Second International Workshop

Durability and Degradation Issues in PEM Electrolysis Cells and its Components

FCH 2 JU Funded Water Electrolysis Projects - Status and Perspectives

Jean-Luc DELPLANCKE
Head of the Programme Unit

http://www.fch.europa.eu/

Strong public-private partnership with a focused objective

Fuel Cells & Hydrogen 2 Joint Undertaking

Hydrogen Europe
Industry Grouping
HYDROGEN EUROPE
92 members

European Union
represented by the
European Commission

N.ERGHY
RESEARCH ON FUEL CELLS & HYDROGEN
Research Grouping
N.ERGHY
63 members

The Joint Undertaking is managed by a **Governing Board** composed of representatives of all three partners and lead by the Industry.

To bring to the point of market readiness a ***portfolio of clean, efficient and competitive solutions*** *based on fuel cells and hydrogen technologies in energy and transport*

Joint Undertaking – Public Private Partnership

Council Regulations:

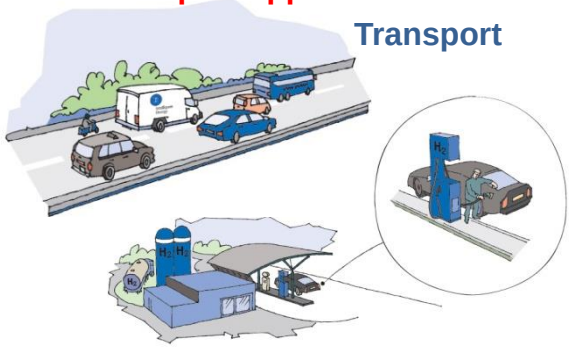
521/2008 of 30 May 2008 **(FP7)**
1183/2011 of 14 November 2011
559/2014 of 6 May 2014 **(H2020)**

FCH 2 JU objectives

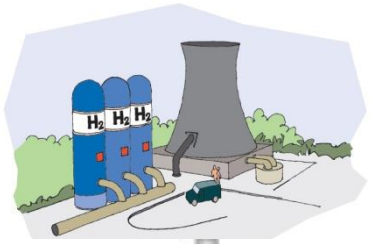
Reduction of production costs of long lifetime FC systems to be used in transport applications

Increase of the electrical efficiency and durability of low cost FCs used for power production

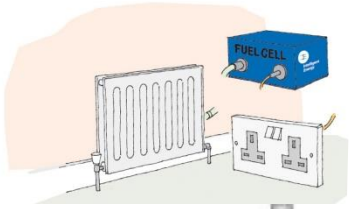
Transport



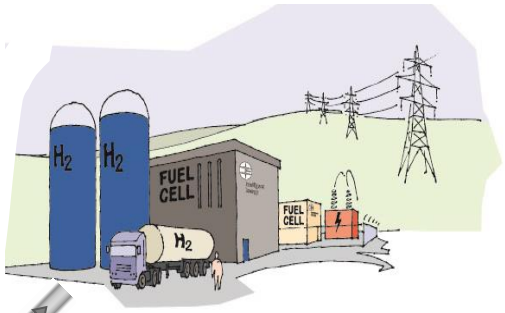
Industrial applications



Residential CHP



Feed to electricity grid

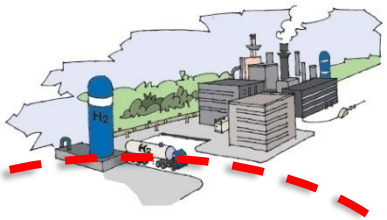


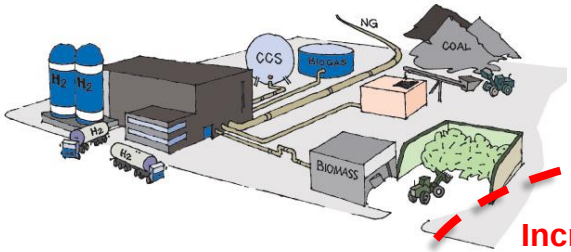
Reduce the use of critical raw materials

Existing natural gas, electricity and transport infrastructures

Methanisation feed to natural gas grid

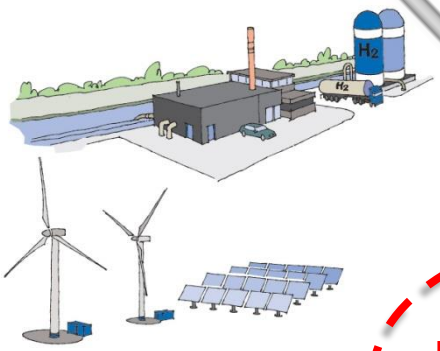
By-product from Chemical Industry



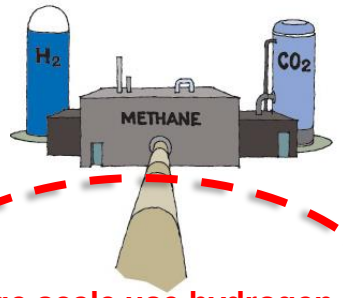


Natural gas, biogas, coal, biomass

Increase the energy efficiency of low cost production of hydrogen from water electrolysis and renewable sources



Renewable generation, storage and 'buffering'



Large scale use hydrogen to support integration of renewable energy sources into the energy systems

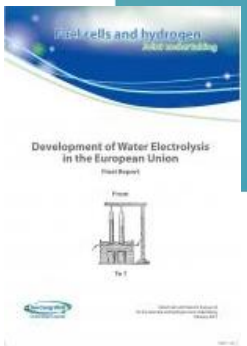
- H_2 Production & Distribution in Energy Pillar

- Road vehicles
- Non-road vehicles and machinery
- Refuelling infrastructure
- Maritime, rail and aviation applications

- Hydrogen production and distribution
- Hydrogen storage for renewable energy integration
- Fuel cells for power and combined heat & power generation

Cross-cutting Issues

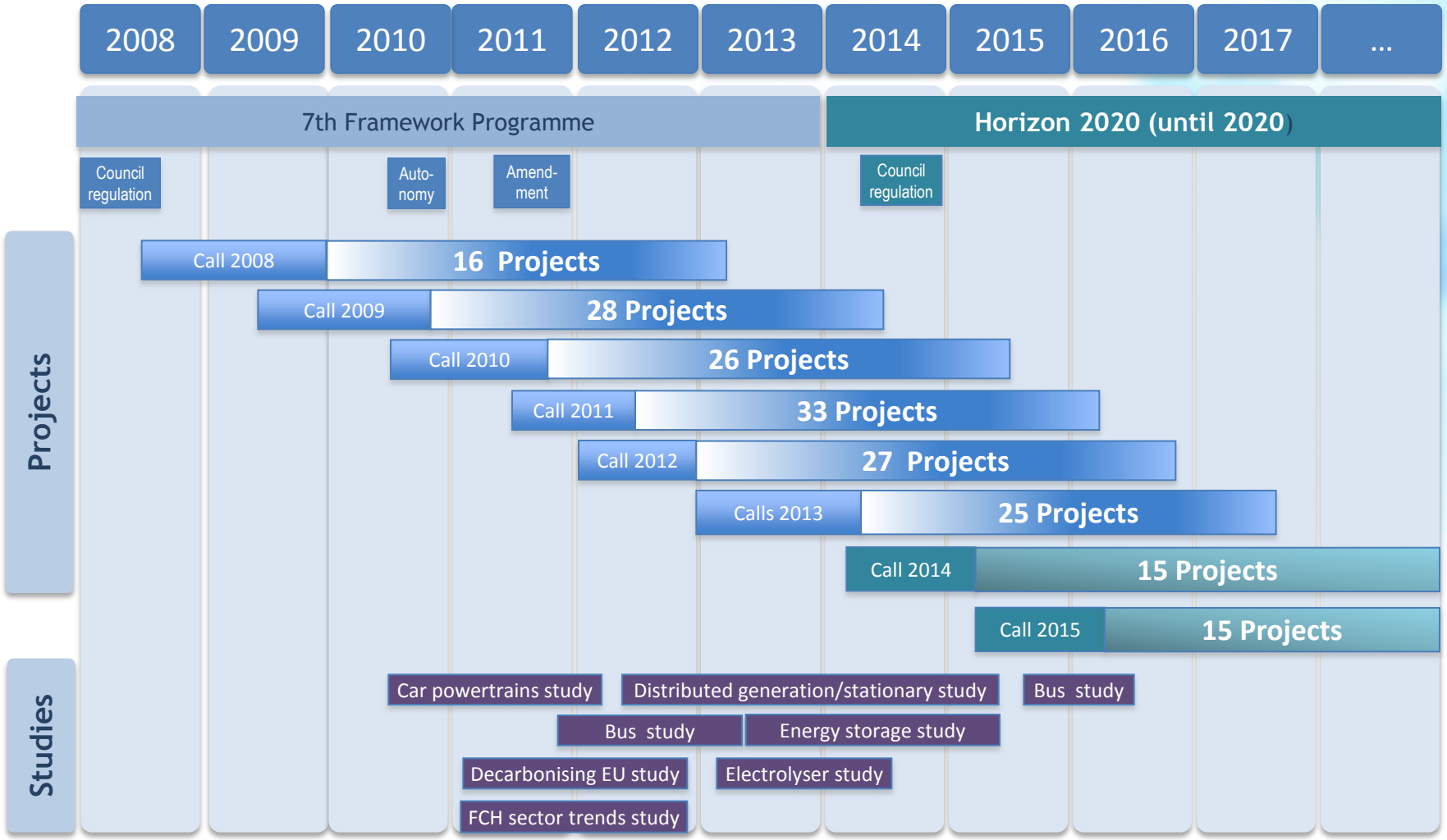
(e.g. standards, consumer awareness, manufacturing methods, …)



Water electrolysis deployment perspectives in Europe

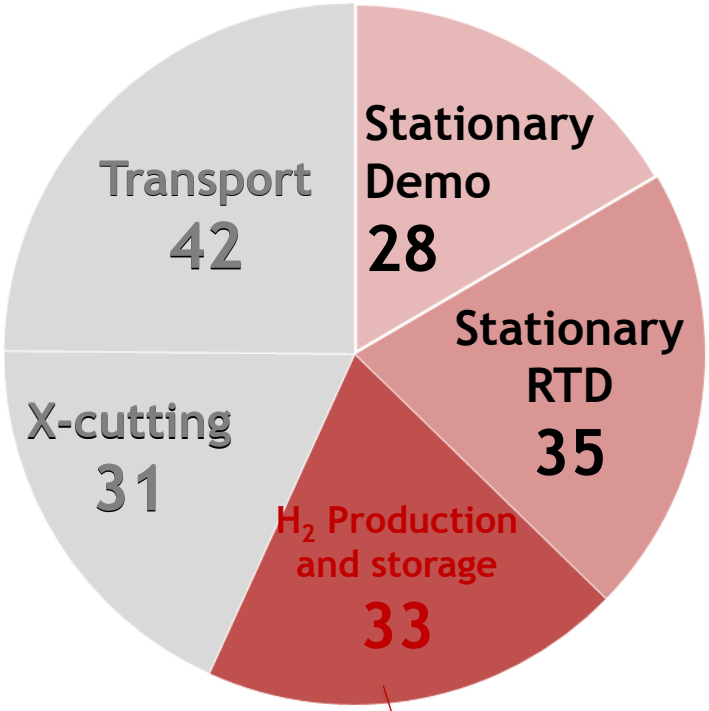
	Now to 2015	2015 - 2020	2020 - 2030	Beyond 2030
Hydrogen as an industrial chemical	Existing markets for electrolytic hydrogen expected to grow moderately		Potentially emerging	Energy system and use cases expected to have evolved significantly by this time
Energy storage, grid services & Renew.-heat	Pilot stations in several countries (MW scale)	Deployment of multi MW systems	Cumulative deployments reach GW scale	
Hydrogen refuelling stations	Hundreds of stations (100 kW – 2 MW)		Thousands of stations (1 MW to 5 MW)	

Supported R&D activities since 2008



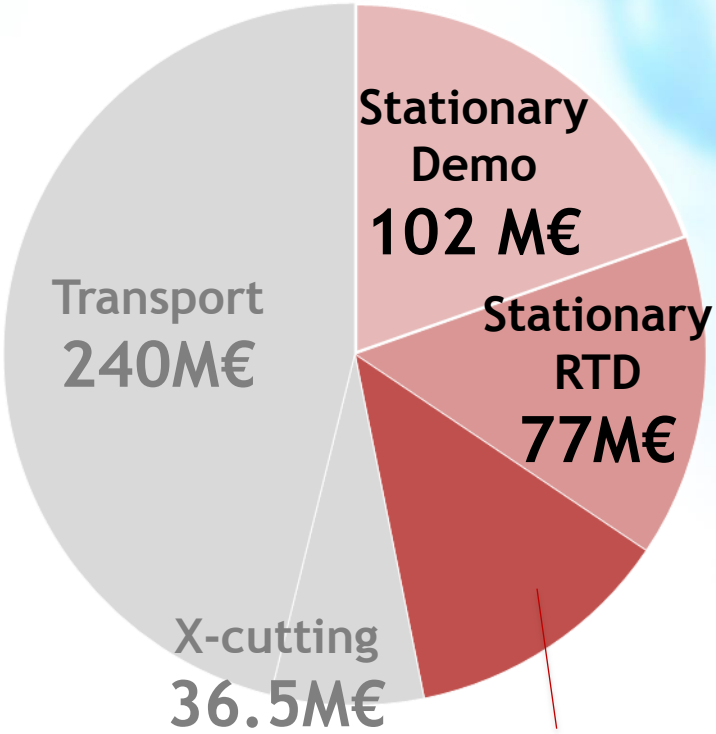
Projects financed since 2008

Number of projects
169 (of which FP7: 155)



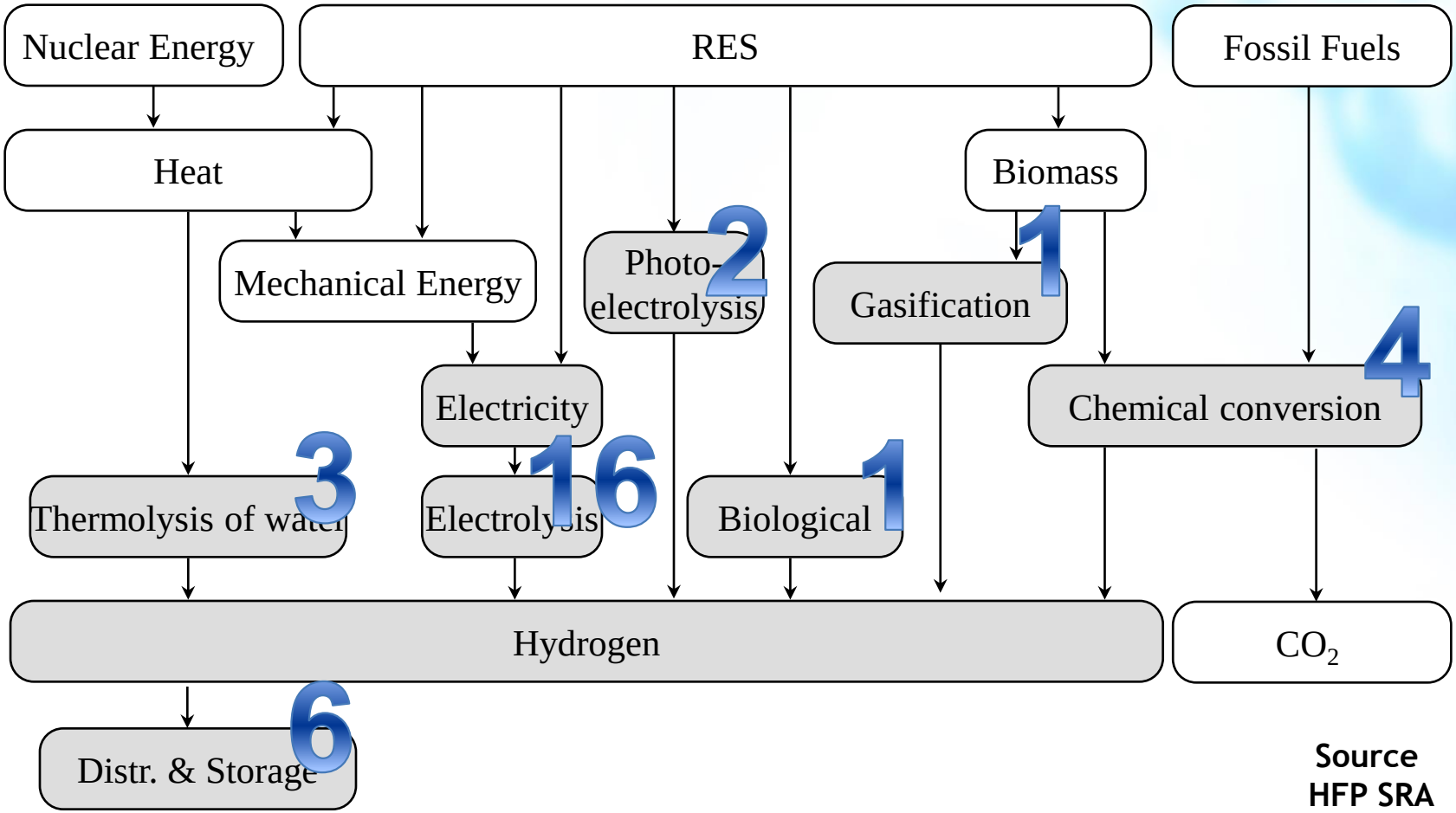
- 8 completed
- 21 active under FP7
- 4 under H2020

Max FCH JU contribution
520 M€ (of which FP7: 446 M)



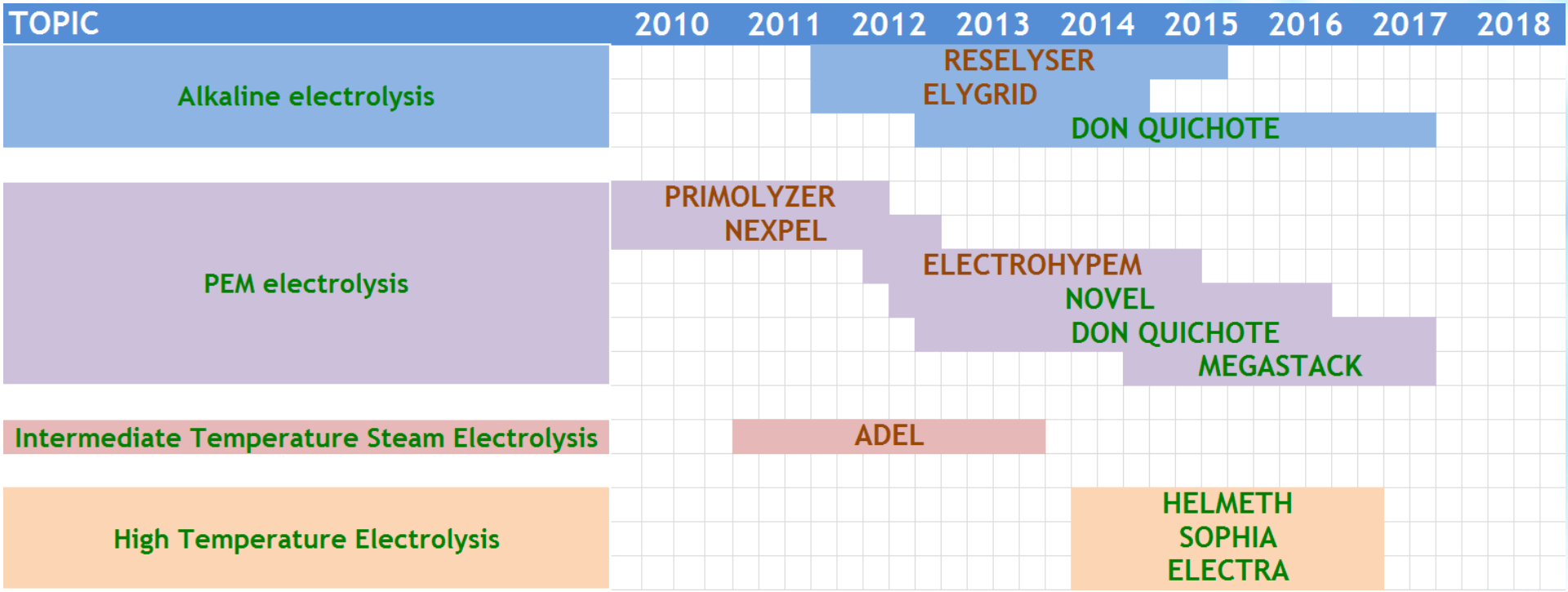
H_2 Production and storage
64.5M€
MAIP 10-12%

Hydrogen Prod., Stor. & Distr. Technical Coverage



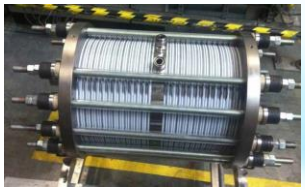
Source
HFP SRA

Electrolysis projects



Programme Targets and Achievements

- Electrolysers - 1
  - Alkaline (RESELYSER, ELYGRID)




	Aim	Status
η	>80%,	76-82%
η retention	>90% over 1,000 on/off	>98% over 1,100
cost (k€/Nm^3.h)	3	7
capacity (tn/d)	1.5	3

  - PEM (ELECTROHYPEM, NOVEL, DONQUICHOTE, MEGASTACK)

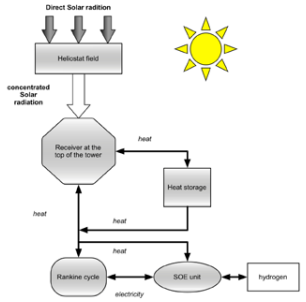
	Aim	Status
η (kWh/Nm^3)	< 4	3.53
V increase (µV/h)	< 15 @ 1 A cm^{-2}	8
H2 cost (€/kg)	< 15	13 (RES cost)
capacity single stack (Nm^3/h)	100	60


Programme Targets and Achievements

- Electrolysers - 2
  - High temperature (HELMETH, SOPHIA, ELECTRA)

Helmeth	Aim	Status
η (%)	85-95%,	86%

  - Achieved: 5kW, 10bar, 700°C, total η 86%
  - Scope:Design, fabrication, and operation on-sun of a 3 kW_e-size pressurized High Temperature Electrolysis (HTE) system, coupled to a concentrated solar energy source
  - Scope: build and test a kW size multi-tubular proton ceramic high temperature electrolyser for production of hydrogen from steam and renewable energy



FCH 2 JU under H2020 – Call 2014

- Call H2020-JTI-FCH-2014-1
- Indicative budget: 93 M€
- Publication date: 09 July 2014
- Deadline: 06 November 2014
- 22 Topics: 11 Energy Topics + 1 Overarching Topic
- 57 Proposals received

2014 Call – Research & Innovation Actions Energy Topics

		Tentative budget (M€)	Proposals received
FCH-02.1-2014: Research in electrolysis for cost effective hydrogen production	Research & Innovation (RIA)		6
FCH-02.2-2014: Decentralized hydrogen production from clean CO2-containing biogas	Research & Innovation (RIA)	16	7
FCH-02.3-2014: Stationary fuel cell system diagnostics: development of online monitoring and diagnostics systems for reliable and durable fuel cell system operation	Research & Innovation (RIA)		5
FCH-02.4-2014: Robust production of stationary fuel cells with reduced quality control costs	Research & Innovation (RIA)		1
FCH-02.5-2014: Innovative fuel cell systems at intermediate power range for distributed combined heat and power generation	Research & Innovation (RIA)		6
FCH-02.6-2014: Development of centrifugal hydrogen compressor technology	Research & Innovation (RIA)		**0**
FCH-02.7-2014: Stand-alone hydrogen purification systems for new hydrogen pathways	Research & Innovation (RIA)		1
FCH-02.8-2014: Improvement of electrolyser design for grid integration	Research & Innovation (RIA)		3

2014 Call –Innovation Actions Energy Topics

		Tentative budget (M€)	Proposals received
FCH-02.9-2014: Significant improvement of installation and service for fuel cell systems by Design-to-Service	Innovation (IA)		3
FCH-02.10-2014: Demonstrating the feasibility of central large scale electrolysers in providing grid services and hydrogen distribution and supply to multiple high value markets	Innovation (IA)	25.5	3
FCH-02.11-2014: Large scale fuel cell power plant demonstration in industrial/commercial market segments	Innovation (IA)		3
FCH-03.1-2014: Hydrogen territories	Innovation (IA)	5	2

2014 Call Evaluation Results

Area/Panel	Submissions	Ineligible	Above thresholds	FCH2 JU contribution requested (EUR)
TRANSPORT PILLAR Research and Innovation Activities	9	0	3	13,398,556
TRANSPORT PILLAR Innovation Activities	1	0	1	32,000,000
ENERGY PILLAR Research and Innovation Activities	29	0	14	41,854,497
ENERGY PILLAR Innovation Activities	9	0	3	15,445,737
OVERARCHING PROJECTS	2	0	0	0
CROSS-CUTTING	7	0	2	3,494,432
TOTAL	**57**	**0**	**23**	**106,193,222**

Based on the budget availability, 15 proposals were selected for funding

Energy related projects

FCH-02.1-2014	671481	SElySOs	Development of new electrode materials and understanding of degradation mechanisms on Solid Oxide High Temperature Electrolysis Cells.	02/11/2015	48	2,939,655.00	2,939,655.00
FCH-02.2-2014	671459	BIONICO	BIOgas membrane reformer for deceNtralIzed hydrogen produCtiOn	01/09/2015	36	3,396,640.00	3,147,640.00
FCH-02.3-2014	671486	HEALTH-CODE	Real operation pem fuel cells HEALTH-state monitoring and diagnosis based on dc-dc COnverter embeddeD Eis	01/09/2015	36	2,358,736.25	2,358,736.25
FCH-02.5-2014	671396	AutoRE	AUTomotive deRivative Energy system	01/08/2015	36	4,464,447.25	3,496,947.00
FCH-02.5-2014	671403	INNO-SOFC	Development of innovative 50 kW SOFC system and related value chain	01/09/2015	30	3,998,081.25	3,998,081.25
FCH-02.8-2014	671458	ELYntegration	Grid Integrated Multi Megawatt High Pressure Alkaline Electrolysers for Energy Applications	01/09/2015	36	3,301,391.25	1,861,309.00
FCH-02.9-2014	671473	D2Service	Design of 2 Technologies and Applications to Service	01/09/2015	36	3,636,797.50	2,953,790.75
FCH-02.10-2014	671384	HyBalance	HyBalance	01/10/2015	60	15,184,265.78	7,999,370.80
FCH-02.11-2014	671470	DEMOSOFC	DEMOnstration of large SOFC system fed with biogas from Waste Water Treatment Plant	01/09/2015	60	5,905,336.25	4,492,561.00

Energy topics not addressed by a project: 2.4; 2.6; 2.7 and 3.1

FCH 2 JU under H2020 – Call 2015

- Call H2020-JTI-FCH-2015-1
- Indicative budget: 123 M€
- Publication date: 05 May 2015
- Deadline: 27 August 2015
- 20 Topics: 9 Energy Topics + 3 Overarching Topic
- 66 Proposals received

2015 Call - Research & Innovation Actions Energy Topics

		Tentative budget (M€)	Proposals received
FCH-02.1-2015: Improved electrolysis for Off-grid Hydrogen production	Research & Innovation (RIA)		3
FCH-02.2-2015: Improved electrolysis for Distributed Hydrogen production	Research & Innovation (RIA)	20	5
FCH-02.3-2015: Development of co-electrolysis using CO_2 and water	Research & Innovation (RIA)		4
FCH-02.4-2015: Proof of concept of HT electrolyser at a scale >70 kW	Research & Innovation (RIA)		3
FCH-02.5-2015: Development of technology to separate hydrogen from low-concentration hydrogen streams	Research & Innovation (RIA)		4
FCH-02.6-2015: Development of cost effective manufacturing technologies for key components or fuel cell systems	Research & Innovation (RIA)		**9**
FCH-03.3-2015: Hydrogen delivery with high capacity compressed gas trailer	Research & Innovation (RIA)	2	**0**

2015 Call –Innovation Actions Energy Topics

		Tentative budget (M€)	Proposals received
FCH-02.7-2015: MW or multi-MW demonstration of stationary fuel cells	Innovation (IA)	34	3
FCH-02.8-2015: Sub-MW demonstration of stationary fuel cells fuelled with biogas from biowaste treatment	Innovation (IA)		2
FCH-02.9-2015: Large scale demonstration µCHP fuel cells	Innovation (IA)		1
FCH-03.1-2015: Large scale demonstration of Hydrogen Refuelling Stations and FCEV road vehicles - including buses and on site electrolysis	Innovation (IA)	39.5	1
FCH-03.2-2015: Hydrogen territories	Innovation (IA)		4

FCH 2 JU under H2020 – Call 2015

Area/Panel	Available budget (mill EUR)	Total number of proposals evaluated	Number of proposals having failed the thresholds	Number of proposals equal or above the thresholds	**Number of proposals retained** (main lists)	Proposed budget (EUR)
TRANSPORT PILLAR Research and Innovation Activities	25	19	15	4	**3**	14,058,470.00
ENERGY PILLAR Research and Innovation Activities	20	28	13	15	**8**	21,428,326.00
ENERGY PILLAR Innovation Activities	34	5	4	1	**1**	33,932,752.75
OVERARCHING Innovation Activities	39.5	5	3	2	**2**	39,999,549.00
OVERARCHING Research and Innovation Activities	2	0	0	0	**0**	0
CROSS-CUTTING	2.5	4	3	1	**1**	497,666.25
TOTAL	**123**	61	38	23	**15**	**109,916,764.00**
		100 %	62.3 %	37.7 %	24.6%	

4 Proposals were withdrawn by FCH 2JU due to abusive submission
1 Proposal was found ineligible
15 Proposals under Grant preparation

Energy topics with selected proposals

FCH-02.1-2015: Improved electrolysis for Off-grid Hydrogen production	Research & Innovation (RIA)	1
FCH-02.2-2015: Improved electrolysis for Distributed Hydrogen production	Research & Innovation (RIA)	1
FCH-02.3-2015: Development of co-electrolysis using CO_2 and water	Research & Innovation (RIA)	1
FCH-02.4-2015: Proof of concept of HT electrolyser at a scale >70 kW	Research & Innovation (RIA)	1
FCH-02.5-2015: Development of technology to separate hydrogen from low-concentration hydrogen streams	Research & Innovation (RIA)	1
FCH-02.6-2015: Development of cost effective manufacturing technologies for key components or fuel cell systems	Research & Innovation (RIA)	3
FCH-02.7-2015: MW or multi-MW demonstration of stationary fuel cells	Innovation (IA)	**0**
FCH-02.8-2015: Sub-MW demonstration of stationary fuel cells fuelled with biogas from biowaste treatment	Innovation (IA)	**0**
FCH-02.9-2015: Large scale demonstration µCHP fuel cells	Innovation (IA)	1

Overarching topics with selected proposals

FCH-03.1-2015: Large scale demonstration of Hydrogen Refuelling Stations and FCEV road vehicles - including buses and on site electrolysis	Innovation (IA)	1
FCH-03.2-2015: Hydrogen territories	Innovation (IA)	1
FCH-03.3-2015: Hydrogen delivery with high capacity compressed gas trailer	Research & Innovation (RIA)	**0**

FCH 2 JU under H2020 – Call 2016

- Call H2020-JTI-FCH-2016-1
- Indicative budget: 117.5 M€
- Publication date: 19 January 2016
- Deadline: 03 May 2016
- 24 Topics: 11 Energy Topics + 1 Overarching Topic

2016 Call - Research & Innovation Actions Energy Topics

		Tentative budget (M€)
FCH-02-1-2016: Establish testing protocols for electrolysers performing electricity grid services	Research & Innovation (RIA)	16
FCH-02-2-2016: Development of compact reformers for distributed bio-hydrogen production	Research & Innovation (RIA)	
FCH-02-3-2016: Development of processes for direct production of hydrogen from sunlight	Research & Innovation (RIA)	
FCH-02-4-2016: Co-generation of hydrogen and electricity with high-temperature fuel cells	Research & Innovation (RIA)	
FCH-02-5-2016: Advanced monitoring, diagnostics and lifetime estimation for stationary SOFC stacks and modules	Research & Innovation (RIA)	
FCH-02-6-2016: Development of cost effective manufacturing technologies for key components or fuel cell systems for industrial applications	Research & Innovation (RIA)	
FCH-03-1-2016: Development of innovative hydrogen purification technology based on membrane systems	Research & Innovation (RIA)	2

2016 Call –Innovation Actions Energy Topics

		Tentative budget (M€)
FCH-02-7-2016: Demonstration of large-scale rapid response electrolysis to provide grid balancing services and to supply hydrogen markets	Innovation (IA)	40
FCH-02-8-2016 Large scale demonstration of commercial fuel cells in the power range of 20-100kW in different market applications	Innovation (IA)	
FCH-02-9-2016 Large scale demonstration of commercial fuel cells in the power range of 100-400kW in different market applications	Innovation (IA)	
FCH-02-10-2016: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas	Innovation (IA)	
FCH-02-11-2016: MW or multi-MW demonstration of stationary fuel cells	Innovation (IA)	

Energy pillar RIA

Topic 2-1: Establish testing protocols for electrolysers performing electricity grid services

Challenge

- Provision of grid services by electrolysers: not only better components, but also benchmarks, standardised tests and economic analysis

Scope

- Benchmarking of components, assessment of improvements through a specific testing methodology to evaluate potential of electrolysers to provide grid services
- Standardization of a testing protocol to evaluate the ability of electrolysers to provide grid services - Establishment of power curves
- Testing power electronics, stack and BoP
- Definition of a business model, assessment of the services with the highest potential

Impact

- Development of standardised tests
- Specific performance indicators for provision of each grid service
- Assessment of economic gains from providing grid services

Other information

- EU contribution of 2 M€ -- 1 project -- 3 years
- TRL from 4 to 6

Topic 2-7: Demonstration of large-scale rapid response electrolysis to provide grid balancing services and to supply hydrogen markets

Challenge

- Demonstration of large electrolysis units (>3 MW) using the latest available PEM or pressurized alkaline technology
- Convert excess renewable electricity to H_2 that can be stored and re-electrified at a later time, or used for other energy consuming or industrial processes
- Provide grid balancing services/power demand management on a commercial basis

Scope

- Develop > 3MW electrolyser of sufficiently rapid response time (of the order of a few seconds) to participate in primary and secondary grid balancing markets
- Improve electrolyser dynamic performance
- <52kWh/kg for alkaline and <48kWh/kg for PEM
- 630 Euro/kW for alkaline and 1000 Euro/kW for PEM
- SOTA systems installed & operated for > 2 years

Impact

- Demonstrate feasible operation of large scale rapid response electrolysis
- Techno-economic analysis of the performance of these systems
- Assessment and operation experience, including safety, of the contractual and hardware arrangements required to distribute and supply hydrogen to multiple markets
-

Other information

- > 1 member of IG or RG
- EU contribution of 16 M€ -- 2 projects -- 4-5 years
  - 1 project PEM, 6MW (1x6 or 2x3), 12 M€
  - 1 project alkaline, 3MW, 4 M€
  - Grid connection & e- for testing eligible / e- for operation not eligible
- TRL from 6/7 to 8

Thank you for your attention !

Further info :

- **FCH JU : http://www.fch.europa.eu/**
- **HYDROGEN EUROPE : www.hydrogeneurope.eu**
- **N.ERGHY : http://www.nerghy.eu**