THE CHALLENGE

The chemical industry consumes vast amounts of energy and contributes significantly to global greenhouse gas emissions. Traditional methods of producing vital chemicals like ammonia and methanol rely heavily on fossil fuels, creating a substantial carbon footprint. As the demand for these chemicals grows, there is an urgent need to shift away from fossil-based hydrogen and adopt greener alternatives to meet environmental goals and create a more sustainable future.

ALCHEMHY'S SOLUTION

ALCHEMHY aims to decarbonise the chemical industry with four electrified, zero-emission pathways to produce ammonia and methanol using renewable hydrogen. The project will develop hybrid digital twins to support the design and operation of the novel processes, optimising them under different conditions. At the same time, efforts will focus on the research for new catalyst materials to improve ammonia and methanol yield while ensuring compatibility with electricity supply. Through technical, economic and environmental assessments, ALCHEMHY will support scale-up and replicability, paving the way for a resilient and sustainable chemical industry.

CONSORTIUM

circe Research Centre for Energy Resources and Consumption

National Institute of Chemistry

CIIAE Centro Ibérico de Investigación en Almacenamiento Energético

universidade de aveiro

BluEnergy Revolution

University of Antwerp

ETH Zürich ICOS

core|IC

Center for Sustainable Energy Fondazione Bruno Kessler

AIT Austrian Institute of Technology

WHITE

ReCatalyst

HYSYTECH | NIPPON GASES

UBE

sonatrach raffineria italiana

CASALE

PROJECT ID

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ALCHEMHY

ALTERNATIVE ROUTES FOR BASIC CHEMICALS PRODUCTION USING HYDROGEN AS FEEDSTOCK

Driving industrial decarbonisation through chemical innovation

ALCHEMHY'S APPROACH

1. Development of catalysts and novel processes

This phase lays the foundation for ALCHEMHY's electrified productions routes for methanol (SFMR and PCH*) and ammonia (MSER and DESA**), focusing on **advanced catalysts** and **reactor designs**. A core part of this phase is the creation of **digital twins** to model the reactor dynamics, enhancing our understanding of process behaviour under various conditions. The combination of experimental data with digital modelling will ensure the processes are optimised for future scaling.

2. Lab-Scale Validation

Next, the focus shifts to the **validation** of the lab-scale prototypes. Each of the processes will be tested **under different operating conditions**, while the digital models will be further developed and fine-tuned. By the end of this phase, ALCHEMHY will have **reliable lab-scale processes** ready for further upscaling, setting the stage for larger industrial applications.

3. Up-scaling and Prototyping

In phase 3, larger prototypes are developed, by focusing on optimisation of **reactor performance** and manufacturing **full-scale demonstrators**. At the same time, the integration of hybrid digital twin models into our **Decision Support System** (DSS) will ensure seamless management of renewable hydrogen integration and overall production efficiency. This phase prepares the processes for real-world industrial use.

5. Impact Assessment and Integration

The final phase evaluates the **environmental, economic** and **social** impact of ALCHEMHY's technologies, examining their viability. This phase concludes with recommendations for scaling up and future research, while creating a roadmap for **policymakers, public authorities** and **industry stakeholders** to facilitate the adoption of ALCHEMHY's innovative methods.

4. Industrial Demonstration

The 4th phase is dedicated to the operation of the processes under industrial conditions. The novel processes will be validated for their suitability for **real-world production** and assessed for their **efficiency, integration with the hydrogen value chain, and safety protocols**. The successful demonstration will offer vital insights and confirm the readiness of ALCHEMHY's solutions for industrial-scale applications.

* **SFMR:** small-flexible methanol reactor, **PCH:** Plasma catalytic hydrogenation

** **MSER:** Magnetic-heated sorption-enhanced reactor (MSER), **DESA:** Direct electrochemical synthesis

PROJECT OBJECTIVES

- **Electrified Production Processes:** Develop zero-emission production routes for ammonia and methanol using renewable hydrogen.
- **Advanced Catalysts and Materials:** Create new catalysts that boost efficiency and ensure sustainability for large-scale applications.
- **Digital Tools:** Implement Digital Twins and DSS for production optimisation and scalability.
- **Pilot-Scale Demonstration:** Test novel processes under real-world conditions, ensuring they meet industry standards.
- **Scalability Assessment:** Analyse the integration into existing industries.
- **Communication Strategy:** Connect with industry, policymakers and stakeholders to promote sustainable transformation and commercialisation.

ALCHEMHY