What India can do to site green hydrogen production plants effectively

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India marked its presence as a serious contender in the green hydrogen space at the World Hydrogen Summit in Rotterdam, the Netherlands, which happened in May this year. The India Pavilion set up by the Ministry of New and Renewable Energy (MNRE) showcased the nation's progress in the green hydrogen (GH2) domain and conveyed the government's intent to deploy it for meeting the nation's energy requirements sustainably. While these events provide strong market signals globally, for investors to piggyback on the prospective opportunities, it is important that the vital facets of the GH2 ecosystem are examined and tweaked.

Renewable energy (RE) plays a pivotal role in GH2 production, but the success of this role largely rests on the effectiveness of the grid transmission lines and the allied infrastructure that transmit power from the RE power generation centres to the GH2 production plants. India has grown its RE capacity from 35.8 giga watts (GW) in 2014 to 144.7 GW this year, at a compound annual growth rate (CAGR) of 14%. Further, to achieve its target of 500 GW of non-fossil-fuel-based installed generation capacity by 2030, the nation needs to put in place a minimum of 50 GW of RE capacity every year till 2030. In 2023 alone, a substantial addition of power transmission lines (of approximately 15,593 circuit kilometres) was made to integrate new generation capacities (both RE and conventional sources), and to meet the rising power demand.

As an RE-rich country, India, under its National Green Hydrogen Mission, plans to produce 5 million tons per annum (MTPA) of GH2 by 2030. A report published by the European Union in 2020 found that for producing 1 kg of green hydrogen, 55 kilowatt hour (kWH) of electricity is required. Considering this, India is likely to require 250 terawatt hour (TWh) of RE to produce 5 MTPA of green hydrogen.

India's target of installing 500 GW of non-fossil-fuel-based generation capacity can enable the generation of approximately 983 TWh of electricity. Assuming we achieve the RE targets, producing 5 MTPA of GH2—for which 250 TWh of electricity is required—can be possible. Actually, on considering the additional electricity requirements of approximately 30 kWh towards the effective production of 1 kg of GH2, the total electricity requirement amounts to 85 kWh per kg of GH2, which translates to 386 TWh for 5 MTPA of GH2. Nevertheless, the target-driven availability of RE can technically fulfil the needs of green hydrogen production plants.

While India has the capability to supply the renewable electricity required for producing GH2, identifying a suitable location for GH2 production plants can be a challenge. Locating them near a functioning urban centre may overload the existing transmission infrastructure, resulting in higher transmission losses and unwarranted power outages. To circumvent these systemic issues, new transmission infrastructure or upgradation of the existing transmission infrastructure to a higher capacity can be planned, depending on the need. Often, the restructuring of transmission infrastructure is an expensive, time-consuming ordeal. To avoid the risks of overloading the transmission infrastructure, the GH2 production plants should be located near RE plants, which are usually situated far away from GH2 demand centres. This set-up can also reduce possible transmission losses in the system.

That being said, setting up GH2 production plants near RE power plants has its own concerns.

Transportation of the produced hydrogen is an onerous task. Hydrogen can either be transported through pipelines directly or through trucks (tanks) after compressing it. This would require additional processes of expansion at the demand side (where GH2 will be utilised) before use. For example, hydrogen can be used as a reducing agent in steel manufacturing plants. The GH2 produced will need to be compressed at GH2 production centres before being transported. Subsequently, this compressed GH2 needs to be expanded at the steel units before use.

For optimal siting of GH2 production plants, it is crucial to find out if it is more expensive to bring electricity to the GH2 production plants or to send hydrogen from GH2 production plants to the GH2 demand centres. A 2021 study by Guidehouse observes that transporting hydrogen offers more advantages—in terms of costs and volumes— than re-structuring the power transmission infrastructure (upgrading existing infrastructure or adding a new corridor). Simply put, on a kilometre-to-kilometre basis, building new pipelines (across varying diameters) to transport hydrogen is a more viable option, as compared to erecting new transmission lines (across different voltage levels). A systemic framework based on multi-criteria decision-making (MCDM) is needed to arrive at ideal locations for setting up GH2 production plants. The framework can identify the potential sweet spots, considering three criteria: (a) proximity to power plants (avoids transmission overload); (b) proximity to demand centres (avoids hydrogen transport); and (c) proximity to water sources (minimises transport of water).

In summary, India's efforts to produce green hydrogen must take into account effective planning towards siting the GH2 production plants. This will enable the shift to a low-carbon economy, while meeting the country-specific RE goals in the long run.