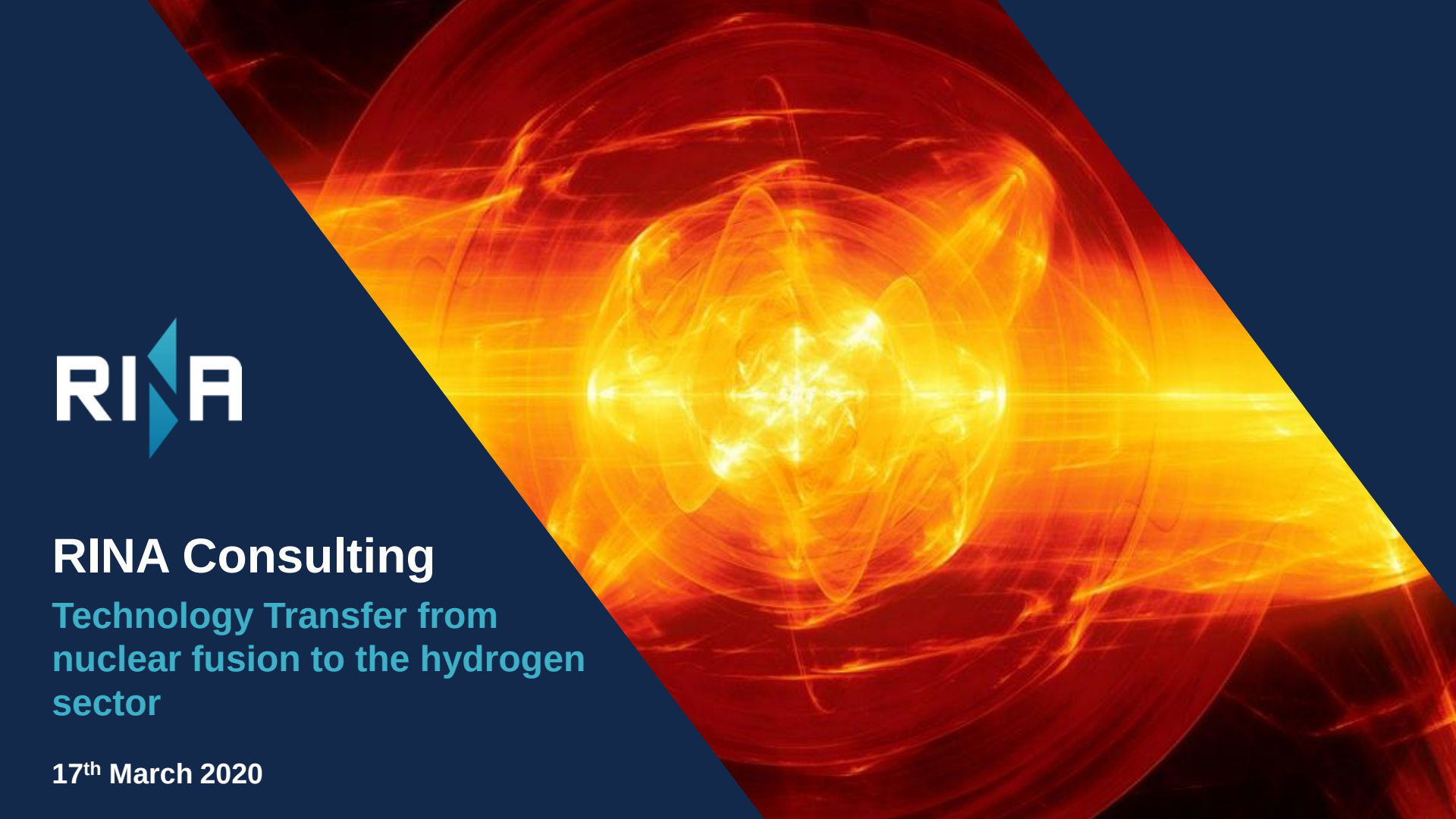
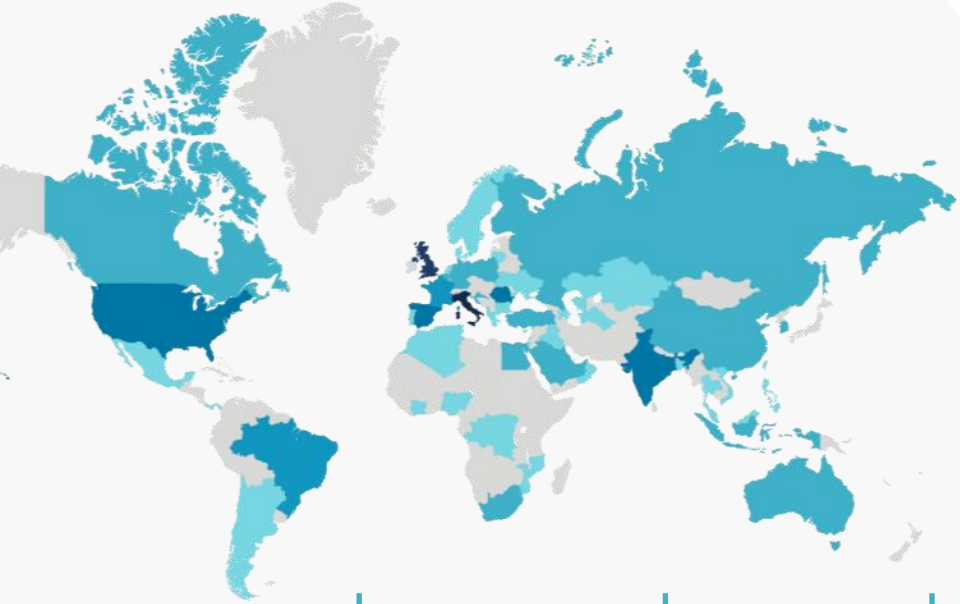


RINA Consulting

Technology Transfer from nuclear fusion to the hydrogen sector

17th March 2020

RINA is a global firm of consulting engineering and compliance services



3.800 Colleagues | 70+ Countries | 200+ Offices | 440+ M€ Turnover

LEVEL OF RINA PRESENCE:

low → high

- INDUSTRY
- CERTIFICATION
- TRANSPORT & INFRASTRUCTURE
- ENERGY
- MARINE

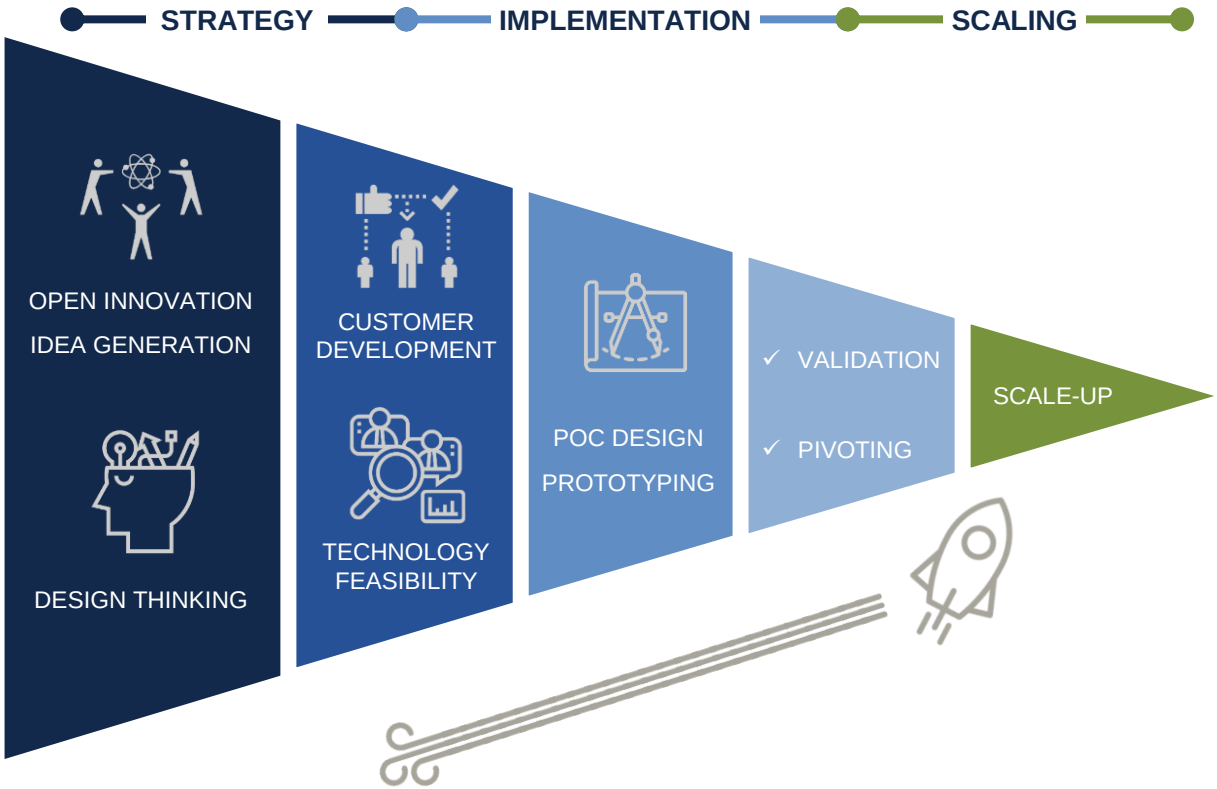
INDUSTRY

Materials, Technology & Innovation

SERVICES

- Innovation & Business Strategy
- Product Design & Engineering
- Materials and Product Development
- Manufacturing Process Innovation & Smart Manufacturing
- Material Selection & Qualification
- Technology Transfer Activities
- Product & Process Sustainability
- Engineering Critical Assessment (ECA)
- Life Cycle Assessment
- Performance Assessment
- Condition Assessment & Forensics

Total Innovation Management



RINA Total Innovation Management framework of services supports organisations in reaching their innovation targets through the design and implementation of Innovation Management systems and processes

RINA Total Innovation Management is designed according to the ISO 56000 guidelines

Technology Transfer – Context and origin

A technology transfer programme built on ESA experience

esa
European Space Agency

AN EXISTING COMMUNICATION NETWORK WITH INDUSTRY

ESA BROKER SYSTEM

Adapted to fusion technology

MEDIATION
EUROfusion Research labs and ESA brokers

FUSION PROMOTION
From brokers to industry

TECHNOLOGY DESCRIPTION
EUROfusion Research labs and ESA brokers

showing promising results

24
TECHNOLOGY DESCRIPTIONS

900
COMPANIES contacted and introduced to fusion innovation by EUROfusion

FUTTA II

Starting 2019, a consortium of 6 country brokers to promote and foster fusion technology in Europe.

European Commission

EUROfusion

RINA within the European network of brokers

EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

- 30 research organisations and universities from 26 EU Member States
- EUROfusion supports, coordinates and funds fusion research activities on behalf of the EC's Euratom programme

FUSION FOR ENERGY

- EU organisation managing the European contribution to ITER, the world's largest fusion experiment building a large Tokamak in Cadarache (France)
- Partnering with industry and SMEs to develop and deliver technology components, engineering, maintenance and support services

Technology Transfer – How does it work?

EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

FUSION FOR ENERGY

Identification of a portfolio of Technologies

Collection of "Technology Needs" from industries and companies

MATCHING & MEDIATION

TECHNOLOGY TRANSFER opportunity

Technologies Overview

EUROfusion TECHNOLOGY TRANSFER PROGRAMME

RINA

Sensors, characterization and diagnostic technologies

- Vision systems components
- Tomography and particle analysis
- Thermography and diagnostics
- Materials characterization
- Remote metal-working solutions

Advanced modeling, data processing and simulation tools

- Radiation simulation and management
- High pressure and temperature
- Thermal loads modeling
- Aging and kinetics

High performance materials (tungsten, composites)

- Surface coatings
- Composites components
- Metal alloys
- Custom production processes

Hydrogen and gas technologies

- Membranes for H_2 production/separation
- Gas detection technologies
- Special valves

Energy and Power Transmission

- Low temperature plasmas
- Nanofluids for enhanced heat recovery
- Cooling composite components

50+

Technologies and services available for Technology Transfer by Eurofusion

Technologies Overview

EUROfusion TECHNOLOGY TRANSFER PROGRAMME

RINA

Sensors, characterization and diagnostic technologies

- Radiation resistant image sensors
- Components for vision and optics systems
- Target Reflectivity Measurement System for large objects and hazardous environments
- Metrology and quality inspection technologies
- High-precision vision systems for dimensional inspection

High performance materials (tungsten, composites)

- Circuits with high radiation resistance
- Support materials (ceramic and silicon-based) for high-performance sensors
- Advanced optical materials
- Electron beam welding technologies for large structures

Advanced modeling, data processing and simulation tools

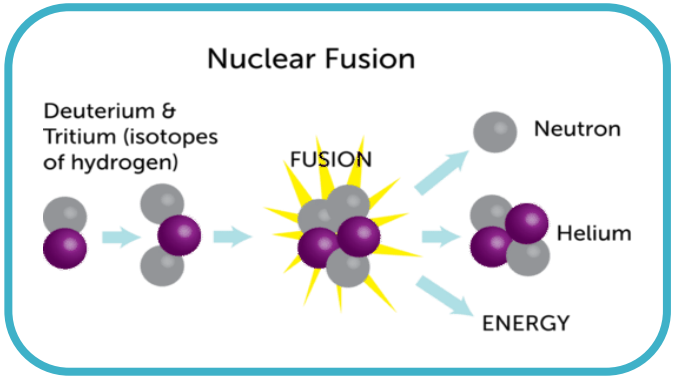
- Software for real-time systems control
- Software for requirements management and verification processes
- Software for the control of robotic systems
- Software for advanced simulation

Energy and Power Transmission

- Control and monitoring systems for particle accelerators and electron beam instrumentation
- Motors and actuators for harsh environments
- Advanced hydraulic control valves

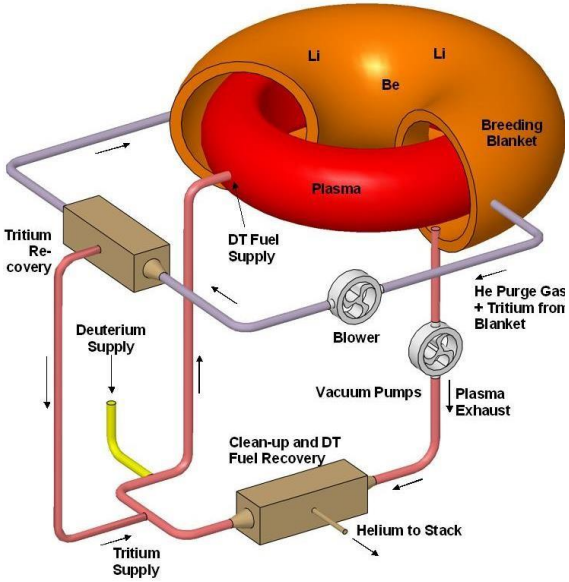
20+ Technologies and services available for Technology Transfer by Fusion for Energy

The role of H_2 in Nuclear Fusion



- The fusion reaction in the ITER Tokamak reactor will be powered with **deuterium** and **tritium**, two isotopes of hydrogen.
- The fusion of these light hydrogen atoms produces a heavier element, helium, and one neutron.

- ITER will be the first fusion machine fully designed for deuterium-tritium operation.
- The fuels used in ITER will be processed in a **closed cycle**. Stored deuterium and tritium are introduced into the vacuum chamber where only a small percentage of the fuel is consumed.
- The plasma exhaust is removed and processed through an isotope separation system that extracts out the fusion fuels for reinjection into the fuelling cycle.



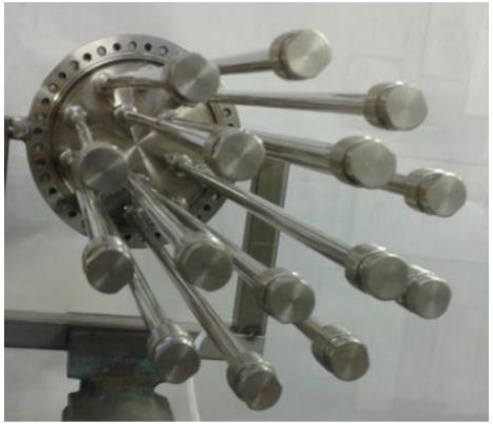
Fusion Technologies for the hydrogen sector

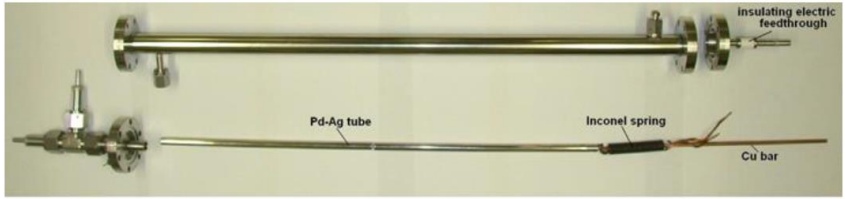
- Decades of international cooperation among major research institutes
- A lot of effort on R&D to study, research and identify technologies and solutions able to withstand extremely demanding environments
- Strong technical background and wide potential for technology transfer

Examples of Fusion-derived technologies for H_2 domain:

1. Highly selective membranes for hydrogen separation and production
2. Sensors to measure hydrogen partial pressure in a flow
3. Transport libraries for dynamic hydrogen transport modeling
4. Software for high precision simulation in high-temperature conditions
5. Materials able to withstand extreme conditions
6. Valves and tubes for demanding applications

Membrane processes for Hydrogen separation and production





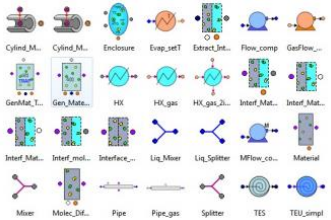
These membrane devices have been developed at ENEA Frascati laboratories for separation of hydrogen isotopes from tritiated water.

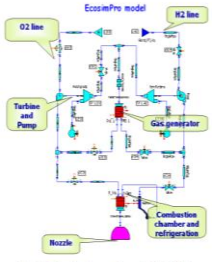
Applied to the production of H_2 from biomass, the dehydrogenation process on which these devices are based, allows the achievement of higher hydrogen and syngas yields than traditional reactors.

Furthermore, these processes represent the only solution available for some kind of biomass (i.e. olive mill wastewater) that cannot be treated via the conventional biological processes.

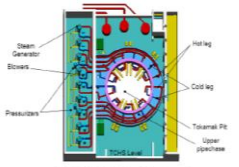
Hydrogen and gas technologies

Transport Libraries for dynamic hydrogen transport modeling

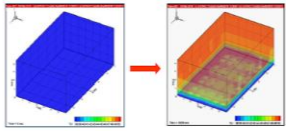




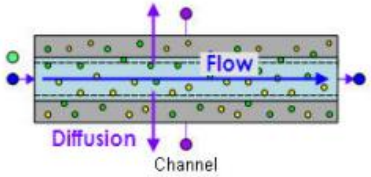
The Vulcain main stage engine model in EcosimPro



DEMO. Blanket Cooling System Layout



GOTHIC



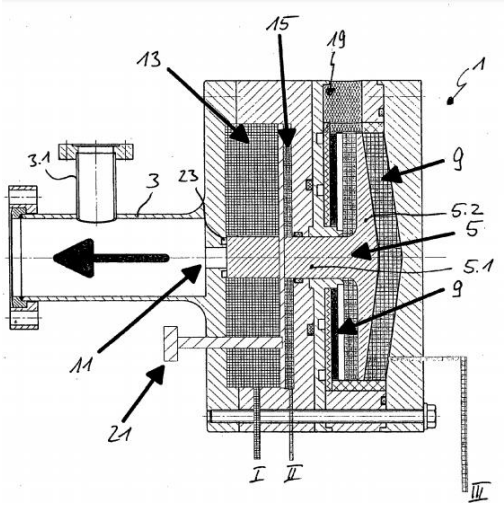
Cryogenic and tritium permeations are strong challenges in fusion technology. Empresarios Agrupados Internacional (EAI) has been working, in close collaboration with CIEMAT, in different EFDA tasks concerning tritium transport modelling.

They especially developed a set of libraries for the simulation of systems and processes involving hydrogen isotopes for the study of transport phenomena and of physico-chemical processes related to the extraction and purification of tritium.

Easy to reuse in many different systems without having to be reprogrammed, this tool could find promising application in every area which requires the simulation of processes involving hydrogen isotopes.

Hydrogen and gas technologies

Fast Gas Inlet Valve insensitive to Magnetic Fields



The technology is a fast gas inlet valve, primarily for emergency situations, fitted inside a magnetic field device, but not sensitive to the magnetic field.

This device was originally developed for use within the nuclear fusion domain, but is also available for use in other domains with similar demanding environments.

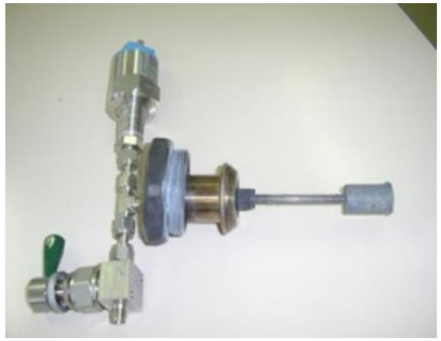
When installing a gas inlet valve in a fusion reactor, it must be mounted within the magnetic field configuration to achieve rapid injection of gas, which demands short gas lines.

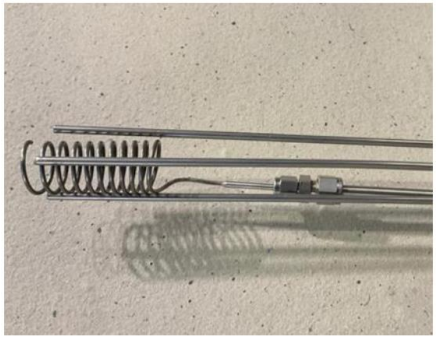
The injected gases are usually noble gases in the case of a fusion experiment. The valve is capable of injecting large volumes of gas in the order of up to several mbarL within very short times such as within less than 10 milliseconds.

This is achieved even inside a strong electromagnetic environment.

Hydrogen and gas technologies

Sensors to measure hydrogen partial pressure in liquid metals





Leading the research on liquid metal technology for breeding blankets in close collaboration with EUROfusion, ENEA Brasimone Research Centre (Italy) has developed a new type of sensor able to perform direct measurements of the hydrogen partial pressure in liquid metals, not considering contribution from other dissolved gases.

Initially developed for fusion research to measure hydrogen isotopes concentration in lead-lithium alloy, the sensors may be useful for process control for metallurgy or other industries that are interested to measure hydrogen content for purification purposes.

The sensors have been qualified in lead alloys and are now open for further developments and adaptations to industrial standards.

Hydrogen and gas technologies

SUCCESS STORY: Fusion know-how helps extracting hydrogen from olive mill wastewater

Internal view of the multi-tube membrane reactor built by ENEA for Eurofusion

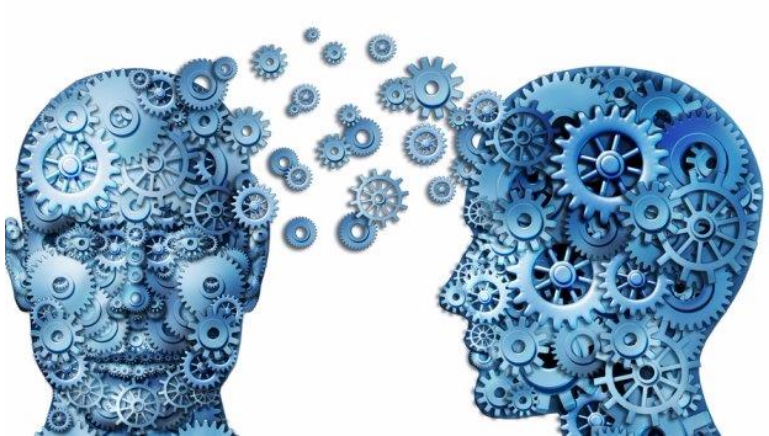
Membrane system for producing ultra-pure hydrogen via reforming of methane and olive mill wastewater

- Pd membrane devices for separation of hydrogen isotopes from tritiated water have been developed to operate in continuous processes characterized by high efficiency and increased safety.
- ENEA design and built a Pd-membrane reformer for producing hydrogen via reforming of methane and biomass (i.e. olive mill wastewater): the high purity hydrogen obtained from the membrane unit was used to feed high efficiency PEM fuel cells.

Conclusions

Many technologies and solutions can be potentially transferred from Fusion domain to Hydrogen sector…

… Do not hesitate to contact us, check the portfolios and identify possible opportunities!



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