

Green Hydrogen: Powering the Future, Global and Indian Energy Transition

Introduction

In the global battle against climate change, green hydrogen stands as a beacon of hope for a cleaner and more sustainable energy future. Green hydrogen, produced through a process that splits water molecules using renewable energy, has gained recognition both worldwide and in India. This remarkable source of hydrogen stands in stark contrast to its grey and blue counterparts, which involve carbon-intensive processes. Nations worldwide being driven by the urgent need to reduce emissions and replace fossil fuels are recognizing the vast potential of green hydrogen. Countries like Europe and the U.S. are leading the way in the green hydrogen revolution, with ambitious targets and investments. India, has also, undertaken an ambitious journey with its National Green Hydrogen Mission, aiming to lead in green hydrogen production, reduce dependence on imported fossil fuels, foster domestic manufacturing, and generate jobs while significantly cutting greenhouse gas emissions. Indian states are implementing progressive policies to support these efforts.

The advantages of green hydrogen are numerous across various sectors, including transportation, industries, and home. However, key challenges, such as cost disparities and ensuring a reliable supply of water and green electricity need to be addressed. Furthermore, safety concerns related to hydrogen storage and transportation must be tackled. To realize the potential of green hydrogen, substantial investments, cost reductions, enhanced safety measures, and standardized regulations are essential. This article explores the global and Indian perspectives on green hydrogen, emphasizing its potential and the challenges it must overcome on its path to become sustainable energy solution.

What is Green Hydrogen?

Green hydrogen is hydrogen gas produced through a process that uses electricity to split water molecules into hydrogen and oxygen. What sets it apart from conventional hydrogen production is the use of renewable energy sources, resulting in a zero-carbon footprint. Depending on the nature of the method of its extraction, hydrogen is categorized into three categories, namely, Grey, Blue and Green.

- **Grey Hydrogen:** It is produced via coal or lignite gasification (black or brown), or via a process called Steam Methane Reformation (“SMR”) of natural gas or methane. These tend to be the most carbon-intensive processes.
- **Blue Hydrogen:** It is produced via natural gas or coal gasification combined with Carbon Capture Storage (“CCS”) or Carbon Capture Use (“CCU”) technologies to reduce carbon emissions.
- **Green Hydrogen:** It is produced using electrolysis of water with electricity generated by renewable energy. The carbon intensity ultimately depends on the carbon neutrality of the source of electricity (i.e., the more renewable energy there is in the electricity fuel mix, the “greener” the hydrogen produced).

Production Methods

Green hydrogen can be generated using two primary methods viz., electrolysis and biomass conversion. Electrolysis involves splitting water into hydrogen and oxygen using renewable energy sources like wind, solar, and hydropower. Biomass-based hydrogen is produced through the pyrolysis of biogas or other organic materials. Both methods have the advantage of producing hydrogen and minimum carbon

emissions.

Global Perspective: The Green Hydrogen Revolution

Across the globe, countries are increasingly recognizing the immense potential of green hydrogen. Europe and the U.S. are at the forefront of the green hydrogen revolution. Finland with the aim for achieving climate neutrality by 2035, plans to produce 10% of the EU's green hydrogen by 2030. Over the past year, significant global developments have shaped the green hydrogen landscape. A notable example is a Norwegian company's substantial \$4.3 billion investment in a steel plant featuring integrated hydrogen production. In Finland, construction has commenced on the nation's first green hydrogen facility, backed by a substantial \$76 million private investment. Meanwhile, Spain is actively advancing a green hydrogen supply chain, with ambition to supply 6 million tons of green hydrogen to Northwest Europe by 2030. In the United States, states are collaborating with 40 industry partners to establish regional hydrogen hubs, marking a critical milestone in the journey toward a green hydrogen future.

The driving force behind this boom is the urgent need to replace fossil fuels and curtail emissions. Green hydrogen's cost is increasingly competitive, and the hydrogen ecosystem is

advancing on both supply and demand. Improved access to green energy from sources like wind and solar power is strengthening grid infrastructure and storage capability. Furthermore, production and storage technologies are steadily improving in terms of efficiency.

India's Green Hydrogen Journey

India is taking bold strides towards energy independence and environmental sustainability by implementing its National Green Hydrogen Mission. With a vision to attain net zero emissions by 2070, India is actively embracing renewable energy sources across various sectors, and green hydrogen is at the forefront of this energy transition.

The National Green Hydrogen Mission, ratified by the Union Cabinet in January 2022, outlines a comprehensive agenda, including positioning India as a global leader in green hydrogen production and export, diminishing reliance on imported fossil fuels, fostering domestic manufacturing capacities, attracting investments, generating job opportunities, supporting research and development initiatives, and significantly reducing greenhouse gas emissions. By the year 2030, the mission aims to achieve an annual green hydrogen production capacity of no less than 5 million metric tonnes, coupled with an impressive addition of 125 GW of renewable energy capacity.

This ambitious endeavor foresees investments exceeding INR 8 lakh crore, the generation of over six lakh jobs, and a substantial decrease in fossil fuel imports by over INR 1 lakh crore, ultimately resulting in the reduction of approximately 50 million metric tonnes of annual greenhouse gas emissions.

India's progression in green hydrogen production is characterized by progressive policies and initiatives implemented across various states, each contributing to the nation's pursuit of sustainability and energy transition. The following is a concise overview of key state policies, including Gujarat, Uttar Pradesh, Andhra Pradesh, Rajasthan, and Maharashtra, highlighting specific policy details:

Gujarat: Gujarat's policy aims to align with the National Green Hydrogen Mission's objective to produce 5 million metric tons of green hydrogen annually by 2030. Noteworthy provisions encompass a 40-year lease of government owned land exclusively designated for green hydrogen production utilizing renewable sources. The policy incorporates incentivization mechanism to facilitate the establishment of green hydrogen plants, with a prescribed land allocation for a 40-year period. It emphasizes on job creation, boosting small industries, sustainable production, technological innovation, and decarbonization.

Uttar Pradesh: Uttar Pradesh aims to reduce the costs associated with green hydrogen and achieve significant blending ratios. The policy offers substantial fiscal incentives, including land and water resource incentives, infrastructure incentives, operational incentives, and additional incentives such as subsidies for green urea production. Furthermore, the policy emphasizes on the importance of skill development, technology advancement, and research in transportation and storage. Additionally, the policy encourages technology demonstration and pilot initiatives aimed at showcasing the application of green hydrogen emerging sectors.

Andhra Pradesh: The policy framework in Andhra Pradesh establishes an ambitious goal to produce 0.5 MTPA of green hydrogen or 2.0 MTPA of green ammonia within the next five years. Developers meeting eligibility criteria through the utilization of electrolysis of water with renewable energy sources and biomass are eligible for incentives. The policy positions Andhra Pradesh as an advantageous investment destination due to its favorable investment conditions and proximity to ports. Incentives offered include SGST revenue reimbursement, exemption from electricity duty, reimbursement of transmission charges, and more. The policy places a significant emphasis on compliance with storage and transportation standards.

Rajasthan: Rajasthan's draft policy outlines a specific energy generation target of 2000 KTPA by the year 2030. It offers incentives for green hydrogen production, including subsidies, grants, and concessions for land, infrastructure, and operation. Green hydrogen is categorized as a thrust sector, making it eligible for additional benefits. The policy aligns with the Rajasthan Investment Promotion Scheme 2022 and aims to promote economic growth and attract investments to the region.

Maharashtra: Maharashtra's Green Hydrogen Policy focuses on promoting renewable energy and green hydrogen projects. It offers incentives to projects that procure renewable energy through open access. These incentives include concessions in transmission and power tariffs, exemptions from cross-subsidy and surcharge, as well as concessions specifically tailored for standalone and hybrid power plants. Moreover, the policy highlights the state's commitment to harnessing the potential of green hydrogen, aligning with national objective to diminish carbon emissions and enhance renewable energy capacity.

Collectively, these state policies underscore India's commitment to embrace green hydrogen as a clean and sustainable energy source, promoting economic growth, employment, and innovation, and contributing to the nation's ambitious environmental and energy goals.

Green Hydrogen Applications and Advantages:

Green hydrogen, acknowledged as a sustainable energy source, possesses several merits. It doesn't emit greenhouse gases or sulfur oxides when used, making it an eco-friendly choice. Additionally, hydrogen's higher energy content compared to gasoline makes it an efficient energy carrier and storage solution, ideal for balancing excess or seasonal energy.

Green hydrogen is increasingly being applied across diverse sectors. Within the transportation sector, adoption of fuel cell electric vehicles ("FCEVs") is gaining traction, paving the way for carbon-neutral mobility. Although FCEVs currently represent a small fraction of low-emission vehicle sales, their market is growing. Hyundai aims to manufacture 500,000 hydrogen vehicles by the year 2030, and Paris is actively developing a fleet of hydrogen-powered taxis. Green hydrogen is already powering waste collection vehicles in European cities, and its potential extends to various modes of transport, including mining vehicles, trains, aircraft, lorries, buses, and maritime vessels.

Within the industrial domain, green hydrogen assumes conventional roles in the chemical industry, particularly in ammonia and fertilizer production, as well as in the petrochemical sector for the generation of petroleum products. Furthermore, there is ongoing exploration of its application in the steel industry, with the objective of rendering its processes more environmentally sustainable and diminishing its ecological impact.

In its domestic applications, there are ongoing projects focused on replacing natural gas networks with green hydrogen infrastructure. This transition aims to provide households with cleaner options for electricity and heating, thereby reducing pollutant emissions.

Key Challenges

Green hydrogen's promising role in clean energy faces significant challenges. Foremost among these hurdles is its relatively high production cost, which surpasses that of hydrogen derived from fossil fuels by approximately \$2 per kilogram. This cost disparity remains a critical barrier to broader adoption. In addition to cost concerns, the intermittent nature of renewable energy sources and the current lack of economically viable energy storage technologies introduce complexity into the equation. India's ambitious plan for green hydrogen plans hinge on the availability of 125 gigawatts of renewable energy by 2030, a target that closes aligns with the existing 127-gigawatt renewable energy capacity.

For widespread success, green hydrogen must secure reliable sources of water and green electricity. To put this into perspective, each kilogram of hydrogen production consumes approximately 8.92 liters of demineralized water, highlighting the precious and limited nature of this resource. Moreover, challenges extend to safety issues in storage and transportation. Notably, liquid and compressed hydrogen, maintained at cryogenic temperatures, require careful handling and risk assessment to prevent unintended releases. Hydrogen's corrosive nature, which can damage storage containers, pipelines, valves, and equipment upon leakage, necessitates stringent safety measures. Addressing these challenges is imperative to realize the full potential of green hydrogen as a clean and sustainable energy solution.

Way forward

To realize the full potential of green hydrogen necessitates substantial investments coupled with reductions in production costs. Safety consideration remains a priority, given hydrogen's volatility, flammability and storage requirements. A uniform regulatory framework conforming to global standards is essential. By embracing these measures, we can fully harness the potential of green hydrogen while mitigating risks for a sustainable energy transition.

Conclusion

Green hydrogen, produced through electrolysis of water molecules using renewable energy, emerges as a promising alternative to grey and blue hydrogen, which entail carbon-intensive processes. Countries worldwide, including Europe and the U.S., are embracing green hydrogen as a solution to reduce emissions and transitioning away from fossil fuels. India, too, is making significant strides through its National Green Hydrogen Mission. With ambitious goals, the mission aims to lead in green hydrogen production, reduce dependence on imported fossil fuels, create jobs, and significantly cut greenhouse gas emissions. As Indian states introduce progressive policies, they contribute to the nation's journey towards a more sustainable energy future. Green hydrogen offers multitude of advantages, spanning transportation, industries, and domestic applications. However, challenges like cost disparities and the need for reliable sources of water and green electricity persists. Safety concerns in hydrogen storage and transportation must also be addressed. To unlock the full potential of green hydrogen, substantial investments, cost reductions, enhanced safety measures, and standardized regulations are essential. The road to a sustainable energy transition is illuminated by green hydrogen, offering a path to a cleaner and more environmentally friendly future.

Disclaimer:

This note is a copyright of Eternity Legal. No reader should act on the basis of any statement contained herein without seeking professional advice. The authors and the firm expressly disclaims all and any liability to any person who has read the report, or otherwise, in respect of anything, and if consequences of anything done, or omitted to be done by any such person in reliance upon the contents of this report. This notes relates only to the laws of India as in force at the date hereof.

For any help or assistance please email us on contact@eternitylegal.com or visit us on www.eternitylegal.com