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

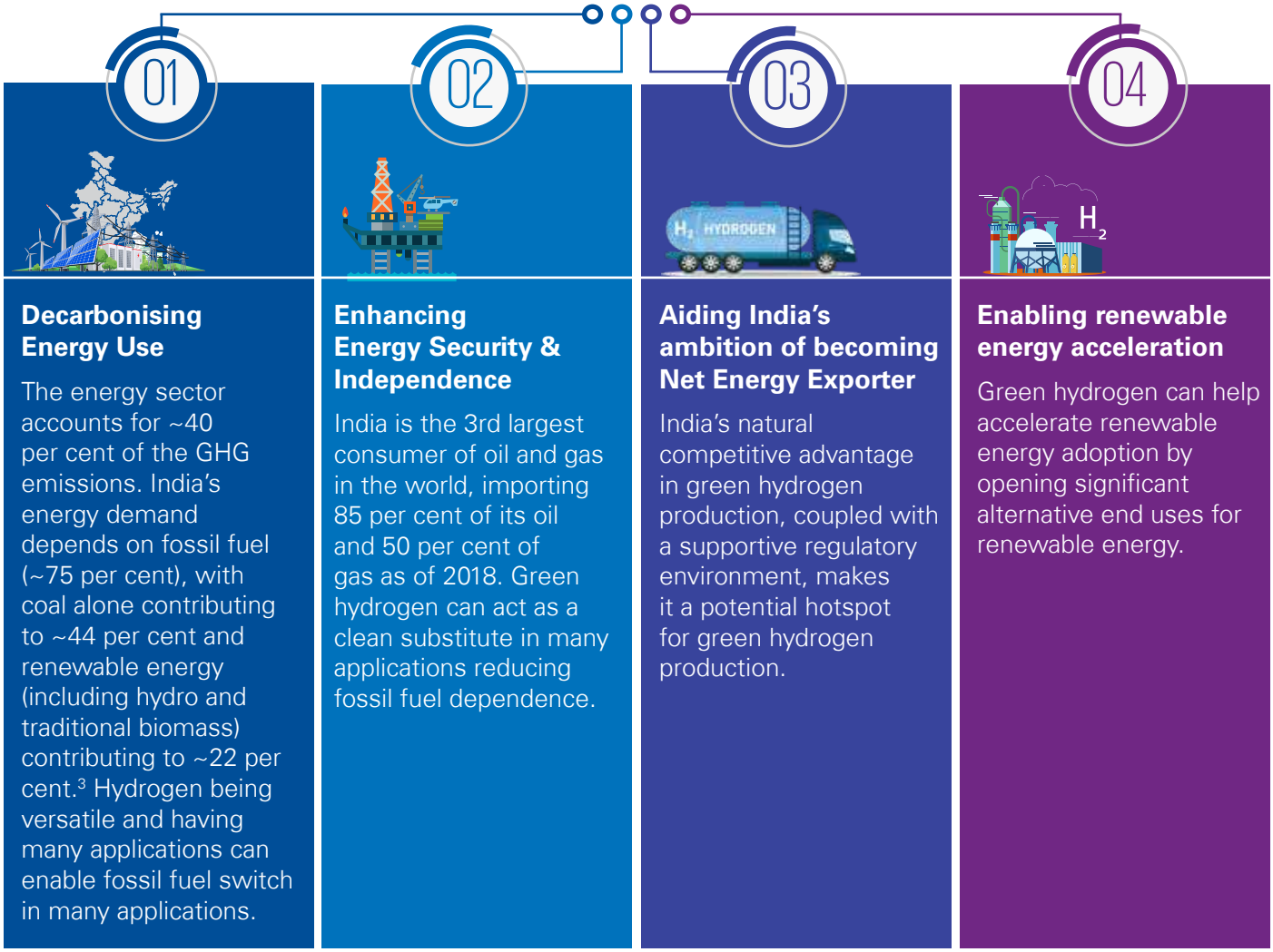
India is one of the largest consumers of hydrogen in the world with a demand of 6.7 MTPA which comprises 7-8 per cent of the global hydrogen demand. Hydrogen is used in India, mainly as an industrial feedstock in the creation of ammonia-based fertilisers and in refineries.

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

Several benefits to India in shifting to a green hydrogen economy



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.

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.

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.

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.

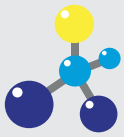
Most recently, in February 2022, the Government of India launched the Green Hydrogen Policy which represents Phase 1 of the measures expected to be announced in this space and seeks to create traction in green hydrogen supply. Equally important is the impetus to stimulate green hydrogen demand which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

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). 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. 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. 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. 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: 1. As the primary fuel within a hydrogen-based (H_2-DRI) Iron production route in the future 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. 2. Co-firing ammonia in coal-based boilers 3. Decentralised power generation or fuel-cells to replace diesel-based power 4. To manage RE intermittency/ variation and for longer term storage

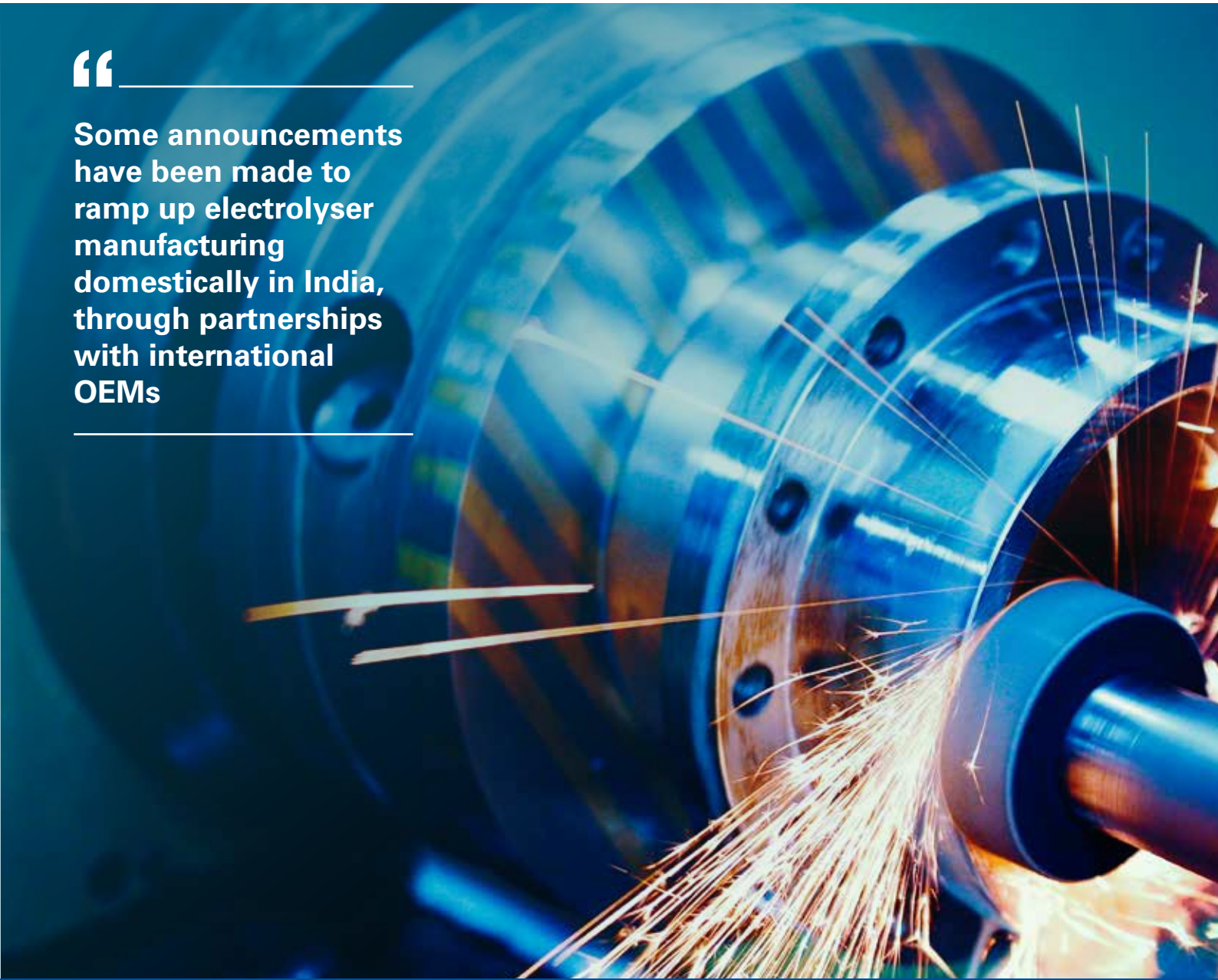
Source: KPMG India analysis

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.

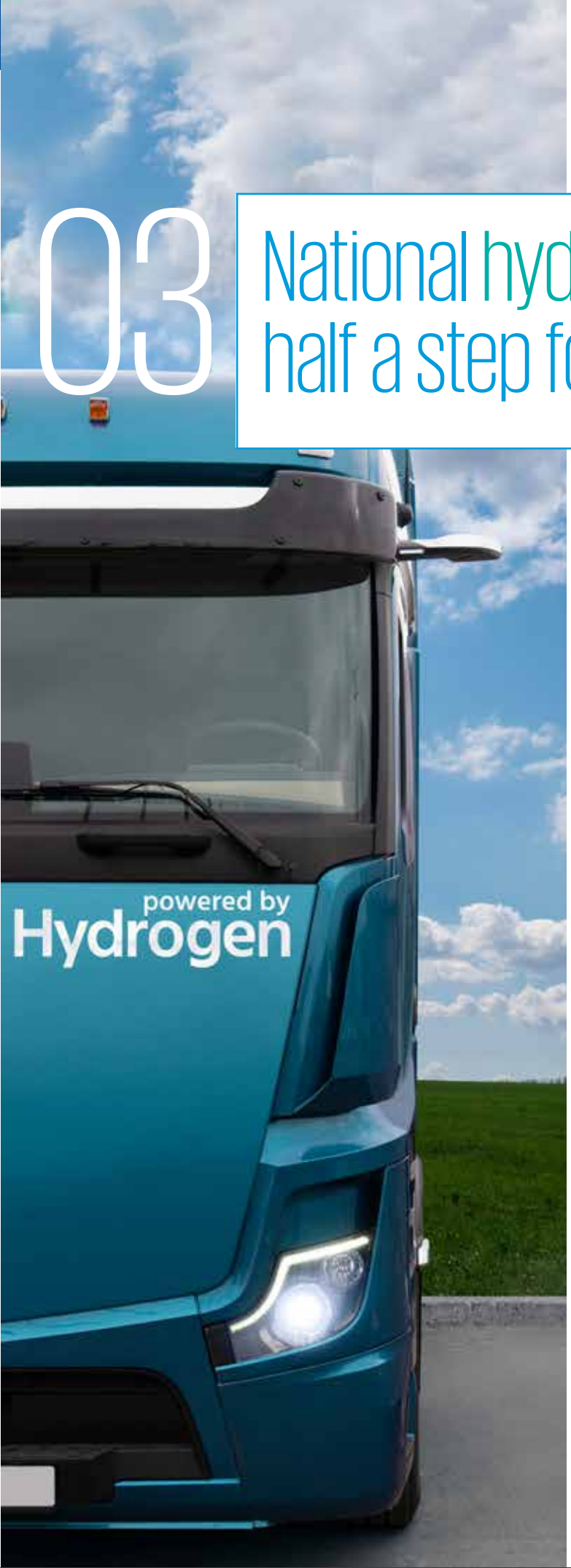
For this to happen reasonable visibility on costs is needed. Aided by various policy measures, it is estimated that by 2030, the hydrogen costs will come down by 50 per cent.[4] These estimates can be aided by factors such as carbon pricing, further scale-led decline in electrolyser costs and innovations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



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.