Consiglio Nazionale delle Ricerche

L’ingegneria delle membrane per la produzione, separazione ed utilizzo dell’idrogeno

Adolfo Iulianelli

National Research Council of Italy - Institute on Membrane Technology (CNR-ITM), via P. Bucci Cubo 17/C University of Calabria, 87036 – Rende (CS) – Italy
Ph: +39 0984 492011; E-mail: a.iulianelli@itm.cnr.it, adolfo.iulianelli@cnr.it



Convegno online ‘’*L’idrogeno nella transizione energetica: dalla circolarità del carbonio all’intensificazione di processo*’’ – Lunedì 23 novembre 2026, ore 15:00 – 17:00

www.cnr.it; areacs.cnr.it

CNR in figures 2026

People, research and organisation

Consiglio Nazionale delle Ricerche



1 **Italy's largest** research organisation for staff engaged in scientific activity

> 9,300 employees

51% Men

49% Women

58% researchers

7 Departments

- Physical sciences and technologies of matter
- Earth system science and environmental technologies
- Biomedical sciences
- Engineering, ICT and technologies for energy and transportation
- Social sciences and humanities, cultural heritage
- Chemical sciences and materials technology
- Biology, agriculture and food sciences

A distributed research network

83 Research Institutes

233 Extensive network of research institutes and laboratories nationwide

144 Facilities within the university network

31 Research units hosted by third parties

3 Permanent research bases at the Poles

1 Oceanographic vessel «Gaia Blu»

CNR counts over **9,371** employees, of whom **8,538** form its scientific community

340 Patent families

65 Spin-Off Enterprises

320 Collaborations

Memoranda of Understanding, Framework Agreements and Bilateral Agreements between CNR and other national and international public and private organisations

CNR actively engages with **society** through numerous outreach initiatives dedicated to the public at large, including **interactive scientific exhibitions**, exhibits at leading Italian and international science centers, conferences, and dissemination events.
Recent exhibitions, including "Anthropocene. The Earth on Fire", "Aquae. The Future Lies in the Ocean", and "Arctic. An Interactive Journey to the North Pole", highlight strategic research themes for the organisation.
The **113** exhibitions produced so far have attracted approximately

1,100,000 visitors

The organisation's records also include that of the first domain name registered in Italy): **cnuce.cnr.it**, which was registered in Pisa in 1987. Since then, CNR has managed and maintained the activities of .it domains through **Registro.it**, the official registry of Italian domain names.

2024 Total Budget*

€ 1.377.808.306,63

47%

Third-party funding

*source General Financial Statement 2024, total income

The organisation also carries out a wide range of science communication activities aimed particularly at **schools**. The catalogue **"CNR goes to school"** gathers over 150 multidisciplinary initiatives developed by the scientific network. It is an easy-to-use guide for teachers that enables them to select activities by geographical area, type of initiative, topic and educational level.

In this context, among the activities aimed at building and sustaining collaborations with civil society, CNR has a strong commitment to **Citizen Science (CS)** as a way to strengthen an open and constructive dialogue with the cultural, social, and economic fabric of diverse communities.
Since 2023, CNR has launched the **CNR Award for Citizen Science – Guglielmo Marconi Library**, recognising projects that actively engage citizens and adhere as closely as possible to the 10 Principles of Citizen Science defined by the European Citizen Science Association (ECSA).

Sources:
"Integrated Plan for Activities and Organization (PIAO) 2026-2028"
"General Financial Statement 2024"

Graphic design by:
CNR – Integrated Communications Unit
Last modified on July 8, 2026


Research Area of CNR di Cosenza: https://areacs.cnr.it



LA RICERCA VENUTA DAL FUTURO

1923 CNR 2023

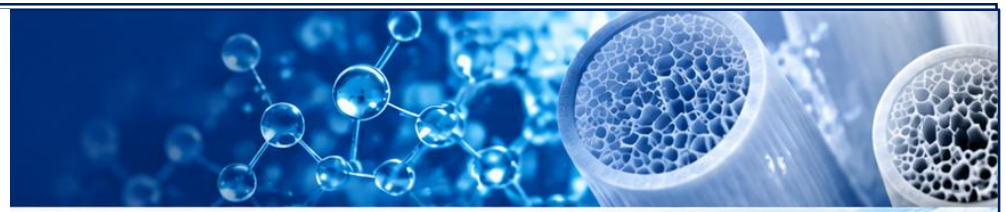
CNR

- 8 CNR Institutes
- 300+ Personnel Units



CNR-ITM in brief

Institute on Membrane Technology
National Research Council of Italy



The **Institute on Membrane Technology (CNR-ITM)** is a structure created in **1993** by the **Italian National Research Council (CNR – Consiglio Nazionale delle Ricerche)** for the development, at National and International level, of Membrane Science and Technology.

CNR-ITM is part of the **Department of Chemical Science and Materials Technologies (DSCTM)**.



Director: **Alberto Figoli**

Headquarter in **Rende (CS)**



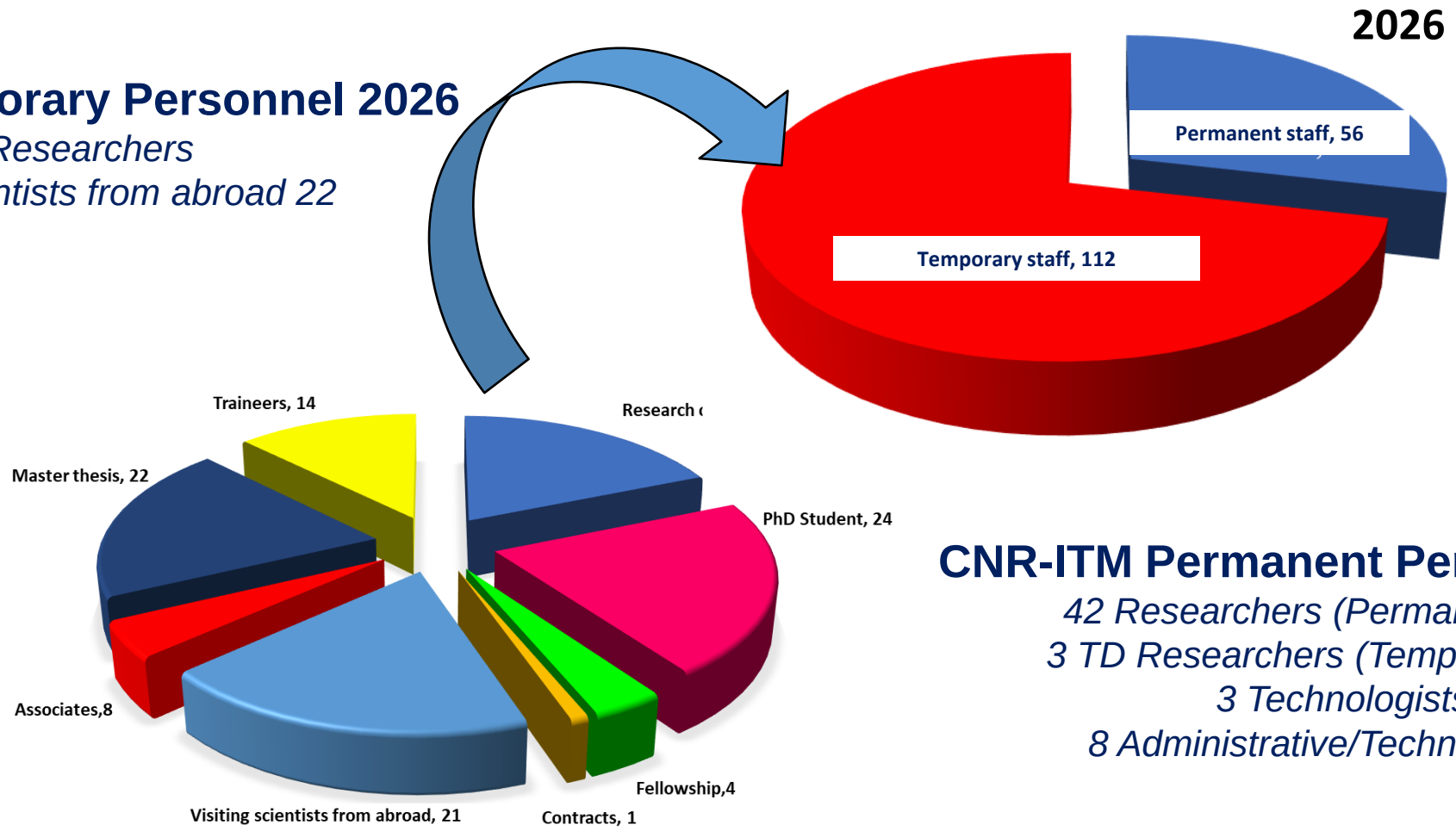
CNR-ITM in brief

CNR-ITM is a multidisciplinary CNR's institute based on backgrounds in chemical engineering, process engineering, chemistry, biological science, food science, material science, physic, geology etc.

CNR-ITM Temporary Personnel 2026

90 Researchers

Visiting Scientists from abroad 22



CNR-ITM Permanent Personnel 2026:

42 Researchers (Permanent Staff)

3 TD Researchers (Temporary Staff)

3 Technologists

8 Administrative/Technical Staff

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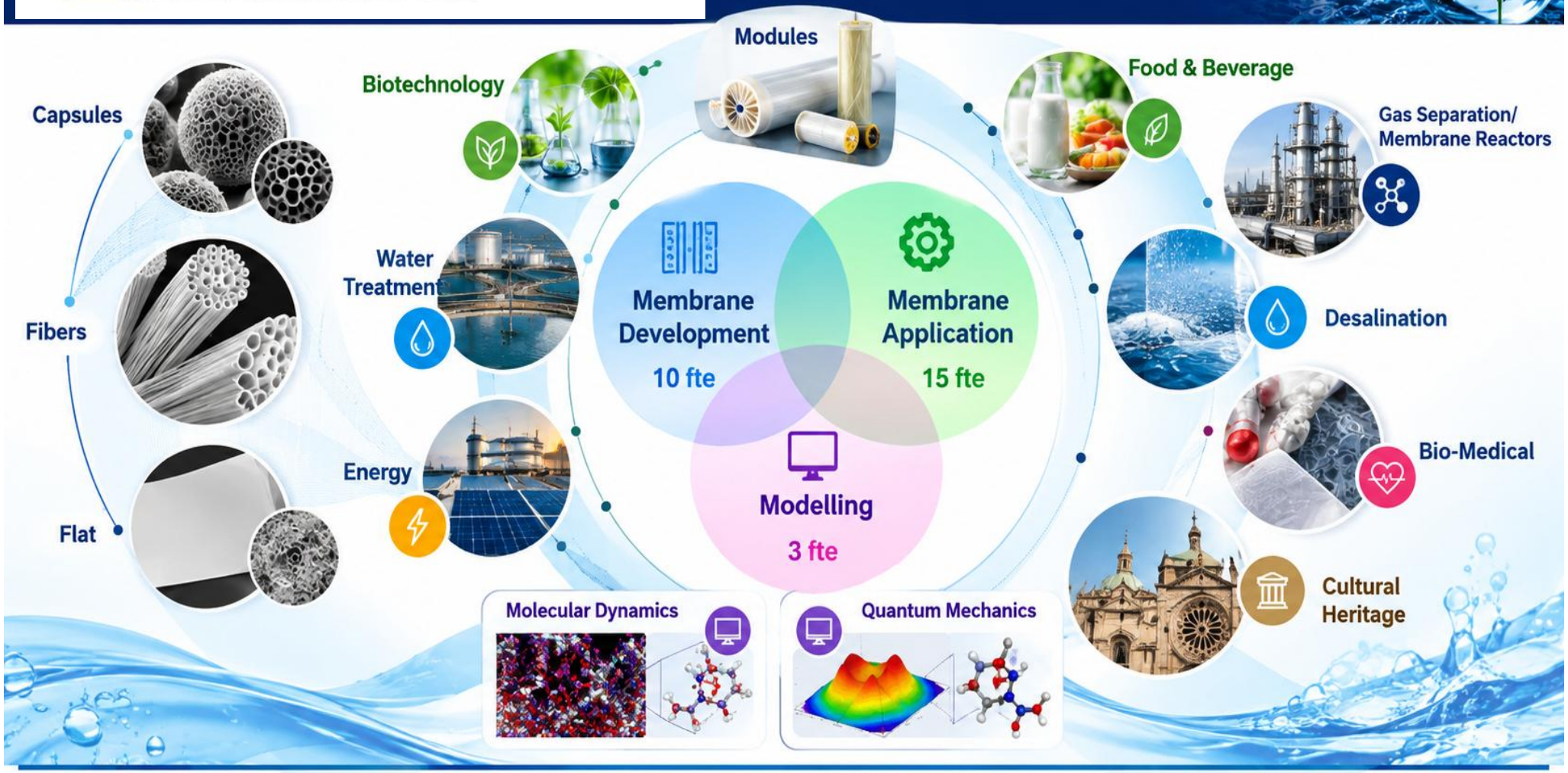
Institute on Membrane Technology
National Research Council of Italy

Research Activities at ITM

From TRL 1 to TRL 6



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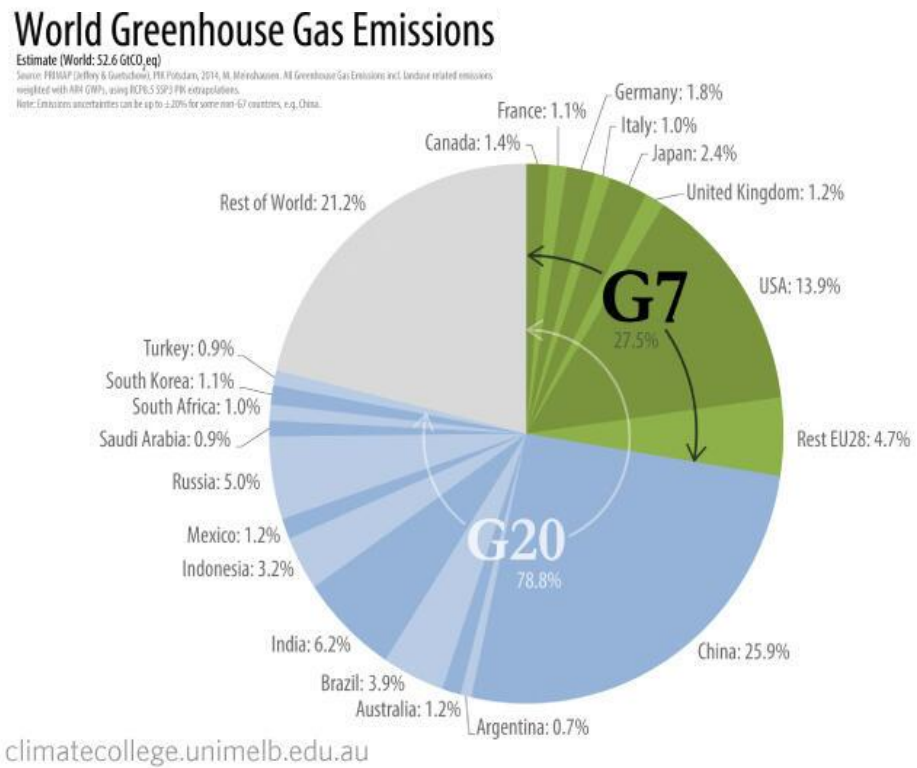
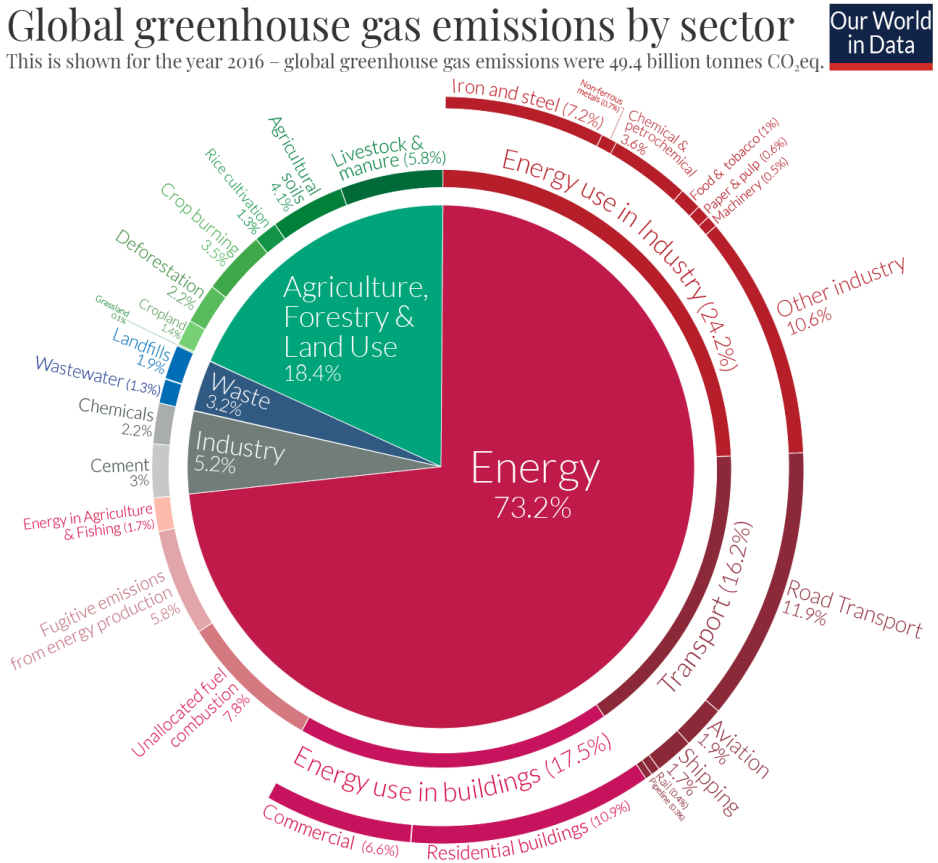
Scenario globale

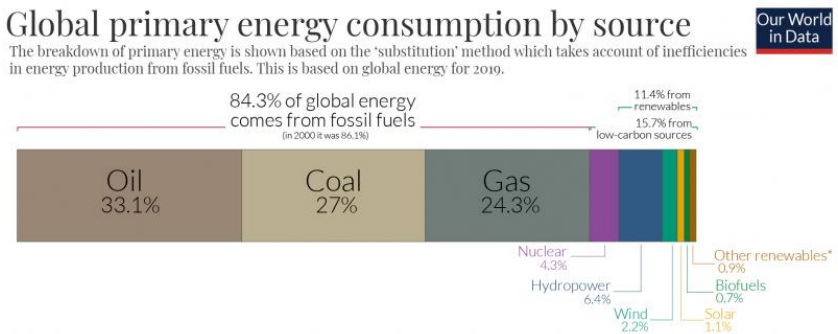


Current
world emissions:
¼ G7 countries
¼ China
¼ Rest of G20
¼ Rest of World

#Facts4Paris



OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020). Licensed under CC-BY by the author Hannah Ritchie (2020).



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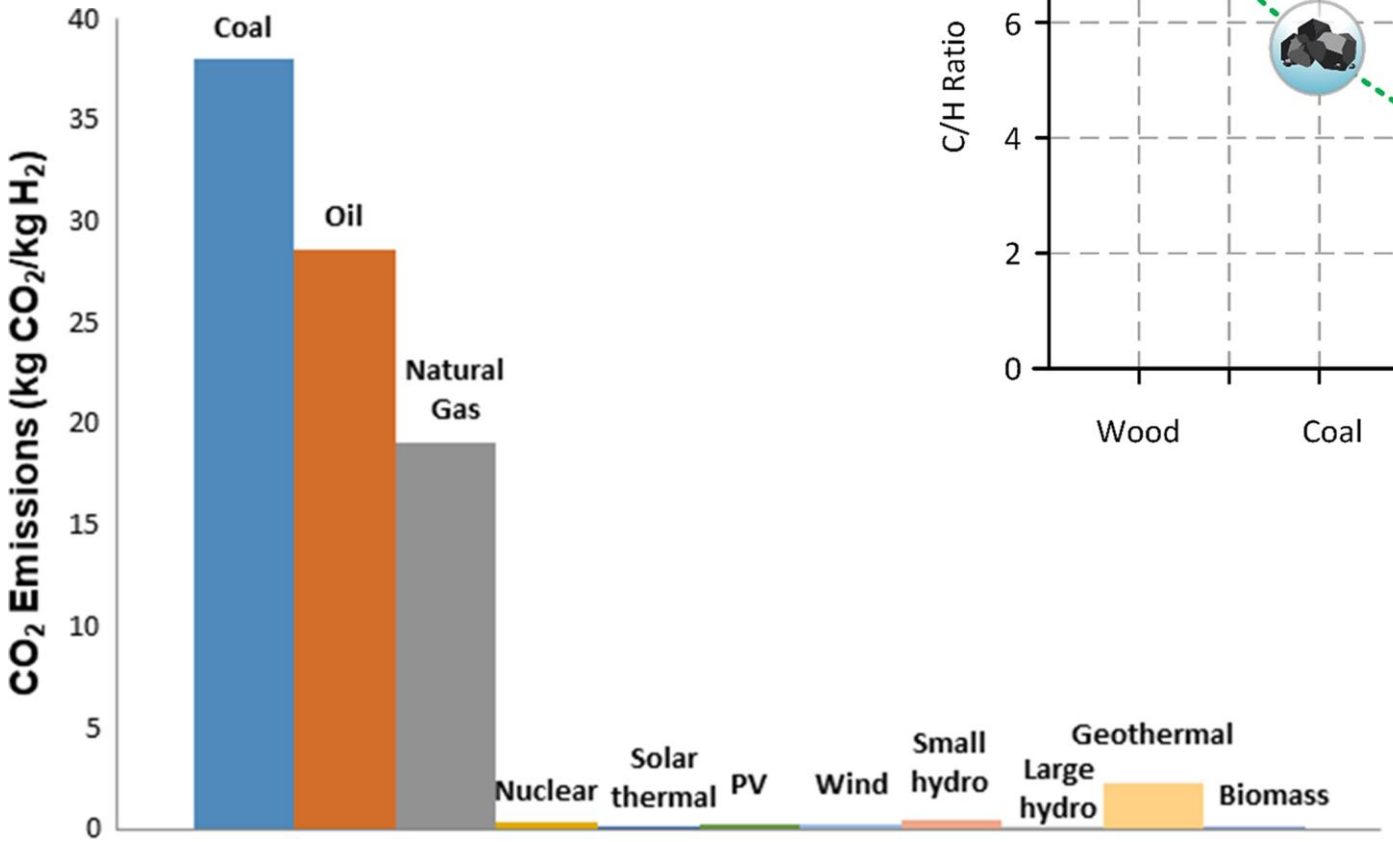
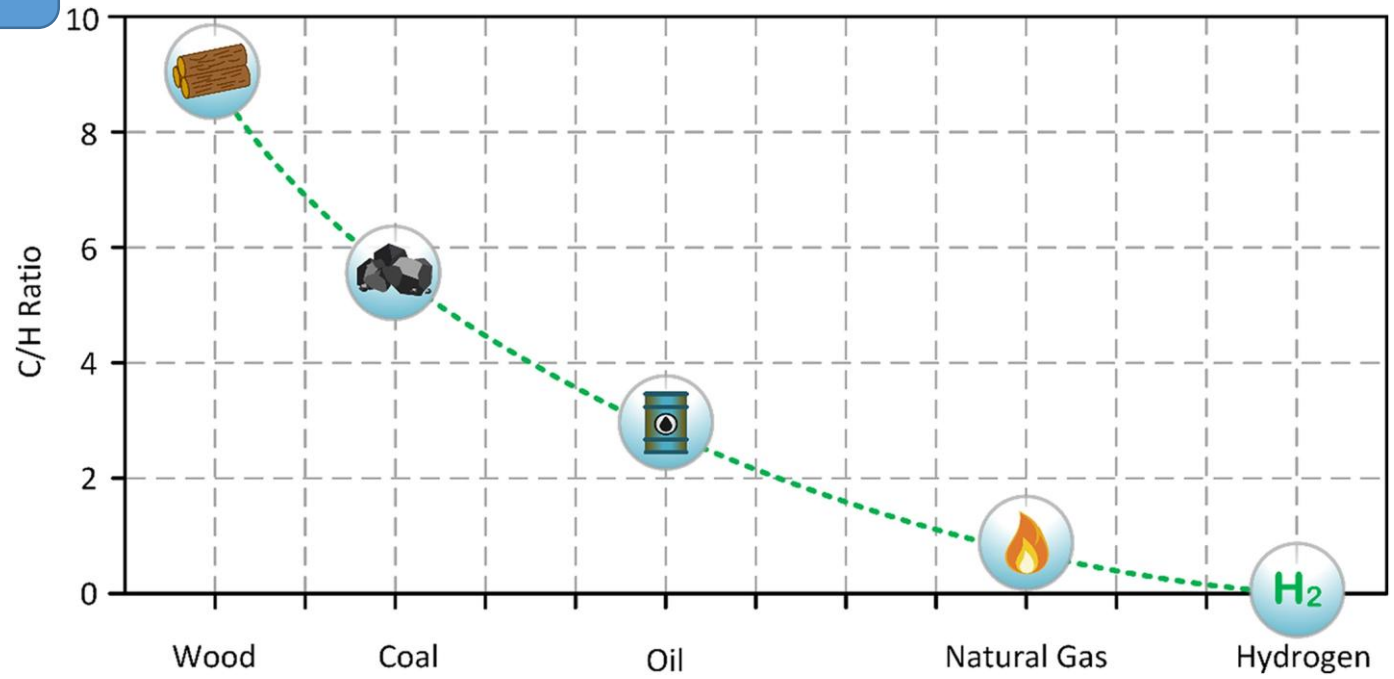
National Research Council of Italy

Energy sources: from high to zero C/H ratio





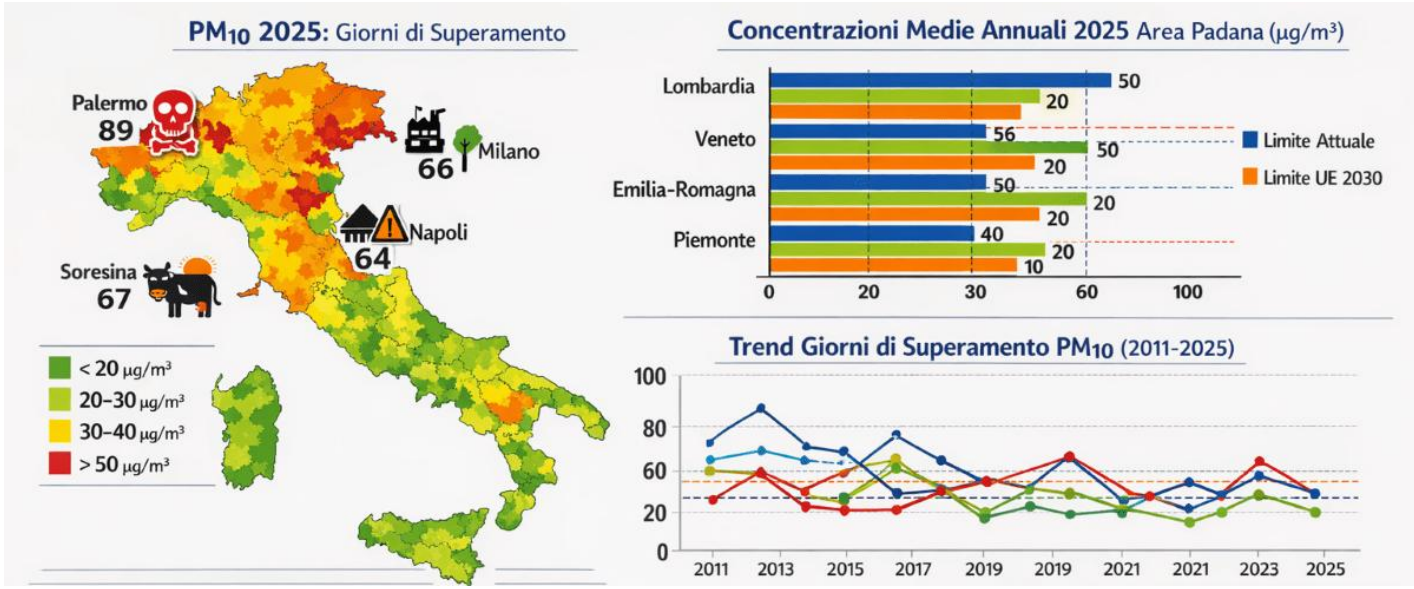
CO_2 emissions vs H_2 production technologies

I. Dincer, Covid-19 coronavirus: Closing carbon age, but opening hydrogen age, Int. J. Energy Research, 44 (2020) 6093-6097

Scenario in Italia



Source: ISDE Italia, Kyoto Club, Clean Cities Campaign (https://www.controlsecurityambiente.com/qualita-aria-2026-italia/)



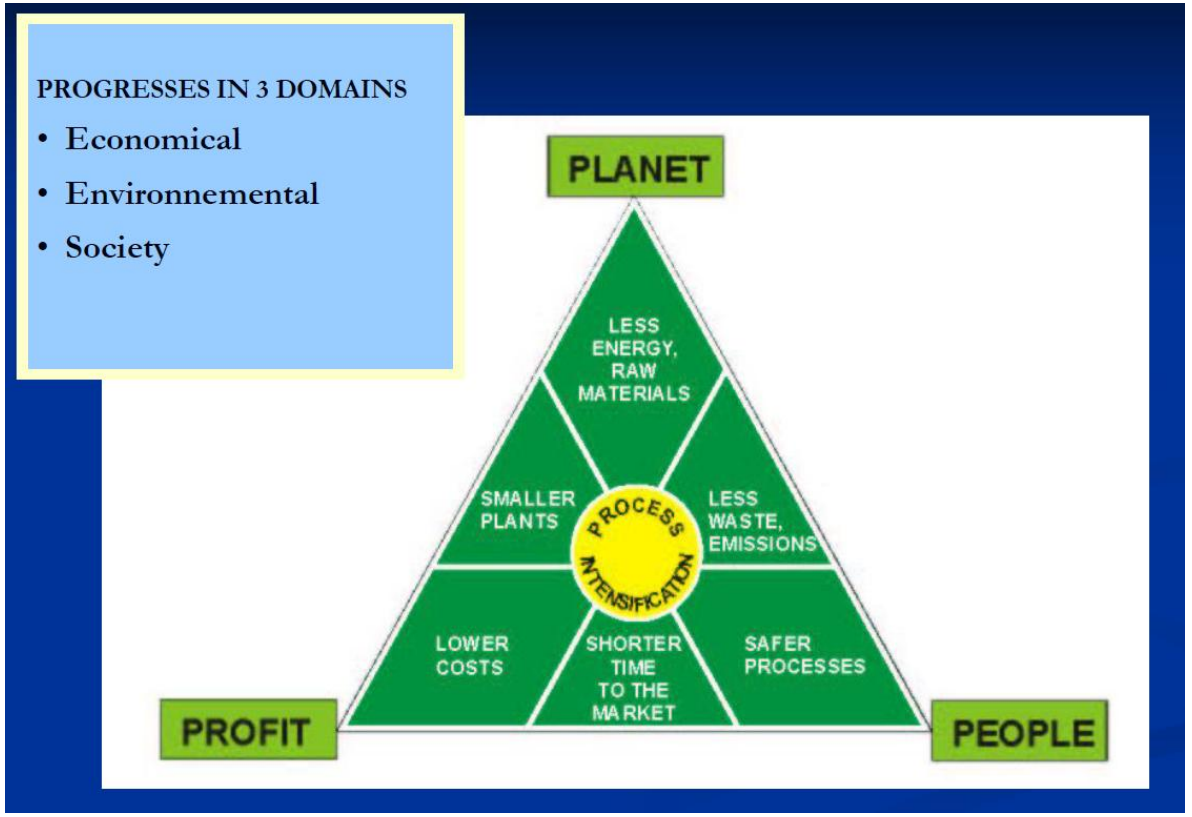
Source: Legambiente, dati stratti ed elaborati dal rapporto Mal'Aria 2026 (https://www.metropolitano.it/wp-content/uploads/2026/02/Report-MalAria-2026.pdf)

A RADICAL TRANSFORMATION

Non durable energy consumption (Non Sustainable Mankind)



Source: Katan et al., Scenario Biomass, University Twente (Ne)



Source: J.C. Charpentier, LRGP/CNRS/ENSIC/Université de Lorraine

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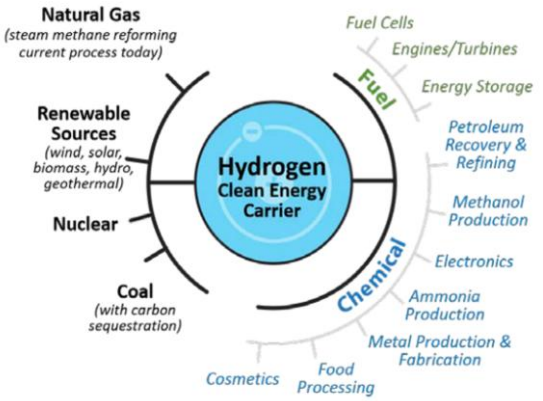
European Clean Hydrogen Alliance

The clean hydrogen revolution

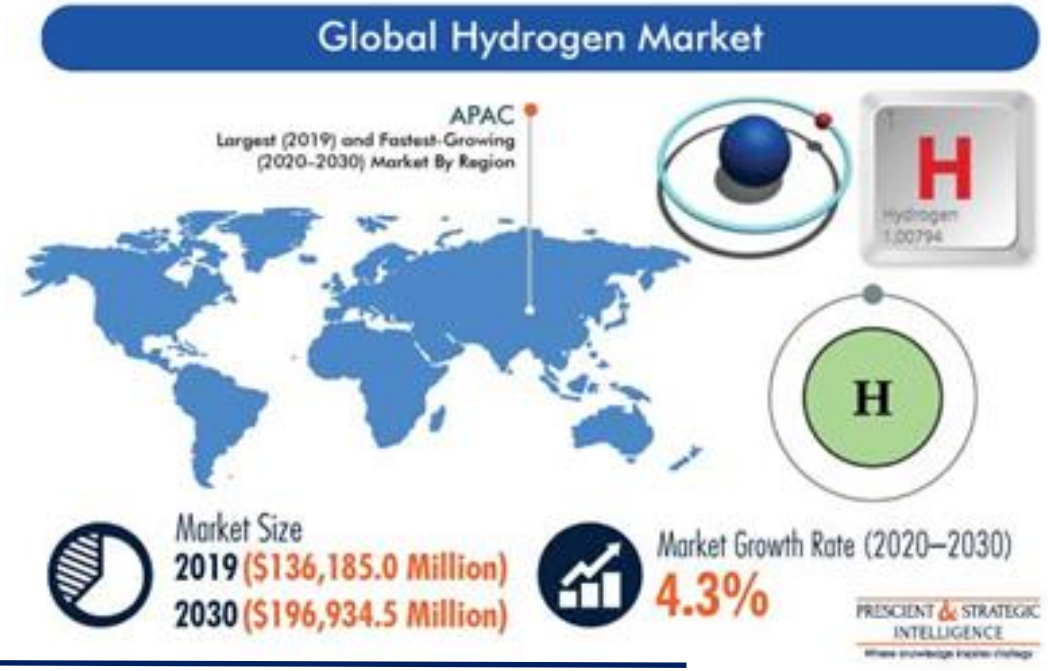
Enabling a zero emissions society





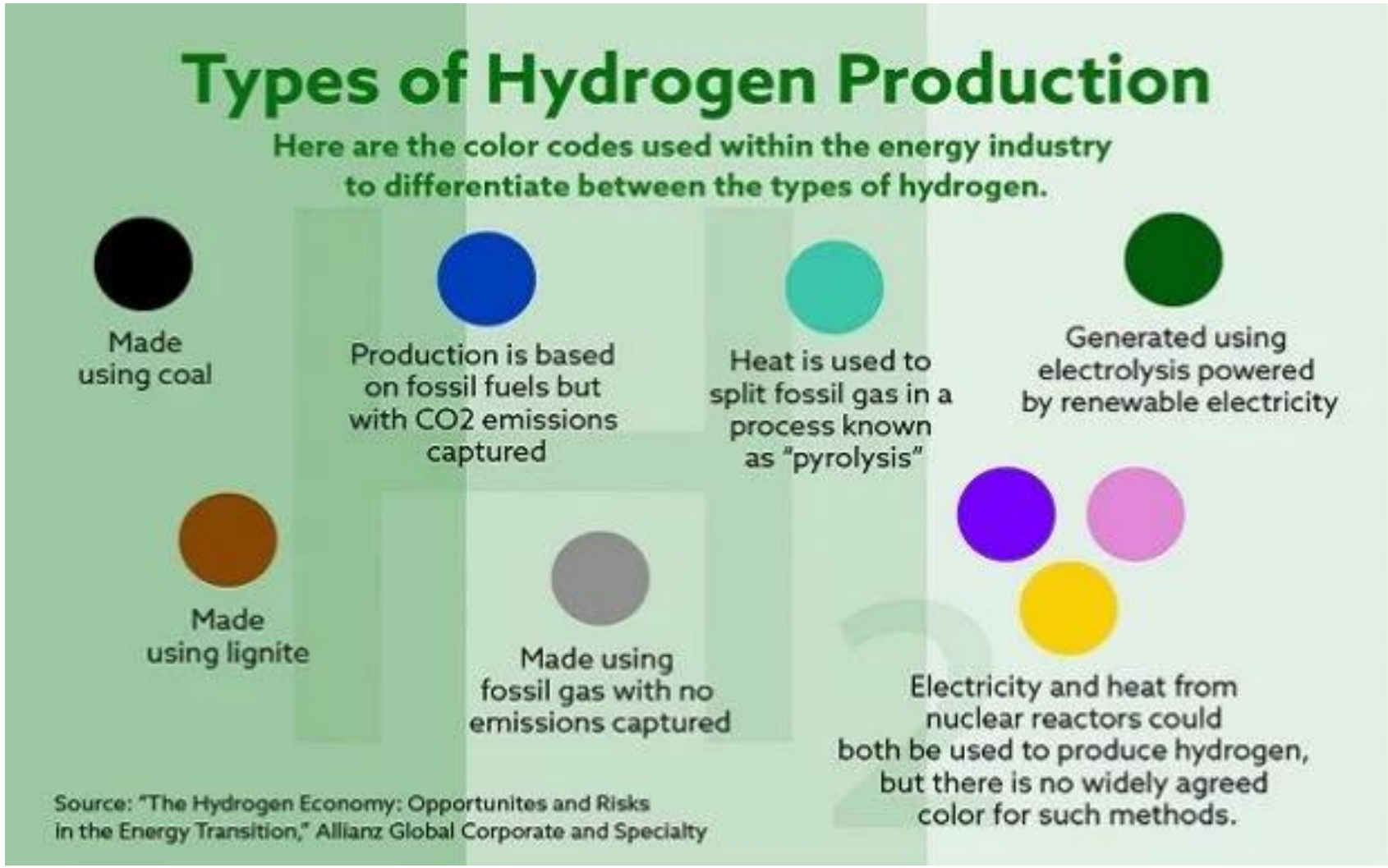






Source: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640

Metodi di produzione di idrogeno



I colori dell'idrogeno e loro significato

Source: C. Van Gend, Hydrogen economy: Opportunities and risks in the energy transition, ALM, 2021

Regolamentazione ufficiale in merito alle categorie associate alla produzione di idrogeno

RENEWABLE HYDROGEN DEFINITION, Example

- Renewable hydrogen is hydrogen produced through the electrolysis of water (in an electrolysers, powered by electricity), and with the electricity stemming from renewable sources;
- The full life-cycle greenhouse gas emissions of the production of renewable hydrogen are close to zero;
- Renewable hydrogen may also be produced through the reforming of biogas (instead of natural gas) or biochemical conversion of biomass, if in compliance with sustainability requirements;
- Renewable hydrogen is commonly known as green hydrogen. Additional environmental, social and governance criteria or grid-connected production criteria can be specified to further differentiate the product (IRENA).

CLEAN HYDROGEN, Examples

- Clean Hydrogen encompasses clean hydrogen generated from both renewables and fossil fuels through the use of carbon capture and storage (CCS) technology.

LOW-CARBON HYDROGEN, Examples

- Low-carbon hydrogen encompasses:
  - Fossil-based hydrogen with carbon capture and
  - Electricity-based hydrogen, with significantly reduced full life-cycle greenhouse gas emissions compared to existing hydrogen production.

Renewable Hydrogen is defined by reference to the definition of the Proposed Directive to Amend RED II, e., as hydrogen that (i) derives its energy content from renewable sources other than biomass; and (ii) achieves a 70% GHG emission reduction compared to fossil fuels.

Low-Impact Hydrogen Emissions is defined as hydrogen with an energy content that is derived from non-renewable sources, and that meets a GHG emission reduction threshold of 70% compared to fossil-based hydrogen.

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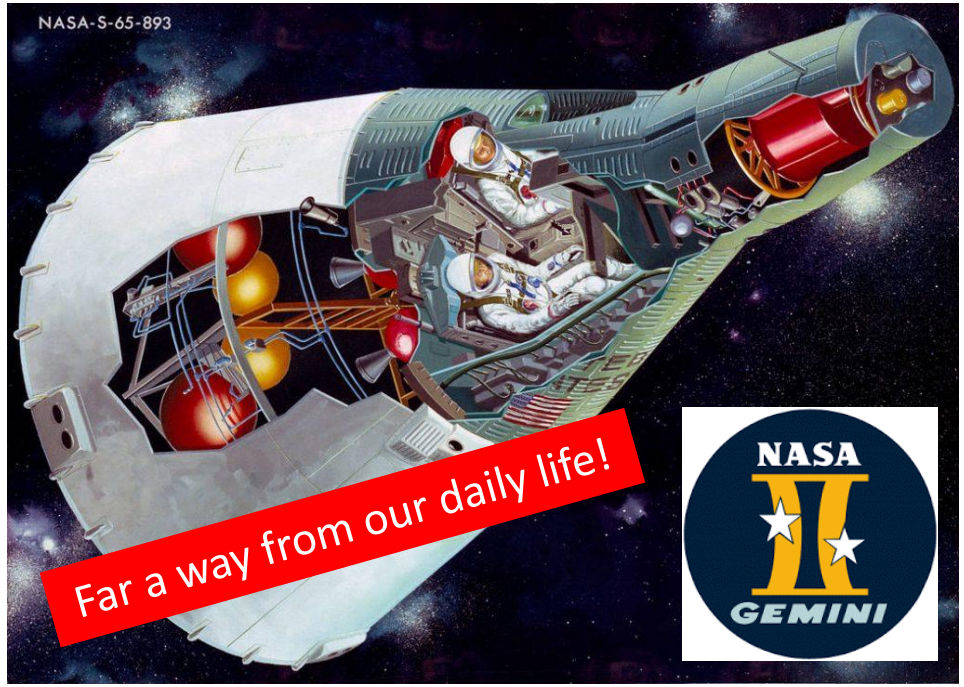
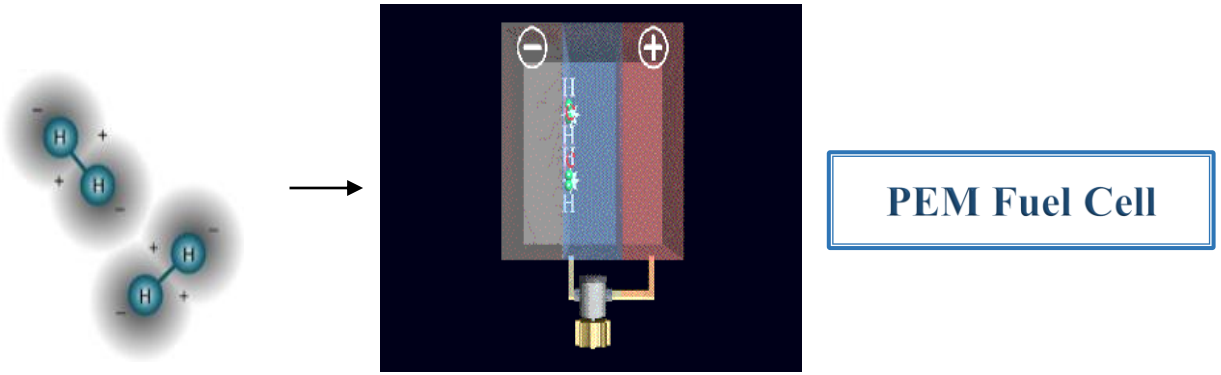
The social dimension of Hydrogen: does H_2 sound in our daily life?

GEMINI PROJECT (NASA, 1963-1966)







Space Shuttle Fuel Cell Stack

(1979 - 2014)



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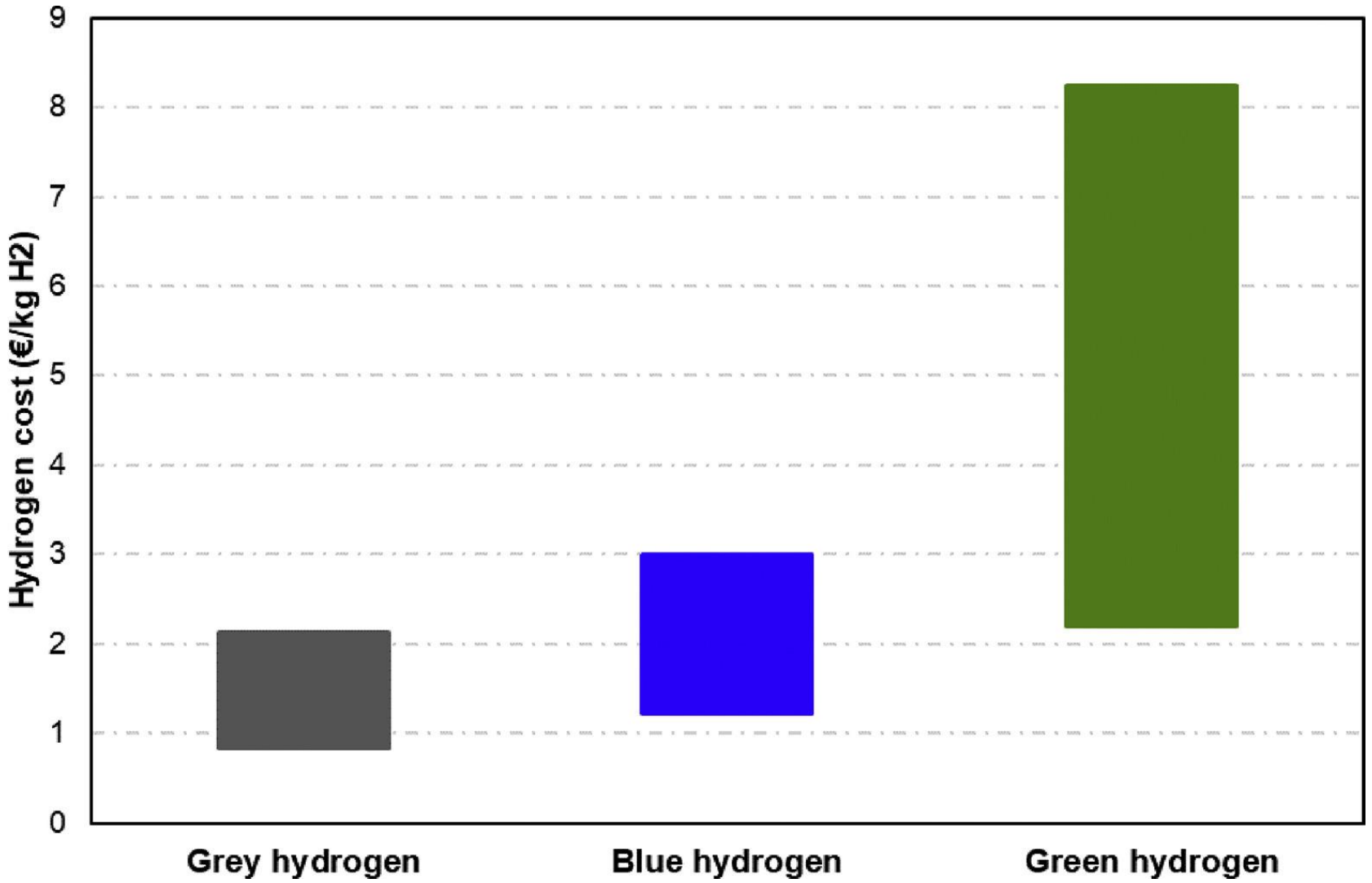
Cost of the hydrogen production

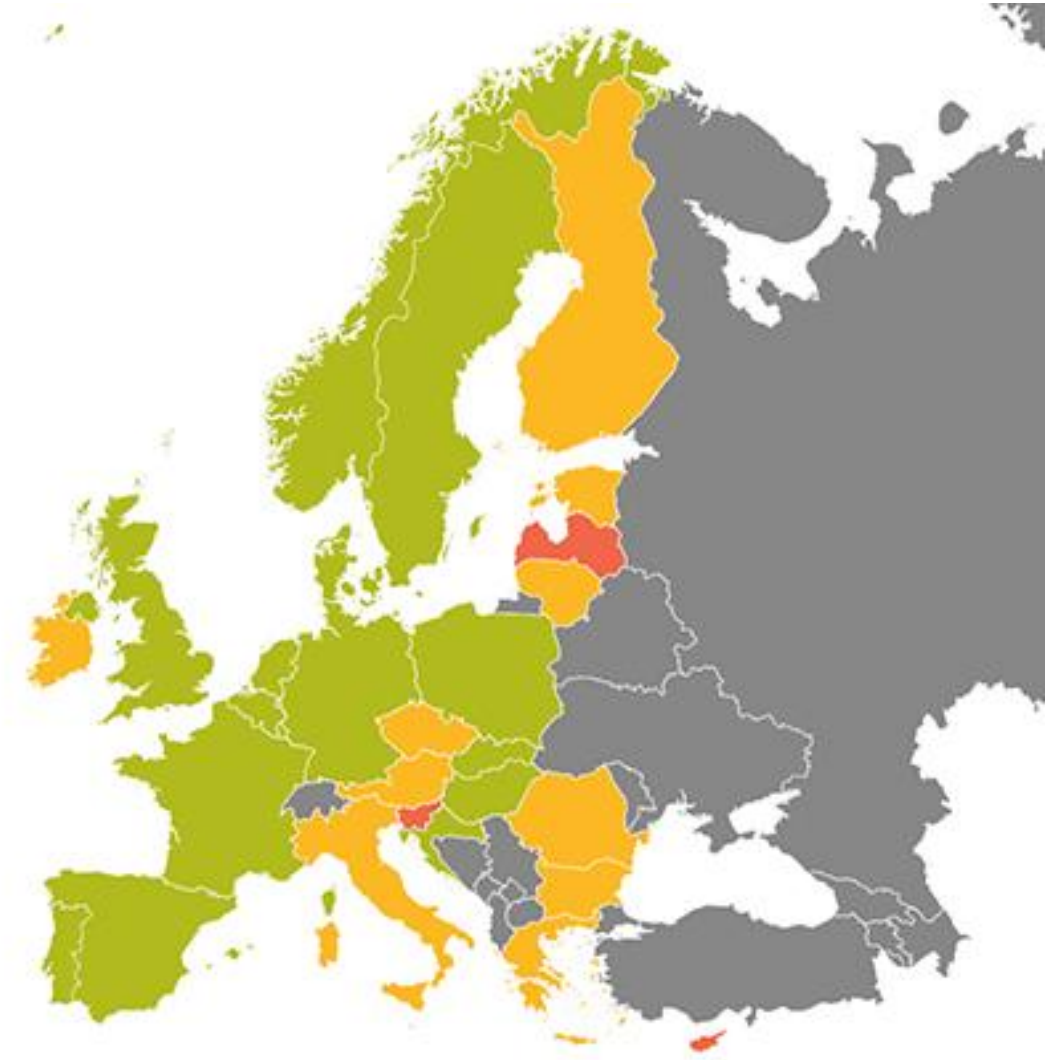


Ajanovic et al., The economics and the environmental benignity of different colors of hydrogen, Int. J. Hydrogen Energy, 47 (2022) 24136-24154

L'economia ad idrogeno in Europa: il ruolo dell'Italia

FLEISHMANHILLARD

ENERGY, CLIMATE & TRANSPORT



"The EU is pursuing a titanesque task: defining a regulatory framework that can support the massive development of a continent-wide hydrogen economy from scratch. A mission that seems as challenging as reaching carbon neutrality by 2050."

Source: M. Miccinilli, Senior Vice-President and Head of Energy and Climate at FleishmanHillard EU, Euractiv Trust Project, 2022

Hydrogen strategy in Italy

Dedicated budget

> **3.5B EUR** of investment on H_2-chain and R&D

PNRR – Mission 2, Componen 2.3 – **Renewable Energy, Hydrogen, Networks and Mobility System**
Investments 3.1-3.5: *Promotion of the Production, Distribution, and Final Uses of Hydrogen*
➡ Budget: 3,19 B€

PNRR – Missione 2, Component 2.5 – **International Industrial and R&D Leadership Development in the key Transition Networks**
Investment 5.2: *Hydrogen*
➡ Budget: 0,45 B€



The National Recovery and Resilience Plan
NextGenerationEU
REPowerEU Plan's

> **200B EUR** investments and infrastructures



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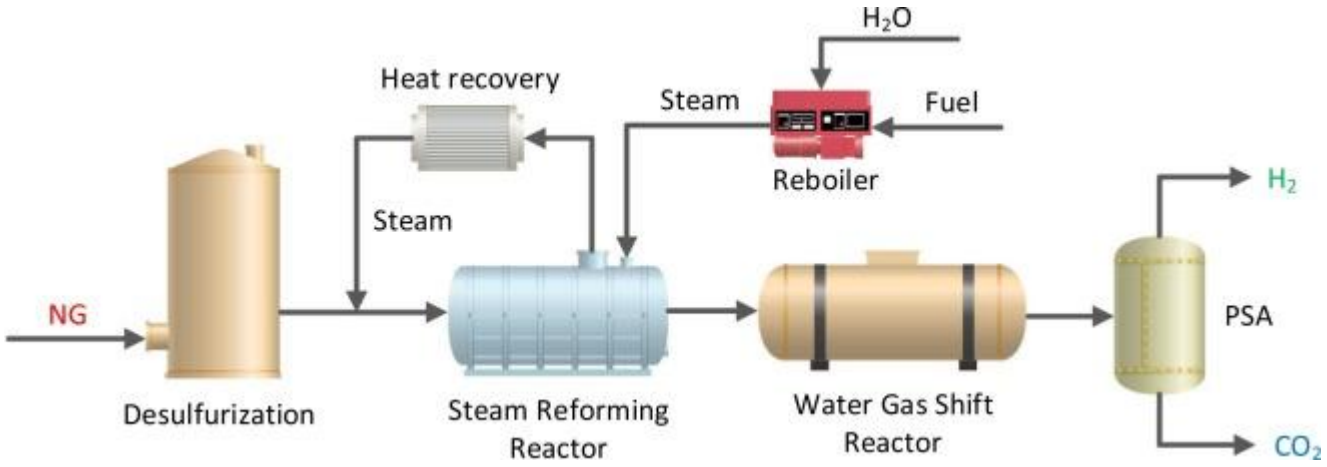
Process intensification by membrane engineering



Conventional H_2 production by SR of NG

Intensification



H_2 production by Membrane Engineering

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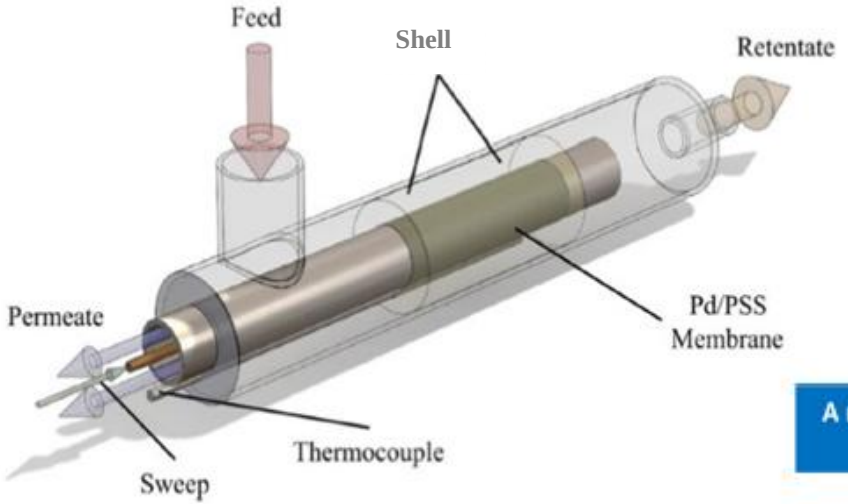
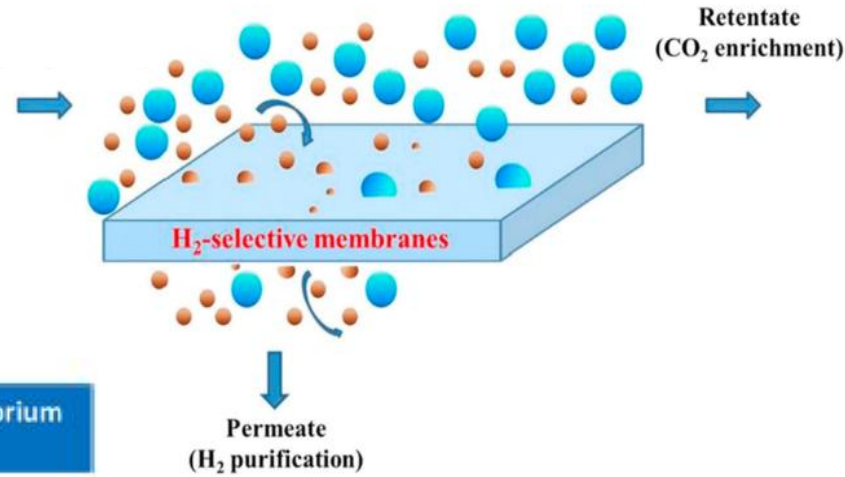
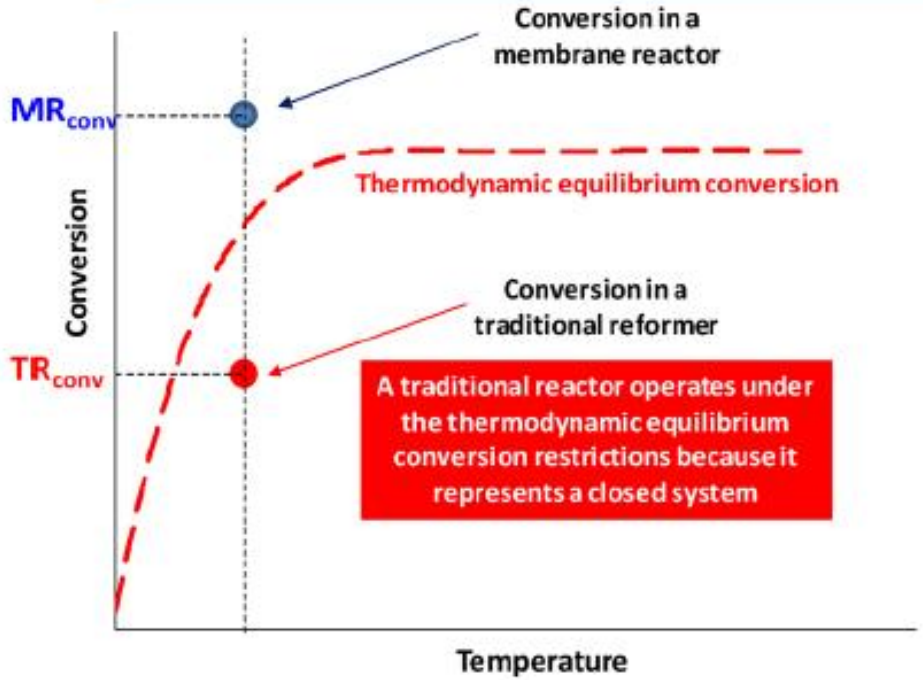
Membrane engineering applied in the Hydrogen production and separation/purification





A membrane reactor is not limited by the thermodynamic equilibrium conversion because it does not represent a closed system



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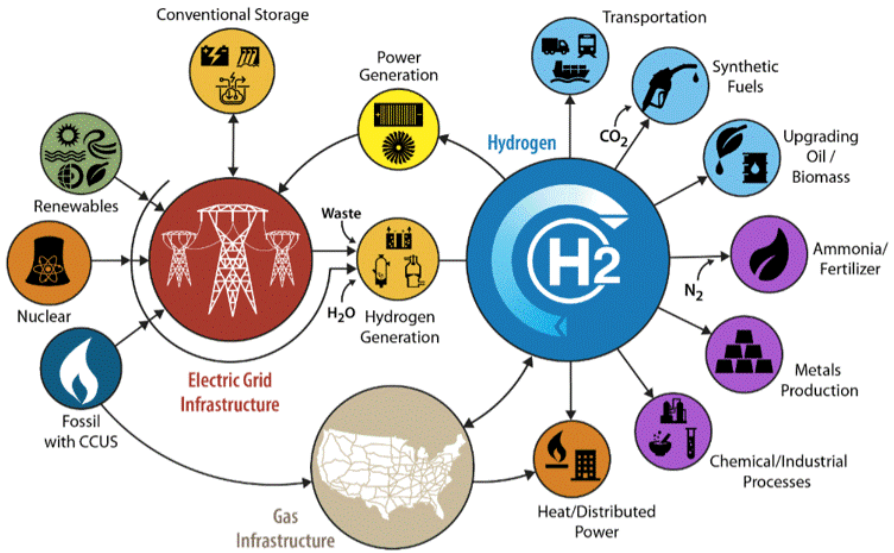
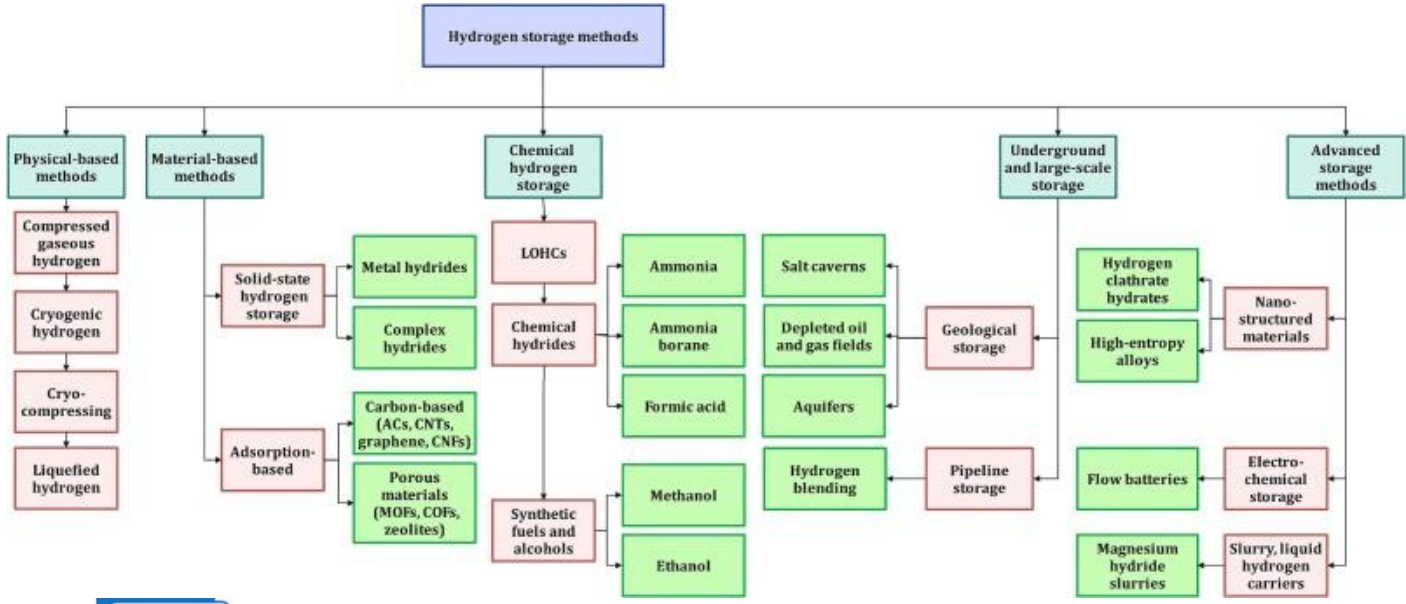
Membrane technologies in Hydrogen production, separation/purification and chemical storage

HYDROGEN PRODUCTION & UTILIZATION

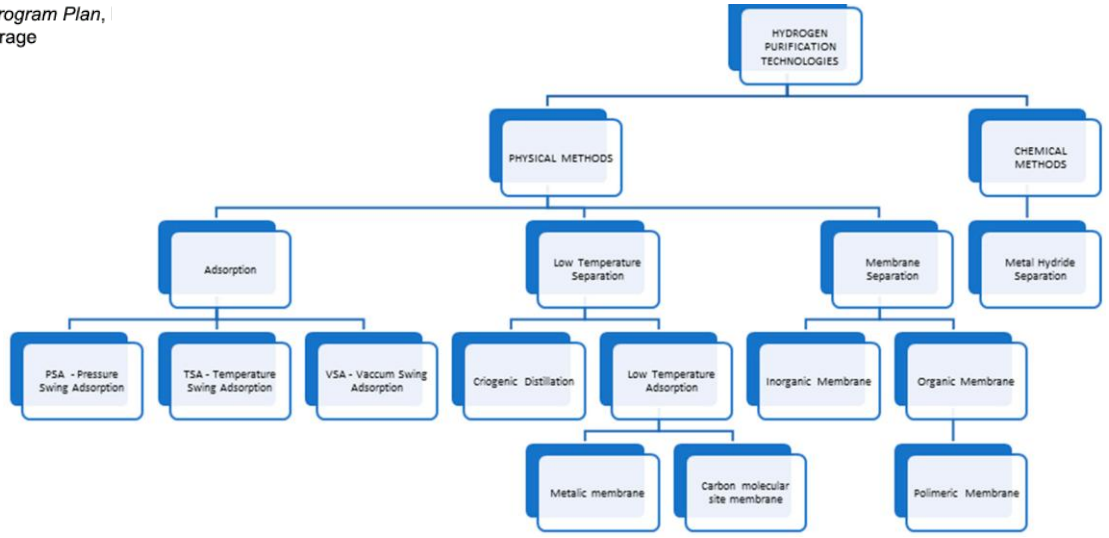


Source: U.S. Department of Energy, *Hydrogen Program Plan*,
Note: CCUS=carbon, capture, utilization, and storage

HYDROGEN STORAGE



HYDROGEN PURIFICATION



ICSET 2026

Consiglio Nazionale delle Ricerche

Our objectives: H_2 targets set by the European Clean Hydrogen Alliance





EU TARGETS

H_2 recovery: **80%** (2024); **90%** (2027); **95%** (2030)

H_2 purity: **99.99%**

Clean Hydrogen Alliance under the Strategic Research & Innovation Agenda 2021-2027

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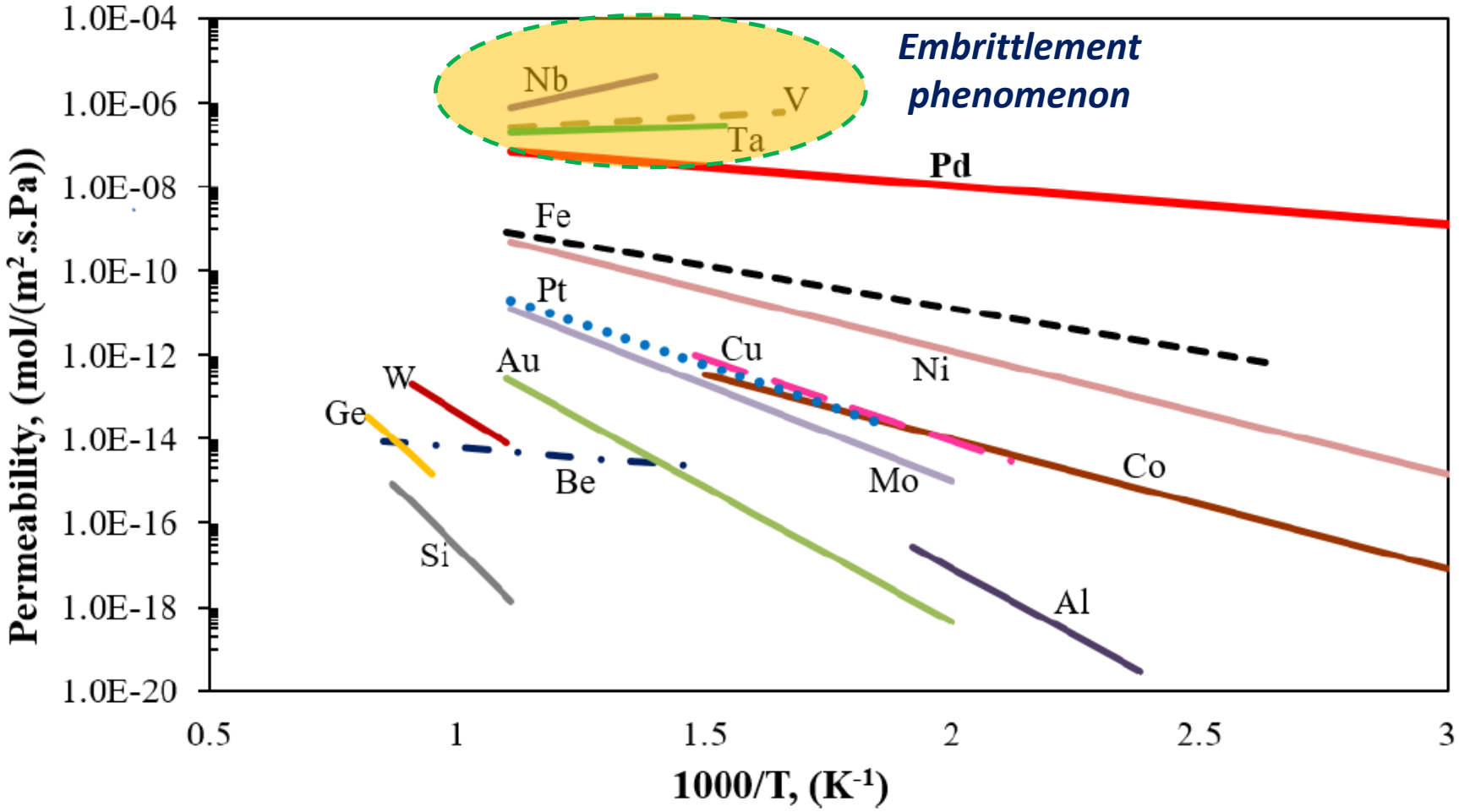
Metallic membranes for H_2 separation/purification



Palladium: dominant membrane material in hydrogen separation/purification

CONSIGLIO NAZIONALE INGEGNERI

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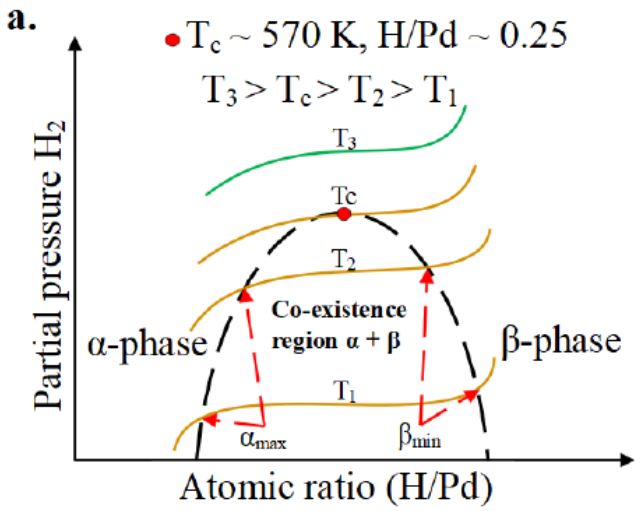
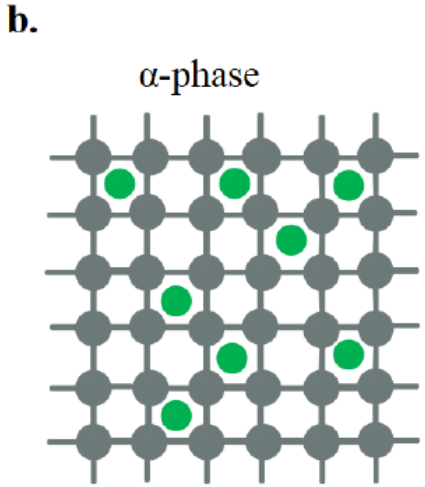
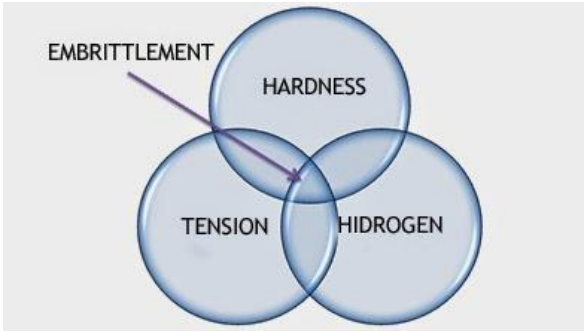
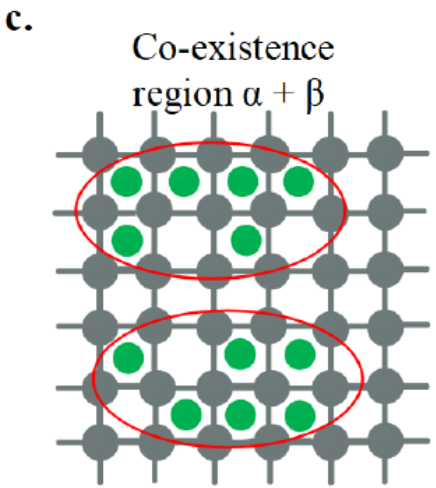
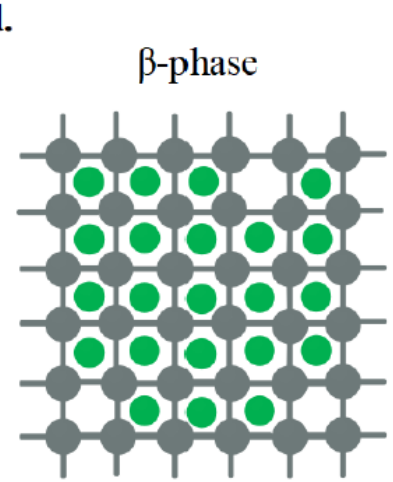
Embriittlement phenomenon in Pd-based membranes: Pd hydride phases: **a.** P-C-T diagram, **b.** α-phase, **c.** α-phase and β-phase, **d.** β-phase and **e.** supercritical region. *Green and gray dots are hydrogen and Pd, respectively*

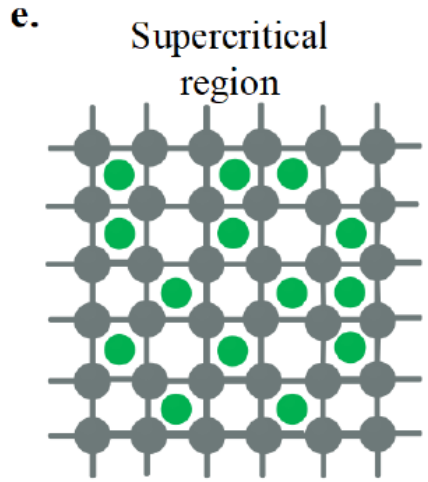


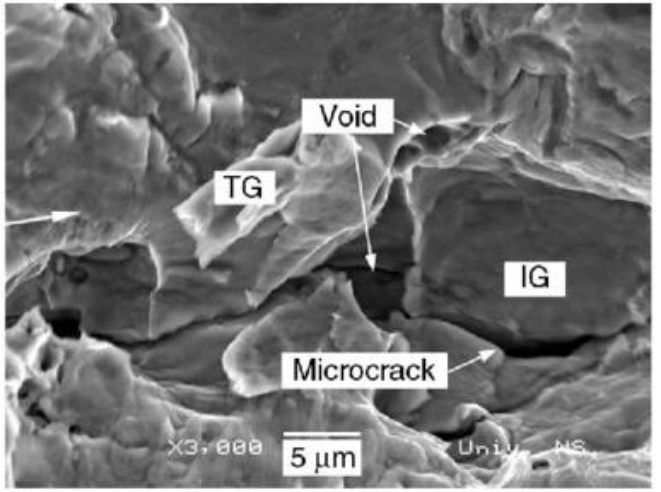












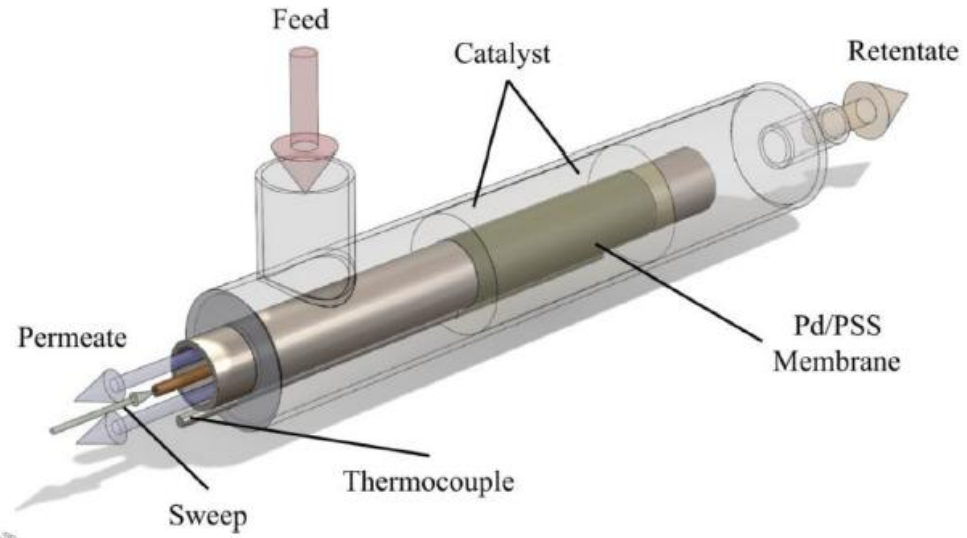
ICSET 2026

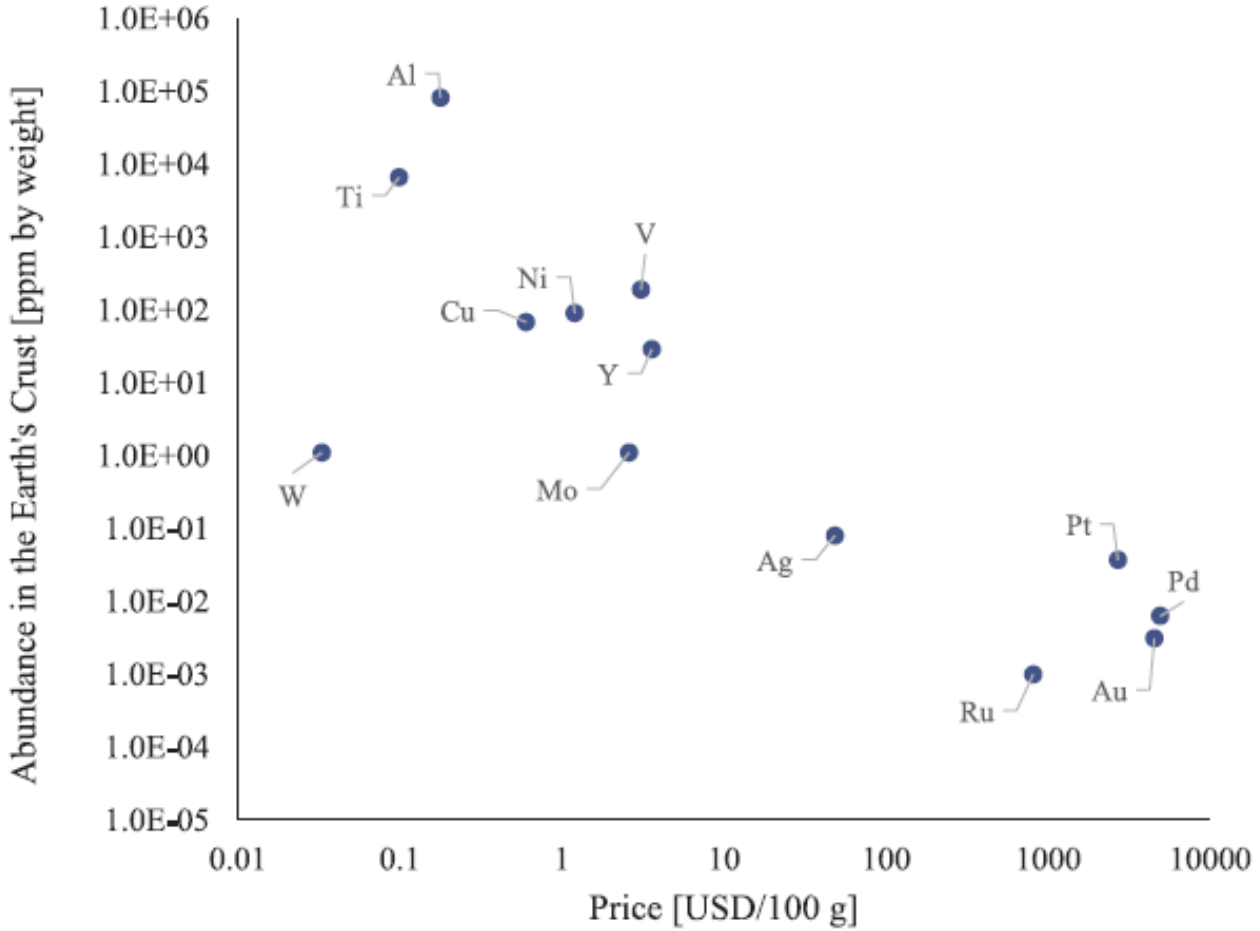
Consiglio Nazionale delle Ricerche

Pd-alloyed membranes

U.S. DOE 2015 targets for hydrogen separation and purification by dense metallic membranes [129]

Performance criteria	Target
Flux	1.135 mol/m^2.s (300 Scfh/ft^2)
Cost of membrane	< 5,400 \$/m^2 (< 500 \$/ft^2)
Durability	> 5 years
H_2 recovery	90 %
Hydrogen purity	99.99%





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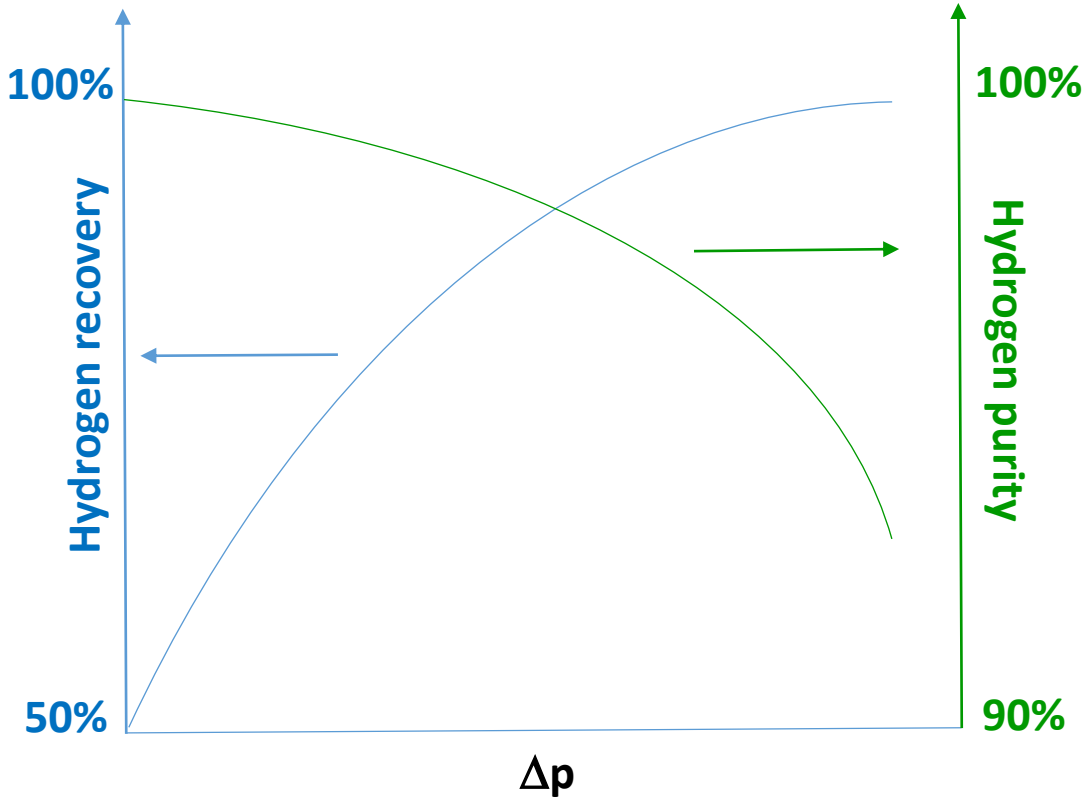
Hydrogen recovery vs purity trade-off



Bench-scale membrane modules used in Hybrid Membrane Separation



Parameter	Hollow Fiber	PdAu/α-Al_2O_3
Length	0.25 m	0.25 m
Outer diameter	0.015 m	0.012 m
Material	Polyimide (Membrain s.r.o.)	Pd-Au alloy on α-Al_2O_3
Sealing	—	Graphite gaskets







a) Hollow fiber polyimide-based membrane module

b) Pd-Au/α-Al_2O_3 tubular membrane module

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南京工業大學 NANJING TECH UNIVERSITY

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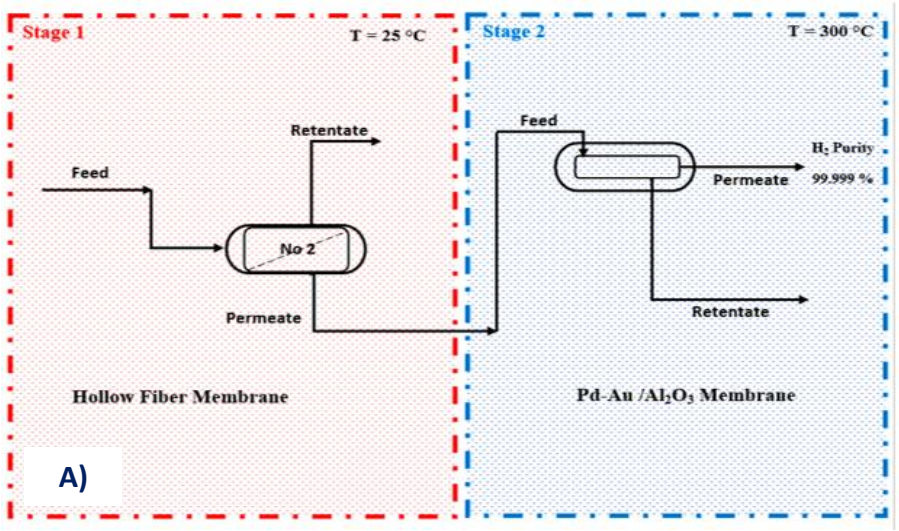
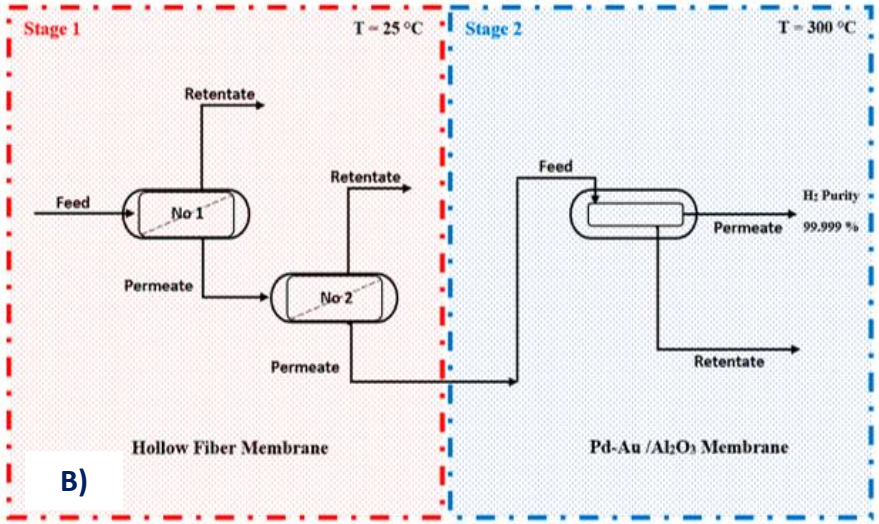
H_2 separation/purification by membrane technology

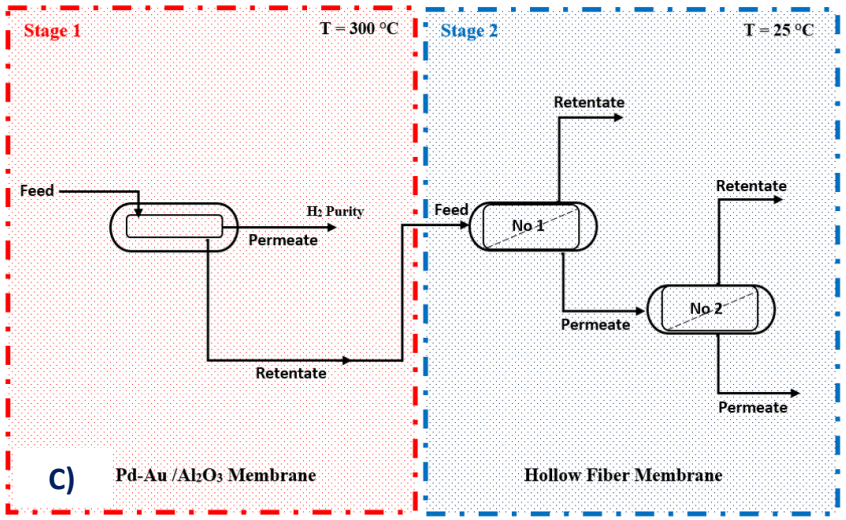
Case (A)



Case (B)



Case (C)



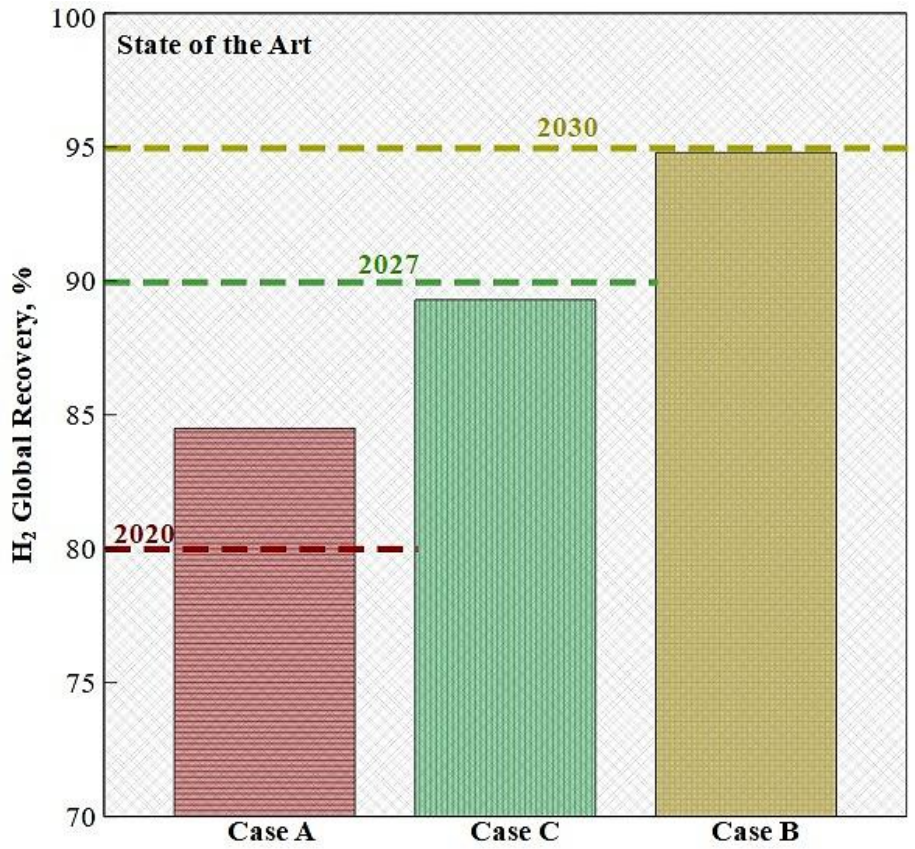
Three Hybrid Configurations Tested

CONSIGLIO NAZIONALE INGEGNERI

Consiglio Nazionale delle Ricerche

Configuration (i): Global H_2 Recovery vs Clean Hydrogen Alliance Targets

All three cases surpass the 2024 target; Case B approaches the 2030 target while keeping a single ultrapure H_2 stream (>99.99%).

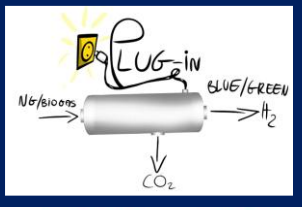


94.7%
Case B — nearly meets 2030 target (95%)

89.3%
Case C — exceeds 2024 target (80%)

84.5%
Case A — exceeds 2024 target (80%)

H_2 production by membrane reactor technology



Renewable Energy 210 (2023) 472–485

Contents lists available at ScienceDirect

Renewable Energy

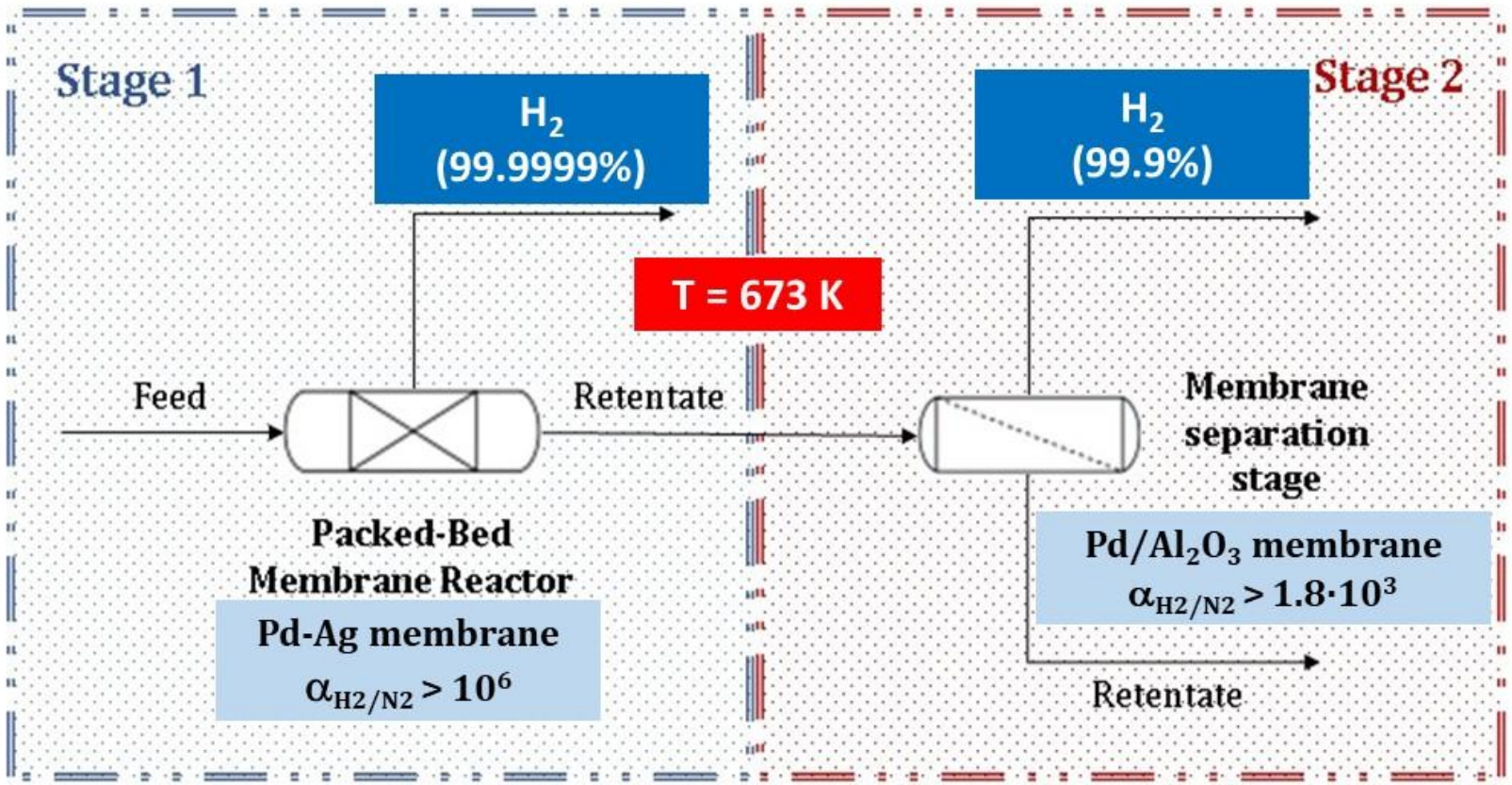
journal homepage: www.elsevier.com/locate/renene

An integrated two stages inorganic membrane-based system to generate and recover decarbonized H_2: An experimental study and performance indexes analysis

Adolfo Iulianelli [a,*,1], Adele Brunetti [a,1], Lidia Pino [b], Cristina Italiano [b,**], Giovanni Drago Ferrante [b], Mario Gensini [a], Antonio Vita [b]

[a] Institute on Membrane Technology of the National Research Council of Italy (CNR-ITM), via P. Bucci 17C, 87036, Rende, CS, Italy
[b] The Advanced Energy Technology Institute of the National Research Council of Italy (CNR-ITAE), Salita Santa Lucia Sopra Contesse 5, 98126, Messina, ME, Italy

Parameter	Stage 1	Stage 2	Target	Integrated system
CH_4 conversion	> 99%	-	-	> 99%
H_2 recovery	40%	67%	80%	80%
H_2 recovered stream purity	> 99.9999%	99.9%	99.99%	99.99%
Net CO_2 reduction	92%	-	-	92%
Conversion index	18[a]	-	-	18[a]
H_2 yield index	5	-	-	5





EU TARGETS

H_2 recovery: **80%** (2024); **90%** (2027); **95%** (2030)

H_2 purity: **99.99%**

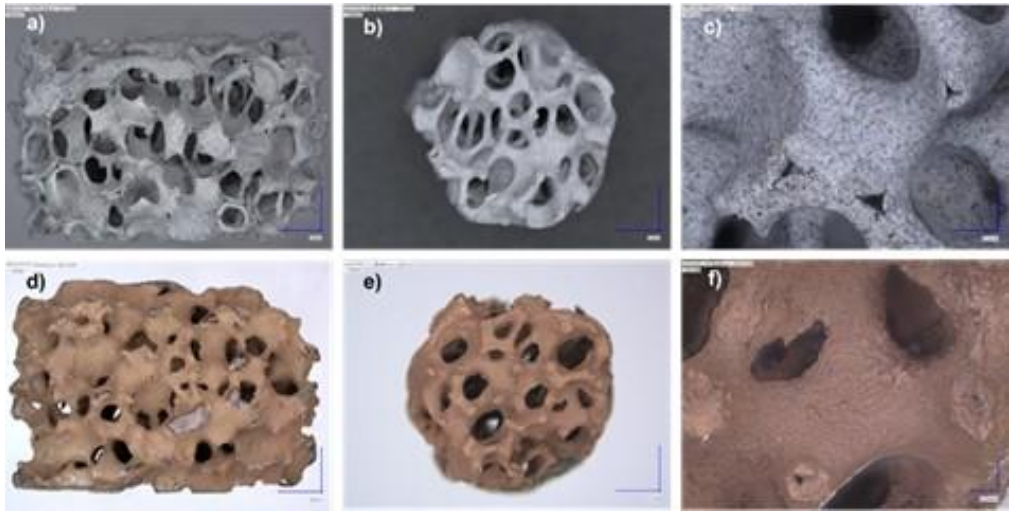
Clean Hydrogen Alliance under the Strategic Research & Innovation Agenda 2021-2027

European Clean Hydrogen Alliance

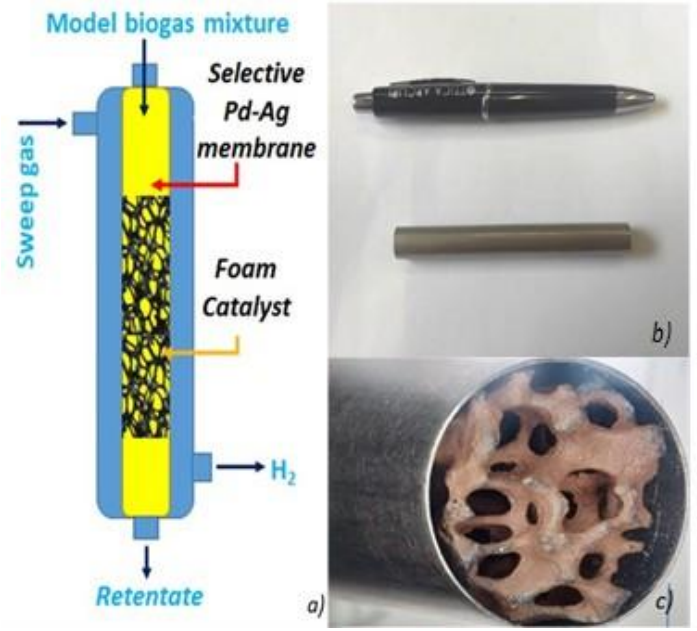
CONSIGLIO NAZIONALE INGEGNERI

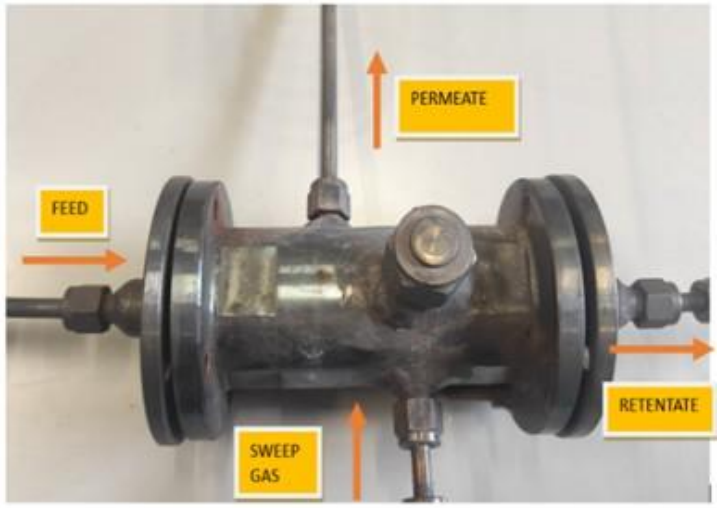
Consiglio Nazionale delle Ricerche

H_2 production: foam structured membrane reactor

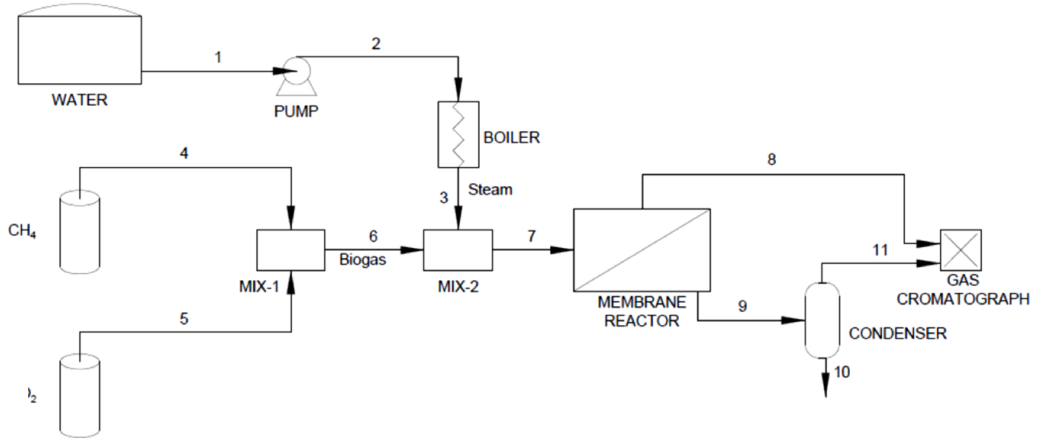


Images of bare (a – c) coated (d – f) 40PPI SIC foam after calcination step (by CNR-ITAE)





a) schematic view of the foam structured membrane reformer; b) Pd-Ag tubular membrane; c) Ni-Ru foam structured catalyst inserted in the lumen of the Pd-Ag membrane



Energy Conversion and Management 326 (2025) 119504

Contents lists available at ScienceDirect

Energy Conversion and Management

journal homepage: www.elsevier.com/locate/enconman

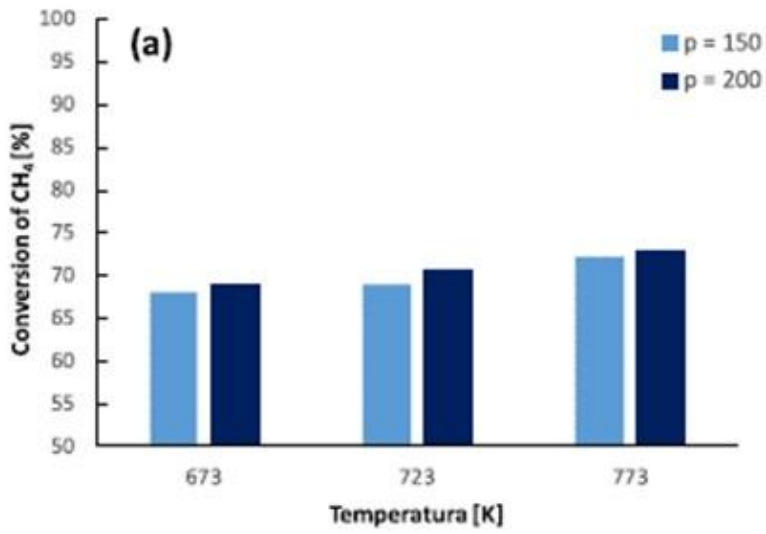
Research Paper

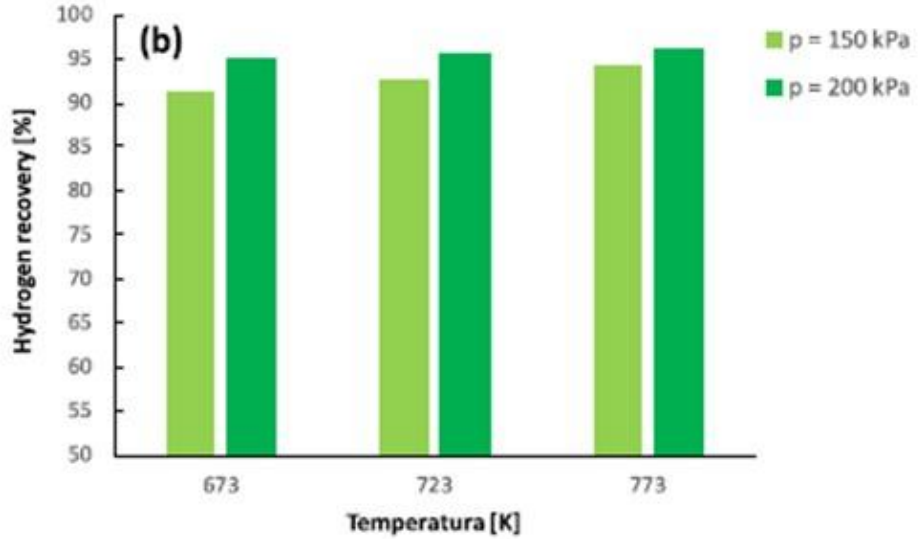
Low impact emissions H_2 production via biogas steam reforming in a foam structured membrane reactor: Energy efficiency and exergy analyses, and H_2 production cost assessment

H.B.Trujillo Ruales [a], C. Italiano [b], A. Vita [b], A. Iulianelli [a,*]

[a] National Research Council - Institute on Membrane Technology (CNR-ITM), via P. Bucci 17C, 87036 CS, Italy
[b] National Research Council - Institute for Advanced Energy Technologies (CNR-ITAE), Via Salita S. Lucia sopra Contesse, 5 - 98126 Messina, ME, Italy

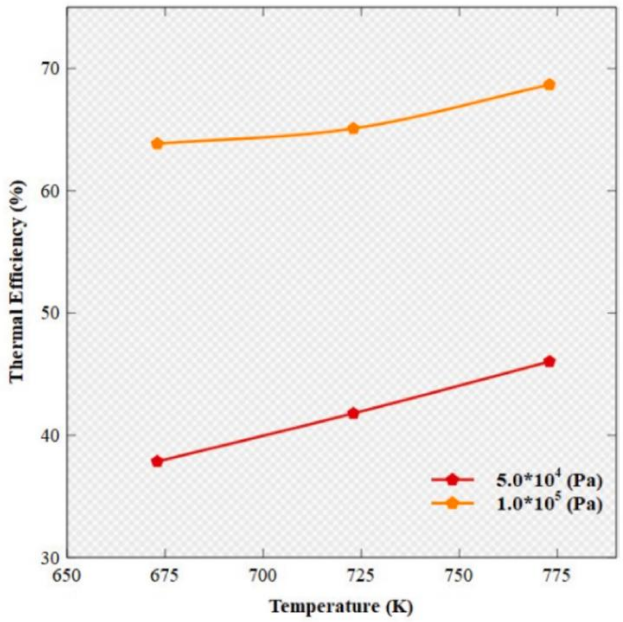
H_2 production: foam structured membrane reactor

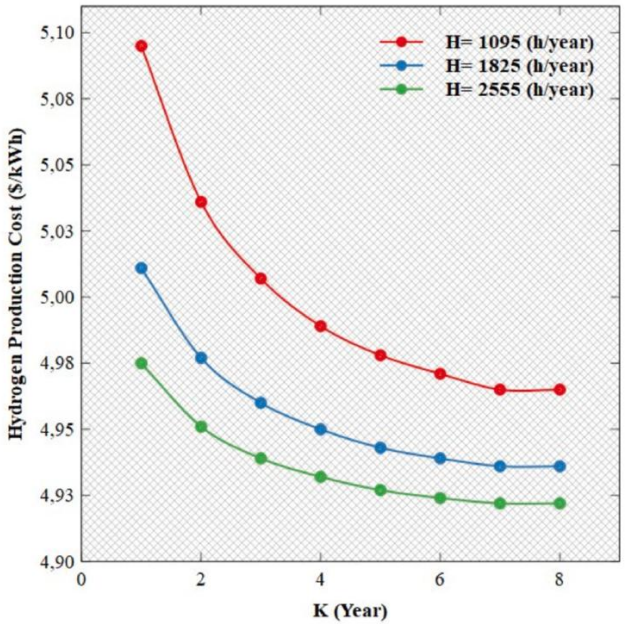




H_2 purity
> 99.99%

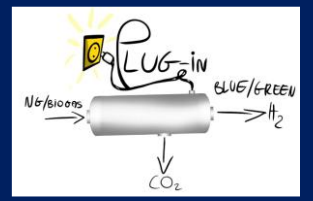
Energy Efficiency
~ 70%





EU TARGETS
H_2 recovery: **80%** (2024); **90%** (2027); **95%** (2030)
H_2 purity: **99.99%**
Clean Hydrogen Alliance under the Strategic Research & Innovation Agenda 2021-2027

H_2 production/purification: electrically-assisted foam structured membrane reactor



PRIN 2020

STEMS

ITM

POLITECNICO MILANO

ATAE

Renewable sources

Electric grid

Decentralized biogas plants

State-of-the-art
Conventional fired packed bed SR reactor

Fuel mixture

Catalyst (pellets)

Flue gas

Exhaust (CO_2 rich gas)

Conventional heating

H_2

PSA

WGS (LT)

WGS (HT)

Separation/purification

Furnace

Syngas

PLUG-IN progress beyond the state-of-the-art

Fuel mixture (NG or Biogas + steam)

Selective membrane

Thermally conductive support

Catalyst

CO_2 sorbent material

Retentate (CO_2)

MICROWAVE HEATING

JOULE HEATING

CO_2

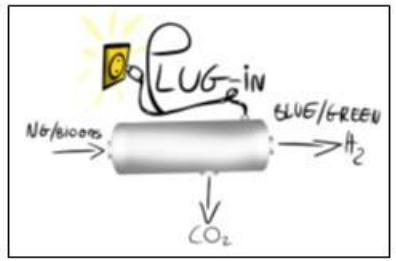
CO_2 storage

H_2

Coated or packed Foam Membrane Reactor

Coated or packed Foam adsorber/desorber reactor

Natural Gas grid



Intensified blue H_2 production/purification membrane reactor-based system

Alternative packed bed membrane reactor

Renewable-based fuel mixture

Selective membrane

Thermal conductive support

Catalyst

Retentate (CO_2)

H_2

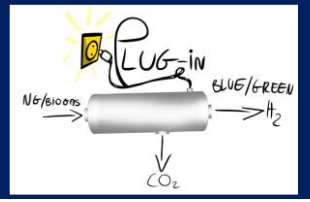
Coated or packed Foam Membrane Reactor

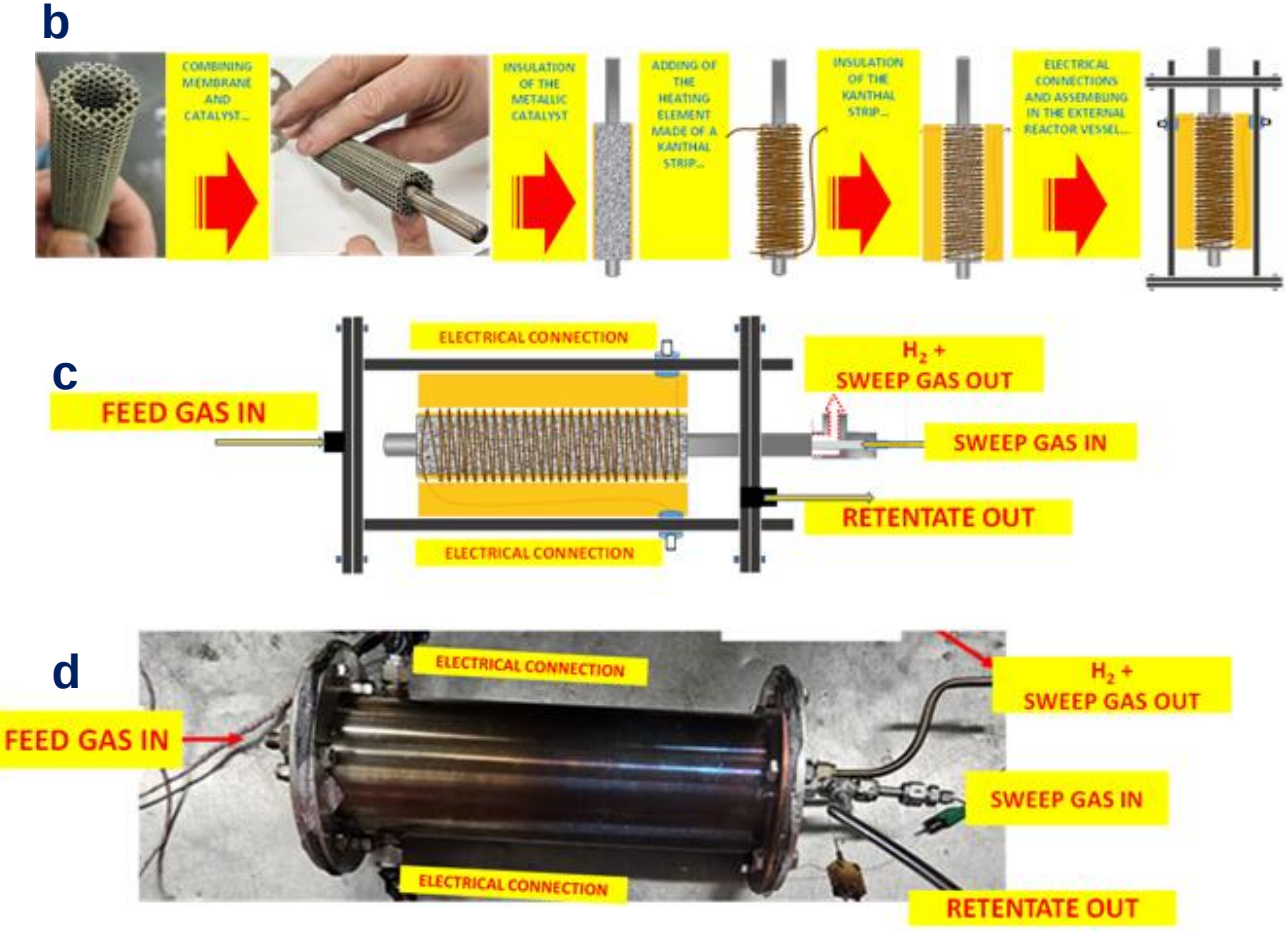
Institute on Membrane Technology
National Research Council of Italy

- *Study of generation and simultaneous H_2 purification of H_2 from biogas as bio-alternative to natural gas by Pd/Pd-alloys membranes housed in membrane reformers*
- *Electrification of the membrane reformer with the renewable energy surplus of the grid to generate decarbonized H_2*

PRIN (Research Program of relevant National Interest) Project – Bando MUR 2020 Prot. 2020N38E75, D.D. 2436 del 20/10/2021. **Budget: 893.000 €.**
CNR-ITM Scientific Responsible:
Dr. Adolfo IULIANELLI

H_2 production by membrane reactor technology: Electrification of a foam structured membrane reactor





Chemical Engineering Journal 531 (2026) 174263

Contents lists available at ScienceDirect

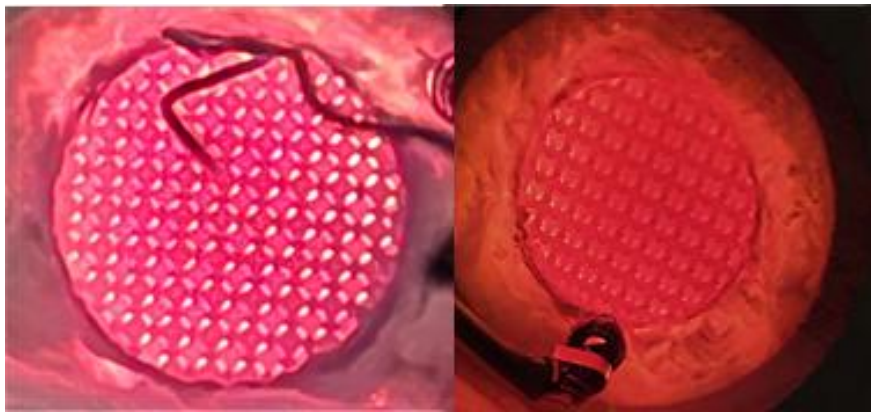
Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Electrically assisted POCS-catalytic reactor with integrated dense Pd—Ag membrane for low-carbon hydrogen production via dry reforming of methane☆

C. Ruocco [a,1], E. Meloni [a,*], A. Vita [b], C. Italiano [b,1], H. Brahim [b], A. Iulianelli [c,1], V. Palma [a]

a



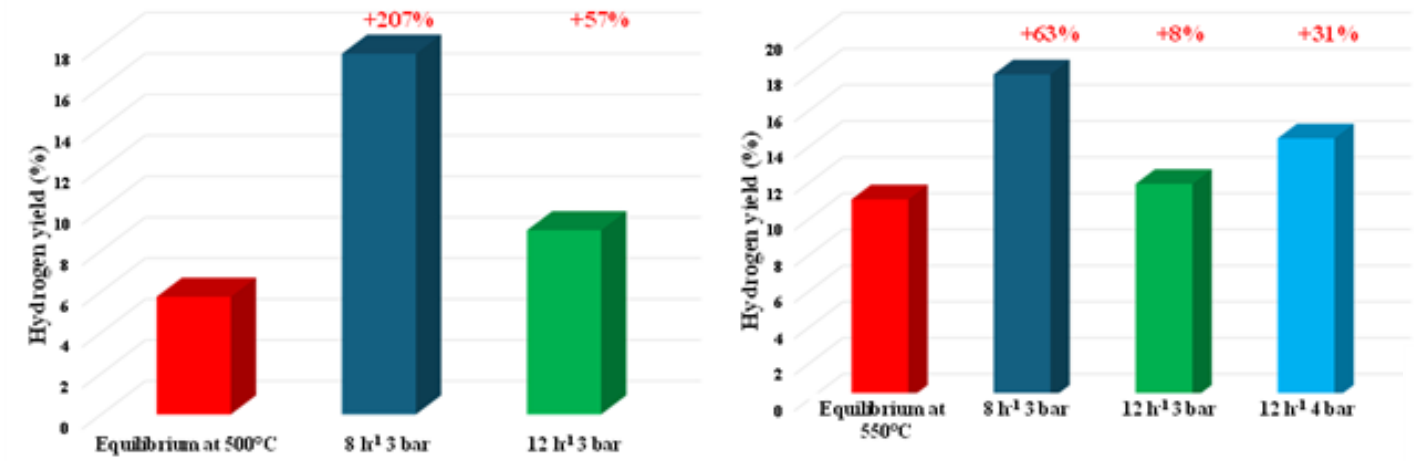
(a) Preliminary Joule-heating tests on cylindrical POCS samples at about 800°C, evidencing the absence of T gradients; (b) Schematic representation of the assembling steps of the electrically heated POCS-based MR and flow directions; (c) scheme of the final integrated MR; (d) photograph of the electrified MR used for the experiments.

CONSIGLIO NAZIONALE INGEGNERI

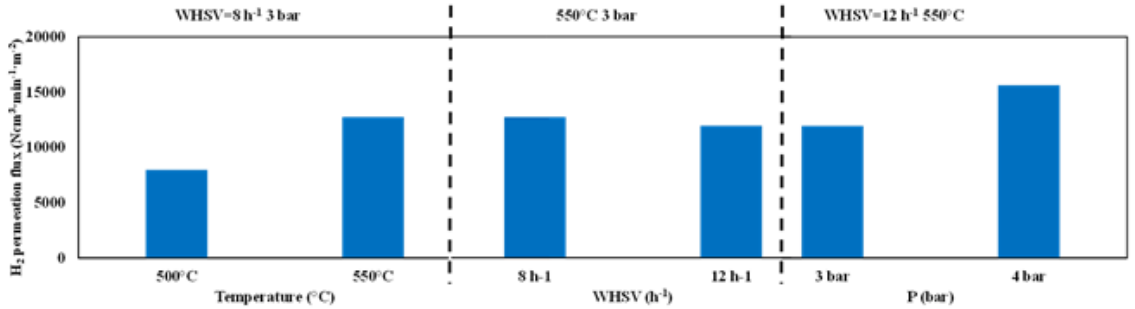
Experimental setup assembly and testing @ UNISA

Consiglio Nazionale delle Ricerche

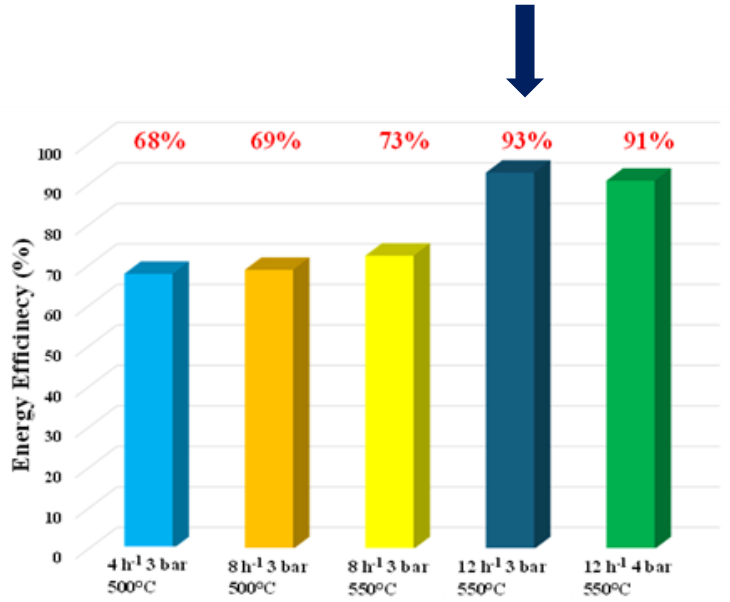
Electrification of the foam structured membrane reactor



Comparison of hydrogen yields recorded at 500°C (left) and 550°C (right) as a function of space velocity between the electrically assisted foam structured membrane reactor and the equilibrium value of the equivalent conventional reactor



Effect of temperature (left), space velocity (middle) and pressure (right) on the hydrogen permeation flux through the Pd-Ag membrane



Consiglio Nazionale delle Ricerche

INDUSTRIA 2015

Ministero dello Sviluppo Economico

Finanziamento ex MiSE = 15 M€

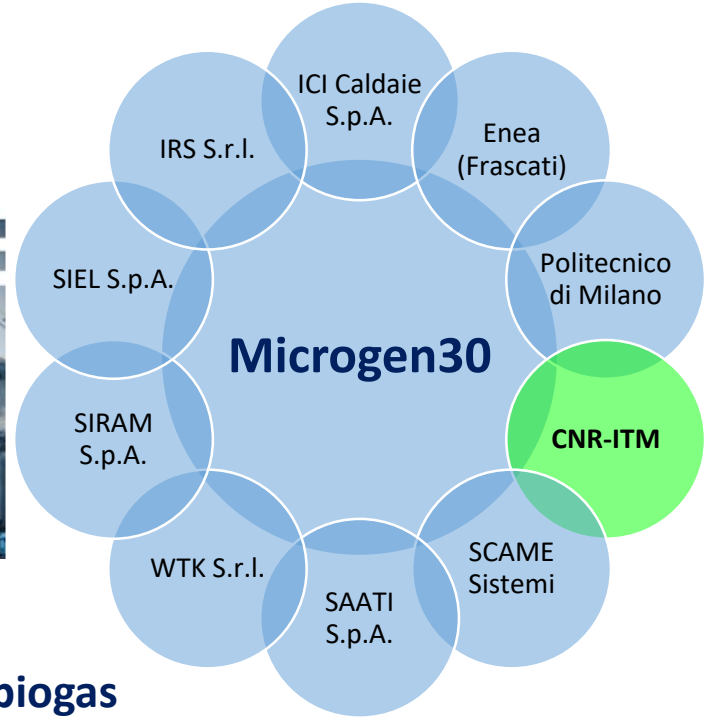


Ieri (2015)

ICI POWERING EVOLUTION



Oggi (2025)



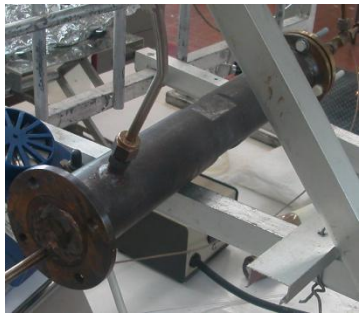
CNR-ITM in the first ranke Projects "Industrial Innovation INDUSTRY2015"

"MICROGEN30 - Medium-small Microcogeneration System based on Fuel Cells for Residential Applications" (Italian Economic Development Ministry, D.M. 5 March 2008)

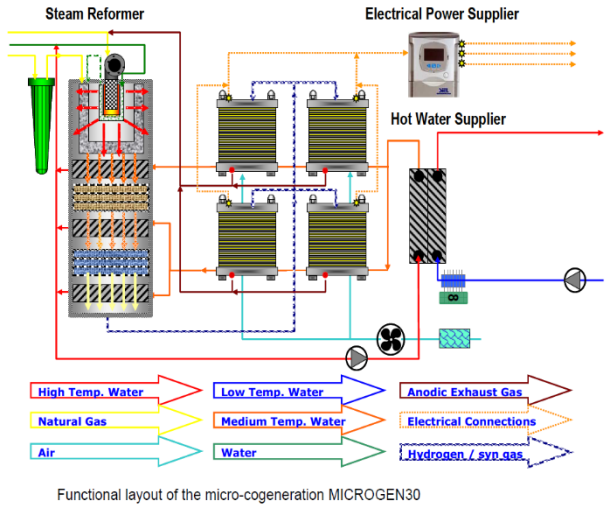
100 kg/day of pure hydrogen from biogas

CONSIGLIO NAZIONALE INGEGNERI



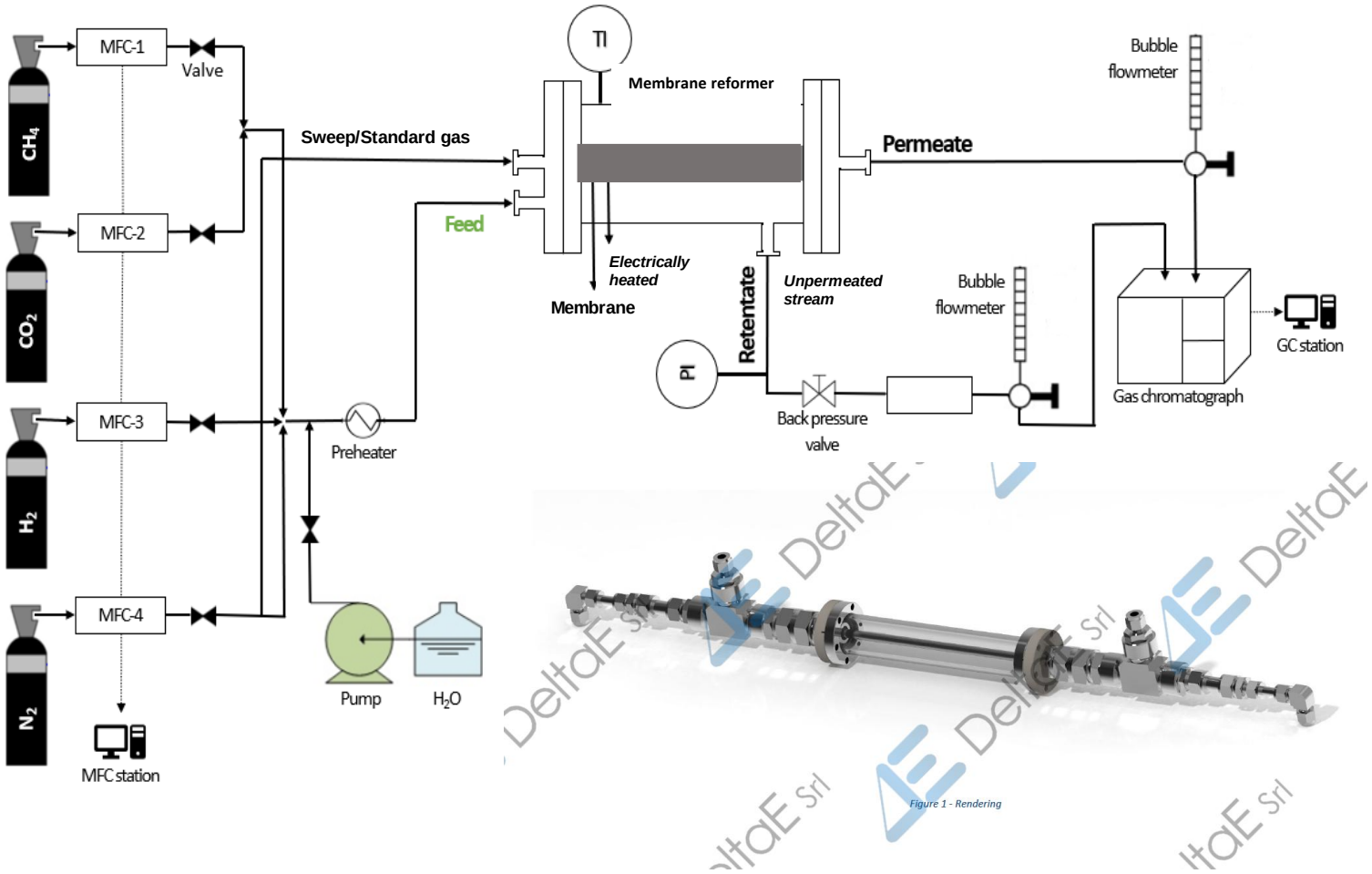


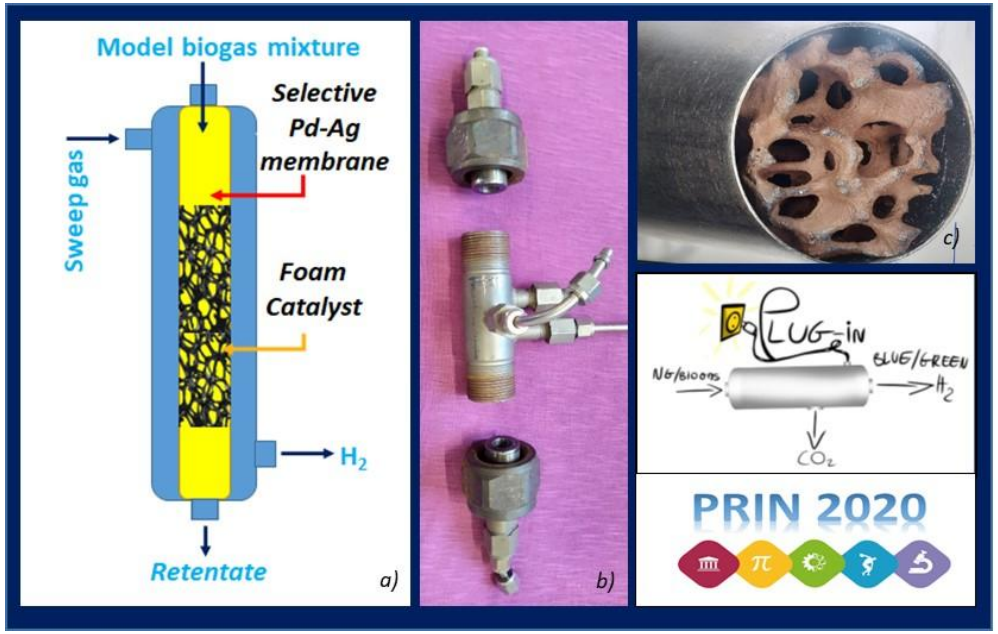




Functional layout of the micro-cogeneration MICROGEN30

PLUG-IN: Process for Low-carbon blUe/hydrogen Generation via Intensified electrified reforming of biogas/natural gas





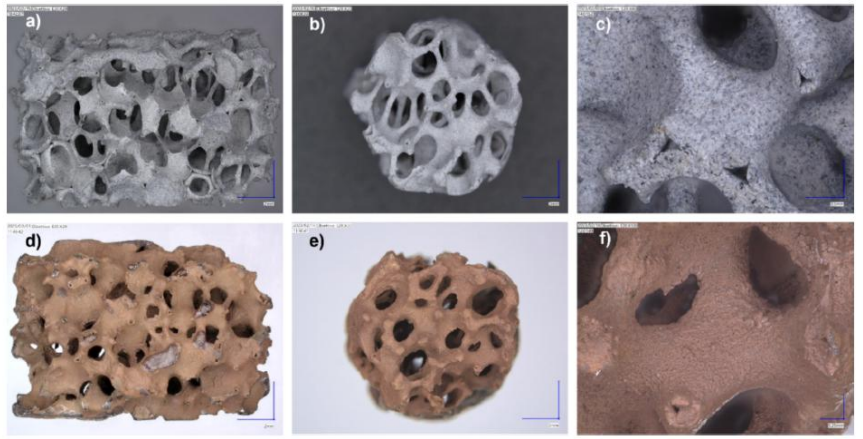


Fig. 5. Images of bare (a – c) coated (d – f) 40PPI SIC foam after calcination step.

Design di un reattore a membrana elettrificato bench-scale

H.B. Trujillo Ruales, A. Vita, C. Italiano, **A. Iulianelli***, Low impact emissions H2 production via biogas steam reforming in a foam structured membrane reactor: energy efficiency and exergy analyses, and H2 production cost assessment, Energy Conversion and Management 326 (2025) 119504. https://doi.org/10.1016/j.enconman.2025.119504

Consiglio Nazionale delle Ricerche

Finanziato dall'Unione europea NextGenerationEU

Italiadomani – Piano Nazionale di Ripresa e Resilienza

Ministero dell'Ambiente e della Sicurezza Energetica

Consiglio Nazionale Ingegneri

NextGenerationEU – Accordo di Programma tra MASE ed ENEA - CNR, RSE SpA, M2C2 Investimento 3.5 – PNRR, Progetto: Ricerca e Sviluppo sull'Idrogeno, Ob. 1, WP1.1., LA1.1.25: Sviluppo di materiali e processi catalitici per il reforming di biogas in H_2

Importo: 110 M€ (CNR-ITM > 1.4 M€)

PNRR – Missione 2, Component 2.3 – **Renewable Energy, Hydrogen, Networks and Mobility System**
Investments 3.1-3.5: *Promotion of the Production, Distribution, and Final Uses of Hydrogen*
Budget: 3,19 B€

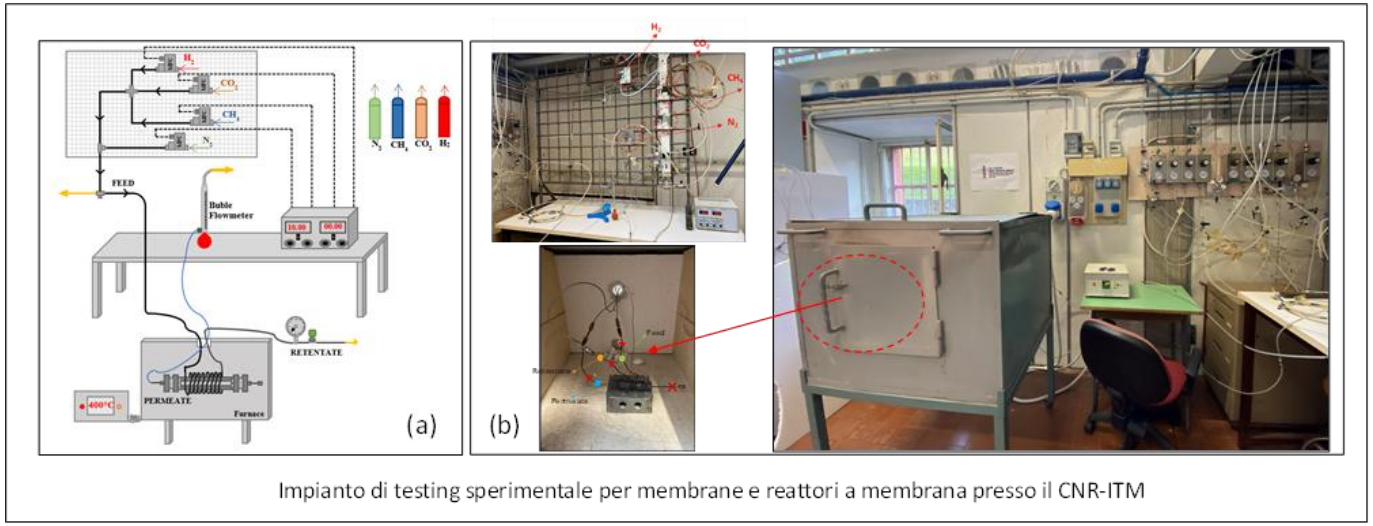
PNRR – Missione 2, Component 2.5 – **International Industrial and R&D Leadership Development in the key Transition Networks**
Investment 5.2: *Hydrogen*
Budget: 0,45 B€



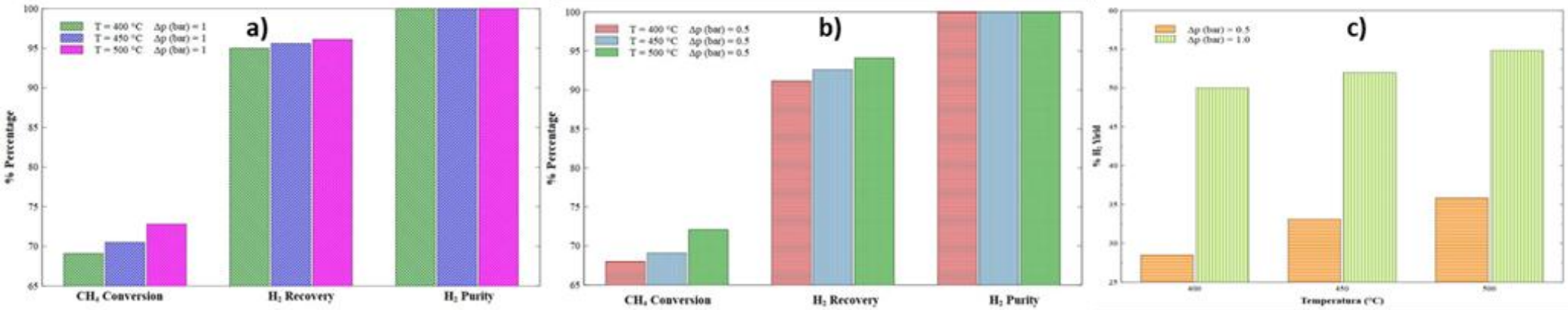
EU TARGETS
H_2 recovery: **80%** (2024); **90%** (2027); **95%** (2030)
H_2 purity: **99.99%**
Clean Hydrogen Alliance under the Strategic Research & Innovation Agenda 2021-2027

ENEA

RSE Ricerca Sistema Energetico



Impianto di testing sperimentale per membrane e reattori a membrana presso il CNR-ITM



PCR H_2

Institute on Membrane Technology
National Research Council of Italy

Consiglio Nazionale delle Ricerche

FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

BEING ENERGY

European Commission

SEVENTH FRAMEWORK PROGRAMME

THEME [SP1-JTI-FCH.2011.4.4]
[Research, development and demonstration of new portable Fuel Cell systems]

Grant agreement for: Article 171 of the Treaty

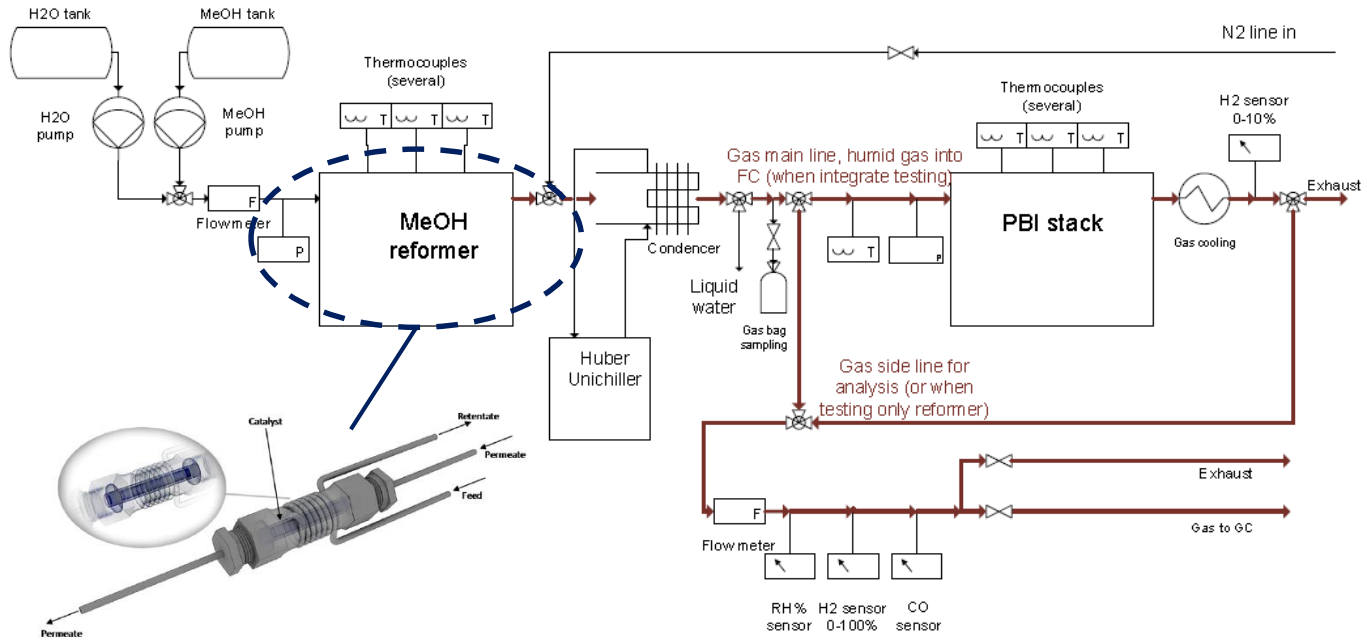
Annex I - "Description of Work"

Project acronym: BeingEnergy

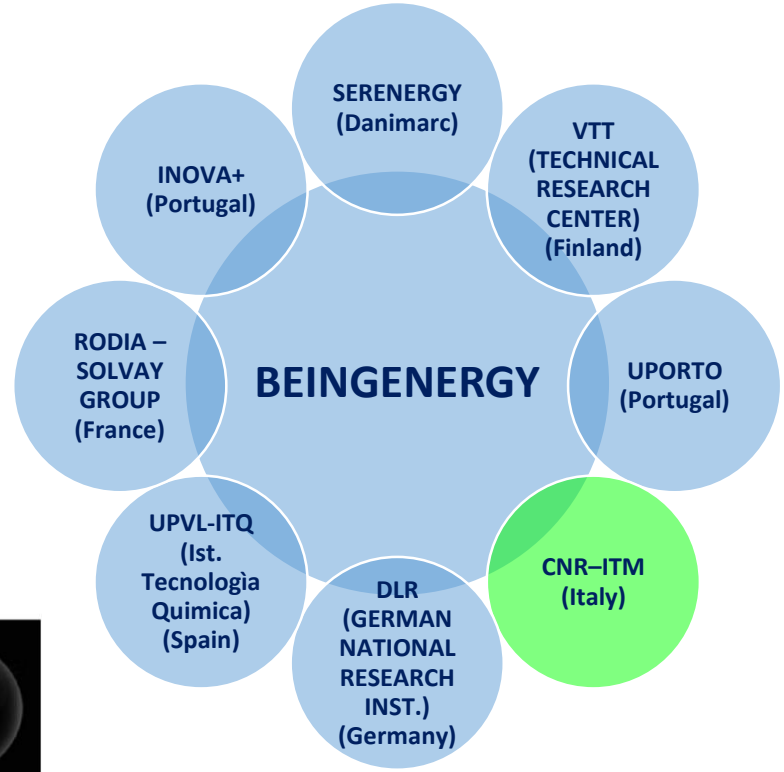
Project full title: " Integrated low temperature methanol steam reforming and high temperature polymer electrolyte membrane fuel cell "

CONSIGLIO NAZIONALE INGEGNERI

Progetto BEINGENERGY: Reformer per la conversione catalitica del metanolo in idrogeno per alimentazioni di celle a combustibile di alta temperatura

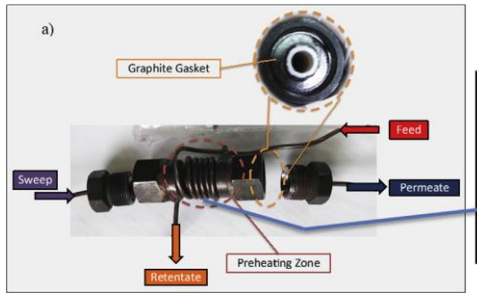


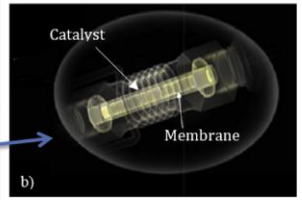
Finanziamento europeo = 4.5 M€











Institute on Membrane Technology
National Research Council of Italy

Consiglio Nazionale delle Ricerche

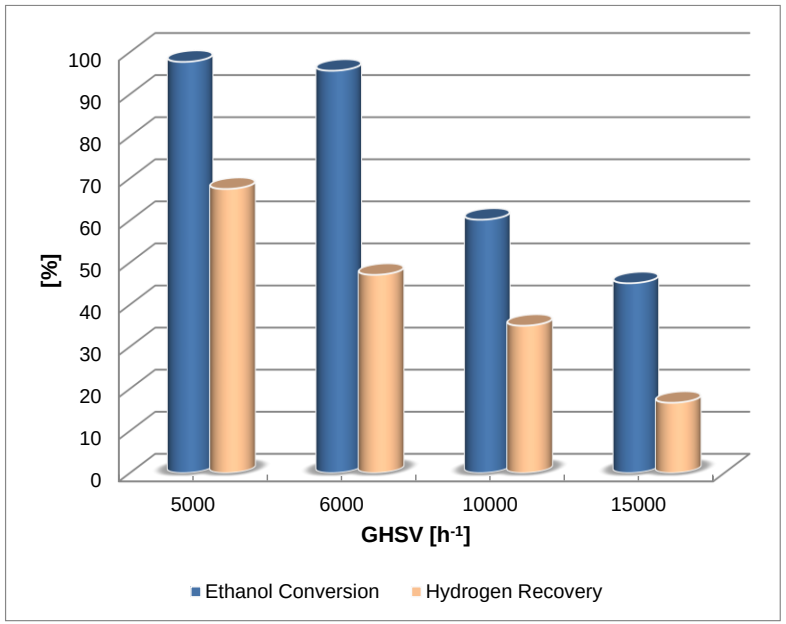
ITM

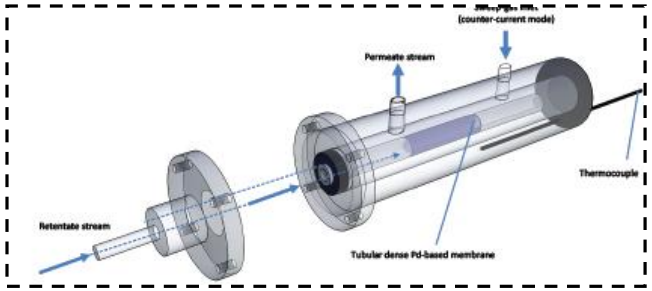
ADVANCED CATALYSTS

UNIVERSITÀ DI SIENA 1240

T.m. tecnologie meccaniche

CONSIGLIO NAZIONALE INGEGNERI





Green Engineering®

STATE OF THE ART ETHANOL PLANTS





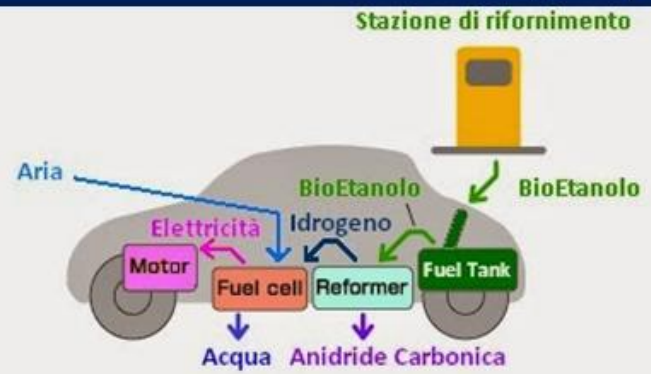






SPEI - BETA Sistema di Propulsione Elettrica ad Idrogeno tramite conversione autosostenuta di BioETANOLO

REGIONE TOSCANA – POR CREO 2007/2013, BANDO UNICO DI RICERCA E SVILUPPO 2012 (2014/15)



Consiglio Nazionale delle Ricerche

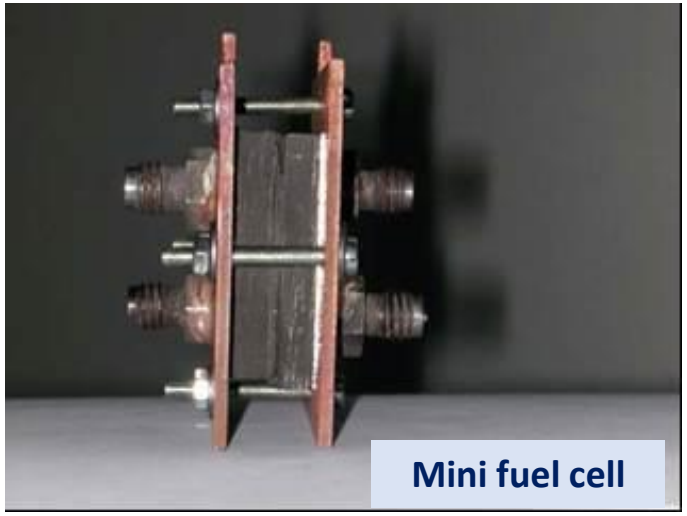
PROGETTO MIUR/FAR N. 9589: "Nuove membrane polimeriche a scambio protonico per celle a combustibile a idrogeno»

CONSIGLIO NAZIONALE INGEGNERI

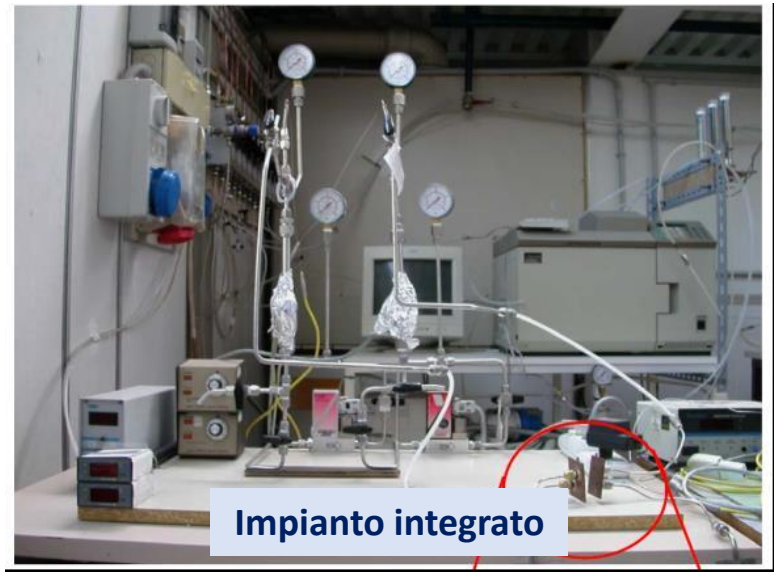
Finanziamento MIUR = 2 M€

Membrane di PEEK-WC solfonato

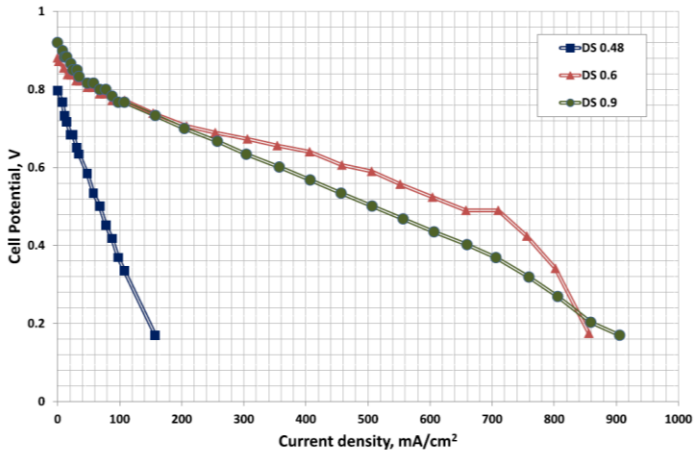




Mini fuel cell



Impianto integrato



Comparison within polarization curves of S-PEEK-WC membranes at different DS (48, 60 and 90%) at $T = 80$ °C.

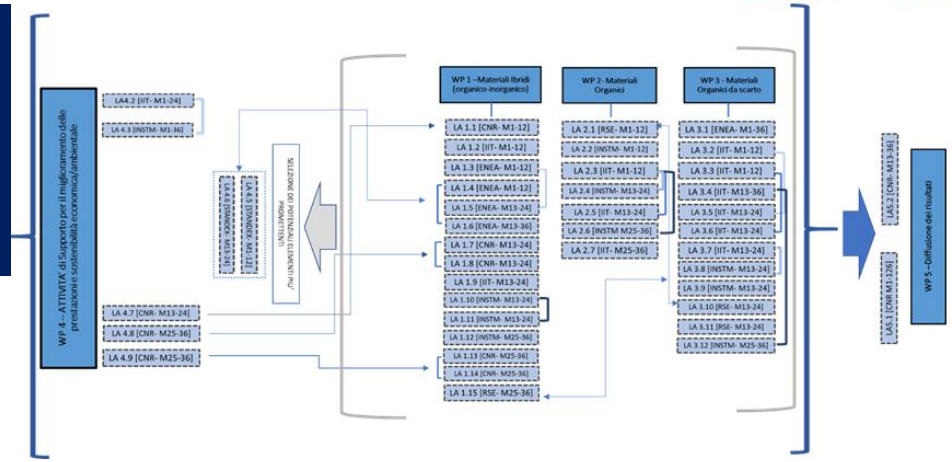
ITM Institute on Membrane Technology National Research Council of Italy



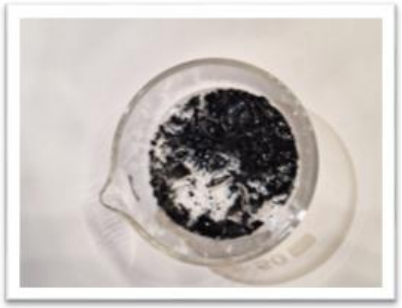
ORANGEES
ORgANics for Green Electrochemical Energy Storage

Ministero dell'Ambiente e per la Sicurezza Energetica - MASE (ex MITE): Bando per progetti di ricerca previsti dal Piano triennale 2019-2021 della Ricerca di sistema elettrico nazionale - 1.2 Sistemi di accumulo, compresi elettrochimico e power to gas, e relative interfacce con le reti» per lo «Studio e sviluppo di materiali per i sistemi di accumulo»

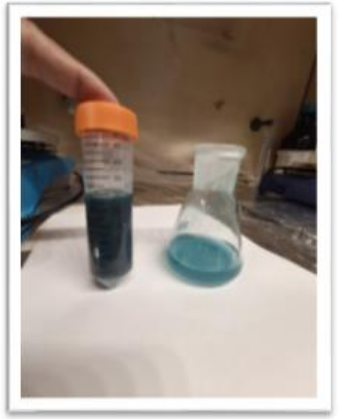
Budget: 3.88 M€



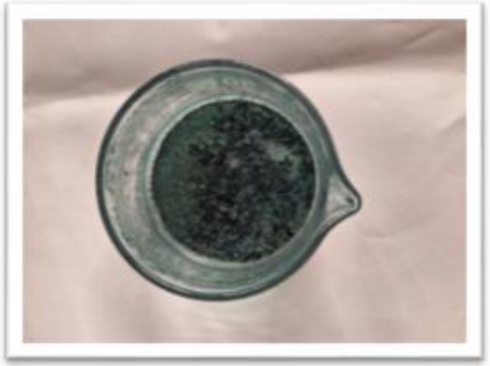
Obiettivo: Preparazione di materiali catodici per batterie Na-ione (quali sistemi di accumulo elettrochimico dell'energia, mediante uso di PB e PBA con nanofibre di carbonio (CNF) mediante tecnica di electrospinning



$Na_2Co[Fe(CN)_6]$



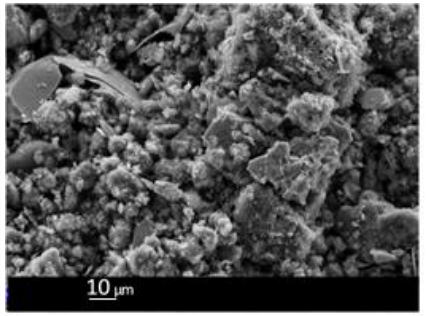
Soluzione di lavaggio della polvere $S@Na_2Co[Fe(CN)_6]$

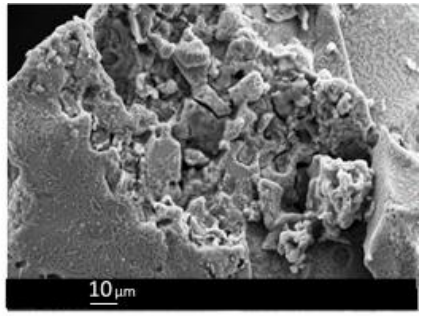


$S@Na_2Co[Fe(CN)_6]$



Soluzione GO





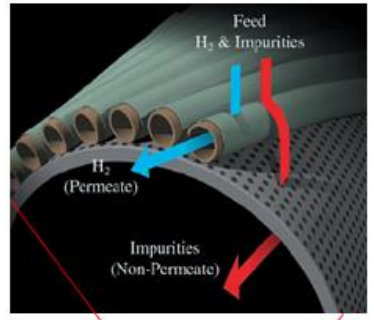
Immagini SEM a) polvere GO; b) polvere $S@Na_2Co[Fe(CN)_6]$

Impact of commercial membrane based modules for H_2 separation/recovery

PRISM® membrane module



POLYSEP™ membrane module

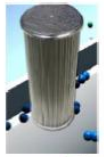
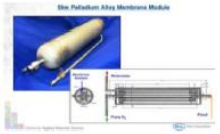
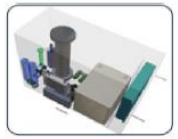
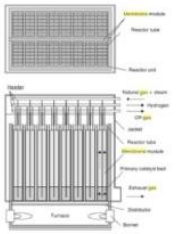




VaporSep-H_2™ membrane module in a Korean refinery



REAL DIMENSION: World Pd-based membrane reactors industrial installations

Company	Country	H_2 prod.	H_2 purity [%]	Reformer details	T [°C]	Catalytic process	Membrane reactor details	Ref.
Power & Energy Inc.	USA	160 Nm^3/h	97–99,9999999	Radial micro channel membrane reactor	–	Methane steam reforming		[259]
Pall Co.	USA	1650 sft^3/h	> 99	Composite Pd-based membrane reactor	600	Natural gas steam reforming		[260]
MRT Ltd.	Canada	15–50 Nm^3/h	> 99,999	Membrane reactor's HydRec™	450	Natural gas/renewables steam reforming		[261]
Tokyo Gas Company Ltd.	Japan	≥40 Nm^3/h	> 99,99	Composite Pd-based membrane reactor	495–540	Natural gas steam reforming		[262]
KT-Kinetics Technology S.p.A	Italy	20 Nm^3/h	99,9	Pd, Pd-Ag membrane reactors	500–650	Natural gas steam reforming		[263]
Linde-Engineering (Linde Group)	Germany	100–400,000 Nm^3/h	99,9999	–	600–650	Natural gas steam reforming	–	[264]
REB Research & Consulting Co.	USA	300 sccm/min	> 99,9999	Micro membrane reactor	200–700	Methane, methanol, ethanol steam reforming & ammonia craking		[265]



Statoil plant in Tjeldbergodden, Norway

Peters et al, Palladium (Pd) membranes as key enabling technology for precombustion CO_2 capture and hydrogen production, Energy Procedia 114 (2017) 37–45



https://www.tecnalia.com/en/press-room/tecnalia-and-h2site-launch-the-first-industrial-scale-membrane-reactor-to-produce-hydrogen

Istituto per la Tecnologia delle Membrane
Consiglio Nazionale delle **Ricerche**

Dissemination of the membrane engineering impact in the H_2 energy and decarbonisation

ECCE AB 23
17 - 21 September 2023, Berlin/Germany



14th European Congress of Chemical Engineering and 7th European Congress of Applied Biotechnology (ECCE-ECAB23)

Special Session: "Hydrogen for a decarbonized future"





Conference: ***14th European Congress of Chemical Engineering***
Special Session Organisation: **'Hydrogen for a decarbonised future'**
Chairs: **Dr. A. Iulianelli & Prof. E. Tronconi**
Place: **Berlin Cube (Berlin, Germany)**







Conference: ***International Congress on Sustainable Energy and related Technologies*** (Eolie's Islands, Italy)
Event: **Hydrogen and Clean Energy: Insights from the IAGE community**
Chair: **Dr. A. Iulianelli**







Special Session Organisation: **"Hydrogen energy and Carbon Capture & Utilization in the circular economy: from materials development to sustainable processes"**
Chairs: **Dr. A. Iulianelli, Dr. F. Dalena**
Place: **Naples (Italy)**





Workshop: **'Innovations on Hydrogen-based Processes & Technologies'**
Chairs: **Dr. A. Iulianelli & Prof. C. Acar**
Place: **Dokuz Eylul University (Izmir, Turkiye)**

Special Session: **'Membrane Technologies in H_2 Production, Separation and Utilization'**
Chairs: **Dr. A. Iulianelli & Prof. O.C. Colpan**
Place: **Dokuz Eylul University (Izmir, Turkiye)**





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ICOM2029

7-13 July 2029, Rome, Italy

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