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Blue Paper

Business case evaluation of hydrogen end use in mobility & transportation sector India

Part-6 (Global demand clusters, international trade and development hydrogen strategy roadmaps for different geographies)

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Transportation Ease

Hydrogen is already playing a vital role in the transport sector across the globe, India too is anticipating major transformation

ROLE OF HYDROGEN IN TRANSPORTATION

Hydrogen has already played a transformative role in many global economies. For instance, the US transport sector has witnessed a significant role of hydrogen in the material handling of goods at distribution centers in all continental states and Canadian provinces. The next sectors of interest include light-, medium- and heavy-duty road transport, heavy and urban light rail, and ships. Altogether, the transport sector accounts for 35 percent of US carbon emissions and is a key contributor to local air pollution, making a transition to zero emissions options a priority. The two primary options for zero emission transportation are electric drive trains powered by hydrogen fuel cells in FCEVs and batteries in BEVs.

Both are used for light-, medium-, and heavy-duty vehicles, but FCEVs store energy as hydrogen (15 kWh per kg) and convert it to electricity – as needed – via a fuel cell, while a BEV stores energy as electricity in a battery. In India also, a lot of development work has been initiated by the government for usage of hydrogen in the transport sector. The Ministry of Road Transport and Highways, India has already notified hydrogen fuel cell vehicles in automotive industry standard (AIS) 157. Also, in September 2020, its has been notified that 18% of the hydrogen to be blended with CNG to make HCNG as an automotive fuel. Various hydrogen powered vehicles have been developed and demonstrated under projects supported by the Indian government. These include 6 fuel cell buses (by Tata Motors Ltd.), 50 hydrogen enriched CNG (H-CNG) buses in Delhi (by Indian Oil Corporation Ltd. in collaboration with government of NCT of Delhi), 2 hydrogen fuelled internal combustion engine buses (by IIT Delhi in collaboration with Mahindra & Mahindra),

> Hydrogen can also be used as a feedstock to produce low carbon fuels like synthetic fuel for aviation and marine shipping
>
> - Hydrogen Roadmap, US

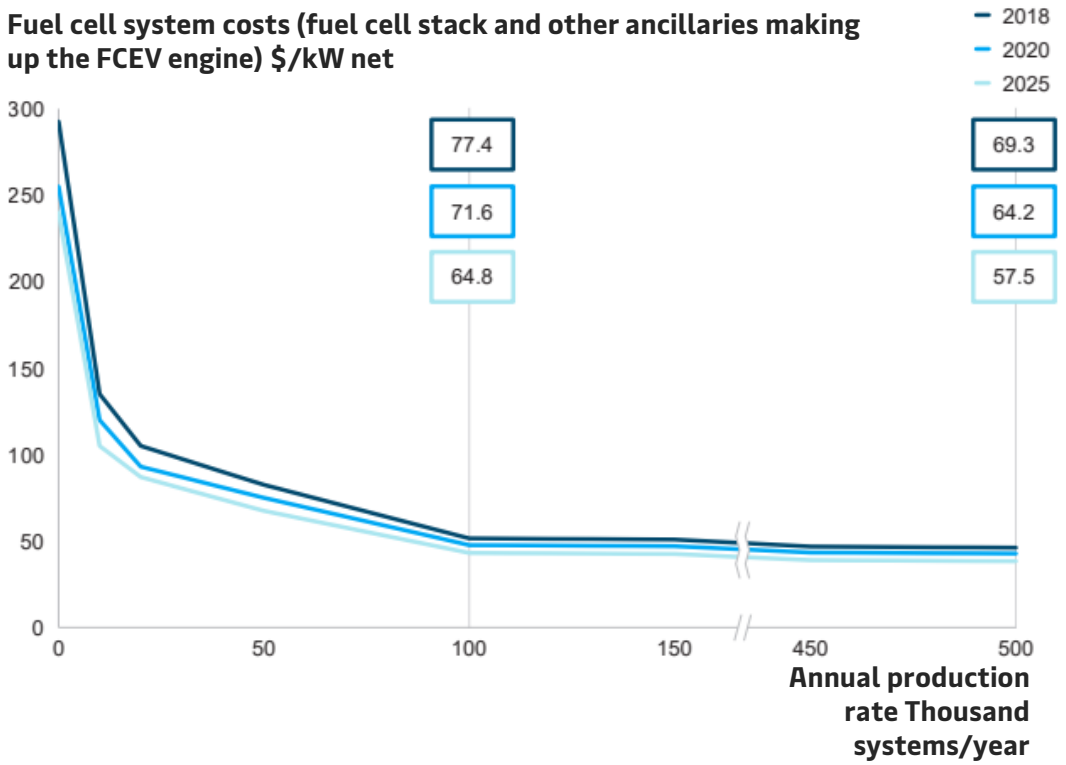
Hyundai, Tata Motors, Toyota eyeing NTPC's hydrogen fuel cell vehicle project

15 hydrogen fuelled 3 wheelers (by IIT Delhi in collaboration with Mahindra & Mahindra), 2 hydrogen –diesel dual fuel cars (by Mahindra & Mahindra) and 1 fuel cell car (by CSIR – National Chemical Laboratory , CSIR- Central Electrochemical Laboratory and CSIR – National Physical Laboratory).

Further, as a part of the pilot project, NTPC may run super- luxury hydrogen buses between Delhi and Jaipur, one of the busiest routes in north India. Initially, a total of 10 buses and 10 cars for Leh and Delhi is expected to be rolled out.

In December 2021, Pune based Sentient Labs launched a 32 seater hydrogen fuel cell bus that shall provide a range 450 kilometers by utilising 30 kg of hydrogen. Satient Labs has designed and developed the hydrogen bus in collaboration with CSIR. Further, there are plans to convert 5 lakh buses from the total of 20 lakh running on roads into fuel cell powered vehicles.

Fuel cell system costs in the US for the transportation sector decrease with greater production



Source: Eninrac research, US Department of Energy, Channel Checks

Low carbon fuel pathways for aviation and shipping segment in the US – Potential Case Study for India

Low carbon fuel pathways tested in the US			Production Process	Source of carbon/main feedstock	Level of maturity
Aviation (Low carbon jet fuel)	Biofuel	HVO biokerosene	Hydrotreatment	Vegetable oil (virgin and recycled), inedible animal fats, municipal solid waste if oil can be extracted (in research)	
		Alcohol to jet fuel	Anaerobic fermentation/ aqueous phase reforming	Edible or inedible biomass (wood, grass, waste), biogas	
		Kerosene equivalent	Metabolic pathway for biomass to kerosene conversion	Biomass	
	Synthetic Fuel	Biomass to liquids	Fischer-Tropsch	Biogas, inedible/edible biomass (wood, grass, waste), municipal solid waste	
		Power to liquids	Fischer-Tropsch	CO2 (CCU)	

Commercially produced
In pilot
In research
Hydrogen to upgrade /improve yield
Pathway uses hydrogen feedstock

Source: Eninrac research, US Roadmap for Hydrogen, Channel Checks

Low carbon fuel pathways for aviation and shipping segment in the US – Potential Case Study for India (Contd.)

Low carbon fuel pathways tested in the US			Production Process	Source of carbon/main feedstock	Level of maturity
Ships (Low carbon bunker fuel) 	Biofuel	HVO renewable diesel	Hydrotreatment	Vegetable oil (virgin and recycled), inedible animal fats, municipal solid waste if oil can be extracted (in research)	
		Biodiesel (Fatty acid esters)	Transesterification	Vegetable oil (virgin and recycled), inedible animal fats	
		Biocrude	Pyrolysis	Inedible biomass (forest, sludge, straw), plastics	
		Compressed/ liquified biogas	Anaerobic digestion	Biogas	
		Solid biomass	Palletization gasification	Biomass	
	Synthetic Fuel	Biomass to liquids	Fischer-Tropsch	Biogas, inedible/edible biomass (wood, grass, waste), municipal solid waste	
		Power to liquids	Fischer-Tropsch	CO2 (CCU)	
		Methanol	Synthesis from syngas	CO2 (CCU)/natural gas, biogas with low carbon hydrogen	
		Dimethyl ether	Dehydration synthesis	Methanol, carbonaceous feedstocks	

Commercially produced · In research · In pilot

Hydrogen to upgrade /improve yield

Pathway uses hydrogen feedstock

Source: Eninrac research, US Roadmap for Hydrogen, Channel Checks

Low carbon fuel pathways for aviation and shipping segment in the US – Potential Case Study for India (Contd.)

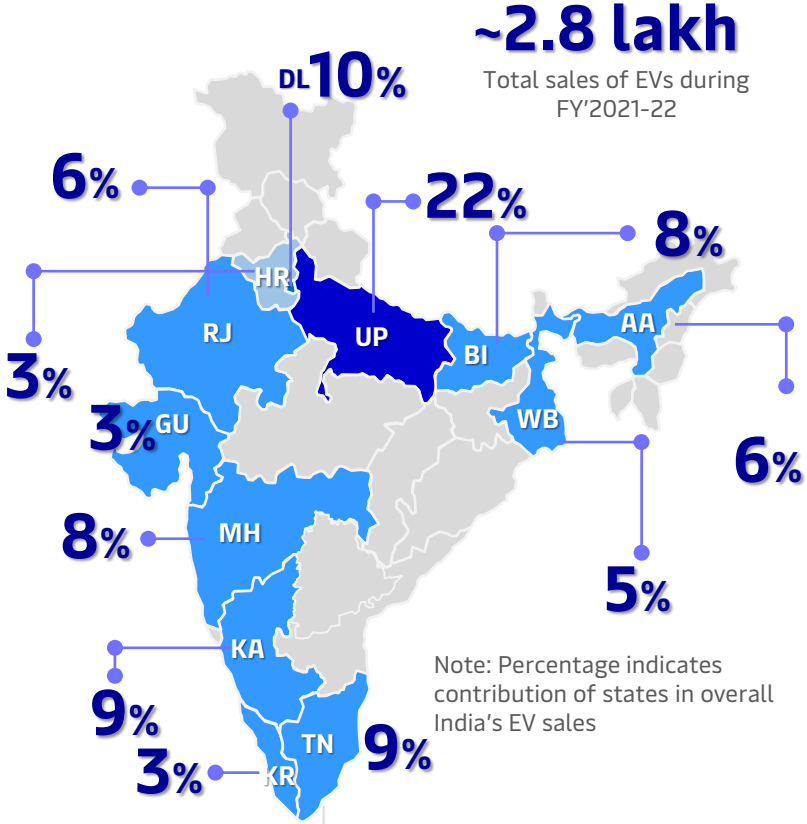
Low carbon fuel pathways tested in the US			Production Process	Source of carbon/main feedstock	Level of maturity
Ships (Low carbon bunker fuel) 	other	Ammonia	Haber Bosch	Nitrogen(air separation) with low carbon hydrogen	
		Liquid Hydrogen	Gas reforming, electrolysis	Natural gas, RNG, water	

Source: Eninrac research, US Roadmap for Hydrogen, Channel Checks

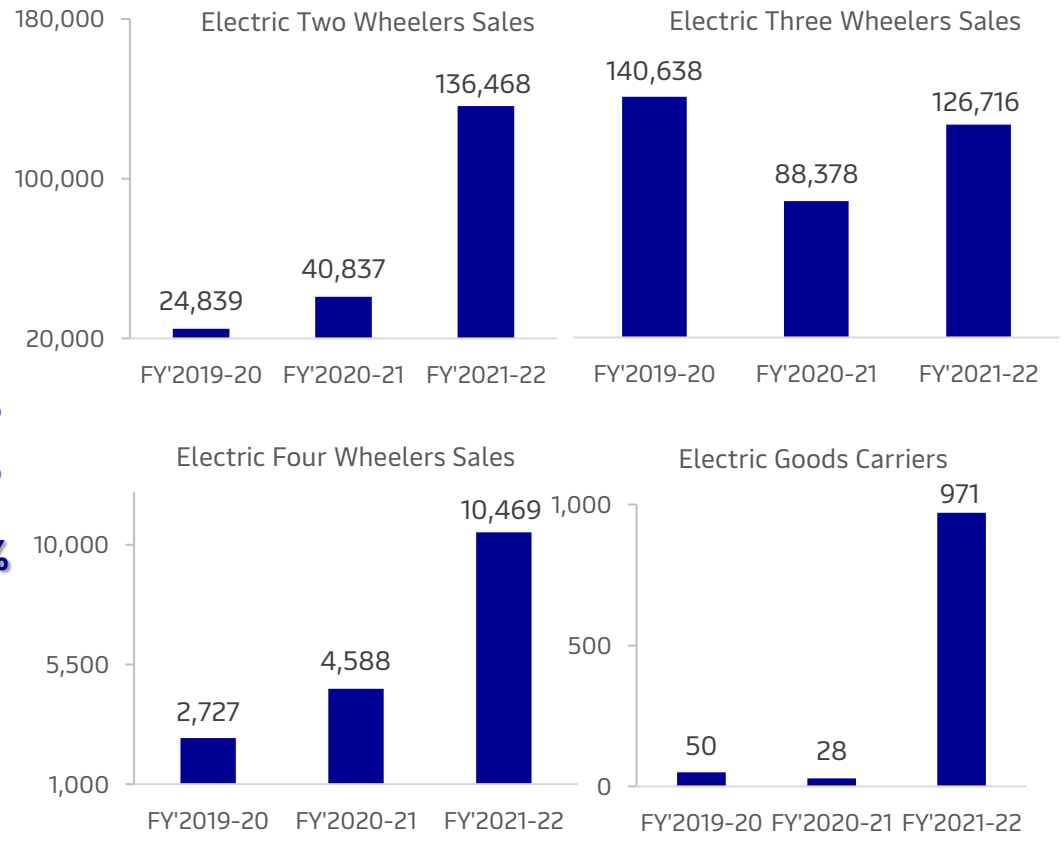
Identification of potential demand clusters for hydrogen powered vehicles

Potential demand clusters for hydrogen powered FCEVs and BEVs

Key states in focus – Potential hubs for hydrogen powered vehicles w.r.t the sales of EV



Vehicle type wise sales of EVs in India from 2020-2022



The two primary options for zero emission transportation are electric drive trains powered by hydrogen fuel cells in FCEVs and batteries in BEVs

Source: Eninrac research, CEEW, Channel Checks

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