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An AI Approach to Optimize the Operation of a Hydrogen Valley

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Abstract

This project aims to develop a comprehensive digital twin for hydrogen valleys, focusing on optimizing the balance between hydrogen production and demand while accounting for storage and transport considerations. Hydrogen valleys, as integrated hubs of production, consumption, and distribution, present unique challenges in managing fluctuating supply and demand, infrastructure constraints, and the need for real-time operational efficiency. The digital twin leverages advanced modeling, simulation, and data analytics to create a virtual replica of the physical hydrogen ecosystem, enabling stakeholders to visualize, predict, and optimize processes across the entire value chain.

By integrating dynamic data streams from production facilities, storage units, and transport networks, the digital twin provides actionable insights into system performance and identifies bottlenecks or inefficiencies. Machine learning algorithms are employed to forecast demand patterns and optimize production schedules, ensuring that hydrogen generation aligns with market needs while minimizing energy waste and operational costs. Storage optimization models help manage surplus hydrogen, allowing for strategic buffering during periods of low demand or high production, whereas transport simulations evaluate routing and logistics scenarios to maximize distribution efficiency and reduce carbon footprint.

The project's digital twin framework supports scenario analysis and decision-making for stakeholders, from energy producers to grid operators and policymakers. It facilitates the assessment of investment strategies, operational responses to market shifts, and the impact of regulatory changes on the hydrogen valley's sustainability. Ultimately, this initiative contributes to accelerating the transition to a hydrogen-powered future by enhancing the resilience, flexibility, and profitability of hydrogen ecosystems. The digital twin serves as a blueprint for scalable implementation in other regions, fostering innovation and collaboration across the growing hydrogen economy. The new tool will be tested in two hydrogen valleys that receive funding from the Clean H2 Partnership: SH2AMROCK (small scale in Ireland) and CyLH2 Valley (large scale in Spain).