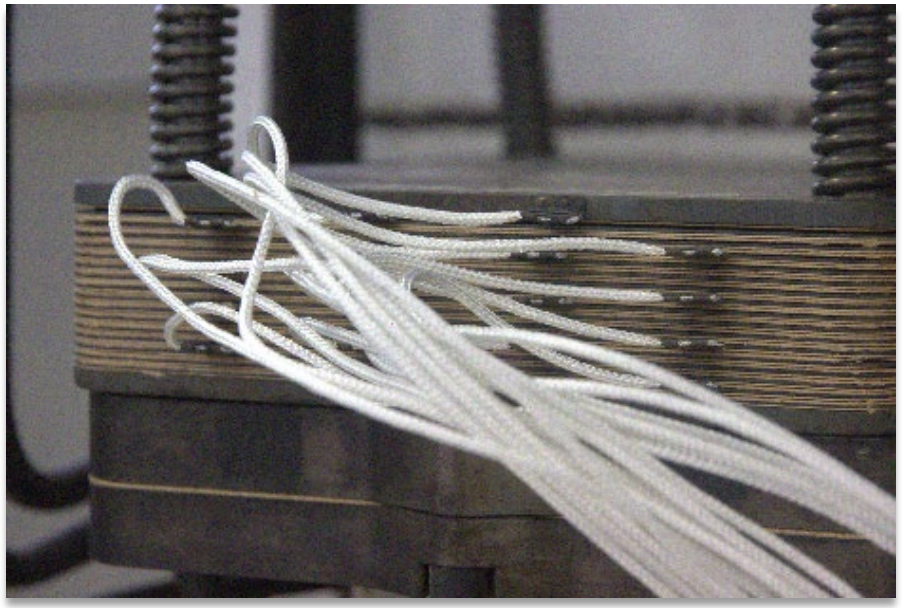






ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES, ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT

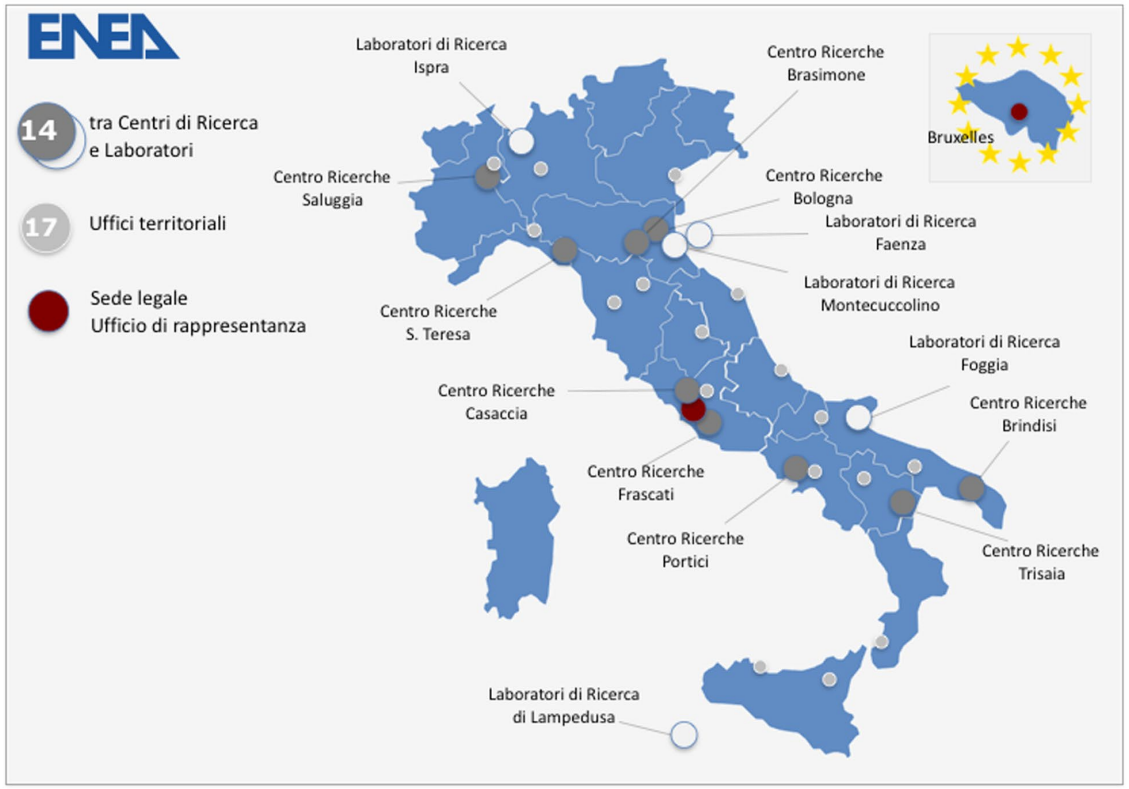
R&D perspectives for green and low-carbon hydrogen technologies

Alberto Giaconia

Head of the Laboratory for Hydrogen and new Energy Vectors (H2V)
Department of Energy Technologies and Renewable Sources (TERIN)
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development

ENEA: Italian National Agency for New Technologies, Energy and Sustainable Economic Development

- 4 Departments:
  - Energy Technologies and Renewable Energy Sources
  - Energy Efficiency
  - Environment and Sustainability
  - Fusion and Nuclear Safety
- 9 Research Centers
- a network of territorial offices providing information and consultancy services
- an ENEA-EU Liaison Office in Brussels
- ENEA headquarter in Rome



the 2nd Italian RTO
around 2200 staff units

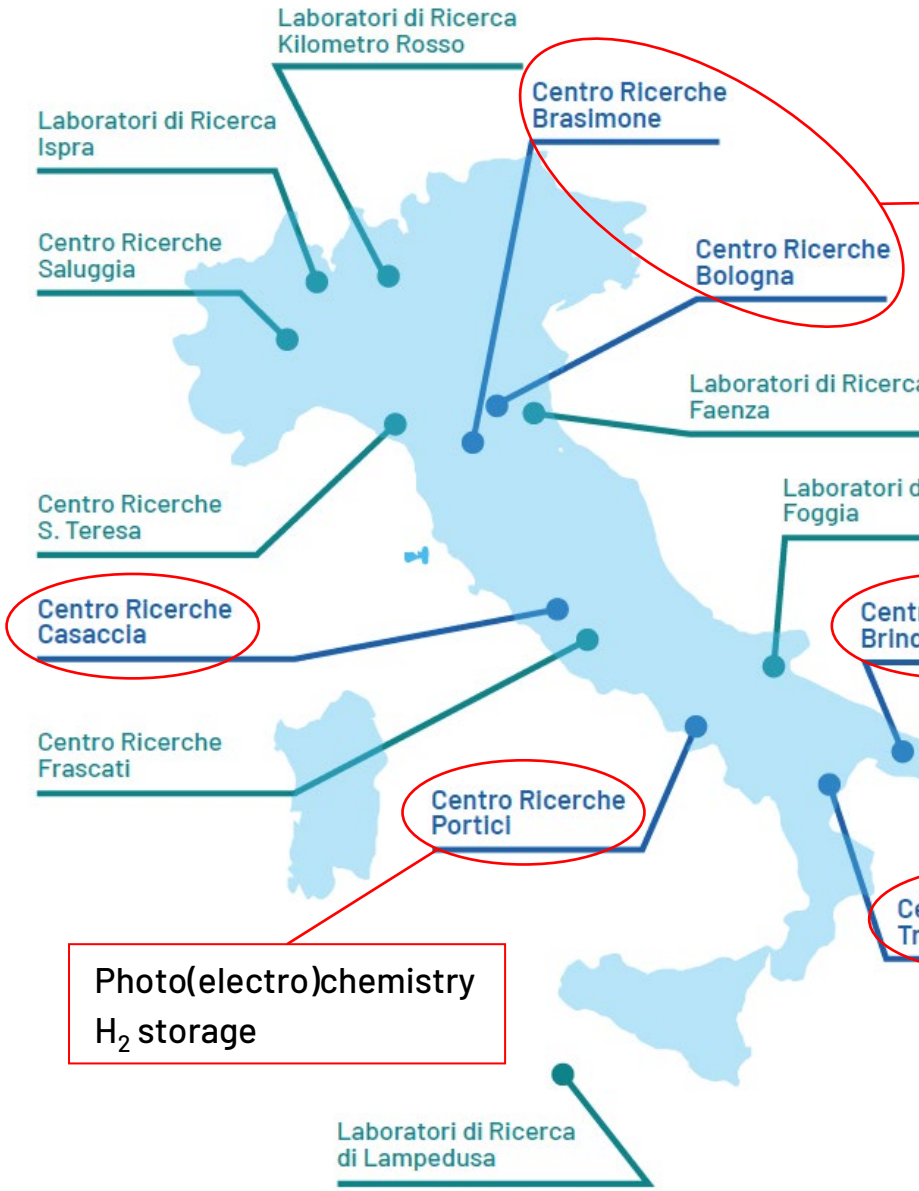
ENEA's hydrogen labs

total >100 staff including senior & young researchers, technicians and PhD

advanced materials
(electrodes, catalysts, membranes, etc.)
electrolysers:
- Low-T: Alkaline, PEM, AEM
- High-T: SOEC, MC, PCC

Fuel Cells:
- Low-T: PEM
- High-T: SOFC, MC

thermochemical processes
bioH2 & biogas
e-fuels
H_2 distribution (pure & blending)
H_2 combustion & turbines
H_2 mobility
IPCEI Hy2Tech labs (electrolysers, FC, mobility)
Pilot & demo plants
Hydrogen Demo Valley
Sustainability analysis (TE, LCA, etc.)



Electrolysers:
- Low-T: PEM, AEM

Fuel Cells:
- Low-T: PEM

e-fuels
Sustainability analysis (TE, LCA, etc.)

Advanced materials
(electrodes, catalysts, membranes, etc.)

biomass gasification
e-fuels
IPCEI Hy2Tech labs (H_2 storage)

Photo(electro)chemistry
H_2 storage

ENEA's hydrogen research project portfolio

Other National & EU projects

Ministero dell'Ambiente e della Sicurezza Energetica

MISSION INNOVATION
accelerating the clean energy revolution

RdS
RICERCA DI SISTEMA

Ministero delle Imprese e del Made in Italy

IPCEI HYDROGEN

Clean Hydrogen Partnership

prometeo

PROTOSTACK

SOFREE
Solid oxide fuel cell combined heat and power: Future-ready Energy

FuelSCIME

NHyRA

ALRIGH2T

H2Excellence

AMIGDALA

e-SHyIPS
ON THE WAVE OF HYDROGEN

HASTA
Hydrogen Aircraft Sloshing Tank Advancement

Innovations in the BIOMETHANE uniVERSE

H2 PORTS

THOTH2

HyPEF
TRACING CLEAN HYDROGEN

R&D activities on hydrogen

ENEA's R&D activities cover the whole H_2 value chain at different levels:

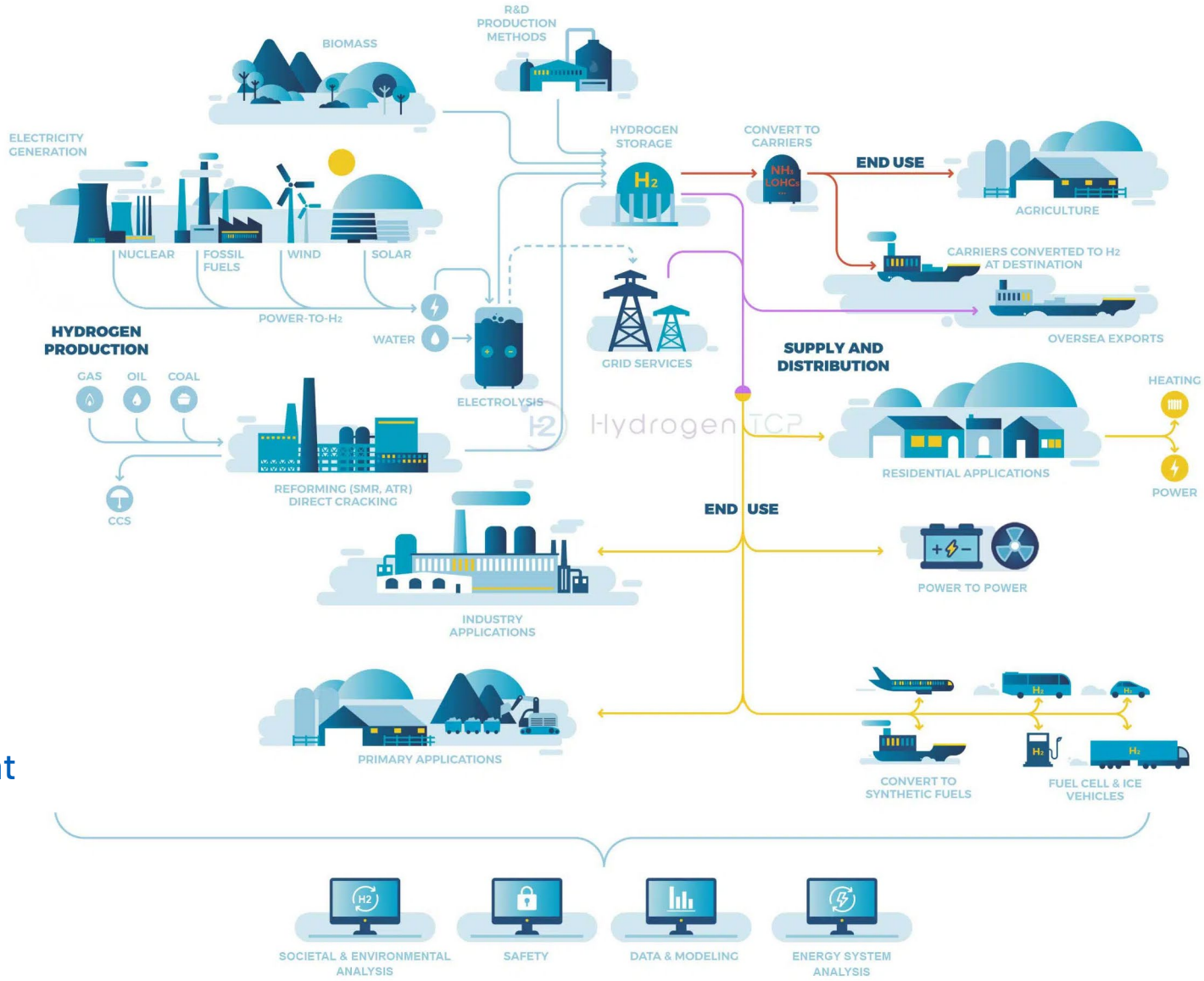
from fundamental research

for the development & characterization of advanced materials and components, with specific focus on sustainability, cost reduction and reduction of critical/strategic materials

to pre-commercial demonstration

with pilot lines and integrated systems for the production, storage, distribution and use of green and low-carbon H_2

plus:
technical-scientific support to stakeholders of different kind, pre-normative research, sustainability analysis (e.g. techno-economic studies, LCA, etc.), technology transfer, intnl. cooperation, training and education



source: IEA Hydrogen TCP, www.ieahydrogen.org

R&D activities on hydrogen

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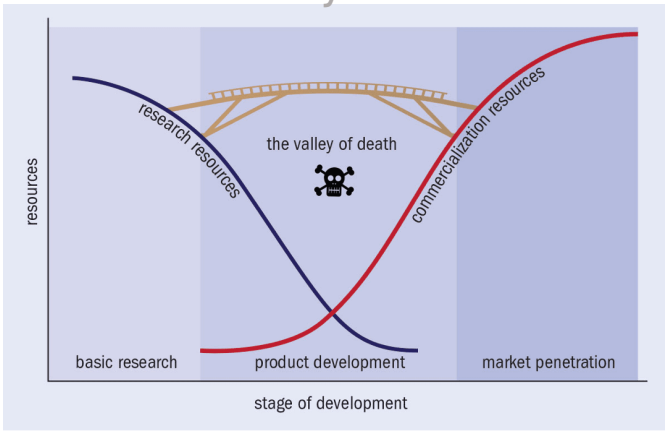
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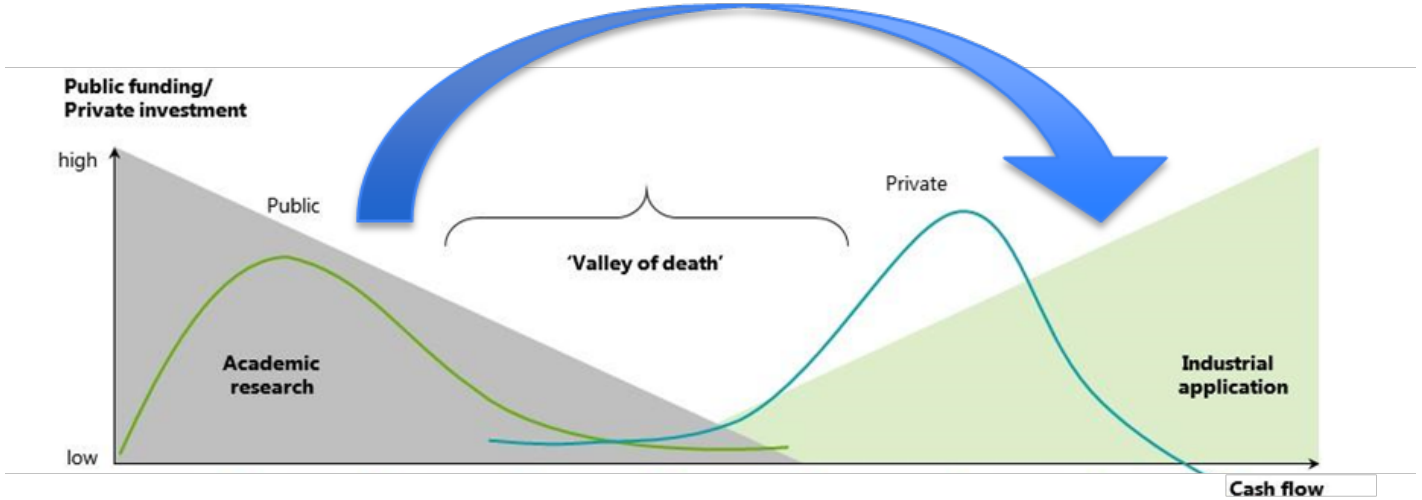
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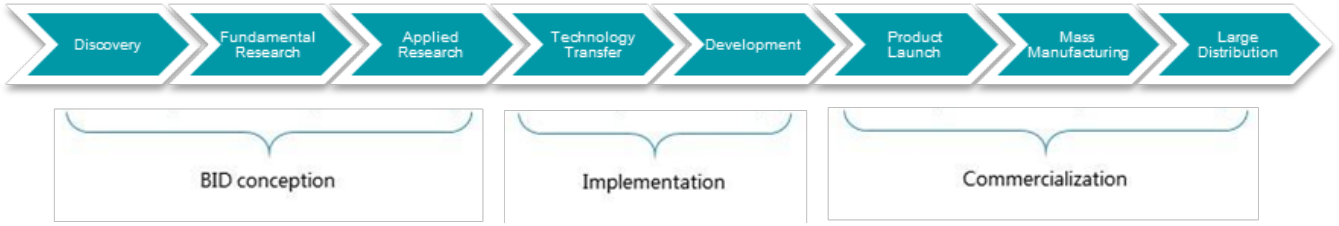
plus:
technical-scientific support to stakeholders of different kind, pre-normative research, sustainability analysis (e.g. techno-economic studies, LCA, etc.), technology transfer, intnl. cooperation, training and education

Filling the gap from fundamental/applied research to industrial application

the "valley of death"







R&D activities on hydrogen

- Green hydrogen production
  - Electrochemical (water-splitting)
  - Photo-Electrochemical (water-splitting)
  - Thermochemical Water-Splitting Cycles (TWSC)
  - Biotechnologies (bioH2)
  - Thermochemical conversion of (bio)wastes
- Hydrogen conversion to synthetic fuels
  - Methanation
  - e-fuels & electro-biofuels
  - Hydrogasification
  - Liquid Organic Hydrogen Carriers
  - Green ammonia production & cracking
- Hydrogen storage
  - Metal hydrides
  - High-p hydrogen gas storage
- End-use applications
  - Fuel cells (low- & high-temperature, reversible)
  - Combustion, Blending
- Other cross-cutting topics
  - Hydrogen distribution
  - Pre-normative studies
  - Hydrogen Refueling Stations (HRS)
  - Hydrogen systems demo & analysis



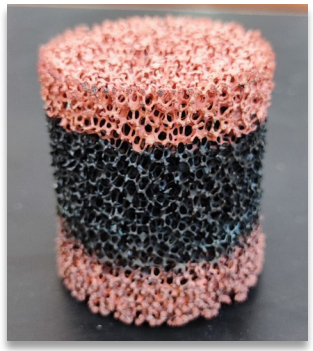


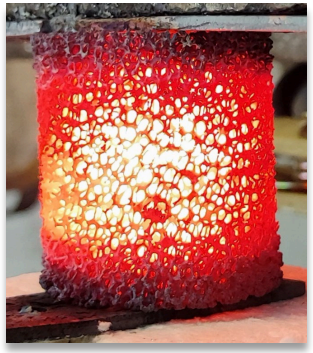


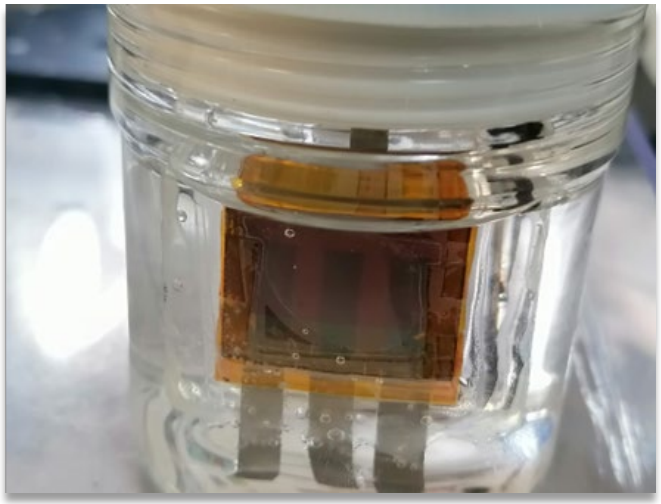


The different levels of hydrogen research....

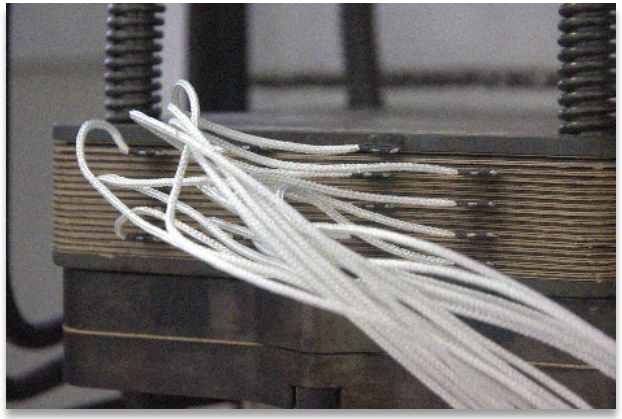
Materials



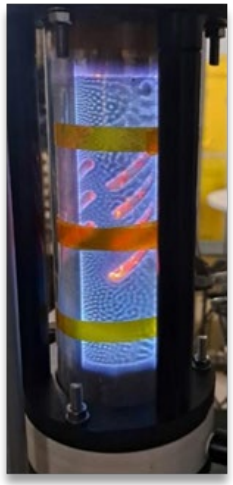




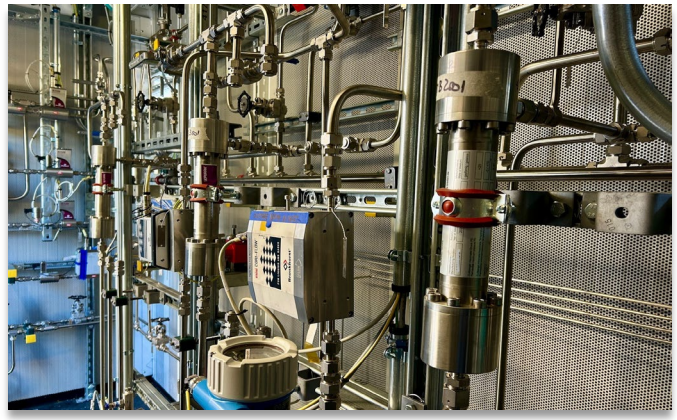
Components





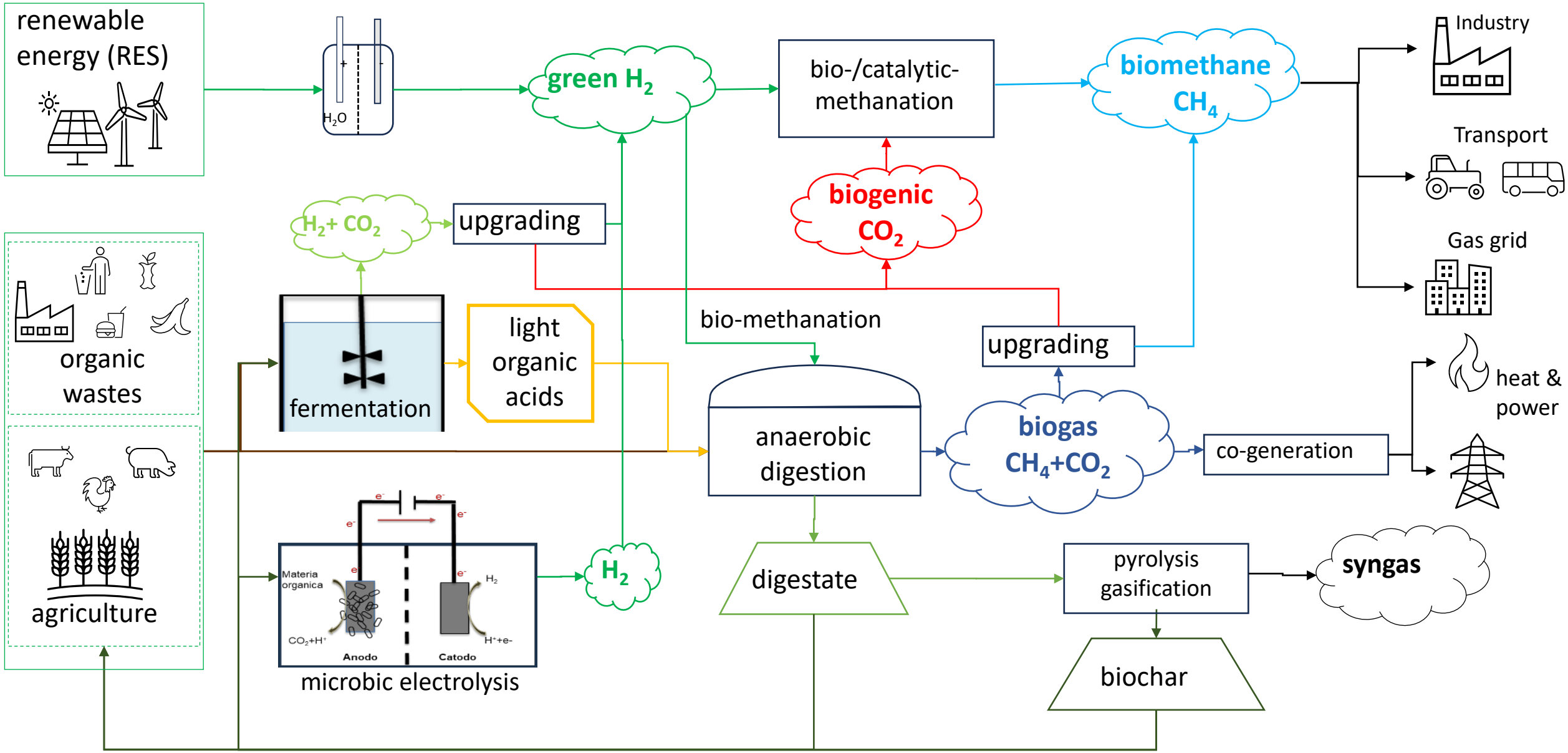


Systems





...and the multi-disciplinary approach – the case of "electro-biofuels"



ENEA's Hydrogen Demo Valley (HDV)

- Several technologies for green hydrogen production

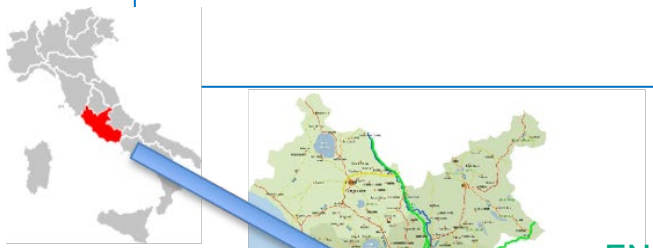
  Electrolysers (AE/PEM/AEM, SOEC), eSMR

- Hydrogen storage at different pressure levels

  200, 450, 900 bar

- Al least 10 end-uses

  Production of synthetic methane, hydrogen gas turbines, burners for residential and district heating, injection in gas grid (blending), PEM e SOFC fuel cells, H2 mobility (HRS), laboratories for components testing and quality assurance (IPCEI Hy2Tech)





ENEA-Casaccia Research Center, Rome





description	unit	value
Renewable Power Plant	kWp	260
Electrolyser installed power	kW	240
H_2 generation capacity	Nm^3/h	~ 50 *
H_2 storage (@200 bar)	kg H2	535
Pipeline	km	2

* 40 Nm^3 from low-temperature electrolysis (AE/PEM/AEM) + advanced units
** 6 000 Nm^3

ENEA's Hydrogen Demo Valley (HDV)





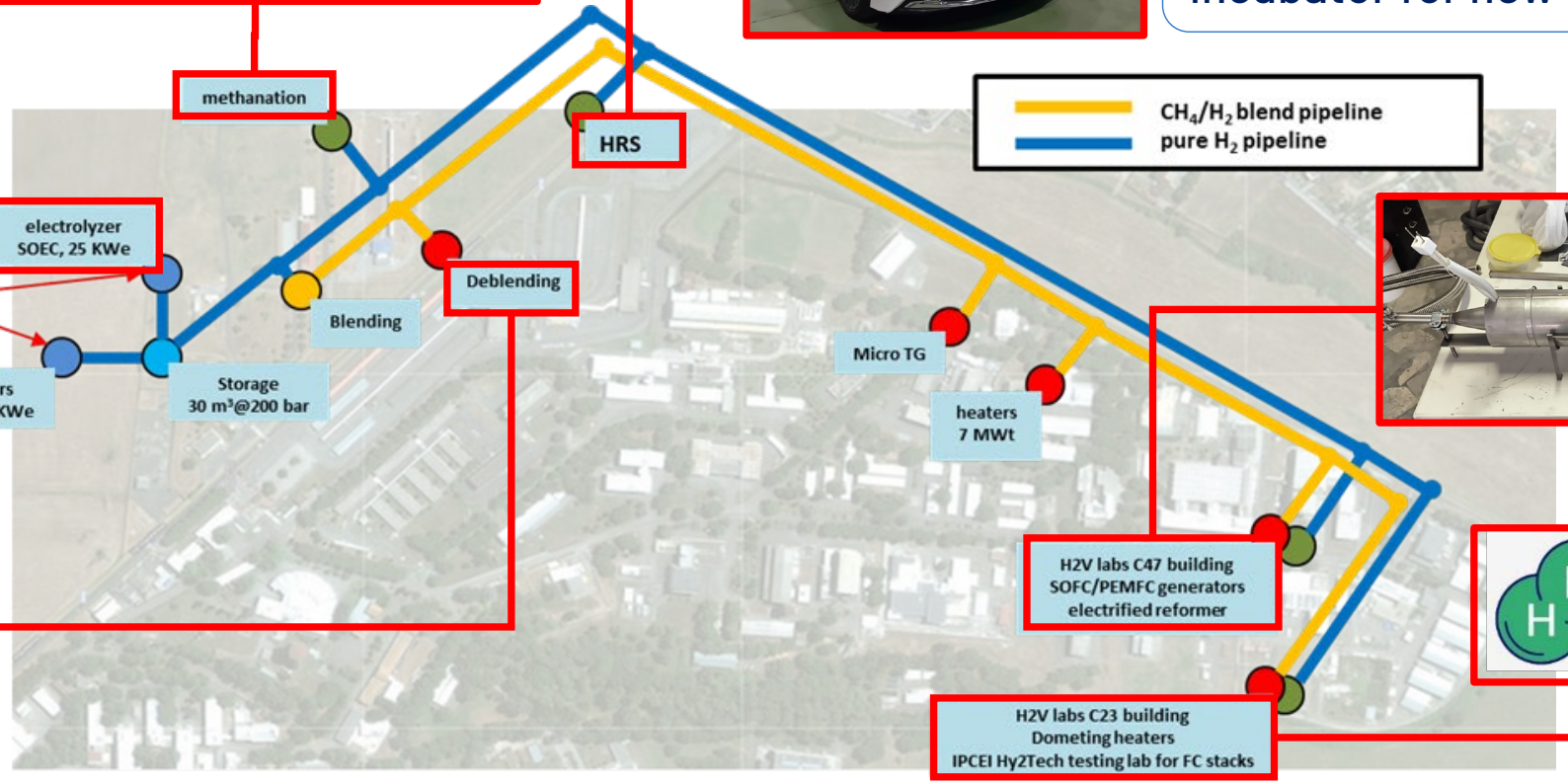


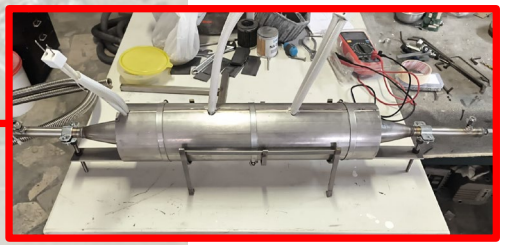
HDV is a:

model for energy transition

"open lab" for innovation

incubator for new technologies







IPCEI HYDROGEN

the Hydrogen Demo Valley (under development, executive project phase) scheme

Why blending hydrogen with natural gas?

Hydrogen blending in existing gas infrastructure can play a central role in unlocking the green transition:

- no extensive investment would be required
- several green H2 production plants have recently been commissioned, but off-takers' demand is still missing
- large H2 volumes can be transported over long distances
- gas cross-border transmission capacities are significantly high, improving countries' renewable energy exports/imports



To date, hydrogen blending is limited also due to uncertainties on the impact of new mixtures on the already installed devices in the gas value chain such as measuring ones.



However, the normative framework, including testing methodologies for Hydrogen and Natural Gas (H2NG) mixtures, is still under-construction.

Validated protocols are required to define the H2 limits and tolerances of the measuring devices installed in the NG grids.

THOTH2 project

Novel MeTHOds of Testing for measurement of natural gas and hydrogen mixtures

OVERALL OBJECTIVE

Develop and validate methodologies, protocols and testing facilities to assess gas-meter performance and degradation with H_2NG blends (up to 30 vol.% H_2) and pure hydrogen.

01

TESTING METHODOLOGIES

Develop validated test protocols and experimental facilities for existing gas meters.

02

H_2 TOLERANCE LIMITS

Determine the maximum hydrogen levels compatible with MID and other applicable requirements.

03

REGULATORY GAPS

Identify gaps in the current regulatory framework for gas metering with hydrogen.

04

STANDARDISATION

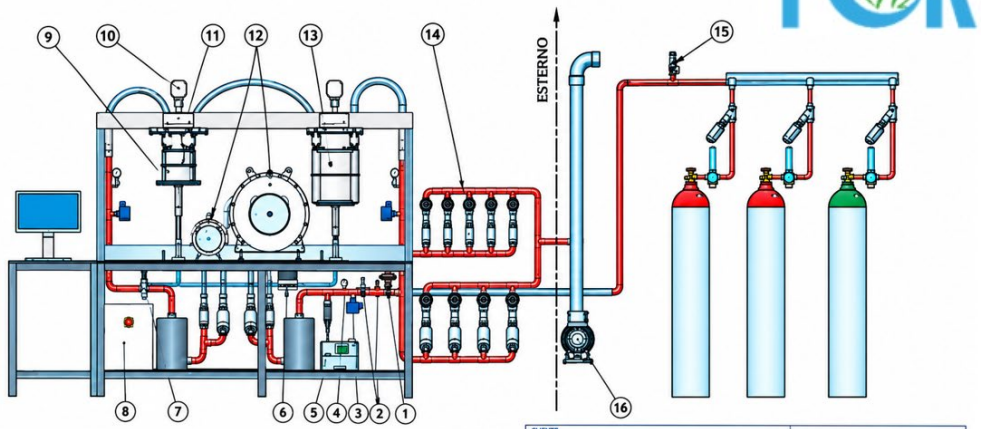
Provide recommendations to international technical committees for new or revised standards.

05 IMPACT & DISSEMINATION

Assess the impact of H_2NG blends on TSO/DSO metering systems and share project results and recommendations with stakeholders.

Validation of gas flow-meters for methane/hydrogen mixtures

- Development and experimental validation of a mathematical and numerical model for the metrological characterisation of gas flow meters operating with natural gas–hydrogen blends containing up to 20 vol.% H_2, through thermo-fluid dynamic simulations.
- Design and construction of an experimental test facility at ENEA Casaccia laboratories to carry out validation tests.
- Experimental testing with gas blends containing up to 20 vol.% H_2: a discrepancy was identified due to the pure methane calibration curve configured in the instrument. The model enables the determination of the correct characteristic curve.
- Analysis of different types of gas meters, including diaphragm, ultrasonic and thermal mass flow meters, subject to specific applicability and compliance standards.



NUMERO	DESCRIZIONE	NUMERO	DESCRIZIONE
1	Valvola di sicurezza	9	MUTF G4 (min 110mm)
2	Riduttore e stabilizzatore press.	10	Sensore rilevatore gas
3	Sensore di temperatura	11	Differenziali di pressione
4	Sensore di pressione	12	Manometro metro a liquido
5	Gascromatografo	13	MUTF G4-10 (min. 250mm)
6	Parco valvole	14	Uscite regolazione portate
7	Ingresso aria compressa	15	Valvola di sovrapressione
8	Quadro elettrico	16	Soffiante

CLIENTE: ENEA C.R. Casaccia
REALIZZATO DA: SAPI Srl
REVISIONE: 02/2024
APPROVATO DA:
DATA: 10/04/2024
NOME PROGETTO:
QUANTITÀ:
DESCRIZIONE: Banco di reazione
IMPIANTO: IMPIANTO TRATTAMENTO GAS
MATERIALE: AISI 304
CODICE: 000
SCALA:
RESSEL

Figure 1: Scheme of the gas meter test bench at ENEA Casaccia Labs

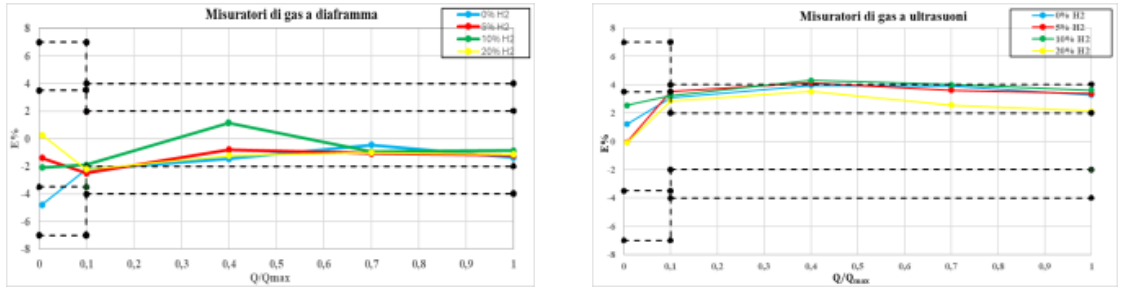


Figure 3: Error trends or diaphragm and ultrasonic meters.

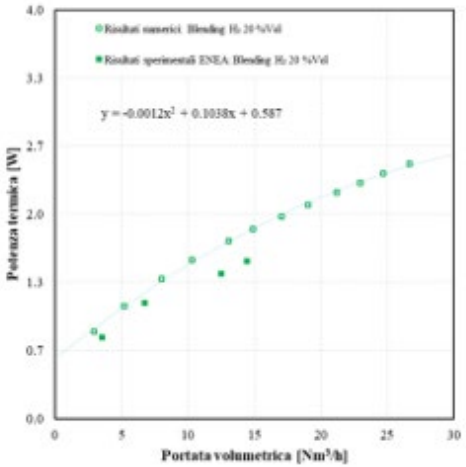


Figure 2: Comparison between the numerical characteristic curve and the experimental characteristic curve: 20 vol.% H_2/NG – insertion thermal mass flow meter.

Effects of Hydrogen Injection into the Natural Gas Network

Experimental tests aimed at characterizing and validating the performance of devices and instruments intended for hydrogen transport in natural gas (NG) distribution networks, using H_2/NG blends with hydrogen concentrations of up to 20 vol.%.
Tests were carried out at the Centria test facility in Arezzo, Italy.



Centria test facility in Arezzo

Pressure regulators testing (static and dynamic tests)



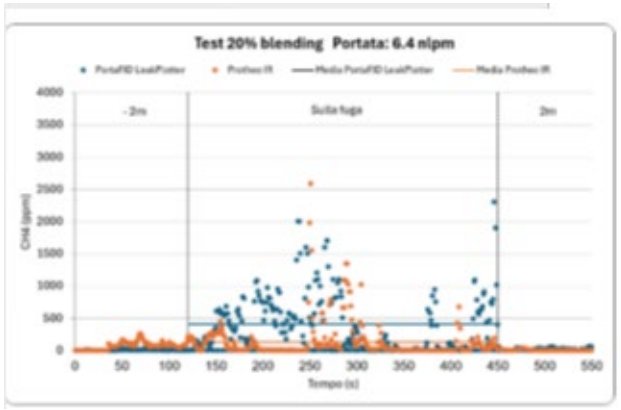
Pressure regulator assembly

Gas leak detection devices

Comparison of three detection technologies

Flame Ionisation Detector (FID), a Tunable Diode Laser Absorption Spectroscopy (TDLAS) infrared detector, and a prototype multiparameter sensor, tested with hydrogen blends at 10 and 20 vol.% and at different leakage flow rates.

High reliability of the FID detector across all flow rate levels, including in the presence of micro-leaks and hydrogen, whereas the TDLAS system showed some limitations at low flow rates.



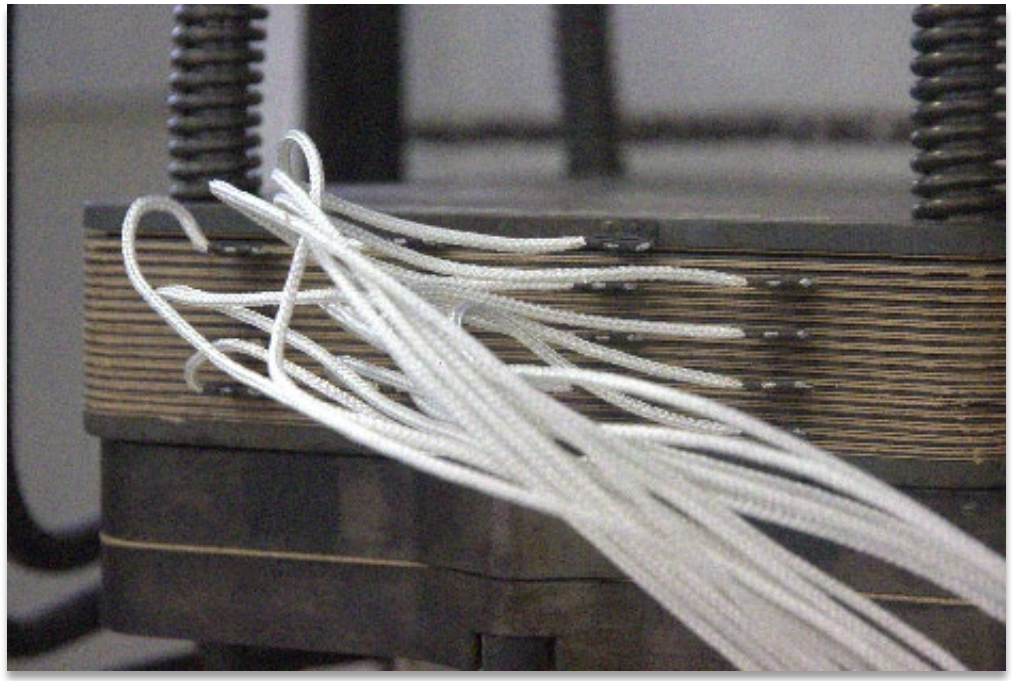
Comparison of the experimental results obtained using the flame ionisation detector (PortaFID) and the infrared detector (ProtheolR) with a mixture of 80% natural gas and 20% H_2 at different flow rates



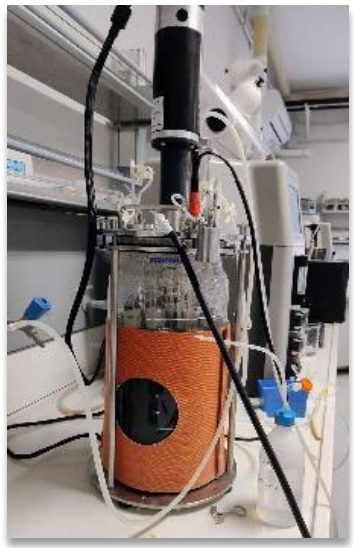
WT1 Pro Sensor (multiparameter sensor)



Development and validation of a three-dimensional CFD numerical model for the atmospheric dispersion of the gas mixture







Thank you for your kind attention

Alberto Giaconia

Head of the Hydrogen and new Energy Vectors Laboratory **(H2V)**
Division of Technologies and Vectors for Decarbonization **(DEC)**
Department of Energy Technologies and Renewable Sources **(TERIN)**

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