hydrogen infrastructure and ecosystem.

— Second pathway spells a cautious wait-and-watch approach till 2030, before taking proactive steps

— Third pathway pushes out any proactive steps to 2040 and is a follower strategy to let developed markets build the global green hydrogen ecosystem first and catch up once the global system is ready.

There was strong support for the first pathway, across the stakeholder group, with concerns/hurdles flagged by stakeholders, namely lack of adequate public funding, public-private partnerships and industry consortia. These are critical and necessary for an early-stage green hydrogen ecosystem to develop in India.

Moving Towards a Green Hydrogen Ecosystem: Recommended Interventions

The first pathway for proactive adoption of green hydrogen strategies assumes the cost of green hydrogen to be USD 2/kg of green hydrogen and a 30 percent[1] fall in cost of production by 2030. This can be complemented by strong policy and industry collaboration, public funding and a clear plan for creating national green hydrogen demonstration projects within specific use cases.

The eight recommendations or interventions are clubbed into three broad categories:

FIVE POLICY-LED GREEN HYDROGEN INTERVENTIONS

1. Creation of a National Hydrogen Policy and Roadmap by 2021, co-created by government and industry
2. Creation of H2India Hydrogen Taskforce and Workgroups to meet roadmap milestones, implementation path
3. Green Hydrogen Investment Fund of USD 100 million to be deployed in next five years till 2025; larger USD 500 million Hydrogen Fund to be raised for 2025-2030
4. National aspiration for four percent hydrogen share in national energy mix by 2030
5. Inter-ministerial green hydrogen government cell to ensure adherence to globally harmonised standards

NATIONAL GREEN HYDROGEN DEMONSTRATION PROJECTS

6. Hydrogen production coupled with use-cases, H20 hydrogen blending in natural gas and exploratory natural gas and coal-gasified grey hydrogen projects
7. Identify at least ten potential H2India national hydrogen projects for large scale demonstration projects:
   a. Long-haul, heavy-duty H2Bharat Trucking project - 10,000 H2 truck fleet and infrastructure on DMIC
   b. Four H2Bharat Port and Logistics clusters, linked to IndiaH2 Trucking project
   c. Four H2India Industrial projects, in high-priority sectors (steel, fertilisers), including brown coal-gasification H2 project in steel/mining cluster
   d. Municipal level H2Maharashtra/ H2Gujarat Urban Bio-Gas project – with urban (solid waste), dairy

GREEN HYDROGEN PUBLIC-PRIVATE PARTNERSHIPS, INDUSTRY CONSORTIA

8. Fiscal incentives for large-scale national H2 projects; partnerships and industry consortiums

The paper recommends a cluster and defined-geography approach, rather than taking a national approach, for planning national hydrogen demonstration projects. This mirrors the EU approach of coupling green hydrogen demonstration use cases with renewable energy corridors; acknowledging the high cost of hydrogen infrastructure and transport networks and draws synergies with national decarbonising initiatives. India-relevant use cases in steel/ mining (using brown coal) and urban municipal waste (urban bio-gas) projects have also been recommended in the proposed national projects, beyond heavy-duty trucking. The paper does not recommend hydrogen for passenger and light-transport vehicles, which may be better served through EV/ battery technologies.

1 https://www.iea.org/reports/the-future-of-hydrogen

Implementation of the above eight interventions, in the first half of the decade, from 2020-2025, should create an enabling environment and momentum for a stronger green hydrogen ecosystem to emerge by 2030. Some assumptions and projections have been made, backed with rationale and underlying assumptions. If all eight interventions are accepted and implemented under Pathway A, India should see the following by 2030*:

H2 ENERGY SHARE 2030 (ASPIRATIONAL)	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, ASPIRATIONAL	H2 PRODUCTION FROM COAL-GASIFICATION 2030, ASPIRATIONAL
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 by 2030	10 percent of Coal Gasification 2030 target (100 MMT) to be converted to H2

*NOTE: All above numbers are aspirational and indicative only; and will depend on a combination of an enabling environment, assumed fall in price of hydrogen production and components, necessary policy and industry actions/ collaboration. The numbers above were discussed with all stakeholders. While representing aspirational numbers, the above chart represents a certain level of ambition that the Indian energy stakeholders and ecosystem should work towards and effort that is required for achieving energy transition and security.

INDIA GREEN HYDROGEN ROADMAP

Energy transition whitepaper prepared by FTI Consulting

POLICY INTERVENTIONS

- 4% by 2030 — Aspirational H2 energy share
- India Green Hydrogen Taskforce
- USD 100 mn — India Hydrogen Fund
- National Green Hydrogen Policy and Roadmap 2021
- Inter-govt H2 Group, fiscal incentives, global harmonisation

NATIONAL DEMONSTRATION PROJECTS (Proposed)

- H2 Bharat Trucking Project on Delhi-Mumbai Industrial Corridor
- H2 Bharat Port & Logistics Clusters
- H2 Industrial Clusters (Steel, Fertilizer)
- Municipal Bio-Gas H2 project
- Coal-Gasification H2 project

DESIRED OUTCOMES BY 2030

India in Global H2 Supply Chain
Domestic Manufacturing of Electrolysers, Fuel-Cell stacks, components; Partnerships and H2 India Consortium

10 National H2 Projects
Large, demonstration -stage, different use cases

USD 500 mn
Expanded Hydrogen Fund (by 2030)

75,000
New Hydrogen Economy jobs, potential

GW-scale
Electrolyser capacity in India

Green Hydrogen economy can scale, working with Renewables, Electric Vehicles and Battery Technology to build India's Net-Zero carbon pathway. An enabling policy environment and cross-industry collaboration are critical for this.

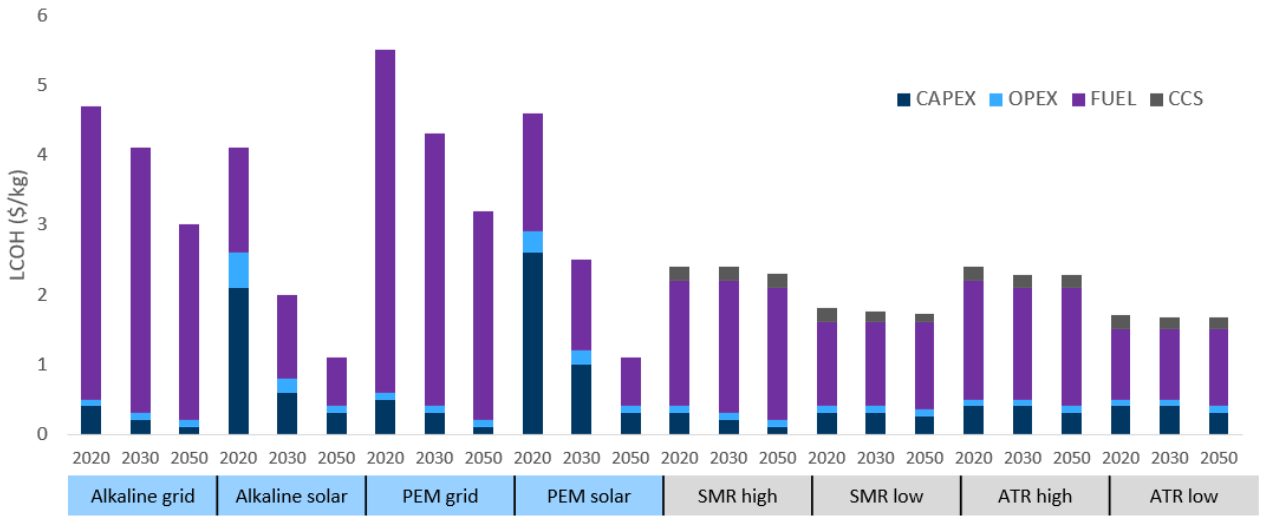
De-carbonising The Economy and Energy Transition – Move to Net-zero

Techno-commercial Developments – Global and Regional

While hydrogen has been around for a long time, most of the hydrogen produced is 'grey hydrogen' i.e., hydrogen produced from fossil fuels. The growth of renewables, and renewable-powered hydrogen production has created global momentum for 'green hydrogen' as a clean fuel as well as an energy storage option.

While still being very expensive, global adoption and faster roll-outs are expected to lead to a drop in the costs of electrolysers, green energy production as well as FCEVs by 2030 – moving from USD 4-6/kg currently to USD 2/kg by 2030 (without government incentives, and USD 1.5/kg with government incentives). As per Wood MacKenzie report,[2] a sharp rise in electrolyser deployments in the 2020-25 period – 3.2 GW of new electrolyzer capacity is going to be added globally (from 252 MW in 2019), leading to further drops in capital costs.

The figure below shows how the different hydrogen production technologies are expected to be priced over the next 10-20 years. Alkaline Electrolyser (AK-EC) technology wins currently on cost but this is expected to change with faster deployment of PEM-ECs, which have shown to work better than AK-EC, for smaller projects.



SOURCE: TERI Analysis; **LCOH:** Levelized Cost of Hydrogen

Does not consider Solid Oxide Electrolyser Cells (SOEC). View that SOECs could become cheaper than PEM or Alkaline in long term, but SOECs not commercially available for next 5 years.

2 https://www.woodmac.com/news/editorial/the-future-for-green-hydrogen