Hydrogen as a Policy-Constructed Market: Transition Governance, Structural Change, and Regional Implications

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Abstract

Hydrogen has moved to the centre of European and global decarbonization strategies, yet its emergence does not follow conventional models of endogenous market formation. Rather than arising through price signals and decentralized innovation, the hydrogen economy is being actively shaped through public intervention, institutional design and anticipatory governance. It can therefore be interpreted as a policy constructed market assembled to pursue climate neutrality, energy security and industrial competitiveness under conditions of uncertainty and infrastructural indivisibility.
Scaling renewable hydrogen requires coordinated investment in electrolysis, transport infrastructures, industrial adaptation and demand aggregation. These activities are capital intensive, network dependent and territorially embedded, making spontaneous market development unlikely. Drawing on insights from the Multi-Level Perspective, Technological Innovation Systems, Mission Oriented Innovation Policy and Transition Management, hydrogen emerges as a process of institutional construction that reshapes industrial trajectories and spatial economic structures.
The resulting structural transformation unfolds unevenly across Europe. Regions combining renewable resources, industrial capabilities and governance capacity are better positioned to capture value along emerging hydrogen value chains, while less developed territories risk marginalization without coherent place-based strategies. Hydrogen thus represents not only an energy transition, but a reconfiguration of structural and territorial dynamics shaped by policy sequencing and institutional capacity.

Extended Abstract

Hydrogen has moved rapidly from the margins of energy debates to the centre of European and global decarbonization strategies. Yet its emergence does not follow the canonical trajectory of market formation described in standard equilibrium models. Rather than arising spontaneously from relative prices and decentralized discovery, the hydrogen economy is being shaped through public intervention, institutional design and anticipatory governance. Hydrogen therefore appears as a policy constructed market, an institutional field deliberately assembled to pursue public missions such as climate neutrality, energy security and industrial competitiveness under conditions of deep uncertainty, infrastructural indivisibilities and long investment horizons (Pigou, 1920; Stern, 2007; European Commission, 2020; Mazzucato, 2018).

This perspective implies that hydrogen is not simply an energy vector but a reorganization of economic structures and territorial hierarchies. The bundle of activities required to scale hydrogen, including renewable powered electrolysis, large scale storage and transport, hydrogen ready industrial processes and coordinated end use demand, exhibits high capital intensity, strong network externalities and long asset lifetimes. Under such conditions, spontaneous bottom up market assembly is unlikely to occur at the speed and scale required for decarbonization. Public policy therefore operates not merely as a corrective mechanism addressing isolated failures, but as a constitutive force that creates and shapes markets ex ante by stabilizing expectations, defining standards, orchestrating infrastructures and underwriting early-stage risks (Pigou, 1920; Stern, 2007; Mazzucato, 2018). European initiatives such as the Hydrogen Strategy, the Important Projects of Common European Interest, Hydrogen Valleys, REPowerEU and the emerging European Hydrogen Backbone illustrate this coordinated logic of market construction (European Commission, 2020; McDowall, 2012).

Understanding hydrogen in this way requires linking market construction to patterns of structural change and regional specialization. Hydrogen value chains are embedded in territorially differentiated contexts characterized by varying renewable resource endowments, industrial capabilities, governance quality and institutional thickness. Regions that combine renewable potential, diversified industrial bases, port infrastructures and administrative capacity are better positioned to host large scale projects and retain value. Other territories, particularly less developed regions with thinner innovation systems, may face structural barriers to integration into higher value segments of emerging chains. Empirical analyses of European less developed regions suggest that sustainability transitions are more likely to generate durable upgrading when embedded in coherent governance structures capable of linking environmental objectives with institutional capacity building and local development strategies (Provenzano & Seminara, 2022). In the absence of such embedded governance, green transitions may reinforce existing asymmetries.

A synthetic integration of six complementary theoretical perspectives clarifies why governance, timing and territorial context are decisive. From the standpoint of the Multi-Level Perspective (Geels, 2002), hydrogen currently occupies the niche level within a socio technical regime still dominated by fossil infrastructures and incumbent actors. Landscape pressures such as climate targets, geopolitical instability and energy security concerns create windows of opportunity. Yet regime inertia persists through sunk investments, path dependence and institutional lock in. Protective measures that shield and nurture hydrogen technologies are therefore structural preconditions for scaling rather than temporary distortions.

The Technological Innovation Systems perspective introduces a functional interpretation of hydrogen's development (Hekkert et al., 2007; Bergek et al., 2008). In the hydrogen case, key system functions remain only partially activated. Market formation still depends on public support mechanisms, legitimation is tied to evolving sustainability standards and certification rules, and resource mobilization relies heavily on coordinated public intervention. These constraints are not spatially neutral. Regions with dense industrial networks, access to finance and coherent governance structures are better able to translate policy signals into investment and capability building. Territories with fragmented institutions or thinner productive bases may struggle to do so. Hydrogen therefore highlights how innovation system capacities are unevenly distributed across space and how this asymmetry shapes structural transformation.

Mission Oriented Innovation Policy frames these dynamics as deliberate design choices (Mazzucato, 2018). European renewable hydrogen targets reflect a normative and strategic orientation that prioritizes decarbonization, resilience and autonomy even before full cost competitiveness is achieved. Mission orientation synchronizes public and private investment and legitimizes risk sharing in capital intensive sectors. Yet missions do not unfold in abstraction. They are enacted in specific territories. The distribution of benefits depends on how effectively regions mobilize institutional capacity, build coalitions and align local strategies with broader missions.

Transition Management highlights the importance of reflexive governance and participatory coordination (Rotmans et al., 2001; Loorbach et al., 2017). Hydrogen Valleys operate as experimental arenas in which firms, utilities, research institutions, ports and regional authorities collaborate to test and refine projects. Their long-term impact depends on governance quality and the ability to transform experimentation into durable capabilities. Where institutional thickness and social capital are present, pilot initiatives may evolve into self-reinforcing ecosystems. Where they are absent, projects risk remaining isolated demonstrations with limited spillovers.

Strategic Foresight plays a performative role in this process (Kanger & Schot, 2019; McDowall, 2012). Roadmaps, scenarios and infrastructure visions stabilize expectations and guide capital allocation in advance of mature price signals. By projecting future supply and demand geographies, foresight shapes present investment patterns and influences territorial positioning. Expectations therefore function as coordination devices in capital intensive transitions.

Tipping Point theory introduces a nonlinear temporal dimension (Lenton et al., 2022). Learning curves in electrolyser manufacturing, network effects in transport infrastructures and rising social acceptance may reinforce each other and accelerate diffusion. Conversely, poorly sequenced interventions may entrench negative lock in dynamics. Over investment in transitional blue hydrogen or fragmented certification regimes may constrain future pathways. The sequencing of instruments therefore affects both technological trajectories and spatial outcomes.

Through this integrated perspective, hydrogen emerges as a driver of structural transformation. Policy instruments such as contracts for difference for renewable hydrogen, guarantees of origin, de risking facilities and coordinated procurement temporarily modify relative prices and risk premia. They redirect capital towards electrolyser manufacturing, renewable integration, hydrogen ready industrial processes, storage networks and port logistics. Over time, scale and cumulative learning may reduce costs, but these processes remain mediated by institutional design. The result is a recomposition of value added, new inter industry linkages and the emergence of specialized capabilities that reshape regional production structures.

Spatially, these transformations are uneven. Activities cluster where infrastructures, institutions and industrial capacities intersect. Northern European port industrial systems combine renewable resources, logistics platforms and anchor firms, positioning themselves as hubs within emerging hydrogen corridors. Other regions may participate primarily as energy exporters or remain peripheral to higher value segments. Without explicit territorial governance, mission-oriented policies may inadvertently reinforce core periphery dynamics and deepen structural polarization. Evidence from less developed European regions shows that transition outcomes are strongly conditioned by governance coherence, absorptive capacity and institutional upgrading (Provenzano & Seminara, 2022).

The global context adds further complexity. The hydrogen economy is unfolding within a multipolar environment structured by distinct policy models. The United States promotes a cost driven approach through tax credits and rapid capital mobilization under the Inflation Reduction Act. China couples large scale manufacturing of electrolysers with integration into domestic renewable supply chains, consolidating cost leadership and technological influence. The European Union emphasizes sustainability standards, cross border coordination and environmental integrity (European Commission, 2020; Mazzucato, 2018). These models interact and compete, shaping trade flows, specialization strategies and capital allocation. For

European regions, this geopolitical landscape introduces uncertainty regarding competitive positioning and regulatory alignment.

To explore potential trajectories under uncertainty, several forward-looking scenarios to 2035 can be outlined. A coordinated European leadership scenario assumes regulatory coherence, interoperable standards and aligned infrastructure planning, enabling large scale renewable hydrogen deployment and more balanced territorial outcomes. A cost driven expansion scenario accelerates global scale up but intensifies competitive pressures and challenges high standard approaches. A manufacturing scale paradigm centred on China restructures supply chains around cost efficiency, forcing European regions to reassess specialization strategies. A retrenchment scenario triggered by fiscal stress or geopolitical disruption fragments coordination and amplifies divergence. These scenarios are not predictions but structured reflections that illuminate how sequencing, complementarities and governance choices influence structural change.

Hydrogen thus appears less as a technological endpoint than as a governance process embedded in spatially differentiated economies. Its trajectory depends on institutional capacity to coordinate actors across scales, align directionality with adaptability and design place sensitive strategies that prevent structural polarization. By integrating multiple transition frameworks and embedding them within a territorial perspective, hydrogen becomes a lens for examining how contemporary states construct markets, redistribute risk and reshape the spatial organization of economic activity in the context of climate transition (Geels, 2002; Hekkert et al., 2007; Mazzucato, 2018; Kanger & Schot, 2019; Lenton et al., 2022; Provenzano & Seminara, 2022).

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