

18. India 2070: The Road Ahead

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Abstract:

India's meteoric economic rise has propelled it to the forefront of global energy consumption. However, this growth comes at an environmental cost, with coal-fired power plants spewing greenhouse gases and contributing to climate change. Recognizing the urgency of climate action, India pledged net-zero emissions by 2070 at COP26 in Glasgow. This chapter delves into the complexities of India's energy transition, excluding nuclear power expansion. We explore the current energy landscape, dominated by fossil fuels, and analyse potential decarbonisation pathways.

The road ahead is fraught with challenges, including ensuring energy security during the shift, mitigating job displacement in coal-reliant sectors, and achieving technological breakthroughs in energy storage and carbon capture. Financial constraints pose another significant hurdle. However, India has embarked on a multi-pronged approach, focusing on maximizing renewable energy potential, promoting energy efficiency and exploring innovative solutions like green hydrogen. Nature-based solutions and demand-side management also play an important role. Effective policy and regulation, international collaboration in areas like technology transfer and climate finance, and a focus on sharing best practices are essential for success. This transition presents significant opportunities for job creation, economic growth, enhanced energy security, and improved public health.

Keywords:

Clean Energy, Renewable, Just Transition, Green, Net Zero

18.1 The Current Energy Landscape (as of 2024):

India's energy sector remains tethered to fossil fuels, with coal accounting for a staggering 53% of power generation in 2022-23 [1]. This dependence stems from the affordability and vast domestic reserves of coal, estimated at 200 billion tonnes [2]. Despite significant strides in renewables, their contribution to the total installed power capacity stands at around 44%, with solar and wind power leading the charge at 18% and 11%, respectively [3]. This heavy reliance on fossil fuels is a significant contributor to India's carbon footprint, projected to peak around 2040-45 before declining [4].

18.2 Challenges on the Road to Net-Zero:

India's ambitious net-zero target by 2070 presents a herculean task. Here are some key obstacles that need to be surmounted:

- **Energy Security:** Transitioning from a readily available and affordable source like coal to intermittent renewables necessitates significant investments in grid modernization and energy storage solutions. Ensuring a stable and secure energy supply throughout this transformation is paramount. Integrating renewable energy sources effectively into the grid and developing large-scale energy storage solutions like pumped hydro and battery storage will be crucial.
- **Just Transition:** A rapid shift away from coal could trigger job losses and economic hardship in coal mining regions. Managing this transition in a just and equitable manner is crucial. This includes:
 - **Skilling and Reskilling Initiatives:** Developing and implementing skilling and reskilling programs for workers in the coal sector is essential to equip the coal transition workers with the skills needed to thrive in the green economy. This could include training programs in areas like renewable energy installation and maintenance, energy efficiency, and green construction.
 - **Social Safety Nets:** Providing adequate social safety nets, such as unemployment benefits and retraining programs, can help mitigate the economic hardship faced by workers during the transition.
 - **Community Development Initiatives:** Investing in community development initiatives in coal-reliant regions can help diversify local economies and create new job opportunities beyond the coal sector. This involves promoting tourism, developing sustainable agriculture practices, and supporting small businesses.
- **Technological Advancements:** Achieving net-zero necessitates breakthroughs in areas like:
 - **Energy storage for renewables:** Efficient and cost-effective energy storage solutions are vital to address the intermittency of solar and wind power. Technological advancements in areas like battery technology and pumped hydro storage are crucial.
 - **Carbon capture and utilization (CCU) technologies for existing power plants:** Retrofitting existing coal plants with CCU technologies can capture carbon emissions and potentially utilize them for beneficial purposes, such as in enhanced oil recovery. However, the economic viability and scalability of these technologies remain under question.
 - **Cost-effective green hydrogen production:** Green Hydrogen, produced from renewable sources like solar and wind, can decarbonize sectors like transportation and industries where electrification may be challenging. Technological advancements are needed to bring down the production costs of green hydrogen to make it commercially viable.
- **Financial Constraints:** The transition necessitates substantial investments in renewable energy sources, grid upgrades, clean technologies, and social safety nets. Estimates suggest trillions of dollars are required. Mobilizing finances from domestic and international sources, including climate finance mechanisms, is essential. Innovative financing models, such as green bonds and public-private partnerships (PPPs), play an important role in attracting investments.

18.3 Strategies for a Clean Energy Future:

India has embarked on a multi-pronged approach to achieve its net-zero target, focusing on maximizing renewable energy potential and exploring innovative solutions beyond just scaling up renewables. Here is a deeper look at some key strategies:

- **Scaling Up Renewables:** India has set ambitious targets for solar and wind power capacity, aiming for 500 GW of renewable energy by 2030 [5]. This necessitates a multi-faceted approach:
 - **Promoting Rooftop Solar Installations:** Encouraging rooftop solar installations in urban as well as rural areas can significantly increase renewable energy generation and empower communities. Government subsidies, net metering policies, and innovative financing models can incentivize rooftop solar adoption, particularly for residential and commercial buildings.
 - **Developing Large-Scale Solar Parks:** Large-scale solar parks on barren or degraded land can harness India's abundant sunshine and contribute significantly to renewable energy generation. Streamlining land acquisition processes, developing robust transmission infrastructure, and promoting competitive bidding for solar projects are crucial for the success of solar parks.
 - **Harnessing Offshore Wind Potential:** India's vast coastline presents a tremendous opportunity for offshore wind power generation. While still in its nascent stages, offshore wind offers several advantages, including higher capacity factors due to stronger and steadier winds compared to onshore locations. Developing a robust offshore wind ecosystem, including specialized vessels, port infrastructure, and a skilled workforce, is essential to unlock this potential.
- **Energy Efficiency:** Promoting energy-efficiency across sectors is crucial for reducing energy demand and emissions. Here are some key initiatives:
 - **Promoting Energy-Efficient Appliances:** Implementing stricter energy efficiency standards for appliances like air conditioners, refrigerators, and televisions can ensure significant reduction in energy consumption in households. Awareness campaigns can educate consumers about the benefits of energy-efficient products.
 - **Building Codes and Retrofits:** Enacting stricter building codes for new constructions and promoting energy-efficient retrofits for existing buildings can reduce energy consumption in the commercial and residential sectors. These measures can focus on aspects like building insulation, lighting systems, and air conditioning systems.
 - **Energy Efficiency in Industries:** Encouraging industries to adopt energy-efficient technologies and processes can significantly reduce their energy footprint. The Perform, Achieve, and Trade (PAT) scheme in India, which mandates energy efficiency improvements for designated industries, can be further expanded and strengthened.
- **Green Hydrogen Mission:** Investing in green hydrogen production from renewable sources like solar and wind can decarbonize sectors like transportation and industry, where electrification may be challenging. Green hydrogen offers the potential for long-term energy storage and clean fuel for heavy-duty vehicles, industrial processes, and

even power generation. India's Green Hydrogen Mission aims to become a global leader in this area by 2030 [6]. However, significant research and development is needed to bring down the production costs of green hydrogen to make it commercially viable.

- **Decentralized Renewable Energy:** Promoting decentralized renewable energy solutions, such as micro-hydel projects, biogas plants, and small-scale solar installations in remote areas, can provide clean and reliable energy access to remote communities and reduce dependence on traditional biomass fuels for cooking and heating. This approach can empower local communities and accelerate rural development.

18.4 Nature-Based Solutions:

- Afforestation initiatives and forest conservation efforts can act as carbon sinks, removing carbon dioxide from the atmosphere. India's ongoing efforts to increase forest cover and promote tree plantation drives can contribute to this goal. Additionally, exploring possibilities for bioenergy with sustainable practices can be part of the solution, but it's crucial to ensure responsible management to avoid land-use change and deforestation.
- **Demand-Side Management (DSM):** Implementing smart grid technologies and encouraging behavioural changes towards energy conservation can significantly reduce energy demand. This includes promoting energy-efficient appliances, implementing time-of-day pricing to incentivize off-peak energy usage, and raising awareness about responsible energy consumption among citizens.

18.5 The Role of Policy and Regulation:

Government policies and regulations play a pivotal role in driving the energy transition. Here are some key areas for policy intervention:

- **Carbon Pricing:** Implementing a carbon pricing mechanism, like carbon tax or emissions trading scheme, can incentivize adoption of clean energy by making fossil fuels more expensive. The revenue generated can be used to finance clean energy projects and social safety nets.
- **Renewable Energy Mandates:** Setting ambitious renewable purchase obligations (RPOs) for utilities can accelerate the deployment of renewable energy sources. RPOs, make it binding that a certain percentage of electricity must be from renewable sources.
- **Feed-in Tariffs:** Offering guaranteed feed-in tariffs for renewable energy producers can provide financial stability and attract investments in the sector.
- **Streamlining Permitting Processes:** Simplifying and expediting the permitting process for renewable energy projects can reduce development timelines and project costs.
- **Research & Development (R&D):** Supporting research and development in areas like energy storage, clean technologies, and carbon capture can lead to breakthroughs that are crucial for achieving net-zero.

18.6 The Importance of International Collaboration:

India's ambitious goal of achieving net-zero emissions by 2070 necessitates a monumental transformation of its energy sector. While domestic policies and actions are crucial, international collaboration will play an indispensable role in propelling India towards a clean energy future. This collaboration can take various forms, each offering unique advantages that can accelerate India's progress.

18.6.1 Technology Transfer and Innovation:

- **Bridging the Technological Gap:** Developed nations with advanced renewable energy technologies possess a significant advantage. Facilitating technology transfer to India at affordable costs can significantly accelerate its clean energy adoption. This transfer can encompass an array of technologies, including:
 - **Next-generation solar panels:** Technologies like perovskite solar cells, which offer higher efficiency and lower production costs compared to traditional silicon panels, can be transferred to India to enhance its renewable energy potential.
 - **Advanced battery storage solutions:** Efficient and cost-effective energy storage solutions are crucial for managing the intermittency of renewables. Sharing advancements in battery technology, such as lithium-sulphur or sodium-ion batteries, can bolster India's grid stability and enable greater penetration of clean energy sources.
 - **Carbon capture, utilization, and storage (CCUS) technologies:** While the economic viability of CCUS technologies remains under debate, international collaboration can facilitate joint research and development efforts to bring down costs and increase efficiency. This could involve knowledge sharing on geological storage sites and best practices for CCUS implementation.
- **Joint Research and Development (R&D):** Collaboration on R&D initiatives can foster innovation specific to India's unique energy challenges. This could involve:
 - **Developing climate-resilient renewable energy technologies:** India is vulnerable to extreme weather events like cyclones and floods. Collaborative R&D can focus on developing solar panels and wind turbines that can withstand these harsh conditions, ensuring energy security during natural disasters.
 - **Innovation in decentralized renewable energy:** Sharing knowledge and expertise in decentralized renewable energy solutions like micro-grids and mini-hydropower plants can be particularly beneficial for electrifying rural and off-grid communities in India.
 - **Exploring indigenous clean energy sources:** Collaboration can foster research into harnessing untapped renewable energy sources in India, such as geothermal energy or tidal power.

18.6.2 Climate Finance:

The financial resources required for India's energy transition are estimated to be in the trillions of dollars. Developed nations have a historical responsibility for a significant portion of global greenhouse gas emissions and a moral obligation to support developing countries like India in their transition to clean energy. Here are some key mechanisms for international climate finance:

- **Green Climate Fund (GCF):** The GCF, established under the “United Nations Framework Convention on Climate Change (UNFCCC)”, provides financial support to developing countries for climate mitigation and adaptation projects. India can leverage these funds to invest in renewable energy infrastructure, energy efficiency upgrades, and clean technologies.
- **Multilateral Development Banks (MDBs):** MDBs like the World Bank and Asian Development Bank play a crucial role in financing clean energy projects worldwide. Collaboration between these institutions and India can unlock significant resources for clean energy investments.
- **Bilateral Partnerships:** Developed nations can establish bilateral partnerships with India to provide targeted financial support for specific clean energy initiatives. This could involve concessional loans, grants, or risk-sharing mechanisms to attract private sector investments.
- **Debt-for-Climate Swaps:** Developed nations can offer debt relief to India in exchange for commitments towards clean energy projects. This can free up resources for India to invest in its energy transition.

18.6.3 Sharing Best Practices and Policy Frameworks:

Knowledge sharing and learning from successful international experiences can be invaluable for India. Here are some ways collaboration can facilitate this:

- **Policy Benchmarking:** Studying and adapting successful policy frameworks from other countries can accelerate India's clean energy progress. This could include learning from countries that have implemented effective carbon pricing mechanisms, renewable energy mandates, or feed-in tariffs.
- **Knowledge Sharing Platforms:** Establishing international platforms for knowledge exchange on clean energy technologies, policies, and business models can foster cross-country learning and accelerate the global energy transition.
- **Capacity Building:** Developed nations can offer capacity-building programs for Indian policymakers, regulators, and industry players. This could include training programs on clean energy technologies, project development, and regulatory frameworks.

18.6.4 Building a Global Clean Energy Market:

Fostering a robust global clean energy market can benefit all countries, including India. Here's how international collaboration can contribute:

- **Standardization of Technologies:** Collaboration can help establish international standards for clean energy technologies, ensuring compatibility and interoperability between different systems. This can facilitate cross-border trade in clean energy technologies and equipment, benefiting both developed and developing nations. Standardized technologies can also reduce costs by fostering economies of scale in manufacturing.
- **Global Supply Chain Development:** Collaboration can support the development of a resilient and sustainable global supply chain for clean energy materials and components.

This can involve joint ventures for mining critical minerals like cobalt, lithium, etc; ensuring responsible sourcing practices and avoiding disruptions in the supply chain.

- **Facilitating Technology Transfer Through Trade Agreements:** International trade agreements can be structured to incentivize technology transfer of clean energy technologies from developed to developing countries. This can be attained by reducing tariffs on clean energy equipment or offering intellectual property rights concessions for companies willing to share clean technologies.

By fostering a collaborative approach that addresses technology transfer, climate finance, best practice sharing, and global market development, the international community can play a critical role in propelling India towards a clean energy future.

18.7 The Road Ahead: Challenges and Opportunities:

India's journey towards net-zero by 2070 is fraught with challenges but also presents significant opportunities. Here is a closer look at both:

Challenges:

- **Geopolitical Tensions:** The ongoing geopolitical tensions with major coal exporters can disrupt coal supplies and potentially heighten India's dependence on this fossil fuel in the short term. Diversifying energy sources and accelerating the transition to renewables is crucial to mitigate this risk.
- **Grid Integration Challenges:** Integrating large-scale renewable energy sources with variable output into the existing grid presents a significant challenge. Investments in grid modernization and smart grid technologies are essential to address this issue.
- **Social Acceptance:** Public concerns about the potential environmental and social impacts of renewable energy projects, such as those related to large-scale solar farms and wind turbines, need to be addressed through effective communication and stakeholder engagement.

Opportunities:

- **Job Creation:** The renewable energy transition presents an opportunity for job creation in sectors like renewable energy, energy efficiency, and green hydrogen. Skilling and reskilling initiatives can ensure a smooth transition for the workforce impacted by the decline of the coal industry.
- **Economic Growth:** Investing in clean energy technologies can stimulate economic growth and technological innovation. India has the potential to become a global leader in clean energy technologies, creating export opportunities and boosting its manufacturing sector.
- **Energy Security:** Shifting towards a more diversified energy mix with a higher share of renewables can enhance India's energy security by reducing dependence on fossil fuel imports. This would make India less vulnerable to price fluctuations in the global energy market.

- **Improved Public Health:** Transitioning away from coal-fired power plants will significantly improve air quality, leading to a healthier population and reduced healthcare costs.

18.8 Conclusion:

India's ambitious net-zero target by 2070 presents a herculean task, but it is a necessary step towards a sustainable future. Achieving this goal will require a multi-pronged approach that prioritizes renewable energy expansion, energy efficiency improvements, technological advancements, and a just transition for workers in the fossil fuel sector. International collaboration will be a crucial driver of success in this endeavour. Achieving this vision also requires a collective commitment from all stakeholders. Governments need to establish clear and stable policies to incentivize clean energy investments. The private sector has a vital role to play in developing and deploying innovative clean technologies. Civil society organizations can raise awareness about the urgency of climate action and mobilize public support for the transition. Finally, international cooperation must be strengthened to ensure that no nation is left behind in the race towards a sustainable future.

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