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Hassan Qudrat-Ullah

Sustainable Energy

A Myth or Reality

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The Springer Series in Sustainable Energy Policy

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Dedicated to, Muhammed Abdul Jabbar, born today, May 16, 2024, with the hope that he will strive for and contribute to alleviate the ongoing suffering of Palestinians and the likes across the world.

Preface

This book is the result of my passion and curiosity for sustainable energy, especially renewable sources such as solar and wind. I have been fascinated by the potential and promise of these sources to provide clean, abundant, and affordable energy for the world, while also mitigating the effects of climate change and enhancing the well-being of people and the planet. However, I have also encountered many myths and misconceptions about sustainable energy, which often undermine its understanding and adoption and create confusion and doubt among the public and policymakers. Therefore, I decided to write this book to critically examine and debunk some of the common myths and to highlight some of the important realities of sustainable energy, using a mixed-methods approach that combines literature review, case studies, interviews, surveys, and data analysis.

My main objective in writing this book is to provide a comprehensive and balanced overview of the myths and realities of sustainable energy and to offer insights and recommendations for improving the understanding and practice of sustainable energy. I hope that this book will be useful and informative for anyone who is interested in learning more about sustainable energy, whether they are students, researchers, professionals, policymakers, or general readers. I also hope that this book will inspire and motivate the readers to take part and benefit from the sustainable energy transition, which is essential for achieving the global climate goals and ensuring the energy security and well-being of all people.

Writing this book has been a rewarding and challenging journey for me, as I have learned a lot from the various sources and perspectives that I have consulted and encountered. I have also faced some difficulties and limitations, such as the availability and reliability of data, the complexity and diversity of the energy system, and the dynamic and evolving nature of the energy landscape. I acknowledge that this book is not exhaustive or definitive and that there are still many gaps and uncertainties in the field of sustainable energy. Therefore, I welcome any feedback, comments, or suggestions from the readers, and I encourage further research and exploration on this topic.

I would like to express my gratitude and appreciation to all the people who have supported and helped me in writing this book, especially my family, friends,

colleagues, mentors, and editors. I would also like to thank the publishers, reviewers, and readers for their interest and trust in this book. I hope that you will enjoy reading this book as much as I enjoyed writing it.

Toronto, Canada

Hassan Quadrat-Ullah

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The creation of *Sustainable Energy: A Myth or Reality* is the result of a collaborative effort inspired by the pressing need to clarify and understand the complex landscape of sustainable energy. This book would not have been possible without the invaluable contributions and unwavering support of numerous individuals and institutions.

First and foremost, we extend our deepest gratitude to the pioneering researchers and experts whose groundbreaking work in renewable energy has laid the foundation for this book. Your insights, dedication, and commitment to advancing sustainable energy have been instrumental in shaping the content and direction of this work.

We also acknowledge the educational institutions and research centers that have fostered an environment of critical thinking and innovation in the field of sustainable energy. Your support and encouragement have enabled us to explore and challenge prevailing myths and misconceptions about renewable energy sources.

A special thanks goes to our colleagues and students, especially those involved in our courses and research projects at PAUWES, University of Tlemcen, Algeria. Your engagement, feedback, and diverse perspectives have greatly enriched this book. Your enthusiasm and commitment to understanding and promoting sustainable energy have been a source of inspiration.

We are profoundly grateful to our families for their unwavering support and patience throughout the writing process. Tahira Qudrat, your enduring support over the past 35 years has been a pillar of strength and encouragement.

Lastly, we extend our heartfelt thanks to our readers. We hope this book inspires you to engage critically with the myths and realities of sustainable energy and to become advocates for informed decision-making in your communities, industries, and policy-making arenas. Together, we can contribute to a more sustainable and resilient energy future.

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Chapter 1

Introduction—What, Why, and How of Sustainable Energy



Abstract Sustainable energy is essential for meeting the world’s energy needs while protecting the environment and promoting social and economic development. This chapter introduces the concept and importance of sustainable energy, especially renewable sources such as solar and wind, and the main drivers and motivations for pursuing it, such as climate change mitigation and economic opportunities. It also sets the stage for the book’s main objective: to critically examine and debunk the common myths and misconceptions about sustainable energy, particularly solar and wind, and to provide evidence-based insights for informed decision-making and public discourse. The chapter also provides some background information on the current state and trends of global energy demand and supply, and the challenges and opportunities of transitioning to a low-carbon economy. The chapter concludes by highlighting the need to understand the factors influencing global energy demand and to devise effective strategies to address the increasing energy needs in a sustainable way.

Keywords Sustainable energy · Renewable sources · Climate change mitigation · Global energy demand · Fossil fuels · Environmental impact · Energy security · Economic opportunities · Myth debunking · Informed decision-making · Transition strategies · Challenges and opportunities

1.1 Introduction

Sustainable energy refers to the production and utilization of energy in a manner that meets present needs without compromising the ability of future generations to fulfill their own requirements. It encompasses energy sources that are environmentally friendly, socially equitable, and economically viable over the long term (IRENA 2017). Key components of sustainable energy include renewable energy sources such as solar, wind, hydropower, and geothermal, alongside energy efficiency measures that minimize waste and optimize resource use (IEA 2020).

The global pursuit of sustainable energy is driven by the urgent need to address environmental challenges, particularly climate change. The burning of fossil fuels for energy contributes significantly to greenhouse gas emissions, leading to global warming and adverse environmental effects (IPCC 2018). Sustainable energy sources, such as solar, wind, and hydropower, offer a cleaner alternative to traditional fossil fuels. By harnessing these renewable resources, we can significantly reduce our carbon footprint and mitigate the detrimental impact on the planet. Moreover, the transition to sustainable energy promotes ecological balance by minimizing the disruption to ecosystems caused by extraction and combustion of non-renewable resources (Jones and Smith 2019). Embracing sustainable energy not only addresses the immediate environmental concerns but also lays the foundation for a resilient and environmentally conscious future.

The importance of sustainable energy extends beyond environmental considerations, playing a pivotal role in shaping the global society and economy. As the world faces escalating energy demands, transitioning to sustainable sources becomes imperative for ensuring long-term energy security (UNDP 2019). The diversification of energy resources through sustainable practices enhances resilience against geopolitical uncertainties and supply chain disruptions. Moreover, sustainable energy practices align with international goals for achieving a more inclusive and equitable society (World Bank 2021). By promoting the accessibility and affordability of clean energy, we contribute to poverty alleviation and empower communities, particularly in regions where traditional energy sources are scarce or unreliable. Embracing sustainable energy not only fosters environmental stewardship but also serves as a catalyst for social and economic development on a global scale.

One of the primary motivations for adopting sustainable energy is the imperative to mitigate climate change. The Intergovernmental Panel on Climate Change (IPCC) emphasizes the crucial role of renewable energy in limiting global temperature rise and reducing the adverse impacts of climate change (IPCC 2018). The transition to sustainable energy sources, such as solar, wind, and hydropower, is seen as a key strategy to curtail the emission of greenhouse gases responsible for global warming. By replacing conventional fossil fuel-based energy with cleaner alternatives, we contribute to a substantial reduction in carbon emissions, thereby slowing down the progression of climate change. This emphasis on renewable energy aligns with international efforts to achieve carbon neutrality and build a sustainable future. As societies recognize the urgent need for action, the adoption of sustainable energy emerges as a pivotal step in addressing the environmental challenges posed by climate change.

Sustainable energy contributes significantly to energy security by diversifying the energy mix and reducing dependence on finite fossil fuel resources (IEA 2020). This diversification not only enhances resilience against supply disruptions but also mitigates geopolitical uncertainties, reducing vulnerability to fluctuations in global energy markets (IRENA 2019). The transition to sustainable energy holds substantial economic promise, acting as a catalyst for positive change. Investments in renewable energy technologies stimulate economic growth, create jobs, and foster innovation,

thereby bolstering the economic well-being of nations (Baker et al. 2022). This economic dimension is crucial for both developed and developing nations alike.

Sustainable energy aligns with principles of social justice by ensuring that energy benefits are distributed equitably among diverse communities (Sovacool 2020). Access to clean and affordable energy becomes a key factor in reducing societal inequalities, promoting inclusivity, and uplifting marginalized populations. By prioritizing sustainable energy practices, societies can address not only environmental concerns but also contribute to a more just and equitable global community. The economic and social benefits derived from sustainable energy adoption have the potential to reshape the energy landscape, fostering a more sustainable and inclusive future for generations to come.

1.2 Purpose of the Book

The primary objective of this book, “Sustainable Energy: A Myth or Reality?” is to critically examine the myths and realities associated with sustainable energy, with a particular emphasis on renewable sources such as solar and wind. The importance of this exploration lies in dispelling misconceptions and fostering a deeper understanding of the challenges and opportunities in the realm of sustainable energy.

The examination of myths and realities surrounding sustainable energy is crucial for developing an accurate and nuanced perspective on the viability and effectiveness of renewable energy sources. Misconceptions about the intermittency of solar and wind power, the economic feasibility of sustainable energy, and other related issues persist and can hinder the widespread adoption of cleaner technologies (Smith and Brown 2018).

Dispelling these misconceptions is vital for fostering informed decision-making at individual, corporate, and policy levels. Incorrect information can lead to misguided choices and inhibit the necessary transitions to sustainable energy (Jones et al. 2021). By presenting evidence-based insights, this book aims to contribute to a more accurate public discourse on sustainable energy.

In the context of global challenges such as climate change, energy security, and economic development, informed decision-making is paramount. The transition to sustainable energy requires well-informed choices that balance environmental, social, and economic considerations (Hawken 2017). Through this book, we aim to empower readers with the knowledge needed to make sound decisions that contribute to a sustainable and resilient energy future.

1.3 Background Information

A comprehensive understanding of the current state of global energy demand and supply is essential for contextualizing the need for sustainable energy. According to the International Energy Agency (IEA), global energy demand has been steadily increasing, with a notable rise in electricity consumption (IEA 2022). In 2021, the world's primary energy demand reached [insert data] exajoules, reflecting the ongoing growth in energy needs (IEA 2022). This surge is driven by factors such as population growth, urbanization, and industrialization.

The dominant sources of energy play a pivotal role in shaping the environmental landscape. Fossil fuels, including coal, oil, and natural gas, continue to be the primary contributors to global energy supply (IEA 2022). However, their combustion releases greenhouse gases, contributing to climate change and air pollution (Davis and Caldeira 2010). Understanding the environmental impact of these sources is crucial for recognizing the urgency of transitioning to sustainable alternatives.

An analysis of historical trends provides insights into the evolution of global energy consumption. Over the past decades, there has been a notable shift in the energy mix, marked by an increasing share of renewable energy sources (REN21 2021). Solar and wind energy, in particular, have experienced significant growth, reflecting efforts to diversify the energy portfolio (REN21 2021). Understanding these trends is essential for anticipating future developments and challenges.

Several key factors influence global energy demand. Population growth, economic development, technological advancements, and policy decisions all contribute to the dynamics of energy consumption (Sovacool and Dworkin 2015). Additionally, the emergence of new industries and shifts in lifestyle patterns impact energy requirements. Identifying and analyzing these factors is crucial for devising effective strategies to address the challenges posed by increasing energy demand.

1.4 Challenges and Opportunities

The current energy landscape poses significant challenges, foremost among them being environmental concerns associated with conventional energy sources. The combustion of fossil fuels releases greenhouse gases, contributing to climate change (IPCC 2018). Additionally, air and water pollution from the extraction, processing, and utilization of traditional energy sources have profound ecological implications (Markandya et al. 2019). The need to address these environmental challenges is critical for the sustainability of the planet.

The reliance on finite resources, such as oil and natural gas, raises concerns about resource depletion. As these resources become scarcer, the global economy faces increased volatility and geopolitical tensions (Heinberg and Fridley 2016). Recognizing the limitations of these conventional resources is crucial for developing strategies that ensure long-term energy security.

Transitioning to sustainable energy sources presents numerous economic opportunities. Investments in renewable energy technologies not only drive innovation but also create jobs and stimulate economic growth (Battisti and Corrado 2016). The renewable energy sector has demonstrated its potential to become a significant contributor to economic development, offering a pathway to a more resilient and diverse economy.

One of the principal opportunities lies in the potential to reduce the environmental impact of energy production. Sustainable energy sources, such as solar and wind, generate electricity with significantly lower carbon emissions compared to fossil fuels (IEA 2020). This shift contributes to mitigating climate change and improving overall environmental quality.

Diversifying the energy mix with sustainable sources enhances energy security by reducing dependence on a limited set of resources concentrated in specific regions (IEA 2020). This diversification promotes energy independence and resilience against geopolitical uncertainties, creating a more stable energy supply.

1.5 Transition to a Low-Carbon Economy

A low-carbon economy marks a transformative shift towards reducing carbon dioxide (CO₂) and other greenhouse gas emissions linked to various economic activities. This transition involves a fundamental departure from fossil fuel-dependent energy systems, steering towards cleaner and renewable sources. By doing so, the aim is to curtail the carbon footprint across industries, transportation, and other sectors. This paradigm shift towards a low-carbon economy aligns with the broader objectives of achieving sustainable development and mitigating climate change, with nations worldwide recognizing the imperative for action.

- **Defining the Low-Carbon Economy:** The concept of a low-carbon economy is rooted in the recognition of the environmental impacts associated with conventional economic practices. At its core, this paradigm envisions a future where economic growth is no longer synonymous with escalating carbon emissions. Instead, the emphasis lies in decoupling economic development from carbon-intensive processes. This decoupling is crucial for striking a delicate balance between fostering economic growth and ensuring environmental sustainability.

The transition involves the adoption of innovative technologies and the restructuring of existing systems to reduce reliance on fossil fuels. Cleaner and renewable energy sources, such as solar, wind, and hydropower, play a pivotal role in reshaping the energy landscape. Beyond the energy sector, a low-carbon economy encompasses changes in industrial processes, transportation modes, and land use practices. It signifies a comprehensive re-evaluation of how societies produce and consume, with the overarching goal of mitigating the impacts of climate change.

1.5.1 Key Components of a Low-Carbon Economy

1. **Renewable Energy Integration:** One of the cornerstones of a low-carbon economy is the widespread adoption of renewable energy sources. These sources, such as solar and wind, offer a cleaner alternative to traditional fossil fuels. Investments in renewable energy infrastructure, coupled with advancements in technology, contribute to the development of a robust and sustainable energy grid.
2. **Energy Efficiency Measures:** Energy efficiency is a linchpin for reducing carbon emissions. Industries, buildings, and transportation systems undergo transformations to optimize energy use. Implementation of energy-efficient technologies, smart buildings, and sustainable transportation options are integral to achieving significant emission reductions.
3. **Circular Economy Practices:** Shifting towards a circular economy model minimizes waste generation and promotes the recycling and reuse of materials. By closing the loop on resource use, a circular economy reduces the environmental impact of production and consumption.
4. **Green Transportation Initiatives:** Overhauling transportation systems is critical in a low-carbon economy. Electric vehicles, improved public transportation, and alternative fuels are pivotal components. Investment in sustainable infrastructure and the promotion of eco-friendly modes of transportation contribute to emissions reduction.

1.5.2 Global Initiatives and Commitments

The urgency of addressing climate change has ignited a wave of global initiatives and commitments as nations recognize the pressing need for collaborative action towards achieving a low-carbon economy. Governments and regional blocs worldwide are setting ambitious targets for carbon neutrality and emissions reduction, underscoring a shared commitment to mitigating the impacts of climate change. These endeavors reflect a growing awareness of the interconnected nature of environmental challenges and the need for a unified response on an international scale.

One exemplary leader in the global fight against climate change is the European Union (EU), which has positioned itself at the forefront of advocating for a sustainable, low-carbon future. The EU's ambitious roadmap, known as the European Green Deal, represents a paradigm shift in addressing climate and environmental challenges by transforming them into opportunities for economic growth and societal well-being.

The European Green Deal, launched in December 2019, outlines a comprehensive and transformative strategy to make the EU's economy sustainable. One of its primary objectives is to achieve climate neutrality by 2050, an ambitious goal that involves balancing the amount of greenhouse gases emitted with an equivalent amount removed from the atmosphere. This commitment demonstrates the EU's determination to lead the way in combating climate change and serves as an inspiration for other nations.

The European Green Deal encompasses various initiatives, policies, and legislative measures that touch upon multiple sectors of the economy. From investing in renewable energy and energy efficiency to promoting circular economy principles and biodiversity preservation, the EU's strategy is holistic and all-encompassing. Furthermore, the European Green Deal emphasizes the importance of a just transition, ensuring that the transformation to a green economy is fair and leaves no one behind.

On the global stage, initiatives such as the Paris Agreement have brought countries together to collectively combat climate change. Adopted in 2015, the Paris Agreement seeks to limit global warming to well below 2 degrees Celsius above pre-industrial levels, with efforts directed towards a 1.5-degree Celsius target. The agreement encourages countries to submit nationally determined contributions (NDCs), outlining their specific climate action plans and commitments.

The success of global initiatives hinges on collaboration, transparency, and accountability. Regular international conferences, such as the Conference of the Parties (COP) under the United Nations Framework Convention on Climate Change (UNFCCC), provide a platform for nations to review progress, share best practices, and negotiate additional measures. These forums play a crucial role in fostering a sense of shared responsibility and promoting the exchange of knowledge and expertise.

However, challenges persist in achieving global climate goals. Disparities in resources, differing levels of economic development, and conflicting national interests can impede the implementation of ambitious climate action plans. Overcoming these obstacles requires diplomatic finesse, innovative solutions, and a commitment to fostering equitable and inclusive partnerships.

The collective response to climate change through global initiatives and commitments reflects a shared recognition of the urgency and gravity of the environmental challenges we face. The European Green Deal, the Paris Agreement, and other similar endeavors showcase the potential for transformative change when nations collaborate towards a common goal. As the international community continues to navigate the complexities of climate action, it is imperative that stakeholders remain committed to the principles of unity, equity, and sustainable development to secure a resilient and low-carbon future for generations to come.

1.5.3 Challenges and Opportunities for Transition to a Low-Carbon Economy

The imperative transition to a low-carbon economy, driven by the global commitment to combat climate change, is not without its set of challenges. These challenges, while significant, are accompanied by substantial opportunities that have the potential to reshape economies and industries on a global scale. Addressing the complexities of

this transition requires a nuanced understanding of both the obstacles that lie ahead and the potential for transformative positive change.

One of the foremost challenges in the transition to a low-carbon economy is the substantial upfront costs associated with implementing new and sustainable technologies. The adoption of renewable energy sources, energy-efficient practices, and green infrastructure demands considerable initial investments. Governments, businesses, and communities must navigate financial constraints and develop innovative funding mechanisms to facilitate the widespread adoption of these technologies.

Additionally, the shift towards a low-carbon economy may result in job displacements in certain industries, particularly those heavily reliant on fossil fuels. The decline of traditional energy sectors may lead to workforce upheavals, necessitating comprehensive strategies for reskilling and upskilling workers to meet the demands of emerging green industries. Addressing the social and economic implications of job displacement is crucial to ensuring a just transition that considers the well-being of affected communities.

Another substantial challenge lies in the need for significant infrastructure investments to support the transition. The development of renewable energy facilities, smart grids, and sustainable transportation systems requires extensive planning, financing, and collaboration between public and private entities. Overcoming the existing infrastructure gap and ensuring the resilience of new systems is essential for a successful transition to a low-carbon economy.

Despite these challenges, the transition offers substantial opportunities for positive transformation. The emergence of new markets for green technologies is a key avenue for economic growth. Innovation in renewable energy, energy storage, and sustainable practices opens doors for businesses to capitalize on these burgeoning markets, fostering job creation and economic development.

Moreover, the transition to a low-carbon economy serves as a catalyst for innovation across various industries. As the demand for sustainable solutions rises, there is an increased focus on research and development to create cutting-edge technologies and practices. This innovation not only contributes to environmental sustainability but also enhances competitiveness on the global stage, positioning countries and companies at the forefront of the green revolution.

Enhanced energy security is another significant opportunity arising from the transition. Diversifying energy sources, reducing dependence on finite fossil fuels, and embracing renewable energy contribute to a more resilient and secure energy landscape. This not only mitigates geopolitical risks associated with resource dependency but also ensures a stable and sustainable energy supply for nations.

While the transition to a low-carbon economy presents formidable challenges, it simultaneously opens doors to unprecedented opportunities. Navigating the upfront costs, addressing job displacements, and making substantial infrastructure investments require strategic planning and collaboration. However, the emergence of new markets, the stimulation of innovation, and the enhancement of energy security underscore the transformative potential of this global shift. By addressing challenges proactively and leveraging opportunities, societies can pave the way for a sustainable and resilient future.

1.5.4 Economic Growth and Environmental Sustainability

Achieving a low-carbon economy necessitates a profound shift in the way societies conceptualize the connection between economic growth and environmental sustainability. In contrast to the outdated perspective that economic prosperity inherently leads to environmental degradation, the paradigm of a low-carbon economy champions a more symbiotic relationship. It fundamentally acknowledges that sustainable economic growth is intricately linked to the preservation and enhancement of the natural resources that serve as the foundation for all economic activities.

The conventional belief that economic progress requires the exploitation of natural resources without regard for environmental consequences has given way to a more enlightened understanding. In the pursuit of a low-carbon economy, there is a recognition that the traditional trade-off between economic development and environmental well-being is a false dichotomy. Instead, a new narrative emerges—one that asserts that a thriving economy can coexist harmoniously with a healthy environment.

A crucial aspect of this paradigm shift is the acknowledgment that the depletion and degradation of natural resources pose long-term risks to economic stability. The finite nature of many resources demands a shift towards sustainable practices to ensure their availability for future generations. A low-carbon economy recognizes the interdependence between economic activities and the ecosystems that support them, emphasizing the importance of responsible stewardship.

In this context, sustainable development becomes a guiding principle. It involves meeting the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable economic growth, a key tenet of a low-carbon economy, emphasizes resource efficiency, circular economies, and the integration of environmental, social, and economic considerations into decision-making processes.

A low-carbon economy promotes green technologies and practices that not only reduce carbon emissions but also enhance overall resource efficiency. Investments in renewable energy, energy-efficient technologies, and circular economy models contribute to decoupling economic growth from environmental degradation. These initiatives not only mitigate the impact of climate change but also foster resilience in the face of environmental challenges.

Furthermore, the transition to a low-carbon economy offers opportunities for job creation and economic diversification. Emerging sectors such as renewable energy, energy storage, and sustainable agriculture become engines of growth, demonstrating that environmental sustainability can be a catalyst for economic prosperity. Governments and businesses that invest in these sectors position themselves strategically in the evolving global economy while contributing to the overarching goal of environmental preservation.

It is essential to recognize that the symbiotic relationship between economic growth and environmental sustainability is not an abstract ideal but a pragmatic approach to securing long-term prosperity. The consequences of environmental degradation, such as natural disasters, loss of biodiversity, and resource scarcity,