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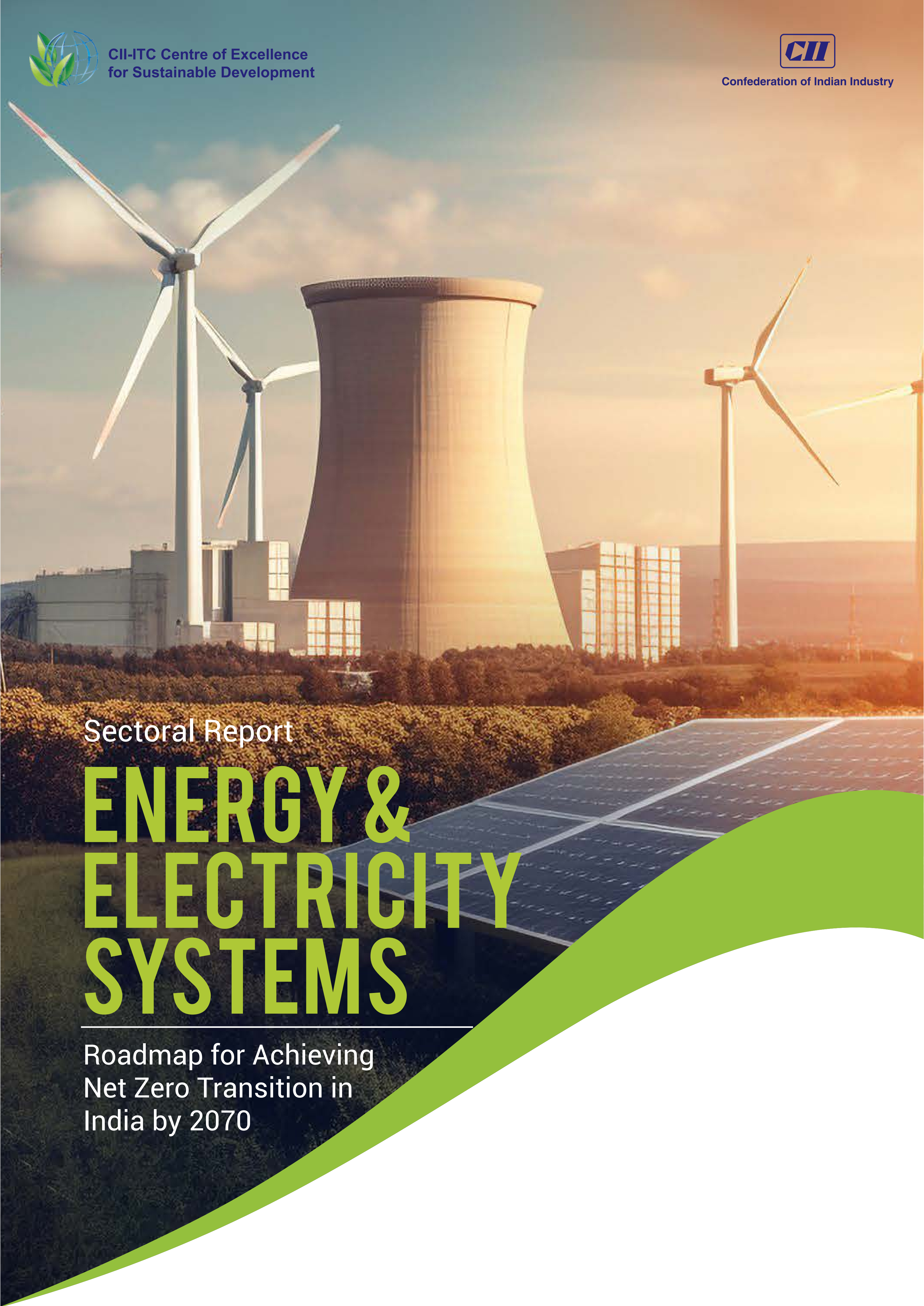

Sectoral Report

# ENERGY & ELECTRICITY SYSTEMS

Roadmap for Achieving
Net Zero Transition in
India by 2070

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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 Energy and Electricity Systems presents a detailed analysis of India's pathways to net-zero emissions within the energy sector. It contrasts the Line-of-sight scenario, based on current policies, and expected technological advancements, with an Accelerated scenario that includes aggressive policy measures and rapid technology adoption. Highlighting challenges such as land availability, grid reliability, and financial health of distribution companies, the report suggests strategies for scaling renewable energy, integrating new technologies, and financing the transition. It emphasizes the importance of policy reforms, increased investment, and collaboration among stakeholders to achieve net-zero emissions 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.**

*India's ambitious targets, aiming to add 40-50 GW of RE capacity annually over the next decade and escalating to 130-140 GW annually from 2040 to 2050, bring forth significant hurdles.*

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.

The transformative role of renewable energy technologies in India's energy transition cannot be overstated. Solar, wind, and hydroelectric power are not merely alternatives to fossil fuels; they are the keystones of a resilient, sustainable energy future that promises economic growth and energy security. This sectoral report on "Energy & Electricity Systems" illustrates the path for integrating these renewable resources into our grid, supported by the necessity of continuous innovation in energy storage and efficiency to make clean energy more accessible and reliable.

The challenges before us are substantial. India's ambitious targets, aiming to add 40-50 GW of RE capacity annually over the next decade and escalating to 130-140 GW annually from 2040 to 2050, bringing forth significant hurdles. These include land acquisition, enhancing grid connectivity, and navigating the complexities of Power Purchase Agreements (PPAs), alongside ensuring grid reliability amidst the rapid growth. Such expansion necessitates a deep dive into the intricacies of integrating a high share of RE into the grid, confronting issues such as solar power curtailment and delays in signing new PPAs.

Addressing these challenges requires innovative solutions and strategic reforms. The establishment of a dedicated agency for RE infrastructure planning, leveraging advanced geospatial analysis for efficient land allocation, is proposed as a pivotal measure. Accelerating the power market and DISCOM reforms to ensure grid integration and financial stability are also essential. This includes deepening power markets through the introduction of risk mitigation tools, ancillary services, and capacity markets, as well as promoting demand-side flexibility. Furthermore, unlocking the potential of Commercial and Industrial (C&I) demand for RE through innovative financing mechanisms and business models is crucial for enhancing the sector's bankability and attracting the low-cost capital necessary for the transition.

This report also advocates for engaging both the public and private sectors to unlock the potential of green bonds, climate funds, and public-private partnerships. These collaborative financial frameworks are integral for catalyzing the energy transition, ensuring that innovative financing mechanisms are in place to support the deployment of renewable energy infrastructure and technologies.

International cooperation and collaboration are paramount in this journey. The report emphasizes the importance of global partnerships in technology transfer and joint research and development initiatives, fostering a global marketplace for clean energy. These international collaborations are crucial for accelerating the adoption of green technologies, and propelling India and the world towards cleaner energy choices.

Moreover, the energy transition necessitates a focus on adaptation and resilience. Our energy systems must be prepared to withstand the impacts of climate change, ensuring continuous and reliable energy supply in the face of extreme weather events, and shifting climate patterns. This underscores the need for a robust strategy that not only focuses on mitigation through renewable energy but also emphasizes the importance of adapting our energy infrastructure to be more resilient in the face of climate challenges.

As 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) 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 Carbon Capture, Utilisation and Storage (CCUS).

In the LoS scenario, India has potential to achieve a 90% reduction in economic emission intensity by 2070, while in the Accelerated scenario, India could surpass the target, narrowing the gap further and achieving 98% reduction in economic emission intensity by 2050.

In the LoS scenario, the emission peak is projected to occur by 2030, while in the Accelerated scenario, the peak is anticipated to be reached by 2025. 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). This 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 exact 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).

*India could surpass the target, narrowing the gap further and achieving 98% reduction in economic emission intensity by 2050.*

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

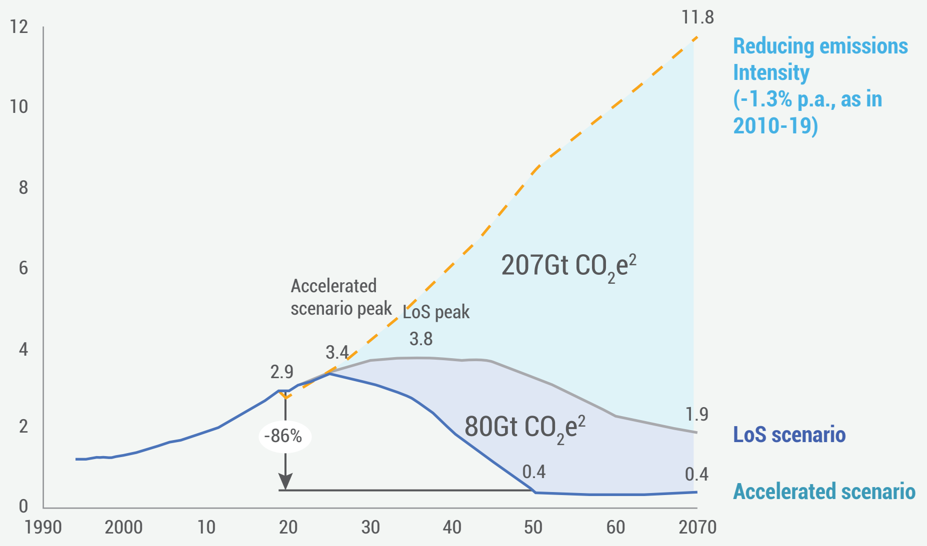


Exhibit 1

## 1.1 Contribution to India's emissions

The power sector contributes about 1100 $MtCO_2e$ or 35% to India's total greenhouse emissions and is the largest contributor by proportion. GHG emissions of the sector have been growing at 2% CAGR (roughly half of the demand growth) over the last decade.

## 1.2 Trends and Trajectories

Trends in demand and supply will determine the emissions profile of the sector going forward.

- **Demand for power** is set to rise further driven by a shift towards electric vehicles, large-scale infrastructural developments, and robust economic growth,These factors will increase per capita consumption from the current relatively low levels of 1,278 kWh, just one-seventh of the Organisation for Economic Co-operation and Development (OECD) average. The overall power demand of the country is expected to surge 8X to 9000 TWh by 2050 and 10X to 12000 TWh by 2070.
- **Supply of power:** Most of the emissions in the sector are from coal-based thermal power plants, which currently meet three-quarters of India's power demand. However, the share of coal generation in the power generation mix peaked in 2015 at 78 percent and has been declining since. This decline is driven primarily by exponential capacity growth in RE and its cost competitiveness. India is a global leader in RE development. India's installed renewable energy stood at capacity is 18484.70 MW (18.5 GW) at the end of March 2024. In 2023, India had fourth largest renewable energy capacity, after China, USA, and Brazil.
- **Tariffs** in the range of INR 2–2.5/ kWh are cheaper than the marginal cost of 60–70 percent of coal power plants. Solar-wind-storage hybrid plants that provide 85 percent round-the-clock power on an annual basis—a common definition of baseload RE in India—have ex-bus bar tariffs between INR 4–5/kWh. These RE-storage hybrids have reached parity with newly built coal plants, and it is expected that they will be cheaper on a marginal cost basis than 30–50 percent of operating coal plants by 2030 and 60–75 percent by 2040.

## 1.3 Aspirations

At COP26, India announced its stake to help slow down global warming with a 2070 Net Zero target. While the aspiration serves as the foundation for the analysis, India's transition can be further hastened towards a 2050 Net Zero target, aligning with global ambitions. The transition, though difficult, is feasible for execution.

# 2. ROADMAP TOWARDS NET ZERO EMISSIONS

## 2.1 Decarbonisation Challenges

Major challenges in the pathway of decarbonising the power sector centre around themes of land availability, limited flexible generation capacity, poor financial health of DISCOMs, policy and heavy reliance on imports for meeting the energy needs.

- **Accelerating India's RE capacity:** India would need to add 40–50 GW of RE annually over the next decade and 130–140 GW annually from 2040 to 2050. Associated challenges involving land acquisition, grid connectivity and counterparty risks (such as problems with PPA adoption, renegotiation, and payment) would also have to be addressed. These issues are expected to multiply as RE scales up. For example, the 2050 solar capacity of 2,000 GW is expected to require 1.3 percent of India's land surface (about a quarter of India's wasteland).
- **Ensuring grid reliability and market reforms:** India has limited flexible generation capacity compared to many other countries. Already, RE integration issues are emerging, leading to solar power curtailment and a slowing down in terms of signing new PPAs. Globally, these issues are evident in geographies like Germany and California that are facing grid curtailment issues.

  For grid reliability with 90 percent RE, massive reforms are required in the power market. Currently, the wholesale market share is under ten percent; there is no ancillary services market; incentives for peak-load plants are inadequate; and time-of-day tariffs are limited. As most of this RE capacity is likely to be in the south and west, the country will likely need to increase interconnection capacity.

  Finally, RE addition must be complemented by either 60–65 GW of storage (short and long duration) by 2030 and 1,200 GW by 2050 or alternative flexibility mechanisms need to be identified.
- **Ensuring financial viability of the distribution sector:** Most public DISCOMs in India are lossmaking, leading to increased financial stress on power generators and reluctance to promote open access RE for Commercial and Industrial (C&I) customers. The financial health of DISCOMs would need to improve to be able to attract low-cost capital for the transition. Policies such as The Electricity (Late Payment Surcharge and Related Matters) Rules, 2022" (LPS Rules), while needed to improve DISCOM payment cycle and assure generators, should also be augmented with adequate support to ensure that distribution companies are not pushed further into the debt cycle.
- **A holistic strategy:** necessitates collaborative efforts among project developers, off-takers, policymakers, and investors to effectively address challenges in the renewable energy sector. Tackling implementation hurdles, including Power Supply Agreement (PSA) backlog and navigating the viability of tariffs amid rising module prices, requires coordinated action. By fostering synergy among stakeholders, industry can mitigate the risk of project delays and cost overruns, ensuring a more resilient and sustainable trajectory for renewable energy initiatives.

***India would need to add 40–50 GW of RE annually over the next decade and 130–140 GW annually from 2040 to 2050.***

- **Streamlining governance, policy-making, and planning:** Multiple ministries are needed to enable the transition, and may need to be aligned fully with this transition. Furthermore, coordination and policy cohesion between federal and state governments would be needed.
- **Heavy reliance on imports:** India's energy imports total $ 170 Bn (oil, gas, coal, PV modules etc.). In PV modules, India imports 80-90% of its requirement. With increasing installation of renewables, this may scale up multi-fold; in case indigenous manufacturing capability is not augmented at scale. This is especially relevant since India has historically under-invested in R&D and innovation on alternative material science applications for technologies like solar PV and battery.

Apart from this, lack of standardization leading to double counting and sometimes incorrect reporting is another major challenge that needs to be addressed.

## 2.2 Possible emissions reduction trajectory

- **LoS:** It is feasible for India to achieve near net zero emissions by 2070 in an LoS scenario while also honouring the NDC commitment of achieving 50 percent of installed power capacity from non-fossil fuels by 2030. In this scenario, emissions may rise for another decade, as coal generation is expected to increase modestly to provide continuous power and balance the grid till RE-storage hybrid ramps up. Correspondingly, power sector emissions would peak in the early 2030s at 1.3 $GtCO_2e$. Emission intensity would, however, gradually decrease from 0.77 $kgCO_2e$/ kWh in 2020 to 0.52 $kgCO_2e$/kWh by 2030. This transition would be enabled by:
  - ***Coal capacity:*** This is estimated to increase from its current 210 GW to peak at 240 GW by 2030, driven by the completion of major projects currently underway or in the advanced planning stage. The LoS scenario assumes that there would be minimal to nil coal capacity addition after 2030—but also no forced plant retirements, as cheaper coal capacity could be maintained at an average plant load factor (PLF) of 60 percent.
  - ***Solar and wind capacity:*** This is expected to increase from the current 95 GW in 2021 to 300 GW by 2030, with 20–25 GW built annually. This is achievable, considering India has succeeded in adding 10–12 GW per year over the past five years (excluding some periods affected by the COVID-19 pandemic) and is further scaling its renewable capacity.
  - ***Enhanced storage and flexibility:*** About 70-80% Round-the-Clock (RTC) renewables availability is attainable – going beyond is not viable commercially, where total storage could increase from its current operational capacity of 3.3 GW to 30 GW by 2030, reaching 600 GW by 2050. Until the mid-2030s, pumped hydro (6–24 hours of capacity) will be the dominant storage technology as lithium-ion batteries (less than six hours of capacity) continue to be scaled up. Pumped hydro is a mature technology that has a 30-50yr economic life within which no significant reduction of cost is expected. However, viable sites are needed for growth of pumped hydro (via a 2 reservoir or 1 reservoir model).

These existing storage technologies with improvements that could reduce capex and increase efficiency would be sufficient to meet the sector's needs for the next two decades. From 2040 onwards, as the share of RE increases beyond 60 percent, intermittent RE sources may require longer-duration storage technologies, such as hydrogen, for seasonal storage, provided the viability cost is achieved within 20 years.

- ***Nuclear power:*** To maintain grid reliability as coal is phased out, it has been assumed that share of nuclear will increase from its current levels of around 7 GW to at least 15 GW by 2030 and around 20 GW by 2050; and offshore wind will increase to a minimum of 5 GW in 2030, 15 GW in 2040 and 30 GW by 2050. India's huge thorium reserves and long coastline mean that both nuclear and offshore-wind power-generation technologies have great potential to enhance grid reliability. If initial support is provided by the government in the form of feed-in tariffs or viability gap funding, offshore wind and new nuclear technology could become cost competitive and help India decarbonise even sooner.

• **Accelerated scenario:** Given the rapid innovations in RE and acceleration in capital deployment, India has a unique opportunity to achieve near net-zero emissions by 2050. This could be made possible by accelerating interventions to address industry challenges and instituting key market reforms to encourage further investment.

Relative to the LoS scenario, net-zero emissions by 2050 could prevent about 16 $GtCO_2e$ of cumulative emissions by 2070, while only marginally increasing generation costs. In the Accelerated scenario, emissions could peak in the mid-2020s at 1.3 $GtCO_2e$, following the coal-generation trajectory. Emission intensity would rapidly decrease to 0.37 $kgCO_2e/kWh$ by 2030. This would be enabled by:

- ***High-cost coal capacity becoming increasingly uneconomical*** in comparison with the declining costs of solar or wind hybrids. Assuming no new coal plant would not be commissioned beyond current capacity, existing efficient low-cost coal plants may continue to generate power Plant Load Factors (PLFs) of 60–65 percent into the mid-2040s. By 2050, the entire current coal fleet could expect to be retired.

- ***Solar and wind capacity*** increasing to 480 GW by 2030 is 45 percent share of all power generation. This would need an acceleration in the annual build out to 40–50 GW (compared to 10–12 GW per year over the past five years) till 2030. By 2050, India may likely need 2,700 GW of solar and wind, representing a 95 percent share of the generation mix.
- ***Enhanced storage***, about 70-80% Round-the-Clock (RTC) availability of renewables is attainable – going beyond is not commercially viable. Battery storage along with hydro and coal reutilised as flexible generation sources, would be needed to balance the higher RE share. The amount of required storage would be 65 GW by 2030 and 1,200 GW by 2050. Until mid-2030, pumped hydro would be the key storage technology (for short to medium-term storage) supported by lithium-ion batteries to provide baseload power. 40-50GWh is an aspirational target for developing pumped hydro capacity by 2030/35-but from the late 2030s onward, long-duration energy storage technologies (including hydrogen) would be needed as seasonal storage.
- ***Generation from nuclear:*** is assumed to increase to around 25 GW by 2030, remaining at this level until 2050. As with the LoS scenario, the share of offshore wind is assumed to gradually increase to reach 30 GW by 2050.

## 2.3 Key decarbonisation levers

- **Reducing land and grid bottlenecks for RE projects:** A central RE infrastructure planning and project monitoring agency could be responsible for resolving the supply-side bottlenecks for RE projects. The agency could identify land pockets (especially wastelands) through geospatial analysis and satellite imaging; maintain a databank on available land with resource potential (which could also lower financing cost and promote insurance products); coordinate with bodies, such as the National Land Monetisation Corporation, the Department of Land Resources and state governments, to either aggregate land in a solar-park model or facilitate acquisition by private players. It would also coordinate with transmission companies to inform their capacity planning. Transmission capacity buildout should be one of the major priorities to ensure sufficient evacuation of power from large RE projects.
- **Accelerating power market reforms and DISCOM reforms to integrate RE and de-risk the sector:** Such reforms would include deepening power markets with the introduction of derivatives and futures for risk mitigation, launching ancillary services and capacity markets, leveraging demand side flexibility by speeding the adoption of consumer time-of-day tariffs and EV charging. It would also include creating supply-side flexibility by enabling existing coal and hydro plants to blend RE into existing PPAs, and incentivising underutilised plants to participate in the capacity market. Market reform could save $150 billion to $200 billion in investments through 2050, which have been built into our investment estimates.

On the DISCOM side, India has already undertaken multiple efforts to reform the power-distribution sector. It can ensure strict monitoring and adherence to the recent revamped distribution sector scheme reforms, make lending to DISCOMs more stringent (including from private banks and financial institutions), strengthen the performance of regulators (for example, by ensuring timely and adequate tariffs) and encourage DISCOMs to create a roadmap for business transformation amenable to improving last mile delivery (quality/ reliability), customer service and competition.

- **Unlock C&I demand:** India could unlock latent C&I demand by removing barriers to open access (for example, through banking, net metering, inter-state open access and extension of the Interstate Transmission System {ISTS} charges waiver); promoting innovative contracting mechanisms (like virtual PPAs) to enable RE procurement for smaller C&I customers (less than 100kW); reducing the financial impact on DISCOMs; improving the bankability of RE projects; improving rooftop solar with grid integration for small to mid  C&I customers, and encouraging DISCOMs to launch green tariffs. Additionally, inter-country transmission networks could be developed in South Asia, Southeast Asia, and eventually the Middle East to enhance the grid's connectivity.
- **Localising manufacturing and key technologies** could be leveraged to further enable the transition by:
  - ***Incentivising end-to-end manufacturing*** for PV modules, storage, electrolysers.
  - ***Acquiring or developing upstream assets*** (such as lithium mines or polysilicon processing plants) to secure critical supply chains.
  - ***Creating green innovation clusters*** consisting of academia, start-ups, incubators/ investors, and industry players to lead R&D, prototyping and the scale-up of future energy technologies (e.g., off-river pumped storage, fuel cells, novel chemistries for storage, perovskite solar cells, thorium based nuclear, electrolysers) enabled by higher R&D spend by the government and industry.
  - ***Leveraging data stack***, democratising data access and incentivising tech players to build AI/ ML solutions across the value chain (e.g., weather and generation forecasting, integrated resource planning and prescriptive models, predictive maintenance).
  - ***Training and reskilling*** power-sector employees for RE.
  - ***Enabling a circular economy*** by recycling and promoting second-life usage of batteries and PV modules for sustainability.

Net zero in power is achievable if India acts fast. With policymakers, industry and companies facilitating RE integration into the grid (by building a flexible, robust grid and ensuring that conventional and storage technologies operate together), India could become a global energy-transition leader and an exporter of green technologies. Favourable RE economics can play a supportive role in this transition, attracting investments from the growing global pool of sustainability themed capital. Decarbonising India's power sector would need significant investments, but can bring with it considerable opportunities, including that of global green energy leadership.

# 3. COST OF TRANSITION TO NET-ZERO

## 3.1 Estimated costs to achieve net-zero emissions

- **LoS:** An investment of $2.5 trillion all the way through to 2050 would be required for the LoS scenario to build RE, storage and distribution capacity (Exhibit 2). And represents an annual investment between $40 and $45 billion until to 2030, rising thereafter to between $70 and $80 billion per annum. It is realistic but challenging, considering that in 2021 India's RE sector attracted $12–$15 billion in investment. In addition, expanding and upgrading the Transmission and Distribution (T&D) infrastructure would need another $1.2 trillion.

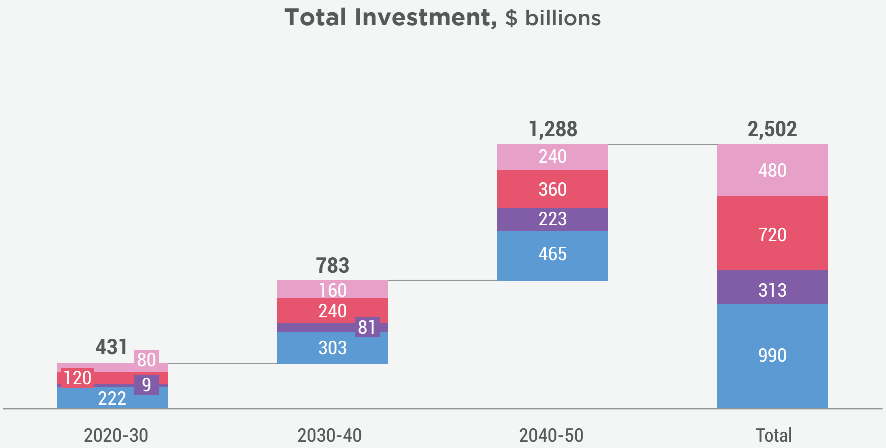


Exhibit 2

- **Accelerated scenario:** An additional cumulative capex investment of $750 billion would be needed for RE and storage capacity amounting to $2 trillion (Exhibit 3), and $550 billion for the transmission and distribution infrastructure through 2050 vis-à-vis the LoS scenario. The investments in RE and storage factor as well as reasonable improvements in the cost and efficiency is expected over the next few years.

Storage considers multiple technologies – lithium-ion, pumped hydro storage, other long duration energy storage technologies and hydrogen – based on the duration needed for storage. Investments in T&D infrastructure have been estimated based on their correlation with capacity additions and peak demand growth. These numbers have also been triangulated with forecasts by other agencies.

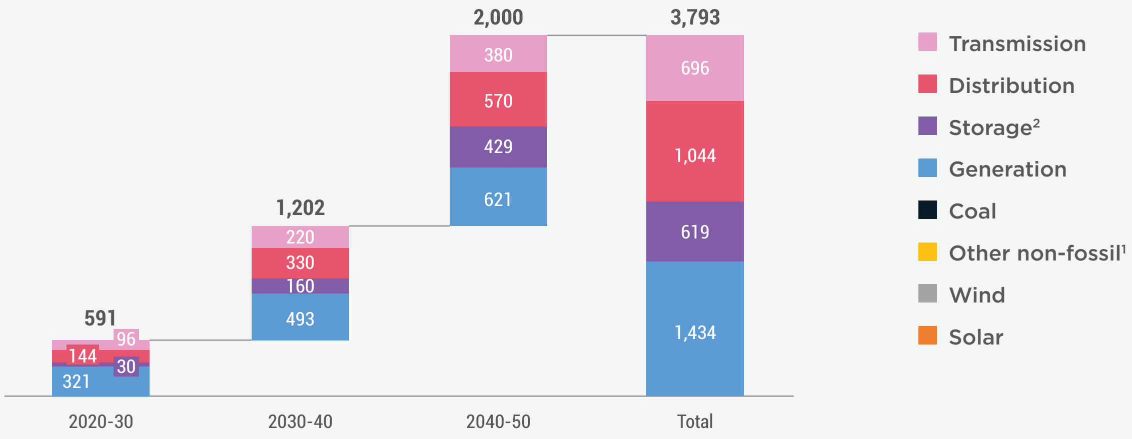


Exhibit 3

## Generation Cost

In both scenarios, the shift from thermal power to renewables is expected to decrease the average cost of generation, given the decreasing cost of RE and storage technologies. Even though a huge sum of investment is required for transition, most of the investment would be NPV, reducing India's power generation costs from the current INR 4/kWh to INR 2.5–3/kWh by 2050 (without considering transmission and distribution costs). When T&D costs are added to the generation cost to get the total system cost, the overall power costs will still decline, but not as steeply as the power generation cost
by itself.

## Imported equipment

India currently imports 80–90 percent of its solar modules, leading to an annual import bill of $5 billion to $10 billion (in 2021). It could increase to $50 billion by 2030 and $300 billion by 2050 in the LoS scenario and increase to $120 billion by 2030 and $450 billion by 2050 in the Accelerated scenario. There is an ongoing race for raw materials for solar PV and storage (e.g., cobalt, rare earth metals). India has historically under-invested in R&D and innovation on alternative material science applications for technologies like solar PV and battery. To secure the future energy mix and make India a global green-energy hub, it will be vital to localise manufacturing

## 3.2 Potential financing solutions

### Carbon Credit Markets

To accelerate the process of decarbonisation, India could explore three types of carbon pricing mechanisms that have been implemented globally

- **Carbon price/ tax**
- **Emissions Trading Systems (ETS)**
- **Voluntary Carbon Markets (VCMs).**

The first two are mandatory and enforced using regulatory measures, whereas VCMs are based on internal targets and buyers can purchase carbon credits based on voluntary commitments.

A carbon tax is a straightforward easy-to-implement solution. 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 their surplus quota in a regulated market to firms that need more allowances than originally received, leading to the formation of a price. ETS's may be very effective provided emission allowances are carefully decided and auctioned from the start. By carefully designing and restricting the supply of allowances, higher carbon prices can prevail, providing critical economic signals for decarbonisation.

There are several arguments for and against the above two policy mechanisms with respect to implementation and in theory, it has the exact same impact. The effectiveness of a carbon tax or ETS depends on the political-economy context in which it is implemented, the ambition and stringency of the price or quantity of emissions cap it sets, and the elasticity of the sectors within the country to move towards low-carbon alternatives.

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 the country right. For example, in the case of steel, without visibility of carbon pricing in the next two or three years, India will likely build and lock itself into long-lasting high carbon-intensive 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 being implemented 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 towards 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.

Additionally, diversifying and expanding the channels through which funds flow from developed nations to developing ones is crucial for fostering sustainable development. One approach involves fostering partnerships between public and private sectors, creating a conducive environment for Foreign Direct Investment (FDI), and promoting international cooperation through platforms such as aid programs, multinational development banks, and strategic alliances. Additionally, the development of innovative financial instruments, such as impact investing and blended finance, can further mobilize capital towards projects that yield both social and financial returns.

> ***India – \$300 million or about 60 $MtCO_2e$ worth of carbon credits were exported from India across different VCMs in 2021.***

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

## 4.1 How does the sectoral net-zero trajectory depend on trajectories of other sectors?

Decarbonisation of the automotive and steel sectors is deeply intertwined with the decarbonisation of the power sector.

- **The electricity grid needs to decarbonise** so that EVs are charged with renewable power instead of power produced using fossil fuels. As much as 50-60% additional potential of scope 2 emissions reduction from EVs lies in the use of green electricity.
- **Green electricity and green hydrogen will eliminate the dependence of steel industry on fossil fuels.** It would not only decarbonize the sector but also lead to forex savings in fuel imports.

Decarbonizing trends in the customer industries of power sector will drive transformation in the power industry. These trends are:

- **C&I open access segment:** The transformation of power sector will be led by the energy demand growth of customers. The Industrial segment is likely to account for ~60% of energy growth, commercial ~30% and data centers ~10%. High growth rates will be led by the ask of investors, regulators and "Net-Zero" commitments by leading corporates. The C&I open access segment in India is growing at ~18% CAGR with majority of demand concentrated across the top 8 sectors (top 8 industries account of 55-60% of energy demand).

  These 8 industries which include auto, cement, consumer, data center, metals, mining, pharma, textiles, and chemicals are most favorable given the:

  - Trend of increased electrification and RE adoption
  - Electricity demand
  - Electricity cost as a % of total Cost of Goods Sold (COGS)
  - Green targets
  - Liquidity and creditworthiness of individual players

- **Adoption of Green hydrogen by different sectors:** Green hydrogen production costs are expected to decline by 55 percent over the next decade, becoming cost competitive against grey hydrogen by around 2030.

  With reduction in green hydrogen prices, existing use-cases – refinery, ammonia, methanol, natural gas blending – for green hydrogen will be in-the-money by around 2030 in both scenarios. With a carbon price of $50 per tonne, new use-cases in long haul trucking and steel making are also expected to be in-the-money by 2030.

> ***Green hydrogen production costs are expected to decline by 55 percent over the next decade, becoming cost competitive against grey hydrogen by around 2030.***

Green hydrogen usage in power storage is expected to be the last to become cost competitive. However, for a products like urea, green hydrogen is not the only answer – an amenable CO2 source should also be developed.

In each of these new adaptors, different dynamics could be at play:

- ***Steel***: The sector could be one of the largest consumers of green hydrogen from 2030 onwards in the Accelerated scenario. This 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. It could be another big consumer of hydrogen post 2030.
- ***Power Storage:*** 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. However, cost of hydrogen as a storage medium is still high and might not be viable for the next 20 years. Nevertheless, as India moves to in firm renewable sources, hydrogen would play a key role in grid balancing and energy storage.

- Substantial demand projected to be unlocked via Inflation Reduction Act (IRA). Most of the demand would be domestic with some global implications.

## 4.2 Potential decarbonisation co-benefits

- **Steel:** Replacing crude and coke in steel with green hydrogen has the potential of savings to the tune of $11 billion in LoS and $26 billion by year 2050 in an Accelerated scenario. 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 $GtCO_2e$, 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 annual savings to the tune of $11 billion in LoS and $26 billion by year 2050 in an Accelerated scenario. 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 by 2050 in LoS scenario and $12 billion annual savings in accelerated scenario. The replacement would lead to reduction of 109 MtCO2e p.a. in an LoS scenario and 68 MtCO2e p.a. in an Accelerated scenario.

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

### Co-efforts

- **Alternatives for the transition phase:** Sustained short-term investment in fossil fuels like natural gas needs to be maintained by industry players. However, gas will be an option only in the transition phase.
- Biofuels might also be a viable intermediate green alternative in the bridge to 2050.
- **Current investment for green hydrogen:** Currently, the proposed investment of $2.1-2.2billion is highly insufficient and needs to be substantially increased to boost the sector in comparison, in US, the outlay is much higher.
- Subsidies will play an important role to increase acceptance of green hydrogen, however, the current market outlook does not foresee any other economy being ready to pay a $3/kg subsidy.
- **Proposed investment required for green hydrogen:** The Accelerated scenario would likely require $430 billion in investment for green hydrogen by 2050, roughly twice of what will be needed in the LoS scenario. It would be split across solar power and electrolyser capacity and midstream for setting up new pipelines and retrofitting existing natural-gas pipelines for hydrogen distribution.

### Co-costs

- **Steel:** The capital outlay, on an end-to end basis, would likely increase, even though the steel-making process becomes less capital intensive. This is because of the extra capex needed for hydrogen and renewable power.

  The capex is front loaded in the Accelerated scenario with a much higher capex than in the LoS scenario in the 2030-2040 period but is subsequently less than the LoS scenario in the 2040–2070 period. 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. It will likely be passed on to consumers, with a small inflationary effect on the downstream sectors.
- **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 this 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).

# 5. POLICY RECOMMENDATIONS

- **Setting up decarbonisation targets and debottlenecking:** Strong policy backing including the waiver of net metering, inter-state open access and extension of the Interstate Transmission System {ISTS} charges waiver and setting up ambitious decarbonisation targets.
- **Authority to define land use plan:** Policy for empowering a nodal authority to define a national land use plan, lay clear land-use guidelines and mandates for optimised use for renewables and other use cases.
- **Implementing a carbon tax/ market-based solution:** It would be good for India to both deliberate on a carbon tax (as a means to compensate for the loss in future fuel tax revenues as the economy decarbonizes) and an emissions-intensity based National Carbon Market simultaneously.

  Policy makers could take a strategic (as opposed to a compliance-oriented) view and work across ministries to accelerate implementation of a compliance carbon market (within three years) and development of NCS that can generate carbon credits. It would also require the creation of demand signals to accelerate decarbonisation, especially in the hard-to-abate sectors, and incentivise investments in the newer technologies like CCUS. Getting this right, fast, can enable both domestic and foreign investment.
- **Enabling banks to support the transition:** The regulator could assist with the necessary taxonomy, disclosure guidelines, actions to reduce risks to enable setting up of green transition banks. Policies can also direct banks to come up with their investment glide paths within a year or two and build the necessary capability for assessing risks in these new spaces.

# 6. PROPOSED ACTION

## 6.1 Actions by Businesses

- To enable transition to green hydrogen, business should invest in building a robust supply stream. Business should invest across solar power and electrolyser capacity and midstream for setting up new pipelines and retrofitting existing natural-gas pipelines for hydrogen distribution. For example:
  - As part of its goal to become carbon neutral by 2035, Reliance Industries has big plans for renewable energy, including spending $10 billion (Rs 81,000 crore) over the next three years. Part of this plan is to manufacture a low-cost and efficient modular electrolyser that will be used for the captive production of green hydrogen for domestic use and global sale. The factory will be set up as part of an $8 billion initiative to build four giga factories in new energy materials.
  - Adani Enterprises, through its subsidiary Adani New Energy Ltd. plans to invest $50 billion, or Rs 4.15 lakh crore, by 2030 into the green hydrogen ecosystem. Like Reliance, Adani Enterprises will set up integrated renewable energy and H2 electrolyser projects.
- **Steel makers** could invest in transitioning to green steel with enhanced use of renewable power in the manufacturing process and investing in the infrastructure to utilise green hydrogen as a substitute for fossil fuels. For example:

- The Kalyani Group became the first company to manufacture green steel in India. It aims to manufacture 250,000 tonnes of 'green steel' from its electric arc furnace plant in Pune operated by Saarloha Advanced Materials. The line of steel products has been manufactured fully with renewable energy and uses 70% scrap material.

- **Automobile manufacturers** could invest in fuel cell and battery technology. Investment in charging infrastructure is very critical to enable transition of the towards net zero.
  - Maruti Suzuki, India's largest automaker has stated that it will dedicate 2 trillion yen ($15.46 billion) for electrification and autonomous driving technologies. It will allocate another 2.5 trillion yen ($20.33 billion) to build battery electric vehicle plant and for renewable energy facilities.
  - Tata Power has also kicked off an ambitious nationwide plan of setting up approximately 25,000 electric vehicle (EV) charging points across the country to support faster adoption of e-mobility over the next five years.
  - Hyundai has already committed an investment of Rs 4,000 crore to come out with half a dozen model portfolios by 2028.
  - EV manufacturer Ather Energy announced that it is working towards installing 2500+ charging stations by end of 2023.

## 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 labor 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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