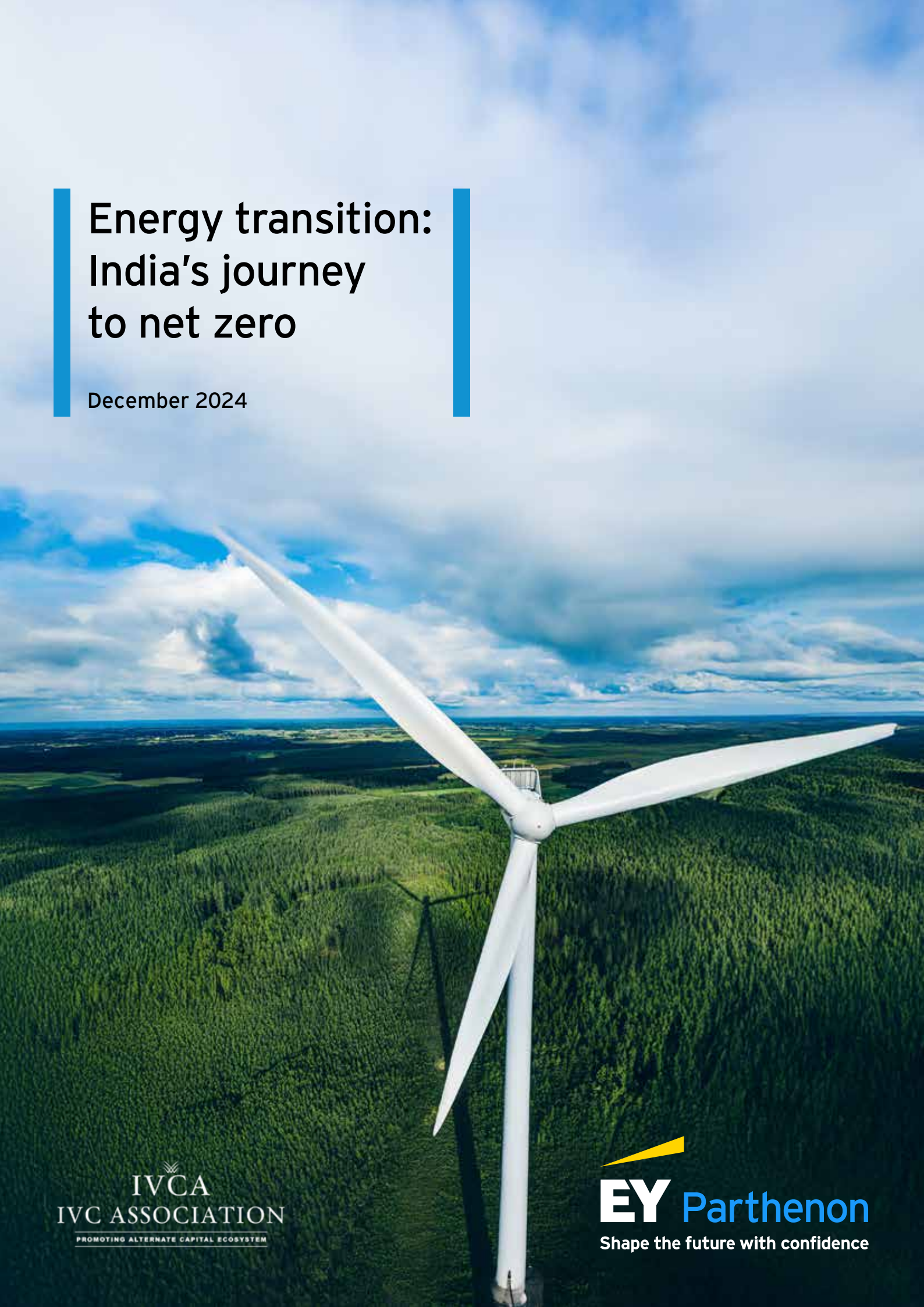
Energy transition: India's journey to net zero

December 2024



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Contents

Foreword

India's journey towards a sustainable future is encapsulated in its ambitious goal of achieving net zero emissions by 2070. This whitepaper sets the stage for an in-depth exploration of India's energy transition, a pivotal movement that addresses not only the nation's burgeoning energy demand but also its commitment to global climate responsibilities.

With a rapidly growing economy and the world's most populous country, the demand for energy is soaring. Yet, the country stands at a crossroads, where traditional sources of energy are being re-evaluated in the face of environmental imperatives. India's response to this challenge is a testament to its resilience and innovative spirit.

India's multi-faceted approach to achieving the net zero target includes policy reforms, technological advancements, and societal participation. India's decarbonization roadmap is not just a blueprint for energy reform; it is a vision for a cleaner, greener, and more self-reliant India. The country's strides in renewable energy deployment, especially in solar and wind energy, are commendable and reflect a clear direction towards reducing its carbon footprint. Energy security remains a cornerstone of India's strategy, ensuring that the shift to greener solutions does not compromise the availability, reliability, and affordability of energy. The integration of new energy solutions, such as advance chemical cells, smart grids, and bioenergy, is pivotal to this transition. These technologies promise to transform the energy sector, making it more sustainable and efficient.

Financing these solutions, however, poses a significant challenge. It requires innovative financial instruments and substantial investments from both domestic and international stakeholders. India's approach to this challenge is holistic, seeking partnerships and collaborations that align with its sustainable development goals. The country's policy framework is increasingly conducive to smoother energy transition.

At EY, we are committed to enabling the nation and our clients execute a transition towards a greener and cleaner future through our value- led services.

EY is delighted to collaborate with The Financial Times under the aegis of Energy Transition Summit platform in the pursuit of creating a cleaner and more sustainable world.

This thought leadership invites readers to engage with India's story of transformation—a narrative that is as inspiring as it is essential. It tells the story of a nation that is not just growing but evolving, not just advancing, but leading the way in the global quest for a sustainable energy future.

Rajiv Memani
Chairman and CEO – EY India

Executive summary

Energy transition is imperative for the economic prosperity of India

As a country vulnerable to climate change, India must ensure that the impact on natural habitats, agriculture and bio-resources is limited, especially considering the population's high dependence on agriculture. Energy transition alsWo represents an opportunity to drive economic growth.

India is on track to meet its 2030 goals

India has set ambitious targets under its 'Panchamrit' framework as part of its Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change (UNFCCC). The country has made significant progress in recent years.

Renewable energy (RE) power generation installed capacity has grown fivefold over the past decade, from nearly 24 gigawatts (GW) in FY 2014-15 to 136 GW in FY 2024-25. Overall, non-fossil fuel-based generation capacity has increased from 78 GW in the FY 2014-15 (representing 29% of India's generation capacity) to 199 GW in the fiscal year FY 2023-24 (representing 45% of India's installed power generation capacity. There is confidence that the NDC target of achieving a 50% share of non-fossil fuel-based capacity will be met by 2030.

India has also set a target of 500 GW of non-fossil fuel-based power generation capacity by 2030. Currently, the country has about 135 GW of generation capacity, either under construction or development. Given the current pace, it is likely that this target will be achieved.

Another important NDC target is to reduce the emissions intensity of the economy by 45% compared to 2005 levels. Based on the real growth of the economy and estimates of emissions published by third parties, emissions intensity has reduced by 40%. This provides confidence that India will achieve the emission intensity target of 45% by 2030. The target of net zero by 2070 will require a multi-stakeholder and multi-pronged approach to energy transition.

Beyond 2030

Energy transition and decarbonization are complex, and there is no single path to achieve them. While a more detailed pathway will emerge overtime, current policies, initiatives and proposals are centered on the development of the following building blocks:

- Demand creation for energy transition through the facilitation of sourcing competitive green power, mandating industries and DISCOMs through renewable purchase obligations, blending of biofuels, and the introduction of market-based instruments like emissions trading system, etc.
- Policy and fiscal support for new technologies such as green hydrogen, offshore power, battery storage, etc.
- Production-linked incentives for the development of a domestic supply chain through financial incentives to ensure competitive supply of energy, economic resilience and energy independence.
- Focus on base load power, currently through an increased share of nuclear energy capacity.
- Policy support to facilitate flow of capital for energy through the introduction of green bonds, green deposits, proposal on green taxonomy, etc.

Continuing focus on renewable energy

The deployment of renewable energy has been a big success story for India in energy transition. All utilities and open access consumers were obligated to procure a certain portion of their consumption from renewable energy in a gradual manner. From the initial 2% to 5% of renewable energy, the obligation now is to meet nearly 30% from renewable energy sources. Several policy measures over the years have helped the renewable energy sector; notable examples include required changes in the Energy Act, notifying green open access rules, definition of captive and group captive power plants, and lowering the requirements for consumer to qualify for open access waiver of inter-state transmission charges for green power. These measures have as encouraged competitive tariffs, higher investor interest and customers demand, resulting in the creation of renewable energy capacity that will continue to grow well beyond existing commitments.

Role of nuclear energy

India is pursuing nuclear energy to access decarbonized base load power, aiming to triple the existing capacity of 22,480 Megawatt (MW) by 2031-32. In the recent budget presented by the Finance Minister of India, it was particularly emphasized that "nuclear energy is expected to form a significant part of the energy mix for Viksit Bharat."

India's nuclear energy sector is state controlled. The government-owned Nuclear Power Corporation of India Limited (NPCIL) is solely responsible for designing, constructing, commissioning, and operating nuclear power reactors in India. While foreign investment in atomic energy is prohibited, there are no restrictions on foreign investment for manufacturing equipment and providing supplies for nuclear power plants and related facilities.

Continuing role of coal-based generation

Coal's role in India's energy mix remains substantial, contributing 59% to the primary energy supply in 2023 even as the country aggressively expands its renewable energy sources. Given the sharp rise in energy demand, India's reliance on coal is likely to persist at least the next few years, underpinning the country's strategy to support future energy requirements. To support this demand, India has established coal production goals, targeting 1.31 billion tons of coal by FY25 , with an ambition to scale up production to 1.5 billion tons by 2030. Coal also has other economic linkages, as coal mining employs 4.43 lakh people, and accounts for approximately 50% of the rail freight volumes, which attract higher tariffs compared to passenger tariffs and contribute INR70,000 crore (US$8.5 billion) through royalties, GST and other levies.

Decarbonizing the transport sector

The transport sector in India contributes 18% of the total GHG emission, with the road transportation segment alone accounting for 87% of the emissions. More than 45% of emissions from road transport in India come from trucks, translating into 94 million tons of oil equivalent energy. If the current consumption trend continues, India will need approximately 200 million tons of oil equivalent energy supply annually by 2030 to meet transportation demands. The energy transition in the transportation sector is currently being undertaken through a combination of:

- Blending biofuels with petroleum products
- Promoting electric vehicles (EVs)
- Electrification of the Indian Railways, progressively replacing diesel traction with electric traction

Growing role of biofuels

In addition to renewable energy, significant progress has been made in bio-ethanol. The use of bio-fuels reduces dependence on imports while driving economic activity, including linkages with the agricultural sector.

The National Policy on Biofuels, notified by the Government of India in 2018, mandates oil marketing companies to blend 20% ethanol, procured using agricultural inputs in petrol by 2030. To ensure effective implementation, the government notifies the price at which ethanol would be procured by the oil marketing companies and facilitates financial incentives towards setting up of ethanol manufacturing capacity in India. Similarly, the Ministry of Power mandates 5% biomass co-firing in Thermal Power Plants (TPPs) from FY 2024-25.

Building on the success, it is proposed that compressed bio-gas (CBG) be blended with compressed natural gas used for transportation and piped natural gas used for domestic purposes. While CBG blending obligations will remain voluntary until FY 2025, they may become mandatory thereafter. Similar proposals are under consideration for aviation fuel. A recent government release on Compressed Biogas Blending Obligation (CBO), government has also approved initial indicative blending percentage target of 1% for sustainable aviation fuel for international flights in 2027.

Growing EV ecosystem in India

India is undergoing a transformative move towards sustainable transportation. With the government's continued focus on bolstering the EV ecosystem, the adoption of EVs in India is strengthening daily, evident from robust growth in EV sales across all segments in recent years.

The government has implemented a series of measures to promote EV in India through demand side incentives, supply side incentives for both EVs and Advance Chemistry Cell (ACC) batteries, funding of charging stations and lower indirect tax on the manufacture and sale of vehicles.

In addition, various state governments incentivize the usage and production of EVs through financial incentives, lower or nil road taxes and subsidies for setting up charging stations. There is also strong investment interest in the sector, with leading players including both start-ups (in two wheelers) and traditional automotive players. The further uptake of e-vehicles will depend on how battery manufacturing is indigenized, the establishment of more charging stations, and innovation that makes products more competitive and attractive to Indian consumers.

Electrification of Indian Railways

The Indian Railways' 'Mission 100% Electrification' plan aims to achieve net zero by 2030. A number of initiatives has been taken by Indian Railways to reduce its carbon emissions, including the use of energy-efficient technologies like completely switching to production of three-phase electric locomotives with regenerative features, use of head-on generation technology, use of LED lights in buildings and coaches, star rated appliances and afforestation. It is estimated that the Indian Railways plan to save INR14,500 crore (US$1,725 million) per year with 100% electrification.

Promoting green hydrogen, battery storage and offshore wind

Given the abundant sunshine in India, green hydrogen is seen as a competitive energy source that can help decarbonize hard-to-abate sectors. The government launched the National Green Hydrogen Mission with a total outlay of INR19,744 crore (US$2.4 billion) up to 2029-30. In addition, five states have formulated independent green hydrogen policies to accelerate green hydrogen production and attract investments, with other states currently drafting their respective policies.

Beyond the domestic market, exports can also play a crucial role in expanding local production, creating economies of scale and reducing cost of green hydrogen. Recent tenders for green hydrogen supply from Japan and countries in the EU have attracted interest from Indian players. Many leading Indian business houses have announced multi-year multi-billion-dollar investment plans.

The Indian government has begun paving the way for offshore wind and battery storage technologies by offering viability gap funding to support incremental capacity expansion. As clean technologies mature and become financially self-sustaining, the need for government fiscal support diminishes, allowing for a more rapid pace of investment. Reflecting on this optimistic trajectory, the Economic Survey 2023-24 states, "Many technologies essential for achieving global net zero are not yet commercially available, such as hydrogen-fueled production of steel and cement, and steel and aluminum manufacturing with Carbon Capture, Utilization, and Storage (CCUS). There is an imperative to bolster international collaboration in research and development, particularly in areas, such as distributed renewable energy, offshore wind, geothermal, tidal energy, biofuels, compressed biogas, green hydrogen, energy storage, electrolyzers, and nuclear power, including Small Modular Reactors (SMRs)."

Incentivizing adoption of lower-carbon footprint technologies

Growth in renewable energy and biofuels has been driven by mandates and market-based instruments, as discussed earlier, with limited reliance on subsidies. Similarly, the government plans to introduce an emission trading system (ETS) in India. India's Carbon Credits Trading Scheme (CCTS), a proposed domestic emissions trading system, will likely follow a cap-and-trade model. The mandatory market is expected to be supplemented by a voluntary carbon market mechanism, allowing non-obligated entities to register and trade credits. India is also working to ensure that its CCTS aligns with international standards, facilitating participation in global carbon markets.

Another key development is the introduction of the Business Responsibility and Sustainability Reporting (BRSR) mandate by the SEBI, India's securities regulator. BRSR requires the top 1000 listed Indian companies by market capitalization to disclose detailed information on their environmental, social, and governance (ESG) performance. The mandate includes quantifiable metrics on sustainability-related factors, including factors related to energy transition, such as electricity consumption, water usage, air emissions, waste management, biodiversity conservation. By mandating disclosures on ESG performance, SEBI encourages companies to integrate sustainability into their core business strategies.

Indian corporations are also actively participating in the decarbonization journey, with major players like Reliance Industries, Adani Group, and ONGC setting ambitious net zero targets and announcing significant investments in green initiatives.

Financing energy transition

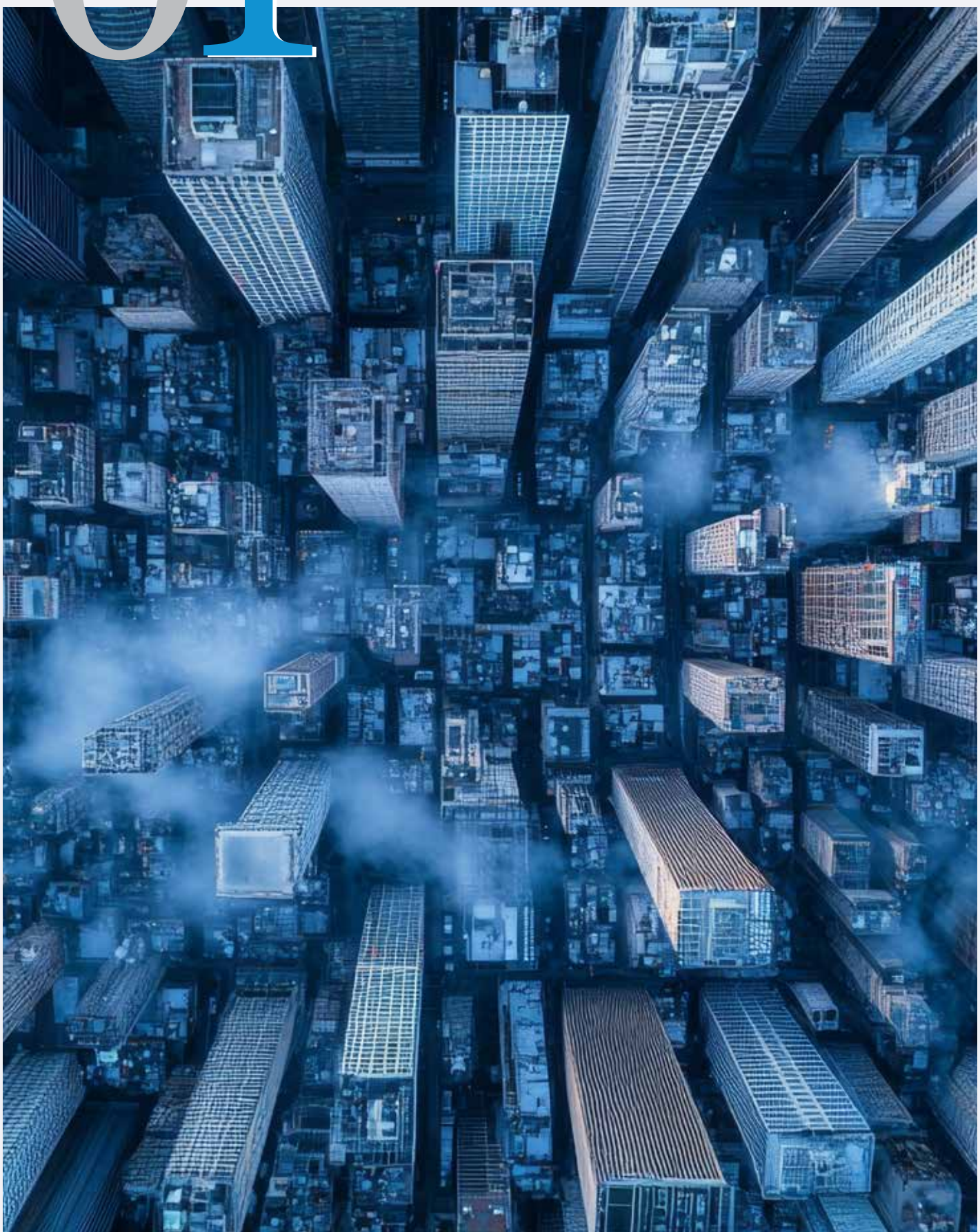
It is estimated that India will need US$150 to US$200 billion of investments annually to underpin energy transition in India. The Reserve Bank of India (RBI) and other financial regulators recognize the importance of decarbonization and are taking pro-active measures to facilitate the flow of capital.

- The RBI has issued a framework for banks to accept green deposits from customers, helping them achieve their sustainability goals while addressing greenwashing concerns. The framework identifies sectors such as renewable energy, clean transportation, and green buildings as eligible for green deposits.
- The Indian government raised INR16,000 crore (US$2 billion) in FY23 through sovereign green bonds to fund green infrastructure development and invest in public sector projects aimed at reducing the economy's emission intensity.
- SEBI has established a clear framework for the issuance of green bonds, outlining the eligibility criteria for green projects, disclosure requirements and verification procedures.
- In the recent budget speech, the Finance Minister of India committed to introducing a green taxonomy for climate finance, which will guide businesses in raising funds for climate adaptation and mitigation based on specific categories and activities.

Currently, only 25% of the required investment is being met to achieve India's nationally determined contributions. Cumulative investments of more than US$10 trillion will be needed to meet the net zero target by 2070. A combination of innovative financing models, including both private capital and government support, will be essential to organize such a high level of funding. With the encouraging policy changes, institutional investors and private capital are showing a positive outlook toward India's energy transition, with funding flowing to both start-ups and large organizations in this space.

Energy transition presents both challenges and opportunities for India. The scale and possibilities across the value chain are immense. With strong economic drivers, government focus, technological advancements, and investor interest, India may even reach net zero before 2070.

01 Introduction



India, the world's fastest-growing large economy, has showcased impressive growth rates of 7% and 8.2% in FY23 and FY24, respectively, and is on a determined path to achieve the status of a developed country by 2047. Recognizing the dual nature of rising global temperatures and climate risks as both a challenge and an opportunity, India is proactively developing businesses in new energy sectors.

Committed to achieving net zero emissions by 2070, India's strategy is to combine inclusive growth with environmental sustainability. As per the Economic Survey 2023-24, "Access to stable energy at a reasonable cost at a pace required to power ambitious targets while on a low-carbon pathway is a sine qua non for development."

With per capita emissions of approximately 2 tons annually, India's environmental footprint is considerably lower than that of other major economies, which range from 4.7 tons per annum in the United Kingdom to 15 tons per annum in Australia. Even as the third-largest contributor to global emissions, with around 7% of the total, India's efforts to reduce emission intensity while enhancing the quality of life for its citizens will play a pivotal role in the global fight against climate change.

Why is energy transition economically important for India

Energy transition is not only a tool to grow the economy but to strengthen it and make it more resilient.

- India is a net importer of fossil fuels and relies on imports to meet nearly 45% of its energy needs. Consequently, volatility in prices of energy commodities impacts the Indian economy. Energy transition provides a pathway for India to reduce its reliance on imports and achieve greater energy independence by using domestically available resources.
- It is estimated that approximately US$150 to 200 billion[1] of investments will be required annually till 2070 to underpin energy transition in India. This provides opportunities for new investments to meet the needs of a growing economy and to tap opportunities for creating new businesses, technologies and industries.
- India aims to increase the share of contribution of manufacturing from 17% to 25% of the total GDP. Investments in developing the supply chain for new energies are witnessing large investment commitments by Indian businesses and also represent a long-term investment opportunity.
- A decarbonized energy system would make the Indian economy more competitive, for example, in the context of implementation of measures, such as Carbon Border Adjustment Mechanism (CBAM). Availability of decarbonized energy will positively impact India's export competitiveness and attract investments into the country.
- Given the natural advantages of scale and adequate sunshine, India has the potential to emerge as an export hub for both carbon-efficient manufactured goods and new energies, such as hydrogen-related products.

India is committed to energy transition and decarbonization agenda with the objective of developing a cleaner energy system that offers reliability, affordability, sustainability and energy independence.

India's robust Nationally Determined Contributions (NDC) targets under the Paris Agreement

Under the United Nations Framework Convention on Climate (UNFCCC), all countries are obligated to formulate their own paths keeping in view their circumstances and needs. India has similarly embarked on an energy transition pathway consistent with its economic needs.

Recognizing the importance of addressing climate change, India has set itself a target of becoming net zero by 2070. Additionally, India has also set the following targets for 2030 as part of its NDCs under the UNFCC:

- To promote and propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE' – 'Lifestyle for Environment' – as a key to combating climate change.
- To adopt a climate friendly and cleaner path than the one followed by others at a corresponding level of economic development.
- To reduce emissions intensity of its GDP by 45 % by 2030, from 2005 levels
- To achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of transfer of technology and low-cost international finance including from the Green Climate Fund (GCF) .
- To create an additional carbon sink of 2.5 to 3 billion tons of CO2 equivalent through additional forest and tree cover by 2030.
- To better adapt to climate change by enhancing investments in development programs in sectors vulnerable to climate change, particularly agriculture, water resources, the Himalayan region, coastal regions, health and disaster management.

1. CEEW

- To mobilize domestic and new, additional funds from developed countries to implement the above mitigation and adaptation actions, considering the resource required and the resource gap.
- To build capacities, create domestic frameworks and develop an international architecture for rapid diffusion of cutting-edge climate technology in India and for joint collaborative R&D on such future technologies.

The Government of India has enacted a series of policy measures to facilitate energy transition and decarbonization of the economy. These are discussed in detail in the following chapters. The success of policy actions can be seen in the substantial investments made in developing renewable energy capacity, the future commitments made by numerous private companies and the decrease in the economy's carbon intensity.

India is on the path to meeting the 2030 NDC targets

Remarkable growth of non-fossil fuel-based generation capacity

India has witnessed a surge in its renewable energy (RE)-based installed capacity for power generation, growing from 78 gigawatts (GW) in the fiscal year 2014-2015 (FY15) to 199 GW in the fiscal year 2023-2024 (FY24)[2]. The government's strong dedication and implementation of a robust policy framework, coupled with reduced generation costs, have supported the significant growth of renewable energy-based power generation. This growth is financially sustainable due to the increasing interest of investors and the entrepreneurial spirit in the sector.

Table 1: Growth in Non-fossil fuel capacity over a decade (in GW)

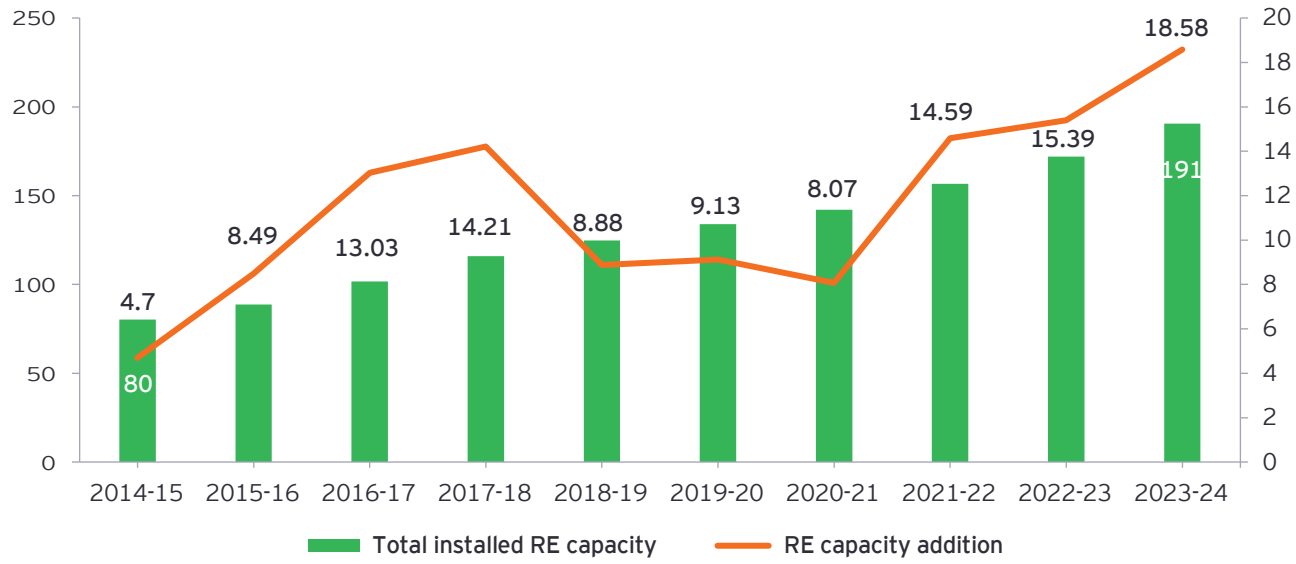
FY Year	Solar	Wind	Hydro	Nuclear	Others	Total
2015	2.6	21.1	45.1	5.8	4.1	78.7
2020	34.4	37.7	50.4	6.8	10.0	139.2
2021	40.1	39.2	51.0	6.8	10.3	147.4
2022	54.0	40.4	51.5	6.8	10.7	163.4
2023	66.8	42.6	51.8	6.8	10.8	178.8
2024	81.8	45.9	51.9	8.2	10.9	198.8
CAGR	41%	8%	1%	4%	10%	10%

Source: CEA

2. India Climate & Energy Dashboard, Niti Aayog

The creation of 18.4 GW capacity in FY24 sets a new record, surpassing the previous record of 15.7 GW set in FY23. This achievement underscores a consistent upward trend over the last three fiscal years, with an average annual capacity addition of approximately 16 GW. Within this sector, the growth of the solar power segment has been prolific, representing 80% of the new capacity addition.

Figure 1: The growing renewable energy (RE) capacity addition



Source: India Climate & Energy Dashboard, Niti Aayog

500 GW of non-fuel based power generation capacity by 2030

While not a part of the NDC, the Government of India has repeatedly reiterated the target of achieving 500 GW of non-fossil fuel-based power generation capacity by 2030. In addition to the near 200 GW capacity that is operational, 90 GW of Hydro, Solar and Wind based generation capacity is under construction and another 44 GW capacity under development.

Table 2: Source-wise renewable energy capacity in pipeline (in GW)

Source of RE	Under construction	Under development	Total pipeline capacity
Solar	54.7	30.49	85.19
Wind	17.52	12.81	30.33
Hydro	18.09	1.24	19.33
Total	90.31	44.54	134.85

Source: India Climate & Energy Dashboard, Niti Aayog

Further, to achieve its goal of 500 GW of non-fossil-based power generation capacity, the government plans to tender 50 GW per annum of renewable energy capacity, with at least 10 GW per annum wind power capacity each year from FY2023-24 to FY2027-28. Four Renewable Energy Implementing Agencies (REIAs) – SECI, NTPC, NHPC, and SJVN – have issued bids totaling 35.51 GW in FY2023-24 until the end of December 2023.

It is reasonable to conclude that India is well on the path to achieve the target of 500 GW of non-fossil based power generation capacity by 2030.

Share of non-fossil fuel-based generation capacity likely to exceed the 50% target

As a result of the rapid increase in non-fossil fuel-based generation capacity in India, its share in the overall capacity has increased sharply from 29% in 2015 to 45% in 2024. India is set to meet the NDC target of non-fossil fuel-based power generation capacity to comprise 50% of the installed capacity by 2030.

Table 3: Non-fossil fuel-based capacity addition (in GW)

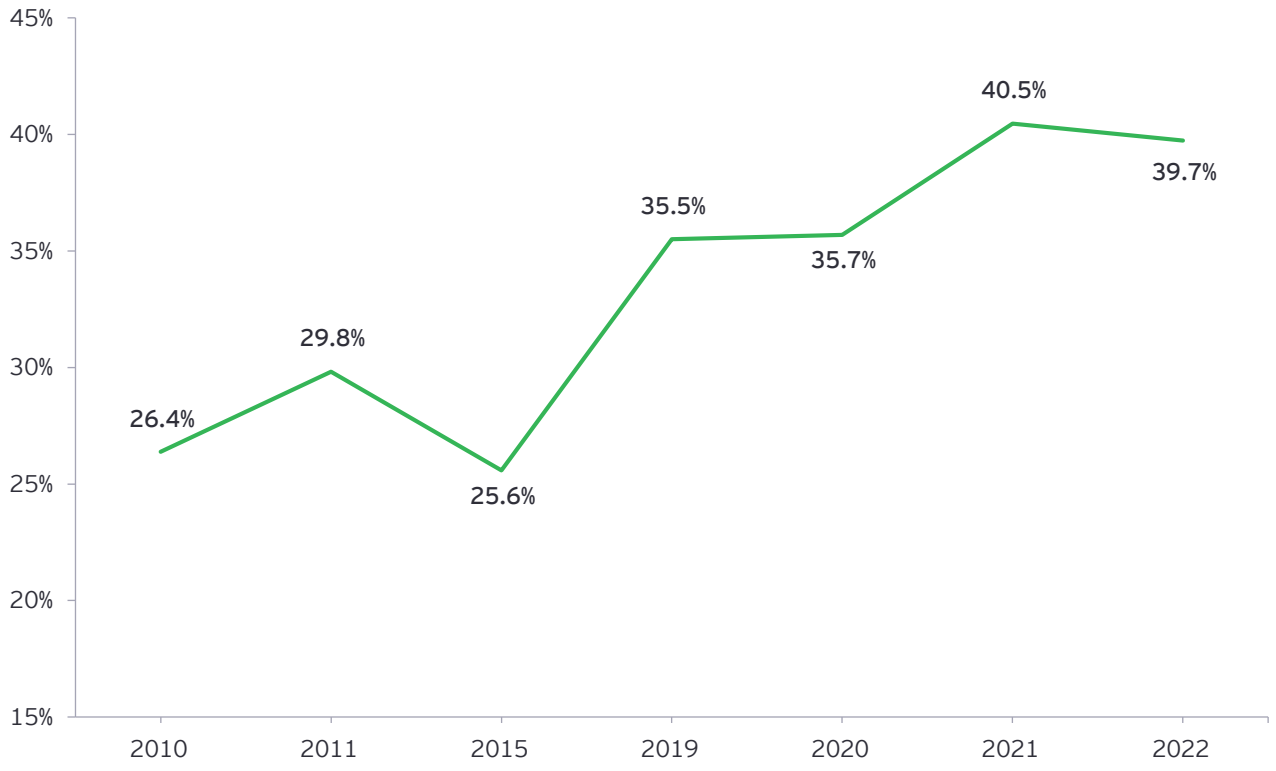
Year	Fossil fuel-based generation capacity	Non-fossil fuel-based generation capacity	Total	Share of non-fossil fuel-based generation capacity
2015	188.9	78.7	267.6	29%
2020	230.8	139.2	370	38%
2021	234.7	147.4	382.2	39%
2022	236.1	163.4	399.5	41%
2023	237.3	178.8	416.1	43%
2024	243.2	198.8	442	45%

Source: CEA

Carbon intensity of the economy likely to reduce by 45% over 2005 levels

India has also committed to reduce the carbon intensity of its economy by 45% compared to its 2005 levels. The following chart plots the real growth in the economy with the growth in emissions:

Figure 2: The falling carbon emission intensity of GDP compared to 2005 levels



Source (base data): International Monetary Fund (IMF) and Our World in Data[3]
Note: GDP has been adjusted for inflation to calculate emission intensity

Given the emission intensity of GDP, India has already achieved 40% reduction in emission intensity of GDP by 2022 and is set to meet the NDC target of reducing emission intensity of GDP by 45% to the 2005 levels by 2030.

3. https://github.com/owid/co2-data?tab=readme-ov-file

02 Beyond 2030 and macro-economic considerations

> The global transition to net zero presents both a significant commercial opportunity and a rapidly growing investable universe. Our goal is to be a key contributor to the global energy transition, driving positive environmental and economic outcomes through strategic investments. Brookfield is dedicated to driving the energy transition in India. Our approach aligns with India's vision of a low-carbon economy, focusing on creating long-term value through green investments and innovative solutions. In India, our investments in renewable energy and energy-efficient technologies are designed to support the country's transition to a more sustainable energy system. Globally, Brookfield is recognized as one of the largest investors in renewable power and transition assets, and we are committed to extending the benefits of our operating capabilities, scale and global reach to our operations in India.
>
> **Naval Saini**
> Managing Director– Investments, Renewable Power and Transition, Brookfield Asset Management

While India is making strides towards fulfilling its 2030 commitments made, it, like the rest of the world, is still formulating a specific roadmap to achieve net zero emissions. In the recent FY24-25 budget speech, the Indian Finance Minister emphasized this vision, stating, "In the interim budget, I announced our strategy to sustain high, resource-efficient economic growth while ensuring energy security through availability, accessibility, and affordability." We will bring out a policy document on appropriate energy transition pathways that balance the imperatives of employment, growth and environmental sustainability."

Some factors that are currently influencing, and will continue to shape India's path to net zero include the following:

- **Meeting India's growing energy demand:** For India, the decarbonization journey is not just about replacing conventional power capacity with low carbon sources of energy (which is the case in many large economies with very low economic growth rates), it is equally about growing its power generation capacity to derive the fast pace of economic growth. Surge in electricity demand is impacting the pace of downsizing the share of coal and growth in the nuclear power generation capacity.
- **Energy independence:** As mentioned previously, imports comprise 45% of India's primary energy supply[4] and its economy has always been vulnerable to increase and volatility in global energy prices. Therefore, India's energy transition needs to ensure that low carbon pathways are not dependent upon large-scale imports into India. This consideration makes transition to biofuels, introduction of green hydrogen and the continuing role of coal-based power attractive for India.

  It also underscores the importance of the development of a domestic supply chain within the country to ensure a competitive supply of energy, economic resilience, and energy independence. The government is prioritizing the development of supply chains through financial incentives and customs tariffs. There are PLI schemes to incentivize the manufacture of solar panels in India which also attracts basic customs duty of 40%.
- **Level of government subsidies:** Decarbonization and energy transition have been underpinned by government subsidies. Some technologies are at an early stage of development and need financial support from the Government to mature and eventually become competitive. The incentives under the Inflation Reduction Act of the US are a good example. Fiscal space available to the Indian government is not comparable with other large economies. In the absence of subsidies, the role of market-based instruments like emissions trading system, mandates e.g., for blending of biofuels and policy support that incentivizes sourcing of green power by businesses becomes very important. Further, the pace of introduction of new technologies such as green hydrogen, offshore power, battery storage, would be impacted by technological development and cost reductions.
- **Access to technology and financing energy transition.** Proposals such as Carbon Border Adjustment Mechanisms (CBAM) force the timeline on emission reduction targets . Rapid decarbonization requires access to technology and access to funding. It is estimated that India would need US$150 billion to US$200 billion of investments annually till 2070. Implementation of fiscal policy measures such as green bonds, green deposits, proposal on green taxonomy and disclosure requirements under the securities law are all extremely important.

Globally, decarbonization has become not only an important part of industrial policy but also as a way of gaining competitive advantage. However, emissions are a global externality and require close co-operation between countries. Therefore, access to technology and financing in economies with low per capita income is a pre-requisite for addressing climate change.

4. EY Analysis, Energy statistics 2024, MoSPI

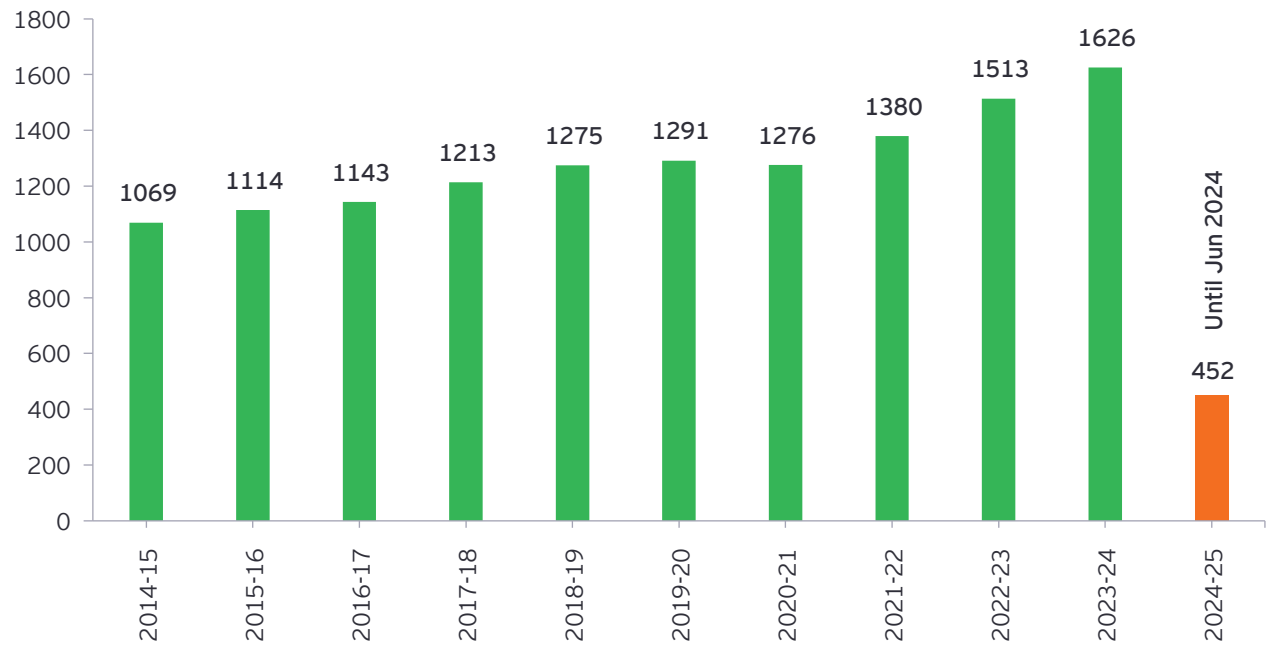
2.1 Meeting the burgeoning demand for electricity

Reflecting the country's economic growth and increased electrification, India's energy requirements have risen from 1,069 billion units (BU) in FY15 to 1,626 BU[5] in FY24. This trend has accelerated in the past two years with electricity consumption increasing at a CAGR of 9%, with the peak demand growing by 10%. In contrast, the global electricity demand grew at 2.2% in 2023 and less than the 2.4% in 2022[6]. Further, it is estimated that the global electricity demand would grow at 3.4% per annum up to 2026.

According to IEA, India's electricity demand growth is the highest among all major economies in the world. The IEA additionally notes, "We expect growth above 6% on average annually until 2026, supported by strong economic activity and expanding ownership of air conditioners. Over the next three years, India will add electricity demand roughly equivalent to the current consumption of the United Kingdom. While renewables are set to meet almost half of this demand growth, one-third is expected to come from rising coal-fired generation." It may also be noted that the electricity demand in the current financial year, i.e., in the period from April to June 2024, has grown 10.56% over the previous year.

The following graphs present the growth in energy consumption and peak demand.

Figure 3: India's rising electricity requirement (in BU)

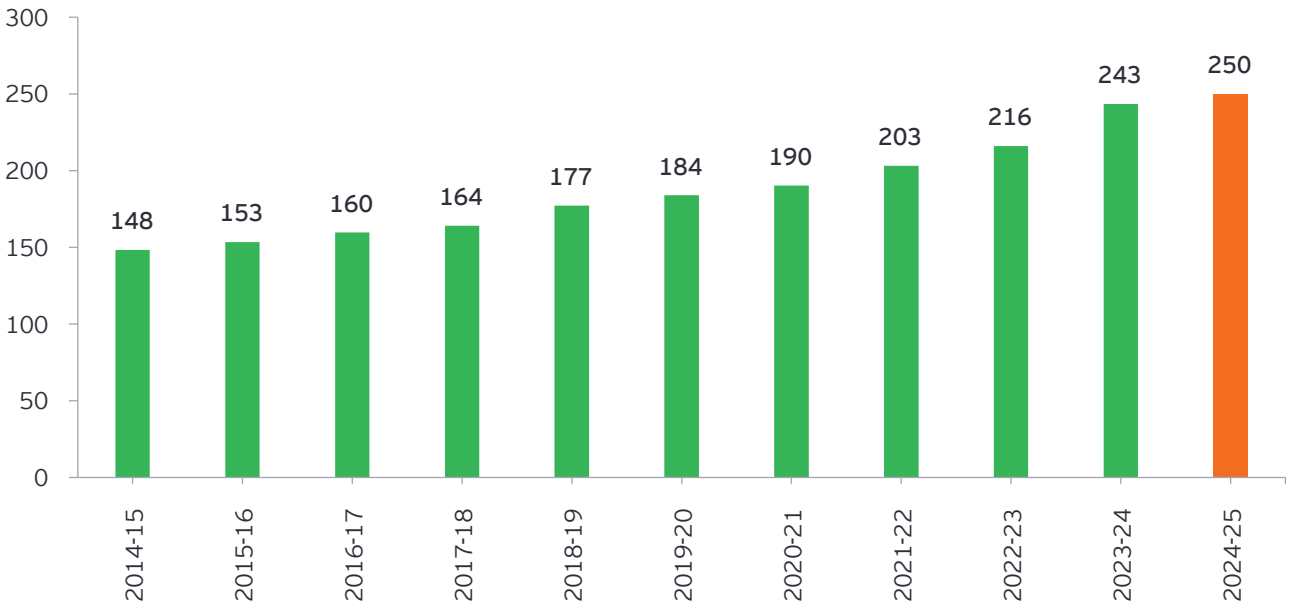


Source: 20th Electric Power Survey, CEA
Note: Orange bars represent electrical energy requirement in Q1 of the current FY25

Further, the peak demand in India touched 250 GW on 30 May 2024, which is 23% higher than the peak demand in the year 2022.

5. CEA power supply position report
6. IEA

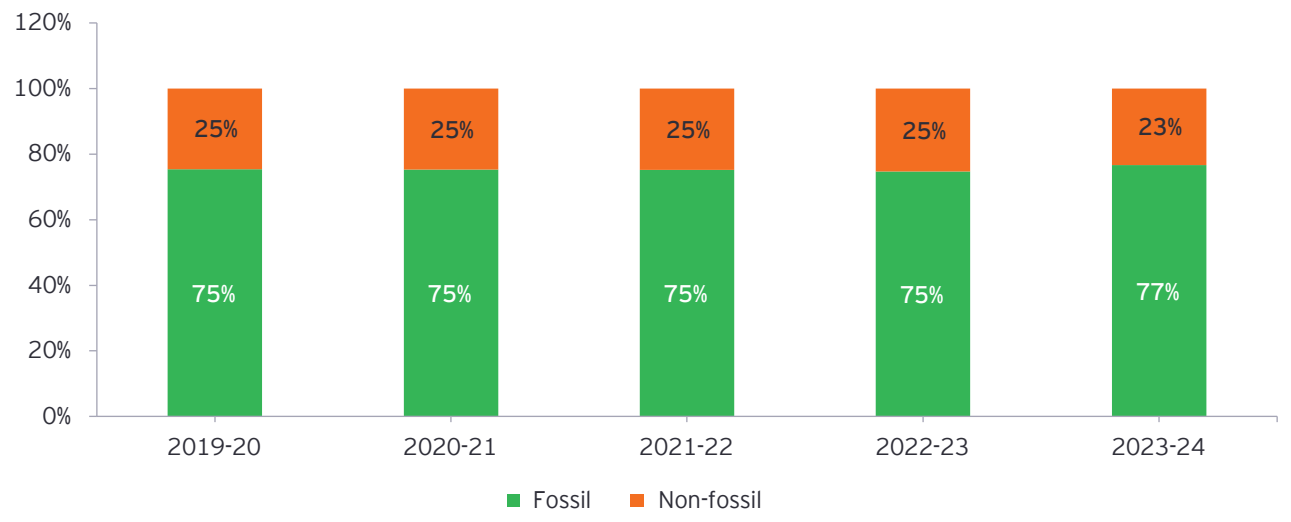
Figure 4: Peak electricity demand surpasses FY25 projections



Source: 20th Electric Power Survey, CEA
Note: Orange bars are projections for the upcoming years by CEA

As a result, despite the impressive growth in the creation of non-renewable capacity, its contribution to the overall mix has been stagnant. However, if the high growth in renewable energy production had not taken place, reliance on fossil fuel-based energy would have been even higher.

Figure 5: Thermal energy dominates the electricity generation mix

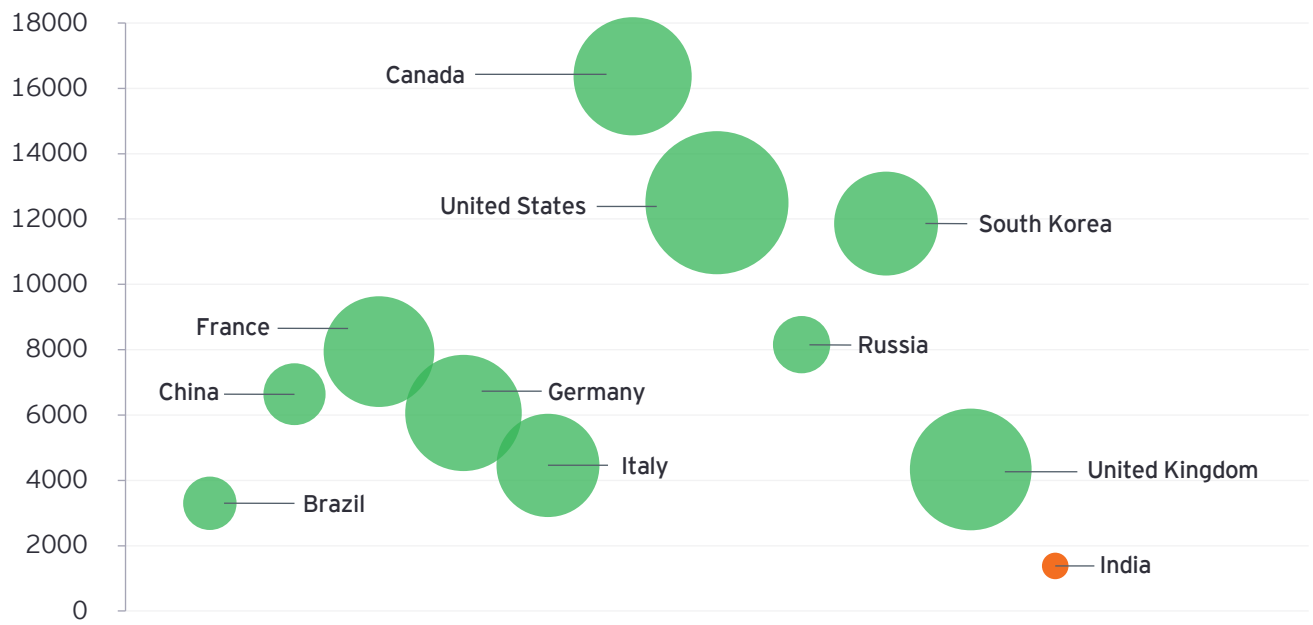


Source: CEA

Future growth

It may be noted that India's per capita energy consumption is still very low and needs for further ramping up of power generation capacity.

Figure 6: Electricity generation per capita (in KWh) across major economies



Source: Our World in Data

Continuing reliance on coal

According to the IEA, India is on the brink of experiencing the most substantial surge in energy consumption worldwide, expected to unfold over the coming three decades[7]. The nation's energy infrastructure, heavily reliant on coal, is pivotal in meeting immediate energy needs, even as it pursues an aggressive expansion of renewable energy sources. Given the modest levels of per capita electricity consumption, a substantial increase is anticipated, compelling the need for adoption of energy policy that judiciously incorporates coal to meet burgeoning demand.

Given the sharp rise in energy demand, India's reliance on coal is set to persist at least over the next few years, underpinning the country's strategy to support future energy requirements. Coal's role in India's energy mix remains substantial, contributing 59% to the primary energy supply in 2023. To support this demand, India has established coal production goals, targeting 1.31 billion tons of coal by the FY25[8], with an ambition to scale up production to 1.5 billion tons by 2030. Coal has other economic linkages, such as:

- Coal mining employs 4.43 lakh people spread across the country including in poorer parts of India[9].
- Coal accounts for approximately 50% of the rail freight volumes in India and contributes significantly towards railway cashflows due to higher tariffs compared to passenger tariffs.
- It is a source of revenue in the form of royalties, GST and other levies for the union and state governments. In FY23, the coal sector contributed INR70,000 crore (US$8.5 billion) through royalties, GST, and other levies, with royalty collections amounting to INR23,184.86 crore (US$2.8 billion).

7. World Energy Outlook, 2022 IEA
8. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1901930
9. https://www.coal.gov.in/sites/default/files/2024-02/PIB2002725.pdf

Role of nuclear power

India is actively pursuing nuclear energy to access decarbonized base load power. Rapid implementation of nuclear power capacity can reduce the share of coal based thermal power generation, which is traditionally been a source of base load power.

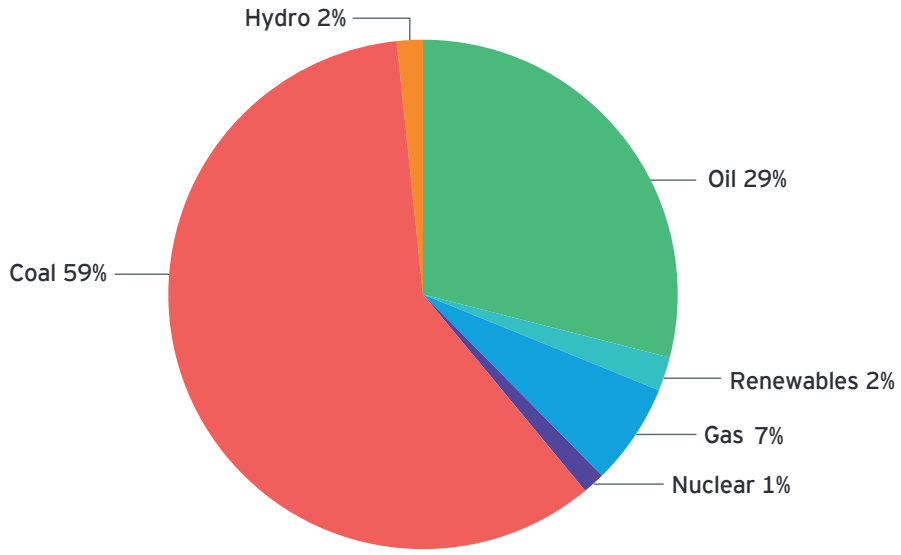
In the recent budget announced by the finance minister, it has particularly been emphasized that "nuclear energy is expected to form a very significant part of the energy mix for Viksit Bharat. Towards that pursuit, our government will partner with the private sector for (1) setting up Bharat Small Reactors, (2) research and development of Bharat Small Modular Reactor, and (3) research and development of newer technologies for nuclear energy. The R&D funding announced in the interim budget will be made available for this sector." Government is pushing for development of indigenous small reactors with the participation of the private sector in nuclear power development.

As the Indian energy landscape undergoes a transformative shift, the imperative to balance the pace of non-fossil fuel-based energy capacity additions with the burgeoning energy demand becomes increasingly critical. This alignment is essential to ensure that the transition to cleaner energy sources is not only environmentally responsible but also economically viable and reliable for meeting the growing energy needs and aspirations of India.

2.2 Ensuring energy independence

Energy security is a critical issue for India, which is grappling with the dual challenge of ensuring energy availability and affordability while transitioning to sustainable production and consumption practices. The volatility and fluctuations in the international energy market impacts inflation and public finances[10].

Figure 7: Source-wise primary energy supply in 2023



Source: India Climate & Energy Dashboard, Niti Aayog

10. EY analysis

Figure 8: Net energy import dependence of energy commodities

Source: Energy Statistics 2024
We have excluded petroleum products above as India is the net exporter for the same and considered only the import value of other energy sources. Net energy import dependency measures the extent to which a country relies on imports to meet its energy requirements[11].

Energy security has also become more critical in the light of geopolitical changes and economic fragmentation, as it provides a buffer that allows the country to pursue its industrial policies and economic objectives with greater confidence and less external vulnerability.

India's recent energy transition policies have been tailored to address its increasing energy deficit and to diversify its energy mix by developing alternative sources such as nuclear, solar, wind energy, and biofuels with the blending of ethanol with petrol. The goal is to reduce dependency on energy imports and secure a steady supply of energy at reasonable prices to support economic growth.

Mandatory blending biofuels with fossil fuels

India's big focus on bioethanol helps it both reduce emissions and enhance energy security, besides linkages with the agricultural sector. The National Policy on Biofuels, notified by the Government of India in 2018, mandates oil marketing companies to blend 20% ethanol, sourced from agricultural inputs, into petrol by 2030. To ensure effective implementation, the government has also set a price at which ethanol would be procured by the oil marketing companies and has facilitated financial incentives towards setting up of ethanol manufacturing capacity in India.

Since India has achieved an intermediate target of 10% blending of ethanol much ahead of target by November 2022. Therefore, the target of 20% ethanol blending was advanced from 2030 to 2025-26. In the future, it is likely that similar mandates are imposed on other fuels:

- National Biofuels Coordination Committee (NBCC) under the aegis of Ministry of Petroleum and Natural Gas has proposed to blend compressed bio-gas (CBG) with compressed natural gas used for transportation

11. Energy Statistics 2024

and piped natural gas used for domestic purposes by entities licensed to supply city gas in India. As per the current plans, CBG blending obligations will be voluntary until FY2025 and become mandatory thereafter. In line with the experience of blending ethanol with petrol, the blending obligation will increase with time.

- Ministry of Power issued revised guidelines for biomass policy and now mandates 5% biomass co-firing in Thermal Power Plants (TPPs) from FY 2024-25. This obligation shall increase to 7% from FY 2025-26.
- Similar proposals are under consideration for aviation fuel. A recent government release stated that 1% target of sustainable aviation fuel may be introduced for international flights in 2027.

Focus on supply chain development

"Our ESG targets are aligned with our business goals and are an intrinsic part of our corporate strategy. We are committed to achieving carbon neutrality by 2035 for Scope 1 and Scope 2 emissions. Since our inception in the 1980s, sustainability has been integral to our operations. We are credited with being the only company globally recognized by the Davos Recycling Forum in 1995 for our technology to recycle multi-layer mixed plastic waste. Our primary ESG goals focus on reducing our carbon emissions, achieving a double-digit decrease in total waste, increasing recycled materials, recycling post-consumer and factory MLP and aseptic waste, implementing advanced technologies to minimize water wastage, and increasing biodiversity. By optimizing our manufacturing processes and embracing sustainable practices, we are leading the way in stewardship for a better future."

Jeevraj Pillai
Director - Sustainability and President - Flexible Packaging Business - Uflex Limited

- Government has prioritized the development of a supply chain for long-term sustenance of energy transition and ensuring both strategic autonomy as well as availability of competitively priced energy.
- The focus has been on developing the supply chain related to renewable energy through incentives for manufacturing Advance Chemical Cell (ACC), EVs and Solar Panels. These are proposed to multi-year financial incentives totaling to INR68,038 crore (US$8.3 billion).
- Recently, the government announced PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) Scheme with an outlay of INR10,900 crore (US$1.3 billion) over a period of two years to support e-2Ws, e-3Ws, e-ambulances, e-trucks and other emerging EVs. The policy excludes four wheeler (e-4W) from the scheme.
- Similarly, there are no budgetary allocations for any demand side incentives for green hydrogen, when the domestic capacity is yet to develop.
- Efforts are also underway to secure the supply of critical minerals.

2.3 Fiscal space for the government to provide subsidies

Governments worldwide are investing billions of dollars in incentives and subsidies to accelerate the energy transition. Public funds are fostering innovation and supporting the deployment of emerging technologies that might otherwise struggle to achieve viability without government backing. Although the scale and emphasis of investment in energy transition differ by country, there is a collective effort to allocate public resources towards this global initiative.

A good example is the Inflation Reduction Act in August 2022 (IRA-2022) enacted by the US Government to support the innovation and development of technologies that are critical for energy transition and decarbonization of economy. The US has earmarked US$369 billion under IRA-2022 for clean energy and climate change mitigation, the Act will catalyze investments over the next decade, making the US one of the most competitive locations for new clean technology like green hydrogen, carbon capture utilization and storage, energy storage, etc. The act is incentivizing through Investment Tax Credits (ITCs) and Production Tax Credits (PTCs) for clean energy generation and gives the producers the choice to opt for either ITC or PTC, according to what works best for them. US$369 billion represents 1.41% of the current US GDP and would represent 10% of the Indian GDP.

According to the World Economic Forum, "IRA Act is an unprecedented level of support from the US Federal Government for the transition to sustainable energy. It is expected that the Act will reduce US GHG emissions to approximately 40%, compared to 2005-levels, by 2030. Without the enactment of the IRA, the US was on course to reduce its Green House Gas (GHG) emissions to only 26%, compared to 2005-levels, over this period."[12]

As another example, Germany has earmarked €60 billion[13] towards emission reduction. It includes €18.8 billion for energy-efficient building renovation and boiler replacements and €12.6 billion for renewable electricity feed-in support.

In comparison, the Government of India has allocated INR42,000 crore (US$5 billion) for FY25 towards capital and revenue expenditure (including financial incentives) towards Energy Transition, including money for atomic energy capacity development through government-owned entities. Further, India does not provide any feed-in tariffs, though it has earmarked US$1 billion of financial support to provide viability gap funding for installation of 1 GW of offshore wind power. Given limited fiscal space, incentivizing businesses to decarbonize through market-based instruments becomes extremely important.

Incentivizing businesses to decarbonize through market-based instruments and mandates

India has made remarkable transformation in its energy mix through the promotion of renewable energy, pumped storage, battery storage and nuclear power. The policy initiative for initiating the growth of renewable energy included a market-based instrument, 'tradeable renewable energy certificates (REC)', launched in 2010-11. All utilities and open access consumers were obligated in a gradual manner to procure a certain portion of their consumption from renewable energy such as solar, bio-mass and wind power. This was implemented at a point the cost of renewable energy was two to three times than the cost of conventional energy. Initial requirement was to source 2% to 5% of energy consumption from green sources. Those entities not procuring green renewable energy directly could fulfill the mandate through the purchase of RECs that were issued to entities generating green energy. This mandate is currently 29.91% and incentivizes all consumers to procure green energy.

Introduction of emissions trading

Similarly, the Government of India also proposed to introduce an emission trading system (ETS) in India. The Indian Finance Minister, while presenting the budget for FY 2024-25 said, "a roadmap for moving the 'hard-to-abate' industries from 'energy efficiency' targets to 'emission targets' will be formulated. Appropriate regulations for transition of these industries from the current 'Perform, Achieve and Trade' mode to 'Indian Carbon Market' mode will be put in place."

India's Carbon Credits Trading Scheme (CCTS) is a proposed domestic emissions trading scheme . The scheme is currently under development and aims to create a market-based mechanism. The scheme is likely to operate on a cap-and-trade principle, where government imposed cap limits the total amount of greenhouse gas emissions allowed. Companies will be allocated emissions allowances, which they can trade with other companies. Further, companies that

12. Why the US Inflation Reduction Act is an important step in the transition to clean energy | World Economic Forum (weforum.org)
13. https://www.cleanenergywire.org/news/germany-earmarks-almost-eu60bln-energy-transition-spending-next-year

reduce their emissions below their allocated cap can generate carbon credits, which they can sell to companies that exceed their cap.

Further, it is proposed that there would be a voluntary carbon market mechanism established as well, where non-obligated entities can register themselves and buy/ sell credits. India is also working to ensure that its CCTS is compatible with international standards and facilitates participation in global carbon markets.

Successful implementation will enable the creation of a competitive market that would provide incentives for the adoption of low carbon technologies. It will also serve as a vehicle for mobilizing investments required to transition toward low-carbon pathways.

Pace of introduction of new technologies would accelerate with technological development

It is expected that technologies such as green hydrogen, off-shore wind, battery storage and carbon capture would have a greater role to play. These technologies are still under development and their deployment globally is dependent upon fiscal support of the government.

India, in particular, has focused on green hydrogen. It is seen as a technology that would rely upon domestic resources, can help decarbonize hard-to-abate sectors and given the abundant sunshine in India, a competitive source of energy. Government has taken initial steps towards the development of the supply chain and creation of initial capacity. As a result, many players are announcing plans to develop giga scale projects.

The Indian government has begun to pave the way for the implementation of offshore wind and battery storage technologies by offering viability gap funding aimed at supporting incremental capacity expansion. This financial backing is designed to evaluate the practicality of deployment, including technological aspects, and to initiate the growth of a supportive ecosystem. Although widespread adoption will ultimately hinge on cost reductions and market competitiveness, the provision of this financial assistance signals the Government's enduring dedication to these initiatives.

As clean technologies mature and become financially self-sustaining, the need for government fiscal support diminishes, allowing for a more rapid pace of investment. Reflecting on this optimistic trajectory, the Economic Survey 2023-24 states, "Many technologies essential for achieving global Net Zero are not yet commercially available, such as hydrogen-fueled production of steel and cement, and steel and aluminum manufacturing with Carbon Capture, Utilization, and Storage (CCUS). There is an imperative to bolster international collaboration in research and development, particularly in areas such as distributed renewable energy, offshore wind, geothermal, tidal energy, biofuels, compressed biogas, green hydrogen, energy storage, electrolyzers, and nuclear power, including Small Modular Reactors (SMRs)." This highlights the opportunity for enhanced global cooperation to advance the development and deployment of these critical technologies.

> "India, a key growth market, is a priority country for British Petroleum (bp). Today, we remain mostly in oil and gas. In a world aiming for net zero, we believe our net zero ambition positions bp for success. As bp works towards transforming from an international oil company to an integrated energy company, its purpose and ambition is well aligned with that of the Government of India. bp is supporting the country's drive towards net zero and achieving energy independence. bp aims to become a trusted partner to the Government of India, as it works towards its stated goal of equitable growth for its citizens and net zero by 2070. We are investing in the oil and gas the country needs today and in transition growth engines that may help support the Government of India's energy transition ambitions.
>
> **Rajeev Kumar**
> Vice President and Director, BP

2.4 Green financing and taxonomy for India

Rapid decarbonization requires access to technology and access to funding. It is estimated that India would need US$150 to 200 billion of investments annually. Implementation of policy measures such as green bonds, green deposits, proposal on green taxonomy, disclosure requirements under the securities law, etc., will have a bearing on the flow of resources for energy transition.

Indian financial regulatory bodies have implemented policies and issued guidelines to encourage investments. While these are at early stages and under development, successful usage of these instruments will impact the energy transition journey. Some examples are discussed below:

- **Green deposits:** RBI has issued a framework for banks to accept green deposits to customers, protect the interests of the depositors, aid customers in achieving their sustainability agenda, address green washing concerns and help augment the flow of credit to green activities/ projects. In the framework, RBI has also listed a few sectors and activities such as renewable energy, clean transportation, green buildings etc., which are qualified to invest the funds raised through green deposits are allocated to the eligible green activities/projects. This would safeguard the interest of retail investors to meet the sustainable goals.
- **Sovereign green bonds:** The Government of India has successfully mobilized INR16,000 crore (approximately US$2 billion) through the issuance of sovereign green bonds in FY23. This strategic financial initiative is aimed at bolstering green infrastructure development and funding public sector projects that contribute to the reduction of the economy's emission intensity. The successful raise highlights the government's strong and ongoing commitment to support environmentally friendly projects with sovereign green bonds.
- **Green bonds:** India's securities regulator, i.e., Securities Exchange Board of India (SEBI) has established a clear framework for the issuance of green bonds, outlining the eligibility criteria for green projects, disclosure requirements, and verification procedures. SEBI has also issued guidelines to combat green washing of the proceeds raised through green debt securities by mandating the issuer to continuously monitor the projects to check whether the path undertaken is towards reduction of the adverse environmental impact and contributing towards sustainable economy.

- **Green taxonomy:** In recent budget speech by the Finance Minister, the government has committed to bring India's green taxonomy for climate finance to enhance the availability of capital for climate adaptation and mitigation. Taxonomy will guide the business to raise funds on more specialized manner as defined by the taxonomy under different categories/activities.
- **SEBI has introduced Business Responsibility and Sustainability Reporting (BRSR) mandate:** BRSR requires top Indian companies to disclose detailed information about their environmental, social, and governance (ESG) performance. The BRSR applies to the top 1,000 listed companies in India by market capitalization. The mandate requires companies to disclose quantifiable metrics on sustainability-related factors, including factors related to energy transition such as electricity consumption, water usage, air emissions, waste management, biodiversity conservation.

The BRSR is aligned with globally accepted reporting frameworks like the Global Reporting Initiative (GRI) and the Task Force on Climate-Related Financial Disclosures (TCFD). By mandating disclosures on ESG performance, SEBI is encouraging companies to integrate sustainability into their core business strategies. This has been discussed in great detail in subsequent sections.

03 Current approach towards energy transition

3.1 Renewable energy capacity creation

Fossil fuels have historically dominated the power sector, but India's commitment to meet 50% of its electricity needs from non-fossil sources by 2030 marks a historic point in the global effort to combat climate change.

Today, India stands fourth globally in renewable energy installed capacity (including Hydro), fourth in wind power capacity and fifth in solar power capacity.

Government strategic intervention for renewable energy growth

State distribution companies (DISCOMs) in India are the primary consumers, accounting for 88%[14] of the total consumption under long-term power purchase agreements (PPAs). Collaboration with the state government has been one of the most strategic decisions taken by the central government to facilitate the development of renewable energy. The key strategies that have paved the way for the development of renewable energy are:

- **Derisking of private investors:** The distribution companies in India are financially distressed and private developers and financiers see as significant credit and offtake risk while developing projects for consumption by the state utilities. The government of India has stepped in by mandating central Renewable Energy Implementing Agencies (REIAs) i.e., Corporation of India (SECI), National Thermal Power Corporation Limited, National Power Corporation Limited (NTPC), National Hydro electric Power Corporation Private Limited (NHPC), Satluj Jal Vidyut Nigam Limited (SJVN) to get the bids and sign Power Purchase Agreements with developers, which provide credit in terms of payment of tariff. REIAs in turn signs back-to-back Power Sale Agreement with DISCOMs and supply electricity, thereby mitigating the risk and facilitating the development of the RE sector.
- **Reduced tariffs due to giga scale projects:** State governments are mandated to identify the lands (waste and non-agricultural land) that can be used to set up solar parks wherein REIAs are tendered giga scale solar parks/projects. The economies of scale and the reduced risk for developers from credits have significantly lowered development costs, making the tariffs competitive with coal-based power generation.
- **Commercial and Industrial Customer (C&I):** C&I customer accounts for more than 50% of demand and plays a pivotal role in the energy transition. In the recent years, C&I customers are looking to source green power by entering into contracts with private developers under third party PPAs or through rooftop solar.

> We are at the cusp of a transformative era where sustainability and economic growth must go hand in hand. The energy transition presents us with the challenge of reducing our carbon emissions while maintaining our competitive edge. Hindalco is at the forefront of implementing sustainable energy practices in primary aluminium smelting. We are poised to become one of the first companies in the global aluminium sector to integrate 100 MW of continuous solar and wind energy, complete with storage capabilities. This achievement is a significant step forward for an industry that relies heavily on consistent and uninterrupted power supply. Our initiative received the Energy Transition Changemaker award at COP28, highlighting the importance of innovative and scalable green solutions in advancing the energy transition. We are committed to expanding our round-the-clock renewable energy capacity, with a target of having at least 30% of our energy capacity come from renewable sources by 2030. Additionally, any future expansions of our smelting operations will rely predominantly on renewable energy.
>
> **Anil Mathews**
>
> President Public Policy, ESG and Chief Risk Officer, Hindalco

- **Policy development for decentralized generation and rooftop solar for households:** Rooftop solar has the potential to provide clean energy to residential customers and extend to rural areas where access to reliable, round-the-clock electricity is a challenge. According to CEEW estimates, the economic potential of household to install rooftop solar is approximately 102

14. IEEFA India: Electricity derivatives will offer more certainty of power offtake for renewable investors | IEEFA

GW, where the tapped capacity is only about 11 GW. Government is supporting the sectors through affordable lending and demand side incentives for residential consumers.

- **Waiver in inter-state transmission charges:** To scale up the renewable energy projects, the Government of India has waived inter-state transmission charges for the projects commissioned till 30 June 2025 for a period of 25 years. This would enable further reduction of tariff to the end consumer, which endeavors the growth in the sector.
- **Simplified guidelines:** Under the new Development of Solar Parks and Ultra-Mega Solar Power Projects guidelines, the approval procedure has also been simplified. The parks that are developed by central public sector undertakings (CPSUs) and joint ventures are exempted from seeking approval from the state government committee for solar park development charges and O&M charges. This enables faster development of ultra mega projects.
- **Renewable Purchase Obligation (RPO):** Renewable Purchase Obligation has been considered as an additional revenue stream/incentive for developers vis-à-vis a push for the DISCOMs and open access consumers to procure RE power from developers or purchase RE certificates from the market. This has facilitated the development of the renewable energy sector, given the government's stringent obligations for entities to contribute to the overall energy mix.

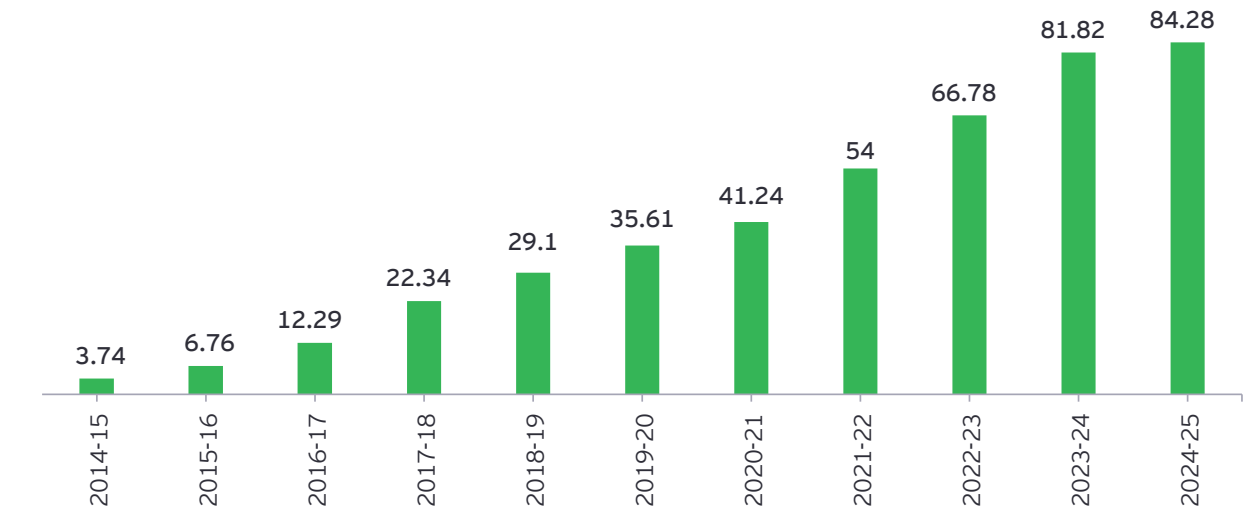
With consistent policy support from the government and improved demand dynamics, the renewable energy sector has become increasingly attractive to investors. While India strives for energy security, renewable energy is poised to play a crucial role in the coming decades. The key drivers for decarbonizing the Indian economy and enhancing energy security are detailed in the following sections.

3.1.1 Developments in solar power sector

India stands as a prominent player in the global solar revolution due to its geographical advantage of receiving 300 days of sunshine. It is estimated that 5000 BU of electricity per year can be generated from solar power, which translates into approximately 2500 GW capacity at the current level of efficiency. These advantages have leveraged to announce the ambitious solar targets supporting with government policies and increased uptake in solar projects. Solar installed capacity has seen an incredible transformation which has grown at a CAGR of 36.5% over a period of 11 years of the Indian solar revolution.

> Tata Power is committed to driving India's energy transition with a target to achieve carbon neutrality before 2045. Guided by the principle of 'Sustainable is Attainable', we empower urban and rural communities through affordable and sustainable energy solutions. Currently, 40% of our portfolio comprises clean and green energy and we are focused on enhancing it to 70% by 2030. Recognizing the importance for a diverse mix of clean energy technologies- battery storage, hydro, nuclear, SMRs, pumped hydro and more- Tata Power is advancing innovative solutions including development of 2800 MW of Pumped Storage Hydro projects in Maharashtra and 600 MW hydro project in Bhutan. As the company is evolving into a solutions-oriented entity, we continue to innovate in rooftop solar, EV charging and smart energy management solutions to provide reliable, affordable and clean power to millions across India.
>
> **Praveer Sinha**
> Managing Director, TATA Power

Figure 9: Multifold growth in Installed solar capacity since FY15 (in GW)



Source: Niti Aayog

Some of the other major policy support for the development of solar power generation is as follows:

1. Development of Solar Parks and Ultra Mega Solar Power Projects, 2014

Indian utility solar parks have been the backbone of the India's solar transition. Moreover, the ultra-mega solar parks have also attracted foreign capital as well as global leaders.

India lies in the high solar insolation region, enabling the installation of solar projects across the country. To maximize the solar potential advantage, the Government of India had rolled out the Development of Solar Parks and Ultra-Mega Solar Power Projects in 2014. MNRE had initially set a target for 40 industrials solar parks with a combined capacity of 20 GW and in 2017 doubled this target to 40 GW by 2022[15].

- As of November 2023, the ministry has approved 50 solar parks with an aggregate capacity of around 37.49 GW in 12 states across the country.
- Out of the 50 solar parks, 11 Solar Parks with aggregate capacity of 8521 MW have been completed and seven Solar Parks with aggregate capacity of 3985 MW are under construction.
- Solar projects of an aggregate capacity of 10,237 MW have already been developed[16].

2. PM Surya Ghar-Muft Bijli Yojana

With a total outlay of INR75,021 crore (US$9 billion) the scheme was launched in February 2024, for installing rooftop solar and providing free electricity up to 300 units every month for 10 million households.

- The scheme will result in the addition of 30 GW of solar capacity through rooftop solar in the residential sector.
- Through this scheme, households will be able to save electricity bills as well as earn additional income through the sale of surplus power to DISCOMs. A 3-kW system will be able to generate more than 300 units a month on an average for a household[17].
- This scheme provides demand side subsidies to propagate renewable energy penetration to the households in remote areas.

3. PM Kisan Urja Suraksha evam Utthan Mahabhiyan (PM KUSUM)

The scheme was launched to provide affordable and accessible power to the farmers throughout the country. The scheme has been divided into three components:

15. Indias-Utility-Scale-Solar-Parks-Success-Story_May-2020.pdf (ieefa.org)
16. Press Release: Press Information Bureau (pib.gov.in)
17. Press Information Bureau (pib.gov.in)

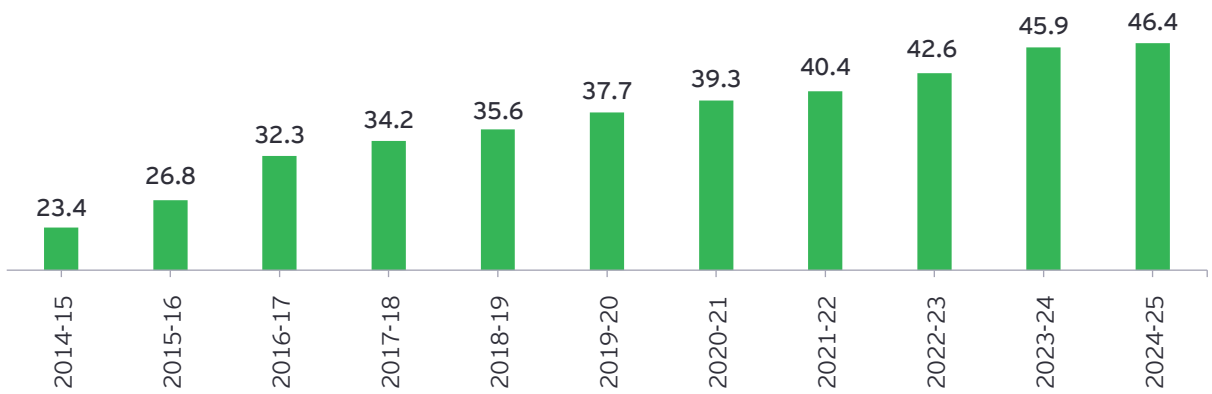
- **Component A:** Setting up of 10,000 MW of decentralized ground/ stilt mounted grid connected solar or other RE based power plants by the farmers on their land
- **Component B:** Installation of 14 lakh standalone off-grid solar water pumps
- **Component C:** Solarization of 35 lakh existing grid-connected agriculture pumps and through feeder level solarization (FLS)

There has been a visible impact of solar energy policies in the Indian Energy scenario during the last few years. The continued focus on innovative policies and financial incentives will further propel the solar energy sector, ensuring a greener and more sustainable landscape.

3.1.2 Developments in wind power sector

India's wind energy sector has shown consistent progress over the years. However, the growth is not as significant as solar power has witnessed over the same period. The expansion of this sector has resulted in developing a strong ecosystem, project operation capabilities and supply chain of about 15,000 MW per annum[18]. India's installed wind power (46.42 GW) stands fourth largest in the world and is mainly spread across the southern, western, and northwestern regions of India.

Figure 10: Installed onshore wind capacity for FY15 till FY25 (in GW)



Source: Niti Aayog
Note:FY24-25 data is till 31 May 2024)

Wind is a site-specific resource of energy and hence, an extensive Wind Resource Assessment is essential for the selection of potential sites. The Government of India through National Institute of Wind Energy (NIWE) has installed over 900 wind monitoring systems all over the country and have successfully issued wind potential maps at 50 meters, 80 meters, 100 meters, 120 meters and 150 meters above the ground level. The recent assessment indicates a gross wind power potential of 695.50 GW at 120 meters and 1163.9 GW at 150 meters above the ground level[19]. Recently, the development of wind energy plants has been witnessed with the requirement of higher Plant Load Factor (PLF) in solar wind hybrid projects to ascertain supply of round the clock (RTC) electricity with or without storage provisions.

In 2023, India commissioned over 2.8 GW of onshore wind capacity, and according to Global Wind Energy Council's 2024 wind report, India ranks as the second largest wind market in the Asia-Pacific region after China. While onshore wind power has been the backbone of India's RE journey, a growing domestic and international appetite exists to tap into India's significant offshore wind resource as well. Harnessing the full potential of offshore wind energy will be needed to achieve the country's net zero target by 2070.

As the second largest hub for onshore wind turbine assembly, India is strategically well placed for wind manufacturing expansion. Recently, during Vibrant Gujarat Summit 2024, Reliance Industries announced that it would set up India's first carbon fiber facility at Hazira, Gujarat, for use in blade manufacturing in the wind sector.

18. Wind Overview | Ministry of New and Renewable Energy | India (mnre.gov.in)
19. Wind Overview | Ministry of New and Renewable Energy | India (mnre.gov.in)

Offshore wind

India's target of 500 GW renewables by 2030 includes approximately 100 GW from wind, out of which 30 GW is estimated to come from offshore wind. MNRE has estimated the offshore wind potential to be around 70 GW, split between Gujarat (36 GW) and Tamil Nadu (35 GW).

Government has made progress in terms of finalizing the policy frameworks and initiatives, directed towards the development of offshore wind potential in India.

- Offshore wind lease rules have been published in February 2024. SECI had announced offshore wind seabed leasing of 4GW capacity in Tamil Nadu, which is pending for allocation.
- Recently, viability gap funding (VGF), with a total outlay of INR7453 crore (US$908 million), has been approved including an outlay of INR6853 crore (US$835 million) for installation and commissioning of 1 GW of offshore wind energy projects (500 MW each off the coast of Gujarat and Tamil Nadu), and grant of INR600 crore (US$7 million) for upgradation of two ports to meet logistics requirements for offshore wind energy projects.
- A revised strategy for development of offshore wind energy projects has been issued in September 2023, indicating a bidding trajectory for installation of 37 GW capacity of off-shore wind energy site leases over the next seven years, which is under development
- Further, Central Transmission Utility has completed the planning of required transmission infrastructure for offshore wind projects for the initial 10 GW offshore capacity (5 GW each off the coasts of Gujarat and Tamil Nadu).

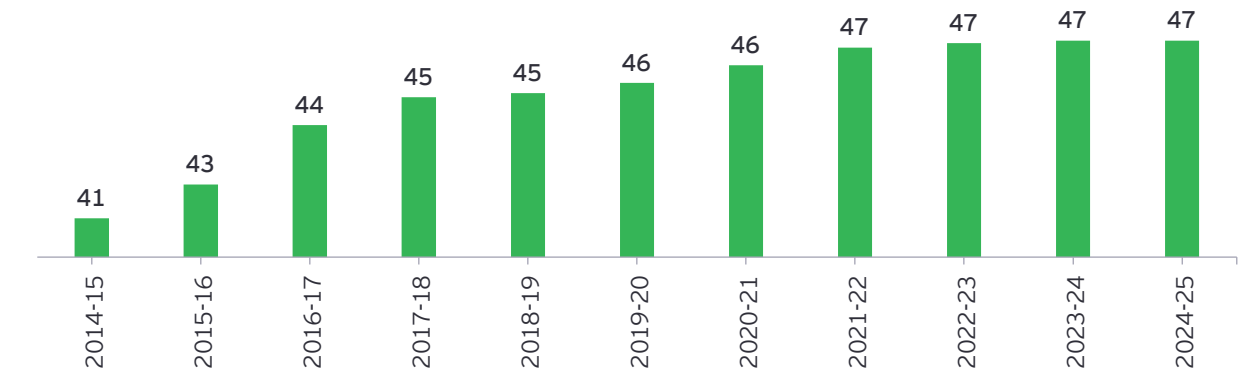
Given the VGF, support from the government would reduce the cost of power from offshore wind projects and make them viable for purchase by DISCOMs. Further, the successful award of offshore wind tenders is likely to attract investments in domestic offshore wind manufacturing with higher capacity turbines.

3.1.3 Developments in hydro power sector

India is set for a significant surge in the hydropower potential and is expected to rise from the current levels of 47 GW to 67 GW by 2031-32, an increase of over 50%. Hydroelectric power projects with an aggregate capacity of 15 GW are under construction. With the government's policy support, this capacity can be achieved.

- Notification by the government regarding Hydro Purchase Obligation (HPO) as a separate obligation to meet by the DISCOMs and open access consumers from the hydro capacity commissioned after 2019. This will help in meeting the projected capacity addition in the hydropower sector.
- Budgetary support had also been provided for funding enabling infrastructure for hydropower projects, i.e., roads/ bridges. As per the 2019 notification, the limit for the grant is INR1.5 crore/ MW for projects up to 200 MW capacity and INR1 crore/ MW for projects above 200 MW plant capacity[20].

Figure 11: Installed hydro capacity from FY15 until FY25



Source: Niti Aayog

20. Measures_to_Promote_Hydro_Power_Sector.pdf (powermin.gov.in)

Global warming which has attributed to climate change is making hydro power projects most vulnerable to flash floods and glacier lake outburst floods (GLOF) in hilly terrains. There has been a fall in hydropower generation in FY 2023-24 in northern and northeastern regions, which cannot be solely attributed to less rainfall but due to flash floods. In southern regions (where ~22% of hydropower is generated), low rainfall has been responsible for lower generation. However, for projects located in Northern and Western regions (which contribute ~60% of hydropower), natural disasters have been the main reason that have severely impacted generation from these projects in FY 2023-24.

Hydroelectric power has always played a significant role in the energy landscape of the country, providing essential peaking support to the electricity grid, thus enhancing the reliability and resilience of the power system.

3.1.4 Tenders issued by the government for development of renewable energy sources viz. solar, wind and hybrid in the last decade

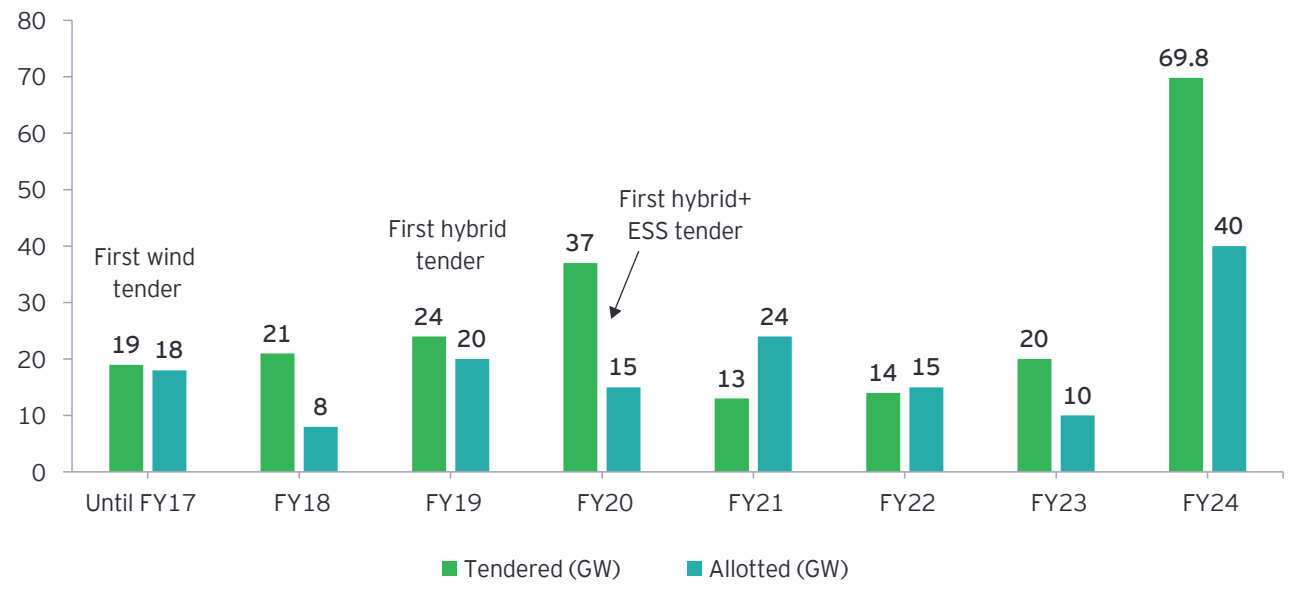
Until 2016, government had issued tenders for development of utility scale solar tenders. In 2016, SECI initiated the first wind tendering process in India. With a focus on supplying round-the-clock renewable energy, In 2018, SECI issued the first solar wind hybrid tender of 1200 MW and later introduced Energy Storage Systems (ESS) in the RE tendering landscape.

Post 2019, RE tendering experienced a downward trend mainly because of COVID-19 pandemic and associated supply chain issues. In March 2023, the government issued the annual bidding trajectory for RE to attain its 500GW non-fossil fuel capacity target by 2030.

The bidding trajectory mandated at least 50GW of RE tenders to be issued for FY2024, which was easily met with a record of over 69GW of tenders issued[21].

In addition, over 22GW of standalone ESS (without RE components) tenders were also issued in the calendar year 2023. Of this, Pumped Hydro Storage projects accounted for about 20GW.

Figure 12: Utility scale RE tender issuance trajectory in India



Source: JMK Research

21. Utility-scale Renewable Energy Tendering Trends in India May 2024, IEEFA

Renewable energy implementing agencies have been given individual targets to meet the tender issuance goals.

- Solar Energy Cooperation of India (SECI)- 15 GW
- National Thermal Power Corporation (NTPC)- 15 GW
- Satluj Jal Vidyut Nigam (SJVN)- 10 GW
- National Hydroelectric Power Company (NHPC)- 10 GW

Against the 10 GW and 40GW targets for FY2024, the agencies cumulatively issued tenders of 4.75GW (47.5% of target) and 38.92GW (97.3%) for the wind and solar power, respectively.

Tender issuance analysis for FY2024[22]

- From FY2020-24, the share of hybrid renewable energy tenders (with or without storage) rose from 16% to 43%, reflecting a greater focus on developing round-the-clock clean energy supply with higher plant load factors (PLF) Of the total awarded tenders in FY2024, only about a quarter are from SECI. The rising prominence of other tendering agencies underlines the strength of India's renewable energy tendering ecosystem.
- The top five tendering agencies, including the four REIAs and Gujarat Urja Vikas Nigam Ltd (GUVNL), account for more than three-quarters of India's entire tender allotment.
- In FY2023 and FY2024, there were three new entrants, namely PFC Consulting, Rajasthan Vidyut Urja Nigam Ltd (RVUNL) and Calcutta Electric Supply Corporation (CESC), which show higher participation from DISCOMs and government agencies.

3.1.5 Tariff competitiveness of renewable energy

A transparent competitive bidding mechanism has been critical in driving the affordable renewable energy growth and in attracting large investments in this sector. India has a long road ahead to reach its 500 GW non-fossil fuel power capacity targets by 2029-30 and cost competitiveness of RE tariffs will play a major role in accelerating addition of solar and wind energy capacity addition.

The tariffs discovered in the bids of Round the Clock (RTC) supply from RE projects have remained highly competitive against the cost of generation from conventional sources. Additionally, a total of 91 tenders have been issued in the period of six months, starting from January 2024 till June 2024, with a cumulative capacity of 66.1 GW.

Solar energy

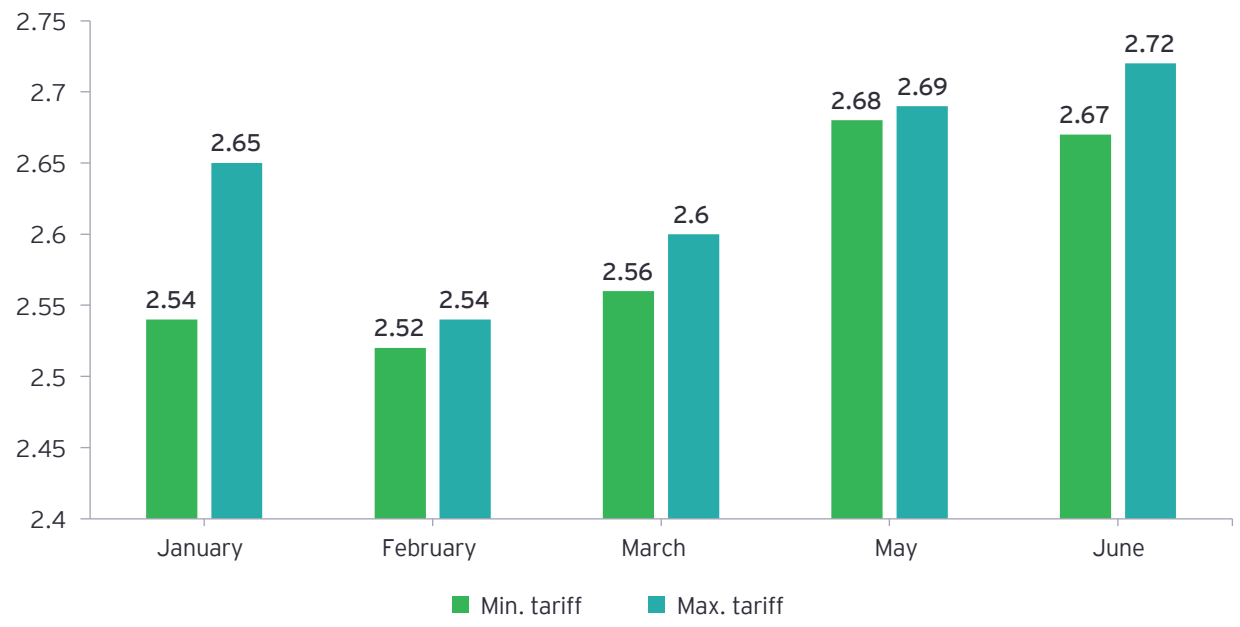
From January to June 2024, developers auctioned a total of 11,225 MW of solar capacity. In January, Avaada secured the maximum solar capacity of 500 MW, followed by ReNew with 400 MW, and Apraava, Solarpack, and Coal India each winning 300 MW. The tariffs during this month ranged between INR2.54/kWh and INR2.65/kWh. In February, SJVN auctioned 1500 MW of capacity, awarding the highest capacity of 700 MW to JSW Neo Energy at a rate of INR2.53/kWh.

March saw an auction of 5625 MW, with SECI issuing tenders for 1500 MW, NTPC for 1500 MW, and GUVNL for 1125 MW. JSW Energy won the highest allocation of 700 MW under the NTPC tender at a rate of INR2.60/kWh. Additionally, SECI allocated 400 MW capacity towards domestically manufactured solar modules and cells, with tariffs ranging between INR2.56/kWh and INR2.67/kWh during these two months.

In May, developers allotted 1500 MW of capacity among four RE developers. Avaada Energy won the highest capacity of 750 MW at a rate of INR2.69/kWh, while Apaarva Energy secured the lowest with 50 MW at INR2.68/kWh. In June, five developers received allocations totaling 500 MW, with the highest tariff rate reaching INR2.72/kWh for the first time in six months.

22. JMK Research

Figure 13: Solar tariffs for the period January to June 2024



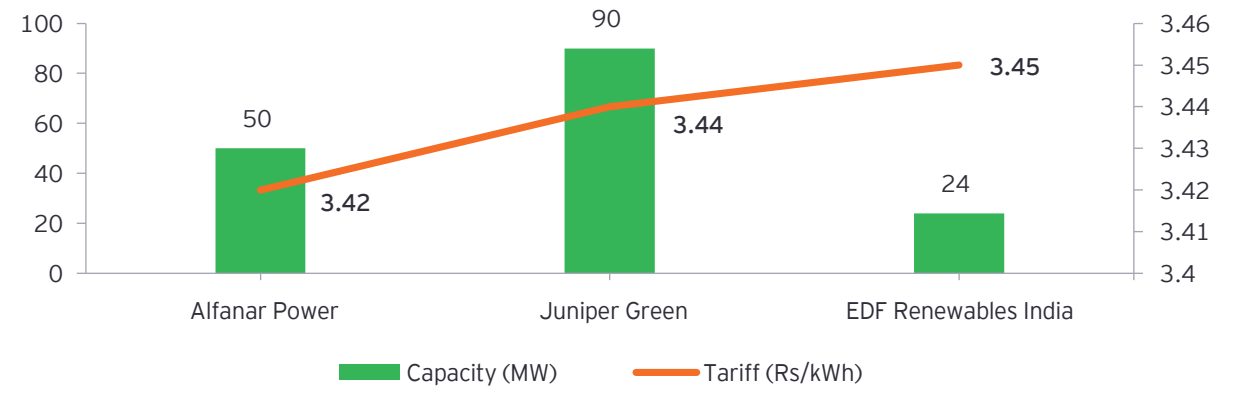
Source: JMK Research, Mercom

On 16 July 2024, RERC approved tariffs for 1000 MW solar projects (7 developers) in Rajasthan. The tariff ranged from INR2.61/ kWh to INR2.62/ kWh. This decision was taken mainly to meet the state's renewable purchase obligation and daytime power demand[23].

Wind and hybrid energy

Out of all the auctions held between January and June 2024 for GUVNL's 500 MW Wind (Phase VI) tender in the wind energy sector, only one was finalized. Unfortunately, only 164 MW of capacity was allocated to this auction. The minimum tariff during this period was INR3.42/ kWh and the highest was INR3.45/ kWh.

Figure 14: GUVNL's 500 MW wind power tender results



Source: JMK Research, Mercom

23. RERC Approves Tariff for 1,000 MW Solar Projects in Rajasthan (mercomindia.com)

Wind solar hybrid segment

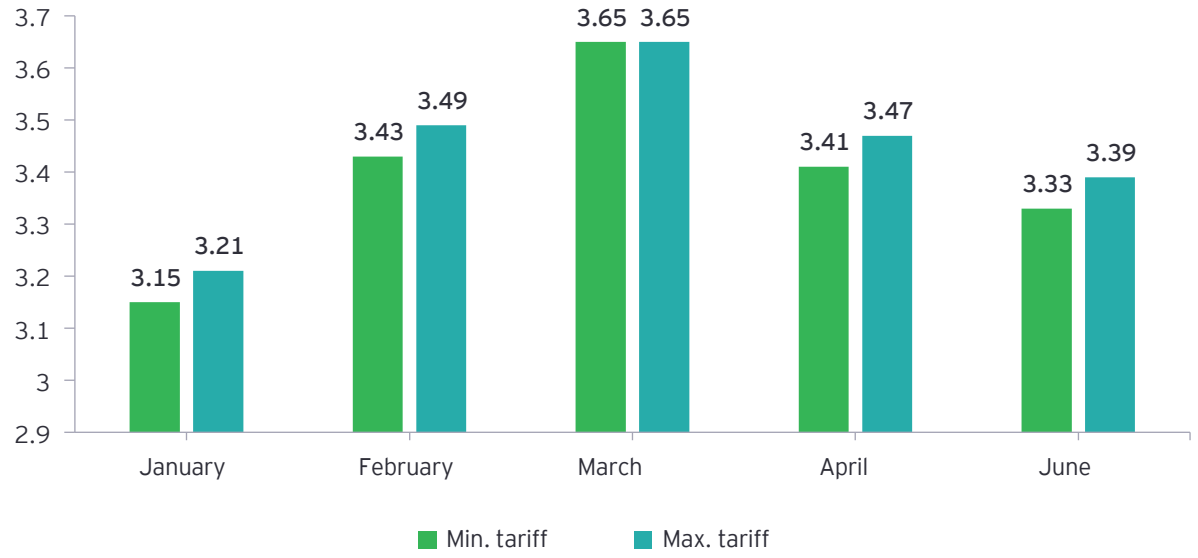
From January to April 2024, the Government of India made an allocation of 5910 MW of hybrid capacity.

- SECI had announced the highest auction of 2000 MW in January 2024, which was then followed by SJVN, NHPC and NTPC with 1500 MW each.
- GUVNL made the lowest bid of 500 MW. During this period, the tariffs ranged between INR2.99/ kWh and INR3.65/ kWh. The highest tariff was observed in Torrent power's auction.

In June 2024, 3200 MW of hybrid capacity was allotted to RE developers, and the tariff ranged between INR3.33/ kWh to INR3.46/kWh. In this, SJVN announced the auction for the highest capacity of 1500 MW, followed by SECI (1200 MW) and GUVNL (500 MW). The lowest tariff was observed in GUVNL's 500 MW wind-solar hybrid auction, where 50 MW was awarded to KPI Green Energy Limited at INR3.33/ kWh. Meanwhile, the highest tariff of INR3.46/kWh was seen in SECI's 1200 MW auction.

In July 2024, GERC has set tariffs for procuring 200 MW of hybrid power for PAN India projects. A tariff of INR2.99 per kWh for KPI Green Energy's 50 MW hybrid project and INR3.04 per kWh for Juniper Green Energy's 150 MW hybrid project has been approved by commission. It also granted GUVNL the authority to execute power purchase agreements with the developers[24].

Figure 15: Hybrid tenders successfully auctioned (Jan to Jun 2024)



Source: JMK Research, Mercom [*no hybrid tenders were successful for the May month]

In the solar and hybrid segment, the last six months have witnessed successful auctions and competitive tariff structure. Solar capacity generation has been on an upward trend in comparison to wind energy. Further, tariffs for BESS have seen a significant decline from INR10.84 lakh/MW/ month in the first SECI tender in August 2022 to INR4.49 lakh/MW/month in March 2024 and further to INR3.73 lakh/MW/month in June 2024. This indicates that, with advancing technologies and larger project scales, achieving cost competitiveness and lower tariffs in storage projects is possible[25].

24. Gujarat Commission Adopts Tariffs for 200 MW Wind-Solar Hybrid Projects (mercomindia.com)
25. ICRA report

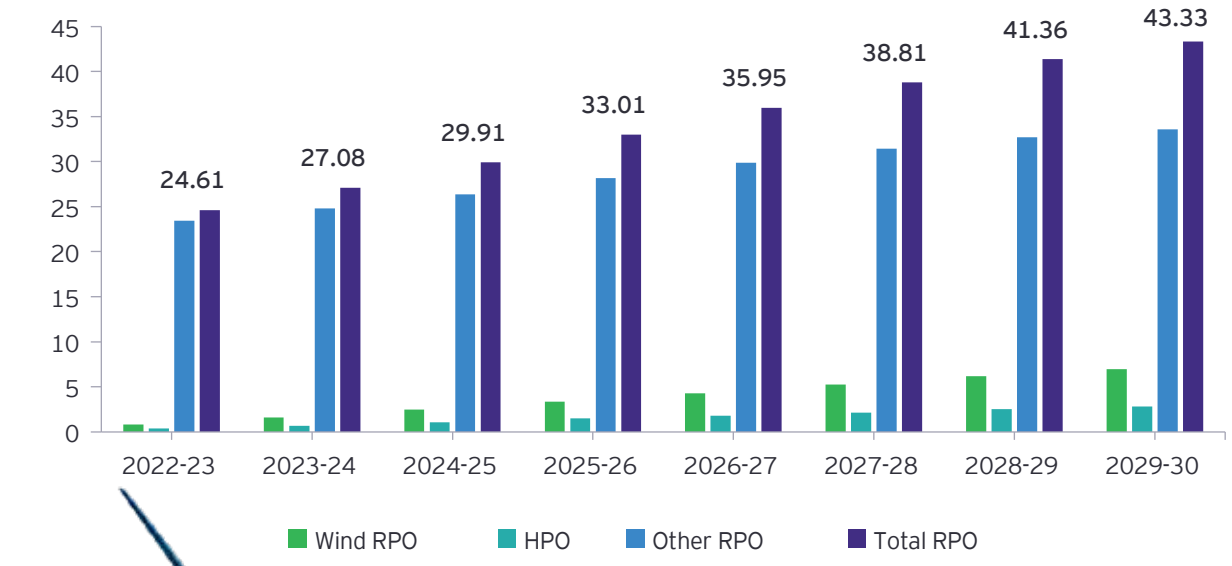
3.1.6 Role of Renewable Purchase Obligation (RPO) in accelerating India's energy transition

India has emerged as one of the leading countries globally in scaling up renewable-based electricity generation, specifically impressive in solar and wind categories. RPOs under the Electricity Act 2003, particularly for distribution companies, have been a key policy intervention for scaling up renewables, with the considerations of energy security and environmental aspects in view.

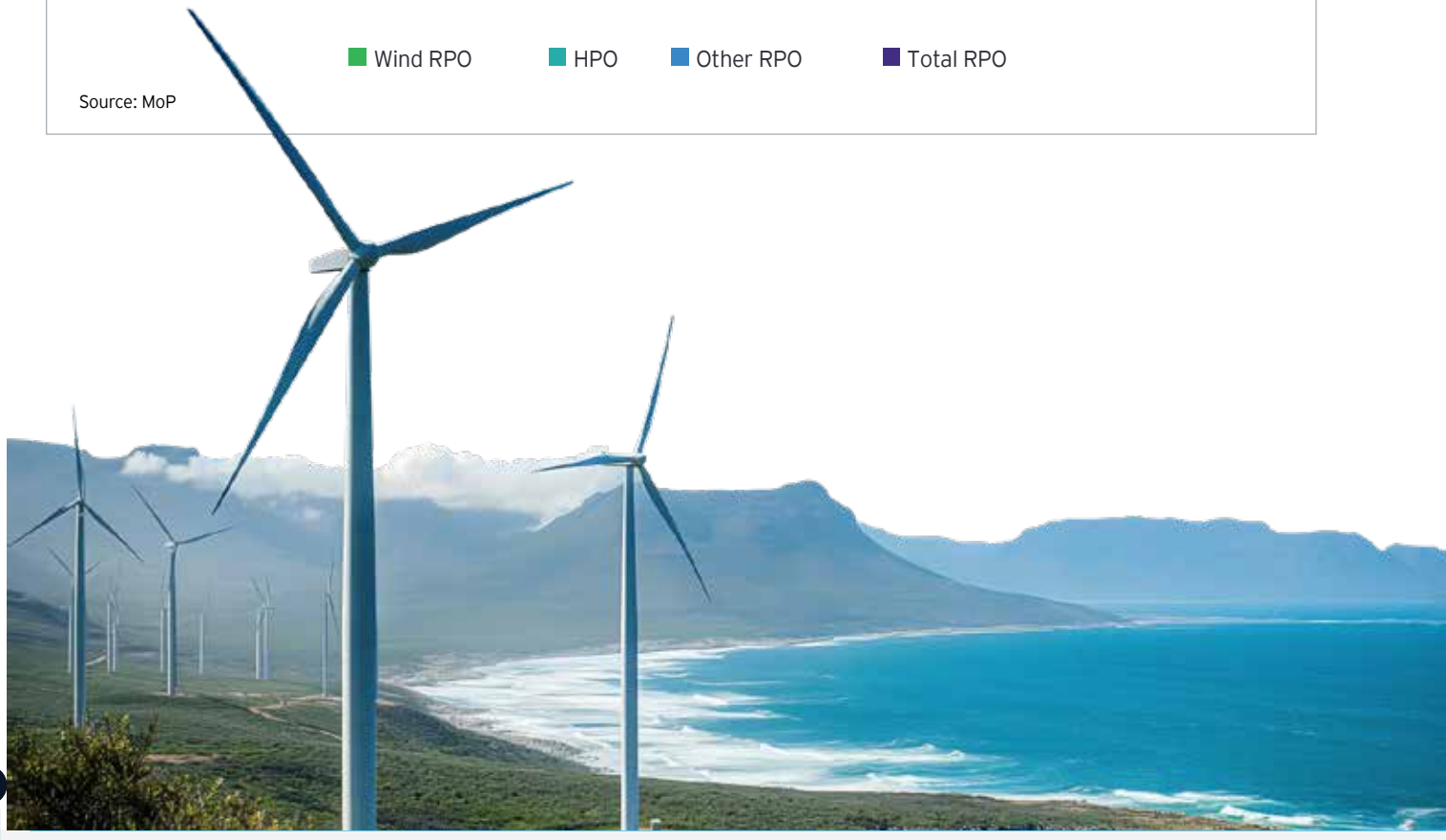
Renewable Purchase Obligation (RPO) mandates that all electricity distribution licensees should purchase or produce a minimum specified quantity of their requirements from RE sources. RPO targets have been pivotal in driving the installations of various RE projects. These targets are set by the government and are set to increase in the coming years (with special emphasis on solar and wind projects). Current targets set are:

- For 2024-25: 29.91% of total energy must come from RE sources
- 2029-30: target rises to 43.33% indicating a significant push towards a greener mix

Figure 16: RPO targets set by the government



Source: MoP



Solar power has experienced significant growth, driven primarily by favorable government policies and financial incentives. RPO mandates have spurred solar installations, pushing capacity to 84 GW. Additionally, the wind energy sector has also gained momentum due to RPO targets. States like Tamil Nadu, Gujarat, and Karnataka have effectively harnessed their wind power potential. Hydro power has emerged as another critical component of the renewable strategy. The emphasis on hydro power within the RPO framework ensures that stakeholders fully realize its potential while maintaining grid stability and enhancing storage solutions.

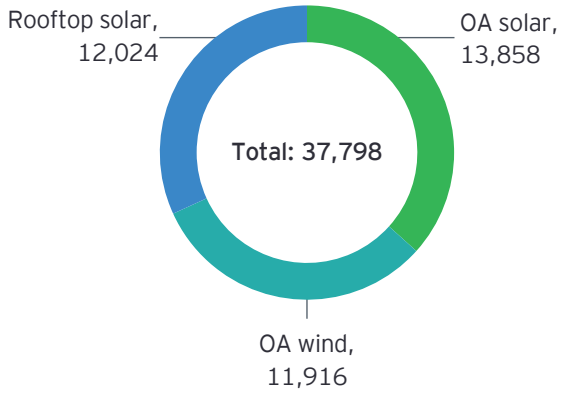
India's RPO targets are a critical driver of the country's renewable energy growth, influencing investment trends and of aligning government policies towards a sustainable energy future.

3.1.7 C&I customers and the future of renewable energy

In India, the commercial and industrial (C&I) segment accounts for 50% of the electricity demand, which underscores the requirement of transition to cleaner source to electricity to achieve their net zero. Before the enactment of the Electricity Act, 2003, the only source of supply to C&I customers was from local distribution companies. However, post Electricity Act, 2003 C&I segment of customers have an alternate to source power through various contracts and sources at affordable tariff. With the decreasing tariff of renewable energy source like solar and wind, in the last few years, there is significant growth in the corporate PPAs leveraging the options available in the market.

While the growing demand for renewable energy capacity addition by the C&I segment is exponential, the tariff competitiveness and strong sustainability/green initiatives played an important role in meeting their energy needs from renewable energy sources. According to a CRISIL report[26], India added 3 GW of corporate renewable energy capacity in the first quarter of 2024, which has seen a jump of 36% QoQ. The total corporate renewable energy capacity is estimated at approx. 37 GW. This capacity addition is attributed to the factors/policy support from the central and state governments like wavier in inter-state transmission charges, exemption of cross subsidy and additional surcharge in case of captive model, green initiatives through corporate net zero strategy, tariff competitiveness, etc.

Figure 17: Total corporate renewable capacity (in MW) by March 2024



Source: CRISIL- BRIDGE TO INDIA research

The C&I customer segment is also leading in adding more rooftop solar capacity, along with total additions in corporate PPAs. As a result, C&I customers are playing a key role leading in the development of renewable energy generation ecosystem.

26. India Corporate Renewable Brief | Q1 2024 - BRIDGE TO INDIA

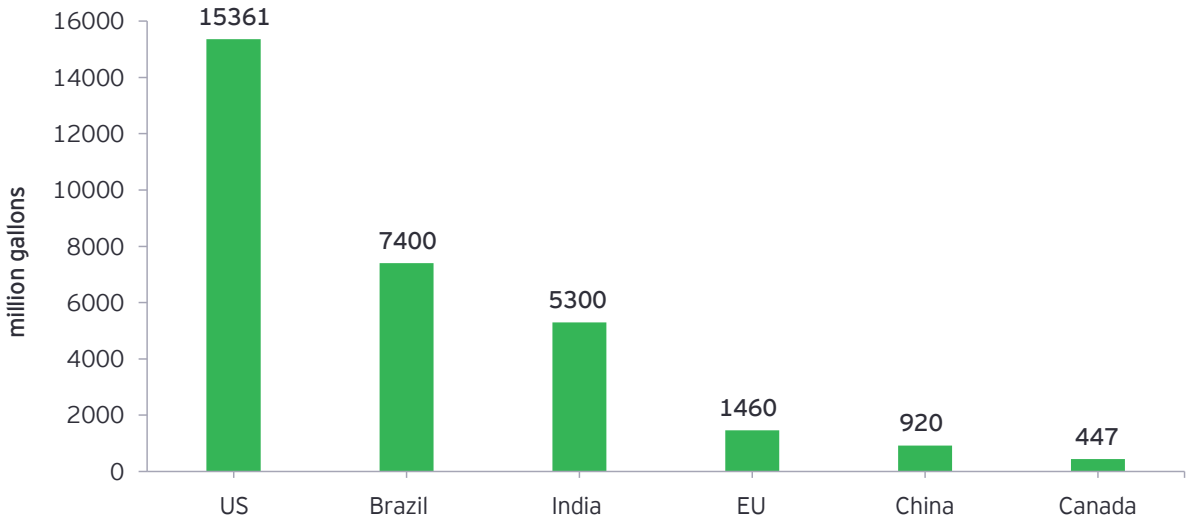
3.2 Promotion of biofuels

As countries embark on the journey to address the climate change crisis, biofuels emerge as a critical avenue for the decarbonization, offering a compelling proposition for developing and developed countries. India has also rapidly become a leading consumer and producer of biofuels, largely driven by rising transport fuel demand, robust government policies and abundant feedstock potential.

India is the world's third largest producer of ethanol after US and Brazil. Developing countries like Brazil, Indonesia and India have witnessed rapid growth in biofuel production, mainly due to robust gasoline and diesel demand. On the contrary, developed economies like US, EU have witnessed growth supported by strong policies to meet bio jet fuel demand[27].

> Energy transition is a key element for a sustainable future of the chemical industry. Chemical Industry has to succeed in the space of energy transition and find a sustainable solution that can be adopted across sectors. As a key contributor within the ecosystem, our industry is uniquely positioned to drive transition by reconfiguring its own processes and enabling sustainability across multiple sectors. We are undertaking this transition by embracing our commitment to environmental stewardship and our responsibility towards the communities we serve. By integrating renewable energy sources, investing in energy-efficient technologies, and advancing green chemistry solutions, our businesses are aligning with global sustainability goals. The chemical industry's innovation and influence across supply chains will help shape industries and enable progress, ensuring that the chemical sector remains a vital force in building a greener and more sustainable world.
>
> **R. Mukundan**
> Managing Director and Chief Executive Officer, TATA Chemicals

Figure 18: India ranks third in global ethanol production (as of 2022)



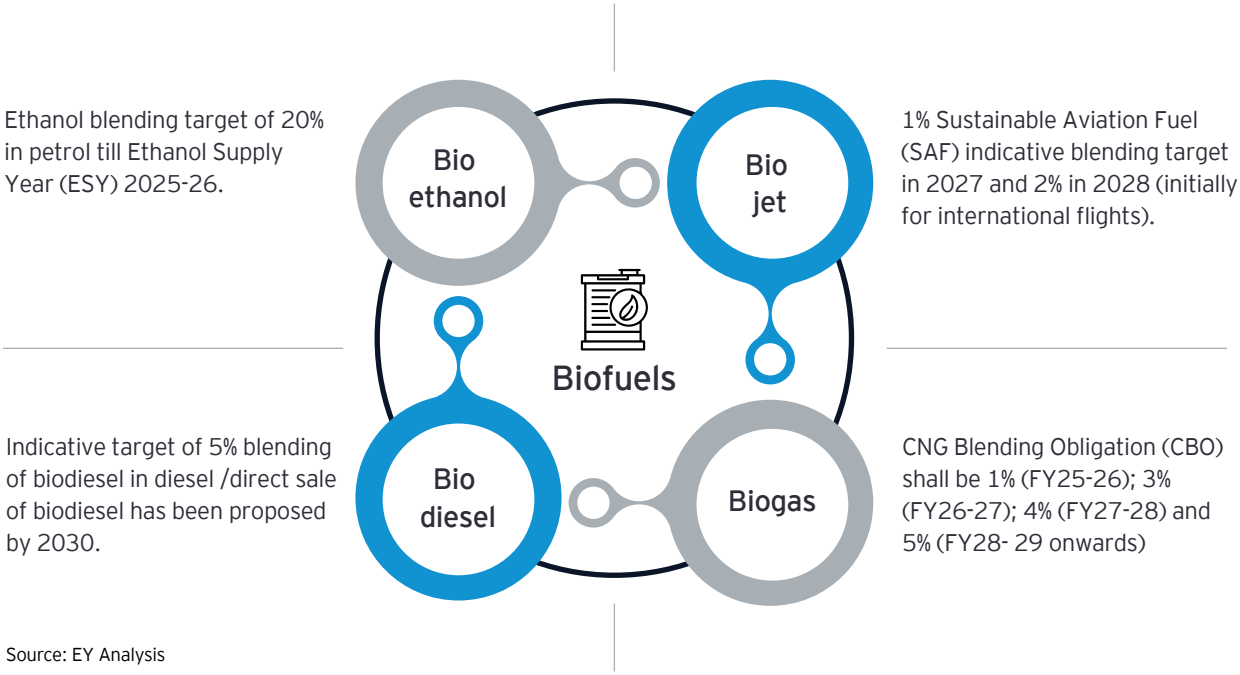
Source: DOE, US

27. *20230203_Biofuel_Study.pdf (powermin.gov.in)

To expedite the energy transition and balance energy security with emissions reduction, India has been actively promoting the use of biofuels as an alternative source of energy. Biofuels come in various forms, but in India, the two primary types are bioethanol and biodiesel.

The Government of India has set a target to increase the share of gas in the energy mix by up to 15% in 2030 to make India a gas-based economy. Based on consumption, India relies on imports for approximately 47% of its natural gas. However, the integration of biogas could enhance the viability and sustainability of this transition. Biogas has multiple benefits, including reduced dependency on fossil fuel imports, lower emissions compared to natural gas, decreased agricultural residue burning and an additional revenue source for farmers.

Figure 19: Categorization of major biofuels and targets as set by the government



Source: EY Analysis

3.2.1 The policy landscape of biofuels

The policy landscape in India focuses primarily on the promotion of ethanol production and the use of biodiesel. The government has introduced several policies and schemes, providing various demand side incentives, further encouraging the development and deployment of biofuel production units in the country.

1. National Policy on Biofuels, 2018

The policy was introduced in 2018, with the objective of setting blending targets for ethanol (20% blending by 2030) and biodiesel (5% by 2030). However, with advancements in the field of biofuel, the National Biofuel Coordination Committee (NBCC) had issued an amendment, in 2022, to the principal policy which allowed:[28]

- Oil companies to sell Ethanol Blended Petrol (EBP) with percentage of ethanol up to 20% throughout the country from 1 April 2023.
- Inclusion of new domestic raw materials that can be used for production of biofuels.
  - Bioethanol: C-heavy molasses, industrial waste and industrial waste off-gases
  - Biodiesel: Short gestation of non-edible oil rich crops
- Import of feedstock for the production of biodiesel has been permitted to the extent necessary (depending upon the availability of domestic feedstock).
- Production of biofuels by units located in SEZ/ EoUs, import of feedstock for production of biofuels meant for export by them, will be allowed without any restriction.

28. Notification-15-06-2022-Amendments-in-NPB-2018.pdf (mopng.gov.in)

- Export of biofuels may be permitted under certain circumstances:
  - When there is a surplus of biofuels in the country/ domestic requirement has been met.
  - In the case of exigencies/ calamities such as COVID, other medical requirements, etc.
  - When the price of biofuels (made from domestic feedstock) becomes high resulting in poor domestic sales.

2. Ethanol Interest Subvention Scheme

- Under this scheme, the government is facilitating entrepreneurs to set up new distilleries or the expansion of existing distilleries throughout the country.
- Interest subvention at 6% p.a. or 50% of ROI charged by banks/ financial institutions, whichever is lower, on the loans to be extended by banks/ financial institutions is being borne by the central government for five years including one-year moratorium.[29]
- Installation of new ethanol distilleries/expansion of existing ethanol distilleries has brought investment opportunities worth over INR40,000 crore (US$4.87 billion) in urban as well as rural areas.

3. Reduction in GST rate

To promote ethanol blending, the government has lowered the GST rate from 18% to 5% on ethanol meant for blending under the Ethanol Blended Petrol (EBP) Programme.

4. Pradhan Mantri JI-VAN Yojana

PM JI-VAN Yojana provides financial support to Integrated Bioethanol Projects using lignocellulosic (plant-based) biomass and other renewable feedstock.

The objective is to support 12 commercial scale and 10 demonstration scale projects with Viability Gap Funding and a total financial outlay of INR1969.50 crore for the period 2018- 19 to 2023-24.

- INR1800 crore for supporting 12 commercial projects.
- INR150 crore for supporting 10 demonstration projects.
- INR19.50 crore to union government for High Technology (CHT) as administrative charges.[30]

Since the commencement of the yojana, INR880 crore has been approved for six commercial projects and two demonstration projects.[31]

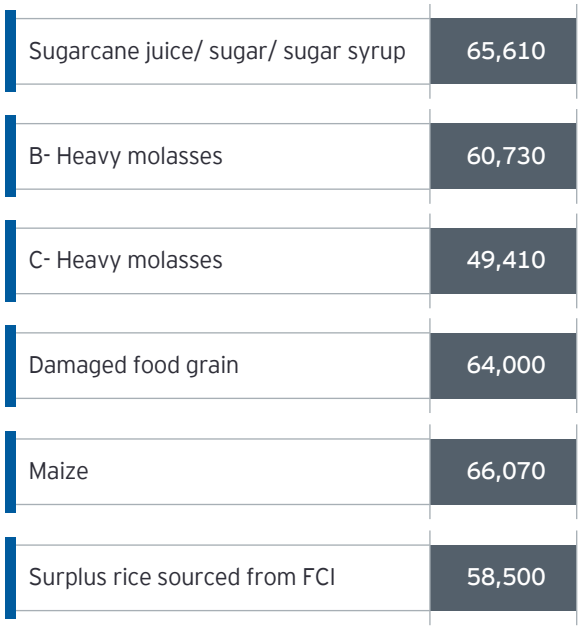
5. Pricing of ethanol

Besides setting blending targets, the Government of India has been notifying the administrative price of ethanol since 2014. Such administrative pricing will enable all distilleries to take benefit of the scheme and remunerative price to ethanol suppliers will help in early payment to cane farmers, in the process contributing to minimize the difficulty of sugarcane farmers.

Moreover, since a large quantity of ethanol is available right from the beginning of sugar season due to conversion of sugarcane juice and B heavy molasses to ethanol, it has been decided to redefine Ethanol Supply Year as a period of ethanol supply from 1st November of a year to 31 October of the following year from 1 November 2023 onwards.

Following are the prices (INR/ thousand liters) for the period 1 November 2023 to 31 October 2024[32]:

Figure 20: Ethanol prices for the period November 2023 to Oct 2024



Source: EY Analysis

29. Scheme_for_extending_financial_assistance_to_project_proponents_for_enhancement_of_their_ethanol_distillation_capacity_or_to_set_up_distilleries_for_producing_1st_Generation_ethanol.pdf (mopng.gov.in)
30. Microsoft Word - 1498 GI (mopng.gov.in)
31. pib.gov.in/PressReleaseIframePage.aspx?PRID=1947504
32. Pricing Methodology | Ethanol for India

On comparing the ethanol prices of ESY 2023-24 with ESY 2022-23, we can observe[33]:

- Prices from C- heavy molasses route prices have increased from INR46.66 per liter to INR49.41 per liter.
- Prices from B- heavy molasses route prices have increased from INR59.08 per liter to INR60.73 per liter.
- Prices from Sugarcane juice/sugar/sugar syrup route be increased from INR.63.45 per liter to INR.65.61 per liter.

3.2.2 Economic impact of biofuel policies

Implementation of government policies and schemes has led to a positive impact:[34]

- Supply of ethanol to oil marketing companies has increased by more than 13 times, from 38 crore liters in ESY 2013-14 to about 502 crore liters in ESY 2022-23.
- Blending percentage has also increased from 1.53% in ESY 2013-14 to targeted 12% in ESY 2022-23. Moreover, ethanol production capacity increased more than 2.5 times and the number of distilleries has also increased by 66% in eight years.
- Through the sale of ethanol, the cash flows for sugar mills have improved, resulting in prompt payment to cane farmers. Sugar mills have cleared 98.3% of cane dues of farmers in sugar season (SS) 2022-23 and 99.9% of cane dues in previous SS 2021-22. In the last 10 years, revenue earned by sugar mills is more than INR94,000 crore (US$11.46 billion) from sale of ethanol.
- Ethanol production has led to a reduction in the import of petrol or crude oil, which has resulted in a saving of foreign exchange for India. In 2022-23, with production of about 502 crore liters of ethanol, India has saved about INR24,300 crore of foreign exchange and improved India's energy security.
- 1 crore liter of ethanol blended petrol can save around 20,000 tons of carbon dioxide (CO_2) emission. Greenhouse gas emissions due to the EBP Programme lowered by 192 lakh tons from 2014 to 2021 (up to July 2021).
- These policies have also led to the initiation of pilot projects using bio jet fuel. On 25 November 2023, Ministry of Petroleum and Natural Gas (MoPNG) announced indicative blending targets of 1% by 2027 and 2% by 2028 for international flights leaving India.[35]

33. Press Information Bureau (pib.gov.in)
34. Press Information Bureau (pib.gov.in)
35. pib.gov.in/PressReleaseIframePage.aspx?PRID=1979705

Agriculture and energy security

India is a nation richly endowed with vast agricultural resources. The use of food crops already present in an agricultural economy has helped in speeding the development of the biofuels industry. For instance, in Brazil, sugar-based ethanol plants were able to co-locate with sugar production. This gives the ability to switch between sugar and ethanol production, based on whichever market offers the best price.

Despite this, a significant portion of agricultural residue and organic waste remains underutilized in the country. Using food waste for biofuel provides an opportunity to recover energy from unused resources, which would otherwise contribute to GHG emissions. Efforts have also been made by the government to include use of industrial and plastic waste for the production of advanced biofuels, further broadening the spectrum of raw materials for biofuel production.

Biofuels represent a sustainable and cleaner energy choice, effectively repurposing agricultural and municipal waste. As per the World Bank estimates, nearly 2 billion tons of municipal waste is generated globally each year, of which at least 33% is not managed in a safe manner.[37] Harnessing these abundant resources for production of biofuel will not only help in reducing waste but also create 'Waste to wealth' and empower rural communities with new revenue streams.

The main purpose is to foster a circular economy, empowering agriculture, strengthening local communities, addressing environmental issues and make sustainability a reality. By leveraging agricultural residue and municipal waste for biofuel production, the country can present a valuable opportunity for energy recovery from resources.

3.3 Promotion of Electric Vehicles (EVs)

Transport sector in India contributes 18% of the total GHG emission with the road transportation segment alone accounting for 87% of these emissions. More than 45% of emissions from road transport in India are from trucks. This translates into 94 million tons of oil equivalent energy[38]. If the current consumption trend continues, India will need approximately 200 million tons of oil equivalent of energy supply annually by 2030 to meet the demands of the transportation.

3.3.1 The growing EV ecosystem in India

In 2020, India had about 246 registered motor vehicles per 1000 people[39]. In this context, it is paramount for India to adopt more sustainable transportation options like Electric Vehicles (EVs) to not only limit carbon emissions but also to reduce crude oil dependence.

While electric vehicles can have high upfront costs, they offer significant savings in terms of running and maintenance expenses. They come with zero or ultra-low tailpipe emissions of local air pollutants. From an efficiency perspective, EVs can covert around 60% of the electrical energy from the grid to power the wheels, but petrol or diesel cars can only convert 17% to 21% of the energy stored in the fuel to the wheels.[40]

The growth of the EV ecosystem in India, therefore, has a significant potential to accentuate India's economic growth along low-carbon pathways, thereby facilitating its net zero vision of 2070. The Council of Energy, Environment, and Water (CEEW) suggests that continued adoption of EVs could enable India to achieve an 18% reduction in CO_2 emissions and save up to US$14 billion in crude oil imports by 2030[41].

37. How to cut emissions from waste by as much as 84% | World Economic Forum (weforum.org)
38. Bureau of Energy Efficiency
39. Statistia
40. Accelerated e-Mobility Revolution for India's Transportation (e-AMRIT) portal, Government of India
41. CEEW (2020), Can Electric Mobility Support India's Sustainable Economic Recovery Post COVID-19?

Figure 21: Expected benefits from EV adoption in India

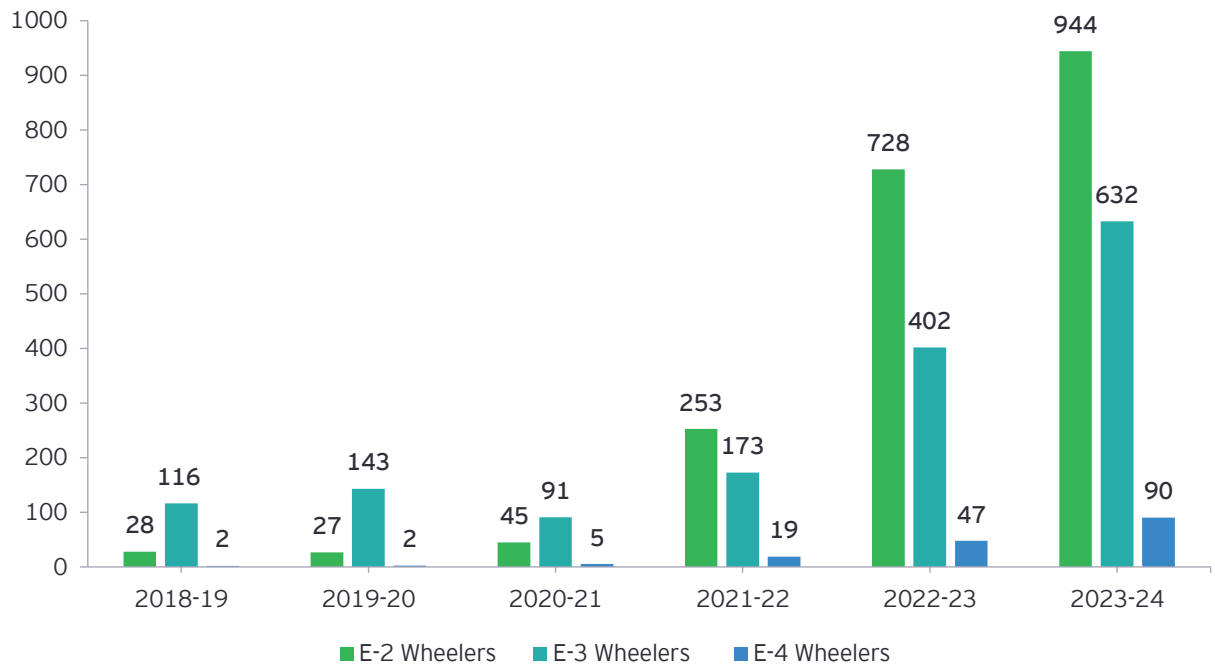
Continued adoption of EVs (30% share in total sales by 2030) can help India achieve the following. This is relative to the business-as-usual scenario by 2030

1. Saving of crude oil imports worth INR1.07 lakh crore (~ US$14.1 billion)
2. 17% decrease in particulate matter
3. 18% reduction in CO_2 emissions
4. 4% reduction in GHG emissions

Source: EY analysis

India is already in the middle of a transformative move towards sustainable transportation. With the government's continuing focus on bolstering EV ecosystem, adoption of EVs in India is getting stronger by the day. It is evident from the robust growth in EV sales across all segments in India in the last few years.

Figure 22: EV sales in India ('000 units)



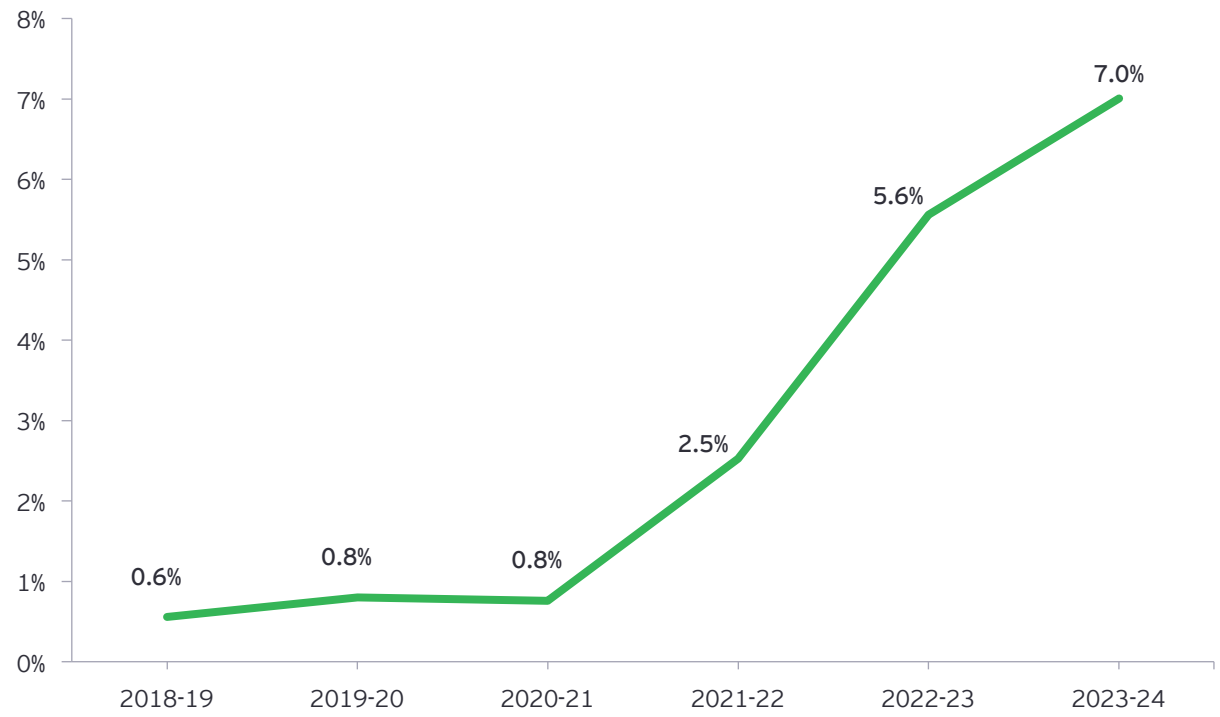
Source: Society of Manufacturers of Electric Vehicles

Sales have continued to be robust in all segments, with the E-2 Wheeler segment standing out for its remarkable exponential growth in recent years. The E-2 Wheeler sales have grown from about 28,000 units in 2018-19 to 944,000 units in 2023-24 (CAGR of 102%). The growing demand for E-2 wheelers is attributable to their relatively lower cost of ownership (the cost per km for an electric scooter is approximately INR0.3/km, considerably lower the cost of INR1.8-2/km for an internal combustion (ICE) motor-based scooter[42]). At present, this particular segment holds the majority share (57%) in India's total electric vehicle sales.

E-3 Wheeler sales have also witnessed a robust growth in the last few years, with the sales rising from approximately 2,000 units in 2018-19 to 632,000 in 2023-24 (CAGR of 216%) which is attributed to the adoption of e-commerce segment for their local logistics. However, the adoption of E-4 wheelers remains relatively subdued. This is attributable to high capital costs and lack of adequate charging infrastructure, which causes 'range anxiety'— fear that the EV will not have sufficient charge to complete a long journey.

The growing share of electric vehicles in India's total auto sales highlights the country's shift towards electric mobility, with EV sales surging from around 0.8% in 2020-21 to 7% in 2023-24. However, this figure remains well below the global average of 18%. The government aims to increase EVs' share in overall vehicle sales to 30% by 2030.[43]

Figure 23: Share of EVs in total auto sales in India (in %)



Source: Society of Manufacturers of Electric Vehicles (for EV sales) and Society of Indian Automobile Manufacturers for total Auto Sales
Note: Total EV sales include sale of E-2 Wheelers, E-3 Wheelers, E-4 Wheelers, and e-buses. Total auto-sales include sale of passenger vehicles, commercial vehicles, two-wheelers, three wheelers, and quadricycle.

42. Economic Times (Jan 2024) " 7 reasons why Electric 2 Wheelers are Popular."
43. PIB

3.3.2 EV charging infrastructure

In order to achieve the goal of 30% share of EVs in total auto sales by 2030, India's EV charging infrastructure requires due attention. Currently, India has only one charging station per 135 EVs. This is much lower than the global average of one charging station per six to 20 electric vehicles[44]. EV owners often feel anxious about the limited availability of charging stations, especially when planning long trips.

If the present state of charging infrastructure continues, India may fall behind its 2030 EV target by 40%. Therefore, to enable continued adoption of EVs, it is pertinent that India enhances its charging infrastructure. BEE expects the number of public charging stations to grow from 5,234 to 46,397 by 2030[45].

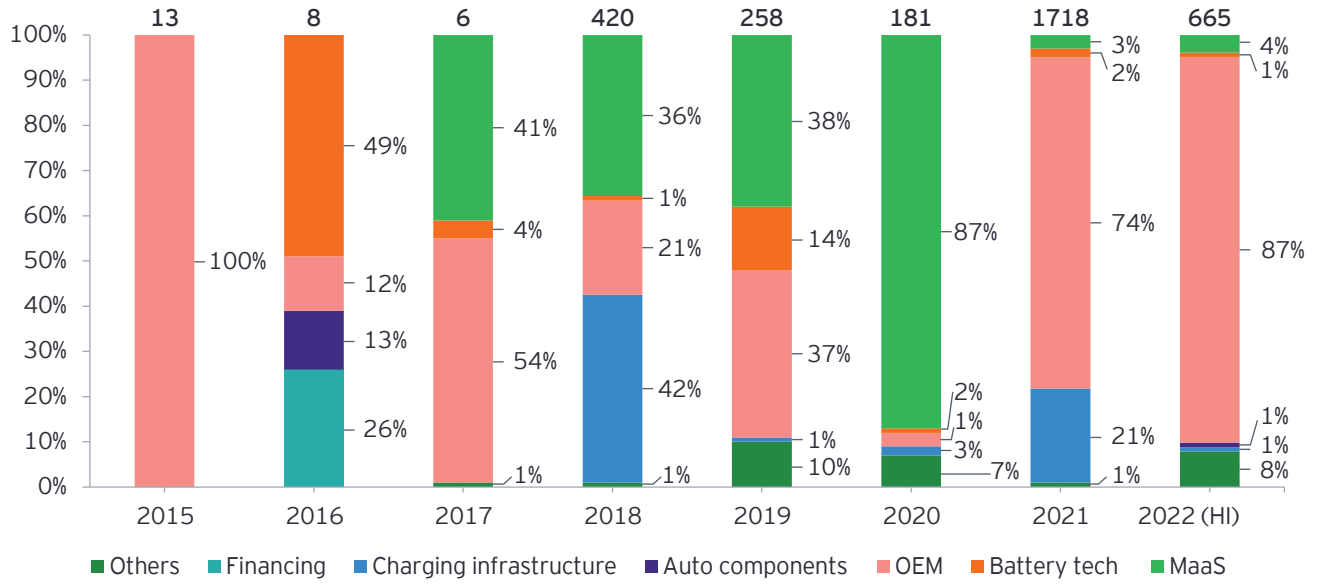
> "At Indian Hotels Company Limited (IHCL), we are committed to advancing the energy transition through our sustainability framework, Paathya. This initiative focuses on integrating environmental, social, and governance principles into our operations. Our efforts in energy transition include investing in renewable energy, achieving EarthCheck Certification, and installing electric vehicle (EV) charging stations across our properties. We are also implementing innovative cooling technologies with IFC's TechEmerge program and replacing plastic water bottles with reusable glass bottles. Our dedication extends to community engagement with skill centers across India, fostering talent in hospitality. By aligning with global sustainability standards, IHCL is setting new benchmarks in the industry and contributing to a greener, more sustainable future while providing exceptional guest experiences.
>
> **Beejal Desai**
> Company Secretary and Legal, Indian Hotels

3.3.3 Investments in the Indian EV space

The EV industry in India garnered US$3.6 billion worth of investments in FY2023 from over 250 businesses. The sector has also attracted robust foreign investments, registering a cumulative FDI inflow of US$32.8 billion during 2000-2022. Approximately 20% (US$6 billion) of these inflows were in 2021. India's growing EV market is also strengthening the start-up ecosystem. In 2022, EV start-ups in India raised over US$1.6 billion, up from US$1.3 billion in 2021[46]. The entire electric mobility value chain in India has witnessed significant PE/VC investments in the last few years.

44. Bolt.Earth
45. Economic Times (May 2024) "Powering ahead: The role of renewable energy in electric vehicle charging infrastructure"
46. USAID and Invest India (March 2023) "INVESTMENT LANDSCAPE OF INDIAN E-MOBILITY MARKET"

Figure 24: PE/VC investments in electric mobility chain (US$ million)



Source: EY Analysis

Several global and Indian players are showing investment intent in India's EV ecosystem:

Clean Motion: In June 2024, Clean Motion, a Swedish company, has planned an investment of US$1 million through its Indian subsidiary Clean Mobility Solution India Pvt. Ltd. to set up a dedicated manufacturing facility in Pune[47].

JSW-Shell India: JSW MG Motors has tied up with Shell India to enhance public EV charging infrastructure in India. They plan to install 50kW and 60kW DC fast chargers across the country [48].

Ather: Ather Energy, leading Indian E-2W maker has plans to invest over INR2,000 crore to set up a manufacturing unit in

47. Business Today (June 2024), "Clean Motion charges into India's EV market with $1 million investment and Make in India plans"
48. Economic Times (July 2024)" JSW MG Motor joins hands with Shell for EV charging infra"
49. LiveMint (June 2024) "Ather Energy to invest 2,000 crore to set up third plant in Maharashtra"
50. Business Standard (Jan 2024) "Tata Motors to commence EV production at Sanand plant from April 2024"

Aurangabad Industrial City, Maharashtra, to produce electric two-wheelers as well as battery packs. The company already has two manufacturing units in Hosur, Tamil Nadu. [49]

Tata Motors: Tata Motors, the leading passenger and electric vehicle player in India, has commenced EV production at its new plant in Gujarat which it acquired from Ford Motors for INR725 crore. [50]

Vinfast: Vietnamese automaker Vinfast has commenced the manufacturing of an EV plant in Tamil Nadu in April 2024. The company plans to invest INR4,000 crore over a five-year period in the facility.[51]

Ola Electric: Ola Electric, leading India EV player has signed an MOU with the Government of Tamil Nadu to set up a E-4W manufacturing plant as well as a 20GW battery manufacturing unit in Krishnagiri district with an expected investment of INR.7,614 crore[52].

Mahindra and Mahindra: India's automotive major has signed an MOU with the Government of Telangana to set up an EV manufacturing facility in Zaheerabad district with an expected investment of INR1,000 crore[53].

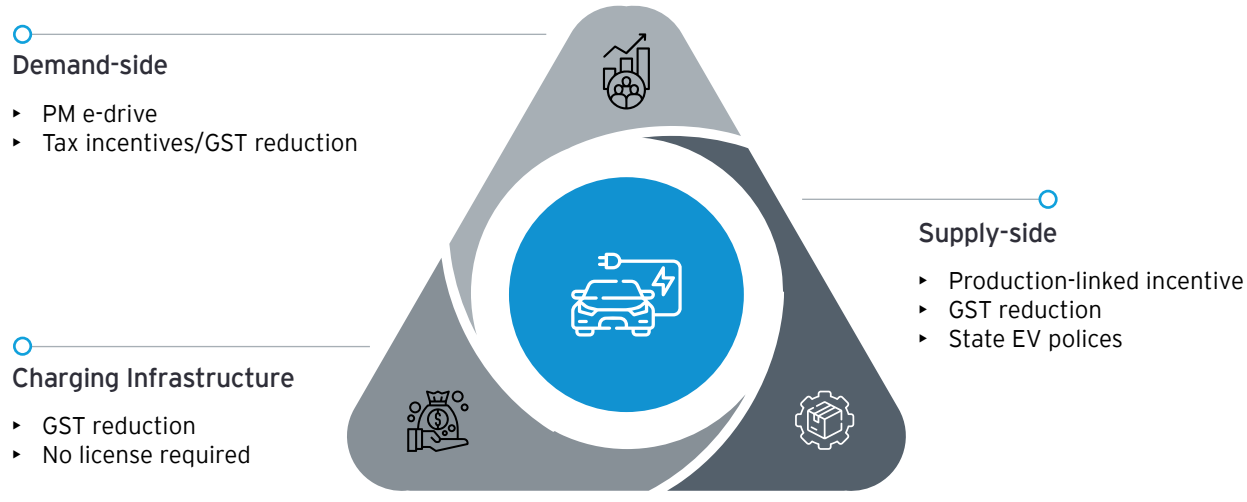
Bajaj Auto: One of India's leading 2-W and 3-W players, Bajaj Auto, has started its new EV manufacturing unit in Akurdi, Pune with an investment of INR300 crore. The unit can produce up to 500,000 E-2W per annum[54].

To achieve the 2030 goal of 30% share of EVs in total auto sales, significant investments are still required across the electric mobility value chain. CEEW estimates suggest that EV OEMs will require an investment of about US$178 billion. Within the OEM component of the value chain, the E-2 wheelers segment will require the largest investment (US$91 billion) followed by E-4 wheelers (US$74 billion). Furthermore, investments of US$12.3 billion and US$2.9 billion are required in the battery manufacturing and charging infrastructure ecosystem respectively[55].

3.3.4 Government policy measures to support EV ecosystem in India

In order to spruce up EV adoption in India, the government has taken several progressive steps on both demand and supply side, aiming to fortify and broaden the landscape for EVs.

Figure 25: Key incentives for EV adoption in India



Source: EY analysis, PIB

51. Vinfast
52. Business Standard (Feb 2023) "Ola to invest INR7,614 cr in TN to make electric cars, lithium-ion cells"
53. Economic Times (Feb, 2023) "Mahindra to set up EV manufacturing facility in Telangana"
54. Bajaj Auto
55. CEEW (December 2020) "Financing India's Transition to EVs"

Demand-side schemes

1. Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India (FAME India):

The main objective of the FAME scheme is to encourage faster adoption of electric and hybrid vehicle by offering upfront Incentives on purchase of Electric vehicles and also by establishing a necessary charging Infrastructure for electric vehicles.

The Department of Heavy Industry launched the first phase of the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India (FAME-I) scheme on 1 April 2015, and it remained in effect until 31 March 2019. This phase had a total budget of INR895 crore, aimed at promoting electric and hybrid vehicle technology across the country. The scheme had four focus areas i.e., technology development, demand creation, pilot projects, and charging infrastructure. The demand incentive was in the form of an upfront reduced purchase price for the buyers to enable wider adoption. Further, specific projects under Pilot Projects, R&D/Technology Development and Public Charging Infrastructure components were approved to enable the development of holistic EV ecosystem in India.

By the end of Phase-1 of the scheme[56]:

- Sale of 2.8 lakh hybrid and electric vehicles was supported by way of demand incentive amounting to about INR359 crore.
- 520 Charging Stations/ Infrastructure projects worth INR43 crore (approx.) were also sanctioned.
- Projects worth about INR158 crore were sanctioned for the technology development projects such as establishment of testing infrastructure, setting up of 'Centre of Excellence' for advanced research in electrified transportation, battery engineering, etc.

The Phase-2 of the FAME scheme (FAME-II) was in play from 1 April 2019 to 31 March 2024, with a total outlay of INR11,500 crore. Continuing from the objectives of the FAME-I scheme, FAME-II planned to support 10 lakh E-2Wheelers, 5 lakh E-3Wheelers, 55000 E-4Wheelers, and 7090 E-Buses[57]. Under FAME-II, over 16.9 lakh EVs were sold[58]. The government extended the FAME-II scheme further and launched it as the Electric Mobility Promotion Scheme 2024 for a period of four months, w.e.f. 1 April 2024 till 30 September 2024 with an outlay of INR778 crore[59].

The Indian government has recently introduced the PM E-DRIVE Scheme, allocating INR10,900 crore (US$1.3 billion) over two years to promote the adoption of electric vehicles such as e-2Ws, e-3Ws, e-ambulances, e-trucks, and other emerging EVs. Out of this total outlay, the government will provide demand-side incentives worth INR3,679 crore (US$448 million), and it has allocated another INR4,391 crore for state transport units and public transport agencies to procure 14,028 e-buses.

The scheme addresses range anxiety concern by promoting a big way of installation of electric vehicle public charging stations (EVPCS). Under EVPCS, it proposes the installation of 22,100 fast chargers for e-4 Ws, 1800 fast chargers for e-buses and 48,400 fast chargers for e-2W/3Ws. The outlay for EV PCS will be INR2,000 crore.

2. GST reduction on EV purchases

On 1 August 2019, the government slashed Goods and Services Tax (GST) rate on EVs from 12% to 5% to propel demand for EVs in the country.

3. Income tax deduction for purchase of EVs

Presently, under section 80EEB of the Income Tax Act, a deduction is available for interest on loans sanctioned between 1st April 2019 to 31st March 2023 for the purchase of an EV. The amount of this deduction shall not exceed INR1.5 lakh. This tax-saving mechanism seeks to promote greater EV adoption.

Supply-side schemes

1. Production-linked incentives (PLI)

PLI for automobile and auto components was launched in September 2021 for a period of five years (2022-23 to 2026-27) with an outlay of almost INR26,000 crore. The focus of this scheme is on Advanced Automotive Technology (AAT) Products and Zero Emission Vehicles (ZEVs) i.e.,

56. PIB
57. PIB
58. FAME-II Dashboard
59. PIB Press Release dated 26th July 2024

Battery Electric Vehicle and Hydrogen Fuel Cell Vehicles to promote clean mobility[60]. As of 31 December 2023, the scheme has attracted close to INR67,700 crore of proposed investment from 85 applicants, including players like Tata Motors, Mahindra and Mahindra, Ola Electric, etc.[61]

2. GST reduction for lithium-ion batteries

In August 2022, the government reduced the GST rate on lithium-ion batteries from 28% to 18% with the aim of lowering the cost of production of EVs and boosting domestic manufacturing.

3. E-vehicle policy

In March 2024, the government approved the e-vehicle policy with the objective of spurring investments into the Indian EV space. The companies that set up manufacturing units with a minimum investment outlay of US$500 million will be allowed to import a limited number of cars at lower customs/import duty of 15% on vehicles costing US$35,000 or above for five years. Such companies must set up and start a facility within three years from the date of approval and reach 50% domestic value addition within five years[62].

4. State EV policies

28 Indian states have notified their respective EV policies, offering several incentives for EV adoption, such as subsidies, investment incentives, tax concessions, etc. Few examples are:

- Delhi's EV policy offers a purchase incentive of INR5000/ kWh of battery capacity (max up to INR30,000/ vehicle) for E-2 wheelers.
- Uttar Pradesh's policy offers EV registration and road tax exemptions to buyers.
- Gujarat provides a 25% capital subsidy (up to INR10 lakh / station) for the first 250 commercial public charging stations63

5. Charging infrastructure

- GST reduction: The government has reduced GST rates on charger or charging stations for electric vehicles from 18% to 5%.[64]
- No license requirements: Charging stations do not need a separate license under the Electricity Act of 2003 to operate.[65] This enables faster development of charging infrastructure.

3.4 Supply chain development for renewables

India's energy transition goals are intricately linked to the robustness of its supply chains for renewables. In a volatile global landscape characterized by adverse climatic shocks and geopolitical concentration of key input materials, the significance of a resilient and adaptable supply chain is paramount. In this context, having robust supply chains is imperative to make shield domestic manufacturing from geopolitical supply chain fragilities and make renewable energy generation in India cost competitive.

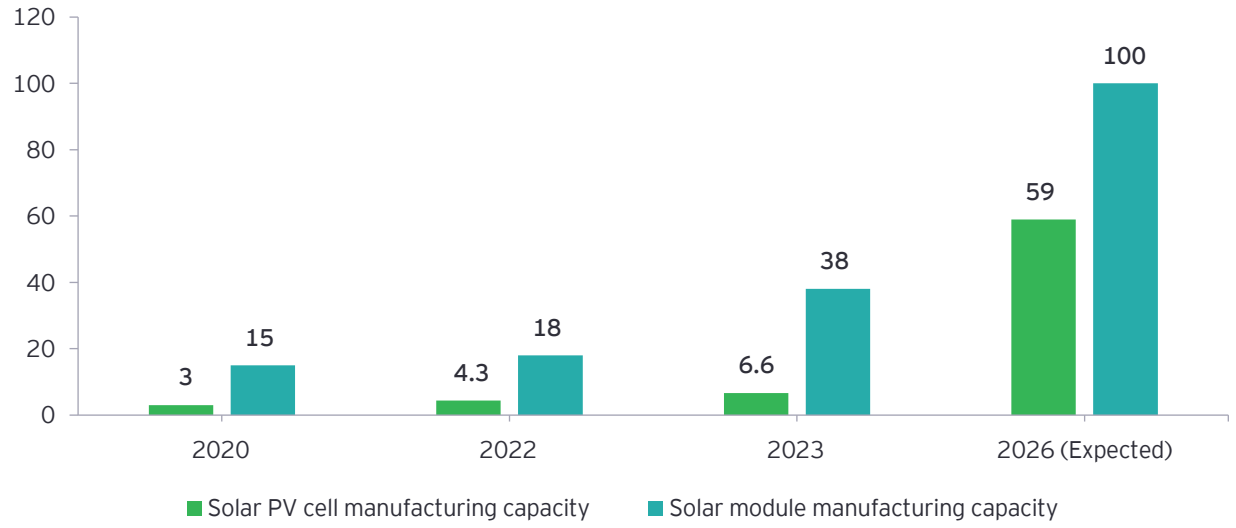
3.4.1 Solar energy

Solar energy is expected to play a significant role in India's energy transition goals. Out of the targeted 500 GW of RE installations by 2030, 280 GW to 300 GW is expected to be contributed from solar installations[66]. Therefore, to continue growth of solar energy in India, it is imperative to secure solar energy supply chains.

With the government's continuing focus on solar power sector, in recent years, India's manufacturing capacity of solar PV cells and solar panels has grown significantly at a CAGR of 26% from 2020 to 2023.

60. Ministry of Heavy Industries
61. PIB
62. PIB Press Release dated 15th March 2024
63. BEE state EV Policies
64. PIB Press Release dated 27th July, 2019
65. The Hindu Business Line (December 2021) "EV charging stations don't need separate license under Electricity Act: Power Ministry"
66. EU-India Clean Energy and Climate Partnership, "PV SUPPLY CHAIN RESILIENCE & SUSTAINABILITY"

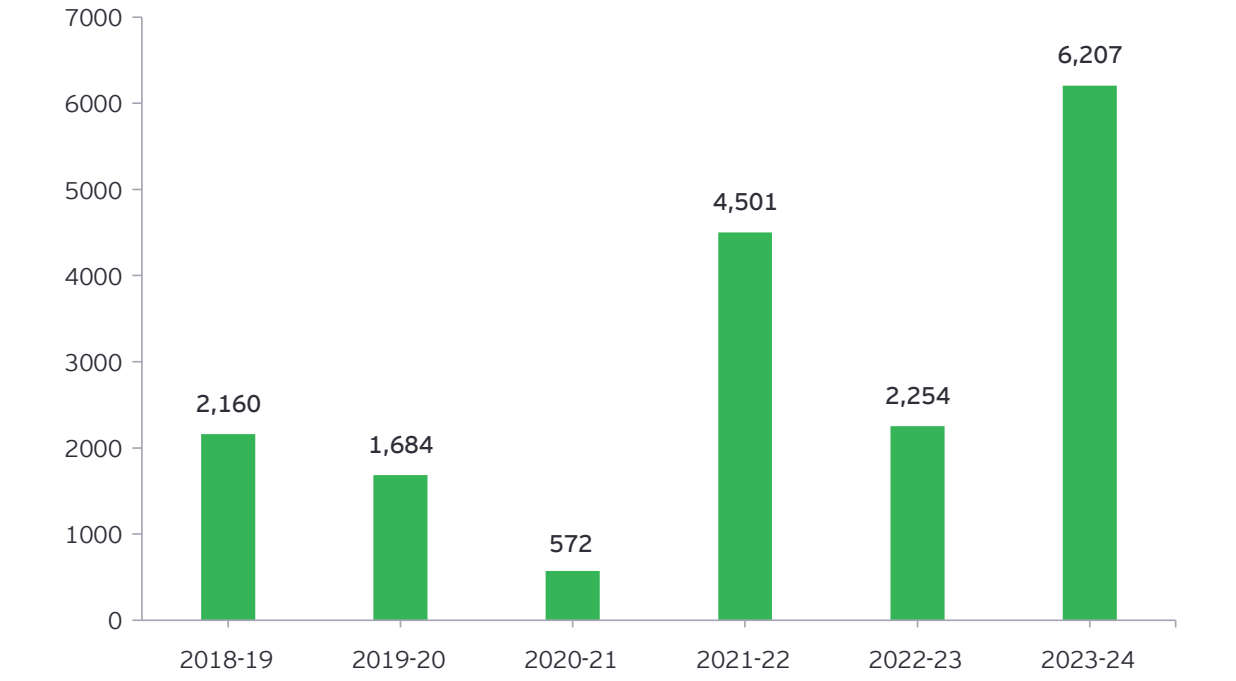
Figure 26: Domestic solar PV and solar panel capacity in India (GW)



Source: Grant Thorton Analysis

India's imports of solar PV cells and modules have been reducing in recent years. The sudden shift in imports in 2021-22 could be attributable to the implementation of ALMM order, which mandates the sourcing of solar modules from domestic manufacturers.

Figure 27: Imports of solar PV cells and modules (in US$ million)



Source: Grant Thorton Analysis

Despite improved domestic manufacturing, the solar energy sector is vulnerable to disruptions due to the concentration of its supply chains in primarily one country, China. The country alone accounts for 80% of global solar photovoltaic cell manufacturing and 70% of global solar module manufacturing. The supply chains may also be vulnerable to adverse climate shocks. For example, in 2020, floods led to the closure of four poly-silicon plants, resulting in an estimated 4% decline in annual production and contributing to price increase in 2020-2021[67]. Therefore, securing and diversifying supply chains is important for India to mitigate potential vulnerabilities, making domestic manufacturing competitive, and thereby expediting progress towards net zero objectives. The government is also cognizant of the importance of developing resilient solar supply chains and has taken several progressive steps in this direction:

1. Import restrictions to boost domestic manufacturing

With effect from 1 April 2022, the government has imposed a 40% BCD and 25% BCD on import of solar modules and solar cells respectively to encourage their domestic production[68].

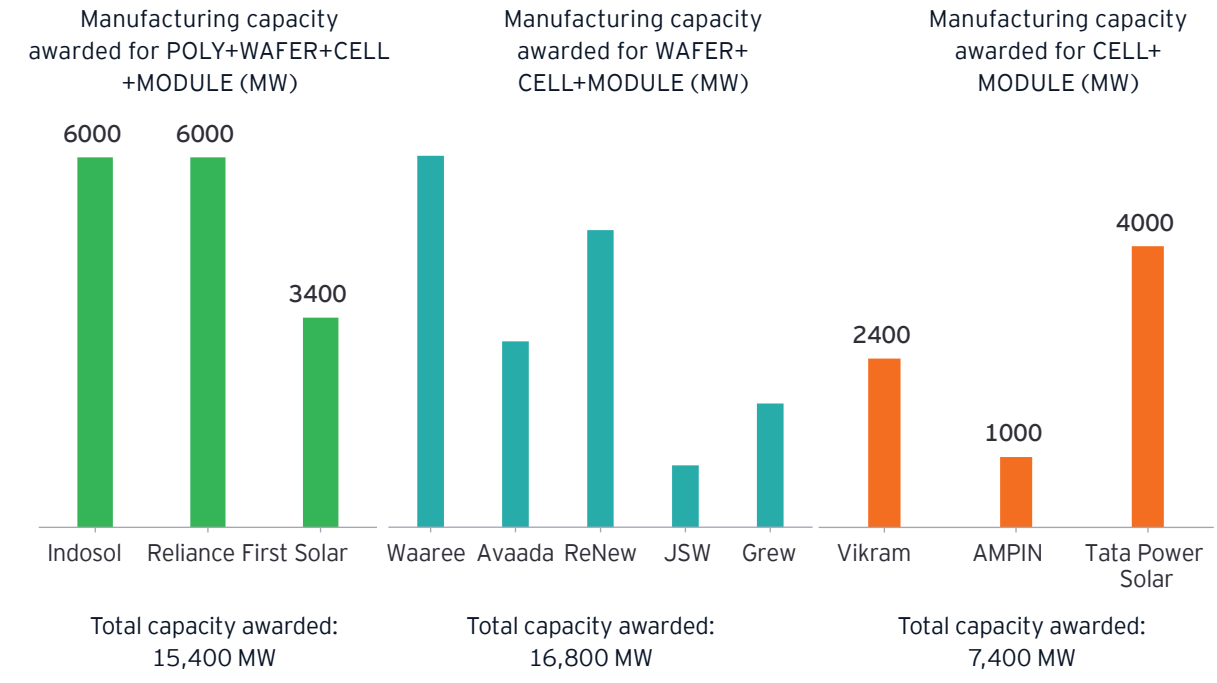
With effect from 2 February 2021, The Ministry of New and Renewable Energy (MNRE) has discontinued the benefit of concessional customs duty on items imported for setting up of solar power projects, such as machinery, equipment, alliances to incentivize deployment of domestically produced equipment for new projects[69].

2. Production-linked incentives

In 2021, the government announced the PLI scheme for high efficiency Solar PV Modules with an outlay of INR24,000 crore (INR4,500 crore for Tranche-I and INR19,500 crore for Tranche-II). Under Tranche -I, the government allocated a total of 8,737 MW capacity to three successful bidders, with an outlay of approximately 4,500 crore.

Under Tranche-II (announced on 30 September 2022) of the scheme, the government has allocated a total capacity of 39,600 MW of domestic Solar PV module manufacturing capacity to 11 companies, with a total outlay of INR14,007. The Tranche-II is expected to bring in an investment of INR93,041 crore[70].

Figure 28: Solar PV module manufacturing capacity under PLI



Source: PIB

67. EU-India Clean Energy and Climate Partnership, "PV SUPPLY CHAIN RESILIENCE & SUSTAINABILITY"
68. PIB Press Release Dated 28th March 2023
69. Ministry of New and Renewable Energy
70. PIB Press Release dated 28th March 2023

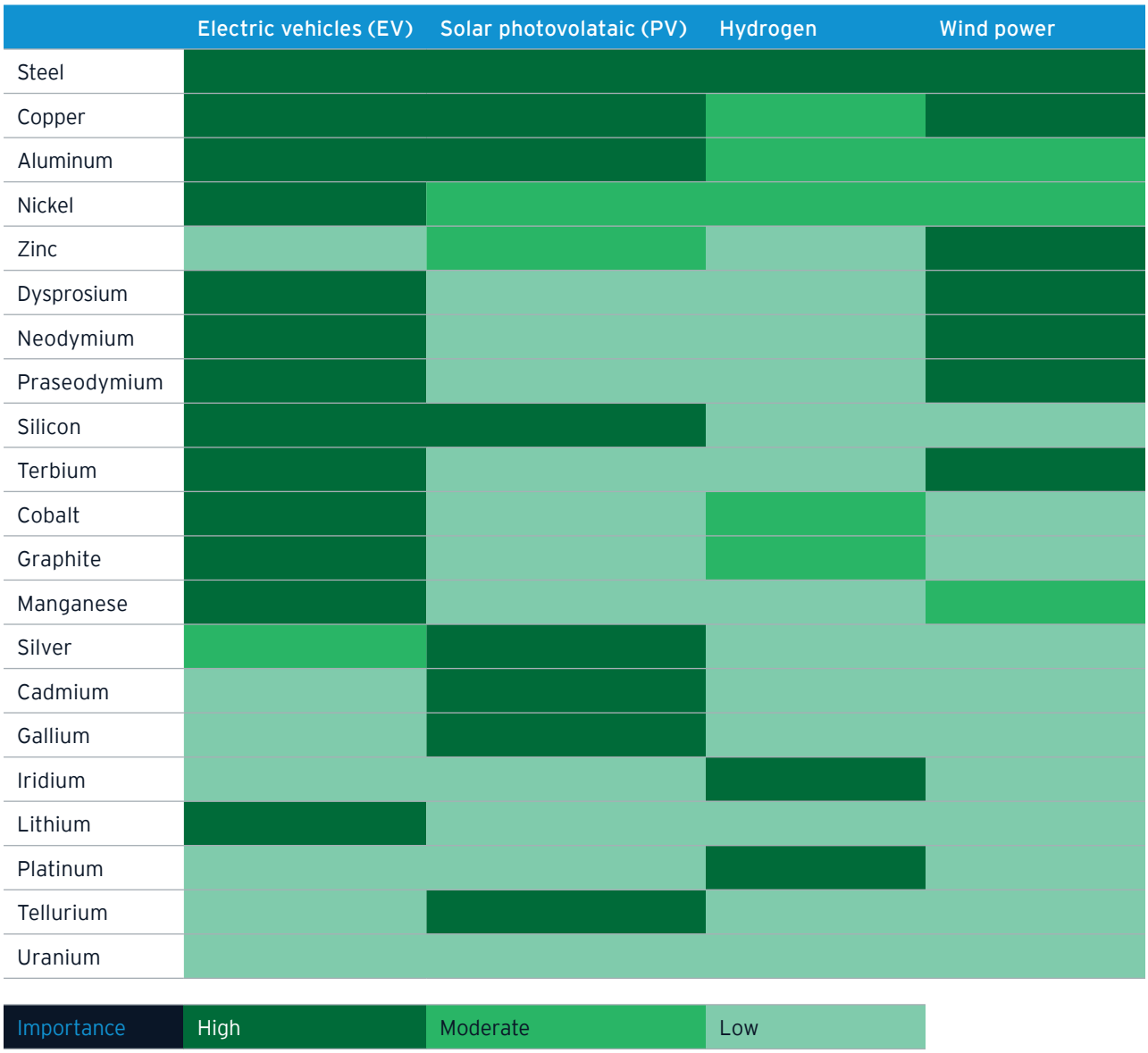
3.
Preference to Make in India in public procurement

Under this scheme, procurement and use of domestically manufactured solar PV modules and domestically manufactured solar inverters has been mandated for government/ government entities.

3.4.2 Critical minerals

Critical minerals such as lithium, nickel, cobalt and rare earth elements (REE) are crucial for manufacturing of renewable energy products such as batteries for EVs, solar PV panels, wind turbines, etc. The demand for these minerals is expected to grow at least 30 times by 2040.[71]

Figure 29: Importance of critical minerals

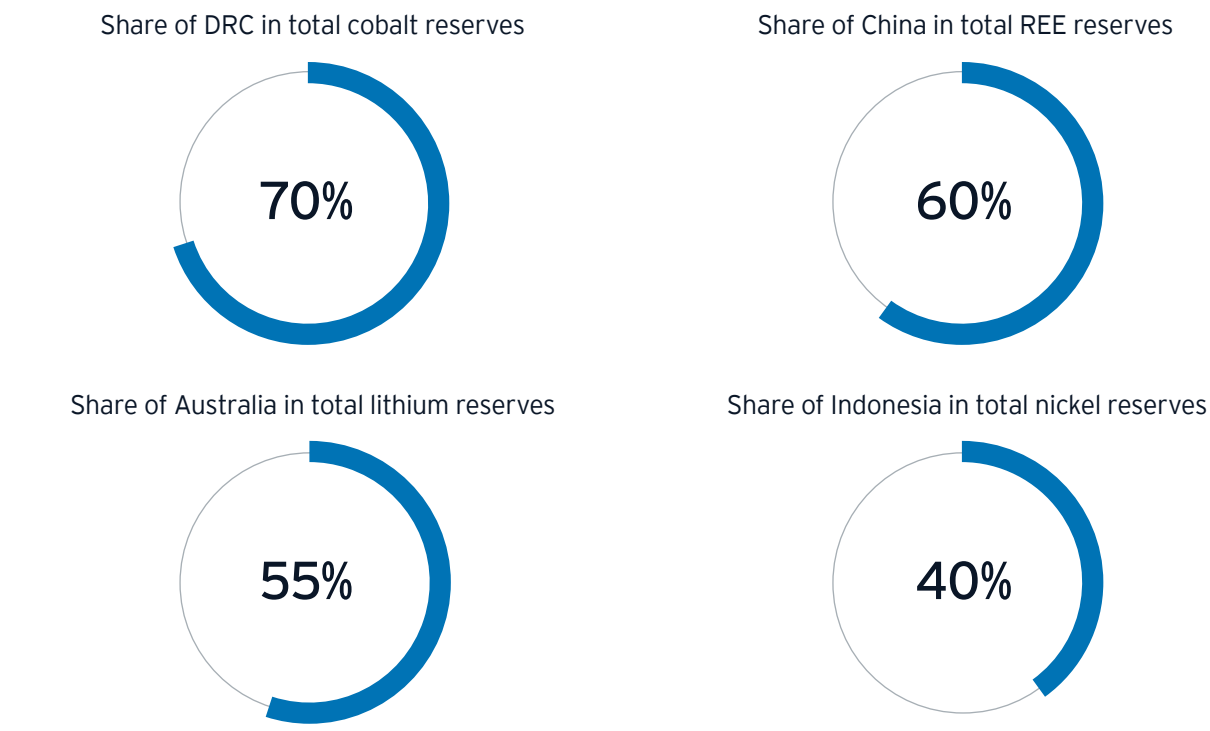


Source: EY analysis, Critical Raw Materials for Strategic Technologies and Sectors in the EU; IEA May 2021

71. Role of Critical Minerals in Clean Energy Transitions (IEA)

However, supply chains of these critical minerals are vulnerable to geopolitical risks as their production and supply chain is concentrated in a few geographies, such as China, Democratic Republic of Congo (DRC), Australia, Chile, etc.

Figure 30: Concentration of critical minerals



Source: EY analysis, International Energy Agency (IEA)

Processing of these minerals is also highly concentrated. China alone processes 90% of REEs and 60% to 70% of lithium and cobalt[72].

India's RE transition goals rely heavily on solar power. However, the manufacturing of photovoltaic cells requires minerals like gallium that are either unavailable or not produced domestically. Similarly, manufacturing of wind turbines requires chromium, nickel, and rare earth metals, which are presently extracted and processed on a large scale in China.

Adoption of EVs is also a significant part of India's energy transition journey. Lithium, cobalt and rare earth metals are the key minerals required for manufacturing of EV batteries. However, India does not mine any of these minerals. Owing to the limited processing domestic capacity of all these minerals, India has been largely dependent on imports for their supply, particularly from countries like China, Australia, the US, the UK, South Africa and Indonesia.

72. International Energy Agency

Figure 31: Import dependence for critical minerals in India

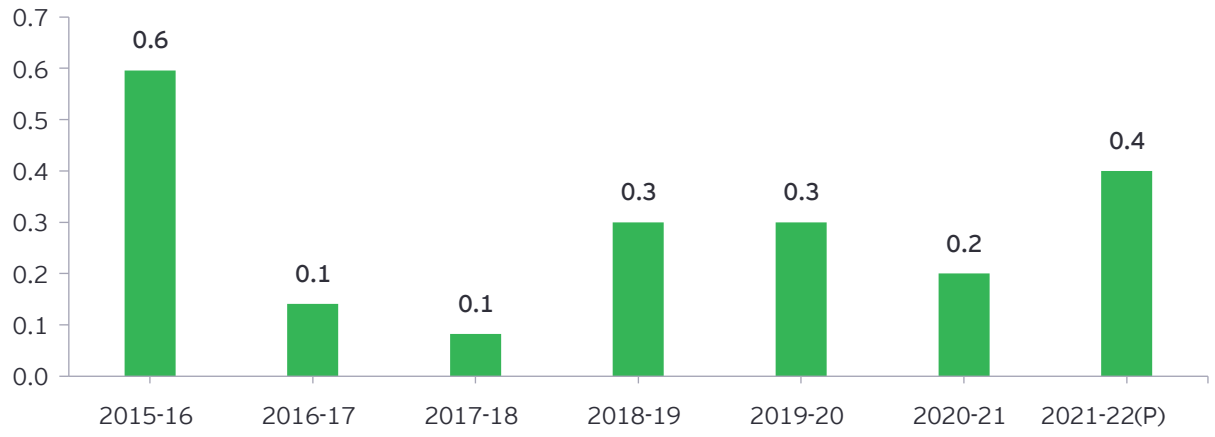
Import dependence for critical minerals in India, 2020		
Critical mineral	Dependence (%)	Major Import Sources (2020)
Lithium	100%	Chile, Russia, China, Ireland, Belgium
Cobalt	100%	China, Belgium, Netherlands, US, Japan
Nickel	100%	Sweden, China, Indonesia, Japan, Philippines
Vanadium	100%	Kuwait, Germany, South Africa, Brazil, Thailand
Niobium	100%	Brazil, Australia, Canada, South Africa, Indonesia
Germanium	100%	China, South Africa, Australia, France, US
Rhenium	100%	Russia, UK, Netherlands, South Africa, China
Beryllium	100%	Russia, UK, Netherlands, South Africa, China
Tantalum	100%	Australia, Indonesia, South Africa, Malaysia, US
Strontium	100%	China, US, Russia, Estonia, Slovenia
Zirconium	80%	Australia, Indonesia, South Africa, Malaysia, US
Graphite (natural)	60%	China, Madagascar, Mozambique, Vietnam, Tanzania
Manganese	50%	South Africa, Gabon, Australia, Brazil, China

Source: EY analysis, Australia Trade Commission Report

India's inability to source these minerals domestically is attributable to several factors. Some of them are as follows:

- India's mining sector has attracted miniscule capital and technology. As per the Federation of Indian Mineral Industries [FIMI], only 10% of the areas with obvious geological potential (OGP) area have been explored in Dec 2020.
- India's mineral policies have been unable to attract significant capital into exploration. The role of the private sector in exploration was limited to the discovery phase only, without rights to mine the deposit. The government had reserved the authority to auction off any discovered deposits and share the auction proceeds with the person who made the discovery.

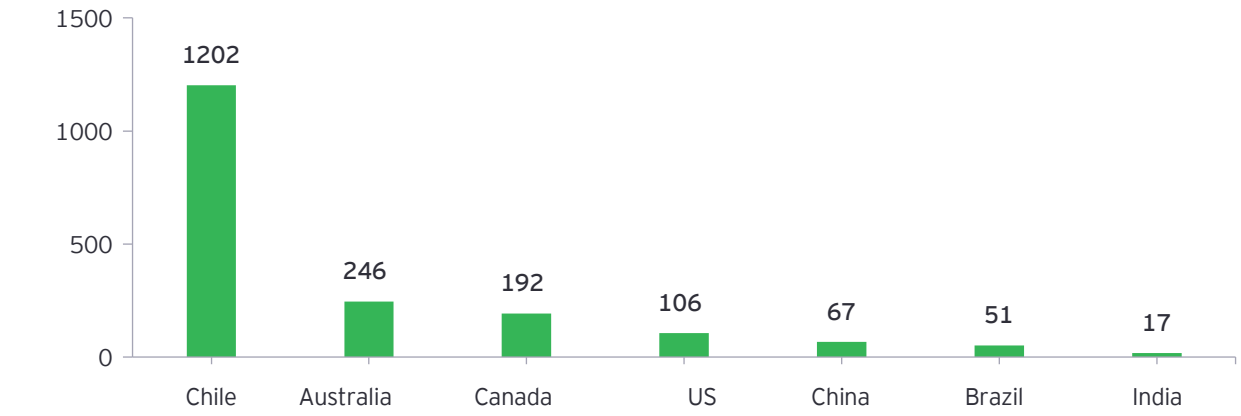
Figure 32: FDI inflow in mining as a percentage of total FDI inflows



Source: Reserve Bank of India

- India's budget allocation towards exploration is substantially lower compared to other dominant mining countries.

Figure 33: Exploration budget (US$) per km²



Source: SNL Metals & Mining; ORF

Since securing these minerals domestically has been challenging, India has relied on imports of key components in the renewables supply chain such as solar PV modules and Lithium-ion batteries. Therefore, to ensure the competitiveness of domestic manufacturing of renewables in India, it is imperative for India to build resilient supply chains for critical minerals.

In order to strengthen the supply chain of critical minerals in India, the government has taken the following steps:

- **Critical Minerals Mission:** The Union Budget 2024-25 proposes to set up a Critical Mineral Mission for enhancing domestic production and recycling of critical minerals as well as streamline overseas acquisition of critical mineral assets. The mission will focus on technological development, employment of skilled workforce, extended producer responsibility framework, and suitable financing mechanisms[73].
- **Increased role of the private sector:** The Mines and Minerals (Development and Regulation) Act, 1957 has been amended to allow the private sector to participate in the exploration and mining of critical minerals such as lithium. The new amendments include[74]:
  - Removal of six minerals from the list of 12 atomic minerals limited to exploration by state agencies (i.e., lithium, beryllium, niobium, titanium, tantalum, and zirconium). This potentially opens opportunities for private sector involvement in their exploration and mining.
  - Central government has taken the power from state governments to exclusively auction mineral concessions for critical minerals, including REEs, graphite, cobalt, lithium, nickel, phosphate, potash and tin.
  - Introduction of a new concession i.e., Exploration Licenses (EL) to attract foreign direct investment (FDI) and engage junior mining companies in exploring deep-seated and critical minerals like gold, platinum, rare earth elements, etc.
- **International partnerships:** The government is also focusing towards developing key partnerships with countries like the US, Australia, Japan to build resilient supply chains:
- **Mineral Security Partnership (MSP):** India became the 14th member of MSP in June 2023 and is currently the only developing country in the group. The partnership seeks to strengthen critical mineral supply chains to support economic prosperity and climate objectives[75].
- **Supply Chains Resilience Initiative (SCRI):** SCRI was launched in April 2021 by India, Australia, and Japan. The partnership aims to build resilient supply chains in the Indo-Pacific region and to reduce dependence on China[76].

Access to critical minerals is imperative for the development of the local supply chain and for energy transition. Significant changes are needed in the Indian exploration investment climate to establish the possibility of domestic mineral resources. Globally, competitive, and transparent markets need to emerge for the energy transition.

73. PIB Press Release Dated 23rd July 2024
74. IEA
75. PIB Press Release dated 7th August 2023
76. PIB Press Release dated 27th April 2021

3.4.3 Batteries

The supply chain of batteries is also highly concentrated with China which produces three-quarters of all lithium-ion batteries and is home to 70% of production capacity for cathodes and 85% for anodes (both are key components of batteries)[77]. With the government's continuing focus on enhancing EV adoption in India, securing battery supply chains is paramount.

With limited domestic production capacity and low reserves of lithium/cobalt, India has relied on imports for battery cells. However, with the growing demand for EVs in India, the demand for lithium-ion batteries is expected to surge from 4 GWh in 2023 to nearly 139 GWh by 2035[78].

The government has been taking several progressive steps to enhance India's domestic battery manufacturing capacity. One of such key measures is Production-Linked Incentives (PLI) scheme for National Programme on Advanced Chemistry Cell (ACC) Battery Storage. The government approved the PLI scheme for ACC Batteries in May 2021 with an outlay of INR18,100 crore to build local manufacturing capacity of 50 GWh of ACC batteries. Eligible firms shall make a minimum investment INR225 crore/GWh within two years while ensuring a domestic value addition of at least 25% and then raising it to 60% within five years. Three firms, Reliance New Energy Limited, Ola Electric Mobility, and Rajesh Exports, have already been allocated 30 GWh of the targeted 50 GWh capacity.[79]

3.5 Green hydrogen

> Cyient is dedicated to advancing the energy transition by leveraging technology and innovation to drive sustainable practices. Our solutions are designed to enhance energy efficiency and support the integration of renewable energy sources, hydrogen/ammonia, battery storage, carbon capture and storage and the balance of power into the existing infrastructure. In India, the energy transition represents a crucial opportunity to modernize our energy systems and reduce environmental impact. Cyient is committed to providing technological solutions that facilitate this transformation, including smart grid /grid modernization technologies, energy management systems, and advanced analytics. Our contributions are aimed at aligning with these global trends, ensuring that our solutions not only meet but exceed industry standards. Our goal is to be a key enabler in the transition towards a more sustainable and resilient secured energy future of the country.
>
> **Karthik Natarajan**
> Executive Director and Chief Operating Officer, Cyient

The Government of India aims to make India a global hub for the production, use, and export of green hydrogen and its derivatives. There are several drivers behind this ambition:

- As a tool for decarbonization of hydrogen and ammonia production (currently being produced with natural gas as a feedstock) for application in refineries and fertilizer. India's hydrogen consumption stands at ~6 MMTPA; predominated by oil refineries accounting for 3 MMTPA and another 2.5 MMTPA is used for urea and other fertilizer.[80]
- The industrial sector, particularly the hard-to-abate industries with high carbon footprints such as steel, cement, heavy trucking, aviation and maritime, requires effective means for decarbonization.
- Green hydrogen is an alternative form of energy storage and can provide flexibility to grids. Hydrogen could be stored either physically or chemically (as ammonia) and then at the time of need could be discharged in through gas turbines or fuel cells.
- Government aims to achieve self-reliance in energy and decrease dependence on fossil fuel with the implementation of green hydrogen mission in India.
- India has the potential of being a low-cost producer of hydrogen as its cost of generating solar and wind energy is among the lowest in the world. It is assumed that the cost of electrolyzer would decrease over time due to increasing economies of scale, R&D spends and policy push worldwide.

77. IEA (July 2022) "Global Supply Chains of EV Batteries"
78. S&P Global
79. Ministry of Heavy Industries
80. India's hydrogen demand projected at 12mmtpa by 2030; prices expected at $2-2.5/kg, ET EnergyWorld (indiatimes.com)

- India can take advantage of emerging as a low-cost producer of hydrogen and become an exporter of hydrogen and green ammonia. Countries like India, Argentina, Australia, Saudi Arabia (rich in renewable energy resources), have the potential to emerge as a future powerhouse in green hydrogen production and export.[81]
- Investments in hydrogen production can drive jobs and create a new ecosystem for fresh investments.

Moreover, various public sector enterprises are taking initiatives to propagate faster deployment of green hydrogen in the country. For instance, Oil India Limited had set up one of India's first 99% pure green hydrogen plant in Jorhat, Assam. NTPC also initiated blending operations in Surat's PNG network, receiving an approval of 5% and gradually will be increased to 20%[82]. Such initiatives have been possible due to supporting government policies.

3.5.1 Policy landscape

To achieve its ambitious goal of becoming a global leader in green hydrogen production by 2030, the government has introduced various policies and financial incentives. The Green Hydrogen Mission envisages financial incentives on the supply side (both electrolyzers and green hydrogen) and pilot projects for utilizing green hydrogen for hard-to-abate sectors.

1. National Green Hydrogen Mission:

The mission was launched with a total outlay of INR19,744 crore (US$2.4 billion) up to FY2029-30. It provides a comprehensive action plan for establishing green hydrogen ecosystem and envisages the addition of 125 GW of RE generation capacity and a total investment of INR8 lakh crore (US$100 billion) in the GH ecosystem by 2030. Objectives include:

- Build capabilities to produce at least 5 MMT of GH per annum by 2030, with the potential to reach 10 MMT per annum with the growth of the export market.
- Make India a leader in technology and manufacturing of electrolyzers.

Under the Green Hydrogen Mission, the government has allocated INR17,490 crore for Strategic Interventions for Green Hydrogen Transition (SIGHT) Programme. Of this, INR4,440 crore has been set aside for manufacturing electrolyzers, while the remaining INR13,050 crore will fund green hydrogen production between FY2025-26 to FY29-30.

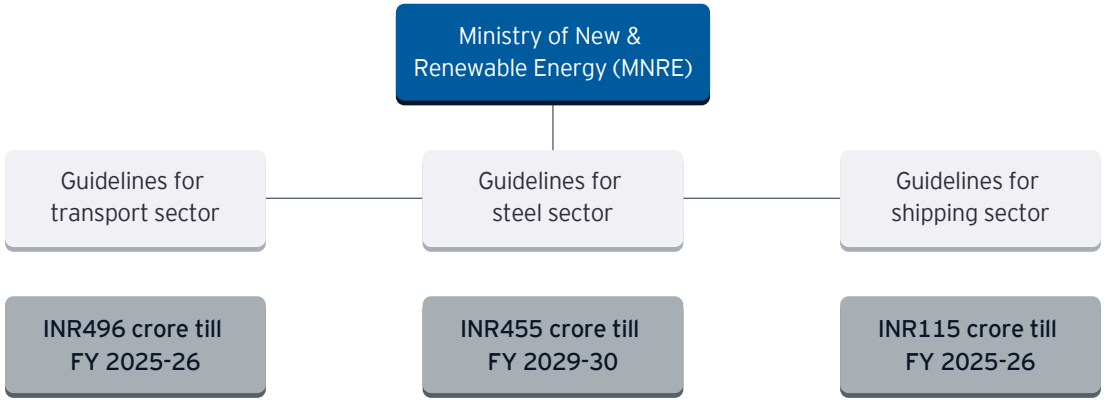
The program includes two distinct financial incentive mechanisms to support domestic manufacturing of electrolyzers and green hydrogen production.[83]

- **Mode 1** – Electrolyzer: On 12 January 2024, the government awarded production linked incentives (PLI) for electrolyzer manufacturing to eight companies under the SIGHT Scheme, supporting a capacity of 1,500 MW per year under the first tranche. Thirteen more companies received awards for an additional 1,500 MW in the second tranche.
- **Mode 1**- Green hydrogen: On 9 January 2024, the government awarded contracts for green hydrogen production under the SIGHT Scheme to 10 companies, totaling a production capacity of 412,000 tons per year. The second tranche, aiming for another 450,000 tons per year, is currently active.
- **Mode 2A** – Green ammonia: On 22 June 2024, the Ministry of New and Renewable Energy (MNRE) increased the annual production capacity for green ammonia under Mode 2A of the SIGHT scheme from 550,000 to 750,000 tons per year. Fourteen fertilizer plants identified in the Solar Energy Corporation of India's (SECI) tender will consume this green ammonia.[84]
- **Mode 2B** – Green hydrogen: On July 24, 2024, the Ministry of New and Renewable Energy (MNRE) introduced a major policy for acquiring green hydrogen. As per the announcement, each oil and gas company will be responsible for aggregating demand and inviting bids to ensure the lowest-cost production and supply of green hydrogen for their individual refineries or across multiple refineries. Additionally, the Centre for High Technology (CHT) will provide secretarial, managerial and implementation support, and will manage additional tasks as assigned by the Ministry of Petroleum and Natural Gas (MoPNG).

In addition, the government has announced allocations for pilot projects in the transport, steel and shipping sectors, aimed at replacing fossil fuels and fossil fuel-based feedstock with green hydrogen and its derivatives.

81. Green hydrogen push: India eyes $7-15 billion import substitution, plans $4-12 billion investment, ET EnergyWorld (indiatimes.com)
82. Understanding the Green Hydrogen landscape in India: Demand from industries, global collaborations are the key, ET EnergyWorld (indiatimes.com)
83. Press Information Bureau (pib.gov.in)
84. Press Information Bureau (pib.gov.in)

Figure 34: Guidelines for green hydrogen



Source: EY Analysis, PIB

2. State policies

So far, states have also formulated an independent green hydrogen policy to accelerate and attract investments. The states that have announced policies incentives are Rajasthan, Uttar Pradesh, Maharashtra, West Bengal and Andhra Pradesh. Assam, Bihar, Punjab, Haryana and Gujarat are currently drafting their respective state green hydrogen policies. States such as Odisha provide capital subsidies to the tune of 30%, in order to attract incentives to their states. States are also providing financial incentives related to water supply, electrolyzer manufacturing, research and development expenditure and on usage of land. Additionally, tax incentives (in the form of GST refunds) and capital subsidies have also been provided by many states to encourage the deployment of green hydrogen. Other than these, benefits of exemptions on various types of electricity associated charges (electricity duty, cross subsidy surcharge, additional surcharge) have also been provided to the eligible developers under the different state specific policies.

3. Other incentives/ policy measures[85]

Additionally, the following incentives/ exemptions are being provided to promote the production and utilization of green hydrogen:

- Waiver of inter-state transmission charges has been granted for a period of 25 years to the producers of green hydrogen and green ammonia for the projects commissioned before 31 December 2030. This measure will help reduce the cost of delivered renewal power for green hydrogen production.
- The Ministry of Environment, Forests and Climate Change has exempted Green Ammonia plants from prior environmental clearances under Environment Impact Assessment notification 2006 vide notification dated 28 July 2023.
- The Electricity (Promoting Renewable Energy through Green Energy Open Access) Rules, 2022, notified in June 2022, includes provisions for facilitating supply of renewable energy through Open Access for green hydrogen production.
- Although there are attractive incentives available, they pale in comparison to the generous US$3/ KG tax credit for green hydrogen provided by the Inflation Reduction Act in the US. In contrast, the financial incentive in India is approximately US$0.36 to 0.6/KG of green hydrogen produced.

85. Press Information Bureau (pib.gov.in)

3.5.2 Investments underway

The green hydrogen sector is still in its nascent stages in India and a widespread adoption of the technology will require a considerable push from both public and private sectors. Scaling of capacity will require capital investment to support the development of a robust ecosystem. Some investments that are underway or have been taken are:

- Reliance Industries Limited (RIL) along with other conglomerates, is planning to set up GH and GA units at Deendayal Port Authority (DDA0 in Kandla in Gujarat. RIL alone envisages and an investment of INR1 lakh crore (over US$12 billion), marking it as one of the largest investments in India's energy infrastructure.[86]
- Kerala government has received investment proposals of worth INR72,760 crore from four major companies to attain subsidies under states' GH policy.[87]
- Essar Group has announced plans to invest INR30,000 crore (US$3.7 billion) over the next four years in setting up a green hydrogen plant in Jamnagar, Gujarat. They plan to develop 1 GW of electrolyzer capacity along with associated green molecules capacity of 1 MTPA.[88]
- Hygenco Green Energy has announced plans to invest $2.5 billion over three years to set up GH projects across different states in India. The company is currently producing GH at two plants and a R&D cum demonstration project of around 140 KW in Ujjain, MP and second plant of ~3MW currently under the final commissioning stage in Hisar.[89]
- Government owned NTPC has signed a Land Lease Agreement to meet the green hydrogen objectives. In Feb 2024, NTPC Green Energy Limited (NGEL) and AP Industrial Infrastructure Corporation signed an agreement for the development of Integrated GH hub.
- Additionally, NGEL had signed and MoU with the Government of Maharashtra for the development of GH and its derivatives such as green ammonia and green methanol of up to 1 MTPA. This MoU has been a part of Maharashtra's Green Investment Plan, and it envisages a potential investment of INR80,000 crore.[90]

A significant boost is seen in investments made by both public and private arena in the green hydrogen landscape. However, domestic demand will play a critical role in driving more investments in the future.

> Energy transition is a collaborative effort that requires a balance between economic growth, socially just transition, and sustainability initiatives. A primary driving force of the transition towards net zero is the uptake of renewable energy sources like solar and wind. While their role in net zero is undeniable, they are heavily dependent on external factors like sunlight and wind speed. Hence, I believe this necessitates the integration of advanced non-dependent dispatchable energy technologies like battery storage and green hydrogen.
>
> At ACG, we have seen firsthand how these innovations can accelerate progress towards net zero, aligning with India's national ambitions. The journey, therefore, is not just about targets and goals, but about finding the right balance. This requires a shift in mindset and culture for a better and sustainable tomorrow.
>
> **Karan Singh**
> Managing Director, ACG

86. Kandla Port: L&T, RIL to invest 1 lakh crore in green energy; Deendayal Port Authority allots 14 land parcels | Mint (livemint.com)
87. Kerala Investment News: Kerala receives investment proposals worth over Rs 72,000 cr to set up green hydrogen, ammonia plants, ET EnergyWorld (indiatimes.com)
88. green hydrogen plant: Essar to invest Rs 30,000 crore in green hydrogen plant in Gujarat - The Economic Times (indiatimes.com)
89. Hygenco to invest $2.5 bn over 3 years to set up Green Hydrogen projects in India, ET EnergyWorld (indiatimes.com)
90. Press Releasel:Press information Bureau (pib.gov.in)

3.5.3 Response to hard-to-abate sectors: the green steel industry

Hydrogen, being one of the most abundant elements on Earth, represents a unique opportunity to decarbonize hard-to-abate sectors. Green hydrogen is versatile as it can be used as combustion fuel or as a feedstock for industrial processes. Thus, it possesses a huge potential for clean energy transition.

In India, the steel sector accounts for ~12% of the CO_2 emissions with an intensity of 2.55 tons of CO_2/ ton of crude oil, higher than the global average of 1. 85 tCO_2/ton of crude oil.[91] Due to the high emissions involved in producing steel using traditional methods, green steel is becoming increasingly important as countries across the globe are focusing on reducing carbon footprints.

Essentially, green steel refers to steel that is produced using environmentally sustainable methods and green hydrogen is one solution that can be used to reduce the sector's carbon footprint significantly. While India is still in its initial stages of green steel production, the Ministry of Steel has set short, medium, and long-term targets to decarbonize this sector. It includes:

- Short-term (2030): Improving energy and resource efficiency in existing steel plants and increasing the use of renewable energy
- Medium-term (2030-2047): Utilization of green hydrogen and CCUS technologies in the production process
- Long-term (2047- 2070): Use of disruptive alternative technological innovations to achieve the transition

MNRE has also recently announced the scheme guidelines for use of GH2 for pilot projects in the steel sector. The scheme envisages that considering that steel plants can begin blending of a small percentage of green hydrogen in their processes and increase this blending proportion progressively, depending on the improvement in cost economics and advancement of technology.

Usage of green hydrogen in the steel sector is still in infancy and at the stage of pilot projects. Success of these pilot projects and reduction in the cost of producing hydrogen would determine the trajectory of usage of green hydrogen in hard-to-abate sectors such as steel.

3.5.4 Export opportunities to the Europe, Japan and Korea

Disparity in production sources and consumption of green hydrogen could catalyze the emergence of markets for green hydrogen as a tradeable energy commodity in the long term.[92]

While supply side incentives have been a good starting point to push the green hydrogen development in the country, domestic demand will be an important driver for its growth. Presently in India, 90% of the hydrogen produced is used for captive use (in refineries and fertilizer plants), resulting in a relatively small market for hydrogen.[93] More importantly, there is a huge cost disparity between grey and green hydrogen, which impacts economics and investments.

Consequently, until green hydrogen demand is not established in the market, the export market can be a crucial strategy for expanding local production, creating economies of scale, and reducing costs. Recent tenders for supply of green hydrogen by Japan and countries in the EU have attracted interest from Indian players.

Export-oriented initiatives

- ACME (India) proposes to supply green ammonia to Japan's IHI Corporation. The Green Hydrogen and Ammonia Project, with a planned capacity of 1.2 MTPA, is proposed to be developed by ACME in the state of Odisha. The IHI Corporation has signed an offtake term sheet with ACME for the supply of green ammonia from Odisha to Japan.
- Singapore's Sembcorp Industries has signed an agreement with Japan's Sojitz Corp and Kyushu Electric Power Co. to export India-made green hydrogen to Japan. Under this arrangement, three companies will be exploring opportunities to produce green ammonia in India and export it to Japan.
- YARA Clean Ammonia (world's largest trader and distributer of ammonia) and Greenko ZeroC (green ammonia production arm of India-based AM Green) are reported to have recently signed a term sheet for supply of renewable ammonia from Phase 1 of Ammonia production facility in Kakinada in the state of Andhra Pradesh in India.[94]

91. Steel decarbonisation in India | IEEFA
92. Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf (niti.gov.in)
93. The East Asian opportunity: Prioritising Japan and Korea in India's green hydrogen strategy (orfonline.org)
94. Yara Clean Ammonia and AM Green (earlier Greenko ZeroC) sign termsheet for sale of renewable ammonia from India to Yara Clean Ammonia's global market | Yara International

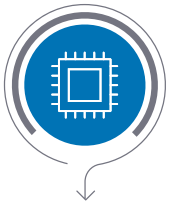
European Union, Japan, and South Korea are seen as the main importers of green hydrogen due to their ambitious consumption targets. In particular, the EU, under its renewable energy power plan, aspires to consume 20 million tons of green hydrogen by 2030. Half of this demand is proposed to be met through imports, which underscores the growing importance of international trade in GH.[95]

To conclude, the Indian government has been focusing on the development of a green hydrogen ecosystem in India and is offering financial incentives and has made policy announcements, especially on the supply side. There are limited demand side incentives in India. However, the cost of producing green hydrogen continues to be high, thereby impacting domestic demand and the financial incentives are considerably lower than in the case of US. Green hydrogen production is at its infancy in India with many pilot projects underway. However, there is considerable interest among Indian companies in investing production facilities' setups, given the policy push in India and the expectation that hydrogen usage may become widespread in India and globally. Recent moves by EU, Korea and Japan to source hydrogen could catalyze the development of the green hydrogen ecosystem in India.

3.6 Nuclear energy development

Development of safe nuclear energy has substantial potential to provide India with long-term energy security. There are several features, such as cost-effectiveness and low carbon-footprint, which make nuclear energy another viable source of decarbonized base load power for India.[96]

Figure 35: Benefits of nuclear energy



Cost-effective	Climate-related advantages	Lesser land requirements
▪ One of the cheapest sources of energy in India presently. ▪ High Plant Load Factor of nuclear power plants (averaging almost 80%) ▪ Long life of a nuclear power plant (sixty years for new generation plants)	▪ The carbon footprint of nuclear energy generation is less than other non-fossil fuel sources of energy (greenhouse gas emission for a nuclear power plant is almost one-fourth of that of a solar power plant)	▪ Land-requirements of a nuclear power are also limited (nuclear power plant requires 20 times lesser land area as that of a solar power plant with the same installed capacity).

Source: Ministry of Atomic Energy

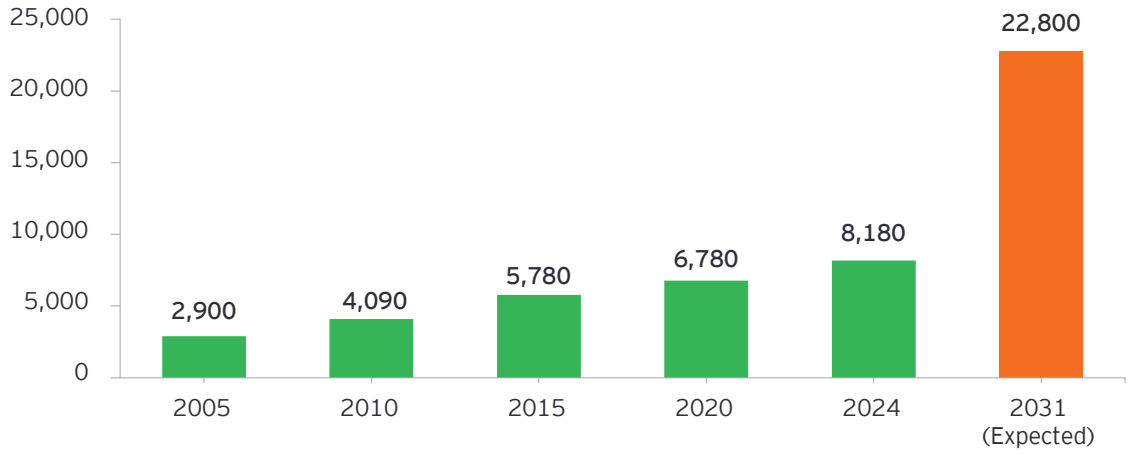
95. Green hydrogen push: India eyes $7-15 billion import substitution, plans $4-12 billion investment, ET EnergyWorld (indiatimes.com)
96. Ministry of Atomic Energy

India's nuclear energy sector is state controlled. Public Sector Enterprise, Nuclear Power Corporation of India Limited (NPCIL) under the Department of Atomic Energy is solely responsible for the design, construction, commissioning and operation of nuclear power reactors in India. The current FDI policy also prohibits foreign investment in atomic energy in India. However, there is no restriction on FDI in the nuclear industry for manufacturing of equipment and providing other supplies for nuclear power plants and related other facilities.[97]

Government's medium-term goal is to triple the existing capacity to 22,480 MW by 2031-32[98]. Currently, India has:

- 24 operational nuclear reactors with a cumulative installed capacity of 8,180 MW
- 21 reactors with a total capacity of 15300 MW under development by Nuclear Power Corporation India Limited (NPCIL)
  - Nine reactors with a total capacity of 7300 MWe are under construction
  - 12 reactors with a capacity of 8000 MW are under pre-project activities

Figure 36: India's installed nuclear capacity (MW)



Source: NITI Aayog Climate Dashboard

Since the operation of nuclear power plants requires high standards of safety and security, the government has kept the nuclear energy sector heavily regulated. However, realizing that growth of the nuclear energy sector is imperative to India's net zero emissions goal, the government has been considering inviting private investments in this sector. According to Reuters, the Government of India is in talks with multiple private players to invest about US$26 billion in India's nuclear energy sector. With these investments, the government aims to add 11,000 MWe of new generation capacity by 2040. However, it is expected to be a hybrid setup, where private players would earn revenues only from plants' electricity sales while the right to set-up and operate these plants would be retained by NPCIL[99].

Besides focusing on inviting private investments, the government has also been focusing on the development of new technologies, such as Small Modular Reactors (SMRs), to accelerate the growth of nuclear energy sector in India. The Union Budget 2024 has earmarked INR 1 lakh crore for research and development in Small Modular Reactors (SMRs), signaling a significant commitment to the deployment of 40 to 50 SMRs. This substantial investment highlights the government's focus on enhancing India's energy security and advancing its capabilities in innovative nuclear technology. An SMR is a small capacity atomic power plant (in the range of 30-300 MW) having unique features of modularity, scalability, small footprint and improved safety which can be deployed in locations not suitable for large size nuclear power plants[100].

Despite its distinct advantages, nuclear energy contributes only 3% to India's total electricity generation. However, with the government's continued focus on the nuclear sector and a growing role for the private sector, significant investments are expected to flow into this space, supporting India's energy transition goals.

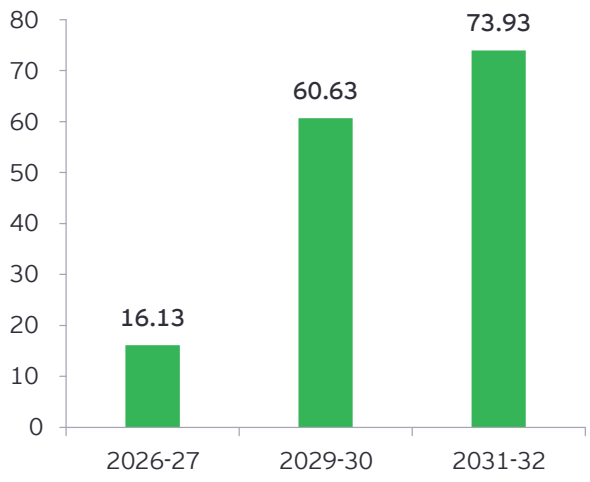
97. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1655136
98. PIB Press Release dated 25th July 2024
99. Reuters
100. PIB Press Release dated 6th December 2023

3.7 Storage

Energy Transition entails increasing presence of Variable and Intermittent Renewable Energy Sources (VRES) like solar and wind in the energy mix. This presents a grid-level challenge for stability and a need for addressing the temporal considerations in power availability. By making renewable energy dispatchable and available around the clock, Energy Storage System (ESS) is expected to play a pivotal role in achieving India's energy transition goals.

With large additions to India's RE capacity in the future, the requirement for energy storage will only increase. The Central Electricity Authority's (through National Electricity Plan 2023) has projected the storage capacity requirement at 16.13 GW by 2026-27 and grow further to 73.93 GW by 2031-32[101].

Figure 37: Projected energy storage capacity requirement (GW)



Source: CEA National Electricity Plan 2023

The Government of India is pursuing a multi-pronged strategy for the development of energy storage and decarbonization of back-up power:

- **Promoting installation of battery energy storage:** Government tenders and financial incentives, such as Viability Gap Funding (VGF), are being used to encourage BESS adoption.
- **Promoting the growth of pumped hydro projects:** Faster approvals and infrastructure development, including access to roads, are being facilitated, along with incentives for utilities and industries to source power from BESS and Pumped Storage Power (PSP) systems through inter-state transmission charge waivers.
- **Mandating Energy Storage Obligations (ESO):** The Ministry of Power has notified that sufficient storage capacity is available with obligated entities, i.e., a minimum percentage of electricity consumption within a Distribution licensee's area shall be procured from renewable energy through ESS. The ESO of obligated entities is proposed to be gradually increased from 1% in FY 2023-24 to 4% by FY 2029-30, i.e., an annual increase of 0.5%.
- **Rules for replacement of Diesel Generator (DG) sets with RE/storage:** The Electricity (Rights of Consumers) Amendment Rules, 2022 notified on 20 April 2022 mandates that the consumers using DG sets shall endeavor to shift to cleaner technology, such as renewable energy, with battery storage and the like in five years or as per the timelines given by the State Electricity Commission for such a replacement.

> IFC is committed to driving the energy transition by integrating sustainable finance into our investment strategies. Our mission is to accelerate the adoption of clean energy technologies and promote sustainable development across emerging economies. In India, we are deeply involved in financing projects that bolster renewable energy infrastructure, enhance energy efficiency, and drive climate resilience. Our projects span a wide range of sectors, including solar, wind, round-the-clock power supply, energy storage, and sustainable urban infrastructure, all aimed at reducing carbon emissions and supporting the country's transition to a low-carbon economy. Globally, IFC is championing innovative financial mechanisms and policies that align with international climate goals and sustainability standards. By fostering public-private partnerships and leveraging our extensive expertise, we strive to create a scalable impact that supports the global shift towards sustainable energy solutions and promotes long-term economic growth. Our commitment is to ensure that financial resources are directed towards initiatives that not only address immediate energy needs but also contribute to a sustainable and resilient future for all.
>
> **Shalabh Tandon**
> Regional Head of Operations and Climate, International Finance Corporation (World Bank Group) South Asia

101. CEA, National Electricity Plan (2023)
100. PIB Press Release dated 6th December 2023

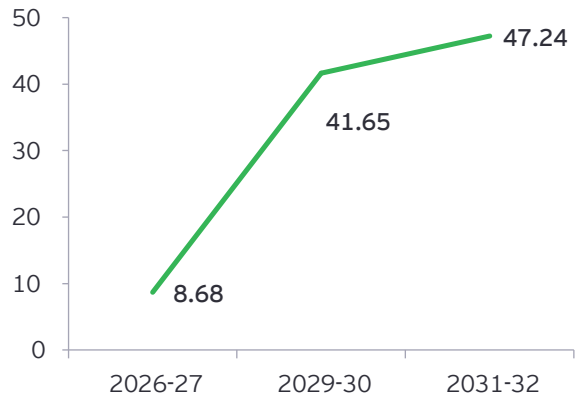
3.7.1 Battery Energy Storage System (BESS)

BESS is a convenient energy storage technology that is not restricted by location and can be deployed quickly. Its flexibility allows it to respond swiftly to fluctuations in supply and demand, while offering long-term reliability by handling frequent charge and discharge cycles with minimal degradation.[102]

As of now, no gigawatt-scale (GW-scale) BESS capacity is operational. However, in February 2024, SECI successfully commissioned India's largest BESS project in Chhattisgarh, designed to store solar energy. The project includes a 40-megawatt (MW) BESS with an energy storage capacity of 120 megawatt-hours (MWh), paired with a solar photovoltaic (PV) plant that has an installed power capacity of 152.325 MW.

With the growth of renewable energy (RE) generation in India, the Central Electricity Authority (CEA) anticipates a need for 8.68 GW of BESS capacity by the fiscal year 2026-27 and 47.23 GW by 2031-32. The estimated fund requirement for developing the necessary capacity during the five-year period from 2022 to 2027 is about INR56,647 crore [103].

Figure 38: Projected BESS capacity requirement (in GW)



Source: CEA

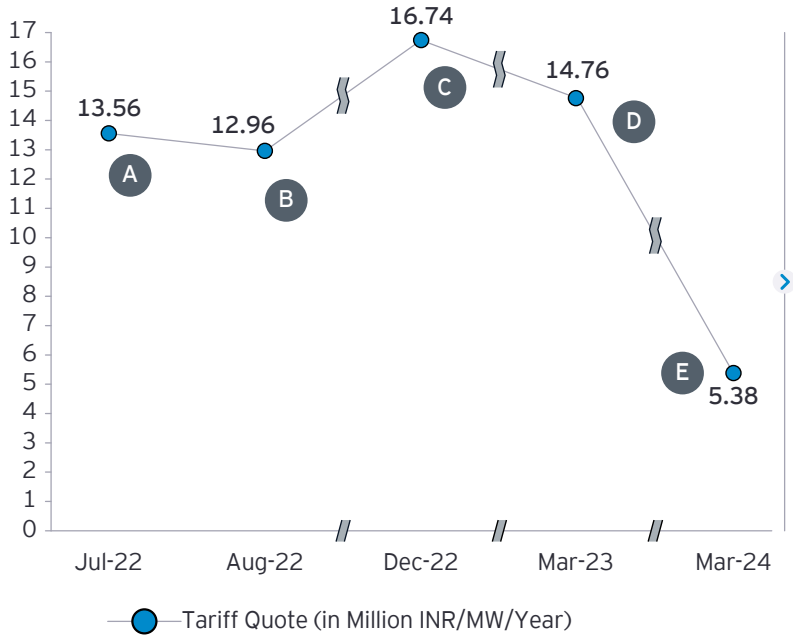
The Government of India is also cognizant of the role of battery storage technology and has taken several steps to enhance BESS infrastructure:

- **Viability Gap Funding (VGF):** In September 2023, the Ministry of New and Renewable Energy approved VGF of INR 9,400 crore (US$1.2 billion) for development of 4 GWh BESS energy capacity. Up to 40% of capital cost for BESS shall be provided by the central government. Entities that can avail the benefit would be selected through a bidding process over a period of three years (2023-24 to 2025-26). The disbursement of funds will extend up to 2030-31 in five tranches[104].
- **Guidelines for Procurement and Utilization of Battery Energy Storage Systems:** These guidelines provide standardization and uniformity in procurement of BESS projects and a risk-sharing framework between various stakeholders involved, thereby encouraging competition and enhanced bankability of these projects. JSW Energy won the SECI tender for 1 GWh of Battery Energy Storage Systems and the plant is expected to be commissioned by June 2025.

The tariffs determined for energy storage tenders in the BESS and Pumped Storage System (PSP) categories have shown a downward trend over the past three years. A continued decrease in battery prices could lead to a lower Levelized Cost of Energy (LCOE) for renewable energy developers.

102. Economic Times (September 2023) "Why it is urgent for India to focus on Battery Energy Storage Systems"
103. CEA
104. PIB Press Release dated 6th December 2023

Figure 39: Price tariff trends for storage tenders



ID	Name of tender	Capacity	Technology
A	KSEB Kerala Storage	10 MW/ 20 MWh	BESS
B	SECI Rajasthan Storage	500 MW/ 1,000 MWh	BESS
C	NTPC pan India Storage	500MW/ 3,000 MWh	PSP
D	PCKL Karnataka Storage	1000 MW/ 8,000MWh	PSP
E	GUVNL Gujarat Storage Tranche-II	250 MW/ 500 MWh	BESS

Source: EY Analysis, BNEF Data, 2023

3.7.2 Pumped hydro-storage power plants (PSP)

Development of PSP projects is an important priority in India. With their ability to store a large amount of energy, frequent starts/stops, and faster ramp-ups/ramp-downs, PSPs are ideally suited to address the dynamic energy supply and demand. They are cost-effective and offer several benefits, which make them an ideal energy storage technology for India[105]:

Figure 40: Benefits of PSP

Eco-friendly

PSP projects have minimal environmental impacts as they are mainly envisaged on existing hydro-electric projects, reservoirs, or off-the-river projects.

Potential for local development

Development of PSPs is highly capital-intensive and can enable development of local upstream industries and infrastructure. It can also provide employment opportunities.

Longer duration of discharge

PSPs are generally designed for a longer duration than six hours of the peak demand period, compensating for the variability in demand or to cater to VRES.

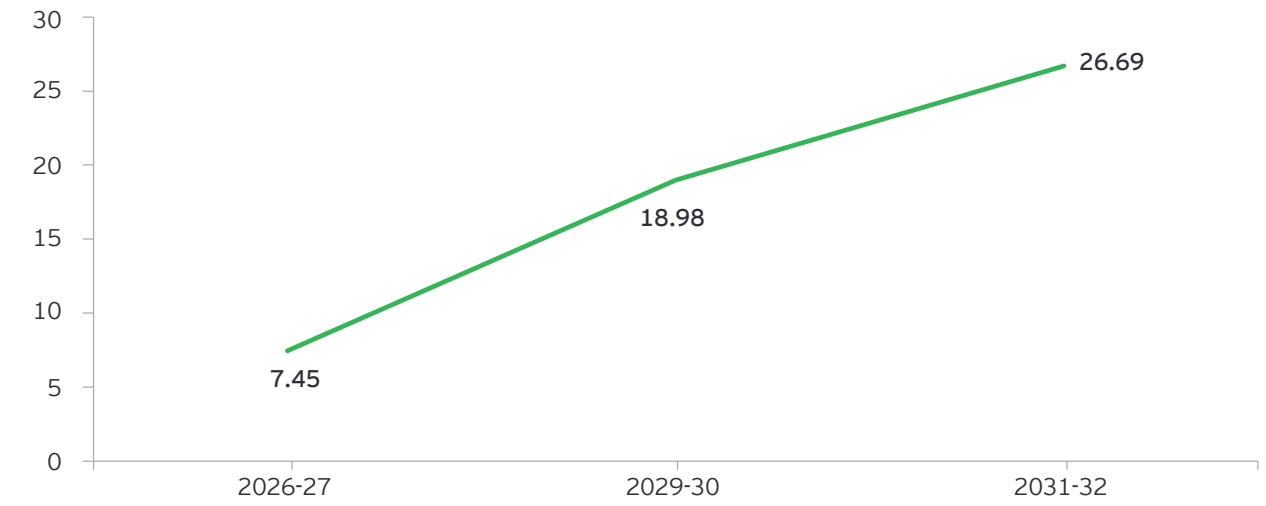
Source: Ministry of Power

105. Ministry of Power

The Indian government acknowledges the importance of Pumped Storage Projects (PSPs) in the country's energy storage landscape and has initiated various steps to foster their growth. In the 2024-25 Union Budget, it was declared that a dedicated policy aimed at encouraging the development of PSPs will be introduced.

As of now, India's operational PSP capacity stands at approximately 4.76 gigawatts, spread across eight different projects. The Central Electricity Authority (CEA) anticipates a substantial rise in the demand for installed PSP capacity in the coming years.

Figure 41: Projected PSP capacity requirement (in GW)



Source: CEA

Pumped hydro storage ecosystem in India has also attracted investments from several leading private players. Some of them are as follows[106]:

- **Adani Green:** In June 2022, the State Investment Promotion Board of Government of Andhra Pradesh cleared four PSPs planned by Adani Green with a cumulative capacity of 3.7 GW and an estimated investment of INR15,740 crore (US$1.9 billion). The projects are proposed in four districts of Andhra Pradesh – two projects in ParvathiPuram (a 1.2 GW plant in Kurukutti and a 1 GW plant in Karrivalasa), one project in YSR Kadapa (a 0.5 GW plant at Chitravathi), and one project in Satya Sai (a 1 GW plant in Gandikota). These projects are likely to be commissioned by December 2028[107].
- **Greenko Energies:** Greenko Energies is developing a PSP in Madhya Pradesh with a capacity of 1,440 MW. The estimated cost of the project is INR6,991 crore (US$852.5 million). The project is likely to be commissioned in December 2024[108]. Greenko Energies also won NTPC's tender for supply of 0.5 GW (six hours storage) standalone pumped storage capacity on a long-term basis (25 years) in December 2022[109].
- **Tata Power:** In August 2023, Tata Power and the Government of Maharashtra have signed an MoU to set up two PSPs with a total capacity of 2.8 GW in Pune (1.8 GW) and Raigarh (1 GW). The estimated cost of these projects is 13,000 crore (US$1.59 billion)[110].

106. The Energy and Resources Institute
107. Business Standard (June 2022) " Andhra Pradesh govt clears Adani green energy projects worth Rs 15,740 cr."
108. Greenko Press Release dated 4th October 2023
109. Greenko Press Release dated 9th December, 2023
110. Livemint (August 2023) " Tata Power inks pact with Maharashtra for two green power projects worth 13,000 cr."

3.8 Waste efficiency

Recognizing the importance of a circular economy, many policies have been introduced by the government to improve waste management. Focus has been on the concept of Enhanced Producer Responsibility (EPR). EPR is a strategy that obligates producers, importers, manufacturers, brand owners and recyclers to control post-consumer waste. It mandates that manufacturers should be responsible for the waste produced during a product's lifecycle because they have a considerable effect on the design, packaging, and material selections of their products.

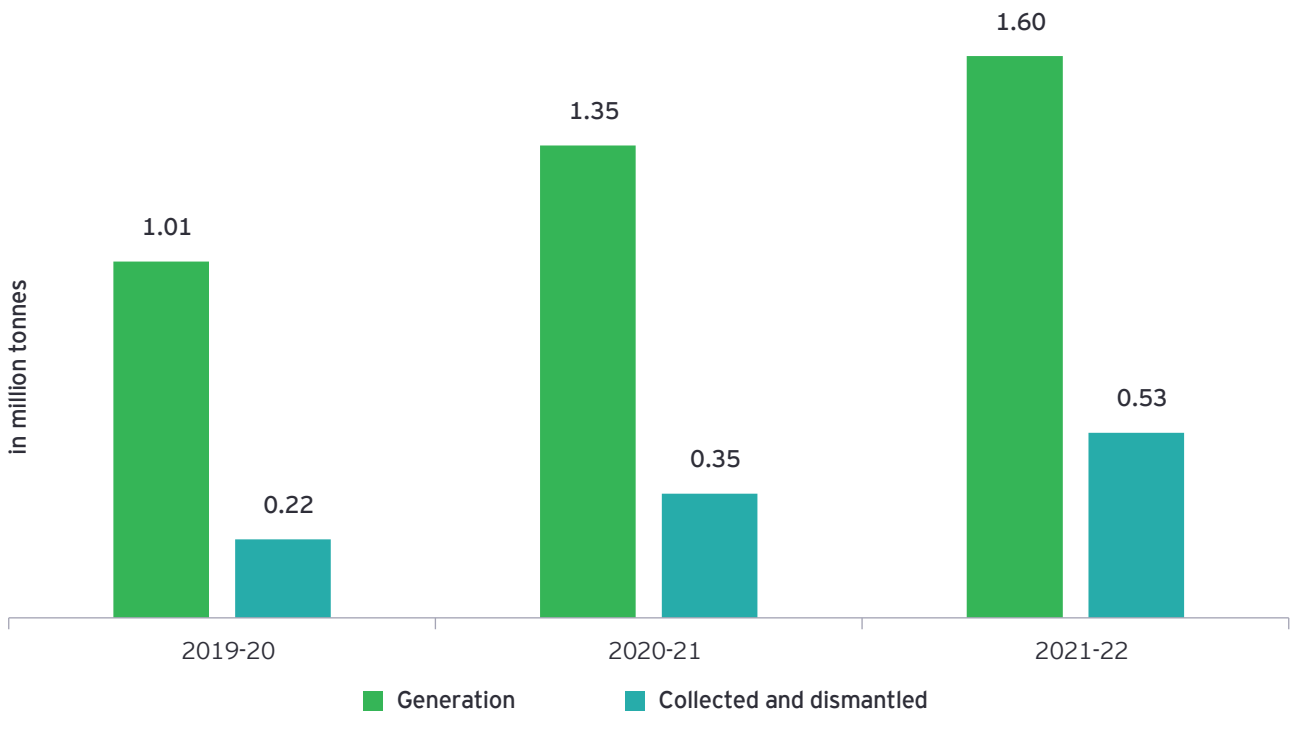
3.8.1. Policy landscape

Several policies have been introduced by the government in line with the different categories of waste (plastic, electronic, biomedical, municipal, etc.).

Electronic Waste (E- Waste) Rules 2022:

India ranks third globally in e-waste generation after China and the US, mainly resulting from increased digitalization. E-waste generation is estimated to have increased from 700,000 tons in 2017-18 to 1.6 million tons by 2021-22. It is projected that nearly 14 million tons of e-waste would be generated by 2030[111]. As per CPCB, e-waste generated and collected, dismantled and disposed in the country from 21 types of EEE notified under the e- waste Management Rules during the last three years have been shown in the below table.[112]

Figure 42: E- waste generation and comparison data



Source: PIB

111. E-waste management in India: Dimensions, regulations and challenges in the current scenario - Lifestyle News | The Financial Express
112. Press Release:Press Information Bureau (pib.gov.in)

Although e-waste management frameworks have existed in India, the rising health and environmental risks from improper disposal methods have prompted the government to implement more stringent measures. E-waste management rules were revised in 2022. These rules focus on managing e-waste in a sustainable manner and additionally mandate the EPR provisions on manufactures, producer and recycler, including:

- The revised rules have expanded the definition of e-waste by including solar PV modules or panels or cells.
- Bulk consumers of e-waste are required to handover the e-waste produced to concerned authorities, thereby reducing the burden of maintaining records/ submitting annual records.
- These rules mandate manufactures, producers, refurbishers and recyclers (MPRR) to register on the portal developed by CPCB.
- Producers can fulfill their targets by purchasing online EPR recycling certificates from registered recyclers.

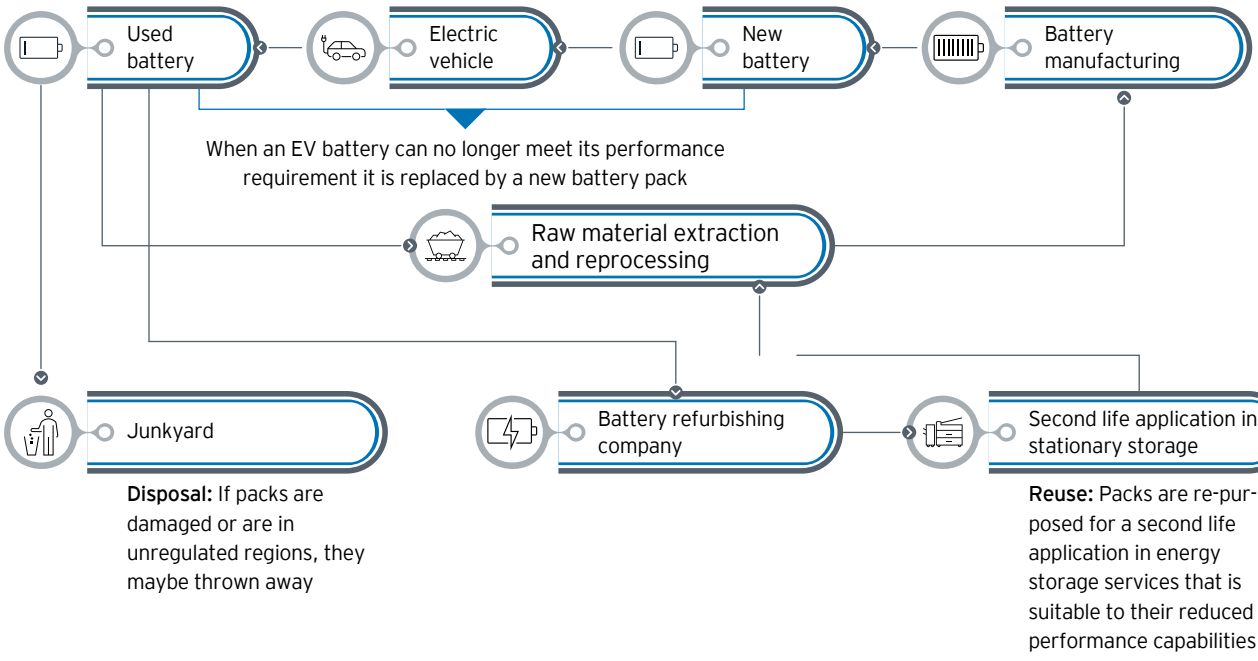
  The number of EPR recycling certificates generated by recyclers is proportional to the amount of e-waste recycled by them.
- Concept of refurbishing certificates and deferred liability have also been introduced in the revised rules, wherein each certificate will correspond to a certain quantity of waste. Purchasing these certificates online allows producers to defer their EPR liability by the period added to the life of the refurbished product.

Electronic waste (e-waste) presents a significant opportunity for the recovery of precious metals such as gold, silver, platinum, and palladium. As technology usage grows, so does the volume of discarded electronic devices, making e-waste recycling not only environmentally crucial but also potentially lucrative. The process involves collecting, dismantling, and extracting valuable materials from old electronics, which can then be refined and reused in new products, gives cost advantage, resource efficiency and reduces the need for mining, leading to a more sustainable and circular economy.

3.8.2 Battery Waste Management Rules, 2022

In 2021, the majority of the battery (Lithium-ion battery) waste was generated from stationary appliances. Electric Vehicles contributed only 15% to this waste.[113] With the growth of EVs, a substantial rise in battery waste is anticipated in the coming years. It is estimated that by 2030, the country will have approximately 128 GWh of lithium-ion battery capacity available for recycling, with 46% originating from electric vehicles alone.[114]

Figure 43: Battery recycling process



Source: JMK Research

113. India: lithium-ion battery waste by source | Statista
114. How can the Indian lithium-ion battery recycling sector lead $6 billion global market? - Express Mobility News | The Financial Express

Battery Waste Management Rules 2022 were notified to ensure environmentally sound management of battery waste. These rules mandate that 90% of discarded battery materials must be recycled and recovered by 2026. Furthermore, 20% of the recycled materials should be used for manufacturing new batteries by 2030.[115]

As per the rules:

- Recyclers and refurbishers are mandated to register with the State Pollution Control Boards/ Committees. Rules have been formulated for the recycling/ refurbishment process.
- Recovery target had also been set for the battery material: 70% by 2024-25; 80% by 2026 and 90% after 2026-27 onwards.
- An environmental compensation will be imposed if the producers fail to achieve the EPR targets, responsibilities and obligations set out in the rules.
- An environmental compensation fund has been developed, wherein funds collected as a part of compensation will be utilized in collection and recycling of uncollected and non-recycled waste batteries.

3.8.3 Investments

As per Bloomberg New Energy Finance, the lithium-ion battery global market is set to grow 10 times from ~180 GWh in 2018 to 2000 GWh in 2030.[116] As per a NITI Aayog report, Europe has the highest battery recycling capacity (>52,000 tons/year) followed by China (>30,000 tons/year). As of 2020, India's recycling capacity was v less than 2000 tons/year.[117]

Recognizing the business potential, investments are underway in the E-waste eco-system. Some examples are:

- Attero, an Indian company, has announced plans to invest around INR8,300 crore (US$1 billion) over the next five years to increase capacity. At present, the recycling capacity of the company is estimated at 144,000 tons of e-waste and 15,000 tons of lithium-ion battery waste.[118]
- Hindalco is investing INR2,000 crore (US$243.9 millions) to establish a state-of-the-art copper and e-waste recycling facility. This new facility aims to introduce advance e-waste recycling technology in the e-waste space.[119]

To conclude, India's e-waste and battery recycling has immense potential in the coming years. Aligning the government rules with new technology and collaborative endeavors in the form of investments from private sector companies can help in paving the way for a cleaner and more sustainable future.

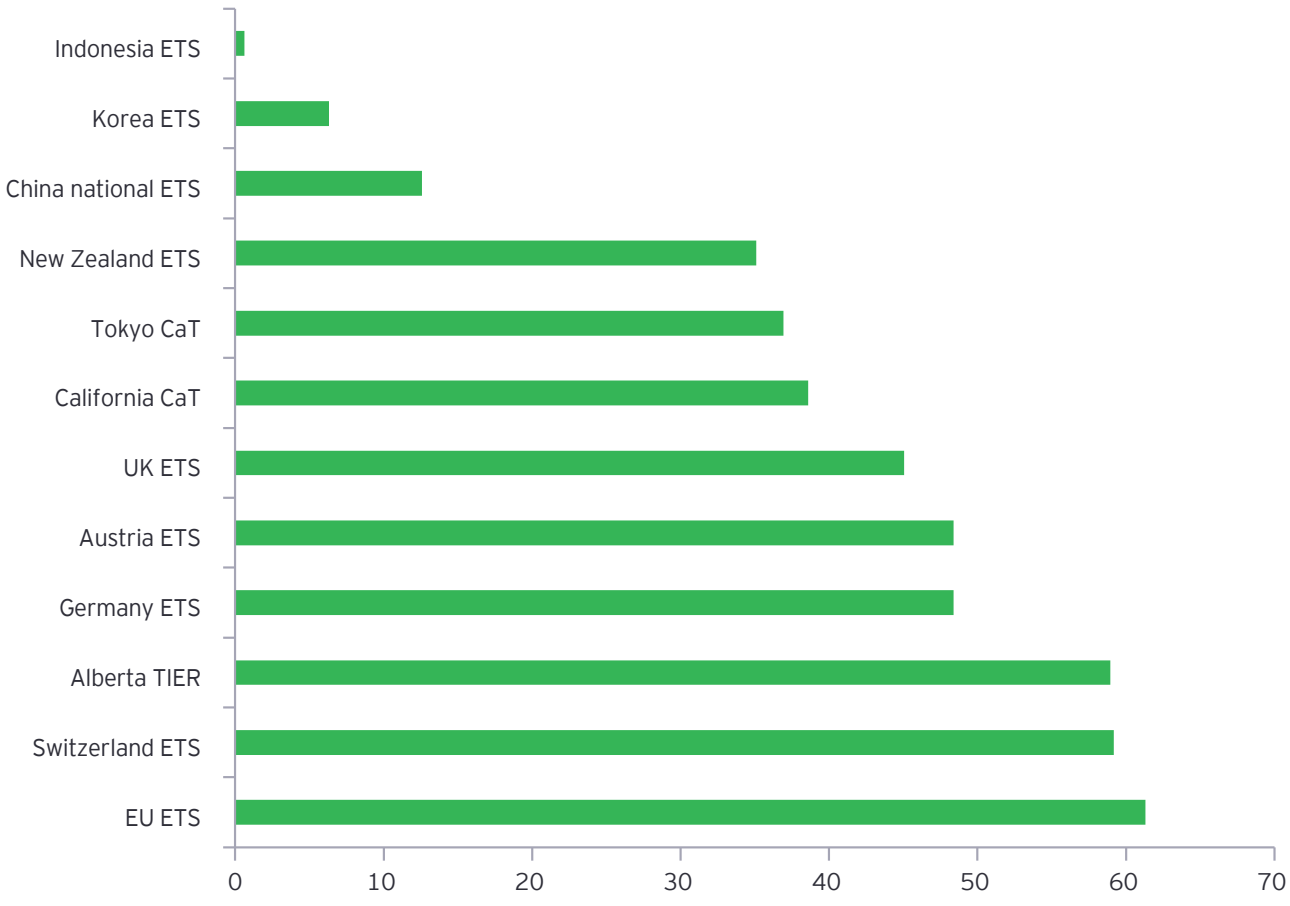
115. How can the Indian lithium-ion battery recycling sector lead $6 billion global market? - Express Mobility News | The Financial Express
116. JMK Research – Recycling of Lithium-Ion battery in India ($1000 million opportunity)
117. ACC-battery-reuse-and-recycling-market-in-India_Niti-Aayog_UK.pdf
118. Attero plans to invest over Rs 8,000 crore in 5 years to ramp up e-waste, battery recycling capacity - The Economic Times (indiatimes.com)
119. Waste to value: The circular solution to e-waste - Stories - Aditya Birla Group

04 Carbon markets

Carbon markets have emerged as a vital instrument used extensively by policy makers. These markets operate on the principle of putting a price on carbon emissions, thereby incentivizing businesses and industries to adopt cleaner technologies and business practices.

> Indian Energy Exchange (IEX) is pivotal in shaping India's energy landscape by fostering the integration of renewable energy and enhancing market efficiency. Our platform is engineered to facilitate integration of clean energy sources, supporting the country's transition towards a sustainable energy future. By streamlining energy trading, we are advancing India's green energy goals. Our commitment to innovation and efficiency in trading systems aligns with international best practices, positioning IEX as a crucial enabler in the global energy transition.
>
> **S N Goel**
> Chairman and Managing Director, IEX

Figure 44: Carbon price (in $) across various ETS in 2024



Source: World Bank

Existing market-based emission reduction schemes

India currently operates two primary market-based emission reduction schemes: the Perform, Achieve and Trade (PAT) scheme and the Renewable Energy Certificates (REC) system.

1.
Perform, Achieve and Trade (PAT) Scheme

The PAT scheme is a regulatory instrument to reduce specific energy consumption in energy-intensive industries, with an associated market-based mechanism to enhance cost-effectiveness through certified energy savings that can be traded. Under this scheme, designated consumers are mandated to achieve energy savings targets, with the option of trading any excess savings in the form of Energy Saving Certificates (ESCerts). While the scheme targets energy efficiency, it is expected that this will also result in a corresponding reduction in GHG emissions.

> UltraTech Cement is committed to leading the energy transition within the cement industry. We believe that enhancing energy efficiency not only drives our business success but also plays a crucial role in lowering the carbon intensity of our operations. This commitment is reflected in our continuous review of energy performance and our investment in advanced, energy-efficient technologies. Our initiatives, such as cooler upgradation, calciner modification, voltage variable frequency drive (VVFD) installation, and burner modification across our manufacturing plants, have drastically improved our energy productivity. Additionally, we focus on generating power from cleaner sources of energy, which reduces carbon emissions and enhances energy security. We are also dedicated to adopting renewable energy sources, optimizing production processes, and investing in green technologies. By setting high environmental standards and implementing innovative practices, we aim to drive significant progress in the cement sector and contribute to a more sustainable construction industry. Our goal is to lead by example and advance sustainability in cement production.
>
> **Atul Daga**
> Chief Financial Officer , UltraTech Cement Ltd.

2.
Renewable Energy Certificates (REC) System: REC mechanism is to incentivize developers of renewable energy sources

The REC system was introduced to facilitate the achievement of renewable energy targets by obligating entities to purchase RECs if they fall short of their renewable purchase obligations (RPOs). All DISCOMs and open access consumers are obligated. RECs represent the environmental attributes of power generated from renewable energy sources and can be traded on the power exchange markets, providing a flexible and market-driven approach to promoting renewable energy.

India proposes to merge the above schemes into a Carbon Trading Scheme.

Introduction of Carbon Credit Trading Scheme (CCTS)

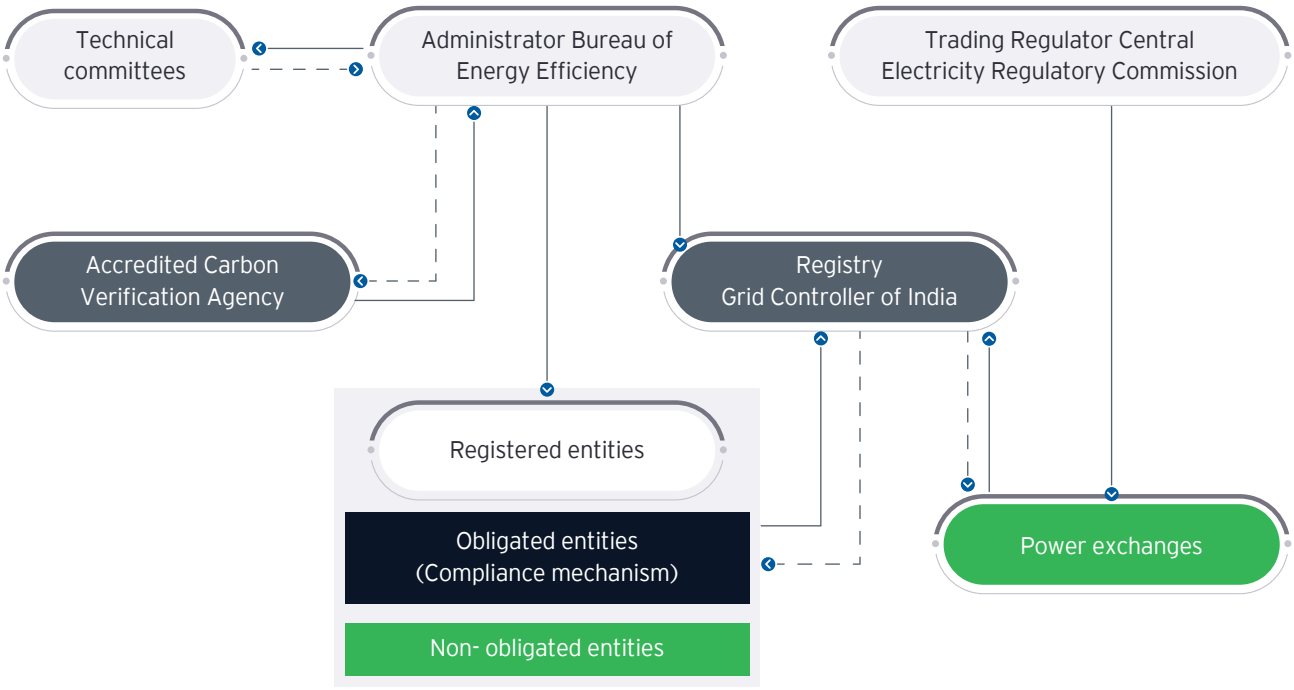
In 2022, the Indian government amended the Energy Conservation Act to introduce the Carbon Credits Trading Scheme (CCTS). Announced on 28 June 2023, the CCTS defines a "carbon credit" as a unit representing the reduction, removal, or avoidance of one ton of carbon dioxide equivalent (tCO_2e) in GHG emissions. The scheme will be governed by the National Steering Committee for Indian Carbon Market (NSCICM), with the Bureau of Energy Efficiency (BEE) as the administrator, the Grid Controller of India Limited as the registry, and the Central Electricity Regulatory Commission (CERC) regulating trading activities. A notification from the Ministry in December 2023 allows non-obligated entities to register projects for carbon credit certificates based on eligibility criteria set by the BEE and NSCICM recommendations. The BEE's Draft Blueprint also proposes potential fungibility between Energy Saving Certificates (ESCerts) and Emission Reduction Units (ERUs).

The launch of a national Emission Trading System (ETS) is expected by 2026[120]. The Union Budget 2024 outlined a roadmap for transitioning industries from 'energy efficiency' to 'emission' targets, indicating a shift to the 'Indian Carbon Market' model. Regulations to support this transition are in development, marking progress in India's approach to carbon market regulation.

120. https://static.investindia.gov.in/s3fs-public/2024-07/carbon_markets_report_0.pdf

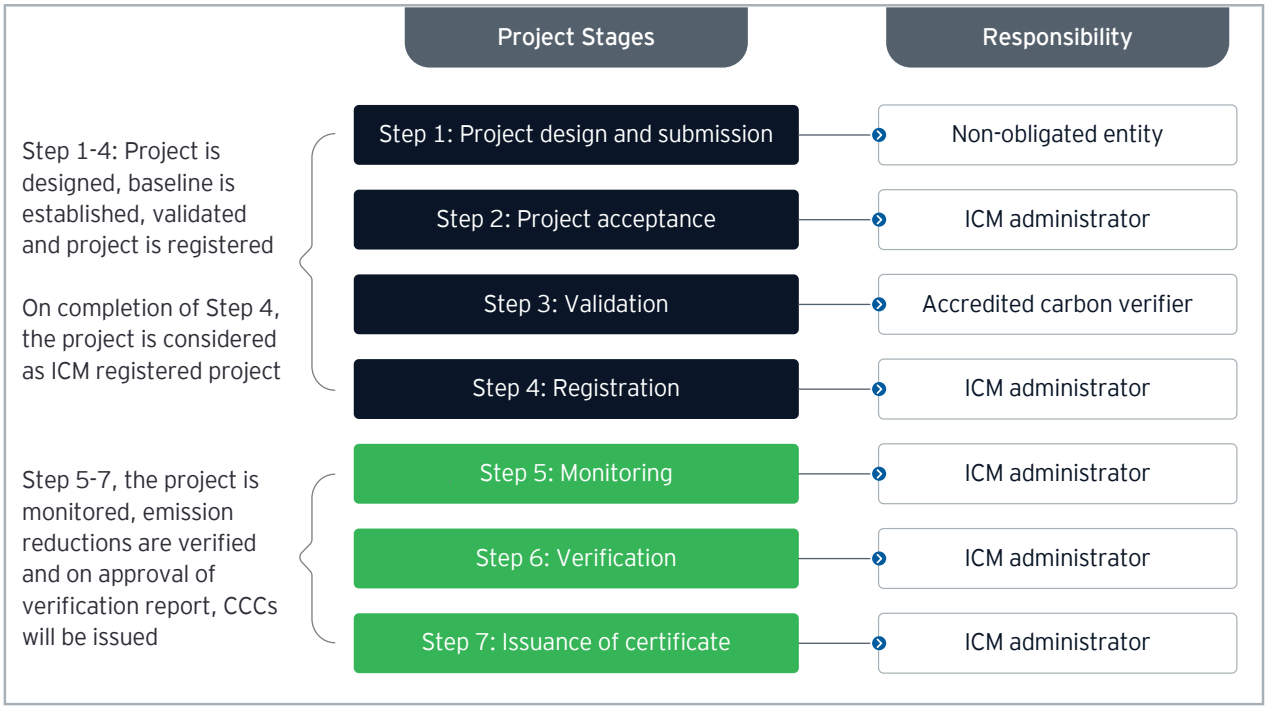
The CCTS is expected to create an additional avenue for entities to trade carbon certificates, supplementing the voluntary market where India is already a prominent player. By integrating various sectors and focusing on emerging technologies, the CCTS is poised to catalyze investment and technological innovation. The CCTS represents a significant leap forward, as it aims to unify the Indian Carbon Market (ICM) by establishing a platform for the trading of carbon credit certificates. These certificates will be issued to entities that outperform their GHG emission intensity targets, allowing them to trade excess reductions as carbon credits. This not only incentivizes reductions in emissions but also provides a mechanism for obligated entities to comply with their targets through market-based transactions.

Figure 45: National Steering Committee for Indian Carbon Market (NSCICM)



Source: Bureau of Energy Efficiency

Figure 46: Project stages for issuance of carbon credit certificates



Source: Bureau of Energy Efficiency

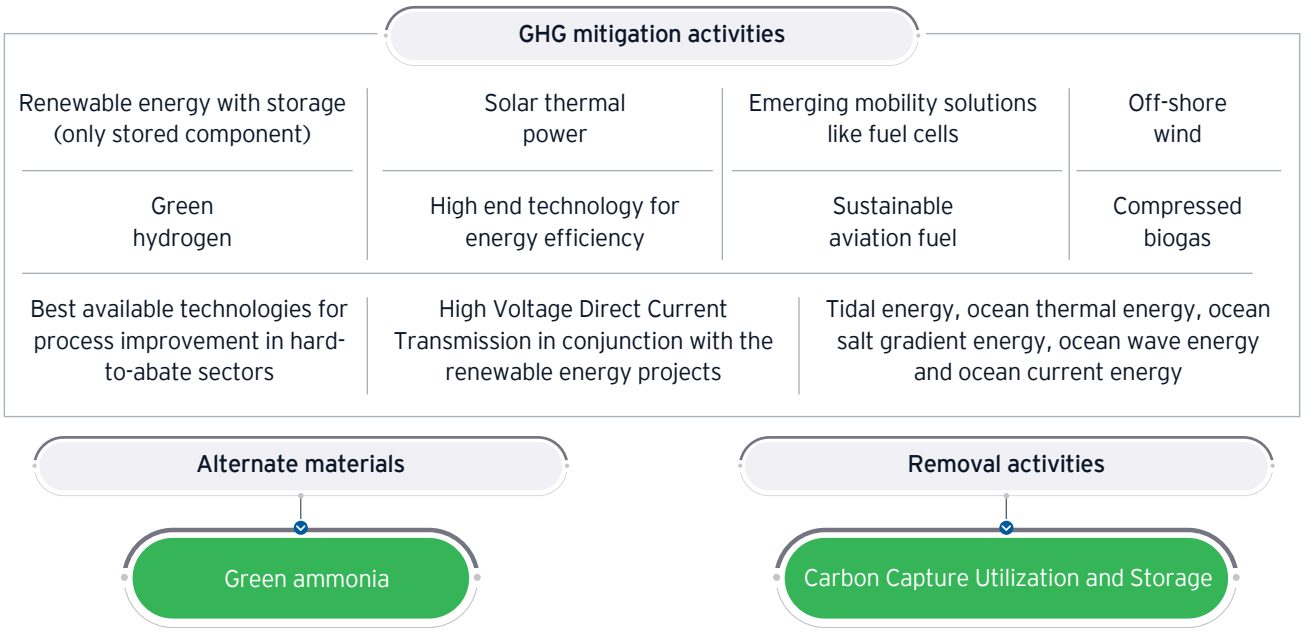
Every project will be registered and have its baseline. For instance, in the case of green hydrogen, the maximum projected emissions of carbon dioxide should be 2 kg per kg of hydrogen, while the baseline is estimated to be 12 kg of carbon dioxide based on grey hydrogen production. Thus, the certificate would recognize the difference of 10 kg as an emission reduction[121].

Paris Agreement Articles 6.2 and 6.4

India has taken a clear stand under Article 6.2 on using Internationally Traded Mitigation options (ITMO) from selected upcoming technologies which are not yet commercially viable. At the same time, a governance process has been established under the aegis of the Ministry of Environment, Forest and Climate Change (MoEF& CC) to approve ITMOs for approval and accounting of an international transaction of carbon credits. International bi-lateral or multiparty MoU, agreements or treaties are in initials stages and expected to gain momentum with increase in the adoption or transfer of cleaner technologies as specified by the government

121. https://static.investindia.gov.in/s3fs-public/2024-07/carbon_markets_report_0.pdf

Figure 47: List of activities approved in India under Article 6.2 of the Paris Agreement



Source: Bureau of Energy Efficiency

For Sustainable Development Mechanism (SDM) under Article 6.4, an additional activity of emission reduction by cook stove usage has been added. While the details of a working mechanism for SDM are still being deliberated by respective bodies of United Nations Framework Convention of Climate Change (UNFCCC), the clarity provide by Government of India will help industries to use these global carbon financing mechanisms effectively for speedy adoption of these technologies.

Carbon taxes

Another way of putting a price on emissions is through the introduction of carbon taxes. This approach directly sets a price on carbon by defining a tax rate on greenhouse gas emissions or on the carbon content of fossil fuels. The idea is to make emitting carbon more expensive, thereby encouraging businesses and individuals to reduce their emissions. The resulting reduction in emissions depends on how much emitters change their behavior in response to the tax. While India does not have an explicit carbon tax, high excise duties on petrol and diesel and coal cess are examples of carbon taxes.

To conclude, India's carbon market is advancing with the introduction of the Carbon Credits Trading Scheme (CCTS) and the Green Credit Program (GCP), which are instrumental in steering the country's decarbonization efforts. The potential for fungibility among various carbon instruments, such as ESCerts, RECs, and carbon credits, transactions under Article 6.2 and 6.4 is expected to enhance market flexibility and support energy transition strategies. Ensuring regulatory clarity, adopting international standards, and establishing robust monitoring systems are critical for maintaining market integrity. Active engagement with stakeholders and setting ambitious sectoral targets will drive the market's success. With these elements integrated, India's carbon market is poised to make a meaningful impact on global climate action.

05 Financing energy transition

> India's path to a sustainable energy future offers a trillion-dollar investment opportunity, spanning energy transition, industrial decarbonization, and urban sustainability.
>
> We are witnessing rapid advancements in renewable energy and a shift towards electrifying transportation, from shared mobility to battery recycling, all supported by an increase in the supporting manufacturing value chain. Furthermore, India's focus on urban sustainability is transforming cities, enhancing air quality, mitigating traffic congestion, and creating more liveable environments. EverSource Capital, through its innovative business models and proven economics, is uniquely positioned to leverage this trillion-dollar opportunity, delivering both substantial climate impact and attractive commercial returns.
>
> **Dhanpal Jhaveri**
> Managing Director, EverSource Capital

To achieve India's ambitious net zero target, efforts need to be made across several key sectors and themes that are integral to the energy transition. This not only includes renewable energy generation such as solar, hydro and wind power, biofuels, green hydrogen, energy storage solutions like battery systems and the electrification of transportation with a focus on electric vehicles, but also includes the technology that supports the energy transition and decarbonization efforts in the hard-to-abate sectors.

The current level of investment accounts for only about **25%** of the total required to meet the country's Nationally Determined Contributions (NDCs).

Both the government and private sectors must contribute, harnessing domestic and international funds across public and private pools of capital. Various projections have been made regarding the total capital needed to support India's journey toward decarbonization. The Council on Energy, Environment and Water (CEEW) projects that India will require a cumulative investment of US$10.1 trillion to significantly advance its climate transition efforts and achieve net zero emissions by 2070. Conventional (more secured) funding sources are projected to supply around US$6.6 trillion, which leaves a significant investment shortfall of US$3.5 trillion that needs to be met to fully realize India's energy transition objectives[122]. This substantial financial requirement underscores the urgency for innovative and less traditional financing mechanisms.

Despite the formidable challenges and huge gaps, India's track record in securing green finance has been noteworthy. According to Climate Policy Initiative's (CPI) estimates for the fiscal year 2019-20, India managed to raise US$44 billion (~50% of which came from domestic private sources), a 150% increase from the 2017-18 fiscal year. While these achievements are significant, they fall short of the mark.

Financial institutions (FIs) and corporates are increasingly being called upon to help meet these targets and explore strategies to fund these financing gaps.

(FIs) play a pivotal role in funding decarbonization and energy transitions. However, they face significant challenges, such as high risks of emerging green technologies that don't have extensive historical data while simultaneously reconciling their preference for shorter investment cycles. The commercialization and scalability (or lack thereof) of new technologies poses risks for FIs, especially venture capital firms, which must finance these projects before they have proven large-scale viability.

To overcome these obstacles, FIs are turning to innovative financing like blended finance, providing technical assistance to companies, engaging in policy advocacy as well as exploring sectors with more public-private partnership potential that reduce their risks.

Additionally, there is an immediate need for large corporates to align their business models with environmental goals. The high cost of emerging greener technologies and the lack of incentives in availing sustainable financial instruments, as well as lack of knowledge on access to such pools of capital impede their potential impact.

It may be prudent to assume that approximately **US$150 to US$200 billion** is required annually to fund India's decarbonization journey. This represents approximately **4% to 6%** of the Indian GDP.

122. Investment Sizing India's 2070 Net Zero Target, CEEW, 2021

Government fostering incentives for energy transition

The Government of India's array of incentives and policies is shaping an attractive landscape for investors in the renewable sector. With supportive measures for renewable energy, including subsidies and favorable regulations, the government is boosting the investment potential of these sectors. For green hydrogen, strategic targets and export incentives signal a growing market with high returns. Biofuel advancements, backed by blending mandates and technological support, are opening new investment channels. In the electric vehicle space, subsidies and infrastructure initiatives are lowering market entry barriers, presenting a compelling case for investment in the burgeoning EV industry. These concerted efforts by the government are not only propelling India's green economy but also offering investors a gateway to sustainable and profitable ventures.

Another important stride was made by the government in the recent budget announcement introducing a 'Climate Finance Taxonomy'. This initiative aims to direct capital towards climate-resilient infrastructure and practices, particularly in sectors such as shipping, aviation, iron and steel, and chemicals. It ensures that investments are efficiently channeled into veritable green projects, increasing capital availability for climate-related initiatives.

Government of India's sovereign green bond was also a successful endeavor. The inaugural sovereign green bond issuance in 2023 comprised two tranches, each raising INR8,000 crore (US$1 billion), with the first tranche catering to a five-year maturity and the second to a ten-year maturity, collectively channeling INR16,000 crore (US$2 billion) towards financing the nation's green initiatives.

Regulators shaping India's climate finance landscape

India's regulatory framework is advancing with a strong emphasis on sustainable finance, reflecting a commitment to environmental stewardship and climate action. To start with, the Reserve Bank of India's (RBIs) strategic initiatives are pivotal in fostering a sustainable financial landscape. Aligning with the global push for greener economies, the RBI's membership in the Network for Greening the Financial System (NGFS) reflects a strong dedication to sustainable finance. The 2023 green deposit guidelines mark a proactive move to direct domestic investments into sustainable projects. Complementing this, the RBI is also committed to institute a robust disclosure framework for climate-related financial risks in lines with the TCFD, applicable to certain categories of NBFCs, thereby reinforcing the financial sector's role in India's broader climate action efforts. As a result, FIs are reassessing their sectoral exposure and increasingly seeking to re-position their portfolios towards greener projects and sectors.

SEBI is actively enhancing ESG accountability with mandatory BRSR reporting for top listed companies and recently introduced a consultation paper on sustainable finance, aiming to broaden the scope of India's green investment landscape. This framework is set to broaden the scope of current green debt securities to encompass social instruments, sustainability-linked instruments, sustainable securitized debt, and more, reflecting a holistic approach to sustainability.

The Carbon Credit Trading Scheme (CCTS) within the Indian Carbon Market Framework is also creating a market-driven impetus for emission reductions, offering a financial mechanism to reward low-carbon initiatives.

Table 4: Financial institutions redirecting capital towards energy transition

Energy transition theme	Market size (2030)	Debt	Equity	DFIs
Renewables	Rooftop solar - $14.5 billion Green hydrogen - $5. 63 billion Biofuels - $10.31 billion Offshore wind - $45 billion	Sterling & Wilson received debt financing of $89 million from RIL Venture Asset Mgt	Ayana Renewables raised $720 million in the PE Round from NIIF, BII, Eversource	Grant of $142 million to the Indian Ministry of Finance and a $76 million loan to the SBI to expand solar generation capacity under the Indo German solar Partnership
		BluePine Energy received debt financing of $29 million from Tata Capital	O2 Power raised $500 million in the PE round from Temasek and EQT	
Sustainable mobility	2W/3W - $8.72 billion Charging Infra - $5.7 billion EV Battery - $16.54 billion	Ola Electric received debt financing of $240 million from State Bank of India	Ather Energy received funding of $17 million from Hero Motorcorp	Mahindra Electric Automobile Limited received funding of $244 million from BII
		GreenCell Mobility received debt financing of $37 million from SMBC	Tata Passenger EV raised $890 million in a Venture Round from the TPG Rise Fund	
Climate-tech	Agri-tech - $78.5 billion Resource efficiency -$16.8 billion	-	Attero raised $12 million in Series C from Forum Synergies	Ulink AgriTech Private Limited received $5.5 million from BII
		Smart Joules received debt financing of $7 million from IFU	DeHaat raised $60 million in Series E from Temasek	
BESS	$5.97 billion	-	Battery Smart raised $64 million in Series B from Acacia Inclusion	
Decarbonization and energy transition	-	Serentica received debt financing of $360 million from REC	■ Serentica raised $650 million in PE round from KKR	-
		Greenko received debt financing of $350 million from Abu Dhabi Investment Authority (ADIA	■ Greenko raised $700 million in PE round from ADIA	

Source: EY Analysis

Indicates foreign investment

Deal activity in crucial energy transition sectors and themes

India's clean energy sectors — solar, wind, green hydrogen, EVs, and battery energy storage systems (BESS) — are seeing robust investment activity. In solar, over US$2 billion has been raised for residential rooftop installations since 2015, with key deals like ZunRoof's US$3 million Series A and Loom Solar's US$2 million seed funding. In wind energy, Inox Wind raised INR800 crore, and Suzlon Energy secured INR1200 crore (US$ 146 million) in post-IPO equity. Green hydrogen is gaining traction with deals like Hygenco's US$25 million funding and Ayana Renewable Power's US$330 million investment. EVs saw US$550 million raised for development by companies like Ola Electric and Ather Energy, while in BESS, Cygni Energy raised US$12.5 million and Battery Smart secured US$7 million.

Financing trends show that solar continues to attract both equity and debt, with international finance playing a key role. Offshore wind energy has the potential to benefit from viability gap funding, while green hydrogen is seeing significant corporate commitment alongside public sector support. EVs are also experiencing a surge in venture capital, with record-breaking funding, and BESS is seeing US$9 to 10 billion in yearly investment, driven by venture capital growth and government-backed tenders.

The quadrupling of venture capital funding in climate tech since 2019 highlights the significant role technology plays in addressing climate change. Climate tech start-ups secured substantial funding in 2023, with momentum continuing into 2024. Investors are expanding their focus beyond traditional areas, scouting for start-ups in sub-sectors like agri-tech, technologies that increase resource efficiency (energy, water, waste), sustainable packaging, and the circular economy. Supportive government policies and a growing consumer demand for sustainable solutions are further enhancing the sector's appeal. This surge in investment activity within India's climate tech space is fueled by the maturation of technologies, stronger R&D capabilities, greater consumer awareness, and the government's clear push toward a green energy transition, offering abundant opportunities for both investors and start-ups.

Role of sustainability-linked instruments (SLIs) in hard-to-abate sectors

Hard-to-abate sectors, such as steel, cement, aluminum, oil and gas, and heavy transport, are significant contributors to global emissions, particularly in India. The industrial sector in India accounts for around 22% of total GHG emissions and is less efficient than equivalent sectors in other countries. Achieving deep decarbonization in these sectors is crucial for India's net-zero target by 2070, but it presents significant challenges due to the energy-intensive processes involved.

Decarbonizing hard-to-abate sectors remains challenging due to the absence of economically viable green technologies at scale. For the steel, cement, and heavy transport industries, existing technologies such as green hydrogen and carbon capture and storage are still in the early development stages and come with high costs.

In this context, SLIs, particularly sustainability-linked bonds (SLBs) and sustainability-linked loans (SLLs), have emerged as flexible tools to incentivize progress across environmental parameters in these industries. SLBs are forward-looking, performance-based debt instruments tied to the achievement of Sustainability Performance Targets (SPTs), often linked to key environmental indicators. These instruments allow companies to raise capital without being bound by the specific use of proceeds, providing flexibility for firms in hard-to-abate sectors to fund their broader decarbonization efforts. SLBs incentivize companies by offering financial rewards or penalties based on the success of achieving their set sustainability targets.

Going beyond SLIs to the overall sustainable bonds market, in 2023, the global market raised approximately US$442 billion in sustainable bonds, with SLBs contributing a substantial portion. In India, as of 2021, the cumulative volume of sustainable debt, including SLBs, reached US$19.5 billion. Additionally, three-quarters (75%) of the cumulative labeled bonds (including green bonds) volume in India originates from the private sector, amounting to US$14.6 billion. Dominating India's sustainable debt market, green bonds represented 89% of the Green, Social, and Sustainability (GSS) market in 2021.

Indian companies, particularly in hard-to-abate sectors, are increasingly accessing international sustainable bond markets to finance their decarbonization efforts. Non-financial corporates comprise the largest share, with US$12.6 billion raised across 40 deals. These figures demonstrate that Indian corporations are increasingly leveraging sustainability debt instruments to fund their transition pathways and are looking at climate finance as an opportunity.[123]

Unlocking private capital: challenges and key recommendations

Barriers to private capital flow

One of the primary challenges hindering private investment in India's climate sector (beyond the mainstream sectors) is the high capital requirements, particularly for early-stage companies. These ventures often require significant investment for research and development, and scaling up production, which can exceed the risk appetite and liquidity preferences of traditional investors. The uncertainty

123. India Sustainable Debt State of The Market 2021, CBI 2021

surrounding long development timelines, uncertain return profiles, untested market adoption, and the potential for unfavorable policy shifts further compounds the risk and renders the companies less investible, making it difficult for these companies to secure the necessary funding. This capital-intensive nature makes them more sensitive to funding cycles and can create barriers to accessing the capital needed to demonstrate product viability and scale operations effectively.

Mobilizing private investment requires navigating the complexities of debt versus equity funding. Companies must carefully assess their financial strategies, considering the long-term viability and control implications of equity funding against the fixed obligations of debt financing. The choice is influenced by the company's lifecycle stage, risk tolerance, and the nature of the investment itself.

These challenges highlight the need for strategic risk transfer mechanisms and innovative financing instruments that can accommodate these unique aspects and offer incentives for sustainable returns with a lower risk profile.

Innovative financing mechanisms

Financial incentives and mechanisms such as blended finance and patient capital are crucial in supporting and mobilizing private investment.

Blended finance instruments like concessional loans, guarantees, first-loss, subordinated debt and performance-based incentives, as well as advisory and technical assistance, can offer a strategic approach to commercialize and de-risk early-stage and non-traditional sectors and facilitate their scalability. By filling funding gaps in collaboration with public, private, DFI and philanthropic capital, particularly in sectors where the economic impact is yet to be fully monetized, blended finance plays a crucial role in ensuring that impactful innovations receive the necessary support, regardless of their development stage.

It is especially vital for technologies with longer gestation periods, where traditional funding mechanisms may fall short. Blended finance's ability to combine grants, equity, and debt creates a powerful tool for supporting climate projects throughout their lifecycle. DFIs have a particularly important role to play in more risky or unconventional sectors, wherein they can provide grants and technical assistance from their global portfolio to support ongoing R&D, pilot projects and make these sectors more viable.

The role of government in bridging the gap

The role of government policy in bridging the financing gap cannot be overstated. Clear, long-term policy signals and regulatory certainty can reduce the perceived risks associated with green investments, making the transition more affordable and attractive to investors. By fostering an environment conducive to investment through supportive policies and incentives, India can attract the necessary global and domestic capital to fund its ambitious green transition.

The government can provide support by facilitating public-private partnerships (PPPs), especially in sectors and technologies where investors may hesitate due to uncertainties and delayed returns. PPPs can offer private investors the confidence they need, attracting private capital to underfunded sectors and creating a win-win situation for all involved.

Conclusion

Companies must continue to innovate and integrate sustainability into their core strategies, leveraging green technologies and enhancing transparency in climate disclosures. They must leverage their company's opportunities and strengths and engage with the right pools of capital to raise green finance.

Private investors have a crucial role in this transition, not only by diversifying their portfolios with green assets but also by venturing into riskier (than usual) investments that have long-term environmental impact and financial returns. They should consider investing across a company's lifecycle and engage with blended finance instruments to balance risk and reward.

Development Finance Institutions (DFIs) are tasked with the critical function of de-risking investments in the green sector. By offering guarantees and other financial instruments, DFIs can provide the assurance needed to spur private sector investment into climate technologies and essential infrastructure.

Venture capital firms have the unique opportunity to fuel innovation by supporting early-stage green start-ups, thus seeding the market with transformative solutions that can scale. Private equity, with its substantial capital reserves and long-term investment horizon, is strategically positioned to fund large-scale green infrastructure projects, playing a pivotal role in the energy transition narrative.

The stakeholders need to work together not only to meet climate targets but also to take advantage of the economic opportunities that come with this transition. To access these opportunities, they must be prepared and make deliberate collective efforts. By aligning their actions towards a common goal, stakeholders can unlock the full potential of climate-aligned capital. This will drive India towards a greener and more resilient future, making it an attractive destination for climate-focused capital.

List of abbreviations

S. No.	Abbreviation	Definition
1	AAT	Advanced Automotive Technology
2	ACC	Advanced Chemical Cell
3	ADIA	Abu Dhabi Investment Authority
4	ALMM	Approved List of Models and Manufacturers
5	BCD	Basic Customs Duty
6	BEE	Bureau of Energy Efficiency
7	BESS	Battery Energy Storage Systems
8	BRSR	Business Responsibility and Sustainability Reporting
9	BU	Billion Units
10	C&I	Commercial and Industrial
11	CAGR	Compound Annual Growth Rate
12	CBAM	Carbon Border Adjustment Mechanism
13	CBG	Compressed Biogas
14	CCTS	Carbon Credit Trading Scheme
15	CCUS	Carbon Capture, Utilization and Storage
16	CEEW	Council on Energy, Environment and Water
17	CERC	Central Electricity Regulatory Commission
18	CESC	Calcutta Electric Supply Corporation
19	CFO	Chief Financial Officer
20	CHT	Centre for High Technology
21	CO_2	Carbon Dioxide
22	COO	Chief Operations Officer
23	CPCB	Central Pollution Control Board
24	CPI	Climate Policy Initiative
25	CPSU	Central Public Sector Undertaking
26	CS	Company Secretary
27	CSS	Cross Subsidy Surcharge
28	DFI	Development Finance Institutions
29	DG	Diesel Generator
30	DISCOM	State Distribution Companies
31	DOE	Department of Energy
32	DPA	Deendayal Port Authority
33	DRC	Democratic Republic of Congo

S. No.	Abbreviation	Definition
34	EBP	Ethanol Blended Petrol
35	EEE	Electrical and Electronic Equipment
36	EOU	Export Oriented Units
37	EPR	Extended Producer Responsibility
38	ERU	Emission Reduction Unit
39	ESCerts	Energy Saving Certificates
40	ESG	Environmental, Social and Governance
41	ESO	Energy Storage Obligation
42	ESS	Energy Storage System
43	ESY	Ethanol Supply Year
44	ETS	Emission Trading System
45	EU	European Union
46	EVPCS	Electric Vehicle Public Charging Station
47	FAME India	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India
48	FDI	Foreign Direct Investment
49	FI	Financial Institutions
50	FIMI	Federation of Indian Mineral Industries
51	FLS	Feeder Level Solarization
52	FY	Financial Year
53	GCF	Green Climate Fund
54	GCP	Green Credit Programme
55	GDP	Gross Domestic Product
56	GERC	Gujarat Electricity Regulatory Commission
57	GH2	Green Hydrogen
58	GHG	Green House Gas
59	GLOF	Glacier Lake Outburst Floods
60	GRI	Global Reporting Initiative
61	GSS	Green, Social, and Sustainability
62	GST	Goods and Services Tax
63	GUVNL	Gujarat Urja Vikas Nigam Limited
64	GW	Gigawatts
65	GWh	Gigawatt Hour
66	HPO	Hydro Purchase Obligation
67	ICE	Internal Combustion Engines

S. No.	Abbreviation	Definition
68	ICM	Indian Carbon Market
69	IEA	International Energy Agency
70	IEX	Indian Energy Exchange Limited
71	IFC	International Finance Corporation
72	IHCL	Indian Hotels Company Limited
73	INR	Indian Rupee
74	IPO	Initial Public Offering
75	IRA	Inflation Reduction Act
76	ITC	Investment Tax Credit
77	ITMO	Internationally Traded Mitigation Option
78	KWh	Kilowatt Hour
79	LCOE	Levelized Cost of Electricity
80	LIFE	Lifestyle for Environment
81	MMT	Million Metric Tons
82	MMTPA	Million Metric Tons per Annum
83	MNRE	Ministry of New and Renewable Energy
84	MoEF&CC	Ministry of Environment, Forest and Climate Change
85	MoPNG	Ministry of Petroleum and Natural Gas
86	MoU	Memorandum of Understanding
87	MPRR	Manufacturers, Producers, Refurbishes and Recyclers
88	MSP	Mineral Security Partnership
89	MT	Metric Tons
90	MTPA	Metric Tons per annum
91	MW	Megawatt
92	MWe	Megawatts Electric
93	MWh	Megawatt Hour
94	NBCC	National Biofuel Coordination Committee
95	NBFC	Non-Banking Financial Company
96	NDC	Nationally Determined Contributions
97	NGEL	NTPC Green Energy Limited
98	NGFS	Network for Greening the Financial System
99	NHPC	National Hydroelectric Power Corporation Limited
100	NIWE	National Institute of Wind Energy
101	NPCIL	Nuclear Power Corporation of India Limited

S. No.	Abbreviation	Definition
102	NSCICM	National Steering Committee for Indian Carbon Market
103	NTPC	National Thermal Power Corporation Limited
104	OEM	Original Equipment Manufacturer
105	OGP	Obvious Geological Potential
106	ORF	Observer Research Foundation
107	PAT	Perform, Achieve and Trade
108	PCKL	Power Company of Karnataka Limited
109	PCS	Public Charging Station
110	PE	Private Equity
111	PIB	Press Information Bureau
112	PLF	Plant Load Factor
113	PLI	Production Linked Incentive
114	PM E-DRIVE	PM Electric Drive Revolution in Innovative Vehicle Enhancement
115	PM JI-VAN	PM Jaiv Indhan-Vatavaran Anukool fasal awashesh Nivaran
116	PM KUSUM	PM Kisan Urja Suraksha evam Utthan Mahabhiyan
117	PNG	Piped Natural Gas
118	PPA	Power Purchase Agreement
119	PPP	Public-Private Partnership
120	PSP	Pumped Storage Power
121	PTC	Production Tax Credit
122	PV	Photovoltaic
123	RBI	Reserve Bank of India
124	RE	Renewable Energy
125	REC	Renewable Energy Certificate
126	REE	Rare Earth Elements
127	REIA	Renewable Energy Implementing Agencies
128	RERC	Rajasthan Electricity Regulatory Commission
129	RIL	Reliance Industries Limited
130	ROI	Return on Investment
131	RPO	Renewable Purchase Obligation
132	RTC	Round the Clock
133	RVUNL	Rajasthan Vidyut Urja Nigam Limited
134	SAF	Sustainable Aviation Fuel
135	SCRI	Supply Chains Resilience Initiative

S. No.	Abbreviation	Definition
136	SDM	Sustainable Development Mechanism
137	SEBI	Securities Exchange Board of India
138	SECI	Solar Energy Cooperation of India
139	SEZ	Special Economic Zone
140	SIGHT	Strategic Interventions for Green Hydrogen Transition Programme
141	SJVN	Satluj Jal Vidyut Nigam
142	SLB	Sustainability-Linked Bond
143	SLI	Sustainability-Linked Instruments
144	SLL	Sustainability-Linked Loan
145	SMR	Small Modular Reactor
146	SPT	Sustainability Performance Target
147	SS	Sugar Season
148	STU	State Transport Undertaking
149	TCFD	Task Force on Climate-Related Financial Disclosures
150	TPP	Thermal Power Plant
151	UNFCC	United Nations Framework Convention on Climate
152	USD	United States Dollar
153	VC	Venture Capital
154	VGF	Viability Gap Funding
155	VRES	Variable and Intermittent Renewable Energy Source
156	VVFD	Voltage Variable Frequency Drive
157	ZEV	Zero Emission Vehicle

List of figures

List of tables

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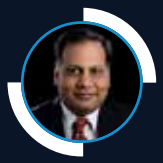

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