Hydrogen Production, Storage & Distribution

European Hydrogen Week

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Project Officers

European Commission

European Hydrogen Week

PRD parallel sessions on H_2 production, storage & distribution

23rd Nov. 11:00 - 12:20

Electrolysers for Industrial & Storage Application

23rd Nov. 12:30 - 13:50

Next Generation Electrolysers

23rd Nov. 14:00 - 15:20

Alternative Renewable Hydrogen Production

24th Nov. 14:00 - 15:20

Hydrogen Distribution & Carriers

#PRD2020
#CleanHydrogen

FCH

European Commission

European Hydrogen Week

Hydrogen Production, Storage & Distribution Technical Coverage

68 projects, 204MEuro, 18% of FCH JU support. Only renewable H_2

H_2O

- 7 Direct Solar
- 38 Electrolysis

Biomass

- 5 Reforming
- 1 Gasification
- 1 Biological

Fossil Fuels

- Reforming
- Gasification

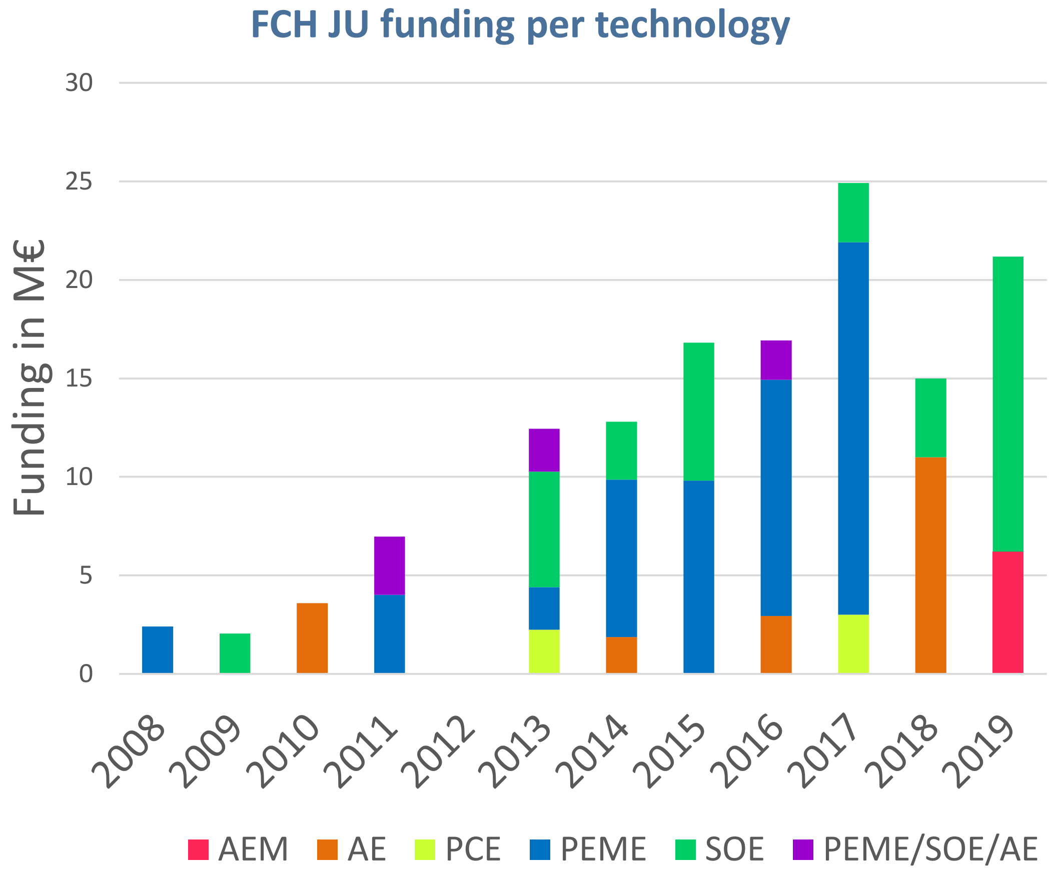
Renewable H_2

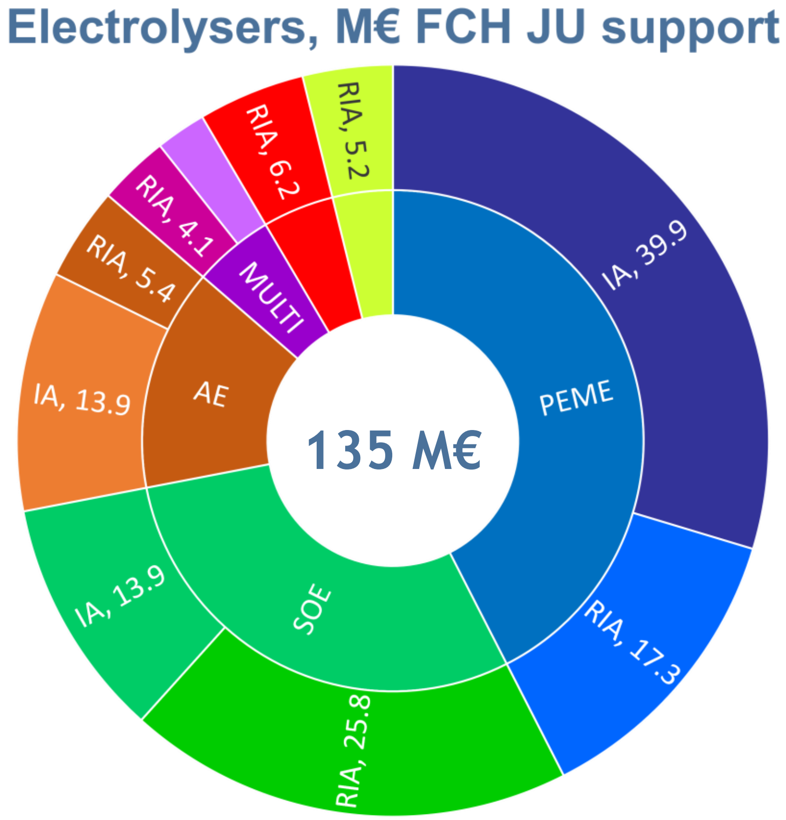
H_2

16 Storage, Distribution, Purification

Electrolysis Research and Demonstration

Support increasing annually, covering different types of electrolysers





RIA: Research & Innovations Actions (RTD)
IA: Innovation Actions (Demo)

#PRD2020
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European Commission

LT Electrolysis Demonstration projects - 1

In 8 years capacity increased 100× and support per MW installed reduced 50×

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

0.15 MW

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

1.2 MW

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

2.5 MW

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

3.4 MW

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

6.0 MW

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

10 MW

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

Djewels
Scale-up
HYDROGEN VALLEY

20 MW → 60MW

100 MW

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

LT Electrolysis Demonstration projects - 2

New challenges; Supporting EU H_2 policies

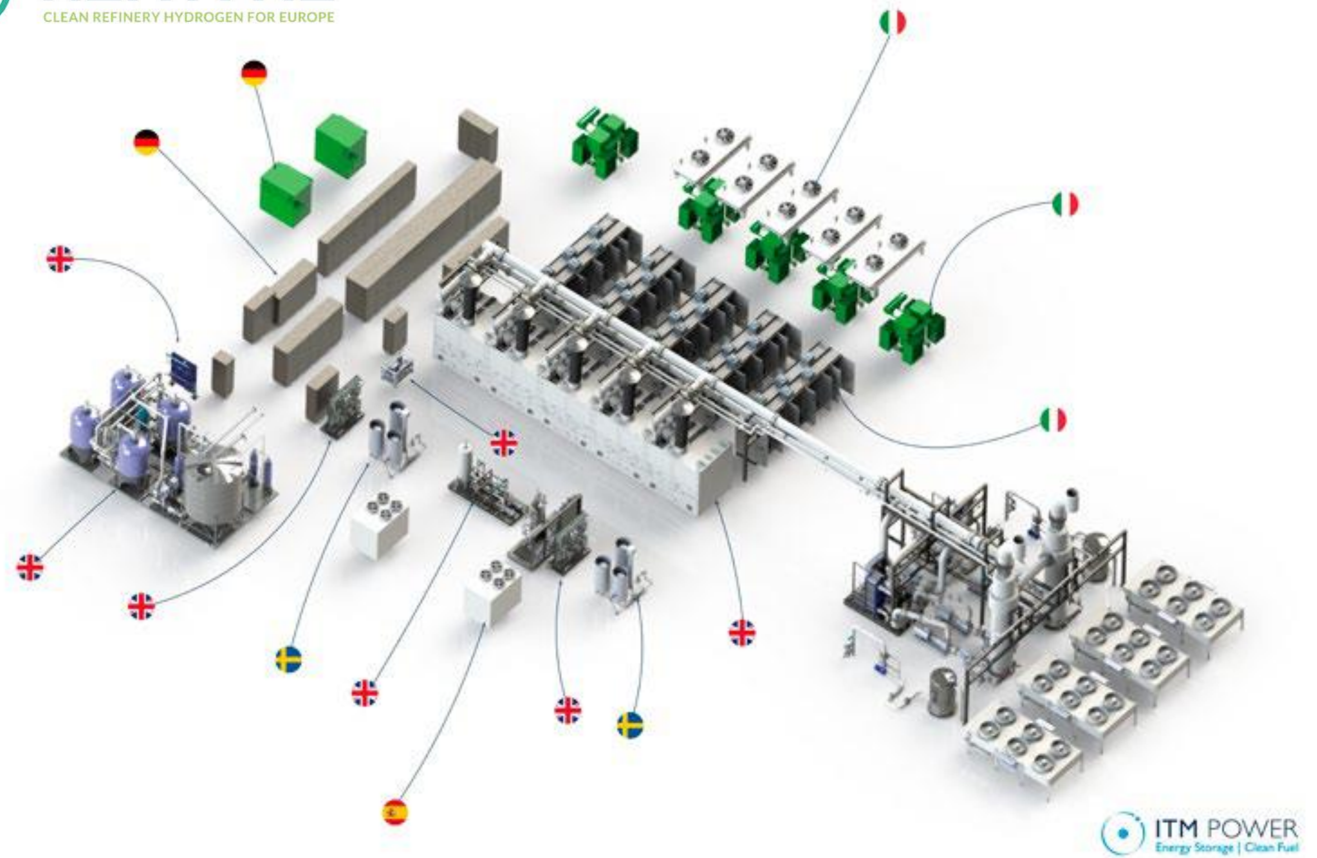
REFHYNE
CLEAN REFINERY HYDROGEN FOR EUROPE

Electrolyser OEMs addressing new challenges when operating electrolysers in industrial courtyards

Industry familiarising with novel electrolysis, updating risk analysis

Established a solid basis on which the EU H_2 strategy was built

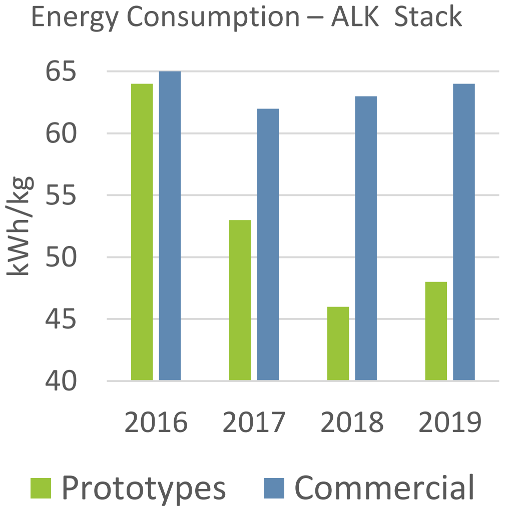
Supporting the European value chain

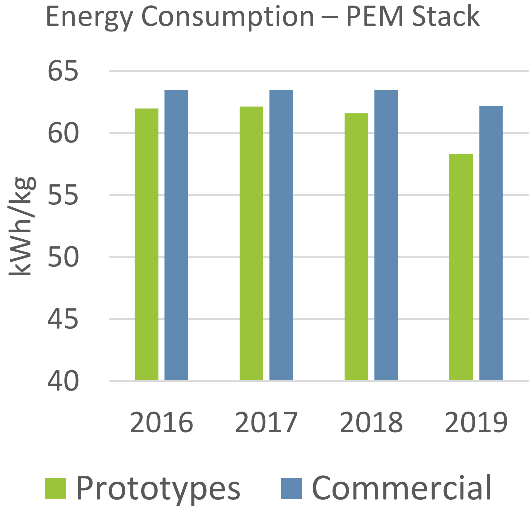


LT Electrolysis R&I projects

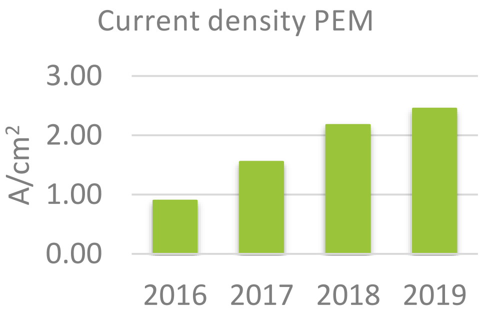
Achievement of MAWP targets safeguards Europe's leading position

Energy cons. @ system level <55 kWh/kg



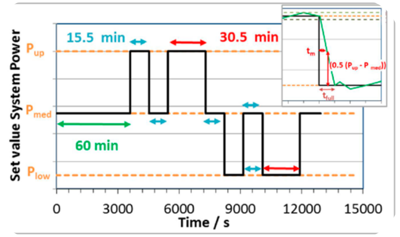


Current density > 3 A/cm²

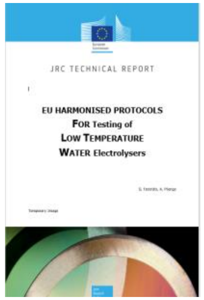


NEPTUNE

Dynamic operation, Testing Harmo



QualyGridS



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HT Electrolysis Demonstration projects

HTEs finding their place in the industrial courtyard, facilitating strategic partnerships

PAUL WURTH BECOMES NEW LEAD INVESTOR AND TECHNOLOGY PARTNER OF SUNFIRE

Saltzgitter
Iron and Steel Works
2018
720kW

GrInHy2.0
Green Industrial Hydrogen

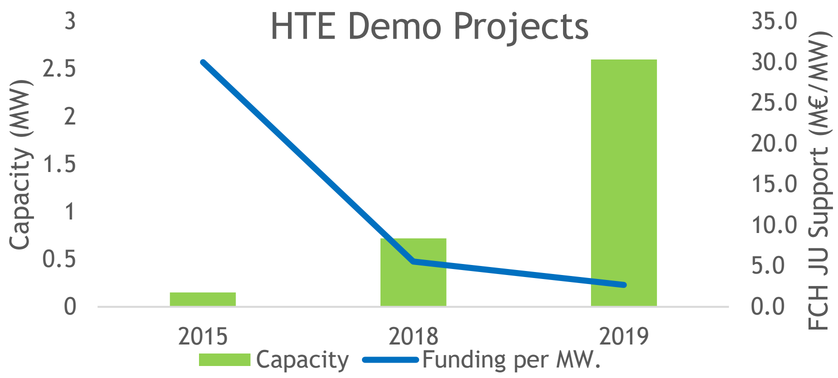
Saltzgitter
Iron and Steel Works
2015
150kW

GrInHy
Green Industrial Hydrogen

Rotterdam
Neste Biorefinery
2019
2.4MW

MULTIPLHY

NESTE INVESTS IN SUNFIRE



In 5 years capacity increased >10x and support reduced by 5x

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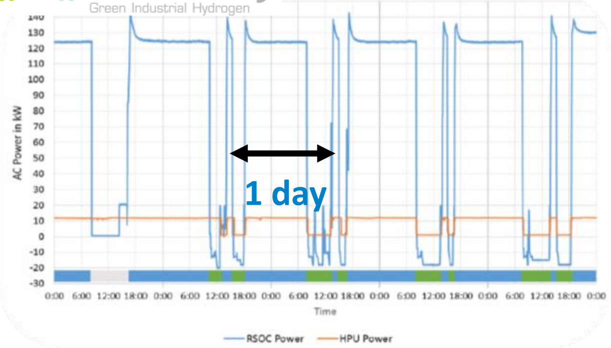
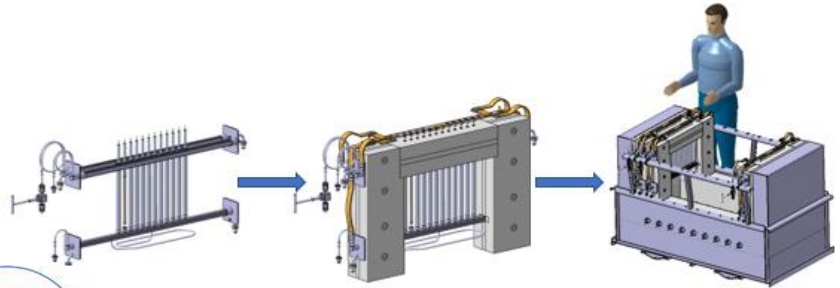
HT Electrolysis R&I projects

Higher efficiencies, improved durability, innovative concepts

GrInHy
Green Industrial Hydrogen



REFLEX



GAMER

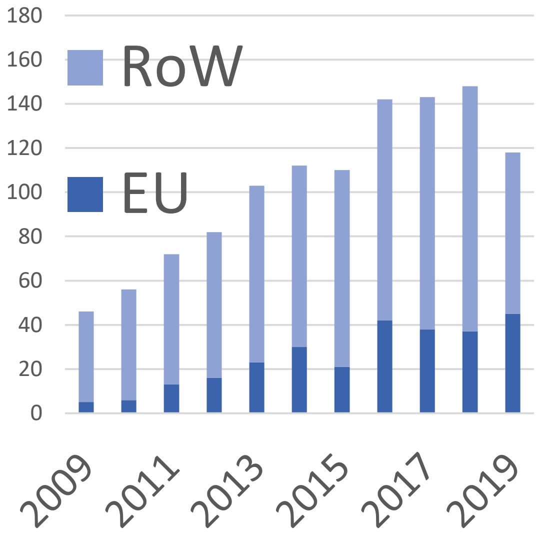
PCE, tubular cells

- Electricity consumption < 40 kWh/kg
- Production loss rate < 1.9%/1000h
- Availability >95%
  Reversible FC efficiency 54%
- Current density 1.25A/cm2
  Steam conversion rate > 85%

Electrolysis: Number of publications, patents, etc. 2009 - 2019 (JRC - TIM tool)

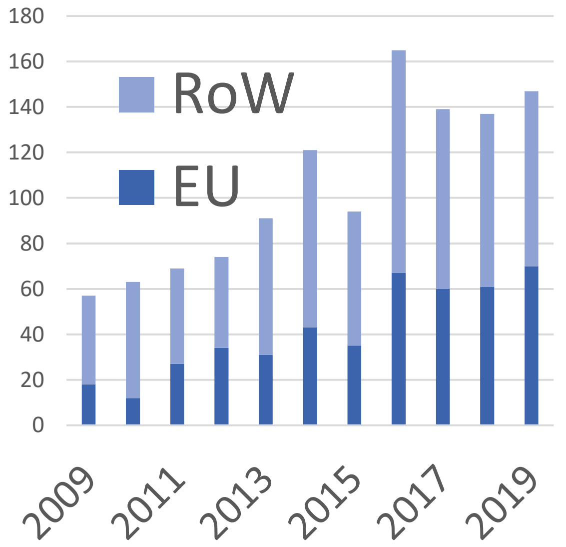
EU has ¼- ½ of global entries

ALK



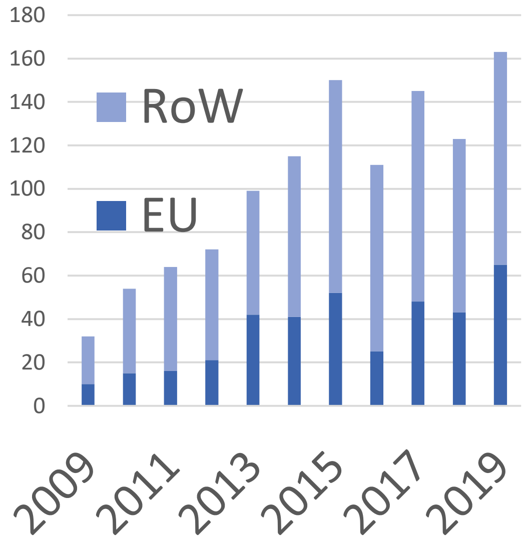
EU 406, China 350, USA 164, Japan 234, S. Korea 118

PEM



EU 593, USA 218, China 145 Japan 126, S. Korea 80

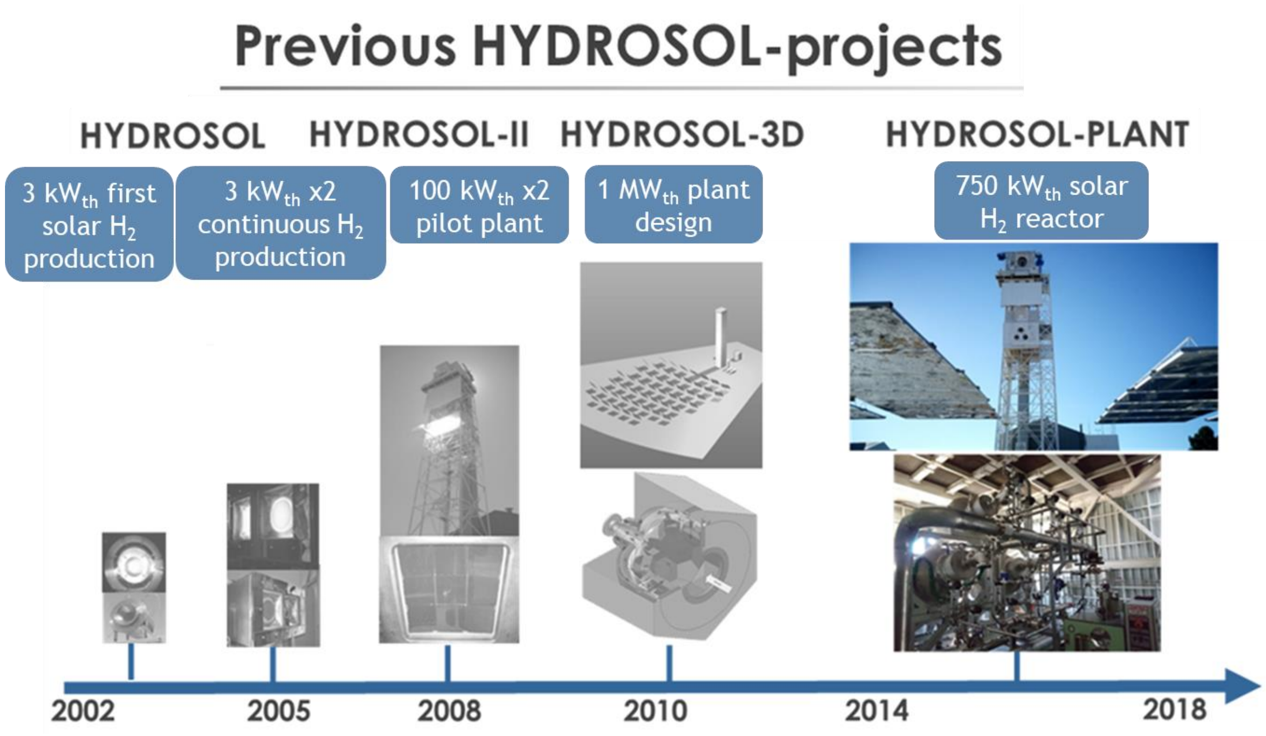
SO



EU 491, China 386, USA 260, Japan 106

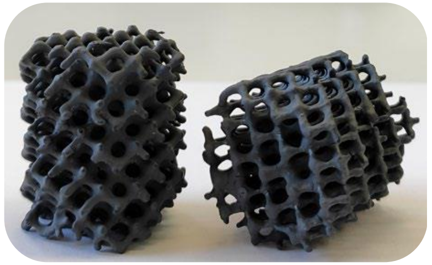
Direct production of H_2 from sunlight - 1

Large improvement of redox thermochemical cycles for water dissociation using concentrated solar-thermal power



- Production of structured redox materials and aging > 150 cycles (out of 1000)
- Improvements of the reactor design for laboratory efficiency of ≥10%
- Demonstration of efficiency >5% in the field tests of the 750 kW$_{th}$ plant

hydrosol beyond

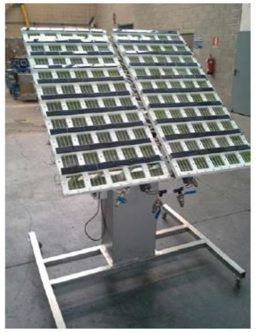


Direct production of H_2 from sunlight - 2

Scale-up and outdoor demonstration of a photo-electrochemical (PEC) system with an PV area exceeding 10 m^2

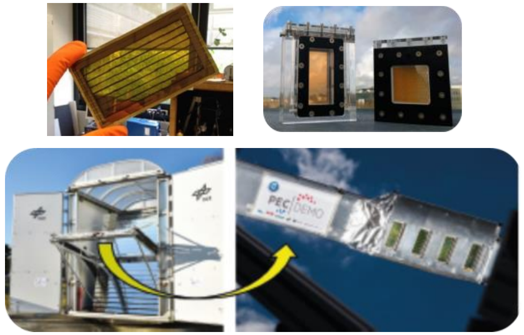
ArtipHyction

- 1.6 m^2 irradiated surface (η=3 % STH)



PECDEMO

- Hybrid PEC-EV
- η =9 % STH
- 4x50 cm^2



PECSYS

- PV-electrolyser concept
- 10 m^2 prototype
- η =9 % STH
- LCOH = 4 - 10 €/kg

2011 | 2013 | 2016

- Demonstration of 10 m^2 direct coupled PV-EC device
- Efficiency record of 14 % for SHJ PV-PEM electrolyser
- 6 €/kg achievable with integrated PV-EC approach
- Constraints in scaling-up a integrated PV-EC device

Biomass gasifiers & reactors; Biogas reformers

Singular projects on biomass; Recent emphasis on biogas compact reformers

Dry biomass: H_2 <5 €/kg from biomass gasification

2012

UnifHy 1MWth plant – 500kg/d

Wet biomass: Dark fermentation at lab scale

2012

HYTIME 1MWth plant – 1 kg/d

Biogas without CO_2 prior removal

100kg/day H_2 Conversion η = 71.5%

2015

BIONICO

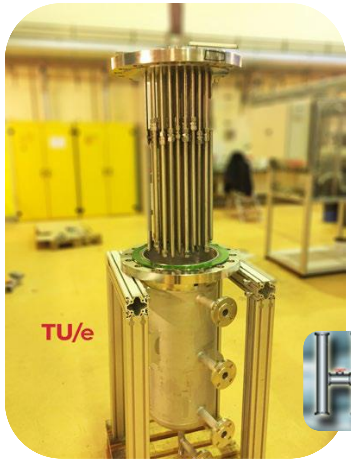
2017

BioRobur plus

Efficient separation / purification of H_2

Preparing for Hythane, underground storage, H_2 as byproduct

- Hydrogen recovery rate > 90% ✓
- H_2 recovery using Pd membranes < 5kWh/kgH2 ✓
- Cost of purified H_2 < 1.5 €/kg ✓
- 5-25 kg H_2/day, H_2 delivery @ 200 bar



HyGrid

MEMPHYS

Storage & Distribution of H_2

MH tanks, & Liquid Organic carriers

<0.5 €/kg additional cost

Undeground storage in salt caverns

2012

HyUnder

Hydrogen capacity of tube trailer >1,000kg
Cost of tube trailer < 350 €kg

LOHCs 2018

HySTOC

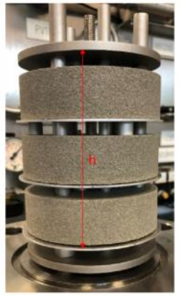
H_2 Capacity with tank (wt%) ≈ 2%

Material cost < 30€/kg (1,500€/kg H_2)

MH Tanks

HyCARE

2019



2011 EDEN

Conclusions

- Best in class electrolysers have met 2020 KPIs with more ambitious targets & improvements in manufacturing coming up to keep EU leadership
- Projects proved electrolysers as a reliable enabler for Sectorial Integration and helped bring renewable H_2 to the centre of EU energy policy
- Alternative routes for renewable H_2 production have moved from lab to field, further improvements required for market readiness
- H_2 storage R&D supported - from MH tanks to salt cavers; major role in the future partnership