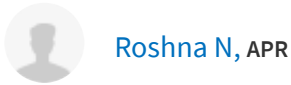
Hydrogen: towards cleaner and sustainable transport



The Toyota Mirai, an hydrogen fuel cell vehicle, is displayed on media day at the Paris auto show. REUTERS

Hydrogen as an energy source is widely touted to be the future transportation fuel. In this context, the Supreme Court of India advised the Delhi government and the Environment Pollution (Prevention & Control) Authority (EPCA) to analyse the feasibility of hydrogen in the transportation sector and the reduction in GST for hydrogen vehicles.

(45 and 46 MJ/kg for diesel and petrol, respectively). Moreover, water is the only by-product of its combustion.

An alternative fuel to reduce fossil fuel consumption is biofuel. But Life Cycle Analysis (LCA) of biofuel shows that it consumes a large amount of water and energy during its production. Electricity is another alternative to fossil fuels. However, as the power sector in India is heavily dependent on coal, and will be so until well into the 2030s, shifting to electric vehicles (EVs) will not reduce overall emissions unless these are charged through solar power. In this context, hydrogen could provide the alternative.

Worldwide adoption of hydrogen has been rising steadily. Currently, hydrogen vehicles are operated in the US, Japan, Denmark, Germany, China, France, and South Korea. Car manufacturers such as Toyota, Hyundai and Honda are selling hydrogen-fuelled cars that can provide fuel economy of upto 28 km/litre of petrol equivalent (~2-3 times of petrol). Hydrogen-fuelled buses have a higher range (around 300-450 km) than EV buses (upto 249 km). The fuel-filling time for hydrogen is comparable to that of petrol and diesel and much better than for charging EVs (4-6 hours). This makes it suitable for adoption in medium-to-heavy vehicles.

However, access to hydrogen fuel stations is limited to a population of 250 million worldwide, with only 6,500 such cars globally. This limited adoption is attributed to the higher cost of installing hydrogen fuel stations (twicethat of a gasoline station in the US) and the higher price of hydrogen vehicles (around 1.8-2.5 times that of electric cars in the US). Unlike EVs and biofuel-blending programmes, the infrastructure required for hydrogen needs to be developed from scratch.

This has become a deterrent to the extensive commercialisation of hydrogen vehicles. However, many developed countries have made plans for the same. Japan is targeting the installation of 160fuel stations and 40,000 hydrogen vehicles by 2021. Germany aims to have 400 fuel stations by 2023. Globally, around 2,800 fuel stations are planned by 2025.

India is one of the few developing countries actively working on the research and development of hydrogen-based transportation. Under the Ministry of New and Renewable Energy's National Hydrogen Energy Roadmap, various research institutes and vehicle manufacturers have been conducting research on developing competitive and safe methods for production, storage and transportation of hydrogen since 2003. Currently, 96% of hydrogen is produced from natural gas, other fossil fuels and biomass. Hydrogen produced from natural gas could reduce CO_2 emissions by 40-65% compared to petrol. Vehicles were also successfully modified and demonstrated to support hydrogen fuel.

Earlier this year, Tata Motors developed a hydrogen fuel-cell bus. However, a complete transformation to hydrogen is difficult, especially for developing countries like India,

at the delivery point is estimated to be Rs 370/kg (equivalent petrol price is Rs 170). With the cleanest method of hydrogen production, electrolysis of water, the price would nearly double.

Way forward

Hydrogen as a fuel for transportation will have huge global traction in the near future. Shifting to hydrogen vehicles will, doubtless, reduce emissions. However, rigorous research is required to reduce the cost of production and transportation of hydrogen in India. The cost of hydrogen vehicles has dropped worldwide by 80% since 2002. Car manufacturers are targeting to reduce their cost by a further 75% by 2030. This would make hydrogen vehicles more affordable in India.

However, infrastructure development will remain the major constraint. As a starting point to this transition, HCNG fuel (with 18-23% H2 blended with compressed natural gas) can be used in existing CNG vehicles with minor modifications. Recently, EPCA has suggested shifting from CNG to HCNG in public buses in Delhi, by utilising the current infrastructure, instead of deploying electric buses. This will help in developing the infrastructure for hydrogen production, supply and storage.

The Delhi government has collaborated with Indian Oil Corporation to deploy 50 HCNG buses and a fuelling station next year. This would reduce greenhouse gas (GHG) emissions from CNG vehicles by 15-20%, carbon monoxide (CO) emissions by 70%, and hydrocarbon emissions by 15%. This will also improve fuel economy. In fact, HCNG can easily meet new BS-VI emission standards, with some emission controls for nitrogen oxides (NOx), such as SCR converters. EPCA has estimated that the fuel cost for HCNG is estimated to increase by Rs 0.75/km compared to CNG, nearly 4.5% of the current CNG price in Delhi. This is marginal compared to the usual annual price hike in CNG.

Other cities in the NCR and in states with a good CNG supply (such as Gujarat and Maharashtra) should also consider a transition towards HCNG. Using HCNG has the potential to reduce GHG emissions by 0.67–1.42 million tonnes annually in India.

The total requirement of HCNG for a complete transition in all vehicles in India is estimated to be around 6,600 tonnes a day. This needs an initial ballpark investment of Rs 5,445 crore, estimated based on EPCA's assessment specific for Delhi. This amount is in the same range as that of the subsidy corpus allocated for EVs for five years. Allocating a budgetary amount for HCNG infrastructure for the next five years would help in transitioning to a cleaner, hydrogen-based economy. Road tax waivers and government subsidies for installing fuelling stations could also help bring about a notable transition to hydrogen-fuelled vehicles.

hydrogen is highly inflammable. Hydrogen is safer than petrol and, till date, no hydrogen vehicle explosion has been reported. Nationwide awareness programmes and vehicle demonstrations in collaboration with vehicle manufacturers and research institutes could allay people's concerns to some extent. Developing safety regulations and codes for hydrogen storage, transportation and fuelling is another area that requires considerable attention.

With proper coordination among research institutes, vehicle manufacturers, safety regulatory authority and state and central governments, extensive commercialisation of hydrogen vehicles is very much possible by the mid-21st century.

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