# India's green hydrogen ambition

## Setting the wheels in motion

March 2022

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# 01 Green hydrogen: Capturing the imagination of world


**Green hydrogen and its derivatives are expected to play a critical role in the world for decarbonisation at scale owing to its versatility enabling its use in many applications. Green hydrogen will also aid the decarbonisation of hard to abate sectors.**

The resource is also a 'drop in' for many applications as the world already consumes nearly 90 Million Tonnes Per Annum (MTPA) of hydrogen.[1]

Currently, more than 95 percent[2] of the world's hydrogen is fossil fuel based, produced via Steam Methane Reforming (SMR) or coal gasification. Production of hydrogen emits 9-10 kg $CO_2$/kg of hydrogen via SMR process[3], and emits 4.1-5.2 kg $CO_2$/kg via subbituminous coal gasification process, even with sequestration of $CO_2$.[4] Through renewable energy-powered electrolysis, net emissions would be minimal in contrast, considering the usage of carbon-free sources of electricity and feedstock fuel in this production value chain.

The demand for hydrogen is expected to be more than 200 MTPA in 2030. By 2050, around one-third of hydrogen demand in IEA's Net-zero Emissions Scenario[5] is expected to be used for hydrogen-based fuels such as ammonia, synthetic kerosene and synthetic methane. Ammonia use could expand

1. IEA, 2021
2. Forbes, June 2020
3. Argonne GREET Publication: Updates of Hydrogen Production from SMR Process in GREET® 2019 (anl.gov)
4. Carbon footprint of the hydrogen production process utilizing subbituminous coal and lignite gasification - ScienceDirect
5. IEA, 2021

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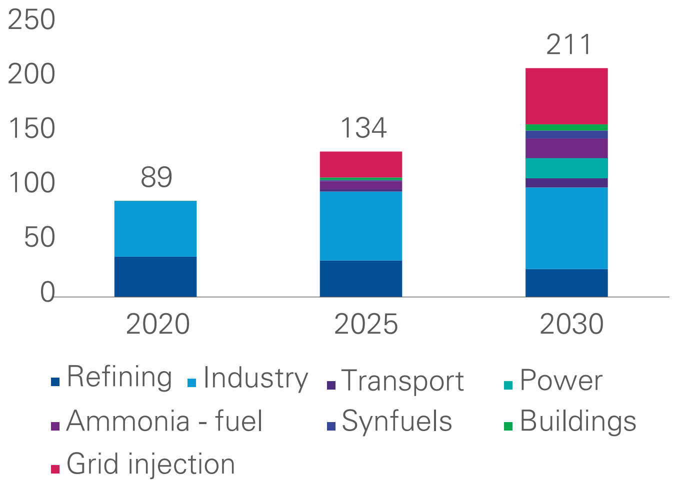
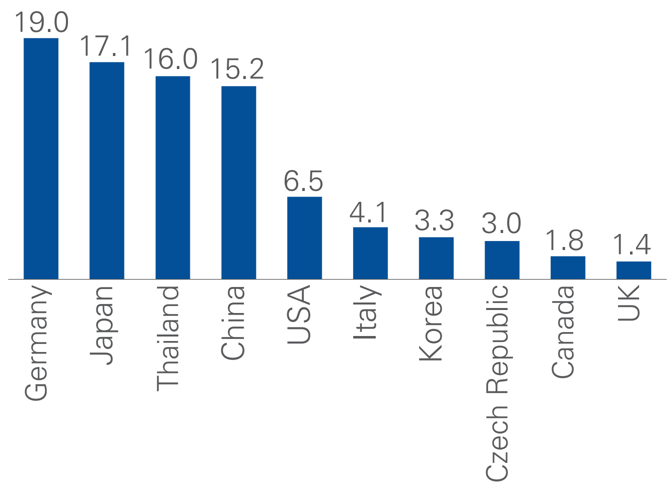
**Global hydrogen demand by sector (Mt $H_2$/year)**




**Source:** IEA, 2020

**Global hydrogen electrolyser market share (2020)**




**Source:** Clean Energy Wire 2020

beyond existing applications (viz primarily nitrogen fertilisers) and could be adopted for use as a fuel. Overall, hydrogen and hydrogen-based fuels are expected to meet 10 percent of global final energy demand in 2050.[5]

This offers a great prospect for low-carbon hydrogen because of its ability to support decarbonisation of many sectors. Many countries have taken the first step towards a low-carbon hydrogen-based economy by establishing strategies, policies, initiatives, and pilot projects. Among low-carbon hydrogen production methods, Green hydrogen is expected to take the center stage at the next round of global decarbonization initiatives.

In 2021 United Nations Climate Change Conference (COP26) in Glasgow, 32 countries and the European Union (EU) agreed to work together to accelerate the development and deployment of clean hydrogen and ensure that 'affordable renewable and low-carbon hydrogen is globally available by 2030'.[6]

As of end-2021,12 countries and the European Union (EU) have published their national low-carbon hydrogen strategies.[7] Several other countries have published or are currently drafting their low-carbon hydrogen strategies, demonstrating a clear acceleration of government interest backed by, potentially, COP26 acting as a catalyst.

Globally, many countries have also made substantial progress towards aligning their strategies as a demand center or a supply leader. Countries such as **Germany**, **Japan**, and **South Korea** are predicted to be net importers of hydrogen, while **Chile** and **Australia** may play a huge role in hydrogen export.

Few countries have been particularly influential with their hydrogen strategies.

**Japan's** early commitment catalyzed interest in the Asia-Pacific region, with South Korea and Australia publishing their own strategies shortly afterwards. **Japan** is pursuing hydrogen (particularly green hydrogen) production facilities projects overseas for large-scale hydrogen imports, with partnerships with Australia and Brunei, as it aims to import 300,000 tons of the fuel a year by around 2030.

6. UNFCCC, 2021
7. National Hydrogen Strategies published until 07/06/2021

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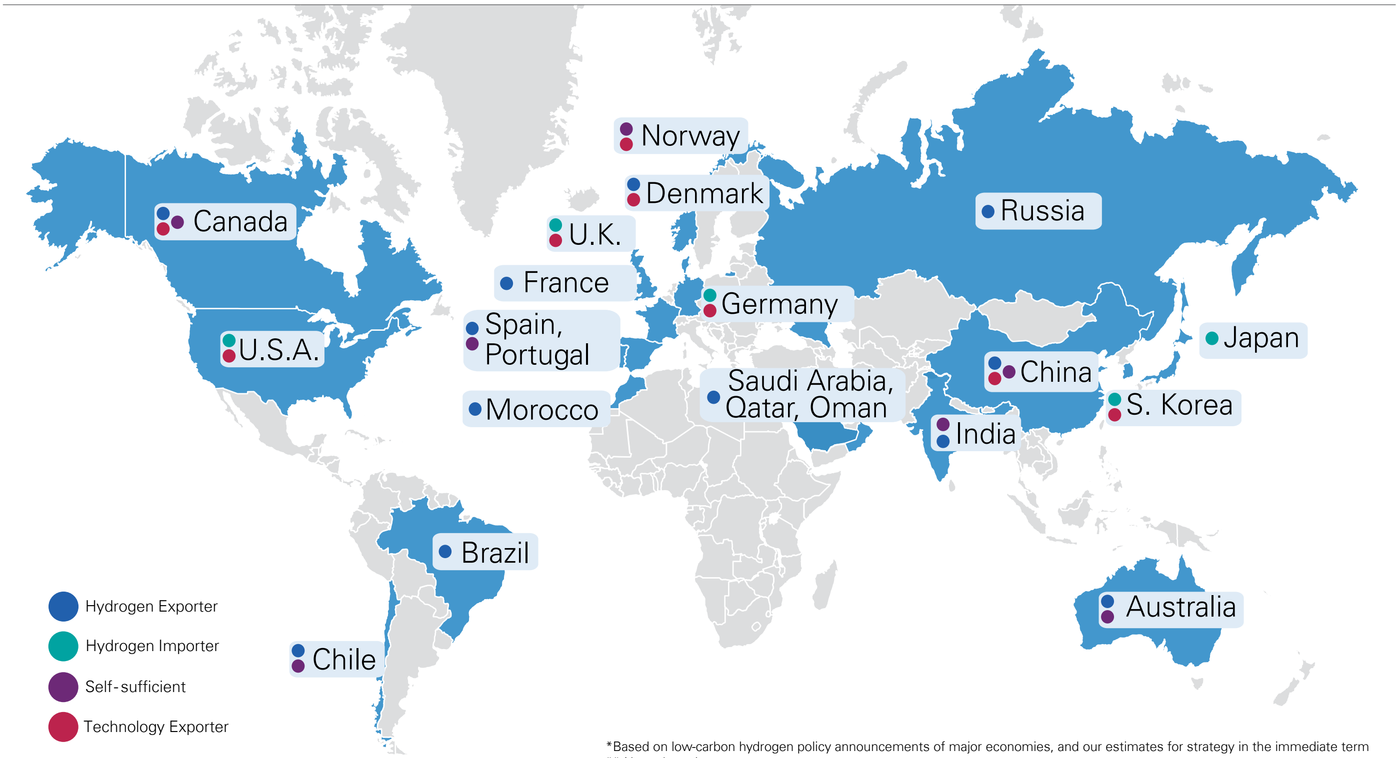
**Australia** is developing an export infrastructure by supporting R&D on green hydrogen and compressed hydrogen ships for transport. Australia is sending the world's first shipment of liquified hydrogen to Japan. The Australian government has dedicated over USD 500 million to build new international technology partnerships. Australian hydrogen production for export and domestic use could generate more than USD 50 billion in 2050.

**South Korea** has entered into a strategic agreement with Australia for import and R&D of hydrogen technologies.

**Chile** has moved quickly with many neighboring countries also now in the process of developing their strategies. It is planning a 25 GW electrolyser capacity by 2025 with the cheapest domestically produced green hydrogen prices (between USD1.30 and USD1.80 per kg) in the world by 2030. It is also exploring export opportunities with Netherlands and Singapore.

**Germany** was an early mover in Europe and helped push the EU low-carbon hydrogen strategy during its EU presidency. The national hydrogen strategy set an import target of 76 to 96 TWh worth of renewable hydrogen for 2030 and as per their national hydrogen strategy. Berlin has reserved USD 405 million for support to green hydrogen projects outside Germany.

### Key global low-carbon hydrogen hotspots




*Based on low-carbon hydrogen policy announcements of major economies, and our estimates for strategy in the immediate term
** Not exhaustive

**Source:** KPMG India analysis

**The world's largest green hydrogen project, with a 150 MW alkaline electrolyser, has been commissioned in Dec. 2021 in China to be used at an oil refinery**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Based on measures observed across countries, the following major groups of movers and leaders are emerging.

**Critical initiatives across strategies**


### Demand side movers

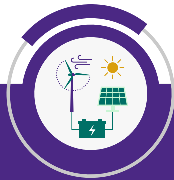
Public-private partnership for hydrogen usage and end-use development, Hydrogen usage obligations, Carbon costs and credits, hydrogen for transportation, hydrogen usage within public infrastructure including buildings and buses, hydrogen subsidies for end use applications

**South Korea (Fuel cell) | Chile (Ammonia) | Japan (Industrial)**

### Technology and R&D leaders

Talent and expertise development, prioritization of R&D initiatives, emphasis on trials and pilots, R&D on innovative approaches to hydrogen generation (such as from Industrial waste, tidal energy etc.)

**U.K. | South Korea | Germany**



### Supply side movers

Supply side contracts for difference mechanisms (ensuring hydrogen offtake prices), Increased emphasis on renewable energy generation, transmission waivers and subsidies, cross sector linkages for hydrogen production, development and harmonization of national regulations

**Australia | Chile | U.K. | India**

The geopolitics of clean hydrogen is likely to play out in decades. The 2020s could be the period of the big race for technology leadership, with costs falling significantly and scaling up of the infrastructure. In many locations, green hydrogen is set to compete on costs with blue by 2030.[8]

Post-2030, the higher ambition scenarios see higher hydrogen demand with another strong pull from 2035 onwards, as per WEC 2021.[9] During this period, international trade of hydrogen and derivatives could grow significantly providing further interesting prospects for RE resource rich country such as India.

> **According to IEA, nearly 320 green hydrogen production demonstration projects have been announced worldwide**

8. IRENA, 2021
9. World Energy Council, 2021

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# 02 For India, green hydrogen offers attractive possibilities for its clean energy ambitions

**India is one of the largest consumers of hydrogen in the world with a demand of 6.7 MTPA which comprises 7-8 per cent of the global hydrogen demand. Hydrogen is used in India, mainly as an industrial feedstock in the creation of ammonia-based fertilisers and in refineries.**

Hydrogen derived from both fossil fuels and electricity has been used for many years in India, with the country's first large-scale alkaline electrolyser[1] being deployed at Nangal in Punjab from 1962. It was later closed as a result of increasing demands for electricity elsewhere in the economy and replaced by hydrogen production from natural gas.

India's deep interest in green hydrogen stems from its high hydrogen demand as well as the ability of this fuel to decarbonise its energy use especially in hard-to-abate sectors such as refineries, fertilisers, steel, transport, etc. Further, India has a high dependence on oil and gas imports with 85 per cent of its oil and more than 50 per cent of its gas being imported in 2018.[2] Green hydrogen which can be produced through the abundant renewable energy resources available in India, can bring energy security and energy independence to the country by potentially displacing fossil fuels usage in end use.

1. The electrolyser under a process called electrolyzes breaks down water molecules into hydrogen and oxygen through passage of electricity
2. Economic Times, Updated 4 February 2022, accessed on 16 March 2022

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**Several benefits to India in shifting to a green hydrogen economy**

01

### Decarbonising Energy Use

The energy sector accounts for ~40 per cent of the GHG emissions. India's energy demand depends on fossil fuel (~75 per cent), with coal alone contributing to ~44 per cent and renewable energy (including hydro and traditional biomass) contributing to ~22 per cent.[3] Hydrogen being versatile and having many applications can enable fossil fuel switch in many applications.

02

### Enhancing Energy Security & Independence

India is the 3rd largest consumer of oil and gas in the world, importing 85 per cent of its oil and 50 per cent of gas as of 2018. Green hydrogen can act as a clean substitute in many applications reducing fossil fuel dependence.

03


### Aiding India's ambition of becoming Net Energy Exporter

India's natural competitive advantage in green hydrogen production, coupled with a supportive regulatory environment, makes it a potential hotspot for green hydrogen production.

04

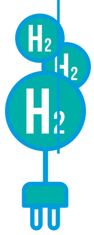

### Enabling renewable energy acceleration

Green hydrogen can help accelerate renewable energy adoption by opening significant alternative end uses for renewable energy.

Recognizing the importance of the switch to green fuels such as green hydrogen, as early as in 2003, National Hydrogen Energy Board was formed and in 2006 the Ministry of New and Renewable Energy (MNRE) laid out the National Hydrogen Energy Road Map identifying transport and power generation as two major green energy initiatives. In 2016, MNRE published a further report, which laid out more up-to-date plans for the Government's ambitions for hydrogen (MNRE, 2016). This report lays out a comprehensive plan for increasing R&D activity in India across several programme areas, with the 2016 report showing ambitious timelines for research activities.

Most recently, in February 2022, the Government of India launched the Green Hydrogen Policy which represents Phase 1 of the measures expected to be announced in this space and seeks to create traction in green hydrogen supply. Equally important is the impetus to stimulate green hydrogen demand which is likely to be the focus of phase 2 of policy announcements.

While green hydrogen demand is expected to initially gain traction in refineries and fertiliser industries where this is largely a 'drop in' technology, sectors such as steel and transport are also expected to open up.




3. IEA India Energy Outlook, 2021

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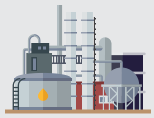
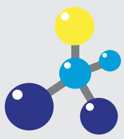
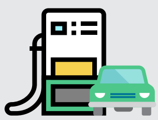
**Potential use cases of green hydrogen and ease of the switch**

The following table illustrates hydrogen usage possibilities within various sectors.

| Sector | | Whether this is a 'Drop in' use | Where/ How green $H_2$ can be used |
|---|---|---|---|
| Refinery |  | Yes | 1. Hydrogen is already used in hydro-treating and hydrocracking for desulphurization and catalytic conversion respectively within the refinery industry and can be replaced by green hydrogen in the future |
| Fertiliser (Ammonia) |  | Yes (partial for Urea) | 1. Used as a feedstock to produce ammonia, which is used to make nitrogenous fertilisers like Urea and DAP (diammonium hydrogen phosphate).<br>2. In the case of Urea, green hydrogen can be used to partially replace grey hydrogen used in the production of ammonia. Green hydrogen adoption is limited by $CO_2$ sourcing limitations for producing Urea.<br>3. Green hydrogen can also be used as fuel for heating and steam generation requirements. |
| Methanol |  | Drop in | 1. Green hydrogen will be used as a fuel for blending with Natural gas used as a fuel in producing methanol through the Natural gas route.<br>2. Green hydrogen can also be used as a feedstock to produce green methanol. |
| Mobility |  | Partial | 1. For FCEVs, green hydrogen can directly be used as fuel for vehicles.<br>2. Green hydrogen can also be blended with CNG, and the blended fuel (HCNG) can be used as a fuel in CNG vehicles |
| Steel |  | Partial | Green hydrogen has two key use possible cases in the steel industry:<br>1. As the primary fuel within a hydrogen-based ($H_2$-DRI) Iron production route in the future<br>2. As a partial replacement of coal and natural gas used within the BF-BOF and Natural gas DRI Iron making routes respectively |
| Power |  | Partial | 1. Used for generator cooling in thermal and gas-based power plants.<br>2. Co-firing ammonia in coal-based boilers<br>3. Decentralised power generation or fuel-cells to replace diesel-based power<br>4. To manage RE intermittency/ variation and for longer term storage |

**Source:** KPMG India analysis

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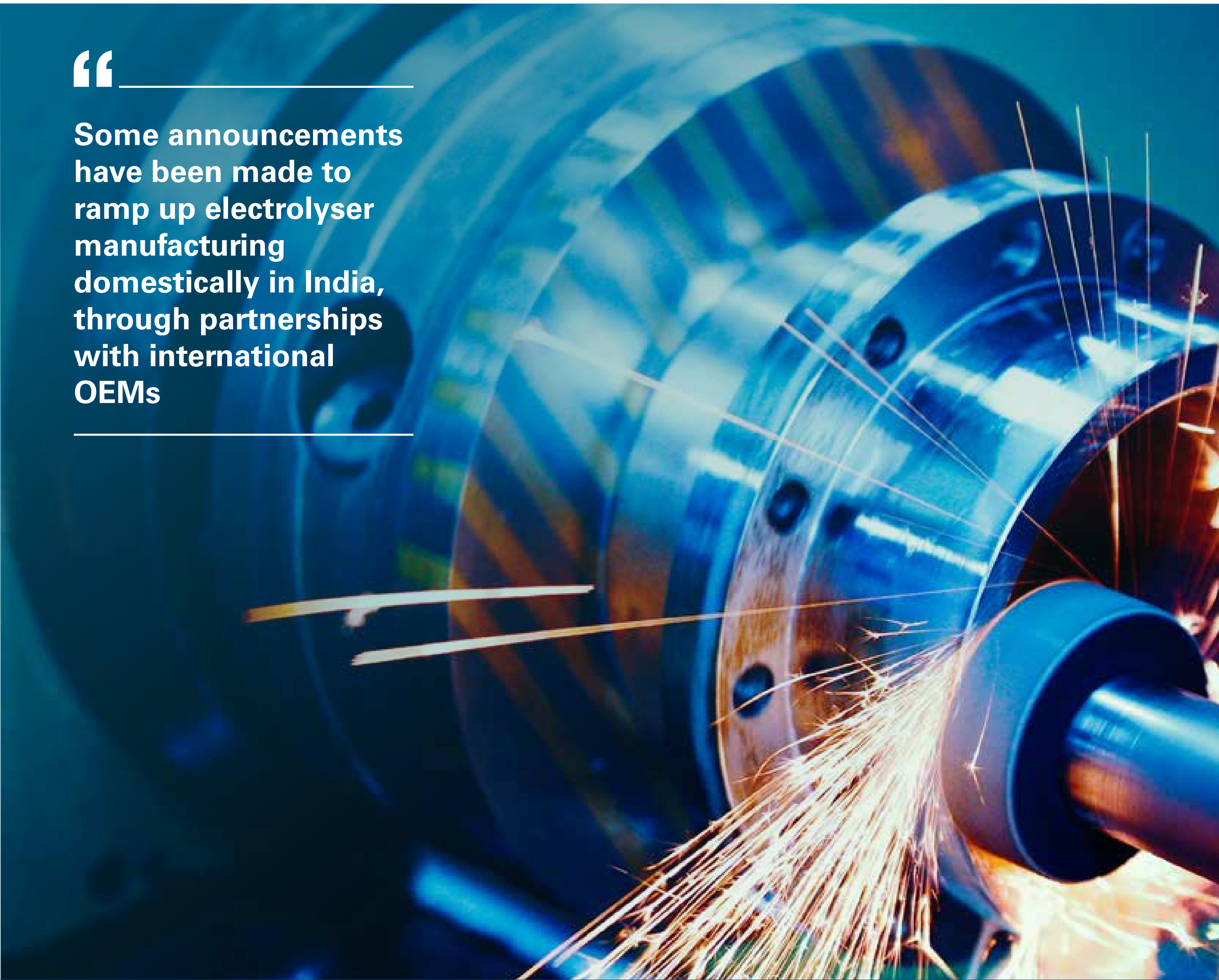
The transitions are likely to be fuelled by decarbonization pressures faced by these sectors as well as improvement in cost economics of green hydrogen. Beyond 'drop in' applications concerted efforts would be needed for adoption as these may require significant capex and process changes for changing the fuel/feedstock used. Especially in industrial manufacturing where India is in the midst of a capex cycle it is essential to signal to capital to be deployed for green technologies and applications, including for green hydrogen.

For this to happen reasonable visibility on costs is needed. Aided by various policy measures, it is estimated that by 2030, the hydrogen costs will come down by 50 per cent.[4] These estimates can be aided by factors such as carbon pricing, further scale-led decline in electrolyser costs and innovations across the value chain to bring down cost and improve efficiencies.

By 2030, if the scenario plays out as expected, green hydrogen demand could comprise 20-30 per cent of the overall hydrogen demand which is expected to jump to almost double at **~12 MTPA**.

4. 'New policy to cut green hydrogen cost by 40-50 per cent, says Indian Oil', The Economic Times, February 2022, Accessed on March 14, 2022



**"Some announcements have been made to ramp up electrolyser manufacturing domestically in India, through partnerships with international OEMs**

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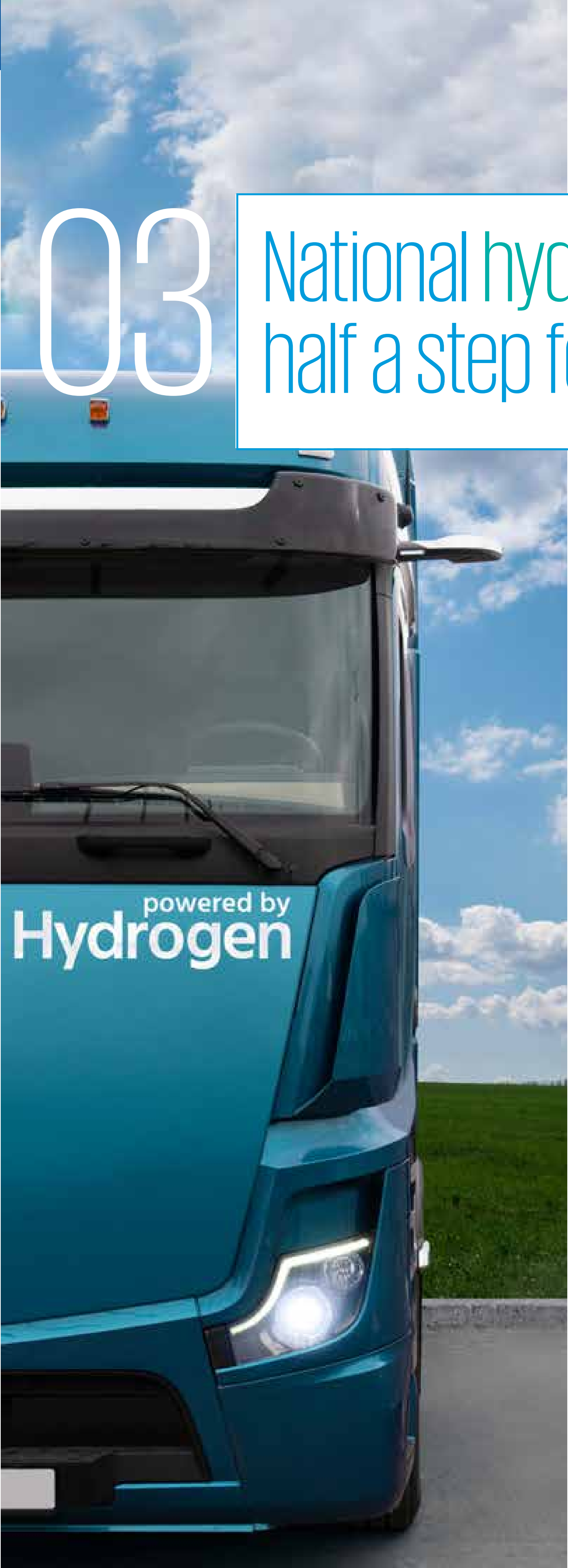
03

# National hydrogen policy: half a step forward




**Government of India, on February 17, 2022, launched the Green Hydrogen Policy aiming at boosting the domestic production of green hydrogen to 5 MTPA by 2030, half of the EU's target of 10 MTPA, and making India an export hub for the energy source.**

At its core, the policy seeks facilitate green hydrogen adoption by bringing down the costs of green hydrogen and improving ease of setting up green hydrogen projects.

Delivered costs of green hydrogen is typically driven by four main elements – renewable energy generation cost, cost of transportation, electrolyser capital costs, and operating costs. Transportation of hydrogen in the form of molecules over long distances is not cost economical at this time. Instead, the typical approach would be to transmit the electrical energy over the power transmission system and produce green hydrogen at or close to the consumption location. Using this model, the cost of green hydrogen production is estimated to be around INR 320-330 per kg (KPMG India Estimates). Cost of transmission typically constituted about 25-35 per cent of the cost of green hydrogen (pre-policy situation). **Currently, the focus of India's present policy is largely around the electricity transmission ecosystem.**

The policy provides for **free and easy open access to the inter-state transmission system (ISTS)**, for 25 years for capacity installed by June 2025 for green hydrogen/green ammonia (GH/GA) production. This is likely to make it more cost-effective for key users of hydrogen and ammonia such as the oil refining, fertiliser to produce green hydrogen for their own use.

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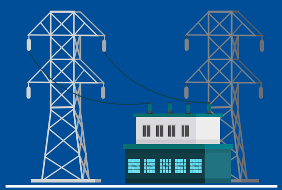
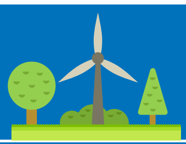
The policy provides a **single window clearance** for setting up green hydrogen production as well as a facility for producers to bank any surplus renewable energy generated for up to 30 days and use it as required, by paying relevent banking charges. The power ministry has mentioned that energy plants set up to produce green hydrogen/ammonia would be given connectivity to the grid on a **priority basis**. Discoms may also procure renewable energy to supply green hydrogen producers but will be required to do so at a concessional rate which will only include the cost of procurement, wheeling charges and a small margin as determined by the state commission. Such procurement would also count towards an obligated entity's **Renewable Purchase Obligation (RPO)** under which it is required to procure a certain proportion of its requirements from renewable energy sources.

In addition, manufacturers of green hydrogen and/or green ammonia shall be allowed to set up bunkers near Ports for storage of Green ammonia for export / use by shipping. There are other measures for ease of setting up projects as indicate in figure below.

### Key Features of the policy

| Incentive/Initiative group | Incentives |
|---|---|
|  01 **Power transmission measures** | • ISTS network connection for GH/GA plants to be granted on priority<br>• GH/GA plants shall be granted open access for sourcing electricity within 15 days of application<br>• ISTS transmission costs shall be waived off for all green hydrogen and ammonia production plants commissioned before June 30, 2025, for a period of 25 years.<br>• Renewable energy banking shall be permitted for a period of 30 days at limited[1] charges set by state commissions<br>• Distribution licensees shall only charge procurement charges, wheeling charges, and a small margin as determined by the state commission on electricity supplied to GH/GA plants. |
|  02 **Ease of doing business** | • Land in RE parks can be allocated towards green hydrogen/green ammonia plants<br>• Manufacturing zones are to be set up by the Government of India where GH/GA plants can be set up<br>• Manufacturers shall be allowed to set up bunkers for GH/GA storage near ports at applicable charges<br>• A single portal is to be established by MNRE for all statutory clearances concerning manufacturing, storage, and transportation of hydrogen. All clearances are to be provided in a swift manner possibly within 30 days of application. |
|  03 **Demand-side measures** | • Renewable energy used in GH/GA production shall be counted towards the renewable purchase obligation of the consuming entity. RE consumed beyond the obligation of the producer shall be counted towards RPO of the obligated entity<br>• MNRE may aggregate demand from different consumers and have consolidated bids for the procurement of GH/GA. This could help create competitive prices for GH. |

1. Banking charges shall not be more than the cost differential between the average tariff of RE bought by the distribution licensee in the previous year and the average market clearing price in the day ahead market during the month in which RE has been banked.

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## Stakeholders have welcomed the Green Hydrogen Policy; however, some gaps do remain.

1. The implementation of **banking provision is unclear.** The mechanics of that need to be understood since there is no framework for banking for ISTS connected facilities. In practice elements of the chain may come under the purview of State authorities. How they react to the policies needs to be seen since the Electricity Act, 2003 only requires State regulators to be guided by the National Electricity Policy and Tariff Policy.
2. Further, the mechanism for the **charges the energy banking** will entail, even if fully implemented by the states need to be understood.
3. There is **no clarity on the application of Cross Subsidy Surcharge (CSS),** especially on Open Access RE projects that are not wholly dedicated to the production of green hydrogen, thereby not necessarily in a Captive structure where CSS is typically waived off. Similarly there is no mention of **Electricity Duty (ED).**
4. The **policy is silent on demand mandates** for sectors such as fertiliser and refineries which was widely expected. It has been hinted that this will come through subsequently in second phase of announcements.
5. The policy also does not provide any specific **fiscal incentive for electrolyser manufacturing** which would be critical to facilitate ecosystem development and self-sufficiency.
6. The policy does not materially attempt to address costs of renewable energy production or the costs of electrolysis other than through banking.

The green hydrogen space cuts across the whole value chain and administrative spaces. Other than aspects that are clarificatory in nature, the substantive issues of mandates for users and specific fiscal incentives would need further interventions to bring down costs and ramp up adoption. In effect the current policy may have provided only the first set of measures, with likelihood of more to come.


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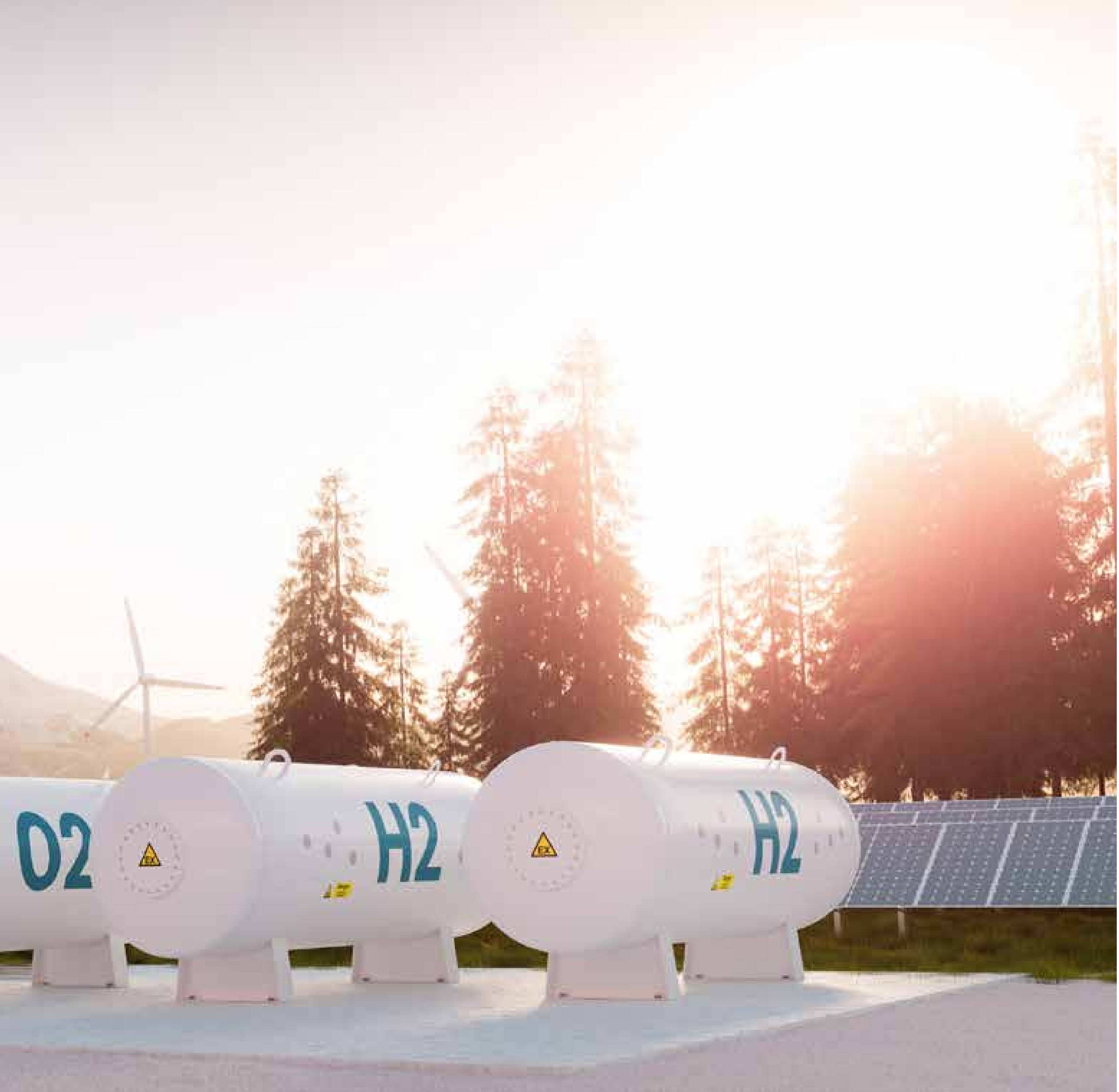
**“Several industry partnerships and early-stage tenders have been announced over 2021-22 involving state-run PSUs as well as private engineering and renewable energy leaders in India**

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# 04 Green hydrogen production cost getting closer to grey hydrogen

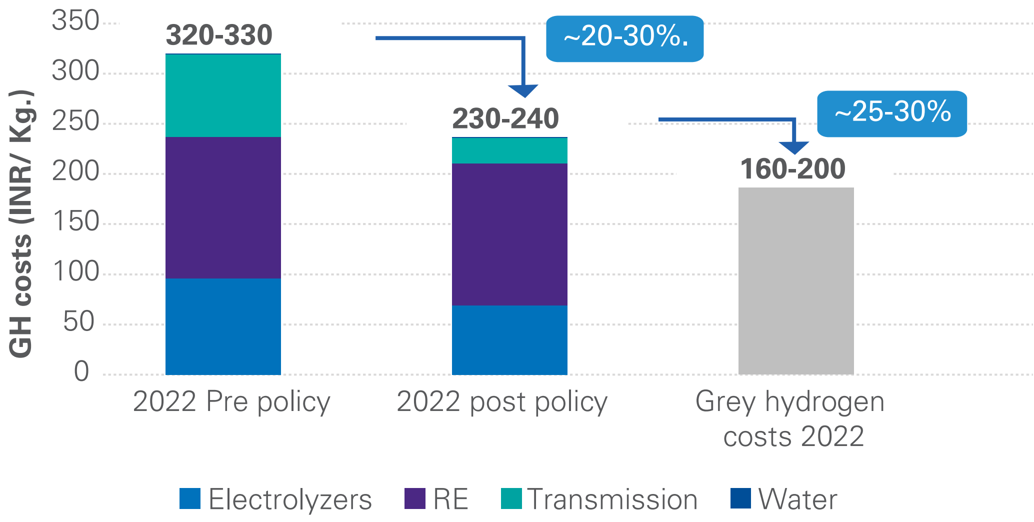
As per KPMG estimates, the National Hydrogen Policy could result in reduction of green hydrogen production costs by ~20-30 per cent to INR 230-240 per kg basis the measures announced (provided issues such as banking are sorted out).

As per KPMG in India estimates, current grey hydrogen costs of INR 160-200/ kg hydrogen consider a natural gas input cost of USD 10-13/MMBtu, possibly rising further due to the price movements seen in the immediate term. (Gas costs considered include weighted average of Asian LNG and Domestic gas costs with 50:50 split as per current consumption data for India).

Various policy and technical measures can reduce current green hydrogen production costs further, such as incentives on capex, aggregation of demand and bulk deployment, improved efficiencies, waivers on STU charges and cheaper renewable energy costs.

As per KPMG in India estimates, by 2030, green hydrogen costs in India could potentially fall to as low INR 160-170/ kg bringing parity with grey hydrogen and other competing fossil fuels in various end uses. To achieve this, it is important for India to have a well-rounded strategy for addressing levers for cost reduction. Some policy recommendations in this regard are provided herein.

**Estimated GH Production Costs pre- and post- India $H_2$ Policy**




**Source:** KPMG India Analysis

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**In our estimates, the gap between green hydrogen and fossil-fuel based Grey Hydrogen may close significantly to 25-30 per cent, supported by policy measures as well as rising input Natural Gas costs (~USD 10-13/ MMBTU or even higher depending on source) driving costs of Grey Hydrogen upwards in the immediate term.**


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# 05 Five critical areas of focus for policy makers

## 01

**The efforts to increase green hydrogen economy should be backed by firm measures to develop a local supply chain to ensure indigenous capabilities:**

India may require at least 30-40 GW of green hydrogen production capacity by 2030 to address the green hydrogen opportunities. To enable self-sufficiency, it is critical that the Phase 2 of the policy brings in clarity on indigenous production of electrolyser manufacturing and incentivizes this through production linked incentives. Further, focus on innovation through promotion of domestic R&D, creation of a startup ecosystem would be extremely critical to increase efficiencies and bring down cost across the value chain.

## 02

**A strong alignment needs to be created between center and states:**

A significant start has been made through supply side measures at the center. However, alignment between center and states will need to be created as projects or consumers may invariably be in the remit of the state regulations. These regulations would not only need to facilitate some of the provisions of the policy such as banking but also provide further incentives such as intra state transmission waivers, cross-subsidy waivers, etc.

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**India needs a well-defined policy framework to not only create a market for green hydrogen but to also ensure its procurement in a cost-effective manner. While the National Hydrogen Policy addresses some of the key demands of the industry, it remains uncertain on certain critical elements. It is important for Government policy to focus on five critical areas as they create durable institutional arrangements:**

## 03

**Demand side impetus would need to be created to facilitate green hydrogen uptake:**

It is vital to build upon the first phase of the policy and for the government to subsequently come up with demand mandates and incentives to create initial demand. In absence of such measures, it would be difficult for businesses to plan their procurement especially as many of them are amidst a major capex cycle.

## 04

**A well-built procurement policy framework will be needed to enable demand aggregation, cost reduction and better risk management.**

The policy should identify or create a nodal agency, such as the Solar Energy Corporation of India (SECI), to tender green hydrogen projects. However, this would need both expertise and capacity building for implementation and execution.

## 05

**Access to finance at low cost would be a pre-requisite to facilitate development of the supply chain:**

Access to low-cost green financing needs to be facilitated to improve viability of the resource. India needs to co-opt assistance from multi-lateral and bilateral financial institutions and also leverage international green finance at low cost through innovations in climate finance.

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# 06 Conclusion

India’s landmark Green Hydrogen Policy released in February 2022 was a welcome initiative. While it sets the ball rolling it marks only the first steps in a long road. Challenges do remain in both implementing these measures as well as additional measures needed. Signals to the demand side to adopt green hydrogen at scale are essential for both ‘drop in’ applications as well as for new industrial processes where hydrogen based processes can replace carbon intensive methods of production.

Directionally, India is clearly seeking to position itself as a strong candidate to lead the world’s low-carbon hydrogen transition, with promise from policy makers and industry alike to implement the subsequent phases of development effectively in this journey.

However, it is critical to ensure that the technology, capital, and capacities do not pose a significant test for India’s domestic capabilities.

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