GLOBAL DYNAMICS OF ENERGY TRANSITION AND SUSTAINABILITY

EDITOR
Mohammad Ruvi

GLOBAL DYNAMICS OF ENERGY TRANSITION AND SUSTAINABILITY- 2025

ISBN: 978-625-92720-8-5

DOI: 10.5281/zenodo.17670717

Edited By

Mohammad Ruvi

November/ 2025

İstanbul, Türkiye

Date: 21.11.2025

Halic Publishing House
İstanbul, Türkiye
www.halicyayinevi.com

adopted by Esra KOÇAK
ISBN: 978-625-92720-8-5

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PREFACE

This book explores how innovation is reshaping education and enterprise in emerging economies. From financial systems to digital platforms, the chapters highlight the urgent need for adaptive strategies that prepare individuals and institutions for a rapidly evolving world.

The first chapter focuses on financial innovation and its impact on business education, while the second addresses cyber risk management for MSMEs navigating digital threats. The third investigates how social media influences academic success among future caregivers in Nigeria.

Together, these studies offer insights into the challenges and possibilities of modern education and entrepreneurship. They invite readers to rethink traditional models and embrace forward-looking solutions for sustainable growth.

Editoral Team
November 21, 2025
Türkiye

CHAPTER 1
RENEWABLE ENERGY CONSUMPTION AND ECONOMIC DEVELOPMENT IN INDIA

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INTRODUCTION

Many countries have experienced economic growth over the past few centuries because of industrialization. It includes a significant reorganization of the economy for manufacturing. However, industrialization comes at a high cost. It depletes non-renewable energy sources like coal and petroleum, and it produces greenhouse gases such as carbon dioxide, methane, and carbon monoxide. These emissions contribute to lower atmospheric warming and climate change. Global awareness of these issues has sparked a worldwide effort to cut carbon emissions. Initiatives began with the Kyoto Protocol in 1997, aiming to lower fossil fuel-driven emissions.

The treaty required industrialized countries to cut greenhouse gas emissions, especially CO_2. As a result, many developed and emerging nations began moving away from fossil fuels and toward renewable energy. However, if emission reduction promises remain at the current level, the world's temperature will rise to nearly twice the limit set in the Paris Agreement by the end of the century. This makes the transition from non-renewable to renewable energy sources and finding a sustainable solution for energy challenges more urgent. The key question is whether using and producing renewable energy will lead to economic growth. There are some differences in views about whether economic growth will happen with increased renewable energy use. These differing ideas can be grouped into four main hypotheses.

Economic growth may be adversely affected by energy conservation regulations and the growing usage of renewable energy. Conventional energy sources are essential to traditional industrial operations. The growth hypothesis is the name given to this concept. Energy-saving measures may be put into place with little to no negative impact on economic development, according to the conservation hypothesis. According to the growth hypothesis, economic advancement depends on energy utilisation. The two components have a reciprocal relationship according to the feedback theory. Analysing these theories can influence energy policies. In order to increase economic growth, energy conservation policies seek to reduce energy use. Understanding the relationship between the usage of renewable energy and economic growth is essential given the importance of renewable energy.

In 2018, coal continues to provide the majority (45%) of India's overall energy consumption, followed by petroleum and other liquids (26%), and traditional biomass and waste (20%). Other renewable fuel sources provide for a modest fraction of primary energy consumption, even though several of these resources, such as solar, wind, and hydroelectricity, have enormous capacity potential.

Over the last few years, the country has shifted away from traditional biomass and garbage as the availability of electricity connections for the household and commercial sectors has increased. Even though natural gas accounts for only 6% of India's total energy consumption, the nation plans to increase its natural gas market share to 15% by 2030 as part of its strategy to minimise air pollution and adopt cleaner-burning fuels.

As a net importer of crude oil and natural gas, India is exposed to global energy price swings. By investing in indigenous renewable energy sources, India has improved its energy security and reduced its reliance on uncertain international energy markets.

1. TRENDS IN THE USAGE OF RENEWABLE ENERGY IN INDIA

Renewable energy has made a considerable contribution to total installed capacity during the previous nine years, accounting for 43.12% in 2023-24, up from 29.44% in 2014-15. The graph shows that the trend of annual capacity construction in the renewable energy sector has continuously outpaced that of the non-renewable energy sector, drastically decreasing the gap between the two.

This represents a growing shift towards the use of renewable energy sources, with a compound annual growth rate (CAGR) of 9.94% from 2014-’15 to 2023-’24. In comparison, non-renewable energy has increased from 194.68 GW in 2014-15 to 251.4 GW in 2023-24, with a compound annual growth rate (CAGR) of 2.88% throughout this period.

India has a lot of different renewable energy options like solar, wind, hydropower, and biomass. Solar power leads the way in renewable energy capacity, with wind and hydropower coming next. Biomass and small hydropower also help out in the renewable energy mix.

1.1 Solar Power

India is making big strides in solar power and is becoming a key player worldwide. The country has a lot of potential for solar energy due to its sunny climate, with about 300 days of sunlight each year. In the past decade, its solar power capacity has skyrocketed, reaching over 110 GW by May 2025. This has made solar a major part of India's renewable energy efforts, which hit 220 GW in total by March 2025. The goal is to reach 500 GW of non-fossil fuel energy by 2030, with a big chunk expected to come from solar. This is essential for meeting climate goals laid out in the Paris Agreement and working toward carbon neutrality by 2070.

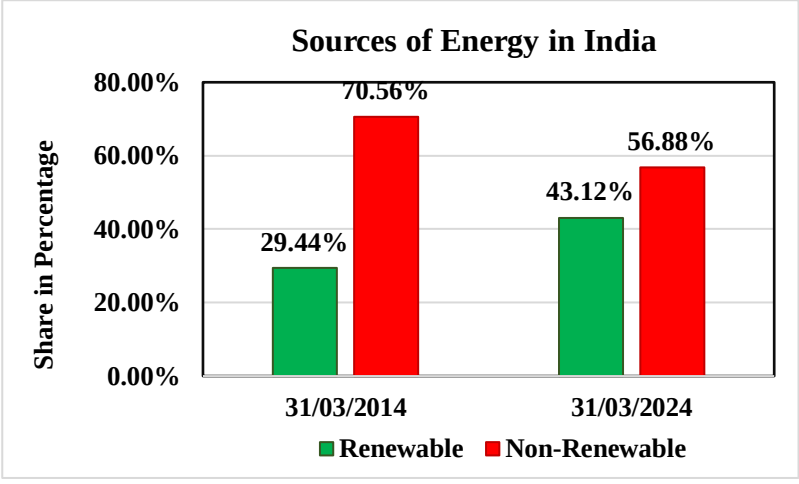

Fig 1. Sources of Energy in India (Source of Data: Ministry of New and Renewable Energy (MNRE) and Central Electricity Authority (CEA)

The growth in solar energy has been boosted by several government initiatives, like the Jawaharlal Nehru National Solar Mission and the Solar Park Scheme. There's also the PM Surya Ghar: Muft Bijli Yojana, which helps households install solar panels and offers subsidies to make residential solar more affordable. The PM-KUSUM Scheme supports farmers by encouraging solar use in agriculture, and the Production Linked Incentive Scheme promotes local production of solar panels. Solar power is helping secure India's energy future, cutting down on fossil fuel use, providing electricity to rural areas, lowering costs for consumers, and creating jobs.

But there are still some challenges to tackle, like securing land for big projects, connecting to the grid, and finding better solutions for energy storage. The installed capacity of renewable energy (RE) increased by an impressive 134.63%, outpacing the installed capacity growth of 60.19% from 2014–'15 to 2023–'24. Furthermore, the installed capacity of renewable energy, which includes solar, wind, biopower, and small hydropower, grew by an even more remarkable 259.55%, underscoring the significant progress made in these fields.

The relationship between energy and economic development is a complex and mutually reinforcing one in India. Energy, particularly electricity, is a critical input for industry, boosting economic growth and raising living standards. Conversely, as the economy grows, it necessitates increased energy consumption to support industrialization and urbanization. This interplay highlights the need for India to ensure both an adequate and reliable energy supply to fuel its development aspirations. The renewable energy consumption in India has also had a positive impact on the country's trade balance. India's energy imports constitute a significant portion of its total imports, leading to a trade deficit in the energy sector. By increasing the share of renewable energy in its energy mix, India has been able to reduce its reliance on energy imports and narrow its trade deficit. The promotion of renewable energy has spurred innovation and technological advancements in India.

The growth of the renewable energy sector has catalysed research and development activities in areas such as energy storage, grid integration, and advanced materials. These technological advancements have not only benefited the renewable energy sector but have also spilled over to other industries, contributing to India's overall technological competitiveness. The deployment of renewable energy has contributed to reducing greenhouse gas emissions in India. As one of the world's largest emitters of greenhouse gases, India has been under pressure to address its carbon footprint.

The adoption of renewable energy sources has allowed India to decouple its economic growth from carbon emissions, demonstrating that sustainable development is possible without compromising environmental objectives. The government of India has implemented various policy measures to support renewable energy consumption and economic development in the country.

Initiatives such as the National Solar Mission, the National Wind Mission, and the Green Energy Corridors project have been instrumental in promoting renewable energy deployment and attracting investments in the sector. These policy measures have provided a supportive regulatory framework and financial incentives for renewable energy projects, fostering a conducive environment for growth and development. The integration of renewable energy into India's energy system has presented challenges such as intermittency and grid instability.

Renewable energy sources such as solar and wind power are intermittent in nature, depending on weather conditions and daylight hours. To address these challenges, India has been investing in energy storage technologies, smart grid infrastructure, and demand-side management measures. By enhancing grid flexibility and resilience, India aims to ensure a smooth transition towards a higher share of renewable energy in its energy mix.

To meet this demand sustainably, the Indian government has set ambitious targets for renewable energy deployment. By 2022, India has 175 GW of renewable energy capacity, including 100 GW of solar and 60 GW of wind power. Between 1990 and 2018, India's primary energy consumption nearly quadrupled, totalling an estimated 916 million tonnes of oil equivalent.

As on 31st March 2024, India’s total installed power capacity reached 441.97 GW, an increase from 275.90 GW of 2014-15, reflecting a growth of 60.19% over the past nine years. Total installed capacity under Renewable Energy sector, including large Hydro was increased from 81.22 GW of 2014-15 to 190.57 GW by 2023-24 with a growth of 134.63% during the period. Installed capacity in Solar, Wind, Bio Power, and Small Hydro Power was 143.64 GW as of March 31, 2024, up from 39.95 GW in 2014-15, representing a phenomenal rise of 259.55%.

During 2023-24, India saw an astounding capacity installation of 18.56 GW in the RE sector, which was much larger than the non-RE sector's 7.35 GW. The annual growth rate for renewable energy installations has regularly above 6%, whereas the growth rate for non-renewable energy has not exceeded 3.01% since 2017-18. By the end of 2023-24, the renewable energy and non-fossil fuel sectors would account for 43.12% and 44.97% of total installed capacity, respectively.

According to the International Renewable Energy Agency (IRENA)'s Renewable Energy Statistics 2024, India has the world's fourth largest installed renewable energy capacity. India is fourth in wind and biopower installations, and fifth in solar and hydroelectric installations.

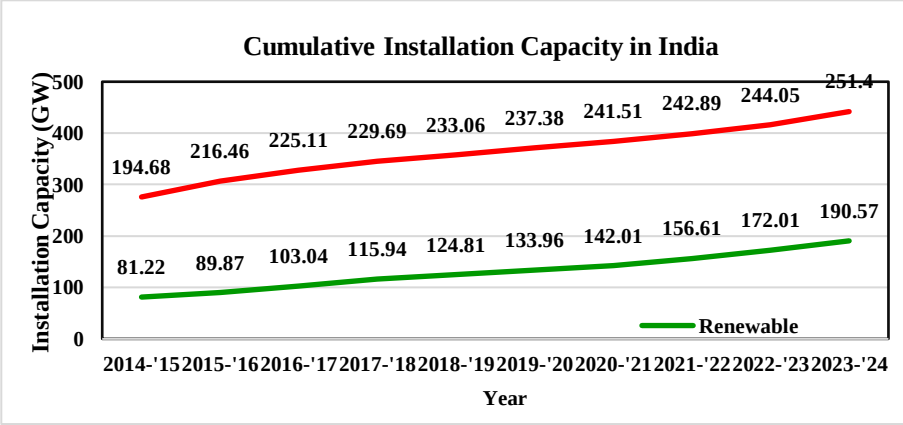

Fig 2. Cumulative Installation Capacity in India (Source of Data: Ministry of New and Renewable Energy (MNRE) and Central Electricity Authority (CEA)

1.2 Wind Power

India is famous for wind power scene due to its long coastline and varied landscape. Right now, it's the fourth largest country in the world when it comes to installed wind power capacity. By May 2025, the total wind capacity was over 51 GW, showing a solid growth of 150% in the past ten years. Wind energy is the second-biggest part of India's renewable energy mix, only behind solar. The country has a big goal of reaching 100 GW of wind energy by 2030, which will include about 30 GW from offshore projects. This plan fits into India's aim to have 500 GW of energy from non-fossil sources by 2030 and to reach net-zero emissions by 2070. The government has rolled out several initiatives to help growth of wind power. The National Offshore Wind Energy Policy from 2015 is focused on developing offshore projects along India's lengthy coastline. There's also the Viability Gap Funding (VGF), which helps in setting up the first offshore projects, including 1 GW planned off Gujarat and Tamil Nadu.

Financial incentives like Generation-Based Incentives (GBI) and Accelerated Depreciation (AD) encourage more private investment in wind power.

Plus, there are rules in place that require electricity companies to get a portion of their supply from renewables, including wind. The Centralized Data Collection and Coordination (CCDC) Wind Initiative is working on better wind resource assessments through improved data collection.

Getting large pieces of land for onshore wind farms can be difficult and time consuming. India's grid needs upgrades to handle more wind energy, which can sometimes lead to power curtailment issues. Since wind energy can be unpredictable, better grid management and energy storage are necessary for a steady power supply. Some local turbines are pricier than those from abroad, and there's still a need to import certain key components. Also, changes in policy can create uncertainty for investors. With ongoing tech improvements, a growing interest in combining wind and solar for consistent power, and the potential for offshore wind, the industry is moving forward. There's also a push to build up local manufacturing to cut down on imports and develop a strong domestic market. With government and private sector involvement, wind energy is set to become a key player in India's clean energy shift.

1.3 Bioenergy

Bioenergy comes from organic materials like leftover crops, animal waste, and trash from cities, and it's a key part of India's renewable energy plan. With India's large agricultural sector and high waste production, there's a lot of room to grow in bioenergy. Each year, India produces around 750 million metric tonnes of biomass, with around 230 million tonnes available for energy use. These holds promise for generating power, biofuels, and biogas. The modern bioenergy makes up about 13% of India's total energy use and is expected to jump by up to 45% from 2023 to 2030, making India the fastest-growing bioenergy market worldwide. By April 2025, India's installed biopower capacity is expected to be around 11.59 GW, coming from various sources like biomass power projects, sugar mill byproducts, and waste-to-energy facilities. India taps into a range of biomass, including sugarcane leftovers, rice straw, corn stalks, cotton waste, and even cattle dung.

The National Bioenergy Programme, overseen by the Ministry of New and Renewable Energy, coordinates different schemes that help develop biogas, biomass energy, and advanced biofuels.

It includes various initiatives like Waste to Energy and Biogas Programs. The National Policy on Biofuels aims to widen the options for biofuel ingredients and set bold blending targets, including blending 20% ethanol in petrol by 2025-26 and 5% biodiesel by 2030. The PM-JI-VAN Yojana offers financial backing for bio-ethanol projects, especially focusing on producing second-generation ethanol from agricultural waste. The SATAT scheme supports the use of Compressed Biogas in transport, aiming for 5% blending by 2028-29. There is a requirement for coal-fired power plants to mix in at least 7% solid biomass by 2026.

The government provides various financial incentives to encourage private investment in bioenergy projects. Bioenergy has many benefits, from cutting down on waste and creating rural jobs to providing a decentralized energy supply. But there are challenges too, like having enough feedstock, managing logistics, and needing improved technology and stable policy support. Overall, bioenergy is a vital part of India's shift to cleaner energy, using its agricultural advantages while tackling waste management issues and bolstering energy security and climate goals.

1.4 Small Hydro Power

Small hydro power (SHP) in India includes hydroelectric plants that can generate up to 25 MW. These projects play an important role in India's renewable energy setup, especially in remote and hilly places where extending the power grid isn't practical. India has about 21,133 MW of SHP potential at around 7,133 sites, mostly in the Himalayan states and other water-rich areas, making it a good option for local power generation. As of March 2024, India’s total installed SHP capacity is about 5,003.25 MW. While this shows progress, a lot of the potential is still not used. Compared to bigger hydro projects, SHP usually has a smaller environmental impact because it often uses run-of-river systems or existing channels, which helps avoid displacement and tree cutting. It's great for bringing electricity to hard-to-reach areas, improving energy access, and helping local growth. SHP can quickly adjust output, which helps balance the power grid alongside solar and wind energy. Some SHP projects can also assist with water supply for farming and drinking. The Ministry of New and Renewable Energy (MNRE) oversees SHP development in India.

There isn't a specific subsidy for individuals starting mini-hydro projects, but the MNRE has updated guidelines to make the process easier and offer financial help to developers through various programs. Getting started can cost a lot, which makes financing tough. Much of the potential is in remote or hilly areas, leading to higher costs for setup and power lines. Different state policies and inconsistent long-term rules can make private investment tricky. Poor hydrological data can complicate feasibility studies, and while it has a smaller impact than larger projects, land acquisition can still be a headache.

The intermittent nature of this energy source and the need for good transmission in remote areas can make integration into the grid challenging. Overall, small hydro power is a key player in India's move towards cleaner energy, offering benefits for local development and grid stability. Ongoing support from policies, new tech, and effective project management will help make the most of its potential. The data in Figure 1 and 2 gives the share of renewable energy consumption (REC) out of the total consumption in India from 2014-'15 to 2023-'24. It shows that the share of renewable energy consumption to total energy consumption has increased in India over the period. India has the potential to create over one million jobs renewable energy projects by 2030.

- Energy as a Driver of Development: Energy, in the form of electricity and other fuels, is essential for powering industries, factories, and agricultural activities, leading to higher output and productivity. Access to reliable and affordable energy enables better quality of life, including improved sanitation, heating, lighting, and access to essential services like healthcare and education. Energy infrastructure, including power grids and transmission lines, is vital for supporting economic activities and ensuring connectivity across regions.
- Economic Growth and Energy Demand: Industrialization and Urbanization: As India's economy grows, there is a corresponding increase in industrial and urban activity, which requires greater energy consumption to support these developments.

  Specific sectors like agriculture and industry have different energy demands. For example, agriculture often requires electricity for irrigation, while industry needs energy for production processes.

- Challenges and Opportunities: As India's energy demand grows, so does the need for sustainable and environmentally friendly energy sources. This includes promoting renewable energy technologies and reducing reliance on fossil fuels. Improving energy efficiency in various sectors, including industry, buildings, and transportation, is crucial to reduce energy consumption and minimize environmental impact. Government policies, investments in infrastructure, and technological advancements are critical for ensuring a reliable and affordable energy supply to meet the needs of a growing economy. The key challenge for India is to balance the need for energy-driven development with the need for environmental sustainability and social equity.

Table 1. Generation of Energy from Renewable Sources in India
(Production in Billion Units)

Year	Wind	Solar	Bio-Power	Small Hydro
2014-'15	33.77	4.6	15.29	8.06
2015-'16	33.03	7.45	16.95	8.35
2016-'17	46	13.5	14.37	7.67
2017-'18	52.7	25.8	15.64	7.7
2018-'19	62.04	39.27	16.75	8.7
2019-'20	64.65	50.13	14.11	9.45
2020-'21	60.15	60.4	16.43	10.26
2021-'22	68.64	73.48	18.32	10.46
2022-'23	71.81	102.01	18.55	11.17
2023-'24	83.39	115.98	17	9.49

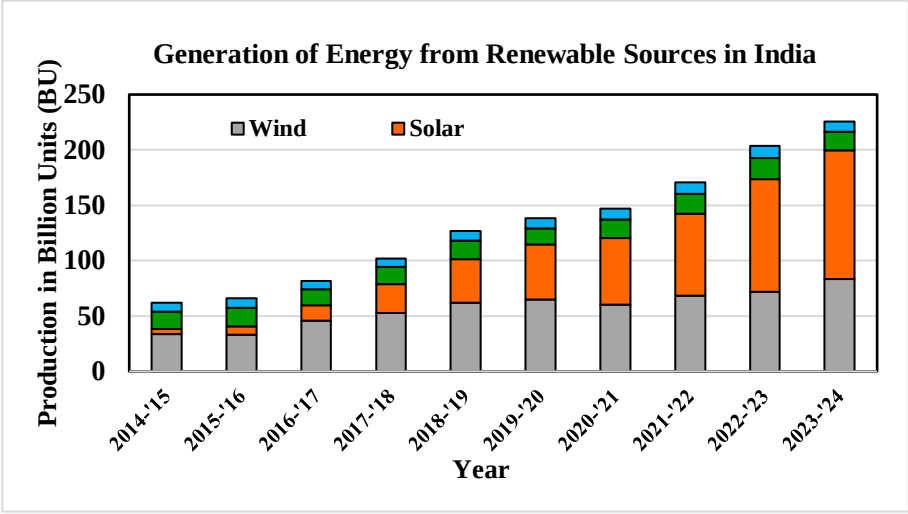

Fig 3. Generation of Energy from Renewable Sources in India (Source of Data: Ministry of New and Renewable Energy (MNRE) and Central Electricity Authority (CEA)

Renewable energy consumption has played an important role in India's economic development. it has achieved tremendous progress in encouraging renewable energy sources to achieve energy security and sustainable growth. As the world's second most populated country and one of the fastest-growing economies, India's energy consumption has been increasing.

Renewable energy technology' lower prices have played a crucial role in their adoption in India. The cost of solar panels and wind turbines has dropped in recent years, making renewable energy more competitive with traditional fossil fuels. This cost competitiveness has resulted in a rapid increase of renewable energy generation in India, drawing investments from both domestic and international sources.

The installed capacity of various renewable energy sources has exhibited differing patterns throughout time. The trend depicts dynamic development patterns across several renewable energy sources, with Solar Power, followed by Wind Power, leading the way in significant capacity increases. Biopower is steadily growing, whereas small hydropower has seen a tiny rise in installed capacity over the years. Solar power capacity installation increased the most dramatically, from 3.99 GW to 81.81 GW, at a CAGR of 39.88% over the previous nine years.

Wind power capacity increased from 23.44 GW to 45.89 GW, with a CAGR of 7.75%. The renewable energy consumption in India has not only environmental benefits but also significant economic advantages. The shift towards renewable energy has created new job opportunities in the renewable energy sector. These jobs span a wide range of sectors, including manufacturing, installation, maintenance, and research and development. The investment in renewable energy infrastructure has also led to improvements in energy access and reliability in rural areas of India.

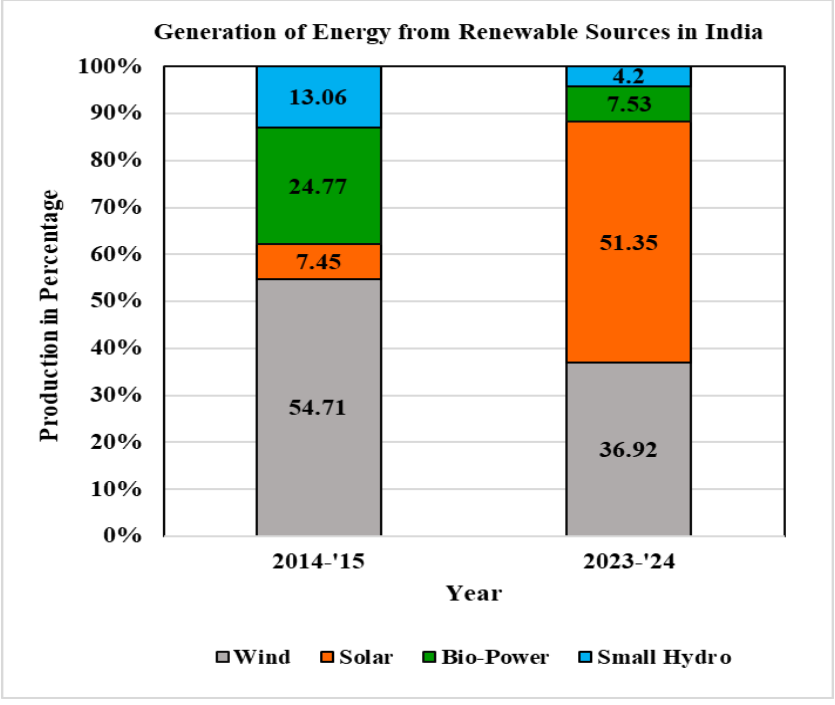

Fig 4. Generation of Energy from Renewable Sources of India
(Source of Data: Ministry of New and Renewable Energy (MNRE) and Central Electricity Authority (CEA)

The decentralized nature of renewable energy sources such as solar and wind power makes them well-suited for off-grid applications. By deploying renewable energy solutions in remote areas, India has been able to provide electricity to millions of people who were previously underserved or lacked access to reliable energy sources.

The use of renewable energy has helped India lessen its reliance on imported fossil fuels. As of March 31, 2024, solar power accounted for 56.95% of the total installed capacity of renewable energy from solar, wind, bio-power, and small hydro power, with 81.81 GW, followed by wind power at 31.95% with 45.89 GW. Biopower accounted for 7.62% of the installed capacity, with 10.95 GW, while small hydropower accounted for 3.48%, with 5 GW.

This increase in capacity installation is a considerable change from 2014-15, when the total installed renewable energy capacity was 40.04 GW. Back then, wind power dominated with a share of 58.54%, with 23.44 GW installed, followed by bio-power installation of 8.55 GW, with a share of 21.35. Small hydropower had a 10.14% share, with 4.06 GW installed, while solar power had the lowest percentage, at 9.97%, with 3.99 GW installed**.**

2. RENEWABLE ENERGY AND ECONOMIC DEVELOPMENT

Renewable energy consumption in India is significantly linked to economic development, with increasing renewable energy production driving job creation, enhancing energy security, and promoting sustainable development. India's ambitious target of 500 GW of renewable energy capacity by 2030, supported by government policies and investments, indicates a strong commitment to transitioning towards a cleaner and more sustainable energy future.

Driving Economic Growth

The renewable energy sector is a major employer, with growth in solar, wind, and other renewable energy sources creating numerous jobs in manufacturing, installation, maintenance, and operation. The increasing demand for renewable energy attracts significant investments, fostering innovation in technologies, processes, and infrastructure.

By expanding domestic renewable energy production, India can reduce its dependence on imported fossil fuels, enhancing energy security and stabilizing the economy.

Enhancing Energy Security

Diversification of Energy Sources: Renewable energy helps diversify India's energy portfolio, reducing reliance on a single energy source (like coal) and making the country less vulnerable to global price fluctuations. Renewable energy sources, particularly solar and wind, can be generated locally, reducing transmission losses and ensuring reliable power supply in remote areas.

Promoting Sustainable Development

Renewable energy sources produce significantly less carbon emissions compared to fossil fuels, contributing to India's efforts to meet its climate goals and combat global warming. Renewable energy technologies, such as solar and wind power, have minimal environmental impact, promoting clean air and water resources. Reduced pollution from fossil fuels leads to improved public health outcomes, particularly in urban areas.

Government Policies and Initiatives

Targeted Renewable Energy Goals: The Indian government has set ambitious targets for renewable energy capacity, encouraging investments and innovation. Financial Incentives and Support: Government policies, including tax breaks, subsidies, and feed-in tariffs, are designed to support the development of renewable energy projects. Collaborations between the government and private sector are key to driving investments and accelerating the deployment of renewable energy technologies. Renewable energy plays a crucial role in India's economic development, contributing to job creation, energy security, and sustainable development. The government's commitment to renewable energy, coupled with increasing investments and technological advancements, is shaping a cleaner and more resilient energy future for India.

CONCLUSION

India's renewable energy sector can be improved by strengthening supply chains, boosting domestic manufacturing, enhancing grid infrastructure, and accelerating project execution. This involves focusing on critical minerals, incentivizing local production, and streamlining regulatory processes.

Strengthening Supply Chains and Manufacturing

Investment in securing domestic and international sources of critical minerals like lithium, nickel, and rare earth elements, which are essential for renewable energy technologies (batteries, solar panels, etc.) can be done. Implementation of policies that encourage local manufacturing of renewable energy components and equipment, potentially through Production Linked Incentive (PLI) schemes, tax breaks, and supportive regulations. Investment in R&D to develop innovative and cost-effective renewable energy technologies, including advanced materials and storage solutions would be helpful to establish robust environmental, social, and governance (ESG) standards and negotiate favourable trade terms to capitalize on global demand for renewable energy products.

Enhancing Grid Infrastructure and Integration

Expansion and modernization of the transmission infrastructure to efficiently transport electricity generated from renewable sources to load centres can support the development and deployment of energy storage solutions (batteries, pumped hydro, etc.) to address the intermittency of renewable energy sources. Implementation of smart grid technologies and digital solutions can optimize energy management, forecasting, and grid stability to encourage the development of microgrids and distributed renewable energy generation to reduce reliance on centralized power plants and transmission lines.

Streamlining Project Execution and Investment

Simplification of the process for obtaining necessary permits and clearances for renewable energy projects can reduce delays.

Development of transparent and efficient mechanisms for land acquisition for renewable energy projects. The issuance of green bonds and other financial instruments can attract investment in renewable energy projects. The issue of delayed PSA signings can be addressed to ensure timely project completion and investor confidence.

Policy and Regulatory Framework

A clear and stable policy framework for renewable energy development, including predictable tariffs and incentives should be provided. Implementation of carbon pricing mechanisms (e.g., carbon tax or cap-and-trade) can be done the adoption of clean energy technologies and reduce reliance on fossil fuels. The regulations related to renewable energy generation, grid connectivity, and power trading can promote a more competitive and efficient market.

Investment should be done in training and capacity building programs to develop a skilled workforce for the renewable energy sector.

Public Awareness and Engagement

Public awareness should be raised about the economic, environmental, and social benefits of renewable energy through targeted campaigns and educational initiatives. Involvement local communities in the planning and development of renewable energy projects will ensure their support and address potential concerns to accelerate the transition to a sustainable energy future, reduce carbon footprint, and create new economic opportunities.

Renewable energy consumption has become a driving force for economic development in India. The country's commitment to sustainable energy is not only helping to mitigate climate change and reduce environmental impact but also creating new opportunities for job creation, technological innovation, and energy security. As India continues its transition towards a cleaner and more sustainable energy future, the benefits of renewable energy consumption are expected to further contribute to the country's economic growth and prosperity.

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CHAPTER 2
GLOBAL RIPPLE EFFECTS: THE INTERNATIONAL IMPACTS OF DECARBONIZATION STRATEGIES

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INTRODUCTION

As climate change accelerates and its impacts become more evident, countries worldwide are embracing decarbonization as a critical step toward sustainability. At its core, decarbonization involves reducing or eliminating greenhouse gas emissions—especially carbon dioxide—by shifting away from fossil fuels and embracing renewable energy sources like wind, solar, and hydro power. While these efforts are crucial for slowing global warming and protecting the environment, their consequences stretch well beyond domestic borders, influencing global trade patterns, geopolitical stability, and socioeconomic development.

The pathways to decarbonization vary widely from one region to another. Wealthier nations, equipped with advanced technologies and stronger economies, tend to move faster in implementing climate policies. Meanwhile, developing countries often face significant barriers, such as limited financial resources, insufficient access to clean technology, and the challenge of prioritizing growth while staying environmentally responsible. These differences contribute to an uneven global playing field, where some nations accelerate progress while others struggle to keep up—shaping both climate outcomes and international competitiveness.

Global trade is also being reshaped by climate policy, particularly through emerging mechanisms like Carbon Border Adjustment Mechanisms (CBAMs). These tools impose taxes on imported goods based on their carbon emissions, aiming to discourage pollution-heavy practices abroad. While intended to promote fairness and curb "carbon leakage," CBAMs can also spark trade disputes and complicate existing supply chains.

At the same time, the energy landscape is undergoing a fundamental shift. As the world reduces its reliance on fossil fuels, nations that once held power through oil and gas exports may see their geopolitical influence decline. In contrast, countries that lead in renewable technology development, critical mineral extraction, and battery production are gaining strategic importance.

Crucially, this transition is not just about technology and economics—it’s also a matter of justice. Ensuring that workers, low-income communities, and developing countries are not left behind is vital for a fair and stable global transformation.

This article examines how national decarbonization efforts are sending ripple effects around the world, highlighting the need for international cooperation and inclusive strategies to build a more sustainable and balanced future for all.

1. SHIFTING TRADE DYNAMICS AND CARBON BORDER ADJUSTMENTS

As countries ramp up efforts to reduce carbon emissions, the global trade landscape is undergoing a significant shift. One of the most influential changes is the adoption of Carbon Border Adjustment Mechanisms (CBAMs). These mechanisms are designed to impose a carbon-related cost on imported goods that are produced in countries with weaker environmental standards. The goal is to protect domestic industries from unfair competition and prevent "carbon leakage"—a situation where companies move high-emission operations to countries with less stringent regulations. CBAMs are reshaping trade by altering the pricing dynamics of goods in the international marketplace. For example, a steel producer in a country with minimal environmental oversight may face steep tariffs when exporting to regions like the European Union, where climate policies are stricter. This additional cost could make their products less competitive. On the other hand, manufacturers in countries that already meet high environmental standards may gain a market edge, pushing industries globally to adopt cleaner, greener practices. However, the introduction of such measures is not without controversy. Many developing nations depend heavily on carbon-intensive exports and may lack the technological or financial means to transition quickly to low-carbon production. From their perspective, carbon tariffs can appear as a new form of trade protectionism—potentially increasing economic inequality under the pretext of climate responsibility. Some critics also argue that these measures could challenge the principles of the World Trade Organization (WTO), as they may act as indirect trade barriers. Despite these concerns, CBAMs have the potential to drive international collaboration on climate action.

By encouraging exporting countries to implement more sustainable production methods and develop domestic carbon pricing systems, such policies could lead to a more uniform global approach to climate regulation.

That said, the success of CBAMs depends heavily on how they are implemented. Ensuring transparency, fairness, and providing technical and financial support to less developed countries will be essential. Revenues generated from these tariffs could be reinvested to help vulnerable nations build cleaner infrastructure and adapt to climate change.

1.1 Energy Transition and Geopolitical Realignments

The global move toward decarbonization is doing more than just changing how we produce and use energy—it's also reshaping international power dynamics. As nations reduce their dependence on fossil fuels and invest in cleaner energy sources, the traditional structures of geopolitical influence are being redefined. Historically, countries rich in oil and natural gas—such as those in the Middle East, Russia, and parts of Africa—have held significant economic and political sway due to their energy exports. But as the world increasingly favors renewable alternatives, these nations face growing challenges. Declining demand for fossil fuels could lead to shrinking export revenues, job losses in energy sectors, and growing budget deficits. In turn, their global influence may diminish as major energy consumers turn to self-sufficiency through domestic renewable generation like wind, solar, and hydropower.

On the other hand, a new group of resource-rich nations is rising in strategic importance. Countries that possess large reserves of critical minerals—such as lithium, cobalt, and rare earth elements—are becoming essential to the clean energy supply chain. These materials are vital for manufacturing batteries, electric vehicles, and other renewable technologies. Nations like Australia, Chile, and the Democratic Republic of Congo now find themselves central to the evolving green economy, attracting foreign investments and forming new trade alliances.

Additionally, nations that have made early investments in renewable energy innovation are emerging as global leaders in the low-carbon transition. Countries such as China, Germany, and Denmark have built strong industries around solar panels, wind turbines, and energy storage solutions. Their technological leadership gives them a strategic advantage in shaping the next phase of global energy markets.

This transformation is also fostering a new kind of energy diplomacy. Countries are forging partnerships to build cross-border electricity grids, green hydrogen production corridors, and collaborative platforms for sharing clean technology. Where energy security once depended on access to oil and gas, it now revolves around technological capability, infrastructure, and resource availability.

However, managing this transition presents challenges. Governments must navigate workforce shifts, address potential supply bottlenecks, and reduce dependency on a few critical material suppliers. To ensure a balanced and inclusive energy future, international cooperation, investment in human capital, and thoughtful policy planning will be crucial.

1.2 Technology Transfer and Innovation Gaps

As the world accelerates toward decarbonization, green technologies have become central to driving sustainable change. Yet, there is a striking imbalance in how these technologies are developed, accessed, and utilized across the globe. While some countries advance rapidly in clean energy innovation, others are struggling to keep pace due to limited resources. This growing innovation divide poses a significant challenge to global climate efforts and risks deepening existing social and economic inequalities.Wealthier nations are often at the forefront of clean technology development. Their robust economies, well-established research institutions, and supportive policy frameworks allow for the rapid growth of solutions such as solar power, wind energy, electric vehicles, and energy-efficient systems. These countries not only have the capacity to innovate but also to scale up and export these technologies to global markets.In contrast, many developing nations face structural and financial barriers that hinder their ability to adopt sustainable technologies. Challenges include insufficient funding, a lack of technical expertise, inadequate infrastructure, and policy environments that may not yet support clean energy integration. As a result, these countries may remain dependent on fossil fuels and older, less efficient systems, despite growing environmental and economic risks. To close this gap, technology transfer becomes essential. It's not just about providing equipment; it's also about sharing know-how, training skilled workers, and building institutional capabilities.

This process involves cooperation between governments, industries, and international organizations. While platforms such as public-private partnerships and multilateral climate funds aim to support this exchange, issues like financing constraints, intellectual property concerns, and regulatory mismatches continue to create obstacles. Still, there are promising signs of progress. Global initiatives like the International Solar Alliance and Mission Innovation have brought together nations and stakeholders to foster collaboration, reduce technology costs, and improve access to sustainable solutions.

These efforts are beginning to shift the tide by enabling developing countries to participate more fully in the green transition. For global decarbonization to succeed, it is vital that technological progress be inclusive. Developed nations not only have the resources but also a shared responsibility to support equitable access to clean technology. By strengthening cooperation and removing barriers, the global community can build a more sustainable and resilient future for all.

1.3 Economic Disparities and Just Transition Challenges

Decarbonization is a crucial step in combating climate change, but its implementation brings a range of challenges—particularly for developing economies and fragile labor markets. As countries shift away from fossil fuels and high-emission industries, the economic impacts are not felt equally. Many low- and middle-income nations, already facing financial and infrastructural limitations, are at risk of being left behind in the global green transition. This raises urgent questions about justice, equity, and inclusion.

In several developing countries, key sectors of the economy—such as coal mining, oil extraction, and heavy industry—are deeply embedded in local livelihoods and national income. These industries often employ thousands of workers and serve as economic lifelines for entire communities. Abruptly moving away from these sectors, without appropriate transition strategies, can result in job losses, economic instability, and widening income gaps, particularly in regions that lack the resources to recover or diversify quickly. These nations also face a double challenge.

Not only are they highly vulnerable to climate change impacts—such as extreme weather, rising sea levels, and food insecurity—but they also have limited fiscal space to invest in green infrastructure or reskill their workforce. Debt, insufficient access to climate finance, and weak institutions further complicate their path toward sustainable development.

A truly *just transition* means that no one is left behind in the move to a low-carbon economy. This involves developing inclusive policies that support affected workers and communities. Initiatives like job retraining programs, direct financial assistance, regional economic diversification, and investments in education and innovation are critical. For instance, regions dependent on coal could be supported in transitioning toward renewable energy production, sustainable agriculture, or ecotourism—given sufficient planning, funding, and time.International support is also key. Wealthier nations, which have historically contributed more to global emissions, have a responsibility to support developing countries through climate finance, technology transfer, and capacity-building programs. Tools like the Green Climate Fund, along with commitments under the Paris Agreement, can help provide the resources and technical guidance necessary for a fair transition. Ultimately, global climate goals cannot be achieved without ensuring that the path to decarbonization is equitable. A transition that deepens inequality or creates new forms of hardship will be both ethically flawed and practically unsustainable. By putting fairness at the center of climate action, the world can build a future that is not only greener but also more inclusive and resilient for all.

1.4 Climate Diplomacy and Multilateral Agreements

As climate change continues to affect every corner of the globe, international cooperation has become a cornerstone of effective environmental action. Since no single country can tackle the crisis alone, climate diplomacy and multilateral agreements are essential for aligning national efforts with shared global objectives. Through coordinated engagement, countries can work together to create climate strategies that are both effective and fair. One of the most significant milestones in global climate governance is the Paris Agreement, adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC).

This agreement marked a turning point in climate diplomacy, bringing nearly every country together with a shared goal: to limit global temperature rise to well below 2°C, and ideally no more than 1.5°C, above pre-industrial levels. The Paris framework allows each country to set its own climate targets—referred to as Nationally Determined Contributions (NDCs)—tailored to their national circumstances and capacities.

While the flexibility of NDCs allows broad participation, it also means that not all commitments are equally ambitious or sufficient. Many submitted targets still fall short of meeting the 1.5°C pathway. As a result, the role of climate diplomacy is evolving—not just to encourage target-setting, but also to push for stronger commitments, monitor progress, and provide support where it's needed most.

Multilateral organizations like the UNFCCC, the Intergovernmental Panel on Climate Change (IPCC), and World Bank are central to this process. They help by offering scientific insight, policy tools, and financial resources to assist countries in meeting their goals. Climate finance is particularly critical, as it enables developing nations to invest in low-carbon technologies, build resilience to climate impacts, and adapt to changing environmental conditions. Wealthier nations are expected to provide funding and technical assistance, in line with their historical responsibility for emissions.

Additionally, newer international coalitions—such as the Climate Vulnerable Forum, the High Ambition Coalition, and the Global Methane Pledge—are helping to bring together countries with common priorities. These partnerships foster peer learning, accelerate policy innovation, and amplify the voices of nations most affected by climate change.

Still, achieving global consensus is not without obstacles. Economic inequality, competing national interests, and geopolitical rivalries can delay progress. That’s why building trust, enhancing transparency, and promoting inclusive dialogue are crucial components of successful climate diplomacy. In the end, a united international effort is the only way to meet the climate challenge. Through effective multilateral agreements and sustained diplomatic engagement, the world.

1.5 Critical Minerals and the New Resource Economy

As countries push forward with cleaner energy solutions, the importance of certain raw materials—particularly lithium, cobalt, nickel, and rare earth elements—is rapidly growing. These minerals are the backbone of key technologies like electric vehicle batteries, solar panels, wind turbines, and other renewable energy systems. As such, they are becoming essential to the success of the global energy transition, significantly influencing economic priorities and geopolitical strategies.

In the past, global power dynamics were largely shaped by access to oil and natural gas. Now, a new era is emerging—one driven by critical minerals. Countries rich in these resources, such as Chile (lithium), the Democratic Republic of Congo (cobalt), Australia (lithium and nickel), and China (rare earth elements), are gaining renewed attention on the world stage. These nations are seeing increased investment from global powers and multinational companies that are eager to secure reliable supplies of materials crucial to green technologies. This shift is prompting major changes in global supply chains. Companies are under growing pressure to ensure that their sourcing practices meet ethical and environmental standards.

Issues like unsafe working conditions in cobalt mines and the ecological impact of rare earth extraction have sparked global concern. As a result, there is a growing movement to enforce responsible mining practices and expand the recycling of critical minerals to reduce reliance on newly extracted resources.

Geopolitically, the race to access and control these minerals is intensifying. Countries are forming new alliances and revising trade strategies to reduce reliance on single suppliers—particularly China, which dominates rare earth processing. The U.S., EU, and other economies are actively working to diversify their mineral sources and build more self-sufficient supply chains.

Looking ahead, innovation in mineral recycling, material substitution, and circular economy models will play a crucial role in ensuring that supply meets demand without causing long-term harm to the planet. These approaches will help manage the limited availability of these materials while reducing environmental pressure. In many ways, critical minerals are becoming the foundation of a new global economy—one that demands careful management, cooperation, and sustainable thinking.

Ensuring fair access and ethical extraction is not just a matter of policy but a necessity for achieving a greener, more balanced future.

1.6 Green Finance and Investment Flows

In the global fight against climate change, the role of finance has become increasingly vital. Green finance—investments that prioritize environmental sustainability—is now seen as a cornerstone in moving toward a low-carbon future. From renewable energy to eco-friendly infrastructure and sustainable agriculture, more financial resources are being channeled into projects that help cut carbon emissions and build climate resilience.

One major area of growth in green finance is the use of green bonds and sustainability-linked investments. These tools are being utilized by governments, private companies, and financial institutions to raise funds for clean energy projects, such as wind and solar farms, or to upgrade buildings with energy-efficient technologies. What makes green bonds attractive is that they not only provide financial returns but also contribute directly to reducing environmental harm, making them increasingly popular among investors seeking both profit and purpose.

Meanwhile, carbon trading systems—both regulatory and voluntary—are expanding globally. These markets work by placing a price on carbon emissions, encouraging businesses to cut their carbon footprint. Companies that emit less than their quota can sell unused credits, creating a financial reward for sustainability. However, for these systems to be truly effective, they must be underpinned by strict rules, transparency, and reliable tracking of emissions reductions. Financial institutions are also becoming more aware of the risk's climate change poses to their portfolios. More investors are now incorporating Environmental, Social, and Governance (ESG) factors when deciding where to allocate capital. This shift is redirecting investment away from carbon-intensive sectors and toward greener industries, such as renewable energy, sustainable transport, and climate-resilient agriculture. On a broader scale, global initiatives like the Green Climate Fund, the EU's Sustainable Finance Disclosure Regulation (SFDR), and the Task Force on Climate-related Financial Disclosures (TCFD) are pushing for greater accountability and transparency in climate-related investments.

These frameworks are especially important for supporting developing nations, which often face challenges in accessing funds for clean energy and climate adaptation. Ultimately, green finance is no longer just an emerging trend—it's a driving force behind economic planning and global decarbonization. By aligning investment strategies with climate goals, the world can move faster and more equitably toward a cleaner, more sustainable future.

CONCLUSION

The worldwide push toward decarbonization is no longer just about addressing environmental concerns—it represents a sweeping shift in economic priorities and global power dynamics. As nations commit to net-zero emissions and adopt cleaner energy solutions, the effects are reverberating across borders, influencing trade systems, financial markets, natural resource distribution, and diplomatic relationships.

Carbon border adjustment measures are transforming trade policies by introducing tariffs on goods from countries with lax climate regulations. This not only encourages cleaner industrial practices globally but also aims to ensure fairness in international markets. Meanwhile, the transition away from fossil fuels is altering geopolitical balances. Countries that have historically depended on oil and gas exports are facing new challenges, while those investing in renewables are gaining influence as future energy leaders.

Yet, the shift is far from equal. Developing countries often struggle with limited access to green technologies and financial resources. Bridging this gap requires stronger international cooperation, including technology sharing and supportive funding. It's also essential to ensure that the green transition is inclusive and fair—supporting workers, communities, and economies that could otherwise be left behind.

At the same time, the rising demand for critical minerals like lithium, cobalt, and rare earth elements is shaping new global supply chains.

Nations rich in these resources are becoming central to energy transitions, prompting fresh alliances and strategic competition. Financial systems are evolving too, with green finance and climate-focused investments directing capital toward sustainable development.

In the end, decarbonization is a shared global task. International collaboration, clear climate policies, and a focus on equity and innovation are essential. Only by working together can we achieve a low-carbon future that is not only environmentally sound but also economically and socially just.

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CHAPTER 3
ENERGY SECURITY AND TRANSITIONS IN DEVELOPING COUNTRIES; THE ROLE OF CLIMATE CHANGE AND POLITICAL POLICIES

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INTRODUCTION

In developing countries, energy security and transition entails finding a compromise between the urgent need for a reliable energy supply and the long-term goals of sustainable development and carbon emission reduction. By diversifying energy sources and reducing reliance on fossil fuels, it is often possible to establish a balance between environmental sustainability, economic growth, and energy demands (Bakhsh et al., 2024). The shift to renewable energy sources is complicated in developing nations due to their particular problems, which include a heavy reliance on fossil fuels, a lack of funding, and inadequate institutional frameworks. To attain safe and sustainable energy futures, there are chances to increase energy production, diversify energy sources, and take advantage of global collaboration (Azubike & Gatiesh, 2024). This change may bring both opportunities and challenges, including better energy availability, less pollution, and financial advantages, in addition to possible disruptions to long-standing industries like coal mining. Nevertheless, the transition to a more sustainable energy future is being spearheaded by developed nations. Global efforts to cut carbon emissions have never been more effective, especially in the wake of landmark events like the 2015 Paris Agreement, COP 28, and many more. (Falcone, 2023).

Energy security and transition are still major concerns in many developing nations where the use of fossil fuels is still common (Abban et al., 2022). The idea of a quick switch to renewable energy sources could seem like an abstract thought given the pressing need to meet basic energy needs. Recent data indicates that in order to fulfill their expanding energy needs, nations like China and India are making significant investments in natural gas infrastructure. By 2040, over 60% of the world's gas consumption will come from Asia. The ultimate goal, though, is to transition to more environmentally friendly energy sources (Lv, 2023). Developing countries must now incorporate sustainability into their energy strategy, even as they continue to rely on traditional energy sources. This can entail making investments in greener technologies, increasing energy efficiency, and looking into more ecologically friendly energy sources (Mavlutova et al., 2025). Collaboration between industrialized and developing nations is crucial to this transition.

We can accelerate everyone's transition to a more sustainable energy future by combining our resources, technology, and knowledge. It is more crucial to strike a balance that ensures both are achieved than to choose between transition and energy security (Zeng et al., 2024). The shift to a low-carbon future may be challenging, but it is not impossible, for developing countries. If we approach the energy transition with innovation, dedication, and collaboration, we can build a more prosperous and sustainable future for coming generations.

1. THE CONCEPT OF ENERGY SECURITY IN DEVELOPING COUNTRIES

Energy is the driving force behind the socioeconomic progress of every country. The only thing that can guarantee energy security in developing countries is constant energy supply. Energy security is the availability of reliable and reasonably priced energy resources that are vital to a nation's economy and well-being (Yusuf, 2023). It consists of several components, including a steady supply of energy, the cost-effectiveness of energy resources, and supply chain stability.

It also implies that modern energy services are available to the weakest in society and to the fastest-growing industrial, service, and urban sectors. This can increase the dependability and cost of the energy supply while guaranteeing that all inhabitants have access to clean cooking energy at all times (Olujobi et al., 2023). It also ensures that everyone has access to a reliable and affordable energy supply while taking social justice and the environment into consideration.

Human well-being, social development, and economic advancement all depend on it, especially in regions that are quickly growing more populated and urbanized. The concept of "energy security" has been used by several countries to justify state control over their energy industries. The fundamental goal of this strategic approach is to reduce dependency on foreign energy sources and ensure a steady supply of energy. It has been mostly adopted by countries where energy security is linked to their position as sovereign governments (Falcone, 2023). Due to a lack of adequate resources, trade-offs have been made between access and the ecological and social impacts of specific energy sources.

The rapidly growing demand for energy has caused problems for many governments around the world, especially emerging countries. Energy stability has been impacted by a number of factors, including expanding populations, fast urbanization, growing expectations for better living conditions for the general public, and an increase in industrial and economic activity (Pan et al., 2024).

Ensuring energy security and independence is essential for social advancement and economic expansion in developing countries. The energy supply and demand models need to be reformed and rethought in order for growing countries to have more secure energy futures. Building reliable, consistent, cost-effective, and environmentally conscious energy service delivery with a focus on energy efficiency and conservation is the only way to lessen the various multi-level aspects of energy security (Abdallah and Odeleke, 2023).

Policies that try to improve this usually focus on finding reliable and reasonably priced clean energy sources for electricity generation and transportation. These days, energy security is a multidisciplinary issue that extends beyond the conventional notions of supply and demand. Sustainability, energy poverty, climate change, and energy efficiency are some of its components, and it is connected to the social, political, and national/human security domains. Determining the factors that govern this intricate relationship is essential to fully understanding it and developing realistic energy security goals for developing countries (Azubike & Gatiesh, 2024).

1.1 Challenges of Energy Security in Developing Countries

- **Lack of Access to Energy Services**: Millions of people in poor countries struggle to get affordable, reliable power, which limits their ability to live, work, and access essential services.
- **Dependency on Fossil Fuels:** Many emerging nations are vulnerable to price fluctuations and supply disruptions because of their significant reliance on fossil fuels.
- **Infrastructure Limitations:** Inadequate power grids and transportation networks are examples of infrastructure that may limit energy distribution and access.

- **Corruption and Governance Issues:** Corruption and bad governance can hinder energy investments, project execution, and efficient resource management.
- **Economic and Social Challenges:** High energy costs, frequent outages, and environmental degradation can all have a negative impact on public health, social stability, and economic activity.
- **Climate Change and Environmental Impacts:** The transition to sustainable energy requires addressing climate change and minimizing the damaging environmental effects of fossil fuels.
- **Funding and Financing:** Obtaining the funds required for renewable energy projects and energy infrastructure projects can be difficult, especially in nations with weak banking institutions.
- **Technological and Skill Gaps:** Developing and implementing effective and clean energy solutions might be hampered by lack of technical know-how and access to cutting-edge technologies.
- **Social and Political Instability:** Energy investments and supply chains can be hampered by social unrest, political instability, and security threats.
- **Regulatory and Policy Barriers:** Lack of incentives, ambiguous rules, and inconsistent policies can all act as roadblocks to investment in the energy industry.

2. THE CONCEPT OF ENERGY TRANSITION IN DEVELOPING COUNTRIES

In developing nations, the energy transition is essential to reaching sustainable development goals and calls for a multipronged strategy that includes technology transfer, capacity building, and financial assistance. The demand for clean energy and economic development must be balanced in developing nations in order to lower greenhouse gas emissions and provide universal access to electricity (Zhang et al., 2024). It is crucial from a social and economic standpoint to guarantee that everyone has access to inexpensive and clean energy, especially in rural areas.

The term "energy transition" describes a significant change in the production and consumption of energy, usually with the goal of shifting away from fossil fuels and toward renewable energy sources (Yang et al., 2024).

Furthermore, energy transition describes the energy change in emerging nations from fossil fuel-based energy production and consumption systems, such as coal, oil, and natural gas, to renewable energy sources, such as solar and wind power and lithium-ion batteries. The desire to combat climate change and lower carbon emissions frequently motivates this shift. For instance, Nigeria's Energy Transition Plan seeks to increase investment in renewable energy and cut emissions in important industries by 2060 (Nwokolo et al., 2023). In addition to initiatives to boost energy availability and efficiency and support sustainable development, developing nations have stepped up their efforts to transition from fossil fuels to renewable energy sources. Additionally, this shift is essential for reducing climate change, enhancing energy security, and stimulating economic expansion. Significant financial backing, technical transfer, and enabling legislation are necessary.

Premises of energy independence, affordability, dependability, and efficiency are all part of the energy shift. Nevertheless, this shift has particular difficulties, such as limited funding, a shortage of skilled technical personnel, and the requirement for steady economic expansion while juggling demands for energy security (Awwad et al., 2025). Since poor nations frequently lack the infrastructure and resources necessary to effectively undertake this transformation, international cooperation and policy support are essential for its facilitation. In emerging nations, energy transitions are desired in order to support social inclusion, economic growth, and environmental sustainability. Furthermore, energy transitions can be accomplished through democratic restructuring, redefining and reclaiming citizen participation in energy planning and policy-making, and adopting and implementing commercially available technologies that increase the efficiency, affordability, and dependability of energy systems (Pan et al., 2024).

2.1 Sustainable Energy Transition

The goal of the energy transition is to switch from fossil fuels to a system that uses renewable energy sources, such as geothermal, hydropower, wind, and solar power. This shift is crucial to tackling the climate crisis since fossil fuels still provide 80% of the world's energy and emit enormous volumes of gases like carbon dioxide and methane that warm the planet.

Restructuring the global energy system is the goal of the sustainable energy transition, which seeks to combat climate change and advance sustainable development (UNDP, 2025). It comprises shifting to greener energy sources, increasing energy efficiency, putting advanced technologies like energy storage into practice, and decarbonizing key sectors like power, transportation, and industry. Nevertheless, this shift is a transformative process that prioritizes human growth, equity, and inclusivity over technology.

The sustainable energy transition is based on the concept of a just transition to ensure equity and inclusion for all, particularly for communities that are more vulnerable to rising living costs and energy insecurity and for those in fossil fuel-intensive industries who stand to lose their jobs and income. Therefore, switching to sustainable energy not only helps the environment but also reduces energy poverty, creates jobs, and encourages innovation (Aliakbari et al., 2025). It provides a rare chance to address widespread global issues like inequality, energy security, disparities in energy access, and health effects through comprehensive and creative solutions, laying the groundwork for a resilient, inclusive, and sustainable future.

A swift switch to low-carbon energy systems is necessary due to the present economic and climate challenges. As per the Intergovernmental Panel on Climate Change (IPCC), between 70 and 85 percent of the world's electricity must come from renewable sources by 2050. To keep global warming to 1,5°C, yearly expenditures in energy efficiency and these technologies are required. The shift is currently happening more slowly than it ought to. According to an IPCC Special Report, current mitigation and decarbonization efforts would cause global warming of at least 3°C by 2100. The widespread adoption of renewable energy sources has been impeded by institutional, societal, and economic barriers (UN, 2021).

The significance of sustainable energy development in developing nations and their expansion in the current energy markets are both weakened by the absence of support for the energy industry. Policymakers must now create plans for economic recovery in order to construct the energy and economic infrastructure for a sustainable future. Transitions to sustainable energy offer a special chance to achieve long-term climatic and economic objectives.

Because they possess the majority of the remaining renewable energy potential and because the demand for power in these regions is predicted to triple in the near future, developing nations are anticipated to play a significant role in the energy transition (Johnson et al., 2020).

Significant changes may be implemented more quickly and easily in these economies due to their size and energy infrastructure than in their more developed counterparts. Because of the link between decarbonization and sustainable development goals, developing nations have started incorporating renewable energy technologies into their development strategies. Based on gross domestic product, these countries have recently made greater investments in specific technology than industrialized ones (Awwad et al., 2025).

However, future investments in renewable energy projects may be severely hampered by the financial and economic challenges that poor countries are currently confronting. A smooth transition to sustainable renewable energy systems within the framework of sustainable development requires careful project and investment selection and prioritization. However, as compared to wealthy nations, emerging nations confront distinct possibilities and difficulties that require customized answers. Effectively switching to clean energy might boost the economy, increase energy access, and lessen its negative effects on the environment. Developing nations require talent development, technological transfer, significant financial support, and supportive legal and regulatory frameworks in order to make the transition to sustainable energy. Developing nations can more easily access knowledge, technology, and financial resources through international collaboration. To get over obstacles including high upfront costs, weak institutional capacities, and limited finance, this shift need for substantial investment, legal changes, and international collaboration (Tay et al., 2022).

2.2 Challenges of Energy Transition in Developing Countries

Transitioning to a low-carbon energy system presents a special set of difficulties for developing nations.

- **Financial Constraints and Investment:** Due to their often-limited financial means, developing countries may find it challenging to invest in expensive renewable energy infrastructure.

To assist their energy transitions, developing countries may rely too much on international investments and help, but obtaining these money can frequently be challenging, competitive, and subject to stringent criteria.

- **Infrastructure Gaps:** In poor countries, especially in rural areas, the infrastructure needed to reliably transfer and distribute electricity from renewable sources is occasionally lacking. Storage solutions are required due to the intermittent nature of renewable energy sources like solar and wind, but they are currently expensive and not always available.
- **Technological and Human Capacity:** Developing nations could find it difficult to create and deploy the required technology, as well as to hire and retain skilled personnel. In certain situations, the innovation and adoption of renewable energy technology may be impeded by a lack of research and development resources.
- **Policy and Regulatory Challenges:** Developing countries usually rely heavily on fossil fuels due to economic dependence and entrenched interests, which makes the transition to low-carbon sources difficult. Uncertain and unhelpful regulatory frameworks may discourage private investment in renewable energy projects.
- **Social and Political Consideration:** People who profit from crude energy activities, like fossil fuels, etc., cause public disruptions, criticism, and uprisings during the energy transition in emerging nations. It might be challenging to attract investors and carry out long-term energy plans in unstable political contexts.
- **Interconnectedness and National Shocks:** Events that can destabilize energy supply chains and raise energy costs, such as wars, interregional and tribal conflicts, wanton killings, pipeline vandalism, and social and environmental dislocation, can impede the pace of energy transitions in emerging nations.

Although national interests and priorities might occasionally conflict and impede energy transitions, effective energy transitions necessitate international cooperation.

3. THE ROLE OF CLIMATE CHANGE POLICIES IN ENERGY SECURITY IN DEVELOPING COUNTRIES

Two of the biggest issues facing rising countries today are climate change and energy security, which policymakers have prioritized. Among the effects of climate change on humans include extreme weather, increasing sea levels, and environmental devastation. Both population growth and economic expansion increase the demand for reliable energy. Laws, regulations, and investment in the energy sector are increasingly being influenced by climate change and energy security.

Climate change and energy security are intertwined, particularly in developing countries (Kala, 2023). Rising temperatures, changed precipitation patterns, and extreme weather events are some of the effects of climate change that can affect how energy is produced, distributed, and consumed. This directly threatens energy security since it gets harder to obtain, depend on, and afford energy resources. In contrast, the use of fossil fuels contributes to climate change, which in turn makes people more vulnerable.

Energy security is significantly impacted by climate change since it changes the resilience of infrastructure, fuel supply, and output. Temperature variations, altered precipitation patterns, and severe weather can all affect the production of hydropower, biomass resources, and the structural stability of energy infrastructure (Garschagen & Doshi, 2022). Transmission lines, power plants, and pipelines are examples of energy infrastructure that is physically vulnerable to climate-related hazards like floods, drought, and sea level rise.

The production of energy, especially thermal, nuclear, and hydroelectric power, depends on the availability of water. Climate change may exacerbate the water deficit, making it more difficult to provide electricity to the world's growing population. While renewable energy sources like solar and wind offer solutions, climate change may potentially affect their accessibility. For example, changes in wind patterns or cloud cover may impact solar and wind energy production.

Climate change presents significant challenges to energy security in developing countries due to the increased dependence on fossil fuels and vulnerability to extreme weather events (Iyke, 2024). These effects can affect human development and economic growth by resulting in lower energy supplies, higher prices, and disruptions to energy infrastructure.

A move toward renewable energy sources, increased energy efficiency, and robust infrastructure are necessary to meet these issues. As a result of climate change, developing nations—particularly those located in areas vulnerable to heat waves, floods, and droughts—are increasingly facing infrastructure damage and energy disruptions. Heat waves, for instance, can put a burden on power systems, and droughts can lower the amount of hydropower produced (Abbass et al., 2022).

Climate change presents significant challenges to energy security in developing countries, but it also presents opportunities for progress through the deployment of climate-resilient infrastructure and renewable energy sources. Sea level rise and extreme weather events are two examples of climate impacts that might interfere with infrastructure and the energy supply, but they also make the case for diversifying energy sources and investing in sustainable technology. Climate change policies are crucial for enhancing energy security in poor countries because they promote renewable energy sources, boost energy efficiency, and reduce dependency on fossil fuels. These rules can reduce the negative impacts of climate change on electricity infrastructure and boost resilience to extreme weather events (Jaiswal et al., 2022).

Investing in low-carbon infrastructure and technology can help developing countries enhance energy availability, reduce emissions, and promote sustainable development. Climate change policy makes a strong case for investing in renewable energy sources, such as solar, wind, and geothermal power, which are more resilient to climatic influences and provide a cleaner energy future. Climate change policies may inadvertently increase energy security in developing countries and build a more resilient and sustainable energy system by promoting investments in renewable energy and increasing energy efficiency (Iyke, 2024).

The need to slow down climate change and reduce reliance on fossil fuels may spur investments in renewable energy sources like solar and wind power, which diversify the energy supply and reduce vulnerability to fluctuations in the price of fossil fuels and geopolitical instability. To increase their ability to withstand climate challenges and maintain energy supplies, developing countries might build climate-resilient energy infrastructure, such as decentralized renewable energy systems, smart grids, and energy storage technologies.

Climate change policies and regulations can promote energy efficiency measures that will cut energy consumption and emissions, improving energy security by strengthening the system's resilience and reducing reliance on imported energy (UNDP, 2025). Climate change policies place a strong emphasis on the benefits of conservation and energy efficiency programs, which can reduce energy demand and dependency on fossil fuels while improving energy security.

Climate change policies can improve energy security in developing countries by promoting diversification away from fossil fuels, reducing reliance on erratic global markets, and increasing energy efficiency. Energy networks become more resilient and less vulnerable to disruptions and price swings as a result.

Climate change policies necessitate international cooperation to share knowledge, technologies, and financial resources in order to assist developing countries in strengthening their energy security and establishing climate resilience (Elkhatat & Al-Muhtaseb, 2024). In order to survive extreme weather events and guarantee the dependability of the energy supply, these policies also require investments in climate-resilient energy infrastructure. The goal of climate change policy is explained in detail below;

3.1 Transitioning to Renewable Energy

Climate change policies often offer incentives for the development and application of renewable energy sources, including solar, wind, and hydropower. This reduces dependency on fossil fuels, which are susceptible to price fluctuations and geopolitical issues.

The availability of renewable energy sources locally enhances energy security even further. For example, projects in poor countries that help integrate renewable energy sources into the grid and improve stability have received support from the Green Climate Fund (GCF).

Diversification of energy sources reduces reliance on fossil fuels, which are vulnerable to price swings and supply disruptions. Renewable energy can assist expand access to energy in remote and rural areas with possibly insufficient grid infrastructure.

3.2 Improving Energy Efficiency

Energy-saving techniques in buildings, industries, and transportation can be encouraged by policies. As a result of lower overall energy usage, energy systems are less susceptible to supply disruptions. Additionally, efficiency improvements reduce the need for costly and time-consuming new power plants. Climate change can have an impact on legislative and regulatory actions that promote the expansion of renewable energy, improve energy efficiency, and increase the resilience of energy systems. By investing in clean energy and energy efficiency, developing countries can create a more resilient and sustainable energy system. This can lead to economic growth, employment creation, and an improvement in living standards.

Climate change policies can promote energy efficiency through regulations, incentives, and guidelines. Overall energy security is increased when buildings, businesses, and transportation use less energy, which lowers emissions and energy demand. Energy efficiency initiatives can save money for businesses and households alike.

3.3 Reducing Reliance on Fossil Fuels

By promoting energy efficiency and renewable energy, climate change policies can reduce the proportion of fossil fuels in the energy mix. The energy sector is therefore less vulnerable to price shocks and supply disruptions caused by events like natural catastrophes or geopolitical conflicts.

Measures to combat climate change can promote sustainable development by promoting a low-carbon economy. Climate change policy aims to reduce greenhouse gas emissions, which are linked to climate change.

Moving away from fossil fuels can help developing countries become more energy independent, reduce their dependency on imported energy, and reduce the dangers associated with price volatility. This also mitigates the negative impacts of climate change on energy systems.

3.4 Enhancing Resilience:

Climate change policies can also make energy systems more resilient to its impacts. This includes actions to prevent extreme weather events like droughts and floods, which can disrupt energy production and distribution.

By investing in climate-resilient infrastructure and design, energy systems can better withstand the stresses of a changing climate. Climate change policies can support the development of resilient energy infrastructure by providing money for solutions that can withstand extreme weather occurrences.

This means building robust grids, increasing energy storage capacity, and diversifying energy sources. Climate-resilient energy systems can assist ensure a consistent supply of electricity even during extreme weather events like heat waves, floods, or droughts.

3.5 Financial and Technological Advantages

Climate change policies can give developing countries access to new technologies and economic prospects. For example, investments in renewable energy could stimulate the economy and create jobs. The creation of new energy storage and efficiency technologies may open up export opportunities.

Figure 1. Climate Change and Energy Security in Developing Countries (Elkhatat & Al-Muhtaseb 2024).

4. THE ROLE OF CLIMATE CHANGE POLICIES IN ENERGY TRANSITIONS IN DEVELOPING COUNTRIES

The energy transition and climate change are inextricably linked. Developing countries, especially those in Africa, are disproportionately affected by climate change-related extreme temperatures, floods, and droughts. These occurrences may potentially disrupt energy production and infrastructure.

Developing countries face unique opportunities and challenges as they navigate the energy transition and climate change.

Even though they are disproportionately affected by climate change, using renewable energy sources offers a path to sustainable development and economic prosperity (Bakhsh et al., 2024). The energy transition can promote overall socioeconomic development, but it also necessitates a just transition that considers social justice and equity. Energy efficiency and a switch to renewable energy sources are necessary to mitigate the effects of climate change, which is brought on by greenhouse gas emissions from burning fossil fuels. The energy transition comprises a shift away from fossil fuels and toward renewable energy sources including solar, wind, and hydropower, as well as the implementation of energy efficiency measures and the decarbonization of various sectors (Azubike, et al., 2024).

Climate change complicates energy transitions in developing countries by creating new problems and exacerbating existing ones. Due to their often-strong reliance on fossil fuels, these countries are more vulnerable to climate impacts like extreme weather and resource scarcity, and they are also disproportionately affected by the detrimental health and environmental repercussions of fossil fuel consumption. The requirement for energy availability and economic growth complicates the problem and may need a trade-off between preserving energy affordability and halting climate change. Climate change may cause harm to existing energy infrastructure, making upgrades and upkeep more difficult (Falcone, 2023).

The energy transition may lose political and financial support as a result of the difficulties it creates. Climate change presents significant obstacles to energy transitions in developing countries, particularly in relation to the long-term sustainability, cost, and accessibility of new energy sources.

These challenges include potential conflicts between the needs of energy security and climate mitigation goals, increased energy prices due to climate-related disruptions, and the inability of low-income populations to finance renewable energy (Lv, 2023). Extreme weather events like heat waves, droughts, and floods can damage energy infrastructure, increase maintenance costs, and disrupt the supply chain, all of which can lead to higher pricing. Climate change may affect the availability and reliability of renewable energy sources. For example, changes in rainfall patterns can affect hydropower generation, while excessive heat or cold can reduce the efficiency of solar panels. The energy transition can lead to decreased emissions, improved energy availability, and economic development, but it also has disadvantages, like inconsistent finance and policies. International collaboration, international funding, and investments in innovation and education are necessary for these countries to effectively manage this transition.

Climate change policies have significantly influenced energy transitions in poor countries, acting as both enablers and accelerators. They encourage the shift to renewable energy, boost energy efficiency, and promote decarbonization, but they also confront challenges like funding, technology transfer, and the need for a "just transition" to ensure fairness and inclusiveness (Abban et al., 2022). Climate change policies, such as those focused on emission reductions and renewable energy, can significantly improve energy transitions in developing countries by reducing reliance on fossil fuels, promoting international cooperation and investment, and offering incentives for the adoption of clean energy. Additional advantages of these programs include increased economic growth, improved energy access, and an improvement in overall well-being.

In essence, climate change policies benefit the economy, society, and environment while providing developing countries with a framework for transitioning to greener energy sources. By adopting the energy transition, these nations can guarantee a more prosperous and sustainable future (Mavlutova et al., 2025). Climate change policies are crucial for accelerating the transition to sustainable energy sources because they promote energy efficiency, the development and application of renewable technology, and the creation of a regulatory framework that supports a low-carbon economy.

For instance, investments in clean energy technologies like wind and solar are encouraged by climate policies like feed-in tariffs, tax credits, and renewable energy requirements that make renewable energy more competitive than fossil fuels.

Carbon pricing schemes, energy efficiency requirements for buildings and appliances, and subsidies for energy-efficient technologies are examples of climate policies that encourage people and companies to reduce energy consumption and waste. Climate policies, such as carbon pricing, emission regulations, and renewable energy ambitions, offer a clear and consistent regulatory framework that promotes investments in low-carbon infrastructure and technologies (Zeng et al., 2024). Governments have the capacity to fund the development of novel clean energy technologies as well as investments in infrastructure that supports the energy transition. Climate policy can support communities impacted by climate change and workers in the fossil fuel industry, ensuring that the shift to a low-carbon economy is fair and just. Global initiatives to cut emissions and quicken the energy transition can be supported by the coordinated implementation of climate change policies on a global scale. International climate finance and the Nationally Determined Contributions (NDCs) of developing nations under the Paris Agreement offer frameworks and resources for energy transformations (Yusuf, 2023). Climate change policies are essential in promoting energy transitions in developing nations; yet, for these transitions to be effective, issues with funding, technology, and the requirement for a fair transition must be resolved. Public-private partnerships, inclusive policies, and international cooperation are necessary to guarantee that developing nations can take advantage of the opportunities brought about by the shift to a low-carbon future. Below is a detailed explanation of how climate change policies might help developing nations with their energy transitions:

Incentives for Renewable Energy

Policies such as carbon pricing and emissions trading schemes can increase the competitiveness of renewable energy sources relative to fossil fuels, hence creating a financial incentive for them. By establishing required renewable energy targets, governments can promote the growth and use of renewable energy sources like hydropower, wind, and solar.

Investment in the renewable energy sector, economic growth, and job creation are all potential outcomes of the energy shift.

Tax Credits and Other Incentives

Policies that lower upfront costs and promote investment in renewable energy projects by offering tax exemptions, subsidies, and other financial incentives. Energy-efficient practices in households, workplaces, and industries can be promoted through public awareness campaigns and reward schemes. Reducing dependency on fossil fuels can lessen the effects of climate change, lower greenhouse gas emissions, and improve air quality.

Investment in Grid Modernization

Energy delivery may be enhanced and energy losses can be decreased by investing in smart grids and effective transmission infrastructure. Underprivileged communities, especially those in rural locations, can have better access to electricity by investing in renewable energy.

Climate Finance

Through climate financing systems, developed countries can give developing countries financial support to help them execute renewable energy initiatives. Energy security can be improved and reliance on imported fossil fuels can be decreased by diversifying energy sources with renewable energy.

Knowledge Sharing and Technology Transfer

International partnerships can help transfer technology, best practices, and knowledge, giving poor nations access to cutting-edge renewable energy solutions. Through infrastructure development, technical aid, and training initiatives, international assistance can help developing nations increase their capability.

Figure 2. Climate Change and Energy Transitions in Developing Countries (Azubuike et al., 2024)

5. THE ROLE OF POLITICAL POLICIES IN ENERGY SECURITY AND TRANSITIONS IN DEVELOPING COUNTRIES

Energy security and transitions in emerging nations are greatly impacted by politics, which has an effect on resource distribution, government policy, and investment. Geopolitical tensions, poor governance, and political instability can all impede energy security by discouraging investment, undermining long-term planning, and upsetting energy supply chains (Javed et al., 2025). Politics affects energy security and transitions because it influences public acceptability of new energy systems, legislation, and investment. Blackouts and delays in gasoline delivery can result from conflicts, political instability, and civil unrest interfering with energy production, distribution, and transportation. Long-term energy security and development may be hampered by political risks that discourage investment in renewable energy and energy infrastructure. Corruption, weak institutions, and unpredictable policy are some of these threats (Moghani & Loni, 2025).

Political instability can exacerbate energy poverty and alter energy supply-demand gaps and preventing the teeming population from accessing reliable and fairly priced energy sources.

Geopolitical instability, commercial conflicts, and even acts of terrorism can disrupt supply networks and energy security. However, to solve the aforementioned problems, effective and workable political solutions must be developed. Energy security and transitions in emerging countries are heavily influenced by political decisions. These political variables must be understood and taken into consideration in order to promote sustainable energy development and achieve universal energy security. Political policies have a major influence on the energy landscape of developing countries.

By creating a stable, supportive, and innovative environment, these rules can pave the way for a cleaner, safer, and more sustainable energy future. Stable political environments and supportive laws can encourage investments in renewable energy and hasten the transition to sustainable energy sources. Political stability and reduced risks are crucial for the energy sector, and particularly for renewable energy, to draw investment and foster innovation (Imran et al., 2023). Improving energy security and easing transitions in developing nations require carefully thought-out political measures.

They can lower risks, foster innovation, and establish a stable and encouraging political climate for investments in renewable energy. Infrastructure development, financial incentives, regulatory reforms, and political legal frameworks are important instruments for accomplishing these objectives (Wang et al., 2025). Attracting long-term investments in the energy sector requires stable political settings and lower financial risks. Innovation in the energy sector and foreign direct investment can both be stimulated by well-defined government policies and regulations.

Political policies are crucial for preserving energy security and facilitating transitions in underdeveloped countries. Strong legal frameworks, supportive funding, and strategic investments are required to promote private sector participation and speed the shift to cleaner, more sustainable energy sources. While tackling systemic barriers like limited access to money and inadequate infrastructure, these policies can promote competition and innovation in the energy sector (Bakhsh et al., 2024). Political choices regarding energy policies, such as subsidies for fossil fuels or incentives for renewable energy sources, have a direct impact on the energy landscape.

Political stability and a stable regulatory environment are necessary to draw investment in energy infrastructure, especially renewable energy projects. By reducing reliance on fossil fuels, expanding energy supply, and creating a stable and encouraging political climate for renewable energy, these policies can support sustainable development, economic expansion, and improved living conditions for all (Jaiswal et al., 2022). Political approaches that promote sustainable development and economic growth provide a number of benefits. These benefits can be seen in the following ways;

5.1 Political Policies in Achieving Energy Security and Transitions in Developing Countries

- **Government Regulatory Frameworks:** Establishing effective, open, and easily comprehensible political regulatory frameworks is essential to creating a stable and predictable climate for investment in energy projects, particularly renewable energy. This means reducing bureaucratic paperwork, ensuring fair competition, and streamlining the permitting process.
- **Financing:** The provision of financial assistance for energy projects by governments, especially through tax credits, subsidies, and public-private partnerships, can be extremely important. This can make large-scale projects more feasible and lower the cost of funding.
- **Investment and Infrastructure:** Ensuring dependable and sustainable energy access for everyone requires governments to invest in energy infrastructure, such as transmission lines and power grids. The private sector's investment in renewable energy infrastructure and technology can also be encouraged by governments.
- **Carbon Pricing:** Governments can encourage companies and individuals to invest in cleaner technology and lessen their carbon footprint by enacting carbon pricing mechanisms like carbon taxes or cap-and-trade schemes.
- **Energy Access:** Policies in addressing energy poverty and increasing access to clean energy for rural and urban communities is very critical for developing countries.

- This can be accomplished through a variety of methods, including decentralized energy production like rooftop solar and microgrids.
- **International Cooperation:** By collaborating with international partners, such as donors and other countries, developing countries through government synergies can access resources, technology, and experience to support their energy transitions (Cantarero, 2020).

Figure 3. Government Policies and Energy Security and Transitions in Developing Countries (Falcone, 2023).

6. STATISTICAL DISTRIBUTION OF ENERGY SECURITY AND TRANSITIONS IN DEVELOPING COUNTRIES

The statistical distributions of energy security and transitions in developing countries are detailed below.

- Nigeria wants to make a significant energy transformation, with 96% of its electricity coming from renewable sources by 2050 and 40% by 2030. The "30:30:30" plan, which is part of the Nigeria Energy Transition Plan, calls for adding 30 GW of capacity by 2030, with 30% coming from renewable sources. Additionally, the strategy aims to achieve net-zero emissions throughout the economy by 2060 and carbon neutrality in the power sector by 2050.
- China's energy revolution is moving forward at a rapid pace. Clean energy accounted for 26.4% of China's total energy consumption in 2023, a significant rise from 2013.

Currently, 39.7% of China's total electricity generation comes from clean energy. Additionally, China's installed capacity for renewable energy has been growing quickly; by 2023, it will make up more than half of the global total.

- Bangladesh relied largely on fossil fuels for 98% of its power generation in 2024, with only 2% coming from low-carbon sources. The nation's present reliance on fossil fuels is much greater than the global average of 41% for low-carbon electricity, despite its ambitious plans to expand the share of renewable energy in its mix, including 16% by 2030.
- India's energy transition is advancing, and a sizable amount of the country's overall electricity generation capacity comes from renewable energy sources. In 2024, 203.18 GW of the 452.69 GW of installed capacity, or 46.3% of the total, came from renewable sources. This covers biopower, hydropower, wind power, and solar power. India has established challenging goals, such as reaching net zero by 2070 and obtaining half of its electricity from non-fossil sources by 2030.
- An important turning point in Brazil's energy transition was reached in 2023, when 49.1% of the country's total energy matrix came from renewable sources. This was made possible by steady hydroelectric power supply as well as contributions from wind, solar, and biomass energy.
- Furthermore, Brazil had the largest percentage of renewable energy among the G20 economies in 2023, with 89% of its electricity coming from these sources.
- By 2030, South Africa wants to produce 33% of its electricity from renewable sources as part of an aggressive shift to a greener energy mix. Even while low-carbon sources presently account for just 17% of South Africa's electricity, the nation is shifting away from fossil fuels and toward renewable energy sources like solar, wind, and hydro.
- As part of its energy transition, Singapore wants to reach net-zero emissions by 2050 and raise the share of renewable energy sources in its electricity mix to 40% by 2035. The nation is actively seeking to include more renewable energy, like as solar and regional power grids, despite its heavy reliance on natural gas for electricity generation.

- Mexico aims to generate 35% of its electricity from renewable sources by 2024 and 45% by 2030. By 2024, the country was expected to produce 27% of its electricity from renewable sources. Mexico is continuing working to increase its generation of renewable energy, even if the 2024 target was not met.
- **xi.** In 2021, the share of renewable energy in Trinidad and Tobago's overall final energy consumption was 0.5%. Even though this is a tiny portion, the government wants to use 30% renewable energy by 2030. The nation is moving toward a more sustainable energy future, emphasizing wind and solar photovoltaics.
- Colombia already generates 75% of its electricity from renewable energy sources including biofuels and hydropower. By 2050, the country hopes to have 19 GW of non-conventional renewable energy on hand, and by 2030, it expects to have reduced its greenhouse gas emissions by 51%. This bold shift is motivated by abundant natural resources for renewable energy sources and a growing awareness of the need to diversify away from dependency on coal and oil (WEO, 2025).

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ISBN: 978-625-92720-8-5