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International Journal of Hydrogen Energy

Volume 37, Issue 2, January 2012, Pages 1184-1203

Re-envisioning the role of hydrogen in a sustainable energy economy

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<https://doi.org/10.1016/j.ijhydene.2011.09.137>

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Abstract

This paper addresses the fundamental question of where hydrogen might fit into a global sustainable energy strategy for the 21st century that confronts the three-pronged challenge of irreversible climate change, uncertain oil supply, and rising pollution. We re-envision the role of hydrogen at national and international strategic levels, relying entirely on renewable energy and energy efficiency. It is suggested the time for an exclusive "hydrogen economy"™ has passed, since electricity and batteries would be used extensively as well. Yet hydrogen would still play a crucial role: in road and rail vehicles requiring a range comparable to today's petrol and diesel vehicles; in coastal and international shipping; in air transport; and for longer-term seasonal storage on electricity grids relying mainly on renewables. Hydrogen fuel cell vehicles are proposed where medium and long distance trips are required, with plug-in battery electric vehicles reserved for just short trips. A hierarchy of spatially-distributed hydrogen production,

storage and distribution centers relying on local renewable energy sources and feedstocks would be created to limit the required hydrogen pipeline network to the main metropolitan areas and regions by complementary use of electricity as a major energy vector. Bulk hydrogen storage would provide the strategic energy reserve to guarantee national and global energy security in a world relying increasingly on renewable energy. It is recommended that this vision next be applied to specific countries by conducting detailed energy-economic-environmental modeling to quantify its net benefits.

Highlights

• Re-envisioning the role of hydrogen in a sustainable energy economy. • A hierarchy of sustainable hydrogen centers relying on local renewables. • Complementary use of hydrogen and electricity as energy vectors to minimize hydrogen pipelines. • Complementary roles of hydrogen and battery storage in transport vehicles. • Hydrogen for longer-duration energy storage on centralized grids.



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Keywords

Hydrogen economy; Global sustainable energy strategy; Renewable energy; Fuel cell vehicles; Battery vehicles; Energy security

Abbreviation

A, Aircraft; AC, Alternating Current; AHC, Autonomous Hydrogen Center; B, Bus; BEV, Battery Electric Vehicle; C, Cycle; CCS, Carbon Capture and Storage; CHC, Coastal Hydrogen Center; DC, Direct Current; DoE, Department of Energy; EERE, Energy Efficiency and Renewable Energy; EO, Electric Overhead; EU, European Union; HE, Hydrogen Economy; HFC, Hydrogen Fuel Cell; HFCV, Hydrogen Fuel Cell Vehicle; HHV, High Heating Value; HISE, Hydrogen in a Sustainable Energy (strategy); IHC, Inland Hydrogen Center; IPCC, Intergovernmental Panel on Climate Change; JetLH, Liquid Hydrogen Jet Fuel; kWh_e, Kilowatt Hours (electrical); LHV, Low Heating Value; LPG, Liquid Petroleum Gas; NHA, National Hydrogen Association; OHC, Off-shore Hydrogen Center; PV, Photovoltaic; R, Rail; R&D, Research and Development; RE, Renewable Energy; S, Ship; T, Tram; UPT, Urban Public Transport; W, Walking; WWS, Wind, Water, and Sunlight

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