CLIMATE AND ENVIRONMENT: ADAPTATION MATTERS

CHAPTER 10

India needs to achieve robust economic growth to attain developed nation status by 2047, with a focus on inclusive and sustainable development. While the country has low per capita carbon emissions, it is committed to pursuing low-carbon growth. However, it faces challenges in deploying renewable energy, particularly due to a lack of storage technology and access to minerals. Given India's vulnerability to climate change, a strong adaptation strategy is essential; the increase in adaptation expenditures from 3.7 per cent to 5.6 per cent of GDP between FY16 and FY22 indicates the prominence adaptation and building resilience play in the development strategy. The Lifestyle for Environment (LiFE) initiative, designed to encourage sustainable practices and circular economy, will play a transformative role in the development process. The flow of international finance has remained grossly inadequate, with much of the action being financed from domestic resources. The outcomes from the recent CoP29 hold little promise on that account.

INTRODUCTION

10.1 India's ambition to achieve developed nation status by 2047 is fundamentally anchored in the vision of inclusive and sustainable development. Notably, India's per capita carbon emissions are one-third of the global average, even as it stands among the world's fastest-growing economies. The country is dedicated to identifying and exploring pathways for low-carbon development that simultaneously ensure affordable energy security, job creation, economic growth, and environmental sustainability. However, India's aspiration for low-carbon economic growth presents significant trade-offs. While the nation has made remarkable progress in building renewable energy capacity, effectively harnessing and scaling these resources remains challenging due to the lack of viable storage technologies and limited access to essential minerals.

10.2 A strong adaptation strategy is a priority for the country, given its significant vulnerability to climate change, stemming from its geographic and agro-climatic diversity.[1] India's Initial Adaptation Communication, submitted to the United Nations

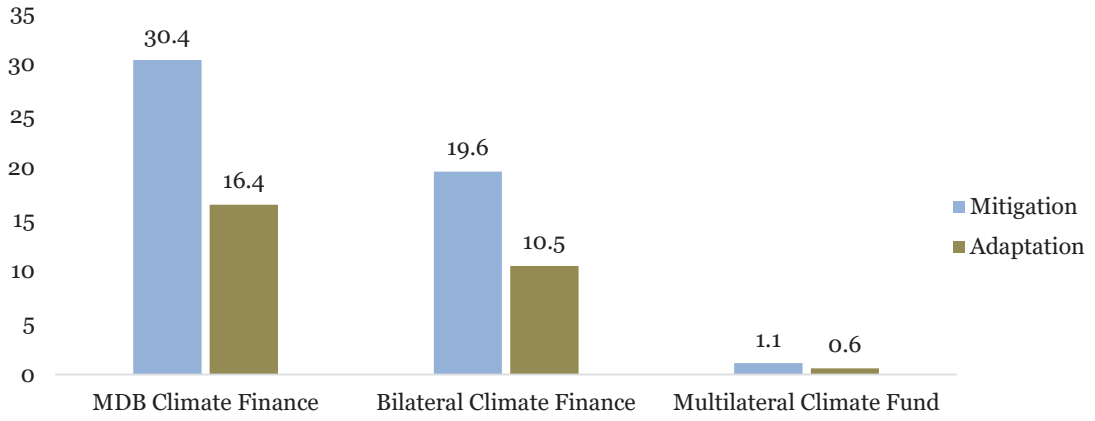
1 Khanna, P. (2024, December 29). India is overlooking the climate drag on its economic growth. Financial Times. Retrieved January 4, 2025, from https://tinyurl.com/cbkc3hjx.

Framework Convention on Climate Change (UNFCCC) in December 2023, reveals that the total expenditure related to adaptation in FY22 was 5.6 per cent of the Gross Domestic Product (GDP), an increase from 3.7 per cent in FY16. Climate action, so far, has been financed through domestic resources, with the public sector playing a central role. On the other hand, the international flow of funds for climate actions is highly inadequate and has a mitigation bias (Chart 1).

10.3 Following a low-carbon development pathway and achieving the net zero carbon emissions goal necessitates a fundamental shift in mindset and behaviour towards mindful consumption and production. The India-led global movement, Lifestyle for Environment (LiFE), aims to enhance the country's sustainability efforts. The LiFE initiatives are being executed in India in mission mode through various regulatory measures and policies that encourage environmentally friendly practices such as waste management, resource conservation, and recycling. Promoting a circular economy is also envisioned as a central component under the Mission LiFE.

10.4 The recent outcome of the New Collective Quantified Goal at CoP29 (29th session of the annual climate conference under the UNFCCC) held in Baku in November 2024 on finance presents little optimism about the possibility of support to developing countries. With the developed countries also falling short of their Nationally Determined Contributions (NDCs) by about 38 per cent,[2] their actions do not reflect the historical responsibility or the leadership in meeting their obligations. The lack of commitment and insufficient delivery of the means of implementation,[3] as mandated in the Paris Agreement, will make the low-carbon transition in developing countries more challenging.

Chart X.1: International flow of finance in 2021-22 (in USD billion)



Source: Based on the Sixth Biennial Assessment and Overview of Climate Finance Flows by the Standing Committee of Finance, UNFCCC. The flow of finance to cross-cutting actions has not been included here. The report can be accessed at https://tinyurl.com/52md2zht.

2 CEEW (October 26, 2023). Trust and Transparency in Climate Action. Retrieved December 23, 2024, from https://www.ceew.in/publications/trust-and-transparency-climate-action-research.

3 Finance, Technology and Capacity Building are regarded as the means of implementation.

10.5 The 29th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 29) and the 6th Session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA 6), held in Baku, Azerbaijan, were designated as the 'Finance COP'. The focus was to establish the New Collective Quantified Goal (NCQG) on climate finance.[4] The meetings of COP29 and CMA6 presented a significant opportunity to serve as a benchmark for international climate cooperation and multilateralism, with the potential to influence the efficacy of climate policies on a global scale and strengthen collaborative efforts by enhancing the financial commitments to support climate action in developing countries.

10.6 Establishing a small mobilisation target of USD 300 billion annually by 2035 is a fraction of the estimated requirement of USD 5.1 - 6.8 trillion by 2030.[5] It is out of sync with the needs of the critical decade when action is required to keep the temperature goals of the Paris Agreement within reach.[6] The decision demonstrates a significant misalignment with the Paris Agreement's mandate to demonstrate a 'progression beyond previous efforts' by developed countries. It underscores the unwillingness of affluent developed nations to assume their equitable share of the responsibility to address emission reduction and mitigate climate change impacts on vulnerable populations in developing regions. The goal contravenes equity and the principle of common but differentiated responsibility in the global climate response by disproportionately placing the burdens of climate change on those nations that have not historically contributed to the crisis.

10.7 COP 30 in 2025 is the COP for Climate Action, before which the parties to the Paris Agreement are to submit their next version of Nationally Determined Contributions. The funding shortfall may lead to a reworking of the climate targets. Considering that domestic resources will be the key to action, resources for meeting development challenges may be affected, undermining progress toward sustainable development objectives and compromising the integrity of international climate partnerships.

10.8 This chapter is structured into three broad parts. It starts with discussing the importance of adaptation for India and the measures taken, focuses on energy transition and the lessons learnt from the experience of the developed countries and weighs options for India. It ends with an overview of the Lifestyle for Environment (LiFE) initiative and measures encouraging sustainable practices and circular economy.

4 Conference of the Parties serving as the meeting of the Parties to the Paris Agreement. (2024). New collective quantified goal on climate finance. In Decision -/CMA.6. Retrieved December 11, 2024, from https://tinyurl.com/45x593ce.

5 UNFCCC Standing Committee on Finance. (2024). Second report on the determination of the needs of developing country Parties related to implementing the Convention and the Paris Agreement. In UNFCCC. Retrieved December 23, 2024, from https://unfccc.int/sites/default/files/resource/UNFCCC_NDR2_ES_Web_Final.pdf.

6 United Nations. (2024). Outcome of the first global stocktake Decision 1/CMA.5 in the Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on its fifth session. In Addendum (FCCC/PA/CMA/2023/16/Add.1). UNFCCC. Retrieved December 23, 2024, from https://unfccc.int/sites/default/files/resource/cma2023_16a01E.pdf.

BRINGING ADAPTATION TO THE FOREFRONT

10.9 India is the seventh most vulnerable country to climate change.[7] It suffers from weather extremes and hazards, slow onset events such as sea-level rise, biodiversity loss, and water insecurity. While greenhouse gas (GHG) emissions are a global bad and the benefits of mitigation are diffused, vulnerable developing countries such as India have to bear a disproportionate burden of climate change and have no choice but to face the climate change consequence of historical emissions. The emissions remain with us. They impose huge costs on already resource-constrained countries. Hence, vulnerable developing countries such as India need to undertake climate adaptation on an urgent footing as this has a direct impact on lives, livelihoods and the economy.

10.10 The Ministry of Environment, Forest and Climate Change (MoEFCC) has initiated the process of developing the National Adaptation Plan (NAP). The NAP is a vital strategic document articulating India's adaptation priorities. The process aims to develop a comprehensive and inclusive NAP that aligns with sustainable development goals and ensures climate resilience for all regions and sectors. This is in addition to the Initial Adaptation Communication submitted to the UNFCCC on 9 December 2023, highlighting the country's adaptation priorities, strategies, policies, and programmes along with implementation support needs for adaptation action.

10.11 Implementing effective adaptation strategies will necessitate a multi-faceted approach that includes policy initiatives, sector-specific strategies, development of resilient infrastructure, research and development, and securing financial resources for adaptation efforts. Furthermore, these adaptation measures should be tailored to regional specificities, given India's significant diversity of geographic and agro-climatic conditions. The following subsections discuss the initiatives to build resilience across sectors.

Adaptation in agriculture

10.12 Heat and water stress can negatively impact yields, posing challenges for India's food security. Adaptation strategies in agriculture have included enhanced focus on research and development of climate-resilient seeds, measures to preserve and enhance groundwater resources, improve soil health, and modify cropping practices, among other measures. The chapter on Agriculture and Food Management discusses measures to improve adaptation in agriculture in detail.

Building resilience in urban areas

10.13 With increasing urbanisation and climate change impacts, comprehensive adaptation action to address heat stress, urban flooding, and depleting groundwater in

7 Global Climate Risk Index. (2021). The 10 most affected countries in 2019. Table 1. Page 8. Retrieved December 27, 2024, from https://www.germanwatch.org/en/19777.

cities has been gaining focus. The National Mission on Sustainable Habitat (NMSH), launched in 2010, one of the nine missions under the National Action Plan on Climate Change (NAPCC), seeks to promote low-carbon urban development and bolster resilience against climate change impacts through five key thematic areas: waste management, water management, energy and green building, mobility and air quality, and urban planning, green cover, and biodiversity. In 2015, sustainable development and climate actions became integral to urban investments through various missions and programs. The Ministry of Housing and Urban Affairs (MoHUA) has introduced a unique assessment framework for cities to evaluate climate-relevant parameters, helping them adopt and share best practices. This framework aligns with international standards for green, sustainable, and disaster-resilient urban habitats, enabling Indian cities to promote sustainable urban development.[8]

10.14 The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) is benefiting citizens by improving water supply systems, augmenting localised water resources through the revitalisation of water bodies, enhancing groundwater recharge, increasing permeable green spaces, promoting the recycling and reuse of wastewater, and implementing energy efficiency reforms, thus, promoting key thematic areas under the NMSH. As of December 2024, 785 stormwater drainage projects have been completed, eliminating 3,631 waterlogging points and constructing 1,380 kilometres of drains to mitigate the effects of urban flooding. Work is currently underway to address an additional 285 waterlogging points. Additionally, 2,438 parks have been developed, contributing 5,070 acres of green space. Over 320 green mobility projects have been completed to encourage environmentally friendly modes of transport and infrastructure, creating 493 kilometres of walkways and cycle tracks.

10.15 AMRUT 2.0[9] aims to enhance ease of living by creating water-secure cities through water conservation, augmentation and rejuvenation. As of December 2024, 3,078 water body rejuvenation projects have been approved with the planned rejuvenation of 475 square kilometres area with 4.65 crore million litres per day (MLD) capacity, of which nine water rejuvenation projects have been completed. These projects are focused on sewer diversion/ treatment before discharge into water bodies, sustainability and emphasis on nature-based solutions. AMRUT 2.0 also focuses on the reuse of water and greywater management. As of December 2024, 1,437 MLD capacity has been developed for recycling/reuse.

8 Ministry of Housing and Urban Affairs. (2021). National Mission on Sustainable Habitat 2021-2030. Retrieved December 17, 2024, from https://tinyurl.com/bdd584zk.

9 Ministry of Housing and Urban Affairs. (2021). Atal Mission for Rejuvenation and Urban Transformation 2.0. Retrieved December 17, 2024, from https://tinyurl.com/24kkjvxn.

BOX-X.1 Vertical Gardens and Environment Sustainability

Rapid urbanisation has intensified environmental challenges, including the urban heat island effect, increasing carbon emissions, and heightened air pollution. A promising solution gaining traction is the concept of vertical gardens, also called living walls or vertical greenery systems (VGS). These systems incorporate vegetation into vertical structures, effectively addressing these issues. By transforming urban facades into vibrant green landscapes, vertical gardens enhance the aesthetic appeal of buildings and contribute to environmental sustainability—improving thermal performance, sequestering carbon, and fostering biodiversity in densely populated cities. (Zaid et al., 2018[10]; Harbiankova & Manso, 2025)[11].

The practical application of this innovation is the Income Tax Department's initiative to create vertical gardens using over seven lakh waste plastic bottles. This project recycles waste and adorns urban structures across 17 states, showcasing the environmental and aesthetic enhancements vertical gardens can offer.[12]

Looking ahead, India's regulatory framework is continuously evolving, exemplified by the introduction of the Energy Conservation and Sustainable Building Code (ECSBC) 2024, which advocates energy-efficient and environmentally sustainable building practices. While this code facilitates the adoption of sustainable designs, there remains an opportunity for further enhancements, such as explicit guidelines for vertical gardens. These additions could significantly improve urban air quality and mitigate heat islands. Such policy advancements would align India with global best practices observed in Singapore, Japan, and the European Union, where vertical greening has become integral to urban development. (Bustami et al., 2018)[13].

The future of urban planning in India stands to gain immensely from embedding these ecological considerations into building policies and approval processes, making vertical gardens a standard feature in the architectural landscape. This shift would ultimately contribute to healthier and more sustainable urban environments.

10.16 The Smart City Mission[14] adopts a people-centric approach anchored around liveability, economic ability and sustainability. The Urban River Management Plan (URMP) aims to assist river cities in reviving and maintaining rivers sustainably. Launched in 2021, the River Cities Alliance (RCA), a partnership between the Ministry of Jal Shakti and MoHUA, focuses on sustainable river-centric development in more than 145 member cities.

10 Zaid, S. M., Perisamy, E., Hussein, H., Myeda, N. E., & Zainon, N. (2018). Vertical Greenery System in urban tropical climate and its carbon sequestration potential: A review. Ecological Indicators, 91, 57-70. https://doi.org/10.1016/j.ecolind.2018.03.086.

11 Harbiankova, A., & Manso, M. (2025). Integrating Green Roofs and Green Walls to Enhance Buildings Thermal performance: A literature review. Building and Environment, 112524. https://doi.org/10.1016/j.buildenv.2025.112524.

12 Press Information Bureau. (2022, October 31). Creation of vertical gardens by the Income Tax Department by using waste plastic bottles. Retrieved January 21, 2025, from https://pib.gov.in/PressReleasePage.aspx?PRID=1872353.

13 Bustami, R. A., Belusko, M., Ward, J., & Beecham, S. (2018). Vertical greenery systems: A systematic review of research trends. Building and Environment, 146, 226-237. https://doi.org/10.1016/j.buildenv.2018.09.045.

14 UN-Habitat. MoHUA, GoI. (2023). Smart Cities Mission, India: Localizing Sustainable Development Goals. Retrieved December 17, 2024, from https://smartcities.gov.in/sites/default/files/2023-09/SCM_UN_Report%20.pdf.

Adaptation in coastal regions

10.17 India's 7,600 km long coastline and many islands make adaptation in the coastal region particularly important. The coastal regions face extreme climate events (such as heavy rain, severe storms, high tide flooding, etc.), and slow onset events, such as sea-level rise, bring the risk of permanent inundation. Adaptation action in coastal regions can include planting and sustaining mangroves, building sea walls and artificial reefs, beach nourishment, dune planting, sand bypassing, etc.

BOX-X.2 Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISHTI)

The 'Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISHTI)' was introduced in the Union Budget for 2023-24. It aims to promote and conserve mangroves, which are unique natural ecosystems known for their high biological productivity and carbon sequestration capabilities. Additionally, mangroves serve as a protective barrier for coastlines against cyclones, typhoons, and tidal waves.

The objective is to restore mangrove forests through reforestation and afforestation measures along India's coast. This will be achieved by adopting the best practices established in India and worldwide, all within a realistic timeline. The aim is to enhance sustainable livelihood options for coastal communities and improve the support and services the mangrove ecosystem provides to the community and the economy.

The programme will cover approximately 540 square kilometres across nine coastal states and four UTs over five years (2023-2028). It will create approximately 22.8 million man-days of employment with an estimated carbon sink of 4.5 million tons of carbon, creating potential areas for nature tourism and livelihood potential for local communities.

The programme is being implemented in convergence mode, with funding from the State Compensatory Afforestation Fund Management and Planning Authority (CAMPA), National CAMPA, Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) and other sources. State forest departments are the primary implementing agencies of the programme. Gap funding to support the core and support activities under MISHTI is through National-CAMPA.

As of 30 November 2024, six states and UTs: Andhra Pradesh, Gujarat, Odisha, West Bengal, Kerala, and Puducherry have been allocated funds under the program. This funding is intended to treat 3,836 hectares under the National CAMPA program, based on the annual plans submitted by these states for their first-year activities. Additionally, through collaboration with other initiatives, including State CAMPA, the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), and various state-specific programs, a total of 22,560.34 hectares of degraded mangrove areas have been brought under restoration across 13 states and UTs.

Source: Based on inputs from the Green India Mission Directorate, MoEFCC.

10.18 The government of India has undertaken several steps to protect and enhance mangrove forests in coastal states/union territories (UTs) through promotional and regulatory measures.[15] Promotional measures are implemented through the 'Conservation and Management of Mangroves and Coral Reefs' scheme under the National Coastal Mission Programme. Regulatory measures are implemented through the Coastal Regulation Zone (CRZ) Notification (2019) under the Environment (Protection) Act, 1986; the Wild Life (Protection) Act, 1972; the Indian Forest Act, 1927; the Biological Diversity Act, 2002; and rules under these acts as amended from time to time.

BOX-X.3 Enhancing climate resilience of India's coastal communities

The "Enhancing Climate Resilience of India's Coastal Communities" project aims to enhance the resilience of the lives and livelihoods of the most vulnerable populations, particularly women, and to build resilience to climate change and extreme events, using an ecosystem-centred and community-based approach. The project is being implemented across India's coastal states and UTs.

As of 31 December 2024, approximately 4955.01 hectares of ecosystem has been restored which includes 3259.11 hectares of mangroves and 1695.9 hectares of degraded watershed. It is estimated that approximately 40,617.8 tonnes CO2 eq. have been sequestered under this project. An assessment of the coastal zone's cumulative vulnerability is proposed to facilitate appropriate adaptive measures. Other proposed activities under the project include promoting/demonstrating alternative climate-resilient livelihood options such as establishing mud crab hatcheries, promoting climate-resilient agriculture practices - and systematic rice intensification (SRI) technology for paddy cultivation.

Source: Based on inputs received from MoEFCC.

Adaptation action for water management

10.19 The Jal Shakti Abhiyan was initiated in 2019 to address the acute water stress in various parts of the country. The recent Jal Shakti Abhiyan: Catch the Rain – 2024, themed "Nari Shakti se Jal Shakti" (9 March to 30 November 2024), was focused on women's role in water conservation through five interventions like rainwater harvesting, water body mapping, intensive afforestation, and awareness generation. The National Aquifer Mapping Project (NAQUIM) has been completed across 25 lakh square kilometres, offering water conservation plans and recharge structures to state agencies for implementation.

15 Press Information Bureau. (2024, February 5). Schemes for Restoration of Mangrove Forests. Retrieved December 16, 2024, from https://www.pib.gov.in/PressReleasePage.aspx?PRID=2002625.

10.20 The Bhu-Neer portal, launched in September 2024, is a Central Ground Water Authority portal for managing and regulating groundwater resources, promoting transparency, efficiency and sustainability in groundwater usage. The FloodWatch India app (Version 2.0) launched by the Central Water Commission provides real-time flood forecasts and detailed data from 592 flood monitoring stations, along with reservoir storage insights to assist flood management.

10.21 Several states have undertaken other initiatives to manage water resources. The 'Jal Sanchay Jan Bhagidari' initiative, launched in Gujarat in September 2024, focuses on constructing 24,800 rainwater harvesting structures across the state to enhance rainwater harvesting and ensure long-term water sustainability. The Smart Laboratory on Clean Rivers (SLCR), established under the India-Denmark Green Strategic Partnership in Varanasi, aims to rejuvenate the Varuna River through sustainable practices and collaboration among government bodies, institutions, and communities. The Mawrah Multipurpose Reservoir Project of Meghalaya in East Khasi Hills district aims to conserve rainwater, recharge groundwater, rejuvenate springs, restore the catchment area and rehabilitate mine-spoilt land. The project serves as a model for integrated water resource management and community-driven environmental conservation efforts. The Dhamtari district of Chhattisgarh launched the Jal Jagar campaign focused on rainwater harvesting, rooftop water collection and wastewater management by engaging the community, especially women. It aims to transfer technology to field functionaries and empower communities to make decisions based on scientific data, and financial prudence. Jal Jagar activities were undertaken across 370 gram panchayats of Chhattisgarh, involving the participation of 80,389 women and 61,580 men.

ENERGY TRANSITION - LEARNING FROM THE EXPERIENCE OF DEVELOPED COUNTRIES AND WEIGHING THE OPTIONS

10.22 The first major energy transition from wood to coal began in the early eighteenth century, coinciding with the advent of the first industrial revolution. Two centuries later, coal was overtaken by oil and gas around 1946 (O'Connor, 2010),[16] and fossil fuels became the primary energy source (Solomon & Krishna, 2011).[17] The energy transition from wood to coal was motivated by several factors, of which industrialisation in Britain and concerns over the loss of forests due to enhanced logging were pre-dominant (Smil, 2019).[18] A more recent transition from oil to nuclear energy in France that began in the

16 O'Connor, P. A. (2010). Energy Transitions. In The Pardee Papers. The Frederick S. Pardee Center for the Study of the Longer-Range Future Boston University. https://tinyurl.com/bddn4b7r.

17 Solomon, B. D., & Krishna, K. (2011). The coming sustainable energy transition: History, strategies, and outlook. Energy Policy, 39(11), 7422–7431. https://doi.org/10.1016/j.enpol.2011.09.009.

18 Smil, V. (2019). Energy in World History. In Routledge eBooks. https://doi.org/10.4324/9780429038785.

1970s was driven by the oil embargo by oil-producing countries in 1973 (Solomon & Krishna, 2011)[19] and the intent to reduce dependence on imported oil.

10.23 The energy transitions witnessed till the last century were driven by commercial interests rather than the will to limit the emissions from advanced economies. Commercial interests and energy security remain the most significant factors in the transition pathway even today. In 2022, the European Union introduced the REPowerEU plan,[20] which aims to reduce dependence on Russian gas supplies. The plan includes a budget of € 10 billion allocated for investment in liquefied natural gas infrastructure and an additional € 1.5 to 2 billion designated for securing oil supplies. The European Union further amended its sustainable taxonomy[21] to include generating power and heat from fossil gaseous fuels as a transitional activity. In 2023, the US administration also approved the onset of the country's largest oil drilling project in the Alaska region, with an estimated total oil and non-gas liquids production of 628.9 million barrels and 260.79 million metric tons of associated indirect carbon dioxide equivalent of emissions.[22] Actions speak louder than words, with the biggest beneficiaries of carbon-intensive growth over several centuries holding on to fossil fuels even as they would want the developing countries to take up the less efficient, costlier and riskier options.

10.24 Recent data about the G7 countries (Charts 2 and 3) for almost the last six decades (1992 to 2023) shows that these countries continue to rely heavily on fossil fuels in their per capita primary energy consumption, shifting from coal and oil-based energy to gas-based energy.

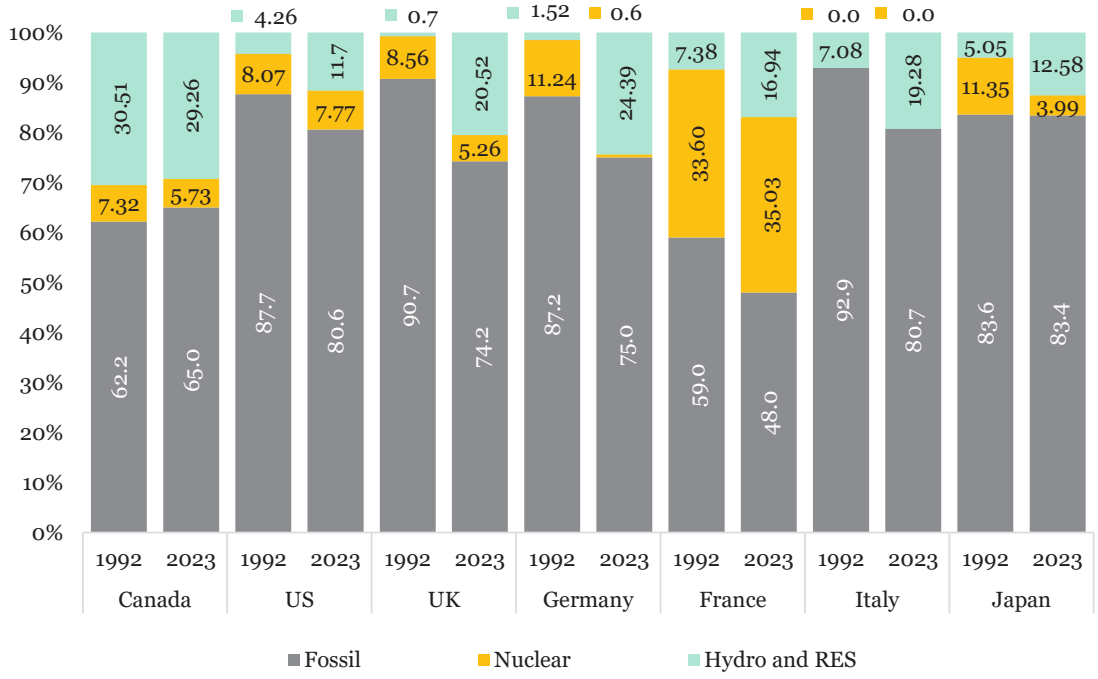
19 Solomon, B. D., & Krishna, K. (2011). The coming sustainable energy transition: History, strategies, and outlook. Energy Policy, 39(11), 7422–7431. https://doi.org/10.1016/j.enpol.2011.09.009.

20 Communication from the commission to the European Parliament, The European Council, Council, The European Economic and Social Committee and the Committee of the region REPowerEU Plan of 18 May 2022. Retrieved December 20, 2024, from https://tinyurl.com/3nw57rmp.

21 Commission Delegated Regulation (EU) 2022/1214 of 9 March 2022 amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities. Retrieved December 20, 2024, from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R1214.

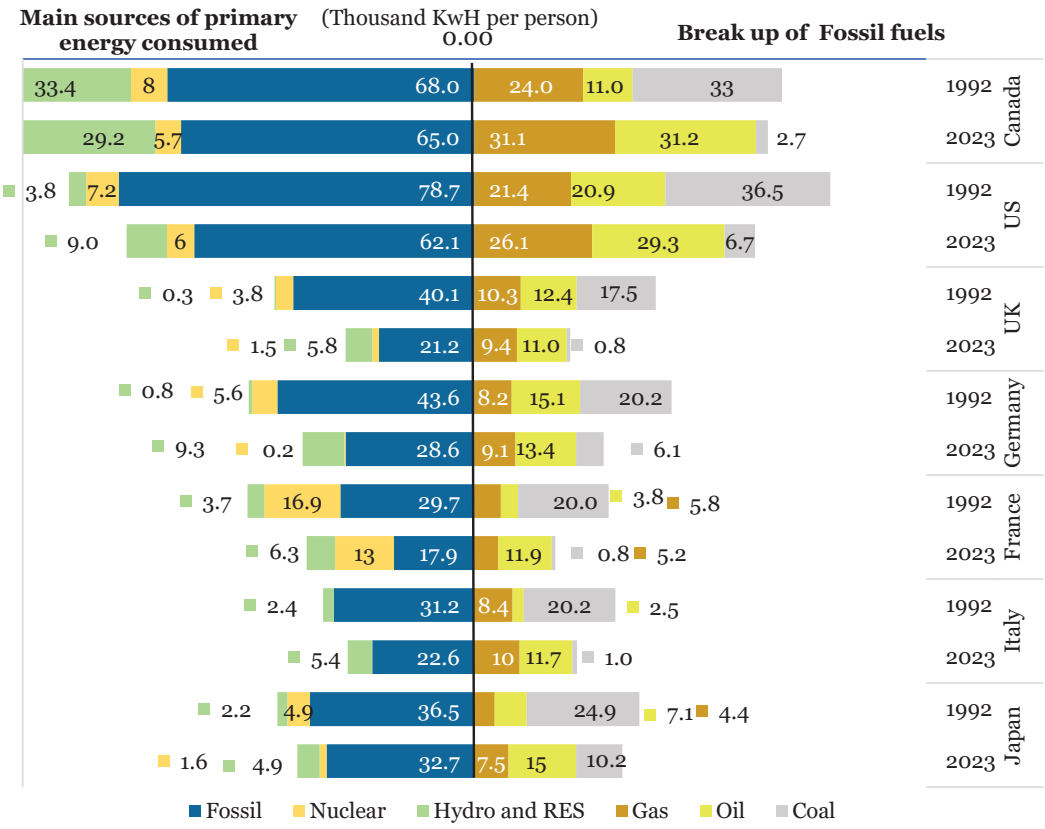
22 Record of Decision under the National Environmental Policy Act (NEPA) for approval of the Willow Master Development Plan Project. (2023). In U.S. Department of The Interior's (DOI). Retrieved December 20, 2024, from https://tinyurl.com/y45fwk2p.

Chart X.2: Contribution of fossil fuels in per capita primary energy consumption in G7 in 1992 and 2023



Source: Internal calculations based on data accessed from 'Our World in Data'.

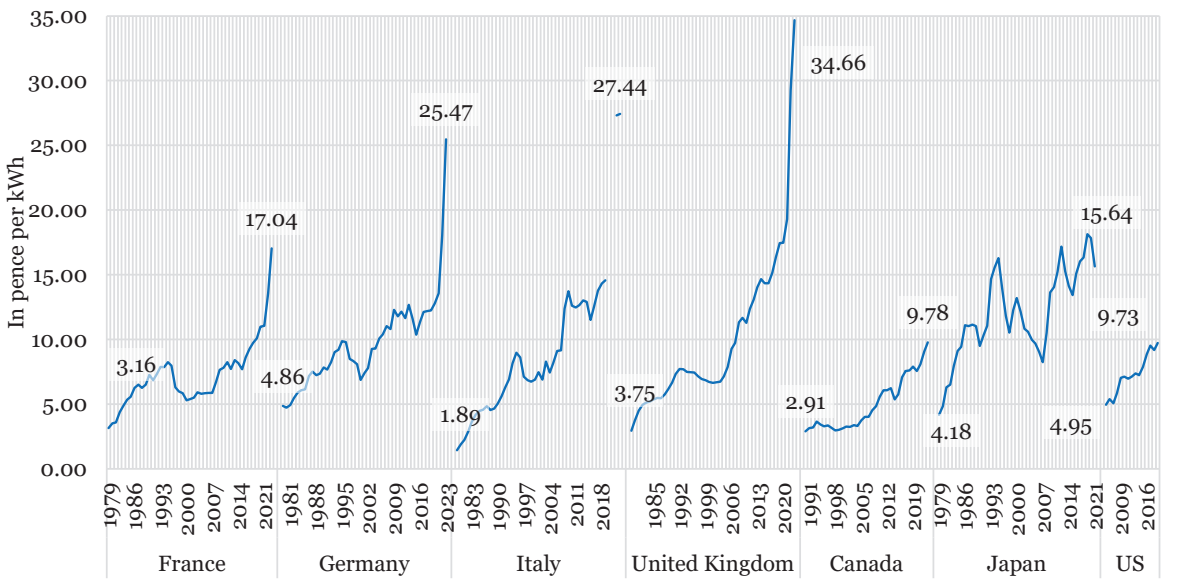
Chart X.3: Per capita energy consumption by sources in G7 in 1992 and 2023



Source: Internal calculations based on data accessed from 'Our World in Data'.

10.25 The friction between energy transition and energy security is clearly evident in the actions of developed countries, revealing the limitations of transitioning to renewable energy sources such as wind and solar. First is the significant 'congestion cost' of managing a complex energy system incorporating fossil fuels and renewables. With the shift to renewable energy, there has also been an increasing trend in electricity prices (Chart 4). The congestion and higher cost have led to instances of wind turbines being curtailed due to grid limitations, necessitating the activation of gas plants to meet peak demand (Will Mathis, 2024)[23], (Oliver, 2024)[24]. The shift from coal to natural gas as the base load has been the policy choice for ensuring grid stability in the UK and other developed countries. Developed countries have utilised their most abundant fuel in their transition. The transition to renewable energy has been tardy, forcing a return to fossil fuels to ensure stable supply and address rising electricity prices.

Chart X.4: Movement in electricity prices for household consumers in the G7 (excluding taxes)



Source: Internal calculation based on data available in 'International domestic energy prices' by the Government of the UK. Retrieved 23 December 2024 from https://tinyurl.com/mr3zs92z.

10.26 India has growing energy needs. The 2030 Agenda for Sustainable Development also includes a dedicated and stand-alone goal on energy, SDG 7, which calls for countries to "ensure access to affordable, reliable, sustainable and modern energy for all". India's Human Development Index currently stands at 0.644.[25] Based on various forms of

23 Will Mathis. (2024, December 2). UK is paying £1 billion to waste a record amount of wind power. Bloomberg. Retrieved December 12, 2024, from https://www.bloomberg.com/news/articles/2024-12-02/uk-is-paying-1-billion-to-waste-a-record-amount-of-wind-power.

24 Oliver, M. (2024, August 7). London and South East warned of net zero blackouts. The Telegraph. Retrieved December 12, 2024, from https://www.telegraph.co.uk/business/2024/08/07/power-chiefs-fear-net-zero-blackouts-in-london/.

25 United Nations Development Programme. Accessed from https://tinyurl.com/2hapfvns.

energy mixes and energy efficiency scenarios, Bhattacharyya et al. 2022[26] estimated that the minimum level of per capita final energy requirement for India to become a developed country with an HDI of 0.9 must be in the range of 45.7 to 75 gigajoules per year. As per the Energy Statistics of India 2024, provisional estimates indicate that the total final consumption of energy per capita for FY23 was 16,699 megajoules or 16.7 gigajoules (~approx.),[27] indicating that the gap between actual and required future energy consumption to fuel growth to achieve Viksit Bharat status is quite huge.

10.27 One of the key pillars of SDG7 is the expansion of renewable energy; however, it is clear that even in the most advanced economies, the technologies for renewable energy and their implementation are not yet at a maturity level that allows them to fully replace fossil fuel-based power plants. Several challenges hinder renewable energy's cost-effective and efficient integration into the energy mix. These include significant investments required for grid integration, the development of battery infrastructure to manage intermittency, scaling up production of the components of renewable energy systems, access to critical minerals that are needed for storage technology, the limited availability of land in densely populated areas and the competing and rapidly increasing energy demands from agriculture, infrastructure, and industry.

10.28 Coal has an important role to play in India's sustainable development.[28] Around 88 per cent of the US's coal-fired capacity was built between 1950 and 1990.[29] On the other hand, the United Kingdom, driven by their industrialisation, started very early and their coal-run power plants dominating the energy supply till the late 1970s when natural gas was identified as a reliable substitute.[30] In India's case, most capacity additions to the coal-fired power plants were made only in the 2010s.[31] There is no valid economic rationale for shutting down coal plants in India, leaving huge investments underutilised and stranded and without a dependable alternative in place. The US and European countries may transition from coal to natural gas because they have access to

26 Bhattacharyya, R., B., Singh, K. K., Grover, R. B., Bhanja, K., Applied Systems Analysis, Homi Bhabha National Institute, & Chemical Engineering Group, Bhabha Atomic Research Centre. (2022). Estimating minimum energy requirement for transitioning to a net-zero, developed India in 2070. In CURRENT SCIENCE (Vol. 122, Issue 5, pp. 517–518). https://tinyurl.com/36mmzfc6.

27 Table 8.4 in the Energy Statistics India 2024 by MOSPI. Retrieved 25 December 2024 from https://tinyurl.com/mrxz4bc7.

28 Srikanth, R., & Bhatt, J. R. (2023). Why India needs Coal to achieve its Sustainable Development Goals. ideas.repec.org. https://ideas.repec.org/p/osf/osfxxx/f6dhe.html.

29 Most coal plants in the United States were built before 1990. (2017, April). U.S. Energy Information Administration. Retrieved 26 December 2024, from https://tinyurl.com/fd8e7ha3.

30 McGarry, T. (2023). UK Electricity capacity and generation by fuel between 1920 and 2020. Department for Energy Security and Net Zero, Government of UK. Retrieved 26 December 2024, from https://tinyurl.com/2cj4v6wk.

31 Srikanth, R., & Nathan, H. S. K. (2017). Towards sustainable development: planning surface coal mine closures in India. Contemporary Social Science, 13(1), 30–43. https://doi.org/10.1080/21582041.2017.1394484 and Chart 7.A in Growth of electricity sector in India from 1947-2024 July, 2024 by Central Electricity Authority, M/o Power, from https://cea.nic.in/wp-content/uploads/pdm/2024/08/Growth_Book_2024.pdf.

that resource, and their older conventional coal-based thermal plants are nearing the end of their life cycle. Unlike many developed countries, India's only reliable energy source is coal,[32] as it possesses around 10 per cent of the world's coal reserves but only 0.7 per cent of the world's natural gas reserves.[33]

10.29 Presently, given the resource endowments, coal cannot be neglected as a reliable and affordable source of energy for India's development. India has, however, taken a leading role in climate action, with the government implementing measures to reduce emissions in the economy. One key strategy has been to promote the efficient use of coal by utilising super-critical (SC), ultra-super-critical (USC) and the recent Advanced Ultra Super Critical (AUSC) technologies in coal-based power plants. Back in 2010, India commissioned its first power unit based on supercritical technology, and by the middle of 2024, a total capacity of 65,290 megawatts (94 Units) and 4,240 megawatts (06 units) in supercritical and ultra-supercritical technology-based power units have been commissioned respectively.[34] Further, more recently, the National Thermal Power Corporation Limited (NTPC) and Bharat Heavy Electricals Limited (BHEL) have developed an Indigenous Advance Ultra Super Critical (AUSC) technology and are setting up an 800-megawatt AUSC technology-based Thermal Power Plant. This AUSC power plant will reduce emissions by about 11 per cent compared to super-critical plants.[35]

10.30 Among the other cleaner sources of energy, nuclear, being an efficient source of energy, has increasingly emerged as a reliable alternative to fossil fuel. However, there are challenges. The expansion of the use of nuclear power has to contend with public concerns about safety and the uncertainty that the latest technologies are controlled by a few countries (Jayanti, 2023).[36] Geographical concentration (Economic Survey, 2022-2023; 2023-2024)[37] of uranium and other essential minerals also poses a challenge. Besides, nuclear energy relies heavily on the stability of fossil fuel supply chains to

32 ICRIER. (2024, May 2). Decommissioning of coal-based plants in India and its ramifications - ICRIER. Retrieved January 6, 2025, from https://tinyurl.com/4xkfwd4k.

33 Tables XI.4: World Proven Gas Reserves (Country-wise) and XI.6: World Natural Gas Production (Country-wise) in Indian Petroleum & Natural Gas Statistics 2022-23 by Ministry of Petroleum and Natural Gas, from https://tinyurl.com/mttnm393.

34 Coal-fired electricity output and emissions. (2024, July). Press Information Bureau. Retrieved 26 December 2024, from https://tinyurl.com/fk5c4mem.

35 Ministry of Heavy Industries, from https://tinyurl.com/bd9munhn.

36 Jayanti, S. (2023, December 4). Nuclear Power Is the Only Solution. TIME. Retrieved 12 December 2024, from https://tinyurl.com/4vtsav9r.

37 The geopolitics of critical minerals and rare earth minerals supply chains were discussed in detail in box VI.4 of Chapter 6, in Economic Survey 2023-24 and Box VII.2 of Chapter 7 in Economic Survey 2022-23. References: Government of India. (2024, July). Economic Survey 2023-24. Retrieved 18 December 2024, from https://tinyurl.com/53f7wfm7; Government of India. (2023, January). Economic Survey 2022-23. Retrieved 18 December 2024, from https://tinyurl.com/scwc88hw.

produce sulfuric acid for uranium extraction (Maslin et al., 2022).[38] By 2040, estimates suggest that a shortfall of sulfuric acid supply could range from 100 million to 320 million tonnes,[39] depending on the extent of efforts to reduce carbon emissions. Furthermore, even in the short run, actions by key players can pose a risk to the growth of the nuclear power sector (Dempsey, 2024).[40] The significance of nuclear energy, given its higher efficiency and low greenhouse gas emissions, requires a forward-looking perspective to address potential challenges in advance, facilitating a smoother transition.

10.31 Further, the challenge of disposing of renewable energy technologies, especially solar panels, reveals how environmental policies can create complex issues. The state of California, a leader in promoting rooftop solar for two decades, did not develop a comprehensive plan for managing the end-of-life of these systems (Kisela, 2022).[41] Disassembling and recycling solar panels is complex and demands highly specialised equipment and skilled workers. Implementing proper waste management strategies for renewable energy systems is imperative, as neglecting to address this issue could lead to significant environmental contamination. Effective disposal methods must be developed to manage by-products and materials associated with renewable energy technologies to mitigate potential negative impacts on ecosystems and public health.

BOX-X.4 New Emission Sources: Are they being accounted for?

The demand for electricity in the United States is projected to increase significantly[42] and in an unprecedented manner.[43] This surge is primarily attributed to the growing requirements associated with the expansion of artificial intelligence operations (Will Wade, 2024).[44]

Globally, electricity consumption by data centres in 2022 was estimated at 460 terawatt hours - around two per cent of final electricity demand and is estimated to reach 1000 terawatt-hours by 2026 (International Energy Agency, 2024).[45] These data centres alone will consume six per cent of the US's total electricity demand in 2026, estimated to be around

38 Maslin, M., Van Heerde, L., & Day, S. (2022). Sulfur: A potential resource crisis that could stifle green technology and threaten food security as the world decarbonises. Geographical Journal, 188(4), 498–505. https://doi.org/10.1111/geoj.12475.

39 ibid.

40 Kazatomprom, the top uranium producer, plans to limit its output for 2025 as per Dempsey, H. (2024, August 23). World's largest uranium producer slashes production target. Financial Times. Retrieved December 12, 2024, from https://tinyurl.com/54evz5a5.

41 Kisela, R. (2022, July 16). California landfills are filling up with toxic solar panels - Los Angeles Times. Los Angeles Times. Retrieved December 12, 2024, from https://tinyurl.com/muuve5p5.

42 North American Electric Reliability Corporation (NERC)'s 2024 Long-Term Reliability Assessment (LTRA). Retrieved December 12, 2024, from https://tinyurl.com/2kkevmvr.

43 AI Is Already Wreaking Havoc on Global Power Systems. (2024, June 21). Bloomberg. Retrieved January 4, 2025, from https://tinyurl.com/3mufa39m.

44 Will Wade. (2024, December 25). US Electricity Demand Forecast to Surge 16% Over Next Five Years. Bloomberg. Retrieved December 12, 2024, from https://tinyurl.com/yexrs3ju.

45 International Energy Agency. (2024). Electricity 2024. Retrieved December 13, 2024, from https://tinyurl.com/4v8mcf5m.

200 terawatt-hours or roughly four per cent of the country's national demand in 2022 (IEA, 2024).[46] Besides, the concerns about 'bad harmonics'[47] of the AI-led surge in power demand from data centres, adversely affecting households, are getting attention as well.

Until recently, the major technology firms have offset their substantial carbon emissions by purchasing 'unbundled'[48] renewable energy certificates (RECs). This practice has allowed them to present a façade of sustainability, as it enables them to claim that the electricity they consume—potentially sourced from fossil fuel facilities like coal plants—originates from renewable sources such as solar farms (Rathi & White, 2024)[49] and pay much less for the purchase of the unbundled REC than the actual cost of abatement of that one unit of GHG emission by them. Instead, the growing power demand from data centres is likely to cause

further expansion in natural gas-based electricity, which will only increase the emissions of developed countries.[50]

The engagement of advanced economies in harmonising their technological goals with the imperatives of the energy transition will become more apparent over time, but it is apparent that increases in emissions are not being factored in.

PROGRESS MADE ON INDIA'S ENERGY TRANSITION

10.32 India's efforts in mitigation have been ambitious. India has successfully established an installed electricity generation capacity of 213,701 megawatts from non-fossil fuel sources, which accounts for 46.8 per cent of the total capacity as of 30 November 2024 (see Chart 5).[51] The goal is to reach 50 per cent by 2030.

46 ibid.

47 Bad Harmonics means the distortions in power supply to households on account of increased power consumption by data centres. This distortion can erode the quality of the power supply, which can damage electrical appliances and increase risk of electrical fires. Based on the research by Nicoletti, L., Malik, N., & Tartar, A. (2024, December 27). AI Needs So Much Power, It's Making Yours Worse. Bloomberg. Retrieved January 4, 2025, from https://tinyurl.com/trehmcpa.

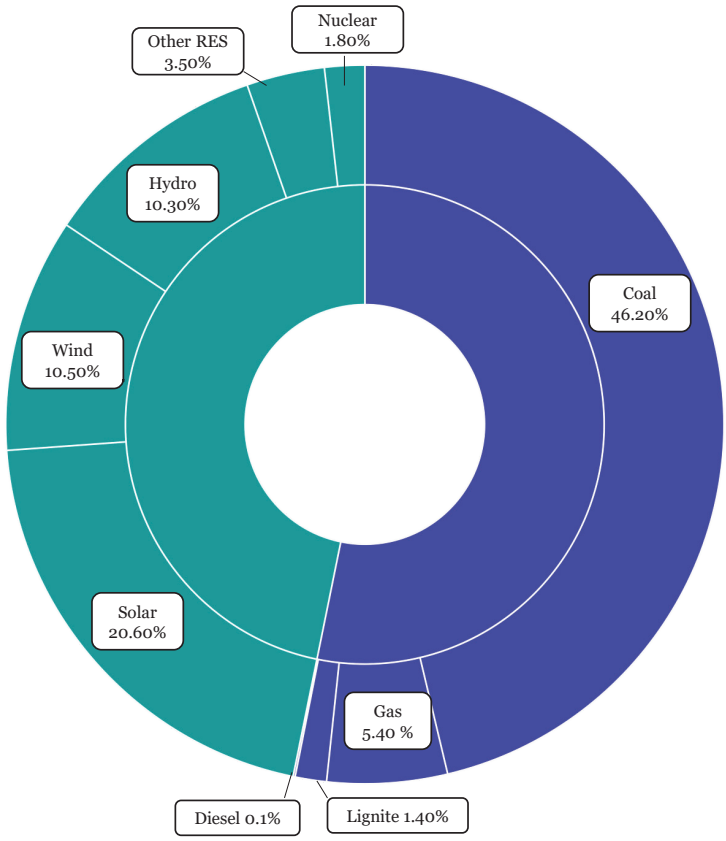
48 Unbundled REC are sold, purchased, or delivered separately from electricity. The REC provides no physical delivery of electricity to customers, and the latter purchases electricity from another producer and the REC from another. Source: Unbundled Renewable Energy Certificates (RECs) | US EPA. (2020, June 11). US EPA. Retrieved January 2, 2025, from https://tinyurl.com/5eujv97a.

49 Rathi, A., & White, N. (2024, August 21). How Tech Companies Are Obscuring AI's Real Carbon Footprint. Bloomberg. Retrieved December 12, 2024, from https://tinyurl.com/3e2sapee.

50 Saul, J., Malik, N. S., & Chediak, M. (2024, September 16). AI Boom Is Driving a Surprise Resurgence of US Gas-Fired Power. Bloomberg. Retrieved on January 4, 2025, from https://tinyurl.com/2ubfaha9.

51 Ministry of Power (November 2024). Power sector at a glance "All India". Retrieved on December 20, 2024 from https://powermin.gov.in/sites/default/files/uploads/power_sector_at_glance_Nov_2024.pdf.

Chart X.5: India's Installed Generation Capacity (fuel-wise) (30 November 2024)

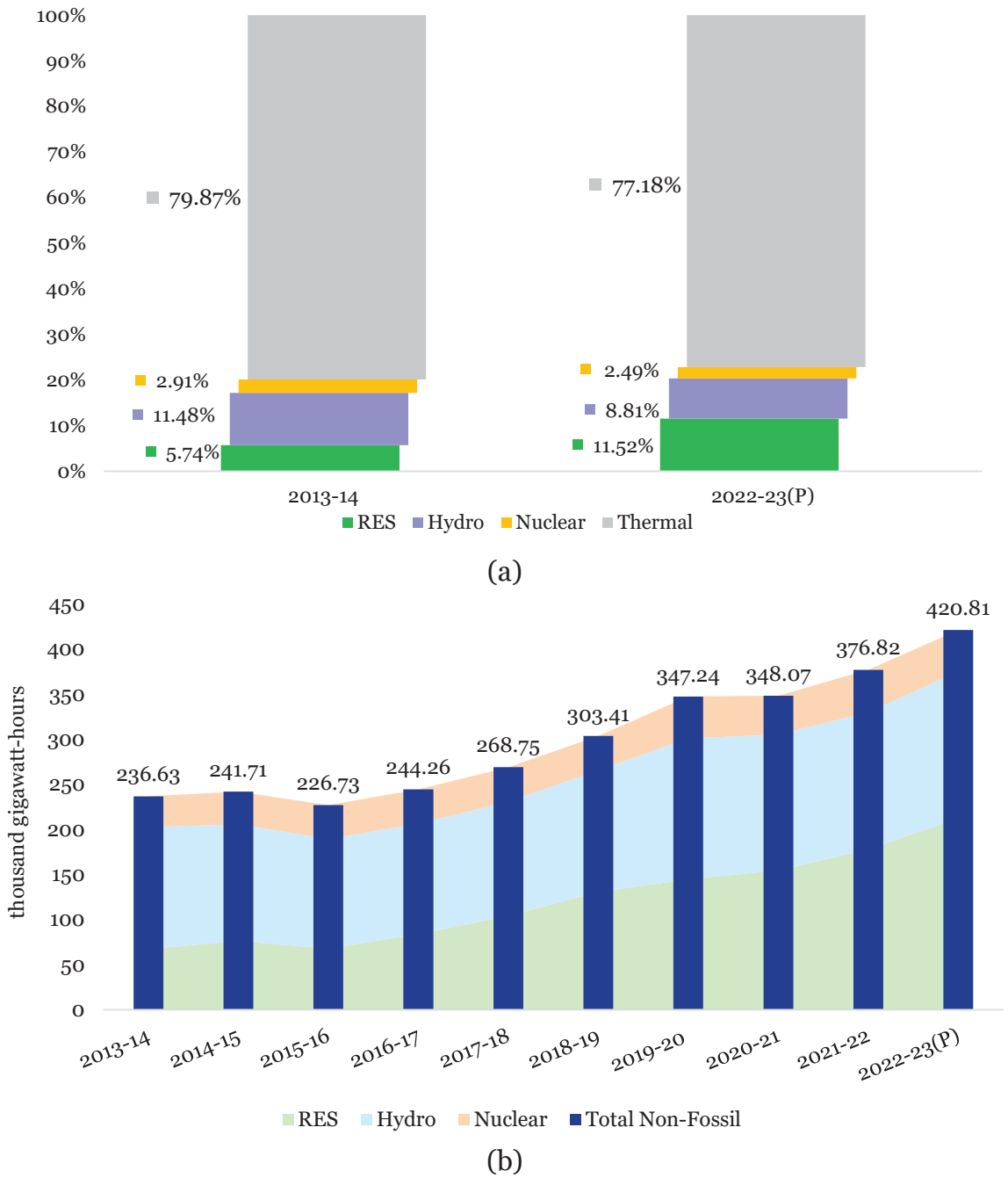


Source: Internal calculation based on data from Ministry of Power https://powermin.gov.in/sites/default/files/uploads/power_sector_at_glance_Nov_2024.pdf.

10.33 There has been notable progress in energy generation from non-fossil fuels, including nuclear, hydro, and renewable sources. This segment reached 420.8 thousand gigawatt hours in the 2022-23 provisional data, making up 22.8 per cent of the total gross energy generation. Within this, large hydro represents 8.81 per cent, nuclear contributes 2.49 per cent, and renewables account for 11.52 per cent (refer to Chart 6(a)).[52]

52 Based on Tables 3.6 (a) and (b) in Energy Statistics of India 2024, M/o Statistics, Planning and Implementation. Accessed from https://www.mospi.gov.in/publication/energy-statistics-india-2024-1.

Chart X.6: Growing energy generation from non-fossil fuels in India (Utilities and Non-Utilities)



Source: Based on Tables 3.6 (a) and (b) in Energy Statistics of India 2024, M/o Statistics, Planning and Implementation. Accessed from https://www.mospi.gov.in/publication/energy-statistics-india-2024-1.

New initiatives and updates on existing policies/schemes to boost energy transition

10.34 The Ministry of New and Renewable Energy (MNRE) initially launched New Solar Power Scheme (for Particularly Vulnerable Tribal Group (PVTG) Habitations/

Villages) under Pradhan Mantri Janjati Adivasi Nyaya Maha Abhiyan (PM JANMAN) on 4 January 2024, which was later revised on 18 October 2024 to also include other tribal habitations/villages and renamed as New Solar Power Scheme (for Tribal and PVTG Habitations/Villages) under PM JANMAN and Dharti Aabha Janjatiya Gram Utkarsh Abhiyan (DA JGUA). The Scheme will cover electrification of one lakh un-electrified households (HHs) in Tribal and PVTG areas of over 63000 villages identified by the Ministry of Tribal Affairs (MoTA) by the provision of off-grid solar systems. The scheme also includes provision for off-grid solar lighting in 1500 Multi-Purpose Centres (MPCs) in PVTG areas and solarisation of 2000 public institutions through off-grid solar systems. The off-grid solar systems shall be provided only where electricity supply through grid is not techno-economically feasible.

10.35 Additionally, the PM - Surya Ghar: Muft Bijli Yojana aims to install rooftop solar plants in one crore households, which is expected to enable approximately 30 gigawatts of residential rooftop solar capacity and contribute to an overall rooftop solar capacity addition of 40-45 gigawatts by 2027. So far, rooftop solar systems for more than 7 lakh households (as on 9 January 2025) have already been installed.

10.36 In offshore wind energy, the Viability Gap Funding (VGF) scheme has been introduced, featuring a total budget of ₹7,453 crore. This includes VGF of ₹6,853 crore allocated for one gigawatt of projects (500 megawatts each off the coasts of Gujarat and Tamil Nadu), and ₹600 crore grant designated for upgrading two ports to enhance logistic infrastructure.

10.37 The projects under the Green Energy Corridor (GEC) aim to establish an intra-state transmission system that enhances grid capabilities for renewable energy. Currently, GEC-I is being implemented across eight states, successfully installing 9,136 circuit kilometres of transmission lines and 21,413 megavolt-amperes (MVA) substations. Meanwhile, GEC-II is progressing across seven additional states.

10.38 The National Bioenergy Programme is structured around three main pillars: the Waste to Energy Programme, the Biomass Programme, which supports the manufacturing of briquettes and pellets as well as promotes biomass (non-bagasse) based cogeneration in industries, and the Biogas Programme, which focuses on promoting family-type biogas plants. As of 31 December 2024, the installed capacity for biomass power and cogeneration projects stood at approximately 9.8 gigawatts (grid-connected) and 0.92-gigawatt equivalent (off-grid), while waste-to-energy projects reached a capacity of 249.74 megawatts (grid-connected) and 370.19-megawatt equivalent (as on 9 January 2025) (off-grid). Under the biogas programme, around 5.1 million small biogas plants and 361 medium-sized biogas plants (totalling 11.5 megawatts) have been installed.

10.39 Furthermore, the Scheme for the Development of Solar Parks and Ultra-mega Solar Power Projects sets a target for establishing 40,000 megawatts of capacity. This scheme focuses on developing essential infrastructure such as land, roads, power evacuation systems, and water facilities, ensuring all necessary statutory clearances and approvals are in place for the expedited development of utility-scale solar projects. As of 31 December 2024, 55 Solar Parks with a cumulative capacity of 39.9 gigawatts have been sanctioned across 13 states. Notably, solar projects with a capacity of 12.2 gigawatts have already been commissioned, while others are at various stages of implementation.

10.40 The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) aims to add 34.8 gigawatts of solar capacity by promoting small grid-connected solar energy power plants, stand-alone solar-powered agricultural pumps, and the solarisation of existing grid-connected agricultural pumps. As of 31 December 2024, a decentralised solar capacity of 397 megawatts has been installed, along with the solarisation of 7.28 lakh agricultural pumps under this scheme.

10.41 To enhance the manufacturing capabilities in the solar sector, the Production Linked Incentive Scheme for the National Programme on High-Efficiency Solar Photo-voltaic Modules has been initiated. The goal is to achieve a gigawatt-scale manufacturing capacity of high-efficiency solar photo-voltaic modules. So far, Letters of Award have been issued to establish manufacturing units with a total capacity of 48,337 megawatts.

10.42 The National Green Hydrogen Mission aims to achieve a production capacity of about five million metric tonnes per annum of Green Hydrogen, along with an associated renewable energy capacity of around 125 gigawatts and the potential for 50 million metric tonnes of CO2 annual emission abatement by 2030. The mission also focuses on bolstering research and development, as well as standards and testing within the green hydrogen ecosystem. Under the mission, the green hydrogen production capacity of 412,000 tonnes per annum and electrolyser manufacturing capacity of 3000 megawatts per annum have been successfully awarded.

10.43 Lastly, the Central Public Sector Undertaking Scheme Phase-II aims to establish grid-connected solar photo-voltaic power projects funded by CPSUs, state PSUs, and government organizations, utilising domestically manufactured solar PV cells and modules with VGF support. Out of approximately 8.2 gigawatts of sanctioned solar photo-voltaic capacity, 1.81 gigawatts have already been commissioned as of 31 December 2024.

Lessons Learned

10.44 Lessons learnt from the experiences of developed economies caution against shutting down thermal energy without adequate technological alternatives that allow a stable energy supply. India is uniquely positioned in terms of its growing energy requirements. India must decisively leverage its best resources, advanced technologies, and expertise to accelerate its journey toward becoming a developed nation by 2047 while ensuring a low-carbon pathway. Following this critical milestone, the nation must pursue its ambitious goal of achieving net zero emissions by 2070. This will demand innovative strategies and strong implementation plans to confront climate challenges while ensuring sustainable development takes centre stage. Innovation and investment in addressing the problems related to renewable energy - battery storage, grid infrastructure and critical minerals - must be the focus in the short to medium term.

Developments in financial regulation on green investments

10.45 Based on the 2019 National Guidelines on Responsible Business Conduct (NGRBC) by the government, SEBI introduced new reporting mandates on ESG parameters - the Business Responsibility and Sustainability Report (BRSR) - for the top 1000 listed companies, mandatory from FY23, replacing the previous Business Responsibility Report (BRR) of 2012. The BRSR norms were further expanded in 2023, with the Board introducing the BRSR core for assurance and ESG disclosures for value chains by the listed entities. The value chain for the purpose of BRSR core reports encompasses the top upstream and downstream partners, cumulatively comprising 75 per cent of the purchases/sales (by value), respectively. From FY26, the top 500 listed entities would be mandated to report under BRSR core, which will be expanded to the top 1000 listed entities from FY27 onwards. The BRSR Core consists of a set of Key Performance Indicators (KPIs)/metrics under nine ESG attributes, including GHG emission footprints, water footprints, energy footprint, embracing circularity, enhancing employee well-being and safety, enabling gender diversity in business, enabling inclusive development, fairness in engaging with customers and suppliers, and open-ness of business.

10.46 SEBI also introduced the regulatory framework for the issuance of green debt securities in 2017, which outlines an illustrative list of activities that can be financed through green debt securities. The framework was revamped in 2023 by introducing the concepts of transition bonds (funds raised for transitioning to a more sustainable form of operations, in line with India's Intended Nationally Determined Contributions), blue bonds (related to water management and marine sector), and yellow bonds (related to solar energy), and circular economy as sub-categories of the green debt securities. The

framework mandates the issuers of green debt securities to disclose details related to the perceived social and environmental risks and proposed mitigation plan associated with the project(s) proposed to be financed/refinanced through the proceeds from the issue of green debt securities, in the offer documents. By March 2024, green debt securities amounting to a total of ₹6,128 crore have been issued by various listed companies.[53]

10.47 In addition to these measures, the Government of India has included Sovereign Green Bonds (SGrBs) in its overall market borrowings with the aim of mobilising resources for green infrastructure. Adhering to the framework for sovereign green bonds that sets forth the obligations of the Government of India as a green bond issuer, the government has issued various lots of SGrBs of varying maturities of 5, 10 and 30 years. On the whole, SGrBs worth ₹16,000 crore were issued in FY23 and ₹20,000 crore in FY24. As for FY25, so far, the Government of India has raised 10-year SGrBs worth ₹11,697.40 crores and plans to raise ₹10,000 crore in remaining period of H2 FY25, i.e., ₹5,000 crore each under 10-year and 30-year securities, respectively.

10.48 In order to foster and strengthen the country's green finance ecosystem, the RBI put in place the framework for accepting Green Deposits for Regulated Entities (REs), with effect from 1 June 2023, to encourage green deposits to augment the flow of credit to green activities/projects address greenwashing concerns. RBI has also classified bank loans of up to ₹30 crore for borrowers seeking funding for renewable energy projects under the priority sector lending category. This includes solar power generators, biomass-based power generators, windmills, micro-hydel plants, and renewable energy public utilities such as street lighting systems and remote village electrification.

BOX-X.5 Growing Carbon sink of forests in India

India's NDC aims to increase the carbon sinks by 2.5 to 3 billion tonnes of CO_2 equivalent through improvement and addition of tree cover by 2030. As per the latest Forest Survey of India 2024, India is estimated to have a total carbon sink of 30.43 billion tonnes of CO_2 equivalent in 2023, as compared to 2005, when the carbon sink was estimated to be 28.14 billion tonnes of CO_2 equivalent. The addition to the carbon sink between 2005 and 2023 is of 2.29 billion tonnes CO_2 equivalent, closer to the NDC target. Based on the trends, the FSI projects a carbon sink of 31.71 billion tonnes in 2030, which would even surpass the NDC target of 2.5 to 3 billion tonnes of CO_2 equivalent.

Source: India State of Forest Report 2023, Volume 1. Ministry of Environment, Forest & Climate Change. Retrieved on December 27, 2024, from https://tinyurl.com/5n7f69zk.

53 SEBI https://www.sebi.gov.in/statistics/greenbonds.html.

OPTIMISING LIFESTYLES FOR SUSTAINABLE DEVELOPMENT

10.49 The policy framework established by Multilateral Environment Agreements provides a foundational structure for advancing environmental sustainability. Effective implementation relies on countries' actions in achieving their national sustainability goals, ultimately determined by individual behaviours. Recognising the need for a movement mobilising collective will towards moderating consumption and production habits, India introduced the Lifestyle for Environment (LiFE) Mission at COP26 in Glasgow in 2021. The LiFE Mission encourages the adoption of lifestyles that are in harmony with nature and are environmentally friendly. This initiative aims to create a collective impact that is "greater than the sum of its parts," significantly shaping the way environmental and climate challenges are addressed. With its endorsement by the United Nations Environment Assembly (UNEA) at its sixth session in 2024, the mission has evolved into a global mass movement committed to promoting sustainable lifestyles among all participating member states while aligning with the principle of equity and common but differentiated responsibilities and respective capabilities, in the Paris Agreement.

10.50 According to estimates, almost 17 per cent of all food available to consumers worldwide is wasted annually, amounting to more than 8 per cent of global greenhouse gas emissions. It is said that *"if food waste were a country, it would be the third-largest emitting country in the world*".[54] This highlights the significant potential for change through initiatives like Mission LiFE, which aims to mobilise at least one billion Indians and other global citizens to take both individual and collective actions to protect and conserve the environment from 2022 to 2028. Again, as brought out in the Economic Survey 2023-24, dietary preferences also impact emissions. Behavioural changes take time, as do lifestyle modifications. Household consumption accounts for around two-thirds of global greenhouse gas (GHG) emissions[55]. As per the UNFCCC, cutting dairy and meat from our diets can reduce our emissions by 66 per cent.[56] *Switching to a plant-based diet can reduce an individual's annual carbon footprint by up to 2.1 tons with a vegan diet or up to 1.5 tons for vegetarians.*[57] Nudging family, friends, and colleagues to a more sustainable dietary preference and moderation in lifestyles globally may be an idea whose time has come.

54 United Nations. (n.d.). Food and Climate Change: Healthy diets for a healthier planet | United Nations. Retrieved January 4, 2025, from https://tinyurl.com/2s4jmjmp.

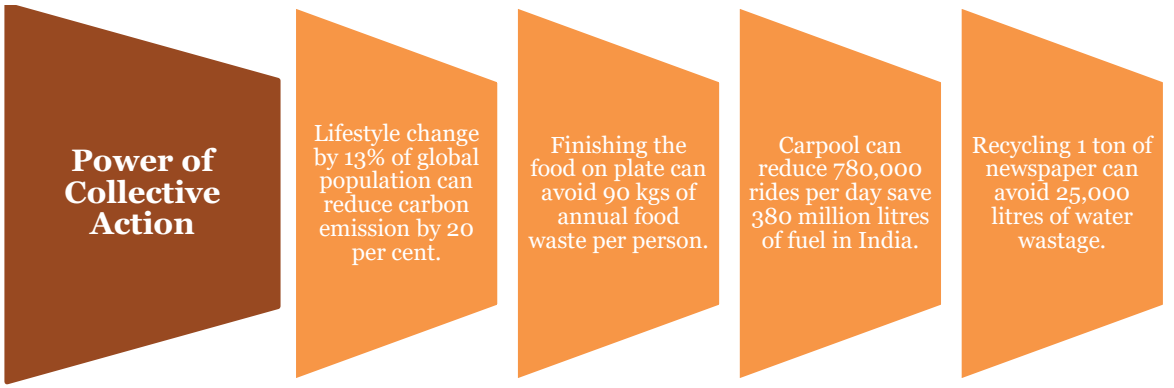
55 UNEP Emissions gap report 2020. United Nations Environment Program (2020). Retrieved December 18, 2024, from https://www.unep.org/emissions-gap-report-2020.

56 https://unfccc.int/news/5-ways-changing-your-diet-can-be-a-climate-action.

57 https://www.un.org/en/actnow/food.

10.51 Within India, the goal is for at least 80 per cent of all villages and urban local bodies to become environmentally friendly by 2028 under this mission. The proactive implementation of LiFE measures can yield substantial co-benefits, including reducing inequalities in energy consumption, mitigating air pollution, achieving cost savings, and enhancing overall well-being and health. By 2030, it is estimated that these measures could save consumers around USD 440 billion globally through reduced consumption and lower prices.[58]

Chart X.7: Harnessing the Power of Collective Action for Environment



Source: Prepared internally based on the NITI Report titled 'Lifestyle for Environment (LiFE): A global mass movement to promote climate-friendly behaviours among individuals'. (https://tinyurl.com/4wzvb4xt)

10.52 There are several effective mechanisms to promote low-carbon lifestyles and advance sustainable development. The Emissions Gap Report 2020 from the United Nations Environment Programme (UNEP) outlines key strategies for fostering meaningful lifestyle changes. Financial incentives, such as tax breaks for electric vehicles and renewable energy use subsidies, can motivate individuals and organizations to adopt greener practices. Additionally, educating the public about the environmental impacts of their choices is essential. Campaigns that highlight the benefits of low-carbon alternatives and provide practical guidance can empower individuals to make sustainable decisions. Harnessing social influence is also important. By leveraging peer pressure and engaging community involvement through social media and local initiatives, we can inspire sustainable behaviours and help establish a culture where low-carbon lifestyles are the norm.

10.53 Furthermore, encouraging citizen participation in sustainability decision-making at local and national levels is crucial for effective policymaking. Platforms for public input can lead to community-driven solutions. Finally, challenging existing habits and creating new norms around sustainability—such as promoting cycling or local food initiatives—can drive significant behavioural change over time. A combination of these

58 IEA (February 2023), "LiFE lessons from India: The benefits of advancing the LiFE initiative through the G20". IEA, Paris. Retrieved December 18, 2024 https://tinyurl.com/mpfde99m.

mechanisms is necessary to foster a transformative shift towards low-carbon lifestyles and a brighter, sustainable future.

10.54 The Indian government has introduced various measures to promote environmental sustainability and influence economic behaviour. Initiatives like the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyaan (PM KUSUM) and PM Surya Ghar: Muft Bijli Yojana encourage solar power adoption. High excise duties on fossil fuels and incentives for electric vehicles push for greener alternatives. The Eco-mark scheme certifies eco-friendly household products, while the star-labelling scheme and 'Go Electric' campaign raise awareness about energy efficiency and electromobility. Market-based incentives, such as the Perform Achieve and Trade (PAT) scheme, enhance energy efficiency, and waste management regulations minimise environmental impact. Expanding city metro networks also promotes a shift from private to public transport for a more sustainable transportation option.

Green Credit Programme

10.55 Several key initiatives have been taken to enhance pro-environment outcomes by implementing measures consistent with LiFE. One notable example is the introduction of the Green Credit Rules, 2023, for implementation of the Green Credit Programme (GCP). These rules are designed to incentivise voluntary efforts toward environmental conservation, resulting in the issuance of green credits. To begin with, voluntary tree plantation is envisaged on degraded land under the control and management of Forest Departments. The Ministry published notification for 'methodology for calculation of green credit in respect of tree plantation' on 22 February 2024. GCP Portal has been developed and is accessible to public and participants. So far, Seventeen state forest departments are participating as implementing agencies with 48,074 hectares of degraded land registered.

Ek Ped Maa Ke Naam

10.56 The tree plantation campaign 'Ek Ped Maa Ke Naam' is another example of nudging individual behaviour to promote pro-environmental activities. Launched in June 2024 on World Environment Day, the campaign attempts to leverage the deep love and respect for mothers towards conserving mother nature. It successfully met its ambitious goal of planting 80 crore seedlings by September 2024. It achieved a remarkable feat by planting over 5 lakh saplings by the 128 Infantry Battalion and Ecological Task Force of the Territorial Army in just one hour on 22 September 2024.

Swachh Bharat Mission

10.57 The Swachh Bharat Mission (SBM) launched in 2014 signifies a fundamental transformation in India's pursuit of universal sanitation access and has revolutionised

the hygiene practices of a substantial portion of the Indian population. SBM 2.0 integrates comprehensive waste management and sanitation practices aligned with sustainability and circular economy principles. The chapter on "Investment and Infrastructure" discusses SBM in detail.

Circular Economy and Resource Efficiency

10.58 The key objective of promoting a circular economy is to minimise waste, recover valuable materials, and reduce reliance on virgin resources. According to an estimate, the circularity of resources could lead to cost savings of 11 per cent of current GDP in 2030 and 30 per cent in 2050.[59] India has followed a multi-pronged approach through regulatory measures, financial incentives, and awareness campaigns in support of the circular economy and the improvement of resource efficiency. Recycling e-waste is important to supplement India's renewable energy drive by extracting useful resources from the wastes of solar and wind energy equipment. Therefore, the government provides incentives to promote circularity, including tax benefits, subsidies, and low-interest loans to the recycling industry.[60] India's extended producer responsibility (EPR) framework is an innovative mechanism for waste management in which manufacturers and producers are made responsible for the waste generated by their products post-consumption. The EPR framework encourages producers to adopt sustainable product design practices, increases the use of recycled materials, and supports waste management and recycling initiatives.

10.59 Plastic pollution is a major driver of biodiversity loss and ecosystem degradation and contributes to climate change. It will account for 15 per cent of global greenhouse gas emissions by 2050.[61] India is one of the lowest per capita plastic consumers and generators of plastic waste in the world, with per capita plastic consumption of only 14 kg compared to that of the developed economies, which is more than 100 kg, much above the global average of 35 kg.[62] India's Plastic Waste Management Rules, 2016 provides the statutory framework for environmentally sound plastic waste management in the country. The rules mandate urban local bodies and gram panchayats to undertake plastic waste management, including plastic waste collection, and impose restrictions on their open incineration. Measures such as the ban on identified single-use plastic

59 Circular economy in India: Rethinking growth for long-term prosperity. (2016, December 5). Retrieved January 4, 2025, from https://tinyurl.com/yyussu2a.

60 EAC-PM Working Paper Series EAC-PM/WP/17/2023. "India's tryst with a circular economy". Economic Advisory Council to the PM. (April, 2023). Retrieved December 18, 2024, from https://tinyurl.com/53ryap2m.

61 UNEP Finance Initiave. "The Finance Statement on Plastic Pollution". United Nations Environment Program. Retrieved December 18, 2024, from https://tinyurl.com/35kmdte9.

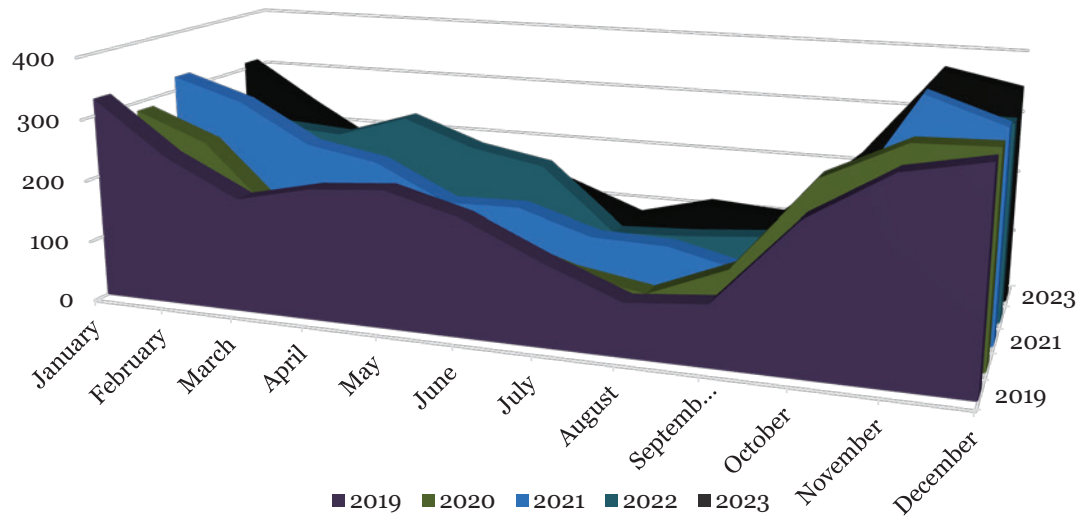
62 Intervention of India, Contact Group I, Evening Session 14112023, Part II (1) Primary plastic polymers. Retrieved December 18, 2024, from https://tinyurl.com/4hvsjm2x.

items, which have high littering potential and low utility, with effect from 1 July 2022, coupled with the implementation of EPR, will further reduce pollution caused by littered and unmanaged plastic waste.

AIR POLLUTION

10.60 The World Health Organisation (WHO) data show that almost all of the global population (99 per cent) breathe air that exceeds WHO guideline limits and contains high levels of pollutants, with low- and middle-income countries suffering from the highest exposures.[63] Air pollution is a concern for the people of the northern part of India, especially Delhi and NCR, during the transition months from autumn to winter when pollutant levels frequently exceed the WHO guidelines (Chart 8). While there are anthropogenic reasons for the increase in particulate matter, such as vehicular traffic due to a distinct modal choice for private vehicles, agricultural practices, and use of coal and wood for cooking, geography and wind direction also play an important part in keeping the particulate matter from being dispersed.

Chart X.8: Month-wise Daily Avg. AQI for Delhi



Source: Based on data of the PIB release of MoEFCC. https://tinyurl.com/ykv94wrw

10.61 The government launched the National Clean Air Programme (NCAP) in 2019 as a national-level strategy to reduce air pollution levels in 130 targeted non-attainment cities/million-plus cities across the country by implementing national, state and city-level action plans. The NCAP emphasises the implementation of City Action Plans (CAPs) through the convergence of resources from various central government schemes such as Swachh Bharat Mission (Urban), AMRUT, Smart City Mission, SATAT, and Nagar Van Yojana, as well as through resources from state governments/UT administration and agencies like municipal corporations and urban development authorities. Actions

63 World Health Organization. Air Pollution. Retrieved December 18, 2024, from https://tinyurl.com/4c6nmyzt.

under the 'Graded Response Action Plan (GRAP)' are also imposed based on AQI. The GRAP calls for a set of emergent preventive/restrictive actions depending on air pollution levels, to be implemented by the identified agencies for combating the adverse air quality scenario. To address the issue of stubble burning, the government launched a scheme for 'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh & NCT of Delhi' in 2018, under which financial assistance is provided for the establishment of custom hiring centres (CHCs) and to farmers for purchase of crop residue management machinery.

CONCLUSION

10.62 India's climate efforts are anchored in its ambitious commitment to achieve net-zero emissions by 2070. This long-term goal is entwined with the country's aspirations for high and stable economic growth, which envisions becoming a developed nation by 2047. Realising this vision necessitates a delicate balance, achieving low-carbon development while ensuring that critical imperatives such as affordable energy security, job creation, sustained economic expansion, and environmental sustainability are met.

10.63 To effectively navigate this dual challenge, India is adopting a holistic approach that embeds mitigation and adaptation in the growth strategy. Mitigation focuses on addressing the root causes of climate change by reducing greenhouse gas emissions, while adaptation seeks to minimize the adverse impacts of climate change through a robust framework for resilience. Given the backdrop of decreasing global financial commitments to support climate action in developing countries, India must increasingly prioritise building resilience to safeguard the benefits of its rapid economic growth against climate-induced setbacks.

10.64 Adaptation and building resilience demand explicit and targeted policy measures, sufficient financing options, and the seamless integration of adaptive strategies into existing policies and developmental programs. It requires a multidimensional approach that encompasses a variety of initiatives, including the creation of appropriate policy incentives, the development of resilient infrastructure, research and development (R&D) in climate-related technologies, and mobilising financial resources dedicated to adaptation initiatives. Additionally, it is essential that adaptation actions are tailored to be region-specific, considering India's vast and diverse geographic and agro-climatic landscape.

10.65 Despite being one of the world's lowest greenhouse gas emitters per capita, India has made notable strides in reducing the emissions intensity of its energy consumption.

This progress is largely due to the increased deployment of renewable energy sources alongside a suite of energy conservation measures. Nonetheless, the growth of renewable energy faces substantial hurdles, particularly in energy storage technologies and the sourcing of critical minerals necessary for this transition. While alternative solutions such as green hydrogen present a viable option for the medium term, affordability issues remain a significant barrier to widespread adoption. Furthermore, although nuclear energy could contribute to India's energy mix, its expansion is impeded by a lack of a supportive ecosystem and the monopolistic nature of nuclear fuel supply chains.

10.66 Lessons learned from the experiences of developed economies underscore the risks of prematurely shutting down thermal energy sources without viable technological alternatives that ensure a stable energy supply. The challenges mentioned above in harnessing renewable energy at scale indicate that India will need to continue the efforts to maximise the efficiency of its existing fossil fuel resources in the medium term. The advancement and deployment of low-emission thermal power technologies, including Advanced Ultra Super Critical (AUSC) power plants, will play a pivotal role in this transition.

10.67 Investments in research and development related to battery storage technologies, as well as the recycling and sustainable disposal of waste associated with renewable energy systems, are critical factors in ensuring a reliable supply of energy from renewable sources and its sustainability. The mission mode approach to developing carbon capture, utilization, and storage technology is essential for the continued use and enhancement of thermal power plants in the medium term. In the agricultural sector, developing climate-resilient seeds and improving agricultural practices, which may include the rejuvenation of water bodies, will be vital components in building resilience against climate impacts.

10.68 The promotion of pro-environment lifestyle changes, as envisaged under India’s LiFE Mission, has significant potential to contribute to climate change mitigation by encouraging low-carbon lifestyles and energy conservation behaviours. To transform the LiFE mission into a widespread public movement, a comprehensive awareness campaign is crucial—this could include integrating the principles of the LiFE mission into school and college curricula to foster an environmental consciousness from a young age. The successful implementation of the LiFE initiative could provide India with compelling evidence of achieving more sustainable outcomes with fewer resources.

10.69 Accomplishing the goal of net zero emissions by 2070 will require innovative strategies and robust implementation plans designed to confront both the challenges

posed by climate change and the need for sustainable development to take centre stage. To strengthen its renewable energy initiatives, India must prioritise investment in extensive grid infrastructure improvements and the secure sourcing of critical minerals necessary for this transformative shift.

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