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Green Hydrogen in India — From Mission to Market

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GS3

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MAINS RELEVANCE:

GS Paper 3



INTERVIEW ANGLE

"What are the three biggest bottlenecks preventing India from becoming a global green hydrogen hub, and what policy interventions are needed to overcome each?"

WHY IN NEWS

IIT Guwahati researchers published a breakthrough MXene-based catalyst achieving 12 mV overpotential for hydrogen evolution — outperforming platinum — reigniting debate on whether India's domestic R&D ecosystem can deliver the cost breakthroughs needed to make green hydrogen commercially viable.

THE PROMISE AND THE GAP

India's **National Green Hydrogen Mission** (launched January 2023) is among the most ambitious clean energy policies in the developing world. The targets are bold: **5 million tonnes** of green hydrogen per year by 2030, an outlay of **Rs. 19,744 crore**, and an aspiration to make India a **global export hub** for the fuel.

The rationale is sound. India imports ~85% of its crude oil, spending billions of dollars annually on fossil energy that simultaneously depletes foreign exchange, deepens energy insecurity, and accelerates emissions. Green hydrogen — produced by splitting water using solar or wind electricity — emits nothing. For sectors that cannot easily electrify (steel, fertilisers, shipping, heavy trucking), it is the only plausible decarbonisation pathway.

Yet the **gap between mission and market** remains large. Green hydrogen today costs approximately **\$4–6 per kilogram** to produce in India. To be competitive with grey hydrogen (from natural gas) or fossil fuels in industrial use, the price must fall to **\$1–2 per kilogram** — a gap of 3x to 6x. Bridging it requires simultaneous cost reductions in three components: **electrolysers, renewable electricity, and capital costs**.

THE TECHNOLOGY FRONTIER: WHAT IIT GUWAHATI DEMONSTRATED

The MXene-Ruthenium catalyst developed at IIT Guwahati is significant for one reason above all: it achieves **12 mV overpotential** — better than platinum, the global benchmark — at a fraction of the cost.

Platinum is expensive. An electrolyser's cost is substantially determined by its catalyst. If Indian researchers can develop and eventually manufacture non-platinum catalysts that perform comparably or better, the **electrolyser cost curve tilts decisively in India's favour**.

This is not merely academic. South Korea's POSCO, German Thyssenkrupp, and Norway's Nel ASA are racing to commercialise cheaper electrolysers. India's IIT research, if translated into scalable manufacturing, could give domestic electrolyser companies a competitive edge — or allow India to become a technology exporter rather than importer in the green hydrogen value chain.

The lesson is not that one paper changes the economics. It is that **consistent, funded, application-oriented R&D** in materials science is the upstream investment that eventually yields downstream industrial advantage. India's green hydrogen mission will succeed or fail partly on the quality of this research pipeline.

THE RENEWABLE ELECTRICITY CONSTRAINT

Green hydrogen's economics are dominated by **electricity costs**. Electrolysis is energy-intensive; roughly 50–55 kWh of electricity is needed per kilogram of hydrogen. At India's current renewable tariff of Rs. 2–3/kWh, the electricity cost alone for one kg of hydrogen is Rs. 100–165 — still too expensive.

The path to cheap green hydrogen runs through **ultra-low-cost renewables**. India's solar tariffs have fallen to under Rs. 2/kWh in recent auctions — among the cheapest globally. As storage improves (reducing the intermittency penalty), round-the-clock renewable power will approach grid parity and the hydrogen cost will fall accordingly.

This is why the green hydrogen mission must be seen as **interlocked** with the solar mission, the battery storage programme, and the offshore wind roadmap. These are not separate sectors — they are interdependent links in a single decarbonisation chain.

ELECTROLYSER MANUFACTURING: THE INDUSTRIAL BOTTLENECK

India currently has **limited electrolyser manufacturing capacity**. Most installed electrolysers are imported, primarily from Europe. This creates a cost and supply-chain dependency that undercuts the mission's strategic rationale.

The Production Linked Incentive (PLI) scheme for electrolysers, and the **Strategic Interventions for Green Hydrogen Transition (SIGHT)** programme under the mission, are designed to address this. SIGHT provides financial incentives for domestic electrolyser manufacturing and green hydrogen production.

However, **scaling PLI-linked manufacturing** requires:

- Anchor demand commitments from public sector undertakings (NTPC, IOCL, SAIL)
- Long-term power purchase-equivalent agreements for green hydrogen offtake
- Port infrastructure and storage for hydrogen export (particularly liquid hydrogen and ammonia carriers)

The Jawaharlal Nehru Port Trust (now Nhava Sheva) and Kandla Port have been identified as potential hydrogen export terminals — but the detailed investment plans remain in early stages.

EXPORT AMBITION AND GEOPOLITICAL OPPORTUNITY

India's green hydrogen mission is not just about domestic decarbonisation. The **geopolitical opportunity** is significant.

Japan, South Korea, and Germany have **legally binding net-zero targets** but insufficient domestic renewable potential to produce all their green hydrogen needs. They are actively seeking import partnerships. India — with its 300+ sunny days, large coastline, and engineering workforce — is a natural supplier.

The **India-Germany Green Hydrogen Partnership** (signed 2022) and the **India-Japan Green Hydrogen Cooperation** framework provide diplomatic scaffolding. What they need next is **commercial-scale demonstration projects** that derisk the technology and logistics for international buyers.

The window is not permanently open. Australia, Chile, and the Middle East (particularly Oman and Saudi Arabia) are competing for the same export markets with significant state backing. India must accelerate from mission to megawatt-scale demonstration in the next three years.

THE WAY FORWARD

Three priorities stand out:

First, translate frontier research (like the IIT Guwahati catalyst) into **industry-academic consortia** with defined commercialisation timelines. The National Hydrogen Energy Board should track research outputs and fund scale-up pilots.

Second, mandate green hydrogen blending in fertiliser and refinery sectors — the two largest grey hydrogen consumers — to create guaranteed domestic demand that funds the initial cost premium while industry scales down costs.

Third, build the ammonia corridor. Green ammonia (hydrogen + nitrogen) is the most practical form for hydrogen storage and shipping. India has the fertiliser infrastructure. Repurposing and expanding it for green ammonia export is the fastest route to building a commercially viable hydrogen export sector.

The IIT Guwahati catalyst is a reminder that the technology frontier is not beyond India's reach. The policy frontier — translating research ambition into manufacturing scale and export markets — now requires equal urgency.

UPSC RELEVANCE

National Green Hydrogen Mission, SIGHT programme, MXene, overpotential, Rs. 19,744 crore outlay, 5 MT target.

MAINS GS-3:

Energy security; clean energy technology; India's hydrogen policy; industrial decarbonisation.

INTERVIEW:

India as a green hydrogen export hub — geopolitical and economic dimensions.

★ FACTS CORNER — KNOWLEDGEPEDIA
NATIONAL GREEN HYDROGEN MISSION:

Launched: **January 2023**

Production target: **5 million tonnes/year** by 2030

Outlay: **Rs. 19,744 crore**

Programme: **SIGHT** (Strategic Interventions for Green Hydrogen Transition) — incentivises domestic manufacturing and production

GREEN HYDROGEN ECONOMICS:

Current production cost in India: **~\$4–6/kg**

Target price for competitiveness: **\$1–2/kg**

Electricity needed: **~50–55 kWh per kg** of hydrogen

Electrolysis minimum thermodynamic voltage: **1.23 V**

IIT GUWAHATI CATALYST:

Material: **MXene + Ruthenium (Ru)** nanostructures

HER overpotential: **12 mV** (vs Pt/C at ~20–50 mV)

Published: **Advanced Functional Materials**

INDIA'S HYDROGEN PARTNERSHIPS:

India-Germany Green Hydrogen Partnership (2022)

India-Japan Green Hydrogen Cooperation

Export terminals identified: **JNPT (Nhava Sheva), Kandla Port**

INDIA ENERGY CONTEXT:

Crude oil import dependence: **~85%**

Solar tariff (recent auctions): **under Rs. 2/kWh** (among cheapest globally)

PLI scheme also covers electrolysers alongside solar panels, batteries

OTHER RELEVANT FACTS:

Grey hydrogen: from natural gas (steam methane reforming) — carbon-intensive; costs **~\$1–2/kg**

Blue hydrogen: grey + CCS (carbon capture); cleaner but expensive

Green hydrogen: electrolysis using renewables — zero emissions

Green ammonia = H₂ + N₂ (using Haber-Bosch process); easiest form for hydrogen export/storage

Competing exporters: Australia, Chile, Oman, Saudi Arabia (all targeting same European/Asian markets)

Sources: The Hindu, PIB, Ministry of New and Renewable Energy

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