INITIATIVES AND CHALLENGES ON INDIA'S TRANSITION TO GREEN HYDROGEN

— GREEN HYDROGEN CAN BE THE TRUMP CARD IN INDIA'S QUEST FOR "ENERGY INDEPENDENCE" —

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SUMMARY

- Indian Prime Minister Narendra Modi has set the goal of "energy independence" by 2047, the centenary of India's independence. The strategy calls for 50% of electricity demand to be met by renewable energy by 2030 and surplus electricity from renewable energy to be used for the production of green hydrogen for domestic use.
- India's demand for hydrogen is forecast to reach 9 million tonnes by 2030, and the government's target is for 5 million tonnes of this to be met by green hydrogen. The main customers for hydrogen are currently oil refineries and fertilizer plants, but demand is expected to expand to the transportation and power generation sectors from 2030 onwards.
- For the use of green hydrogen to become widespread, it will be necessary to solve the problems surrounding distribution infrastructure and cost. If India can promote the production of hydrogen electrolyzers through collaboration with technologically advanced foreign companies and build facilities for producing green hydrogen at a low cost, it will be possible not only to secure domestic supplies, but also to contribute to the spread of green hydrogen globally.

At COP26, the Indian government pledged to reduce greenhouse gas emissions per unit GDP by 45% from 2005 levels by 2030 and to achieve carbon neutrality by 2070. To realize this commitment and simultaneously to resolve India's problem of reliance on imports for over 80% of its oil, the Modi government has set an ambitious goal of achieving "energy independence" by 2047, the 100th anniversary of the country's independence. This report examines the efforts of the Indian government and private sector in relation to the domestic production of green hydrogen using renewable energy, which is considered to be the key to achieving India's goal of energy independence, and looks at the challenges involved.

1. "ENERGY INDEPENDENCE" AND GREEN HYDROGEN

1-1. Why the quest for "energy independence"?

In May 2020, the Indian government launched the slogan "Self-Reliant India". This constitutes a long-term strategy that aims to build industry structures that are not reliant on imports. The centerpiece of this policy is the PLI (Production Linked Incentive) scheme announced in April 2020. The focus of the scheme was initially on strengthening the electronics industry in areas such as the production of mobile phone parts, and it was designed to boost the country's manufacturing industry. However, following the rapid deterioration in China-India relations after the clash between Chinese and Indian troops in June 2020, the Modi government

significantly changed course to turn its back on China[1], and has strengthened its policy of promoting domestic production by progressively expanding application of the PLI scheme to 13 strategic industries, including pharmaceutical raw materials, solar cell modules, and lithium-ion batteries (providing a total of 2 trillion rupees in subsidies)[2].

As a result, the PLI scheme became the principal policy for achieving "desinicization". However, to realize a truly self-reliant India, in addition to strengthening the manufacturing industry, India's biggest challenge is to free itself from a structure that relies on imports for over 80% of its oil and more than 50% of its gas. This is not because of the need for decarbonization; it is because India's energy import-dependent structure creates a trade and current account deficit, which is a major factor behind the country's macroeconomic fragility, and there is an urgent need to resolve this issue.

While various targets have been set for achieving energy independence (Figure 1), the key is the production of green hydrogen using surplus electricity from renewable energy sources, primarily solar power generation. The spread of renewable energy will lead to a reduction in fossil fuels and energy imports, and if green hydrogen produced using renewable energy becomes more common, it is possible that it will replace gray hydrogen, which is derived from fossil fuels and accounts for most of the hydrogen produced today. In that case, it will be possible to switch to using green hydrogen to produce ammonia, methanol, chemical fertilizers, and other hydrogen derived products, thereby further accelerating the process of decarbonization and energy independence. The government's goal of energy independence has been set against the backdrop of these situations in the country.

Figure 1: Examples of initiatives towards energy independence

1	Promotion of domestic oil and gas production
2	To increase the use of natural gas (India aims to increase the share of primary energy consumption from the current 6.7% to 15% by 2030)
3	Promotion of electric vehicles, introduction of E20 (20% ethanol blended gasoline), promotion of fuel cell vehicles, deployment of hydrogen supply stations, expansion of CNG vehicles
4	Expansion of the town gas grid and blending with hydrogen
5	Large-scale introduction of renewable energy (from current capacity of 150GW to 500GW by 2030)
6	To develop a green hydrogen production hub (domestic production and export of equipment)
7	To expand the production and use of green hydrogen from renewable energy sources (used in oil refining, fertilizer production, ironmaking, ammonia/methanol production)

Source: Compiled by MGSSI based on announcements by the Government of India and other sources

1-2. National Hydrogen Mission

In November 2020, Prime Minister Modi announced the introduction of a comprehensive national hydrogen energy mission. Under the 2020-2021 budget plan, the government launched the National Hydrogen Mission (NHM), which specifically aims to fuel India's economic growth through the production and use of green hydrogen. The goal is to expand the production of green hydrogen in India, and to become a global base for the production and export of the electrolyzers and related products required for its production. Concrete initiatives have already been planned, including the introduction of a PLI scheme for the production of electrolyzers used to produce green hydrogen (with an investment of approx. US$2 billion). In February 2022, the Ministry of Power announced measures to promote the production of green hydrogen and ammonia (Figure2). There is also a plan (awaiting government approval) that would require 10% of the hydrogen used by

[1] India has also introduced de-facto restrictions on investment from China.

[2] While the weakness of India's manufacturing base was already an issue, this is also seen as an opportunity to strengthen the manufacturing industry.

oil refineries and the fertilizer industry to be green hydrogen by 2024, and the percentage of green hydrogen used would be increased gradually toward that target.

Figure 2: Green Hydrogen and Ammonia Policy (extract) (announced Feb. 16, 2022)

Production target of 5 million tonnes of green hydrogen by 2030
No inter-state transmission charges for a period of 25 years to the producer of green hydrogen and green ammonia from the projects commissioned before June 2025.
No additional surcharge on renewable energy procurement. Companies may generate renewable energy themselves or procure it free of surcharge from electricity exchanges, or from other developers, etc. They will be granted open access for sourcing of renewable energy within 15 days of receipt of application.
Priority connection to power lines. Prioritized development of interstate power lines from renewable energy plants to green hydrogen/green ammonia plants.
Unconsumed pre-contracted renewable energy may be banked with the distribution company for up to 30 days, and used later as required.
Incentives granted for Renewable Purchase Obligations (RPO)
Permission to establish export/transportation storage facilities close to ports.

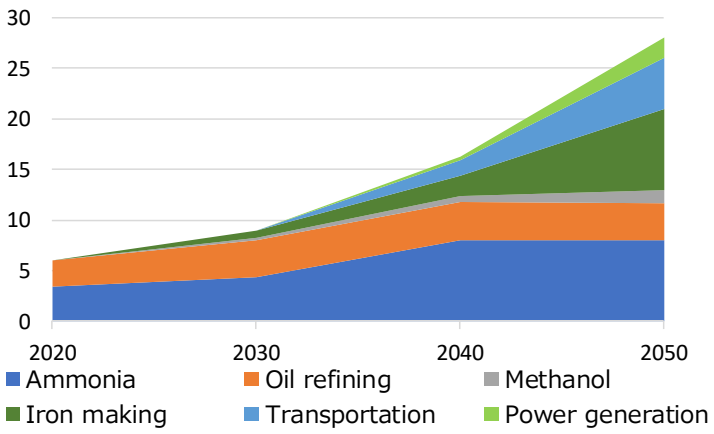
Source: Compiled by MGSSI based on announcements from the Indian Ministry of Power
https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1799067

2. INDIA'S HYDROGEN MARKET

2-1. Demand

Global hydrogen demand was approximately 90 million tonnes in 2020, but under the IEA's (International Energy Agency) net zero scenario, it will rise by more than double its current level to 212 million tonnes by 2030, of which 38% (80 million tonnes) is predicted to be green hydrogen. India's annual hydrogen demand in 2020 was approximately 6 million tonnes. While this is expected to reach approximately 9 million tonnes by 2030 and about 28 million tonnes by 2050, India aims to produce 5 million tonnes of green hydrogen annually by 2030. Currently, 42% of India's hydrogen demand is consumed by oil refineries, and 41% by the chemical and fertilizer manufacturing sectors. While major change is not expected in the sectors requiring hydrogen until around 2030, demand is expected to begin gradually extending to the transportation and power sectors (Figure 3).

Figure 3: Hydrogen demand forecasts by sector (India)

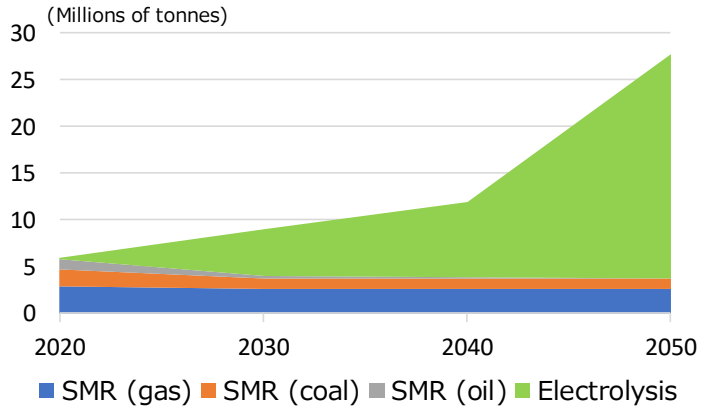


Note: Only the major consuming sectors are shown.
Source: Graph and forecasts compiled by MGSSI based on data from India's TERI (The Energy and Resources Institute) and other media sources

2-2. Production methods

Currently, so-called gray hydrogen, which is derived from fossil fuel, is generally produced using the steam methane reforming (SMR) method. In India, natural gas accounts for 50% of the raw materials used for this process and the remaining ingredients are related to coal and petroleum. However, the water electrolysis method, which is used to produce green hydrogen, is projected to become the mainstream in the future (Figure 4).

Figure 4: Hydrogen production and supply forecasts by production feedstock (India)



Source: Graph and forecasts compiled by MGSSI based on data from TERI, MEC Intelligence, and other sources

3. PRINCIPAL PLAYERS AND INTERNATIONAL COLLABORATION

Aside from Western companies, many entities have announced their plans to produce and use green hydrogen, including domestic conglomerates, renewable energy companies, and government-affiliated oil and gas companies. (Figure 5). India's largest conglomerate, Reliance Industries, has announced an investment of US$10 billion over the next three years, and another leading conglomerate, Adani Group, has stated its aim of becoming the world leader not just in renewable energy, but in green hydrogen production as well. The Indian government has instructed state-affiliated oil and natural gas companies to establish seven or eight pilot plants. India has also begun a process of international collaboration with the US, the EU, and Australia for the purpose of financial cooperation in the development of clean energy and promotion of decarbonization in the industrial sector (Figure 6).

Figure 5: Initiatives by major players in India's green hydrogen sector

Name	Organization type	Projects
Ohmium	Foreign company (US)	Opened India's first large-scale green hydrogen electrolyzer production plant in August 2021, with an initial annual production capacity of 500MW, slated to rise to 2GW. Commenced export of Indian-made electrolyzers to the US in November of the same year
HydrogenPro	Foreign company (Norway)	In January 2022, concluded an MOU with leading Indian construction company L&T to establish a joint venture to produce green hydrogen electrolyzers in India
ReNew Power / L&T/IndianOil	JV between three companies	In April 2022, IndianOil, L&T and ReNew Power concluded a partnership agreement to jointly develop, own, execute, and operate green hydrogen projects. The IndianOil/L&T/ReNew JV will focus on developing green hydrogen projects in a time-bound manner to supply green hydrogen at an industrial scale. It is expected that green hydrogen electrolyzers will be produced at L&T's production facilities on the outskirts of Surat in Gujarat State.
Reliance Industries	Indian conglomerate	Announced entry into solar PV (cells/modules), batteries, fuel cells, electrolyzers for hydrogen production, and green hydrogen production in June 2021. Plans to invest US$10 billion and build 4 large-scale plants over 3 years. Expects to produce electrolyzers equivalent to 2.5GW annually, and aims to produce hydrogen at US$1 per kg within a decade.
ACME Solar	Indian renewable energy company (solar power)	In February 2021, announced plans to produce green hydrogen in India and Europe in collaboration with France's Lhyfe Labs. In August of the same year, announced plans to invest US$3.5 billion in the production of 4GW of green hydrogen and ammonia in Oman, JV with Scatec ASA (Noeway). Has concluded a memorandum with an Oman public agency to secure land within the country's Duqm Port Special Economic Zone.
Adani Group	Indian conglomerate	Plans to build an ammonia, green hydrogen value chain in partnership with Italy's Maire Tecnimont. Adani has announced plans to invest US$20 billion in renewable energy related sectors over 10 years. It has stated its intention to become the world's largest renewable energy company, and has set itself the goal of becoming the world's largest producer of green hydrogen utilizing its own renewable energy. It also plans to produce methanol, ammonia, and fertilizers from green hydrogen.
Government affiliated public companies, etc.		
GAIL	Public sector gas corporation	Has launched a global tender to procure electrolyzers for a 10MW plant to be built as a pilot project. Two to three sites have been selected for the unit to be installed in Madhya Pradesh State and elsewhere. Gail is conducting a trial to blend natural gas with hydrogen in Indore in Madhya Pradesh, and will expand production of green hydrogen based on the outcome. In the future, it also plans to supply green hydrogen to fertilizer manufacturers.
NTPC	Public sector thermal power company	Plans to develop a green hydrogen-based energy storage system and build a nation-wide off-grid hydrogen storage and microgrid power supply system in partnership with US energy solutions provider Bloom Energy. NTPC is currently operating a 5MW green hydrogen pilot production facility in Vindhyachal in Uttar Pradesh State, and estimates that hydrogen can be produced at about US$2.8 to 3/kg. It has future plans for large-scale green hydrogen production. It is also planning to produce green hydrogen at a 4.75GW solar park it intends to build in Gujarat State, and plans to build the first green hydrogen refueling station in Ladakh, and supply hydrogen for five hydrogen buses.
IOC	Public sector oil company	India's largest state-owned oil company IOC, plans to use electricity from its wind power project in Rajasthan State to produce green hydrogen at a 160,000 barrel/day oil refinery planned for Mathura in Uttar Pradesh State. IOC has set its sights on replacing at least 10% of the hydrogen consumed at its oil refineries with green hydrogen, and plans to achieve this at the Mathura refinery by 2024.
SECI / ONGC	Public sector solar power company and oil & natural gas company	In August 2021, the Solar Energy Corporation of India (SECI) announced a tender for a green hydrogen pilot facility project. In December 2021, SECI concluded an MOU with India's public Oil and Natural Gas Corporation (ONGC) for the joint development of projects spanning the entire renewable energy sector, including solar power, wind power, green hydrogen, and EVs.

Source: Compiled by MGSSI based on information from Livemint.com and other media sources

Figure 6: International collaborative projects in India's energy and hydrogen sectors

Country/ Region	Projects
US	The Strategic Clean Energy Partnership (SCEP) was formed in 2018. In April 2021, the Climate and Clean Energy Agenda 2030 Partnership was launched, and in September 2021, the public-private Hydrogen Task Force and Biofuels Taskforce was launched to expand the use of clean energy technologies.
EU	The Clean Energy and Climate Partnership was established in 2016. In December 2021, the two countries agreed to strengthen their efforts in the environmental sector, and furthered their cooperation on clean hydrogen production and applied technologies. India anticipates support from the US and EU in the areas of green policy, technological cooperation, and financing.
Australia	The India-Australia Energy Dialog has been established, and at the 4th dialogue held in February 2022, an LOI was signed with a view to lowering the price of technology relating to renewable energy and promoting its introduction. The LOI also includes the promotion of ultra-low cost solar power generation and clean hydrogen production (involving carbon capture and storage [CCS]).
Japan	In 2017, the Japan-India Clean Energy and Energy Efficiency partnership was launched. In March 2022, Japan and India extended clean energy partnership to cover EVs, battery storages, collaborate on green hydrogen and ammonia, LNG, biofuels and strategic oil reserve. Japanese companies are conducting domestic and overseas trials of coal-ammonia co-firing, which may be useful for the future of india, as India relies on coal-fired power plants for 70% of its electricity.

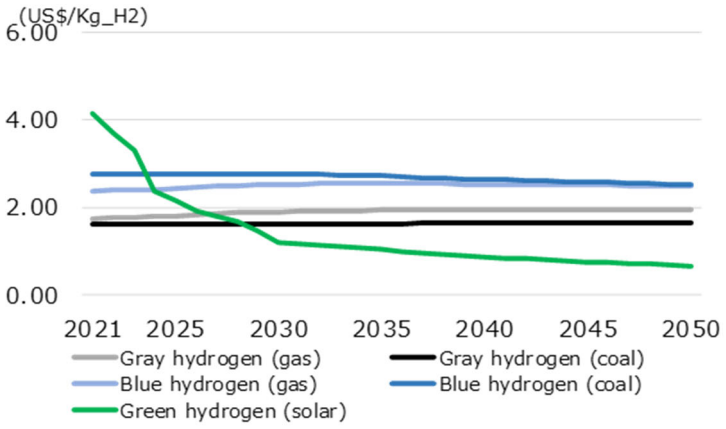
Source: Compiled by MGSSI based on announcements and other information from each country/region

4. FUTURE OUTLOOK – THE CHALLENGE LIES IN COMPARATIVELY HIGH PRODUCTION COSTS –

As of 2021, the levelized cost of hydrogen (LCOH2) was approximately US$0.5 to 1.7/kg in the case of gray hydrogen and approximately US$1.0 to 2.0/kg for blue hydrogen, for which CCUS (Carbon Capture, Utilization and Storage) is used. On the other hand, the cost of producing green hydrogen from renewable energy is comparatively high at US$1.74 to 12.13/kg. However, this is predicted to drop to US$1.3 to 3.5/kg by 2030, which will make it economically competitive.

In India, however, the cost of producing both gray hydrogen and blue hydrogen is relatively high, at approximately US$1.7/kg and US$2.8/kg, respectively, due to the high price of gas. At the same time, the cost of producing green hydrogen is even higher at about US$4.1/kg (Figure 7).

Figure 7: Hydrogen production cost (LCOH2) forecasts (India)



Source: Forecasts and graph compiled by MGSSI based on data from BloombergNEF

For this reason, reducing the price of electricity and the cost of related products is the key to India's aspiration to become a green hydrogen production hub and export base. Norway's HydrogenPro has pointed out that if the price of electricity drops to 2 cents/kWh, green hydrogen will become more competitive than gray hydrogen[3]. For that to happen, there are two bottlenecks that need to be eliminated. One is the transmission and distribution network from large-scale solar power plants to the areas of demand (oil refineries, fertilizer plants, etc.). While the cost of generating solar power (bid price) has already dropped to 2.6 cents/kWh in India, the production cost of green hydrogen is expected to fall further as the transmission and distribution network is improved[4].

The other bottleneck is the fact that many of the technologies relating to the production, transportation, and use of green hydrogen are in the development or demonstration stages, and compared to developed countries and China, which can provide financial support for technologies from these stages, the Indian government is only able to offer support in a few areas. It will therefore also be necessary to seek ways to reduce costs, including by collaborating with leading Western companies, utilizing innovative technology ahead of other countries, and introducing low-cost technology from countries like China. Examples of investment from Western companies have already begun to appear (Figure 5). Moreover, the aforementioned HydrogenPro has worked on hydrogen production in China through a joint venture with a Chinese company, and has agreed to produce electrolyzers in India in partnership with the Indian company L&T. If Indian companies can introduce competitive production technology from China and the country's power grid can be improved with government support, it may be possible to compete in price with the existing gray hydrogen in two or three years at the earliest[5].

As of 2020, by energy source, India's primary energy consumption was 55.0% coal, 28.0% oil, 9.1% renewable energy, 6.7% natural gas, and 1.2% nuclear power. Most of the country's demand for coal can be met from domestic reserves, however, it will be essential to replace oil and gas with green fuels, including hydrogen, at the same time as expanding domestic oil and gas production. Needless to say, it will also be necessary to move away from dependence on coal and oil in order to achieve the goal of decarbonization. The government has announced plans to open up domestic oil and gas concessions to private sector companies and to put more focus on domestic oil and gas production, while at the same time it is making efforts to rapidly introduce renewable energy centered on solar power generation as mentioned above. However, the surplus electricity from daytime solar power generation is not on its own sufficient to raise green hydrogen production efficiency. To ensure a stable power supply, an effective policy would be to utilize hydroelectric power, which is a stable source of renewable energy, along with a hybrid wind and solar power system. In addition, if a system akin to electricity sales contracts is established, whereby the green hydrogen purchase price and volume are guaranteed, it would create an environment in which the users of the hydrogen, i.e., the government affiliated oil and gas companies, would be able to focus their efforts on the introduction of renewable energy and the production of green hydrogen. The government also needs to introduce legislation to this effect.

If India can overcome these challenges, and lead the way in the production of green hydrogen at a low cost, it will contribute not only to the domestic supply of green hydrogen, but also to the expansion of its global production.

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[3] If that can be achieved, it is said that India will be able to supply green hydrogen at about US$1.2/kg by as early as 2022.

[4] The handling of hydrogen for transportation is expensive, and it is effective to produce it as close as possible to the point of use.

[5] It is said that by proceeding with the policy to promote the production of green hydrogen and green ammonia announced by the government in February 2022 (Figure 2), the cost of producing hydrogen can be reduced by 40 to 50% of the current level.