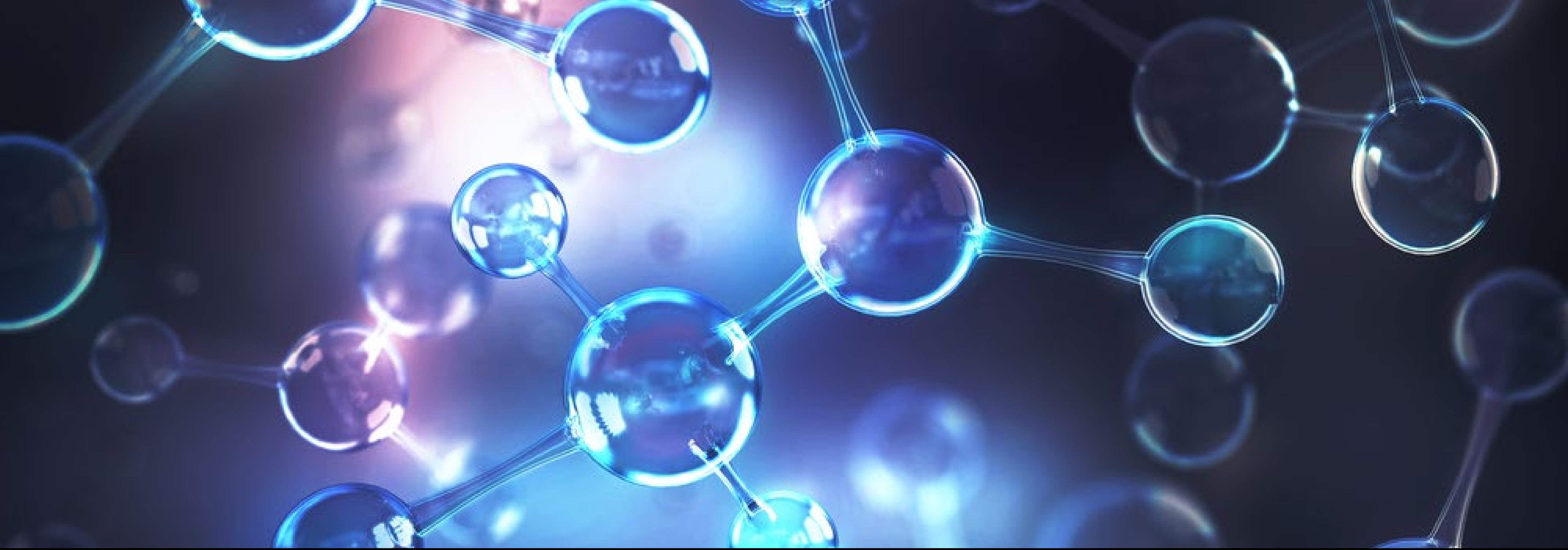


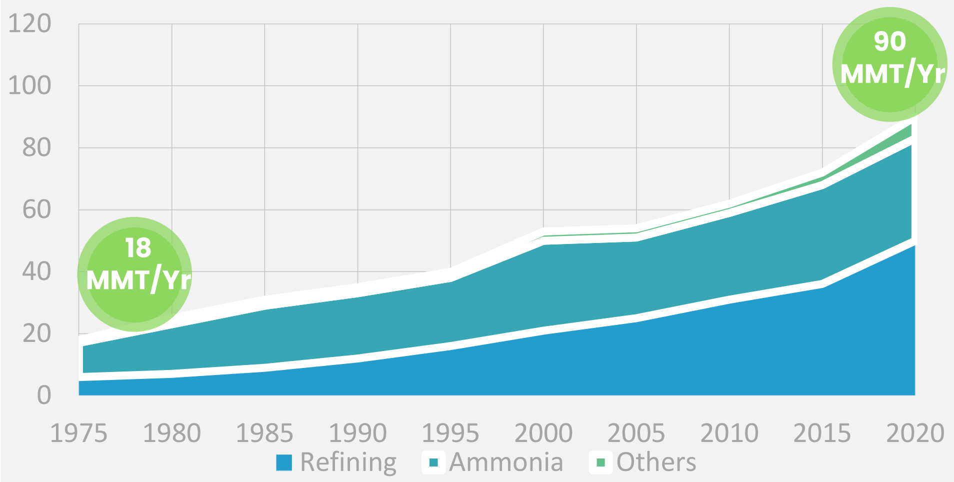
Hydrogen market in India

Asia Clean Energy Forum, 2023

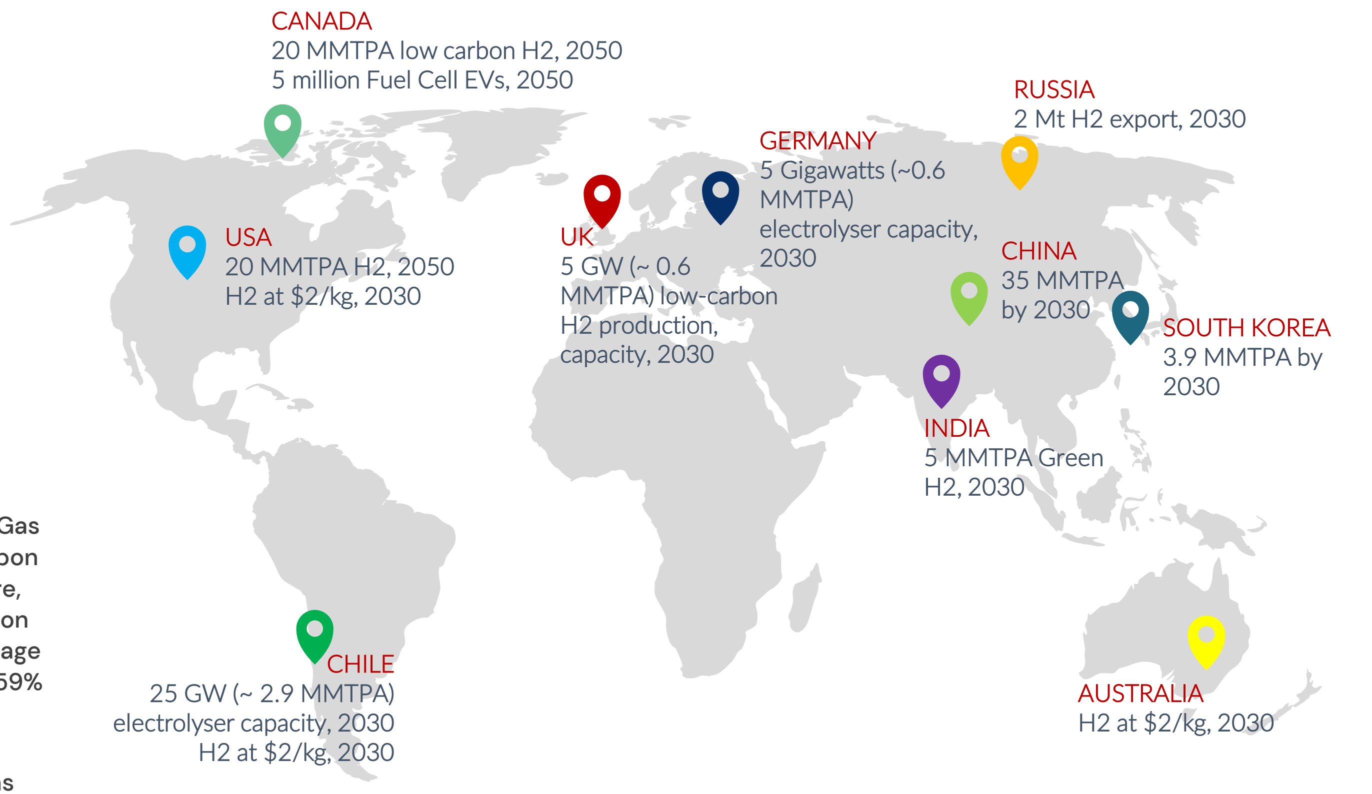
Gurpreet Chugh, Managing Director,
ICF India

15-Jun-2023

Global demand for hydrogen, 1975–2020 (MMT/yr)



The map below shows some key developments related to hydrogen development in different countries.

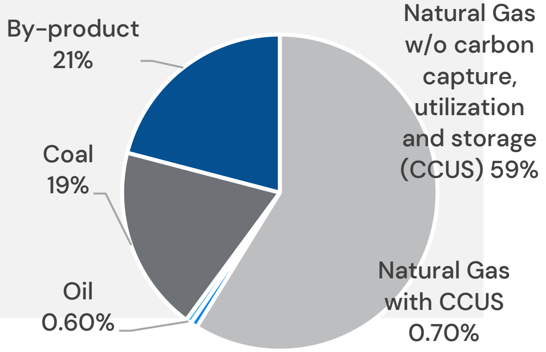


Sources of hydrogen production 2020

Dedicated hydrogen production
72 Million Metric Tons (MMT)/yr Hydrogen (H_2)

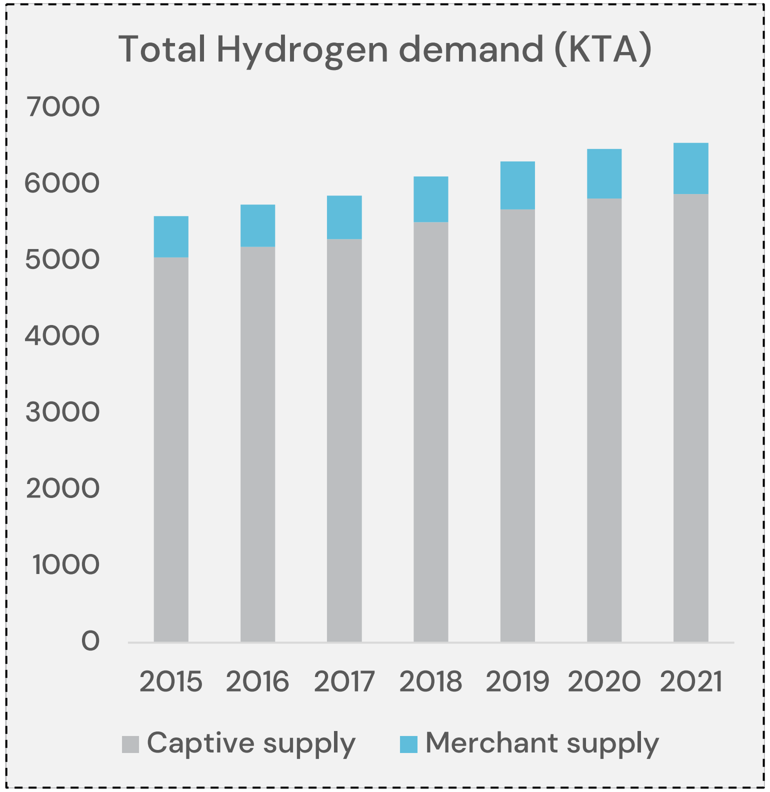
By-product hydrogen
18 MMT/yr H_2

Hydrogen production through water electrolysis
30 kt/yr H_2 (~0.03%).

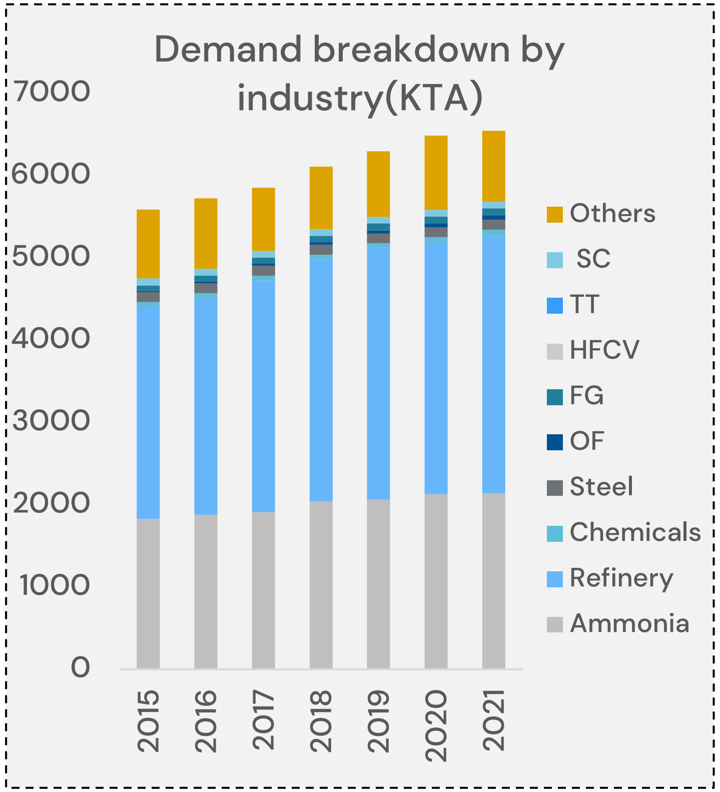


Current global H2 demand is around 90 MMT/year, which grew at 2% since 1975; demand will increase further as countries set targets.

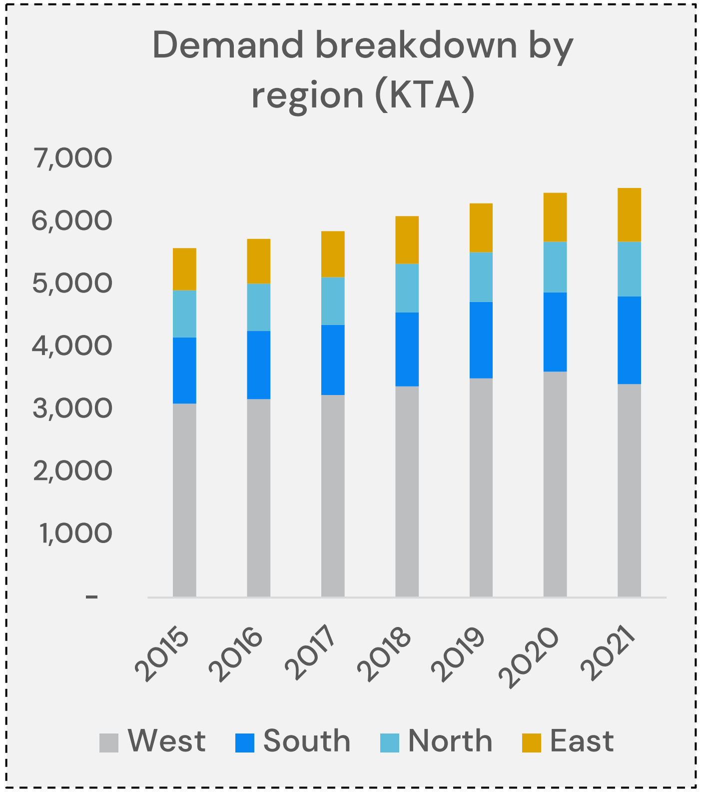
Source:
1. IEA. (2019), The Future of Hydrogen, IEA, Paris https://www.iea.org/reports/the-future-of-hydrogen
2. IEA. (2021), Global Hydrogen Review 2021, IEA, Paris https://www.iea.org/reports/global-hydrogen-review-2021



- 90% of the demand is by captive consumers which includes mainly fertilizers, refineries, and chemicals.
- Growth has been witnessed in merchant sale.
- Merchant sale in OF, FG, SC, and others, which has insignificant footprint



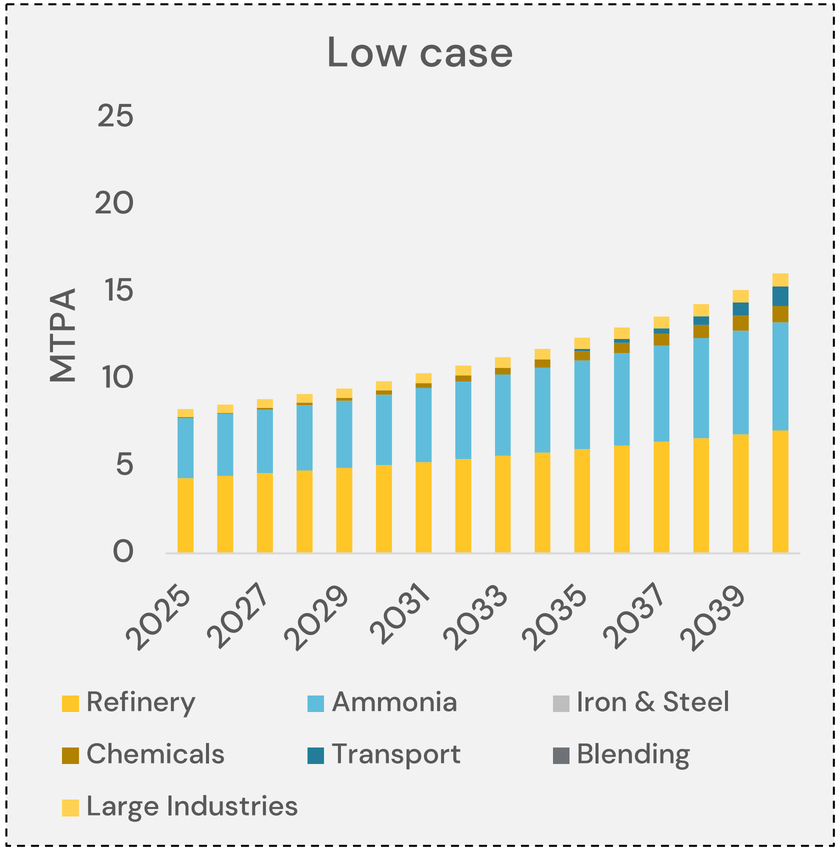
- Fertilizer and refineries remained the key demand drivers.
- Demand in chemical and steel is increasing rapidly.

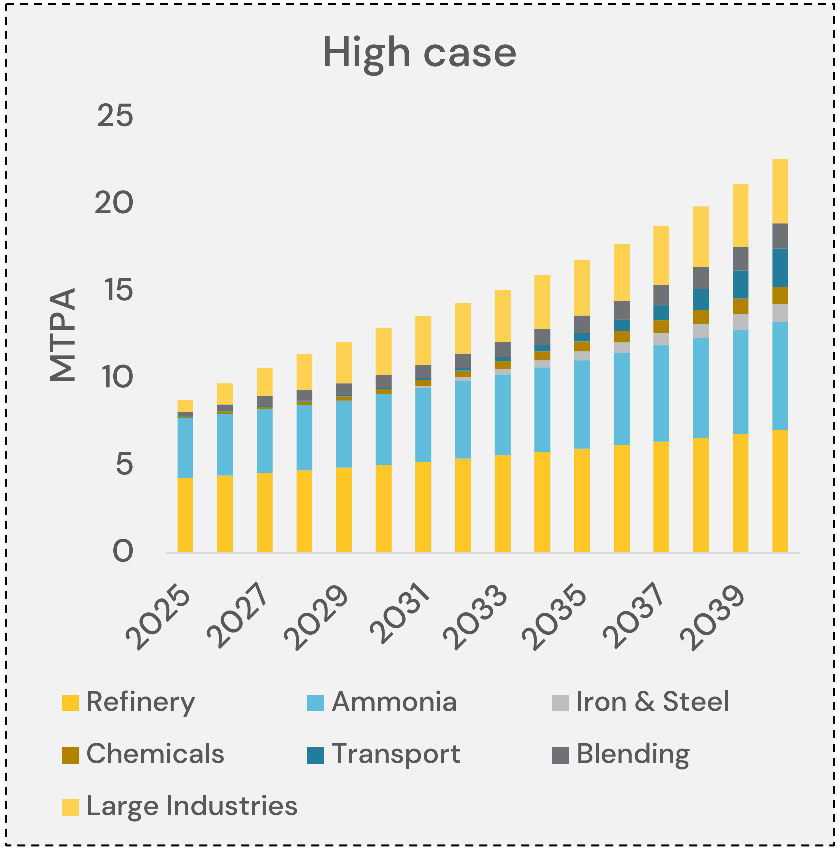


- The West remains the key demand center given the concentration of refineries and fertilizer units.

Current demand of hydrogen in India is ~6 MTPA; driven by captive consumption of refineries and fertilizer units

Source: ICF Research
OF: Optic Fibre; FG: Float Glass; SC: Sintered Glass; TT: Telecom Towers; HFCV: Hydrogen Fuel Cell vehicles





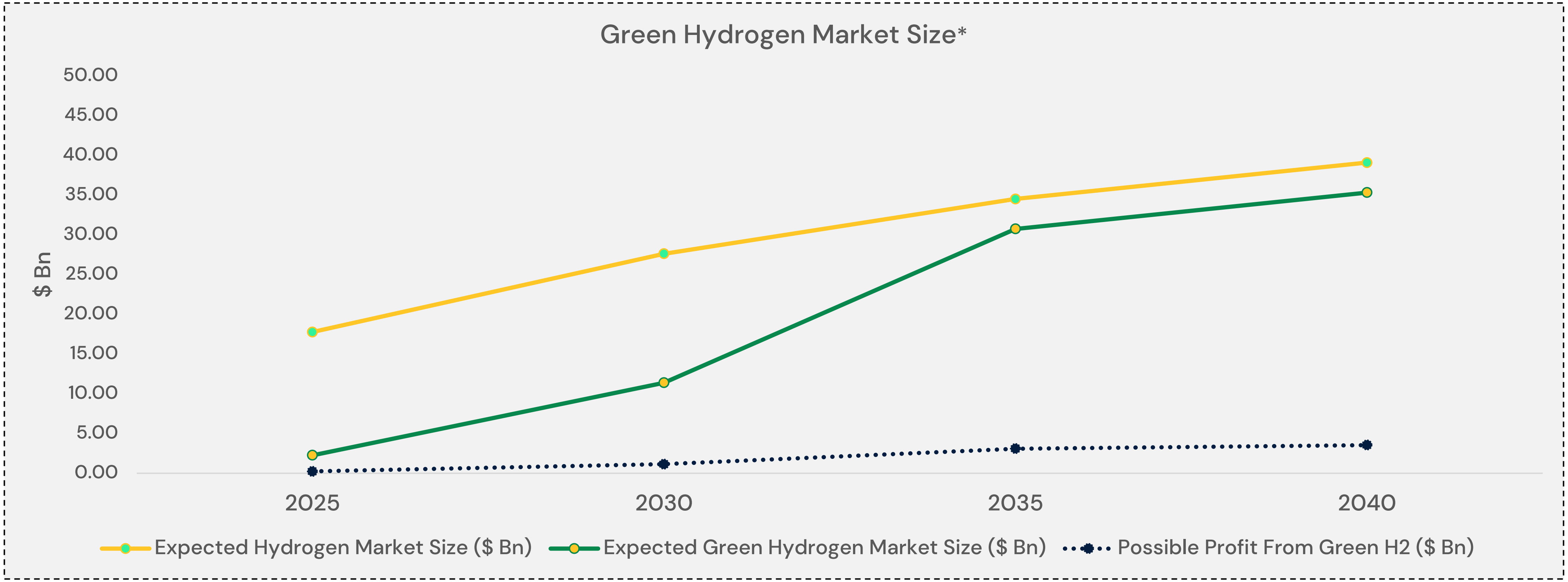
- Increased debcarbonisation initiatives coupled with reducing prices could lead to significant rise in in green H2 consumption by 2040
- We expect demand to be anywhere between *15–25 MTPA* depending on market development and policy initiatives. Demand is likely to be driven by mainly driven by *refinery and fertilises sectors*.

India's hydrogen demand could reach anywhere between 15 (conservative) – 25 (optimistic) MTPA by 2040

Source: ICF Analysis

Low Case : When the additional demand of hydrogen on a year over year (YOY) basis is decided based purely on the market dynamics (considering cost of green hydrogen production and supporting infrastructure)
High Case : When the additional demand of hydrogen on YOY basis is fulfilled based on obligation/government push/ supporting policies

H2 demand In India is expected to increase by 2.5-3.5 times by 2040 but is still not expected to meet more than 5% of total primary energy consumption of India by 2040.

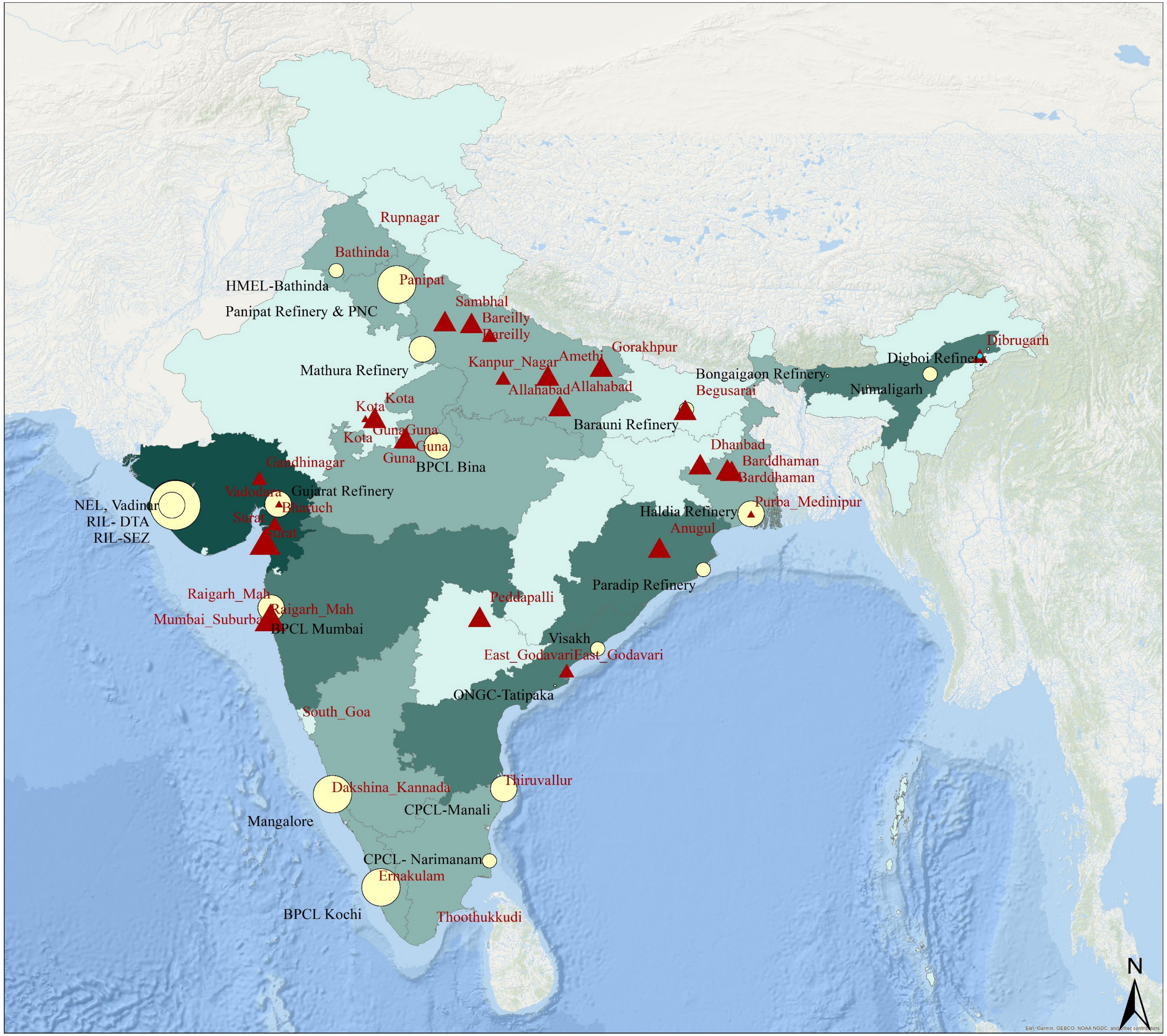


- The green hydrogen market (sales) is likely to reach ~$10 billion by 2030 & ~$35 billion by 2040 in India (per annum figures).
- The green hydrogen developers can generate significant annual profits by 2040 (considering 10% margin on the business).

→ Green hydrogen market is likely to be at $30–35 billion by 2035-2040 in India (under the optimistic demand case).

Source: ICF Research & Analysis; based on Case 3 of demand estimation

- Hydrogen demand is likely to be concentrated in regions with refineries and fertilizer plants
- Green hydrogen supply hubs near the demand centers will provide cost effective solution to meet the demand



Hydrogen Demand 2040

Legend

India States Boundary

Fertilizer Plants

Refineries

Hydrogen demand (MTPA)

- 0.000211 - 0.289
- 0.290 - 0.866
- 0.867 - 2.57
- 2.58 - 5.18

Fertlizer Plants

- 0.001 - 0.064
- 0.065 - 0.145
- 0.146 - 0.218
- 0.219 - 0.368

Refineries

- 0.00723 - 0.238
- 0.239 - 0.636
- 0.637 - 0.991
- 0.992 - 1.61
- 1.62 - 3.82

0 125 250 500 750 1,000 Km

Source: ICF Analysis

The hydrogen demand in each state is excluding refinery and fertilizer hub demand and is shown separately in legend.

Gaseous and liquid H2 are the primary methods of storage across the globe.

- *Hydrogen is mainly being stored in gaseous tanks or cryogenic tanks across the world. Based on geographical availability, some countries (UK and US) have utilized salt caverns*

Higher storage costs for liquid hydrogen make it unviable at small distances.

- *Due to high liquefaction costs and cryogenic storage required for liquid hydrogen, on-site storage cost of liquid hydrogen is approximately 5 times that of gaseous H2, making it unviable at extremely small distances.*

Larger transport capacity of liquid hydrogen makes it cost effective for medium distances.

- *One single liquid H2 trailer can deliver 10–15 times more hydrogen than a single gaseous H2 trailer, so, at medium-range distances, liquid H2 becomes more viable than gaseous H2 due to fewer trucks/trips required.*

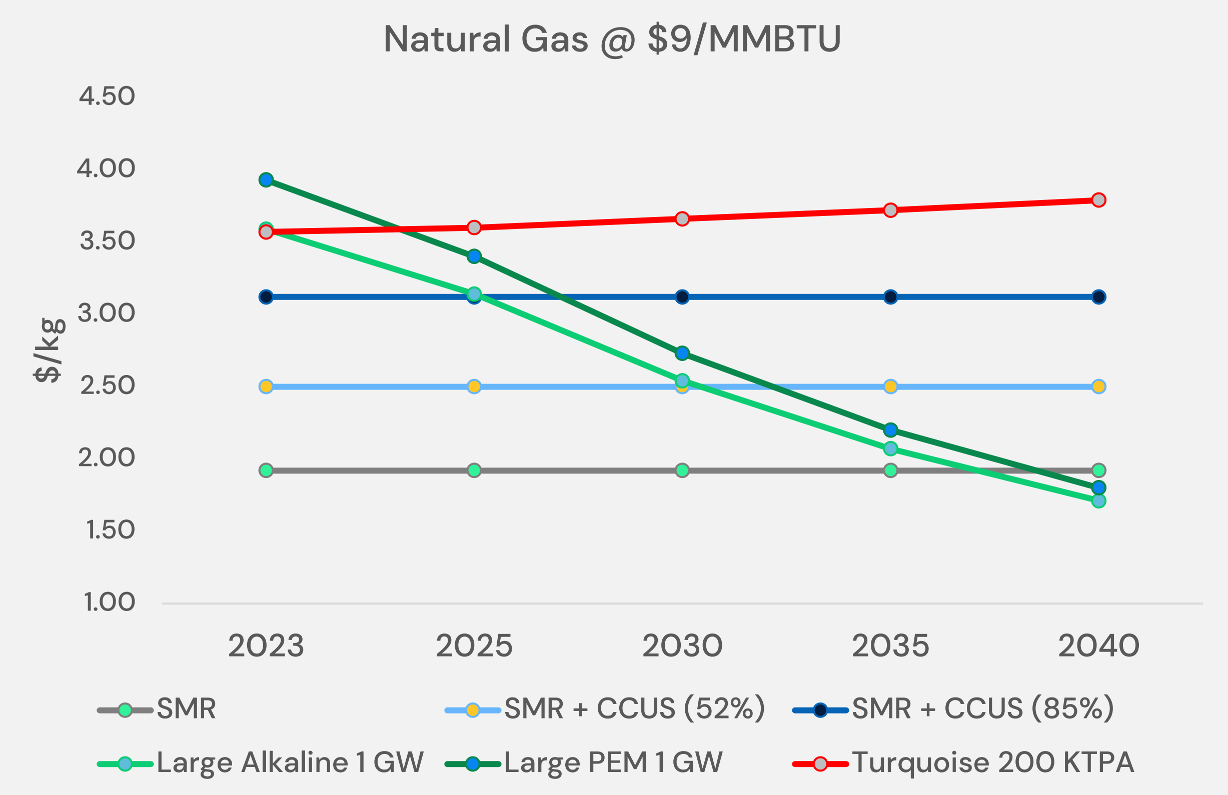
For large capacities, pipeline transport is cheapest.

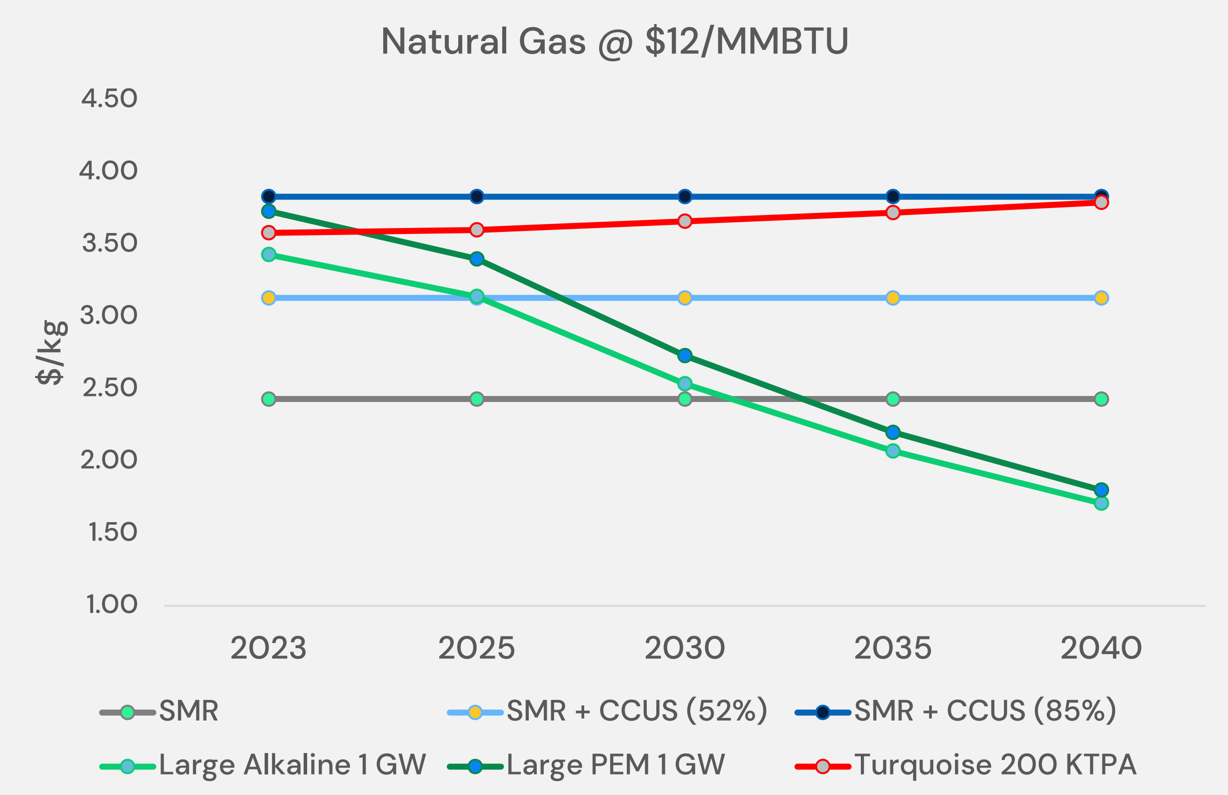
- *With increasing capacities, pipeline costs reduce drastically at smaller capacities. The cost of H2 transportation by pipelines is 8.8% the cost of gas tank trailers and 20% of liquid trailers for a 20-inch pipeline for 120 km.*

Ammonia is used for extremely long-range transport—intercontinental distances.

- *Ammonia with a volumetric hydrogen density about 45% higher than that of liquid hydrogen, so it becomes an excellent choice for transport at intercontinental distances.*

→ Green hydrogen production hubs near demand centres make more commercial sense





- Solarl module costs may not reduce much further, but electrolyser costs are likely to drop rapidly over next few years.

- Higher natural gas costs or carbon prices on fossil fuels can further accelerate the cost parity of green hydrogen with grey hydrogen.

→ Green vs. grey hydrogen economics will depend on fossil fuel prices, carbon prices, cost reduction and efficiency improvements in electrolysers and Government support for green hydrogen.

Source: ICF Research & Analysis
SMR: Steam Methane Reforming: PEM: Polymer Electrolyte Membrane

Measures taken in India to date

National Hydrogen Mission

- Launched in 2021 with specific strategy in the short term (4 years), and broad principles for long term (10 years and beyond)
- National Green Hydrogen Mission updated in January 2023
- Mission Outlay ~ $ 2.41 bn; of which: $ 2.13 bn is for SIGHT, $0.18 bn is for pilot projects, $0.05 bn for R&D and $ 0.05 bn is for other mission components

Key expected outcomes:

01 Development of green hydrogen production capacity of at least 5 MMTPA and renewable energy capacity addition of about 125 GW

02 Close to $ 100 bn expected investment and creation of over 600,000 jobs

03 Cumulative reduction in fossil fuel imports over Rs. $ 12 bn

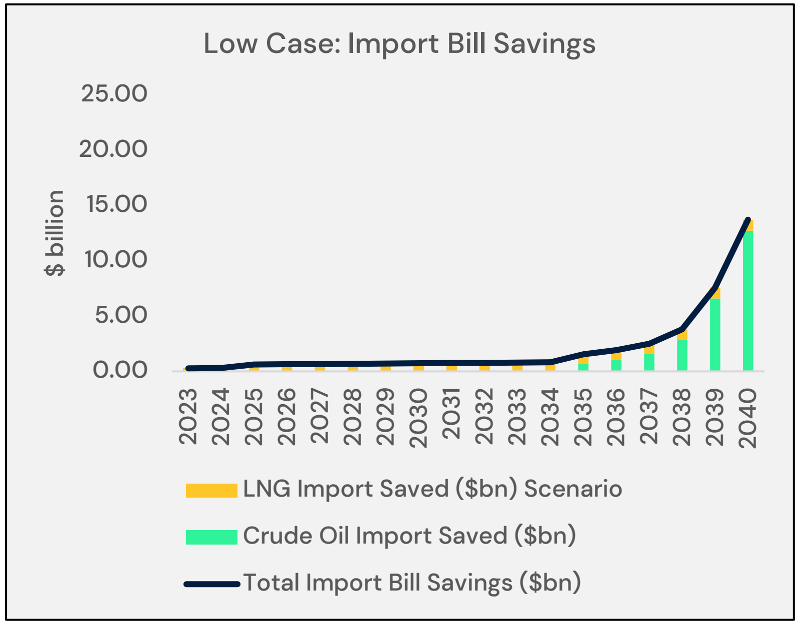
04 Abatement of nearly 50 MMT of annual greenhouse gas emissions

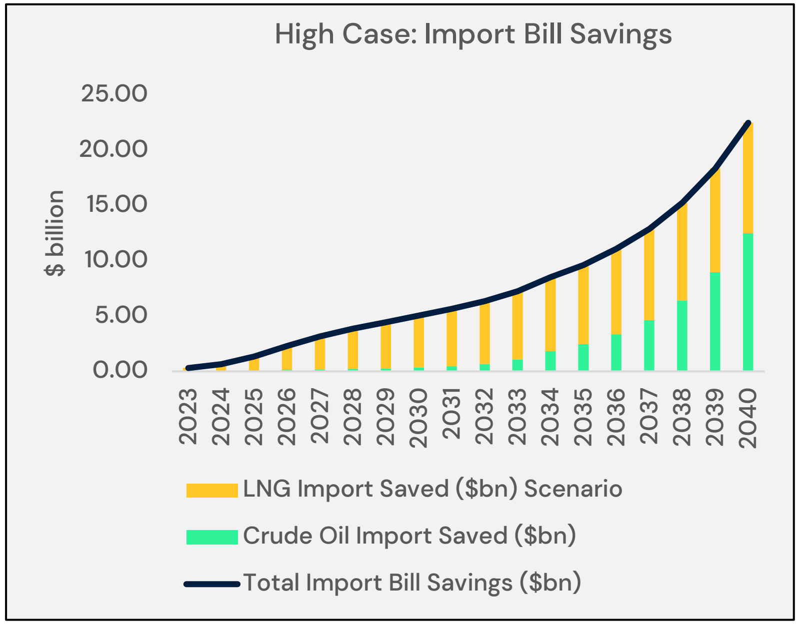
Green Hydrogen Policy 2022

- Green Hydrogen Policy 2022 defines green H2/ammonia to also include H2 and ammonia produced from the banked renewable energy (RE) and that produced from biomass.

1. Waiver of interstate transmission charges for 25 years to the producer of green hydrogen/green ammonia from projects commissioned before June 30, 2025
2. Banking of RE for period of 30 days permitted for making green H2/ green ammonia—banking charges to be fixed by state commission.
3. Land in RE parks and manufacturing zones can be allotted for manufacture of green H2
4. RPO: RE consumed in manufacture of green H2/ammonia; excess consumption beyond RPO of producer will be accounted for as RPO by DISCOM
5. Priority in providing connectivity to green H2/ammonia producing plants and the energy supplying generators

RE: Renewable Energy, RPO: Renewable Power Obligation, DISCOM: Distribution Company, GOI: Government of India





- At present, India spends more than *$160 billion* every year on energy imports.
- India can replace fossil fuels by hydrogen in *transport, iron and steel, CGD, and large industries.*

India can achieve savings of $15–20 billion in fossil fuel imports by replacing them with locally-produced green hydrogen.

Source: ICF Analysis

Conclusions

H2 demand In India is expected to increase by 2.5-3.5 times by 2040; it is still not expected to meet more than 5% of total primary energy consumption of India by 2040.

The H2 market in India is likely to reach ~$30n-35 bn/yr by 2035 - 2040.

RE power requirement for green hydrogen will be significant at 400 GW.

Cost parity between green hydrogen and grey hydrogen will depend on factors such as fossil fuel prices, carbon market prices, cost reduction and efficiency improvements in in electrolysers, and, importantly, government support/ incentives for green hydrogen.

India can achieve savings of $15-20 billion per year in fossil fuel imports by replacing fossil fuels with locally produced hydrogen in end use sectors.

Summing up

Get in touch with us:
Gurpreet Chugh

Managing Director—India
Email: Gurpeet.Chugh@icf.com
Mobile: +91 9910483574

icf.com

linkedin.com/company/icf-international/

twitter.com/icf

https://www.facebook.com/ThisIsICF/

About ICF

ICF (NASDAQ:ICFI) is a global consulting and digital services company with approximately 9,000 full- and part-time employees, but we are not your typical consultants. At ICF, business analysts and policy specialists work together with digital strategists, data scientists and creatives. We combine unmatched industry expertise with cutting-edge engagement capabilities to help organizations solve their most complex challenges. Since 1969, public and private sector clients have worked with ICF to navigate change and shape the future.