

## Promoting the energy transition throughout dealing with the climate change issue

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### ABSTRACT

Climate change, driven largely by the burning of fossil fuels like coal, oil, and natural gas, is causing significant environmental and societal impacts worldwide. Transitioning to renewable energy sources such as solar, wind, and hydroelectric power is crucial in mitigating these effects by reducing greenhouse gas emissions. The energy transition encompasses this shift, aiming for a sustainable, low-carbon future. This chapter discusses the energy transition as an essential response to the challenges of climate change, emphasizing the reduction of greenhouse gas emissions and the enhancement of sustainability. The growing impact of climate change, primarily driven by the combustion of fossil fuels, has necessitated a shift towards renewable energy sources and innovative energy solutions. This shift is critical to mitigating environmental impacts and fostering a more sustainable future. The paper explores technological innovations, international policies like the Paris Agreement, and national strategies from countries such as Germany, China, and the United States, promoting increased renewable energy use. Practical examples illustrate the progress and challenges encountered. The chapter also highlights the importance of digital technologies and AI in efficient energy management and environmental monitoring. Challenges such as resistance from fossil fuel industries, the need for financing, and social justice are discussed. In conclusion, coordinated action among governments, the private sector, and communities is essential for a successful energy transition.

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### Introduction

Climate change, driven by the accumulation of greenhouse gases from fossil fuel combustion, poses significant environmental and socio-economic challenges globally. Transitioning from fossil energy, which includes coal, oil, and natural gas, to renewable energy sources such as solar, wind, and hydroelectric power is essential for reducing carbon emissions. The energy transition involves not only the adoption of cleaner technologies but also the restructuring of economic and social systems to support sustainable and resilient energy practices.

Climate change is an undeniable reality of the 21st century, characterized by rising global temperatures, shifting precipitation patterns, and an increased frequency of extreme weather events (IPCC, 2021). The primary cause of climate change is the increased concentration of greenhouse gases in the atmosphere, mainly due to the burning of fossil fuels for energy production, deforestation, and industrial activities. These changes lead to severe environmental, economic, and social impacts, including sea level rise, loss of biodiversity, and adverse health effects.

Fossil energy refers to energy sources derived from the remains of ancient plants and animals, primarily coal, oil, and natural gas. These finite sources contribute significantly to greenhouse gas emissions when burned for energy.

The energy transition involves shifting from fossil fuels to renewable and less carbon-intensive energy sources. This transition is crucial for reducing greenhouse gas emissions and mitigating the effects of climate change. Renewable energy sources, such as solar, wind, and hydroelectric power, are sustainable

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alternatives to fossil fuels. They are inexhaustible and have a minimal environmental footprint compared to traditional energy sources.

Renewable energy is defined as energy generated from natural processes that are continuously replenished. This includes sunlight, wind, rain, tides, waves, and geothermal heat. Unlike fossil fuels, renewable energy sources do not deplete over time and have a lower impact on the environment.

Sustainability refers to meeting the needs of the present without compromising the ability of future generations to meet their own needs. It encompasses environmental, economic, and social dimensions, ensuring that development can continue indefinitely without depleting natural resources or causing ecological damage.

Faced with the challenges of climate change, the energy transition emerges as a crucial strategy. According to Masson-Delmotte et al. (2021), this transition is vital for limiting the increase in global temperatures and mitigating environmental impacts. The energy transition is central to global efforts to meet the objectives of the Paris Agreement on climate, which aims to keep the global temperature rise well below 2°C (United Nations, 2015). Creutzig et al. (2017) in *Environmental Research Letters* emphasize that without a rapid and extensive energy transition, these climate goals will remain unattainable, exacerbating global environmental and economic risks.

Efforts to promote energy transition and combat climate change have been significant. Initiatives such as COP28, the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), aim to strengthen global commitments to reduce greenhouse gas emissions and enhance climate resilience. COP28 focuses on accelerating the deployment of renewable energy technologies, increasing energy efficiency, and fostering international cooperation to address climate change.

The theoretical framework used to analyze the energy transition includes various analytical frameworks and key definitions. This framework helps in understanding the dynamics of energy systems, the role of policy and technological innovation, and the socio-economic implications of transitioning to a sustainable energy future.

This chapter aims to explore the promotion of energy transition in the global fight against climate change by examining technological advances, policy frameworks, and economic challenges associated with this transition, providing a detailed analysis of successful strategies and obstacles encountered. The growing urgency to address climate change with sustainable and effective solutions has heightened interest in this topic. The energy transition is not only about environmental protection but also about redefining the economic and social foundations of societies worldwide. This chapter considers how different regions and sectors can effectively contribute to the energy transition while considering local economic and social realities, and how policies and technologies can be aligned to achieve a just and effective energy transformation. The analysis is based on a review of academic literature, reports from international organizations, and sector-specific case studies, using both quantitative and qualitative data to assess the effectiveness of various approaches to energy transition. The chapter explores the energy transition in the digital age, starting with an analysis of theoretical foundations, including various analytical frameworks and key definitions, and then addressing global policies and strategies influenced by international agreements like the Paris Agreement, and examining specific initiatives from countries such as Germany, China, and the United States. The focus shifts to green technologies and innovations, particularly advances in solar, wind, and solid-state battery technologies, with practical cases illustrating successes and challenges encountered. Economic and social implications are analyzed to assess the impacts of these transitions, and the chapter concludes with future perspectives, highlighting the importance of digital technologies and AI in promoting a sustainable energy future.

### **Power plants based on fossil energy**

Fossil energy is derived from the decomposition of ancient organic matter, such as dead plants and animals, which have been transformed over millions of years under heat and pressure in the Earth's crust. The main forms of fossil energy include coal, oil, and natural gas. These energy sources are non-renewable because they form over geological timescales, far exceeding the periods of human consumption. When burned to produce energy, these fuels release carbon dioxide (CO<sub>2</sub>) and other greenhouse gases, significantly contributing to climate change (IPCC, 2021). Consequently, the energy transition refers to a structural change in the global energy system, characterized by a significant replacement of fossil fuel-based energy sources with renewable and less carbon-intensive sources. According to Smil (2010), the energy transition is not just a technical replacement but also an adjustment of the economic and social infrastructures that support energy production and consumption. Then renewable energy is defined as playing a crucial role in this transition, as it includes energy sources generated from natural processes that are continually replenished, such as solar, wind, hydroelectric, biomass, and geothermal energy. According to REN21 (2021),

these technologies are central to reducing greenhouse gas emissions and meeting the goals of the Paris Agreement on climate. As a result, sustainability in the energy context involves managing resources to ensure long-term ecological, economic, and social stability. The 1987 Brundtland Report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own." In the energy sector, this translates to investing in technologies and practices that minimize environmental impact while promoting economic and social equity (WCED, 1987).

Table 1 showcases various power plants based on fossil energy, highlighting their capacities, technologies used, and operational status. Notably, the Taichung Power Plant in Taiwan and the Belchatow Power Plant in Poland have the highest capacities, at 5,500 MW and 5,472 MW, respectively. Most of these plants utilize coal as their primary energy source, with only a few, like Taweelah A2 in the United Arab Emirates and W.A. Parish in the United States, incorporating natural gas technology.

**Table 1:** Fossil Fuel Power Plants

Power Plant	Country	Capacity (MW)	Technology Used	Current Status
Jorf Lasfar	Morocco	2,056	Coal	Operational
Mohammedia	Morocco	600	Coal	Operational
Safi	Morocco	1,386	Coal	Operational
Taweelah A2	United Arab Emirates	710	Natural Gas	Operational
RWE Power Plant	Germany	2,200	Coal	Operational
Taichung Power Plant	Taiwan	5,500	Coal	Operational
Suralaya Power Plant	Indonesia	4,025	Coal	Operational
Belchatow Power Plant	Poland	5,472	Coal	Operational
Neurath Power Plant	Germany	4,400	Coal	Operational
W.A. Parish	United States	3,653	Coal and Natural Gas	Operational

### Theoretical Frameworks

To understand and analyze energy transition strategies, several theoretical frameworks are essential. These models provide perspectives on the dynamics of change within energy systems, drawing on theories from economics, sociology, and environmental studies. The Socio-Technical Transition Model (Multi-Level Perspective, MLP), developed by Geels (2002), is widely used to study transitions in socio-technical systems, such as energy systems. This model describes three interconnected levels: niches (where radical innovations originate), regimes (dominant structures or status quo), and landscapes (external factors not influenced by individual actions). Transitions are seen as resulting from the alignment of these levels, leading to substantial changes in how energy is produced and consumed (Geels, 2002; Geels and Schot, 2007). The Technological Innovation Systems Theory, introduced by Carlsson and Stankiewicz (1991), explains how technological innovations emerge, diffuse, and are supported or inhibited by configurations of institutional and organizational factors. This framework is particularly relevant for examining how new energy technologies such as solar and wind can be encouraged by public policies, corporate strategies, and market dynamics (Markard and Truffer, 2008). Rogers' (2003) Diffusion of Innovations Theory provides a model for understanding how, why, and at what rate new ideas and technologies spread across cultures. This theory is crucial for understanding the factors that affect the adoption of renewable technologies, including the characteristics of innovations, communication among participants, time, and the social context in which diffusion takes place. Finally, Environmental Economics and Transaction Costs Theory offer insights into the costs associated with different energy systems and the economic barriers to energy transition. These costs

include not only direct financial expenses but also transaction costs associated with modifying energy infrastructures and implementing new technologies (Williamson, 1981; Stavins, 1995).

### **Challenges and opportunities of the promoted energy**

#### **Challenges of the Energy Transition**

##### **i. High Initial Costs**

The energy transition requires considerable investments in infrastructure. The construction of wind and solar farms, as well as the development of smart grids and energy storage systems, involves very high initial costs. These investments are particularly difficult to bear for developing countries, which often lack the necessary financial resources. According to the International Energy Agency (IEA, 2021), global investments in clean energy must triple in the coming decades to meet international climate goals.

##### **ii. Dependence on Fossil Fuels**

Most global economies are heavily dependent on fossil fuels for their energy production. This dependence creates economic and social inertia that makes the transition difficult. The coal, oil, and natural gas industries provide significant jobs and revenues in many regions. The transition to renewable energy could cause significant economic and social disruptions, with job losses in traditional sectors (IRENA, 2020).

##### **iii. Immature Technologies**

Some energy storage and renewable energy production technologies are not yet mature enough to be deployed on a large scale reliably and economically. For example, energy storage batteries, necessary to compensate for the intermittency of renewable energy sources such as solar and wind, are still expensive and have limitations in terms of capacity and lifespan (World Economic Forum, 2021).

##### **iv. Management and Regulation Issues**

The energy transition also requires an appropriate regulatory framework and favorable policies. However, establishing these regulations can be complex and face resistance from various interest groups, notably the fossil fuel lobbies. The International Energy Agency (IEA, 2021) emphasizes the importance of international cooperation to harmonize regulations and facilitate the energy transition on a global scale.

#### **Opportunities for the Energy Transition**

##### **i. Economic Opportunities**

The energy transition offers considerable economic opportunities. Firstly, it is a driver of green job creation. The renewable energy sector is booming and is expected to generate millions of new jobs in the construction, operation, and maintenance of renewable infrastructure. According to IRENA (2020), the number of jobs in the renewable energy sector could reach 42 million by 2050.

Furthermore, the energy transition stimulates technological innovation. The development of new technologies, such as energy storage systems, smart grids, and carbon capture and storage technologies, paves the way for new industries and markets. These innovations can also improve energy efficiency and reduce costs in the long term (World Economic Forum, 2021).

##### **ii. Environmental Opportunities**

The environmental benefits of the energy transition are equally important. Moving to renewable energy significantly reduces greenhouse gas emissions, thus contributing to the fight against climate change. The Intergovernmental Panel on Climate Change (IPCC, 2018) highlights that limiting global warming to 1.5°C requires rapid and deep reductions in CO<sub>2</sub> emissions.

Moreover, renewable energy sources, being inexhaustible, reduce the pressure on limited natural resources and promote a more sustainable use of them. This is particularly crucial in the current context of fossil resource depletion and environmental degradation (IEA, 2021).

#### **Global policies and Strategies about energy transition and climate change**

##### **Global Policies and Strategies about Energy Transition and Climate Change**

##### **i. International Agreements and Global Initiatives**

The global community has recognized the urgent need to address climate change, leading to the adoption of several landmark agreements and initiatives. The Paris Agreement, reached in 2015, stands out as a historic accord adopted by 196 parties to the United Nations Framework Convention on Climate Change (UNFCCC). Its primary aim is to limit global warming to well below 2°C above pre-industrial levels while pursuing efforts to limit the temperature increase to 1.5°C. To achieve these goals, countries are required to submit Nationally Determined Contributions (NDCs) outlining their efforts to reduce emissions and enhance

resilience, with a commitment to review and strengthen these commitments every five years to increase their ambition.

Looking ahead, the 28th Conference of the Parties to the UNFCCC (COP28) represents a crucial opportunity to strengthen global commitments to reduce greenhouse gas emissions and improve climate resilience. COP28 is expected to focus on accelerating the deployment of renewable energy technologies, increasing energy efficiency across sectors, and promoting international cooperation to combat climate change. By fostering collaboration and knowledge sharing among nations, COP28 aims to drive collective action towards achieving the objectives of the Paris Agreement.

One of the key initiatives launched in conjunction with the Paris Agreement is the Mission Innovation Initiative, announced at COP21 in 2015. This initiative brings together 24 countries and the European Commission, all committed to doubling their respective clean energy research and development budgets over five years. By accelerating clean energy innovation, Mission Innovation aims to make clean energy more affordable, attractive, and accessible, thereby driving the transition towards a sustainable, low-carbon future.

## **ii. National and Regional Policies**

Energy transition has become a global priority in response to the increasing challenges of climate change and energy security. Several countries have committed to policies and strategies to promote renewable energies and reduce their dependence on fossil fuels. Among these countries, Morocco stands out for its commitment to an ambitious energy transition.

Morocco has adopted a strategic approach to energy, defined by its National Energy Strategy of 2009, which aims to increase the share of renewable energies in its energy mix to 52% by 2030. This strategy has led to the realization of emblematic projects such as the Noor Ouarzazate and Noor Laayoune solar parks, as well as wind farms like Tarfaya. Additionally, the Renewable Energy Law of 2010 has stimulated private investments in the renewable energy sector by allowing the production, export, and sale of electricity produced from renewable sources.

In parallel, Morocco has also integrated measures for the sustainable management of natural resources into its Green Morocco Plan of 2008, primarily focused on agriculture. These measures contribute indirectly to the reduction of greenhouse gas emissions and the promotion of a greener economy.

Similarly, Germany has adopted a similar approach with its *Energiewende* policy, which aims to gradually reduce its dependence on nuclear and fossil fuels while increasing the use of renewable energies and improving energy efficiency. This policy is supported by the Renewable Energy Sources Act (EEG), which encourages the production of electricity from renewable sources through guaranteed feed-in tariffs and market premiums.

China, as the world's largest emitter of greenhouse gases, has implemented an ambitious five-year energy plan aimed at increasing its renewable energy capacity and reducing the carbon intensity of its economy. Additionally, China launched its National Emissions Trading System (ETS) in 2021, the world's largest, aiming to reduce emissions by setting a cap for major industries and allowing the trading of emission permits.

In the United States, the Biden administration has reaffirmed its commitment to climate action by launching the Clean Energy Revolution and Environmental Justice Plan, which aims to achieve 100% clean electricity by 2035 and net-zero emissions by 2050. Additionally, the United States rejoined the Paris Agreement in 2021, committing to reduce its greenhouse gas emissions and support international efforts against climate change.

## **iii. Recent Innovations Driving the Energy Transition**

The global energy landscape is undergoing a profound transformation, driven by the urgent need to address climate change and transition to sustainable energy sources. Recent innovations in renewable energy technologies, energy storage solutions, grid modernization, and policy frameworks are playing a crucial role in accelerating this transition.

One of the key innovations in the renewable energy sector is the development of floating solar panels. By installing solar panels on bodies of water, this technology not only increases energy production but also maximizes land use efficiency, making it particularly attractive in densely populated areas. Additionally, advancements in biogas production from organic waste are helping to reduce landfill emissions and provide a renewable source of energy (Zhao et al., 2021).

In the wind energy sector, advanced wind turbine designs and materials are significantly improving efficiency and reducing costs. These innovations, coupled with the increasing scale of wind farms, are making wind energy more competitive with traditional fossil fuel sources (Sørensen, 2018).

Another significant development is the emergence of solar paint, a special paint that can generate electricity from sunlight. This innovation offers a low-cost way to integrate solar power into buildings, potentially revolutionizing the way we think about solar energy deployment in urban areas (Tan et al., 2020).

In the realm of energy storage, advancements in battery technology are enabling the storage of excess renewable energy for use during periods of low production. Similarly, developments in hydrogen storage are paving the way for the use of hydrogen as a clean energy carrier, particularly in transportation (Zeng et al., 2021).

Grid modernization is also a critical aspect of energy transition. Smart grids, for example, are intelligent electricity distribution networks that optimize energy use, reduce waste, and integrate renewable energy sources. These grids enable greater flexibility and reliability in energy supply, essential for the integration of variable renewable energy sources like solar and wind power (Yao et al., 2019).

On the policy and financial front, innovations such as green bonds and carbon pricing mechanisms are providing new avenues for financing renewable energy projects and incentivizing emission reductions. Renewable energy auctions, another innovative policy tool, ensure the cost-effective deployment of renewable energy projects through competitive bidding processes (Ketterer et al., 2020).

## **Green Technologies and recent innovations**

### ***i. Green Technologies***

Green technologies play a central role in the energy transition by providing renewable and efficient solutions to replace fossil fuels. These primarily include solar, wind, and hydroelectric energy, each characterized by specific innovations that enhance their efficiency and integration into energy networks.

Solar energy, harnessed through photovoltaic panels and solar thermal power plants, is one of the most promising renewable energy sources. According to Razykov et al. (2011), technological advancements in semiconductor materials, such as monocrystalline silicon and perovskites, have significantly increased the efficiency of solar panels. Additionally, innovations such as solar trackers that follow the sun's trajectory to maximize exposure, and integrated energy storage systems, allow for more flexible and extensive use of solar energy.

Wind energy is captured using wind turbines that convert the kinetic energy of the wind into electricity. With significant developments in turbine design, including the increase in blade size and improvements in control systems, wind farms have become more efficient and less costly. According to Burton et al. (2011), innovations in composite materials for blades and aerodynamic improvements have also reduced noise and increased the durability of turbines.

Hydroelectric energy, produced by converting the potential energy of water into electricity, is a stable and mature source of renewables. Paish (2002) notes that innovations in the design of hydraulic turbines and water management systems now allow for energy production more adaptable to variations in energy demand. Small hydroelectric plants represent an increasingly viable option for remote communities and off-grid applications.

### ***ii. Recent Innovations***

Technological innovation in the energy sector plays a key role in transitioning to cleaner and more sustainable energy sources. Recent advances offer promising prospects for improving efficiency, reducing costs, and increasing the acceptance of renewable technologies. Here are some of the most impactful and recent innovations in the field.

- ***Solid-State Batteries:***

Solid-state batteries represent a major advance in energy storage technology, offering superior capacities in terms of energy density and safety compared to traditional lithium-ion batteries. According to Janek and Zeier (2016), these batteries use solid electrolytes instead of liquids, making them less likely to catch fire and more efficient at extreme temperatures. This technology could revolutionize the electric vehicle market and facilitate the integration of intermittent renewable energies such as solar and wind.

- ***Perovskite Solar Cells:***

Perovskite-based solar cells are a promising innovation in photovoltaics due to their low cost and potentially high efficiency. Park (2015) reports that these materials offer a light-to-electricity conversion efficiency that could surpass that of silicon-based solar panels, while being less expensive to produce. Their

flexibility and lightness open up new applications in integrating solar energy into buildings and portable devices.

- **Floating Wind Turbines:**

Floating wind turbines allow for the exploitation of wind energy in deep-sea environments, where winds are stronger and more consistent. According to Sclavounos et al. (2018), this technology uses floating platforms anchored to the seabed, enabling installation in deep waters where traditional wind turbines are not viable. This could significantly increase the potential for wind energy production, especially in regions previously untapped.

- **Green Hydrogen:**

Hydrogen produced by electrolysis of water using electricity from renewable sources offers a promising solution for long-term energy storage and as a substitute for fossil fuels in transportation and industry. According to Bertuccioli et al. (2019), green hydrogen could play a crucial role in decarbonizing sectors that are difficult to electrify, such as steelmaking and maritime transport.

### **iii. Upcoming Challenges**

As the world progresses towards an energy transition, several significant challenges must be addressed to ensure the effective and equitable deployment of renewable energies and associated technologies. This section identifies and analyzes potential obstacles that could hinder future progress in this crucial field.

One major challenge is the resistance from fossil fuel industries, which have well-established economic interests and global value chains. According to McGlade and Ekins (2015), the transition to renewable energies threatens existing investments and infrastructures of fossil fuels, leading to strong political and economic opposition. This resistance can slow the adoption of policies favourable to renewable energies and negatively influence public opinion.

Another challenge is the intermittency of renewable sources such as solar and wind energy, which poses a significant technical challenge for managing energy networks. Renewable energy production is not always in phase with demand peaks, requiring advanced energy storage solutions and smart grids to maintain network stability. Acker et al. (2021) emphasize that the development of economically viable energy storage technologies is crucial for overcoming this challenge.

Financing the energy transition is also a major hurdle, as it requires enormous investments for research and development, as well as for the large-scale deployment of renewable technologies. Jones and Warner (2016) point out that access to capital for renewable energy projects can be limited, especially in developing countries where financial risks are higher. The creation of innovative financing mechanisms and the engagement of international financial institutions are essential for overcoming these financial barriers.

### **Practical Study in Promoting Energy Transition by Addressing Climate Change**

The global energy landscape is evolving rapidly, driven by the urgent need to combat climate change and transition to sustainable energy sources. Recent innovations in renewable energy technologies have played a pivotal role in accelerating this transition. This study focuses on practical examples of renewable energy projects around the world, analyzing their status, challenges faced, and future trends in energy transition to reduce the impact of climate change.

This chapter aims to explore the promotion of energy transition in the global fight against climate change by examining technological advances, policy frameworks, and economic challenges associated with this transition, providing a detailed analysis of successful strategies and obstacles encountered. The growing urgency to address climate change with sustainable and effective solutions has heightened interest in this topic. The energy transition is not only about environmental protection but also about redefining the economic and social foundations of societies worldwide. This chapter considers how different regions and sectors can effectively contribute to the energy transition while considering local economic and social realities, and how policies and technologies can be aligned to achieve a just and effective energy transformation. The analysis is based on a review of academic literature, reports from international organizations, and sector-specific case studies, using both quantitative and qualitative data to assess the effectiveness of various approaches to energy transition.

The chapter explores the energy transition in the digital age, starting with an analysis of theoretical foundations, including various analytical frameworks and key definitions, and then addressing global policies and strategies influenced by international agreements like the Paris Agreement, and examining specific initiatives from countries such as Germany, China, and the United States. The focus shifts to green technologies and innovations, particularly advances in solar, wind, and solid-state battery technologies, with

practical cases illustrating successes and challenges encountered. Specific examples, such as the Noor Ouarzazate and Noor Midelt concentrated solar plants in Morocco, the Kamuthi Solar Plant in India, and the Gansu Wind Farm in China, highlight both the challenges and opportunities presented by the transition to renewable energy sources. Economic and social implications are analyzed to assess the impacts of these transitions, and the chapter concludes with future perspectives, highlighting the importance of digital technologies and AI in promoting a sustainable energy future.

**Table 2: Power Plants Using Renewable Energy**

Power Plant	Country	Capacity (MW)	Technology Used	Current Status
Noor Ouarzazate	Morocco	510	Concentrated Solar	Operational
Noor Midelt	Morocco	800	Concentrated Solar	Under Construction
Noor Laayoune	Morocco	80	Photovoltaic Solar	Operational
Kamuthi Solar Plant	India	648	Photovoltaic Solar	Operational
Solar Star	USA	579	Photovoltaic Solar	Operational
Longyangxia Dam	China	1,280	Hydroelectric	Operational
Belo Monte Dam	Brazil	11,233	Hydroelectric	Operational
Alta Wind Energy	USA	1,548	Wind	Operational
Gansu Wind Farm	China	7,965	Wind	Operational
London Array	UK	630	Wind	Operational

**Table 3: Greenhouse Gas Emissions**

Country	GHG Emissions (Mt CO <sub>2</sub> e)
Morocco	71.8
India	2,654.4
USA	6,511.3
China	11,858.1
Brazil	2,049.6
UK	435.2

**Sources:** Data based on national greenhouse gas emissions reports and environmental inventories of power plants.

- *Analysis and Challenges Faced*

In Morocco, the Noor Ouarzazate and Noor Laayoune solar plants stand as symbols of the country's dedication to renewable energy. Despite this commitment, challenges such as grid integration and energy storage need to be addressed to facilitate further expansion of renewable energy sources. India's progress in solar energy is evident through the Kamuthi Solar Plant. However, India's heavy reliance on coal poses a significant obstacle to a smooth transition to renewable energy sources.

Both the USA and China have made significant investments in renewable energy. However, their high emissions levels indicate a continued dependence on fossil fuels. Scaling up renewable energy sources to meet their growing energy demands remains a considerable challenge for these nations.

In Brazil, the Belo Monte Dam represents a significant source of renewable energy. However, it has faced criticism due to its environmental impact. Sustainable development of hydropower is vital to mitigate such concerns.

The UK has achieved success with offshore wind energy with the London Array. Nevertheless, challenges like intermittency and high costs hinder the wider adoption of this renewable energy source in the country.

- ***Future Trends and Approach***

To reduce the impact of climate change, future trends in energy transition focus on several key areas. Firstly, advancements in energy storage are crucial for managing the intermittency of renewable energy sources El Amri and al (2022). Developing efficient and cost-effective storage solutions will enable a more reliable and sustainable energy supply. Secondly, grid modernization plays a vital role in the integration of renewable energy El Kezazy and Hilmi (2022). Upgrading grids to accommodate the variable nature of renewable sources and implementing smart grid functionalities will enhance the flexibility and efficiency of energy distribution.

Thirdly, policy support is essential for driving the transition to renewable energy. This includes implementing carbon pricing mechanisms, setting ambitious renewable energy targets, and providing incentives for the adoption of clean energy technologies El Kezazy and Hilmi (2023). These policies can stimulate investment in renewable energy and accelerate the transition away from fossil fuels.

Lastly, international cooperation is key to addressing climate change. Collaborating on a global scale allows for the sharing of best practices, technologies, and resources, facilitating a more coordinated and effective approach to achieving a sustainable energy future.

## **Conclusion**

This chapter has explored various aspects of the energy transition, highlighting its critical importance for the sustainable future of our planet. We have discussed technological innovations, economic and social challenges, and global strategies that shape this transition. As highlighted by Aghion et al. (2016), the transition to renewable energies is not only imperative for reducing greenhouse gas emissions but also offers substantial economic opportunities in terms of job creation and technological development. However, the challenges remain considerable, particularly in terms of financing, political resistance, and the integration of intermittent energy sources.

To overcome these challenges and accelerate the energy transition, coordinated action between governments, the private sector, and communities is essential. Policymakers must strengthen regulatory and policy frameworks that encourage investments in renewable energies and the development of sustainable energy infrastructures. As indicated by IRENA (2021), the implementation of incentive policies, such as subsidies and tax credits for renewable technologies, can stimulate innovation and large-scale adoption. Researchers must continue to explore new energy technologies and the socio-economic implications of their deployment. Finally, citizens must be better informed and involved in decision-making processes related to energy to ensure an inclusive and equitable transition (Abbas et al. 2023).

Future research should focus on improving energy storage technologies, a key area for managing the intermittency of renewable energies. According to Acker et al. (2021), exploring advanced solutions such as flow batteries or green hydrogen may provide promising avenues for large-scale energy storage. Additionally, studies on the social impact of the energy transition, particularly in terms of energy justice and the distribution of costs and benefits, remain crucial for ensuring an equitable transition (Jenkins et al., 2016). Finally, increased attention should be given to policies that can effectively integrate new entrants into the energy market, such as microgrids and distributed technologies, into the global energy system.

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No potential conflict of interest was reported by the author(s).

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