CII-ITC Centre of Excellence
for Sustainable Development

CII
Confederation of Indian Industry


Sectoral Report

# NEW AND EMERGING TECHNOLOGIES

Roadmap for Achieving
Net Zero Transition in
India by 2070

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# Acknowledgment

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This report draws insights and data from McKinsey's "Decarbonising India: Charting a pathway for sustainable growth." The recommendations contained in this report are of the CII Mission Net Zero.

**Context setting:** The CII Mission Net Zero sectoral report on New and Emerging Technology explores strategies for integrating new and emerging technologies that could be leveraged to achieve India's net-zero emissions goals. It provides an in-depth analysis of the potential of green hydrogen and Carbon Capture, Utilization, and Storage (CCUS) technologies within two scenarios: the current policy and technology trajectory (Line of Sight) and an enhanced, Accelerated adoption scenario. The report delves into the technological, financial, and policy challenges of scaling these technologies, emphasizing the need for substantial investments and collaborative efforts among stakeholders. It offers detailed policy recommendations, strategic actions for businesses, role in promoting these technologies to ensure India meets its ambitious net-zero goals by 2070.

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# Foreword

**Mr. T V Narendran**
**Past President CII**
**Chairman  CII Mission Net Zero &**
**Global CEO and Managing Director**
**Tata Steel Ltd.**

*There is a potential for digital technologies to reduce global emissions by up to 15%, underscoring the critical role these innovations play in our collective journey towards sustainability.*

In an era where the clarion call for climate action resonates stronger than ever, India's journey towards net-zero emissions is both a monumental challenge and a historic opportunity. Standing at the cusp of transformative change, the  CII Mission Net Zero is committed to leading from the front to achieve this ambitious goal.

This report on 'New and Emerging Technologies' serves to highlight the key role technologies such as Carbon Capture, Utilization and Storage (CCUS), digitalization and green hydrogen will have to play in decarbonisation of Indian industry.

The decarbonisation of heavy industries through advanced technologies like Carbon Capture, Utilization, and Storage (CCUS), digitalization, and the production and utilization of green hydrogen, is paramount. CCUS offers promising solutions for decarbonizing hard-to-abate sectors. Advancements in carbon capture technologies, particularly Direct Air Capture (DAC), can significantly reduce costs.

The revolution in Digital technologies, including Artificial Intelligence (AI) and the Internet of Things (IoT), are redefining efficiency and optimization across sectors. They offer a lens into a future where energy use is not only minimized but optimized, contributing significantly to our net-zero goals. There is a potential for digital technologies to reduce global emissions by up to 15%, underscoring the critical role these innovations play in our collective journey towards sustainability.

Green hydrogen, an essential component for India's energy transition, can become more competitive through mass-scale electrolyser manufacturing automation and localized production. Additionally, decreasing renewable electricity costs will boost green hydrogen's viability. Government incentives, such as T&D waivers and capital subsidies for electrolysers, are crucial, along with sector-wise mandates for green hydrogen use.

To achieve net-zero emissions, substantial investments in these technologies are required. The green hydrogen value chain demands an investment of $232 billion for the Business as Usual(BAU) scenario and $432 billion for the Accelerated scenario. The deployment of these technologies, as the report reveals, could reduce industrial carbon dioxide emissions by up to 3.2 gigatons annually by 2050, marking a significant step towards our net-zero ambition.

As the Chair of the CII Mission Net Zero, I am privileged to witness and contribute to this collective endeavour. Our actions today will determine the legacy we leave for future generations. Let this report serve not just as a testament to our commitment but as a blueprint for the transformative actions we must undertake.

Together, we have the power to achieve India's net-zero ambitions and lead the global charge in climate action. It calls for a strategic and collaborative approach, uniting policymakers, industry stakeholders, and the financial community to address the multifaceted challenges of this transition. By fostering innovation, enhancing local manufacturing, and developing skills, and by leveraging global partnerships for technology transfer and joint R&D initiatives, we can drive India—and indeed the world—towards a sustainable, clean energy future.


# 1. BACKGROUND

The report discusses emission reduction levers across two scenarios, both of which assume an orderly transition(a) the Line of Sight (LoS)/Business as Usual (BAU) scenario with current (and announced) policies and foreseeable technology adoption and (b) the Accelerated scenario with further reaching polices like carbon prices and accelerated technology adoption, including those of technologies like CCUS. In our LoS scenario, India could get to net-zero emissions by 2070, while in Accelerated scenario, India could get to net zero by 2050. Getting to the LoS scenario would create 207 $GtCO_2e$ of carbon space till 2070, while the Accelerated scenario would add a further 80 $GtCO_2e$. (Exhibit 1)

It is equivalent to 36 percent and 14 percent, respectively, of the remaining carbon budget for an even chance at limiting warming to 1.5 degrees Celsius.
This is despite India not reaching net zero in either of our scenarios, due to the residual emissions from agriculture and select industrial sectors (remaining emissions in 2070 of 1.8 and 0.4 $GtCO_2e$ in the LoS and Accelerated scenarios, respectively).

***In the LoS scenario India could get to net-zero emissions by 2070, while in accelerated scenario, India could get to net zero by 2050.***

**India's GHG emissions,** Gt $CO_2e$ per annum[1]

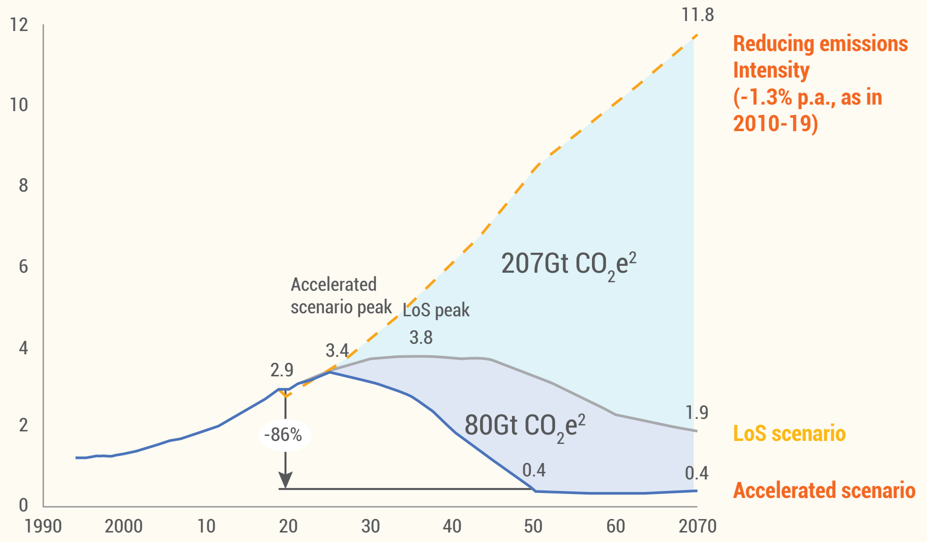


Exhibit 1

## 1.1 Contribution to India's emissions

- India ranks as the third largest emitter in the world. Emissions from India amounted to 3274 Gt$CO_2$e in 2019 alone led by power sector, manufacturing, agriculture, transport etc. (Exhibit 2). For abatement of these emissions, investment in new & emerging technology is critical. This report has considered green hydrogen and CCUS as the two technologies.
- Green hydrogen, made from renewable energy, is essential for India's decarbonisation - as a replacement for grey hydrogen for fertilisers and refineries and for newer uses like green steel and long-haul trucking. CCUS will be important for bringing down emissions of the steel, power, and cement sectors.

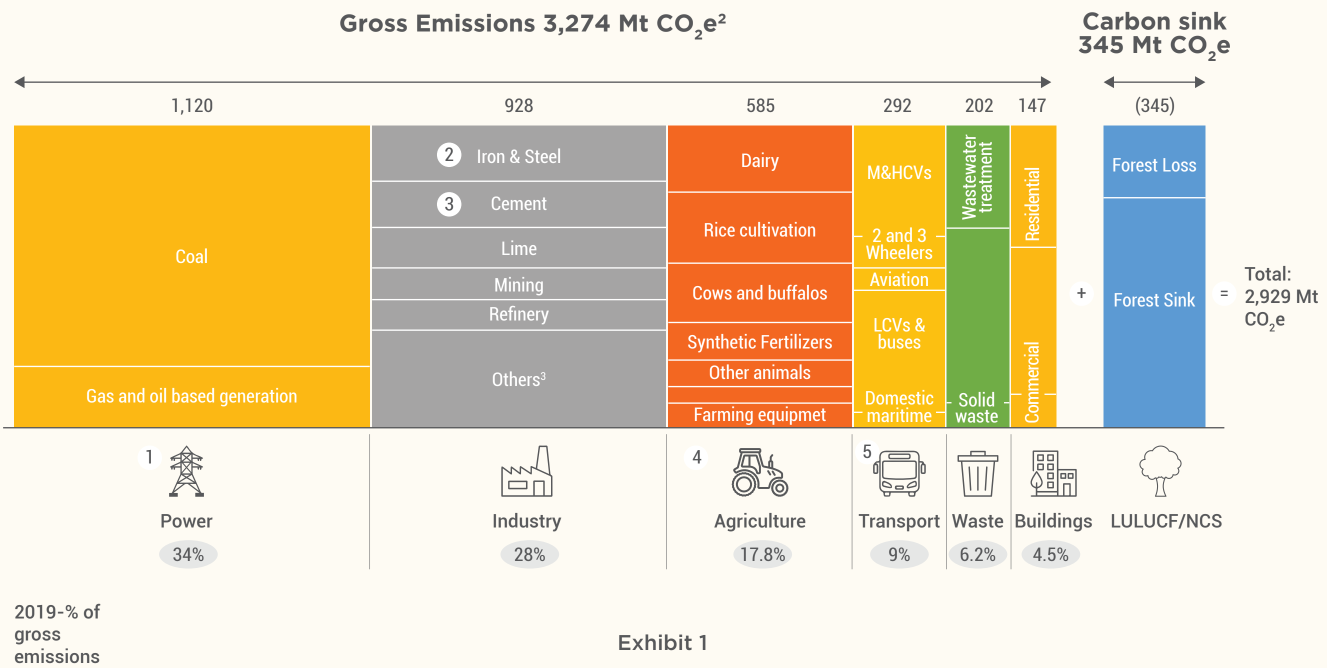


Exhibit 1

## 1.2 Current trends/trajectories

- There has been global momentum towards a hydrogen economy as more than 30 governments have announced hydrogen strategies. India has also announced its green hydrogen policy in February 2022 which promises lower cost power with inter-state transmission charges waived, banking for in the grid and a green hydrogen mission. Currently on-site Steam Methane Reformer (SMR)-based grey hydrogen is used in most downstream processes such as refineries and ammonia production. The current production cost of $1.90/kg will increase with natural gas prices. In contrast, green hydrogen production costs are expected to decline by 55 percent over the next decade, becoming cost competitive against grey hydrogen by around 2030.

- Globally, CCUS is emerging as a viable solution, with 40 Mt per annum capture and storage capacity plants operational at a pilot level, even though it is currently not economically viable. Demand for CCUS is growing globally—with an announced capacity of 90 Mt per annum (two-and-a-half times the current installed capacity). New projects are extending CCUS into other industries, like chemicals, cement, steel, and power. In addition, storage in subsurface hubs is being explored.  From 2014–2020, more than ten capture technologies have matured to a Technology Readiness Level (TRL) of more than seven, which is typically required for concept deployment. Numerous CCUS solutions based on wide-ranging technologies are also rapidly being tried, and multiple vendors have recently focused on modularisation and containerisation of CCUS technology and business models, e.g., CCUS-as-a-service, which accelerates adoption and hence hastens learning.

## 1.3 Aspirations

- By 2070, green hydrogen could account for 15–20 percent of India's primary energy mix, helping to abate 12–18 Gt$CO_2$e of cumulative emissions. Local production of green hydrogen also offers India a path to energy independence, reducing the need for crude oil, gas, ammonia, and urea imports. The LoS scenario assumes that the technology costs for electrolysers and green power costs will as expected and current policies continue. The Accelerated scenario assumes a somewhat faster decline in green hydrogen production costs ($1.8/kg by 2030 versus $2/kg in LoS) with a $50 carbon price and blending mandates.
- Assessing the CCUS scope, India's residual gross emissions will likely persist at around 1.4 Gt$CO_2$e annually till 2050 in the Accelerated-scenario, particularly from the hard-toabate sectors, i.e., agriculture, cement, chemicals, and steel. CCUS can help reduce these emissions by 329 Mt$CO_2$e per annum by 2050 and 403 Mt$CO_2$e per annum by 2070.

# 2. ROADMAP TOWARDS NET-ZERO EMISSIONS

## 2.1 Decarbonisation challenges

### CCUS

India has a CCUS demand of 15-20 Gt CO2e (cumulative) by 2070 which can address the gap of 40-45% in the journey to Net Zero. One of the biggest roadblocks faced by CCUS and green hydrogen relates to their investment requirements. Some roadblocks that CCUS faces are as follows:

- **Large capacity building:** In our LoS scenario, since India will likely still emit roughly 1.4 Gt$CO_2$e per annum in 2050, the CCUS capacity needs to increase one-hundredfold by 2050 which would require substantial investment. Carbon pricing is required for creation of substantial CCUS capacity to compensate for high CCUS opex ($49–$55/t$CO_2$).
- **R&D investments:** R&D investments are essential to improve the efficacy and costs of CCUS. Technologies needs to be scaled up to use captured carbon in industries such as cement, chemicals, and synthetic fuels. Investments are also required to identify and develop the storage potential through saline aquifers.
- **Transportation:** Captured carbon can be transported to storage or utilisation sites. However, the transport of captured carbon requires additional stages of compression, especially for longer distances increasing the opex.
- **Limited storage potential:** India has a limited storage potential of 3 Gt$CO_2$e in existing oil fields, which could only address the country's carbon-storage demand until 2045. To tackle the cumulative demand till 2070 of 11–11.5 Gt$CO_2$e, further storage sites would need to be identified and built across the country.
- **Limited utilisation:** Captured carbon can be used in multiple ways. However, the current uses such as fuel (including synfuel), enhanced oil recovery (EOR) biochar and greenhouse fertilisation have limited potential. Moreover, newer uses like construction materials (artificial limestone and carbon-cured cement), chemicals (plastics) are still in the early stages of development.

*One of the biggest roadblocks faced by CCUS and green hydrogen relates to their investment requirements.*

### Green Hydrogen

The Accelerated scenario would likely require \$430 billion in investment for green hydrogen by 2050, roughly of what will be needed in the LoS scenario. However, widespread acceptance of green hydrogen will require resolving the following challenges:

- **High cost of technology:** High cost of electrolysers presents the challenge of large scale manufacturing of green hydrogen. Substantial investments are needed in research and development to bring the cost of electrolysers down.
- **Large investments for consumer industries:** Scaling up of green hydrogen usage by customer industries like steel and power requires large investments to modify the existing processes and build capacity for handling hydrogen. Industries might also bear higher initial operational cost led by increased electricity to substitute for fossil fuels.

## 2.2 Possible emissions reduction trajectory

### CCUS

India's residual gross emissions will likely persist at around 1.4 Gt$CO_2$e annually till 2050 in the Accelerated scenario, particularly from the hard-to-abate sectors, i.e., agriculture, cement, chemicals, oil& gas, and steel. CCUS can help reduce these emissions by 399 Mt$CO_2$e per annum by 2050 and 575 Mt$CO_2$e per annum by 2070 (Exhibit 3). Overall Gap with respect to Net Zero for India in the Aspirational Scenario is 1.6 Gt $CO_2$p.a. by 2070. However, to reach this scenario, technological improvements and significant cost reduction is needed for Direct Air Capture adoption in India. Further, retrofitting young coal plants with CCUS presents a short-term opportunity to capture additional 0.6-0.9 Gt $CO_2$e by 2050. The overall CCUS potential could be 780 million tonnes $CO_2$e p.a. by 2050 and ~1 Gt $CO_2$e p.a. by 2070 as per a CEEW study on the role of CCUS in India.

**Cumulative Demand For CCUS (by 2070) 15-20 Gt $CO_2$e[1]**

Including Point Source Emissions Capture and BECCS

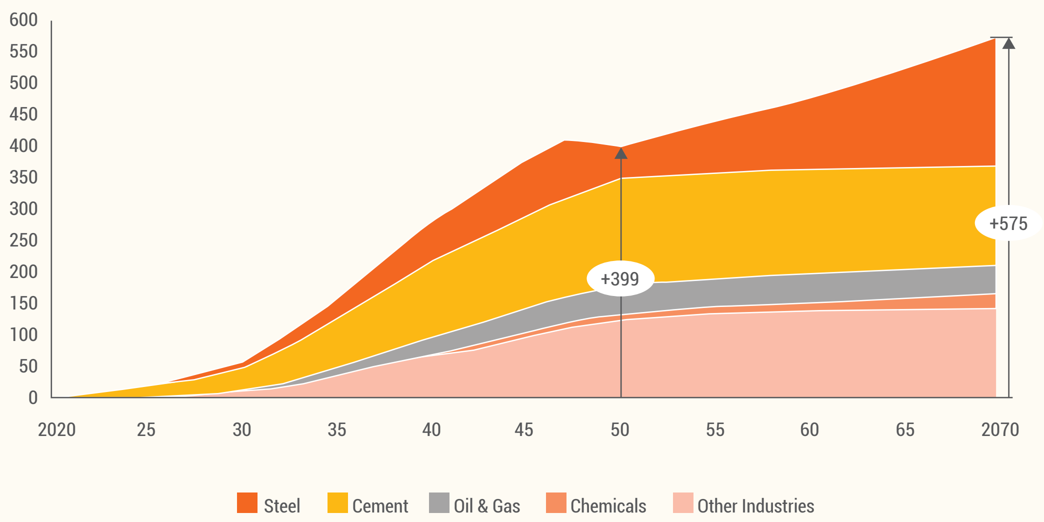


Exhibit 3

### Green Hydrogen

Green hydrogen is another avenue that could prove to be vital for India's energy requirements and help fulfil India's decarbonisation objectives. Creating carbon space in both the LoS and Accelerated scenarios. In the LoS scenario, 12.5 $GtCO_2e$ is abated cumulatively till 2070 (1.9 $GtCO_2e$ by 2050 and an additional 10.6 $GtCO_2e$ by 2070), while in the Accelerated scenario, this increases by 6.3 $GtCO_2e$ (3.8 $GtCO_2e$ by 2050 and an additional 2.5 $GtCO_2e$ by 2070).

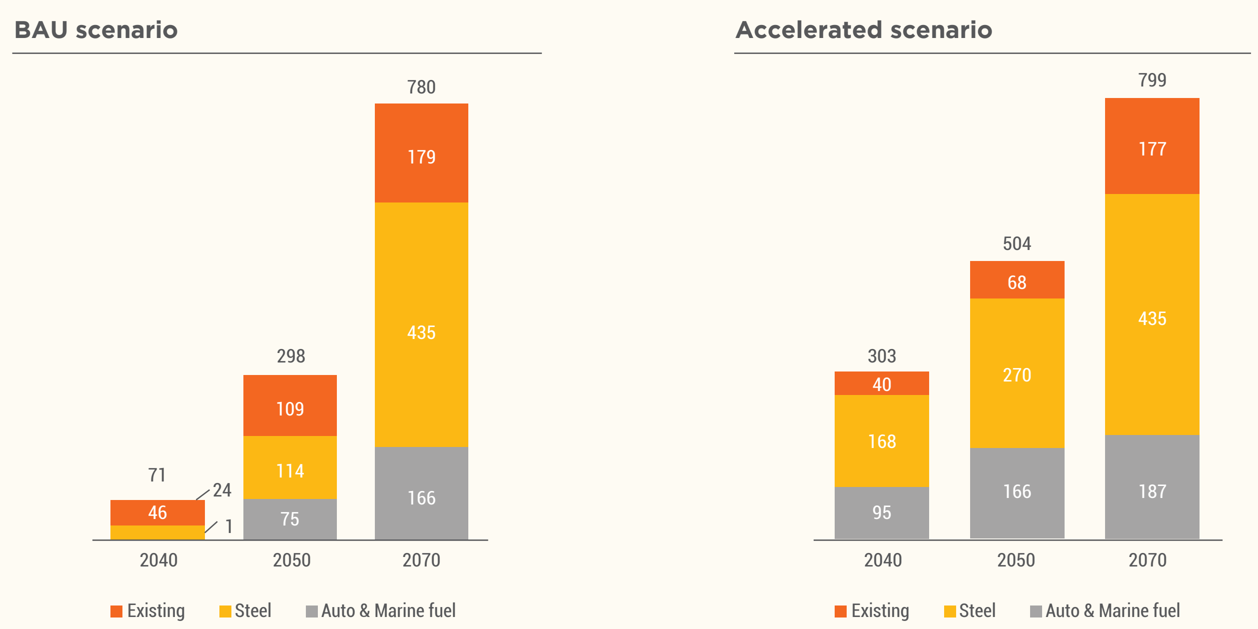


Exhibit 4

## 2.3 Key decarbonisation levers

### Green Hydrogen

- **Electrolyser capex costs** can be reduced by the mass scale-up and automation of electrolyser manufacturing. It can be largely driven by a dedicated ramp-up of local electrolyser production in India. Additionally, with larger electrolyser module sizes, the $/kW could decrease by 60% in LoS scenario and 69% in Accelerated scenario in a period of 10 years.
- **Reducing RE cost:** Another major driver in increasing green hydrogen competitiveness is the foreseeable decrease in renewable electricity cost in the next decade. By decreasing the capex and project finance cost, increasing the efficiency and improvements in Levelised Cost of Electricity (LCOE) can result in a significant decrease.
- **Government incentives:** Policy efforts to improve the cost economics of green hydrogen production through T&D

waivers for renewable energy and issuing capital subsidies for electrolysers along with PLI schemes would accelerate the adoption rate in India. The growth can further be aided by sector-wise mandates for and hydrogen usage and development would also require substantial infrastructure investments to enable distribution.

## CCUS

- **Technological advancements** in carbon capture and utilisation could also significantly reduce costs, e.g., a significant Direct Air Capture (DAC) cost reduction could help capture fugitive emissions and enable India to decarbonise by 2050.
- **Policy interventions** could help increase CCUS investment and adoption in India and potentially reduce costs. For example, a carbon price (likely more than \$75–\$100/t$CO_2$) could spur hard-to-abate industries to decarbonise. A negative emissions market (including voluntary offsets) may incentivise producers to capture biogenic carbon (as is done It can be assumed that in trading schemes in China and Korea). 195 regulatory de-risking could support large-scale $CO_2$ storage throughout the asset life of 50–100 years.
- **Saline aquifers:** Storage potential exploration and assessment of saline aquifers would likely be needed to meet the storage demand.
- **Innovative business models** such as CCUS-as-a-service, cluster integrator (for distributed point source emissions in a hub) and transportation and compression pure play could be potential business models for CCUS in India. Further, carbon removal technologies such as Bio-energy CCS (BECCS) and DAC could also get incremental support for advancement through advance market commitment mechanisms such as Frontier Climate.


# 3. COST OF TRANSITION TO NET-ZERO

# 3.1 Estimated costs to achieve net-zero emissions

## Green Hydrogen

The value chain demands an investment of $232 billion to facilitate LoS scenario driven by set up costs of renewable energy generation systems, electrolyser, and pipeline & storages. On the other hand, an Accelerated scenario requires $432 billion for the same inputs, resulting in a 1.8x of LoS requirements. The investments are front loaded, particularly in the Accelerated scenario, ~30 percent by 2040 and ~60 percent by 2050 vs ~10 percent by 2040 and ~33 percent in the LoS scenario.

## CCUS

Capture makes up the majority of CCUS costs. Capex across capture, transportation and storage adds up to $1130 billion by 2070 for a 300 km network and $1320 billion for a 500 km network (Exhibit 5). Utilisation costs have not been estimated in the analysis.

*The investments are front loaded, particularly in the Accelerated scenario, ~30 percent by 2040 and ~60 percent by 2050 vs ~10 percent by 2040 and ~33 percent in the LoS scenario.*

**Hub Model Costs (300 kms radius)**
US $ Bn

**Hub Model Costs (500 kms radius)**
US $ Bn

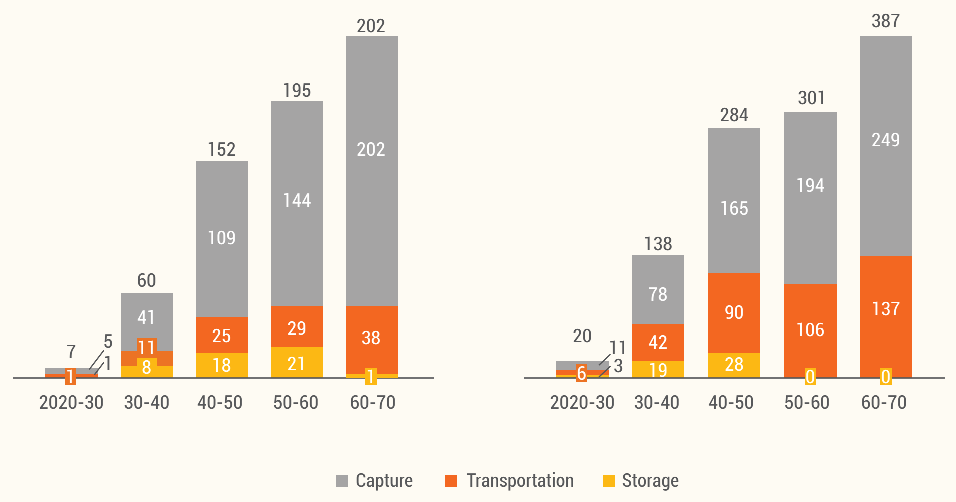


**Exhibit 5**

## 3.2 Potential financing solutions

To accelerate the process of decarbonisation, India could explore three types of carbon pricing mechanisms that have been implemented globally—carbon tax, Emissions Trading Systems (ETS) and Voluntary Carbon Markets (VCMs). The first two are mandatory and enforced using regulatory measures, whereas VCMs are based on internal targets and buyers can buy carbon credits based on voluntary commitments. Carbon tax is comparatively easy to implement but it has limitations—for example, it has a higher impact on low-income households and no market-based adjustments—and many developing countries are now shifting to an exchange-based carbon-pricing mechanism.

### Carbon Markets

In the ETS, the regulator sets a cap of $CO_2$ to be emitted (overall or for a sector). Firms emitting lower emissions can sell the surplus quota in a regulated market to firms that need more allowances than originally received, leading to the formation of a price. It has proven to be the most effective way to reduce GHG emissions. By restricting the supply of allowances, higher carbon prices can prevail, providing critical economic signals for decarbonisation. India has already announced that it will transition its successful PAT scheme into a compliance carbon market. It is also being legislated as a part of the Energy Conservation bill, currently in Parliament. Carbon markets will likely need to be accelerated in India to build India right. For example, in the case of steel, without visibility into carbon pricing in the next two or three years, India will likely build and lock itself into long-lasting high carbon steel-making assets in the decade of the 2030s.

In the short term, India could consider launching a VCM to build awareness, signal future policy intent and build the necessary capabilities and administrative muscle needed for launching and operating ETS. Carbon trading by tapping global VCM markets has already started gaining momentum in India – $300 million or about 60 $MtCO_2e$ worth of carbon credits were exported from India across different VCMs in 2021. Multiple local initiatives are already running to generate value by selling carbon credits (e.g)., the Indian Agricultural Research.

### Indian Financial Institutions

Indian banks could play a pivotal role in shaping India's decarbonisation pathway, too. The banks would need to define net-zero ambition on their loan books and show commitment toward financed emissions and for facilitating the necessary transitions, defining sector-specific glidepaths and building a comprehensive net-zero roadmap.

Furthermore, a holistic sustainable finance strategy can help banks create long-term value by offsetting transition-related risks (such as potential market share loss or increased risk with newer technologies) and tapping into new opportunities for value creation.

## Green Transition Bank

A green transition bank could come into play:

- As an innovative transition structure to mobilise low-carbon investment and support local community development.
- To orchestrate government funds and support financing for early-stage projects before they become viable for other investors.
- As a market maker to channel global green capital into local projects and as a catalyst for securitising green loans (rated and classified into tranches), which could create additional avenues for green-focused investors with different risk profiles.

A green transition bank could help India unlock finance in its goal toward net-zero, as in other parts of the world-Australia, Japan and the United Kingdom have all created nationalised banks to leverage private investments in sustainable technologies.

# 4. INTERDEPENDENCIES, CO-BENEFITS, AND TRADE-OFFS

## 4.1 Interdependencies

The commercial success of green hydrogen and CCUS technology is critical for India's net zero emission goals. Green hydrogen will impact sectors like steel, automotive and power and, CCUS technology will help decarbonise the cement, chemical and power sectors.

### Green Hydrogen

Accelerating hydrogen adoption in industries could help India build the right assets, reduce the risk of being left stranded and create additional carbon space.

In each of these hard-to abate sectors, different dynamics could be at play and economic feasibility of hydrogen will lead to faster adoption in the consuming industries:

- **Steel:** Could be one of the largest consumers of green hydrogen from 2030 onwards in the Accelerated scenario. It is because even a relatively small carbon price makes hydrogen-based steel-making much more competitive relative to the blast furnace-coking coal route.
- **Automotive:** Hydrogen fuel cell based long-haul trucking is expected to become progressively more cost competitive in lifecycle value terms versus the internal combustion engine as well as battery EVs. The sector could be another big consumer of hydrogen post 2030.
- **Power:** Hydrogen is a small part of the storage solution with other options being much more economical.

  Power storage could be the last to adopt green hydrogen since the current alternatives will likely be at a 40–50 percent lower cost. Nevertheless, as India moves to in firm renewable sources, hydrogen would play a key role in grid balancing and energy storage.

### CCUS

Lower carbon intensity of existing fossil fuels is a very pertinent 'here and now' problem for which CCUS is critical. The cost of carbon capture per ton declines with the increase in concentration of carbon in flumes.

- **Gas processing Industries:** Gas processing industries have high concentration of carbon in flumes and hence the cost of extraction declines to $1-20.
- **Power, Steel and Cement:** Industries with low purity carbon emission sources contribute about 40% to emissions, these are power (coal and natural gas), steel and cement. Low purity source increases cost to about $90. Technological advancement in carbon capture is essential to reduce the cost from these industries.

## 4.2 Potential decarbonisation co-benefits

### Green hydrogen

- **Steel:** Replacing crude and coke in steel with green hydrogen has the potential of saving to the tune of of $11 billion in LoS and $26 billion in an Accelerated scenario by by year 2050. The replacement would lead to reduction of 114 MtCO2e p.a. in an LoS scenario and 270 MtCO2e p.a. in an Accelerated scenario.
- Indian steel makers may start investing early in green hydrogen-based steelmaking instead of the conventional blast furnace route to the tune of 200 Mt starting from 2030. It could create additional carbon space of 3.1 Gt$CO_2$e, and result in cumulative Forex savings of $420 billion in oil/gas imports and $280 billion in coking coal imports by 2050.
- **Automobile:** Replacing crude oil-based fuels in mobility by liquid hydrogen will lead to an annual savings to the tune of $11 billion in LoS and $26 billion in an accelerated scenario by year 2050. The replacement would lead to reduction of 72 MtCO2e p.a. in an LoS scenario and 166 MtCO2e p.a. in an Accelerated scenario. Furthermore, electrification of fleet in the Accelerated scenario saves $1.2 trillion till 2050 and $2 trillion till 2070 in Forex for oil.
- **Replacement of Grey hydrogen:** Replacing grey hydrogen in use cases like refining, urea, methanol will lead to annual savings of 20 billion $ in LoS scenario and 12 billion $ annual savings in accelerated scenario by 2050. The replacement would lead to reduction of 109 MtCO2e p.a. in an LoS scenario and 68 MtCO2e p.a. in an Accelerated scenario.

### CCUS

CCUS could capture 329 Mt$CO_2$e per annum by 2050 and 403 Mt$CO_2$e per annum by 2070, particularly from hard-to-abate sectors such as cement, chemicals and oil and gas.

- **Cement:** Adopting new CCUS technologies may be necessary for capturing 65 percent of the remaining emissions and abating 156 Mt$CO_2$e per annum by 2070. Part of the captured carbon could be utilized in the cement industry for carbon cured concrete, artificial limestone, and other applications. However, the technological and economic feasibility of these need to be established first.
- **Enhanced Oil recovery:** Captured carbon may be used for enhanced oil recovery, 0.4 MtCO2e p.a will be consumed for the process until 2050.
- **Chemicals and Plastics:** 0.4 MtCO2e p.a. will be consumed for the manufacture of PE, PP, MeOH based plastics until 2050, lowering the cost of inputs. EOR, EGR use cases are already widespread. Methanol to alcohol to chemicals is another interesting space awaiting development.

## 4.3 Potential decarbonisation trade-offs/co-costs

### Green hydrogen

- **Steel:** A capex of 1300-1400$ per ton would be required by 2040 for green hydrogen-based steelmaking including capex for electrolyser and RES. The average cost of steel production in the Accelerated scenario is estimated to be higher (by 25 percent in 2040) than in the LoS scenario, driven by the carbon price, higher cost of scrap and the need for more electricity to partially offset the lower met coal needs.
- **Cement:** Decarbonisation of the power and steel sectors would reduce the availability of clinker substitutes (fly ash and slag). In the absence of sufficient clinker substitutes like pozzolan and calcined clay, clinker use could grow, increasing the cost of cement by $70/ton to $75/ ton by 2050 (around a 30 percent cost increase) and emissions by 0.55 $tCO_2$/ ton of clinker (a 93 $MtCO_2e$ per annum increase by 2070).
- **Automobile:** To power up the EVs, substantial investment will be needed for the charging infrastructure. The total incremental Capex for green transition is sizeable – $1.9 trillion till 2070 for the LoS scenario; and an extra $1.3 trillion till 2070 for the Accelerated scenario. On the positive side, migration to EVs would have significant savings on opex – with opex totalling $9.0 trillion till 2070 for the LoS scenario ($6.1 trillion without taxes), and additional opex savings of $3.7 trillion in the Accelerated scenario ($2.5 trillion without govt support).

### CCUS

- **Cement:** $387 billion would likely be required by 2070 for the CCUS set up (for capture, transportation, and storage), with cumulative opex costs of $162 billion by 2070. The cost of capturing 1 ton of CO2 with the available technology is $50-90.
- **Power generation Coal:** With the available technology the cost of capturing 1ton of CO2 is $45-80.
- **Power generation Natural gas:** The cost of capturing 1ton of CO2 is $60-120 with the available technology.
- **Iron and steel:** With the available technology the cost of capturing 1 ton of CO2 is $50-85.

# 5. POLICY RECOMMENDATIONS

The following measures could be considered for accelerating the hydrogen and CCUS economy in India:

- **Introducing carbon pricing** through compliance carbon markets in a calibrated but accelerated manner, providing steel makers with the policy-certainty to be able to invest. It will need to be accompanied by appropriate carbon border adjustment mechanisms to ensure the global competitiveness of India's steel and manufacturing industry.
- **Building a local equipment** industry by instituting actions such as PLIs to induce local manufacturing for electrolysers, electrodes, and the balance of plants. For example, a subsidy of $60–80/ KW in electrolyser manufacturing can accelerate green versus grey hydrogen competitiveness by five years. Investing in R&D for developing indigenous, hydrogen-based electrolysers, fuel cells and hydrogen DRI would provide the necessary thrust for domestic production. Further, since Indigenous electrode manufacturing is a primary lever for green hydrogen, PLI schemes must be launched to facilitate import substitution.
- **Initiating bilateral MoUs with importing countries** such as Japan, the UK, and South Korea for green hydrogen-based products. Australia, for example, has agreements with South Korea and Japan to establish an international hydrogen supply chain. India could attempt something like incubate a green hydrogen and hydrogen-based product industry even as local demand develops.
- **Create a blending mandate across ammonia, refinery, and fertiliser,** to kickstart the adoption of green hydrogen (and derivatives) as a replacement for grey hydrogen. Similar steps are being taken globally. For example, in Japan, co-firing of ammonia for power production is under consideration.
- **A market-making mechanism through innovative auctions** such as the Hydrogen Global Initiative in the EU could also be considered (like the tenders that India's Solar Mission launched to spur on demand for renewables).
- **Policy interventions could help increase CCUS investment** and reduce costs. For instance, a carbon price (likely more than $75–$100/t$CO_2$) could spur hard-to-abate industries to decarbonise. A negative emissions market (including voluntary offsets) may incentivise producers to capture biogenic carbon (as is done in trading schemes in China and Korea).

  Regulatory de-risking could support large-scale $CO_2$ storage throughout the asset life of 50–100 years.
- **Coal abatement in easy to abate sectors** (shorter lock-in periods) such as textiles and diesel genset- HIGHLIGHT- why coal usage in diesel
- **Streamline land acquisition and introduce land subsidies** for higher green hydrogen generation to facilitate decarbonation demands of various sectors such as heavy trucking, shipping etc.
- **Set up an effective secondary debt marketing** to circulate cash/debt to enable infrastructure financing.
- **Green hydrogen facilities on lines of CCUS hub** may be explored around clusters of primary industries - viz. steel, cement etc.

***Initiating bilateral MoUs with importing countries such as Japan, the UK, and South Korea for green hydrogen-based products.***


# 6. PROPOSED ACTION

## 6.1 Actions by businesses

- Innovative business models such as CCUS-as-a-service, cluster integrator (for distributed point source emissions in a hub) and transportation and compression pure play could be potential business models for CCUS in India. Further, carbon removal technologies such as Bio-energy CCS (BECCS) and DAC could also get incremental support for advancement through advance market commitment mechanisms such as Frontier Climate.
- Businesses pertaining to heavy duty trucking, shipping and mobility can explore green hydrogen as an alternative avenue to crease a substantial impact on its carbon footprint.
    - Adani Enterprises Ltd. (AEL) said it has signed an agreement with Ashok Leyland, and Ballard Power of Canada to start a pilot project to develop a hydrogen fuel cell electric truck (FCET) for mining logistics and transportation operations.
- Invest in developing technology for end use cases of hydrogen.
    - Tata Hydrogen Combustion Engine (HCE) revealed at Auto Expo 2023. On the first day of the Auto Expo 2023, Tata Motors revealed 3 vehicles to showcase their hydrogen propulsion technology. 2 of them (1 truck, 1 bus) used the hydrogen fuel cell technology while 1 truck had a hydrogen combustion engine (HCE).
- Business must create a structured plan for making a shift to green energy with clear sited goals and roadmaps in defined periods- present plan of action, 5-year plan of action, 10+ year plan of action. These goals must be in line with global and local development of energy usage as well as government efforts in the same direction.
- Businesses must establish sectoral linkages in terms of demand creation from end-sectors.
- Leveraging energy efficiency and digitization could unlock a 15% fall in energy and fuel emissions.
- Pink hydrogen potential can also be assessed to achieve decarbonisation objectives.

## 6.2 Actions by CII

The CII can play a key role in shaping and charting the path of the transition.

- It can create awareness and sensitization across the ecosystem while stimulating green investments. There is a need for more information dispersal in the market to increase sensitization about cost of not transitioning. Example - IPCC has listed out cost of climate related events to spread awareness.
- It can create a forum for key industry players across the value chain to participate in dialogue and align on a plan of action. Cross-sector partnerships could be promoted to take advantage of synergies, and thus maximise the impact of financed emissions reduction.
- CII should facilitate deliberations among industry players for ensuring a just transition like labour force reskilling requirements, shift in jobs from the eastern coal belt to the west etc.
- It can help mobilise industry to contribute to the capacity building of the next generation of green MSMEs, helping supercharge national development and providing fulfilling livelihoods to millions of Indians.

**Confederation of Indian Industry**

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government and civil society, through advisory and consultative processes.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. With its extensive network across the country and the world, CII serves as a reference point for Indian industry and the international business community.

As India strategizes for the next 25 years to India@100, Indian industry must scale the competitiveness ladder to drive growth. CII, with the Theme for 2023-24 as 'Towards a Competitive and Sustainable India@100: Growth, Livelihood, Globalisation, Building Trust' has prioritized 6 action themes that will catalyze the journey of the country towards the vision of India@100.


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## CII-ITC Centre of Excellence for Sustainable Development

CII-ITC Centre of Excellence for Sustainable Development (CESD) is one of CII's 11 Centres of Excellence. The Centre is a not-for-profit, industry-led institution that helps businesses become sustainable organisations. It is on a mission to catalyse innovative ideas and solutions, in India, and globally, to enable business, and its stakeholders, in sustainable value creation. Its knowledge, action and recognition activities enable companies to be future ready, improve footprints profiles, and advocate policymakers and legislators to improve standards of sustainable business through domestic and global policy interventions.

The Centre leverages its role of all-inclusive ecosystem player, partnering industry, government, and civil society. It has been a pioneer of Climate Change, environment management systems, biodiversity mapping, sustainability reporting, integrated reporting, and social & natural capital valuation in India, thus upgrading business in India to sustainable competitiveness. The Centre operates across the country and has also been active in parts of South and South-East Asia, the Middle East, and Africa. It has held institutional partnerships and memberships of the United Nations Global Compact, Global Reporting Initiative, International Integrated Reporting Council, Carbon Disclosure Project, development agencies of Canada, the USA, the UK, and Germany.


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