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India's vision for Green Hydrogen

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Introduction

Green Hydrogen is Hydrogen produced using renewable energy, such as solar or wind power, instead of fossil fuels. In this process water is split into hydrogen and oxygen through electrolysis, using electricity from solar panels or wind turbines. According to standards notified by Govt of India, Hydrogen made this way is considered "green" if the total emissions from the process are very low, not more than 2 kg of CO_2 equivalent for every 1 kg of Hydrogen produced. Green Hydrogen can also be produced by converting biomass (like agricultural waste) into hydrogen, as long as emissions remain below the same limit.

India's energy transition is entering a decisive phase, as the country reduces its dependence on fossil fuels and increases domestic clean energy production. This is in line with its vision of becoming a developed nation by 2047 and achieving Net Zero by 2070. In this transition, Green hydrogen, has emerged as a clean, scalable fuel alternative that can decarbonize hard-to-abate sectors, reduce import dependence on fossil fuels, and support India's goals for energy security and industrial growth. The Indian government launched the National Green Hydrogen Mission (NGHM) in 2023, as an umbrella programme that aims to establish a Green Hydrogen ecosystem and catalyse a systemic response to the opportunities and challenges in this sector. The NGHM is supported by an initial outlay of ₹19,744 crore (around $2.4 billion USD).

The Mission focuses on four key pillars, including policy and regulatory framework, demand creation, research and development & innovation, and enabling infrastructure and ecosystem development — aimed at positioning India as a global hub for green hydrogen production, use, and export. The sector is witnessing significant policy momentum, technological advancement, and industrial participation, with production costs projected to halve from current levels of $3.5-4 per kilogram to approximately $1.6 per kilogram by 2030. The green hydrogen ecosystem in India encompasses the entire value chain, from electrolyser manufacturing to production, storage, transportation, and end-use applications across sectors including fertilizers, refineries, steel, mobility, and shipping. By 2030, the Mission is expected to attract investments exceeding ₹8 lakh crore, generate around 600,000 jobs, reduce fossil

fuel imports by ₹1 lakh crore, and avoid nearly 50 million tonnes of annual greenhouse gas emissions.

Key initiatives under India's National Green Hydrogen Mission includes:

Strategic Interventions for Green Hydrogen Transition (SIGHT) Programme: The Strategic Interventions for Green Hydrogen Transition (SIGHT) Programme is a key financial component of India's National Green Hydrogen Mission, designed to boost domestic manufacturing of electrolysers and production of green hydrogen through production-linked incentives (PLI), with an outlay of ₹17,490 crore, aiming to make India a global hub by supporting R&D, creating Green Hydrogen Hubs, and developing an enabling ecosystem. It's essentially India's PLI scheme for the burgeoning green hydrogen sector, offering incentives for a set period to foster a competitive industry.

Green Hydrogen Hubs: In October 2025, the Ministry of New and Renewable Energy (MNRE) has announced the recognition of three major ports Deendayal Port Authority (Gujarat), V.O. Chidambaranar Port Authority (Tamil Nadu), and Paradip Port Authority (Odisha) as Green Hydrogen Hubs under the NGHM.These coastal gateways will serve as integrated centres for production, consumption, and future export.

Standards, Certification and Safety: Launched in April 2025, the Green Hydrogen Certification Scheme of India (GHCI) provides a national framework to certify hydrogen as "green" by assessing its greenhouse gas emissions across the entire production cycle. The scheme ensures that only hydrogen produced using renewable energy, and within the prescribed emission limits, can be officially labeled as Green Hydrogen. It provides transparency, traceability, and credibility for producers, buyers, and export markets. Under the GHCI, obtaining a 'Final Certificate' is mandatory for any green hydrogen production facility in India that (a) receives subsidies or incentives from the central or state governments, or (b) sells or uses the hydrogen domestically (in India).

Strategic Hydrogen Innovation Partnership (SHIP): The Mission fosters public-private partnerships for R&D through the Strategic Hydrogen Innovation Partnership (SHIP). It is designed to support the development of advanced, globally competitive hydrogen technologies through collaborative research involving Government institutions, industry, and academic organisations. The programme includes the creation of a dedicated R&D fund with contributions from both the Government and industry. Under SHIP, consortium-based research will be encouraged to leverage the strengths of national scientific institutions such as BARC, ISRO, CSIR, IITs, IISc, and other partners. The objective is to drive innovation across the Green Hydrogen value chain and support domestic manufacturing capability.

India's adoption roadmap for Green Hydrogen

India is taking active measures to introduce green hydrogen in key sectors to reduce emissions, supporting domestic manufacturing, and replacing fossil-based hydrogen and feedstock. This includes:

Industrial

Fertilizers: The emphasis remains on replacing fossil-fuel-based feedstocks with Green Ammonia. An auction in 2025 for a long-term supply of green ammonia to fertilizer units, with an aggregate procurement capacity of 7.24 lakh metric tonnes per annum,at a price of ₹55.75 per kg.

Petroleum Refining: The Mission aims at seamlessly facilitating the replacement of fossil-based hydrogen with green hydrogen in refineries, directly reducing the carbon footprint of this essential industry. India's refining sector is emerging as a major early consumer of green hydrogen. Larsen & Toubro, through its clean energy arm, is developing one of India's largest green hydrogen plants to supply Indian Oil Corporation. The plant is designed to produce approximately 10,000 tonnes of green hydrogen annually, replacing grey hydrogen currently used in refinery processes. This long-term offtake arrangement reflects growing industry confidence that green hydrogen can become cost-competitive with supportive policy measures and declining renewable energy prices.

Steel: Five pilot projects have been initiated in collaboration with public and private steel producers to evaluate the use of Green Hydrogen for iron reduction and other process applications. These pilots are designed to assess the technical feasibility, economic viability and safety of hydrogen-

based steelmaking in Indian operating conditions.

Mobility and Transport

Road Transport: In March 2025, five major pilot projects were initiated involving 37 hydrogen vehicle (buses and trucks), and 9 refueling stations across 10 different routes. The vehicles to be deployed for the trial include 15 hydrogen fuel cell-based vehicles and 22 hydrogen internal combustion engine-based vehicles. These pilots include hydrogen fuel cell buses and trucks, along with the development of refuelling stations along selected corridors such as Greater Noida–Delhi–Agra and Ahmedabad–Vadodara–Surat. While still at a demonstration scale, these projects are intended to generate operational data, assess safety and costs, and support future commercial deployment of hydrogen-powered transport in long-haul and heavy-duty segments.

Shipping: A port-based Green Hydrogen Pilot Project was commissioned at V.O. Chidambaranar Port in September 2025, featuring a ₹25 crore, 10 Nm^3/hr facility that will supply green hydrogen for applications such as street lighting and an EV charging station. Equally significant, Deendayal Port Authority, Kandla has commissioned a megawatt-scale, indigenous Green Hydrogen Facility developed at a cost of about ₹13 crore, with an annual production capacity of nearly 140 metric tonnes. Additionally, a ₹42 crore, 750 m^3 Green Methanol Bunkering and Refuelling Facility is being developed to support cleaner maritime operations and establish a Coastal Green Shipping Corridor between Kandla and Tuticorin.

High-Altitude Mobility: NTPC in November 2024 was commissioned the world's highest altitude (3,650 m) Green Hydrogen Mobility Project in Leh, which includes 5 hydrogen intra-city buses and a fuelling station proving the fuel's reliability in extreme conditions. This station shall mitigate the carbon emissions of approx. 350 MT/year and contribute 230 MT/year of pure oxygen into the atmosphere which is equal to planting of approx. 13000 trees.

Private Sector Manufacturing and Off-Grid Projects

Private conglomerates are also advancing large-scale projects aligned with India's clean hydrogen ambitions. Adani New Industries commissioned India's first off-grid 5 MW green hydrogen plant in Gujarat's Kutch region. The project is powered entirely by renewable energy and

serves as a demonstration of integrated production using solar and wind resources. In parallel, companies such as ACME Cleantech Solutions are developing green hydrogen and green ammonia projects across Odisha, Rajasthan, Karnataka, and Tamil Nadu, with a strong focus on exports to international markets.

Hydrogen Use in Inland Water Transport

India has also begun exploring hydrogen applications in inland waterways. The country's first hydrogen fuel cell-powered vessel, often referred to as the National Hydrogen Ship, has been deployed on the Ganga River in Varanasi. The project serves as a proof-of-concept for zero-emission maritime transport and aligns with broader efforts to green inland shipping and tourism. Such initiatives highlight hydrogen's potential beyond industrial use, particularly in niche transport segments where electrification may be challenging.

Key Challenges for implementation of Green Hydrogen projects in India

Infrastructural Hurdles

The inadequate grid buildout and missing last-mile connectivity represent critical barriers to project development. The National Green Hydrogen Mission's 5 million tonnes per year target requires approximately 125 GW of additional renewable energy capacity, but transmission infrastructure has not kept pace. The lack of hydrogen transportation and distribution infrastructure is another significant challenge. Unlike natural gas, which benefits from existing pipeline networks, hydrogen requires dedicated infrastructure due to its unique properties (smaller molecule size, embrittlement effects on certain materials). The development of hydrogen corridors and refueling networks requires coordinated planning and significant capital investment.

Cost-Timeline Factor

Achieving $1.6 per kilogram by 2030 requires several assumptions to materialize: continued decline in renewable energy costs, successful scaling of electrolyser manufacturing, effective utilization of viability gap funding, and supportive regulatory environment. Any delays in these enablers could postpone cost competitiveness and slow market adoption. Grey hydrogen's continued cost advantage, combined with lack of carbon pricing mechanisms in India, means green hydrogen faces an uphill battle in price-sensitive markets. Without mandates or premium pricing mechanisms for green

products, industrial consumers have little economic incentive to switch from cheaper grey hydrogen.

Skill and Workforce Development

The green hydrogen sector requires specialized skills across the value chain, from electrolyser operation and maintenance to safety management and system integration. India faces a shortage of trained personnel in these areas, necessitating significant investment in education and training programs. Universities, technical institutes, and industry needs to collaborate to develop curriculum and training facilities to mitigate this gap.

Safety protocols and standards for hydrogen handling, storage, and transportation need to be established and widely disseminated. The inherent properties of hydrogen (highly flammable, wide flammability range, invisible flame) require careful safety managements.

Water requirement

Green hydrogen production through electrolysis requires significant quantities of water, approximately 9-10 litres of pure water per kg of hydrogen produced. For India's target of 5 million tonnes/year, this translates to approximately 45-50 million tonnes of water annually. In a water-stressed country where many regions face seasonal or chronic water scarcity, this poses important sustainability considerations.

Projected benefits for implementation of Green Hydrogen projects in India

When fully implemented, the National Green Hydrogen Mission is expected to avoid nearly 50 million metric tonnes of greenhouse gas emissions annually by 2030. This represents a significant contribution to India's climate commitments under the Paris Agreement and net-zero target by 2070. Green hydrogen production through renewable-powered electrolysis demonstrates substantially lower carbon footprints compared to conventional methods. Green hydrogen pathways are expected to consistently reduce warming impacts from fossil fuel technologies by over 60% across all time scales, with this benefit exceeding 90% when hydrogen emission rates are maintained below 1%. In India's fertilizer sector, which currently produces approximately 12.5 million tonnes of ammonia annually using grey hydrogen, transitioning to green hydrogen could abate 25-30 million tonnes of CO_2 annually. For the steel industry, which contributes approximately 7% of India's total CO_2

emissions, green hydrogen-based direct reduced iron (DRI) technology offers emission reductions of 85-95% compared to conventional blast furnace routes. The refinery sector, consuming approximately 4-5 million tonnes of hydrogen annually, could reduce emissions by 40-50 million tonnes of CO_2 annually through complete green hydrogen substitution.

Latest developments

India's Green Hydrogen Sector Pushes For Policy Shift in Budget 2026

With Budget 2026 around the corner, India's green hydrogen ecosystem is pushing for a decisive policy shift that can convert early-stage pilots into commercial demand. Industry bodies are lobbying the finance ministry for clear mandates, predictable incentives and lower taxes so that green hydrogen becomes viable not only for big industrial groups but also for MSME suppliers across steel, fertiliser and refinery value chains. The Confederation of Indian Industry (CII) has emerged as the most vocal proponent of demand-side signals, urging the Centre to pair green hydrogen use obligations with targeted fiscal support in the upcoming Budget. In its pre-Budget submission, CII has called for phased mandates in hard-to-abate sectors, backed by subsidies and credit support, arguing that policy clarity can unlock long-term offtake contracts and accelerate investment in domestic electrolyser capacity.

Kandla Port Moves to Hardwire Green Hydrogen into Its Industrial Base

Deendayal Port Authority has signed a memorandum of understanding with Green-Kutch NextGen Pvt. Ltd. to advance the development of a green hydrogen ecosystem at Kandla, aligning the port's long-term strategy with India's National Green Hydrogen Mission. The agreement was formalised during the Vibrant Gujarat Regional Conference in Rajkot, underscoring Gujarat's push to convert renewable ambition into industrial execution. Under the MoU, DPA will lead the development of a dedicated Kutch Green Hydrogen Park, designed around plug-and-play infrastructure. The concept is straightforward and pragmatic: provide ready-to-use land, utilities and interfaces so industry partners can deploy modular green hydrogen production and storage facilities without the friction that has slowed similar projects elsewhere.

Union Minister Pralhad Joshi Announces ₹100 Crore Call for Proposals for Biomass-Based Hydrogen Pilots

Union Minister for New & Renewable Energy Shri Pralhad Joshi said that the National Green Hydrogen Mission

(NGHM) is accelerating India's clean energy shift and creating jobs, attracting investments, and positioning India as a global hub for green hydrogen. Announcing the new initiative, Shri Joshi said the Ministry will invite proposals for pilot projects using biomass and waste materials to produce green hydrogen. A total of ₹100 crore has been allocated for these pilots, in addition to ₹100 crore already sanctioned for start-ups under the Mission. The scheme will be implemented through BIRAC (Biotechnology Industry Research Assistance Council) to encourage participation from industries, start-ups, and research institutions. The Minister further said the initiative would strengthen the innovation ecosystem and demonstrate new, cost-effective technologies capable of accelerating India's hydrogen transition.

India's Hydrogen Age Has Begun: Hardeep Puri

Petroleum and Natural Gas Minister Hardeep Singh Puri on 14 January 2026 announced that "India's Hydrogen Age" has begun, with the country targeting 5 million metric tonnes of green hydrogen production by 2030, which would account for 10 per cent of the global market. He said that the price of green hydrogen is expected to fall below $3 per kg from the current $3.5 per kg. He pointed that under Prime Minister Narendra Modi's leadership, Bharat is building a trusted hydrogen hub — fuelling growth, exports, and a cleaner future. The minister added that around 1 million tonnes per annum (MTPA) of green hydrogen capacity is planned, starting with 42,000 tonnes per annum tenders, which will be scaled up to 170,000 tonnes per annum. In the pilot phase, 37 hydrogen-powered vehicles will be launched along with nine refuelling stations. The minister also noted that 19 companies have been awarded a combined capacity of around 9 lakh tonnes per annum (TPA).

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Non-Traditional Security Centre

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