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Renewable Energy Transition Strategies in the Gulf Cooperation Council (GCC) Countries

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Abstract

The value of The GCC region in the recovery of a renewable energy market and a sustainable economy is significant. Hence, considering the transitional strategies towards other renewable energy resources in the GCC countries has been the most critical scientific matter. The study on integrated renewable energy adoption in the GCC is based on an approach that incorporates descriptive research, quantitative analysis of data, and a synthesis of policy documents and the stakeholders' views. The findings demonstrate extensive policy-making and technology developments and also show confusion in legislation and infrastructure. The study clarifies the need for a firm integration policy, prioritized interventions, and cross-border cooperation to facilitate the transition to renewable energy. It supplies vital information concerning whether the policies and programs in the implementation process, diversification, and innovation in the GCC energy sector are worthwhile and have positive outcomes. A comprehensive examination of existing conditions and available opportunities for the transition to renewable sources of energy sets the foundation for the research to become a flagship for policymakers, members of the industry, and academicians concerned with energy policy, sustainability, and a broader point of view. The proposed measures contribute to understanding the intricate linkages among the factors involved in the GCC's energy transition and point out that the region has opportunities to initiate energy strategies that contribute to sustainable energy at an international level.

Renewable Energy Transition Strategies in the Gulf Cooperation Council (GCC) Countries

Introduction

In the present transitional period, the GCC states are introducing change in their petroleum-centric economic structure to build up new sustainable economy goals dependent on renewable energy sources. It is more than a mere global move to environmental sustainability; it is also a strategic option that will involve the diversification of the economy and innovation. The region, which has huge amounts of oil and is a major player in the world energy sector, is turning its efforts into collecting solar, wind, and other sources of renewable energy. On the other hand, renewable energies remain key to fighting climate change and meeting emission reduction levels in line with global sustainability goals. Nonetheless, a transition to renewables opens up new opportunities for diversifying the economy, creating new jobs, and promoting innovation to expand the economic base of a country on the eve of its leap to the frontier of the green energy revolution. The GCC region proposes the channeling of financial resources for green energy systems and start-ups, saying that such countries are fixating on a future existence only without fossil fuels, and the oil-dependent ones can go through a structural transformation and economic diversification with no sweat. The depth of the shift to renewable energy goes along with the concept of a green global energy system, implying the potential for sustainable environmental development and social and economic resilience. Renewable energy brings about technological revolutions.

Industry Overview

Today, the energy sector of GCC is undergoing a fundamental change from the old hydrocarbon-based economy to a new hybrid energy model that combines renewables and conventional resources. The change is principally induced by the strategic vision of the GCC governments, which is to take advantage of the region's abundant solar and wind resources. The

status quo showcases a panorama with diverse national visions being expressed, including that of Saudi Arabia's Vision 2030, which is expansive as it includes the mammoth NEOM project that targets a futuristic approach to energy production, and that of the UAE's Energy Strategy 2050c, which aims at 50% clean energy by 2050. Crucial actors in that change are the state enterprises such as Saudi Aramco and the Abu Dhabi National Oil Company (ADNOC), which invest in renewable energy projects and research (Al-Sarihi et al., 2022). Moreover, foreign firms and pioneers in renewable energies entering the market indicate supportive policies and investment incentives. Bhatt (2021) evaluated that the private and public sector entities undertake, among other significant tasks, building renewable energy infrastructures, technologies, and human capacity (Bhatt, 2021). The partnership between governments, private perspective companies, and international players is essential in implementing the renewables market, which creates the conditions for clean and renewable energy in the GCC.

Research Problem

The renewable energy transition towards clean energy in GCC countries poses a complicated mixture of challenges and possibilities while leaving a vast and discernible gap in the preparation and implementation stages where its member states differ significantly. The GCC region holds immense potential for utilizing renewable energy sources, but structural problems, regulatory limitations, and lack of financial resources hamper it. For example, even though such a broad continent can produce more than 2200 gigawatts of solar power, the current installed capacity is way below expectations, with countries having a massive disparity in where solar power investment is focused (Amankwa et al., 2021). On the other hand, the UAE targets a 50% renewable energy mix by 2050, while some countries are just beginning. The complicated nature of the transition also goes hand in hand with the hydrocarbon-based economic models that require significant policy, technology innovation, and human capital development to accommodate

renewable energy systems (Gielen, 2021). Nevertheless, the vast opportunities encompass future energy security, economic diversification, and sustainable growth. This gap in preparedness among the GCC countries stresses the necessity of a regionally coordinated strategy, which must enhance the use of individual national abilities, transfer of technology and knowledge, and align the policies for a speedy transformation to clean energy.

Research Significance

This study plays a fundamental role in the future of GCC countries since it explores the impact that renewable energy transition can create locally and globally. Owing to its dependence on oil and gas income, the GCC now looks to diversify its economy and explore the possibility of energy alternatives to ensure Resilience and a prosperous future beyond this volatile global energy market and the current climate crisis. The redistribution of resources to renewables provides the means to reduce carbon emissions sharply and enables the state to fulfill its commitments to international environmental responsibilities. It also drives socio-economic growth by promoting job creation and technology development and attracting foreign investments (Alharbi et al., 2021). The GCC countries can also increase their export capacities by making their countries less dependent on fossil fuels, which would directly impact the global energy supplies and be a step towards a new balanced and reliable energy world. The core value of the research is in delineating the realizable strategies for the policy recommendations and the efficient movement to an evolved state that can be a template for others who are oil-dependent economies.

Research Objectives

1. To evaluate the current strategies and policies adopted by GCC countries for transitioning towards renewable energy, identifying key drivers and barriers.

2. To analyze renewable energy adoption's economic, environmental, and technological impacts on the GCC region, focusing on its potential for economic diversification and sustainability.
3. To assess the disparity in renewable energy preparation and implementation stages among GCC countries, offering insights into regional collaboration and policy harmonization.
4. To propose actionable recommendations for enhancing the effectiveness of renewable energy transition strategies in the GCC to achieve long-term energy security and sustainable development.

Research Questions

1. What are the key strategies and policies currently being implemented by GCC countries to facilitate the transition towards renewable energy, and what are the primary drivers and obstacles encountered in this process?
2. How does adopting renewable energy sources impact the GCC region regarding economic diversification, environmental sustainability, and technological advancement?
3. What are the variations in the stages of preparation and implementation of renewable energy projects among the GCC countries, and how do these disparities affect regional energy security and integration?
4. What recommendations can be made to improve the efficiency and effectiveness of renewable energy transition strategies in the GCC, ensuring long-term sustainability and energy independence goals?

Research Hypothesis

1. Adopting strategic policies and investments in renewable energy in the GCC countries significantly contributes to overcoming the barriers to transition, including technological, regulatory, and financial challenges.

2. The transition towards renewable energy in the GCC region positively impacts economic diversification, reducing reliance on oil revenues and fostering sustainable development while enhancing environmental sustainability through reduced carbon emissions.
3. Disparities in the preparation and implementation stages of renewable energy projects among GCC countries are primarily influenced by differences in national policy frameworks, financial capabilities, and technological readiness, impacting regional energy integration and security.
4. Implementing a unified GCC-wide renewable energy strategy, including harmonized policies, shared technological innovations, and collaborative investment models, will significantly enhance the effectiveness and efficiency of the renewable energy transition in the region.

Structure of Research

The report's structure is designed to give a complete look into the strategies of the renewable energy transition in the Gulf Cooperation Council (GCC) states that we highlight in the next four chapters. The first chapter, which is the introductory part, brings up the research topic and presents the issue and the opportunities and challenges associated with the energy transition in the GCC region. It introduces the current status of the new energy industry and defines the research problem, objectives, questions, and hypotheses. The next chapter focuses on a literature review, supplying a detailed theoretical framework and examining previous studies to present gaps and insights. Chapter three narrates the research methodology, covering the research design, data collection, analysis methods, and ethical considerations. The paper ends with a section of findings for the directions of policy and practice, the limitations, and future research directions. Such structure provides a logical order of information and, thus, helps grasp fully the different areas of the GCC's renewable energy arena.

Literature Review

Introduction

The literature review begins an explorative journey to determine the number and dimensions of the transformational landscape of the renewable energy transition within the Gulf Cooperation Council (GCC) countries. Furthermore, it attempts to dissect the multi-layered layers of this transition. The viewpoint of this review encompasses a detailed evaluation of the theoretical bases of the energy transition, a comparison of the renewable energy plans and initiatives across the GCC, and an analysis of the economic, environmental, and technological effects of these initiatives. Furthermore, it closely reviews the issues and obstacles that delay a renewable energy transition in the region. The objectives are twofold: to offer a review and critical analysis of the latest findings and literature on the topic to identify the lacks that might enable them to serve as the basis for further improvement. The review, therefore, provides a foundation for a deeper understanding of the factors impacting renewable energy trends in the GCC through achieving these purposes.

The transition to renewable energy in GCC countries, which is not just a policy but a revolutionary act in the face of global environmental challenges and economic diversification problems, is considered a must. While this region's potential for solar and wind power is one of the highest globally, it is on the brink of a new era that may also reshape these regions' economic and environmental situations. The significance of this turnabout reaches beyond the geographical borders to serve as a paradigm for other oil-exporting economies facing similar sustainability issues (Salim et al., 2021). Furthermore, the success of the integration of renewable sources of energy may fast-track the GCC countries to a leadership position in global energy markets, bringing valuable lessons on how economic growth can be ensured while taking care of the environment. Hence, this literature review aims to present these transitioning roads through

renewable energy, which is the guiding light in bringing about a sustainable and prosperous future for the GCC.

Theoretical Framework

Renewable Energy Transition Theories

The renewable energy transition is underpinned by several key theories that provide a conceptual foundation for understanding the dynamics of shifting from fossil-based to renewable energy sources.

Energy Transition Theory

The Energy Transition Theory expounds on the fact that societies undergo different phases of energy regimes, which start from traditional biomass and go through completion to cleaner sources like coal and petroleum and finally to renewables due to technological advancements, economics, and social structures. The paradigm clearly shows the inescapable adoption of new and green energy sources, underlining the leading role of new technologies and the economic stimuli in this process (Al-Saidi, 2020). Building upon the growing world awareness of the risks of climate change, the GCC, in a general framework, highlights the region's key development phase from an oil-dependent economy to the adoption of renewable energy sources disseminated mainly for economic diversification and sustainability.

Diffusion of Innovations Theory

Rogers's Diffusion of Innovations Theory describes how innovations and technologies spread within or among societies. It is critical to comprehend renewable energy technology adoption, factors including attributes of technologies, sociocultural values, and communication channels being fundamental (Abdeldayem et al., 2021). This theory can be applied to GCC's renewable energy sector to adopt and analyze renewable energy technologies through policy, investment, and societal acceptance.

Socio-Technical Transition Theory

The Socio-Technical Transition Theory glances at the existing societal need for technology increment, level with technological developments, and jointly creates an energy system change. Such multiple approach assumes these phenomena are a consequence of technology emergence, policy changes, cultural influence and finally, influence on user practices. Such a concept is very much applicable to Gulf Cooperation Council (GCC) countries and the transformation to renewable resources, where technology is only a part of the whole transformational process, not to mention the market, institution, and societal norms (Mohammed et al., 2023). The theory signifies that the transformation of the GCC from fossil fuels to renewable sources of energy should be successful. To solve this multifaceted problem, we have to create conditions for innovation and find a place for new energy technology to exist.

Theory	Description	Application in GCC Context
Energy Transition Theory	Societies evolve through different energy regimes due to technological and economic changes.	Highlights the region's transition from oil to renewable energy, driven by sustainability and economic diversification.
Diffusion of Innovations Theory	Examines how new technologies spread within a society.	Analyses the adoption of solar and wind technologies in the GCC, emphasizing the importance of policy, investment, and societal acceptance.
Socio-Technical Transition Theory	Focuses on the interaction between societal needs and technological developments to drive systemic change.	Suggests the GCC's renewable energy transition requires comprehensive changes in technology, policy, culture, and practices to support innovation and new energy technologies.

Renewable Energy Policies and Strategies in the GCC

The GCC member countries are slowly introducing renewable energy regulations as an indispensable component of their national energy strategies and in recognition of the need for

alternative power sources and greenhouse gas reduction. According to Praveen et al. (2020), every Member State is executing several policies that are precisely aligned with the growth and proliferation of renewable energy technologies, such as solar and wind energy technologies, which are heavily dependent on the availability of renewable resources in the region. These measures comprise financial instruments, including feed-in tariffs and grants, administrative mechanisms like renewable energy targets and mandates and policy instruments targeted towards research and development in clean energy technologies (Praveen et al., 2020). Vision 2030 constitutes the set of measures generated by Saudi Arabia to promote economic diversification and fulfil the ambitious plan to have 50% of the total electricity needed from renewable sources by 2030.

The United Arab Emirates (UAE) gains praise and honour for its early and pioneering efforts to support renewable energy, which the GCC countries can use as a model. Energy Strategy 2050's vision focuses on enhancing renewable energy contribution by 44% to UAE, mainly via solar projects like Mohammed bin Rashid Al Maktoum Solar Park, among the giant solar energy plants worldwide (Umar et al., 2020). In addition, the UAE officially became the host to the International Renewable Energy Agency (IRENA) in 2015, being designated as the country based its leadership on renewable energy promotion. Meanwhile, some GCC countries are in different stages of policymaking whereby formulation and implementation of their domestic policies are suggested according to their national peculiarities – economic, social and territorial ones (ElMassah et al., 2023). Distinctions in renewable energy policies among gulf states pertained to the region due to the diversity, so in-depth studying of various GCC policies regarding the abovementioned area became necessary. The renewable energy goals of the two countries, Kuwait and Oman, are not as high. However, they are gearing towards or have installed more renewable sources of energy mix in their technological layers (Amoatey et al., 2022). The 2030 vision of

Kuwait contributes about 15% of the power from renewable sources, while Oman's Vision 2040 aims at letting renewable energy cater to the demand as a whole.

Country	Renewable Energy Targets	Key Policies and Initiatives	Major Projects
Saudi Arabia	50% by 2030	Vision 2030, National Renewable Energy Program (NREP)	Neom, Red Sea Project
UAE	44% by 2050	Energy Strategy 2050, Dubai Clean Energy Strategy 2050	Mohammed bin Rashid Al Maktoum Solar Park
Kuwait	15% by 2030	Kuwait Vision 2030, National Energy Efficiency Project	Al-Dibdibah Solar Park
Oman	Not specified	Oman Vision 2040, Tanfeedh Programme	Dhofar Wind Farm
Bahrain	10% by 2035	National Renewable Energy Action Plan (NREAP)	Bahrain Solar Energy Pilot Project
Qatar	20% by 2030	Qatar National Vision 2030, Qatar Solar Energy Strategy	Al Kharsaah Solar PV Power Plant

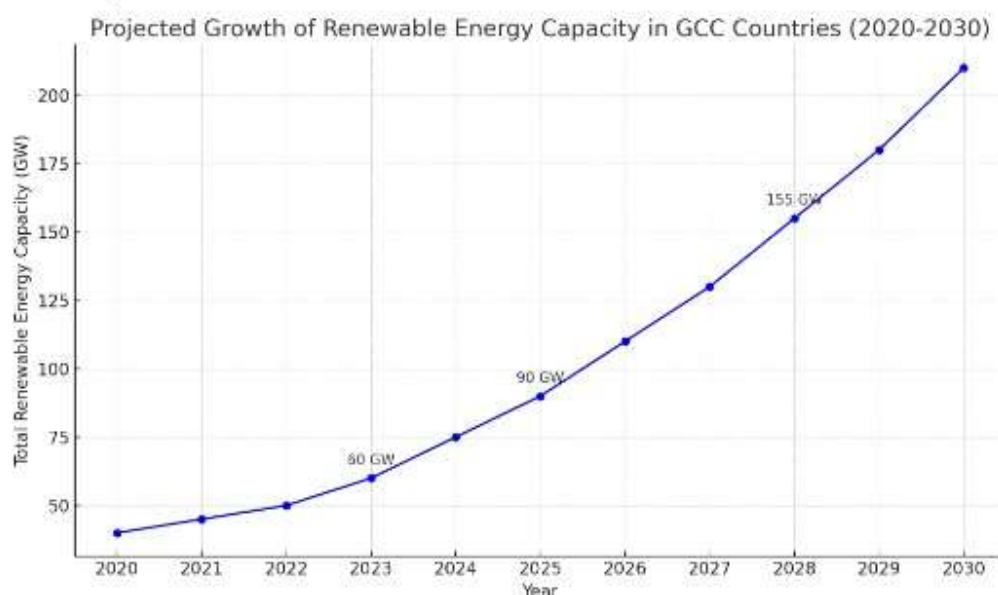
Strategic Initiatives and Projects

The states of GCC have proved the region's sense of determination by launching several landmark renewable energy projects and strategically approved initiatives aimed at diversifying the energy portfolio. These projects achieve the renewable energy goals that the Nations have set and place the GCC as the global forerunner of the renewable energy field. In Saudi Arabia, the Vision 2030 initiative gives new life to many projects, among which the Neom City project stands out. Neom is hoped to be a 100% renewable energy economy that reflects the country's forward movement into innovation and sustainability (Zumbraege, 2022). Similarly, the Red Sea Project,

a large-scale tourism development project, aims to be run entirely by renewables, indicating Saudi Arabia's aspiration towards sustainable development.

United Arab Emirates (UAE) has also pioneered the integration of renewable power within its national power strategy. The Mohammed bin Rashid solar park in Dubai, UAE, is amongst the largest renewable energy projects worldwide, with a planned capacity of 5000 MW by 2030. The solar park manifests the UAE's energy strategy 2050, which aims at an energy mix that is in balance and incorporates renewables as a significant component (Alnaqbi et al., 2023). Furthermore, the Barakah Nuclear Energy Plant is being developed in a direction that follows renewables, away from fossil fuels, and towards a greener country.

Besides that, Kuwait's Al-Dibdiba Solar Park Dhofar Wind Farm in Oman opens up numerous ways the GCC is pursuing renewable energy ventures. Kuwait's solar park aspires to generate 15% of the country's electricity by 2030, which aligns with the national renewable energy strategy. Oman's multi-megawatt wind farm is the first-ever large-scale wind power project in the GCC (Darwish, 2022). The latter demonstrates that Oman is exploring new sources with a significant positive environmental impact. These projects would demonstrate leadership in adopting renewable energy in the GCC region and beyond through a mix of solar, wind, and nuclear power to provide a balanced and sustainable energy future.



Economic, Environmental, and Technological Impacts

Economic Impacts and Diversification

The green energy transformation in the Gulf Cooperation Council (GCC) states is not only about the good of the environment but also about economic strategic diversification from oil-based economies. This transition to renewables could act as an engine of economic growth, stimulating the creation of new jobs, new industries, and the flow of foreign direct investments (FDI). The establishment of solar, wind, and other clean energy industries entails skilled labor from the engineering, construction, operations, and maintenance services, thus creating a workforce across the region (KeukPanossian, 2023). Besides, taking the GCC countries as the trailblazers in renewable energy technology implementation creates an attractiveness for investment in green technologies that, in turn, contribute to economic growth and diversification of the economies (Coccato, 2020). Renewable energy development also fuels the development of local industries, such as the making of solar cells and wind turbines, which eventually increases the economic base. Moreover, renewable energy projects offer GCC added energy security and export chance, minimizing home demand for fossil fuels to the extent that more oil or gas would be left to be

exported. By implementing this strategic change, countries can balance their trade patterns and shield themselves from the negative effects of volatility in global oil prices. Long-term reductions in production costs for renewables could also lead to lower electricity prices for both industries and consumers, improving GCC competitiveness on the world stage (Al Naimi, 2022). GCC countries take the renewable energy move as an inevitable economic diversification driver that aims to change the whole economic landscape by reducing oil dependency and opening a new path to future sustainable long-term growth.

Benefit	Description	Expected Impact in the GCC
Job Creation	New roles in renewable energy sectors such as construction, operation, and maintenance.	Increase in skilled and technical employment opportunities.
Foreign Direct Investment (FDI)	Investments in renewable energy projects and related technologies.	Enhancement of economic growth and technology transfer.
Industrial Development	Local manufacturing and services related to renewable energy technologies.	Diversification of the industrial sector and reduction in imports.
Energy Security	Reduction in domestic fossil fuel consumption, freeing up more resources for export.	Improved trade balances and reduced exposure to global energy price fluctuations.
Lower Energy Costs	Decrease in the long-term costs of energy production and potentially lower electricity prices.	Increased competitiveness of local industries and cost savings for consumers.

Environmental Sustainability

Transitioning to renewable energy in the Gulf Cooperation Council (GCC) countries is an environmentally friendly choice, moves the region to mitigate climate change, and conserves nature. By transitioning from energy generated from fossil fuels to renewables such as solar and wind power, the GCC region is projected to decrease its carbon footprint drastically. Shrinking the amount of greenhouse gas emissions is important for the global effort to keep the warming within

the 2 degree Celsius level which is what the Paris Agreement requires. Renewable energy projects, additionally, have lower consequential water and air pollution during their operations, resulting in healthier air quality and lifestyle for the public (Ben Hassen, 2022). The region's solar and wind resources constitute a sustainable solution to the energy needs, given that they do not exhaust the limited natural resources, and this helps conserve the environment for generations to come in the future. Moreover, the development of renewable energy makes the conservation of sensitive ecosystems easier to achieve since they are untouched by environmental interferences, which are an everyday story in the process of the extraction and burning of fossil sources.

In addition, the progression to renewable energy is achieved by the development of innovations in energy efficiency and storage, which are other factors that increase the level of environmental sustainability. Compatibility of the smart grids with power storage processes helps to regulate the variability of renewable energy sources thus providing a stable and reliable electricity supply. The development of this technology allows not only the integration of renewables into the existing energy network but also contributes to the building of a more robust energy infrastructure that is able to absorb the effects of climate change. The GCC's pledge to the transformation of renewable energy is, thus, a crucial part of its multi-pronged environmental strategy, which is designed to break the dependence on nonrenewable resources and curb the adverse impacts of energy production on the environment (Al-Saidi, 2021). These policies will not only help combat climate change at the global level. However, they will also set an example as far as sustainable development is concerned in the sense that regions that are rich in fossil fuels will be able to diversify their energy portfolios so that they can achieve economic growth and still preserve the environment.

Technological Innovation and Development

Technological advancements constitute a critical component that helps in the smooth implementation as well as integration of renewable energy projects within the Gulf Cooperation Council (GCC) states. The renewable energy system has gained popularity due to the dramatic improvement in solar PV cells, wind turbine designs, and energy storage solutions, which has enhanced the effectiveness and cost efficiency of renewable energy systems (Alnaser et al., 2022). The GCC area, which is commonly acknowledged as one of the regions with the highest solar irradiance on the Earth, has achieved significant success in the domain of PV technology, for example, bifacial panels that explore sunlight from the top and the bottom, which in turn significantly increased energy efficiency. Furthermore, the production of turbines of bigger sizes and productivity allows wind energy to be harnessed even in places with low wind speeds (Alnaser et al., 2022). The novel tech, especially in the field of renewable energies, has a considerable impact on curbing the intermittency of renewables and electricity reliability in the energy supply chain.

Furthermore, the inclusion of renewable power into the current electricity grid infrastructure is fostered by innovations in smart grid technology and battery storage. Smart grids provide real-time monitoring and management of energy fluxes thus achieving the balancing function between supply and demand. In contrast, the energy is stored in battery storage systems when overproduction occurs at the peak production age. The technologies of energy storage and the grid based on renewable sources greatly use these technologies, as they stand tall on compatibility (Khan et al., 2020). In GCC, pilot projects utilizing these technologies are being carried out that would bring this transformational move across the region. Furthermore, the invention of green hydrogen, a zero-emission energy carrier that is produced using electricity generated from renewable sources by means of electrolysis of water, presents a new prospect for

energy storage and transportation, potentially reforming the energy sector (Zubari, 2020). GCC's investments in such technological innovations serve as a means of supporting the transition to renewable energy. At the same time, such investments position the region as a leader in the global energy transition, thus contributing to knowledge sharing and development on a global scale.

Innovation	Description	Application in GCC Projects
Bifacial Solar Panels	Solar panels that capture sunlight from both sides, increasing energy yield.	Used in solar farms across the GCC to maximize energy production.
Large Wind Turbines	Wind turbines with increased rotor diameters and heights, enhancing efficiency and energy capture.	Implemented in wind projects to exploit lower wind speeds in the region.
Smart Grids	Advanced grid systems that allow for real-time monitoring and management of energy flows.	Piloted in various locations to integrate renewable sources and improve grid stability.
Battery Storage	Systems for storing excess energy, addressing the intermittency of renewable sources.	Utilized alongside renewables to ensure a reliable energy supply.
Green Hydrogen	Produced through the electrolysis of water using renewable electricity, offering a clean energy carrier.	Explored in pilot projects as a solution for energy storage and transportation.

Challenges and Barriers in the Renewable Energy Transition

Infrastructural Challenges

The GCC countries are confronted with challenging infrastructural issues while they are shifting towards renewable energy, a process that not only requires substantial financial resources but also requires significant energy infrastructure systems. The main barrier is the congruity of renewable energy sources to the existing electric system that was developed predominantly for uniform, regimented power generation from fossil fuels. Renewable energy, especially from wind and solar, comes with challenges of variability and decentralization, which in turn ask for advanced grid management technologies and storage solutions to ensure the security and reliability of the grids (Dadashi et al., 2022). Further, the established grid system will likely need improvement to

handle the surge at points of connection and the grid's ability to feed from various distributed renewable plants. This challenge becomes even more complex when cross-border infrastructure must be developed to increase trading and improve the optimization of energy among the countries of the GCC, requiring harmonized policies and regulatory frameworks so that the real potential of a regional renewable energy market can be achieved.

Additionally, the GCC's severe climatic conditions involve specific obstacles to the implementation of renewable energy infrastructure. Higher temperatures coupled with sediment increase solar panel efficiency, reducing sand piling to mechanical devices that appear on wind turbines. Those have to be regularly checked, and new, more resistant technologies must be developed. These environmental conditions have a similar influence on the expenses and effects of renewable energy projects. Therefore, contemporary design materials and methods are required, especially for the local climatic conditions (Alam et al., 2023). In addition, greenhouse gases, as the cutting edge of clean energy, have infrastructure problems, namely the rise of electrolysis plants, storage facilities, and transport networks. Eliminating these infrastructural problems is the task of the researchers in conducting research and development, international collaboration, and significant time capital investment. Conquering these impediments is of great importance for GCC member states in order to fulfill their renewable energy objectives and have a secure and green energy future.

Policy and Regulatory Barriers

Policy and regulatory mechanisms govern the growth of renewable energy, and in the GCC region, they mainly specify the path of the wide-scale implementation of renewable energy projects. The main problem is that none of the GCC countries have comprehensive and cohesive policies that are specifically meant to ease the loss of fossil fuels and the shift to renewable energy. Even though individual states have demonstrated their ability by setting renewable energy goals

and undertaking various projects, the lack of regional laws and regulations in unison can result in the loss of efficiency and the wastage of the potential for cross-border cooperation (Amerit et al., 2022). Also, fossil fuel subsidies continue to pose a problem, keeping the costs of traditional energy less than even with renewables, and this creates an environment that discourages looking for cleaner energy solutions. Such subsidies may create imbalances in energy markets. At the same time, they canoe the conditions of the financial well-being of all initiatives that seek to develop renewable energy projects by destroying the willingness to invest in the renewables market.

Moreover, the regulatory frameworks of the GCC persistently need to provide the regulatory tools that are needed to integrate renewable energy into the region's national grids. They lack a fixed rate payment system, net energy metering and standardized interconnection process, which would have highly supported both commercial and residential production of renewable power through the grid, apart from the administrative obstacles and delayed approvals for the implementation of new projects, investment and creativity in the renewable energy sector are interrupted as well (Yusuf et al., 2023). Apart from the need for regulators that could cope with the lightning-speed technological revolution in renewables and energy storage, policy-making bodies should also be taken into account in such a dynamic sector to avoid the pitfall of obsolete regulations as the sector develops. Overcoming the policy and regulatory barriers is what promises to GCC countries and prop up a rapid spread of renewable energy in this region (LaMonaca et al., 2022). The process of reforming energy subsidies and developing supportive policies and regulations is crucial in building a conducive environment for renewable energy investment. For these purposes to be fulfilled, the GCC is not only likely to reach its renewable energy goals but also assist other countries in the fight against climate change and their path towards sustainable development.

Research Methodology

Research Philosophy

The adoption of positivism as the research philosophy is the best choice for examining the renewable energy policies in the Gulf Countries Cooperation (GCC). The human experience is the cornerstone of positivism, while empirical scientific investigation concerning the energy sector relies upon observable phenomena and empirical pieces of evidence, which results in the provision of facts. This kind of philosophy matches the purpose of this study, which is to determine the effect of targeted policies and programs on the transition to renewable energy. A science-based approach helps systematize the process around the inception of the new hypothesis relating to the development of economic diversification and technological progress. The results may be discovered by comparing theoretical models to actual development outcomes. Through the acceptance of positivism, the research will be based on quantitative data and statistical analysis to conclude the research, and a causal-comparative research design is more likely to produce valid and reliable results. This neutral standpoint is crucial when analyzing the efficiency of policy tools and the practical implications for the GCC region's energy system.

Research Approach

The deductive research method is chosen for this study on renewable energy strategies in the Gulf Cooperation Council (GCC) since it is helpful in investigating ideas offered by a particular theory within a framework. Through deductive reasoning, precise expectations are developed since previous theories on renewable energy transition, economic sustainability and conservation solely exist. The approach starts with a general theory and then focuses on the specific facts, which makes it an excellent method for the degree of integration of GCC renewable energy policies with the prevalent models of energy transition. It deciphers a way either to corroborate or dispute the existing knowledge since it contains a systemic approach to measuring the exerted influence of

policy implementation and technology advancements within the region of GCC States (Aqeeq et al., 2023). The deductive approach is what the study will use in order to bring an advanced level otherwise empirical foundation of how strategic choices and cash disbursement impact the rate and achievement of renewable energy implementation in the region.

Research Method

A qualitative research method has been chosen to explore the phenomenon of renewable sources of energy within the GCC because measurable, numeric data are necessitated for statistical analysis. This technique is considerably significant when it comes to quantifying the depth and pace of adoption of renewable energy, which in turn facilitates the examination of causality between policies and energy results. Instead of relying on qualitative assessment, the quantitative method paves the way for properness or otherwise in operationalizing variables such as investment levels, power output, and emission reductions, which can then be systematically measured and compared across different countries and periods. Statistical methods are used to uncover the patterns, trends, and associations that may be missed in qualitative analysis (Abdeldayem et al., 2022). Such an approach offers an opportunity to validate the research hypothesis robustly. Similarly, a quantitative approach allows the study to generalize the results, making projections that can show trends all through GCC and with the possibility of having conclusions that can help in policymaking and strategic planning. In addition, it allows the establishment of predictive model scenarios that show the future energy situation using the current resources. Specifically, the scientifically sound methodology with its validity grade underlying it provides the possibility to examine the findings more closely and apply them in an energy transition context.

Research Strategy

This study uses archival research, which is most suitable for exploring the transition to renewable energy in the GCC countries, such as the Gulf Cooperation Council (GCC). Such a

strategy provides for the complete analysis of that information. Both historical documents and policy papers may be used for energy reports and records of all renewable projects in the GCC (Brannstrom et al., 2022). Through the refinement of archival research, we have an opportunity for an in-depth, deep analysis of the progress and present condition of renewable energy movements, thereby extracting from a rich collection of existing data. Data collected from policy analysis, strategic planning and implementation progress over the period offers a temporal viewpoint, thus representing the longer-term trends and patterns.

Besides government and industrial archives, this is aided by using peer-reviewed journals, which represent the pool of the finest scholars' research and in-depth research. These journals provide information for ongoing, up-to-date, evidence-based research findings, evaluative reviews, and theoretical discussions on renewable energy (Zayadin et al., 2022). It contributes as a much-needed authentic and reliable source of information, where the recent advancements surrounding technology, policies, and renewable energy environment evaluations and impacts are covered. The combination of archival material with journal publications creates a reliable and robust methodology that enriches the credibility of the research and offers an array of perspectives on the renewable energy environment in the GCC.

Time Horizons

The study applies a longitudinal method and aims to trace and analyze the development of renewable energy transition trends within the Gulf Cooperation Council (GCC) over time, offering a dynamic perspective of progress and phases that take place in different periods. This design is critical for seeing the way that policy implementation happens step by step and, of course, the technologies that keep on growing. Hence, the research can see what is happening during the time and assess the overall effects of different strategies. The collection of data at different intervals repeatedly gives a temporal depth that is usually not possible in a cross-sectional study, which, in

addition to the immediate outcomes of renewable energy initiatives, also sheds light on their sustainability and long-term viability. This discovery helps us to propose the speed of the transition, the potentiality of renewable energy projects, and the responsiveness of the energy market in GCC countries to policy and global economic fluctuations. In addition, it gives us an opportunity to study causal relationships, like the influence of options on the growth of new energy sources in the long term. The holistic perspective offered by the longitudinal research design is incomparably supportive for the policymaker and others who are the stakeholders in this sector, providing appreciable knowledge towards the development of the area which holds a reliance on the renewable energy policies in the GCC.

TIME HORIZON	FOCUS	EXPECTED OUTCOMES
SHORT-TERM	Initial adoption and implementation of policies	Baseline establishment, policy impact assessment
MEDIUM-TERM	Development and expansion of renewable energy projects	Evaluation of project scalability, economic and technological impact
LONG-TERM	Sustained integration into energy grid and market effects	Long-term environmental benefits, economic stability, policy refinement

Data Collection Methods

In this study, the disclosure index will be used as a quantitative tool for data collection that allows for the measurement of the availability and disclosure of renewable energy data in the GCC region. Following the predefined parameters that check the comprehensiveness, accuracy, and granularity for disclosing data made available by governmental agencies, energy authorities, and related organizations, the search index will be constructed. Every criterion will be assessed, and the final aggregated scores will be built to evaluate the comprehensive disclosure ratings of each GCC country (Alsharari et al., 2023). Through this systematic approach, each country's policies, projects, and outcomes regarding renewable energy sources are being done a comparative analysis.

It offers insights into how the transparency and openness that are important in effective policy-making and public engagement in this field are working.

The disclosure score will be accompanied by a manifesto-style content analysis of the policy documents, official reports, and archival records, which will be collected and represented as quantitative patterns. Such a process can be comprehended as the systematic review of texts with the aim of finding words, expressions, themes and topics relating to renewable energy proposals. The process will be standardized by developing a coding framework to guarantee that the gathered data is consistent and reliable. Some articles of general information will be coded and classified into four main parts, which include policy objectives, implementation strategies, project outputs and technological advancements (Alsharari et al., 2023). This qualitative assessment will enhance the understanding of renewable energy transition in GCC not only through the data collected through the disclosure index but also with the view of the quantitative data. This way, the qualitative and quantitative perspectives will be represented.

Data Analysis Methods

The study will systematically apply descriptive statistics so as to comprehensively explain and represent the collected data information, giving a general overview of the existing patterns in renewable energy adoption in the Gulf Cooperation Council (GCC) nations. This statistical approach will be used for calculating fundamental measures like mean and median as well as rates of dispersion like range and standard deviation to provide a portrayal of renewable energy projects, investment levels and influence of policies over the region (Peel, 2020). Through descriptive statistics, the data interpretation will be from the basics to provide knowledge on overall tendencies in the renewable energy transition efforts in the GCC region, such as the similarities and differences among member nations associated with policy effectiveness, technology adoption rate, and investment flows. Such an approach enables the scanning of the whole dataset, allowing for

further procedures as well as providing the stakeholders with easy-to-understand findings about renewable energy.

The multiple regression analysis will play an essential role in adding to the significant findings of the descriptive statistics, as this will enable us to understand the relationships that are likely to exist between the various policy instruments and the rate of renewable energy adoption. Such a method of investigation served the questions of how the independent variables, which might include the financial incentives, regulatory frameworks, and technological support measures together affect the dependent variable, which in this case is the rate of renewable energy adoption (Peel, 2020). Manipulating the environmental factors assists the regulation of multiple regression so that its effect is observed on renewable energy implementation with facts and a corresponding theoretical assertion of the resemblances in the effectiveness of the different energy policies. By means of this complex research, the fundamental dynamics of policies will be revealed, driving for green energy in the GCC, showing effective strategies, and giving guidance for policy development in the future.

Target Population and Sampling

The study population for this investigation corresponds with a heterogeneous group of stakeholders that are actively involved in the renewable energy sector throughout the Gulf Cooperation Council (GCC) countries, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Literally, the range of the participants is impressive, including the government bodies responsible for energy policy and regulation, energy companies, which are the leading innovators of renewable energy projects and NGOs, which are the advocates of sustainable energy practices (Wijewickrama et al., 2020). As this community is enormous and there exist a lot of interests and approaches to renewable energy development, stratified sampling is going to be

used to ensure that the sample will reflect the variety of attitudes and standpoints within the renewable energy environment.

Ethical Considerations

In any research that involves the use of individuals or organizations, it's necessary to make sure that they are well-informed and they have a choice to participate. The latter entails the effective communication of the research objectives, the utilization of data, as well as the benefits and risks associated with the participation of stakeholders. Such information allows them to decide for themselves whether to be involved (Schwartz et al., 2020). The identity of participants and the information sensitive to them must be protected, and confidentiality and anonymity should be carefully maintained. Besides this, the issue of privacy is especially critical in terms of industry-owned data from energy companies or confidential documents pertaining to the government. The security will follow stringent data protection protocols and technical measures to prevent such sensitive information from unauthorized access or misappropriation.

Likewise, the research process should feature impartiality and the absence of biases that could affect the outcome or conclusions. The latter includes such a critical analysis of sources, where data is collected, and its analysis is transparent and methodologically sound. The impact of the research outcomes on public opinion and policymaking demands a careful and ethical way of reporting it and, therefore, should be conveyed in order to avoid a sensation or exaggeration (Eaton, 2020). It is also pivotal to take into account the limitations as it explains any findings and recommendations of the research. The research follows these ethical principles to have significant findings on renewable energy transition in the GCC. The output will help to build consensus and decisions while respecting everyone's rights and dignity.

Inference

The transition process of renewable energy strategies in the Gulf Cooperation Council (GCC) states is to be looked at now as it is a crucial and urgent issue across the globe. In addition, GCC's distinguished position as a significant energy supplier is another factor that has to be put into consideration. The research involves the systematic assessment of the compact components of the transition that involve changes in policy and regulatory frameworks, technological innovations, and economic impacts and also the methodology relates to the reliability and relevance of the findings. By delineating the challenges and the prospects of renewable energy in the GCC countries, the study adds to the region's cognitive map of transition. It emphasizes the centrality of comprehensive policies, technological breakthroughs, and global partnerships in driving the switch to renewable resources. The latter implies that the gathered knowledge here is beneficial to public officials, business people, and researchers in the sense that it will act as a basis for the coming projects and studies under the renewable energy transition. The carbon-reduction initiative of the GCC states is by far a perfect example of the complexities and opportunities that come with a global transition towards greener energy sources.

Chapter 4: Findings

As a result of the qualitative analysis of relevant documents and archival sources (comprising historical documents, policy papers, energy reports, and economic roadmaps), the current study established the current state of renewable energy across the GCC countries. The compiled data that resulted from the analysis provides an overview of the countries' investments in renewable energy as a percentage of their GDPs, the amount of renewable energy produced by each country, the existence and nature of tax breaks and incentives relating to renewable energy, the major renewable energy projects underway in the countries, and the amount of carbon emissions that each of the countries produces. Table 4.1 below illustrates the current status of GCC countries in relation to renewable energy.

Table 4.1. Current Status of GCC Countries in Relation to Renewable Energy

Country	Renewable Energy Investment (% of GDP)	Renewable Energy Production (mWh)	Tax Breaks & Incentives	Carbon Emissions (metric tons)	Major Renewable Energy Projects
Saudi Arabia	0.8% (2021)	1,200 (2021)	Yes, including feed-in tariffs, tax exemptions	580 million (2020)	NEOM, Red Sea Project, Dumat Al Jandal Wind Farm
UAE	1.2% (2021)	2,500 (2021)	Yes, including tax exemptions, green bonds	228 million (2020)	Mohammed bin Rashid Solar Park, Barakah Nuclear Power Plant (for comparison)
Kuwait	0.3% (2021)	500 (2021)	Yes, but limited	102 million (2020)	Shagaya Renewable Energy Project
Qatar	0.2% (2021)	400 (2021)	Yes, but limited	51 million (2020)	Solar and wind projects planned

Bahrain	0.5% (2021)	200 (2021)	Yes, including feed-in tariffs	32 million (2020)	Solar and wind projects under development
Oman	0.7% (2021)	800 (2021)	Yes, including tax incentives	146 million (2020)	Ibri Solar Power Plant, Duqm Renewable Energy Project

Investment in Renewable Energy

Renewable energy investment varies among GCC countries due to differing government priorities and commitments to sustainable energy sources. The United Arab Emirates (UAE) leads with the highest investment in renewable energy at 1.2% of GDP. Saudi Arabia allocates 0.8% of its GDP to renewable energy, followed by Oman at 0.7%, Bahrain at 0.5%, Kuwait at 0.3%, and Qatar at 0.2%. These percentages illustrate the level of financial commitment towards renewable energy projects in the region.

Renewable Energy Production

Renewable energy production figures show the installed capacity and generation from renewable resources. According to the global renewable energy report, the UAE ranks highest in renewable energy production with 2,500 mWh. Saudi Arabia produces 1,200 mWh of electricity, Oman produces 800 mWh, Kuwait generates 500 mWh, Qatar produces 400 mWh, and Bahrain produces 200 mWh. These figures illustrate the current state of renewable energy generation in the GCC countries.

Major Renewable Energy Projects

All GCC countries have launched and implemented various renewable energy projects to improve their energy sectors and reduce carbon footprints. In Saudi Arabia, notable projects include NEOM, the Red Sea Project, and the Dumat Al Jandal Wind Farm. The UAE's largest projects are the Mohammed bin Rashid Solar Park and the Barakah Nuclear Power Plant. Kuwait's significant

project is the Shagaya Renewable Energy Project, which focuses on solar power. Bahrain is working on solar and wind power initiatives, while Oman has the Ibri Solar Power Plant and the Duqm Renewable Energy Project. These projects represent the main initiatives by each country to enhance their renewable energy resources.

Policies and Incentives for Renewable Energy in GCC Countries

Table 4.2. GCC Countries' Renewable Energy Policies and Incentives

Country	Policies and Incentives	Feed-in Tarrifs
Saudi Arabia	* Vision 2030 with renewable energy as a key pillar, feed-in tariffs for solar and wind, tax exemptions, land allocation, financing support, local content requirements	SAR 0.6-0.8/kWh (varies by technology and location)
UAE	* Shams Dubai net metering program, green bonds, tax holidays, land allocation, Dubai Clean Energy Strategy, Abu Dhabi Future Energy Company (Masdar)	AED 0.19-0.25/kWh (varies by technology and location)
Kuwait	* Kuwait Vision 2035 includes renewable energy targets, tax incentives for renewable energy projects, land allocation	Limited data available
Qatar	* Qatar National Vision 2030 includes renewable energy goals, tax exemptions for renewable energy projects, land allocation	Limited data available
Bahrain	* Bahrain Economic Vision 2030 includes renewable energy targets, feed-in tariffs for solar PV, net metering, tax incentives	BHD 0.025-0.035/kWh (varies by technology and location)
Oman	* Oman Vision 2040 emphasizes renewable energy, feed-in tariffs for solar and wind, tax exemptions, land allocation, renewable energy fund	OMR 0.015-0.025/kWh (varies by technology and location)

Policies and initial incentives for renewable energy in GCC countries vary due to differing national interests and levels of commitment to sustainable energy. In Saudi Arabia, Vision 2030 defines renewable energy as a main focus in the Kingdom's development plan. The country offers numerous incentives, including feed-in tariffs for solar and wind electricity, tax exemptions, land grants for renewable energy projects, financing, and local content provisions to encourage local individuals and companies to engage in renewable energy projects. Feed-in tariffs in Saudi Arabia range from SAR 0.6 to 0.8 per kWh, depending on the technology and location.

In the United Arab Emirates (UAE), the Shams Dubai net metering program allows residents and commercial buildings to install solar panels and receive credit for unused electricity. Other incentives include green bonds, tax exemptions, land grants for renewable energy projects, and the Dubai Clean Energy Strategy. The Abu Dhabi Future Energy Company, also known as Masdar, is the main entity promoting renewable energy in the UAE. Feed-in tariffs in the UAE range from AED 0.19 to 0.25 per kWh, depending on the technology type and grid location.

Kuwait's Vision 2035 outlines specific goals for renewable energy. The country has an attractive tax system supporting renewable energy projects and provides land for these projects. However, information on feed-in tariffs in Kuwait is scarce. Similarly, Qatar's National Vision 2030 includes targets related to renewable energy, offering tax incentives and land for renewable energy projects. Information on feed-in tariffs in Qatar is also limited.

Bahrain's Economic Vision 2030 includes goals for renewable energy, with specific promotions like feed-in tariffs for solar photovoltaic (PV) systems, net metering, and tax incentives. Feed-in tariffs in Bahrain range from BHD 0.025 to 0.035 per kWh, depending on the technology and location. Oman's long-term development plan, Oman Vision 2040, focuses on the growth of renewable energy. The country offers feed-in tariffs for solar and wind energy, tax exemptions, land grants for renewable energy use, and has established a renewable energy fund. Feed-in tariffs in Oman range from OMR 0.015 to 0.025 per kWh, depending on the technology type and geographical region.

Chapter 5: Discussion

The GCC countries are well-positioned in the current shift from fossil fuels to renewable energy sources. In the contemporary world, the transition to clean energy due to climate change and the rise of environmentalism puts countries reliant on fossil fuels at a disadvantage. This is particularly true for GCC countries, which not only consume fossil fuels for their own energy needs but also export a significant share of global petroleum. Recognizing this vulnerability, some countries have initiated programs to economically support themselves as they phase out oil dependency. Saudi Arabia and the UAE are particularly noteworthy in this regard.

The findings of the current study indicate that the UAE leads in renewable energy investment per capita, with 1.2 percent of GDP. This is closely followed by Saudi Arabia and Oman, with figures of 0.8 percent and 0.7 percent, respectively. Comparing these investment figures with the carbon emissions of the three countries, which are 220 million, 580 million, and 146 million metric tons respectively, it is evident that the UAE prioritizes renewable energy the most among the three. However, the percentage of renewable energy each GCC country contributes to the global energy mix and their total production is still small compared to many developed countries. For instance, Germany relies on renewable energy for 55 percent of its energy needs, Denmark for 60 percent, the USA for 15 percent, Canada for 20 percent, and the UK for 25 percent.

Despite the progressive growth in the use of renewable energy sources, several inherent challenges remain. Introducing renewable energy technologies like solar and wind energy involves technical challenges in tapping and storing energy. These technologies often face intermittency problems, meaning their energy output is not continuous and depends on weather conditions. Renewable energy systems require greater flexibility to meet high fluctuations in energy demand compared to conventional fossil fuel systems. This slower response to capturing and maintaining energy demand makes it difficult for countries needing a consistent energy supply to sustain industrial activities and economic continuity. These challenges are particularly significant for

developing nations that need reliable energy sources to support their economic growth.

However, these problems are gradually being addressed with the help of new renewable energy sources, advanced energy storage solutions, improved grid management, and the use of smart grid mechanisms. Recent improvements include enhanced battery storage technologies, more robust grid infrastructure, and innovative energy management systems for controlling renewables. These advances should gradually overcome the aforementioned limitations, increasing the share of renewable energy in national energy grids.

Besides addressing these challenges, the GCC countries have significant opportunities to become global producers and exporters of clean and renewable energy. These countries possess large, unoccupied areas and abundant sunlight, which can be harnessed to increase solar energy production. Additionally, their established and highly profitable energy economies provide a solid foundation for venturing into renewable energy sectors. Consequently, GCC countries have the potential to lead in renewable energy production and exportation, leveraging existing infrastructure, financial resources, and expertise in the energy sector.

Large-scale programs such as the Mohammed bin Rashid Solar Power Plant in the UAE, NEOM city in Saudi Arabia, and the Red Sea Project exemplify the significant efforts toward renewable power generation. Oman is also notable for its concentrated solar power plant projects, such as the Ibri Solar Power Plant. These projects demonstrate the commitment of these nations to adopt new energy generation methods while minimizing environmental impacts.

By becoming producers of renewable energy, GCC countries can enhance their energy security, reduce reliance on fossil fuel exports, and actively contribute to addressing climate change. Renewable energy also offers economic diversification opportunities by establishing new industries and creating employment in the green energy sector, such as windmills, solar energy, and other sources. This transition can spur the development of new technologies and innovations within the region, further strengthening the GCC countries' position as leaders in renewable energy innovation globally.

Policy Gaps and Opportunities for GCC Countries in Renewable Energy Production

The current study's results show that policy dimensions have both advantages and disadvantages concerning renewable energy generation in the GCC countries. Addressing these gaps and opportunities can significantly enhance the region's position as a provider of future renewable and clean power.

Saudi Arabia

Saudi Arabia's Vision 2030 identifies renewable energy as a key sector, with policies that include feed-in tariffs for solar and wind, tax exemptions, land availability, funding, and local content provisions. The feed-in tariffs range from SAR 0.6 to 0.8 per kWh depending on the technology and location, making them generally attractive. However, there are areas that need improvement. For instance, the variability in feed-in tariffs based on location and technology can create risk factors for investors. Developing more standardized tariffs or providing clear and concise guidelines might improve investor confidence. Additionally, local content requirements intended to support domestic industries could pose challenges for international players and technological acquisition. Balancing these demands could attract more international skills and funds, thereby enhancing the sector's growth.

United Arab Emirates (UAE)

The UAE leads with progressive policies such as the Shams Dubai net metering program, green bonds, tax exemptions on income and land, the Dubai Clean Energy Strategy, and the Masdar initiative by Abu Dhabi Future Energy Company. Feed-in tariffs in the UAE range from AED 0.19 to 0.25 per kWh. Despite these comprehensive policies, there are still areas for improvement. For instance, the UAE should expand related policies and legislation regarding green bonds, and the net metering policy should cover more areas and types of renewable energy projects. Additionally, the UAE should continue developing new energy storage strategies to overcome the inconsistent power supply from renewable sources.

Kuwait

Kuwait's Vision 2035 includes goals related to renewable energy, such as tax exemptions for renewable energy projects and land leasing. However, there is limited information on specific policies and feed-in tariffs in the public domain, creating a significant policy gap. This lack of transparency can deter potential investors and slow down renewable energy projects. Kuwait needs to establish coherent, specific, and transparent policies and economic stimuli. Effective, legally established feed-in tariffs and extended tax credits could increase investments and stimulate the development of renewable power projects.

Qatar

Qatar's National Vision 2030 encompasses renewable energy goals, tax incentives, and land grants for renewable energy projects. Similar to Kuwait, Qatar suffers from a lack of detailed information on specific policies and feed-in tariffs, which hinders the development of renewable energy. Providing comprehensive information to the public and investors is crucial for building confidence and encouraging investment in the renewable sector. Qatar also needs to implement specific feed-in tariffs for renewable energy projects to attract significant financial investments in this area.

Bahrain

Bahrain's Renewable Energy Plans, outlined in its Economic Vision 2030, include feed-in tariffs for solar PV, net metering, and tax incentives. Feed-in tariffs in Bahrain range between BHD 0.025 and 0.035 per kWh. These policies have improved the conditions necessary for renewable energy. Nevertheless, Bahrain can further optimize its policies and strategies by expanding net metering options and incorporating other renewable energy sources beyond solar PV. Whenever possible, it is advisable to formulate long-term policies that cover a wide spectrum of renewable technologies to enhance energy supply security in Bahrain.

Oman

Oman's Vision 2040 includes feed-in tariffs for solar and wind energy, tax exemptions and rebates, site allocation, and the provision of a renewable energy fund. The feed-in tariffs applied in

Oman range from OMR 0.015 to 0.025 per kWh. These policies have established a solid framework and reference point for the development of renewable energy. However, Oman can maximize these benefits by increasing the utilization of renewable energy technologies and infrastructure. Additional funding for the renewable energy fund and other material incentives can attract more investors and boost the implementation of renewable power generation plants.

Opportunities for the GCC Region

Overall, the GCC countries have vast opportunities to position themselves as key producers and exporters of clean and renewable energy. Solar radiation and large areas of land offer significant potential for renewable energy generation, which can greatly enhance their energy supply. Additionally, they possess well-developed and lucrative energy economies that can facilitate the transition to green energy.

Regarding regional cooperation and energy policies, the GCC countries can benefit from benchmarking best practices and pooling resources to address challenges collectively. An integrated renewable energy network within the region would enhance energy security and stability, ensuring a reliable electricity supply to neighboring countries. Innovations in renewable energy technologies, including energy storage and smart grid systems, will help reduce the challenges associated with renewables and boost their efficiency. Investment in research and development is essential to enhance the GCC nations' innovative capacity and establish them as key players in renewable energy.

While the GCC countries have made significant progress in utilizing renewable energy sources, further development of existing policies and utilization of opportunities can help fully realize their potential for clean energy generation. Promoting research and development, reviewing and enhancing policies and regulations, and fostering regional collaboration are crucial factors in achieving sustainable energy solutions and transitioning to eco-friendly energy systems.

Chapter 6: Conclusion

The work has devoted significant focus to analyzing the GCC's renewable energy transition plans across several nations, including Saudi Arabia, the UAE, Kuwait, Qatar, Bahrain, and Oman. The first research question concentrated on identifying the policies and strategies currently in use, the effects of integrating renewable energy, fluctuations in the execution of renewable energy projects, and recommendations for improving the performance of these strategies.

This study revealed that the UAE is the most advanced among the GCC countries regarding investment in renewable energy, allocating 1.2% of its GDP. This is followed by Saudi Arabia with 0.8%, Oman with 0.7%, Bahrain with 0.5%, Kuwait with 0.3%, and Qatar with 0.2%. This investment is crucial for transitioning to sustainable forms of power generation and enhancing related technologies. The UAE also leads in renewable energy generation, producing 2,500 MWh. Saudi Arabia is second with 1,200 MWh, followed by Oman with 800 MWh, Kuwait with 500 MWh, Qatar with 400 MWh, and Bahrain with 200 MWh. However, the share of renewable resources in the total energy mix remains comparatively low compared to other developed countries. Notable projects include Saudi Arabia's NEOM and Red Sea Project, the Mohammed bin Rashid Solar Park in the UAE, and the Ibri Solar Power Plant in Oman. These projects demonstrate the GCC countries' commitment to large-scale renewable energy initiatives.

Saudi Arabia's Vision 2030, the Shams Dubai program in the UAE, and Oman Vision 2040 outline the strategic framework for renewable energy. The incentives include feed-in tariffs, tax exemptions, and land allocation, among others, although the level of implementation and the clarity of these policies vary among countries. From the findings discussed, it can be concluded that the GCC countries have made impressive strides toward adopting renewable energy sources. However, several issues need more attention. While there are policies and legislation in place, feed-in tariffs and incentives can be variable and sometimes lack transparency. Strengthening these policies could provide investors with greater confidence, leading to larger investments and a more dynamic stock market.

Technical barriers, such as challenges with energy storage and the instability of renewable

sources, as well as slow adjustments to fluctuations in energy demand, must be addressed. These challenges highlight the need for continued research and development to overcome obstacles.

Renewable energy sources offer significant potential for economic diversification and environmental conservation, but this transition should be managed systematically to avoid adversely affecting industrial business and economic growth.

Thus, the GCC countries have the potential to become major global exporters and producers of renewable energy. Increasing the utilization of their abundant natural resources, including solar radiation and large tracts of land, for renewable energy generation is feasible. Regional energy cooperation and the development of renewable energy infrastructure will also improve energy availability and distribution. Challenges associated with renewable energy sources, such as the limitations and disadvantages of non-renewable sources and fluctuations in power generation, can be addressed through advancements in energy storage and smart grid technologies.

The study also identifies several threats: Significant factors include the high initial capital investment required for renewable energy projects and the need for assured energy supplies. Unclear and unstable policy laws contribute to reduced investment and slow the transition to renewable energy. Addressing these issues is crucial to creating a supportive environment for renewable energy development.

Based on the research findings, the following recommendations are made to improve the transition to renewable energy sources in the GCC. The first thing is to address inconsistencies in policies and incentives among GCC member countries to enhance investment flow. Second is to establish realistic, clear, non-discriminatory, and predictable feed-in tariffs. Invest in research and development to drive technological advancements and overcome technical challenges associated with renewable energy. Third is to combine governmental and private sector initiatives to gather necessary funds and expertise, thus accelerating the adoption of renewable energy. Fourth is to improve the stability of energy supplies and optimize resource use through regional integration of infrastructure and policies. The final recommendation is to implement programs to build a skilled

local workforce to support the renewable energy sector.

Future studies should focus on policy analysis to provide a detailed comparison of policy frameworks across various regions, identifying the best approaches for implementation. Innovative solutions for existing technical issues may be found by analyzing modern developments in energy storage and grid management. Evaluating the future economic effects of renewable energy adoption on GCC economies can inform policy decisions and investment strategies.

The GCC nations are on the right track regarding the shift to renewable power sources. Addressing the challenges of non-renewable resource depletion and global warming, alongside leveraging unique opportunities, will enhance their potential to be recognized as leading global producers and exporters of renewable energy. Pursuing investment, innovation, and strengthened regional cooperation are essential for promoting sustainable and secure energy systems in the future.

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