CLIMATE CHANGE AND ENERGY TRANSITION: DEALING WITH TRADE-OFFS

06

CHAPTER

Despite being one of the fastest-growing economies in the World, India's annual per capita carbon emission is only about one-third of the global average. India envisions a 'Viksit Bharat' by 2047, which translates to 'Developed India'. This vision and the goal of achieving Net Zero carbon emissions by 2070 guide the country's interventions for high and robust economic growth, which is inclusive and environmentally sustainable. 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 quo non for development. This task is a challenge, considering that cleaner and greener energy sources require viable battery storage technologies and access to critical minerals to allow these sources to be stable energy suppliers. Balancing development needs with a low-carbon pathway is a tightrope, especially when financed predominantly through domestic resources.

INTRODUCTION

6.1. Since the last Economic Survey was written, there has been no dearth of conferences, meetings, and summits dedicated to climate change. It continues to dominate policy and other discourses around the world. It provides a ready-made topic for think tanks, experts, and policy wonks to appear suitably concerned. However, the world is realising what experts and policymakers in advanced nations are resisting - that its current approach to dealing with climate change is flawed for one very simple reason. It continues to ignore trade-offs. But practical men and women have been unable to avoid recognising trade-offs. Countries had to push back their own timelines.

6.2. The United Kingdom postponed its decision to ban the sale of vehicles that run on petrol and diesel for five years from 2030 to 2035. Germany had to dilute its rules for banning boilers running on fossil fuels before they could be passed. The rise of alternative political parties in developed nations is attributed to the public's resistance to climate-related rules that are perceived as unfairly targeting the poor and low-income by raising their cost of living. According to Bloomberg, German businesses cite rising energy costs as the single biggest reason for relocating out of the country[1]. That is the crux of the challenge that governments are grappling with.

6.3. Alternative energy sources require fiscal subsidies to be affordable. However, most governments worldwide are fiscally stretched, especially after dealing with the economic and

1 'Germany's Days as an Industrial Superpower Are Coming to an End', 10th February 2024, Bloomberg (https://www.bloomberg.com/news/features/2024-02-10/why-germany-s-days-as-an-industrial-superpower-are-coming-to-an-end)

health dislocations caused by the pandemic. Many countries also tax fossil fuels heavily. By clamping down on their usage, governments will lose those revenues. Geopolitically, the thrust on renewable energy and electric vehicles has set off a race to secure critical minerals and rare earths. China has positioned itself as an indispensable source of several of these materials. Securing supply in crunch times is a matter of concern. Nuclear energy is the cleanest and safest option. However, some nations are reluctant to consider it given that their public overestimates probabilities of rare events, as humans are wont to. Three-mile island, Chernobyl and Fukushima, loom large in people's minds. Prof. Daniel Kahneman, who passed away earlier this year, would have chuckled.[2]

6.4. Relatively common metals like copper and nickel are going to become scarcer. In 'The Material World', Ed Conway wrote that the world might need more copper in the next few decades than it has ever used since the metal was known to humans. Not just copper but other metals will also be in short supply. The price of energy transition will be too much for most nations. It will only get worse. More importantly, extracting materials and minerals requires a tremendous amount of energy. Analysts in JP Morgan wrote[3], "... just developing the forecasted wind and solar capacities would require *~10EJ of energy during 2024-30, which is equivalent to ~20% of our projected global energy demand growth over the same period (forecasts based on our Global Energy Outlook) and will emit ~1,450 mn tonnes of CO2e (~207 mn tonnes on average, equivalent to the annual emissions of Pakistan or Argentina in 2022). Additionally, the projected penetration of electric vehicles in the global light-duty vehicle fleet requires another ~10EJ of energy to build and charge these EVs.*"

6.5. The other factor is time. Nowhere in the world has energy transition of this scale happened within the short time envisaged. Vaclav Smil wrote in 2014,[4]"... *each widespread transition from one dominant fuel to another has taken 50 to 60 years.... Energy transitions on a national or global scale are inherently protracted affairs. The unfolding shift from fossil fuels to renewable energy sources will be no exception. It will require generations of perseverance.*" In fact, he wrote that the more effective solution was to lower overall energy use. Alas, that is one advice that the world is either unable to or unwilling to heed. It is hard to fault developing countries for not wanting to curb their energy consumption. It is morally wrong to tell developing countries to abandon their aspirations for better living standards so that developed countries can maintain their ways of living in cleaner environments and cooler climates.

6.6. However, the Paris Agreement signed in December 2015 did precisely that. It trumped the Sustainable Development Goals agreed upon barely three months earlier. Professor Mike Hulme wrote, [5] "*The goal of securing global temperature within a certain numerical range took precedence over a broader set of welfare ambitions, in part because of the success of*

2 His research showed that humans beings consistently overestimate the probability of rare events
3 "The Energy Transition", 18th April 2024, Global Energy Strategy, JP Morgan
4 Vaclav Smil: 'A Global Transition to Renewable Energy Will Take Many Decades', Scientific American, January 2014 (https://www.scientificamerican.com/article/a-global-transition-to-renewable-energy-will-take-many-decades/)
5 Hulme, Mike. Climate Change isn't Everything: Liberating Climate Politics from Alarmism (p. 51). Polity Press. Kindle Edition.

climate scientists and Government negotiators in characterising the goal of climate policies in terms of a single, and seemingly simple, index. Yet, …global temperature is a seriously flawed index for capturing the full range of complex relationships between climate and human welfare and ecological integrity."

6.7. Not only have development goals been downgraded in the process of elevation of containing global emissions to the pinnacle of all economic policies, but developing nations are also being threatened with a carbon tax at the border, in full negation of the spirit of common but differentiated responsibilities and respective national capabilities that was supposed to have undergirded the Paris Agreement.

6.8. It would be a comedy if it were not real and tragic. Even as developed nations prepare to impose a carbon tax at the border on imports coming into their countries laden with carbon, they are ramping up energy demand like never before, thanks to their obsession with letting Artificial Intelligence (AI) guide, take over and dominate natural intelligence. One of the leading global technology companies promised to achieve Net Zero by 2030 at the turn of the decade. But, the race to dominate the emerging technology of Artificial Intelligence has caused its emissions to be higher by 30 per cent by 2023. In a research report[6] published in April, analysts in Goldman Sachs wrote that the demand for power in the United States would experience a growth not seen in a generation, thanks to AI and that "*transmission, one of the major bottlenecks for clean energy transition, and the addition of data centres and AI could exacerbate this*". This and other issues pertaining to managing energy demand as a sensible way of dealing with climate change are examined intensely and analysed forensically in Chapter 13 in a special essay.

6.9. However, these developments should convince any reasonable reader that the developed world has not only tied itself into knots but is also contributing – wittingly or otherwise – to deepening and entrenching poverty and inequality in developing and consigning them to perpetual underdeveloped status by coercing them into prioritising emissions over their economies. Developed countries, having relied on a fossil fuel-based growth strategy for the past two centuries to reach where they are today, seek ambitious cuts in emissions from developing countries, pushing them to adopt policy measures, instruments and production and energy systems that are distinctly different from the carbon-emitting traditional strategies that fuelled the growth of the former. The fact that these novel pathways are untested or trusted is apparent from the recent deliberations of the G7 countries on ending the use of unabated coal power plants only in the first half of 2030,[7] even when their carbon emissions peaked several decades ago. Japan and Germany did not agree to this. In contrast, Germany has written into its legislation a final target to shut coal plants by 2038, while Japan has yet to set a date. This is a recipe for intra and international conflicts.[8]

6 'Generational growth: AI, data centres and the coming US power demand surge', 28th April 2024, Goldman Sachs Equity Research

7 G7, Climate, Energy and Environment Ministers' Meeting Communiqué, (Torino, April 29-30, 2024), https://www.meti.go.jp/press/2024/05/20240501001/20240501001-a.pdf.

8 Francesca Landini, G7 to sign exit from coal by 2035, but may offer leeway, sources say, Reuters, (April 30, 2024), https://www.reuters.com/business/energy/g7-ministers-agree-coal-plants-shutdown-by-2030-2035-uk-says-2024-04-29/.

6.10. The impact of climate change will affect developing countries disproportionately because these countries are already vulnerable and less resilient and must prioritise their economic development needs. Though not part of the problem, developing countries are part of the solution. Developing countries have already accepted the need for ambitious greenhouse gas emissions reduction, as evidenced by their Nationally Determined Contributions (NDCs), on the condition that the developed countries provide resources at a reasonable cost. Incorporating the impact of climate change into the development model, also called the low-carbon development pathways, requires access to technology and financial resources in the order of trillions of dollars. Even by conservative standards, the estimate of resource requirement (considering that not all the needs have been costed) ranges between USD 5.8 - 11.5 trillion till 2030[9]. With financial resources and technology not reaching developing countries at the desired pace, quantity, or terms, economic growth, and prosperity, albeit sustainably, will equip developing countries with the strength to address climate change.

6.11. Globally, recognising trade-offs is critical to bringing climate goals into the realm of feasibility and acceptability. To recognise trade-offs, we need to be able to ask the right and, more importantly, honest questions.

6.12. One such question is "*Is imagining a world without climate change all that useful? It almost goes without saying that if we could keep the benefits of fossil-fuelled industrialisation and jettison the negative side effects of climate change, we would do so. But what makes decision-making so thorny is that for most climate-sensitive societal outcomes….the net effect of fossil-fuelled industrialisation and technological change has been good…Thus, "without climate change" is not always the most relevant hypothetical counterfactual, and often "without fossil-fuelled industrialisation and technological progress" is more relevant. This framing gives a more honest and holistic picture of the state of the climate change problem, and it does not misleadingly paint the current systems as being less attractive than they actually are. When we assess the best course of action going forward, we must compare alternative systems and weigh the benefits of avoided climate change against the costs of transitioning to alternative energy and agricultural systems over time. This is the only way to be accurate and forthright on the trade-offs we face.*"[10]

6.13. Fittingly, the last word of this introductory section should be left to Mike Hulme, who has been studying the phenomenon for more than four decades:

"Climate change isn't everything. It is quite easy to imagine future worlds in which global temperature exceeds 2°C warming which are 'better' for human well-being, political stability and ecological integrity, for example, than other worlds in which – by all means and at all costs – global temperature was stabilised at 1.5°C."

6.14. As for India, despite the challenges mentioned above, managing the impact of climate change while ensuring that developmental priorities continue to get the focus has been the hallmark of its growth strategy. The chapter reviews India's initiatives and performance in

9 The First report of the Standing Committee on Finance on the determination of the needs of developing country Parties related to implementing the Convention and the Paris Agreement, https://tinyurl.com/5n92sppt.

10 Patrick Brown, A Rhetorical Ambiguity That Propagates Climate Misinformation, Breakthrough Institute, (July 3, 2024). https://thebreakthroughjournal.substack.com/p/a-rhetorical-ambiguity-that-propagates.

addressing climate change, discusses energy transition issues, and deliberates upon the status of the multilateral negotiations. The chapter ends by exploring the options and the way forward

PRESENT STATUS OF INDIA'S CLIMATE ACTION

6.15. India has adopted the mission-mode approach to address climate change. The National Action Plan on Climate Change (NAPCC)[11] outlines the strategy to enhance the sustainability of the country's development path. Based on the principles of achieving high economic growth while also improving the ecological sustainability of India's developmental path, NAPCC includes nine national missions covering solar, water, energy efficiency, forests, sustainable habitat, sustainable agriculture, sustaining the Himalayan Ecosystem, strategic knowledge for climate change, and the recently added mission on human health. A broad spectrum of climate action - adaptation and mitigation, including demand side management - is being taken through the programme. States and Union Territories (UTs) have been encouraged to prepare their State Action Plan on Climate Change (SAPCC) consistent with strategies in the NAPCC. So far, 34 SAPCCs are operational, laying out sector-specific and cross-sectoral, time-bound priority actions for the state.

6.16. India has made significant progress on climate action. The addition to the installed solar power capacity was 15.03 GW in 2023-24, reaching a cumulative of 82.64 GW on 30 April 2024.[12] Under the National Mission on Enhanced Energy Efficiency, the eighth cycle of the Perform Achieve and Trade (PAT) scheme[13] was notified in June 2023 for the period 2023-24 to 2025-26 and covers sectors like Aluminium, Cement, Chlor-Alkali, Iron & Steel, Pulp & Paper, and Textile with a total energy saving target of 0.3370 MTOE (million tonnes of oil equivalent). The PAT scheme in its various cycles has resulted in a significant amount of energy savings and a reduction in greenhouse gas (GHG) emissions (Box 2).

6.17. As a result of the coordinated action, most targets of the first NDC were achieved well in advance. For instance, the country achieved 40 per cent cumulative electrical power installed capacity from non-fossil fuel-based energy sources in 2021 and reduced the emission intensity of India's GDP from 2005 levels by 33 per cent in 2019– nine and eleven years before the target year of 2030, respectively. The NDC was further updated in August 2022.[14] The target to reduce the emissions intensity of India's GDP was enhanced to 45 per cent (from the earlier 33-35 per cent) by 2030 from the 2005 level, and the target on cumulative electric power installed capacity from non-fossil fuel-based energy resources increased to 50 per cent (earlier 40 per cent) by 2030. As of 31 May 2024, the share of non-fossil sources in the installed electricity

11 National Action Plan on Climate Change (NAPCC), Frequently Asked Question, December 01, 2021, PIB, https://static.pib.gov.in/WriteReadData/specificdocs/documents/2021/dec/doc202112101.pdf.

12 Year-wise Achievements, M/o New and Renewable Energy, https://mnre.gov.in/year-wise-achievement/.

13 Perform, Achieve and Trade (PAT) is a regulatory instrument to reduce Specific Energy Consumption in energy-intensive industries, with an associated market-based mechanism to enhance the cost-effectiveness through certification of excess energy saving which can be traded. Currently, the eighth cycle of this scheme is under operation, https://beeindia.gov.in/en/perform-achieve-and-trade-pat-0.

14 India's Updated First Nationally Determined Contribution Under Paris Agreement (2021-2030), (August 2022), Submission to UNFCCC,https://unfccc.int/sites/default/files/NDC/2022-08/India%20Updated%20First%20Nationally%20Determined%20Contrib.pdf.

generation capacity has reached 45.4 per cent.[15] India is on track to make an additional carbon sink of 2.5 to 3.0 billion tonnes through tree and forest cover by 2030, with a carbon sink of 1.97 billion tonnes of CO2 equivalent having already been created from 2005 to 2019.

6.18. Parties to the United Nations Framework Convention on Climate Change (UNFCCC) must periodically submit National Communication (NC) with information on their greenhouse gas emissions, their vulnerability to climate change, and the measures they are taking to mitigate emissions and adapt to the impacts of climate change. India submitted its Third National Communication (TNC),[16] including India's first Adaptation Communication (AC),[17] to the UNFCCC in December 2023. India's TNC mentions that the energy sector contributed the most to the overall anthropogenic emissions at 75.81 per cent, followed by the agriculture sector at 13.44 per cent, Industrial Process & Product Use (IPPU) at 8.41 per cent, and waste at 2.34 per cent. It also mentions that the Land Use, Land-Use Change & Forestry (LULUCF) sector remained a net sink in 2019, accounting for removing 4,85,472 GgCO2e[18] emissions. Considering total emissions and removals, India's net national emissions in 2019 were 26,46,556 GgCO2e.

6.19. The plethora of cross-sectoral measures taken in the economy and the several schemes to modify consumer and producer behaviour and promote energy saving have resulted in India's total national emissions (including LULUCF) increasing by 4.56 per cent since 2016, which compares favourably with the growth experienced by the country. Interestingly, India's GDP between 2005 and 2019 has grown with a Compound Annual Growth Rate (CAGR) of about seven per cent, whereas the emissions grew at a CAGR of about four per cent. i.e., the rate of emissions growth is lower than the rate of growth of our GDP. This shows that India has successfully decoupled its economic growth from greenhouse gas emissions, reducing the emission intensity of its GDP. A recent report by the International Finance Corporation recognises India's efforts to achieve committed climate actions, highlighting that it is the only G20 nation in line with 2-degree centigrade warming.[19] Notably, these outcomes have been achieved primarily through domestic resources,[20] which have predominantly formed the basis of India's climate action. Given the financing needs, estimated at USD 2.5 trillion (at 2014-15 prices) for meeting the NDC targets till 2030, access to finance and technology at a reasonable cost, including from the developed countries, as mandated by the UNFCCC and its Paris Agreement, is essential to ease the constraint on the required resources.

ADAPTATION IS CRITICAL FOR INDIA

6.20. According to UNDP,[21] climate change adaptation refers to actions that help reduce vulnerability to climate change's current or expected impacts, like weather extremes and

15 Power Sector at a Glance "ALL INDIA", Ministry of Power, https://powermin.gov.in/sites/default/files/uploads/power_sector_at_glance_May_2024.pdf.
16 IAC is a part of the NC document. National Communication, NC 3, India, (09 Dec 2023), https://unfccc.int/documents/636235.
17 Ibid. Submission made under Article 7 of the Paris Agreement.
18 Gigagram of Carbon Dioxide Equivalent.
19 International Finance Corporation. 2023. Blended Finance for Climate Investments in India. The World Bank Group, Washington, DC.(2023), https://www.ifc.org/content/dam/ifc/doc/2023/Report-Blended-Finance-for-Climate-Investments-in-India.pdf.
20 National Communication, NC 3, India, (Dec 09, 2023), https://unfccc.int/documents/636235.
21 What is climate change adaptation and why is it crucial?, UNDP, (January 30, 2024) https://climatepromise.undp.org/news-and-stories/what-climate-change-adaptation-and-why-it-crucial

hazards, slow onset events such as sea-level rise, biodiversity loss, or food and water insecurity. Lower-income countries are particularly vulnerable to the economic impacts of climate change. According to a meta-analysis of several empirical growth studies by Richard Tol (2024),[22] the welfare-equivalent income loss due to a 2.5 °C warming relative to pre-industrial times is significantly higher for lower-income countries. Wealth accords a buffer that can mitigate the adverse effects of climate change through resilient infrastructure, adequate healthcare coverage, and access to adaptive technologies, allowing high-income countries to withstand better and adapt to the challenges posed by a warming climate. In contrast, lower-income countries that need to achieve their development priorities face high opportunity costs. Lack of resources makes them more susceptible to increased vulnerability and potential economic disruption. Economic growth enhances the ability of a country to take adaptation action and builds resilience. Therefore, from a developing country's perspective, continued economic growth is the best insurance against climate change.

6.21. India is one of the most climate-vulnerable countries;[23] there is a greater need for adaptive strategies in agriculture and conservation efforts to mitigate the detrimental effects of climate change on natural habitats, vegetation, and vital bio-resources. The Government of India has taken several initiatives to address this. Much of the emphasis in the NAPCC has been on adaptation, with seven of the nine missions addressing it. Further, the promotion of micro irrigation under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), the introduction of the National Innovations on Climate Resilient Agriculture (NICRA) to enhance the resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration, flood forecasting and early warning system, etc. are some significant initiatives in this direction. India's adaptation-relevant action also includes steps taken to improve resilience in the economy through developmental programs such as Swachh Bharat Mission, Mahatma Gandhi National Rural Employment Guarantee Act, Pradhan Mantri Awas Yojana, Saubhagya Scheme, etc., to name a few.

6.22. The Initial Adaptation Communication of India estimates that the total adaptation-relevant expenditure was 5.60 per cent of the GDP in 2021-2022, growing from a share of 3.7 per cent in 2015-16, indicating integration of climate resilience and adaptation into development plans. This reflects the importance that the Government is placing on adaptation action and, at the same time, is reflective of the significant pressure on domestic resources. An increase in adaptation finance flows to India would ease the resource constraint and enable the country to meet its long-term sustainable development and economic growth objectives.

6.23. Coastal regions in India are more vulnerable to climate change. Wetland conservation can be an important adaptation measure in such regions. They provide a buffer and other coping strategies to protect against storm surges and flooding. Urban wetlands can help absorb excess rainfall, protecting cities. Moreover, mangroves are a natural coastal barrier that traps sediment and prevents coastal erosion, which strengthens the shoreline. In addition, many wetlands sustain local communities by supporting fisheries, agriculture, livestock, and the

22 Tol, R. S. (2024). A meta-analysis of the total economic impact of climate change. Energy Policy, 185, 113922, https://www.sciencedirect.com/science/article/pii/S0301421523005074.

23 The 10 most affected countries in 2019, Table 1, Page 8, Global Climate Risk Index 2021, https://www.germanwatch.org/en/19777.

production of fuel. They are a part of the solution to food security issues that may be affected by climate change. India has, therefore, adopted wetland and mangrove conservation as a priority. Since 2014, 56 new wetlands across the country have been designated as Ramsar sites (wetlands of international importance), taking the total number to 82 and covering an area of about 1.33 million ha. The Government of India announced the 'Amrit Dharohar' initiative as part of the Budget announcement 2023 to promote nature tourism in the conserved Ramsar sites, with the view to generating better appreciation for the value of conserving and enabling enhancement of job opportunities. The Mission Sahbhagita is another milestone step towards participatory conservation and wise use of wetlands to enable a societal ownership approach with communities leading at the forefront. The Mission envisages the preparation of wetland health cards, ground-truthing of wetlands against the satellite-based data, and promoting the concept of 'Wetland Mitras' by engaging women, youth, local communities, and the private sector in this work.

Box VI.1: Case Study on Micro Irrigation- Role of Community-led Water Governance[24]

Navanagar is a small agricultural village in Himmatnagar taluka of Sabarkantha District, Gujarat. Over the years, due to farming practices, the village's water table decreased to 500-600 feet below the ground level. Total Dissolved Salt (TDS), ranging from 900 to 1100 mg/litre, made the water unsuitable for agriculture. Due to these reasons, farming became a loss-making profession for the farmers. Farmers could only produce one conventional crop like cotton & castor. The Water Resource Department, Gujarat, and Gujarat Green Revolution Company (GGRC) mobilised local farmers to rejuvenate the village pond by drawing water from the nearby sub-minor canal of the Guhai Dam.

The village farmers' co-operative society under the 'Som Sarovar', deepened the village pond with the help of the Gram Panchayat to store and conserve water. The farmers built a sump (40 ft diameter x 40 ft depth), drew water from the village pond, took individual electricity connections, and installed water lifting facilities (pump & motor) from the sump. The farmers bore the total cost of electrical connections and pumping/lifting of water.

Farmers also created the piped water conveyance from the sump to their respective fields. The farmers' body made it compulsory for all the member farmers to adopt drip irrigation for efficient water use under Per Drop More Crop (PDMC). Since then, agriculture productivity has seen a revival with an increase of 30 per cent along with a reduction in fertilizer and power consumption and crop diversification away from conventional crops like wheat, castor, cotton, etc., to fruits & vegetables like watermelon, musk-melon, fennel, cumin and chilly that are more remunerative. Water governance by the community transformed the village from water deficient to water sufficient, ensuring equity in water distribution.

24 Based on inputs from the Department of Agriculture & Farmers' Welfare.

LOW CARBON DEVELOPMENT[25] AND ENERGY COMPOSITION

Energy Composition and Efficiency

6.24. India's energy needs are expected to grow 2 to 2.5 times by 2047 to meet a growing economy's developmental priorities and aspirations.[26] Considering that resources are limited, the pace of energy transition would need to factor in alternative demands on the resources for improving resilience to climate change and for sustained social and economic development. Achieving Net Zero by 2070 requires an orderly transition to a diversified mix of energy sources with a significant share of non-fossils and enhancement in energy production and usage efficiency. Phasing renewable energy into the country's energy mix is paramount in India's drive towards cleaner energy sources.

6.25. India's primary energy mix in 2022-23 was fossil-fuel dominant, with almost 84 per cent met from coal, oil, and natural gas combined (Figure 1). However, the composition in the electricity sector has significantly changed due to the phasing in of renewables, with the share of non-fossil power capacity being 45.4 per cent as of May 2024 from around 32 per cent in April 2014.[27] Recent initiatives for enhancing the production of renewables are noteworthy. First, PM-Surya Ghar Yojana, launched in February 2024 with a total outlay of ₹75,021 Crore, is expected to add 30 GW of solar capacity and reduce 720 million tonnes of CO2 equivalent, creating around 17 lakh direct jobs across the solar value chain.[28] Second, given India's 7,600 km long coastline, the Government has notified the national offshore wind energy policy and offshore wind energy lease rules, 2023.[29] Several offshore zones have been identified for harnessing this potential, and viability gap funding for an initial capacity of one gigawatt has been announced recently.[30] Third, underscoring the importance of green hydrogen in reducing carbon emissions in the hard-to-abate sectors, India's Green Hydrogen Mission targets five MMT of green hydrogen by 2030.[31] The scheme offers financial incentives to boost electrolyser manufacturing and production. The tender for selecting green hydrogen producers & electrolyser manufacturers under the Strategic Interventions for Green Hydrogen Transition (SIGHT) scheme has been awarded for a total capacity of 4,12,000 tons.[32]

6.26. India's ambitious green hydrogen production target is subject to various constraints, including on the supply side - the cost of production and delivery, and, on the demand side -

25 Low-carbon development is defined as a development strategy that aims at reducing emissions while ensuring economic development and improved welfare. It places economic development as a priority while taking mitigation actions that enable a reduction in emissions.

26 Based on inputs from NITI Aayog

27 Data for 2014 is from MoSPI's Energy Statistics 2024, https://www.mospi.gov.in/sites/default/files/publication_reports/EnergyStatistics_India_publication_2024N.pd

28 Cabinet approves PM-Surya Ghar: Muft Bijli Yojana for installing rooftop solar in One Crore households, PIB, (February 29, 2024), https://pib.gov.in/PressReleasePage.aspx?PRID=2010130.

29 Offshore Wind Energy Lease Rules, 2023, (December 19, 2023), https://tinyurl.com/5ssvpsk4

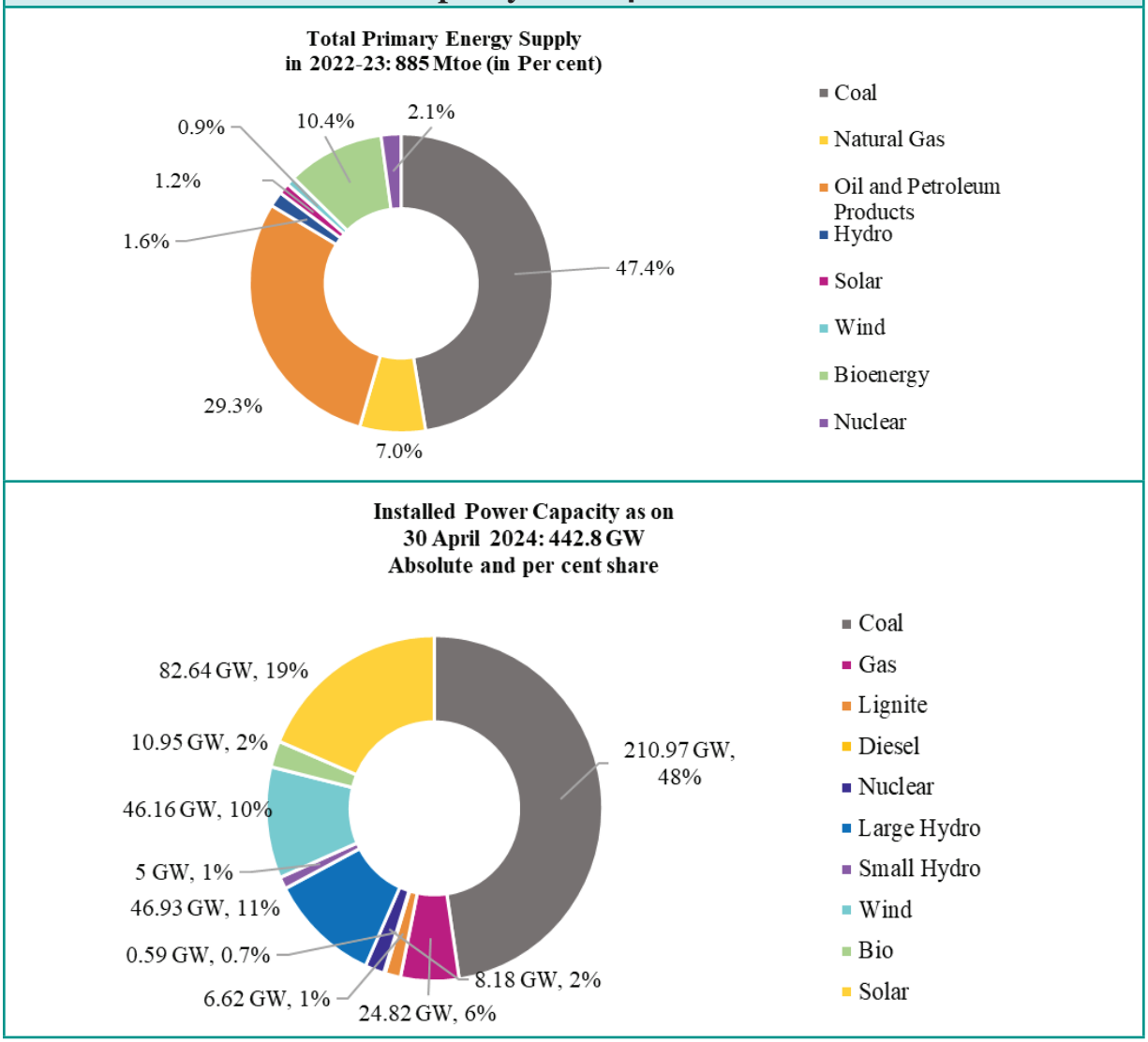
30 Cabinet approves Viability Gap Funding (VGF) scheme for implementation of Offshore Wind Energy Projects, PIB, (June 19, 2024), https://pib.gov.in/PressReleasePage.aspx?PRID=2026699.

31 National Hydrogen Mission - Decarbonising India, Achieving Net-Zero Vision, Ministry of New & Renewable Energy, PIB, updated on January 10, 2023, https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/jan/doc2023110150801.pdf

32 Tenders awarded for 4.12 lakh tonnes per annum of green hydrogen production and 1,500 MW per annum of electrolyzer manufacturing under National Green Hydrogen Mission: Union Power and New & Renewable Energy Minister, PIB, (Feb 07, 2024), https://tinyurl.com/mrx6wzy3.

readiness to consume green hydrogen in traditional industrial processes. The electrolysers and renewable energy used as inputs are the two major components of green hydrogen production cost. The cost of capital, water supply and treatment, storage and distribution, conversion of hydrogen to suitable derivatives, and an enabling infrastructure would also contribute to the final delivered cost of green hydrogen for any particular application. As green hydrogen is produced using renewable energy, the sector inherits all the limitations of the renewable sector, including the issue of intermittency and the huge requirement of land for solar and wind energy generation.

Chart VI.1: India's Primary Energy Supply Mix in 2022-23 and Installed Power Capacity in 2024 in terms of fuel sources



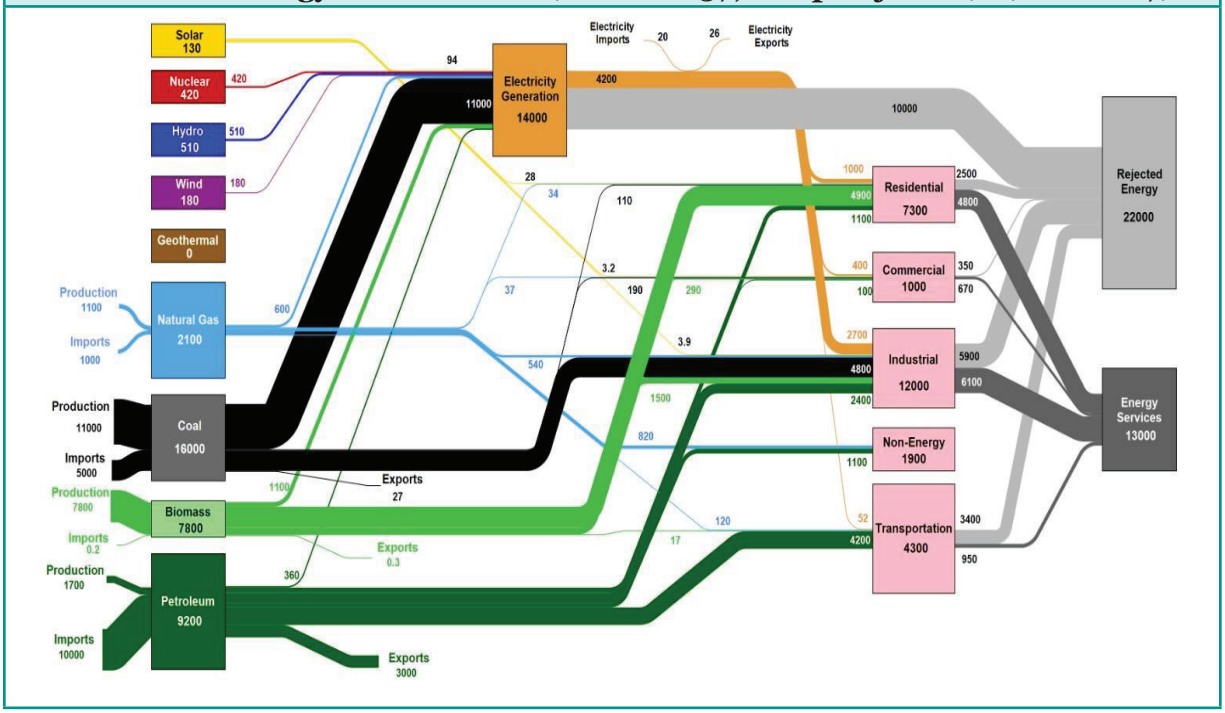
Source: Data obtained from NITI Aayog and Central Electricity Authority (https://cea.nic.in/installed-capacity-report/?lang

6.27. At present, three typical features characterise India's energy use - high use of biomass as a share of the total primary energy supply, predominance of imports of fossil fuel (mainly petroleum) and use of domestic coal for electricity generation. The high use of biomass is set to change significantly with the advancement of solar rooftop installations, the proliferation of

solar appliances, and the ramping up of LPG-based cooking. Petroleum (85 per cent of which is imported) has a diversified presence across transport, industrial sector, residential, and commercial, which poses a significant challenge given the volatility in oil prices and limited access to natural gas.

6.28. Coal accounts for nearly 70 per cent of the total electric generation. It is also a critical input in various industries, such as steel, sponge iron, cement, and paper. Addressing the transition when coal is a predominant energy source, even though the Government has been stimulating the phasing-in of renewables, requires a sequenced movement towards cleaner coal and more efficient technologies. The Government has launched several clean coal initiatives, including the Coal Gasification Mission. It aims to gasify 100 million tonnes of coal by 2030 through surface coal/lignite gasification projects. Adopting gasification technology in India can revolutionise the coal sector, reducing reliance on imports of Natural Gas, Methanol, Ammonia, and other essential products while reducing emissions. Initiatives such as extracting Coal Bed Methane (CBM) gases, exploring coal to hydrogen, Carbon Capture and Storage (CCS), and coal beneficiation through washeries, etc. can mitigate emissions and enhance environmental sustainability. Encouragement to adopt super-critical and ultra-super-critical technologies[33] for coal power plants has also led to lower emissions and higher efficiency.

Chart VI.2: Energy Flow in India (a total of 37,000 petajoule (PJ)[34] in 2017)



Source: Lawrence Livermore National Laboratory. https://flowcharts.llnl.gov/commodities/energy

33 Such plants operate at temperatures and pressures above the critical point of water (above the temperature and pressure at which the liquid and gas phases of water coexist in equilibrium). As on 10th August 2023, 94 coal-based thermal units of a total capacity of 65150 MW are operating with super-critical/Ultra super-critical technologies. [Phasing out of coal-based thermal power plants and adoption of super-critical technologies in thermal power plants, PIB, (Aug 10, 2023) https://pib.gov.in/PressReleasePage.aspx?PRID=1947384.].

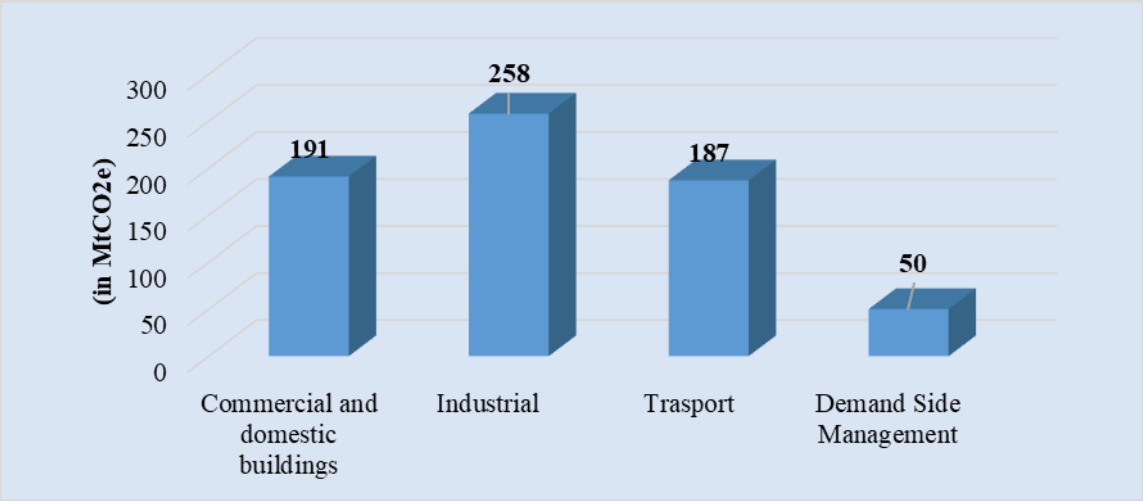
34 1 petajoule = 1015 and 1 calorie = 4.18 joules.

6.29. Policymakers recognise the importance of energy efficiency measures in accelerating clean energy transitions while supporting energy security. It may be noted that the outcome of the first Global Stocktake (GST) seeks to double the global average annual rate of energy efficiency improvements by 2030, pursued in a nationally determined manner and as per differing national circumstances.[35] The measures taken by the country to increase energy efficiency are presented in Box 2.

Box VI.2 Steps taken to improve Energy Efficiency[36]

India has an ambitious target of Emissions Intensity (EI) reduction of 45 per cent by 2030 from the base of 2005. To achieve this, absolute emissions must be restricted to around 4584 million tonnes of CO2 equivalent (MtCO2e). This means that the overall emissions in the economy would have to be reduced by 3753 MtCO2e (over the baseline scenario) to meet the NDC target. The sectoral breakup under the energy efficiency domain to achieve 2030 targets is given in Figure 3.

Chart VI.3: Target emissions reductions to achieve the NDC commitment by 2030 (in MtCO2e)



Source: Based on data provided by Ministry of Power, GOI

Energy efficiency improvement in buildings and appliances is a priority for India as over 50 per cent of the 2030 building stock is yet to come up – a situation that is fundamentally different from developed countries.[37] A reduction in emission intensity in the building sector will play a key role in achieving the target. Presently, around 33 per cent of the total electricity consumption is in consumers' commercial and residential categories, estimated to grow to approximately 40 per cent of total electricity consumption by 2031-32.

35 Para 28, Decision 1 CMA.5 (https://unfccc.int/sites/default/files/resource/cma2023_16a01E.pdf?download)
36 Based on inputs from the Ministry of Power.
37 Energy Conservation Building Code (ECBC), Bureau of Energy Efficiency, Government of India, Ministry of Power, https://beeindia.gov.in/en/energy-conservation-building-code-ecbc.

The Energy Conservation Building Code (ECBC) sets minimum energy performance standards for commercial buildings. A voluntary star rating program has also been launched for existing commercial buildings. Shunya labelling program identifies and commemorates Net Zero Energy Building (NZEB) and Net Positive Energy Buildings (NPEB). For appliances, the Standards and Labelling (S&L) program was launched to provide consumers with an informed choice about the energy and cost-saving potential of the labelled appliances/ equipment being sold commercially. As per the 2022-23 Impact Assessment report of BEE, the S&L program helped save 81 billion units of electricity. The Government has also implemented a Star-rated program to offer high-efficiency ACs for consumers, and BEE has designed an incentive-based market transformation program offering incentives for consumers to switch from ACs older than eight years to 5-star rated models.

The Lifestyle for Environment (LiFE) initiative was launched by the Prime Minister of India at COP26 in Glasgow in November 2021. It aims to encourage the adoption of sustainable lifestyles to address the challenges of environmental degradation and climate change. India has integrated several policies in its energy transition strategy that are aligned with LiFE.

Adopting energy-efficient practices is at the heart of LiFE.[38] Household consumers can, by adopting energy-efficient appliances and buildings, sustainable mobility and virtuous energy management foster a widespread culture of energy efficiency. According to IEA analysis, adopting worldwide LiFE actions – including behavioural changes and sustainable consumption choices – would save consumers about USD 440 billion and amount to one-fifth of the emissions reduction needed by 2030. Behavioural and lifestyle changes are also among the pillars put forth by India during the G20 presidency's strategic plan for advancing energy efficiency across demand sectors by 2030. An energy-efficient lifestyle not only benefits individuals but also helps governments to reduce or delay new investments in energy infrastructure and allows for the use of that money in other investments needed in the country.

In India, mission LiFE is being unfolded by BEE in three distinct phases focusing on individual behavioural change:

- encouraging people to adopt simple yet effective energy-saving practices in their daily lives,
- influencing industries and markets to cater to sustainable consumption patterns and
- to trigger a shift in large-scale industrial and Government policies, promoting sustainable production and consumption.

BEE's efficiency policies also extend to promoting behavioural change and consumer awareness. Mindful consumption is promoted through programmes such as the recent campaign on setting air conditioners at 24 °C. The AC @ 24 campaign uses an approach based on optimizing consumption, switching to efficient technologies, shifting to energy-saving behaviour, and upgrading technologies.

38 Mission LiFE aims to build a mass movement to adopt sustainable lifestyles based on mindful utilisation, minimising waste, and making green choices, for themselves, their families, and their communities.

For the industrial sector, the Perform, Achieve, and Trade (PAT) scheme is another measure of demand management that aims to reduce emissions in energy-intensive industries. For a particular cycle, the mechanism involves assessing Specific Energy Consumption (SEC) in the baseline year and projected SEC in the target year. It covers different forms of net energy going into the plant's boundary and products leaving it. Eight cycles of the scheme have been launched so far. As the next level of action, the Ministry of Power has come out with the Carbon Credit Trading Scheme (CCTS).

For the transport sector, fuel consumption standards and norms have been set for cars, heavy-duty vehicles (HDVs), and others. Considering the burgeoning numbers of Electric Vehicles (EVs), 'Charging Infrastructure for Electric Vehicles – Guidelines and Standards' have been notified to promote the ecosystem of charging infrastructure.

Demand-side management (DSM) has traditionally been recognised as a significant intervention to reduce energy demand. It is an ultimate irony that even as developed nations obsess over prospective emissions from the developing world, the widespread adoption of artificial intelligence is going to result in the demand for power to expand to levels not seen in decades in America.[39] The failure and unwillingness to restrain energy demand and the search for so-called alternative energy sources – with their much lower energy density compared to fossil fuels – comes with unprecedented demand for financial and other resources and heightened geopolitical vulnerabilities and stress. The warped priorities of advanced economies are sought to be achieved at the cost of legitimate economic aspirations in the developing world.

In India, DSM interventions have helped utilise and reduce the peak electricity demands and defer high investments in generation, transmission, and distribution networks. Measures that enable efficiency gains can be an effective way to reduce demand.[40] A few of these measures include energy-efficiency pump sets in agriculture, improving the efficiency of the local bodies' drinking and sewage water pumping systems, improving the efficiency of the distribution transformer network, and star rating of appliances and white goods.

The above interventions have led to significant energy savings. Total annual energy savings are around 51 million tonnes of oil equivalent (MTOE) – amounting to around 6.6 per cent of the total primary energy supply of the country. This translates to a total annual cost savings of approximately ₹1,94,320 Crore and an annual CO_2 emissions reduction of around 306 million tonnes. Program-specific results are as follows: The S&L Scheme has so far reduced emissions by approximately 60 $MtCO_2$, while the PAT scheme reduced emissions by 110.7 $MtCO_2$, and the energy-efficient LED bulbs allowed a saving of 125 $MtCO_2$.

Challenges of Energy Transition

6.30. Renewable energy faces intermittency and discontinuous supply, impacting grid stability in the absence of battery storage. Energy demand is expected to increase substantially as the country develops in line with the goal of 'Viksit Bharat', and a concomitant rise in renewable

39 'AI, data centres and the coming US power demand surge', Goldman Sachs, 28th April 2024
40 Smil, V. (2014). A global transition to renewable energy will take many decades. Scientific American, 310(1), 52-57.

capacity may lead to a decline in base load efficiency as the supply composition changes. Large-scale phasing-in of renewables poses several risks[41] associated with intermittency and dispatchability in the energy system. Addressing the issue is critical for the more significant deployment of renewable energy.

6.31. Some estimates suggest that the Levelised Cost of Electricity (LCOE)[42] of renewables such as solar has fallen below that of fossil fuels in several countries, including India, Brazil, Australia, and Italy.[43] From an investor's perspective, the LCOE represents the total cost of building and operating the asset per unit of electricity generated over an assumed lifetime. Investing in the project may be viable if the LCOE is lower than the electricity tariff. However, even as the LCOE for renewables has been falling, it does not reflect the total cost the economy faces. The metric of LCOE ignores the costs associated with intermittency and dispatchability. Renewable power needs to be backed up by a stable power source when the sun is not shining and the wind is not blowing. If the producer is not mandated to make the power dispatchable, then energy procurement at LCOE reflects an implicit subsidy for the producer. One way to resolve this is to have Round-The-Clock (RTC) renewable energy supply contracts, which allow the internalisation of risks related to intermittency and dispatchability.

Box VI.3: Round-the-Clock (RTC) Supply of Renewable Energy (RE)

The objective of the Round-the-Clock (RTC) supply is to match the buyer's energy demand curve through renewable energy power projects with energy storage systems.

Ministry of Power issued 'Guidelines for Tariff Based Competitive Bidding Process for Procurement of Firm and Dispatchable Power from Grid Connected Renewable Energy Power Projects with Energy Storage Systems' in 2023 to provide a framework for Power Purchase Agreements (PPAs) for RTC supply.

A few examples of the tariffs discovered during the recent round of biddings are as follows:

- Solar Energy Corporation of India (SECI) for Interstate Transmission System (ISTS)-connected solar PV power projects were in the range of 2.6 to 2.74 ₹/kWh.[44] For ISTS-connected wind and solar hybrid, the range was 3.43 to 3.54 ₹/kWh.[45] For ISTS-connected wind power, it was 3.18 to 3.49 ₹/kWh.[46] The range was 4.64 to 5.96 ₹/

41 Risk reflects the potential inability of the energy system to deliver on its essential function – a reliable, stable, and sustainable supply of energy at affordable prices and social costs.

42 The levelized cost of electricity (LCOE) is a measure of the average net present cost of electricity generation for a generator over its lifetime.

43 Ram, M., Child, M., Aghahosseini, A., Bogdanov, D., Lohrmann, A., & Breyer, C. (2018). A comparative analysis of electricity generation costs from renewable, fossil fuel, and nuclear sources in G20 countries for the period 2015-2030. Journal of cleaner production, 199, 687-704, https://www.sciencedirect.com/science/article/abs/pii/S0959652618321486.

44 Selection of 1500 MW ISTS-connected Solar PV Power Projects (SECI-ISTS-XIV), Solar Energy Corporation Of India Limited, (Jan 18, 2024), https://www.seci.co.in/upload/Bidder/638532654344846316.pdf.

45 Selection of 1200 MW ISTS-connected Wind-Solar Hybrid Power Projects in India (Tranche-VIII), Solar Energy Corporation Of India Limited, (Feb 20, 2024), https://www.seci.co.in/upload/Bidder/638545687623852290.pdf.

46 Selection of 1200 MW ISTS-connected Wind Power Projects (Tranche-XIV), Solar Energy Corporation Of India Limited, (Feb 20, 2023), https://www.seci.co.in/upload/Bidder/638233876572205236.pdf.

kWh for ISTS-connected wind-solar hybrid power projects with assured peak power supply.[47]

- Railway Energy Management Company Limited's (REMCL) auction for round-the-clock renewable power led to tariffs in the range of 4.25 to 4.43 ₹/kWh.[48]
- The lowest bid for the auction carried out by Satluj Jal Vidyut Nigam (SJVN) Ltd. was 4.38 ₹/kWh.[49]

The examples indicate that tariffs for RTC projects are higher than those for solar and wind projects without energy storage, reflecting the internalisation of externalities related to intermittent power generation.

RTC-RE is at a nascent stage, and its deployment faces several challenges,[50] such as the dynamic requirements of the utilities and growing energy demands, especially in the context of schemes like the SAUBHAGYA scheme, agricultural feeder segregation, Time of Day (ToD) mechanism, promotion of solar rooftops; and those incentivising changes in consumer behaviour. Owing to these rapid changes, the RTC product designed for the present demand pattern might need to be revised later .

- The least cost solutions may be obtained by combining solar and wind projects from multiple projects spanning multiple states. This, however, poses a challenge in terms of arranging long-term PPAs with multiple generators, obtaining transmission access at multiple locations, setting up remote control centres for real-time control, etc.
- Higher upfront costs, technology risks, longer payback periods, and limited access to critical and rare earth minerals required for battery storage technology also pose serious challenges. In this context, pump storage-based energy storage solutions can be utilised to reduce system costs, owing to their longer lifetimes compared to battery energy storage systems.

6.32. Many technologies required for global Net Zero are currently commercially unavailable, such as hydrogen-fuelled steel/cement, steel and aluminium production with CCUS[51], etc. There is a need to enhance international cooperation in R&D, especially in the domains of distributed RE[52], offshore wind, geothermal, tidal energy, biofuels, compressed biogas, green hydrogen, energy storage, electrolysers, and nuclear power (including Small Modular Reactors SMR[53]). Grid balancing is equally essential for grid stability and storage. Experience indicates that the

47 Selection of 1200 MW ISTS-connected Wind-Solar Hybrid Power Projects with assured Peak Power Supply in India (Tranche-VI), Solar Energy Corporation Of India Limited, (Nov 02, 2022), https://www.seci.co.in/upload/bidder/638180388803848112.pdf.

48 REMCL declares winners of its 750 MW renewable projects, Renewable Watch, (February 2, 2024), https://renewablewatch.in/2024/02/02/remcl-declares-winners-of-its-750-mw-renewable-projects/.

49 Sangita Shetty, India's SJVN Auction Results: 1.5 GW Renewable Energy Projects with Storage Draw Strong Interest and Competitive Tariffs, , (November 8th, 2023), https://solarquarter.com/2023/11/08/indias-sjvn-auction-results-1-5-gw-renewable-energy-projects-with-storage-draw-strong-interest-and-competitive-tariffs/.

50 Techno-Economic Analysis of Renewable Energy Round the Clock (RE-RTC) Supply for Achieving India's 500 GW Non-Fossil Fuel Based Capacity Target by 2030, Central Electricity Authority, (2024), https://cea.nic.in/wp-content/uploads/notification/2024/02/RE_RTC_Final_Report.pdf.

51 Carbon Capture, Utility & storage (CCUS).

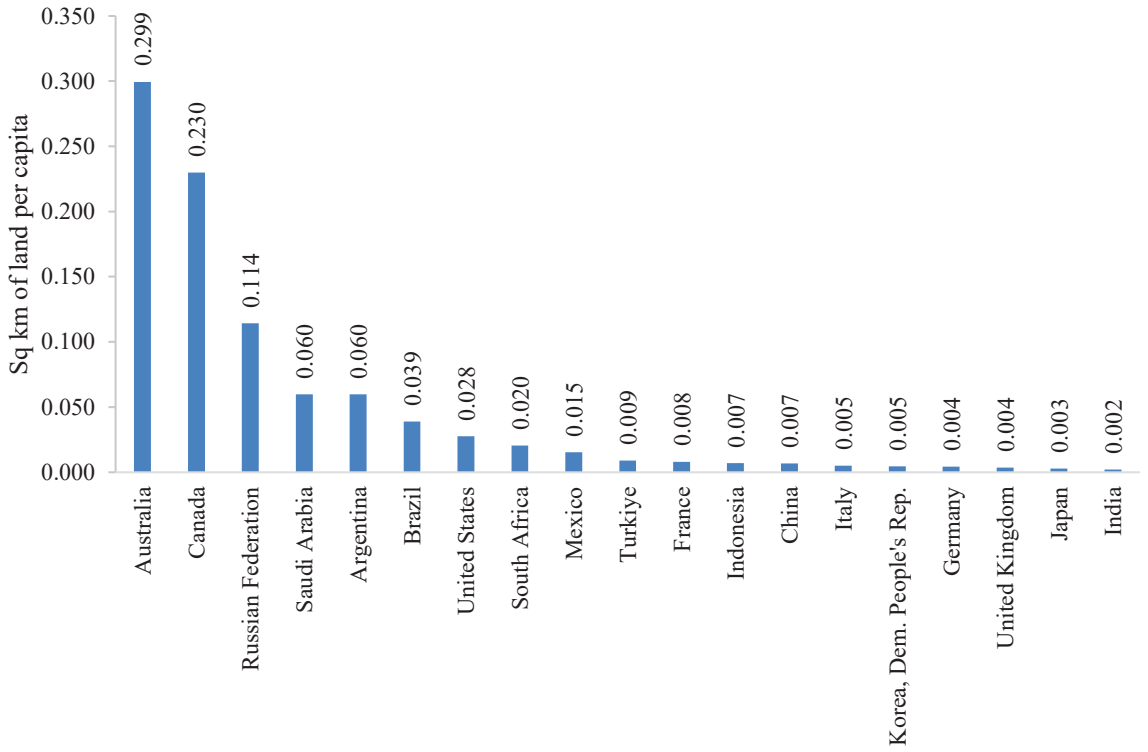
52 Distributed RE refers to small-scale generation units located closer to points of use.

53 SMRs are smaller nuclear power plants (300 MWe or less) than current generation baseload plants (1,000 MWe or higher). These smaller, compact designs are factory-fabricated reactors that can be transported by truck or rail to a nuclear power site. SMR output is scalable by putting several smaller units to achieve a larger capacity. Synergistic deployment of such factory-manufactured, made-in-India SMRs along with medium-size 700 MWe Pressurized Heavy Water Reactor (PHWRs) that have been standardised and are being deployed in fleet mode may be a relevant strategy for rapid scale-up of nuclear power capacity in India.

innovation process takes 20 to 70 years from prototype to commercialisation.[54] However, given the need to contain emissions within the next three decades, this innovation cycle needs to halve.

6.33. Expanding renewable energy and clean fuels will increase demand for land and water. The future scenarios of an increase in energy demand to meet the higher standard of living need to be analysed in the context of rapidly depleting land and water resources. Most renewables are land-intensive and demand the highest land use requirements among the different energy sources. The scaling required for renewable technologies faces several major challenges, including the large requirement for land.[55] For instance, according to a study,[56] about 1 MW of solar photovoltaic (PV) may require around 1–1.5 hectares (ha) of land, so 60 GW of solar power would need about 600–900 sq. km of land area at an all-India level. The availability of land is a major challenge for India, which has the lowest land availability per capita amongst the G20 countries (Figure 4). The transition cost would be amplified with the expected increase in the need for land for renewable energy projects.

Chart VI.4: Land per capita in India is the lowest among the G20, 2021



Source: Calculated using data from the World Bank.
Note: sq. km of land per capita is reciprocal of people per sq. km of land area. Population density is taken from the World Bank (https://data.worldbank.org/indicator/EN.POP.DNST).

54 Gross, R., Hanna, R., Gambhir, A., Heptonstall, P., & Speirs, J. (2018). How long does innovation and commercialisation in the energy sectors take? Historical case studies of the timescale from invention to widespread commercialisation in energy supply and end-use technology. Energy policy, 123, 682-699, https://www.sciencedirect.com/science/article/pii/S0301421518305901.
55 https://psa.gov.in/CMS/web/sites/default/files/publication/ESN%20Report-2024_New-21032024.pdf
56 Ibid.

6.34. Renewable waste recycling is another challenge. Globally, solar photovoltaic (PV) waste is estimated to be as massive as 78 million tonnes[57] by 2050.[58] Solar PV panels have a lifetime of 25-30 years, after which the discarded material can either make its way to a landfill or be recycled. The route to landfills is remarkably cheaper than recycling, however, this may lead to leaching of harmful chemicals and heavy metals mills into the soil. PV waste recycled as scrap poses risks to the environment and human health due to toxic metals, for which we need a comprehensive policy for managing PV waste. India's amended E-Waste (Management) Rules, 2022,[59] attempts to address concerns regarding disposal practices. However, the challenge imposed by scale cannot be overlooked.

6.35. Critical minerals are required for renewable energy and battery storage technologies. The source of such minerals is geographically concentrated, notably Graphite (China, 79 per cent), Cobalt (DRC, 70 per cent), rare earth (China, 60 per cent), and Lithium (Australia, 55 per cent). The concentration level is even higher for processing, with China dominating across the board. India's initiative to build domestic capacity should be seen in the backdrop of the current supply chain for RE, which is heavily skewed. Box 4 discusses how the geographical concentration of critical and rare earth minerals is increasing and the risks this poses. India has joined the Mineral Security Partnership (MSP) to enable access to critical minerals to smooth the green transition. MSP includes 14 countries, with India being the only developing country. The Government has also released a list of 30 critical minerals for India. At the domestic level, there is a greater focus on exploration. The total number of projects on critical minerals rose from 59 in 2020 to 123 in 2023.

6.36. Further, Khanij Bidesh India Limited (KABIL)[60] undertakes the identification, acquisition, exploration, development, mining, and processing of strategic minerals overseas by building mutually beneficial G2G partnerships with mineral-rich countries such as Australia, Africa, and Argentina, undertaking trading opportunities and strategic acquisitions or investments in exploration and mining.[61]

Box VI.4: Geographical Concentration of Critical and Rare Earth Minerals

IEA's Global Critical Minerals Outlook 2024[62] highlights a profound surge in the geographical concentration of critical and rare earth minerals (Figure 5). In the case of refined materials, the share of the top three producing nations has increased since 2020 as may be observed in Figure 6. Further, rare earth elements (REE) that play an important role in clean energy transition are among the least geographically diversified of all key energy transition minerals.

57 This corresponds to projections by IRENA for a Global cumulative PV capacity of 4,500 GW in 2050.

58 IRENA and IEA-PVPS (2016), "End-of-Life Management: Solar Photovoltaic Panels," International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems. https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels.

59 E-Waste (Management) Rules, 2022, https://cpcb.nic.in/uploads/Projects/E-Waste/e-waste_rules_2022.pdf.

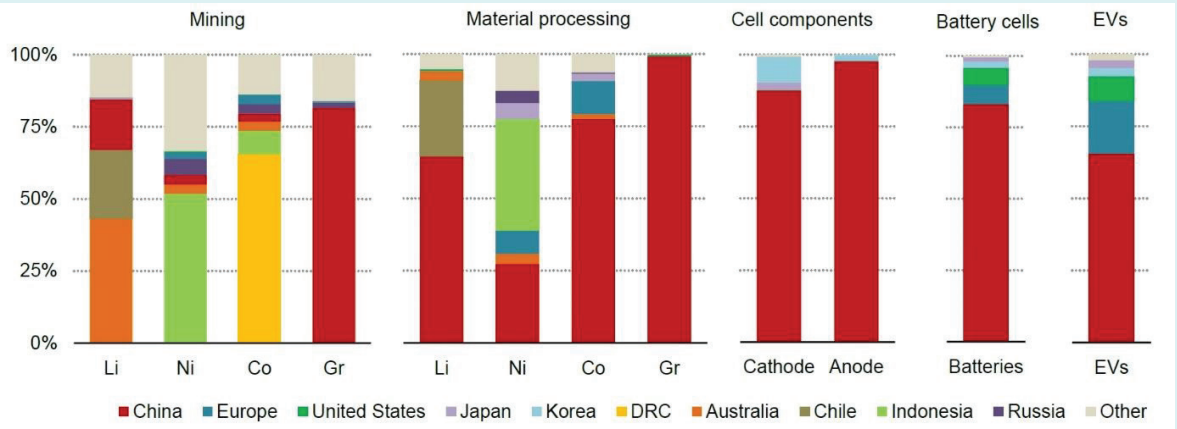
60 KABIL is a joint venture company among NALCO, HCL, and MECL, whose target is to identify, acquire, develop, process, and make commercial use of strategic minerals in overseas locations for supply in India. KABIL is focusing on identifying and sourcing battery minerals like Lithium and Cobalt and engagement with a few companies/projects is underway in Australia and Argentina. [https://mines.gov.in/webportal/content/kabil]

61 KABIL Set up to Ensure Supply of Critical Minerals, PIB, (Aug 01, 2019), https://pib.gov.in/PressReleasePage.aspx?PRID=1581058

62 IEA (2024), Global Critical Minerals Outlook 2024, IEA, Paris, https://www.iea.org/reports/global-critical-minerals-outlook-2024.

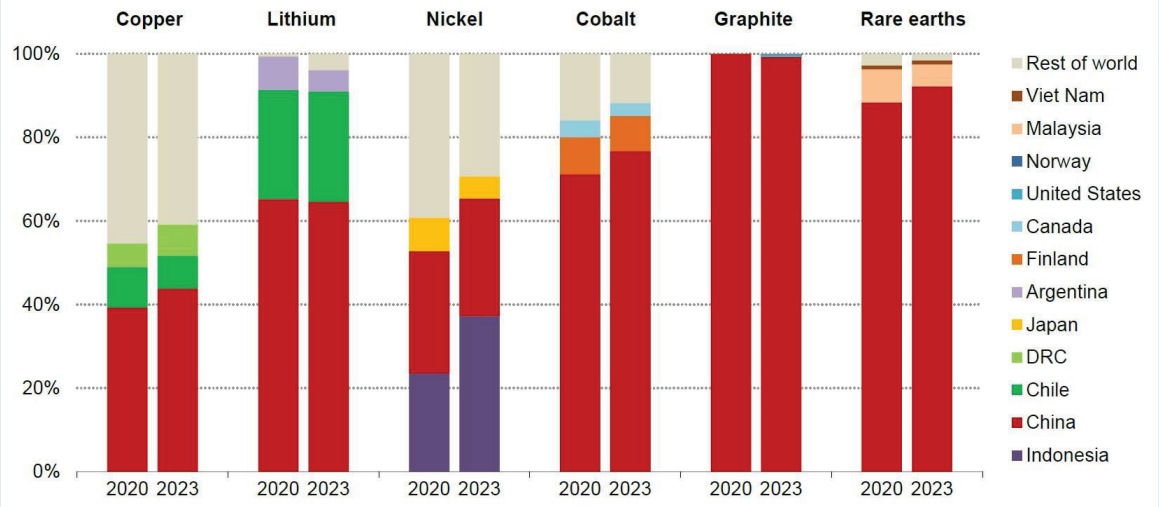
Magnets made from these are used in achieving higher energy efficiency for automotive traction motors in EVs and wind turbine motors. According to IEA projections, these are likely to remain heavily geographically concentrated in the future (Figure 7). Meanwhile, 2023 also witnessed a proliferation of trade restriction measures on the ores as well as technologies for processing them, which has implications for the availability and access to essential raw materials for solar PV, wind turbines, EVs, and other consumer goods. This concentration of rare earth and critical minerals in mining and processing is a significant constraint on the use of renewables and EV ambitions for most countries, including India.

Chart VI.5: Geographical distribution of critical mineral global supply chains, 2023[63]



Source: IEA's Global Critical Minerals Outlook 2024

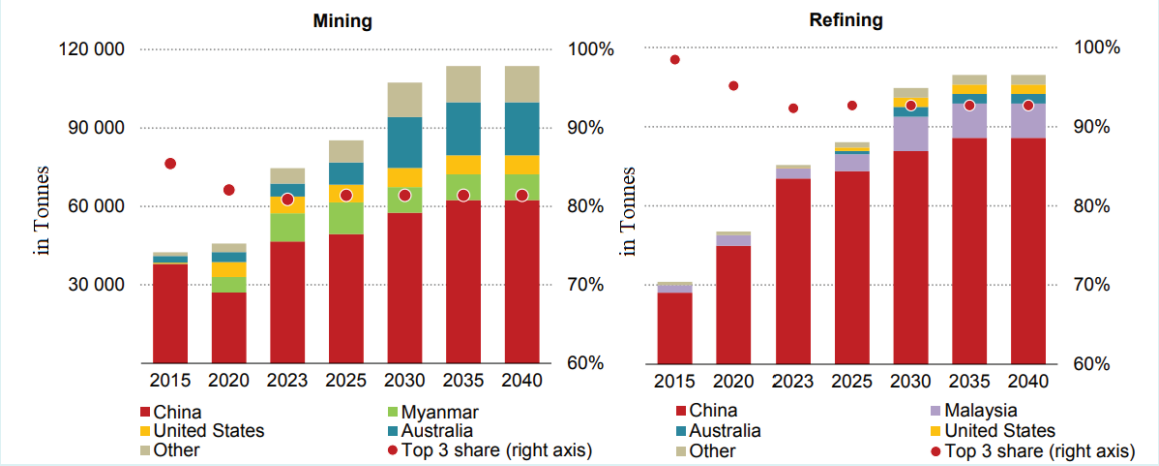
Chart VI.6: Share of refined material production by country in 2020 and 2023



Source: IEA's Global Critical Minerals Outlook 2024

63 Notes: Li = lithium; Ni = nickel; Co = cobalt; Gr = graphite; DRC = Democratic Republic of the Congo. Geographical breakdown refers to the country where the production occurs. Mining is based on production data. Material processing is based on refining production data. Cell component production is based on cathode and anode material production capacity data. Battery cells are based on battery cell production capacity data. EVs based on electric cars production data. For all minerals mining and refining shows total production not only that used in EVs. Graphite refining refers to spherical graphite production only.

Chart VI.7: Geographical concentration of Magnet rare earths over the years[64]



Source: IEA's Global Critical Minerals Outlook 2024. The left axes represent quantity; right axes represent shares of the Top 3 countries.

6.37. Other than risks related to access to technology and raw materials, availability and access to affordable finance are arguably the most significant challenges to India's development of a low-carbon path. There are several estimates about the financial requirements for the transformation of India's energy system to align with the Net Zero announcement. They all point to one fact – the requirements are of the order of trillions. As per the NITI's IESS 2047 model, India's total investment cost until 2047 is conservatively estimated at ~ USD 250 billion per year to prepare its energy systems for Net-Zero pathways.

Box VI.5: Report on Synchronizing Energy Transitions towards Possible Net-Zero for India: Affordable and Clean Energy for All

A study titled 'Synchronizing energy transitions toward possible Net Zero for India: affordable and clean energy for all' was conducted by the Indian Institute of Management Ahmedabad with the support of the Office of the Principal Scientific Adviser to the Government of India and the Nuclear Power Corporation of India Ltd. The report contains the projection of the energy mix in the backdrop of India's Net Zero 2070 announcements and cleaner, affordable energy for all. The projected future energy basket for 2030, 2050, and 2070 across various growth and climate commitment scenarios have been presented in the report.

Main Conclusions of the Report

1. A sustainable energy transition needs the co-existence of several energy sources.
2. Coal is projected to continue until the next two decades as the backbone of the Indian energy system. Although technologies such as Carbon Dioxide Removal technologies (CDRs), such as Bioenergy with CO2 Capture & Storage (BECCS), and CCUS need to be explored to reduce the emissions from the use of coal. However, the energy penalty[65] for deploying BECCS/CCUS at power plants would need a closer examination.

64 Note: Graphite is based on spherical graphite for battery grade. Rare earths are magnet rare earths.
65 The energy penalty is the extent of energy required to power the CCUS technologies.

3. Renewable Energy (RE) and nuclear power are expected to be the predominant sources of energy by 2070.
4. Coal phase-down will be heavily dependent on the import of critical minerals required for renewable energy and battery storage unless the country invests in the development of technologies based on domestically available mineral resources and those that enable the reuse, recovery, and recycling of critical minerals.

Finance for Sustainable Development

6.38. The country has taken many measures to improve the business environment and catalyse greater quantum of resources. The 'Framework for Sovereign Green Bonds' released in 2022 has enabled the mobilisation of resources from diversified investors for green projects, deepening the bond market. The framework has been rated as 'Medium Green' with a 'Good' governance score by CICERO, a Norway-based Second Party Opinion provider, highlighting India's credibility and readiness to issue sovereign green bonds. The Government undertook the issue of sovereign green bonds amounting to ₹16,000 Crore in January-February 2023 to raise proceeds for public sector projects that would contribute to the efforts to reduce the intensity of the economy's emissions, followed by ₹20,000 Crore raised through sovereign green bonds in October-December 2023.

6.39. SEBI has been one of the early adopters of sustainability reporting for listed entities and has required mandatory ESG-related disclosures for the top 100 listed entities (by market capitalisation) since 2012. Over the years, SEBI strengthened the reporting to cover the top 500 and then the top 1000 entities. SEBI issued new sustainability reporting requirements under the Business Responsibility and Sustainability Report (BRSR), which are more granular with quantifiable metrics in line with the principles ensconced in the 'National Guidelines on Responsible Business Conduct'. The BRSR was mandatory for the top 1000 listed entities (by market capitalisation) from 2022–23. In July 2023, the SEBI also introduced the BRSR core for ESG disclosures for value chains. From 2024-25, these disclosure requirements apply to the top 250 listed companies and will be extended to the 1000 top-listed entities in a phased manner by 2026-27. The value chain shall encompass a listed entity's top upstream and downstream partners, cumulatively comprising 75 per cent of its purchases/sales (by value), respectively. The BRSR Core is a sub-set of the BRSR, consisting of a set of Key Performance Indicators (KPIs)/metrics under specific ESG attributes.[66]

6.40. RBI has implemented the Framework for Acceptance of Green Deposits for the Regulated Entities to foster and develop a green finance ecosystem in the country. In addition, the RBI promotes renewable energy through its Priority Sector Lending (PSL) rules. The notified PSL rules by RBI facilitate concessional credit for renewable energy generation and certain mitigation projects. This includes, for example, bank loans up to a limit of ₹30 Crore to borrowers for purposes like solar-based power generators, biomass-based power generators, windmills, and micro-hydel plants. Non-conventional energy-based public utilities, such as street lighting systems and remote village electrification, are also eligible for priority sector classification per the notification.

66 BRSR Core - Framework for assurance and ESG disclosures for value chain, SEBI, https://www.sebi.gov.in/legal/circulars/jul-2023/brsr-core-framework-for-assurance-and-esg-disclosures-for-value-chain_73854.html

PUTTING IN PLACE A MARKET FRAMEWORK TO PRICE CARBON: INDIAN CARBON MARKET (ICM)

6.41. The regulations on the Carbon Credit Trading Scheme (CCTS), also called the Indian Carbon Market, were notified by the Ministry of Power on 28 June 2023. The objective of CCTS is to allow the determination of a price for one tonne of carbon dioxide equivalent emissions, encouraging an obligated entity to factor in the cost of a resource that was not priced earlier, thereby incentivising investment in alternative low-emission technologies. CCTS will subsume the existing PAT scheme, where the Designated Consumers (DCs) under the PAT scheme will gradually transition to CCTS by 2028-30. Under the CCTS, the Government shall set entity-wise GHG emission intensity targets to enable a per-output emissions limit (i.e., GHG emissions intensity target) in place of specific energy consumption targets under the existing PAT scheme. Key institutions and stakeholders that will play a crucial role in the oversight, implementation, and guidance of the ICM are as follows (Table 1):

Table VI.1: Institutional Architecture of Carbon Market in India

Function	Institution
Governance, oversight and functioning	National Steering Committee for the Indian carbon market
Policy & administrator	Bureau of Energy Efficiency
Implementor of targets	Obligated entity
Trading regulator	Central Electricity Regulatory Commission
Registry	Grid Controller of India Limited (GCIL)
Trading platform	Power exchange – IEX, PXIL, HPX

6.42. The CCTS envisages a compliance mechanism whereby the registered entities notified under the mechanism, called obligated entities (OE), will be notified of GHG emission intensity targets for each annual year in the trajectory period (called the compliance year). On completion of the trajectory period, the targets shall be revised for subsequent periods. The obligated entities would be required to comply and furnish the compliance status with the targets set after the verification and trading process within nine months from the completion of the compliance cycle. The entity obligated to achieve greater than the target notified can get the Carbon Credit Certificates (CCC) issued by the difference between the actual and target. These CCCs can be sold in the carbon market or banked by the obligated entity on completion of the compliance year. The banked CCCs can be sold or used to achieve compliance in the following years. An obligated entity failing to meet the targets would be required to buy the CCCs in the Indian carbon market or use their banked CCCs for compliance.

Voluntary Carbon Market (VCM)

6.43. Carbon markets can be compliance markets run and regulated by governments or international bodies, with specific industries required to participate (compliance market), or could be voluntary carbon markets- which are not regulated by governments and are entirely voluntary. The global voluntary carbon market is worth over USD 1.2 billion, and India is the second-largest supplier of carbon offsets.

6.44. A VCM allows entities to compensate for their emissions through emission reduction/ removal/avoidance achieved in projects elsewhere or by other entities – a process termed 'carbon offsetting'. The purchaser of an offset credit can retire the offset to claim the underlying reduction towards their own emission reduction goals. However, there are concerns about double counting in VCM when sellers and buyers can claim the carbon reductions. There is also uncertainty about whether a credit being used as an offset by a foregin entity can be simultaneously claimed by the country where the credit was generated for their emission reduction target. If this is not, then with India's ambitious NDC and Net Zero announcement, carbon credits sold to foreign entities will make India's emissions reduction more expensive and difficult.

Box VI.6: Evolution of Carbon Markets

The existence of the first market-based regulation to abate the air pollution level and address environmental problems can be traced back to the sulphur dioxide (SO2) allowance trading programme by the United States in the 1970s. The Montreal Protocol (1987) served as an early international precedent for trading emissions permits to address ozone depletion. Article 4.2(a) of the UNFCCC (Convention) set the foundation for early carbon markets by allowing the Parties to implement emission reduction policies jointly.

The Conference of the Parties or COP of the UNFCCC adopted a legal instrument in this regard - the Kyoto Protocol (KP) in 1997. The KP established legally binding GHG emissions reduction targets for 38 industrialised countries and Economies in Transition (EIT) – Annex-B Parties to the KP. Market-based mechanisms under the KP allowed Parties to meet part of their Kyoto caps with 'Kyoto units' bought from other Parties. It had three mechanisms – (i) Clean Development Mechanism (CDM) leading to Certified Emission Reductions (CERs) from mitigation projects in developing countries,[67] (ii) Joint Implementation creating Emission Reduction Units (ERUs) achieved by projects in countries with emission caps, and (iii) International Emissions Trading (IET) enabled trading of Assigned Amount Units (AAUs) and other Kyoto units between countries with emission caps. These mechanisms laid the foundation for the first-ever effort in the international carbon market, though its initial implementation faced challenges like limited participation and complex rules. However, after the launch of the European Union Emission Trading Scheme (EU-ETS) in 2005, the significance of the carbon market was realised for the first time. It was around the mid-2000s that EU-ETS started functioning, and Voluntary Carbon Markets began to gain traction. The fungibility of the credits with EU-ETS helped the Kyoto Protocol to establish a stronger carbon price in its first commitment period (2008-2012).

The second commitment period (2013-2020) of the KP was adopted in December 2012, while the EU-ETS entered its third phase in 2013-2020. The cumulative inflow of international credits led to a large surplus in the European carbon market and undermined the carbon price incentive; for example, prices fell from €15/tCO2e in 2011 to a price range of €3 - €8/ tCO2e in the 2013 - 2015 period. The EU decided not to allow CERs and ERUs from KP to be compliance units within the EU-ETS and made it mandatory to exchange the Kyoto units for EU-ETS emission allowances. The second phase of the KP's carbon markets failed mainly

67 Developing countries did not have obligation to cap emissions.

due to the non-participation of some major developed economies and due to the non-interchangeability of the Kyoto credits with EU-ETS[68]. With the end of the KP in 2020, the CDM also dried up and was replaced by the unregulated buyers and sellers of the carbon market, the VCM.

The Paris Agreement, adopted in December 2015, provides countries the option to voluntarily cooperate for higher ambition in their NDCs through a unified global carbon market.

a. Article 6.2 calls for 'voluntary cooperative approaches' at the bilateral level involving the use of Internationally Transferred Mitigation Outcomes (ITMOs)[69] in meeting NDCs, promoting sustainable development, and ensuring environmental integrity and transparency while avoiding any double counting.

b. Article 6.4 defines an international mechanism to issue emission credits against mitigation outcomes. Article 6.4 of the Paris Agreement mechanism thus became the successor to the Kyoto Protocol's CDM.[70] If authorised by the host country, the emission credits (or Emission Reductions) generated by mitigation activities become ITMOs. Another country can use them to fulfil its NDC or for other mitigation purposes, and calls for the corresponding adjustment in the origin county to avoid any double counting.

Negotiations are still ongoing on the implementation of Articles 6.2 and 6.4.

6.45. The carbon market's effectiveness in emission reduction in India will depend on its regulation and implementation in the context of the target of Viksit Bharat by 2047 and Net Zero by 2070. While the domestic compliance market developed under the CCTS is essential to ensure that the industry internalises the emission costs into its production and investment decisions, we may not subsidise the transition of other countries.

6.46. The Government of India's Mission LiFE is envisaged as a mass movement to address climate change and foster sustainable living based on conservation and moderation principles. The Government supports voluntary environmental actions such as the Green Credit Programme (GCP), which incentivises individuals, communities, private sector industries, and companies to participate in environment-positive activities by offering green credits as rewards. Box 7 presents a brief discussion on GCP.

Box VI.7: LiFE in Action: India's Innovative Green Credit Program[71]

The LiFE movement is a grassroots, mass initiative to combat climate change and promote sustainable living rooted in conservation and moderation. To bolster this effort and encourage eco-friendly practices, the Ministry of Environment, Forest and Climate Change

68 Use of international credits in EU ETS after 2020, European Commission, https://tinyurl.com/55mn5s79.
69 Internationally transferred mitigation outcomes are units for emissions trading between Parties to the Paris Agreement
70 Michaelowa, A., Samaniego, X., Kessler, J., Ahonen, H. M., Spence, C., & European Capacity Building Initiative. (2022). Pocket Guide to Article 6. Under the Paris Agreement. https://www.zora.uzh.ch/id/eprint/230043/
71 Gazette notification by MoEFCC, 26 June 2023 https://egazette.gov.in/WriteReadData/2023/246825.pdf

introduced two pioneering programs: the Green Credit Programme (GCP) and the Ecomark Scheme.[72]

Objectives of GCP: The GCP is an innovative market-based mechanism aimed at encouraging individuals, communities, private sector industries, and companies to engage in voluntary environmental positive actions through the issuance of green credits.

Implementation and governance: According to the Green Credit Rules, 2023, notified in October 2023, GCP shall be implemented through a phased and iterative approach. In the initial phase, it focuses on voluntary tree plantation on degraded land, wasteland, watershed, etc., under the control and management of the Forest departments. The governance structure of GCP includes the Steering Committee members from concerned ministries, experts, and institutions. Indian Council of Forestry Research and Education (ICFRE) is designated as the GCP administrator and is responsible for the implementation and management of GCP. GCP's digital processes include a dedicated web platform and a green credit registry for streamlining operations. Registration, accounting, and green credit issuance monitoring ensure the transparency and accountability of GCP. The generation of green credits under Green Credit Rules, 2023, is independent of the carbon credit under the Carbon Credit Trading Scheme, 2023.

A 'Green Credits Programme' was co-hosted by India and UAE on the side-lines of COP-28. India invited all nations to join the global green credit initiative, aimed at facilitating global collaboration, cooperation, and partnership through the exchange of knowledge, experiences, and best practices in planning, implementing, and monitoring environment-positive actions through programs/mechanisms like Green Credit. Chapter 13, a special essay, makes the case for the international relevance of LiFE.

INTERNATIONAL COMMITMENTS ON CLIMATE FINANCE: THE DEVELOPMENTS

6.47. Lack of access to adequate and affordable financial resources remains a significant constraint for developing countries in implementing their climate commitments. The Standing Committee on Finance (a body under the UNFCCC) has estimated that resources from USD 5.8 trillion to USD 11.5 trillion are required till 2030 to meet the targets set by developing countries in their NDCs and other communications. The 2023 UN Adaptation Gap Report estimated adaptation costs in developing countries to be 10 to 18 times greater than current international adaptation finance flows of USD 21.3 billion.[73] The UNFCCC and its Paris Agreement mandate that developed countries provide financial resources on a grant or concessional basis and provide access to technologies to developing countries to enable their climate actions. The first GST outcome also underscored the current needs of developing countries and the criticality

72 Notification issued for Green Credit Program (GCP) and Ecomark scheme Under LiFE Initiative to Promote Sustainable Lifestyle and Environmental Conservation, October 13, 2023, PIB, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1967476

73 United Nations Environment Programme (2023). Adaptation Gap Report 2023: Underfinanced. Underprepared. Inadequate investment and planning on climate adaptation leaves the world exposed. Nairobi. https://doi.org/10.59117/20.500.11822/43796.

of new and additional, grant-based, highly concessional finance and non-debt instruments in supporting developing countries. The finance flows to developing countries from developed nations have been very meagre. Currently, most of the international finance available for developing countries is in the form of loans rather than grants.

6.48. The preliminary estimates of the overall resource requirement, as stated in the country's NDC, is USD 2.5 trillion for 2015-2030. The Long-Term Low Emission Development Strategy (LT-LEDS) submitted by the country highlighted that financial resources of the order of tens of trillions of dollars would be required by 2050 for India's transition towards a low-carbon development pathway. India's 1st Adaptation Communication (AC) submitted to UNFCCC mentioned the cumulative need for expenditure for adaptation to be ₹56.68 trillion by 2030. However, much of the resource flow for climate action - mitigation and adaptation - is primarily from domestic resources.

6.49. Available, accessibile and affordable financial resources are essential to meet the needs of developing countries. UNFCCC and its Paris Agreement mandate that developed countries provide the resources and take the lead in mobilising finance through various sources. However, much of the climate action by developing countries has been done through domestic resources, and the emphasis of the developed countries has mainly been on private finance taking the lead in financing climate action. Given the scale of financial requirements, the ability of private capital to meet the needs even partially remains debatable. Further, the cost of such capital would have implications on the macroeconomic stability of the developing countries. While recognising the importance of private capital, a working paper by the Centre for Social and Economic Progress[74] identifies various challenges for developing countries in attracting it such as limited depth of their financial markets and vulnerable debt profiles. There is further evidence[75] to suggest that even MDBs mobilised less than a dollar from the private sector for every dollar of committed finance by MDBs for climate action. As reflected in an article in the Financial Times- *'There's too much to do, and given the urgency and the need to get the solution right, this isn't a task for .... favourite ESG-focused portfolio manager ... The sheer scale of the physical infrastructure that must be revamped, demolished or replaced is almost beyond comprehension. Governments, ..., will have to lead .... The Western nations that did so much of the damage will have to finance the transition in the developing world — it is astonishing that this idea is still debated.'*[76]

CoP 28 and the Global Stocktake

6.50. The 28th session of the Conference of Parties (COP 28) to the United Nations Framework Convention on Climate Change (UNFCCC) was held in Dubai, UAE. The primary outcome of COP 28 included the decision on the outcome of the first GST, which seeks to ratchet up global climate ambition before the end of the decade, implemented in a nationally determined manner, taking into account the Paris Agreement and their different national circumstances. Another

74 Natarajan, G., and Anantha Nageswaran, V., (2023). Harnessing private capital for global public goods: Issues, challenges and solutions (CSEP Working Paper 57). New Delhi: Centre for Social and Economic Progress, https://csep.org/wp-content/uploads/2023/10/Harnessing-private-capital-for-global-public-goods-1.pdf.

75 2019 Joint report on multilateral development banks climate finance. (2020). https://www.ebrd.com/2019-joint-report-on-mdbs-climate-finance.

76 Brower, D., Chu, A. & McCormick, M, The energy transition will be volatile, The Financial Times, (2023, June 29). https://www.ft.com/content/86d71297-3f34-48f3-8f3f-28b7e8be03c6.

significant outcome of COP 28 is the agreement on operationalising the Loss and Damage Fund and its funding arrangements. In line with the mandate under the Paris Agreement to develop a Global Goal for Adaptation (GGA), COP 28 finalised the Emirates Framework for Global Climate Resilience. The decision calls for all countries to have adaptation plans by 2030. Parties agreed on targets for the Global Goal on Adaptation, reflecting a global consensus on adaptation targets and the need for finance, technology, and capacity-building support to achieve them.

6.51. Under the first GST, the Parties took decisions on different themes of climate action, viz., mitigation, adaptation, and means of implementation, including finance, capacity building, technology development, and technology transfer. Under finance, the GST decision recalls that developed country Parties shall provide financial resources to assist developing country Parties in continuing their obligations concerning mitigation and adaptation under the Convention (UNFCCC). The decision also recognises that adaptation finance must be significantly scaled up to support the urgent and evolving need to accelerate adaptation and build resilience in developing countries. Under mitigation, the decision calls upon Parties to contribute to the tripling of global renewable energy capacity, accelerating efforts towards the phase-down of unabated coal power, phasing out inefficient fossil fuel subsidies, etc. These decisions are to be implemented in a nationally determined manner, taking into account the different national circumstances, pathways, and approaches of the Parties. The decision also noted that measures taken to combat climate change, including unilateral ones, should not constitute arbitrary or unjustifiable discrimination or a disguised restriction on international trade.

New Collective Quantified Goal (NCQG)

6.52. A New Collective Quantified Goal (NCQG) on climate finance is being negotiated under the UNFCCC to decide an annual goal of climate finance to be mobilised by the developed countries for the developing countries from 2025 onward. The mandate is to set a new quantified goal from the floor of USD 100 billion per year, considering the needs and priorities of developing countries aiming to strengthen the global response to the threat of climate change in the context of sustainable development and efforts to eradicate poverty. Developing countries seek a) an ambitious mobilisation goal that adequately addresses their needs, b) grant-based or highly concessional and accessible financial resources, and c) a balance between the financing of mitigation and adaptation actions. These aspects have also been articulated in the discussions under the Indian presidency of the G20 and are duly reflected in the Delhi Declaration.

INDIA'S INTERNATIONAL INITIATIVES TO ADDRESS CLIMATE CHANGE ISSUES

6.53. India has led several international initiatives towards climate change mitigation and building resilience. Some of these are discussed as follows:

1. The International Solar Alliance (ISA) was established by a joint initiative of India and France in 2015 to deploy solar energy solutions. It is a treaty-based inter-governmental organisation with 119 Member and Signatory countries. The organisation aims to unlock USD one trillion of investments in solar by 2030 by crowding in private sector investment through guarantees, buildings capacities and through measures to reduce the cost of technology adoption. Its

programmatic support has identified a pipeline of 9.5 GW of solar energy capacity in its member countries. ISA assists in setting up solar energy demonstration projects with a grant of USD 50,000 for its Members categorised as Least Developed Countries (LDCs) or Small Island Developing States (SIDS). As of March 2024, 19 solar energy demonstration projects are under implementation. ISA also works on capacity building, and as part of this effort, around 4,000 professionals from around the globe have been trained on various aspects of the solar energy industry. ISA has successfully established the Solar Technology and Application Resources Centres (STAR-C) in Ethiopia and Somalia.

2. One World, One Sun, One Grid (OSOWOG) is an ambitious project led by India and the UK to interconnect solar energy systems on a massive scale. The vision behind the OSOWOG is the mantra that 'the sun never sets', and the idea is to harness solar and other renewable energy sources from different parts of the world, where the sun is shining at any given moment, and efficiently transmit that power to areas where it is needed. The OSOWOG initiative is to be carried out in three phases. In the first phase, the Indian grid would be connected to the Middle East, South Asia, and South-East Asia grids to develop a common grid. The second phase would connect the functional first phase to the pool of renewable resources in Africa, and finally, the third phase would look at achieving true global interconnection with the aim of 2,600 GW of interconnection by 2050. [77]

3. The Coalition for Disaster Resilient Infrastructure (CDRI) was launched by India during the United Nations Climate Action Summit on 23 September 2019. It is a global partnership of National Governments, UN agencies and programmes, multilateral development banks and financing mechanisms, the private sector, and academic and knowledge institutions that aims to promote the resilience of new and existing infrastructure systems to climate and disaster risks in support of sustainable development. CDRI aims to enhance infrastructure resilience through capacity building, informed policy, planning, and management, leading to improved quality of the environment, livelihoods, and lives of over three billion people by 2050. The organisation released its first Biennial Report on Global Infrastructure Resilience in 2023. It is CDRI's contribution towards monitoring the SDGs, the Paris Agreement, and the Sendai Framework targets. Other interventions include financial support for peer learning, capacity development opportunities and sectoral programs on power, transport, telecommunication, health, and urban infrastructure. Further, 11 projects were awarded across 13 SIDS in 2023, in partnership with USAID and Miyamoto International, under the Disaster Resilient Infrastructure (DRI) connect, a one-stop digital knowledge exchange, learning, and co-creation platform. The Infrastructure Resilience Academic Exchange (IRAX) Programme has been conceived as a structured engagement initiative with global academic institutions to offer value-added education, research opportunities, and professional development on DRI. As part of this, in 2023, USD 5 million was provided by USAID to support a partnership between US universities and Indian higher education institutions to offer education, research, training, and professional development opportunities on DRI. [78]

77 One World, One Sun, One Grid (OSOWOG), International Solar Alliance, https://isolaralliance.org/work/osowog/

78 Based on information received from the Coalition for Disaster Resilient Infrastructure (CDRI)

4. The Infrastructure for Resilient Island States' (IRIS), led by India, is a flagship strategic initiative of CDRI and Small Island Developing States (SIDS) designed to achieve and deliver resilience and climate adaptation solutions to the SIDS, which are among the most vulnerable and exposed countries. Launched in 2021, IRIS is already supported by commitments of USD 35 million from Australia, India, the EU, and the UK, with a target to attract and deploy USD 50 million to support SIDS by 2030. [79]
5. Realising the importance of partnership between the Government and industry to achieve the goal of Net Zero, the Leadership Group for Industry Transition (LeadIT) was launched by the governments of India and Sweden in September 2019. LeadIT brings together countries and companies committed to action to achieve the goals of the Paris Agreement. At COP 28, India and Sweden launched the second LeadIT (LeadIT 2.0) phase for 2024-26, marking a joint commitment by member countries and companies to shape policy frameworks and international cooperation for an inclusive industry transition. This new phase will focus on inclusive and just industry transition, co-development & transfer of low-carbon technology, and financial support for industry transition in emerging economies.

CONCLUSION

6.54. As India aims to achieve its ambitious growth targets, it faces the dual challenge of meeting energy demands while reducing carbon emissions. Given the close linkage between energy consumption and various social indicators, the Government has a priority to ensure access to sustainable and clean energy sources. Non-fossil fuel sources are critical to India's ambitious NDCs and Net Zero commitment. However, phasing in of non-fossil sources has its challenges – intermittency related to renewables, handling of nuclear and solar panel waste, implications of biofuel production on food security, etc. Depending on the evolving and ambitious NDC targets and the objective of ensuring energy security, it is amply clear that India needs to target a diversified set of energy sources. Such diversification will help minimise risks associated with energy systems while pursuing low-emission pathways in line with national commitments. The integration of renewables, alongside exploring nuclear energy and biofuels, presents a path towards achieving these objectives. This will also include a significant role for thermal power, especially coal-based power plants, in providing base-load to support large-scale deployment of renewables.

6.55. In exploring the landscape for ensuring energy security, it has become evident that risks are not merely obstacles but also harbingers of opportunities. While uncertainties loom, they present avenues for innovation, adaptation, and growth for India. While phasing in renewables to the extent possible is imperative, in the short to medium term, the focus should also be on actively adopting clean coal technologies. The Government's initiatives for (cleaner) coal, such as the Coal Gasification Mission, extraction of Coal Bed Methane gases, exploring Coal to Hydrogen, Carbon Capture and Storage (CCS), and Coal beneficiation through washeries, etc. to mitigate emissions and enhance environmental sustainability needs to be promoted. With the advent of ultra super-critical technologies for coal power plants, it would be possible to lower emissions and achieve higher efficiency.

79 Infrastructure for Resilient Island States (IRIS), UN Department of Economic and Social Affairs, Sustainable Development, https://sdgs.un.org/partnerships/infrastructure-resilient-island-states-iris.

6.56. India's successful renewable energy growth story is well-established. Solar power installed capacity has increased drastically by over 25 times between 2014 to 2023. However, several risks are associated with the large-scale phasing-in of renewables, such as intermittency, grid integration, backup power generation, storage, etc. It is important to supplement with other non-fossil fuel sources such as Nuclear, Biofuels, and Hydrogen.

6.57. It should not be that India's high dependency on imports mainly for petroleum for its energy needs, shifts to high import dependency for Solar PV panels and critical minerals (systemic risks), whose supply chain and geopolitics may be even trickier. India needs to target diversified energy sources, including renewables (Solar, Wind, Large and Small Hydro), green hydrogen, nuclear, and biofuels. Such diversification will help minimise risks associated with energy systems while pursuing low-emission pathways in line with national commitments. The diversification also includes a significant role for thermal power in providing the base load to support large-scale deployment of renewables.

6.58. Many technologies required for global Net Zero are commercially unavailable, such as hydrogen-fuelled Steel/Cement, Steel and Aluminium production with CCUS, etc. There is a need to enhance international cooperation in R&D, especially in the domains of distributed RE, offshore wind, geothermal, tidal energy, biofuels, Compressed Bio Gas, green hydrogen, energy storage, electrolysers, and nuclear power (including Small Modular Reactors SMR).

6.59. Availability, affordability, and accessibility of financial resources will drive the green transition. While India has relied upon its resources so far, it is vital that resources from developed countries and mobilised by the latter flow to the developing countries in line with the objectives of the UNFCCC and its Paris Agreement. The negotiations on the New Collective Quantified Goal must lead to outcomes required to meet the temperature goal of the Paris Agreement. The global narrative on the issue of climate change, describing it as a climate emergency, shifts focus from the equally, if not more, critical developmental problems and can cause panic.[80,81] The world needs a more balanced approach to the issue of climate change. It should also focus on nearer-term policy goals of improving human welfare rather than being excessively preoccupied with one large, longer-term goal of global climate management.

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80 Hulme, M. (2023). Climate change isn't everything: Liberating climate politics from alarmism. John Wiley & Sons.

81 V. Anantha Nageswaran, Climate change: Scaring people will only yield scars and no solutions, MINT, (Apr 16, 2024), https://www.livemint.com/opinion/online-views/climate-change-scaring-people-will-only-yield-scars-and-no-solutions-11713237716747.html.