MAKE HYDROGEN IN INDIA

Driving India towards the clean energy technology frontier

Will Hall, Associate Fellow

POLICY BRIEF

SUMMARY

- The energy transition is continuing at an unprecedented pace and scale, requiring new low carbon technologies.
- To date, India has had limited success in capturing the manufacturing benefits of certain clean energy technologies, such as solar PV and batteries.
- TERI sees green hydrogen as the next 'clean energy prize', which will require coordinated action from industry and government for India to capture the benefits.
- Early demand markets for hydrogen include fuel cells for trucking, balancing supply and demand in the power sector and replacing fossil fuels in industry.
- The potential scale of hydrogen use in India is huge; increasing between 3 and 10 times by 2050.
- Hydrogen can provide a supplementary role to renewables and batteries, in a transition to a carbon neutral economy.
- Hydrogen can be divided into 'grey' (produced from fossil fuels), 'blue' (produced from fossil fuels with carbon capture and storage) or 'green' (produced from renewable electricity).

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Technology for the energy transition

The world is undergoing a transition to clean, low carbon sources of energy at an unprecedented pace and scale. New technologies are required to replace existing fossil fuels in order to move towards a net carbon neutral economy at the earliest. Keeping ahead of the technology curve is a matter of strategic importance for all countries but especially India, which will be one of the world's largest markets for these technologies in the decades to come. India needs to position itself at the technology frontier to maximise the benefits of the energy transition – to be a technology maker, not a technology taker.

Whilst the markets for clean technologies such as solar PV and lithium ion batteries have already been dominated by a few leading companies, there is a need for new technologies to reduce emissions from other sectors of the economy, beyond electricity. One such area is technologies related to the production, transportation, storage and use of low carbon hydrogen.

India's track record on technology innovation

There are a few clean energy technologies which have dominated the energy transition so far, namely, solar PV, wind (both onshore and offshore) and lithium ion batteries. The large-scale manufacture and deployment of these technologies has seen their costs plummet, with costs falling by 84% for batteries, 87% for solar PV, 47% for onshore wind and 32% for offshore wind between 2010 and 2018 (see Figure 1).

The development and manufacture of these technologies has occurred largely outside India (apart from onshore wind), with companies weighted towards the US, Europe and China (Mazzucato, Semieniuk, & Watson, 2015). To become technology leaders, these countries have implemented strong supply-push policies for priority technologies, in part by ensuring adequate and appropriate financing across the innovation chain (see Figure 2), with both public and private funding playing

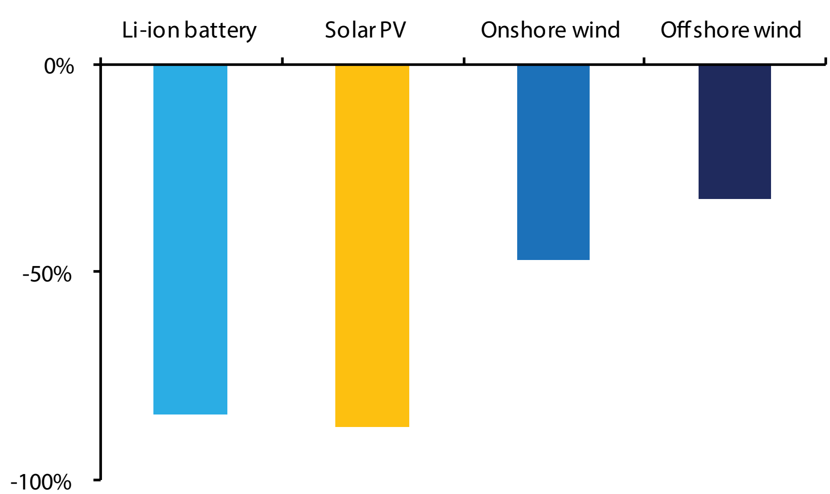

Figure 1: Cost reductions for key clean energy technologies, 2010-2018

Source: TERI analysis based on (NREL, 2019; BNEF, 2019). Shows world average data. Data for different regions and countries will vary.

an important role. In parallel, they have also introduced demand-side policies to pull technologies towards deployment and diffusion, including subsidies for novel technologies or standards and regulations, which have limited the deployment of fossil fuel equivalents (Mazzucato & Semieniuk, 2017). Deployment, in particular, played a significant role here. For example, the German Feed-in-Tariff scheme and subsequent solar auctions guaranteed markets for the mass manufacture of solar panels in China, which in turn caused costs to plummet.

India has largely lost out on the benefits of manufacturing these technologies, which include high value-added employment, increased tax return and the ability to innovate on existing manufacturing processes to develop the next generation of renewable technologies. To avoid missing out on the future benefits of the energy transition, India needs to be proactive in creating a productive innovation ecosystem for the development, deployment and diffusion of technologies. This policy brief outlines how this can be achieved for hydrogen-related technologies.

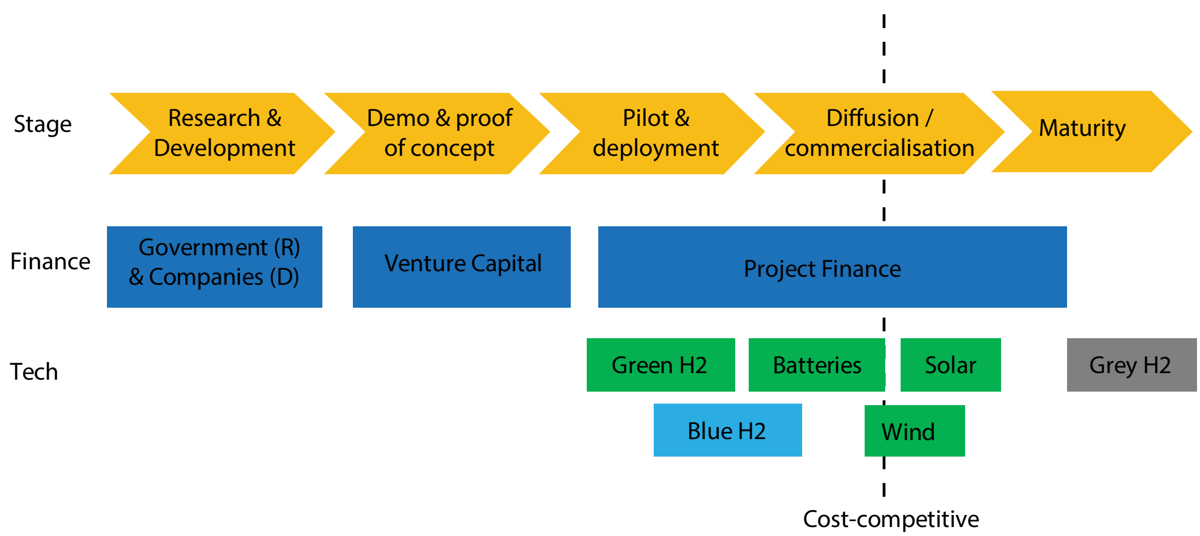

Figure 2: Innovation chain, finance requirements and key clean technologies

Source: Adapted from (Mazzucato & Semieniuk, Public financing of innovation: new questions, 2017). Grey H2 = hydrogen produced from fossil fuels; Blue H2 = hydrogen produced from fossil fuels, with carbon capture and storage (CCS); Green H2 = hydrogen produced using renewable electricity.

It is also the case that India has played an important role in helping to bring down the costs of these technologies by deploying them at scale. From 2014 to 2018, a total of $42bn was invested in India's renewables sector, helping to further drive down costs (IBEF, 2019). Whilst there are significant benefits of deploying renewables, not least reducing local air pollution and carbon dioxide emissions, unfortunately for India, much of this spending was to the benefit of companies based outside the country.

The limits of direct electrification

India is already experiencing first-hand the range of benefits that come with renewable electricity, including providing greater energy access, reducing local air pollution and carbon dioxide emissions and reducing energy imports. There are clear routes for increasing the role of renewable electricity in the grid (Pachouri, Spencer, & Renjith, 2019), as well as in end-use sectors, such as transport and industry. There are nonetheless cost, technology and practicality barriers to the full-scale electrification of all existing energy uses, which limits the extent to which renewable electricity can directly replace fossil fuels.

Transport

In transport, whilst the majority of light passenger vehicles look set to be electrified over the coming decades, the options for heavy-duty vehicles looks less certain. This is largely due to the limiting factors of batteries energy-to-weight ratios and the speed at which such large batteries could be recharged versus the rate of hydrogen refuelling (ETC, 2018). Presently, hydrogen fuel cell vehicles (FCEVs) can be recharged between 5-15 minutes, versus the well over 90 minutes required for battery electric vehicles (BEVs).

India's heavy-duty transport market is set to rapidly expand and with it, associated CO_2 emissions. According to the IEA, oil demand from heavy-duty road transport in India will nearly treble by 2040 (IEA, 2017). India will see the greatest increase in heavy-duty road transport of any region in the world, presenting both a huge challenge and an opportunity.

Zero-carbon trucks, using hydrogen fuel cells are already technically feasible, although the cost and carbon intensity are currently greater than that of diesel equivalents, assuming an emissions intensity of grid electricity for India of around 700gCO_2/kWh. Nonetheless, there is a clear path towards cost parity, which is expected in the 2020s. Companies are showing support for this technology, with the US-based FCEV truck manufacturer, Nikola, already receiving orders for 14,000 trucks (Freightwaves, 2019).

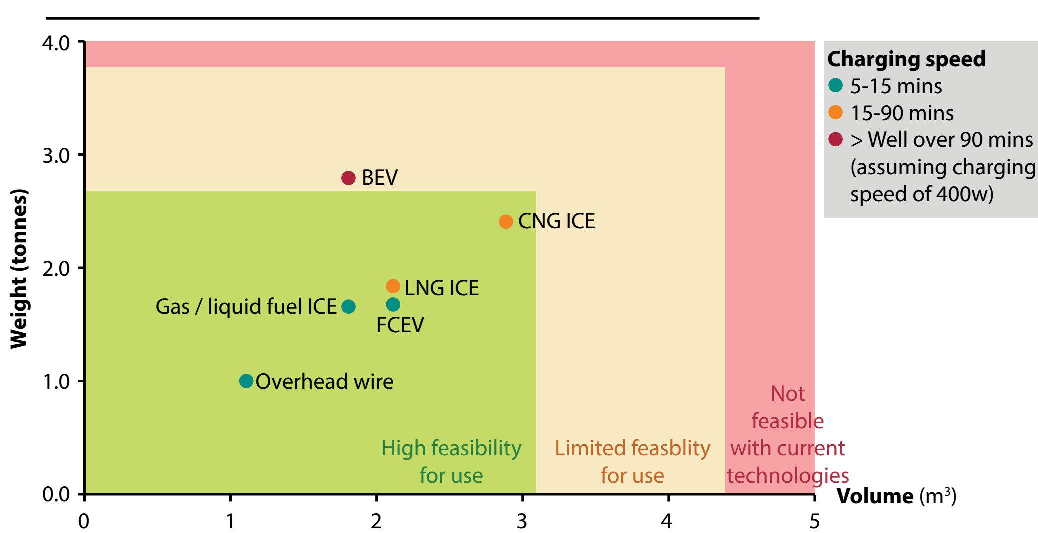

Figure 3: Weight and volume characteristics of different vehicles

Source: (ETC, 2018)

Industry

In industry, full-scale electrification of process heat can incur significant costs and is often impractical or technically challenging. It is also the case that many industrial processes require chemical feedstocks, such as iron ore direct reduction for primary steel production, that switching to direct electrification would not provide (Hall, Spencer, & Kumar, 2020). Whilst carbon, capture and storage (CCS) has a potential role to play in decarbonising industry, its future is highly uncertain in India, given the lack of understanding around its potential scale and costs.

Taking the steel sector as an example, pilot plants using high shares of hydrogen are already being established in Europe. The HYBRIT project in Sweden aims to have a demonstration plant up and running by 2026, a full-scale plant operating in 2035, with the intention to have switched over their entire fleet by 2045 (SSAB, 2019). If supplied with zero-carbon hydrogen and combined with an electric arc furnace supplied with zero-carbon electricity, this has the potential to reduce emissions by over 94% compared with conventional technologies. Residual emissions occur from the use of graphite electrodes in the EAF, as well as use of lime and natural gas. These could be brought down to zero with further research and development (Vogl & Ahman, 2019).

Power

In the power sector, as the electricity grid approaches higher and higher shares of variable renewable electricity generation from the likes of wind and solar, it will become increasingly difficult to balance the electricity grid over long periods, without thermal or hydro generation (or other forms of long-term seasonal storage). This is especially true for India's renewable generation, which can experience significant seasonal variation during monsoon and winter periods.

Batteries will be able to provide cost-effective intraday storage, as a result of their high round-trip efficiencies and ability to cycle multiple times within 24 hours. This allows energy to be shifted from times of the day of high renewable energy production to times of low production and high demand. However, batteries are unlikely to provide cost-effective storage on the time scale of several days or weeks and for this purpose, hydrogen may be a more suitable option (see Figure 4). This is due to the lower capital costs of developing hydrogen storage facilities at scale, including salt caverns or steel tanks. The lower the electricity input cost, the lower the final cost of electricity stored, with hydrogen becoming competitive at lower costs as the capital costs become the dominating factor, over the operating efficiencies.

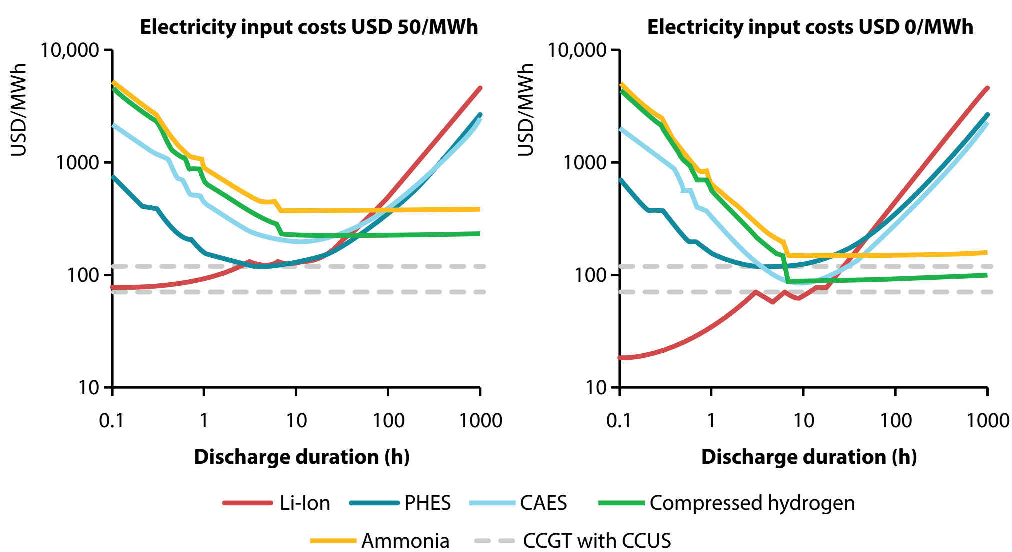

Figure 4: Levelised costs of storage as a function of discharge duration

Source: (IEA, 2019). PHES = pumped-hydro energy storage; CAES = compressed air energy storage; Li-ion = lithium-ion battery; Compressed hydrogen storage refers to compressed gaseous storage in salt caverns, ammonia storage to storage in tanks.

Scale

When combining these end-uses together, across several sectors, demand for hydrogen has the potential to increase significantly in the coming decades. Global demand for hydrogen is currently around 70Mt but the ETC, BNEF and the Hydrogen Council all expect this to multiply many times over by 2050, to enable countries to transition to low carbon. There is still considerable uncertainty in these projections given the unknowns around levels of policy support, speed of cost reduction and cost-effectiveness versus alternatives.

In India, current hydrogen demand is largely focused in the chemical and petrochemical sectors. Future demand will be driven by greater use across transport, industry and power. Scaling this demand to these existing projections could see demand for hydrogen increasing between 3 to 10 times in India by 2050. This represents a significant scale of demand for India, which in turn can generate further cost reductions as technologies, such as electrolysers, are deployed.

Hydrogen as the next clean energy prize

Given the limits of direct electrification and the potential of hydrogen to overcome some of these barriers, we see it as the next clean energy prize under the energy transition. A range of countries, companies and multi-lateral organisations are already pushing ahead with ambitious plans to develop and deploy hydrogen at scale. Whilst 'grey' hydrogen production technologies are mature, many 'green' hydrogen technologies are still at a stage of emergence, whereby markets are still developing and manufacturers are engaged in experimentalist learning (Victor, Geels, & Sharpe, 2019).[1]

At the country level, Japan has been at the forefront of developing hydrogen technologies, with strong support from government and industry. The Ministry for Economy, Trade and Industry (METI) first developed a Strategic Roadmap for Hydrogen and Fuel Cells in 2014. This was most recently revised in 2019, where the Council for a Strategy for Hydrogen and Fuel Cells set out (i) new targets on the specification of basic technologies and the

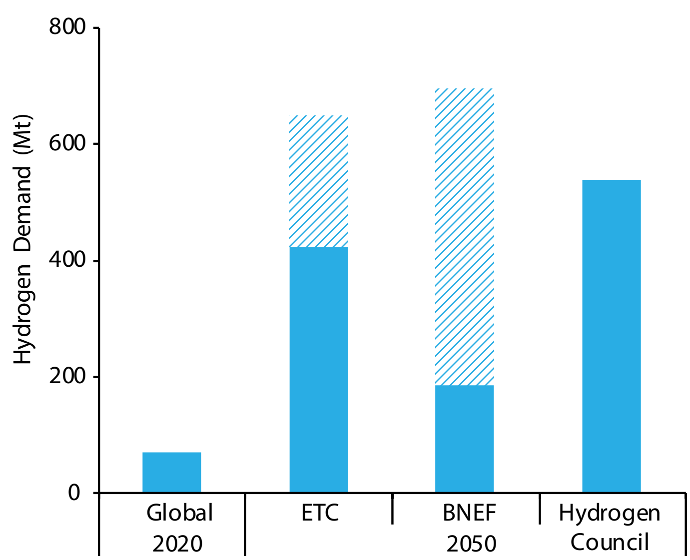

Figure 5: Potential scale of hydrogen demand

Source: TERI analysis based on (ETC, 2018; BNEF, 2020; Hydrogen Council, 2017). Shaded bars represent the range of forecasts.

[1] Grey H2 = hydrogen produced from fossil fuels; Blue H2 = hydrogen produced from fossil fuels, with carbon capture and storage (CCS); Green H2 = hydrogen produced using renewable electricity.

breakdown of costs; (ii) necessary measures for achieving these goals; and (iii) the intention to convene a working group to review the status of implementation in each area of the roadmap (METI, 2019). Recently, Japan opened the largest green hydrogen plant, with a 20 MW solar array feeding a 10 MW electrolyser plant (RECHARGE, 2020). Interest is also now growing elsewhere, with the European Union, the United States, Australia and China all developing serious plans for the deployment of hydrogen technologies in sectors such as steel, shipping, petrochemicals and power.

In terms of companies, there are a number of multinational corporations undertaking serious activity on hydrogen. This includes **Shell**, who has hydrogen refuelling stations operational in Europe and the US and is working with truck manufacturers to expand into the heavy-duty transport sector. The Swedish steel company, **SSAB**, along with partners **LKAB** and **Vattenfall** are planning to deploy a commercial-scale hydrogen direct reduction steel plant by 2026, the first in the world. **Maersk**, the shipping company, have identified low carbon hydrogen as vital for decarbonising sea-borne freight, through using it to produce green ammonia. The German-based engineering firm, **Siemens**, is also expanding its activity in hydrogen, continuing to manufacture PEM electrolysers, as well as developing hydrogen-fuelled turbines to facilitate clean electricity generation. Lastly, **Mitsubishi Hitachi Power Systems** are planning to switch natural gas turbines to run on 100% hydrogen in Los Angeles before 2035.

There is also growing interest in hydrogen among multilateral organisations focused on coordinating innovation activities between countries. This includes Mission Innovation, which India is a founding member of, who launched an innovation challenge on 'Renewables and Clean Hydrogen'. Also, the Clean Energy Ministerial, coordinated by the International Energy Agency (IEA), launched their 'Hydrogen Initiative' in 2019, focused on the use of hydrogen in industry, transport and communities.

Current status of hydrogen in India

Hydrogen is already used extensively in India, mainly as an industrial feedstock in the creation of ammonia-based fertilisers. Most hydrogen in India is produced through reforming methane (CH_4), resulting in significant carbon dioxide emissions. There is the potential to capture these emissions using carbon capture and storage (CCS) technology, although this is relatively underdeveloped in India. An alternative means of production is electrolysis, where water (H2O) is split into its component parts using electricity. India has claim to one of the first large-scale alkaline electrolyser facilities in the world, which produced hydrogen from electricity at the Nangal Facility from 1962. Whilst there is significant research activity around electrolysis, photolysis and biogenic methods of producing hydrogen, these low carbon technologies are yet to be deployed at scale.

In part, this is due to the costs of hydrogen production from low carbon sources today, which are higher than fossil fuel-based hydrogen or other fossil-fuel equivalents. It is however possible that these costs could reach parity in future, with green hydrogen undercutting grey hydrogen in favourable regions. This is made more possible in India, where renewable electricity tariffs are already among the lowest in the world and supplies of natural gas are limited and costly.

Along with electricity prices, the other important factor for reducing the costs of green hydrogen is the capital cost of electrolysers (see Figure 6). These are expected to continue to fall with a scale-up in deployment, as most electrolysers today are manufactured on a relatively small-scale (BNEF, 2019). Marco Alvera, CEO of Snam Chemicals, estimates in his book 'Generation H' that the world will need to build 50 GW of electrolyser capacity (vs. 135 MW today) to help drive the prices of green hydrogen down to $2/kg, where it will become competitive with a range of fossil fuels (Alvera, 2019; BNEF, 2020).

In this context, it is also worth comparing electrolysers with previous clean energy technologies, such as those illustrated in Figure 1. Arguably, electrolysers are similar to batteries, being modular in design and relatively easy to transport. Batteries and electrolysers also share the same electrochemical foundations, both applying electrolyte and membrane materials. As a result, we could see global supply chains developing for electrolysers, as we have with batteries, where a significant amount is

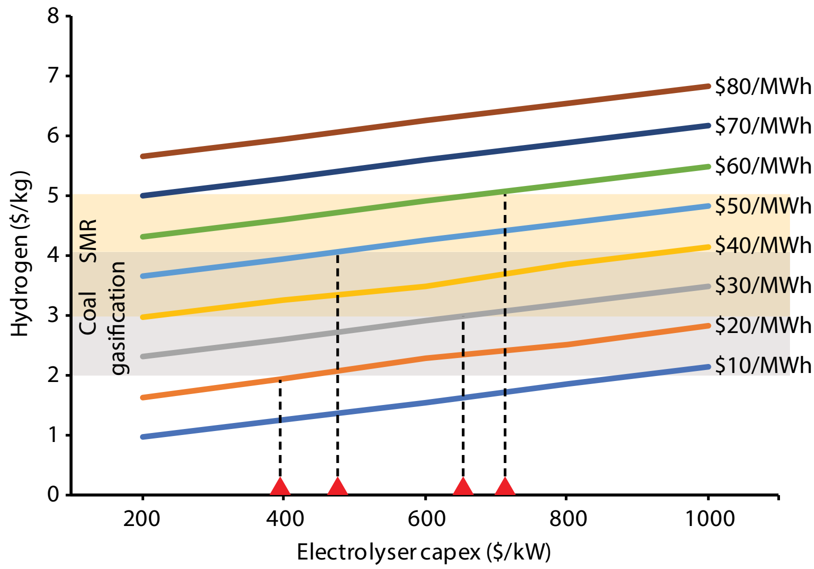

Figure 6: Costs of hydrogen from electrolysis

Source: (Hall, Spencer, & Kumar, 2020)

manufactured in China but used throughout Europe and the US. This provides India with an opportunity to develop a manufacturing hub here, taking advantage of competitive labour costs and a technically proficient workforce.

The Ministry of New and Renewable Energy (MNRE) has seen hydrogen as an area of strategic interest since at least 2006, when the first Hydrogen and Fuel Cell Roadmap was launched (MNRE, 2006). More recently, in 2016, MNRE published a report laying out a comprehensive plan for increasing R&D activity. This included significant funding for different electrolyser technologies and their integration with renewable electricity sources, which has strong potential in India given the cost and availability of renewable electricity.

Across Indian industry, there are considerable efforts to establish a hydrogen economy in India, not least, the work being taken forward by Indian Oil (see box).

Despite these positive moves from Government and industry, current activity is still an order of magnitude below where it needs to be to fully take advantage of a transition to hydrogen technologies, with manufacturing centred in India. In terms of the investment requirements, if India is to deploy green hydrogen as a clean energy solution for key sectors, including transport, industry and power, by 2050, this would require significant investment in electrolysers. Beyond this, additional investment in renewable electricity would be required, at a time when other demands for electricity in India will still be growing rapidly. This would clearly be a challenge to deliver, which is why it is imperative that India begins now in scaling-up activity.

Indian Oil Corporation Limited (IOCL) has been proactive in pushing for the adoption of hydrogen technologies in India, motivated by environmental considerations, energy security, positive technology developments and the versatility of hydrogen as an energy carrier. IOCL see hydrogen's potential across the economy in mobility, industrial heating, domestic / commercial uses and in the power sector. In terms of their R&D focus, IOCL has projects investigating new hydrogen technology solutions in the following areas:

Hydrogen production

In terms of hydrogen production, IOCL has a wealth of experience looking across the range of production technologies, including hydrogen from biomass, methane reformation, electrolysis and photolysis (photoelectrical water splitting).

Most recently, they have announced plans to establish a hydrogen production station, outputting 95Nm3/hr, which will test three different electrolyser technologies:

- Polymer electrolyte membrane (PEM) electrolysis
- Alkaline electrolysis
- Solid Oxide Fuel Cell (SOFC) electrolysis

Hydrogen storage

The development of the **Type-3 High Pressure Hydrogen Cylinder**, in collaboration with IIT Kharagpur, which increases the energy storage density over existing cylinders.

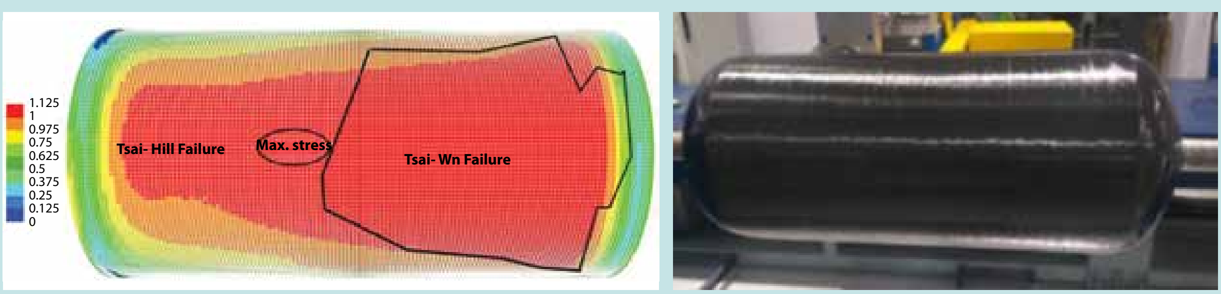

Diagram and photo of the Type-3 Cylinder

They have also focused on the development of material-based hydrogen storage, including metal-organic frameworks, or MOFs. Their research is focussed on producing high energy density MOFs, which can be scaled up cost-effectively.

Hydrogen infrastructure

IOCL is owner and operator of the 1st high pressure hydrogen storage and dispensing terminal in India, with the refuelling station located in Delhi. This refuelling station uses a PEM electrolyser, outputting hydrogen at $30Nm^3$/hr at a purity of 99.999%, which is required for fuel cell vehicles.

Hydrogen fuel cells

One of the barriers to the wide-scale use of hydrogen fuel cells is the requirement of high purity hydrogen, which can be more expensive to produce. IOCL is carrying out work to customise hydrogen fuel cells to operate with lower purity hydrogen, therefore expanding their applicability and potentially lowering the cost of operation. They have also recently put out a tender for 15 fuel cell buses, as part of a Rs 300 crore ($40mn) demonstration project for hydrogen fuel cell vehicles.

Source: (IOCL, 2020)

An ambitious Hydrogen Mission for India

For India to guarantee its role as a technology leader in the next phase of the energy transition, it will need to greatly increase activity across the public and private sectors to develop a hydrogen economy. India should focus public money for R&D and technology development to try and be on the global frontier in each part of the value chain of green hydrogen, with the objective of lowering costs and increasing deployment. This requires a coordinated push from the supply-side, with increased investment and R&D commitments by government and industry, as well as demand-side support in the form of guaranteed markets, enabled by government procurement, subsidy schemes or regulations / standards on fossil fuel alternatives.

To ensure success, significant commitments under a National Mission, along with effective public-private partnerships, are required; there would be little point in a sub-optimal effort that fails to mobilise sufficient resources. This is an opportunity for India to expand on the successes seen in the Defence and Pharmaceutical sectors, to commit strategic resources to deliver breakthroughs for hydrogen technologies, yielding significant benefits for the Indian economy.

Whilst it is important that India pushes ahead with developing and manufacturing hydrogen technologies domestically, it will also be important for other countries to do the same. Only through the mass manufacture and deployment of hydrogen technologies at scale will we see cost reductions where hydrogen can start to displace significant amounts of fossil fuel use, without government subsidy.

Our recommendations for driving forward hydrogen in India include:

Mission statement:

> *'India is committed to the rapid expansion of the hydrogen economy, ensuring the cost-effective deployment of low carbon hydrogen technologies across the transport, industry and power sectors by 2030'*

- Clear recognition of hydrogen's **cross-economy role**, with outlines for scaling-up use in transport, industry and power
- Commitment to **update existing regulations** to permit the safe use of hydrogen, at high pressure, across a number of end-use sectors
- **'Make in India' policy support** to maximise domestic manufacturing content across all parts of the value chain, including joint ventures with multinational companies
- **Champion electrolyser manufacture and commercialisation**, realising their suitability to the Indian market and significant potential for emissions reduction
- Significant increases in existing hydrogen **R,D&D spending**, to support demonstration projects in the steel and power sectors, as well as the commercialisation of more mature technologies
- Policies to create a **guaranteed market** for hydrogen technologies, where they are not yet at cost parity with fossil-fuel equivalents, for example in the steel sector
- Meaningful engagement in **international collaborations** on developing hydrogen technologies, including Mission Innovation and the Clean Energy Ministerial

Bibliography

Alvera, M. (2019). *Generation H: Healing the climate with hydrogen.*

BNEF. (2019). *2018 Battery Price Survey.* Retrieved from https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

BNEF. (2020). *Hydrogen Economy Outlook*. Retrieved from https://about.bnef.com/blog/hydrogen-economy-offers-promising-path-to-decarbonization/

ETC. (2018). *Mission Possible.* Retrieved from http://www.energy-transitions.org/mission-possible

Freightwaves. (2019). *Early adopters see great potential in Nikola hydrogen-electric truck.* Retrieved from https://www.freightwaves.com/news/equipment/early-adopters-believe-in-nikola-hydrogen-electric-truck

GoI. (2016). *LED Retail Prices come down to Rs. 65 under UJALA Scheme; 17.90 Crore LED bulbs distributed across the Country.* Retrieved from Press Information Bureau: https://pib.gov.in/newsite/PrintRelease.aspx?relid=154712

Hall, W., Spencer, T., & Kumar, S. (2020). *Towards a Low Carbon Steel Sector: Overview of the Market, Technology, and Policy Context for Indian Steel.* Retrieved from https://www.teriin.org/project/decarbonisation-iron-and-steel-sectors

Hydrogen Council. (2017). *Hydrogen Scaling Up*. Retrieved from https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf

IBEF. (2019). *Indian Renewable Energy Industry Report.* Retrieved from https://www.ibef.org/industry/renewable-energy.aspx

IEA. (2017). *Energy Technology Perspectives.* Retrieved from https://www.iea.org/reports/energy-technology-perspectives-2017

IEA. (2019). *The Future of Hydrogen.* Retrieved from https://www.iea.org/reports/the-future-of-hydrogen

IOCL. (2020). Hydrogen Economy: Global Imperatives and Indian Initiatives. *2nd Indo-Japan Workshop on Hydrogen and Fuel Cell.* Delhi.

Mazzucato, M., & Semieniuk, G. (2017). Public financing of innovation: new questions. *Oxford Review of Economic Policy*, 24-48.

Mazzucato, M., Semieniuk, G., & Watson, J. (2015). *What will it take to get us a Green Revolution?* Retrieved from https://www.sussex.ac.uk/webteam/gateway/file.php?name=what-will-it-take-to-get-us-a-green-revolution.pdf&site=264

METI. (2019). *The Strategic Road Map for Hydrogen and Fuel Cells.* Retrieved from https://www.meti.go.jp/english/press/2019/pdf/0312_002b.pdf

MNRE. (2006). *National Hydrogen Energy Road Map: Path Way for Transition to Hydrogen for India.* Retrieved from https://mnre.gov.in/file-manager/UserFiles/abridged-nherm.pdf

MoC&I. (2019). *Export Import Data Bank*. Retrieved from https://commerce-app.gov.in/eidb/default.asp

NREL. (2019). *Renewable Power Generation Costs in 2018.* Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf

Pachouri, R., Spencer, T., & Renjith, G. (2019). *Exploring Electricity Supply-Mix Scenarios to 2030.* Retrieved from https://www.teriin.org/sites/default/files/2019-02/Exploring%20Electricity%20Supply-Mix%20Scenarios%20to%202030.pdf

RECHARGE. (2020). *Japan opens world's largest green-hydrogen plant near Fukushima disaster site*. Retrieved from https://www.rechargenews.com/transition/japan-opens-worlds-largest-green-hydrogen-plant-near-fukushima-disaster-site/2-1-769361

SSAB. (2019). *SSAB to be first to market with fossil-free steel.* Retrieved from https://www.ssab.com/news/2019/11/ssab-to-be-first-to-market-with-fossilfree-steel

Victor, D., Geels, F., & Sharpe, S. (2019). *Accelerating the Low Carbon Transition: The case for stronger, more coordinated international action.* Retrieved from http://www.energy-transitions.org/content/accelerating-low-carbon-transition

Vogl, V., & Ahman, M. (2019). *Assessment of hydrogen direct reduction for fossil-free steelmaking.* Retrieved from https://lup.lub.lu.se/search/publication/47f58242-a20b-4d85-a43d-92c5904590c1

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The Energy and Resources Institute (TERI)
Darbari Seth Block, IHC Complex, Lodhi Road,
New Delhi- 110003

Tel: 71102100 or 24682100
Fax: 24682144 or 24682145
Web: www.teriin.org
E-mail: ETCIndiaSecretariat@teri.res.in