Strategic Directions for Netherlands–India Joint Initiatives on Green Hydrogen Technologies

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For this task, a Generative AI tool (Copilot, based on GPT-4, June 2024 version) was used to support searching for and summarizing relevant information. The outputs were manually reviewed by experts and adjusted where necessary. The use of this tool has been documented to ensure reproducibility.

Contents

Foreword

The Netherlands and India stand at a pivotal moment in the global energy transition. Both countries have set ambitious climate and development goals, recognising that clean hydrogen will play a central role in decarbonising industry, strengthening energy security, and fostering sustainable economic growth. In this context, collaboration is not only desirable - it is essential.

The Netherlands brings deep expertise in innovation, system integration and hydrogen technologies, guided by its National Technology Strategy themes such as the Energy materials and Process Technologies, etc. India offers scale, rapidly expanding renewable capacity and a strong commitment through its National Green Hydrogen Mission. Together, these complementary strengths create a powerful foundation for long-term cooperation.

This report reflects a shared commitment to translate that potential into concrete action. Developed by TNO with support from RVO and the Netherlands Innovation Network India, it builds on our growing collaboration under Mission Innovation's Clean Hydrogen track and highlights early success stories in joint R&D such as the DST- University of Groningen Hydrogen Valley Fellowship Program, the Horizon EU Biohydrogen proposal involving research institutions and industry players from both countries and the successful innovation mission to India on hydrogen this year. These initiatives have already sparked interests from both sides on joint research, pilots and policy alignments. The report provides an independent, evidence-based assessment of India's evolving green hydrogen landscape and identifies strategic directions for Dutch companies, startups, research institutions and policymakers. The report also incorporates insights from a wide range of experts, stakeholders and financiers, whose perspectives are essential for shaping the next phase of Indo–Dutch engagement.

We hope that this publication will serve as a practical guide for strengthening innovation partnerships, supporting the development of pilot and demonstration projects, and exploring pathways to bankable, impactful collaborations. By working together, the Netherlands and India can accelerate the global hydrogen economy and contribute meaningfully to a more sustainable, resilient future.

We look forward to continued cooperation in the years ahead.

Jan Reint Smit – Innovation Counsellor Embassy of the Kingdom of the Netherlands to India

Executive Summary

The Netherlands and India are at a pivotal juncture in the global energy transition. Both countries recognise green hydrogen as a cornerstone for enhancing energy security, decarbonising industry, and driving sustainable economic growth. This report is commissioned by the Netherlands Enterprise Agency (RVO) and developed by TNO with support from RVO and the Netherlands Innovation Network. It provides a strategic assessment of India's green hydrogen landscape and identifies actionable joint opportunities for Dutch and Indian stakeholders.

Key Context and Purpose

Complementary Strengths: Both countries have complementary strengths; The Netherlands brings advanced innovation, system integration, and expertise in hydrogen technology, while India offers scale, rapid expansion of renewable capacity, and a strong policy commitment through its National Green Hydrogen Mission (NGHM).

Strategic Collaboration: Building on government-to-government MoUs and successful joint R&D initiatives, the partnership could aim to translate potential into concrete action, focusing on technology development, pilot projects, green hydrogen trade corridors and policy alignment.

Main Findings

The Netherlands is a major player in European hydrogen production, transport, and consumption. It has unique strengths in several key areas: large-scale electrolysis technologies, technology scale-up and demonstration, biomass gasification and system integration. A robust innovation ecosystem and transportation infrastructure positions the Netherlands as a gateway for green hydrogen imports into Europe.

India is rapidly advancing toward becoming a global leader in green hydrogen through the National Green Hydrogen Mission (NGHM), which sets an ambitious target of 5 million tonnes of annual green hydrogen capacity by 2030. The NGHM provides production-linked incentives, coordinated state-level support, and a comprehensive certification regime. A key pillar of NGHM is the SIGHT program, which allocates substantial funding to accelerate domestic electrolyser manufacturing and production of green hydrogen/hydrogen derivatives. Individual states are also complementing national efforts with region-specific policies and incentives.

The market's momentum is evident: India's green hydrogen sector reached 1.4 billion USD in 2024 and is projected to soar to 25.3 billion USD by 2033. India is emerging as one of the world's most cost-competitive suppliers of green hydrogen derivatives, with estimated delivered costs of green ammonia to Rotterdam in the range of 710-794 USD per ton of ammonia in 2030, among the lowest globally.

Although India's electrolyser industry is still in its infancy, the SIGHT program is catalysing the development of 3 GW of domestic production capacity. Alkaline technology currently dominates, but there is growing interest in advanced PEM and solid oxide technologies. Companies that can localise supply chains for electrolyser stacks, power electronics, and balance-of-plant components are poised to gain a significant competitive edge. India's commitment to innovation is reflected in the commissioning of diverse green hydrogen pilot projects across the country. Recent financial investment decisions and offtake agreements in green ammonia production are strengthening India's export competitiveness.

India's Green Hydrogen Certification Scheme (GHCI) sets a stringent lifecycle emissions threshold of 2 kg CO_2e per kg H_2. However, differences in certification and regulatory frameworks present hurdles for exports. Harmonising GHCI with the EU's RFNBO framework is therefore essential for enabling seamless cross-border trade and investment. Despite significant progress in developing a green hydrogen ecosystem over the past few years, India faces several challenges, including scaling up production, expanding renewable energy capacity, scaling up technologies, localising supply chains, reducing costs, and developing infrastructure. This study identified joint opportunities for the Netherlands-India and made specific recommendations to leverage the strengths.

Building on this shared ambition, the next phase of the Netherlands–India partnership requires a shift from intent to execution, translating strategic alignment

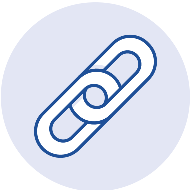
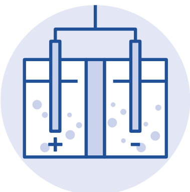
into coordinated action across policy, markets, technology and investment.

This study provides a structured overview on joint opportunities and makes targeted recommendations across five key stakeholder domains; policy and mission, financial & investment, infrastructure & supply chain, R&D & innovation and electrolyser manufacturing (see figure on next pages). The mutually reinforcing opportunities highlighted in this study are:
1) aligning policy and regulation to meet government ambitions;
2) valorising India's green hydrogen targets into bankable projects that reach final investment decision;
3) developing a dedicated India–Netherlands green hydrogen corridor to unlock European demand;
4) accelerating innovation and technology scale-up through joint R&D and centres of excellence; and
5) building resilient supply chains for large-scale electrolyser manufacturing.

Together, these pathways respond directly to the four critical barriers identified (certification, infrastructure, demand certainty and technology transfer). By sequencing policy alignment, project development and industrial scale-up, the framework illustrates how Indo-Dutch cooperation can deliver near-term impact while laying the foundations for long-term leadership in the global hydrogen economy.

The Netherlands-India partnership offers a unique opportunity to accelerate the global hydrogen economy by integrating Dutch technological leadership with Indian scale and ambition. India can benefit from the Netherlands as a gateway to the European market, where there is demand and a higher hydrogen production cost, making it attractive to import sustainable chemicals and fuels. Success will depend on moving beyond MoUs to address regulatory barriers, harmonise standards, and deliver bankable, impactful collaborations across the hydrogen value chain.

Stakeholders	Opportunities and Recommendations
Policy and mission	**Drive collaboration by policy and regulatory alignment to meet governments' ambitions**
	• **Launch annual joint India–EU funded R&D calls across the technology readiness spectrum**: Relevant technology areas of joint R&D calls include low- and zero-iridium/platinum electrolysers; advanced membranes and power electronics; biobased hydrogen production using industrial biotech pathways; low-water/seawater electrolysis suitable for water-scarce India. • Set up an "**India-EU/Netherlands Green Hydrogen Working Group**" for joint strategic planning on policy, industry, R&D and investments . • Promote **multi-stakeholder "hydrogen valleys"** drawing on Dutch cluster development models and Indian regional industrial hubs. • Set up an annual "**India-EU/Netherlands Green Hydrogen Summit**" for joint policy planning, project matchmaking, and dialogue between the public sector, industry, and academia. • **Production and Trade**: Joint incentives by the Netherlands and India for EU/Dutch technology providers to invest in or collaborate with Indian green hydrogen and green ammonia manufacturing facilities.
Financial & Investment	**Valorise the Indian ambition into concrete projects that can reach FID**
	• **Develop Rotterdam-anchored hydrogen export corridors**: Prioritise investment in corridor-enabling assets such as ammonia and methanol export terminals in India, import and cracking facilities, storage and bunkering infrastructure in the Port of Rotterdam, and RFNBO-compliant certification and MRV systems, where revenue models are clearer, and Dutch infrastructure expertise adds strong value. • **Deploy blended finance for first-of-a-kind projects**: Use Dutch public financiers (Invest International, FMO, Atradius), alongside MDBs, to de-risk early pilot and early-commercial hydrogen, ammonia and methanol projects through guarantees, concessional debt and subordinated capital, enabling projects to reach financial close and crowd in private investment. • **Anchor investments in long-term offtake**: Focus on structuring bankable projects around committed offtake in maritime fuels, synthetic fuels and industrial feedstock, leveraging Dutch shipping, port and industrial demand to reduce market risk and accelerate scalable NL–India hydrogen value chains. • **A dedicated Netherlands–India TechBridge** could serve as an execution mechanism to translate promising R&D and pilot concepts into investable projects by combining technical validation, partner matchmaking and early engagement with financiers.

Stakeholders	Opportunities and Recommendations
Infrastructure & supply chain	**Develop a green hydrogen corridor between India and the Netherlands to unlock the European market**
	• Make use of Dutch expertise in the hydrogen industry and infrastructure to accelerate India's infrastructure development. Develop joint projects with a focus on storage solutions, distribution networks, maritime corridors, and the development of engineering and safety standards. • Establish a bilateral Green Hydrogen "**Certification Harmonisation Task Force**" to align India's Green Hydrogen Certification Scheme (GHCS) with the EU's RFNBO framework, facilitating mutual recognition of certificates and smooth cross-border trade. • **Co-develop sectoral standards:** (steel, ammonia, shipping) and MRV platforms using EU digital best practices and Dutch experience with port hydrogen fuels.
R&D & Innovation	**Accelerate the development and scale up of technologies towards innovation**
	• Establish Joint Centre of Excellence(s) by bringing together 1-2 key research facilities in both countries with matching strategic research focus and synergies on hydrogen. • Start one to two R&D projects between technology developers of the Netherlands having advanced PEM and SOE electrolysis capabilities with India's manufacturing players, to drive cost reductions by scale-up and technology optimisation . • Stimulate Knowledge Exchange by conducting staff exchanges, technical trainings, and skills transfer programs for pilot and test facilities.
Electrolyser Manufacturing	**Develop supply chains for large-scale electrolyser manufacturing**
	• Invest in shared validation and audit labs to ensure product traceability and protocol compliance • Electrolyser Manufacturing: Promote co-location of gigafactories by providing incentives for EU/Dutch technology providers to invest in or collaborate with Indian electrolyser manufacturing facilities.

Chapter 1 Green Hydrogen as next phase in Indo-Dutch partnership

Hydrogen is a flexible energy carrier and an essential component for a resilient, climate-neutral energy system [1]. Both the Netherlands and the EU see green hydrogen as a key feedstock and energy source to replace fossil fuels, strengthen energy security, and generate sustainable economic growth [2]. The Netherlands is set to become a major gateway for hydrogen imports into Europe. Because future demand cannot be met domestically, the Netherlands must build strategic partnerships with countries well-positioned to supply and co-develop green hydrogen value chains.

India has rapidly emerged in the clean Hydrogen sector over the last few years. The National Green Hydrogen Mission (NGHM), launched in 2023, signals a strong ambition to become a global hub for renewable energy and green hydrogen [3]. Following India's strong presence at the 2024 & 2025 World Hydrogen Summits, growing EU engagement with India, and a successful Dutch hydrogen innovation mission to India, there is a clear need to consolidate insights and identify where Dutch and Indian interests align. The two countries have already built a solid foundation through multiple government-to-government MoUs, including cooperation on science and technology, renewable energy and green hydrogen [4]. The 2025 Hydrogen Innovation Mission from the Netherlands further strengthened R&D and business connections and underscored the need for a structured understanding of India's fast-evolving hydrogen ecosystem.

The Netherlands and India share a longstanding diplomatic relationship in science, technology and innovation, which has progressively evolved into a focused partnership on the energy transition and, more recently, hydrogen (Figure 1). Since the mid-2000s, structured bilateral dialogue on energy, climate and sustainability (embedded in broader science and technology cooperation) has provided an institutional foundation for trust, knowledge exchange and joint agenda-setting. Throughout the 2010s, this collaboration deepened through renewable energy and clean technology engagement, innovation diplomacy, and trade missions, gradually aligning both countries' strategic interests in decarbonisation and industrial transformation. As hydrogen emerged as a critical vector for net-zero pathways, this existing STI relationship enabled an early shift from exploratory expert exchanges to more formalised policy dialogue and joint analytical work on hydrogen systems and value chains. The signing of the 2024 MoU on Renewable Energy, explicitly including green hydrogen, marked a transition from dialogue to structured cooperation, which has since been reinforced through collaboration with NITI Aayog, targeted innovation missions and high-level trade engagement. Together, these developments position hydrogen not as a standalone topic, but as the next phase in a mature, innovation-driven Indo-Dutch partnership rooted in science, technology, and system-level problem-solving.

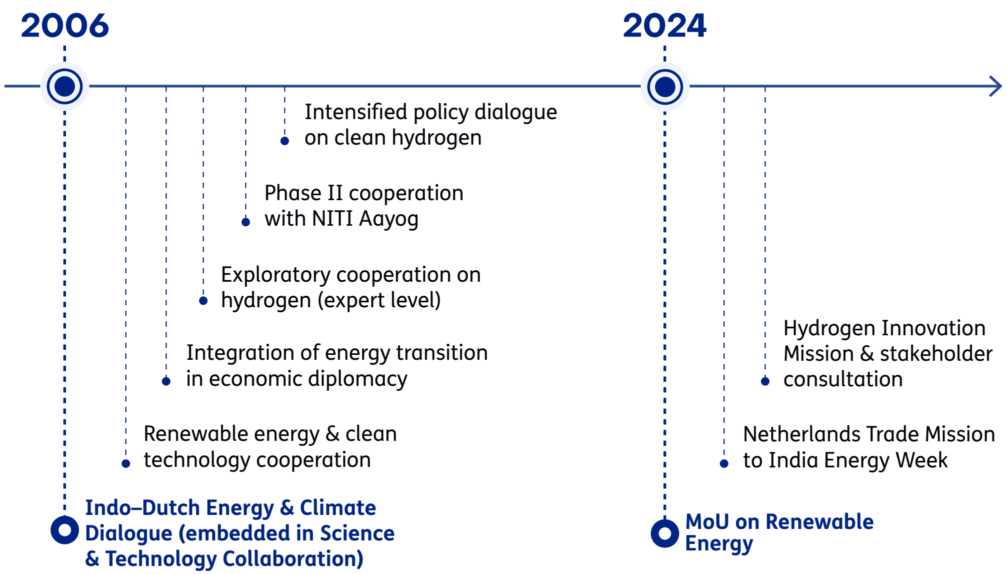


Figure 1. Bilateral collaboration between India and the Netherlands is based on a long-standing diplomatic relationship

This study builds upon the existing diplomatic relationship. It identifies opportunities for Dutch technology developers, companies, start-ups, and research institutes. It examines enabling policies, innovation ecosystems, and financial viability - an aspect repeatedly emphasised by sector experts during the stakeholder consultation meeting in the Hague. Collaboration mechanisms focus on energy and energy transition, covering collaboration on energy and carbon modelling, sustainable energy security, sectoral energy efficiency, natural gas and bioenergy deployment and industrial and transport decarbonisation. Also clean air technologies, hard-to-abate sector transitions, next-generation technologies such as hydrogen and CCUS, carbon pricing mechanisms, and climate finance frameworks are included.

This Phase 1 report lays the groundwork for Phases 2 and 3, which will analyse technology pathways, joint innovation and pilot opportunities, and the realistic long-term potential for trade in hydrogen and its derivatives. The subsequent phases of the study will also assess bankability and financing conditions, including the barriers and enabling factors that determine how initiatives can progress from ideas to pilots and ultimately to investment-ready projects. The findings will also support future Indo–Dutch and EU–India R&D calls, pilot programmes, and market-entry strategies, contributing to long-term bilateral cooperation and concrete economic opportunities.

The primary purpose of this study is to provide a practical and strategic assessment of India’s green hydrogen landscape across production, storage, transport, and end-use.

Chapter 2 Stakeholder Consultation

On 11 November 2025, TNO convened a strategic stakeholder consultation in collaboration with the NIN India and RVO to reflect on the evolving Indo-Dutch hydrogen agenda by bringing together leading experts from industry, academia and government. Contributors such as Jörg Gigler (Energy Innovation NL), Han Feenstra (Ministry of Climate Policy and Green Growth) and Mark-Simon Benjamins (Port of Rotterdam) reaffirmed that India now features prominently in their long-term strategic priorities, driven by its rapidly expanding hydrogen market and the geopolitical relevance of deepened engagement. The Netherlands–India corridor was identified as particularly compelling because it combines India's potential for large-scale, cost-competitive green hydrogen production with the Netherlands' role as a system integrator and gateway to European demand, offering regulatory alignment, diversified offtake access and reduced market risk for early international hydrogen trade. Of the twelve organisations that participated in the 2025 Hydrogen Innovation Mission, nine were represented at the session.

The session validated a shared understanding that the Indo-Dutch collaboration must now move beyond mapping opportunities towards identifying specific opportunities where Dutch expertise delivers genuine strategic added value in India's fast-moving hydrogen landscape. Stakeholders emphasised the opportunities for Dutch parties as an R&D partner or supplier of enabling technologies, such as high-efficiency electrolysers & advanced materials, hydrogen storage solutions, and safety and system-integration capabilities, which align with India's needs for localisation, cost-competitiveness and reduced dependence on critical raw materials. These technologies should support large-scale demonstration and pilot production facilities for hydrogen. Participants also stressed opportunities around **maritime decarbonisation, hydrogen carrier logistics, biomass-to-hydrogen, and hydrogen valley collaborations**.

A key theme emerging from the consultation was the need to integrate financial viability and bankability considerations early in structuring cooperation in a potential export chain

Picture 1. Jorg Gigler (Energy Innovation NL) at the stakeholder consultation on 11 november 2025.

Picture 2. Participants of the stakeholder consultation

toward the Netherlands and North-Western Europe. Discussions underscored that successful Indo-Dutch pilots will depend on clear offtake structures, risk-sharing mechanisms, long-term visibility on hydrogen and ammonia demand, and early engagement with financiers such as FMO, Invest International, Indian development finance institutions, and multilateral development banks. The Dutch stakeholders noted that India's auction schemes, carbon credit mechanisms and state-level hydrogen initiatives already provide partial incentives. Still, bilateral cooperation will be needed to address remaining gaps in project finance, standardisation, and infrastructure readiness for strengthening bilateral opportunities.

Session participants also stated that the Netherlands should position itself through its unique system-level strengths, port and logistics leadership, regulatory expertise, and a strong innovation ecosystem. Several speakers highlighted the importance of comparing and differentiating the Dutch approach from those of other international players (particularly Germany and Denmark), while leveraging the Netherlands' reputation for agility, "polder-style" collaboration, and globally recognised infrastructure capabilities. European partners should collaborate to combine their scale and leverage complementarities.

The consultation session provided direction that the Indo-Dutch hydrogen partnership should prioritise complementary strengths across the value chain, align closely with the Dutch National Technology Strategy (e.g., process technologies, energy materials), and identify concrete technological and market segments where bilateral cooperation is both feasible and mutually beneficial. The insights from the stakeholder consultation will directly shape Phase 2 and Phase 3 of the study and help sharpen the focus on:

1. enabling conditions for bankable pilot and demonstration projects,
2. broadening the scope to hydrogen derivatives,
3. value-chain niches where Dutch capabilities have the highest leverage, and
4. actionable pathways that translate innovation potential into **investable Indo-Dutch projects and long-term cooperation frameworks**.

Chapter 3 Netherlands Green Hydrogen Landscape

The Netherlands positions hydrogen as a strategic enabler of its energy transition. It offers a triple opportunity for the country: large-scale decarbonisation, enhanced energy system flexibility, and sustainable economic growth [1]. The Netherlands aims to lead the global hydrogen transition by combining strong technological capabilities with world-class infrastructure development. With pioneering R&D ecosystems, major initiatives in hydrogen (enabling) innovation, and flagship projects such as PosHYdon and NorthH2, the country is positioning itself at the forefront of hydrogen technology development [5], [6]. The Netherlands is currently both the second-largest hydrogen producer and consumer in Europe, with Dutch industry consuming approximately 1.5 MTPA of hydrogen [7]. European hydrogen demand in 2023 was 7.9 MTPA, rising to 14.9 MTPA in 2030 [6].

The **National Technologies Strategy (NTS)** highlights hydrogen-related innovation as a strategic area by prioritising process technologies and energy materials as domains in which the Netherlands seeks to reinforce technological leadership and accelerate industrial scale-up through coordinated public–private collaboration [8]. Reflecting these priorities, Dutch strengths in the hydrogen field are particularly evident in electrolysis technologies, technology scale-up, large-scale storage solutions, network and port infrastructure, and system integration. The Netherlands also has a strong technological position in biomass gasification and waste-to-hydrogen. It has advanced thermochemical expertise, proven pilot projects, and a mature ecosystem for converting residual streams into hydrogen-rich syngas [9]. The Netherlands' strong position is demonstrated by a diverse, regionally distributed portfolio of hydrogen initiatives across the country, as mapped by TKI Nieuw Gas, ranging from green hydrogen production to infrastructure development, mobility applications, and research pilots. The hydrogen agenda is further enabled by the **GroenvermogenNL programme**, which, backed by €838 million in public funding and over €1 billion in total investment, is driving innovation and deployment across the entire hydrogen value chain.

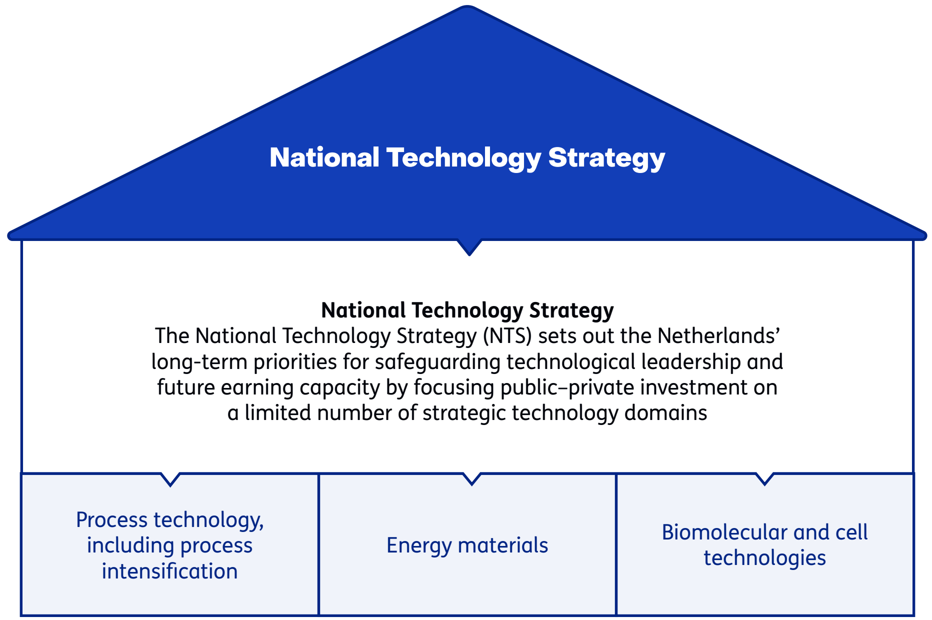


Figure 2. National Technology Strategy supporting hydrogen technology on three topics

At the same time, large-scale infrastructure investments are being made, including the national hydrogen backbone and cross-border integration with Germany, Belgium and the rest of Europe. The national hydrogen backbone has already started construction and includes 1,200 km of dedicated hydrogen pipelines and a HyNetwork (≈1,200 km) and selective repurposing of the natural gas grid for hydrogen transport [7]. The national hydrogen network being developed in the Netherlands is designed to integrate with the broader European Hydrogen Backbone initiative, making the Netherlands a key landing hub and transit route for hydrogen flows into and across Europe [2]. As the Port of Rotterdam already handles energy imports equivalent to 13% of total European energy consumption [10], it plays a central role in international energy trade and positions the Netherlands as a primary gateway for future hydrogen imports into the European market.

Local challenges underscore the need for international collaboration for the Netherlands. These challenges include high energy and feedstock costs, and a shortage of skilled technical labour for manufacturing, installation, and maintenance. Therefore, the Netherlands actively positions itself in global hydrogen diplomacy, having formalised nearly twenty hydrogen-related Memoranda of Understanding (MoUs) with partners ranging from Spain and Portugal to South Africa, Japan, Australia and India (Figure 3). These partnerships are designed to co-develop hydrogen production capacity, port infrastructure, certification frameworks and long-distance supply chains. Beyond MoUs, the Netherlands also operationalises international cooperation through multi-year programmes such as the Partners in Business (PIB) instrument, which supports Dutch industry consortia in developing overseas hydrogen value chains. Recent PIBs focus on creating hydrogen supply corridors and on technology cooperation with Australia, Chile, the Gulf region, and Japan, helping Dutch companies jointly position themselves abroad, organise trade missions, develop project leads, and engage with foreign governments on standards, infrastructure planning, and regulatory alignment. Together, instruments such as PIBs and MoUs with countries enable coordinated international positioning and strengthen the Netherlands' role in shaping emerging global hydrogen markets.

Partners in Business (PIB)	Memoranda of Understanding (MoUs)		
Australia	Australia	Japan	Saudi Arabia
Chili	Canada	Marocco	Spain
Japan	Chile	Namibia	Uruguay
Oman	Denmark	Norway	United Arab Emirates
United Arab Emirates	India	Oman	United States
	Indonesia	Portugal	South Africa

Figure 3. International hydrogen collaborations of the Netherlands

3.1 Dutch Hydrogen Technology Landscape

Large-scale electrolysers
The Netherlands' hydrogen technology landscape is characterised by a dense concentration of leading-edge projects across the full value chain, with several first-of-a-kind (FOAK) demonstrations that showcase Dutch strengths in electrolysis technologies, thermochemical conversion, offshore integration and system design. Industrial-scale electrolysis is a particular area of leadership [9],[11]: projects such as Shell's Holland Hydrogen I (200 MW alkaline), Air Liquide's ELYgator (a world-first hybrid PEM–alkaline 200 MW system), the HyNetherlands 100 MW Phase I project, and Sunfire's MultiPLHY SOEC electrolyser (2.6 MW) at Neste demonstrate Dutch capacity to deploy advanced electrolyser technologies at a significant industrial scale [12], [13], [14], [15]. The Netherlands is also advancing next-generation concepts, including xINTC's CRM-free electrolyser, which addresses dependence on iridium, platinum and other critical materials, an area of high relevance for Indo–Dutch manufacturing collaboration [16]. Offshore system integration is another Dutch strength, illustrated by PosHYdon, the world's first offshore hydrogen pilot integrating a 1 MW PEM electrolyser on an operational gas platform, linking offshore wind, existing gas infrastructure and hydrogen production under real marine conditions [17].

Biomass gasification
The Netherlands is also a frontrunner in biomass gasification and waste-to-hydrogen, building on decades of thermochemical R&D and technology scale-up. Flagship initiatives such as Bio Energy Netherlands (Terneuzen, 50 MW), Bio-TecH_2 (Groningen), and HVC's sewage-to-hydrogen pilots demonstrate advanced conversion of municipal waste, biogenic residues and sludge into hydrogen-rich syngas [9]. These pathways complement

electrolysis by offering decentralised production options aligned with India's waste and biomass valorisation priorities.

Infrastructure & system integration

A third distinctive Dutch capability lies in hydrogen infrastructure and system integration, where the Netherlands benefits from world-class ports, a dense energy network and strong expertise in gas transport. The national backbone project HyNetwork will repurpose major sections of the existing high-pressure gas grid into a dedicated hydrogen network connecting Rotterdam, Amsterdam, Zeeland, Limburg and the Northern Netherlands, with cross-border links to Germany and Belgium [18]. Ports such as Rotterdam and Eemshaven are developing comprehensive import, conversion and storage ecosystems, including ammonia cracking, liquid hydrogen handling and multimodal distribution, supported by projects such as Porthos, H2-Fifty, and the Rotterdam Hydrogen Hub [19]. In the north, the HEAVENN Hydrogen Valley integrates production, distribution and end use, providing one of Europe's most advanced real-world testbeds for full-chain hydrogen system integration [20]. Complementary enabling technologies such as AEG's high-efficiency power electronics, HyET's electrochemical compression, and the Battolyser (a battery–electrolyser hybrid) strengthen Dutch leadership in linking renewable electricity, hydrogen production and industrial demand [9]. Together, these combined capabilities position the Netherlands as one of Europe's most advanced hydrogen technology and infrastructure ecosystems and create a strong basis for Indo–Dutch collaboration in R&D, manufacturing and large-scale pilots.

3.2 Netherlands Hydrogen Valleys

The Netherlands is building a network of integrated hydrogen ecosystems, known as Hydrogen Valleys, to accelerate its energy transition and strengthen European hydrogen infrastructure [5]. Core features of the Dutch Hydrogen Valleys are described in Figure 4. These valleys combine production, storage, distribution, and end-use of hydrogen, with a focus on green and blue hydrogen applications. Out of the six major Dutch Hydrogen Valleys, the flagship project, HEAVENN in the Northern Netherlands, serves as a model for replication [20]. HEAVENN is Europe's first fully integrated Hydrogen Valley, demonstrating large-scale deployment of hydrogen production, storage, distribution, and end-uses. It has over €1 billion in coordinated investments and 30+ sub-projects and provides a replicable governance and technology model for regional hydrogen ecosystem development. In total, the Netherlands has invested over €5 billion in their Hydrogen Valleys. The valley has an emphasis on system integration, public–private collaboration, and cross-border infrastructure planning. It can offer practical lessons for India for scaling its own hydrogen hubs. HEAVENN Valley is also focusing on pathways for industrial demand, developing multimodal mobility applications, and building bankable project pipelines. These topics are directly relevant to India's emerging hydrogen valleys and export ambitions. While HEAVENN is currently the most advanced, other valleys are in various stages of development, forming a future network aimed at creating an export-oriented hydrogen hub for Northwest Europe. Rotterdam Hub leads large-scale projects such as Holland Hydrogen I and ELYgator [19]. The province of Friesland focuses on mobility, the province of Zeeland on chemicals and grid balancing, and the province of Utrecht on shipping and mobility [22], [23]. Together, these valleys aim to create an export-oriented hydrogen hub for Northwest Europe [18].

Table 1. Key Characteristics and Development Status of Major Hydrogen Valleys in the Netherlands (status: 2025)

Valley Location	Key Focus	Scale & Status	Cluster/ Site	Funding (2025)	Key Companies	Reference
Northern Netherlands	Integrated hydrogen chain: production, storage, mobility, aviation, industry	HEAVENN project (EU Hydrogen Valley); ~€1B investments across 30+ projects	Chemie Park Delfzijl, Groningen Airport	€1B EU/regional; €850M future	Gasunie, RWE, Holthausen, SkyNRG, Nouryon, Engie	[20], [21]
Rotterdam / Maasvlakte	Electrolysis, import, pipelines, hydrogen carriers (ammonia, LOHC), fuels for shipping	>2 GW electrolysis planned; 200 MW under construction (Holland Hydrogen I); import terminals and backbone infrastructure	Port of Rotterdam	€1.5B+ incl. hydrogen backbone and pipelines	Shell, Air Liquide, BP, Vopak, Uniper, Gasunie, TenneT	[18], [19]
Zeeland / North Sea Port	Circular hydrogen from waste and biomass, import via port, ammonia, industrial decarbonisation	Bio Energy Netherlands gasification (50 MW), Yara ammonia, Arcelor decarbonisation, H_2 backbone	Terneuzen / Vlissingen	€500M+ (DEI+, EU, regional)	Yara, Ørsted, Arcelor, Gasunie, Bio Energy Netherlands	[22], [23]
Amsterdam / North Sea Canal	Synthetic fuels, e-methanol, import corridor from Oman and Spain	Future Fuels Hub; 100 MW Hemweg electrolyser; links to RIB and national H_2 grid	Port of Amsterdam, Tata Steel, Nouryon	€400M+ regional / private	Nouryon, Tata Steel, Port of Amsterdam, HyCC	[24]
Limburg / Chemelot	Green and blue hydrogen integration in chemicals	HyInfra and HyDelta; pipeline connection to Rotterdam and Germany underway	Chemelot Industrial Park	€500M+ in planning	Chemelot, OCI Nitrogen, TNO, Gasunie, Brightsite	[25]
East Netherlands (Brick Valley)	Hydrogen for ceramics and high-temp industry	Brick Valley program (RVO 2025), industrial pilots with hydrogen kilns	Gelderland / Overijssel	€250M (regional, GroenvermogenNL)	Vandersanden, Strikotherm, regional SMEs	[26]

Core Features of the Netherlands Hydrogen Valleys

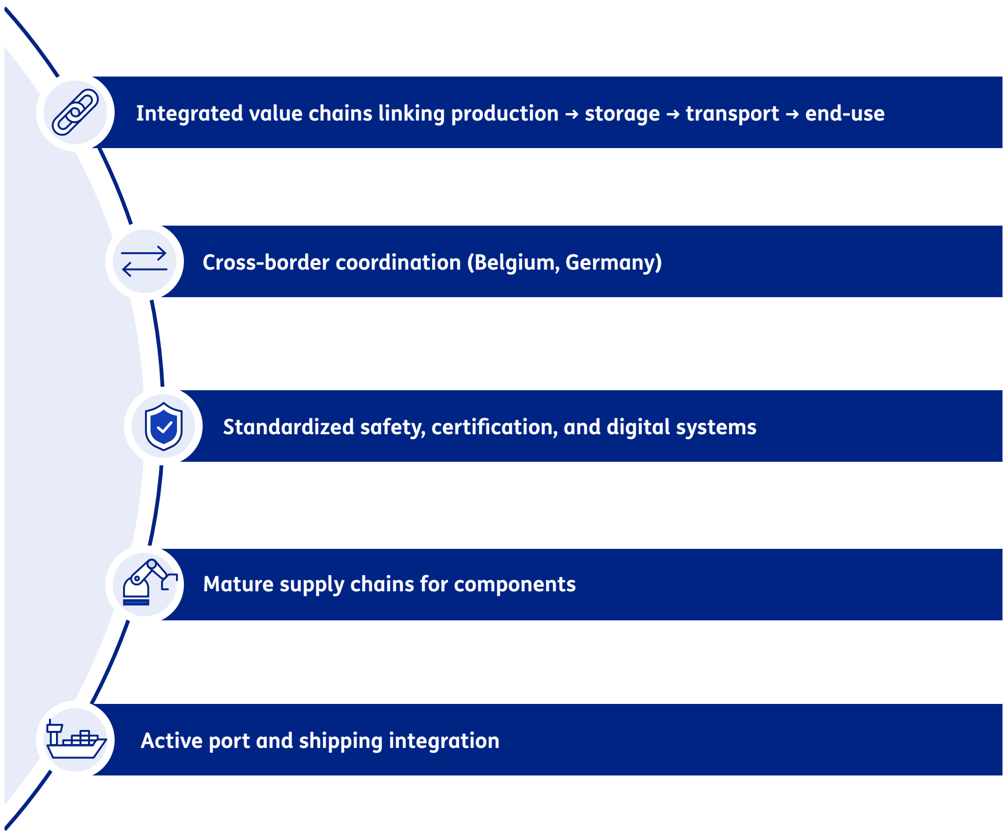


Figure 4. Core features of the Netherlands Hydrogen Valleys

3.3 Policy Landscape

For hydrogen collaboration between India and the Netherlands, Europe's regulatory architecture plays a decisive role in shaping the conditions. Central to this landscape is the Renewable Energy Directive III (RED III) and its Delegated Acts on Renewable Fuels of Non-Biological Origin (RFNBOs) [27]Regulation (EU, [28]. These acts define when hydrogen and its derivatives qualify as renewable for the European market, introducing requirements on additionality, temporal correlation between renewable electricity production and hydrogen generation, and geographical proximity. For any producer outside the EU seeking market access, whether shipping green ammonia, methanol or hydrogen, alignment with RFNBO criteria is essential. These rules are complemented by the emerging EU Hydrogen and Decarbonised Gas Market Package, which introduces a dedicated hydrogen market structure with rules for network access, Guarantees of Origin and future cross-border hydrogen transport [29].

Certification is becoming another cornerstone of international hydrogen trade. While the EU is working toward a harmonised system under RED III, voluntary schemes such as CertifHy, TÜV SÜD CMS 70 and ISO/TC 197 standards currently serve as important benchmarks [30], [31], [32]. These schemes provide the transparency needed for traceability, carbon-intensity accounting and eligibility under European import standards, influencing how international projects are designed from the outset.

At the same time, sector-specific European regulations are creating clear long-term demand for renewable hydrogen and its derivatives. FuelEU Maritime sets progressively stricter greenhouse gas intensity requirements for marine fuels from 2030 onward, strengthening the role of green ammonia, methanol and hydrogen in future bunkering [33] and in particular Article 100 (2). ReFuelEU Aviation follows a similar path by mandating the uptake of Sustainable Aviation Fuels, including synthetic kerosene produced from RFNBO hydrogen and captured CO_2 [34]. These frameworks provide predictable demand signals that shape investment decisions both in Europe and abroad.

The policy landscape is further reinforced by the Carbon Border Adjustment

Mechanism (CBAM), which places a carbon price on imported products such as steel and fertilisers [35]. This creates incentives for producers outside the EU to adopt low-carbon production methods, including the use of green hydrogen in direct-reduction iron (DRI) pathways or ammonia synthesis. As a result, CBAM indirectly strengthens international interest in hydrogen-based decarbonisation solutions.

At the national level, the Dutch Hydrogen Strategy translates European ambitions into concrete action, emphasising large-scale imports, the development of the HyWay27 hydrogen backbone and scaling of domestic electrolysis capacity to 3–4 GW by 2030 [36]. The Netherlands positions itself as a future hydrogen landing hub for Europe, with Rotterdam and Eemshaven central to this vision. Complementary Dutch policy instruments, such as SDE++ for industrial decarbonisation, OWE for large-scale hydrogen production and participation in IPCEI Hydrogen. These policy instruments reinforces its climate and industrial agenda and stimulates technology development and early-scale deployment [37], [38], [39].

3.4 Excelling in Hydrogen: Strategic Insights from the Dutch Hydrogen System

The *Excelling in Hydrogen report* provides a system-level interpretation of why and how the Netherlands is emerging as a leading green hydrogen country, moving beyond a project inventory or technology overview [40]. The report emphasises the green hydrogen transition as a system transformation challenge, in which success depends not on individual technologies but on the coordinated development of production, conversion, transport, storage, end-use markets, and governance. As per the report, the Dutch hydrogen strategy is explicitly shaped by **scarcity conditions**, such as limited space, constrained electricity grids, competing industrial demand, and tight labour markets. This has forced the Netherlands to prioritise **efficient system design, selective hydrogen use and rapid learning through deployment**. As a result, Dutch hydrogen development is characterised by a strong focus on integration across energy carriers, early coupling with industrial demand, and deliberate choices on where hydrogen adds most value relative to electrification or sustainable carbon pathways.

The Netherlands has developed a **distinctive governance and execution model** for green hydrogen economy, built on close public–private coordination, risk-sharing mechanisms and programme-based scaling rather than fragmented project support [40]. Instruments such as large-scale demonstration programmes, coordinated infrastructure planning and targeted innovation funding function as market-creation tools. These instruments enable first-of-a-kind (FOAK) projects to progress despite cost gaps, regulatory and market uncertainty [40]. Dutch green hydrogen projects are intentionally designed as **learning platform**s to generate operational experience, critical cost data and regulatory insights that feed directly into policy refinement and international standard-setting [40]. This feedback loop between technology scale-up, FOAK projects, and policy is presented as a core competitive advantage of the Dutch approach.

From an international perspective, the Netherlands is positioned as a country that **exports system knowledge rather than standalone hardware** [40]. This system knowledge export position is built on several unique Dutch strengths such as value-chain orchestration, infrastructure planning, safety and certification, integration of hydrogen carriers, and alignment with European market rules. These capabilities are particularly relevant for countries that aim to scale hydrogen rapidly and link production to international demand, but face similar challenges around system integration, permitting, financing and market creation.

The Netherlands positions itself as a strategic partner for governments, trade agencies and industry by clearly articulating its hydrogen proposition in international dialogues. Dutch engagement focuses on structuring bilateral cooperation around concrete system challenges and identifying where Dutch expertise adds the greatest value to the international partnerships. Rather than approaching hydrogen as a purely technological race, the Netherlands emphasises its strength in integrating hydrogen into a functioning, investable and internationally connected energy system.

Table 2. Overview and key elements of the Netherlands and EU regulatory and policy

Regulation / Policy Area	Key Elements	Relevance for Indo–Dutch Collaboration
EU Renewable Energy Directive III (RED III) & Delegated Acts on RFNBOs	• Defines when hydrogen and derivatives qualify as renewable • Requirements on additionality, temporal correlation, geographical correlation	• Essential for Indian exporters targeting the EU market • Determines design of renewable electricity sourcing for Indian hydrogen projects • Gatekeeper regulation for market entry
EU Hydrogen & Decarbonised Gas Market Package	• Establishes dedicated EU hydrogen market structure • Rules for network access, tariffing and unbundling • Guarantees of Origin (GO) framework	• Shapes future cross-border hydrogen trade via the Netherlands • Requires alignment of Indian production with EU GO and documentation standards
Hydrogen Certification Schemes (CertifHy, TÜV SÜD CMS 70, ISO/TC 197)	• Current voluntary standards until EU-wide system fully harmonised • Provides traceability and carbon-intensity accounting	• Early adoption helps Indian producers meet EU import requirements • Influences design of Indo–Dutch pilots and early commercial projects
FuelEU Maritime	• Progressive GHG intensity reduction for marine fuels from 2030 • Incentivises green ammonia, methanol and hydrogen bunkering	• Drives demand for renewable fuels at Dutch ports • Enables India–Netherlands green shipping corridors, collaboration on ship manufacturing sector
ReFuelEU Aviation	• Mandates uptake of Sustainable Aviation Fuels (SAF) • Includes synthetic kerosene from RFNBO hydrogen and captured CO_2	• Creates demand for synthetic fuels imported through the Netherlands • Opportunity for Indian RFNBO–SAF value chain development
Carbon Border Adjustment Mechanism (CBAM)	• Applies carbon pricing to imports (steel, fertilisers, etc.) • Encourages low-carbon production pathways	• Incentivises Indian industry to adopt green hydrogen for steel (DRI) and ammonia • Indirectly increases Indian interest in hydrogen-based decarbonisation
Dutch Hydrogen Strategy	• Focus on large-scale hydrogen imports • Development of HyWay27 national hydrogen backbone • 3–4 GW domestic electrolysis by 2030	• Positions the Netherlands as Europe's hydrogen landing hub (Rotterdam, Eemshaven) • Creates strong commercial links with Indian suppliers
Dutch Policy Instruments (SDE++, IPCEI Hydrogen)	• Industrial decarbonisation subsidies • Support for first-of-a-kind hydrogen projects	• Enables early-stage Indo–Dutch pilots and technology deployment • Supports Dutch companies entering India-backed projects
Dutch National Technologies Strategy (NTS)	• Prioritises technologies relevant to hydrogen: process technologies, energy materials, biomolecular technologies	• Guides Indo–Dutch R&D alignment • Helps identify priority domains for joint innovation and research projects

3.5 Summary of Dutch Strengths and Offerings

The Netherlands has one of Europe's most advanced hydrogen ecosystems with strong technological capabilities with world-class energy and port infrastructure. The Netherlands hosts a dense portfolio of electrolysis, biomass-to-hydrogen and system-integration projects, supported by leading R&D institutions and flagship demonstrations such as PosHYdon, NorthH2 and Holland Hydrogen I. Dutch innovation strengths are particularly evident in large-scale electrolysis, thermochemical conversion, power electronics, hydrogen storage, offshore integration and system-wide optimisation. These capabilities are reinforced by national programmes such as GroenvermogenNL and the priorities set out in the National Technologies Strategy. With Rotterdam serving as a major global energy gateway and the national hydrogen backbone progressing towards European integration, the Netherlands is positioning itself as a key import and transit hub for clean hydrogen. It is also building a strong testing infrastructure. These combined assets create a strong offering for India across technology co-development, manufacturing cooperation, certification and standards alignment, and the development of port-based hydrogen and ammonia supply chains.

Large-scale electrolysis projects

The Netherlands is home to some of Europe's most advanced large-scale electrolysis developments, including multiple 200–250 MW plants already in progress and multi-GW expansion pathways across industrial clusters. These early flagship projects position the country as a frontrunner in commercial-scale green hydrogen production.

Biomass gasification

With decades of experience in waste-to-energy and advanced biomass conversion, the Netherlands is a leader in biomass gasification technologies. These capabilities enable renewable hydrogen and circular carbon streams, supporting pathways for bio-based hydrogen, green chemicals, and negative-emission fuels.

System integration

The Dutch energy ecosystem excels in integrating electricity, hydrogen, heat, and CO_2 networks. Supported by world-class research institutes and dense industrial clusters, the Netherlands provides a living laboratory for end-to-end system integration—from offshore wind to hydrogen production, storage, distribution, and industrial offtake.

Hydrogen backbone

Rotterdam harbor connects directly to the European pipeline backbone, enabling large-scale green hydrogen import and export, securing continental supply. This link integrates industrial clusters to accelerate decarbonization and provides cross-border access to Germany and Belgium, creating a unified European hydrogen network.

Handling 13 percent of EU energy imports

As Europe's energy gateway, Dutch ports handle roughly 13 percent of all EU energy imports. Combined with deep-water terminals, large tank storage capacity, and strong logistical expertise, the Netherlands is ideally positioned to become a major hub for global hydrogen and hydrogen-derivative trade.

Figure 5. Summary of Dutch strengths and offerings

Chapter 4 India Green Hydrogen Landscape

4.1 India green hydrogen ambition

India is emerging as a global player in green hydrogen, driven by ambitious policy frameworks, cost competitiveness, and industrial demand. The National Green Hydrogen Mission (NGHM), launched in 2023, provides a robust foundation through production-linked incentives, state-level support, and a certification regime [41]. India's competitive advantage lies in its low renewable energy costs, large industrial base, and strategic port infrastructure. These strengths position it as a key potential exporter of green hydrogen derivatives and Liquid Organic Hydrogen Carrier (LOHC) to Europe and the Asia-Pacific [42].

Market size and growth outlook

India's hydrogen demand and production are set to nearly double by FY 2030, from ~5.6 MTPA in FY 2020 to ~12 MTPA in FY 2030, led primarily by its core hydrogen-consuming sectors. India's captive grey hydrogen market is estimated at approximately USD 8.5-10 billion, based on production costs of USD 1.5-1.8 per kg [43]. India's green hydrogen market reached USD 1.4 billion in 2024 and is projected to grow to USD 25.3 billion by 2033, a compound annual growth rate (CAGR) of 39.5% [44]. Total hydrogen consumption is expected to increase from ~5.6 million tonnes in 2020 to 30 million tonnes by 2050, with green hydrogen projected to have a significant share [45]. India is emerging as one of the world's most cost-competitive suppliers of green hydrogen derivatives, with estimated delivered costs of green ammonia to Rotterdam in the range of USD 710-794 per ton ammonia, 2030, which is among the lowest globally [46].

In 2024, global hydrogen demand increased to almost 100 million tonnes (Mt) up 2% from 2023 and in line with overall energy demand growth. Global hydrogen demand remains concentrated in traditional uses: oil refining, chemical manufacturing (notably ammonia and methanol production), and steel making [2]. Demand for new applications accounts for less than 1% of global hydrogen demand and is driven by hydrogen use in biofuel production [2]. Low-emissions hydrogen (or green hydrogen) production is set to reach 4.2 Mtpa by 2030, a fivefold increase from 2024 levels. According to the IEA, the total volume of green hydrogen covered by offtake agreements reached more than 6 Mt at the end of 2024, with only 25% of them being firm offtakes. The majority of firm offtakes are for the subsequent production of hydrogen-derived products (e.g. ammonia) and in existing uses like refining, rather than the direct end-use of hydrogen [2]. Ammonia is the largest offtake vector, accounting for approximately 43% of all binding offtake capacity [47].

India aims for a hydrogen production cost of ₹89/kg (~1.07 USD/kg) by 2030 [48] with green ammonia as a primary export vector. India's landed cost of green ammonia to Europe is projected to be among the lowest globally by 2030, with SECI tender prices at 570–625 USD/ton [49]. This is comparable to Chile and Brazil, despite India's longer shipping routes, due to India's low renewable energy and electrolyser costs [48]. This positions India as a leading, cost-competitive supplier for European and East Asian markets. The price discoveries at the recent auctions from Solar Energy Corporation of India (SECI) validate India's cost advantage, with ACME Cleantech winning the first green ammonia auction at ₹55.75/kg (~0,62 USD/kg) for fertiliser supply- a historic low setting a new global benchmark [50].

Strong regulatory push with the India National Green Hydrogen Mission (NGHM)

The National Green Hydrogen Mission (NGHM) was launched by the Ministry of New and Renewable Energy (MNRE) to position India as a global hub for the production, consumption, and export of green hydrogen and its derivatives. **NGHM aims for 5 million tonnes per year of hydrogen capacity by 2030, with 862,000 tonnes per year already allocated to 19 companies** [51]. Its core components include demand creation through domestic consumption mandates, export facilitation, competitive bidding mechanisms, and a certification framework for renewable-based hydrogen. A significant intervention under the mission is the Strategic Interventions for Green Hydrogen Transition (SIGHT) program. The SIGHT scheme allocates ₹17,490 crore (~ **2.4 billion USD**) via two components: production-linked incentives (PLI) for electrolyser manufacturing and production-linked incentives (PLI) for green hydrogen production. For green hydrogen producers, direct financial support per kg of green hydrogen produced is provided at ₹50/kg (~0.55 USD/kg in Year 1), ₹40/kg

(~0.44 USD/kg in Year 2), and ₹30/kg (~0.33 USD/kg in Year 3).

Additional initiatives include pilot projects in low-carbon steel, mobility, and shipping, as well as the development of at least two green hydrogen hubs. Policy support measures such as transmission charge waivers, infrastructure development for storage and transport, harmonised regulations, and alignment with international standards have also been initiated. The mission also puts emphasis on research and development through the Strategic Hydrogen Innovation Partnership (SHIP), skill development programs, and global cooperation.

The vision and objectives of NGHM are the following:

- Transform India into a global hub for production, consumption, and export of green hydrogen and its derivatives by 2030.
- Facilitate India's energy transition, aligning with the COP26 commitment of net zero by 2070.
- Promote clean industrial development and reduce reliance on fossil fuels.

Figure 6. National Green Hydrogen Mission (NGHM): Mission Objectives and Mission Comments

The NGHM's strategic importance is that it:

- Leverages India's abundant renewable resources (solar, wind) for zero-emission hydrogen.
- Positions India as a major clean energy exporter.
- Enhances energy security and industrial competitiveness.
- Enables large-scale decarbonization of hard-to-abate sectors.

4.2 Sustainable Hydrogen Technology Landscape

In the financial year 2025-2026, NGHM's dedicated R&D scheme has allocated ₹400 crore (~45 million USD) to research and develop sustainable hydrogen technologies [52]. In the first round, 23 projects were awarded, covering safety and integration, hydrogen production from biomass, hydrogen applications, and hydrogen production from electrolysis [52]. Leading academic and applied research institutes (IITs, IISERs, CSIR labs) and industry partners are, or will be, implementing these projects. A second round of R&D proposals opened in July 2025. In September 2025, the government launched a separate ₹100 crore (~11 million USD) call for proposals specifically targeting start-ups. The call provides a grant up to ₹5 crore (~0.56 million USD) per project for innovative pilot projects in hydrogen production, storage, transport, and utilisation technologies [53]. To support R&D collaborations, the inaugural Green Hydrogen R&D conference was launched in September 2025, where 25 start-ups showcased innovations on electrolyser manufacturing, AI-driven optimisation and biological hydrogen solutions [54]. International collaboration is expanding under the EU-India Trade and Technology Council. In the recent joint EU-India call on waste-to-renewable hydrogen close to 30 joint proposals were received on hydrogen production from waste [55].

Despite having strong research potential, the transition from pilot projects (Technology Readiness Levels 4-7) to large-scale commercial deployment in India remains limited [56]. Several R&D and supply chain gaps still need to be addressed, such as 1) developing alternatives to scarce materials like iridium, platinum, and zirconia, 2) increasing investment in electrolyser testing facilities with standardised test methods for optimization of indigenous designs both for mature technology options such as alkaline and for next generation designs for PEM and solid-oxide electrolysers, 3) coordination with Ministry of Mines to develop resilient supply chains for critical minerals 4) harmonization of certification standards with EU RFNBO requirements and 5) implementation of hydrogen-specific Harmonised System codes (HS codes) for accelerating technology deployment through standardization and for monitoring component imports [56].

Enhanced industry-academic collaboration in green hydrogen research could accelerate innovation and commercialisation. To transform industry-academic collaboration for practical impact, an organised, interdisciplinary, and problem-driven ecosystem is necessary. Significant chances for industry-academia cooperation include:

- **Electrolyser Testing Facilities**: Setting up standardised testing to confirm effectiveness and foster industry trust.
- **Closing TRL Gaps**: Assist high-TRL initiatives and separate the schedules of academia and industry. Transition from lab-scale (TRL 3) to commercial deployment (TRL 7+) by using structured pathways, pilot demonstrations, and funding.
- **Industry-aligned Research**: Aligning academic research with industry challenges to guarantee interdisciplinary research, technology transfer, and industry-need-based, market-ready solutions.
- **Tri-Party Collaboration**: Priorities and commercialisation strategies should be jointly established by industry, academia, and policymakers.

Green Hydrogen Pilots

India's green hydrogen ecosystem has progressed rapidly under the NGHM with several pilot projects commissioned across diverse regions and applications. Table 2 summarises the key attributes of these pilots. The first operational milestone was achieved in 2022 when Oil India Limited commissioned India's first pure green hydrogen plant in Assam using AEM electrolysis. In 2023, NTPC launched the country's first green hydrogen blending project in Gujarat, integrating PEM electrolysis with floating solar for PNG networks. In the same year, ACME also commenced operations of its integrated green hydrogen and ammonia facility in Bikaner, Rajasthan. Adani Total Gas also initiated a hydrogen-blending pilot in Ahmedabad in 2023-2024. In 2025, BPCL and Cochin International Airport Limited (CIAL) commissioned an airport-based hydrogen plant for road mobility applications. Further, in 2025, the Adani Group also launched its 5 MW off-grid green hydrogen pilot in Kutch, Gujarat, featuring renewable integration and battery storage.

Electrolyser Manufacturing Under SIGHT Scheme

India's electrolyser manufacturing industry is currently in the nascent stage of development [52]. In order to accelerate domestic capacity and reduce reliance on imported electrolysers, the Government of India has introduced the SIGHT program under the NGHM (Solar Energy Corporation of India Limited, n.d.). The SIGHT scheme provides financial incentives to support the establishment of 3 GW of indigenous electrolyser production capacity. The primary objectives of SIGHT are to mitigate risks for early manufacturers and ensure economic viability for initial market participants.

Table 3. Summary of India's green hydrogen pilots (non-exhaustive list; status as of 2025)

Project Name / Partner	Location	Capacity	Technology	Main Application / Target Use	Commissioned Year
Oil India Limited [57]	Assam	10 kg/day (expandable to 30 kg/day)	AEM Electrolysis	Industrial supply, research & demo	2022
NTPC Kawas [58]	Surat, Gujarat	1 MW	PEM Electrolysis	PNG blending for households	2023
ACME Bikaner [59]	Bikaner, Rajasthan	500 Nm³/hr (~1.07 t/day)	Renewable-coupled Alkaline Electrolysis	Green ammonia & industry	2023
National Institute of Solar Energy [60]	Gurugram, Haryana	10 Nm³/hr (650 kg/month)	Solar-powered Electrolysis	R&D pilot	2024
SJVN Nathpa Jhakri [61]	Himachal Pradesh	14 kg/day	Alkaline Electrolysis + Fuel Cell	Combined heat and power (CHP)/grid; for High Velocity Oxygen Fuel (HVOF) coating facility	2024
Adani Total Gas/ TotalEnergies [62]	Ahmedabad, Gujarat	PEM/Alkaline, Solar	PEM Electrolysis; Up to 8% H_2 blend for 4,000+ PNG users	City gas blending pilot, emission reduction	2024
BPCL & CIAL Cochin Airport [63]	Kochi, Kerala	1 MW (~200 kg/day)	Alkaline Electrolysis	Airport mobility & buses	2025
Adani Group/ Adani New Industries [64]	Kutch, Gujarat	5 MW (off-grid), fully solar	5 MW Alkaline, Solar will be integrated with a Battery Energy Storage System	Off-grid hydrogen production	2025

SIGHT Scheme Specific Objectives

- Maximize the indigenous electrolyser manufacturing capacity
- Achieving lower levelized cost of Hydrogen production
- Ensuring globally competitive performance and quality of products
- Progressively enhancing domestic value addition

Figure 7. Specific objectives of the SIGHT scheme

To ensure technology diversity and promote domestic innovation, Solar Energy Corporation of India (SECI) structured the Tranche-I & II (1,500 MW each) electrolyser manufacturing allocations into three distinct buckets.

Table 4. Key elements of the three SIGHT scheme buckets

Bucket	Capacity	Bid Range	Technology Requirement	Purpose
Bucket 1	1100 MW	100–300 MW	Any stack technology	Large-scale manufacturing using proven technologies
Bucket 2A	300 MW	100–300 MW	Indigenously developed stack technology	Promote domestic innovation and reduce imports
Bucket 2B	100 MW	10–30 MW	Domestically developed stack technology	Support smaller, niche players and R&D initiatives

The current allocations under the SIGHT scheme (Tranche-I and Tranche-II), a combined capacity of approximately 3 GW, have been awarded to 21 companies [52]. Leading industry players, including Reliance, L&T, Adani, Waaree, Greenko and Ohmium have secured significant capacities to establish electrolyser manufacturing facilities in India (Figure 8). These allocations are dominated by Alkaline (~89% of total capacity), with PEM accounting for ~9.5%. Emerging electrolyser technologies such as Solid Oxide electrolysers and membrane-less electrolysers have a minimal share. All winners of Tranche-I and Tranche-II have received Letters of Award (LoAs) and are required to set up manufacturing facilities within 30 months of LoA issuance. The scheme guidelines mandate that construction should begin soon after LoA to meet the Scheduled Commissioning Date (SCD), 2026 for Tranche-I and 2027 for Tranche-II.

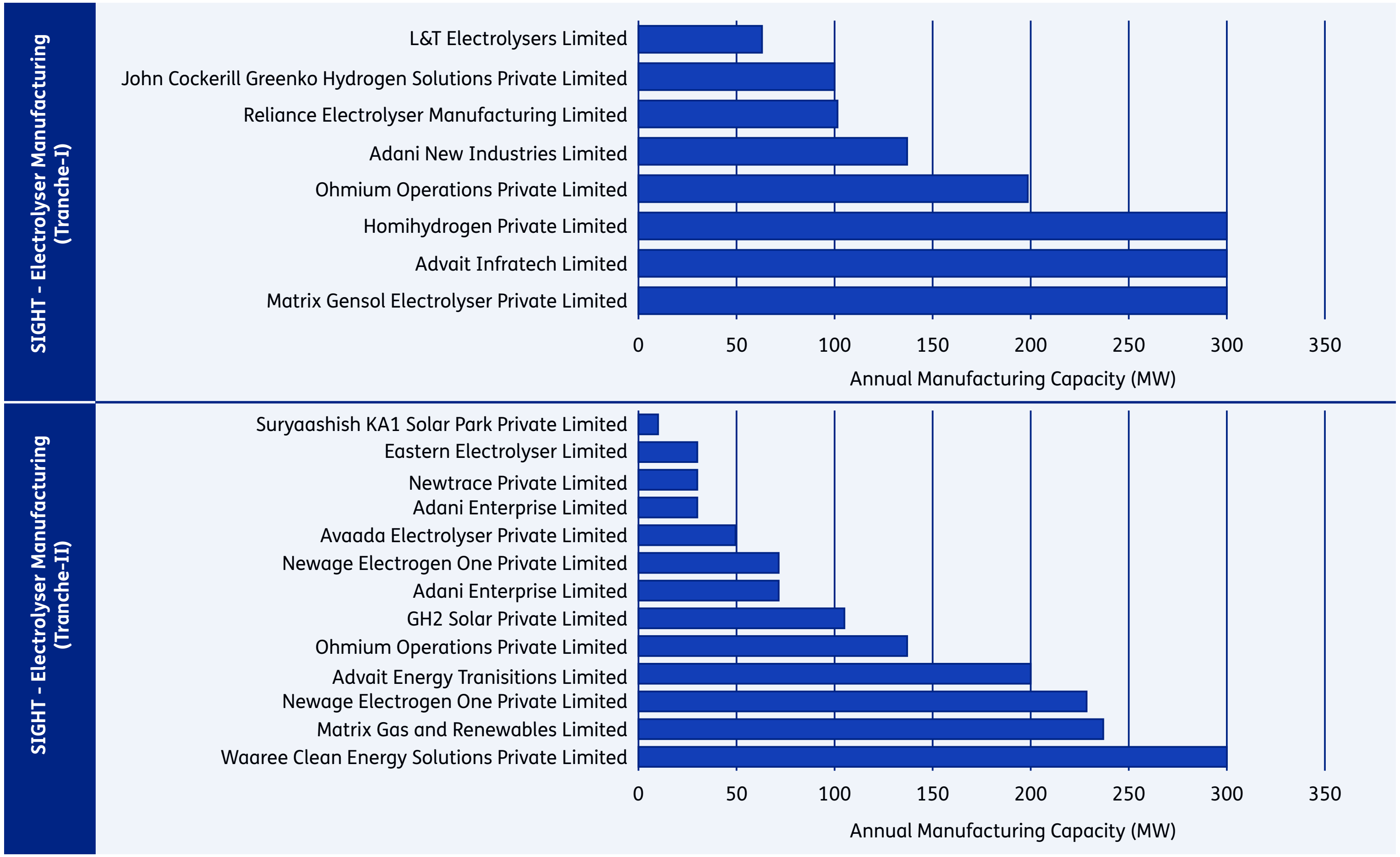


Figure 8. SIGHT scheme electrolyser manufacturing capacity allocations

Technology Insights from SIGHT Allocations

Dominance of Alkaline Electrolyser Technology: The majority of allocated capacity is for Alkaline electrolysers, reflecting the SIGHT scheme's design (Bucket I) and indicating strong industry confidence in this mature, cost-effective technology. Alkaline systems are well-suited for large-scale hydrogen production due to lower capital costs and proven reliability.

Emerging Role of PEM Electrolysers: Companies like Ohmium have secured allocations for PEM (Proton Exchange Membrane) technology, which offers higher efficiency and better integration with variable renewable energy sources.

Capacity Allocations and Infrastructure Development
India's regulatory landscape includes open competitive auctions for green hydrogen/ammonia capacity, renewable energy decoupling, environmental and quality standards, infrastructure priority, and export incentives. As of August 2025, India has awarded 862,000 tonnes per annum (TPA) of green hydrogen production capacity under the National Green Hydrogen Mission (NGHM) tender process [65],[43]. 3,000 MW of electrolyser manufacturing capacity has also been allocated to 15 companies to scale domestic production infrastructure. These allocations represent a significant acceleration compared to the minimal commissioned capacity in 2024, which consisted primarily of pilot projects below 0.01 MTPA [66].

India's state-owned refineries are accelerating green hydrogen adoption through projects collectively valued at USD ~23 billion under the NGHM. Recent tenders secured ~42,000 tonnes of renewable hydrogen per year. Indian Oil Corporation (IOC) is leading in the initial tenders with a 10,000-tonne-per-year plant at Panipat, which is scheduled for commissioning by December 2027.

Table 5. Green hydrogen tenders by Indian state-owned refineries

Refinery / PSU	Tender Details	Capacity In TPA	Status (2025)	Reference
Indian Oil Corporation (IOCL)	Supply of green hydrogen to Panipat Refinery under the Build-Own-Operate model	10,000	Awarded project; project under development	[67]
Hindustan Petroleum Corp. Ltd (HPCL)	Annual supply of green hydrogen to Visakhamptan Refinery	5,000	Project awarded to Ocior Energy in 2025 and is under development under a build, own, and operate model.	[68]
Bharat Petroleum Corp. Ltd (BPCL)	Supply of green hydrogen to Mumbai, Kochi & Bina Refineries	5,000	Likely under technical evaluation	[69]
Mangalore Refinery & Petrochemicals Ltd (MRPL)	Procurement of gaseous green hydrogen on BOO basis	10,000	Evaluation phase; award pending	[69]
Numaligarh Refinery Ltd (NRL)	Installation of green hydrogen generation unit on BOO basis	10,000	Evaluation phase; award pending	[69]

In order to ensure demand, the Solar Energy Corporation of India (SECI) released a tender in 2024 for the supply of renewable ammonia (NH3) to 13 fertiliser plants that had been pre-selected. After using a reverse auction process to evaluate the bids, SECI awarded contracts in the range of ₹55.75-64.74/kg NH3 (~580-750 USD/t NH3) [64].

The integration of green hydrogen into large-scale refineries signals a preference for decarbonising the refining & petrochemical sectors, leveraging the industry's existing expertise and overcoming lower technology integration barriers. Green ammonia projects strengthen India's export competitiveness in the emerging hydrogen corridors. The tender activity's scale indicates strong policy alignment and private-sector confidence, creating opportunities for technology providers, electrolyser manufacturers, and renewable energy developers.

4.3 India Hydrogen Valley Program

India's hydrogen valley program is a multi-phase initiative under the NGHM aimed at developing local hydrogen ecosystems called "Hydrogen Valley Innovation Clusters" (HVICs) [70]. The program focuses on establishing integrated hydrogen value chains—from production to end use—to accelerate green hydrogen deployment across the industry, energy, and mobility sectors with a goal for market readiness by 2030. The Ministry of New and Renewable Energy (MNRE) has launched four flagship HVICs located in Pune (Maharashtra), Kerala, Bhubaneswar (Odisha), and Jodhpur (Rajasthan). These clusters will serve as geographically concentrated test beds promoting R&D, innovation, and standards development.

The program has a phased roadmap:
- Activation (2023–2027): Set up pilot projects.
- Upscaling (2028–2033): Broaden techno-economic models and market linkages.
- Market uptake (2034–2050): Enable widespread adoption.

Program Structure and Funding: MNRE has allocated ~7.8 million USD as the first tranche of central financial assistance to four hydrogen valley clusters. Total project costs for all four valleys amount to ~56 million USD, of which ~USD36 million USD is committed by lead institutions and industrial partners, with the remainder supplied by MNRE's dedicated CFA program. Funding is distributed to dedicated project companies in each cluster following rigorous appraisal by the MNRE's Project Appraisal Committee and in accordance with central guidelines.

Pune Hydrogen Valley (CSIR-NCL): Focuses on leveraging its existing chemicals and industrial base for hydrogen production and application with a strong orientation toward industrial, mobility, and advanced laboratory R&D initiatives.

Kerala Valley (ANERT): Integrates hydrogen production into maritime applications (hydrogen-powered boats, buses), export corridors, and the state energy mix. It's recognised internationally for rapid pilots and public-private partnerships, with links to the World Economic Forum and global hydrogen networks.

Bhubaneswar Valley (IIT Bhubaneswar): Prioritizes decarbonizing fertilizer production, coal-to-hydrogen blending, and integrating hydrogen in grid/industrial parks and is focused on leveraging Odisha's industrial ecosystem.

Jodhpur Valley (IIT Jodhpur): Specializes in distributed hydrogen from solar electrolysis, aiming to exploit Rajasthan's desert solar resources for cheap, decentralized hydrogen. It's focus is on early-stage pilots on grid storage and local industry integration.

Table 6. Hydrogen Valleys in India with sectoral focus, integration features and challenges addressed.

Cluster	Lead Institution	Central Funding (USD M)	Sectoral Focus	Early Pilots	Sectoral Integration Features	Challenges Addressed by the Hydrogen Valley
Pune	**CSIR-National Chemical Lab**	~2.0	Industry, Mobility, R&D	Yes	Focus on decarbonizing chemical value chains and enabling clean transport	Technology validation, demand scaling, infrastructure limits
Kerala	**ANERT (Govt. of Kerala)**	~2.4	Energy, Maritime, Export	Yes	Strong emphasis on hydrogen for water transport, state shipping, and international export	Water/renewable optimization, workforce scaling
Bhubaneswar	**IIT Bhubaneswar**	~1.7	Fertilizer, heavy industry	Planned	Targeted decarbonization for fertilizer sector, with grid and coal-to-hydrogen blending	Coal transition challenges, industrial integration
Jodhpur	**IIT Jodhpur**	~1.6	Distributed Solar, Grid	Research	Primary focus on renewable-powered distributed hydrogen generation for local use	Storage, grid integration, tech readiness

4.4 Policy

State-level Incentive Ecosystem

State-level policies complement the NGHM by addressing region-specific challenges and opportunities. Several states are working to position themselves as key players in India's green hydrogen transition by offering incentives, promoting industrial applications, and investing in research and infrastructure. Several states have announced targeted strategies to promote green hydrogen production, infrastructure development, and sectoral adoption. These policies focus on leveraging regional strengths, ensuring energy security, and establishing India as a global leader in GH_2 production [56].

A Council on Energy, Environment and Water (CEEW) study estimates potential state-level support at INR 5.05 lakh crore (USD 61 billion)—26 times the NGHM's central budget—through power-related and non-power-related incentives [42]. Seven states—Odisha, Maharashtra, Tamil Nadu, Uttar Pradesh, Rajasthan, Andhra Pradesh, and Gujarat—account for 92% of this support. Power-related incentives (≈62%) are in the form of transmission charge waivers, renewable energy banking, and duty exemptions, and Non-power-related incentives (≈38%) are in the form of capital subsidies and interest subvention. Further, Gujarat has reserved ~1.99 lakh hectares (~1,990 sq km) for renewable energy parks dedicated to green hydrogen production [71].

Certification, Regulation & Standards

Green Hydrogen Certification Scheme (GHCI): Unveiled in April 2025, India's Green Hydrogen Certification Scheme sets a lifecycle emissions threshold of 2 kg CO_2 equivalent per kg of hydrogen [2], [72]. Lifecycle emissions are averaged over 12 months [2], [72]. The certification framework recognises two primary production pathways: 1) electrolysis using renewable electricity and 2) biomass conversion processes. The certification scheme is implemented by the Bureau of Energy Efficiency (BEE) with annual audits by Accredited Carbon Verifiers (ACVs). It aligns with ISO 14064 (GHG accounting) and ISO 19870 (hydrogen standards), ensuring compatibility with global trade norms [2], [72].

A critical challenge involves harmonising India's Green Hydrogen Certification Scheme (GHCI) with the European Union's Renewable Fuels of Non-Biological Origin (RFNBO) standards under the Renewable Energy Directive III (RED III). While both frameworks share the goal of credible certification, key divergences exist in emissions accounting, power sourcing rules—particularly hourly matching requirements—system boundaries, and feedstock eligibility [72], [73], [74].

Table 7. GHCI vs RFNBO (RED III) and implications for India-EU trade

Aspect	GHCI (India)	RFNBO (EU RED III)	Implications for India-EU Trade
Objective	Certify green hydrogen produced with renewable energy and with strict emissions limits.	Certify renewable fuels of non-biological origin for EU compliance.	Alignment is needed for export certification acceptance.
Emissions Accounting	$\leq$ 2.0 kg $CO_2e/kg\ H_2$ (well-to-gate).	$\approx$ 3.4 kg $CO_2e/kg\ H_2$ (well-to-gate).	India's stricter threshold may ease EU compliance but requires verification.
Power Sourcing Rules	Annual matching allowed; no hourly matching.	Hourly matching mandatory from 2030; additionality required.	Indian producers must adapt to hourly matching for EU market access.
System Boundaries	Production site only; excludes transport.	Full lifecycle, including transport.	Additional data and audits are needed for EU compliance.
Feedstock Eligibility	Renewable electricity and water; excludes fossil feedstocks.	Renewable electricity and water; CO_2 from biogenic/ DAC sources.	CO_2 sourcing rules may require adjustments for Indian exporters.
Certification Body	MNRE-accredited agencies.	EU-recognised voluntary schemes (CertifHy, ISCC).	Dual certification or mutual recognition agreements are needed.
Implementation Timeline	Launched April 2025; annual audits.	Full compliance by 2030.	Transition planning is critical for exporters to meet EU deadlines.

Harmonising India's GHCI with EU RFNBO Standards

The divergences between India's GHCI and EU RFNBO standards present export challenges. While India's stricter emissions threshold (≤ 2.0 kg CO_2e/kg H_2) aligns well with EU requirements [72], differences in power sourcing rules - particularly the EU's mandatory hourly matching and additionality from 2030 - pose compliance hurdles for Indian producers currently operating under annual matching [73], [74]. Furthermore, RFNBO's broader system boundaries, which include transport and upstream electricity, demand additional lifecycle data and audits beyond GHCI's well-to-gate scope [73]. To ensure market access, Indian exporters must adopt dual certification or seek mutual recognition agreements, while planning for infrastructure and contractual changes to meet EU timelines [72], [73].

4.5 Key Challenges

Green Hydrogen Production

To go from existing ~175 tonnes to 5,000,000 tonnes of annual green hydrogen production in under 5 years, India must achieve exponential growth in green hydrogen output – far steeper than historical trends. This calls for a clear, actionable roadmap with year-by-year milestones to guide industry and policy efforts [43].

Renewable Energy for Green Hydrogen

An additional ~125 GW of new renewable power capacity is estimated to be needed solely for powering green hydrogen production by 2030. Some analyses suggest up to ~168 GW of solar PV or ~130 GW of wind might be required under certain scenarios – a massive expansion given the current 209 GW of installed renewable electricity capacity [75].

Electrolyser Manufacturing

- **Import Dependency and slow indigenization**: Despite strong policy support, India's electrolyser ecosystem remains import-dependent for critical components such as iridium and platinum for PEM systems and nickel and zirconia for alkaline technologies [43]. Domestic manufacturing of membranes and bipolar plates is still nascent, slowing indigenization [43].
- **Technology Maturity**: Technology adoption also reflects global trends: alkaline electrolysers dominate with a high market share but offer lower efficiency (around 65%) and limited operational flexibility compared to PEM and emerging SOEC solutions [76].
- **Scale-up Challenges**: Scale-up challenges persist, with electrolyser manufacturers seeking extensions from the government for the Production Linked Incentives scheme targets from 2026 to 2027 due to supply chain constraints [77].

Project Cost, Competitiveness & Economics

- **Green Premium Remains**: As per industry estimates, current levelized costs of green hydrogen are estimated to be USD3.5–4.5/kg vs. USD2.3–2.5/kg for grey hydrogen. Majority of this cost can be attributed to high capital investments and imported electrolysers costs [50], [78].
- **Intermittency Penalty**: Low plant load factors, tied to renewable energy variability, further raise delivered hydrogen costs by underutilizing assets [79].
- **Cost Reduction Limited by Supply Chain Risks**: Foreign exchange volatility and commodity price swings increase capital expenditure unpredictably.

Infrastructure Gaps

Critical bottlenecks are gaps in the infrastructure for distribution, storage, and transportation. For instance, India does not have a nationwide network of hydrogen pipelines, and technical issues like hydrogen embrittlement in steel pipes are still unsolved [75]. The lack of large-scale storage options, such as cryogenic systems and salt caverns, raises reliability issues for both domestic supply and exports [76]. Hydrogen-ready port infrastructure is under development at Kandla, Paradip, and Tuticorin, but operational readiness for ammonia and methanol carriers is still limited [80].

Standards and Certification Coverage:

Standards and Certification Coverage: Certification programs and regulatory frameworks are developing but still lacking. Only 88 hydrogen-related standards have been released as of 2025, which leaves gaps in international harmonisation and application-specific guidelines. To enable export competitiveness, alignment with EU-compatible certification continues to be a top priority [67], [78].

Water Use and Resource Constraints

- Water Scarcity: Electrolysis of water requires ~10 L water/kg H_2. Majority of the announced green/blue hydrogen projects are in high and extreme water stress locations. This creates sustainability risks and community pushback [81]. Greywater and desalination strategies are under consideration but not yet widely deployed at the scale needed; additional cost and technical challenges persist [82].

Indigenization Status and Import Dependencies

- According to a bottom-up cost analysis, approximately 80% of alkaline electrolyser manufacturing costs be indigenized. The indigenization potential can be further increased to 88% through strategic processing of imported raw materials [43]. For PEM electrolysers, indigenization potential ranges from 70-80%, depending on component categories [83]. However, critical import dependencies exist in several areas which needs long term strategy to increase indigenization. For example, India lacks domestic nickel resources, necessitating imports for nickel-coated bipolar plates and electrodes in alkaline systems [83]. Zirconia (ZrO_2) for Zirfon membranes in alkaline electrolysers must also be imported due to limited domestic reserves [83]. Platinum and iridium catalysts for PEM electrolysers also face supply constraints with iridium being particularly scarce [83]. Nafion membranes and titanium for porous transport layers (PTL) in PEM systems require imports, though titanium powder processing, compacting, sintering, and gold coating can be accomplished domestically [83]. Power electronics constitute 15-30% of total electrolyser costs, requiring integration with existing government schemes like Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS) and the Modified Electronics Manufacturing Clusters (EMC 2.0) for domestic electronics manufacturing [83].

4.6 Key International Bilateral Engagements

India's green hydrogen diplomacy has expanded rapidly in the last few years. Several strategic partners have committed long-term policy, technology and financial support. Germany stands out due to its deep institutionalised hydrogen partnership with India, combining large-scale financial commitments, policy alignment and a clear import-oriented market pull from Europe's largest industrial economy [83]. **Japan** is distinguished by its long-standing engagement in hydrogen technology development and deployment in India, with a strong focus on innovation, end-use applications and supply-chain resilience [84]. **Australia** is a key partner because of its ambition to position itself as a major exporter of renewable hydrogen and derivatives to Asian and global markets, supported by structured bilateral cooperation frameworks [85]. The **United Arab Emirates (UAE)** plays a prominent role through its capacity to rapidly scale hydrogen production linked to global energy trade networks, leveraging strong state-backed investment and established logistics infrastructure [86]. India's principal international research collaborators are the United States, the United Kingdom and South Korea. [84]. The collaboration between **India's Department of Science and Technology (DST) and the Netherlands Organisation for Scientific Research (NWO)** provides a structured framework for joint research funding, enabling Indo-Dutch cooperation on science, technology and innovation. It includes energy transition and hydrogen-related research, through coordinated bilateral calls and researcher exchange [85]. Also other Dutch organisations can contribute to research and innovation funding to help acceleration of developments in the green hydrogen field.

These partnerships focus on aligning on certification standards, establishing resilient supply chains, joint R&D, and early-stage market creation for hydrogen derivatives and e-fuels. Germany provides the most extensive structured financing package. Relationship with Japan offers access to advanced technology and strong demand. Australia emphasises research collaboration and Indo-Pacific supply chains, while the UAE focuses on investment corridors and maritime trade routes. Together, these bilateral engagements shape India's positioning in global hydrogen markets, influence project bankability, and open pathways for long-term export opportunities. They also strengthen India's ambition to meet domestic decarbonisation goals across industry, transport and power. The Netherlands could be a key partner to complement India's portfolio of international collaborations, by focusing on system integration, port-based hydrogen valleys, large-scale electrolyser Through platforms like GH2 India, the country has also engaged in high-level dialogues with the EU, Germany, and Belgium, focusing on certification standards, technology transfer, and trade frameworks. Key initiatives include the EU-India CEO Roundtable, collaborations under the Indo-German Energy Forum, and the India-Belgium Hydrogen Dialogue, which address production, infrastructure, and port readiness for green shipping [86].

manufacturing, maritime applications and innovation collaboration.

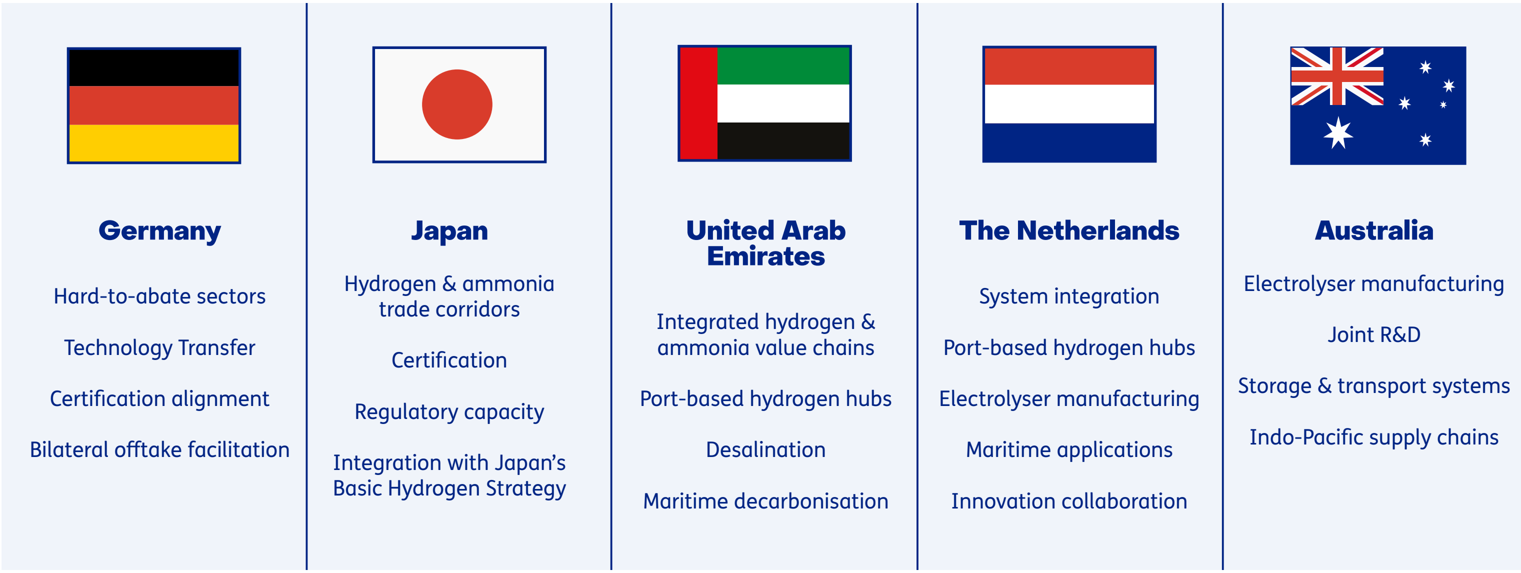


Figure 9. Strategic focus areas of key International bilateral engagements

Chapter 5 Status of Netherlands–India Joint Initiatives

5.1 Overview of Existing Frameworks

Strategic Foundations
India and the Netherlands discuss issues across the entire gamut of bilateral relations through annual consultations, led by the Ministries of Foreign Affairs on both sides at the Secretary level. The two sides have Joint Working Groups (JWGs)/ Dialogues at the functional level in the fields of Science & Technology, Agriculture, Healthcare, Urban Development, Counter Terrorism, Maritime Cooperation, Water, Policy Planning, Cyber Dialogue and Consular [87]. The Department of Science and Technology (DST) of India and the Netherlands Ministry of Economic Affairs have an existing Memorandum of Understanding (MoU) under which they cooperate on science, technology, and innovation. This collaboration is part of a broader strategic partnership between India and the Netherlands. The Netherlands Organisation for Scientific Research (NWO) collaborates with major national research funders in India, including the Department of Science and Technology (DST), the Department of Biotechnology (DBT), and the Ministry of Electronics and Information Technology (MEITY) [87].

The Indo-Dutch partnership on climate and energy transition is built on a strong institutional foundation and received a significant boost in 2024 through a Memorandum of Understanding (MoU) between India's Ministry of New and Renewable Energy and the Netherlands' Ministry of Climate Policy and Green Growth. This MoU promotes cooperation in renewable energy technologies, green hydrogen, offshore wind, solar, biomass, and energy storage. To oversee implementation and identify priority projects a Joint Working Group (JWG) has been established [88].

Complementing this framework is the long-standing instrument Climate and Energy Response Facility (CERF), managed by the Netherlands Enterprise Agency (RVO). This instrument serves as a flexible instrument to accelerate climate mitigation through knowledge sharing, policy advice, and capacity-building programs. Focus of CERF is on high-impact sectors such as offshore wind, hydrogen, solar energy, and the circular economy, and supports multi-annual collaboration strategies tailored to partner countries [89]. With initiatives such as CERF, the Netherlands Embassy aims to strengthen the collaboration with the Government of India.

The MoU and CERF share common objectives: facilitate technical collaboration across renewable energy sectors, promote joint research and technology exchange, and enable structured policy dialogues. The JWG plays a pivotal role in developing roadmaps and prioritizing projects.

Institutional mechanisms such as the India–Netherlands Joint Working Group on Science, Technology, and Innovation (STI) and annual Indo-Dutch Tech Summits strengthen cooperation in emerging technologies e.g. hydrogen, bioeconomy, semiconductors, and digital energy systems [90], [91].

India and the Netherlands are both part of the Clean Energy Ministerial (CEM), including the Hydrogen Initiative (H2I) & trade forum, which promotes real-world hydrogen projects and partnerships [92]. Under CEM, India helped launch the International Hydrogen Trade Forum during the 2023 G20 and CEM in India, bringing together countries, including the Netherlands, to explore cross-border hydrogen trade routes. India and the Netherlands are also active under the Biofuture platform in the Clean Energy Ministerial.

India and the Netherlands are active participants in Multilateral innovation-focused projects such as Mission Innovation, where India and the Netherlands co-lead the Integrated Biorefinery track, and in Clean Hydrogen, where both countries are active members.

Recent developments highlight the growing momentum of this partnership with discussions centred on green hydrogen, particularly on electrolyser testing facilities and pilot-scale green ammonia projects. The Netherlands recently joined the Global Biofuel Alliance that is led by India [93]. Additionally, India and the Netherlands are collaborating on a green, digital maritime corridor between Rotterdam and Indian ports to enable the export of green hydrogen derivatives, such as ammonia and methanol [94].

Research and innovation remain central to the Netherlands-India partnership. The **NWO-DST bilateral programs** are designed to fund joint research consortia with budgets up to €1.47 million per program to support projects in sustainable energy, advanced materials, and digital energy systems [85]. The Netherlands Innovation Network in India facilitates innovation linkages, organises missions, and publishes strategic roadmaps for sectors like clean hydrogen and bioeconomy to support to promote cooperation and joint developments [95]. There are academic collaborations between Indian Institutes of Technology (IITs) and Dutch universities to advance joint research in hydrogen technologies, energy storage, and circular economy solutions

5.2 Key Indian and Dutch Stakeholders

To understand how different stakeholders contribute to India's green hydrogen ecosystem, we grouped them into nine categories: 1) policy and mission, 2) research and innovation, 3) innovation platforms, 4) industrial deployment (private), 5) industrial deployment (public), 6) electrolyser manufacturing, 7) industry associations, 8) financial & investment, and 9) international partnerships. At the policy level, MNRE leads the NGHM. The National Institution for Transforming India (NITI Aayog) role is provide a strategic roadmap. State governments are implementing additional incentives and policies to tap into the green hydrogen opportunity and to be front runners. Research and innovation agenda is driven by DST, CSIR labs, IITs, and NCL. A non-exhaustive category-wise list of Indian stakeholders active in the green hydrogen ecosystem is presented in the Figure 10. Efforts from these stakeholders are collectively contributing towards India's ambition to be a major player in the global hydrogen economy by combining policy support, industrial scale, and international collaboration.

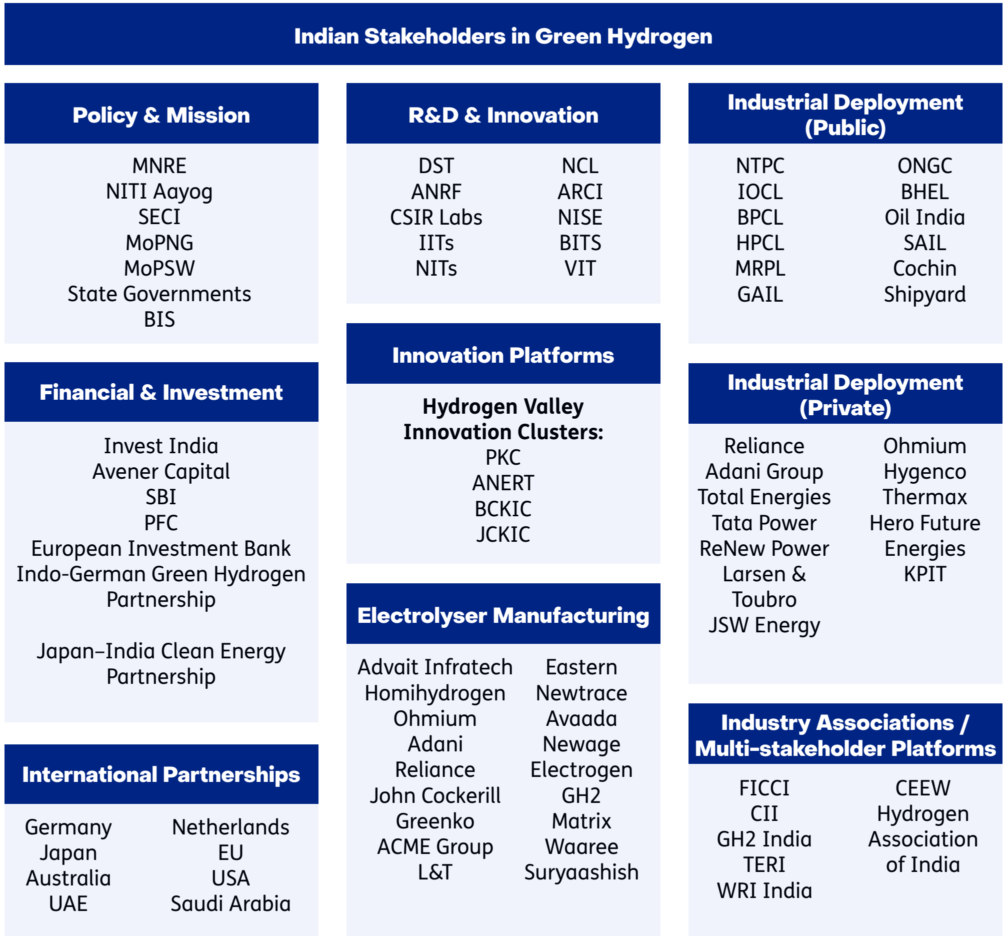


Figure 10. Indian stakeholders active in the green hydrogen ecosystem (non-exhaustive list)

Dutch Stakeholders in Green Hydrogen

Policy & Mission

Ministry of Climate & Green Growth
Ministry of Economic Affairs
Netherlands Enterprise Agency
Ministry of Infrastructure & Water Management
Ministry of Foreign Affairs
Provincial Governments
NEN Standards Body

R&D & Innovation

TNO
VoltaChem
TU Delft
TU Eindhoven
University of Groningen

Utrecht University
Hanze University
DIFFER
MARIN
NLR

Industrial Deployment (Public)

Gasunie
EBN
Port of Rotterdam Authority
Port of Amsterdam
North Sea Port

Groningen Sea Port
TenneT
Regional Development Agencies (ROMs)

Innovation Platforms

TopSector Energy (TSE)
GroenvermogenNL
ISPT Hydrohub
FME Hydrogen Platform
NL Hydrogen Supplier Platform
HEAVENN
Smart Delta Resources
Hydrogen Hub Twente

Financial & Investment

Invest-NL
Nationaal Groeifonds
Invest International
EIB

Rabobank
ABN AMRO
Triodos
Pension Funds (APG, PFZW)

Industrial Deployment (Private)

BP
Air Liquide
Vopak
OCI

RWE
Uniper
Eneco
Shell

International Partnerships

Memoranda of Understanding
Partners in International Business
Horizon Europe calls & IPCEI's
Clean Hydrogen Partnership
Hydrogen Corridors

Electrolyser Manufacturing

HyCC
Nedstack
Plug Power EU / Frames
Battolyser Systems VDL
McPhy (NL Projects)
Proton Ventures

Industry Associations / Multi-stakeholder Platforms

NL Hydrogen
FME
TopSector Energy
New Energy

Coalition
ISPT
Hydrogen Europe (Dutch members)

Figure 11. Dutch stakeholders active in the green hydrogen ecosystem (non-exhaustive list)

5.3 Key Collaborative Projects and Programs

India-Netherlands Hydrogen Valley Fellowship Programme

The India-Netherlands Hydrogen Valley Fellowship Programme, announced on 6 June 2025, is a collaborative initiative between the Indian Department of Science and Technology (DST) and the University of Groningen (RUG). Its goal is to enable talented Indian scholars—doctoral candidates, post-docs, and senior academics —to conduct part of their research at the RUG and within the Northern Netherlands Hydrogen Valley for 1 to 2 years. The programme supports joint PhD and postdoctoral projects with co-supervision by UG experts, building long-term academic partnerships and alumni networks to accelerate the development of hydrogen technologies. Funding is shared between DST (India), which covers research costs, and UG (Netherlands), which co-funds the stay in the Netherlands. This fellowship is aligned with the strategic priority of green hydrogen for both countries and strengthens the Hydrogen Valley ecosystem.

Innovation Mission to India 2025

In September 2025, a Dutch delegation of hydrogen sector leaders, researchers, and innovators visited India for an Innovation Mission on Hydrogen Technology. The mission brought together representatives from leading Dutch companies and was organised by the RVO. Participants included technology developers such as Circonica, Hydroflexx, REDstack, and ROSEN Europe B.V.; research institutions like Groningen University and TNO; infrastructure leaders, including the Port of Rotterdam and VTTI; and ecosystem enablers such as Energy Innovation NL, RVO, and the Netherlands Innovation Network. Together, they represented expertise in production, storage, transport, system integration, and international collaboration. The mission aimed to promote international cooperation, identify R&D opportunities, understand the rapidly evolving hydrogen ecosystem in India and build strategic partnerships between the Netherlands and India. Through targeted workshops, participants explored opportunities for joint R&D, technology transfer, and scalable deployment of hydrogen-based solutions.

Picture 3. Netherlands and India delegates at the high-level workshop at the Ministry of Science & Technology, Delhi during the Netherlands green hydrogen innovation mission to India.

In Kerala, the delegation visited the Kerala Hydrogen Valley, witnessing India's first hydrogen-powered boat at Cochin Shipyard and the country's inaugural 1 MW green hydrogen pilot plant at Cochin International Airport. In Gujarat, the team explored the state's emergence as a hydrogen hub, including site visits to Adani Total Gas's innovative hydrogen blending facility and collaborative workshops at IIT Gandhinagar. In New Delhi, the mission connected with leading policy and research organisations such as the World Resources Institute and IIT Delhi, and participated in a high-level stakeholder workshop with the Indian Department of Science and Technology. These interactions not only highlighted India's commitment to scaling up green hydrogen but also opened the door to future Dutch-Indian collaboration in research, technology development, and pilot projects.

The mission identified several promising avenues for potential Dutch-Indian cooperation:

- **Joint R&D**: Collaborative research on electrolyser technology, hydrogen storage, and Power-2-X solutions.
- **Pilot Projects**: Participation in demonstration projects and technology scale-up (TRL 6-8) initiatives.
- **Test Facilities**: Consulting and partnership on hydrogen testing infrastructure and standards development.
- **Policy & System Studies**: Joint studies on energy transition, policy frameworks, and techno-economic analysis.

Picture 4. Netherlands Delegation visit to a hydrogen refueling station commissioned by Cochin International Airport (CIAL) and BPCL.

Picture 5. The 1 MW green hydrogen pilot refueling station showcases ongoing advancements in clean energy infrastructure and sustainable mobility solutions in India

Chapter 6 Joint Opportunities

India and the Netherlands represent distinct archetypes and possess a complementary strategic fit in the global green hydrogen economy. India is a scale-focused, demand-driven emerging leader with vast renewable resources and industrial needs. At the same time, the Netherlands is a technology-mature, import-focused hub with advanced infrastructure and global trading expertise. India aims to be a low-cost global hub for green hydrogen production. At the same time, the Netherlands, through the Port of Rotterdam, positions itself as the primary energy gateway to Northwest Europe. The Netherlands is a leader in technology development & scale-up, industrial deployment, infrastructure readiness, and operational scale. India surpasses the Netherlands in renewable energy capacity and addressable market size. These characteristics create opportunities for both countries.

The partnership has already moved from “intent” to “early execution”, evidenced by the Green & Digital Corridor agreement, government and commercial MOUs (e.g. the collaboration between Port of Rotterdam and AM Green) [96] ,[97].

The collaboration is driven by mutual necessity and competitive advantage.

The “Factory” and the “Gateway”

India (The Factory): India offers high potential for renewable energy and low-cost production (targeting <USD 2/kg). India is positioned as one of the world’s lowest-cost green hydrogen producers with green ammonia production costs ranging ~USD 0.6-0.7/kg NH_3 and a targeted hydrogen production cost below USD 2/kg by 2030 [98]. The NGHM acts as a policy backbone but requires assured offtake markets to reach bankability.

The Netherlands (The Gateway): The Port of Rotterdam supplies ~13% of Europe’s total energy. With limited domestic land for renewables, the Dutch economy depends on imports to meet decarbonization targets. It offers critical infrastructure (terminals, pipelines) and deep expertise in green hydrogen technologies, scale-up and deployment.

Infrastructure and Trade Corridors: The Netherlands-India bilateral collaboration can leverage India’s production excellence and the Netherlands’ logistical infrastructure to meet the EU’s mandate on hydrogen use in the EU industry as RFNBO by 2035 (RED III) [48]. The India–Port of Rotterdam Green & Digital Corridor, launched in April 2025, serves as the institutional backbone for bilateral trade. It aims to reach 1 million tonnes/year of renewable molecules in its initial phase [48]. The Port of Rotterdam, as Europe’s primary hydrogen import hub, with its infrastructure expansion, can support India becoming a strategic supplier of green hydrogen derivatives.

Policy and Regulatory Alignment

Both countries must align their certification and regulatory frameworks to enable smooth trade and project development. India’s Green Hydrogen Certification Scheme (GHCI) allows annual matching of renewable electricity. Whereas the EU’s RFNBO standard requires hourly matching from 2030. This difference in the regulatory framework means that Indian producers must adapt their systems to meet EU export requirements. To bridge these gaps, a practical step is to establish a bilateral task force to harmonise certification, develop joint audit protocols, and invest in shared validation labs. Further, to provide long-term certainty on policy and trade, bilateral policy alignment discussions should also be initiated with a structured, outcome-based agenda.

Financial and Investment

The evolving green hydrogen partnership between India and the Netherlands presents a broad set of financial and investment opportunities across the value chain, underpinned by strong policy momentum on both sides. In India, the National Green Hydrogen Mission is expected to mobilise large-scale private capital into renewable generation, electrolyser manufacturing, hydrogen and derivative production, and port-based export infrastructure, creating entry points for Dutch investors, technology providers, and project developers. For Dutch stakeholders, opportunities lie not only in direct equity participation or EPC roles in Indian projects, but also in structuring project finance, blended finance, and risk-mitigation instruments in collaboration with institutions such as Invest International, FMO, multilateral development banks, and Indian development finance institutions. On the European side, predictable demand signals from regulations such as RED III, FuelEU Maritime and ReFuelEU Aviation strengthen the bankability of export-oriented projects, enabling long-term offtake arrangements that can anchor financing. Together, these dynamics create scope for joint investment platforms, pilot-to-scale financing pathways, and innovative contractual structures that link Indian cost-competitive production with European demand and Dutch financial and structuring expertise.

Building on these opportunities, there is a clear need to translate the identified financial potential into concrete, coordinated action. TNO recently published a report that provides a common analytical basis for Dutch–Indian collaboration by clarifying where projects currently face bottlenecks and how first-of-a-kind initiatives can be structured to become bankable [99]. By aligning expectations among policymakers, financiers and companies, it supports the design of blended-finance structures, risk-sharing mechanisms and offtake arrangements. In this way, the report serves as a practical tool to move beyond exploratory engagement and to shape a focused Netherlands–India cooperation agenda that delivers replicable, investable hydrogen projects aligned with both domestic transition objectives and international market demand.

Accelerate Development and Scale up of Technologies towards Innovation

The partnership also offers opportunities for pilot demonstrations to validate the commercial viability of green hydrogen technologies. The countries now need to move beyond general “knowledge sharing” to specific technology co-creation, where Dutch expertise fills Indian gaps, such as PEM and SOEC electrolyser technologies, hydrogen blending, technology scale-up and integration within industry. There is a need to facilitate joint ventures between Indian manufacturers (aiming for scale) and Dutch companies and research institutes to design electrolysers specifically for India’s heat and dust conditions. Technical alignment is also required on interoperable digital monitoring, testing infrastructure, test methods, and verification systems. Further, alignment is also required for creating a simplified framework for the transfer and joint development of intellectual property. Concrete investments opportunities can be analysed in later phases of this research.

Develop Supply Chain Opportunities for large-scale Electrolyzer manufacturing

There is a significant policy push by the Indian Government to indigenise green hydrogen technologies, electrolyser manufacturing, and component supply chains. This creates specific opportunities and implications for companies active in the green hydrogen technology and production supply chains.

- **Electrolyser Manufacturing**: Companies that can localise supply chains for electrolyser stacks, power electronics, and balance-of-plant components will gain a competitive edge. Component makers should set up local assembly or JV partnerships.

- **Component and Materials**: Alkaline dominance will drive demand for traditional components like nickel-based electrodes. At the same time, PEM growth will require advanced materials such as platinum-group catalysts and specialized membranes.

- **EPC and Project Management Consultancy**: With strict commissioning deadlines, accelerated procurement and construction activity is expected in the coming 2 years. This creates opportunities for EPC and project management companies.

- **Technology Development/Licensing**: While Alkaline electrolyser dominates the current SIGHT scheme auctions, India is keen on high-efficiency PEM and emerging technologies- areas where Dutch innovators excel. Dutch providers with PEM expertise can partner with Indian firms for mobility and renewable integration projects. The adoption of solid oxide technology could stimulate R&D in ceramic and high-temperature materials. Dutch companies specialising in compression, storage, and purification systems can fill critical gaps in Balance-of-Plant Solutions. Dutch strengths in technology, manufacturing, predictive maintenance, process safeguarding and process control can differentiate offerings.

6.1 Conclusions and Recommendations

The Netherlands–India strategic partnership presents an opportunity to accelerate the global energy transition by integrating Dutch innovation leadership with India's manufacturing capabilities. The collaboration aims to deliver on green hydrogen growth ambition, scientific advancement, and measurable climate impact by working on coordinated flagship programs, joint research and innovation, and harmonisation of standards. This partnership can serve as a global model for practical international cooperation in green hydrogen technologies. **By combining Dutch technological leadership, the European market's demand potential and willingness to pay and India's scale and ambition, both countries can accelerate the global transition to clean hydrogen and unlock new opportunities for sustainable growth**.

The Indo-Dutch partnership is poised to become a model for North-South cooperation in the energy transition. The focus of the alliance must now shift from signing MOUs to removing non-tariff barriers. To realise the collaboration's full potential, four critical aspects (or barriers) need to be prioritised. These are (1) certification harmonisation, (2) infrastructure investment, (3) long-term demand certainty, and (4) technology transfer and localisation. Recent momentum, driven by AM Green, the Port of Rotterdam MoUs, and the Green & Digital Corridor MOU, demonstrates the viability of this relationship. However, execution speed is critical, as revised timelines suggest India will achieve 3 MMTPA by 2030 (vs. the originally targeted 5 MMTPA). Further, Indo-Dutch export volumes must accelerate to capture the near-term window before alternative suppliers (MENA, Australia) establish European market positions.

Building on this shared ambition, the next phase of the Netherlands–India partnership requires a shift from intent to execution, translating strategic alignment into coordinated action across policy, markets, technology and investment. Figure 12 provides a structured overview to operationalise this transition. The figure on the next page summarizes actionable opportunities and targeted recommendations across five key stakeholder domains: policy and mission, financial & investment, infrastructure & supply chain, R&D & innovation, and electrolyser manufacturing. The mutually reinforcing opportunities identified in this study are:

1) aligning policy and regulation to meet government ambitions;

2) valorising India's green hydrogen targets into bankable projects that reach final investment decision;

3) developing a dedicated India–Netherlands green hydrogen corridor to unlock European demand;

4) accelerating innovation and technology scale-up through joint R&D and centres of excellence; and

5) building resilient supply chains for large-scale electrolyser manufacturing.

Together, these pathways respond directly to the four critical barriers identified (certification, infrastructure, demand certainty and technology transfer). By sequencing policy alignment, project development and industrial scale-up, the framework illustrates how Indo-Dutch cooperation can deliver near-term impact while laying the foundations for long-term leadership in the global hydrogen economy.

Stakeholders	Opportunities and Recommendations
Policy and mission	**Drive collaboration by policy and regulatory alignment to meet governments' ambitions**
	• **Launch annual joint India–EU funded R&D calls across the technology readiness spectrum**: Relevant technology areas of joint R&D calls include low- and zero-iridium/platinum electrolysers; advanced membranes and power electronics; biobased hydrogen production using industrial biotech pathways; low-water/seawater electrolysis suitable for water-scarce India. • Set up an "**India-EU/Netherlands Green Hydrogen Working Group**" for joint strategic planning on policy, industry, R&D and investments . • Promote **multi-stakeholder "hydrogen valleys"** drawing on Dutch cluster development models and Indian regional industrial hubs. • Set up an annual "**India-EU/Netherlands Green Hydrogen Summit**" for joint policy planning, project matchmaking, and dialogue between the public sector, industry, and academia. • **Production and Trade**: Joint incentives by the Netherlands and India for EU/Dutch technology providers to invest in or collaborate with Indian green hydrogen and green ammonia manufacturing facilities.
Financial & Investment	**Valorise the Indian ambition into concrete projects that can reach FID**
	• **Develop Rotterdam-anchored hydrogen export corridors**: Prioritise investment in corridor-enabling assets such as ammonia and methanol export terminals in India, import and cracking facilities, storage and bunkering infrastructure in the Port of Rotterdam, and RFNBO-compliant certification and MRV systems, where revenue models are clearer, and Dutch infrastructure expertise adds strong value. • **Deploy blended finance for first-of-a-kind projects**: Use Dutch public financiers (Invest International, FMO, Atradius), alongside MDBs, to de-risk early pilot and early-commercial hydrogen, ammonia and methanol projects through guarantees, concessional debt and subordinated capital, enabling projects to reach financial close and crowd in private investment. • **Anchor investments in long-term offtake**: Focus on structuring bankable projects around committed offtake in maritime fuels, synthetic fuels and industrial feedstock, leveraging Dutch shipping, port and industrial demand to reduce market risk and accelerate scalable NL–India hydrogen value chains. • **A dedicated Netherlands–India TechBridge** could serve as an execution mechanism to translate promising R&D and pilot concepts into investable projects by combining technical validation, partner matchmaking and early engagement with financiers.
Infrastructure & supply chain	**Develop a green hydrogen corridor between India and the Netherlands to unlock the European market**
	• Make use of Dutch expertise in the hydrogen industry and infrastructure to accelerate India's infrastructure development. Develop joint projects with a focus on storage solutions, distribution networks, maritime corridors, and the development of engineering and safety standards. • Establish a bilateral Green Hydrogen "**Certification Harmonisation Task Force**" to align India's Green Hydrogen Certification Scheme (GHCS) with the EU's RFNBO framework, facilitating mutual recognition of certificates and smooth cross-border trade. • **Co-develop sectoral standards:** (steel, ammonia, shipping) and MRV platforms using EU digital best practices and Dutch experience with port hydrogen fuels.

Stakeholders	Opportunities and Recommendations
R&D & Innovation	**Accelerate the development and scale up of technologies towards innovation**
	• Establish Joint Centre of Excellence(s) by bringing together 1-2 key research facilities in both countries with matching strategic research focus and synergies on hydrogen. • Start one to two R&D projects between technology developers of the Netherlands having advanced PEM and SOE electrolysis capabilities with India's manufacturing players, to drive cost reductions by scale-up and technology optimisation . • Stimulate Knowledge Exchange by conducting staff exchanges, technical trainings, and skills transfer programs for pilot and test facilities.
Electrolyser Manufacturing	**Develop supply chains for large-scale electrolyser manufacturing**
	• Invest in shared validation and audit labs to ensure product traceability and protocol compliance • Electrolyser Manufacturing: Promote co-location of gigafactories by providing incentives for EU/Dutch technology providers to invest in or collaborate with Indian electrolyser manufacturing facilities.

Figure 12. Summary of opportunities and recommendations for different stakeholder groups

The creation of a "Certification Harmonisation Task Force" is the most critical next step. Investments in physical infrastructure carry a substantial regulatory risk if there is disagreement over what constitutes "green" under EU law.

Through this strategic partnership, India can secure its first significant premium export market, and the Netherlands can ensure a dependable energy stream by solving the certification puzzle. To translate ambition into impact, all stakeholders must now move from dialogue to delivery.

Governments should use policy alignment between India, the Netherlands and the EU to launch joint R&D calls, establish permanent working groups and hydrogen valleys, and provide stable platforms for coordination and matchmaking. Financial institutions and public authorities are called upon to deploy blended finance and risk-mitigation instruments that enable first-of-a-kind projects to reach final investment decision, while supporting Rotterdam-anchored export corridors with clear revenue models.

For companies, the call to action is equally clear: position early for execution by designing projects and products that are certification-ready, RFNBO-compliant and underpinned by robust MRV systems; build consortia around concrete demand and long-term offtake rather than standalone pilots; and engage financiers at an early stage to structure bankable projects. Infrastructure developers and standards bodies should accelerate alignment on certification, MRV and sectoral standards to enable seamless access to European markets.

In parallel, research institutes and manufacturers should focus on joint innovation, skills development and electrolyser manufacturing scale-up through shared facilities and co-investment. Acting in concert across policy, finance, industry and innovation will allow the NL–India partnership to move beyond pilots and establish a credible, investable green hydrogen corridor of global relevance.

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Picture 6. TNO facility in Petten, including the Faraday lab, focusing on optimising, testing, scaling up and manufacturing of different electrolysis technologies such as Alkaline, PEM, SOEC and AEM.

Glossary of Terms

Abbreviation	Full Form
ACV	Accredited Carbon Verifier
AEM	Anion Exchange Membrane (Electrolyser Technology)
ANERT	Agency for Non-conventional Energy and Rural Technology (Kerala)
BEE	Bureau of Energy Efficiency
BCKIC	Bhubaneswar City Knowledge and Innovation Cluster
BPCL	Bharat Petroleum Corporation Limited
CBAM	Carbon Border Adjustment Mechanism
CEM	Clean Energy Ministerial
CERF	Climate and Energy Response Facility
CFA	Central Financial Assistance
CHP	Combined Heat and Power
CII	Confederation of Indian Industry
CSIR	Council of Scientific and Industrial Research
DAC	Direct Air Capture
DRI	Direct Reduction Iron
EMC 2.0	Modified Electronics Manufacturing Clusters scheme
EPC	Engineering, Procurement, and Construction

Abbreviation	Full Form
EU	European Union
FICCI	Federation of Indian Chambers of Commerce and Industry
H2-Fifty	Rotterdam Hydrogen Hub Project
H2I	Hydrogen Initiative
HEAVENN	H2 Energy Application Valley Northern Netherlands
HPCL	Hindustan Petroleum Corporation Limited
HVIC	Hydrogen Valley Innovation Cluster
HVOF	High Velocity Oxygen Fuel (Coating Facility)
HyNetwork	Dutch National Hydrogen Backbone Project
IISER	Indian Institute of Science Education and Research
IIT	Indian Institute of Technology
IOCL	Indian Oil Corporation Limited
IPCEI	Important Projects of Common European Interest
ISO	International Organization for Standardization
JCKIC	Jodhpur City Knowledge and Innovation Cluster

Abbreviation	Full Form
JV	Joint Venture
JWG	Joint Working Group
LOHC	Liquid Organic Hydrogen Carrier
MNRE	Ministry of New and Renewable Energy (India)
MoPNG	Ministry of Petroleum and Natural Gas
MoPSW	Ministry of Ports, Shipping and Waterways
MRPL	Mangalore Refinery & Petrochemicals Limited
MRV	Monitoring, Reporting, and Verification
NCL	National Chemical Laboratory
NGHM	National Green Hydrogen Mission
NH_3	Ammonia
NITI Aayog	National Institution for Transforming India
NIT	National Institutes of Technology
NRL	Numaligarh Refinery Limited
NTS	National Technologies Strategy
OCI Nitrogen	Dutch chemical company
OWE	Offshore Wind Energy
PEM	Proton Exchange Membrane (Electrolyser Technology)

Abbreviation	Full Form
PIB	Partners in Business (Dutch international business instrument)
PNG	Piped Natural Gas
Porthos	Port of Rotterdam CO_2 Transport Hub and Storage
PKC	Pune Knowledge Cluster
PtX	Power-to-X (conversion of electricity to other energy carriers)
R&D	Research and Development
RED III	Renewable Energy Directive III
RFNBO	Renewable Fuels of Non-Biological Origin
RVO	Netherlands Enterprise Agency
RWE	Rheinisch-Westfälisches Elektrizitätswerk (German energy company)
SDE++	Dutch Sustainable Energy Production and Climate Transition subsidy scheme
SECI	Solar Energy Corporation of India
SIGHT	Strategic Interventions for Green Hydrogen Transition
SOE	Solid Oxide Electrolyser (Electrolyser Technology)

Abbreviation	Full Form
SPECS	Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors
STI	Science, Technology, and Innovation
TenneT	Dutch-German electricity transmission system operator
TNO	Netherlands Organisation for Applied Scientific Research
TPA	Tonnes Per Annum
TRL	Technology Readiness Level
Vopak	Dutch tank storage company

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