Is India ready for the switch to Green Hydrogen in passenger trains?

Are we ready for the switch to green hydrogen in our trains? Let's assess the economic and technical feasibility of the switch from diesel to hydrogen in passenger trains.

By Dhiraj Kumar

Ashwini Vaishnaw, the Minister of Railways, has announced that the country would have its first hydrogen-powered passenger train by December 2023. The train will run on the Sonipat–Jind route in Haryana, which is 89 km. The announcement has created a buzz among researchers in the country.

But are we ready for the switch to green hydrogen in our trains? Let's assess the economic and technical feasibility of the switch from diesel to hydrogen in passenger trains.

Imagine a passenger train commute between Bengaluru and Chennai. The distance between Bengaluru and Chennai is 344 km, and a passenger train uses 4 l/km of fuel. Therefore, the total fuel requirement for the trip will be about 1,400 l considering the efficiency of standard locomotive diesel engines, which corresponds to a total energy consumption of approximately 28 GJ. The fuel cost for one trip using a diesel-powered train will be INR 0.9 lakh.

According to research and ratings agency ICRA, green hydrogen (or hydrogen produced through renewable energy) costs about INR 492/kg in India. If we consider a green hydrogen–based engine with similar energy output as a diesel engine, it will consume ~228 kg of green hydrogen for a one-way trip from Bengaluru to Chennai. The cost of producing that hydrogen for the passenger train will be INR 1.1 lakh. In lieu of a diesel engine, fuel cells are used to convert the chemical energy of hydrogen to electricity. So, based on current costs, the cost of operating a fuel cell–based hydrogen engine will be 27% higher than that of a diesel engine. Moreover, there will be the added cost of fuel cells and the associated (hydrogen) storage.

Now, let us take the WDP-4 engine as an example, which is a commonly used diesel engine for passenger trains in India. This engine has a maximum power output of 4,000 HP, or 2,960 kW. The cost components in making a fuel cell are the fuel stack and ancillary components. One would need 60 fuel cell modules (each of capacity 50 kW) to power this engine. Thus, the cost of fuel cells for a single passenger train can be as high as approximately INR 12 crore.

Even though the switch to hydrogen does not look like it holds obvious financial viability considering the exorbitant initial cost of hydrogen and fuel cells, there are niche spaces where the technology holds promise. A diesel locomotive emits 9.5 g of carbon dioxide per tonne km as per an Indian Railways notification. In addition, diesel engines are also known to emit fine carbon in the form of soot and non-negligible quantities of NOx, a gas that is known to negatively affect pulmonary health. On the contrary, hydrogen-powered locos emit water and nothing else!

Despite the high costs at the current juncture, there are regions and spaces where hydrogen-fuelled trains have the potential to play a positive role. Electrifying hilly terrains requires a huge capital with relatively low returns; hydrogen trains can be considered in such terrains. Also, industrial yards having a multitude of tracks with low to medium usage can also be considered as candidates for the transition from diesel to hydrogen.

While the Indian Railways should continue to focus on electrifying key routes, hydrogen-based mobility should be looked at for routes that are difficult to electrify, given the nature of the terrain or the cost of electrification.

Over time, as technology matures, the price of green hydrogen and allied technologies is expected to fall. Distribution networks enabling wider availability are also expected to go up with increasing adoption. This will automatically incentivise the adoption of green hydrogen across sectors where it is cost-prohibitive today. Thus, it is reasonable to believe that the future will see strategic routes of the Indian Railways being run on hydrogen.

[This article was written exclusively for ETEnergyworld by Dhiraj Kumar, who works in the area of strategic studies at the Center for Study of Science, Technology and Policy (CSTEP), a research-based think tank]