CARMA-H2

CARBON-NEGATIVE PRESSURIZED HYDROGEN PRODUCTION FROM WASTE USING AN ENERGY EFFICIENT PROTONIC MEMBRANE REFORMER

Project ID	101137756
PRR 2025	Pillar 1 - H_2 Production
Call Topic	HORIZON-JTI-CLEANH$_2$-2023-01-05
Project Total Costs	12 818 293.75
Clean H_2 JU Max. Contribution	9 954 418.76
Project Period	01-10-2024 - 30-09-2028
Coordinator Beneficiary	ASOCIACION DE LA INDUSTRIA NAVARRA, ES
Beneficiaries	HAFFMANS BV, NAVARRA DE INFRAESTRUCTURAS LOCALES SOCIEDAD ANONIMA (NILSA), HERA HOLDING HABITAT, ECOLOGIA Y RESTAURACION AMBIENTAL S.L., SNAM S.P.A., SINTEF AS, FONDAZIONE ICONS, UNION ENGINEERING AS, SERVICIOS DE LA COMARCA DE PAMPLONA SA, COORSTEK MEMBRANE SCIENCES AS, SHELL GLOBAL SOLUTIONS INTERNATIONAL BV, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS

https://carma-h2.eu/

PROJECT AND GENERAL OBJECTIVES

CARMA-H2 aims to develop and demonstrate an innovative modular reactor at the Arazuri wastewater treatment plant in Navarra, Spain. The project integrates multiple technologies to transform biogas from organic waste into pressurised hydrogen (500 kg/day) and CO_2 (over 4 000 kg/day) with great energy efficiency.

At the core of CARMA-H2 is the Protonic Membrane Reformer (bioPMR), a breakthrough technology that enables direct separation of high-purity hydrogen and capture-ready CO_2 in a single, continuous step. The bioPMR will be deployed alongside three key sub-systems: a biogas pre-treatment unit, a CO_2 liquefaction system, and the existing waste-to-biogas plant at Arazuri. This fully integrated setup ensures a streamlined and highly efficient production process.

To optimise performance and scalability, CARMA-H2 will develop a digital twin, leveraging advanced computational models and control systems to enhance real-time monitoring and process efficiency.

A life cycle assessment will evaluate the CARMA-H2's environmental impact, considering waste streams, biogas sources, and energy inputs. Additionally, CARMA-H2 will assess critical raw material (CRM) usage, ensuring compliance with sustainability and regulatory standards. By combining cutting-edge hydrogen production, circular economy principles, and digital innovation, CARMA-H2 paves the way for decentralised, cost-effective hydrogen generation, supporting Europe's clean energy transition.

NON-QUANTITATIVE OBJECTIVES

CARMA-H2 is more than a technological project—it is a step toward a sustainable hydrogen ecosystem, through:

- Fostering strong collaboration with industry stakeholders and regulatory bodies in the biogas, hydrogen, and CO_2 sectors, ensuring alignment with market needs and evolving policies.
- Creating synergies with European research initiatives, particularly EURAMET's EMPIR program and the European Partnership on Metrology, to enhance hydrogen quality assurance.
- Implementing Guarantees of Origin (GOs) in Spain, to certify the renewable nature of its hydrogen and reinforcing its credibility.
- Engaging directly with end-users across mobility, industry, and energy.
- Exploring real-world hydrogen applications, ranging from urban transport and logistics to metallurgy and power generation.
- Strengthening a circular approach, minimising emissions and maximising resource efficiency by CO_2 utilisation in the agri-food and beverage sectors.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Start of design and construction of auxiliary facilities at the Arazuri wastewater treatment plant in Navarra, setting the stage for the installation of the innovative bioPMR.
- Analysis of renewable electricity usage to optimise energy costs and ensure a sustainable power supply for the demonstration phase.
- Ongoing efforts to enhance manufacturing capacity, with new equipment being installed at CTMS's pilot fabrication line to support the production of bioPMR components.
- Launch of CARMA-H2's communication strategy, focusing on engaging multiple audiences through the website and social media.

FUTURE STEPS AND PLANS

- Optimising each stage of the process to maximise efficiency and performance.
- Conducting a comprehensive safety assessment of all sub-systems, ensuring that every component meets the highest standards before full-scale implementation.
- Enhancing the waste-to-biogas conversion process, refining it to achieve higher efficiency and an ideal composition for seamless integration with the bioPMR unit.
- Improving the hydrogen production system by recycling gaseous streams, thereby increasing yield while simultaneously enhancing the value of the CO_2 captured through an upgraded liquefaction unit.
- Technical evaluations including testing the catalytic performance of the Protonic Membrane Reformer under real biogas conditions, alongside verifying the reliability of individual engineering units before full-scale deployment. These steps are crucial to ensuring the robustness and long-term viability of CARMA-H2's innovative technology.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year for reported SoA result
Project's own objectives	System energy use	kWh/kg	59		64	2020
	System CAPEX	€/(kg/d)	900/2 000		1 250	2020
	System OPEX	€/kg	1.3		1.35	2020

PRR 2025 PILLAR
H2 Production

Clean Hydrogen Partnership

Co-funded by the European Union