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Evaluating use cases of hydrogen in India

Part -13 (Hydrogen cost benchmarks, demand built-up, transport infra & market size evaluation for India)

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Use of Hydrogen in India – 2022 –Current Context

Future market size of hydrogen by region by value (in US$ Billion)

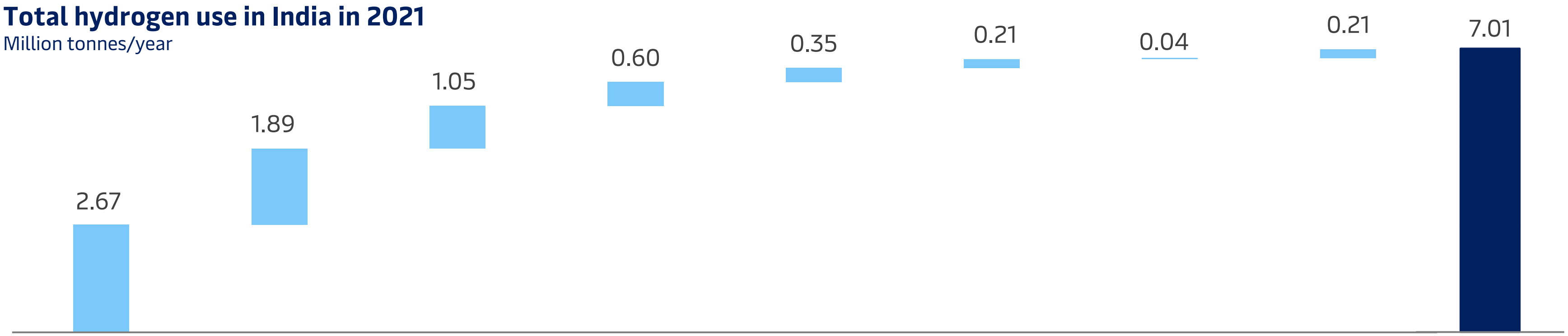
About 85 percent of the hydrogen currently consumed in India serves as a feedstock or reactant in industrial processes in refining, ammonia, and methanol plants. Other industries using hydrogen today in much smaller quantities include cement, glass, and rocket fuel production, as well as some minor applications in the food industry.

85%

of the hydrogen currently consumed in India serves as a feedstock or reactant in industrial processes

Total hydrogen use in India in 2021

Million tonnes/year



Fertilizer	Refineries	Chemical	Transport	Power Generation	Fuel for Industry	New Feedstock	Others	Total
Ammonia production	Hydrocracking	Liquid methanol	Transport fuel	Power backup solutions	Welding	Heat treatment of steel	Polymers and petrochemical	
Ammonia derivatives (such as urea)	Hydrotreating	Chemical derivative production from methanol			Glass production	Forming and blanketing of gas	Float glass	
	Refining of biomass/biogas						Electronics	

Source : eninrac research & analysis, D2I Model & Channel Checks

Hydrogen blending with natural gas in India – Use cases

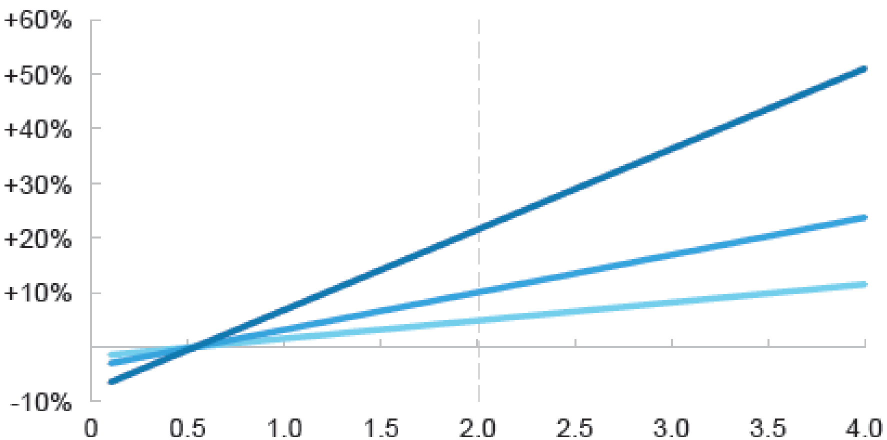
Blending use cases with hydrogen in India

Companies can blend low percentages of hydrogen into existing natural gas networks without the need for major changes in infrastructure or new home appliances. The ability of utilities to blend hydrogen will be dependent on infrastructure and end-use characteristics, and each utility needs to assess its own pipeline systems on a case-by-case basis to determine actual acceptable levels of hydrogen blending without major changes or enhancements to existing pipeline infrastructure

Total hydrogen use in India in 2021

Million tonnes/year

Change in fuel price BTU
Variation in gas price for $/kg hydrogen, percent



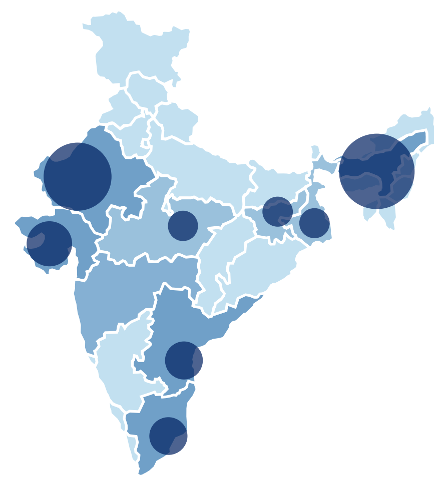
Energy cost increase blending $2/kg hydrogen with natural gas
Percent difference

22%

10%

5%

Natural gas production in India (2021-22) MMSCM



Note: Size of bubbles represents the extent of production in the states

Source : eninrac research & analysis, D2I Model & Channel Checks

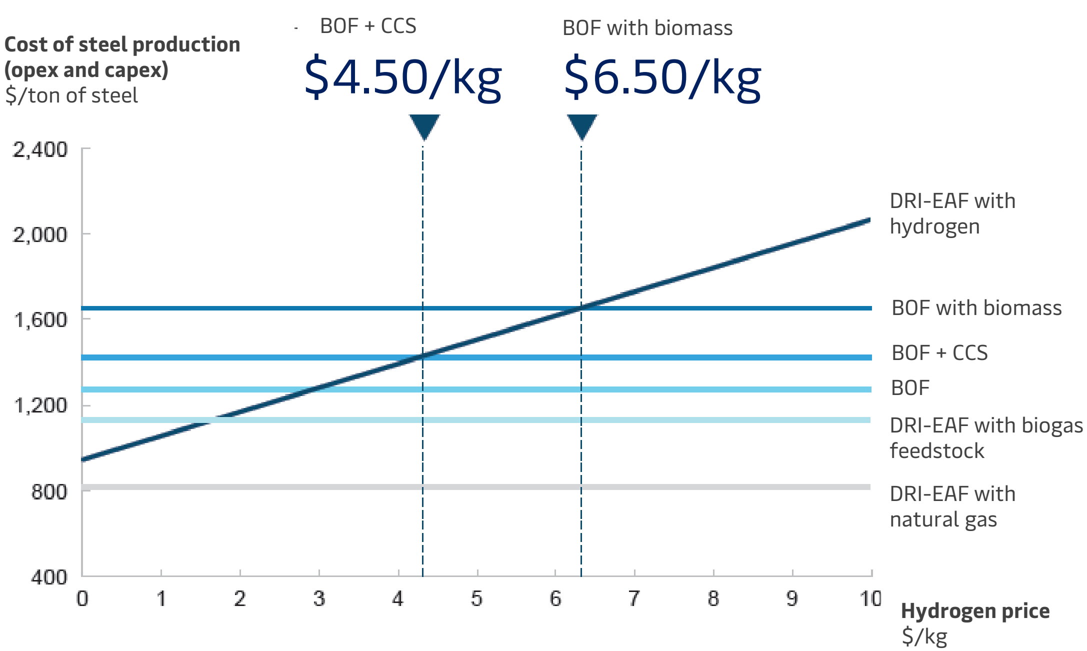
Cost comparison for greenfield steel production methods depending upon H_2 prices in India

India’s hydrogen vision for steel production

In the ambitious scenario, 6 percent of steel plants could switch to a hydrogen-blend feedstock by 2030. By 2050, 14 percent of steel plants could switch to hydrogen, meaning steel production would use 1.4 million metric tons of hydrogen every year.

Break-even costs of hydrogen in comparison with another feedstock in India

Million tonnes/year



Source : eninrac research & analysis, D2I Model & Channel Checks

Hydrogen could play a pivotal role as a low carbon alternative to firm the national grid in India – with solar and wind power

Centralized power generation

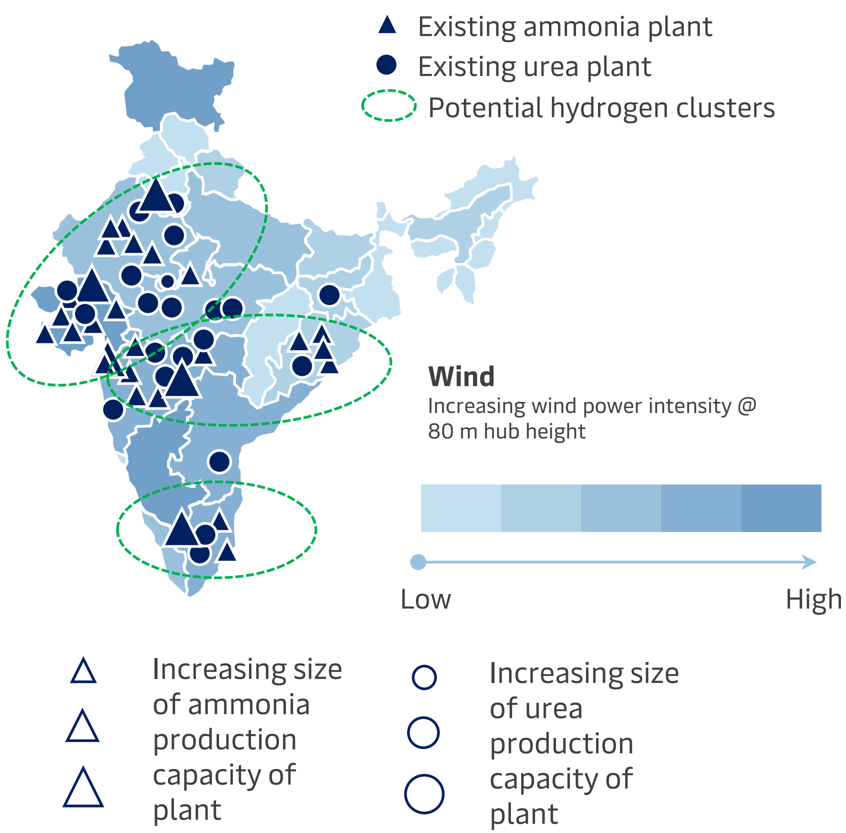
Hydrogen can be converted to electricity in two different ways: combustion (as a hydrogen/natural gas blend today or as pure hydrogen in the next decade) in gas turbines (which can be retrofitted gas power plants), or electrochemical conversion back into electricity using fuel cell technology. Hydrogen could play an important role as a low-carbon fuel for firming a low-carbon grid. Hydrogen provides the benefits of long-term storage capability (if one season) and ready dispatchability – and can be a lower-carbon fuel pathway than natural gas without CCS. Thus, hydrogen could play a role during extended periods of insufficient energy generation from variable renewables due to the natural intermittency and seasonality of sunshine and wind. Hydrogen could be a form of dispatchable power (in the case of generation) or load (in the case of hydrogen production with electrolysis) to meet or manage peak demand ("peaker" plants or "interruptible load"), on a path to 100 percent zero-carbon power, especially in isolated areas or in states with few flexible power supply options. In a 100 percent zero-carbon scenario, with large shares of wind and solar power, grid operators need a dispatchable, low-carbon energy source to provide electricity during extended periods of low renewables supply.

Balancing and buffering: flexibility benefits of electrolysis through renewables

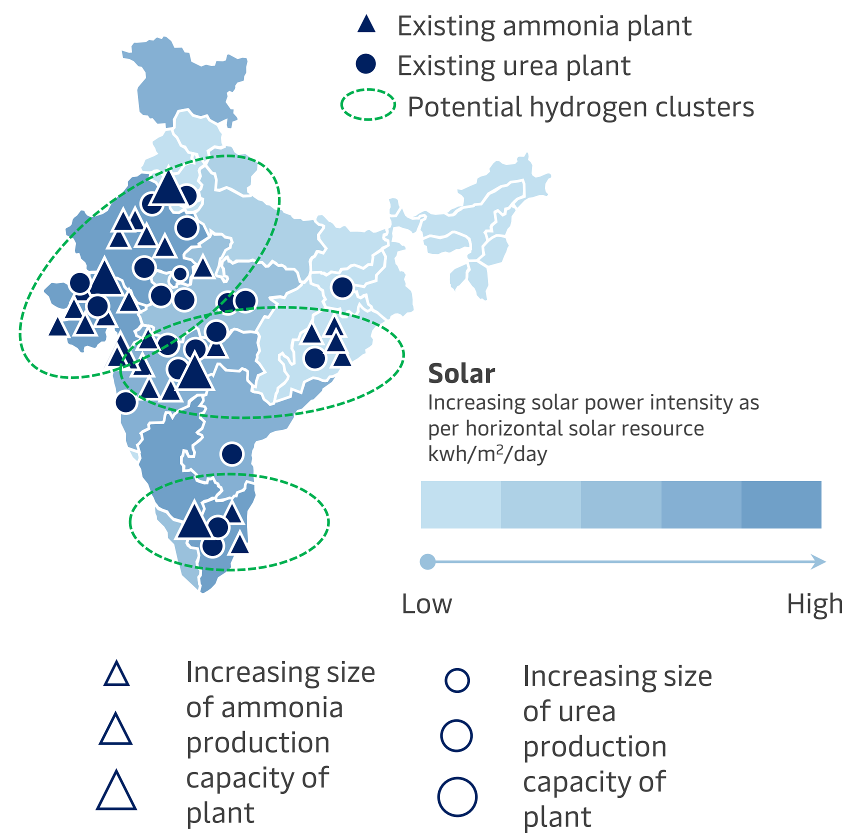
Water electrolysis can provide a large source of flexible demand to the power system, which makes it an attractive complement to solar and wind power. Although this could increase the overall electricity demand, it would also introduce more flexibility into the power system and increase the utilization of carbon-free electricity sources. This could reduce the need for other flexible solutions like batteries in certain applications or complement batteries as long-duration storage. Modelling a 100 percent clean energy grid in India shows that when grid electricity is used to meet an assumed hydrogen demand, the need for battery capacity is reduced by 70 percent with flexible hydrogen demand, while the total generation capacity required increases by 50 percent. Hydrogen fuel cells are already replacing diesel generators for off-grid and backup power (including microgrids), lowering carbon and air pollutant emissions, odor, and noise. Hydrogen is more reliable (fuel cells have far fewer moving parts than diesel generators, and the hydrogen doesn't degrade, even during long periods of storage). Current hydrogen fuel cell microgrid models are implemented in greenhouses and gardens within communities and business complexes.

Hydrogen could play a pivotal role as a low carbon alternative to firm the national grid in India – with solar and wind power (contd.)

Wind power intensity, existing ammonia and urea plants and potential hydrogen clusters in future for India



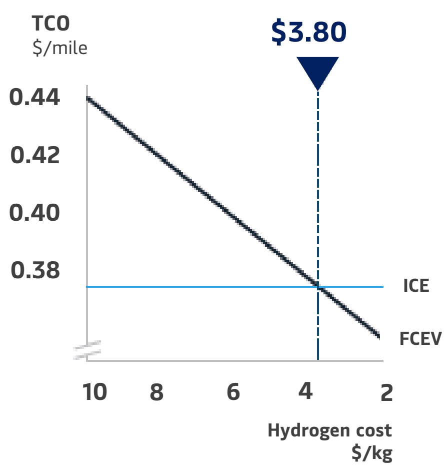
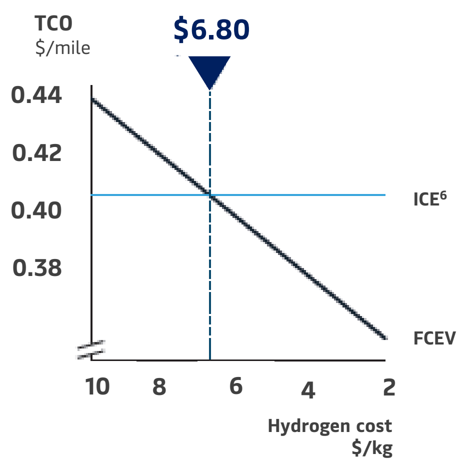
Solar irradiation intensity, existing ammonia and urea plants and potential hydrogen clusters in future for India



Source : eninrac research & analysis and Channel Checks

Hydrogen could play a pivotal role as a low carbon alternative to firm the national grid in India – with solar and wind power (contd.)

SUV Total Cost of Ownership (TCO) analysis
TCO per mile (US$/mile) in 2030

	Assumption 1 ICE efficiency of 39 mpg	**Assumption 2** ICE efficiency of 29 mpg
Capex[1,2]	**FCEV: Hyundai Nexo – 39K** **ICE: Honda Pilot – 32K**	**FCEV: Hyundai Nexo – 39K** **ICE: Honda Pilot – 32K**
Lifetime	**200,000 miles** **~ 35 miles/day**	**200,000 miles** **~ 35 miles/day**
Efficiency	**FCEV:5 kwh battery** **0.015 H_2 kg/mile (67 GGE[3])** **ICE:39 mpg[4]**	**FCEV:5 kwh battery** **0.015 H_2 kg/mile (67 GGE[3])** **ICE:29 mpg[5]**
Break-even price of hydrogen at the pump		

Notes for TCO analysis

[1]Capex is annualized assuming 7% interest
[2]Press search on select models and segment averages; assume a 5% p.a. drop in FCEV cost from 2019 to 2020 in terms of the manufacturer's suggested retail price
[3]Gasoline gallon equivalent
[4]ICE Fuel Economy 2030 outlook from the EIA Annual Energy Outlook 2019; McKinsey analysis
[5]Assumes equal to today's ICE efficiency of 29 mpg
[6]Gasoline price of $3.26/gal from the EIA's annual energy projections for 2030

Source : eninrac research & analysis and Channel Checks

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