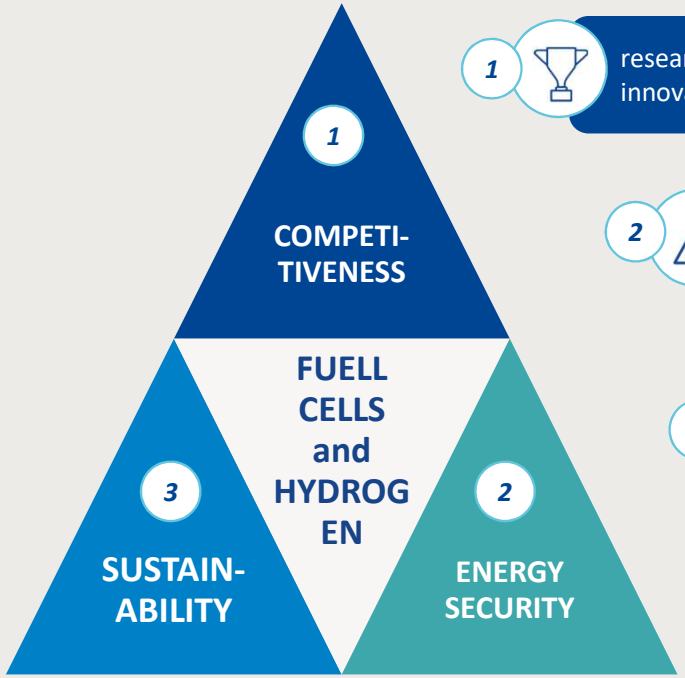
FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

FCH-JU making hydrogen and fuel cells an everyday reality

Bart Biebuyck

18 10 2019 Groningen NL

Fuel Cells & Hydrogen technologies in the context of the European Energy policy



1 research excellence leading to industry innovation and growth

2 Increase independence from unstable outside regions

3
- H2 is a clean energy carrier
- Transport and Energy applications, generate electricity and heat with very high efficiency
- Possibility for storage of renewable energy sources
- Reduction of CO2 emissions

50-55% CO_2 reduction for discussion "The green deal"

20% CO_2 reduction
20% Renewables
20% Energy Eff.

40% CO_2 reduction
~~27%~~ 32% renewables
~~27%~~ 32.5% Energy Eff

80-95% CO_2 reduction

2020 2030 2050

Hydrogen in the international context

In the past year many high level international cooperation agreements have been signed where NL is part of

IPHE – International Partnership for Hydrogen and Fuel Cells in the economy
19 member countries; meeting 2 times / year
Objective: to facilitate and accelerate the transition to clean and efficient energy and mobility systems using Hydrogen and fuel cell technologies across applications and sectors

MISSION - INNOVATION – Innovative Challenges 8 « Renewable and Clean Hydrogen Challenge"
May 23-24, 2018, Malmö, Sweden
Objective: To accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale

Informal EU energy ministerial – The Hydrogen Initiative (signed by 29 countries)
Sept. 17-18, 2018, Linz, Austria
Objective: the signatory states commit themselves to continue research and investment in the production and use of hydrogen as a future-oriented technology

HEM - Hydrogen Energy Ministerial Meeting 2019
1st one held Oct. 23, 2018; 2nd one on Sept. 25, 2019, Tokyo, Japan
Objective: Follow up "Tokyo Statement" to realize it and set "Global Hydrogen Target" to share global goal.

CEM -New Hydrogen Initiative
May 27-29, 2019, Vancouver, Canada
Objective: Advance policies, programs and projects to accelerate commercial scale deployment of hydrogen and fuel cell technologies across all sectors of the economy

G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth
June 15-16, 2019, Karuizawa, Japan
The importance of hydrogen mentioned for 1st time in the G20 Ministerial Communique and IEA released their H2 report.
=> Japan, US and EU agree to a hydrogen partnership

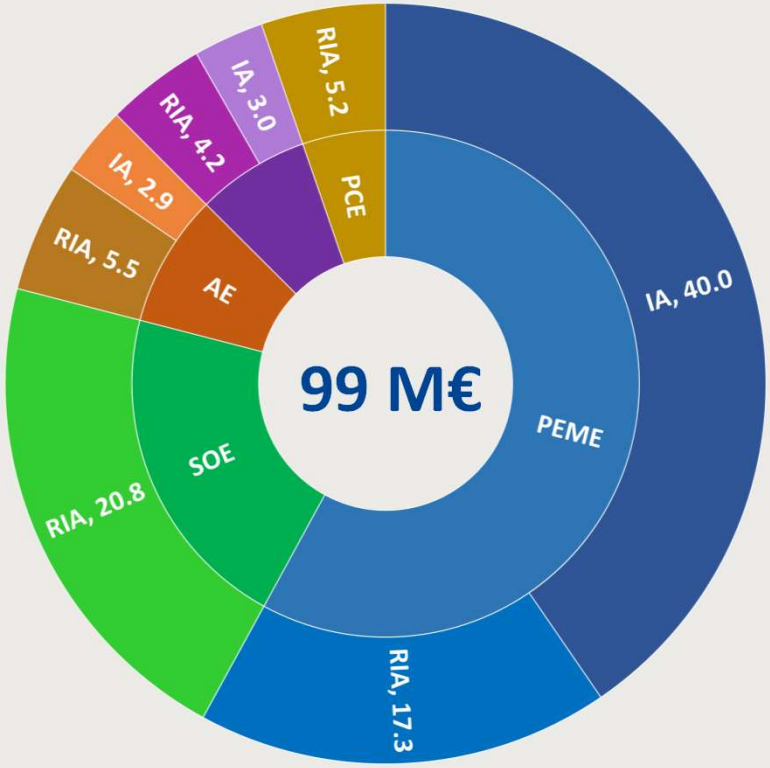
SECTOR

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

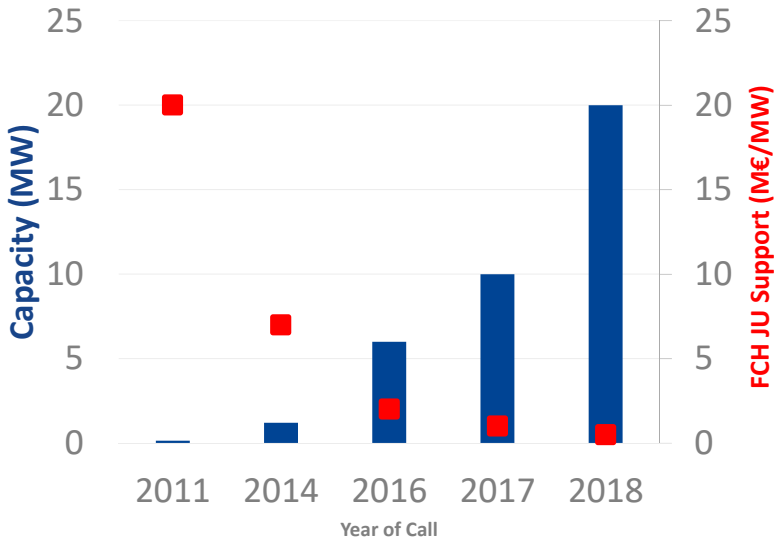
Electrolysers, M€ FCH JU support



30 Projects

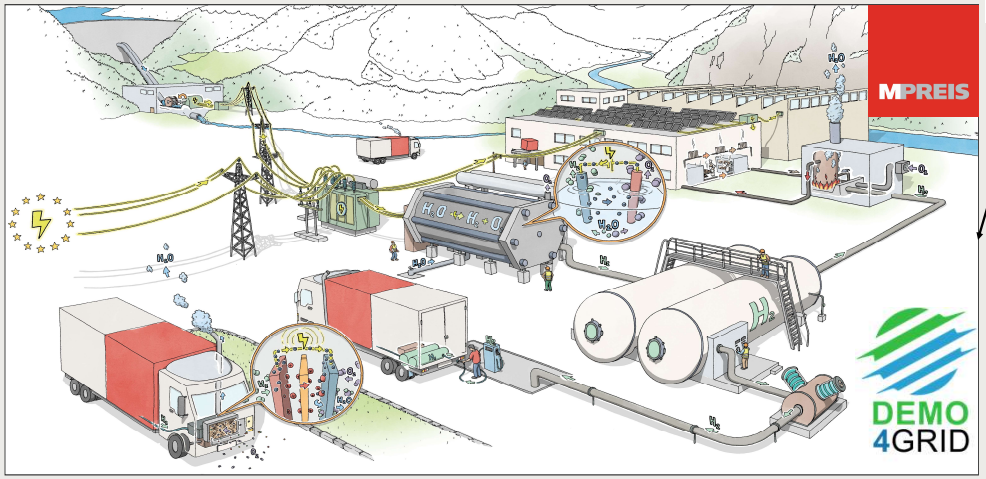
HRS *Steel industry* *Refineries* *Food industry*

Electrolyser Demo Projects



Big industries are discovering the potential of Hydrogen (1/2)

Thanks to FCH-JU research projects the costs of electrolysers decreased and became interesting for big industries to invest



3.4 MW electrolyser at MPREIS (bakery plant) in Völs

- The green H_2 is produced from hydro-electricity (from Alps)
- 1st phase: it is used to heat the ovens to bake the bread
- 2nd phase: distribution by using H_2 trucks

DURATION: 2017-2022; project 7.74 M€ (2.93 M€ by FCH-JU)

https://www.demo4grid.eu/

6 MW electrolyser at VOESTALPINE (steel plant) in Linz

- The green H_2 is produced from hydro-electricity (from Alps)
- It is used to produce steel in this way the industry can make a first step towards CLEAN STEEL

DURATION: 2017-2021; project 18 M€ (12 M€ by FCH-JU)

https://www.h2future-project.eu/

Big industries are discovering the potential of Hydrogen (2/2)

Thanks to FCH-JU research projects the costs of electrolysers decreased and became interesting for big industries to invest

10 MW electrolyser at SHELL in Köln

- The green H_2 is produced from curtailed wind energy due to a full electricity grid.
- The produced H_2 will be injected in their current H_2 stream used for desulfurization; later to be used in fuelcell vehicles

DURATION: 2018-2022; project 16 M€ (10 M€ by FCH-JU)

https://www.refhyne.eu/

150/30kW Reversible electrolyser, Salzgitter

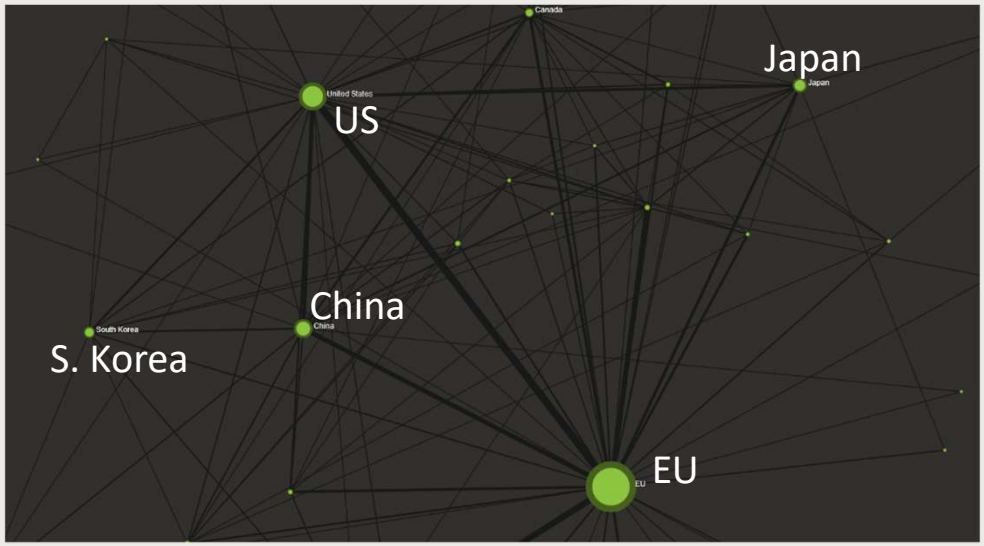
- To operate a high-temperature Electrolyser as reversible generator (rSOC, reversible Solid Oxide Cell) in the industrial environment of an integrated iron and steel work.
- The system is flexible to produce either H_2 or electricity.

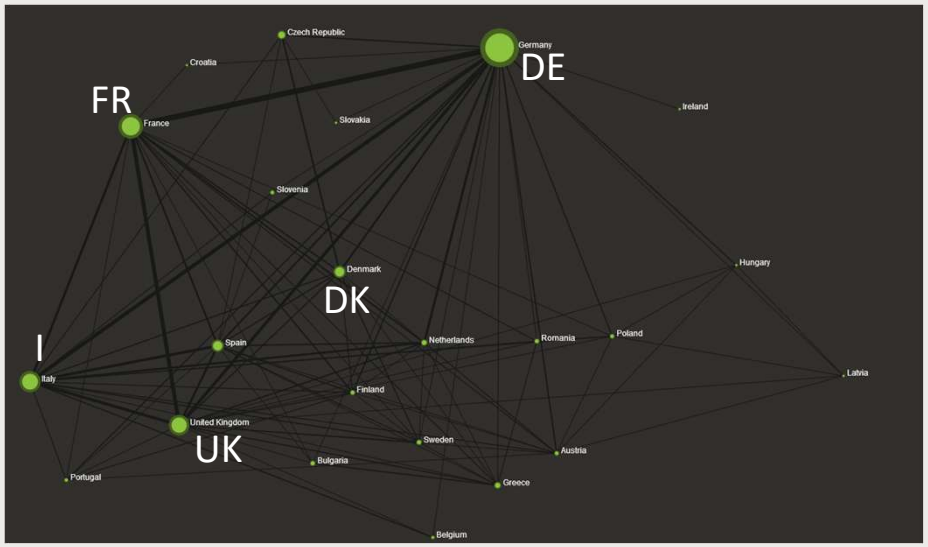
DURATION: 2016-2019; project 4.5 M€ (100% by FCH-JU)

(http://www.green-industrial-hydrogen.com/home/)

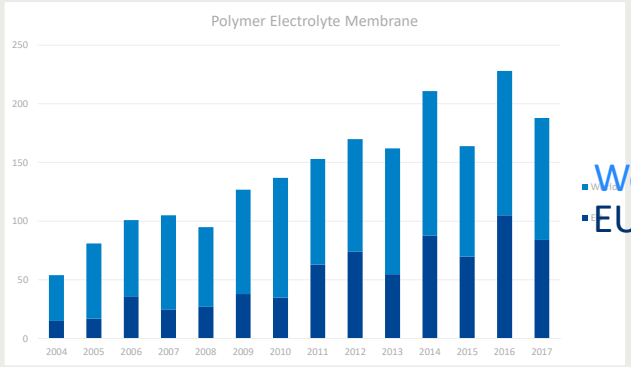
PEM electrolysis: Number of publications, patents, etc. 2004 - 2017

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





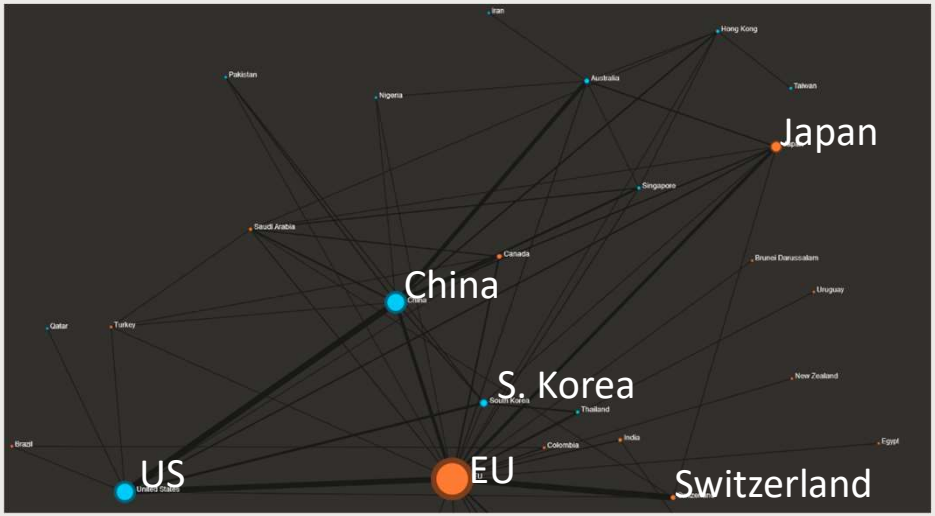
EU 823, US 430, China 270, JPN 193, S. Korea 143



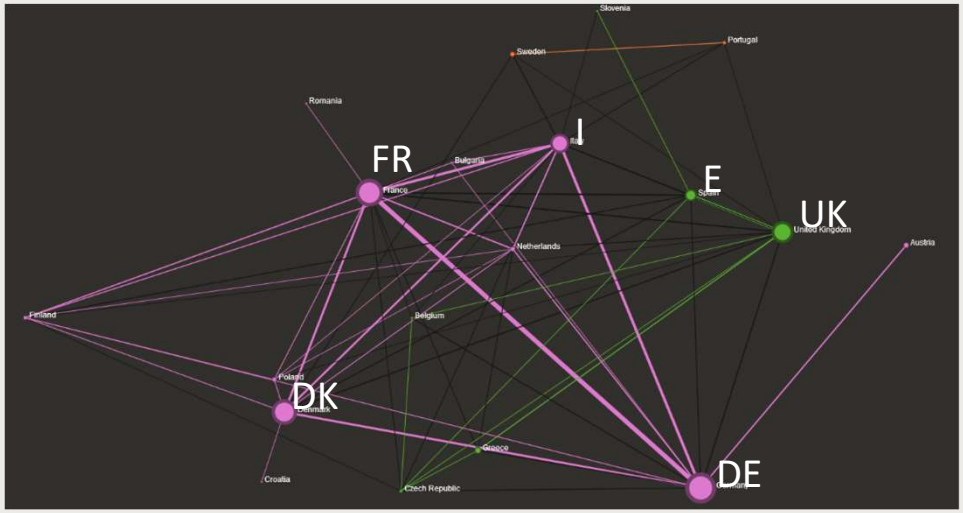
DE 224, FR 136, I 116, UK 111, DK 62

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

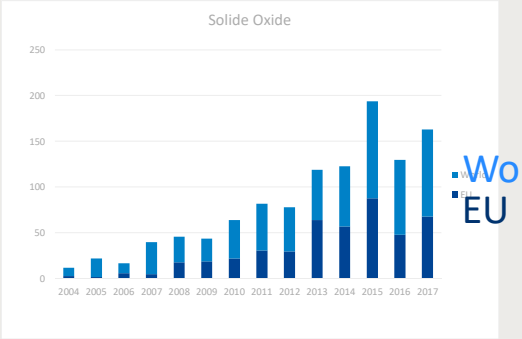
https://fch.europa.eu/page/tools-innovation-monitoring-tim



EU 508, China 255, US 246, JPN 121, S. Korea 74



DE 117, FR 103, DK 94, UK 79, I 69, E 40



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

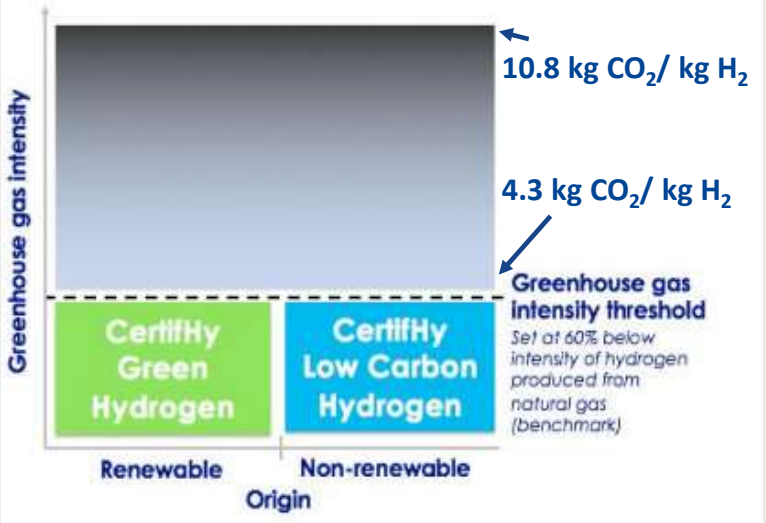
Air Liquide, Port Jerome (SMR +CCS)

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



Energy Source	Issue	Transfer	Cancel	Export	Import	Certificate expiry
F01000000 Renewable	2 868	10	1 663	-	-	-
F02000000 Fossil	73 739	-	1 964	-	-	-
Total	76 607	10	3 627	-	-	-

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.

It would be important for many countries to join this platform

TRANSPORT

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.

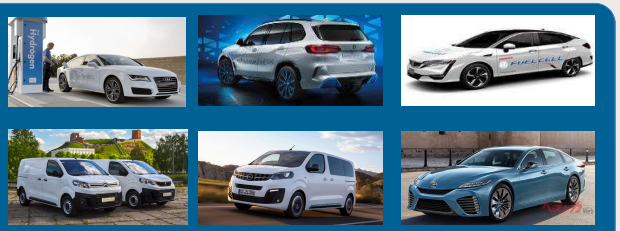
Fuel Cell vehicles

~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

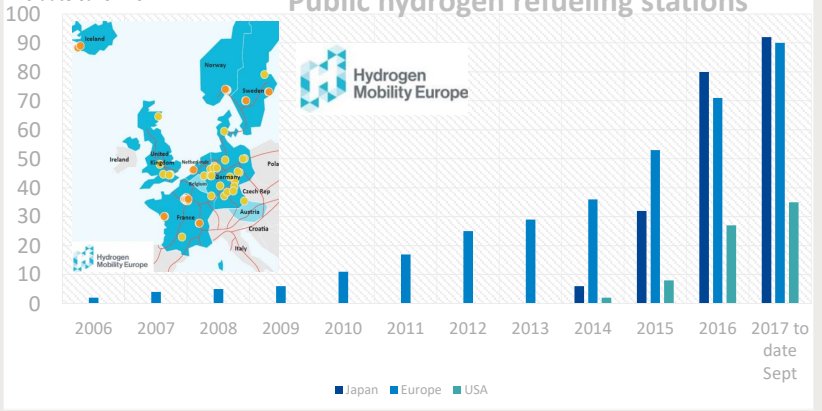


	S1 '19	2020	2022	2025	2030
Europe	1731	-	-	(0.9 -1 mill)*	1.2 million **
China	112	5000	-	50.000	1 million
Japan	3219	40.000	-	200.000	800.000
USA	7450	-	-	-	-
S-Korea	2353	-	67.000	-	-

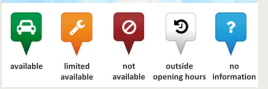
- EU OEM's: small demo's ~2025, mass production 2025~
- FIA: In 2024 a H_2 class @ Le Mans
- California & Japan sales higher due to strong policy support

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

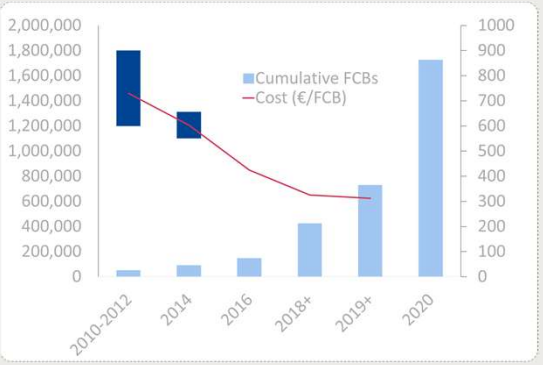
	S1 '19	2020	2022	2025	2030
Europe	134	-	-	(820~842)*	3750 **
China	12	100	-	350	1000
Japan	108	160	-	320	(900)
USA	41	100	-	200~225	-
S-Korea	27	-	310	-	-

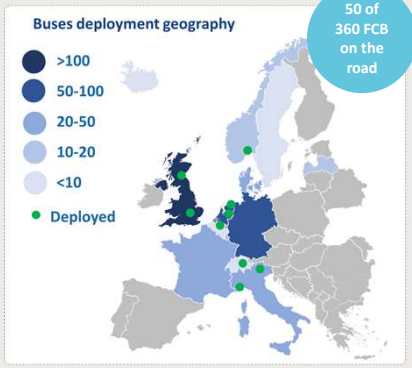
* According to the action plan of Alternative Fuel Directive
** McKinsey study H2: Europe roadmap (ambitious scenario).

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.





50 of 360 FCB on the road

Van Hool bus in PAU crowned best bus of the world 2019

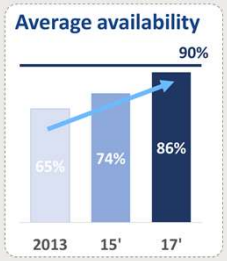
10 European OEM's are developing H_2 buses: www.fuelcellbuses.eu

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.

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



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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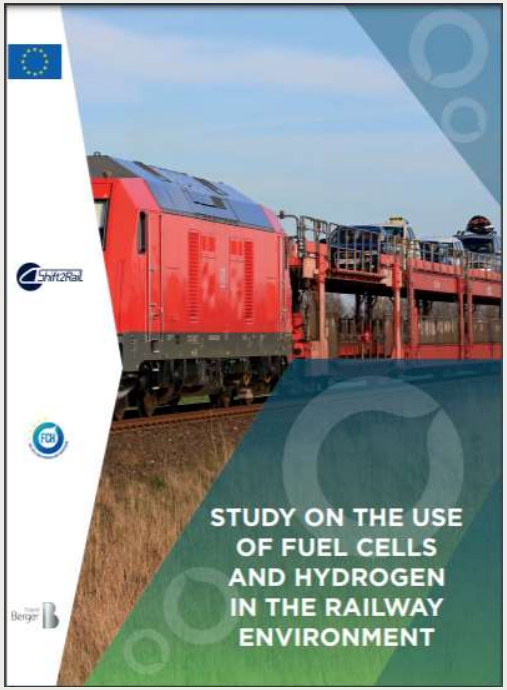
Norway aims for 1000 hydrogen trucks by 2023

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 and Aviation are discovering Hydrogen and Fuel Cells

The first business models are appearing in hard to abate sectors

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

Pusher
- Lyon, France
- 400 kW FC power

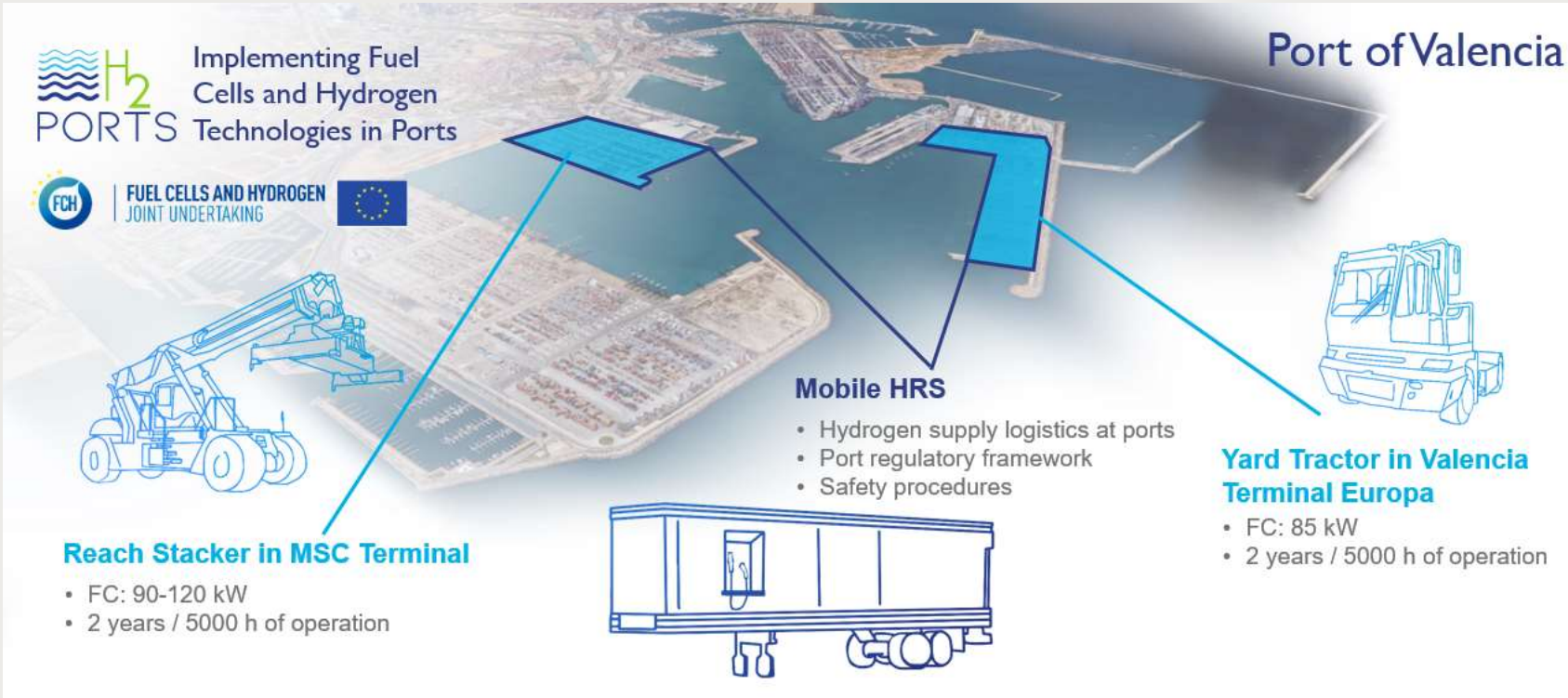
- First demo projects appear
  - Maranda: H2 PEMFC based hybrid powertrain for marine applications, validated on board the research vessel Aranda
  - H2Flagships: will deploy 2 commercially operated 0-emission hydrogen vessels in France and Norway
  - 2019: one more project on track to be awarded
- H_2 needed to reach IMO target of 50% C02 reduction by 2050
- URGENT need for regulation to homologate a H_2 powered ship
- R&D needed e.g. L H_2 storage, MW scale Fuel Cells

- 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
- Auxiliary power (infotainment / kitchenette) produced by H_2 for big airplanes (maiden flight begin ’19)

Would welcome any support towards moving the IMO to develop faster H2 regulations

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

Heating and Cooling

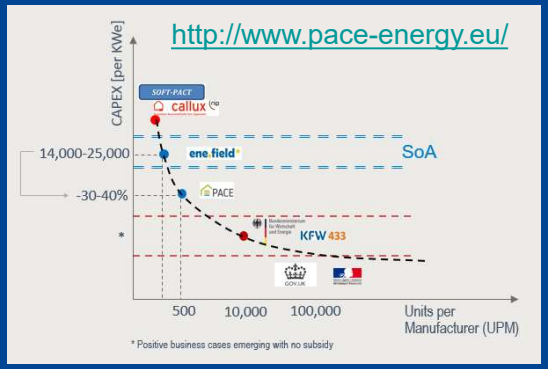
Over 1000 fuel cell µCHP systems installed across EU

Track record of domestic heat and power systems created

0.5~1.5 kW

PACE

http://www.pace-energy.eu/



1046 units deployed in various European 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

DEMOSOFC FCH2-JU PROJECT

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

DEMCOPEM 2MW

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€

SAFETY, STANDARDS, EDUCATION…

Supporting activities for market uptake - Overview

Cross-cutting projects and complementary actions

Cross-cutting Areas

- **Legal, administrative and regulatory framework**
- **Education and training**
- **Safety**
- **Social awareness & public acceptance**
- **Sustainability**
- **Databases & Monitoring**

Complementary Actions

- **Regulations, Codes and Standards Strategy Coordination Group (RCS SCG)**
- **European Hydrogen Safety Panel (EHSP)**
- **Collaboration with the Joint Research Center (JRC)**
- **Initiatives: FCH Regions, FCH Value Chain, …**
- **Funding and financing support services**
- **Studies, …, … ,…**




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

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/

European Hydrogen Safety Panel (EHSP) initiative

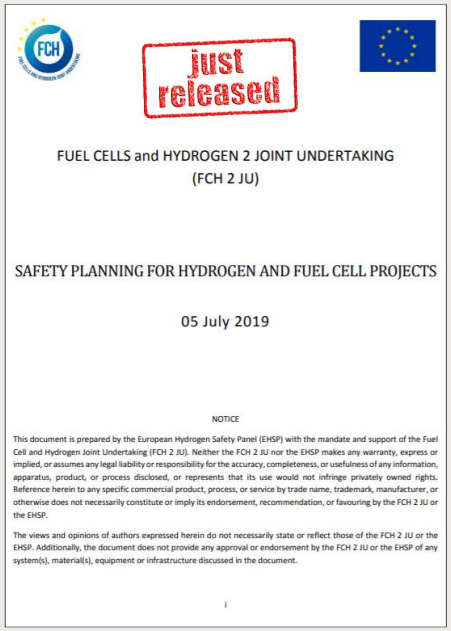
Expert group on hydrogen safety assisting the FCH 2 JU at project and programme level

EHSP Launched and running!

17 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


just released

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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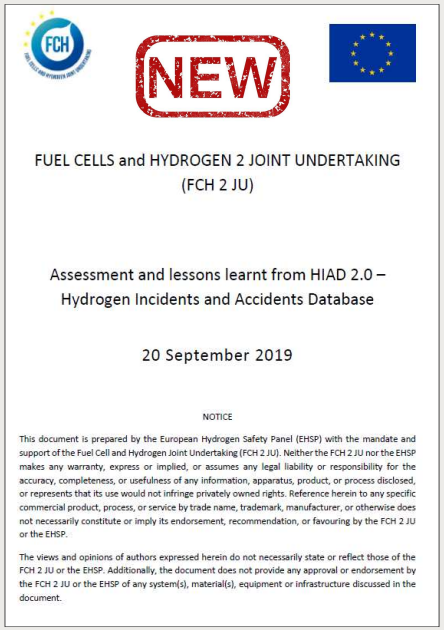
NEW

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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Projects are encouraged to cooperate with the European Hydrogen Safety Panel !!!

FCH-JU outreach activities in central and East European Countries

Hydrogen events are scheduled on the official presidency agenda => Maybe we can do something in Croatia in 2020

CROATIA 2020

HUNGARY: Budapest 2018 | ROMENIA: Timisoara 2018 | BULGARIA: Sofia 2018 | SLOVAKIA: Tale 2019 | ROMENIA: Bucharest & Constanta 2019

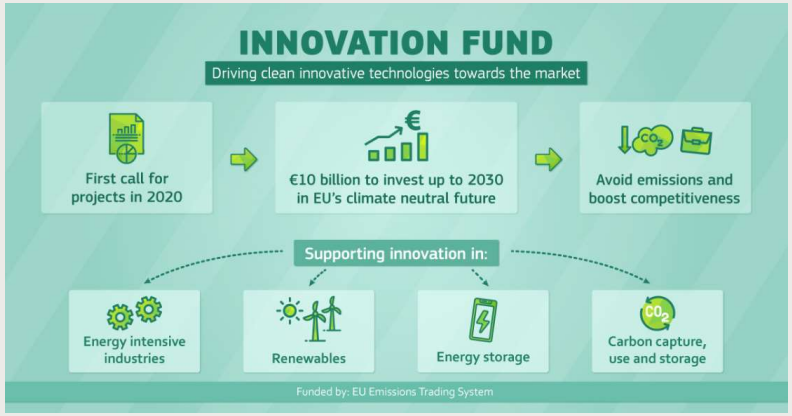
Future European Funding opportunities for hydrogen

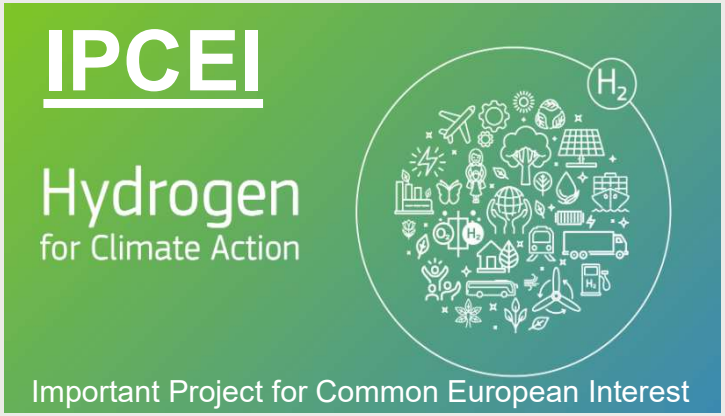
Depending on the project seize and goal, the right funding instrument should be chosen, FCH can help you

New partnership: CLEAN HYDROGEN EUROPE

- **Channel cross-sectoral collaboration**
- **Involve more energy companies**
- **Include waterborne and rail transport industry**
- **The industrial sectors** (chemical, steel, refineries, etc.)
- **Include civil society and NGOs.**

Impact assessment (on-going) => Open public consultation for EU partnerships
https://ec.europa.eu/info/law/better-regulation/initiatives_en
Start in Jan 2021 with industry request a doubling of the budget





NEXT

Yearly program review days and stakeholder forum

Program Review days
19 & 20 Nov. 2019

Stakeholder Forum
21 Nov 2019

Charlemagne building Brussels, Belgium

Registrations just opened

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

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