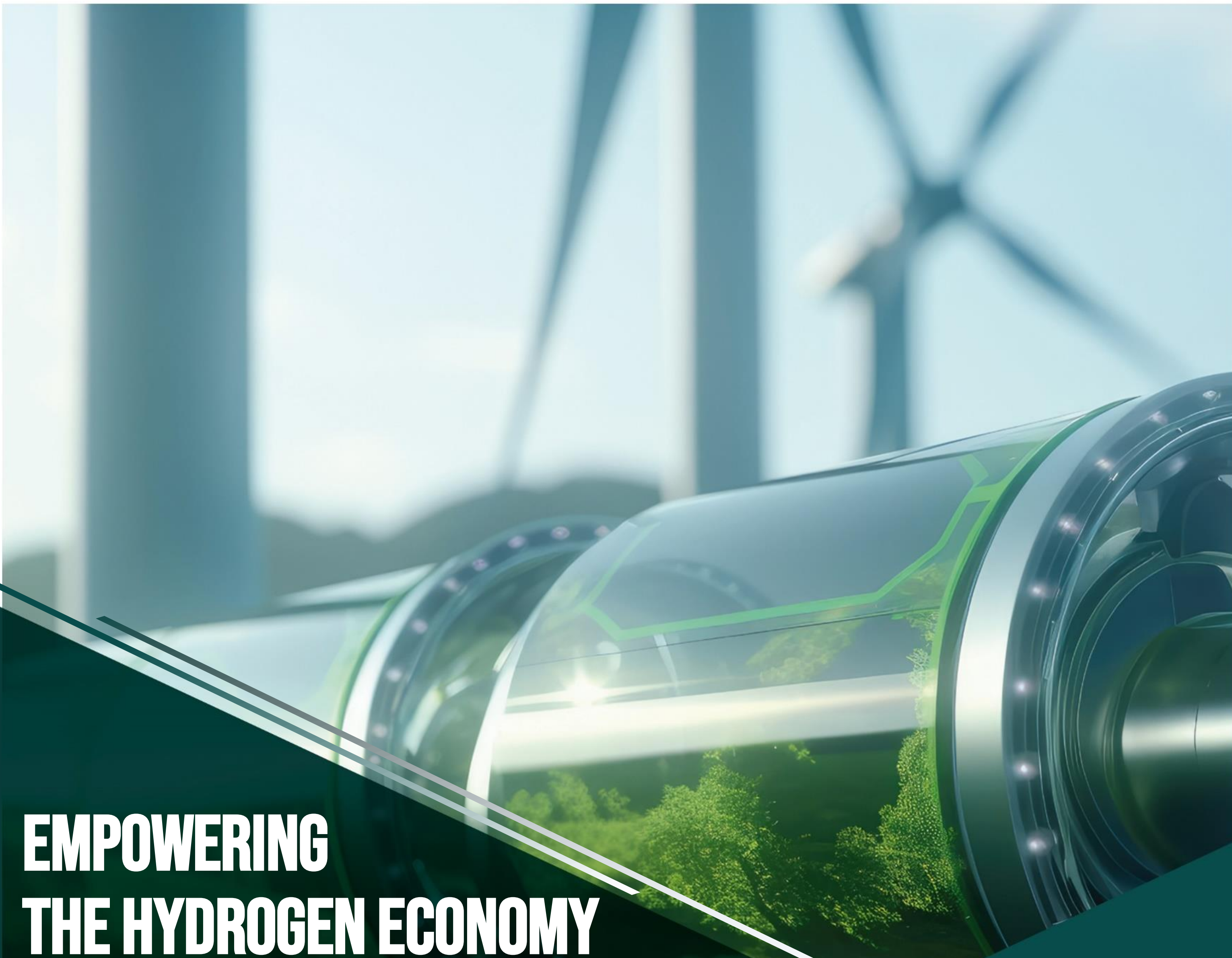
AVALON Consulting

Cordence WORLDWIDE | Get ahead of what's next

AN AVALON PERSPECTIVE



EMPOWERING THE HYDROGEN ECONOMY IN CHEMICAL INDUSTRIES

India's Green Hydrogen Mission and Global Energy Transition

ABSTRACT

Hydrogen emerges as a pivotal energy carrier in global decarbonization efforts across sectors, fuelled by its zero-emission potential and declining production costs. Its role as a fossil fuel alternative drives the shift towards a hydrogen economy, particularly in emissions-intensive sectors like steel and transportation, underscoring its importance in fostering sustainability. But not all sources of hydrogen production are carbon neutral which brings our attention to Green Hydrogen and Blue Hydrogen (followed by CO2 sequestration). India's renewable energy abundance positions it as a potential leader in green hydrogen production, supported by initiatives like the National Green Hydrogen Mission targeting 5 million metric tons annually by 2030. Embracing hydrogen is pivotal for decarbonizing the chemical industry, offering a pathway to cleaner manufacturing processes and economic resilience through localized production. This synergy between hydrogen advancements, industry decarbonization, and global energy transitions signifies a transformative era in sustainable development.

INTRODUCTION

The escalating global pursuit of sustainable energy solutions has propelled hydrogen into a prominent position as a key facilitator of decarbonization efforts across various sectors. India, leveraging its abundant renewable resources, stands poised to spearhead this transformative endeavour with its ambitious National Green Hydrogen Mission. Aiming for an annual production capacity of 5 million metric tons by 2030, this initiative holds substantial promise in reshaping emissions-intensive industries, such as refineries, petrochemicals, fertilizers, and downstream chemical sectors, by seamlessly integrating green hydrogen into their operational frameworks.

Amidst the imperative of combating climate change, the cost-effectiveness of green hydrogen production stands as a pivotal factor shaping its broader adoption. Steady technological progressions and innovative production methodologies are steadily narrowing the cost differential, rendering green hydrogen an increasingly competitive alternative to conventional fossil fuels. Nevertheless, significant challenges persist in the realms of storage and transportation, necessitating concerted efforts to fully harness the potential of this renewable energy carrier and facilitate its seamless integration within the global energy landscape.

CURRENT HYDROGEN CONSUMPTION

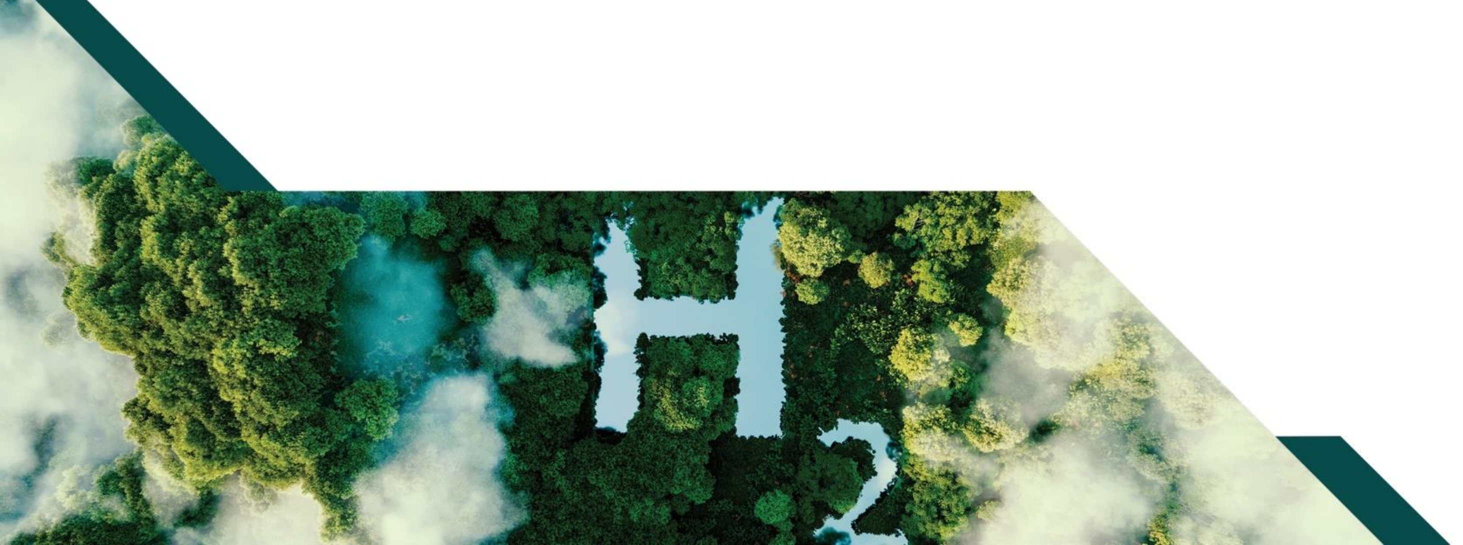
Total global hydrogen production was ~95 Megatons (MT) in 2022 of which only 0.7 MT (~1%) of hydrogen was from renewable sources indicating that green hydrogen initiative across the globe still has long way to go in terms of production, adoption, storage and transportation with ~80% of hydrogen being produced from coal and natural gas. Over 80% of the hydrogen demand comes from refineries and ammonia (fertilisers) manufacturing, however there are many use cases of Hydrogen in other industries which may shape the future consumption patterns and industries like steel, methanol production, power generation, etc. might witness the large scale usage of hydrogen in the future.

India however currently consumes approximately 6 Million Tons per annum (MTPA) of hydrogen, with 3 MTPA in refineries for fuel desulfurization and product upgradation, 2.5 MTPA for fertilizer production, and the rest for steel and chemicals.

OIL AND GAS

Green hydrogen, produced using renewable energy sources, has several potential applications in the oil and gas industry. It can be effective in the decarbonization of operations by replacing fossils fuels that have traditionally been used in powering oil operations, reducing carbon emissions up to 70%. It can also be used in the process of refining, to convert heavy petroleum fractions into lighter products by removing sulphur, nitrogen, and other metals from the fractions. When it comes to energy transition, green hydrogen can serve as a bridge in the transition from grey hydrogen to a more sustainable alternative. Additionally, mixing hydrogen with conventional fuels can enhance thermal efficiency and reduce unburned hydrocarbon emissions. Oxyhydrogen gas injection into internal combustion engines (ICE) lowers petrol consumption and CO_2 emissions.

To lower carbon emissions and improve energy security, India is aggressively investigating and funding green hydrogen. Green hydrogen presents a self-sufficient and potentially limitless energy source since it is generated from renewable resources like solar and wind power. India is planning to lessen its reliance on fossil fuel imports by using green hydrogen. The National Green Hydrogen Mission was introduced by the national government on January 4, 2023, with an expected budget of INR 20,000 crores and increasing yearly green hydrogen generation capacity to at least 5 million tons is the mission's main goal. However, most of this hydrogen comes from fossil fuels and is mostly utilized in the refining of petroleum and the manufacturing of ammonia for fertilizers. India has previously shown that it can create supply chain ecosystems for a variety of industries. Adoption of green hydrogen will advance if there is a robust domestic market for consumption. Demand for green hydrogen is predicted to increase to 2.85 million tonnes by 2030 as more sectors switch to cleaner fuels.



OIL REFINERIES

Oil refineries can become more sustainable with the use of green hydrogen. Green hydrogen is a clean fuel that refineries can use for a variety of internal operational procedures. Boilers and furnaces in refineries, powered by hydrogen, can take the place of traditional fossil fuel-based systems. Refineries have the lowest green-premium (switch-over cost) when using green hydrogen in comparison to other demand sectors. Refinery methods that incorporate 20% green hydrogen usually result in a 1-5% increase in the finished product's cost. Because of the stricter sulphur laws in place all over the world, there is a predictable and steady demand for petroleum refining using greener methods, which is expected to grow soon. It is anticipated countries like India will greatly increase their refining capacities, opening the possibility of greenfield refinery designs based on green hydrogen. Benefits from ESG compliance and future carbon credit opportunities may easily outweigh the cost increase

Increased use of green hydrogen as a feedstock in refineries has the potential to cut carbon emissions from refineries by 25% by 2050. Meeting sustainability goals and environmental laws is greatly aided by this reduction. In conclusion, the oil and gas industry may move toward cleaner energy, lower emissions, and a more sustainable future by implementing green hydrogen in refineries. In India, The SIGHT program, funded by the NGHM, was launched in June 2023 at a cost of Rs174.9 billion (US$2,098.8 million). SIGHT is in favour of producing green hydrogen and electrolysers domestically. Strong industry engagement was shown by the flotation of tenders and the high level of market interest. A rising mandate is in place, requiring refineries to use green hydrogen for 10% of their needs in 2023-24, increasing to 25% in five years. India currently uses over 6 Million Tons per annum (MTPA) of hydrogen, with 3 MTPA in refineries for fuel desulfurization and product upgradation, 2.5 MTPA for fertilizer production, and the rest for steel and chemicals highlighting India's commitment to using green hydrogen in its refineries, aiming for a cleaner and more sustainable refining sector.

.

PETROCHEMICALS

In India's drive towards green energy, the use of green hydrogen is being explored not only in refineries but also in petrochemical facilities, albeit with some key considerations. Unlike refineries that might need to import hydrogen, petrochemical plants are large-scale producers of hydrogen for their own internal processes. These processes, consuming over 3 million metric tons annually in India alone, utilize hydrogen for functions like desulfurization (cleaning fuels) and upgrading raw materials into higher-value products. Currently, some petrochemical processes burn hydrogen as fuel, but it's important to note that this hydrogen currently often comes from fossil fuels, resulting in minimal environmental improvement.

However, green hydrogen offers a promising alternative pathway. It can be used to produce green methanol, a renewable feedstock that can then be used to create various chemicals like olefins, aromatics, and synthetic fuels. This green methanol route presents a potential outlet for utilizing green hydrogen within the petrochemical industry. Nevertheless, there are challenges to overcome before widespread adoption of these hydrogen technologies can occur. The most critical factor is the availability of abundant, cheap, and reliable green electricity. Without this, producing green hydrogen becomes less feasible. In conclusion, while green hydrogen is revolutionizing the refining sector, within the realm of petrochemicals, the focus might shift towards electrification and green methanol production using clean electricity as the primary driver for achieving sustainability, although the role of green hydrogen as a fuel source and for captive use within the industry shouldn't be entirely discounted.

FERTILIZERS

Green hydrogen offers a more environmentally friendly method for producing ammonia, a key component of fertilizers, by replacing fossil fuels. This shift can reduce the fertilizer industry's carbon footprint and reliance on natural gas imports. Additionally, green hydrogen can provide the energy needed for ammonia synthesis, making the production process more sustainable.

India, the world’s second-largest consumer and third-largest producer of fertilizers, produced 43.66 million metric tons in 2021-22. India's fertilizer sector heavily depends on imports of natural gas, ammonia, and fertilizers. Geopolitical conflicts and supply chain disruptions have led to abnormal spikes in these commodity costs, increasing the subsidy burden on the government. Domestically produced green hydrogen and ammonia can reduce this dependence, enhance food security, and lower emissions from fertilizer manufacturing. Technological advancements, such as the world's first green ammonia plant in Bikaner, Rajasthan, exemplify India's active role in this transition. The Indian government’s National Hydrogen Mission aims to create demand for green hydrogen in sectors like fertilizer production. Despite its potential, implementing green hydrogen faces various challenges. Identifying these challenges and leveraging green hydrogen can ensure food security and foster resilient agricultural value chains.

DOWNSTREAM CHEMICAL INDUSTRIES

Countries rich in hydrocarbons can leverage their existing infrastructure to produce and export clean hydrogen, including green hydrogen made via water electrolysis without emissions, and blue hydrogen created from hydrocarbons with carbon capture. Clean hydrogen can help these countries decarbonize downstream industries like oil and gas, chemical manufacturing, long-distance aviation, and marine transport. Green hydrogen can replace fossil-fuel-derived hydrogen in hydrogenation reactions essential for producing fine chemicals, pharmaceuticals, and chemical intermediates. It can also be used as a starting point for methanol production, which is used in fuels, solvents, and polymers. Additionally, green hydrogen serves as a reducing agent in various chemical reactions and powers fuel cells used in transportation, power generation, and industrial processes. It is also employed in hydrogenating vegetable oils, enhancing their shelf life and texture, and in the production of hydrogen peroxide, a versatile chemical used as an intermediate, bleaching agent, and disinfectant.

India’s downstream chemical industry is adopting green hydrogen as part of a broader green transformation. To support this, the government is exploring production-linked incentive (PLI) schemes to promote electrolyser manufacturing, which will reduce costs and encourage green hydrogen adoption in downstream processes. Efforts to lower green hydrogen production costs include advancing renewable energy sources such as solar and wind, improving electrolyser efficiency, and developing cost-effective hydrogen storage solutions. India is conducting several pilot projects to demonstrate green hydrogen's feasibility in downstream chemical processes. These projects involve collaborations between government agencies, research institutions, and private companies, fostering innovation and knowledge sharing. With supportive policies, technological advancements, and ongoing pilot projects, India is poised to lead the green hydrogen revolution. This shift will enhance environmental sustainability and create new economic opportunities in the chemical sector.

LATEST ADVANCEMENTS IN MANUFACTURING GREEN HYDROGEN

Improved Electrolyser Technologies

Electrolysers are the workhorses of green hydrogen production, splitting water into hydrogen and oxygen using renewable electricity. Advancements in Solid Oxide (SOEC) and Proton Exchange Membrane (PEM) electrolysers are driving efficiency gains in green hydrogen production. SOECs operate at very high temperatures (around 700-1000°C). This high temperature allows for efficient use of waste heat from other industrial processes, potentially reducing overall energy consumption for hydrogen production. PEM electrolysers function at lower temperatures (around 50-80°C) compared to SOECs. This makes them more compact and easier to integrate with renewable energy sources.

Development of Efficient Catalysts

AI and Digital Twins optimize production processes by collecting real-time data, identifying potential issues, and improving operational efficiency. This digitalization allows for remote control and automation, enhancing safety and scalability.

Utilization of AI and Digitization

New catalysts are essential for reducing energy requirements and costs in electrolysis. These catalysts accelerate hydrogen and oxygen separation reactions, making electrolysis more efficient and cost-effective.

Exploration of Alternative Methods of Production

Researchers are exploring alternative methods like biohydrogen production from biomass and wastewater, as well as solar water splitting. These methods offer sustainable pathways for hydrogen production, contributing to a circular economy and reducing environmental impact.

CHALLENGES

Green hydrogen shows potential as a sustainable energy solution, yet it faces challenges in storage and transportation. The storage challenges include safety and cost concerns, hydrogen's flammability requires specialized materials and robust safety protocols, including leak detection systems and pressure relief valves. Energy-intensive liquefaction at -253°C raises costs and reduces environmental benefits. Large, bulky tanks are needed due to hydrogen's low energy density, complicating space-constrained applications. Strong, lightweight, and durable materials are essential for storage tanks to withstand high pressures without degrading. Researchers are exploring solid-state storage materials and utilizing salt caverns or depleted oil and gas fields for large-scale storage to address these challenges.

Transporting green hydrogen is costly, often accounting for over half the total delivery cost. Its low volumetric density requires expensive, specialized methods like high-pressure vessels, cryogenic trucks, and tube trailers. The lack of widespread refueling stations and potential hydrogen embrittlement in existing pipelines pose additional challenges. High purity is essential for fuel cells, necessitating robust filtration and leak-proof infrastructure. Regulatory inconsistencies globally further complicate transportation. Standardizing regulations is crucial for large-scale adoption and global trade.

CONCLUSION

The global shift towards sustainable energy solutions has highlighted hydrogen's potential as a key player in decarbonization efforts across various industries. India, with its National Green Hydrogen Mission, is well-positioned to lead this transition, leveraging its abundant renewable resources to achieve an annual production capacity of 5 million metric tons by 2030. This initiative aims to transform high-emission sectors such as refineries, petrochemicals, and fertilizers by integrating green hydrogen into their processes.

The cost-effectiveness of green hydrogen production remains crucial for its widespread adoption. Technological advancements and innovative production methods are gradually closing the cost gap, making green hydrogen a more competitive alternative to fossil fuels. However, significant challenges in storage and transportation persist, necessitating dedicated efforts to fully exploit this renewable energy carrier's potential.

India's current hydrogen consumption, predominantly derived from fossil fuels, underscores the substantial journey ahead for green hydrogen adoption. As India enhances its refining capacities and explores green hydrogen applications in petrochemicals, fertilizers, and other sectors, the country demonstrates its commitment to a sustainable future. By addressing storage and transportation challenges and fostering a robust domestic market, India can achieve its green hydrogen goals, contributing to global decarbonization and energy security.

Our Values-
The Avalon EDGE

E — ENTREPRENEURSHIP
Enterprising ownership to transform ideas into pragmatic and profitable solutions

D — DEDICATION TO EXCELLENCE
Commitment to premier quality and highest standards in everything we do

G — GREAT VALUE CREATION
Focus on delivering maximum client impact through innovation and collaboration

E — ETHICAL APPROACH
Respect, fairness, and transparency in all our interactions

Contact Us:

Ayush Patodia| Associate Vice President
ayush.patodia@consultavalon.com | +91 9163064140

Priyabrata Mohapatra| Consultant
priyabrata.mohapatra@consultavalon.com| +91 9791088019

Ujjwal Tripathi| Consultant
ujjwal.tripathi@consultavalon.com | +91 8004920194

MUMBAI
WeWork, Embassy 247 Park,13B107, 13th Floor,
Lal Bahadur Shastri Rd, Gandhi Nagar,
Vikhroli West, Mumbai – 400079,
Maharashtra
Phone : +91 73045 29720 / 21
E-mail : mumbai@consultavalon.com

WeWork, Raheja Platinum, Sag Baug Road, off,
Andheri – Kurla Rd, Marol,
Andheri East, Mumbai,
Maharashtra 400059
Phone : +91 73045 29720 / 21
E-mail : mumbai@consultavalon.com

DELHI
WeWork, Eldeco Centre, Block A,
Shivalik Colony, Malviya Nagar,
New Delhi – 110017
Delhi
Phone : +91 74286 24664
E-mail : delhi@consultavalon.com

WeWork, 5th Floor Two Horizon Centre DLF,
DLF Phase 5, Gurugram,
Haryana 122002
Phone : +91 74286 24664
E-mail : delhi@consultavalon.com

CHENNAI
Spaces Olympia, Olympia Technology Park,
9th Floor, Citius Block, 1-SIDCO Industrial
Estate, Guindy, Chennai - 600 032,
Tamil Nadu
Phone : +91 7305152869 / +91 7305189261
E-mail : chennai@consultavalon.com

BANGALORE
WeWork, Prestige Atlanta,
80 Feet Main Road, Koramangala 1A Block,
Bengaluru 560034
Phone : +91 9886348187
E-mail : bangalore@consultavalon.com

SINGAPORE
65 Chulia Street,
#38-02/03 OCBC Centre
Singapore 049 513
Phone: +65 3138 2042
Email : admin@apex-avalon.sg

AVALON Consulting
www.consultavalon.com