network and purchasing might

Alan Adler · 2 days ago · 2 minutes read

ESORO COOP

ASKO-SCANIA

VDL - COLRUYT

FCH-JU started with Fuel Cells in trucks for APU's but was found to expensive, therefor focus shifted to developing and testing trucks with range-extenders or fuel cell only e.g.: garbage trucks in mayor cities.

~~1600~~

Hyundai signs deal to sell ~~1,000~~ hydrogen-powered trucks in Switzerland

Hyunjoo Jin · 3 MIN READ

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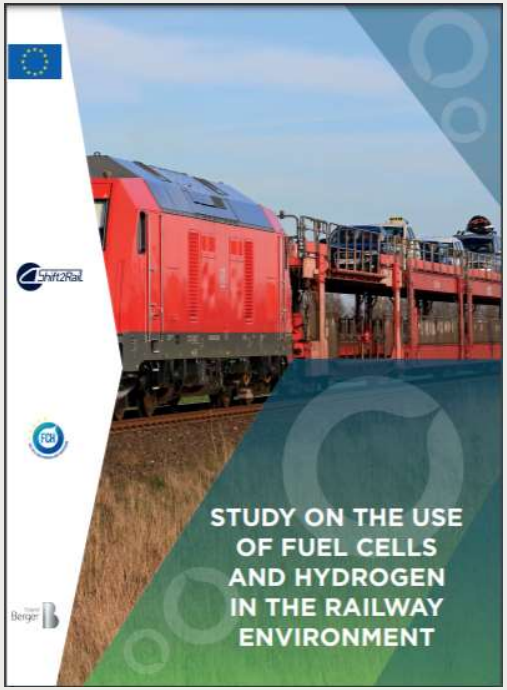
Norway aims for 1000 hydrogen trucks by 2023

September 19, 2018

Rail accelerates Hydrogen and Fuel Cells technology

The first business models are appearing

- 42% of EU railway not electrified
- 17 Sept. ’18 commercial operation starts in Germany. Other EU countries are on the way. Recently a big order of 27 H_2 trains placed in Germany.



- 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.

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

Maritime discovering Hydrogen and Fuel Cells

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

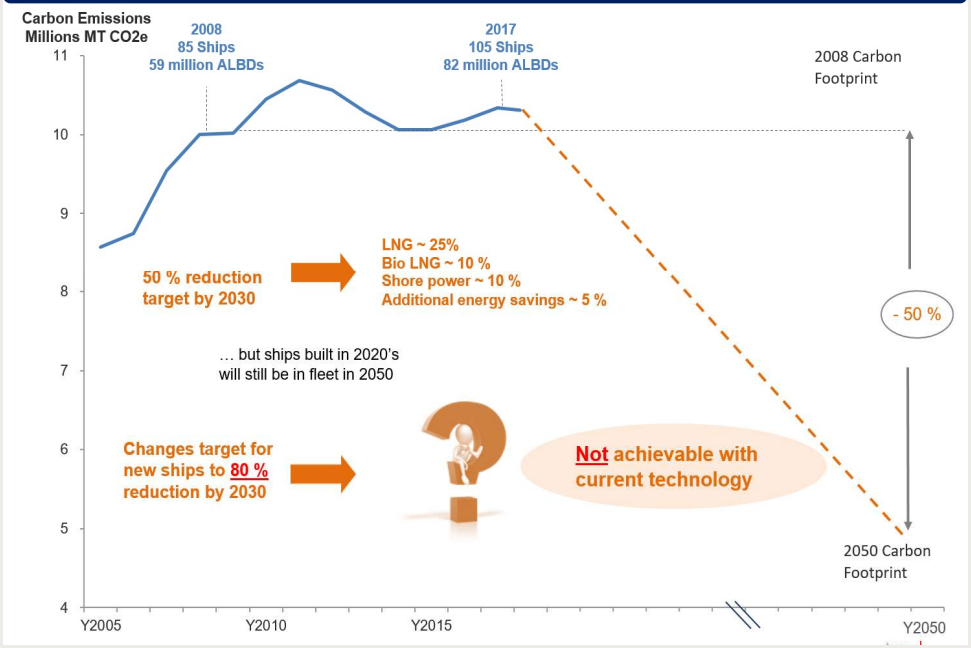
International Maritime Regulations

Class Rules

International Standards

National Regulations

- 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**

MARANDA: H2 PEMFC based hybrid powertrain for marine applications, validated on board the research vessel Aranda

DURATION: 2017-2021
FCH JU Funding: ~3M€

Passenger & car ferry
- Stavanger area Norway
- 600 kW FC power

Pusher
- Lyon, France
- 400 kW FC power

FLAGSHIPS:
will deploy 2 commercially operated 0-emission hydrogen vessels in France and Norway

DURATION: 2019-2022
FCH JU Funding: ~5M€

SHIPFC:
Aims to show case a large scale 0-emission ship for a year (2MW, ammonia)

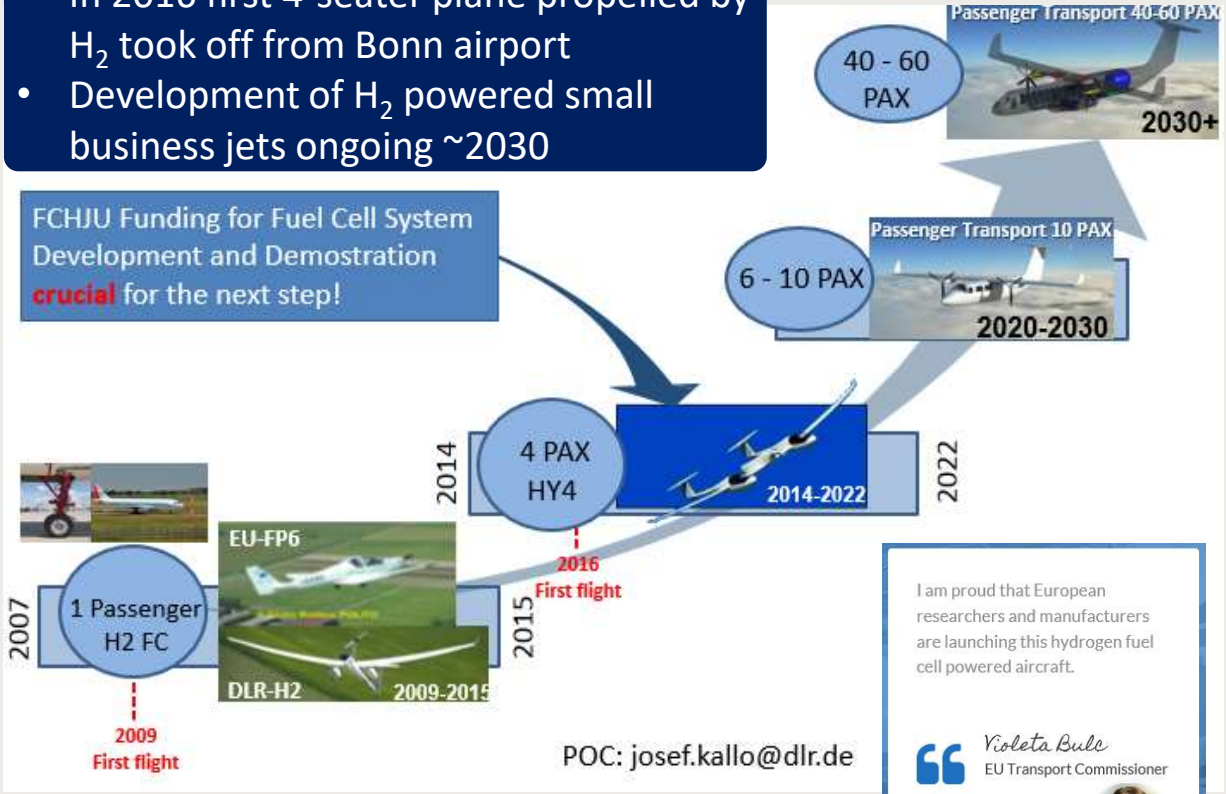
DURATION: 2020-2024
FCH JU Funding: ~1.6M€

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

Aviation sees a future in Hydrogen for small planes

Hydrogen in the aviation sector causes much less noise and no pollution.

- In 2016 first 4-seater plane propelled by H_2 took off from Bonn airport
- Development of H_2 powered small business jets ongoing ~2030

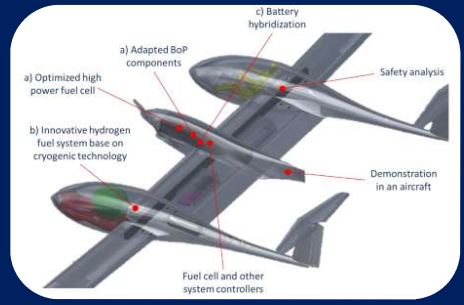


- HYCARUS (5.2 **M€)** where the kitchenette runs entirely on Hydrogen and Fuel Cells

HEAVEN (4 **M€)**

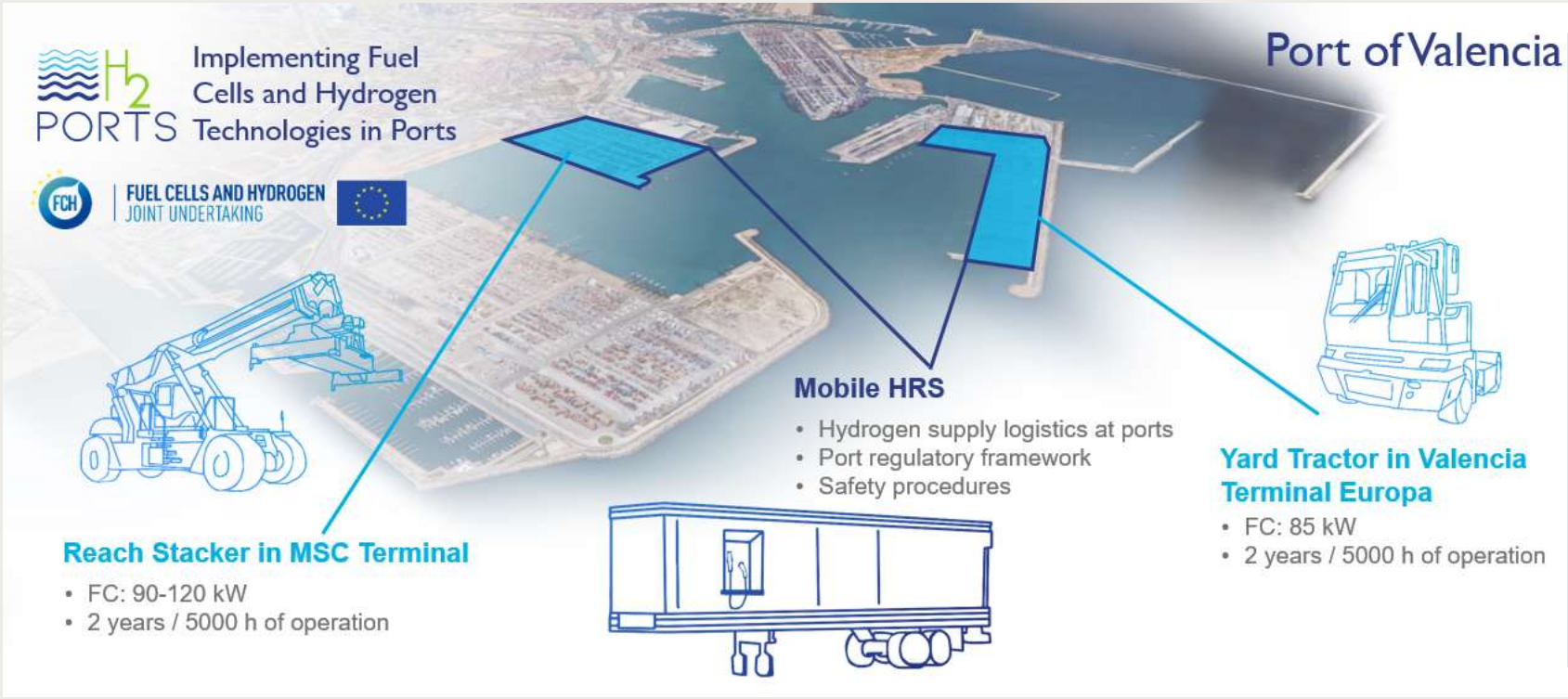
- Modular architecture of a 90 kW fuel cell based on two 45 kW FC stacks fit for aeronautic use

- Cryogenic H_2 storage with 10% weight efficiency



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)

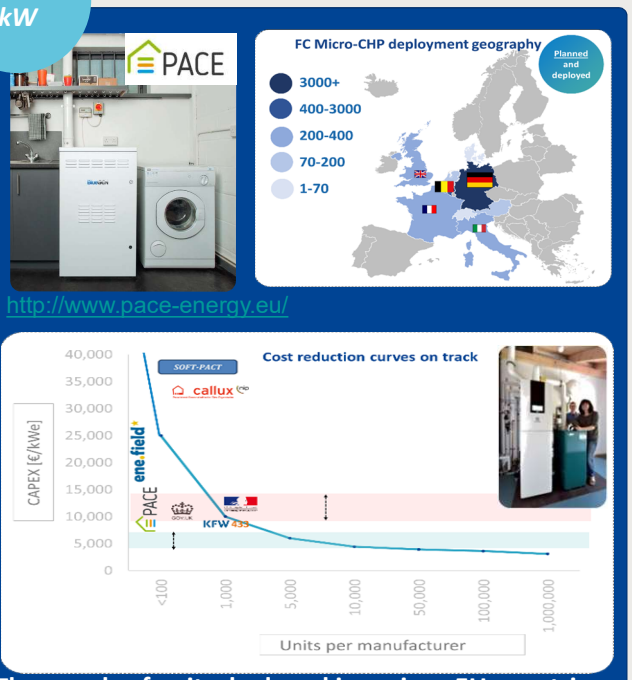
Next: to build a worldwide hydrogen ports coalition under CEM

Heating and Cooling

Fuel cell systems generating heat and power installed across EU

Depending on the application fuel cells in the range from 1kW up to 2MW can be selected

0.5~1.5 kW



Thousands of units deployed in various EU countries

- >1 MWe capacity installed; >5 million operating hrs.
- Cost reduced drastically through various projects
- National authorities start own subsidy scheme (e.g. >1,000 units deployed by a German scheme)

DURATION: 2016-2021 with FCH JU Funding: ~34M€

50~200 kW

175kW SOFC in waste water treatment plant, Turin Italy

Area will guarantee the supply of around 30% of the site electrical consumption, and almost 100% of the thermal requirement.

DURATION: 2015-2020 with FCH JU Funding: ~4.5M€

1 ~ 2 MW

2MW plant at Ynnovate, Yingkou (province Liaoning), China

Design, build and operate a 2 MW power generator, with full integration of heat and power with an existing chlorine production plant. Fully automated way of operation + remote control

DURATION: 2015-2018 with FCH JU Funding: ~5.5M€

Coordinating of cross cutting activities

SAFETY, STANDARDS, EDUCATION…

Preparing the European workforce

Projects running include training packs in different languages, formats, means, etc.

European hydrogen emergency response training program for first responders
Follow-up project to start in Jan ’20

HyResponse A comprehensive training program

Educational	Virtual reality	Operational

in person training, e-learning, blended learning…virtual reality, serious games…
…mock-up installations…

TeacHy

undergraduate & graduate education PhD BEng/BSc MEng/MSc

KnowHy

Courses for professionals/ general public

FCHgo!

https://fchgo.eu/

Happy to share the knowledge or good practices with the African countries

European Hydrogen Safety Panel (EHSP) initiative

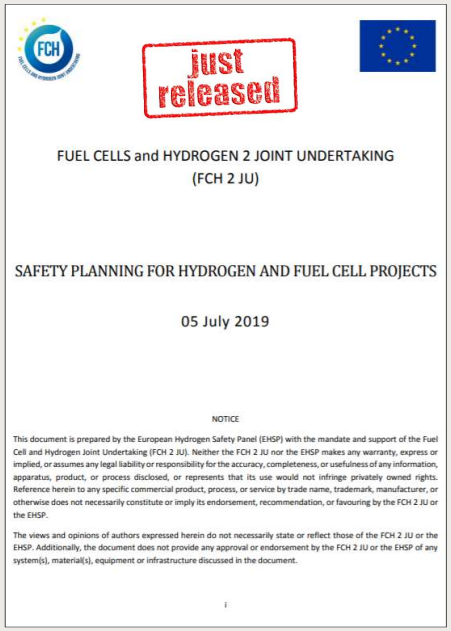
Expert group on hydrogen safety assisting the FCH 2 JU at project and programme level

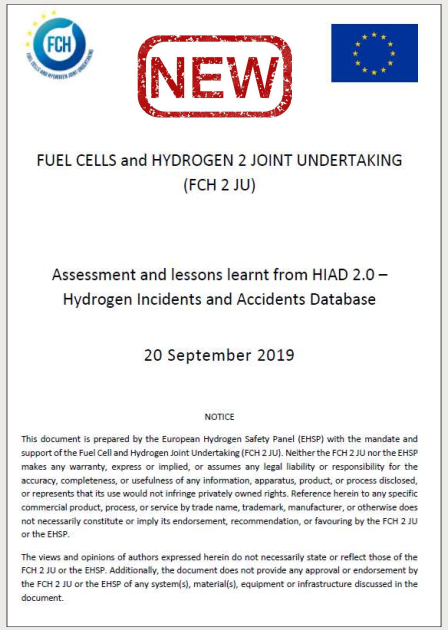
EHSP Launched and running!

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





African countries are welcome to cooperate with the European Hydrogen Safety Panel !!!

FUTURE...

Annual Work-Plan 2020 around 93 m€

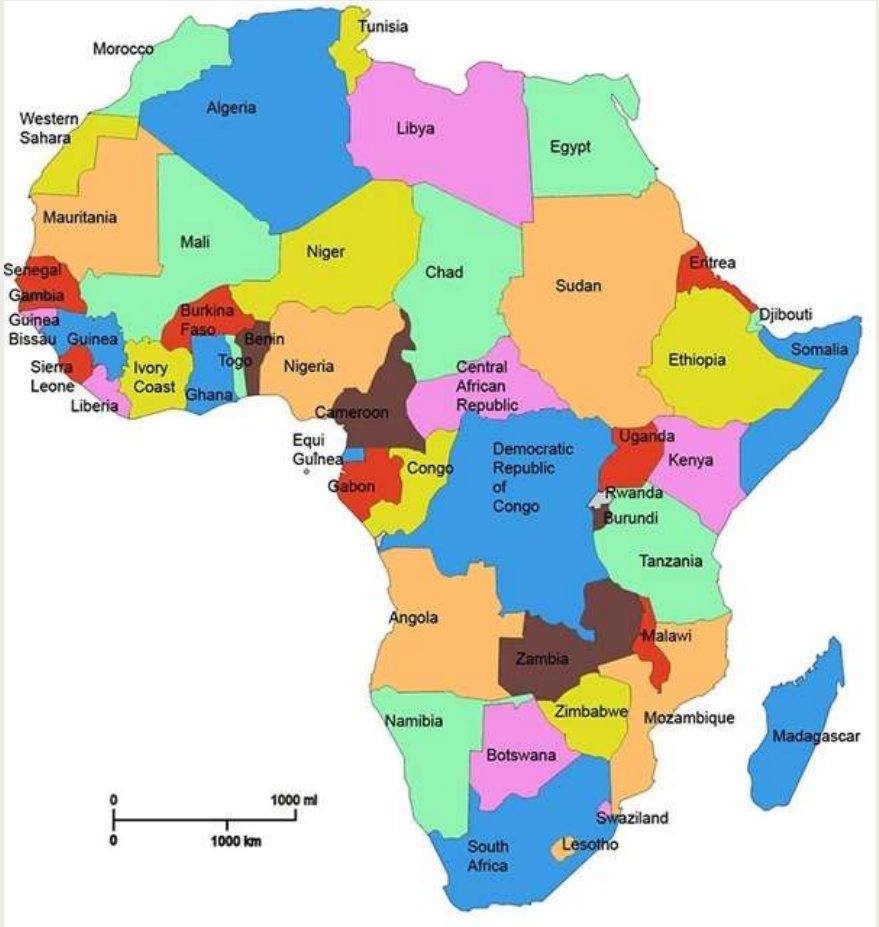
Call launched 14th January 2020 and proposals to be submitted by 21st April 2020 at 17:00 Hrs
https://www.fch.europa.eu/page/call-2020

All topics are opened to international cooperation

11 topics where international cooperation are strongly encouraged (e.g. Mission Innovation countries)	*Type of Action*	*Ind. Budget (M€)*
FCH-1-1-2020: Development of hydrogen tanks for electric vehicle architectures	RIA	2.0
FCH-1-2-2020: Durability-Lifetime of stacks for Heavy Duty trucks	RIA	3.5
FCH-1-6-2020: Demonstration of liquid hydrogen as a fuel for segments of the waterborne sector	IA	8.0
FCH-02-1-2020: Catalyst development for improved economic viability of LOHC technology	RIA	2.5
FCH-03-1-2020: HT proton conducting ceramic materials for highly efficient and flexible operation	RIA	3.0
FCH-03-2-2020: Decarbonising islands using renewable energies and hydrogen - H2 Islands.	IA	10
FCH-04-1-2020: Overcoming technical and administrative barriers to deployment of multi-fuel hydrogen refuelling stations (HRS)	RIA	2.0
FCH-04-2-2020: PNR on hydrogen-based fuels solutions for passenger ships	RIA	2.5
FCH-04-3-2020: Development of eco-design guidelines for FCH products RIA 1	RIA	1.0
FCH-04-4-2020: Development and validation of existing and novel recycling technologies for key FCH products	RIA	1.5
FCH-04-5-2020: Guidelines for Life Cycle Sustainability Assessment (LCSA) of fuel cell and hydrogen systems	CSA	2.0

African countries eligible for funding

Tunisia is an associated country in H2020, other countries are eligible for H2020 founding



African countries eligible for H2020 funding:

Tunisia (associated country)

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Djibouti, Egypt, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Republic of the Congo, Rwanda, São Tomé and Príncipe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe

I strongly encourage you to participate in the FCH-JU call for proposals

Biggest conference in Europe regarding Hydrogen and fuel cells.

Yearly FCH-JU program review days and stakeholder forum

Program Review days
8 & 9 Dec. 2020

Stakeholder Forum
10 Dec. 2020

The Square Meeting Centre,
Mont des Arts, 1000 Brussels,
Belgium

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

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