Summary of activities 2025 – OntzHi-II Project

During the first half of the OntzHi-II project, the priority activities required to achieve the established technical objectives have been carried out. The work performed provides a solid foundation that will enable the consolidation of developments during the second year of the project.

The main actions and results have been structured according to the different work streams of the project:

Barrier coatings on metals to prevent hydrogen embrittlement

- CIDETEC has developed several surface treatments aimed at optimising interlayer adhesion in duplex coatings. In addition, a methodology has been defined for the preparation and GD-OES characterisation of ceramic coatings intended to act as the top layer of the duplex system, with the aim of gaining deeper insight into their behaviour in contact with hydrogen.

- TEKNIKER has defined the systems to be deposited using PECVD technology, as well as the bonding-layer configurations and the single-layer and multilayer structures to be analysed. These configurations are designed to maximise adhesion to the substrate and minimise permeability, thereby reducing the risk of hydrogen embrittlement. In addition, new coating configurations with optimised properties to withstand fatigue loading have been designed. In parallel, an electrochemical permeability testing protocol has been established to characterise the different types of traps present in the material, distinguishing between reversible and irreversible traps during the test itself. These characterisations will be applied to the substrates under study in 2026 and subsequently to the deposited coatings, provided that the detection signal allows it.

- TECNALIA has investigated different barrier coating configurations deposited using PVD-HiPIMS technology, analysing their physical, microstructural and compositional properties. Initial results point to relevant insights into their barrier behaviour against hydrogen permeation. In addition, preliminary dynamic tribological tests have been set up and carried out under hydrogen and in comparative environments (inert and humid). The results show significantly different material behaviour depending on the environment, both qualitatively and quantitatively, including wear mechanisms and friction levels.

Coatings to prevent hydrogen permeation and leakage in metals and composites

- TECNALIA has defined hybrid coating formulations using the sol-gel method to prevent hydrogen permeation and leakage in metals and composite materials, tailoring their characteristics to each specific substrate (e.g. elastic modulus and curing temperature). Evaluation methods have also been defined for comparative analysis of materials with and without coatings. In particular, embrittlement tests on metallic materials are being planned.

Alternatives in composite materials and sustainable, innovative processes

- TECNALIA has incorporated a laser triangulation profilometer into its flexible AFP tape-laying cell, enabling real-time monitoring of the evolution of the tape-laying layer in the outer reinforcement of Type IV hydrogen storage tanks, improving process control and deposition quality.

- GAIKER has commissioned a multimodal DMA-DEA characterisation station equipped with a UV irradiation module and has initiated the development of UV-curable formulations based on recyclable reactive resins for producing structures via 3D printing. In parallel, the kinetic behaviour and mechanical performance of 3D printing resins using DLP/LCD technologies have begun to be characterised.

Pipeline solutions

- TECNALIA has manufactured specimens from a real industrial X52 carbon steel pipeline. These specimens are undergoing controlled surface ageing to reproduce different degrees of corrosion and will subsequently be tested in a hydrogen atmosphere at 160 bar pressure. In addition, the necessary welds have been carried out to study post-weld heat treatment (PWHT) in pipelines resistant to hydrogen embrittlement and to investigate the effect of load amplitude on crack initiation location. The associated mechanical tests will be carried out in 2026.

- TEKNIKER has performed finite element simulations to determine the optimal configuration for studies using hollow specimens, considering designs with through and blind holes, as well as the effect of internal pressure on fatigue characterisation. Each configuration requires a specific gas supply system, whose design will be addressed in the next project year together with the study of the impact of internal roughness in dynamic tests.

- CIDETEC has selected the optimal conditions for ex situ electrochemical hydrogen charging of metallic specimens intended for mechanical behaviour studies. In addition, the experimental setup for coupling non-destructive acoustic sensors has been optimised, improving the acquisition of elastic waves during mechanical testing.

Predictive computational models and mechanical characterisation techniques

- MULTIVERSE COMPUTING has deployed the cloud-based computational resources required for processing large volumes of data and training artificial intelligence models, including AWS S3 storage and GPU computing capacity on AWS EC2, as well as direct communication between both services.

  In addition, datasets from Meta's Open Catalyst Challenge (OC20 and OC22) have been preselected and analysed to understand their structure, variables and prediction tasks that could be addressed using AI models. Other recent datasets, such as AQCat25 from SandBoxAQ, have been discarded due to licensing incompatibilities for potential commercial application.

- TECNALIA, for its part, is progressing in the design of a test to establish equivalence between electrochemical charging and gas-phase charging, including the definition of the procedure, specimen geometry and the selection of a carbon steel for model calibration through progressive loading cycles.

The close coordination between the research centres and the Industrial Advisory Board throughout 2025 has ensured sectoral alignment and the applicability of the results in real industrial environments.

This first project year has consolidated the methodological foundations required to address the technological maturation phase planned for 2026, ensuring compliance with the strategic objectives of the OntzHi-II project.