OPINION: Delivering the Hydrogen economy

Hydrogen demand will increase rapidly as several sectors realise its applications. It is important to start building capacity of storage technologies like compressed or liquefied hydrogen now.

A defining provision in India's 2021–22 Union Budget was the announcement of the National Hydrogen Mission. With it, India has shown its intent to adopt one of the more important future energy technologies. Globally, hydrogen is creating a buzz, thanks to its potential for use across a variety of sectors, such as fuel for vehicles, as an energy substitute for fossil fuels in hard-to-abate industrial sectors, etc.

Beyond production and consumption, there is the third pillar of a future hydrogen economy — the delivery for end-use applications. Hydrogen is flammable, and its storage and transmission in its elemental form is inefficient and not cost-effective. Despite high energy content, it has an extremely low density, and thus, occupies a lot of volume. These arguments are regularly used against the use of hydrogen in future energy systems. Until these technical barriers are addressed, hydrogen delivery will remain a bottleneck in wide-scale adoption.

Currently, hydrogen in India is produced close to its usage location (e.g., in industries such as oil refineries, ammonia production), with little requirement for storage. However, this will change in the future to meet the proposed high demand. NTPC Ltd is working on building infrastructure for hydrogen-powered buses in Ladakh. Corporate players too have unveiled plans to invest in low-carbon technologies, with hydrogen a key part of these plans.

Going forward, hydrogen will have a bigger role in the industrial and transportation sectors. This requires cost-effective options for storage and transmission in order to integrate hydrogen into India's energy mix. Transmission of hydrogen primarily occurs through three routes — via ships across continents, through pipelines (for longer distances, higher volumes), and by trucks (for local distribution). While pipelines are expected to have lower costs of transmission (due to economies of scale), they require a high initial investment. There are also concerns over the degradation of the pipelines due to the nature of hydrogen.

Storage options

The medium used for storing hydrogen is key, with a variety of technologies being developed for it. These include compressed hydrogen, liquefied hydrogen, ammonia, liquid organic hydrogen carriers (or LOHCs), geological storage, metal hydrides, etc.

Compressed Hydrogen is a well-established technology, mainly in the application as on-board storage in transportation. However, two technologies, in particular, could play an important role in the future of hydrogen delivery in the Indian context. Liquefied hydrogen is significantly more energy-intensive as a process and requires specialised insulated tanks to avoid evaporation losses. However, it can be discharged rapidly. Importantly, the higher storage capacity of hydrogen in its liquid form can ultimately result in lower transmission costs. Ammonia is an interesting choice of storage technology, given its extensive use worldwide as a feedstock itself. Nevertheless, ammonia contains a high amount of hydrogen and can be stored as a liquid in near-ambient form. This translates into much lower delivery costs of hydrogen for larger volumes and longer distances.

A graph was made based on literature, breaking down the final costs for delivering hydrogen under various pathways and the cost uncertainties (highlighted in grey) involved:

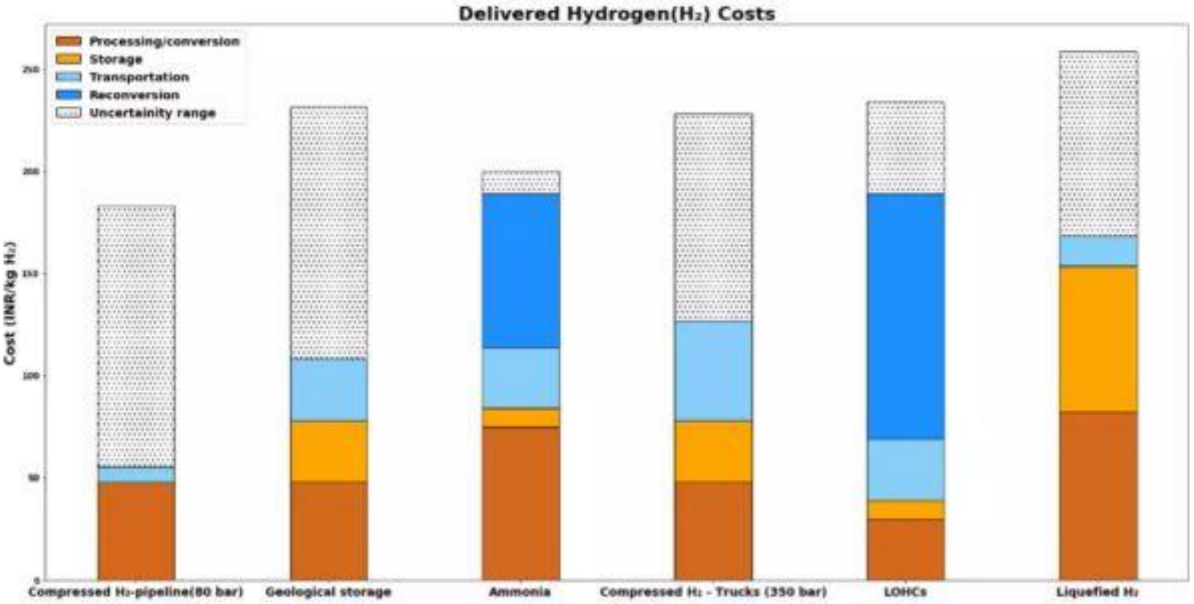

Figure 1 : Hydrogen delivery costs under various pathways

As these technologies mature and system sizes expand, the costs of delivering hydrogen are expected to drop further. Economics is vital to understand feasible pathways for hydrogen delivery. However, other factors such as resource (land, water, material, equipment) requirements, energy densities, volume capacities, etc., also have to be considered. Naturally occurring geological formations such as salt caverns, aquifers or depleted gas fields have high storage capacities and can hold hydrogen for extended periods of time. Such geological storage systems typically have lower costs for storing hydrogen and would be an ideal option. Yet, there is little data on the availability of sites in India that would be technically feasible. Multiple pathways will likely be used for delivering hydrogen, depending on the application, location, and other factors.

However, is it just better to produce hydrogen at the site of an application instead? Energy availability (coal, natural gas, electricity, biomass, solar, or wind resources, etc.) and land and water requirements may be constraints for on-site hydrogen production. Both pathways of hydrogen production or hydrogen storage and transmission have different equipment and material (electrolysers, storage tanks, catalysts, etc.) requirements. The decision to produce hydrogen must also factor in the availability of local technology service providers for such components.

Hydrogen demand will increase rapidly as several sectors (in addition to the conventional ones) realise its applications. This is similar to the nascent stages of the solar revolution a decade ago. It is important to start building capacity of storage technologies like compressed or liquefied hydrogen now. There is much progress desired in the deployment of hydrogen delivery systems. But similar ‘difficult’ elements such as ammonia and natural gas are now extensively used worldwide on the back of a well-developed supply chain. With adequate research and investment towards the delivery systems, hydrogen too can emerge as a key component of the energy future.

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