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A Government of India Undertaking
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Perspective on Hydrogen in India

Presented by

Shri Debasish Nanda

Director (BD), Coal India Limited

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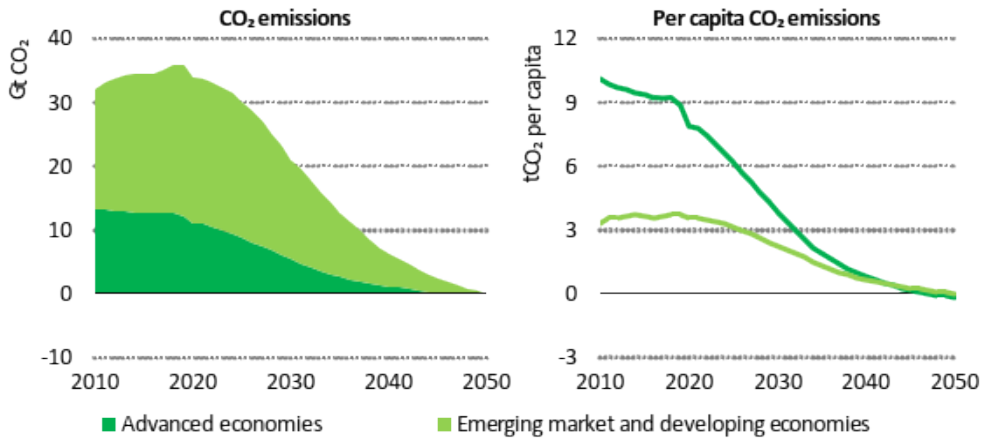
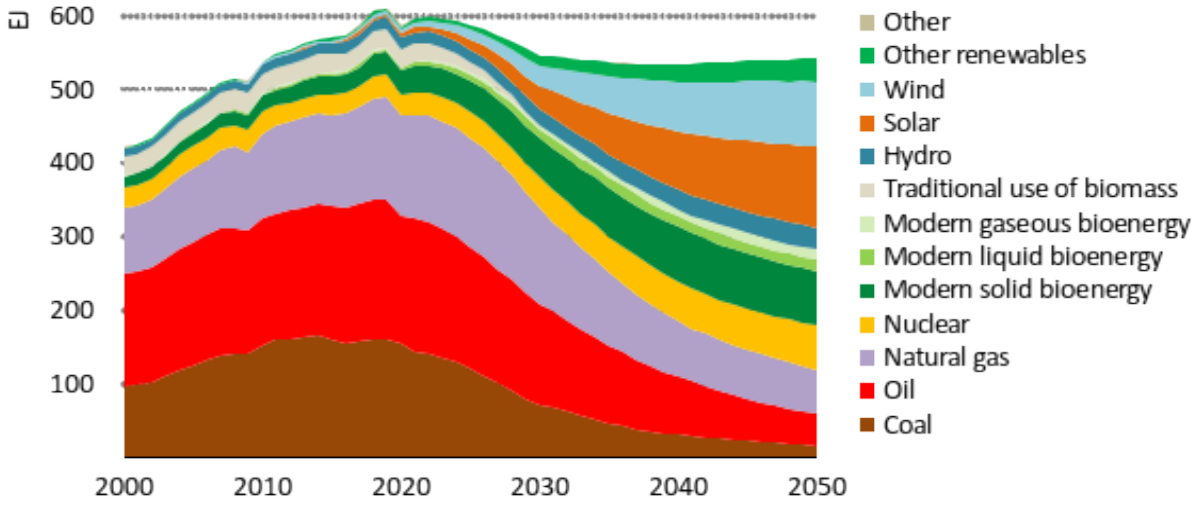
The global energy mix is shifting from fossil fuels to renewables in an effort to reduce CO_2 emissions

Global decarbonization scenario



Total energy supply in EJ



…this has paved the path for cleaner energy like 'Green Hydrogen'

Technology enablement

- **Declining cost of Renewable power** has enabled commercial viability of **green hydrogen** production
- Electrolysers have shown **signs of steep cost decline** similar to Solar PV, Wind turbine and batteries

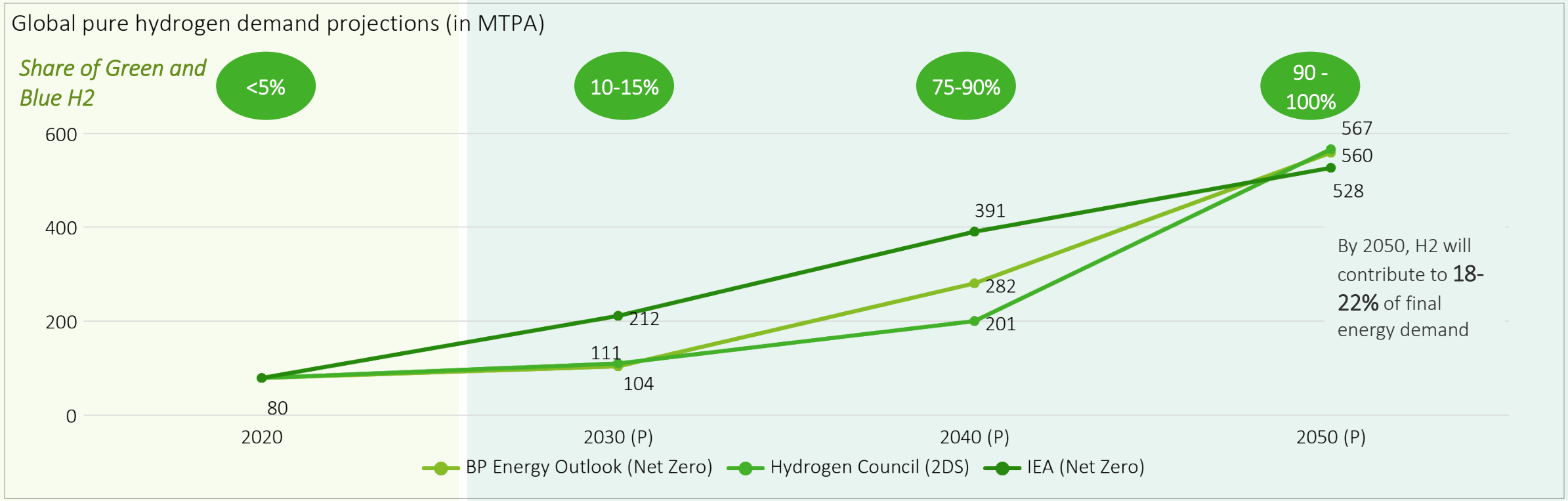
Government focus

- Globally, policy focus has shifted to **decarbonize the hard-to-abate-sectors**
- Governments across the globe have committed **large investments** in hydrogen production and related infrastructure
- Countries are developing **'National Hydrogen Strategies'** with a medium to long term vision

Source: IEA Net-Zero 2050 scenario, BP Statistical Review 2022

Globally, Hydrogen demand is expected to grow exponentially with emerging next age applications

Today → Future projection



- **~80 MTPA** is the current H_2 production
- **~96%** of today's production is Grey H_2
- **~90%** of H_2 is consumed by **Refineries and Ammonia sectors**

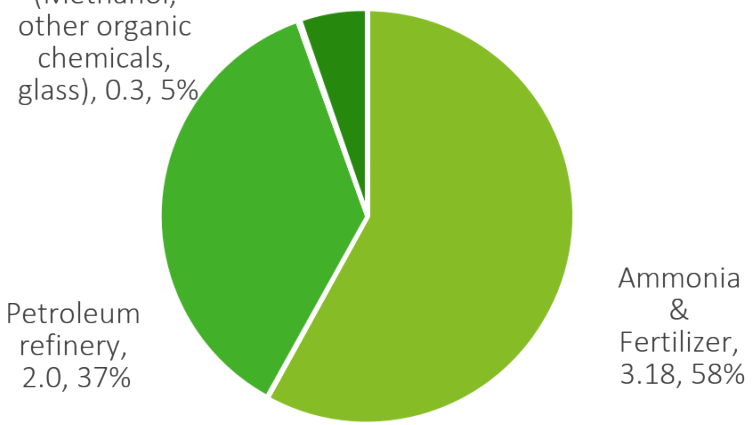
- **~6x** increase in H_2 production expected by 2050; next age applications will be in **sectors such as transport, buildings, steel production, cement, Power etc.**
- Entire grey hydrogen will transit to Green **or** Blue **hydrogen,** driven by the increasing emphasis on **energy transition and decarbonization**

Source: BP Energy Outlook, Hydrogen Council, IEA Net Zero

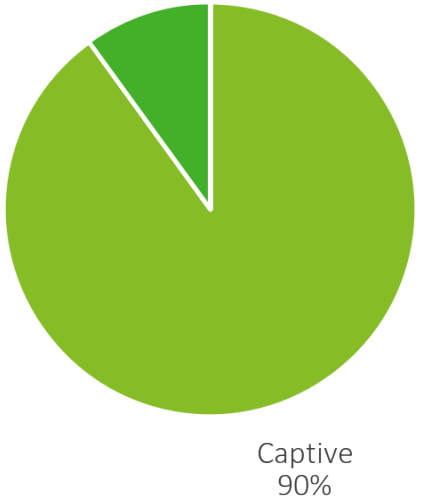
Current scenario of Indian Hydrogen Market; current consumption is ~5.5 MTPA

India's current demand is mainly from refinery and ammonia/fertilizer industry

Consumer Mix
(Hydrogen consumption, MTPA)



User mix



Current applications of hydrogen lean towards industry and chemicals

- As a chemical in ammonia (NH_3) production (for fertilizers)
- As a chemical feedstock for industrial processes e.g. methanol, food industry etc.
- In petrochemical and refining processing

Key Insights:

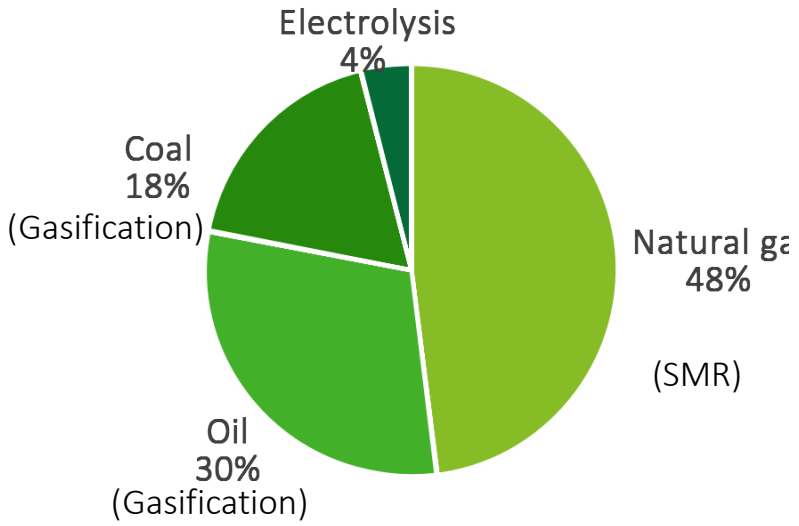
- Currently, hydrogen is produced from fossil fuel only (SMR, Gasification) and the entire hydrogen used is Grey Hydrogen (except in power sector)
- Production is mostly captive (onsite) with cost of production hovering around **~$1.6 – 1.8/kgH2**
- Demand is mainly driven by Chemical and Petroleum industries

Source: Secondary research, Deloitte estimate

Current status - production of 'Green Hydrogen' is still in a nascent stage

Colors refer to different types of hydrogen according to how it was produced, in the following way		
Green	• Produced from water by electrolysis, using renewable electricity (e.g., solar, wind) • Nuclear electricity can also be used in this manner to produce hydrogen, and this is referred to as 'yellow hydrogen'.	**Mostly pilot projects.** Commercial maturity expected to take time
Blue	• Produced by steam methane reforming with carbon capture, utilization and storage (CCUS), using natural gas or biomass (thus with very low or no CO_2 emissions)	Numerous demonstration size plants exist and are in development. The technology is proven but needs to be scaled to industrial size.
Grey	• Produced by steam methane reforming without CCUS, using natural gas. Gray hydrogen produces a lot of CO_2.	**Most of the current production**

Current Production Scenario

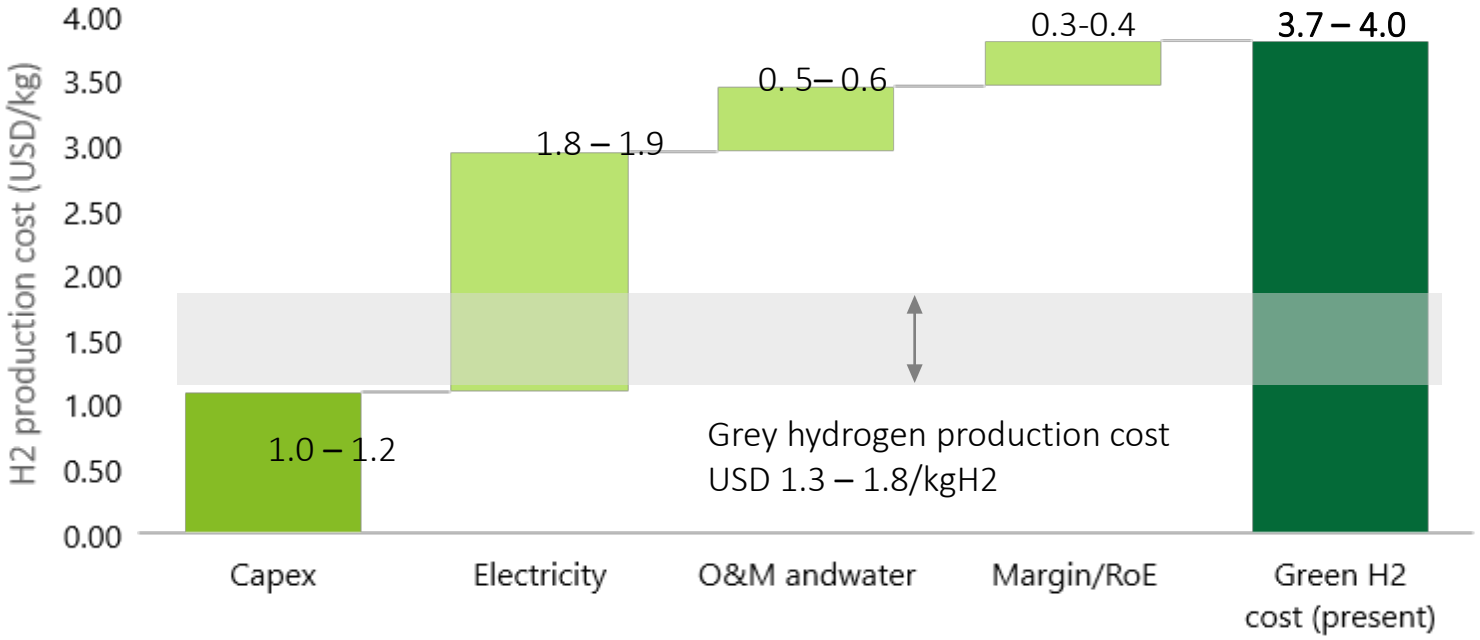


Over 95 % of current hydrogen production is fossil-fuel based. Steam-methane reforming (SMR) is the most common way of producing hydrogen

Source: Secondary Research

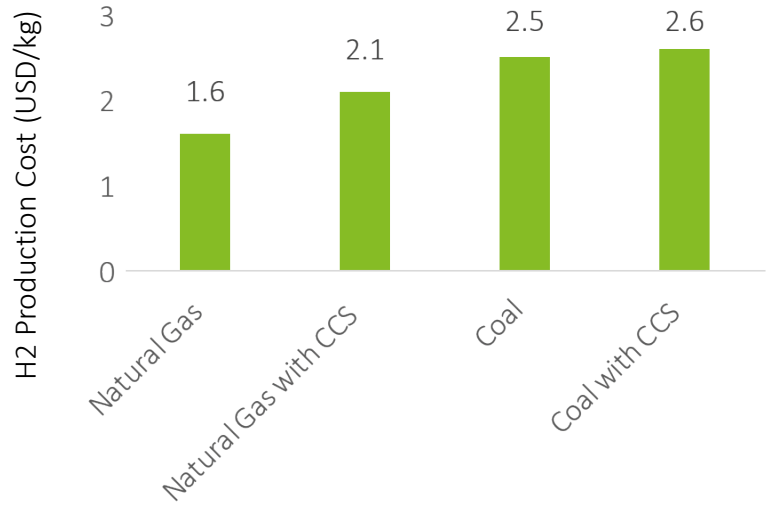
Current cost of production of green hydrogen is not commercially viable; future cost reduction will depend on scaling up of electrolyzer technology, utilization and availability of cheap renewables

Current Costs in Indian Scenario



Assumptions: This is only cost of production, without storage & transportation cost, taxes & duties, Useful life 20 years, Utilization 40%, Capex- ~USD 700 to 900 kW, Levelized cost of electricity (LCOE) (based on RE-RTC) - ~$c 3.5/kWh, Cost components are levelized

Comparative Global Costs of H2 Production



Even though global costs of H2 production coal is ~USD 2.5-2.6/kg, other estimates indicate a cost of ~USD 1.1-1.5/kg based on Chinese coal

Key Insights:

- Current production cost is much higher than substitutes – grey hydrogen and Natural Gas (NG)
- Major cost levers are – cost of electrolyzer, cost of renewable energy and utilization (hours of operation)

Source: Secondary Research, IEA, TERI Analysis for Study in China based on BIES, BNEF, IEA

Transportation of hydrogen is a key challenge other than economic considerations of H_2 production

Mode of transportation	Truck	Pipeline	Ship
Usage modalities	Low volume, short distance travel	**Transmission** - Large volume, long distance travel **Distribution** –for local distribution (low volume, short distance)	Large volume, long distance, intercontinental travel
Key challenges	• Gaseous trucking requires very high compression (200-500 bar) due to low volumetric density • **Liquefaction is costly** – energy intensive and high evaporation loss	**Use of existing infrastructure** • Hydrogen corrosion may lead to embrittlement of steel pipes – maximum 5% mixing could be allowed • GI / Cu pipes are not suitable for H2 transportation • Low energy content **New infrastructure** • Large investment required for SS piping or High Density Polyethelene (HDPE) in transmission line	Likely to remain a **high-cost option** due to costs of liquefaction, refrigeration, and regasification
Cost ($/kg)	Gaseous trucking: **0.5 – 1** Liquid trucking: **1 – 1.5**	**0.3 – 1** (cost may vary depending on infrastructure requirement)	**1.5 – 2.0 (Liquid)**

Globally, onsite production is most preferred to avoid high cost of transmission and distribution and associated technical challenges

Source: Secondary Research

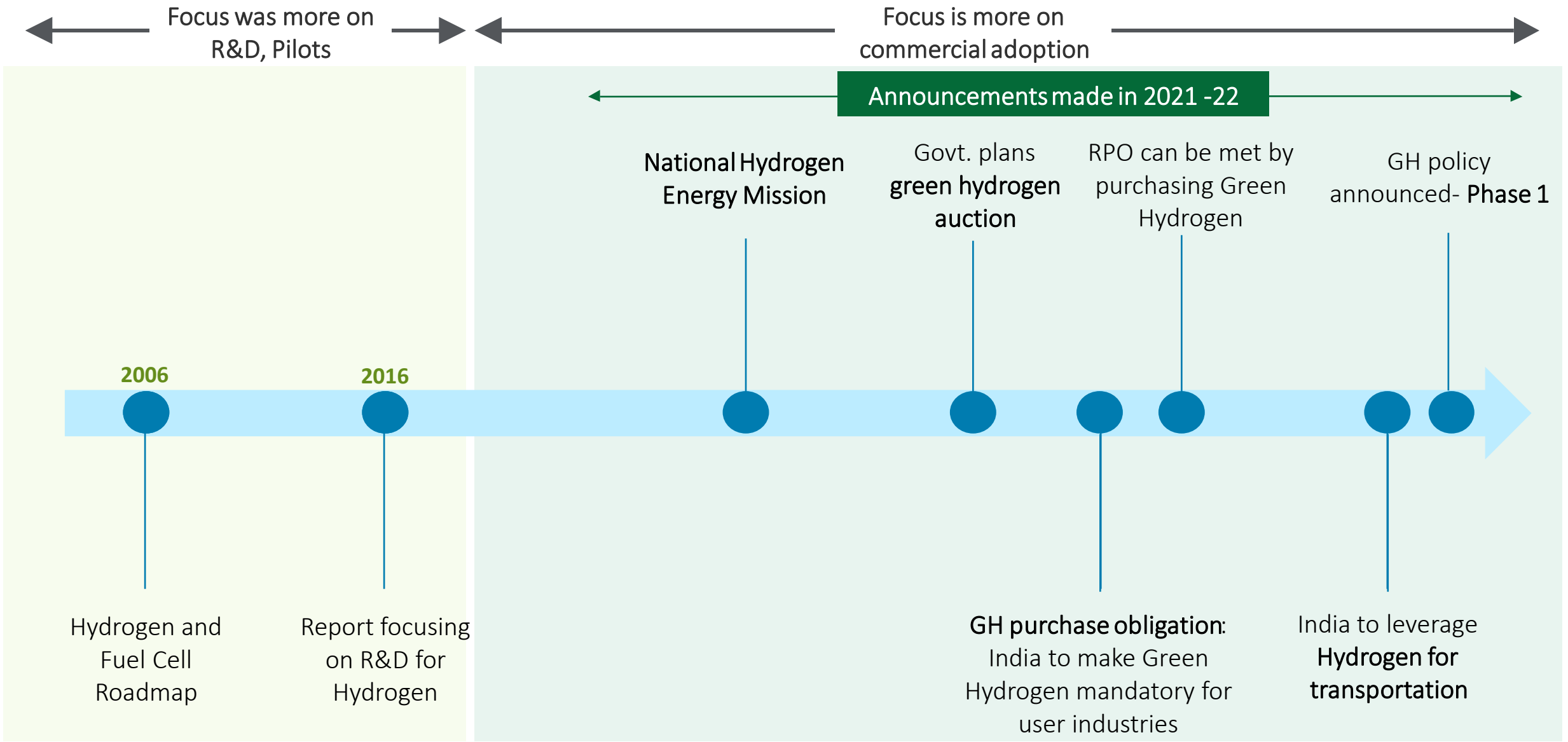
Policy support for Hydrogen is gaining momentum across the world

	Country	Electrolyzer Capacity target	Other targets	Funding
	Germany	10 GW by 2030	Possible 20% quota of RE in aviation by 2030; H2 to make up 10% refinery demand and 5% fertilizer demand	• Eur 7 bn for H2 market rollout • Eur 2 bn for international partnership
	France	6.5 GW by 2030	Target for FCEV; 20-40% industrial demand to be met by low carbon H2 by 2028	• Eur 7.2 bn by 2030
	Netherlands	0.5 GW/3 GW by 2025/30	Aggressive FCEV and refueling station target. 14% Synthetic Aviation Fuel (SAF) blending by 2030	• Eur 9 bn by 2030
	Portugal	0.5 GW/2 GW by 2025/30	10 – 15% grid injection; widespread use of green H2 in transport and shipping; 75 -100% ammonia production met by green H2 by 2030	• Eur 7 – 9 bn by 2030
	China	10 - 20 GW by 2035; 100 GW by 2030	100k and 1000k FCEV by 2025 and 2035 respectively	• NA
	USA	100 GW by 2050	Cost reduction of GH2 by 80% to USD1/kg by 2030	• USD 9.5 bn

Over 30 countries have released hydrogen roadmaps, industries have announced more than 200 hydrogen projects and ambitious investment plans

Source: Secondary Research

Recognizing the need of deep decarbonization, the GoI has announced several potential measures to boost a green hydrogen economy



Source: Secondary Research

National Green Hydrogen Mission & other key Initiatives taken by the Government of India

Key Objectives of National Hydrogen Mission

- To become **Aatmanirbhar(self-reliant)** through clean energy and serve as an inspiration for the global Clean Energy Transition.
- To make India the **Global Hub for production**, usage and export of **Green Hydrogen and its derivatives**.
- To contribute towards **decarbonisation of the economy**, reduced dependence on fossil fuel imports, and enable India to lead in Green Hydrogen technology and market.

Expected Outcomes of National Hydrogen Mission

#	Particulars	Expected Outcome by 2030
1	India's Green Hydrogen Production Capacity	**At least 5 MMTA**
2	Renewable Energy Capacity Addition	**125 GW**
3	Creation of Full Time Jobs	**6 Lakhs**
3	Total Investments	**Over ₹8 lakh crore**
4	Expected aversion of CO_2 Emissions	**Up to 50 MMT per annum**

Other Initiatives

- Single window clearance for setting up green hydrogen production
- ISTS waiver until 30th June 2025
- Distribution licensees shall only charge procurement charges, wheeling charges, and a small margin on electricity supplied to GH/GA plants.
- Connectivity and land allotment on priority basis
- Manufacturing zones to be set up by the Government of India where GH/ GA plants can be set up

Source: Secondary Research

Key factors to pave way for adoption of hydrogen economy with a long-term perspective

Business plan creation with Investment Outlay

- Creation of a 15-year plan for Coal / Power to hydrogen (up to 2035) with considerations for rapid growth post 2030 with projected capital outlay
- Demand assessment – medium term and long term, business model selection and technology roadmap

Initiation of 'Pilot' and technology partnership

- Initiation of a 'Pilot' before launching full-scale adoption of green hydrogen production through electrolysis
- Collaboration with a technology player for selection of electrolysis technology and detailed cost benefit analysis, jointly with technology partner

Adoption of Blue Hydrogen for Hard to Abate Sectors

- Blue hydrogen can produce low-carbon hydrogen at scale to help decarbonize hard-to-abate sectors such as transportation
- Currently, it is also significantly cheaper than green hydrogen. But it does depend on natural gas, which has been subject to high price volatility and geopolitical turbulence

Policy advocacy for scaling up

- Initiate policy advocacy in select areas to promote hydrogen use as well as de-risk investment for setting up electrolyzer and associated infrastructure
- Explore opportunities to be the nodal body for aggregation of green hydrogen generation and supply to industries as feedstock

Thank you

Shri. Debasish Nanda is presently serving as the Director – Business Development of Coal India Ltd. He was working as Executive Director (Gas) in Indian Oil before taking over as Director-BD at CIL.
A graduate in mechanical engineering from UCE Burla, Sambalpur University, Shri. Nanda is a Post Graduate in production engineering from REC Rourkela and has to his credit a Masters in International Business from IIFT, New Delhi.
Shri. Nanda joined Indian Oil in 1988 as a Management Trainee in the Marketing Division and spent 11 years in marketing of Servo lubricants. Thereafter, he moved to Business Development Group in 1999. He did a stint in Business Development activities comprising of expansion of lube business overseas, exports of POL, setting-up of Indian Oil's subsidiaries etc. before moving to Indian Oil's Gas Business in 2009.
Shri. Nanda headed the 'Natural Gas' business of Indian Oil which had a turnover of over Rs. 20,000 crores. He developed many robust strategies for increasing the penetration of Indian Oil in the natural gas business.
He has also handled various diverse positions for liaising with MoP&NG, PNGRB and other Industry bodies. He has chaired the US-India Energy Task Force, headed the work on pipeline RLNG exports to Bangladesh & Sri Lanka and was accorded status of aggregator of HP-HT domestic gas for urea plants.