


MISSION GREEN HYDROGEN

TARGETING 5 MILLION METRIC TONNES OF GREEN HYDROGEN PER ANNUM BY 2030, ONE-FIFTH OF GLOBAL PRODUCTION, INDIA HAS SET ITS EYES ON BEING A MAJOR PRODUCER AND EXPORTER. HERE'S HOW CORPORATE INDIA IS READYING WITH ITS MOVES.

By P.B. Jayakumar



VISITORS TO VARANASI will soon get a travel experience of a lifetime on the Ganga—a voyage on India's first hydrogen fuel cell (HFC)-powered catamaran, an air-conditioned twin-hull yacht for 100 passengers. Public sector ship builder Cochin Shipyard, which built India's first indigenous aircraft carrier, INS Vikrant, has already started fabrication work. The Fuel Cell Electric Vessel (FCEV) is a pilot for use of zero emission water vessels for carrying cargo and passengers.

At Vadodara in Gujarat, public sector Indian Oil Corporation (IOC) has started India's first commercial scale hydrogen storage and fuelling station, similar to a petrol pump. Hydrogen-powered buses will take visitors from Vadodara to Statue Of Unity on banks of Narmada at Kevadia.

National Thermal Power Corporation's (NTPC's) subsidiary, NTPC Renewables, plans to operate five hydrogen fuel cell buses in Leh, Ladakh. Amara Raja Power Systems is setting up a green hydrogen fuel station for this.

In August 2022, India's first indigenously developed HFC bus, made by CSIR's National Chemical Laboratory and KPIT Technologies, was launched in Pune. It was a demonstration project for the feasibility of running buses powered by hydrogen.

Indian Railways is getting ready to

run 35 hydrogen-powered trains at a cost of ₹80 crore per train on various heritage and hill routes. A pilot to fit diesel electric multiple unit rakes with HFCs will soon start on Jind-Sonipat section of Northern Railway.

India is making its earliest moves in clean energy revolution as the world prepares to unleash the potential of the ultimate fuel—green hydrogen. The first fleet of hydrogen trains is already running in Germany. China is launching Asia's first hydrogen-powered trains that will run at 160 kms per hour. U.K.-based ZeroAvia, which is planning HFC-powered commercial flights by 2025, recently flew a 19-seater plane for 10 minutes using hydrogen to power one of the two propellers.

Targeting producing at least five million metric tonnes (MMT) green hydrogen per annum by 2030, one-fifth of International Energy Agency's (IEA's) global target of 25 MMT, India has set its eyes on being a major producer and exporter of green hydrogen. The plan will entail investment of ₹8 lakh crore in what will be one of the largest energy transitions in the world. This can reduce fossil fuel imports by ₹1 lakh crore per year. Government expects this will create six lakh jobs and reduce CO₂ emissions by 50 MMT per annum. India's target is net zero emissions by 2070. It currently emits 2.9



Grey Hydrogen

Produced via coal or lignite gasification (black or brown), or steam methane reformation of natural gas or methane (grey). These are carbon-intensive processes

GT (giga tonnes) CO₂ a year. One GT is one billion tonnes.

Leading corporates such as RIL, Adani, Tata, JSW and L&T and all big public sector energy companies have taken up the task of building India's hydrogen ecosystem. Here's the roadmap. But first, the challenges.

The Green Hurdle

Managing the transition from fossil fuels to hydrogen without hurting the country's economic momentum is a challenge in itself. Pricing will be key as capturing and transporting hydrogen is expensive.

Scientists have been exploring the possibility of using hydrogen to produce energy for decades as it is an abundant element. There are three types of hydrogen. 'Grey hydrogen,' produced from coal/lignite gasifica-

Blue Hydrogen

Produced through natural gas or coal gasification combined with carbon capture storage or carbon capture use technologies to reduce carbon emissions

Green Hydrogen

Produced by electrolysis of water with help of electricity generated from renewable sources. Carbon intensity depends on source of electricity

tion or steam methane reformation (methane from natural gas is heated with steam to produce carbon monoxide and hydrogen). 'Blue hydrogen' is produced from natural gas or coal gasification. Both pollute the air—one more, one less than the other. The only net zero fuel is 'green hydrogen,' which burns cleanly, releasing only water vapour.

However, today, the cost of splitting water to generate green hydrogen is more than the value of energy produced. Current production cost of green hydrogen, \$3-6 per kg, has to come down to under \$2-2.5 per kg to make it viable. "India can bring down the cost of hydrogen to \$1 per kg. This will make it the first to reach \$1 per one kg in one decade—the 1-1-1 target," Reliance Industries (RIL) Chairman Mukesh Ambani said at International Climate Summit in 2021. IEA says it's possible to reach \$1.3-4.5 per kg as cost of producing renewable energy falls and electrolyzers become 70% cheaper by 2030. Electrolyzers split water into hydrogen and oxygen. A report by Institute For Energy Economics And Financial Analysis (IEEFA) says electrolyser costs must fall below \$250 per megawatt from \$700-1,000 and renewable energy from \$30-35 per megawatt hour to \$20 for green hydrogen to become viable.

Sumant Sinha, chairman and CEO

of ReNew, a renewable energy company, says power costs matter the most. "Electrolyser cost is 30-35%. Green power to run electrolyzers accounts for about 60% cost. That has to come down. India will have an advantage as we are adding huge scale in renewables," he says.

Hydrogen For Mobility

Experts say large scale transition to hydrogen will start with HFC-powered automobiles and ships. Prime Minister Narendra Modi flagged off India's first hydrogen internal combustion engine (ICE)-powered heavy duty truck at India Energy Week at Bangalore in February. RIL and Hinduja Group's vehicle maker Ashok Leyland, which implemented the project, say the truck's architecture is similar to ICE vehicles due to which it will cost less than other hydrogen vehicles.

Tata Motors, which last year bagged a deal from IOC for supplying 15 HFC buses, has set up a lab in Pune and developed hydrogen handling & storage capabilities. It has also built a hydrogen fuel station and a test-track in Sanand. Tata Motors displayed hydrogen concept vehicles such as Starbus HFC electric bus, PRIMA E.55 cargo truck and PRIMA H.55S, company's first hydrogen ICE engine truck, at Auto Expo in New Delhi.

WHY HYDROGEN

- It will replace fossil fuels as source of clean energy
- Green hydrogen can help India meet net-zero ambition since it burns cleanly, leaving only water vapour behind
- 5 MMT green hydrogen per year can reduce fossil fuel imports by ₹1 lakh crore, greenhouse gas emissions by 50 MMT
- Green ammonia and hydrogen can reduce LNG import bill and help reduce fertiliser subsidy bill of nearly ₹1 lakh crore.

PRICING CHALLENGES

- With existing technologies, the cost of splitting water to get green hydrogen is more than the value of energy produced
- Production cost is \$5-6/kg. Need to bring it below \$2-2.5/kg
- To compete with grey hydrogen at \$2/kg, cost of two main inputs, electrolyzers and renewable energy, must decline. Electrolyzers must fall from \$700-1,000 to below \$250/MW, and renewable energy from \$30-35 per MWh to \$20 per MWh

SOURCE: INSTITUTE FOR ENERGY ECONOMICS AND FINANCIAL ANALYSIS

Oil Refiners Lead Way

Mobility companies may be the first off the block but green hydrogen will make the greatest impact in high carbon emitting industries such as refining, petrochemical, steel, cement, fertiliser, shipping, mining and metals. Oil refineries use hydrogen from naphtha or natural gas for desulphurisation. Usually, they make hydrogen through steam reforming, which causes high carbon emissions (grey hydrogen).

IOC is building a seven kilo tonnes green hydrogen facility at Panipat in Haryana at a cost of ₹2,000 crore. It's scheduled to take off by 2025-26. All IOC refineries will eventually get green hydrogen units. Bharat Petroleum Corporation is setting up a 20 MW electrolyser plant and plans to produce 10 kilo tonnes green hydro-

gen per annum by 2030. Hindustan Petroleum Corporation is setting up a green hydrogen plant at Vizag refinery with 7.3 kilo tonnes capacity by 2025. By 2024, Mangalore Refinery And Petrochemicals' 0.5 kilo tonne pilot is planned to go onstream while Numaligarh Refinery's five kilo tonnes plant in Assam will take off by 2030. Chennai Petroleum Corporation's one kilo tonne plant will take off by 2026-27. In all, public sector oil refiners plan to produce 30.8 kilo tonnes green hydrogen a year by 2030.

In the private sector, RIL has laid out its roadmap: "We aim to progressively commence transition from grey to green hydrogen by 2025," Ambani said at AGM in August last year.

Among non-refiners, Tata Steel Netherlands is switching to green steel at three plants in the Netherlands using DRI (direct reduced iron) technology. DRI reduces iron ore directly by using natural gas or hydrogen rather than coal. Tata Power, which is investing ₹60,000 crore in renewable energy over five years, will start pilots in green hydrogen, says chief executive officer and managing director Praveer Singh. India's largest steel maker, JSW, which has a big power business, has tied up with Australia's Fortescue Future Industries for producing green hydrogen.

Electrolyser Opportunity

The massive investments expected to flow into green hydrogen have turned electrolyzers into a huge Make In India opportunity. Global electrolyser capacity was 0.3 GW in 2020. It's expected to reach 17 GW by 2026, says IEA. India will require about 10 GW by 2030. Independent business research company Rystad Energy says capacity may reach 8 GW by 2025 with five-six big players. Prominent will be Ohmium International, RIL-Stiesdal, Adani, L&T-McPhy Energy, Greenko-John Cockerill, H2e Power Systems and Thermax-Fortescue Future Industries.

U.S.-based Ohmium International has tied up with Hero Future Energies



INDIA CAN BRING DOWN THE COST OF HYDROGEN TO \$1 PER KG. THIS WILL MAKE IT THE FIRST TO REACH \$1 PER ONE KG IN ONE DECADE"

Mukesh Ambani
chairman, Reliance Industries

Reliance Industries

- ₹5.95 lakh crore for developing 100 GW renewable energy plant and green hydrogen ecosystem in Gujarat over 10-15 years
- Dhirubhai Ambani Green Energy Giga Complex over 5,000 acres in Jamnagar
- ₹60,000 crore investment in PV, storage, hydrogen technologies, electrolyser manufacturing
- ₹15,000 crore to develop value chain, partnerships and future technologies

to develop 1,000 MW green hydrogen plant in India, U.K. and Europe. Ohmium was the first company to start an electrolyser manufacturing facility in India in 2021 with 500 MW capacity. The Bangalore plant is being scaled up to 2,000 MW. Hero Future Energies CEO Srivatsan Iyer says they are partnering with companies in polluting sectors.

GAIL (India) is setting up one of the largest PEM (polymer electrolyte membrane) electrolyzers in India at Guna, Madhya Pradesh. It will be able to make 4.3 MT hydrogen every day.

RIL, which is building one of the largest integrated renewable energy facilities at a cost of ₹60,000 crore, has tied up with Denmark's Stiesdal for making electrolyzers. Stiesdal is one of the world's largest players in offshore wind, storage and fuel technologies. The other big players are L&T and Hyderabad-based Greenko, which has joined hands with Belgium's John Cockerill to make electrolyzers in India. Poonawalla family-backed H2e Power Systems is building a 1,000 MW electrolyser plant.

One of the most promising technologies for high purity and efficient hydrogen production, both in terms of sustainability and environmental impact, is PEM electrolysis. INOXGFL group's flagship company and fluorine specialist Gujarat Fluorochemicals is developing its own fluoropolymer-based PEM to tap green hydrogen opportunities, says Devansh Jain, group executive director, INOXGFL group. "It is a big opportunity as fluoropolymer-based PEM forms the heart of fuel cells and electrolyzers," he adds.

The Ecosystem Builders

Big groups such as RIL and Adani are building complete ecosystems for producing and transporting green hydrogen. RIL's complex rides on its ₹5.95 lakh crore investment in green energy over 10-15 years. The plan involves building 100 GW renewable energy projects and a green

hydrogen ecosystem.

Its main competitor in green hydrogen will be Gautam Adani. "We want to become the largest green hydrogen manufacturer and exporter in the world," Gautam Adani told *Fortune India*. Adani New Industries (ANIL) is investing \$50 billion over next 10 years to build a green hydrogen ecosystem. The company will develop green hydrogen capacity of one million tonnes per annum before 2030 in initial phase. Energy major TotalEnergies of France will acquire 25% stake in ANIL to jointly explore the hydrogen market. "This allows us to shape market demand," Adani said while announcing the deal in January last year.

State-owned power giant NTPC has initiated work on a hydrogen hub in Andhra Pradesh. It will have facilities for production and export of green hydrogen and ammonia.

The complexity of implementing integrated projects has made L&T, IOC and ReNew form a joint venture. They calculate that green hydrogen demand in India for applications such as refineries, fertilisers and city gas grids will require investments of more than \$60 billion. In August 2022, L&T had commissioned a pilot that can produce 45 kg green hydrogen daily at its plant at AM Naik Heavy Engineering Complex in Hazira, Gujarat. The plant is for captive consumption. "This will reduce greenhouse gas footprint for us

**₹8
Lakh Crore**

Investment required to meet green hydrogen targets by 2030. Government expects this to create six lakh jobs and reduce CO2 emissions by 50 MMT per annum

as well as our clients by approximately 300 tonnes per annum," says Subramanian Sarma, whole-time director and senior executive vice president (energy), L&T.

Transport Challenge

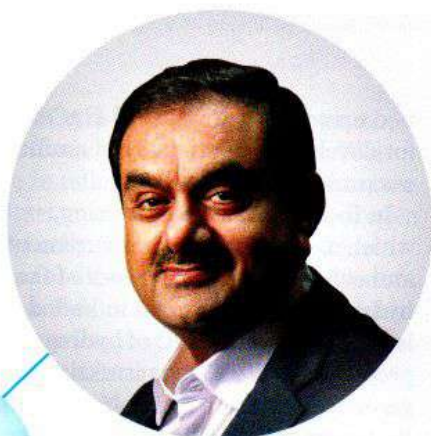
Hydrogen is 20 times more explosive than petrol, which makes storage and transport difficult. The safest way to transport is by converting it into ammonia (special pipelines to transport hydrogen are very expensive at present). Ammonia is a carbon-neutral hydrogen compound with high energy density and hydrogen storage capacity. It can be easily liquefied, stored and transported and re-converted into hydrogen when required. That is why companies are vying with each other for building ammonia facilities.

Gurgaon-based Acme Group is planning 1.2 mtpa green hydrogen and

ammonia projects in Karnataka and Odisha. It is commissioning an integrated green hydrogen and ammonia plant in Bikaner. In Tamil Nadu, it plans to set up a 5,000 MW solar PV plant, 1.5 GW electrolyser capacity and 1.1 million tonnes ammonia synthesis loop near Thoothukudi. The company is backed by renewable project developers such as Scatec, IFU, Unops and Brookfield and recently raised \$334 million through green bonds for its hydrogen play. It plans to invest ₹20,000 crore in equity of these projects over five years. Acme has 2.2 GW solar parks in operation while 3.05 GW are under construction.

Hyderabad-based Greenko is setting up a one million tonne green ammonia plant in Una, Himachal Pradesh. It has signed an MoU with ONGC to pursue opportunities in renewables and other derivatives of green hydrogen. Mumbai-based Avaada Energy is planning a green ammonia facility and a renewable energy power plant in Kota, Rajasthan. It has raised \$1 billion from Brookfield Renewable. Another major project is from Jakson Green, part of the Jakson Group, which will set up a 3.65 lakh tonnes per annum green hydrogen and ammonia plant along with an integrated renewable power complex at Kota in Rajasthan.

"India is climatically blessed and has top-class entrepreneurship to become



**WE WANT TO
BECOME THE
LARGEST GREEN
HYDROGEN
MANUFACTURER
AND EXPORTER
IN THE WORLD"**

Gautam Adani
chairman, Adani Group

Adani Group

- **\$50 billion:** Adani New Industries Ltd's (ANIL's) investment in green hydrogen and associated ecosystems over next decade
- **1 million** tonne/annum green hydrogen production capacity before 2030
- TotalEnergies of France will acquire **25%** in ANIL to jointly explore the hydrogen market

POLICY PUSH

NATIONAL HYDROGEN MISSION...

- Approved by Union Cabinet on January 4, 2022
- Aims to make India a hub for production and export of green hydrogen
- Focus on domestic manufacturing of electrolyzers and production of green hydrogen
- Pilots to develop green hydrogen valleys

...OUTCOME TARGETS BY 2030

- Production capacity of at least five MMT.
- Developing associated renewable energy capacity of 125 GW
- Developing 60-100 GW electrolyser capacity
- Total investment of over ₹8 lakh crore
- Creation of over 6,00,000 jobs
- Cumulative reduction of ₹1 lakh crore fossil fuel imports



HYDROGEN VALLEY HUBS: THE BLUEPRINT

| PLACE | HUB | CAPACITY OF ELECTROLYSERS (MW) | PRODUCTION PER ANNUM (TONNES) |
|--|---|--------------------------------|-------------------------------|
| Ankleshwar-Vadodara (Gujarat) | National Green Chemicals & Ammonia Fertiliser Hub | 40 | 8,000 |
| Bellary-Nellore (Karnataka-Andhra Pradesh) | National Green Steel And Chemicals Corridor | 30 | 5,000 |
| Pune-Mumbai (Maharashtra) | National Green Steel And Transport Hub | 30 | 5,000 |
| Kochi (Kerala) | National Green Refinery And Transport Hub | 30 | 5,000 |

SOURCE: IH2A RECOMMENDATION TO NITI AAYOG

25

Scalable green hydrogen projects aggregating 150 MW installed electrolyser capacity by 2025

12

Industrial de-carbonisation projects in chemical, refinery, steel industries

3

Heavy duty transport projects

3

H2 blending in city gas projects

7

Distributed waste-to-H2 municipal projects

the least cost producer and major exporter of green hydrogen as well as producer of electrolyser," Amitabh Kant, India's G20 Sherpa and former CEO of NITI Aayog, said at a recent event in New Delhi.

Project Specialists

Indian companies are also making their mark in emerging hydrogen mobility space globally. Cochin Ship-

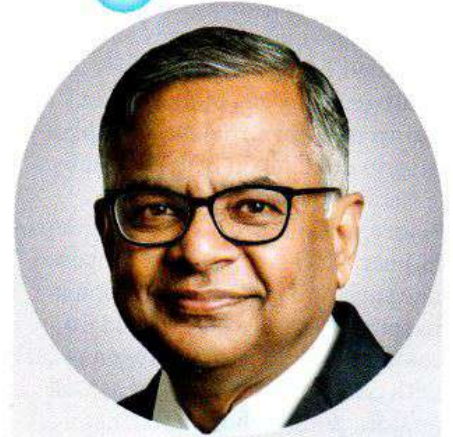
yard has received a ₹550 crore order from Netherlands-based Samskip Group, a logistics solutions provider, to build two 'zero emission feeder container ships' for operation in Europe. "It will be one of the world's first zero-emission feeder container ships powered by hydrogen fuel cells. It will eventually run on green hydrogen," says Cochin Shipyard, which will start deliveries from mid-2025. L&T has

tied up with Norway-based H2Carrier for developing floating green ammonia projects.

In India, Nuberg Engineering, which did engineering, procurement and construction (EPC) work of the hydrogen fuelling station in Vadodara, is looking to enter EPC of hydrogen projects. Jackson Green is setting up a green hydrogen station in New Delhi's Badarpur which will produce 260 kg

PSU GREEN HYDROGEN PLANS

| | CAPACITY (TONNES PER ANNUM) | COMMISSIONING |
|---|-----------------------------|---------------|
| BPCL, Bina, Madhya Pradesh | 10,000 | 2030 |
| HPCL, Vishakhapatnam | 7,300 | 2025 |
| IOC, Panipat, Haryana | 7,000 | 2025-26 |
| Numaligarh Refinery (Oil India), Assam | 5,000 | 2030 |
| Chennai Petroleum Corporation (IOC), Chennai | 1,000 | 2026-27 |
| Mangalore Refinery and Petrochemicals (ONGC), Mangalore | 500 | 2025 |



N. Chandrasekaran,
chairman, Tata Group

OTHER PSU INITIATIVES

| | |
|----------------------|--|
| Cochin Shipyard | Constructing India's first hydrogen fuel cell (HFC)-powered catamaran (twin-hulled); building two zero-emission feeder container ships for Netherlands-based Samskip Group |
| NTPC Renewables | Will operate five HFC buses in Leh and New Delhi |
| IOC | Has launched India's first commercial scale hydrogen compressor storage and hydrogen fuelling station at Vadodara, Gujarat |
| Indian Railways | Will run 35 hydrogen trains at ₹80 crore per train on various heritage/hill routes |
| GAIL (India) | Setting up electrolyzers to make 4.3 metric tonnes of hydrogen per day at Guna, Madhya Pradesh |
| Ministry of Shipping | Will develop Paradip (Odisha), Deendayal (Gujarat) and V.O.Chidambaranar (Tamil Nadu) ports as green hydrogen generation hubs |

green hydrogen per day, enough to run five electric buses in a day. "We are in talks with fleet operators to run diesel trucks retrofitted with hydrogen fuel cells. The same can be done in case of diesel generators", says Iyer of Hero Future Energies. ReNew, which is transforming itself into a decarbonisation solutions specialist, is planning to rope in partners to tap green hydrogen export opportunities.

States Join Race

Building hydrogen valley hubs (about 37 such valleys are coming up in 20 countries) to host production, storage, transmission and end-use infrastructure for green hydrogen in compressed and liquefied form will be a major element of the green hydrogen ecosystem.

Indian states are also competing with each other to attract investments

TATA POWER, WHICH IS INVESTING ₹60,000 CRORE IN RENEWABLE ENERGY OVER FIVE YEARS, WILL START PILOTS IN GREEN HYDROGEN

Tata Group

- Tata Steel Netherlands is making 'green steel' at its three plants using DRI (direct reduced iron) technology
- Tata Steel is working with Welspun to develop special steel pipes for transporting hydrogen
- Tata Motors has developed hydrogen fuel cell buses and is planning commercial hydrogen-powered trucks

in green hydrogen. Gujarat is working out policies and incentives and has allocated 1.99 lakh hectares for green hydrogen projects. Maharashtra, Orissa and Karnataka are also planning to build green hydrogen hubs.

Kerala government and India Hydrogen Alliance (IH2A), a group of industry and experts, have proposed one such hub in Kochi. The plan is to spend ₹4,700 crore to build 60 tonnes per day green hydrogen plant with a 150 MW electrolyser as well as storage and other infrastructure.

Jackson Green

- To set up 3.65 lakh tonnes/annum green hydrogen and ammonia complex at Kota, Rajasthan
- To build 10 tonnes/day methanol plant for NTPC in Vindhyachal, Madhya Pradesh

ACME Group

- Plans green hydrogen projects in Rajasthan, Tamil Nadu, Karnataka and Odisha
- Pilot green hydrogen and ammonia plant at Bikaner, Rajasthan
- To set up 5,000 MW solar PV plant, 1.5 GW electrolysers and 1.1 MT ammonia synthesis plant at Thoothukudi
- MoUs with Karnataka and Odisha governments

Avaada Energy

- To set up green ammonia facility and renewable energy plant at Kota
- Has raised \$1 billion from Canada-based Brookfield Renewable

“The hub will be developed through a public-private project consortia structure, with participation from industry, state-owned enterprises, government and multilateral funding agencies,” says Amrit Singh Deo, senior managing director, FTI Consulting and IH2A secretariat lead. The state government allocated ₹200 crore in FY24 budget for hydrogen hubs in Kochi as well as Thiruvananthapuram.

The India Advantage

Experts say India has significant advantages over others in this business. The biggest being the scale of renewable energy transition already in the works which lays a strong foundation for green hydrogen to build on. India is on course for 500 GW renewable capacity by 2030, about half of all energy produced then. Solar energy produced in India has already become cheaper than power from coal and gas. In early January, the Union Cabinet approved National Green Hydrogen Mission.

Two financial incentive mechanisms for domestic manufacturing of electrolysers and production of green hydrogen will be provided under Strategic Interventions For Green Hydrogen Transition Programme. Finance Minister Nirmala Sitharaman allocated ₹19,700 crore for green hydrogen production in 2023 Budget.

Government plans to give green hydrogen producers incentives of at least 10% of project cost and subsidy of ₹30-50 per kg (costs are ₹300 per kg in India). At least two committees of experts are working on finalising the fine print for bids, subsidies and incentives like viability gap funding and aggregator for offtake, say sources. Ministry of New And Renewable Energy is finalising the bidding process.

A major beneficiary of the hydrogen ecosystem will be the fertiliser sector. India uses about 55 million tonnes chemical fertilisers every year and natural gas, the most crucial feedstock



S.N. Subrahmanyam
MD & CEO, L&T

IN AUGUST 2022, L&T COMMISSIONED A PILOT THAT CAN PRODUCE 45 KG GREEN HYDROGEN DAILY AT ITS PLANT AT HAZIRA, GUJARAT

L&T

- Exclusive licence from France's McPhy Energy to make electrolysers in India
- Tie-up with Norway-based H2Carrier for developing floating green ammonia projects
- Pilot green hydrogen plant (45 kg/day) at Hazira for captive consumption
- JV with IOC for manufacturing electrolysers
- Green hydrogen projects with ReNew Power
- To explore green hydrogen buses along with ReNew Power, L&T and IOC





IT IS A BIG OPPORTUNITY AS FLUOROPOLYMER-BASED PEM IS THE HEART OF FUEL CELLS AND ELECTROLYSERS"

Devansh Jain, group executive director, INOXGFL Group

INOXGFL

- Developing fluoropolymer-based proton exchange membranes for electrolyzers
- ₹4,500-5,000 crore investment in EV batteries, solar panels, hydrogen fuel cells and electrolyzers in next three years

for fertilisers in India, accounts for 70-80% production cost. By 2025, demand for hydrogen in fertiliser industry could rise to 7.5 MT from current 3 MT as fertiliser demand touches 130MT. More than doubling of fertiliser demand will increase fertiliser subsidies whose bill has been exceeding ₹1 lakh crore.

Export Ambition

Since land availability for installing renewable energy plants is a constraint in many nations, they are looking to import large amounts of green hydrogen, usually in the form of gas or ammonia. "Developed parts of the world such as European Union are planning to import a bulk of green hydrogen. Japan and South Korea are also keen on imports. This can put India at an advantage," says Raghunath K., country representative, ThyssenKrupp India.

German government has already announced a 900 million euro auction for green hydrogen imports. H2 Global, a foundation formed by German companies such as Siemens Energy, Linde and ThyssenKrupp, will import green hydrogen and derivatives such as ammonia, methanol and sustainable aviation fuel. More than 30 countries and regions have green hydrogen strategies that include import or export plans, say experts.

Another trigger for demand will be

new technologies for use of hydrogen in engines and industrial plants. Finland-based Wartsila is developing engines and power plants running fully on green hydrogen by 2025. "Now, our engines can run on about 25% blended gas or hydrogen. In future, ships or engines will be able to run on fuels like green hydrogen, synthetic methane, methanol and ammonia," says Venkatesh R, managing director and director, energy, Wartsila India.

Global hydrogen demand (mainly refining and industrial applications like steel, cement, fertilisers) could reach 115 MT by 2030 from 94 MT in 2021. If all projects in the pipeline go on stream, production of low-emission (green) hydrogen could reach 16-24 MT per year by 2030, with 9-14 MT based on electrolysis and 7-10 MT on fossil fuels with carbon capture, utilisation and storage technologies, estimates IEA. Production of low-

emission hydrogen was less than one MT in 2021.

A report by Capgemini Research Institute says 62% heavy industry companies are looking to replace carbon-intensive systems with low-carbon hydrogen. Energy and utilities companies expect low-carbon hydrogen to account for 18% of energy consumption by 2050.

"The strong flow of announcements for low-emission hydrogen projects is another indicator that a new energy economy is emerging," says IEA Executive Director Fatih Birol.

In what was considered a milestone in development of a global hydrogen market, the world's first shipment of liquefied hydrogen from Australia to Japan was sent in February 2022. Global engineering solutions major Honeywell recently developed a Liquid Organic Hydrogen Carrier, a solution that enables long-distance transport of clean hydrogen. In August last year, INOXCVA, an Indian cryogenic equipment and solutions manufacturer, made one of the largest liquid hydrogen storage tanks ever made in India with a storage capacity of 238 cubic meters for a clean energy demonstration project in South Korea.

The scale of India's ambitions and its private sector capacity throw an opportunity to be a big player in global green hydrogen supply chains. ■

5 MMT

Planned green hydrogen capacity per annum by 2030, one-fifth of global production. This can reduce fossil fuel imports by ₹1 lakh crore per year.