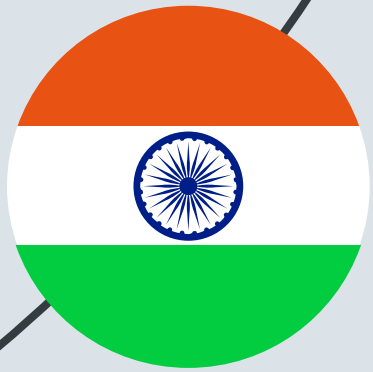
NEW CLIMATE INSTITUTE

Case study

THE LANDSCAPE OF GREEN HYDROGEN IN INDIA

India has the potential to produce green hydrogen at some of the lowest costs in the world and to play a major role in export markets given its high renewable energy resource endowment. Green hydrogen will also enable decarbonisation of its domestic industries and reduce its energy import dependence in line with its principle of self-reliance. The government targets 5 million tonnes annually (MTPA) by 2030 and has allocated USD 2.4 billion to meet this target, with the majority being provided in the form of production subsidies for green hydrogen and electrolyser manufacturers. However, green hydrogen production should be accompanied by local value creation to prevent public money from subsidising exports at the expense of domestic consumers. Environmental safeguards will also be needed to avoid water and land stress due to green hydrogen production, given the scarcity and competing uses of these resources and the vulnerability of local communities relying on them.



This case on green hydrogen in India is part of NewClimate's broader work on the role of green hydrogen in a just, Paris-compatible transition. As part of our work, we also developed cases on Namibia and Colombia and a background report which delves into the sustainable development and climate considerations of green hydrogen production in developing and emerging economies. A third output will be published in 2024 focused on analysing the role of multilateral development banks in supporting green hydrogen initiatives.

KEY DEVELOPMENT INDICATORS

India is the world's most populous country, home to about 1.4 billion people or 17.5% of the world's population as of 2023 [1]. It is also one of the youngest countries in the world, with about 60% of its population aged between 15-60 [2]. Despite remarkable progress, India remains a lower middle-income country with high inequality and poverty levels. Most of the wealth in the country is owned by the top 10% of the population and 15% of Indians live in multidimensional poverty, that is, deprivation in health, education, and living standards [3], [4]. Youth unemployment in the country stands at about 24%, concentrated among educated urban youth [5], [6].

India has a large and complex economy. It ranked fifth in the world in terms of size, with a gross domestic product (GDP) of USD 3.74 trillion in 2023 [7]. The services sector accounts for the majority (54%) of India's economic composition, followed by industry (26%) and agriculture (20%) [8]. India has several regionally and globally important export industries, notably iron and steel, refined petroleum products, precious metals, and agricultural products [9]. Agriculture employs almost half of the working age population, with the rest almost evenly distributed among industry and services [10].

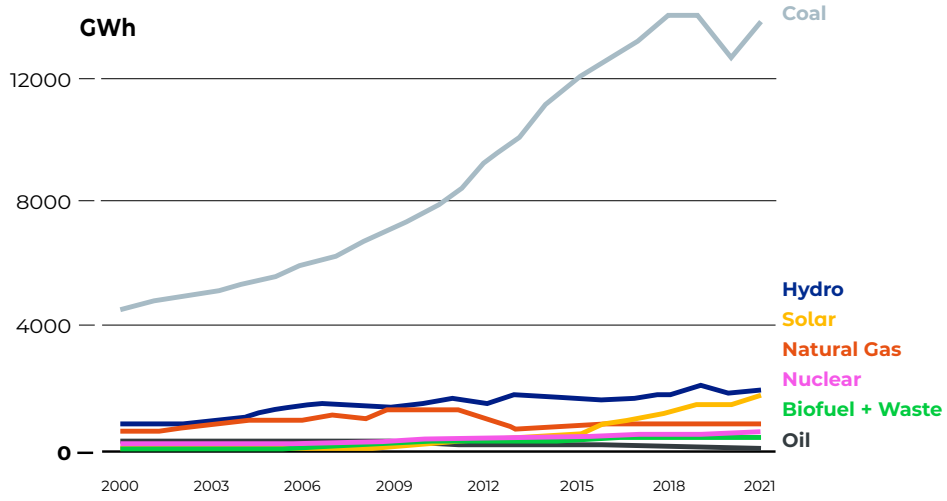
India has several economic and social development priorities, among which access to education, health, water, energy, and quality infrastructure are key [11]. India has already achieved nearly 100% household electrification, although the reliability and quality of power supply remains a challenge [12]. The country aims to grow the size of its economy to USD 5 trillion by 2025 mainly by emphasising infrastructure development and industrial expansion [13]. Self-reliance and local value creation are identified as key principles in this economic growth journey, reflected in flagship policy programmes such as "Aatmanirbhar Bharat" and "Make in India" respectively [14], [15].

ENERGY SECTOR OVERVIEW

India's energy mix is predominantly coal-based. It is a net energy importer, with fossil fuel imports mainly from Qatar, UAE, Russia, USA, and Indonesia accounting for 41% of its energy consumption in 2021. Import dependence has left the country exposed to market volatility and unstable energy bills, making energy security a high priority. India aims to become energy independent by 2047 and achieve net zero emissions by 2070 [16], [17].

As of 2021, India ranked fourth globally in terms of total renewable energy installed capacity, but renewables account for only over 20% of electricity generation [18]. Much of the recent renewable energy boom in India has been driven by solar PV and onshore wind, but significant water and land scarcity issues pose a challenge for further sustainable expansion of renewables capacity in the country. Biomass, including traditional biomass, plays an important role in the energy supply, particularly in rural areas where it is abundantly available. The country is now exploring offshore wind, marine, and tidal energy, as well as several energy storage options that can enable increased reliance on renewables **(see → Figure 1)**.

India has targets to install 500 gigawatts (GW) of non-fossil energy capacity and meet 50% of electricity generation from renewables by 2030 [16]. The government plans to auction 50 GW of renewable energy annually between 2023-2028 to help achieve that target [19].



Source: Authors based on IEA data.

Figure 1:
Sources of Namibia's electricity generation

CURRENT STATUS OF HYDROGEN AND DERIVATIVES

The current level of demand for hydrogen in India is estimated at around 6 million tonnes (Mt) per annum), mainly driven by export-oriented industries like petroleum refining, ammonia production for fertilisers, chemicals, and steel production through the direct reduction of iron ore route [17]. Virtually all the current demand is met with domestic production; hydrogen imports accounted for less than 1% of the demand in 2021 [20].

Hydrogen production in India is done mainly through the process of steam reformation of fossil fuel derived feedstocks, such as natural gas and naphtha (grey hydrogen). Hydrogen is also produced to a lesser extent as a byproduct of the chlor-alkali industry and through electrolysis using grid electricity (predominantly coal-based) for some applications. A few recent pilot projects have produced green hydrogen through electrolysis with captive renewable electricity or with biomass through thermochemical and biochemical routes [17].

By 2040, demand for hydrogen is projected to grow 2.5-3.5 times the current level to reach 15-25 Mt per annum, mainly driven by the refinery and fertiliser sectors [21]. However, the projected expansion of demand from the petroleum refining sector (~5 Mt per annum) is not compatible with a 1.5°C-aligned development pathway, and global trends might indeed lead to reduced import demand from this sector.

India has great potential for green hydrogen production given its abundant renewable energy resources and domestic manufacturing potential. It is projected that India's green hydrogen productions costs could fall as low as USD 0.75 per kg by 2050, one of the lowest in the world, owing to rapid decline in renewable energy and electrolyser costs [22]. This could give India a comparative advantage in green hydrogen export markets, depending on transportation costs. There are also potential gains for India's domestic value-added goods industries, such as steel and fertiliser, which can substitute fossil fuel feedstocks with green hydrogen and maintain access to a changing export market in light of policies like CBAM. This would also help reduce India's fossil fuel and commodity import bills as well as provide an opportunity to further develop its industries. For example, it is estimated that the cumulative reduction of fossil fuel imports by substituting with green hydrogen is worth USD 12 billion and the reduction of fertiliser imports is worth USD 6 billion annually [17].

POLICY FRAMEWORK

India's Green Hydrogen Standard defines green hydrogen as that which is produced by either a renewables-based electrolysis- or biomass-based thermochemical pathway having emissions of no more than 2 kg CO_2 per kg of hydrogen produced [23].

In 2021, the Government of India launched the National Green Hydrogen Mission with the objective "to make India

the global hub for the production, usage and export of green hydrogen and its derivatives". It sets a production target of 5 Mt per annum of green hydrogen by 2030, with the potential to scale up to 10 Mt per annum depending on the growth of export markets. The Mission is expected to add 125 GW RE capacity by 2030, contributing a quarter of the country's total 2030 RE capacity target. Overall, the Mission expects to create 600,000 full time jobs in green hydrogen and contribute to re-skilling and absorption of workforce employed in polluting sectors by 2030 to enable a just transition [17].

The Government of India has allocated USD 2.4 billion for the Mission up to 2030 and aims to raise USD 100 billion in private investment by the same year [17], [24]. Most of the budget allocation will be used to provide financial and non-financial incentives for green hydrogen and electrolyser production, and the remaining amount will subsidise selected pilot projects (particularly in hard-to-abate sectors), research and development, and skills development. Notably, the government has announced production-linked incentives for green hydrogen production and electrolyser manufacturing worth USD 2.1 billion until 2030 under the Strategic Interventions for Green Hydrogen Transition (SIGHT) programme [24].

The Mission has also proposed local content mandates to support domestic industry, such that projects will be required to use domestically manufactured equipment, including electrolysers, to be eligible to participate in competitive procurement [17]. Further incentives such as waiver of inter-state transmission charges and accounting toward renewable purchase obligations are also provided under the Green Hydrogen Policy, implemented in February 2022 [25]. Cumulatively, such incentives are expected to reduce costs of producing green hydrogen by 75% to reach USD 1-1.5 per kg by 2030 [26], [27].

The Mission envisions several applications for green hydrogen, starting with replacing fossil fuels in key export industries, such as petroleum refining, fertiliser production, and steel manufacturing [17]. A proposal to set mandates for green hydrogen use in certain industries (e.g., refining, fertilisers) to spur demand is currently awaiting approval [28]. Other eventual domestic applications with proposed or existing pilot projects include fuel cells for long-haul mobility (automobiles, railways, and marine vessels), blending in city gas distribution networks, energy storage for renewable energy, and providing renewable energy access in islands and remote areas [17], [29].

Not all potential applications of green hydrogen are cost-effective compared to other decarbonisation alternatives. For example, the proposal to use green hydrogen for energy access in islands and remote areas involves high efficiency losses compared to direct electrification with distributed renewables and microgrid solutions. Road and rail transport can also be directly electrified. Gas blending is associated with safety and logistical concerns and does not lead to significant emissions savings [30]. It is thus important to ensure that green hydrogen is prioritised for applications

that cannot be directly electrified.

Green hydrogen production should also create local sustainable development impacts. India's green hydrogen industry will exploit local land, water, and renewable energy resources to cater mainly to export demand, at least at the beginning, and it is unclear whether this will translate to proportionate local benefits. The same is true for the proposal to produce green hydrogen in islands and remote areas to supply to the mainland. It will therefore be crucial to ensure that public subsidies incentivising green hydrogen production do not favour exports at the expense of local consumer welfare.

Environmental sustainability concerns are likely to arise while implementing the Mission. For example, one of the production routes endorsed by the Mission is based on biomass, given its surplus availability and high technical potential [17]. Biomass-based hydrogen production is classified as green in India's Green Hydrogen Standard [23]. However, it would be critical to ensure that only sustainable biomass is used to avoid net positive emissions from deforestation and to ensure that the green hydrogen meets global production standards.

Water scarcity is another key challenge. India will require around 50 billion litres of demineralised water to meet its 2030 target [31]. Pilot projects are being planned close to industrial demand centres, which are arid regions with high solar potential and extreme water shortage issues. To address this concern, the Mission proposes to recycle industrial or municipal wastewater for green hydrogen production wherever possible [17]. However, treated wastewater is limited and has several competing uses, most importantly in the agriculture sector facing worsening droughts [32]. Municipal wastewater capacity will thus need to be expanded significantly to meet the country's irrigation requirements before being able to meet the water demand for green hydrogen production.

Land availability is also an issue that India's renewable energy industry has already been facing in recent years. Under the Mission, states have been asked to create land banks for renewable and green hydrogen capacity deployment through "fair and rational policies" for provisioning land [17]. However, it does not specify if adequate environmental and social protection measures will be applied to prevent displacement of local populations, shifting of agricultural lands, or encroachment on protected zones.

RECENT ENGAGEMENT WITH MULTILATERAL DEVELOPMENT BANKS

As of July 2023, there were 48 announced plans for green hydrogen projects in India with a combined production capacity of 3.5 Mt per annum if realised [33]. Several publicly and privately funded pilot projects, including electrolyser manufacturing facilities, are already underway across the country [34].

Multilateral development banks (MDBs) have expressed interest in India's green hydrogen activities, although specific

projects are not yet announced. The European Investment Bank (EIB) has officially joined the industry association India Hydrogen Alliance (IH2A) and committed EUR 1 billion to support green hydrogen hubs in the country [35]. Separately, IH2A has proposed a National Green Hydrogen Hub Development Plan for the creation of 25 first-generation green hydrogen projects and five green hydrogen hubs by 2025. The 25 proposed projects would aggregate to 150 MW of installed electrolyser capacity, and the 5 clustered hubs would be located in the coastal states of Gujarat, Karnataka, Maharashtra, Kerala, and Andhra Pradesh near important ports and end-use industries. The proposal, which seeks USD 360 million in financing to meet capital expenditure and price support of USD 2 per kg of green hydrogen produced, represents a good opportunity for MDB engagement in India's green hydrogen development [36].

Further, the World Bank has approved USD 1.5 billion to support India's low-carbon transition, particularly the National Green Hydrogen Mission [37]. The Asian Development Bank has also expressed intent to provide USD 20-25 billion over five years for India's green growth journey, also likely to be spearheaded by green hydrogen development [38]. Other development partners are also getting involved in producing knowledge to facilitate project finance. For example, GIZ, the German development agency, recently awarded a tender to MEC Intelligence to develop a roadmap for a green hydrogen hub in Kochi, Kerala [39].

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