vantedge+

Blue Paper

Roadmap for hydrogen economy development in India - Marking key indices

Part -1 (Scaling policy, support infrastructure and trade opportunities for hydrogen in India with technology and policy comprehensive roadmap)

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List of clearances & respective timelines for development of hydrogen project in India

Roadmap to a hydrogen economy

The full benefits of hydrogen & fuel cell technologies play out when deployed at scale and across multiple applications

Hydrogen is at a turning point and will benefit from economies of scale as it ramps up across states and sectors in what is known as sector coupling. Sector coupling refers to "the idea of interconnecting (integrating) the energy-consuming sectors – buildings (heating and cooling), transport, and industry - with the power-producing sector in order to provide grid-balancing services to the power sector, including supply-side integration focused on the integration of the power and gas sectors for reliability and resiliency. When deployed across multiple applications, systemic benefits start to kick in: infrastructure costs are shared across applications, technological developments in one application can be applied to others, and sector coupling benefits play a meaningful role.

In this section, we describe a road map for transitioning to a hydrogen economy in which hydrogen becomes a mainstream fuel option.

The road map was developed to put forward a concrete proposal for various sectors and applications that may be developed and deployed in the coming years. It provides milestones for deployment and leverages domestic strengths to deliver on the vision set out to develop hydrogen industry in the country.

The road map is organized into four key phases: 2020 to 2022, 2023 to 2025, 2026 to 2030, and post-2030. Each phase has specific milestones for the deployment of hydrogen across applications. Each phase also describes the key enablers required, categorized as:

(i) policy enablers and

(ii) hydrogen supply and end-use equipment enablers. Policy enablers are needed initially to create the right incentives to enable the private sector to invest in and develop the hydrogen market.

Global Benchmarking
GH2 policy roadmaps and strategies

						
GH2 POLICY	**ADAPTIVE** GH2 EXPORTS	**MATURE** FCEV PV FOCUS	**INDICATIVE** DEV. PROJECTS – CLUSTERS	**MATURE** INFRA FOCUS	**MATURE** TRANSPORT, CALIFORNIA FOCUS	**EARLY STAGE** TECH. DEMOS, ICE-H2 (PAST)
GH2 PRODUCTION	Leveraging RE strengths to produce, export GH2; Carbon capture to be used extensively	GH2 imports from Australia	**6 GW electrolyser capacity, 1 MT GH2 by 2024**; and 2X40 GW electrolysers capacity, 10 MT GH2 by 2030	**World's largest 10 MW** Fukushima Hydrogen Energy Research Field FH2R, GH2 imports	Focussed on RE electrolyser production, exploring biogas/methane (from dairy)	R&D and demonstration pilots on electrolyser and FC tech (across technologies)
GH2 SUPPLY CHAIN & MANUFACTURING	H2 Energy Supply Chain (HESC) Pilot Project, H2 Utility Renewable Hydrogen and Green Ammonia Supply Chain Demonstrator	Global leadership in FC Passenger Vehicles and Power Generation, **constructing new nationwide H2 pipeline network**	**Global lead on PEM electrolyser** tech, FC tech; coupling strategies by use-cases – H2 valleys, industrial clusters	Building GH2 infra, imports and strategic co-production/ transport from Australia, KSA, Brunei	Primarily privately funded initiatives, manufacturing	Domestic manufacturing imperative to bring costs down
FUNDING & INVESTMENTS	Committed **over AU$146 mn on H2 supply chain projects** in last five years	**USD 1.8 bn budget for establishment of a public-private H2 vehicle industry ecosystem by 2022**	Strong state funding, private investments; Country plans (Germany USD 7bn, France, Netherlands, Spain, Portugal)	**Spent $1.5 billion on H2** tech R&D and subsidies, USD 664 mn 2020 budget	DOE has been spending USD 100 mn annually, separate USD 30 mn SO-FC program	R&D spends on demonstration projects, 2 re-fuelling stations in Delhi, CoE established
PRIORITY USE-CASES – TRANSPORT, INDUSTRY, POWER, BUILDING/HEAT	H2 Hubs/Valleys, H2 in remote applications (microgrids for mining)	**By 2030, 800K FCEVs target (100K trucks)** 6.2 mn FCEVs production by 2040. FC Power Generation target is 15 GW by 2040	Global leadership in EC, FCEV, Focus on Industrial Clusters	FCEVs through private sector collaboration and residential use/ building	**Largest FCEV Vehicle population**, focus on refuelling infra and H2 transport (gas/liquified).	Not articulated beyond H2-ICE engines, 2020 targets unmet; bus/vehicle prototypes
PUBLIC & INDUSTRY PARTNERSHIPS	NERA supporting SMEs; legal framework for large-scale production, H2 as energy carrier	**H2Korea PPP, HyNet SPV** – 13 companies, Hydrogen Law	Open, competitive H2 market by 2030; European Clean Hydrogen Alliance, Hydrogen Europe, FCHJU	**JapanH2Mobility (JHyM)** consortium – 11 companies	CEC Clean Transport 64 H2 refuelling program. US DOE Fuel Cell Tech Office H2@Scale research	MoUs with Japan, Korea, US and Australia on G2G collaboration
ECO-SYSTEM DEV STRATEGIES						

Source: FTI Consulting, eninrac research

Roadmap to a hydrogen economy (Contd.)

The supply of hydrogen scales up and shifts to low-carbon technologies. Hydrogen is currently produced mainly from natural gas without CCS globally, which could deliver 40 to 50 percent lower GHG emissions than gasoline ICEs and zero tailpipe emissions for light-duty FCEVs. New low carbon hydrogen production pathways using natural-gas reforming techniques exist, such as steam methane reforming (SMR) and autothermal reforming (ATR) with CCS or with renewable natural gas (RNG). Likewise, players can scale up existing water electrolysis with low-carbon electricity, including renewables. As these production pathways grow, costs will decline significantly.

- **2020 to 2022: Immediate Next Step**

In the first two to three years, the aim is to establish dependable and technology-neutral decarbonization goals in more states and at the central level, which will serve as a guide to specific policy and regulatory actions, including updates to codes and standards. Public incentives and standards can bridge barriers to initial market launch, bring a wider range of mature hydrogen solutions to market, increase public awareness and acceptance, and continue to pilot hydrogen use in other applications. Progress focuses on early commercially viable applications in early adopter markets, like the expansion of FCEV nationwide and further deployment of both light-duty and heavy-duty vehicles. These early applications require a combination of incentives to reduce barriers to entry and market-facing mechanisms to enable scale.

In this phase, mature applications, and applications close to breaking even, such as back up power solutions, scale up. In transport, early adopter states focus on developing fueling infrastructure to support FCEV adoption and begin to see second-generation products in passenger vehicles and fueling stations. Fleets relying on depot fueling, such as buses and light commercial vehicles, and first-generation medium- and heavy-duty trucks, do not require a nationwide network of fueling stations. Demand growth is sufficient for the first dedicated hydrogen production facilities for transport, along with for the development of gaseous and liquid distribution.

Pilots in other applications, such as blending in the gas grid, are pursued to prepare for broader hydrogen adoption.

Roadmap to a hydrogen economy (Contd.)

- **2023 to 2025: Early Scale-Up**

By 2025, large-scale hydrogen production is being developed, bringing the cost down and kicking off the scale-up of applications beyond early adopter states. This requires clear regulatory guidelines to coordinate market participants and attract investment. Policy incentives in early markets begin transitioning from direct support to scalable market-based mechanisms. In this phase, the first large-scale hydrogen production facilities are built using water electrolysis from renewables, gas reforming with RNG, or CCS. With the larger scale, production costs fall, enabling new applications. Hydrogen-related equipment, in particular vehicle fuel cell production and fueling station equipment, also scales up, enabling cost and performance improvements. Medium- and heavy-duty fuel cell electric trucks and new light-duty FCEV makes, and models are brought to market, increasing the offering for customers. Second-generation high-throughput hydrogen fueling stations for medium- and heavy-duty vehicles increase adoption in commercial fleets in early markets.

In transport, early adopter states build on their existing fleet and pilot stations to increase coverage and capacity in the fueling infrastructure for light-duty passenger vehicles. The next wave of states follows their lead and develops hydrogen fueling infrastructure rollout plans. Medium- and long-haul trucking infrastructure is deployed where there is known demand on highly frequented routes. In addition, the use of hydrogen fuel cells expands beyond newly constructed data centers and telecommunication towers to backup generation for buildings. Existing hydrogen markets begin to convert to low-carbon hydrogen sources as feedstock for industry.

- **2026 to 2030: Diversification**

The 2026 to 2030 phase is about diversification beyond early adopter states such as transportation & backup power, and about scaling up infrastructure across the country. Expanded use of various hydrogen production pathways and continued scale-up of electrolytic hydrogen production begins to create meaningful sector coupling with electricity grids and renewable power production. The first hydrogen transmission pipelines enable further cost reduction with seasonal grid firming and storage.

Roadmap to a hydrogen economy (Contd.)

In transport, medium- and long-haul trucking scales up across the country, as heavy-duty, high-throughput hydrogen fueling station infrastructure connects regional networks and creates nationwide coverage. A majority of states now implement hydrogen road maps, creating widespread fueling infrastructure and unlocking the full market for FCEVs.

In industry, ammonia, methanol, and petrochemical production transitions to low-carbon hydrogen, driving production costs down for all sectors through large-scale hydrogen production. Hydrogen-based synthetic fuel for aviation and shipping scales up as those industries seek to decarbonize their fuel supply.

- **Post 2030: Broad Rollout across India**

After 2030, hydrogen is deployed at scale in India, across regions and industries. Most applications achieve cost parity with fossil fuel alternatives through sufficient pricing of externalities, and public support for market introduction can be phased out. The cross-sector benefits of hydrogen deployment create further synergies and drive costs down. The backbone infrastructure of the hydrogen economy starts consolidating through the emergence of large-scale, low-carbon hydrogen production facilities across the US, a hydrogen distribution pipeline network, and a large fueling station infrastructure network. There are a wide variety of FCEV models available to meet varying customer needs. As a result, significant GHG reduction in hard-to-decarbonize industrial sectors and widespread building decarbonization are achieved, and a higher share of ZEVs are on the road.

Implementation of the above road map should create an enabling environment and momentum for a stronger hydrogen ecosystem to emerge by 2030. Some assumptions and projections have been made, backed with rationale.

Roadmap to a hydrogen economy (Contd.)

2020-2022	2023-2025	2026-2030	2031 and beyond
Immediate Next Step	**Early Scale-Up**	**Diversification**	**Broad Rollout**
Policy Support			
Dependable, technology neutral decarbonization goals in more states and at the central level. Public incentives to bridge barriers to initial market launches, bring a wider range of mature hydrogen solutions to market, increase public awareness and acceptance, and continue to pilot hydrogen use across applications. Hydrogen codes and safety standards, including blending standards, in certain Indian states. Policy/regulatory framework to include grid stability mechanisms for long-duration energy storage, including hydrogen Workforce development programs	Policy incentives (state and central) in early markets to transition from direct support to scalable market-based mechanisms. Spread public incentives bridging barriers to initial market launches beyond pioneer states. Regulatory framework for wider implementation of H2 energy storage. Implementation of cross-sectoral decarbonization policy initiatives to support distributed energy resources.	Transition of policy incentives in fast-following markets from direct support to scalable market-based mechanisms Applications to broaden beyond transport with specific enabling policies in other sectors (such as industry, power)	Reduced/no direct policy support in certain applications when reaching cost parity. Robust hydrogen code at federal level

Roadmap to a hydrogen economy (Contd.)

If the above roadmap is implemented, India should see the following by 2030:

H2 Energy Share 2030 (Highly Optimistic)	H2 Blending in Gas 2030 (Assumed)	H2 Jobs by 2030 (Projected)	H2 Public Funding (Desired)
Four percent of total energy consumption by 2030 13 MMT H2 demand	20 percent H2 Blending in Gas	75,000 new H2 jobs – direct and indirect	USD 100 million (2025) USD 500 million (2030)

Potential Mobile FCEVS – Fleet & Infra 2030	H2 Demonstration Stage Projects 2030 (Potential)	Electrolyser Production Capacity 2030 (Highly Optimistic)	H2 Production From Coal-Gasification 2030 (Highly Optimistic)
12,000 heavy-duty FCEVs 10 H2 refueling stations by 2030	10 proposed projects ✓ H2Bharat Trucking ✓ H2Bharat Ports, Logistics Clusters ✓ H2India Industry Clusters ✓ H2State BioGas Production	GW-scale Electrolyser Capacity 2030	10 Percent of Coal Gasification 2030 Target (100 MMT) to be converted to H2

Source: FTI Consulting, eninrac research

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