Pathway A – Proactive Policy-led Hydrogen Plan By 2022

Pathway A works with the premise that India wants to increase hydrogen adoption by India in the 2025-30 timeframe for the country to emerge as a significant global green hydrogen champion by 2030, with an integrated view of how India's renewables, electric/battery-power and green hydrogen technologies will work together to help India achieve a net-zero carbon scenario faster.

Economic assumption for hydrogen production by 2030 is that costs would drop to USD 2/kg (without government subsidy, and USD 1.5/kg with subsidy), and capex for electrolysers would be USD 300/kW (for Alkaline Electrolysers) and USD 500/kW (for PEM Electrolysers), as a result of growth in local electrolyser manufacturing and reductions would be between 40-50 percent from the IEA 2030 scenarios (400/kW for AK-EC, 650/kW for PEM-EC).[7] Fuel Cell costs are assumed to be USD 80/kW (20 percent lower than the US DOE target of USD 100/kW, which is the cost at which the systems become comparable with diesel engines) by 2030, with an estimated annual domestic production of 150,000 Fuel Cell systems.

LARGE DEVELOPMENT-STAGE PROJECTS	POLICY INTERVENTIONS AND PARTNERSHIPS
— Ten large-scale H2 national infra projects with state subsidies/ incentives, within 3-5 years i.e. by 2025 INDUSTRIAL CLUSTER CANDIDATES • Ports & Logistics Hubs - Nhava Sheva/Mah, Mundra/Guj, Chennai/TN, Vizag/AP, Paradip/Odisha • Sector-specific H2 Clusters/Valleys – Eastern India Mining/ Steel Cluster (Paradip/Jharsugda/Odisha) with Brown Coal/ Gasification; PetroChem/Fertiliser Plant (Guj) • Municipal / Urban Biogas hubs – Ahmedabad, Pune, Greater Mumbai LONG-HAUL, HEAVY DUTY TRANSPORT • Delhi-Mumbai Industrial Corridor (DMIC), Dedicated Freight Corridors (DFCs) — India H2 manufacturing capability to be part of GH2 global value-chains – inviting global investments, shared IP • Electrolyser design, manufacture (Alkaline, PEM) • Storage & transport systems (pipelines, tanks) • FCEV components, systems/stacks, re-fuelling stations • GH2 engineering and manufacturing jobs/ skills development — National hydrogen infra project & supply chain funding • Incentivize GH2 investments, as carbon-offsets – to encourage industry incumbents to de-carbonise • Multilateral and climate change/energy transition funds for consortium-led hydrogen projects	— Combined GH2-EV national energy transition strategy and roadmap towards net-zero carbon • 20 percent H2 blending in natural gas • Aspirational H2 energy share target of four percent by 2030 • Accelerated EV+GH2 adoption by decarbonising long-haul transport and industry in next 10 years (2020-30), with 10 national H2 infra projects in next 3-5 years • State subsidy/incentives support for national H2 infra projects, ten publicly tendered H2 infra projects, — Formation of India H2 Taskforce • Identify and promote green H2 plan of identified champions in public sector and private sector — Hydrogen Transition Fund for national projects • Funding for national hydrogen projects • Subsidy/incentives, funded by national carbon/energy transition taxes, multilateral funding — 'Make-In-India' domestic manufacturing opportunity in GH2 and FCEV global supply chains • Global Tier I/II supplier to global OEMs within 5 years, with clear 2030 targets, for export markets • Expand Centre of Excellence (CoE), academic collaboration with industry, facilitate co-development

7 Page 18, https://theicct.org/sites/default/files/publications/final_icct2020_assessment_of%20_hydrogen_production_costs%20v2.pdf

Pathway B – Cautious 'Fast-Follower' Approach to Build Green Hydrogen Roadmap by 2030

Pathway B works with the premise that India wants to take a cautious view, identifying a few demonstration in the 2025-2030, which would help it articulate its Green Hydrogen Roadmap by 2030, and work towards faster adoption in the 2030-40 decade after it has built its EV infrastructure. With this approach, the global green hydrogen and supply chain investments would have been made already, and India would be hoping to be a 'fast-follower' putting aside significant public funds to ensure it is able to catch up with other hydrogen-mature economies. India will have to forfeit its ambition of being a significant global green hydrogen champion, and will rely on imported technologies to make the energy transition towards green hydrogen.

The economic assumption for hydrogen production costs would drop to USD 2/kg (without government subsidy, and USD 1.5/kg) by 2040 (i.e. a decade later than Pathway A), and capex for electrolyzers would be USD 400/kW (for Alkaline Electrolysers) and USD 650/kW (for PEM Electrolyzers) by 2030, as a result of growth in local electrolyser manufacturing and reductions between 20-40 percent to be in line with the IEA 2030 scenarios.[8] Fuel Cell costs are assumed to be USD 100/kW by 2030 (in line with US DOE target, at which FC systems become comparable with diesel engines), with estimated annual domestic production of 150,000 Fuel Cell systems.

LARGE DEVELOPMENT-STAGE PROJECTS	POLICY INTERVENTIONS AND PARTNERSHIPS
— Three large-scale H2 national infra projects with state subsidies/ incentives, within 8-10 years INDUSTRIAL CLUSTER CANDIDATES • Ports & Logistics Hubs - Nhava Sheva/Mah, Mundra/Guj, Chennai/TN, Vizag/AP, Paradip/Odisha • Sector-specific H2 Clusters/Valleys – Eastern India Mining/ Steel Cluster (Paradip/Jharsugda/Odisha) with Brown Coal/ Gasification/ PetroChem/Fertiliser Plant (Guj) LONG-HAUL, HEAVY DUTY TRANSPORT • Delhi-Mumbai Industrial Corridor (DMIC) — India H2 manufacturing capability to be part of global value-chains – inviting global investments, shared IP • Electrolyser design, manufacture (Alkaline, PEM) • Storage & transport systems (pipelines, tanks) • FCEV components, systems/stacks • GH2 engineering and manufacturing jobs	— Combined GH2-EV as national energy transition strategy and roadmap in next 10-15 years • 20 percent H2 blending in natural gas • Aspirational H2 energy share target of four percent by 2030 • EV+GH2 adoption by decarbonising long-haul transport and industry in 15-20 years (2035-40), with three national H2 infra projects in 8-10 years — Formation of India H2 Taskforce • Identify and promote green H2 plan of identified champions in public sector and private sector — Hydrogen Transition Fund for national projects • Funding for national hydrogen projects; Subsidy/incentives, funded by national carbon/energy transition taxes, multilateral funding — 'Make-In-India' domestic manufacturing opportunity in GH2 and FCEV global supply chains • Global Tier I/II supplier to global OEMs within 10 years, for export markets

8 https://theicct.org/sites/default/files/publications/final_icct2020_assessment_of%20_hydrogen_production_costs%20v2.pdf

Pathway C – Reactive Approach to Green Hydrogen till 2040

Pathway C works with the premise that India wants to pursue energy transition with EV/battery tech and wait for global hydrogen ecosystem to mature before it develops an India roadmap, assuming that this will take place only in the 2040-50 decade. India would be a 'slow-follower' if it were to take this pathway.

The economic assumption for hydrogen production costs would drop to USD 2/kg (without government subsidy, and USD 1.5/kg) by 2040 (i.e. a decade later than Pathway A), and capex for electrolysers would be USD 400/kW (for Alkaline Electrolysers) and USD 650/kW (for PEM Electrolysers) by 2030[9] – the same as in Pathway B. Fuel Cell costs are assumed to be USD 120/kW by 2030 (20 percent higher than the US DOE target and Pathway B), with estimated annual domestic production of 150,000 Fuel Cell systems.

LARGE DEVELOPMENT-STAGE PROJECTS	POLICY INTERVENTIONS AND PARTNERSHIPS
— H2 to follow EV/battery tech for energy transition, with lag — Large, aspirational national infra projects in 15-20 years • Industrial Clusters • Long-haul Transport Corridors (for heavy trucking) — No India H2 manufacturing capability, Make-In-India plan for green hydrogen	— GH2-EV as aspirational energy transition plan to net-zero carbon • 10 percent H2 blending in natural gas • Aspirational H2 energy share target of four percent by 2040 — EV+GH2 adoption by decarbonising long-haul transport over next 20-25 years (2040-45 timeline), scaling up from national H2 infra projects in next 15-20 years

9 https://theicct.org/sites/default/files/publications/final_icct2020_assessment_of%20_hydrogen_production_costs%20v2.pdf

India's Green Hydrogen Roadmap and Energy Transition Vision

Building on Pathway A and a proactive role for policy and partnerships in creating a green hydrogen ecosystem, eight key interventions or recommendations are being made in the white paper. These eight recommendations provide important inputs for creating a green hydrogen roadmap for India, moving beyond the five policy interventions, to include key opportunities and hurdles for both government and industry to resolve together – from questions around the scope and scale of demonstration projects to building collaborative frameworks between stakeholders.

Recommended Policy Interventions for Creating A Green Hydrogen Ecosystem In India

1. NATIONAL HYDROGEN POLICY AND ROADMAP BY 2021, CO-CREATED BY GOVERNMENT AND INDUSTRY

Articulating the importance of a hydrogen economy and ecosystem in India's energy transition journey should start with a national hydrogen policy and creation of a roadmap or blueprint that signals regulatory certainty when it comes to hydrogen projects. This can be a 'rolling' framework that is refreshed every five years, to acknowledge the rapidly changing hydrogen ecosystem and strategic fit between green hydrogen adoption strategies and those for EVs and battery technologies. A look at global hydrogen policies reveal a range of approaches – from a broad and indicative framework in the case of Australia, to detailed frameworks used by the US State of California, with detailed economic modelling and assumptions on costs and pricing.

The recommendation for India is to signal policy intent with a national policy, provide an implementation timeline for large-scale hydrogen demonstration projects and funding so that India is considered a serious global hydrogen player. Due to the commercial nature of large demonstration projects, the paper recommends that an India green hydrogen policy should be prepared by the government with active involvement of hydrogen-champions from the industry.

2. H2INDIA GREEN HYDROGEN TASKFORCE AND WORKGROUPS TO IMPLEMENT THE ROADMAP

Moving beyond stated green hydrogen ambitions in the long term, it is important to create an executive body, in the form of an H2India Green Hydrogen Taskforce that will act on the national policy and implement the steps in the roadmap. This will ensure that there is accountability and a sense of urgency in creating in the green hydrogen ecosystem in India. The Taskforce should be constituted with members from industry, the government and hydrogen experts; drawn from global as well as Indian organizations, to ensure that India has access to the best available global expertise on the hydrogen economy. The India Taskforce would have multiple Work Groups to address the different policy and implementation issues pertaining to the different stages of the hydrogen value chain – from production, storage and distribution, to the appropriate use cases. In many ways, the taskforce (along with the policy and roadmap) provides a governance framework that will govern hydrogen-related policy and decision making. The India Taskforce would also ensure hydrogen strategies are being considered in national as well as sectoral net-zero carbon plans and aligned with the EV, battery storage, and energy transition policies across multiple agencies and ministries of the government.