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EDITORIAL

India is making huge strides under the National Green Hydrogen Mission. A detailed snapshot of the different Mission components by PHD Chamber of Commerce & Industry, along with a brief on the encouraging Green Hydrogen policy that offers many incentives for setting up such facilities near end-users and promoting renewable energy transmission, has been covered this time.

The Petroleum and Natural Gas Regulatory Board (PNGRB) is expected to play a key role in regulating the transportation of hydrogen through pipelines. It may oversee the retrofitting of existing pipelines or the creation of new pipelines for hydrogen transportation, ensuring that safety and operational guidelines are adapted for hydrogen's unique properties. A detailed article on their initiatives and plans for the Green Hydrogen sector, throws light on the challenges ahead.

The Department of Science and Technology (DST), Ministry of Science and Technology, Government of India, initiated the development of a hydrogen and fuel cell (HFC) technology program in 2018, focusing on creating volumes and infrastructure, demonstrating niche applications, facilitating policy support, and establishing symbiotic international linkages. We are covering updates on these initiatives every quarter.

We have also provided a synopsis of the World Hydrogen 2024 Summit C Exhibition in Rotterdam (NL), where the World Bank, Invest International, and the Government of the Netherlands co-organized the Finance Forum to address the challenges and find solutions in the development and financing of Green Hydrogen projects in emerging markets and developing countries (EMDCs).

The Xynteo Energy Leap's Clean Hydrogen Innovators continue to "shape the future". Three innovators have been introduced this time, along with a special feature on a promising innovator that's redefining hydrogen storage.

A thought-provoking Viewpoint Article on Green Hydrogen's journey to transform industrial heating hinges on breakthrough advances in efficiency and scale. The opportunities, challenges, and alternatives have been discussed.

Although there have been announcements on green hydrogen projects in the last few years, it remains unclear how India's green hydrogen industry is shaping up. Electrolysis is not a mature technology for hydrogen production, and there are many uncertainties around the availability of electricity, energy storage, transportation, and logistics. Most studies on the cost of green hydrogen do not consider the cost of transporting and storing hydrogen. Anecdotal evidence suggests that while green hydrogen has been the government's focus, the increase in hydrogen production from 2020 to 2023 was entirely from fossil fuels. This indicates a mismatch between ambition and action or delayed action, which is unfavorable for the green hydrogen industry. There is also

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DST's Hydrogen & Fuel Cell Program in India: An Update

HFC-18

The Department of Science and Technology (DST), Ministry of Science and Technology, Government of India, initiated the development of a hydrogen and fuel cell (HFC) technology program in 2018, focusing on creating volumes and infrastructure, demonstrating niche applications, facilitating policy support, and establishing symbiotic international linkages. This has advanced HFC technologies through R&D and validation, aiming to make these technologies competitive in terms of cost and performance, while also reducing institutional and market barriers to commercialization – directly supporting Ministry of New and Renewable Energy's (MNRE) National Green Hydrogen Mission.

A total of 30 proposals under the Research and Technology Stream were approved for funding, with an approximate cost of Rs. 31 crore. These proposals focused on the development of new electrode materials, exchange membranes, and catalysts for hydrogen storage and fuel cell applications (*refer Vol 1 Issue 4 in Oct 2024 of this newsletter for details*).

AHFC

Under HFC-18, DST also supported 11 projects (*refer table below*) under the Advanced Hydrogen and Fuel Cell Program (AHFC). The objective of this program is to promote and support activities related to the indigenous development of new and existing materials in large quantities, including catalysts, membranes, components for fuel cells,

S. No.	Project Title	Investigator	Institute	Sanctioned Cost (INR)
1	Design & Demonstration of Prototype Green Hydrogen Production Process in Biorefinery Platform with Net Zero Emissions	Dr. S. Venkata Mohan	CSIR Indian Institute of Chemical Technology	49,965,760
2	Indigenization of the HT-PEMFC[1] Technology at Raw Materials and Sub-Component Level by Establishing Pre-Production Scale Manufacturing Facilities	Dr. Sreekumar Kurungot and Dr. Vishal Mahesh Dhavale	National Chemical Laboratory	60,767,280
3	Development of Alkaline Water Electrolyser Stack Prototype for Green H_2 Production from Dynamic Renewable Energy Devices using Self-repairable Electrocatalyst and Stable Membrane	Dr. Nainesh Patel	Christ University, Bengaluru (Deemed to be University)	7,062,360
4	Development of Electrodes and Modular Compact Membrane-less Electrolyser set up for Sustainable H_2 Production from Sea/Tap/Ground Water	Prof. Akhoury Sudhir Kumar Sinha	Rajiv Gandhi Institute of Petroleum Technology	25,328,000
5	Indigenous Development of Electrolyte-Supported Reversible Solid Oxide Fuel Cell (RSOFC) Stack and its Demonstration in Power Generation and Hydrogen	Dr. S.T. Aruna and Dr. Abhijit Das Sharma	CSIR National Aerospace Laboratories	22,337,640
6	Smart Hydrogen Supply Chain-supported Polymer Electrolyte Membrane Fuel Cell in Telecom Tower Power Backup	Dr. Ramya Krishnan	International Advanced Research Center for Powder Metallurgy and New Materials	55,494,000
7	Development and Determination of Operability Margins of a 3D Printed Hydrogen Burner System	Dr. Saravanan Balusamy	Indian Institute of Technology Hyderabad	7,329,268
8	Development of High-efficiency Opposed-piston (OP) Engine for Hydrogen and H-CNG[2] fuels	Prof. R.V. Ravikrishna	Indian Institute of Science Bangalore	30,800,848
9	Long-term Decarbonization Strategies for Indian Steel Sector with Hydrogen as One Option	Dr. Anjana Das	Integrated Research and Action for Development	6,000,000
10	Advanced Process Simulation Modelling for Hydrogen Application in Hard-to-abate Industries – A Technical and Economic Assessment	Murali Ramakrishnan Ananthakumar	Center for Study of Science, Technology, and Policy (CSTEP)	7,175,033
11	Design of Power Converter for 3-Phase Grid Integration of Hydrogen Fed PME Fuel Cell Using High Frequency Link Multistage Converter	Dr. Rupesh Wandhare	Indian Institute of Technology Hyderabad	4,652,670

[1] High temperature proton exchange membrane (HT-PEM) fuel cell (HT-PEMFC)
[2] Hydrogen-Compressed Natural Gas (H-CNG)

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PNGRB's Role in Hydrogen Ecosystem: A Comprehensive Outlook

The Petroleum and Natural Gas Regulatory Board (PNGRB), established under the PNGRB Act of 2006, enacted by Parliament in the 57th Year of the Republic of India, regulates the refining, processing, storage, transportation, distribution, marketing, and sale of petroleum products and natural gas, excluding the production of crude oil and natural gas. Its mandate is to safeguard consumer interests, ensure the availability of uninterrupted supplies, foster competitive markets, and address related regulatory matters.

Since its inception, PNGRB has authorized over 35,000 kilometres (km) of natural gas pipelines, with 25,000 km operational, and the remainder set for commissioning in the next 2-3 years. In addition, PNGRB has approved City Gas Distribution (CGD) networks in 307 geographical areas (GAs), in which natural gas steel pipeline network is projected to expand from 20,000 to 50,000 km by 2032. This infrastructure positions PNGRB as a cornerstone in India's clean energy transition, particularly in integrating hydrogen into the energy framework.

PNGRB is expected to play a key role in regulating the transportation of hydrogen through pipelines. It may oversee the retrofitting of existing pipelines or the creation of new pipelines for hydrogen transportation, ensuring that safety and operational guidelines are adapted for hydrogen's unique properties.

Hydrogen: The Fuel of the Future

As Francesco La Camera, Director of the International Renewable Energy Agency (**IRENA**), has noted, "Rapid green hydrogen scale-up lies on a systemic innovation approach beyond technology, which means we need innovative regulatory and policy frameworks, finance, and business models." This moment is critical for hydrogen, especially given its complex history. Despite early setbacks and hydrogen-related disasters, the gas has remained integral in industries like petroleum refining. In the 1970s, hydrogen gained attention for fuel cell vehicles (FCVs), yet it never truly disappeared. By the 2010s, hydrogen was rediscovered as a potential driver for decarbonization. Today, hydrogen is once again at the centre of a global conversation, with some advocating for its role in decarbonizing the gas industry, while others view it as a potential smokescreen for the fossil fuel sector to extend its life. This duality underscores hydrogen's significance in the future of energy.

Countries such as **Japan**, the **European Union (EU)**, the **US**, and **Australia** are leading the charge in hydrogen adoption. Japan's **Basic Hydrogen Strategy** aims to integrate hydrogen across transportation, energy storage, and industrial sectors. The EU's Hydrogen Strategy for a Climate-Neutral Europe envisions scaling up green hydrogen production and establishing a trans-European hydrogen network by 2050. Similarly, the US has launched initiatives like the **Hydrogen Shot** to decarbonize industries and transportation by reducing the cost of clean hydrogen by 80% to $1 per kilogram in one decade, while Australia positions itself as a hydrogen export leader to meet the growing demand in Asia.

In India's scenario, transition toward a hydrogen economy is crucial for addressing climate change and fulfilling its Paris Agreement commitments. As India experiences rapid economic growth, energy demand is rising, making the reduction of reliance on imported fossil fuels a key priority for energy security. Green hydrogen, produced using renewable energy, presents a sustainable solution to meet India's energy needs and decarbonization goals.

Hydrogen demand is growing in critical sectors such as fertilizers, refineries, and ammonia production, all undergoing a shift from fossil fuels to renewable energy. India's **National Green Hydrogen Mission** plays a pivotal role in facilitating this transition. However, efficiently transporting green hydrogen from supply-rich regions (with abundant renewable energy) to industrial demand centres is essential. This can be achieved by using existing natural gas pipelines or dedicated hydrogen pipelines, though challenges related to infrastructure optimization, safety standards, and regulatory frameworks must be addressed.

A practical pathway which seems to accelerate hydrogen

Pilot project on Green Hydrogen Blending by Gujarat Gas in NTPC Kawas Township, Surat, Gujarat

Hydrogen generation unit at NTPC Kawas Township, Surat, Gujarat

adoption is blending hydrogen with natural gas in existing infrastructure, which can be retrofitted at a lower cost. Low-level blending (**5-20% v/v**) of hydrogen with natural gas can significantly reduce carbon emissions, providing an incremental solution that allows industries and consumers to gradually transition to cleaner energy. This approach paves the way for the global shift toward sustainability and will facilitate the transition towards pure hydrogen (100% hydrogen with no natural gas blended) transmission.

As India looks to integrate hydrogen into its energy landscape, blending hydrogen with natural gas becomes a vital component of its decarbonization strategy. In the initial stages, hydrogen can be transported through rail or road using compressed or liquefied trailers. Over time, a network must be developed and retrofit existing infrastructure where feasible. Material compatibility and safety standards will remain top priorities in these efforts. International studies suggest that blending hydrogen up to **10-20%** by volume is feasible, but India must assess local conditions to determine the optimal ratio, ensuring the integrity of pipeline materials, given that India's existing natural gas infrastructure comprises various grades of steel such as X52, X60, X70, and X80, all requiring extensive testing to ensure compatibility with hydrogen.

PNGRB's Initiatives for Hydrogen Integration

PNGRB is spearheading efforts to facilitate hydrogen transmission through pipelines in India, focusing on developing infrastructure, ensuring regulatory compliance, and authorizing pilot projects to assess the feasibility and safety of hydrogen integration with natural gas.

A. Comprehensive Studies

1. **Hydrogen Pathways Study**: In collaboration with the World Bank and ICF India, PNGRB completed a study in 2024, titled *Pathways for Hydrogen Transmission through Natural Gas Pipelines and City Gas Distribution Networks*[1]. This study evaluates hydrogen demand-supply dynamics, infrastructure compatibility for various blending levels, and compares global best practices. Key tasks included:
   - Mapping demand-supply of low carbon hydrogen with respect to pipeline supply infrastructure.
   - Technical and commercial assessments of pipeline sector.
   - Assessment of Policy and Regulatory Framework, including international experience.
   - Developing a roadmap to integrate hydrogen into pipelines aligned with India's National Green Hydrogen Mission.
2. **Roadmap Development**: PNGRB, together with ICF, is creating a roadmap, expected to be completed at the end of the current financial year, for hydrogen blending in existing natural gas infrastructure, as well as development of dedicated 100% hydrogen pipelines, focusing on regulatory frameworks, safety standards, and technical specifications, including action plans and funding identification.

B. Pilot Projects on Hydrogen Blending

PNGRB has approved several pilot projects to test hydrogen blending with natural gas. These projects are vital for assessing the technical feasibility, infrastructure readiness, and hydrogen's impact on existing pipelines. Key pilot projects include:

1. **Indore, Madhya Pradesh:** GAIL (India) Limited and Aavantika Gas Limited conducted a pilot project on hydrogen blending with natural gas, starting with 2% v/v hydrogen into natural gas directly at the City Gate Station (CGS) in the steel pipeline catering to all segments

Hydrogen pressure regulation skid at City Gate Station of Indore GA of Aavantika Gas

[1] https://pngrb.gov.in/pdf/press-note/ICF_20241017.pdf - ICF presentation at PNGRB Oct 2024 stakeholder interaction

Hydrogen storage cascades with hydrogen pressure regulation skid at City Gate Station of Indore GA of Aavantika Gas

of the CGD network, i.e. Domestic piped natural gas (PNG), compressed natural gas (CNG), and Commercial & Industrial (C&I) consumers. Later, the blending ratio increased up to 5% in the MDPE[2] CGD network (excluding CNG), catering to domestic PNG, and C&I customers only.

2. **NTPC Kawas, Gujarat:** Gujarat Gas Limited (GGL) is conducting a pilot project on hydrogen blending with natural gas up to 5% v/v in the MDPE PNG distribution network of NTPC Kawas township, Surat, Gujarat. The blending percentage has now been increased from 5% to 8% v/v.
3. **Jorhat, Assam:** PNGRB granted approval to Assam Gas Company Limited (AGCL) for hydrogen blending with natural gas up to 2% v/v in the MDPE network of domestic households located within the premises of Base Pumping Station of Oil India Limited (OIL) at Jorhat, Assam. The project is yet to be commissioned.
4. **Ahmedabad, Gujarat**: Adani Total Gas Limited (ATGL) is conducting a pilot project to blend hydrogen up to 5% in the MDPE network.
5. **Gorakhpur, Uttar Pradesh:** PNGRB granted approval to Torrent Gas Limited for blending hydrogen up to 2% in the CGD network, which will be catering to all segments, i.e., Domestic PNG, CNG, and C&I consumers. The project is yet to be commissioned.

C. Regulatory and Policy Framework

Under National Green Hydrogen Mission, Ministry of Petroleum and Natural Gas (MoPNG) will play a key role in promoting the adoption of green hydrogen in refineries and CGD, involving both public sector entities and private sector participation. Additionally, MoPNG will facilitate development of necessary regulatory framework to support this transition through PNGRB. The latter's role is crucial in enabling the regulatory infrastructure needed for the effective integration of green hydrogen into the sector.

PNGRB is in the process of amending regulations to accommodate standards related to hydrogen and establish a robust regulatory framework for hydrogen infrastructure. Notable regulatory updates include:

- PNGRB is working with Ministry of New and Renewable Energy (MNRE) to review proposed hydrogen standards for inclusion in CGD and natural gas pipeline regulations. PNGRB has amended its Technical Standards and Specifications (T4S) to include standards for hydrogen blends, such as AGA Report No. 8 (compressibility factors for hydrogen-natural gas blends) and IS 15677 (protocols for metering hydrogen blends).
- PNGRB is in the process of preparing a draft typical guideline for hydrogen blending with natural gas, which is under deliberation of the PNGRB CGD T4S technical committee.
- PNGRB is in talks with GAIL (India) Limited to set up a state-of-the-art testing facility at its Vijaipur, Madhya Pradesh plant, to assess pipeline compatibility with hydrogen. Furthermore, PNGRB is actively engaging with industry stakeholders such as IOCL, BPCL, HPCL[3] and OIL to explore opportunities for collaboration in the development of a joint testing facility.

D. Formation of Hydrogen Cell

To streamline efforts, PNGRB has established a **dedicated Hydrogen Cell** tasked with overseeing the regulatory and infrastructure requirements for hydrogen transmission in India.

Way Forward for PNGRB

Facilitating the establishment of hydrogen ecosystem

Currently, hydrogen does not come under the purview of PNGRB as per the existing provisions of the PNGRB Act, 2006. However, the study on 'Pathways for Hydrogen Transmission through Natural Gas Pipelines and CGD Networks', conducted by PNGRB in association with the World Bank and ICF, outlined a comprehensive way forward for PNGRB to facilitate hydrogen blending with natural gas. Based on the study, several potential initiatives and tasks that PNGRB may undertake in this direction were identified, including:

- **Amendment in the PNGRB Act, 2006:** This Act needs to be amended to include provisions for hydrogen-blended natural gas and pure hydrogen.
- **Development of testing facility for hydrogen blending with natural gas:** PNGRB is planning to facilitate the establishment of a state-of-the-art testing facility with various stakeholders to evaluate the suitability

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[2] Medium Density Polyethylene (MDPE)

[3] IOCL (Indian Oil Corporation Ltd.), BPCL (Bharat Petroleum Corporation Ltd.), HPCL (Hindustan Petroleum Corporation Ltd.)

of existing pipeline infrastructure for transporting hydrogen blended with natural gas. The facility is to include various test beds, comprising closed-loop pipeline networks with sections made from different grades of steel and aged pipeline sections that were once part of operational natural gas networks. These sections will help simulate the conditions of pipelines currently in service. Testing is to be conducted in a time-accelerated manner to replicate long-term operational scenarios. The primary objective is to assess the feasibility of repurposing existing natural gas pipelines for the transmission of hydrogen-blended natural gas and pure hydrogen, ensuring safety, reliability, and efficiency in the transition to a hydrogen-based energy system.

- **Amendment in Existing Regulations:**
  - a) **Access Code & Authorization Regulations –** Amendment in these regulations is required to incorporate hydrogen into the gas mix, with corresponding regulations enforced for the transportation of hydrogen-blended natural gas.
  - b) **Tariff Regulations –** Amendment in tariff regulations is required to update the tariff structures to account for the additional costs involved in transporting hydrogen blends.
  - c) **Capacity Determination –** Amendment in these regulations will be required to address the specifics of hydrogen-blended natural gas for ensuring accurate capacity determination of the pipeline carrying hydrogen-blended natural gas.
  - d) **T4S/IMS/ERDMP Regulations** – Safety standards specific to hydrogen-blended natural gas to be adopted in the Regulations.
- **Introduction of New Regulations:** Notification of new regulations related to Technical & Safety, Access Code, Authorization, Tariff, and Capacity Determination, etc., will be required for dedicated hydrogen transmission pipelines post inclusion of provisions for pure hydrogen in PNGRB Act, 2006. This will facilitate in enforcing PNGRB regulations on dedicated hydrogen pipelines, which will be transporting pure hydrogen from supply sources to demand centers.

Furthermore, PNGRB is to focus on the development of regulatory framework for 100% hydrogen pipelines enabling more localized and efficient hydrogen transportation across hydrogen hubs. PNGRB aims to assess and ensure the technical compatibility of these segments before expanding to broader areas. This approach is crucial for reducing costs and addressing infrastructure challenges.

Conclusion

PNGRB is at the forefront of India's hydrogen transition by facilitating the development of infrastructure for hydrogen transportation through pipelines, driving regulatory reforms, pilot projects, and international collaborations. By enabling hydrogen blending in existing pipelines and preparing for dedicated hydrogen networks, PNGRB is laying the foundation for a **sustainable and resilient energy ecosystem**.

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Farhan Akhter is an Assistant Consultant at the Hydrogen Cell (PNGRB). He, along with the Hydrogen Cell team, oversees operations related to integrating hydrogen into natural gas infrastructure. This includes collaborating with various stakeholders to support pilot projects and testing facilities, conducting pipeline compatibility studies, and contributing to the development of regulatory frameworks crucial for the successful adoption of hydrogen as a clean energy source.

Farhan completed his Bachelor of Engineering in Electronics and Instrumentation in 2023 from RV College of Engineering, and is also a Cisco Certified Networking Associate (CCNA). He started his career as a Systems Reliability Engineer, gaining expertise in hyper-virtualization and server technologies. Later, he worked as a Graduate Engineer Trainee (GET) in the petroleum and EV retail outlet sector, with the engineering division on dispenser operations, and with the instrumentation team, before joining PNGRB.

Ambikesh Tiwari, Assistant Consultant at the Hydrogen Cell, PNGRB, has a Bachelor's in Applied Petroleum Engineering from UPES Dehradun. He brings knowledge and experience in regulatory compliance, project management, and strategic planning within the City Gas Distribution (CGD) sector.

In his current role at the Hydrogen Cell, he plays a pivotal role in evaluating and approving pilot projects on hydrogen blending, contributing to the advancement of sustainable energy initiatives. Additionally, he oversees the adherence of CGD operators nationwide to PNGRB's T4S, IMS, and ERDMP regulations, ensuring the safe and efficient functioning of gas distribution networks.

India's Steady Path Towards a Green Hydrogen Powerhouse

The dynamic reforms and ease of doing business will create economies of scale and bring down the Green Hydrogen production costs to among the lowest in the world. A global demand of over 100 MMT of Green Hydrogen and its derivatives like Green Ammonia is expected to emerge by 2030, of which India can potentially export about 10 MMT Green Hydrogen/Green Ammonia per annum, which will be about 10 per cent of the global market.

India has declared the goal to achieve Net Zero emissions by 2070. As India's growth story unfolds, its demand for energy and resources is set to rise. Energy use has doubled in the last 20 years and is likely to grow by at least another 25% by 2030.

India currently imports over 40% of its primary energy requirements, worth over USD 90 billion every year. Major sectors like mobility and industrial production are significantly dependent on imported fossil fuels. This necessitates a shift towards technologies that enable an enhanced share of renewable sources in the energy mix, and progressively reduce the reliance on fossil fuels.

Green Hydrogen Potential

Green Hydrogen has the potential to play a key role in such low-carbon and self-reliant economic progress. It can enable utilization of domestically abundant renewable energy resources across regions, seasons, and sectors, feeding multiple usage streams, either as a fuel or as an industrial feedstock. It can directly replace fossil fuel-derived feedstocks in petroleum refining, fertilizer production, steel manufacturing, etc. Hydrogen-fueled long-haul automobiles and marine vessels can enable decarburization of the mobility sector.

As the global consensus towards Net Zero gathers momentum, the demand for Green Hydrogen and its derivatives will accelerate. The asymmetries in expected demand and production capabilities for Green Hydrogen,

Source: ETN News, Projects Today, Adani Website

in different countries and regions, are likely to result in international trade of Green Hydrogen and its derivatives like Green Ammonia and Green Methanol. This presents a unique opportunity for India to capitalize on its abundant renewable energy and land resources, and the growing global demand for Green Hydrogen, to become a leading producer and exporter of Green Hydrogen and its derivatives. It is therefore an opportune moment for India to scale up Green Hydrogen production and utilization across multiple sectors, and align with global trends in technology, applications, policy, and regulation.

Environmental pollution and petroleum imports are challenges in India. Addressing the nation on the 75th Independence Day, 15 August 2021, Hon'ble Prime Minister Narendra Modi announced the National Hydrogen Mission with an aim of making India a hub for the production and export of Green Hydrogen, with a vision to make India an energy-independent nation, and to de-carbonize critical sectors. Furthermore, the Indian Government announced the National Green Hydrogen Mission on 4 January 2023 with an initial outlay of INR 19,744 crore[1]. The Mission will facilitate demand creation, production, utilization and export of Green Hydrogen, and mobilization of over INR 8 lakh[2] crore of investment by 2030.

All concerned ministries, departments, agencies and institutions of the Central and State Government are undertaking focused and coordinated steps to ensure successful achievement of the Mission objectives. They are together supporting pilot projects in other hard-to-abate sectors like steel, long-range heavy-duty mobility, shipping, energy storage, etc. for replacing fossil fuels and fossil fuel-based feedstocks with Green Hydrogen and its derivatives.

Dynamic Reforms

India's Green Hydrogen policy offers many incentives for setting up such facilities near end-users and promoting renewable energy transmission. These incentives include:

- Single-window clearance for faster project approvals
- Allotment of land in renewable energy parks
- Priority access to inter-state transmission network
- Open access procurement within 15 days, waiver of inter-state transmission charges
- A 30-day energy banking policy

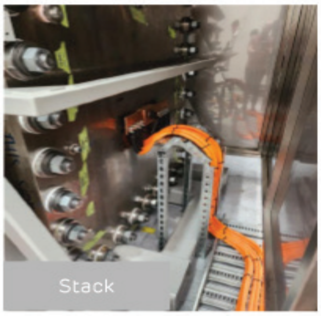
[1] crore = 10 million
[2] lakh = 100,000

Green Hydrogen Mission: A Snapshot

Mission Components	Description
Demand Creation – Exports Markets	India's Green Hydrogen production costs are expected to be among the lowest in the world. A global demand of over 100 MMT of Green Hydrogen and its derivatives like Green Ammonia is expected to emerge by 2030. Aiming at about 10 per cent of the global market, India can potentially export about 10 MMT of Green Hydrogen/Green Ammonia per annum.
Competitive Bidding for Procurement	The Ministry of New and Renewable Energy (MNRE) has framed model guidelines for transparent competitive bidding for procurement of Green Hydrogen and its derivatives, and develop a suitable regulatory framework for certification of Green Hydrogen and its derivatives, as having been produced from renewable energy sources. The bidding guidelines will be technology agnostic to allow both electrolysis and biomass-based generation of Green Hydrogen.
SIGHT Program	Under the Strategic Interventions for Green Hydrogen Transition Program (SIGHT), two distinct financial incentive mechanisms – targeting domestic manufacturing of electrolysers and production of Green Hydrogen – will be provided under the Mission.
Pilot Projects	The Mission will also support pilot projects in emerging end-use sectors and production pathways. Regions capable of supporting large-scale production and/or utilization of hydrogen will be identified and developed as Green Hydrogen Hubs.
Domestic Manufacture of Fertilizers using Green Ammonia	MNRE will formulate model bidding guidelines for procurement of Green Hydrogen-based fertilizers, in consultation with the Department of Fertilizers. Two plants each for the production of Green Hydrogen-based Urea and Green Hydrogen-based DAP[1] are targeted to be set up through the competitive bidding route. By 2034-35, it is targeted to substitute all Ammonia-based fertilizer imports with domestic Green Ammonia-based fertilizers.
R&D Projects	Public-private partnership (PPP) framework for R&D (Strategic Hydrogen Innovation Partnership – SHIP) is being facilitated under the Mission. R&D projects will be goal-oriented, time-bound, and suitably scaled up to develop globally competitive technologies.
Skill Development	A coordinated skill development program will also be undertaken under the Mission.
Transport	To support deployment of FCEV[2] buses and trucks, in a phased manner on pilot basis, financial assistance will be provided to close the viability gap due to the relatively higher capital cost of FCEVs in the initial years. The learnings from the pilot projects will help inter-city bus and truck operators (including State Transport Undertakings) in gaining experience with the deployment and usage of hydrogen fuel cell vehicles and refueling technologies. The Mission will also explore the possibility of blending Green Hydrogen-based Methanol/ Ethanol and other synthetic fuels derived from Green Hydrogen in automobile fuels.
Steel	It will support efforts to enhance low-carbon steel production capacity. Considering the higher costs of Green Hydrogen at present, steel plants can begin by blending a small percentage of Green Hydrogen in their processes. The blending proportion can be progressively increased as cost-economics improve and technology advances. Further, upcoming steel plants should be capable of operating with Green Hydrogen, to enable them to participate in future global low-carbon steel markets. Greenfield projects aiming at 100% green steel will also be considered.
Shipping	Prospects include development of Green Hydrogen/Ammonia refueling hubs at Indian ports; development and operation of Green Hydrogen/Ammonia-fueled vessels; use of Green Hydrogen/Ammonia to fuel zero-emission technologies for vehicles and terminal equipment at ports; and development of supply chains and capabilities to support future export of Green Hydrogen/Ammonia from India.

Source: PHD Research Bureau, PHDCCI, Compiled from various sources.

[3] Di-ammonium phosphate (DAP)
[4] Fuel cell electric vehicle (FCEV)



Source: ETN News, Projects Today, Adani Website

The dynamic reforms and the ease of doing business will create economies of scale and bring down the Green Hydrogen production costs to among the lowest in the world. After the release of India's Green Hydrogen policy, private and state-owned companies have made many announcements about setting up such projects.

In the Union Budget 2023-24, "greening" the economy is one of the top seven priorities (Saptarishi). It will help in implementing many programs for green fuel, green energy, green farming, green mobility, green buildings, and green equipment; and policies for efficient use of energy across various economic sectors. Ethanol blending with petrol, the National Green Hydrogen mission, promotion of electric vehicles, and tremendous push on the renewable energy front are some of the significant initiatives that India is pursuing towards a clean and green energy future. These initiatives are playing an important role in India's energy transition and to provide large-scale green job opportunities.

The Union Budget 2024-25 focuses on development of taxonomy for climate finance, which will guide investors, policymakers, and financial institutions in directing capital towards sustainable and climate-friendly projects. This will also support the achievement of the country's climate commitments and green transition. Reduced basic customs duty on minerals such as lithium, copper, cobalt and rare earth elements, which are critical for sectors like nuclear energy, renewable energy, space, defense, telecommunications, and high-tech electronics, will provide a major fillip to the processing and refining of such minerals and help secure their availability for these strategic and important sectors. It will boost domestic production, recycling of critical minerals, and reduce overseas acquisition of critical mineral assets.

Recently, addressing the second edition of the International Conference on Green Hydrogen (ICGH-2024), Hon'ble Prime Minister Narendra Modi reiterated India's commitment to tackling climate change and the emergence of Green Hydrogen as a promising addition to the world's energy landscape. He also emphasized on India's leadership in renewable energy development, as India's non-fossil fuel capacity has increased nearly 300% over the last decade, and the solar energy capacity has seen an astounding 3000% growth in the same period. The Green Hydrogen Mission not only has the potential to attract INR[5] 8 lakh crore in investments and generate 6 lakh jobs, but will also significantly reduce reliance on imported natural gas and ammonia, leading to savings of INR 1 lakh crore.

Conclusion

In conclusion, India stands committed to reduce emissions intensity of the GDP by 45% by 2030, and subsequently reach Net Zero by 2070. India's commitment to a sustainable and carbon-neutral future is being guided by its enhanced Nationally Determined Contributions (NDC) and Long-Term Low Carbon Development Strategy, which call for clean and efficient energy systems, disaster-resilient infrastructure, and planned eco-restoration. India's Net Zero goal entails a five-decade long journey, and therefore India's strategy is evolutionary and flexible, accommodating new developments in technology.

Courtesy:
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Dr SP Sharma holds a PhD in International Economics from Punjab University, Chandigarh, and has worked with the Government of Punjab, Government of India (GoI), ASSOCHAM, PwC, and the Tatas. Currently, he is serving as Chief Economist and Deputy Secretary General at PHD Chamber of Commerce & Industry, India. During 27+ years of his research and policy advocacy experience, he has worked on various projects for GoI, State Governments, UNCTAD, European Commission, Industry Chambers, and Corporates.

Based on his diverse experience in the various areas of the economy, trade and industry, he has contributed to more than 200 research studies, papers and projects. Dr Sharma has been an invited keynote speaker, panellist, and Chair/Moderator at more than 250 National and International Conferences, and is a member of Advisory/ Governing Committees of various prestigious educational institutions. He has been frequently invited to comment on various economic, industry, trade and finance issues and developments by media such as TV channels like Lok Sabha TV, Sansad TV, Doordarshan, CNBC, and NDTV, among others. He is also a regular participant in the prestigious program 'Market Mantra' of All India Radio.

[5] INR = Indian Rupees

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== SUGAR COMPLEX CAPACITIES ==

- **Sugar Plant = 4500 TCD**
- **Distillery Plant = 200 KLPD**
- **CO2 Plant = 40 TPD**
- **Co-gen Plant = 10 MW**
- **CBG Plant = 10 TPD**
- **2G Ethanol Plant (R&D) = 3 KLPD**

= Awards =

Best Distillery Award 2019.
Best Overall Performance Private Sugar Mill Award 2022.
Best Cogeneration Power Plant Award 2023.
Best Sugar Factory Award 2024.

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Access to Finance for Hydrogen Initiatives in Emerging Markets and Developing Countries

Challenges and Solutions

On 13 May 2024, during the World Hydrogen 2024 Summit C Exhibition in Rotterdam (NL), the World Bank, Invest International, and the Government of the Netherlands co-organized the Finance Forum. The aim of the Finance Forum was to address the challenges (Panel 1) and solutions (Panel 2) in the development and financing of Green Hydrogen projects in emerging markets and developing countries (EMDCs). Over 150 participants enjoyed the deep insights and lively exchanges among world leading experts on how to accelerate financing for Green Hydrogen projects in EMDCs. The World Bank presented the 10 GW Lighthouse Initiative, a programmatic solution of Development Financing Institutions (DFIs) and Multilateral Development Banks (MDBs) for enhanced financing of Green Hydrogen projects in EMDCs.

In his welcoming remarks, Michel Heijdra, Vice Minister for Climate and Energy of the Dutch Ministry of Economic Affairs and Climate Policy, emphasized the potential significance of Green Hydrogen projects for emerging and developing markets, and the relevance to foster international partnerships to realize this potential. He highlighted the importance of Green Hydrogen projects for green growth in emerging markets as well as the decarbonization of the European industry. He welcomed the growing active role of development banks in enabling Green Hydrogen projects and stated that the Netherlands has expanded coverage of the Dutch export credit insurance facility: this now includes coverage of transactions related to national hydrogen imports, ensuring comprehensive backing.

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Panel 1:

Filling the Green Hydrogen financing gap - Private sector challenges in developing and financing Green Hydrogen projects in emerging markets and developing countries.

- Opening remarks and moderation by Itske Lulof, Sector Head Energy and Climate, Invest International
- The panel consisted of:
  - Florian Merz, Associate Director of Business Development (Europe), Masdar
  - Marco Raffinetti, Chief Executive Officer, Hyphen Hydrogen Energy
  - Vibeke Rasmussen, SVP Product Management and Certification, Yara Clean Ammonia
  - Dr. Hans Hermes, Executive Vice President, Hydrogen C Renewable Energies, SEFE (Securing Energy for Europe) GmbH
  - Letitea du Plessis, Senior Investment Manager, Climate Fund Managers
  - Ilona de Haas, NL Head, Hydrocarbons C New Energies, ING Bank

The first panel addressed current challenges experienced by key market actors in the development and financing of Green Hydrogen projects in EMDCs. In her opening presentation Itske Lulof stated that, research by Hydrogen Council and McKinsey of May 2023 reveals that 795 large-scale Green Hydrogen projects worth USD 320 billion have been announced to be developed by 2030. However, she stated, most of these projects are still of a conceptual nature. Less than 50% have entered the planning stage or have taken Financial Investment Decision (FID), and only a small fraction has reached Financial Close. Securing offtake and potentially government support and financing (to ensure project bankability) are key enabling factors for developers to reach FID. So far, the projects most advanced are located in developed countries. For projects under development in in EMDCs, additional bottlenecks apply that may hamper seizing the benefits of excellent production circumstances.

The project developers, Masdar and Hyphen Hydrogen Energy stressed the importance of shaping the nascent market. Projects cannot happen in isolation. Mitigating country risk and the strengthening of Government to Government (G2G) support are critical factors. Strategic alliances and partnerships of mutual benefit could lead to enhanced project bankability. An example is Masdar, whose project implementation centers on partnerships across the Power-to-X value chain. This also includes local partners to ensure the local added value and utilization of hydrogen. Creation of a common methodology for international certification mechanisms and standards should be strengthened further; this is crucial to ensure international trade of green hydrogen. In this context, transparent tracking processes are needed.

The two midstream offtake companies, Yara Clean Ammonia and SEFE (Securing Energy for Europe) GmbH, emphasized the challenge on the demand-side offtake, especially offtake from production in EMDCs as the logistics aren't there yet (to move molecules in the form of derivatives that can be shipped). Production-side incentives should be complemented with regulatory targets/mandates and public support on the offtake side. In the beginning of the market, offtake guarantees are crucial. Offtake contracts should be of a sufficient duration, seven-year contracts were seen as too short. As the market still evolves, too detailed regulation can be detrimental. SEFE highlighted the importance of regulatory changes that come in waves and evolve as the industry develops.

Finally, Climate Fund Managers and ING provided the investor and financier perspectives. Flexible financing structures for clean hydrogen can help to accommodate specific project needs, while bringing down the cost of financing. The most salient risks that prevent projects from reaching FID are lack of bankable offtake agreements, technology risks (i.e. in the case of electrolyzers) and country risks, including political risks, foreign currency risks, and finally political stability. These risks can be mitigated through appropriate financing structures, risk mitigation measures, and proper risk sharing. Providing early-stage development capital, Climate Fund Managers Namibia mentioned the importance of blended financing and the key role of government participation. Namibia sees a lot of potential projects across the value chain and access to early-stage capital is critical to allow developers to enhance their projects. ING referred to legal and regulatory risks as a main challenge in the Global South. Certain recurring risks are related to the changing political environment and the relative strength of contracts. Export Credit Agencies can play a role to alleviate such risks (insurance for political and project risks). There is also an aspect of risk sharing (for example through syndication of loans) and sharing of technical and financial expertise among participating banks.

Panel 2:

Convening financing to deploy large Green Hydrogen projects in emerging markets and developing countries: 10 GW Lighthouse Initiative.

- Opening remarks were given by Dr. Dolf Gielen, Senior Energy Economist and Hydrogen Lead, World Bank
- The moderation was done by Mikaa Mered, Special Advisor, Hy24
- The panel consisted of:
  - Dr. Ruud Kempener, Acting Deputy Head, Renewables and Energy System Integration Policy, Directorate-General Energy, European Commission
  - Ignacio de Calonje, Chief Investment Officer - Energy, Green Hydrogen, Metals C Mining, IFC
  - Christiaan Gischler, Lead Energy Specialist, Inter-American Development Bank
  - Susana Moreira, Executive Director, H2 Global Foundation
  - Michiel Slootweg, Director - Private Sector, Invest International

The second panel discussed solutions to address bankability issues for Green Hydrogen projects in EMDCs and the mechanisms to de-risk financing. It showcased the 10 GW Lighthouse Initiative as a solution by MDBs to unlock financing for Green Hydrogen projects in EMDCs.

Dolf Gielen presented the 10 GW Lighthouse Initiative in his opening presentation. Referring to the Scaling Hydrogen Financing for Development Report he highlighted the annual investment need for EMDCs of USD 100 billion per year until 2030 to move projects forward at the needed speed. So far projects in EMDCs are not developing at the required rate and the funding need is too big for a single MDB. The 10 GW Lighthouse Initiative aims to streamline MDB financing and unite support. The World Bank emphasized the importance of international coordination and public- private partnerships around potential markets in the Global South. The rationale behind the 10 GW Lighthouse Initiative is to create an initial EMDC project base of 100 MW to 1 GW projects through which more than 10 GW total capacity can be realized (FID) in total in the coming years. Mikaa Mered moderated the second panel. He asked the panelists which hydrogen financing and support they have provided, which de-risking instruments or strategies they deem effective, and how they expect this to grow in the coming years. The European Commission mentioned that Member States are trying to find common projects and look at how to reduce the cost gap. Ruud Kempener highlighted the European Hydrogen Bank, a financing instrument to accelerate the establishment of a full hydrogen value chain in Europe. He also referred to financing opportunities as part of Global Gateway projects.

Speakers from second panel.

The European Commission held a stakeholder consultation to discuss the draft Terms and Conditions for the Innovation Fund. This was followed by the launch of three calls for proposals on 3 December 2024.

Invest International highlighted the importance of diversification in EMDCs. Michiel Slootweg stated that government guarantees are key, as they can solve offtake issues and reduce costs. Invest International is teaming up with Climate Fund Managers and the Namibian Environmental Investment Fund in setting up a blended finance vehicle unlocking, through public funding, private capital for early-stage development, and equity investments for Green Hydrogen projects in Namibia. Also, according to Ignacio de Calonje of IFC, of critical importance for the bankability is the de-risking of offtake. It's an uncertain world for project developers. IFC has expertise across the whole value chain and funding for feasibility studies (of different scale: 5 GW to 400 MW). The institution encouraged coordination among the public and private sector.

Christiaan Gischler of the Inter-American Development Bank (IADB) explained that the MDB is working on different types of projects in Latin America. In particular, the IADB highlighted the work in Chile, where the role of MDBs has been instrumental in the creation of a USD 1 billion Green Hydrogen fund. The IADB stated that the example could serve as a best practice model for the region, e.g. Brazil, Mexico and Colombia. For several countries in Latin America the IADB is providing grants for the development of roadmaps. It commented that export projects should also provide national socioeconomic benefits in the producing countries.

Finally, Susana Moreira of H2Global referred to their 900-million-euro auction, a German funding instrument which is being implemented in three lots by Hintco. The goal of H2Global is to accelerate the international market ramp-up for sustainable hydrogen products through an innovative and efficient funding mechanism. The production of the hydrogen derivatives must take place outside the European Union (EU) and European Free Trade Association (EFTA) states. H2Global emphasized the lack of clarity concerning EU regulation and tries to foster more international understanding. The government-run scheme can offer learnings in terms of how to mitigate risks needed for making Global South projects bankable. The telling conclusion of the last panel discussion – who should be first movers in large-scale Global South Financing – seemed mixed:

Dr. Dolf Gielen presenting the "Scaling Hydrogen Financing for Development" report.

1 MDBs – including World Bank,
2 Governments – by creating schemes to compensate first movers, and
3 Not a single entity but rather coalitions/partnerships.

In sum, the panel welcomed the 10 GW Lighthouse Initiative and shared the following:

- There is a need for better coordination and collaboration among the various financing institutions (address fragmentation and document best practices in the coming years as experience with Power-to-X project grows).
- There are so far few initiatives to support financing of hydrogen projects in EMDCs (example Chile, H2Global, Climate Investor 3 blended finance fund for Namibia), and the existing ones take time as projects are not ready.
- Various approaches towards EMDC project financing support are being tested (e.g. auctions). It's still not clear which approach is best suited and this needs to be assessed further.
- There is a key role for MDBs and DFIs in enabling first projects jointly (as in the case of Chile).

Source: May 2024, Summary Report & Key Take-Aways - WORLD HYDROGEN 2024: FINANCE FORUM; Access to Finance for Hydrogen Initiatives in Emerging Markets and Developing Countries: Challenges and Solutions

Editorial... contd from pg 1

limited understanding of the current status of the sector. Such understanding is required to support evidence-based policymaking and provide confidence to the industry. A Viewpoint Article by IIT-Kanpur therefore, examines the recent developments in the green hydrogen industry in India to understand the status of these projects, the operational model, demand sectors, and the policy environment. Further, the comparison is drawn to the global developments to identify commonalities and challenges in the industry.

Last, but not least, a clear regulatory framework is absolutely essential, which provides the much-needed comfort for long-term investments and boosts investor confidence in the Green Hydrogen sector.

As we at Cogeneration Association of India continue to bring you updates in the Green Hydrogen space, we look forward to your feedback to make this newsletter more useful to our readers, and hope all stakeholders will join us as members to take this "Green Revolution" forward.

A Realistic Stock-Take of Green Hydrogen Optimism in India: Missing Value Chain Approach

Viewpoint Article by Dr. Mousami Prasad, Asst. Professor, Dept. of Management Sciences, IIT Kanpur

Introduction

India, like many other countries, considers green hydrogen to be a key component of its energy, climate, and economic policy. With the decline in costs of renewable energy sources like solar and wind, there is optimism that green hydrogen's target price of below USD 2/kg in the developed markets is achievable much sooner than what is otherwise expected. The current cost of producing green hydrogen is USD 4-7 per kg. India's target for green hydrogen is USD 1/kg by 2030. In addition, when compared to the costs of current technology based on fossil fuels, with carbon capture and carbon price, green hydrogen may become competitive or even cheaper. Green hydrogen, therefore, is being looked upon as a homegrown solution to cutting dependence on fossil fuel imports, driving decarbonization, especially in sectors like ammonia, refining, steel, and heavy-duty vehicles, and creating jobs. Globally, hydrogen is expected to reduce 6% of emissions between 2021 and 2050 in a Net-Zero scenario. While 6% may still appear small in comparison to what other mitigation measures can achieve, its role becomes very crucial in cutting emissions from hard to abate sectors like steel, cement, and aluminum. Many countries have thus released their hydrogen strategies.

India, too, is capitalizing on the growing interest in creating a green hydrogen industry. Since 2020, the Indian government has taken several initiatives to place hydrogen in the energy mix. In January 2023, the central government released the National Hydrogen Mission, which targets to reach green hydrogen production of 5 Mt/year by 2030 and is supported by budgetary allocation. A phase-wise timeline is provided, similar to the National Solar Mission document presented in 2010.

Although there have been announcements on green hydrogen projects in the last few years, it remains unclear how India's green hydrogen industry is shaping up. Electrolysis is not a mature technology for hydrogen production, and there are many uncertainties around the availability of electricity, energy storage, transportation, and logistics. Most studies on the cost of green hydrogen do not consider the cost of transporting and storing hydrogen. Anecdotal evidence suggests that while green hydrogen has been the government's focus, the increase in hydrogen production from 2020 to 2023 was entirely from fossil fuels. This indicates a mismatch between ambition and action or delayed action, which is unfavorable for the green hydrogen industry. There is also limited understanding of the current status of the sector. Such understanding is required to support evidence-based policymaking and provide confidence to the industry. This article, therefore, examines the recent developments in the green hydrogen industry in India to understand the status of these projects, the operational model, demand sectors, and the policy environment. Further, a comparison is drawn to global developments to identify commonalities and challenges in the industry.

Green Hydrogen Sector Developments

Continued interest but uncertain investments

Although not a recent discovery, hydrogen has seen a renewed interest in the wake of Net-Zero's commitments to decarbonize economies. There are two main ways that hydrogen is looking to help decarbonization. First, hydrogen can substitute the already existing applications when it is made from cleaner sources like solar and wind. Second, hydrogen use can be explored in newer applications like heating, steelmaking, and transport. Currently, the world produces around 97 Mt of hydrogen. Between the years 2020 and 2024, the production has increased by 7 Mt. However, almost all current hydrogen production uses fossil fuel (Figure 1). Despite the call for green hydrogen as a way forward, the natural gas route of hydrogen production remains the most important production technology.

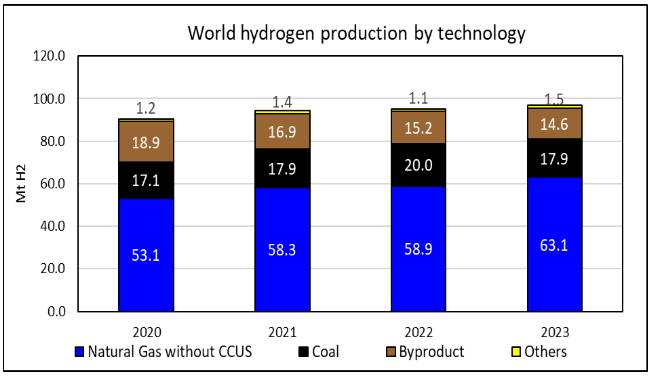

Figure 1: World hydrogen production classified by technology

Since the release of the first global hydrogen review by the International Energy Agency in 2019, there has been a growing interest from academia, industry, and governments in understanding the sector. A bibliometric analysis of more than 4,000 academic articles published on "green hydrogen" from the Web of Science shows the rising trend (Figure 2).

The interest comes from multiple disciplines and in various aspects of the green hydrogen economy. A network map based on the co-occurrence of the term green hydrogen

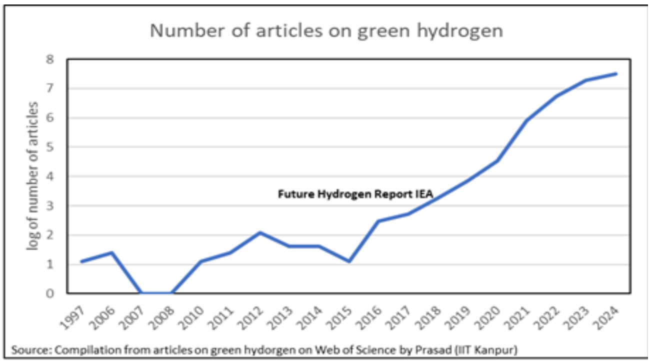

Figure 2: The number of articles on green hydrogen has been increasing

in articles with other keywords shows different lenses for examining green hydrogen. Figure 3 shows the keywords grouped in different clusters, distinguished by color codes. The clusters suggest different themes associated with hydrogen like (a) the technologies to produce green hydrogen-like electrolyzers, water splitting, biomass, biogas, waste, and solar energy, (b) the costs of producing green hydrogen, (c) the role of green hydrogen in energy transition, (d) the countries where studies are being conducted like China, Europe, Africa, and (e) emission reduction potential of hydrogen economy.

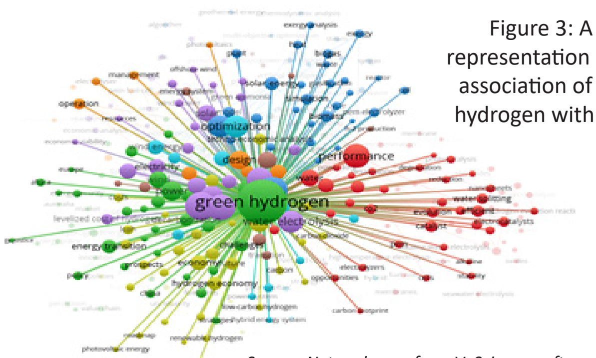

Figure 3: A visual representation of the association of green hydrogen with other terms

Source: Network map from VoSviewer software tool

Despite the general interest, there has been mixed evidence from the investments made in the sector. There have been delays and cancellations of announced hydrogen projects, with only 30% of projects likely to be completed, as reported by Hydrogen Supply Outlook 2024. Most projects are at the announcement stage, and very few are under construction, suggesting that the industry remains in 'wait and watch' mode. This global trend is true for India as well.

Work in Progress

The Indian government is targeting at least 5 Mt of green hydrogen production by 2030 under the National Green Hydrogen Mission. The green hydrogen industry is expected to create 600 thousand full-time jobs and reduce emissions by 50 Mt. India currently produces about 9 Mt of hydrogen, mainly through coal gasification and natural gas routes. India has added 2 Mt of hydrogen production since 2020, all coming from fossil fuel routes. Since coal is domestically available, efforts have been made to increase hydrogen production from coal gasification. The natural gas route is also being explored as a transition fuel, until the costs for green hydrogen become competitive. However, this could lock in gas imports and become counterproductive to the green hydrogen mission of reducing dependence on imports and reducing emissions. An analysis of the green hydrogen project database hosted at the National Green Hydrogen Mission Portal of India shows that there are 130 projects as of 6 December 2024 spread across different Indian states. Figure 4 shows the location of green hydrogen projects across India. The 130 projects cover a green hydrogen production capacity of 12.5 Mt and an electrolyzer capacity of 33 GW (Table 1). If these projects materialize, the targets under the National Hydrogen Mission can be met. However, over 99% of these projects have not moved beyond the announcements at this stage. Only 9.7 kt of hydrogen production capacity is under construction (Table 1). In addition, 74% of the demand for green hydrogen is from the ammonia sector (Figure 5) which has been the traditional user of hydrogen from fossil fuels, also known as grey hydrogen. This suggests that existing demand sectors are the early adopters of green hydrogen in India.

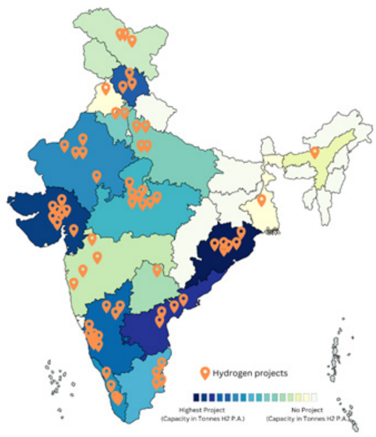

Figure 4: Distribution of green hydrogen projects in India

Source: Compilation by Prasad IIT Kanpur using data from the green hydrogen project, created on https://www.mapchart.net/

Table 1: Status of green hydrogen projects in India

	Electrolyzer Capacity (MW)	Capacity (kilotons H2 per annum)	Number of Projects
Announced	33,191	12,581.8	112
Commissioned	15	2.2	9
Decommissioned	149	0.0	1
Planned	0	0.0	1
Under Construction	66	9.7	7
	33,421	12,594	130

Source: Author compilation from green hydrogen project database accessed on 6 December 2024 (National Green Hydrogen Mission Portal of India)

At least three models are emerging to operationalise green hydrogen production. First, public-private partnership, which typically involves a state government and a private company. Second, private consortiums are where companies from sectors like renewable energy, infrastructure, and oil and gas join to explore hydrogen production, such as the consortium of Indian Oil, L&T, and ReNew. Third, a partnership of central public sector units with private sector companies like NTPC, Ohmium, and Spirare Energy.

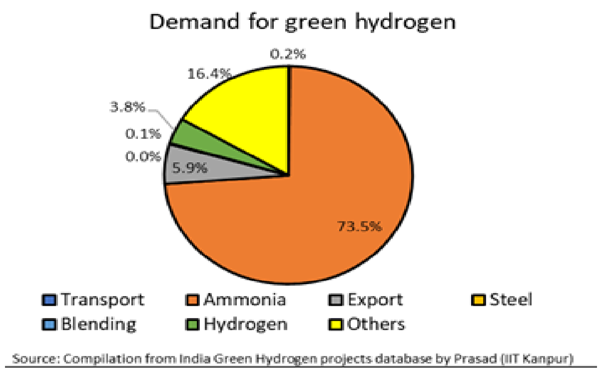

Figure 5: Green hydrogen end-use

Costs of Production & Technology Availability

Remain a concern for scaling of green hydrogen

In the case of green hydrogen, the main factors affecting the costs are electricity cost, capital cost, and operating capacity factor. If the capital cost is reduced or the electricity cost declines, the cost range of green hydrogen can be reduced to below USD 1-4 per kg. Further, it is typically assumed that green hydrogen will be produced from surplus electricity generated from solar and wind, thereby reducing the curtailment and storage needs. This way, while cheap green electricity finds demand, the other sectors, especially hard to abate, can decarbonise too.

In India, electricity from renewable energy sources makes up 12-15% of total electricity generated. This meets the additional energy demand but does not substitute fossil fuels. For hydrogen to become competitive, green electricity should be available and affordable. Solar energy has seen exponential growth in India but now faces challenges regarding land availability, grid integration, and storage solutions. In addition, there is a reluctance to aggressively push renewable energy, especially when the supply chains are import-dependent, and the electricity system still needs to manage integration. This translates into higher costs for green electricity and higher costs of green hydrogen. In 2022, it was estimated that the cost of green hydrogen production in India is about USD 4-7 per kg, which remains the case in 2024. The reports on electrolyzers for hydrogen production in India remain ambiguous on indigenous technology and whether the hydrogen production will depend on imported electrolyzers. Solar industry experience in India suggests that to increase solar penetration, the government focused on adding solar capacity without worrying about whether it was domestically produced or imported. Domestic manufacturing of solar panels, therefore, took a hit until 2020. If India misses the manufacturing in the hydrogen sector, the estimates on job creation cannot be realized.

Implication of Current Progress

The implications of green hydrogen progress for the industry and public policy are noteworthy.

1. **Realism rather than optimism to drive the investment in the sector**

   The complex geopolitical situation has prioritized the security of the energy supply chain and the need to reduce dependence on imports to drive the energy transition. The earlier optimism on green hydrogen is settling down with expected production numbers and target years not matching the actuals. For instance, India's hydrogen production is expected to increase by another 3-5 Mt by 2030. To be aligned with the green hydrogen mission target, all this increase should come from green hydrogen, which looks challenging since there is no current capacity. Globally, green hydrogen production also does not match the expectations as IEA reports have revised the targets downwards in the years following 2020. Europe, which is leading the efforts on hydrogen production, suffered a massive increase in energy costs following the conflict in Russia-Ukraine. For Global South countries, including India, the technology transfer or indigenous technology development remains critical for transition. Therefore, in the background of complex geopolitical situations and heightened priority of national security, investments in green hydrogen will be weighed against the realism of cost declines in green electricity and incentive mechanisms combined with policy certainty.

2. **Public policy needs to attract private investment through a market-based mechanism**

   The current costs of producing green hydrogen are higher than the conventional fossil fuel routes. Green hydrogen can become competitive, if there is sufficient carbon price on fossil fuel routes. However, in the absence of any carbon price, the premium on green hydrogen will have to be either subsidised by the government (tax payers' money) or absorbed by the industry in terms of higher costs. In India, many of the green hydrogen projects are for ammonia production, which is used in fertilizer and heavily subsidized. As a result, a market-based funding mechanism will be needed for the sustainability of the green hydrogen sector and help create new demand. Green steel could stimulate demand for green hydrogen. India already has established direct reduced iron (DRI) -based steel-making routes. They are typically small plants with less than 1 Mt annual capacity. Currently, there are 310 DRI plants with an annual capacity of 55 Mt steel using coal and natural gas. Even if 10% of this capacity or 5 Mt steel is produced from hydrogen-based DRI, this will create demand for 250-300 kt hydrogen, assuming 50-60 kg of hydrogen is needed to produce 1 ton of steel (5000000 X 0.05). Currently, existing industries are greening their processes, but new demand creation has not happened. The transport sector, driving the global demand for hydrogen, is responsible for less than 0.5% of hydrogen use in India.

The Ministry of New and Renewable Energy (MNRE), which is the nodal agency, has experience in creating a solar industry with private sector participation. Lessons can be drawn to inform the development of the hydrogen sector. However, two things need to be kept in mind. First, manufacturing cannot be left behind; otherwise, job creation will be at risk, and so will the energy supply chain. Second, medium and small players must be incentivized to share the gains of a new industry with many Indian companies rather than a few big companies.

3. **Investment in the whole value chain approach**

A typical hydrogen value chain comprises inputs, production, storage, transportation, and use combined with an enabling policy environment (Figure 6).

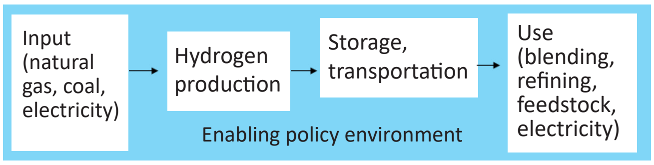

Figure 6: Typical hydrogen value chain

The current developments in green hydrogen are concentrated on the production side. However, production is only one element in the whole value chain. There needs to be more clarity on the other aspects, such as what green hydrogen is, who will certify its greenness, how it should be stored and transported, and how it should be integrated with the existing electricity grid, among others. In addition, there needs to be trained manpower and skilled professionals who can understand and handle hydrogen.

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DST's Hydrogen & Fuel Cell...contd from pg 2

electrolyzers, hydrogen storage materials, materials for Type IV cylinders, and prototypes for the implementation of various hydrogen and fuel cell applications in the country, which aligns with the R&D roadmap requirements of the National Green Hydrogen Mission and the Make in India initiative.

Hydrogen & Fuel Cell (HFC-2023) Program: An Update

The HFC Program-2023 was launched on 20 October 2023, with the deadline for proposal submissions set for 30 January 2024. A total of 196 proposals were received, including 190 submitted online and six offline. Following the initial screening process, 95 proposals were shortlisted based on merit, and invited to present their work during the final defence before an expert panel.

The final defence expert panel meeting for the HFC-2023 program was held during 21-13 August 2024, with the participation of Expert Panel Members and DST officials. Of the 95 proposals reviewed, 21 were recommended for funding, while seven proposals were advised to undergo revision and re-evaluation by the expert committee.

Courtesy:

Dr. Ranjith Krishna Pai is the Senior Director at DST, Ministry of Science and Technology, Government of India. He is an experienced scientist with a demonstrated history of working in National and International Research Laboratories and Centers. Dr. Pai obtained his PhD in Chemistry from Ulm University, Germany, and is skilled in Nanomaterials, nanofabrication, and polymer chemistry.

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Pioneering Tomorrow: Energy Leap's Clean Hydrogen Innovators Shape the Future

Energy Leap is a platform designed and conceptualized by Xynteo to accelerate the production and consumption of clean hydrogen in India through the adoption of scalable technologies. The aim of Energy Leap is to identify, incubate, and support innovative solutions across the clean hydrogen value chain by driving innovation and facilitating the commercialization of high-potential technologies.

As Energy Leap continues to accelerate the transition to clean hydrogen, we are proud to showcase three more groundbreaking companies from our inaugural cohort. These innovative startups are revolutionizing different aspects of the hydrogen value chain, from production to storage and power generation.

AqGas

Revolutionizing Green Hydrogen Production Through Flow-Through Electrolysis

AqGas, founded in 2022 and based in Nottingham, UK, is transforming the hydrogen production landscape with its innovative flow-through electrolysis technology. Its groundbreaking approach offers a substantial capital expenditure saving compared to conventional alternatives, driven by its membrane-free, flow-through technology that minimizes parasitic load, simplifies assembly, and reduces maintenance costs.

The company's proprietary electrode development program utilizes sustainable materials, ingeniously repurposing aerospace "waste" streams to create durable, efficient, and ultra-low-cost electrodes. Its system's modular design ensures easy maintenance and upgrades, with an impressive lifecycle.

AqGas has already begun implementing its technology in real-world applications, with a notable project at Springvale Farm, Nottinghamshire (UK) demonstrating CO_2 capture and hydrogen injection for anaerobic digestors. This innovation has immediate potential for replication across 30 similar sites, with over 3,000 anaerobic digestors in Germany alone presenting a vast market opportunity.

The company partners globally for licensing and aims to revolutionize hydrogen production by providing affordable, low-maintenance solutions with a focus on renewable energy and industrial applications

https://aqsorp.com/

Gudlyf Mobility

Advancing Hydrogen Storage Solutions

Based in Madurai, India, Gudlyf Mobility was founded in 2022 by Dr. Ajeet Babu and a team of industry veterans, including experts from Indian Space Research Organization (ISRO) and Automotive Research Association of India (ARAI). The company specializes in manufacturing Type IV hydrogen storage cylinders, designed to be lightweight (~83% lighter than conventional solutions), non-corrosive, and capable of withstanding pressures up to 700 bar (*refer page 19*).

Gudlyf's breakthrough lies in its proprietary wet filament winding process, which incorporates a unique carbonaceous material formulation in the overwrap material, enhancing fracture toughness while reducing hydrogen permeation. The company's innovative approach extends to the liner material, which combines polymer with natural cellulosic material, making it both environment-friendly and effective at preventing gas permeation.

The company has already garnered attention from major industry players, including Cummins, Ashok Leyland, and Reliance, positioning itself at the forefront of India's ambitious hydrogen mobility sector.

https://www.gudlyfmobility.com/

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Powering the Future: Energy Leap's Trailblazers in Clean Hydrogen Innovation

Energy Leap is proud to introduce Gudlyf Mobility, a promising innovator that's redefining hydrogen storage. Their game-changing technology isn't just advancing clean energy storage – it could unlock new possibilities across the entire hydrogen ecosystem.

Gudlyf Mobility

Revolutionizing Hydrogen Storage and Gas Logistics

Gudlyf Mobility's mission to pioneer high-pressure gas storage, especially for hydrogen mobility, emerges from a powerful intersection of personal values, technical innovation needs, and transport sector challenges. It was also one of the top six teams selected for its impactful contributions, receiving seed funding to further develop its prototype and advance sustainability initiatives at the Carbon Zero Challenge (CZC 4.0), an annual pan-India competition organized by IIT Madras to promote eco-innovation and entrepreneurship. The team presented an innovative solution featuring hydrogen storage cylinders made from agricultural waste.

Gudlyf Mobility team winning the IIT Madras Carbon Zero Challenge in 2024

"In today's world, where pollution threatens our future, our core mission is developing solutions that actively combat climate change and minimize environmental impact – values that sit at the heart of everything we create," says Dr. Babu.

Challenges & Solutions

Metal embrittlement poses a critical challenge when hydrogen atoms infiltrate metals, leading to brittleness and potential cracking under high pressure conditions. Gudlyf Mobility's breakthrough Type IV non-metal cylinders, engineered to operate at 700 bar nominal working pressure, directly addresses this safety and durability concern in high-pressure gas storage and transport.

The hydrogen ecosystem faces a defining challenge in logistics costs, particularly in the oil and gas sector, where transport expenses can make or break hydrogen's viability as a clean energy source. The low volumetric energy density of hydrogen demands either compression or liquefaction – both significantly impacting costs. Gudlyf Mobility's innovation transforms this landscape with cylinders that are 80% lighter than conventional Type I solutions, enabling more cost-effective gas transport and revolutionizing supply chain efficiency.

Gudlyf Mobilty's technology advances multiple UN Sustainable Development Goals: powering affordable clean energy (Goal 7), driving industry innovation (Goal 9), enabling sustainable cities (Goal 11), and promoting responsible production (Goal 12). Through these alignments, the company is not just creating technology, it is actively shaping a more sustainable future.

Gudlyf Mobility's intellectual property portfolio centers on Type IV hydrogen storage cylinders, incorporating proprietary materials, innovative design, and advanced manufacturing processes. Its breakthrough technology combines cutting-edge material science with precision engineering to deliver cylinders that excel in lightweight construction, durability, and safety for high-pressure hydrogen storage. This technology directly addresses efficiency and cost challenges in the hydrogen supply chain, establishing Gudlyf Mobility's position as a pioneer in the field. The company's cylinders have demonstrated their excellence through rigorous burst test validation according to Indian Standards (IS).

The company has already garnered attention from major industry players, including Cummins, Ashok Leyland, and Reliance, positioning itself at the forefront of India's ambitious hydrogen mobility sector.

In the near future, Gudlyf Mobility plans to collaborate closely with these industry leaders to execute pilot projects, ensuring that its Type IV hydrogen storage cylinders meet the industry's stringent technical requirements. These projects will help validate Gudlyf Mobility's solutions under real-world conditions and align their product development with market needs. Additionally, the team is focusing on establishing a state-of-the-art manufacturing facility in Madurai (Tamil Nadu), dedicated to producing Type IV cylinders. This dual approach will enable the company to refine its technology, scale production efficiently, and meet the growing demand for reliable hydrogen storage solutions.

https://www.gudlyfmobility.com/

Green Hydrogen in Industrial Heating: Opportunities, Challenges, and Alternatives

India's industrial sector is a major contributor to energy demand and significantly influences the country's carbon emissions profile. In 2021-22, the industrial sector accounted for ~44% of India's total energy consumption[1]. The energy consumed for heating purposes constitutes a significant portion of total industrial energy demand which, in turn, contributes to the emissions problem as well.

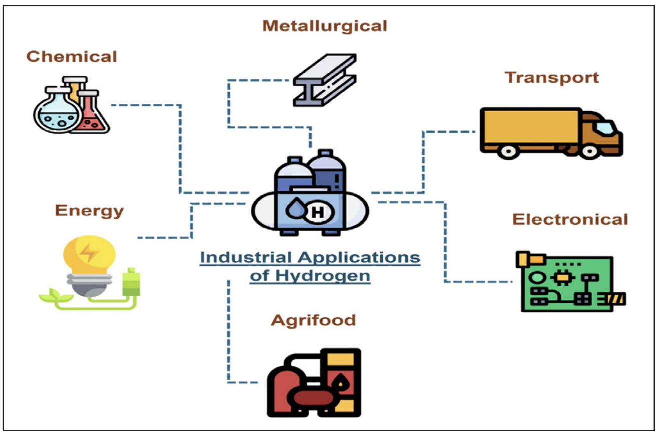
According to the International Energy Agency, in India, the industrial sector is responsible for about 31% of energy-related CO_2 emissions[2]. With diverse heating requirements across industries, the choice of heating sources plays a crucial role in shaping their energy use and environmental impact.

Unlocking low-carbon industrial heating demands a holistic view beyond green hydrogen's promise. While green hydrogen offers transformative potential, businesses must weigh its advantages alongside other alternative solutions – from bio-derived fuels to advanced industrial electric heating systems and thermal storage innovations. Only by examining the full spectrum of emerging technologies through the lens of efficiency, maturity, and implementation challenges, can we get a clearer view on the role of green hydrogen.

Industrial heating: Energy demand in key sectors

Sectors such as steel, cement, and glass manufacturing often require high temperatures (>500⁰C) and primarily rely on coal, natural gas, furnace oil and diesel (for redundancy)[3]. Meanwhile, sectors such as textiles and food processing operate at lower temperatures (up to 500⁰C), utilizing steam generated from fossil fuels[4].

Table 1 provides an overview of some of these sectors, detailing the specific processes requiring heat.



Source: https://www.researchgate.net/publication/382568694_Hydrogen_Revolution_in_Europe

Sustainable alternatives for industrial heating applications

By reimagining industrial heating through low-carbon technologies, businesses can dramatically cut emissions while maintaining the operational excellence that drives growth. The shift to cleaner process heating technologies represents a critical step in industry's decarbonization journey.

Table 2 presents a comparative analysis of different technologies including green hydrogen, aimed at decarbonizing heat production, highlighting their achievable temperatures, efficiency levels, current scale of operation, and associated challenges.

Green hydrogen for industrial heating applications

Powering industrial heating demand, green hydrogen can play a significant role in high-temperature processes. Yet for lower-temperature applications, electric heating technologies like heat pumps could emerge as frontrunners, delivering superior efficiency and a smaller carbon footprint.

Table 1: Heat requirements and sources by industry type[5]

Industry	Process	Required temperature	Fuel sources
Steel	Blast Furnace	1100⁰C - 1200⁰C	Coke/Coal
	Electric Arc Furnace	1500⁰C - 1800⁰C	Electricity
	Direct Reduced Iron	800⁰C - 1100⁰C	Coal/Natural Gas
Cement	Clinker Production (Kiln)	1400⁰C - 1500⁰C	Coal, Petcoke
Glass	Glass Melting Furnace	1200⁰C - 1600⁰C	Natural Gas, Oil, Electricity
Aluminium	Bayer Process	180⁰C - 250⁰C	Electricity
	Hall–Heroult Process	900°C - 1000°C	Electricity
Brick & Tiles	Firing in Kiln	1000⁰C - 1200⁰C	Coal, Biomass
Petrochemical	Cracking Furnace	800⁰C - 900⁰C	Natural Gas, Naphtha
Fertilizer	Steam Methane Reforming	700⁰C - 1000⁰C	Natural Gas

Challenges

Despite its potential, green hydrogen adoption faces several challenges:

- **Efficiency losses:** Green hydrogen production, especially via electrolysis, is less efficient than direct electrification methods such as heat pumps, which can be 4-5 times more efficient, due to energy losses at various stages of the hydrogen lifecycle.
- **Cost and alternatives:** For low-to-medium temperature heating, electrified solutions appear to be more cost-effective than

Table 2: Industrial heat technologies: An overview of efficiency, scale and challenges [5,6,7,8,9]

Heat source	Achievable temperature	Overall efficiency#	Technology maturity	Operational facility (Developer)	Challenges
Low carbon fuels					
Green hydrogen*	~2000 ^{0}C	40-50%	Pilot	H2 Stahl project, Duisburg (Thyssenkrupp)	High production costs, nascent infrastructure, storage & transportation related safety concerns
Bio-derived fuels	~1000 ^{0}C	70-90%	Commercial	Torero project, Gent (ArcelorMittal Steel)	Feedstock availability, nascent supply chain, feedstock price volatility
CO_2- derived fuels (e-methanol, e-methane, di-methyl ether)*	~300 - 1000 ^{0}C	60-70%	Pilot	George Olah facility, Iceland (CRI)	High production cost, low technology readiness
Electrification of heat					
Heat pumps*	~200 ^{0}C	300-400%	Commercial	Aurivo, Ireland (GEA)	Limited temperature range (low-medium), high up-front cost, limited scalability
Resistive heating*	~1800 ^{0}C	95-100%	Commercial	ELROS project, Sweden (Swerim)	Non-uniform heat distribution, frequent maintenance requirement
Zero-carbon heat					
Thermal energy storage	~750 ^{0}C	60-70%	Pilot	ETES pilot plant, Hamburg (Siemens Gamesa RE)	High capex, integration challenges, limited temperature range

** Renewable source of electricity;* # Overall efficiency – calculation covers input source (e.g. electricity, biomass) to final output (e.g. heat)

Notes: CRI: Carbon Recycling International, GEA: Gesellschaft für Engineering und Automation, ELROS: Electrification of Reheating for Sustainable Steel, ETES: Electric Thermal Energy Storage, POSCO: Pohang Iron and Steel Company

green hydrogen-based heating. Additionally, for high-temperature heating, alternative technologies such as biofuels, geothermal, and electric heating could be more viable options, especially in regions without access to cheap renewable energy or existing gas transportation infrastructure.

- **Infrastructure and scalability:** Green hydrogen's widespread adoption depends on significant advancements in production efficiency, storage, transport technologies, and infrastructure development. Without these improvements, hydrogen may remain a niche solution, particularly in regions lacking the necessary infrastructure.

Green hydrogen's journey to transform industrial heating hinges on breakthrough advances in efficiency and scale. While poised to revolutionize sectors like petrochemicals and fertilizers, its wider adoption demands robust infrastructure and cost reductions. Success stories will likely emerge in regions blessed with abundant renewable energy, hydrogen storage and transportation infrastructure, and favourable policies, while other markets may find their low-carbon industrial heating solutions in alternative technologies that better match their local advantages.

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xynteo.com

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Green Hydrogen: Towards a Clear Regulatory Framework

The recently concluded 29th Conference of Parties (COP-29) of the United Nations Framework Convention on Climate Change (UNFCCC) has faced flak and criticism on various aspects, including its failure to address financing for climate mitigation and adaptation meaningfully. Yet, there are a few silver linings, including a pledge on green hydrogen. The pledge underscores the role of green hydrogen as a solution to address energy transition. Zero-emission and low-carbon hydrogen production has a significant role in accelerating the decarbonization of existing hydrogen production from unabated fossil fuels. The pledge sets out the dual challenge of significantly increasing green hydrogen production from one million tonnes annually and reducing the 96 MT of hydrogen currently produced globally from unabated fossil fuels.

Opportunities for India

This presents significant opportunities for India, given the cost efficiency with which India can scale up its green hydrogen production. The potential is not only for India's domestic use of using green hydrogen to reduce carbon emissions, but also to position itself as an exporter of green hydrogen to address the growing global demand.

The National Hydrogen Mission, Green Hydrogen Policy, followed by India's Ministry of New and Renewable Energy's green hydrogen standards and R&D roadmap, provide the building blocks for the development of green hydrogen production and associated technologies. The logical next step is scaling up and implementing green hydrogen projects. This will require a uniform, predictable and stable long-term framework to enable the high-value investments that are critical for the sector.

Creating a Stable Legal Framework

A key issue in this regard is that of legislative competence to create a stable legal framework. As of now, initiatives on green hydrogen are being driven by the Central Government. To ensure legislative clarity, it would be important to maintain a clear distinction between "hydrogen" and "green hydrogen". The reason this is necessary is because hydrogen is a gas, manufactured through and used in industrial processes, and this would fall under "gas and gas works"- an entry in the State List of the Seventh Schedule to the Constitution of India, which vests exclusive legislative competence with states. "Green hydrogen" on the other hand, is clean and sustainable hydrogen produced by using renewable energy to split water to its constituent molecules. Its objective is to meet India's obligations under the UNFCCC. The focus on green hydrogen therefore, has its genesis in ensuring compliance with obligations under international treaties – a power exclusively vested with the Central Government under the Constitution of India. The jurisdiction to address environmental matters falls within the concurrent jurisdiction of both the Centre and states under the constitutional framework.

PNGRB's Role

https://www.nrel.gov/news/

India has existing and rapidly developing infrastructure of natural gas pipeline and gas distribution networks. This can be utilized and be available for transporting green hydrogen through blending with natural gas. In this regard, the Petroleum and Natural Gas Regulatory Board (PNGRB), the statutory regulator established under the PNGRB Act, 2006, recently undertook a study on the feasibility of utilizing the vast network of gas pipelines for carrying green hydrogen.

Since PNGRB already has the jurisdiction and function to regulate the operations, safety and technical standards of natural gas pipelines, it is best placed to create the regulatory framework allowing for blending of hydrogen with natural gas, and enable transportation of natural gas through the natural gas pipelines already developed, as well as those under development and being operationalized. Allowing for such blending and transportation will enable usage of common carrier capacity that may otherwise not be presently utilized. This will be the most efficient manner to create the required framework to enable distribution and availability of green hydrogen.

However, while developing the regulatory framework under PNGRB's jurisdiction, special care should be taken to ensure that the thrust is on light-touch regulations that can enable utilization of natural gas pipelines for transport and distribution of green hydrogen. It would be advisable, for instance, that PNGRB should not regulate tariff for transporting hydrogen, since this is outside its jurisdiction. It would be most efficient to leave this to contractually determined rates between the relevant entities and the authorized pipeline entities whose infrastructure is sought to be utilized.

The recent feasibility study undertaken by PNGRB indicates certain proposed changes to the PNGRB Act to make the former the regulator for hydrogen-related projects. This, however, would be an over-regulation at this point and is not required. Moreover, placing PNGRB as regulator for "hydrogen" projects, as the study proposes, instead of simply creating a distinct framework for "green hydrogen", would result in an unstable regulatory framework, by stepping directly on the exclusive jurisdiction of states. This should be avoided, to ensure there are no protracted legal battles.

Legal Classification

The Central Government should also consider creating a 'regulatory sandbox' framework for green hydrogen projects, that provides regulatory flexibility to entities to implement arrangements for development and operation of green hydrogen projects. A regulatory sandbox is a legal classification that creates a space where participating businesses are not subject to onerous regulations, usually for a limited amount of time, which is linked to the testing period required to assess the viability of the relevant technology or business endeavor. The concept of regulatory sandbox was first introduced by UK Financial Conduct Authority in 2014 in relation to innovative fintech products, services and business models, without incurring all the normal regulatory consequences for engaging in the heavily regulated financial services sector. In India, frameworks to implement regulatory sandboxes have been developed in the financial services and telecommunications sectors.

In respect of green hydrogen projects, a regulatory sandbox is crucial to test not only the viability of specific technologies, but also the nature of 'light-touch' regulations required to mitigate burdensome requirements under a plethora of regulatory requirements, ranging from debt exposure and other Reserve Bank of India (RBI) norms to regulations under labour laws, land laws, environment laws, water usage laws, explosives regulations, transportation regulations, as well as export-import regulations.

Clear, predictable frameworks ultimately will provide the much-needed comfort for long-term investments and boost investor confidence in this sector.

Courtesy:
Piyush Joshi & R.V. Anuradha
Partners at Clarus Law Associates, New Delhi

Pioneering Tomorrow...... contd from pg 18

H2C0

Commercializing Fuel Cell Technology

Led by Santosh Gurunath and Laxmikant Banjarey, H2C0, based in Noida, Uttar Pradesh, was founded in 2019 and is making significant strides in the fuel cell sector with its modular, end-to-end fuel cell systems. The company's innovation addresses key market challenges by offering solutions that achieve lower CAPEX while delivering higher efficiency than conventional systems.

H2C0's systems stand out for their stackable design and ease of integration, making them ideal for various applications from material handling to backup power. The company's technology promises an impressive 25,000-hour lifetime, setting new standards for system reliability and maintenance requirements.

With its first 25 kW system operational in Jhakri, Himachal Pradesh (2024) in India, H2C0 emphasizes indigenization to reduce costs and drive adoption, while targeting the global market to meet the rising demand for low-carbon hydrogen solutions. It envisions transforming the energy landscape by advancing fuel cell technology for sustainable and versatile power generation.

https://h2c0.com/

The Path Forward

These three companies exemplify Energy Leap's commitment to accelerating the clean hydrogen economy through innovation and collaboration. From AqGas's efficient production methods to Gudlyf's advanced storage solutions and H2C0's accessible fuel cell systems, each startup is addressing critical challenges in the hydrogen value chain.

As we continue to support these pioneering companies, we remain focused on our mission to create a sustainable, hydrogen-powered future. The combined innovations of our cohort members are not just advancing technology – they're reshaping the possibilities for clean energy adoption across industries.

For more information about Energy Leap and our initiatives, visit https://xynteo.com/coalitions-programmes/energy-leap/

Energy Leap
WITH xynteo

JOIN ENERGY LEAP WITH XYNTEO

Energy Leap, a platform by Xynteo, aims to accelerate the production and consumption of clean hydrogen in India through technology innovation, commercialisation and deployment.

Are you a leading renewable energy project developer, heavy industrial company, or automotive company looking for technological solutions to produce, transport, utilise clean hydrogen or deploy pilot projects?

Are you a venture capital or private equity investor or project financier, looking for opportunities to invest in clean hydrogen technologies and projects?

Are you a clean hydrogen technology company looking to accelerate your growth through market access and fund raise?

Join us at Energy Leap to accelerate the adoption of clean hydrogen.
Let's connect and explore how we can work together!

WHAT WE DO

- Project Conceptualisation
- Technology Incubation & Acceleration
- Technology Discovery

HOW WE DO IT

- Strategic Partnerships
- Catalytic Funding
- Innovation Challenge

We have discovered 15 clean hydrogen technology companies and are working with several corporates, foundations, investors and eco-system enablers to commercialise these technologies to drive clean hydrogen production and consumption in India.

LEARN MORE

OUR PARTNERS

ankur capital, Cambridge Cleantech, Catapult Energy Systems, IIMA Ventures, nasscom deeptech, RICH Research and Innovation Circle of Hyderabad, T.EN Technip Energies, The Energy Consortium IIT Madras, Transition

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