



International Partnership *for the* Hydrogen Economy



## Country Report: Italy

**17th IPHE Steering Committee Meeting**

**May 3 – 4, 2012**

**Cape Town, South Africa**

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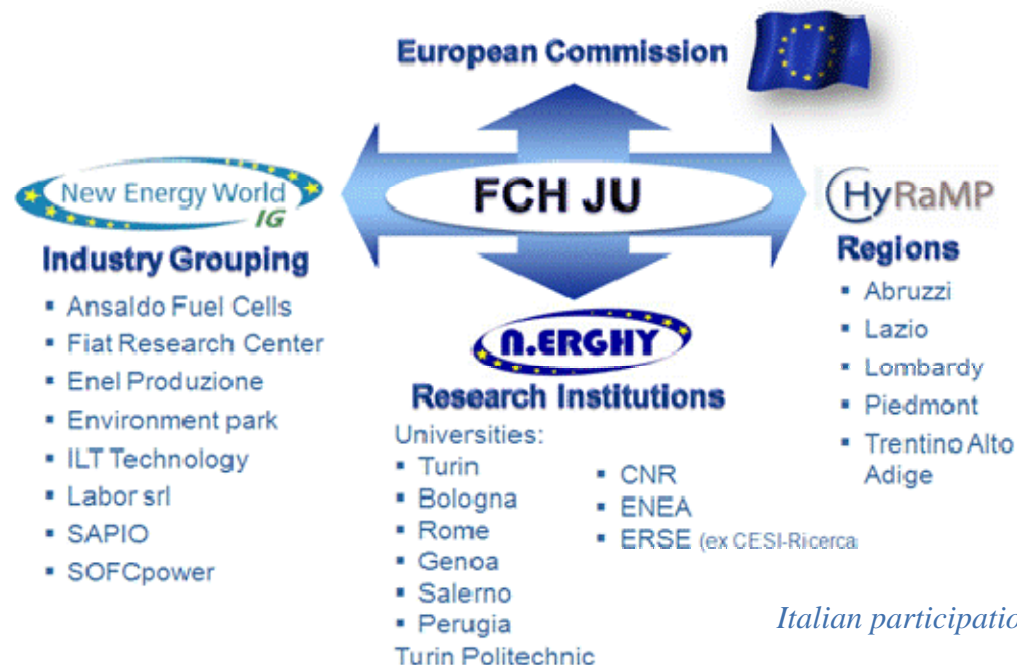
## Italian vision on hydrogen and fuel cells

- ◆ In the last years, in Italy, the interest for hydrogen and its related technologies has grown according with similar trends characterising the major industrialised countries
- ◆ RD&D projects are being carried out in this field, in the frame of European and national programmes, with the involvement of industries, research organisations and users
- ◆ Many demonstration activities are promoted from Local Authorities (Regions and Municipalities)



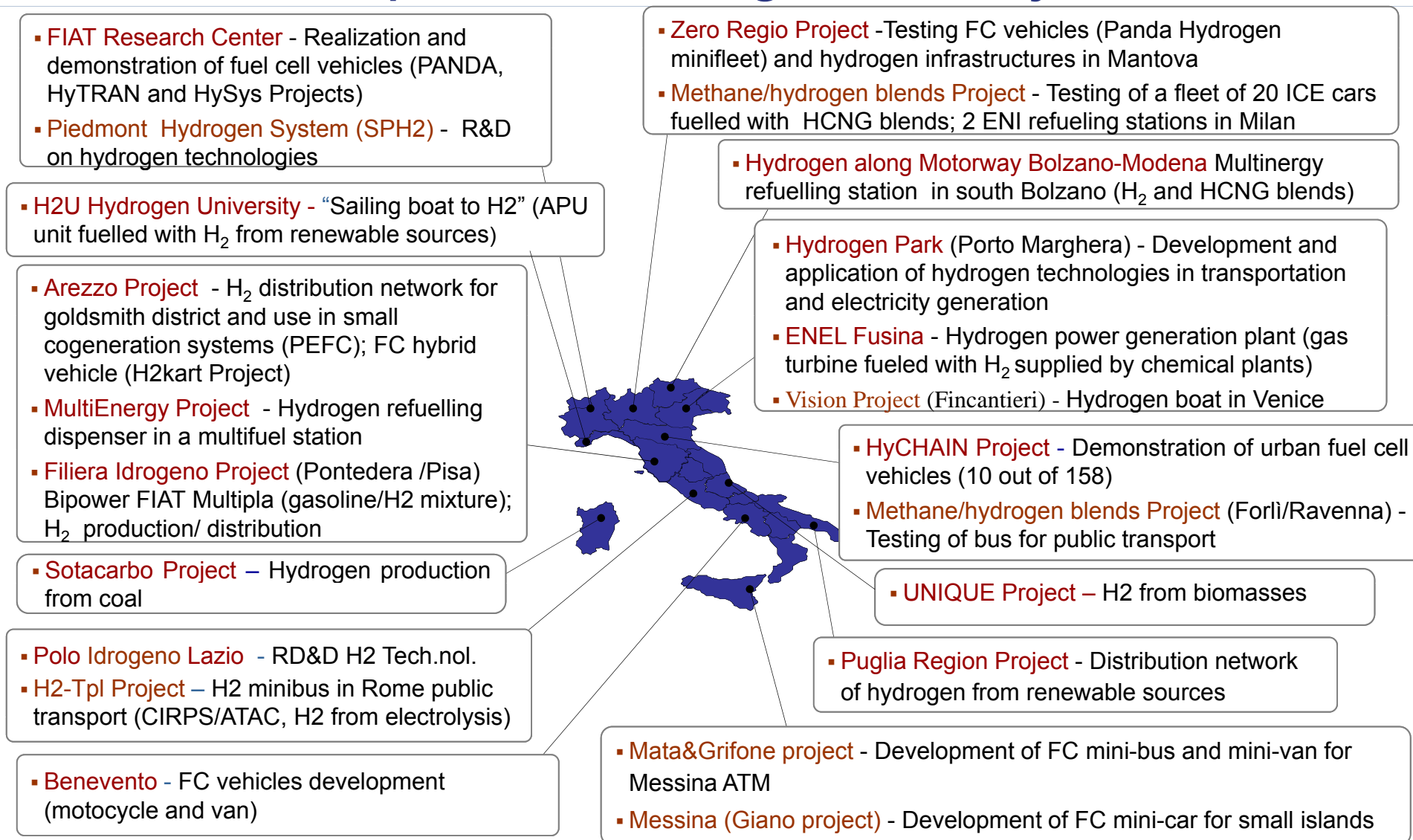
### INTERNATIONAL COLLABORATIONS

- ◆ International Partnership for Hydrogen Economy 
- ◆ Implementing Agreements IEA 
- ◆ Fuel Cells & Hydrogen Joint Undertaking





## European and Regional Projects







## New Industrial Projects



### INDUSTRIA 2015



Ministry of Economic Development has launched in the 2007 the "Industria 2015" Program aimed at assisting Industrial innovation projects in the thematic areas:

- ◆ Energy efficiency
- ◆ Sustainable mobility
- ◆ New technologies for life
- ◆ New technologies for Made in Italy
- ◆ Innovative technologies for cultural heritage

*Hydrogen and Fuel Cells: 5 projects*

*MSE funding: 30,1 M€*

*Total cost of the projects: around 70 M€*

*Duration: 3 years*

### ENERGY EFFICIENCY

- **MICROGEN 30 / ICI Caldaie** - 30 kWe CHP system with PEFC for residential applications (6.08 M€ funded)
- **EFESO / Merloni Termosanitari** - 1-2.5 kW micro-CHP prototypes with SOFC (planar and tubular technologies) (10.92 M€ funded)
- **HYDROSTORE / Venezia Tecnologie** - Study and development of storage systems (metal hydrides) (5,3 M€ funded)

### SUSTAINABLE MOBILITY

- **VISION / Fincantieri** – Hydrogen ferry for Venice lagoon with fuel cell hybrid system (3.07 M€ funded)
- **PBI (Innovative Bus Platform) / Breda Menarinibus** - Systems for the safe and integrated mobility (vehicles and infrastructures for passenger and/or freight transport) (4.73 M€ funded)



## “Industria 2015” Program



Environmentally Friendly Energy from Solid Oxide Fuel Cell



INDUSTRIA 2015

1- 2.5 kW micro CHP prototypes,  
based on solid oxide fuel cell  
technology for residential use  
(planar and tubular configurations)



The project aims at obtaining a  
system industrial cost that has a  
payback of 5 years in absence of  
economic incentives

### Main Objectives:

- Realise 4 Micro CHP prototypes in the power range of 1 and 2.5 kWe, based on SOFC technology (both planar and tubular)
- Target the industrial cost that has a payback of 5 years in a non incentive economic overview.
- Target appliances for residential use both single-family and multi-family houses with low specific emissions.



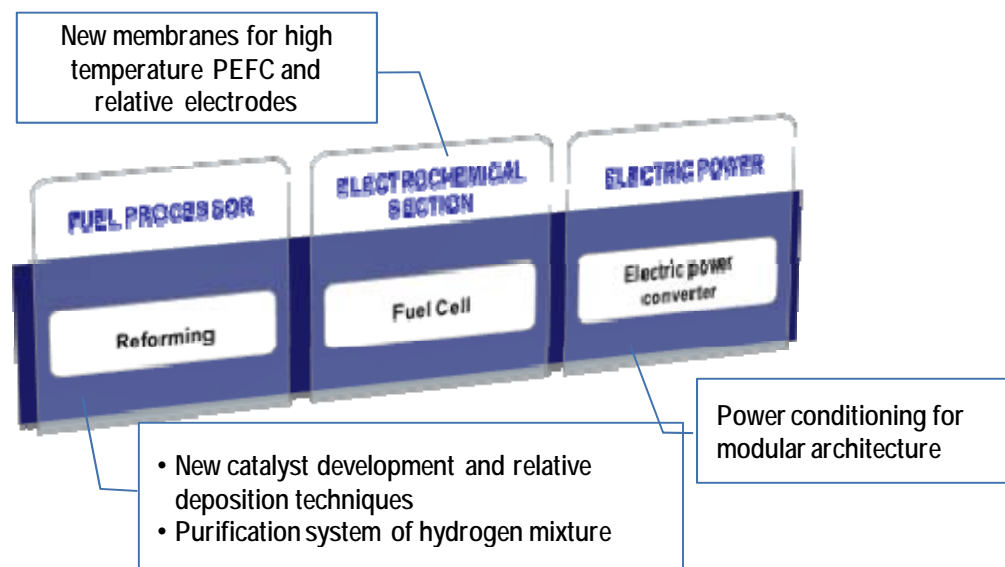
## “Industria 2015” Program



INDUSTRIA 2015

### MICROGEN<sub>30</sub>

30 kWe CHP system based on polymer electrolyte fuel cells fed by natural gas for residential applications



#### Main Objectives:

- ◆ high electrical efficiency (higher than 35%, and up to 40%, 10% higher than existing systems),
- ◆ global efficiency up to 85-90%,
- ◆ very low polluting gas emissions,
- ◆ high reliability and costs comparable with that of centralized boilers.

MICROGEN 30 presents **innovations** with respect to the systems actually in use, in terms of **design and performance of single components**



## Regional and industry Demo activities (1)

- **Lightening Ercolano ruins (PV 30 kW; FC 10 kW)**
- **FC blue car (7kW): Emilia Romagna Region**
- **PEM cogeneration unit: ICI Caldaie Sidera: (electricity, heating, cooling: H2 from NG ref)**
- **LEAF: zero emission building (advanced insulation and H2 storage)**
- **IDRA 08: Piedmont region: Polytechnic Torino: FC and high efficiency electric engine**
- **Celco YACHT: Piemonte Reg: Environmental Park (FC 8kW for auxiliary power gen: H2 from diesel reforming on board)**





## Regional and industry Demo activities (2)

- **TURBOCARE: (Siemens): FC powered canteen**
- **“IMPETUS” (Idrogeno marino per energie terrestri utilizzabili e sostenibili) is a project funded by the Italian Ministry for Environment Land and Sea (240k€) aimed to H2 production by electrolysis from waves . H2 will be used to fuel a public bus.  
Partners : University of Palermo, Consortium of University of Trapani and SGES (SME) The plant will be realized near Torre di Ligny.**
- **FCLAB (PON):Campania Region, just approved**
- **Energy District: Campania Region, just approved**



## Regional and industry Demo activities (3)

### **First hydrogen power plant (ENEL)**

- This power plant is situated in Fusina, near Venice in the Veneto region.
- Powered by hydrogen by-products from local petrochemical industries such as the ENI group's Polimeri Europa factory,
- Can meet the needs of 20,000 families, while saving emissions equivalent to more than 17,000 ton CO<sub>2</sub>eq/y.
- The power station forms part of a project dubbed Hydrogen Park



## Research Program for Electric System

- 3 years program 100% founded by Ministry of Economic Development, concerning:
  - Energy systems: both conventional (turbines, ICE) and innovative (FC)
  - Fuels: clean coal, H<sub>2</sub> (from fossil, from renewable, from wastes), secondary fuels, biomass, biofuels
- ENEA has, for the second year, about 20 M€ for several projects, among these:
  - ✓ MCFC integration into waste to energy chain (2 M€)
  - ✓ Clean coal: gasification and use of syngas both in gas turbine and in MCFC
- ENEA is waiting for the the approval of the new 3 years program



## Research Program for Electric System

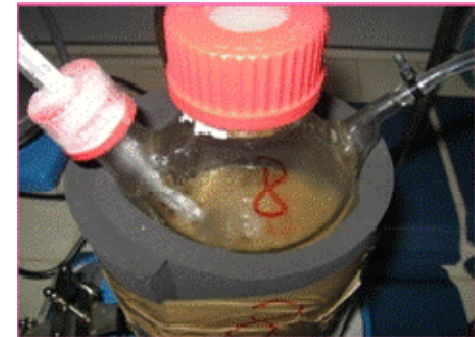
### Biomass gasification coupled with high temperature fuel cells (SOFC – MCFC)

- ◆ System engineering
- ◆ Construction and testing of a 125 kW MCFC plant fuelled with biomass gasification (Trisaia Research Centre)



### Anaerobic Digestion

- Selection of suitable bacteria and process parameters
- Development of system fuelled with biogas (catalysts for gas clean-up, study of the influence of contaminants on cell performance (MCFC))
- Development of pilot scale systems (1 kW)





## R&D EU FP Projects (6&7 FP)

- **ZERO REGIO** FC cars and stations, Mantova & Frankfurt
- **ENFICA FC** Politecnico Torino, City Aircraft
- **HOST** Roma Univ, New concept of city cars & city vehicles
- **LIFE** Emilia Romagna Reg, City bus Mix H<sub>2</sub>/NG





## R&D EU FP Projects: ENEA EU Project

- **COHYGEN**      Sotacarbo, ENEA, Ansaldo Ricerche, University of Cagliari
- **HYRAIL**      ENEA & Pisa University, H2 in railways
- **UNIQUE**      Aquila University & ENEA, H2 from biomass gasification
- **H2FC INFRA**      KTI, ENEA
- **COMETHY**      ENEA, H2 production via NG low temperature reforming using solar concentrators



## R&D EU FP Projects: ENEA EU Project

### ◆ FCTES<sup>QA</sup>

Definition of testing procedures, codes and standards for FC in several application (2006-2009)



### ◆ FCTEDI

Dissemination of FCTES<sup>QA</sup> results and analysis of what is needed about normative, codes and standards for FC in stationary applications (2006-2009)



### ◆ HYSYS

Components developments for hybrid vehicles on Fuel Cell (2005-2009)



### ◆ MCFC-CONTEX

Study of degradation mechanism of MCFC and clean up systems ( FCH JU 20092-2012)



### ◆ FC-HY Guide

Development of a Manual for LCA applications to fuel cell (FC), for PEMFC, SOFC, MCFC (2010)

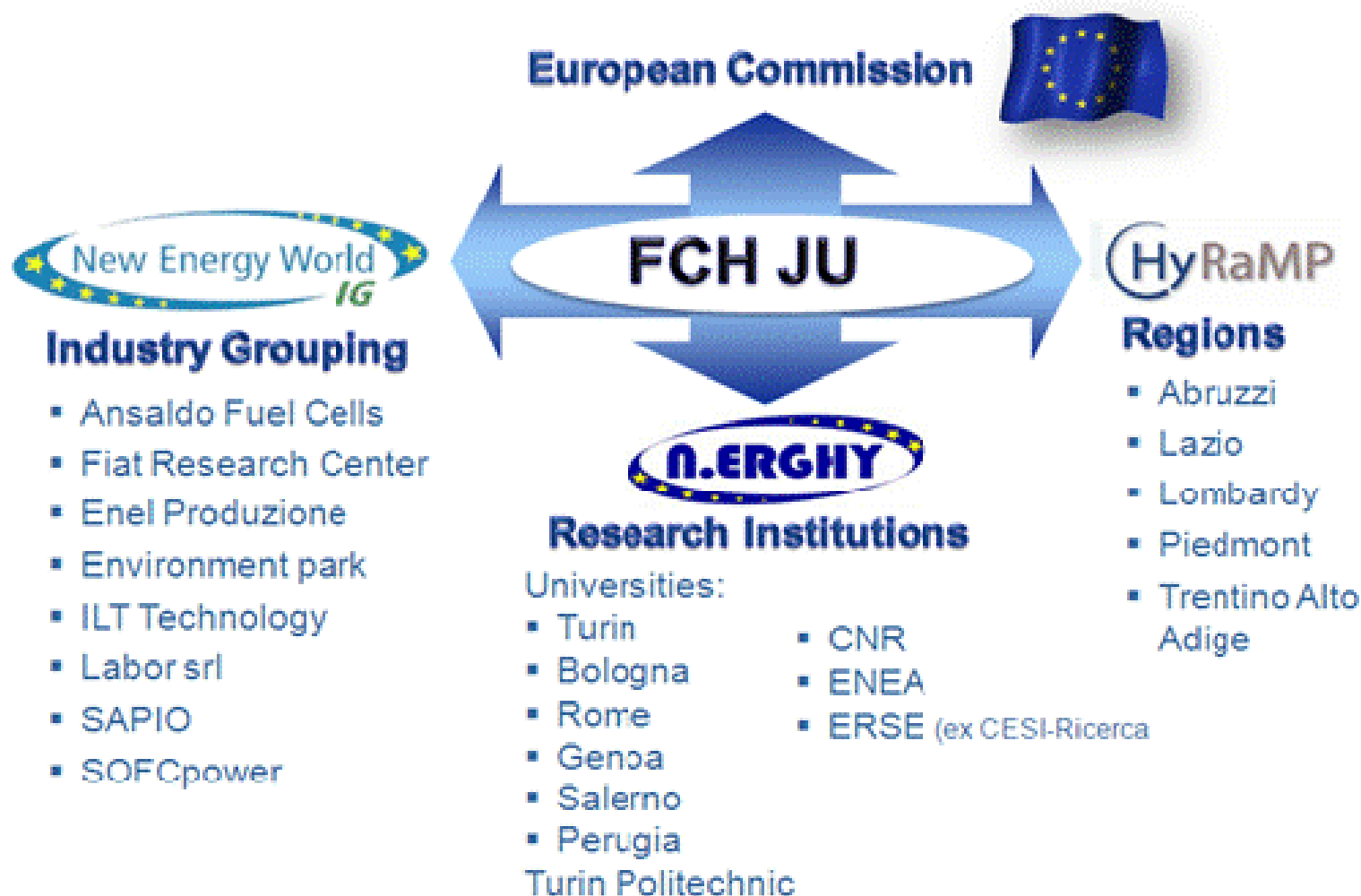


### ◆ FC-EuroGrid

Development of benchmarks and targets for stationary fuel cell applications in Europe (2010-2012)



## JU: Italian participation

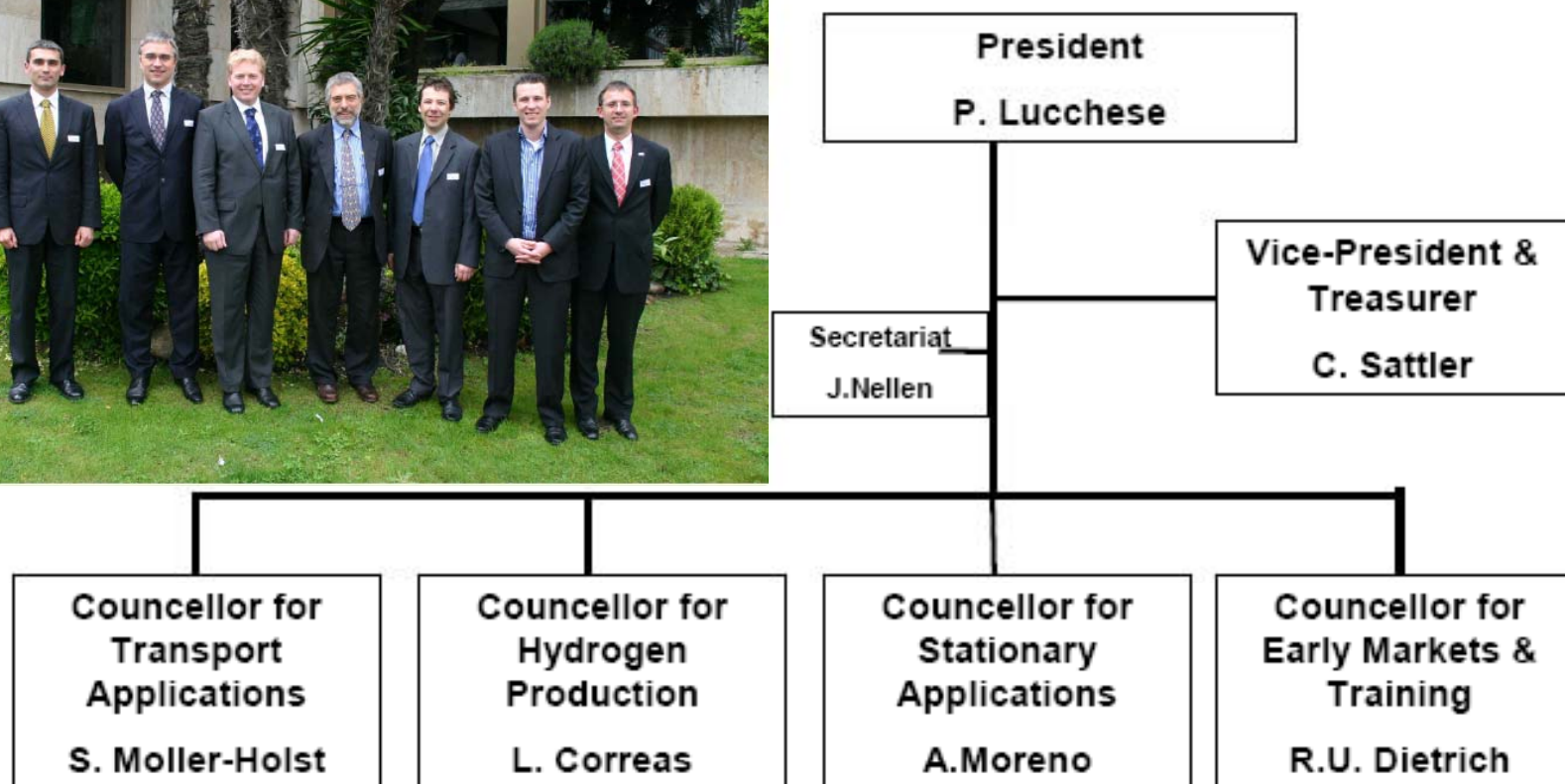




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## N-ERGY Board





## European Energy Research Alliance: EERA

- In framework of European Strategic Energy Technology Plan (SET-plan), fifteen leading European Research Institutes have taken up the challenge to found a **European Energy Research Alliance (EERA)** to contribute to achieve Europe 2020 and 2050 targets and visions on greenhouse gas emissions, renewable energy and energy efficiency fostering the deployment of more efficient and new technologies.
- Thus key objective of the EERA is to accelerate the development of new energy technologies by conceiving and implementing Joint Research Programmes in support of the SET plan pooling and integrating activities and resources, combining national and Community sources of funding and maximising complementarities and synergies.
- An overall number of 13 Joint Programmes have been started since EERA was launched





## EERA: 13 Joint programs (JP)

- |                  |  |
|------------------|--|
| 1. Photovoltaic, | 8. Concentrated Solar Power            |
| 2. Wind Energy,  | 9. Carbon Capture and Storage,         |
| 3. Smart Grids,  | 10. Materials for Nuclear              |
| 4. Geothermal,   | 11. Advanced Materials & Processes for |
| 5. Smart Cities  | Energy Applications,                   |
| 6. Bioenergy,    | 12. Energy Storage                     |
| 7. Ocean Energy, | <b>13. Fuel Cells and Hydrogen</b>     |

More than 2000 researchers from over 150 public research centres and universities are actively collaborating today in the EERA JPs identifying and bringing together national centres of excellence in the energy research sector, and highlighting common needs, objectives and areas of research for the 2013-2020 programming period.

<http://www.eera-set.eu/>



## General structure of FCs&H2 JP

### ***Guidance principles for JP structure***

- Dedicated both to FC and H2, with more focus, in the launching phase, to FC and electrolyzers
- Open to further implementation of new sub programs according to internal decisions
- “Function oriented” topics and FC technology neutral. All type of fuel cells can be investigated in relation with the established topics.
- Constant interaction with other JPs strictly linked with FC&H2 JP

### ***Six sub-programs***

1. Electrolytes
  2. Catalysts & Electrodes
  3. Stack Materials and Design
  4. Systems
  5. Modelling, Validation and Diagnosis
  6. Hydrogen Production and Handling
- ... possibly more sub-programs in the future



## Partnership and Resources

n.	Name	Country	Role	Resource committed (Person years per year)
1	<i>ENEA</i>	<i>Italy</i>	<i>JP Coordinator</i>	<i>13,00</i>
2	<i>CNRS</i>	<i>France</i>	<i>SP Coordinators</i>	<i>18,00</i>
3	<i>SINTEF</i>	<i>Norway</i>		<i>5,00</i>
4	<i>FZ-Jülich</i>	<i>Germany</i>		<i>5,00</i>
5	<i>VTT</i>	<i>Finland</i>		<i>5,50</i>
6	<i>CEA</i>	<i>France</i>		<i>6,10</i>
7	<i>UoB</i>	<i>United Kingdom</i>		<i>12,00</i>
8	<i>NBFCE</i>	<i>United Kingdom</i>	<i>Participant</i>	<i>17,00</i>
9	<i>DLR</i>	<i>Germany</i>		<i>6,50</i>
10	<i>JRC</i>	<i>EU/Netherlands</i>		<i>5,00</i>
11	<i>CNR</i>	<i>Italy</i>		<i>12,60</i>
12	<i>TUD</i>	<i>Netherlands</i>		<i>8,00</i>
13	<i>CIEMAT</i>	<i>Spain</i>		<i>5,00</i>
14	<i>Risø-DTU</i>	<i>Denmark</i>		<i>8,00</i>
15	<i>POLITO</i>	<i>Italy</i>	<i>Associate to ENEA</i>	<i>2,00</i>
16	<i>UoU</i>	<i>United Kingdom</i>	<i>Associate to UoB</i>	<i>2,00</i>
17	<i>IMPPAN</i>	<i>Spain</i>	<i>Associate to UoB</i>	<i>1,00</i>
			<b><i>SUM</i></b>	<b><i>131,70</i></b>

***17 members***

- *14 participants*
- *3 associates*
- *10 countries*

***HR commitment***

*131,7 py/y*



## Italian Energy Research Alliance: AIREN

- The “Alleanza Italiana per la Ricerca sull’Energia (AIREN)” in 2011 was started by the Ministry of Research (MIUR) launching a working group composed by 5 Italian research institutions.
  1. ENEA
  2. CNR
  3. Polytechnic of Turin
  4. Polytechnic of Milan
  5. Polytechnic of Bari
- Main goal of AIREN is the promotion of synergies at national level with the aim of improving the impact in EERA of Italian research institutions
- A report on the status of the art of research activities in Italy has been prepared by the WG: a) activities b) main players, c) infrastructures, d) filed of excellences .



## Status of Fuel Cell activities in Italy

### ***PEFC***

- ◆ MICROGEN project - 30 kWe CHP for residential applications
- ◆ Development of systems for transportation
- ◆ Prototypes of FCEV (car, bus, scooter)

### ***MCFC***

- ◆ Development of systems for stationary applications
- ◆ Development of integrated system based on "Waste to energy systems" and on biomass
- ◆ MCFC for CO<sub>2</sub> separation

### ***SOFC***

- ◆ Basic research on novel materials and components
- ◆ EFESO Project - 1-2.5 kW micro-CHP

### ***DMFC***

- ◆ Basic research on materials and components
- ◆ Development of stacks for portable applications



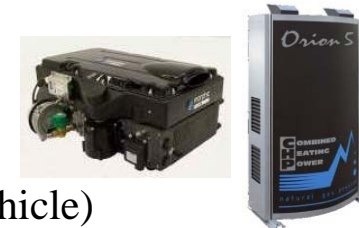


## Fuel cells: Industrial situation

**PEFC**



- Units in the range 150 W- 5 kW for different market sectors
- 1-5 kW CHP systems (LPG)
- 5 kW APU power generators (hydrogen)
- Power modules for transport use (fork lift, small hybrid vehicle)



Small-medium size  
micro-cogeneration systems  
(30 kW) fed with NG



3-7 kW UPS units fuelled  
with hydrogen



**MFC**

Several SMEs active as possible system integrator and /or  
end-user (NG and Biogas). Projects under discussion with  
FCE – USA ,Danbury and FCES (Fuel Celle Energy solution)  
Germany-Dresden



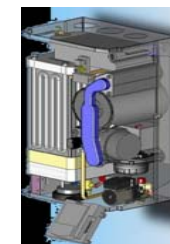
**SOFC**



Components and stack for integration  
in cogeneration systems (0.5-5 kW)

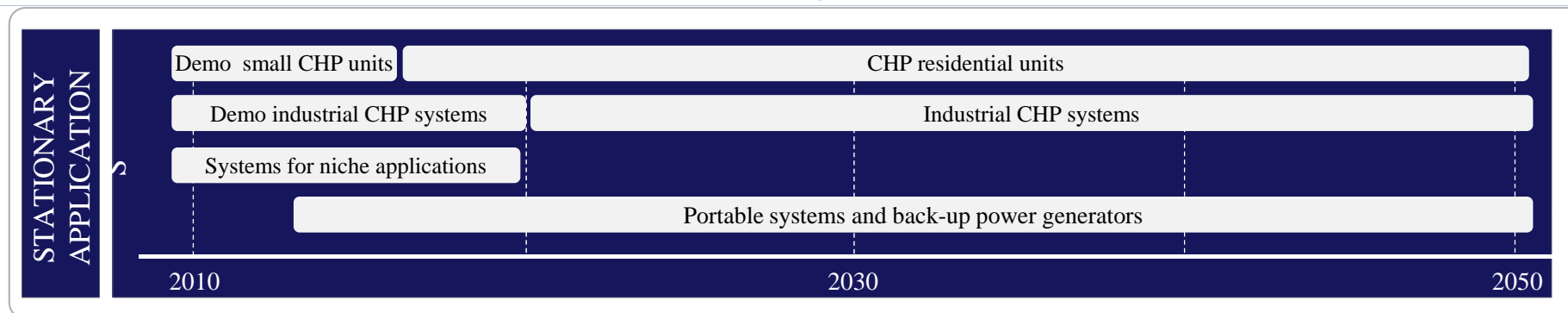


1-2.5 kW micro-CHP systems



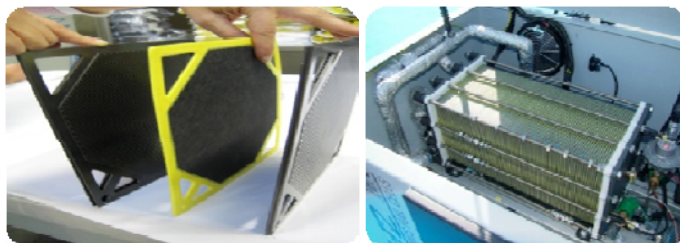


## Fuel cells for stationary power applications



### Basic research activities

- ◆ Improvement of fuel cell performances and cost reduction through the development of innovative materials and components and development of relative manufacturing processes



### Systems under

- ◆ Portable units for camping and leisure markets (< 1 kW) - *PEFC, DMFC*
- ◆ CHP systems for residential uses up to 30 kW - *PEFC, SOFC*
- ◆ 1-7 kW generators for back-up power and telecommunication sector - *PEFC*
- ◆ 100 kW - 1 MW plants for distributed generation - *MCFC*





# ENEA Activities on Hydrogen and Fuel Cell

## HYDROGEN

- *Sustainable production from renewables and fossil fuels*
- *Materials for hydrogen storage (metal and chemical hydrides)*
- *Vehicle testing*



## FUEL CELLS

*Development and demonstration of:*

- ◆ *polymer electrolyte fuel cell for stationary and transport applications*
- ◆ *molten carbonate and solid oxide fuel cell for on-site and distributed generation*







## Hydrogen production from fossil fuels

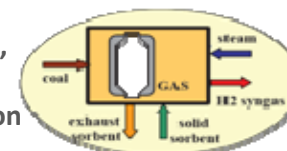
### Coal gasification for hydrogen & power generation with zero emissions and very high efficiency

- ◆ Experimental tests in lab. test rigs
- ◆ Process simulation/optimization
- ◆ Design and realization of plant
- ◆ Process control and integration

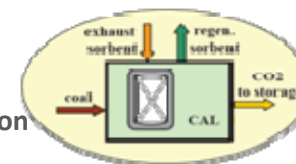
MIUR-FISR Project / **TEPSI**, 2005-2010 coordinated by ENEA

Partners: Ansaldo Ricerche, Universities of Rome "La Sapienza", "Roma 3", L'Aquila, Cassino, Polytechnic of Milan

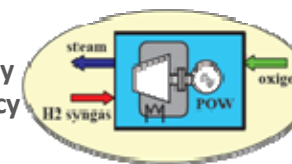
Coal gasification,  
CO<sub>2</sub> capture,  
and H<sub>2</sub> production



CO<sub>2</sub> separation and  
sorbent regeneration



Electricity production by  
advanced high efficiency  
H<sub>2</sub>-O<sub>2</sub> gas turbine cycle



**ZECO**  
mx

### Combined production of hydrogen and electrical energy from coal gasification

- ◆ Pilot platform at the Sotacarbo Research Centre (Sardinia)
  - ✓ 35 kg/h laboratory plant
  - ✓ 700 kg/h pilot plant
- ◆ Modeling activities: component and system simulation

**COHYGEN** Project - European Commission / MIUR, coordinated by Sotacarbo

Partners: Ansaldo Ricerche, University of Cagliari



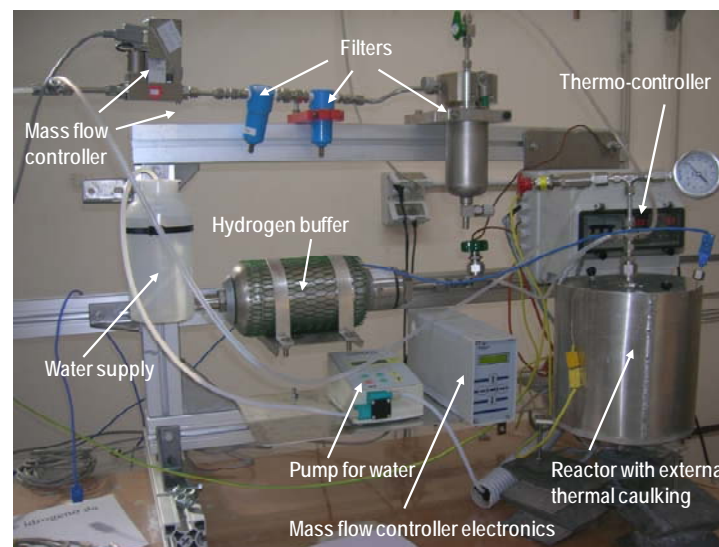


## Material for hydrogen storage

### Chemical Hydrides

- ❖ Study of materials and processes (based on hydrolysis of  $\text{NaBH}_4$ , solid and in solution, with suitable catalysts)
- ❖ Development and testing of laboratory prototypes
- ❖ Collaboration with industries for small  $\text{H}_2$  generators and fuel supply systems of portable fuel cells

MIUR-FISR Project / **TECSA** 2005-2010 coordinated by ENEA  
Collaboration with Defence Ministry



Hydrogen by  $\text{NaBH}_4$  hydrolysis  
ENEA facility with the parallel configuration reactor

$\text{H}_2$  generator from  $\text{NaBH}_4$  in  
alkaline solution  
(ENEA, ErreDue srl)







## Hydrogen fuel cell vehicles

### Irisbus Project / CRF-Iveco, GTT, Sapio, ENEA, CVA, Ansaldo

- ◆ Demonstration of a hybrid fuel cell bus

*ENEA activities* : Field tests to evaluate vehicle energy performance (fuel consumption, reliability) and emissions



### Neo project / Microvett, Exergy Fuel Cells, Sapio, ENEA

- ◆ Development and demonstration of a hydrogen-powered light duty vehicles

*ENEA activities* : Field tests to evaluate vehicle performance and test procedures focused at vehicle certification (ENEA. Brasimone)



### Realization of a filling station for hydrogen vehicles at ENEA Brasimone Research Center

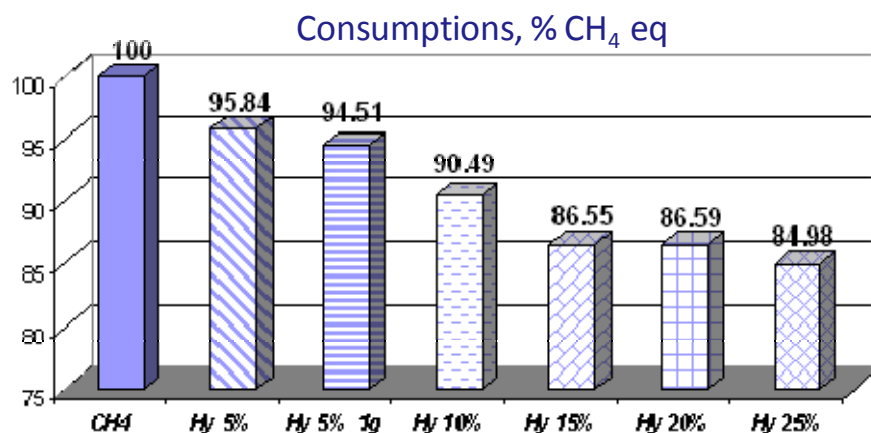
*The project is co-financed by Emilia Romagna Region*





## Blends of natural gas and hydrogen in ICE vehicles

- ◆ Bench test of vehicle (IVECO Daily) and road test of ICE buses (Bredamenarinibus) with blends at different hydrogen content (5-15%)
- ◆ Evaluation of vehicles performance, efficiency and emissions, with very positive results in terms of fuel consumption and emissions reduction





# Material for hydrogen storage

## Metal Hydrides

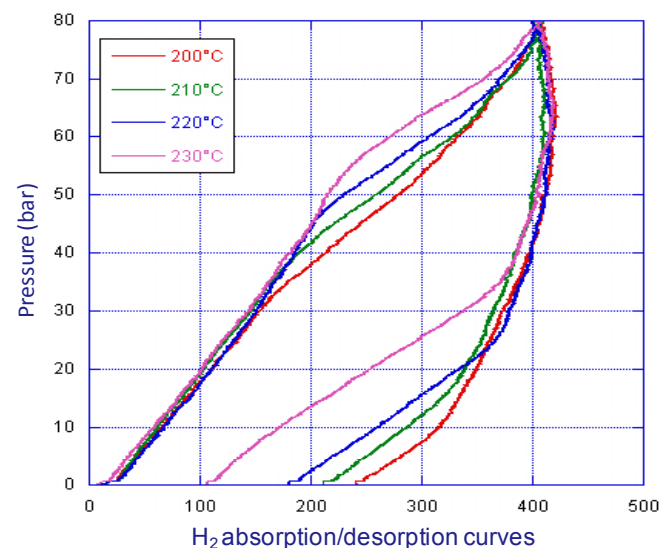
- ❖ Synthesis and characterization of alloys ( $\text{LaNi}_5$ ) embedded in polymeric matrices
- ❖ Study of complex hydrides ( $\text{NaAlH}_4$ )
- ❖ Study of magnesium based systems
  - Mechanical synthesis of nanocomposites ( $\text{MgH}_2$  + catalysts) to improve kinetics and cyclability
  - Production of Mg nanoparticles by inert gas condensation
  - Molecular dynamic simulations

MIUR-FISR Project / **TEPSI**, 2005-2010 coordinated by ENEA  
*Collaboration with CNR and Universities of Trento, Bologna, Padua*

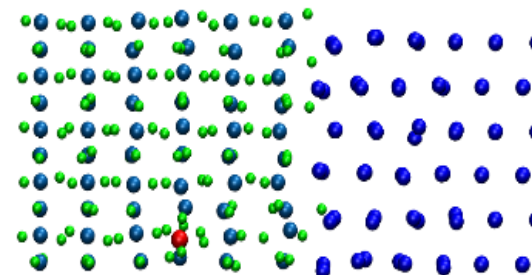
Innovative hydrogen storage systems for stationary and transport applications

MSE Industria 2015 / **HYDROSTORE** coordinated by Venezia Tecnologie

Carbon effect on  $\text{H}_2$  sorption in  $\text{NaAlH}_4$  and Ti doped  $\text{NaAlH}_4$



Mg atom replaced by Fe one in a snapshot of  $\text{MgH}_2/\text{Mg}$  interface





## Conclusion

- Lack of National framework, i.e. Italy has not yet a National Hydrogen and Fuel Cell platform
- As consequence, lack of incentives to promote hydrogen and fuel cells
- No clear strategy towards decentralized generation that could promote domestic and residential CHP systems, thus promote FC in the stationary
- Very scarce commitment of Italian car industry on FC cars
- Lack of continuity
- And ... of course “no funds”





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# Thank you for your attention

**Angelo Moreno**

National Agency for New Technologies,  
Energy and Sustainable Economic  
Development

Hydrogen and Fuel Cell Project



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