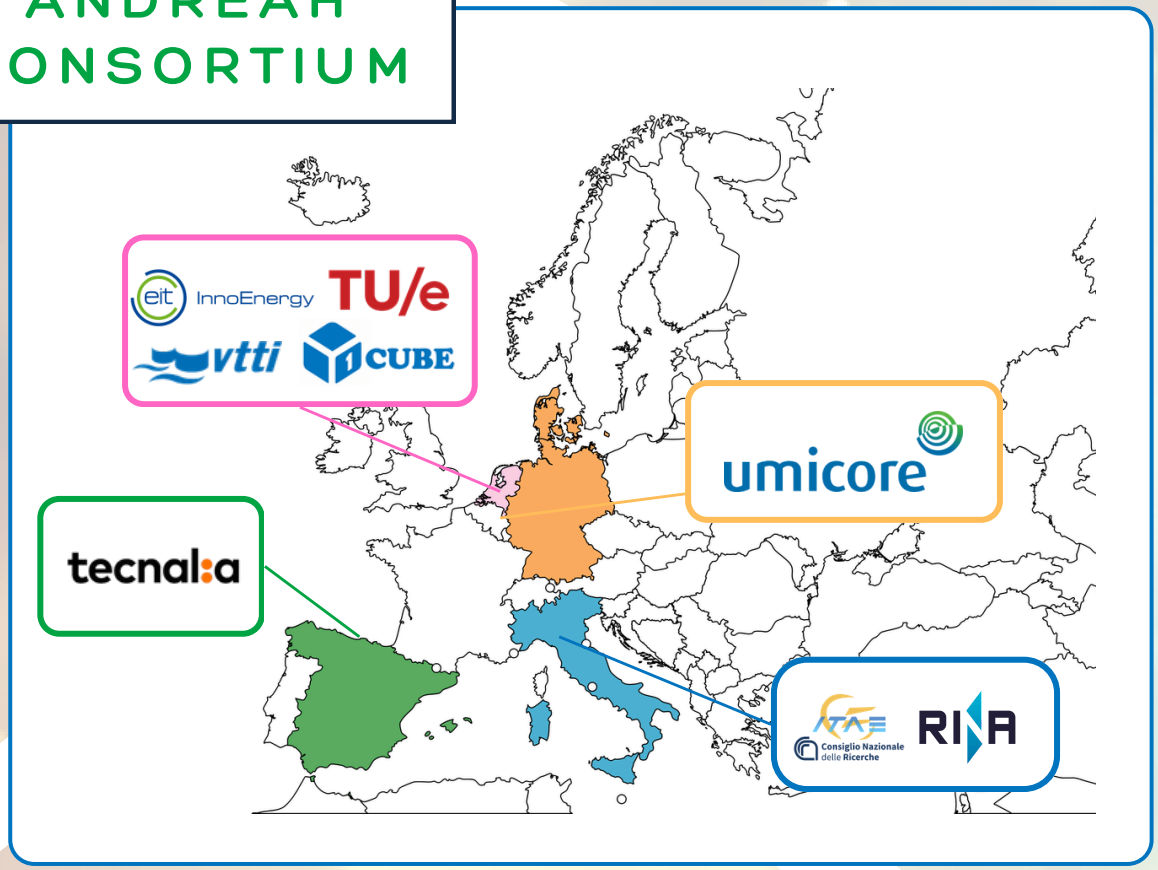
# ANDREAH CONSORTIUM




# AndreaH

AmmoNia baseD membRane rEActor for green Hydrogen production

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The project is supported by the Clean Hydrogen Partnership and its members Hydrogen Europe and Hydrogen Europe Research.

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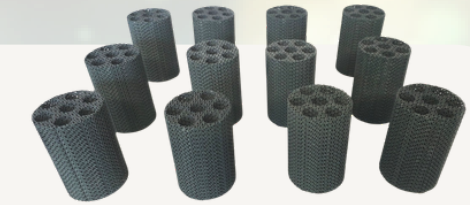
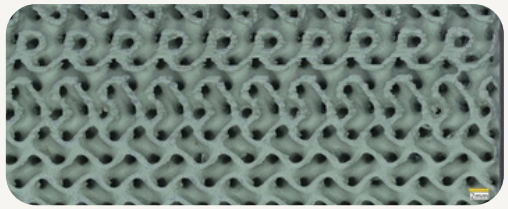
# Milestone achieved by CNR-ITAE, RINA and TECNALIA

## From lab scale to demonstrator: 3D-printed structured catalysts for ammonia cracking by CNR-ITAE



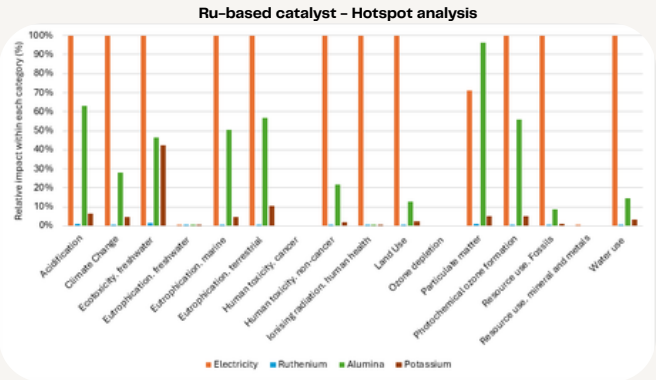


Within ANDREAH, CNR-ITAE has scaled up 3D-printed structured catalysts to demonstrator size (TRL5).

The supports are nickel-alloy gyroid Periodic Open Cellular Structures (POCS), 6.5 × 10 cm, printed by Selective Laser Melting. The Triply Periodic Minimal Surface (TPMS) open architecture combines a high surface area with low pressure drop, and seven channels house the hydrogen-selective membranes.
Twelve POCS were activated with a catalyst with low ruthenium content, developed and scaled up by UMICORE.

An optimised dip-coating procedure gave a uniform, crack-free catalyst distribution over the whole structure.
The structured catalysts are now being integrated with the membranes in the ANDREAH prototype.

## Preliminary Hotspot Analysis of Ru-Based Catalyst Production by RINA-C




The preliminary hotspot analysis refers to the production of 1 kg of Ru-based catalyst at laboratory scale. Electricity is the main contributor across most EF 3.1 impact categories because long preparation and thermal operations are allocated to a small batch, resulting in high electricity consumption per kilogram.

Alumina, which represents 96% of the catalyst mass, becomes the main contributor to particulate matter because its upstream production involves mining, milling and high-temperature calcination, associated with dust and particulate-precursor emissions. At industrial scale, larger batches, improved equipment utilisation, heat recovery and lower-impact electricity could substantially reduce the energy burden.

Catalyst regeneration and material recovery could further limit demand for virgin alumina and critical raw materials.

## Ultra-thin Pd based double skin membranes for the ANDREAH prototype by TECNALIA



Within the ANDREAH project, TECNALIA originally developed carbon molecular sieve membranes (CMSMs) to be integrated in the membrane reactor, but their selectivity at 450 °C fell far short of project targets ($H_2/N_2$ > 300), limiting hydrogen purity and reducing ammonia conversion. To address this, the consortium replaced the CMSMs with ceramic pore-filled metallic membranes incorporating palladium within the pore structure.

Pd-based membranes operate via a solution-diffusion mechanism: hydrogen dissociates into atoms on the Pd surface, diffuses through the metallic lattice, and recombines on the permeate side. This confers an intrinsically very high selectivity for hydrogen, as other gases ($N_2$, $NH_3$) cannot permeate the Pd layer.

During Reporting Period 2, TECNALIA fabricated 21 membranes and delivered them to TU/e. These membranes will be integrated into the prototype to validate the membrane reactor concept for ammonia cracking and to demonstrate the low-ruthenium catalyst and hydrogen purification sorbents.