Role of Green Hydrogen in Achieving NDC Targets

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Rathin Kukreja
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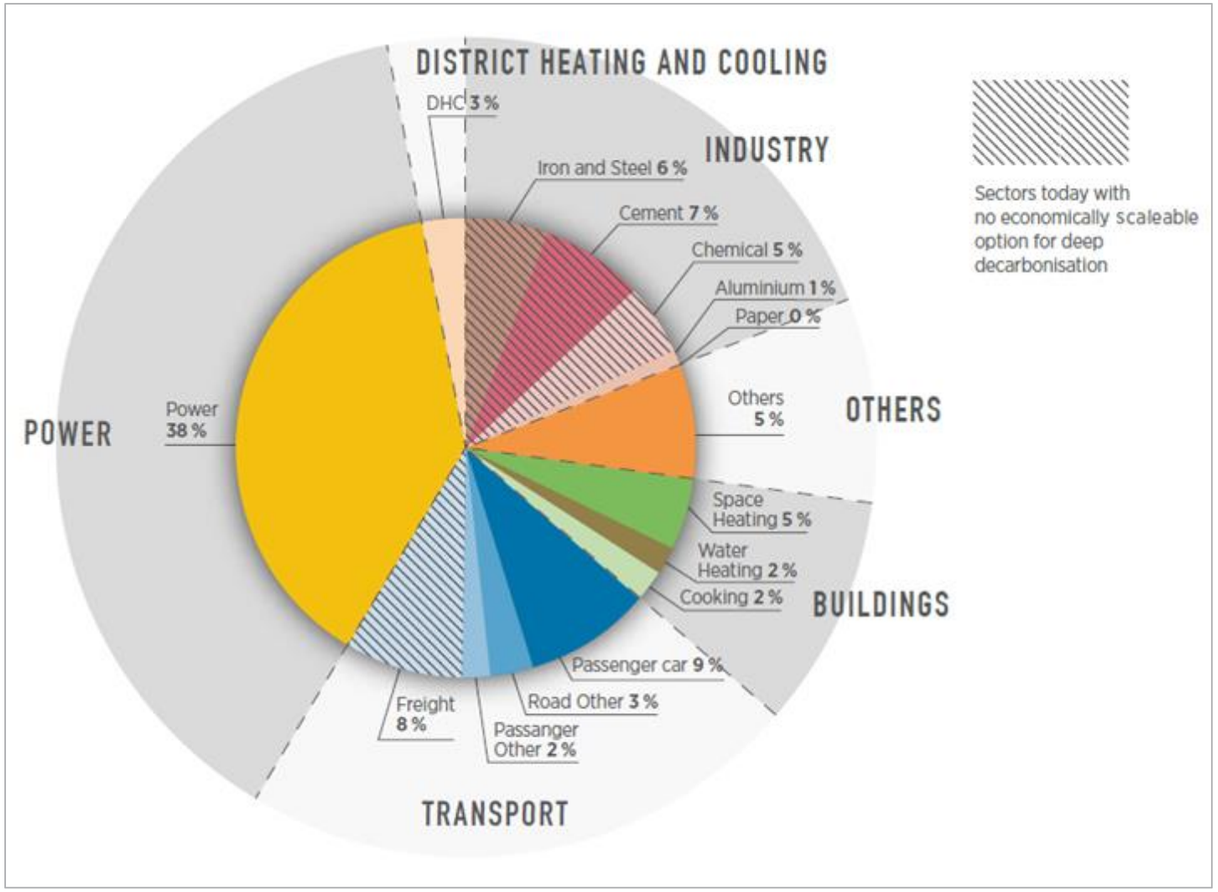
Outline

Hydrogen can address specific applications across sectors that are hard to decarbonize.

- Hydrogen is versatile (finds usage in all sectors). Increase energy-system resilience through integration of renewable energy.
- Electricity costs through renewable sources has become very competitive as compared to earlier years.
- Electrolyzer performances have improved over the years.
- Growing Concern on climate change

Global Energy related CO_2 Emissions by Sector*



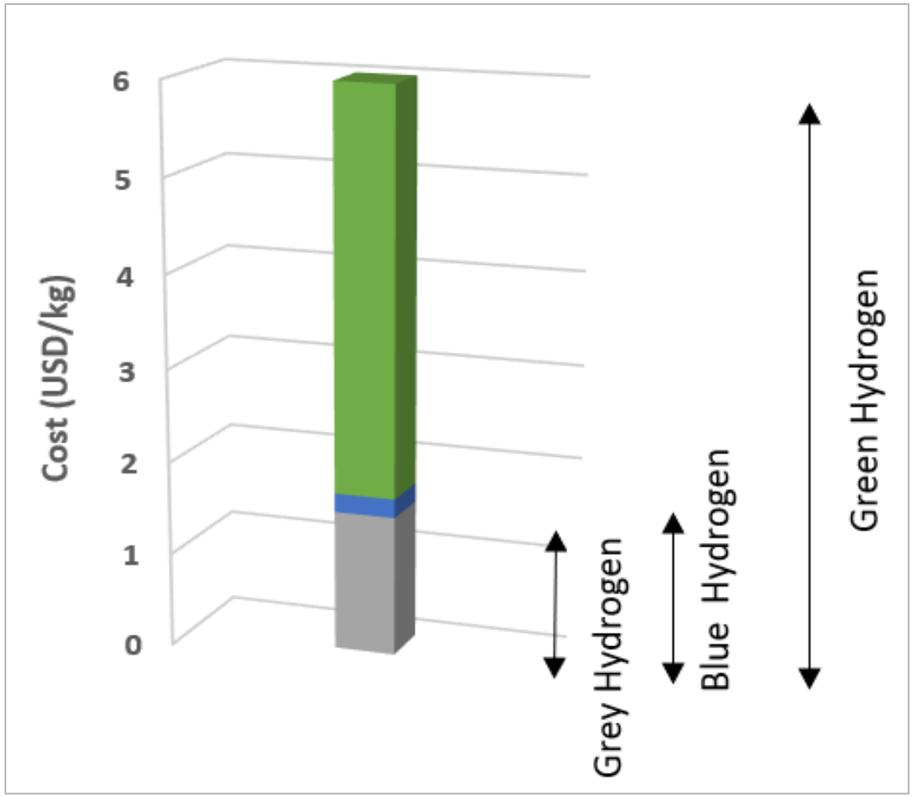
Why Hydrogen? Why Now?

*Source: IRENA (2017a); Hydrogen from renewable power

Besides improvement in electrolyzer efficiencies and expansion of renewable energy, it is important to create a demand pull to ensure investment in new production capacity, transportation and storage infrastructure.

- Fossil-based hydrogen without carbon capture, known as “grey” hydrogen, can deliver less than $1.50/kg.
- Carbon capture will add $0.10/kg to $0.30/kg, to form blue Hydrogen economy.
- Green hydrogen currently delivers approximately $5/kg unit costs, though expected to reduce sharply.

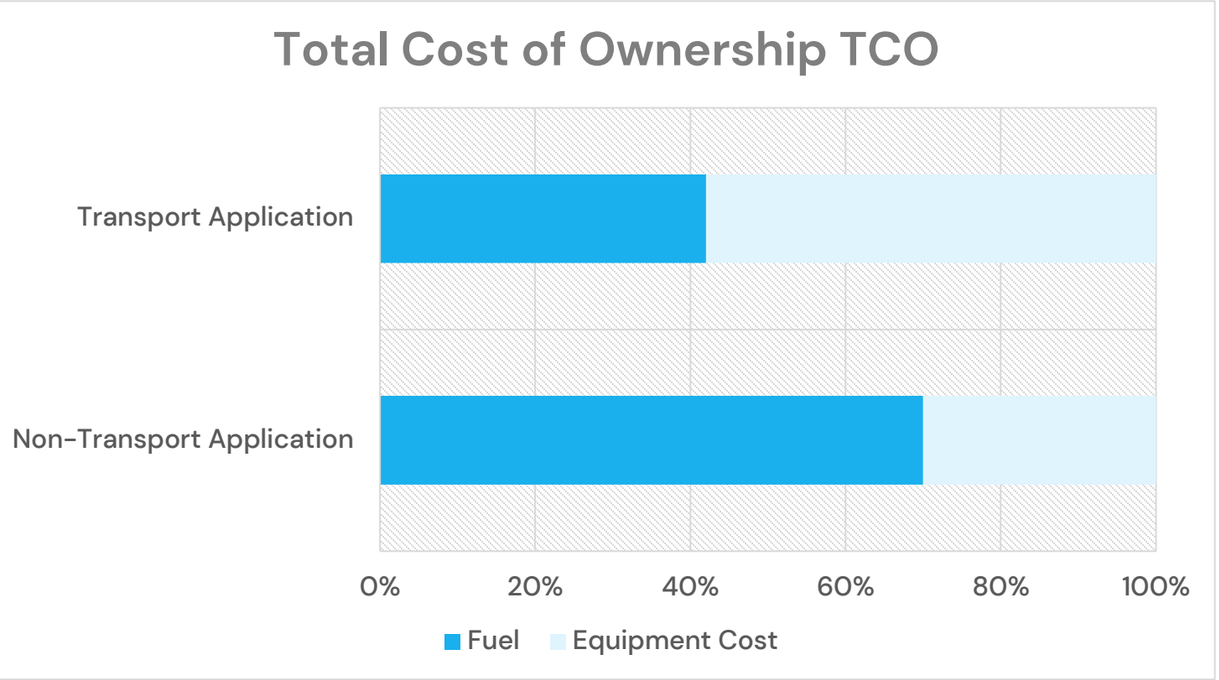
Current cost of Hydrogen production and CO2 intensity*



Hydrogen – Production Routes Vs Costs

TCO defines total costs incurred over the lifetime in owning and using an asset

- On an average, the cost of hydrogen supplied (fuel) comprises more than 70 per cent* of the TCO for non-transport applications.
- The cost of hydrogen supplied (fuel) comprises only 45 per cent of the TCO for transport applications (Buses, Medium and heavy-duty trucks, Light commercial vehicles).



Lowering the total cost of hydrogen production is needed to make it viable for non-transport application whereas to make a similar break through in transportation sector, an equal reduction is needed in costs of FCEVs and fuel tanks.

Hydrogen – Total Cost of Ownership (TCO)

*Source:: Adapted from "Path to Hydrogen Competitiveness" (Hydrogen Council)

The lack of domestic natural gas supply and high cost of import supply coupled with cheap renewable power would make green hydrogen competitive sooner than in other parts of the world.

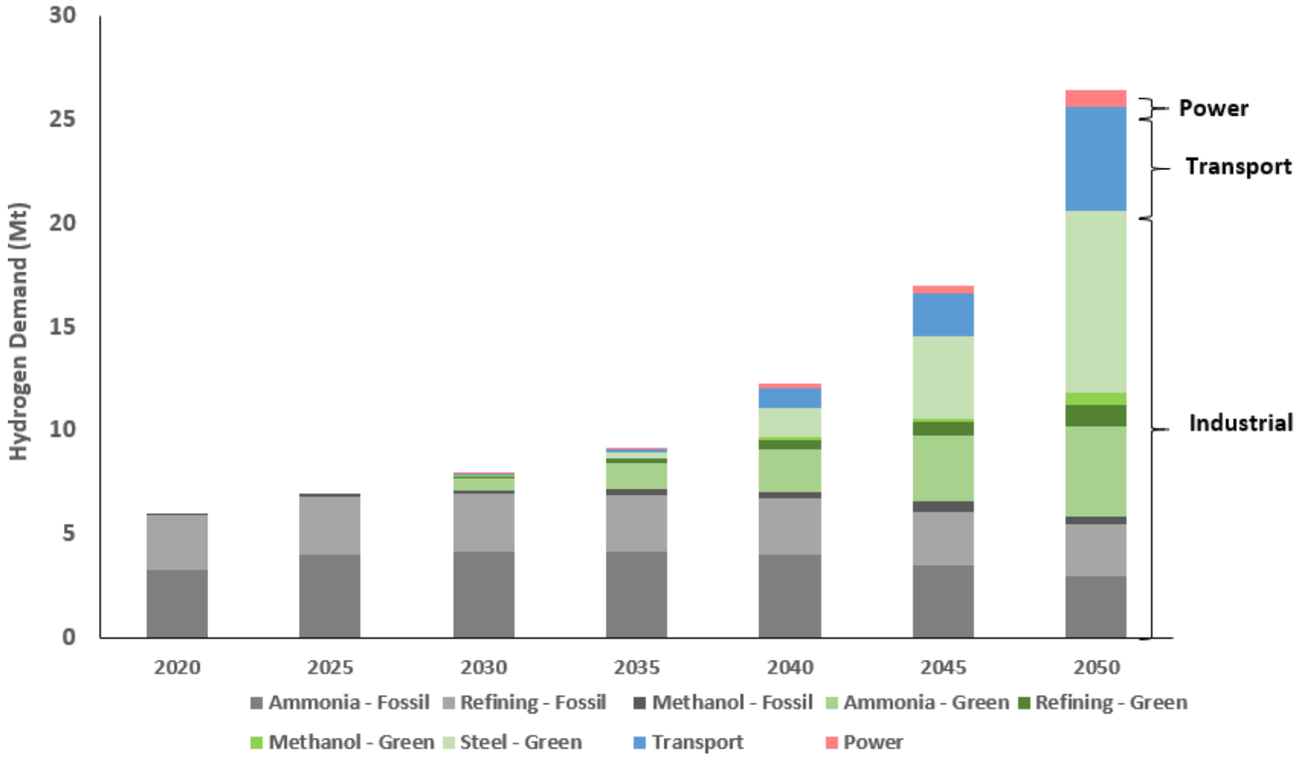
- Essentially all the hydrogen used (6 Mt) in India is produced on-site with fossil fuels, with demand from mainly sectors- fertilizers, refineries and methanol.

If India were to reach a net-zero by 2060, its green hydrogen production is expected to becomes

40 times

from the existing level, with additional demand from sectors such as steel, power and transport, besides the existing demand sectors.

Hydrogen demand projection in the low-Carbon scenario*



Indian's Hydrogen Scenario-Production & Demand

*Source: Adapted from "The Potential Role of Hydrogen in India" (TERI)

Green Hydrogen can help reduce India's fossil fuel imports and decarbonize industrial processes that are difficult to electrify

Only 18% of total energy consumption is in the form of electricity.

82%

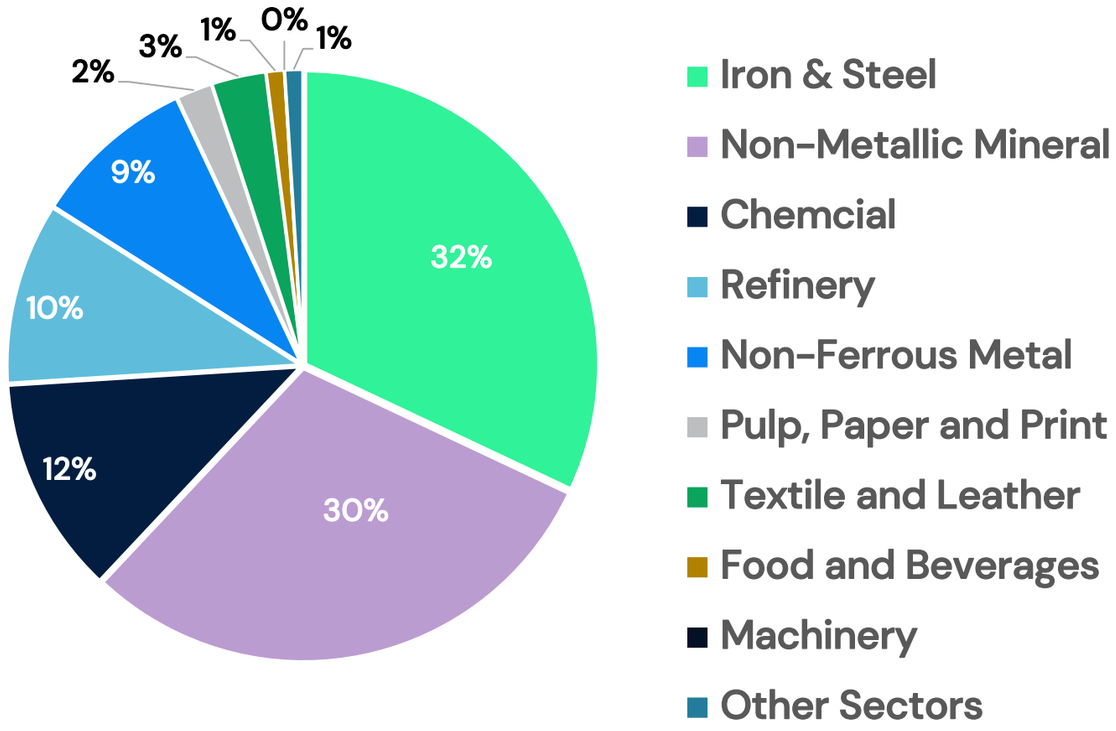
Needs some form of decarbonization*

India's Import dependency:

- Oil-85% import
- Coal-24% import
- Gas-53%import

} $160 Billion

India Industrial Emissions by Sector



→ Decarbonizing India's Industrial Sector with Hydrogen

*Source:: NITI Aayog

Storage of hydrogen can help address seasonal problems associated with Renewable Energy and play an important role in power sector

Stationary Applications (Industries)	Mobile Applications (Vehicles)
H_2 can be stored as gas at high pressures (100 bar) or as liquid	H_2 can be stored as gas (500-700 bar) and supplied to FCEVs
Infrastructure Needed	
• Compressed gas tanks • Cryo-compressed tanks • Underground caverns	• Compressors & several Dispensing stations(As of now India has only 2 stations) • Codes and standards to ensure safety

Compression and Liquification need further energy

This compression (700 bar) of hydrogen requires around 0.13 kWh/kWhH_2.

The liquefaction of hydrogen is much more energy intensive than compression, roughly requires 0.33 kWh/kWhH_2.

Stand-alone green hydrogen production from decentralized renewable energy should be preferred wherever possible. Existing pipeline infrastructure (with proper H_2 blending) should be leveraged to save transportation cost.

→ Indian's Hydrogen Scenario- Storage & Transportation

Strengths

* Abundant and low-cost labor.

*Strong presence of both private and public sector

* Good potential for renewable energy

Weaknesses

* No clear road map and policies

*Higher production costs

* Lack of Infrastructure/ R&D set up

Opportunities

* Energy security and resilience

*Global Collaboration in technology transfer

* Reduce import of fossil fuels

Threats

* Competition with other renewable energy routes

*Uncertainty in demand

* Rising cost for electrolyzer raw materials

SWOT Analysis-Transition to Hydrogen Economy for India

- ❑ Creation of a National Hydrogen Policy and Roadmap (for supply chain- production, transportation, storage & distribution).
- ❑ Develop Investment Fund and finance instruments to incentivize H_2 production.
- ❑ Commit target for share of hydrogen in India' energy mix by 2030, 2040 & 2050.
- ❑ Demonstrate pilots and create a demand pull to enable H_2 adoption and unlock further cost reduction.
- ❑ Focus on domestic manufacturing of electrolyzers and fuel cells.
- ❑ Form Green Hydrogen Public-Private Partnerships and Industry Consortium
- ❑ Continue to expand renewable energy (wind & solar) & increase their plant load factor.

→ The way forward – Making Green Hydrogen Economy Viable for India

Get in touch with us:
Rathin Kukreja

Manager – Energy Efficiency & Climate Change
+91-7087020172
Rathin.Kukreja@icf.com

icf.com

linkedin.com/company/icf-international/

twitter.com/icf

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