Energy Internet Hydrogen Energy System



Overview

Electricity- and hydrogen-based sector coupling contributes to realizing the transition towards greenhouse gas neutrality in the European energy system.

Key Takeaways

An Energy Internet Hydrogen Energy System integrates hydrogen production, storage, and distribution into a flexible, multi-carrier energy network to enhance decarbonization, grid stability, and renewable energy utilization.

Concept Overview

The Energy Internet is a multidisciplinary framework combining electricity, information and communication technologies (ICT), artificial intelligence, and energy economics to optimize energy flows across networks. When hydrogen is incorporated, it acts as a versatile energy vector, enabling power-to-hydrogen conversion, storage, and transport, which can balance intermittent renewable energy sources like wind and solar. Hydrogen can be produced via electrolysis using renewable electricity, stored in large-scale facilities, and later converted back to electricity or used in transport, heating, and industrial applications.

Hydrogen Integration in Power Systems

Hydrogen production through electrolysers provides both energy storage and grid flexibility. Electrolysers can adjust their operation based on electricity supply and demand, offering short- and long-duration flexibility to the power system. This integration allows excess renewable energy to be converted into hydrogen, reducing curtailment and supporting grid stability.

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Multi-objective optimization models, such as energy hub frameworks, can coordinate multiple energy carriers, reducing total costs, primary energy demand, and carbon emissions while accounting for uncertainties in renewable generation and demand. Infrastructure and Market DevelopmentLarge-scale hydrogen infrastructure is being developed globally. In Europe, the European Hydrogen Backbone (EHB) initiative plans to leverage existing and new pipelines to create a pan-European hydrogen network, enhancing market liquidity, cross-border collaboration, and security of supply.

In the US

A, projects like Hydrogen City in Texas aim to produce green hydrogen at gigawatt scales using solar and wind energy, with storage in salt caverns for later use. These initiatives demonstrate the feasibility of integrating hydrogen into energy systems at both regional and national scales.

Global Trends and Policy

According to the IEA Global Hydrogen Review 2024, hydrogen is increasingly recognized as a critical component for achieving climate goals, with growing investments in low-emission hydrogen production, infrastructure, and trade. Policies such as the EU's REPowerEU Action Plan target large-scale green hydrogen production and import by 2030, supporting the transition to a decarbonized energy system. Hydrogen's role spans electricity, heating, transport, and industrial sectors, making it a key enabler of a multi-carrier Energy Internet.

Key Benefits

Grid Flexibility: Hydrogen production can absorb excess renewable energy and provide demand-side response. Decarbonization: Enables low-carbon energy supply across multiple sectors. Energy Storage: Long-duration storage for seasonal or peak energy needs.

Multi-

Sector Integration: Supports electricity, transport, heating, and industrial applications simultaneously. In summary, an Energy Internet Hydrogen Energy System represents a transformative approach to energy management, combining advanced ICT, renewable energy, and hydrogen technologies to create a flexible, low-carbon, and economically optimized energy network.

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The U.S. Department of Energy Hydrogen Program, led by the Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and

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European Hydrogen Bank

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