ON.ERGHY

RESEARCH ON FUEL CELLS & HYDROGEN

Fuel Cells & Hydrogen Research in Europe

Laurent ANTONI

President

Outline

- Introduction
- Role and impact of the European research N.ERGHY
- N.ERGHY roadmap
- N.ERGHY and regional cooperation
- Conclusions

Introduction

- European Energy Union priorities are security of energy supply, energy efficiency, competitiveness
  - Success will be based on science and technology innovations
  - Accelerated Innovation is the ultimate solution to climate change

Post COP 21

Bringing wishes to reality

N.ERGHY is the research partner of the FCH 2 JU

Fuel Cells & Hydrogen Joint Undertaking

Industry Grouping
Hydrogen Europe
105 members

European Union represented by the European Commission

Research Grouping
N.ERGHY
65 members

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

A portfolio of clean, efficient and competitive solutions *based on fuel cells and hydrogen technologies in energy and transport*

Role and Impact of N.ERGHY

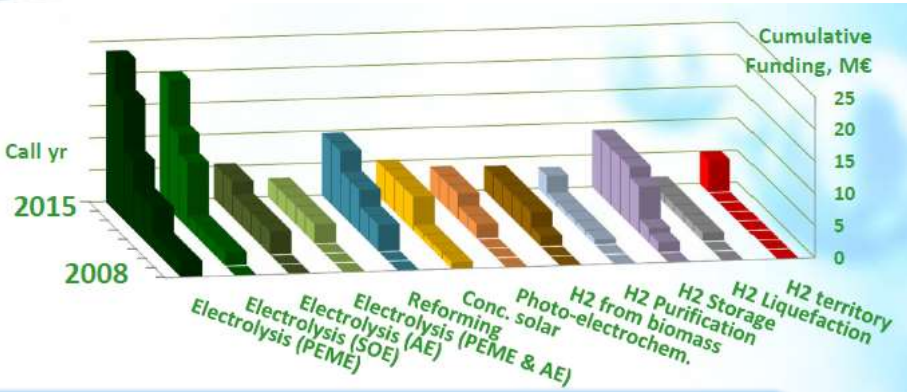
- **N.ERGHY**
  - **Mission** is to **promote, support and accelerate** the deployment of H2&FC technologies by **aligning the European R&D** community and by providing a stronghold for cooperation with industry increasing the **impact of research**
  - **Address critical technical** barriers to foster Hydrogen & Fuel Cells technologies to achieve commercialization (TRL 3-6)
    *This activity is done in close collaboration with **Hydrogen Europe**.*
  - **Propose clear R&I targets** for the future (TRL 1-3)
    *This activity is done in close collaboration with the **EERA Joint Program on FC&H2**.*

Role and Impact of N.ERGHY

- **N.ERGHY coordinates H2&FC R&I efforts in Europe since 2008**
  - Close cooperation with EERA Joint Program on FC&H2 (national R&D monitoring, low TRL proposals). More than 80% of the EERA JP members are today member of N.ERGHY
  - Member of the FCH 2 JU Governing Board
  - Stakeholder of SET Plan actions

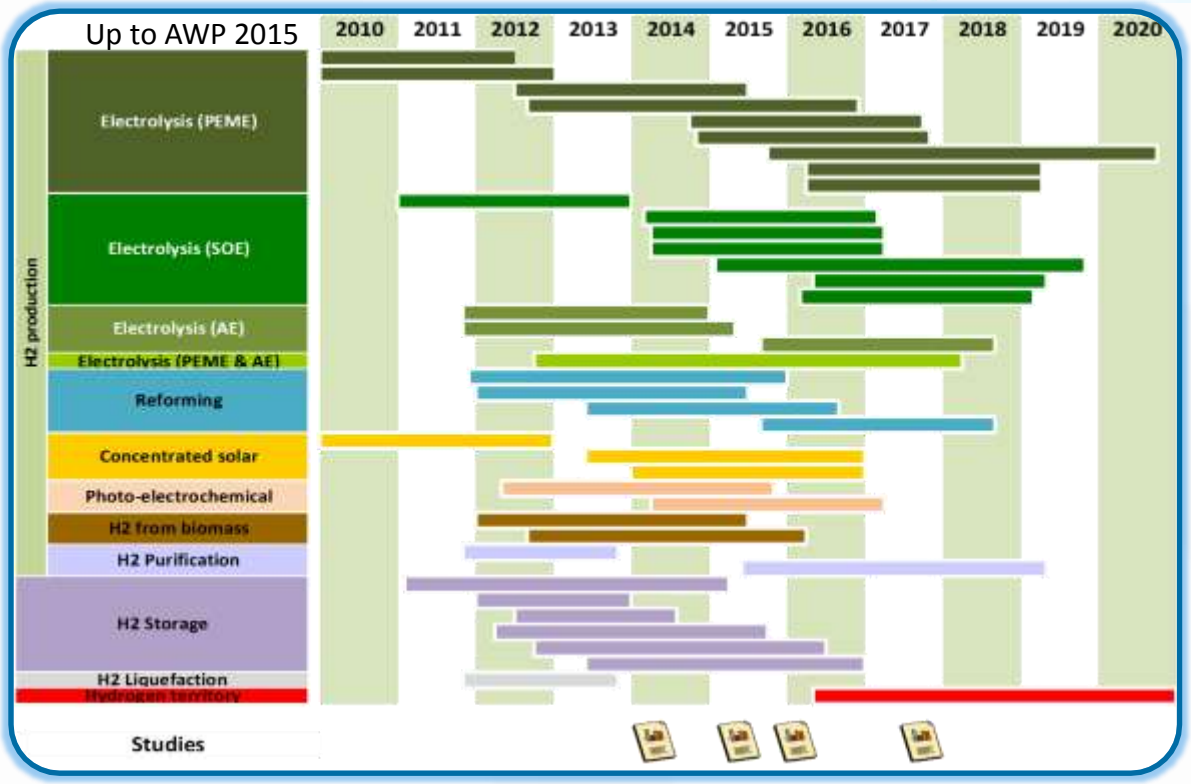
- **N.ERGHY will continue to contribute to the FCH JU public-private partnership**
  - Deployment of commercial products:
    - European Hydrogen Refilling Station and Electrolyzer manufacturers
    - European fuel cell stack manufacturing
    - European fuel cell vehicles
  - Active participation of Europe in international **Regulation, Codes & Standards** activities

Impact of N.ERGHY on H_2 production



- **97% of FCH JU support towards green H_2**
  - Demonstrate on a large scale H2's capacity to harness power from renewables and support its integration into the energy system
  - Increase efficiency and reduce costs of H2 production, mainly from water electrolysis and renewables

47 projects
178 M€



Impact of N.ERGHY on H_2 production

PEM and Alcaline Water Electrolysis

8 electrolysers installed
100 tons of H2 produced
>93% availabililty

	FCH JU project results 2015		MAWP target 2017		non-European SoA
	PEME	AE			
CAPEX, M€/(t/d)	⚠	✓	<	3.7	1.7-3.5 @ 1 MW / 500 kg/d
Energy consumption, kWh/kg	⚠	⚠	<	55	65
Efficiency degradation, %/y	✓	✓	<	2	1.1
Min load, % of nominal capa.	✓	-	<	5	0
Max load, % of nominal capa.	⚠	-	>	150	100
Hot start, seconds	✓	✓	<	10	10
Cold start, seconds	⚠	⚠	<	120	300

Based on 2015 project data gathered in the FCHJU 2016 data collection exercise

Impact of N.ERGHY on H_2 production

High temperature electrolysis with CO_2 methanation

Proof of concept of a highly efficient PtG technology

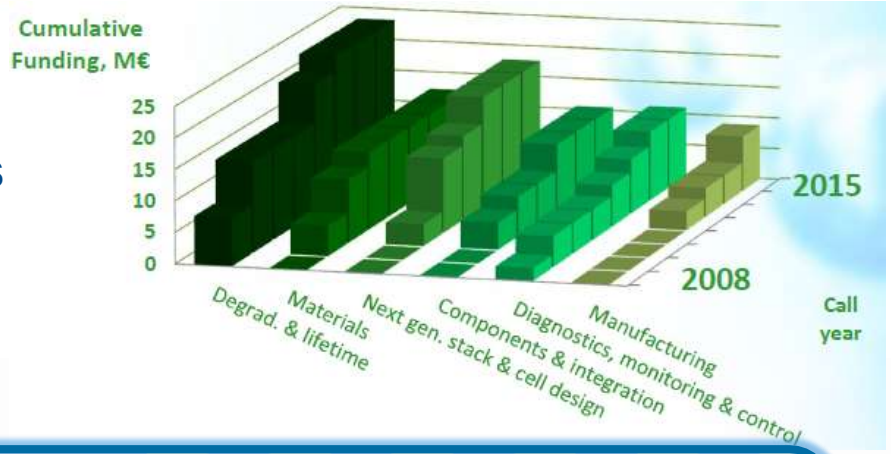
- SOEC short stack tests show degradation rates < 0.5 %/ 1000 h and feasibility of coelectrolysis.
- Multiple nickel based catalysts for the methanation developed & optimized.
  Lab tests confirm that SNG quality requirements are met with chosen concept.
- Process simulation of HELMETH concept confirm efficiencies > 85 % for large scale plants based on realistic assumptions

SOEC module *(in operation)*

Methanation module *(assembling phase)*

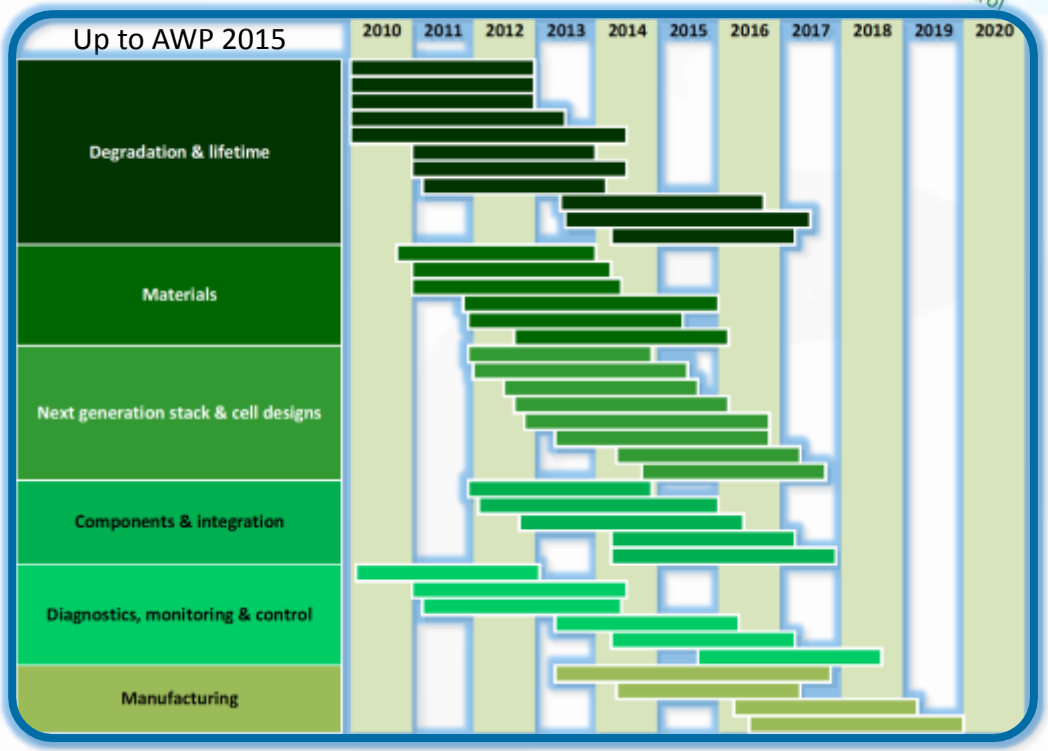
Impact of N.ERGHY on energy

- **Covering all technologies at all stages of development**
  - Increase the efficiency and the durability of fuel cells for power production, while reducing costs



42 projects
166 M€

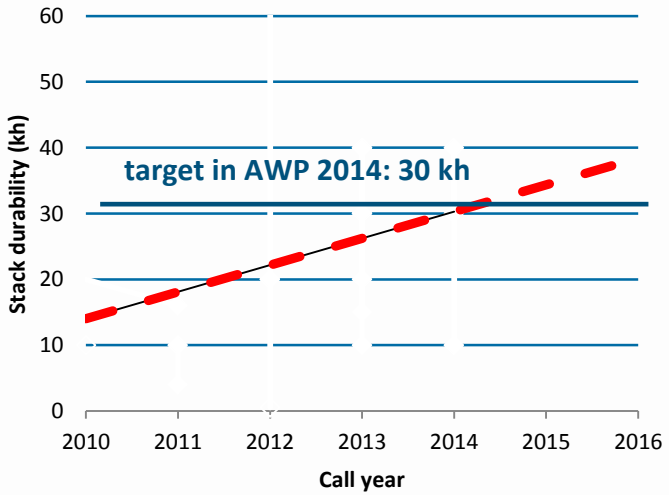
More than 220 publications, 15 PhDs and 17 post docs



Impact of N.ERGHY on energy

CHP SYSTEM	FCH JU project results 2015	Objectives 2017*
System electrical efficiency, %	⚠	> 57
Total system efficiency, %	✓	> 82
Stack lifetime, kh	✓	> 30

**Based on AWP2014*



2015 achievements:

- 76,000 h+ of operation
- 4.2 k€/kW SOFC stack average cost
- 5.3 k€/kW PEMFC stack average cost
- 92% of average stack availability

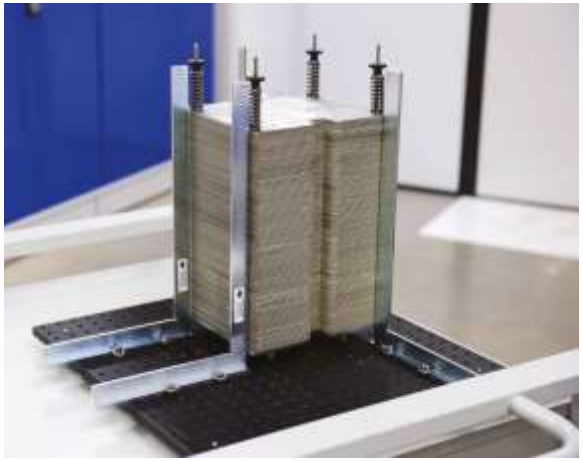
Based on 2015 project data gathered in the FCHJU 2016 data collection exercise

Impact of N.ERGHY on energy

DEVELOPMENT OF INNOVATIVE 50 KW SOFC SYSTEM AND RELATED VALUE CHAIN

INNOSOFC

Designing, assembling and demonstrating a novel **60 kW SOFC power plant** based on an all-EU value chain from component manufacturers to end-user.



Efficiency performance and lifetime:

- 3,000 hours operating time, with two years continuous operation;
- 60% electrical efficiency, and 85% total efficiency;
- life-time of key-components validated in 10,000 hours tests to ensure 3,0000 hours operating time.

Cost reductions:

- 35-60% cost reduction compared to current SoA (6-10 k€/kW in FCH JU Multi Annual Work Plan);
- cost optimization of SOFC stack manufacturing, leading to 2 k€/kW stack costs in serial production;
- cost levels will be achieved already below 1 MW annual production level.

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Impact of N.ERGHY on energy

REAL OPERATION PEMFC HEALTH-STATE MONITORING AND DIAGNOSIS BASED ON DC-DC CONVERTER EMBEDDED EIS

Implementing an **advanced monitoring, diagnostic and prognostic tool** for **air-fed μ-CHP (Ballard)** and **oxygen-fed backup (EPS)** PEMFC systems via **on-board EIS HW**.
A **scaling-up algorithm** is also conceived to reduce testing costs.

3 test benches are testing 2 systems under 5 different faults
An overall amount of 1500 spectra is expected

EPS short stack @ UFC

- 4 stacks tested
- 1 system tested
- 4 faults tested

Ballard stack @ AAU

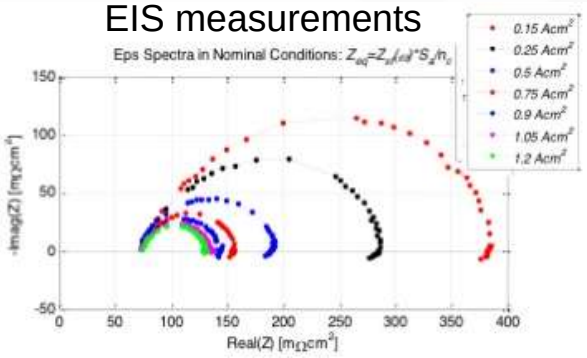
- 5 stacks tested
- 1 system tested
- 5 faults tested

Ballard stack @ EIFER

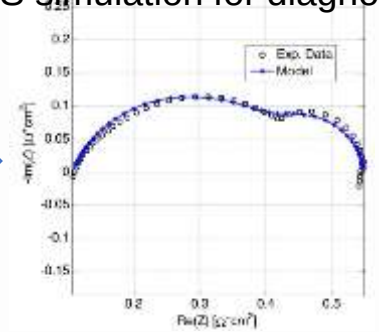
- 4 stacks tested
- 1 system tested
- 4 faults tested

EIS board

EIS measurements

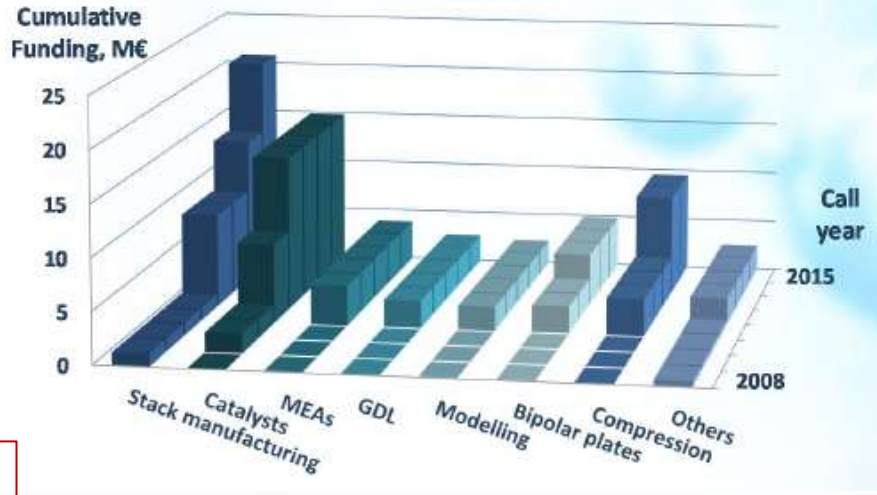


EIS simulation for diagnosis



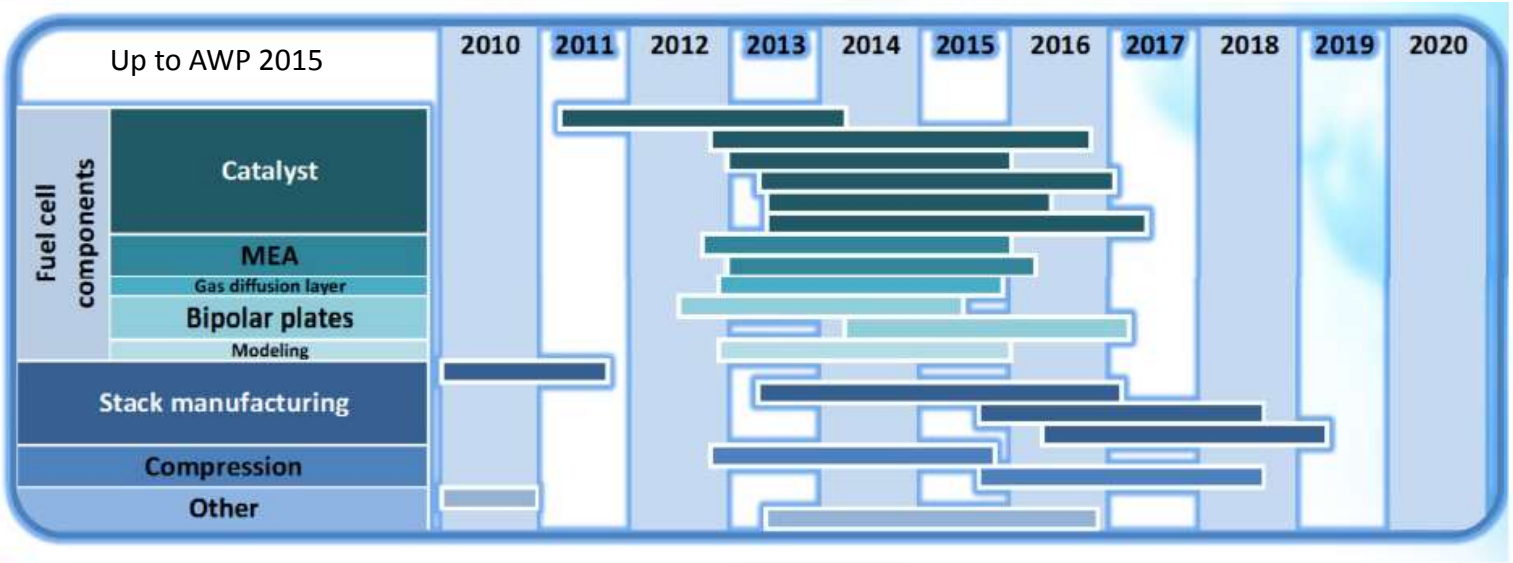
Impact of N.ERGHY on transport

- **From materials research … to system manufacturing**
  - Reduce fuel cell system costs for transport applications while increasing lifetime
  - Reduce use of critical raw materials

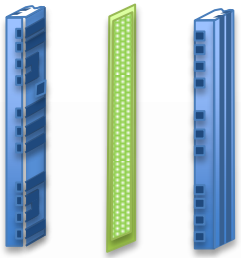


More than 110 publications, 15 phDs and 17 post docs

28 projects
127 M€



Impact of N.ERGHY on transport

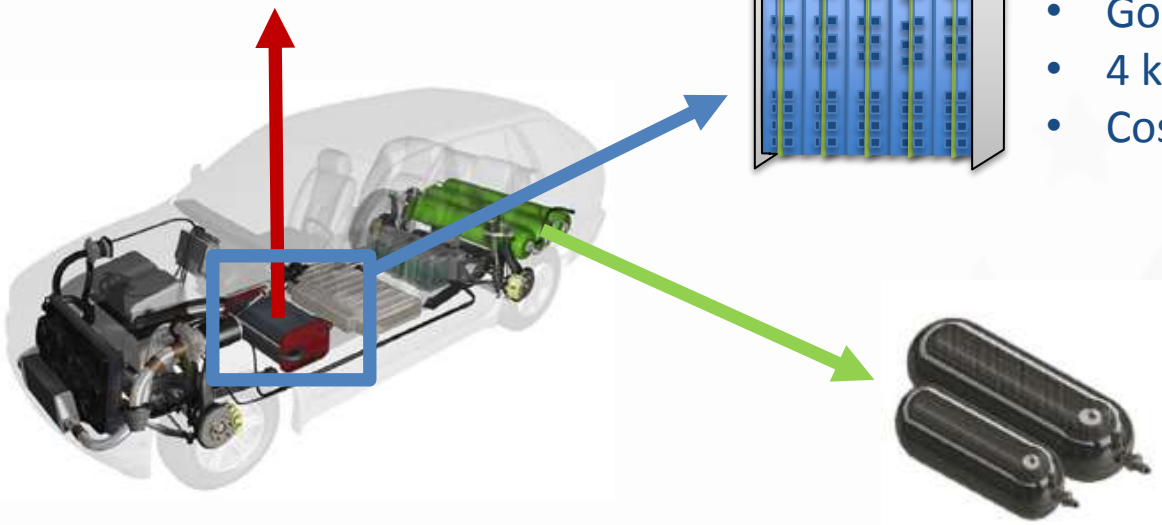


FC Components

- Membranes: +25% in performance
- GDL: +12% in performance & 7% cost savings
- BPP: Improved corrosion coatings; stable >6,000hrs

FC Stacks

- Good performance in Gen 1 (2.8kW/l)
- 4 kW/l in Gen 2
- Cost: 32€/kW @30,000units/yr



H2 Storage

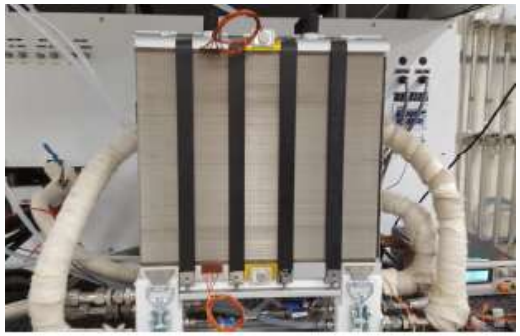
- +22% gravimetric density
- -55% cost savings

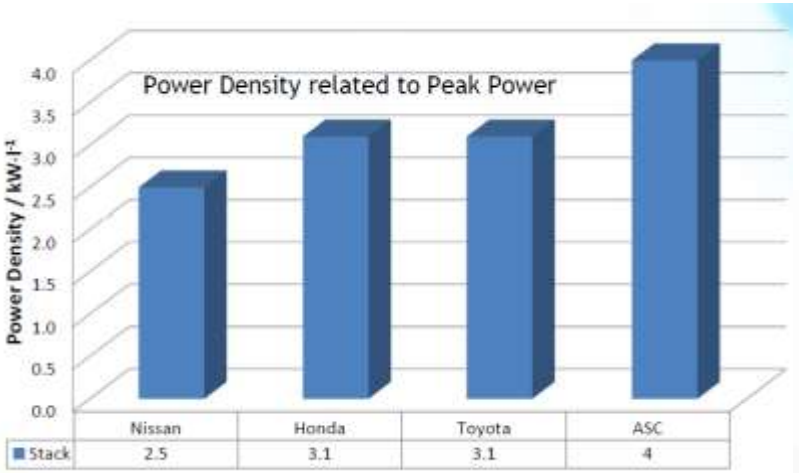
Impact of N.ERGHY on transport

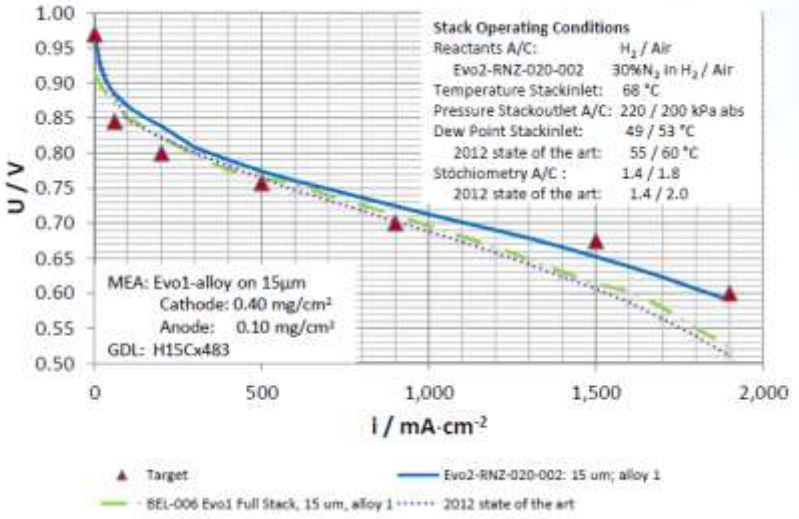
autostack core

Automotive Fuel Cell Cluster for Europe II

Develop best of its class automotive stack technology







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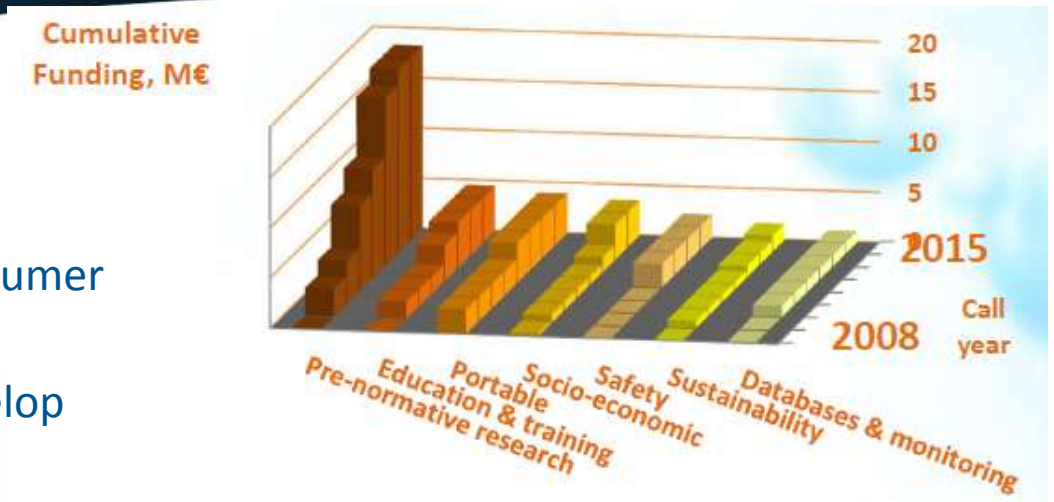
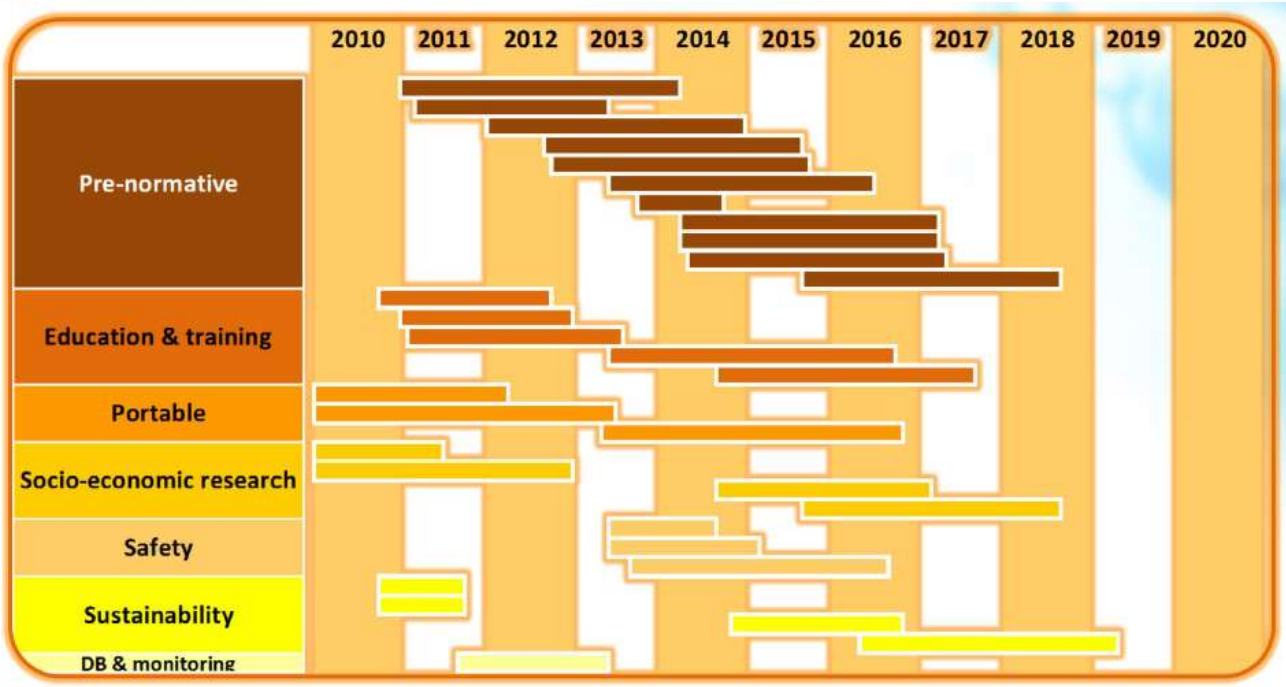
Impact of N.ERGHY on cross-cutting

- **Cross-cutting**
  - standards, safety, education, consumer awareness, …
  - providing new knowledge to develop and improve RCS



31 projects
35 M€



Impact of N.ERGHY on cross-cutting

PNR projects
provide solid information to improve and develop standards at international level, contributing to develop an adequate regulatory framework

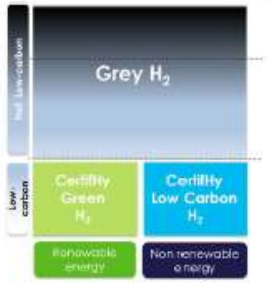
ISO | IEC

fireCOMP | HyPACTOR | HyCoRA

Exporting technology to train first responders outside of Europe

Carrying out the biggest exercise ever to gain a deeper understanding of the social acceptance of hydrogen technologies across Europe

Europe is becoming a reference worldwide and is pioneer in designing a GoO scheme for green hydrogen to inform about the renewable content of the hydrogen



FCH

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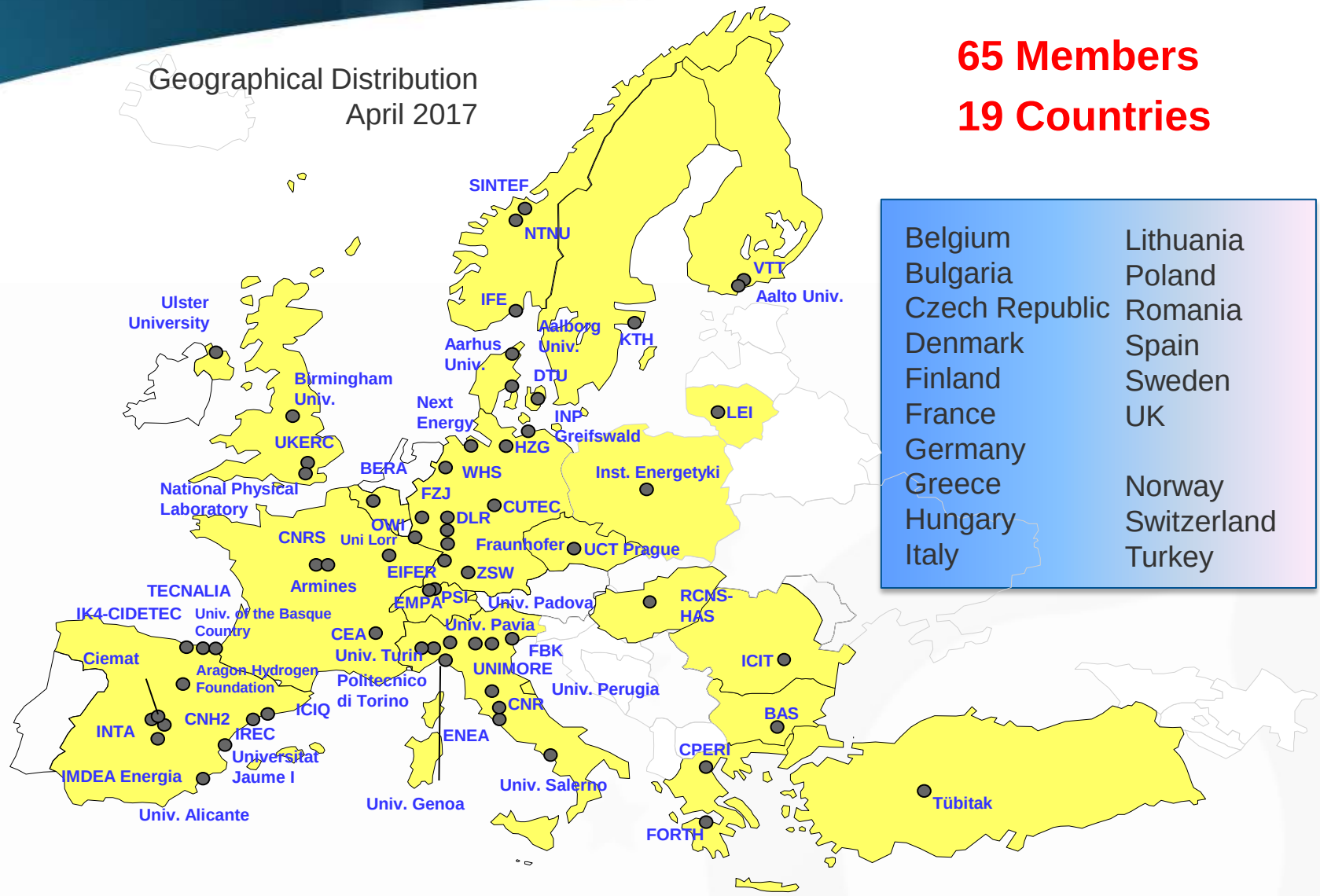
N.ERGHY ROADMAP

- Take advantage of world R&I activities (USA, Japan, Korea and now China) and focus on European industry needs
- Contribute to build the Multi Annual Working Plan (MAWP), the Annual Working Plan (AWP) and to ensure H2&FC involvement in FP9
- Some examples
  - Energy storage
  - Flexible low and high temperature electrolysis
  - PGM free catalysts
  - Stack architectures
  - On-board tanks
  - Hydrogen compressors
  - …

N.ERGHY actions are based on regional cooperation all over Europe



65 Members

19 Countries

Belgium	Lithuania
Bulgaria	Poland
Czech Republic	Romania
Denmark	Spain
Finland	Sweden
France	UK
Germany	
Greece	Norway
Hungary	Switzerland
Italy	Turkey

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N.ERGHY is integrated in regional ecosystems

- Universities, laboratories, research institutes have strong links with
  - local industries,
  - local authorities,
  - attracting young people in their scientific and technical educations.

- **Education** is of utmost importance to train engineers, technicians and operators and thus to ensure a **qualified manpower** the Hydrogen and Fuel Cells industry will need.
  Integrate H2&FC specialities in the generic cursus.

Conclusions

- Hydrogen and Fuel Cells are part of the European energy transition
- A strong Public-Private Partnership with a focused objective to accelerate the development of technology base towards market deployment of FCH technologies
- Strong, competitive Research and Innovation in close collaboration with European Industry is essential to foster commercialization
- N.ERGHY has succeeded in FCH JU to coordinate and focus all over Europe the technological research
- N.ERGHY has identified potential breakthroughs for next generation of products
- N.ERGHY is integrated in regional ecosystems and will contribute to educate qualified manpower that Hydrogen and Fuel Cells industry will need
- Progress in Research & Innovation is worldwide.
  All the strength of European Research & Innovation is needed.
  A sustainable European support is crucial to keep Europe in the top players.

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Further information

- FCH2 JU : www.fch.europa.eu/
- HYDROGEN EUROPE : www.hydrogeneurope.eu
- N.ERGHY : www.nerghy.eu