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Challenges and Opportunities of Renewable Energy for Achieving Sustainable Development Goals

Mohammed Sulaiman Abuzaid Mahmoud

Independent Researcher, Jeddah, KSA
Email: eng.enviro.moh@gmail.com

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Abstract

The study identifies the pathways to promote renewable energy in the Middle East and assesses its scope to attain the United Nations' Sustainable Development Goals (SDGs). The research undertakes a comparative thematic analysis of available literature on the subject to categorize the Middle Eastern countries into three groups based on their economic and political systems: hydrocarbon-producing countries, non-hydrocarbon-producing countries, and countries facing conflicts. The research reveals that there is a considerable gap in the adoption and utilization of renewable energy in the Middle East, which can be attributed to the differences in the governing systems, policies, financial conditions, and stability in these countries. The study reveals that renewable energy can play a pivotal role in the economic diversification and generation of employment opportunities in the Middle East, which can be achieved by reducing carbon dioxide emissions and increasing energy security. The research highlights that the adoption and utilization of renewable energy can be restricted due to its high capital costs and geopolitical conditions in the Middle East.

Keywords

Renewable Energy, Sustainable Development Goals, Energy Pollution, Sustainability, The Middle East Region

1. Introduction

Improving energy efficiency is one of the principal means of minimising energy pollution producing economic growth, and will produce wider energy access and better living standards. This leads to a decrease in fossil fuel consumption while at the same time an increase in the supply of clean sources of energy. The Gulf

states have the same number of renewable resources available as hydrocarbons; significant amounts of solar energy and a large amount of wind energy, and a good source of geothermal energy. The economy of the Middle Eastern region relays heavily on the export of fossil fuels. The decline in supply of fossil fuels, and the rise in prices of energy globally, are leading to a greater reliance on renewable sources of energy. Although the Middle East region is geographically positioned to be a prime candidate for the expansion of renewable energy resources, most of these have not yet been developed [1].

Over the last decade, Middle Eastern countries have become a major player in the global energy market because of their large reserves of oil and natural gas. The development of these resources has led to significant economic growth for the region, especially among Gulf Cooperation Council (GCC) countries, and has provided them with a unique position within the global energy marketplace. As countries continue to face the increasing urgency to address climate change, many are developing policies to transition away from fossil fuels and towards renewable energy sources. This presents a significant challenge for the Middle East; many of the largest producers of fossil fuels also have economies that rely heavily on these resources. There are many questions about how post-oil economies will affect the future development of Middle Eastern societies, and whether these nations will continue to play a significant role in an economy that is not dependent on fossil fuels [2].

The Middle East, like many other regions of the world, is facing what has been popularly described as a "global multiple crisis", which refers to the combined impact of a variety of phenomena including climate change, the mass extinction of species, the tension being created by social and economic inequalities and instability, the depletion of fossil fuels and natural resources, the increasing number of forcibly displaced persons and overwhelmed governments. Among the many concepts that have emerged from the response to this crisis has been a general agreement about the need for a basic, strategic framework across many sectors of society (government, business, non-profit) with respect to sustainable development as the means of addressing these issues affecting current and future generations. In 2015, all UN member states committed to the Agenda for Global Sustainable Development 2030 and agreed to incorporate the United Nations Sustainable Development Goals (SDGs) into the policies and actions of their respective nations. The Agenda 2030 for Global Sustainable Development is a binding treaty on all member states and a shared framework for achieving global sustainable development by establishing 17 specific goals (SDGs) and 169 specific targets that are to be implemented, established and achieved at all levels—from global to local. Each nation has its own unique circumstances that will determine how quickly it implements the SDGs. All countries in the Middle East Region have made some level of progress towards meeting the SDGs, but this progress has been determined by the amount of effort that was put forth during the time the MDGs were in effect. There are areas where sub-regions within the MENA Region have been rel-

atively successful in developing SDGs, particularly in the Gulf, while there is a tremendous lack of success in some areas, particularly the Mashreq; most notably, the differences among sub-regions in the area are the result of disparate priorities based on the needs and requirements of the individual countries [3].

The Middle East faces many energy and sustainable development-related issues. Historically, its economy has been based largely on fossil fuels which, in addition to increasing competition from climate change and the volatility of the global energy market, pose unique challenges for the region's economies today. Although the region contains some of the largest solar and wind resource areas in the world, those resources are still not being utilized to their fullest potential. Based on this situation, we will compare some of the renewable energy experiences of the Middle Eastern countries, identify opportunities and barriers faced by the countries in meeting the Sustainable Development Goals (SDGs), and draw lessons learned in the hopes of identifying commonalities that will aid policymakers and researchers in developing better targeted and more effective renewable energy policies specific to each country's needs. To help achieve these goals, this study will provide an overall framework that can be utilized as a guide to assist these countries in achieving a sustainable and inclusive transition to renewable energy.

2. Methodology

This study uses a structured comparative case study method to investigate the renewable energy transitions and the role played in the achievement of the Sustainable Development Goals (SDGs) established by the United Nations in the selected countries in the Middle East region. The selection criteria for the case study are guided by a Maximum Variation logic, where the countries were chosen with the intention of including diverse economic systems, hydrocarbon dependence, energy import dependence, and political instability or conflict. The selected case studies are considered illustrative rather than exhaustive, capturing the dominant structural types in the region and enabling in-depth qualitative comparisons. The final sample of countries includes Saudi Arabia, Qatar, Bahrain, Kuwait, Oman, Iran, Iraq, Jordan, Egypt, Türkiye, Morocco, Lebanon, and Yemen. The selected countries cover hydrocarbon-exporting countries (Saudi Arabia, Qatar, Kuwait, Oman, Iran, Iraq, Bahrain), energy-importing or mixed-structure countries (Jordan, Morocco, Lebanon, Türkiye, Egypt), and conflict-affected or fragile countries (Iraq, Yemen, Lebanon, and Syria in the broader regional classification, although Syria is not included because of data limitations).

The research method employed in the paper is based on a qualitative secondary data research protocol. The secondary data research protocol employed in the paper is founded on the basis of systematic document analysis. The data was identified through a systematic search in Scopus, Web of Science, Google Scholar, as well as official institutional portals such as the International Energy Agency, World Bank, United Nations Development Programme, as well as official energy ministry portals of the countries. The inclusion criteria for the research paper were

as follows: The research paper had to directly deal with renewable energy policy, investment, infrastructure, or sustainability in the identified countries. The research paper had to include empirical evidence, modelling, or policy analysis. The research paper had to be published in a peer-reviewed journal, official government strategies, or official international reports. The research paper had to exclude opinion articles, undocumented policy commentary, as well as research articles without empirical evidence.

To minimize selection bias, a structured thematic framework was employed to code the documents. The sources were systematically reviewed and coded according to a range of analytical dimensions such as renewable potential, policy instruments, institutional capacity, grid readiness, investment levels, and measurable sustainability. The findings were coded into two main themes: Opportunities—economic diversification, technological development, energy security, employment creation—and Challenges—financial constraints, grid readiness, institutional capacity, political instability, and market volatility. To ensure that the coding criteria were consistently applied across all countries, cross-case matrices were employed.

In terms of the temporal scope of the study, it is based on literature and policy documents published between 2010 and 2025. Although the original study design was based on literature published before 2020 in order to assess foundational renewable energy strategies, the analysis was subsequently extended to include literature published after 2020 in order to reflect recent changes in policy, new technologies, and post-pandemic economic conditions. The inclusion of literature published before 2020 was used to assess foundational conditions, with literature published after 2020 being included in the analysis in order to assess the progress of implementing these policies, new targets, and emerging issues such as market volatility and geopolitical shifts.

The above said comparative thematic methodology therefore offers a rigorous analytical base for both structural patterns and country-specific dynamics. By using systematic document selection, transparent coding, and maximum variation selection, the study can increase the validity of its cross-country comparisons and enhance the relevance of its findings for renewable energy transitions in the Middle Eastern region.

3. Literature Review

The increasing demand for energy worldwide is making our planet feel like a smaller, more connected place, even though the Earth itself can't change its shape. To meet our individual, social, and economic needs, like education and health, we're using more and more energy. Every aspect of our lives, from basic needs like security and lighting to more complex things like transportation and communication, relies on energy. The power industry plays a crucial role in securing our electricity supply and reducing emissions that contribute to climate change. Currently, there's a serious electricity shortage in many places, especially in rural areas

where 85% of people live. It's estimated that by 2030, around 2.7 to 2.8 billion people in rural communities will still be relying on traditional biomass for energy [4].

The "Middle East" region is taken to be the set of countries included in the Middle East and North Africa region by the World Bank and the International Monetary Fund. It is a geographic area that focuses particularly on West Asia and the Arabian Peninsula. It includes Bahrain, Iran, Iraq, Palestine, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the UAE, and Yemen. Of these, hydrocarbon-producing countries are taken to be those countries whose government revenues and/or export earnings are derived primarily from oil and/or natural gas. These countries are Saudi Arabia, the UAE, Qatar, Kuwait, Oman, Iraq, Iran, and Bahrain. On the other hand, the energy-importing countries are those countries whose energy demands are met primarily by imports. These countries are Jordan, Lebanon, Palestine, Yemen, and Syria. Moreover, there are several countries in the region that are classified as conflict-affected or fragile countries, according to the World Bank's Fragile and Conflict Framework and UNDP reports, including Syria, Yemen, Iraq, and Lebanon, which have faced prolonged political instability or conflict. Such classifications can serve as an analytical tool to compare transitions to renewable energy between countries with varying economic structures and political systems.

3.1. The Reality of Achieving Sustainable Development Goals in Middle Eastern Countries

***Saudi Arabia*:**

The article, "The Potential for Renewable Energy Investment in Saudi Arabia," presents research conducted by Al Yousif (2020) on the benefits of investing in renewable energy in Saudi Arabia. Investing in renewable energy will create future, enduring, sustainable career opportunities for the citizens of Saudi Arabia, therefore helping to locally diversify the economy of Saudi Arabia. In addition to creating new careers for citizens, development of the renewable energy sector will ultimately increase the portion of the non-oil private sector contributing to Saudi Arabia's total economic output. The methodology used to compute the effects of investing in renewable energy are based on Leontief. There are three cases for investment (SAR 25, SAR 50, and SAR 85 billion) made over the five-year period from 2020-2025. The estimated GDP contribution of these investments over this period of time is to produce a total of approximately 2.7%, 4.7%, and 6% of the investment amounts made in renewable energy, respectively. These cases and the numbers of jobs projected to be produced by them are, respectively, 44,000, 90,000, and 150,000 new jobs. Continuing the development of renewable energy in Saudi Arabia enables greater use of energy by allowing for increased energy efficiency and reduced pollution; however, the growth of the renewable energy sector is being delayed due to obstacles, such as technology limitations, operational costs, and lack of capital. The writer has suggested several ideas that could

help alleviate these obstacles [5].

To estimate the potential benefits resulting from investments in renewable energy, this report uses the Leontief model, using three scenarios (total initial investments of (SAR) 25 billion, 50 billion, and 85 billion) over a period of 5 years (2020-2025). Estimated GDP growth rates for the period are approximately 2.7%, 4.7%, and 6.0% respectively for total investments in renewable energy in amounts of (SAR) 25 billion, 50 billion, and 85 billion [5]. New jobs expected to be created in each of the three scenarios will total 44,000, 90,000, and 150,000, respectively. The continued development of the renewable energy sector in Saudi Arabia will allow for increased energy efficiency and pollution reduction. However, there are several factors that may impede the continued development of the renewable energy sector, including problems with technology, cost of operation, and a lack of financial resources [6].

Qatar:

With plentiful quantities of both non-renewable (especially oil and gas), as well as renewable (such as terrestrial and marine resources) resource bases, Qatar's wealth of natural assets generates enormous potential for pursuing sustainability through development initiatives. In addition, this large resource base creates a stable source of funding to support diversification toward developing an innovation-based economy based on a knowledge economy while simultaneously maintaining Qatar's traditional cultural heritage and providing for innovative advanced technology development (e.g., biotechnology) along with sustainable urban planning/engineering strategies. The National Development Strategy 2011-2016 and the Qatar National Vision 2030 are examples of national frameworks that combine environmental, economic and social goals in order to provide a clear strategic direction towards sustainability, with the goal of creating opportunities for Qatar to diversify its GDP away from hydrocarbons, improve education and healthcare, increase research and development and provide higher-value employment to Qatari citizens. There are also a number of significant barriers that have the potential to impede Qatar's ability to achieve these opportunities, including rapid population growth, industrial and urban development exerting pressure on natural and cultural resources, and a continued reliance on non-renewable energy sources. In addition to these issues, Qatar faces challenges related to the implementation of policies, management of labor dynamics, preservation of social and cultural identity during a period of modernization, and the ability to inspire future generations to pursue higher education and innovation. As a result, although Qatar is well-situated to assume a leadership role in sustainable development, for it to reach this point, effective policy implementation, balanced planning for urban and industrial development and ongoing leadership to turn natural capital into long-term economic and human capital will need to be implemented [7].

Moreover, Sustainable energy transitions in hydrocarbon-dependent economies, such as Qatar, are fraught with technical feasibility, economic viability, and policy coherence challenges. Despite these hurdles, Qatar has emerged as a leader

in sustainable energy investments and renewable infrastructure development since the 2010s. This paper analyzes Qatar's energy diversification efforts from 2014 to 2024 and how they reshape its economic landscape and socio-economic dynamics. Through a comprehensive review of approximately 57 scientific sources, data sets, and case studies, this study identifies and analyzes the unique drivers, challenges, and opportunities associated with Qatar's energy transition. The paper delves into Qatar's government's strategic initiatives to enhance public awareness, foster innovation, and stimulate research and development in the energy sector. Moreover, this review introduces a novel perspective on Qatar's readiness for the sustainable energy transition, emphasizing the interplay between limited energy diversification, global energy market fluctuations, and policy implementation and monitoring effectiveness. The findings suggest that while Qatar is strategically positioned to advance its sustainable energy goals, it must navigate significant obstacles, including the volatility of international markets and the complexity of enforcing and adapting policies in a rapidly evolving energy landscape [8].

Bahrain:

Alabbasi *et al.* [9] conducted a study on sustainable indicators for power generation in Bahrain which identified both the opportunities and challenges facing Bahrain's renewable energy sector. The Renewable Energy Sector can be integrated into Bahrain's Power System through a combination of Technical, Economic, Environmental, and Social Indicators (such as Efficiency, Reliability, Availability of Resources, Job Creation and Reduction in emissions). The Sustainable Indicators identified in the study create a pathway to support the link between the sustainability objectives of the country to energy planning, thereby creating opportunities for economic contributions, social benefit and protection for the environment. In addition to the opportunities for integrating Renewable Energy into the power system, the study identified a number of challenges to overcome, including weak political and security concerns, gaps in institutional support, and a need for better knowledge about how best to promote sustainability in each of the various sectors of the country. Bahrain's future development will require a strategic approach to developing a Policy Framework, engaging Stakeholders in the Planning Process, and supporting Capacity Development to maximise the potential of Renewable Energy while addressing the issues identified in Alabbasi *et al.* [9] regarding Structural Barriers and Operational Barriers in the development of this sector.

Kuwait:

Kuwait's goal is to incorporate Renewable Energy Resources (RER) in the existing power grid (utilized for grid reliability). The Amir of Kuwait, at the UNFCCC's Doha Climate Change Conference in 2012, created a goal that 15% (1.5 gigawatts, or 4800 megawatts) of electricity will come from renewable sources by 2030. Currently, the Supreme Council of Energy has created a target to reach 15% of projected peak loads from RER by 2030. While this is, currently, Kuwait's goal, the goal of the Supreme Council of Energy is to significantly increase the amount of RER in the long-term. Research indicates that annual energy share forecasts

(the Amir's original goal) are the second-largest rater of total installed RER in the world; however, the way that this is achieved in the long term is through a requirement that 15% of the total annual electrical consumption of electricity by 2030 is produced from RER. While, historically there is little correlation between RER production and peak (hourly) electrical use, there is a direct relationship. Hence, using a greater amount of RER that can be utilized during the peak timeframe is a requirement of the model for incorporating RER into the existing power grid. As a result, the production of electricity from renewable sources is expected to become increasingly inconsistent during the winter months. Potential solutions to resolve this inconsistency include reducing renewable energy production, reacting to demand for electricity, and using fossil-fuel-powered plants as alternative sources of electricity. Conversely, in the summer months, solar-generated electricity tends to be generated in large quantities when electrical demand is high because of the requirement for cooling during hot summer months in Kuwait and because there are many hours of sunlight available [10].

***Oman*:**

Through its larger objectives of a low-carbon future, Oman has committed large amounts of money to both clean and renewable energy sources. The country has a very large amount of solar potential; therefore, the central and southern regions of Oman have the potential for large-scale solar power projects. In addition to solar, wind energy projects are currently receiving significant investments from both private and public entities; these investments support the chlorine energy agenda of Oman. The most notable goals set forth by the government of Oman include a 20% penetration of renewable energy into the energy mix by 2030, with an increase to between 35% - 39% by 2040. The creation of Hydrogen Oman (Hydrom) as a fully owned government entity responsible for both the strategic planning and land leasing/developing for hydrogen projects as a major milestone in Oman's clean energy journey in October 2022. As of February 2023, approximately 65,000 km^2 of land has already been identified for the purpose of supporting renewable energy and clean hydrogen projects; of this total, 50,000 km^2 has been designated for the future development of green hydrogen. The ultimate objective is to produce in excess of 1 million metric tons of green hydrogen by the year 2030, with the long-term objective being as much as 8 million metric tons by the year 2050. The achievement/fulfillment of these ambitious objectives will further establish Oman's position as a major global centre for sustainable energy generation and produce green hydrogen, therefore significantly contributing to its goal of becoming a zero-emission country and a sustainable economy [11].

The integration of renewable energy sources into the electrical grid is currently challenging. The technologies associated with the generation of power through Wind, Water and Solar must be integrated with a price point that allows for a zero-sum game between cost and demand response of different energy sectors (transportation, heating and cooling). By optimizing the different storage methods available for renewable energy, by utilizing the storage option that is most cost

effective and responsive to the highest demand, a system can be developed whereby a portion of the renewably-generated energy is converted into hydrogen. With water and solar resources from 145 different nations, there exists a viable option of being able to transition to a 100% renewable resource base, since the abundance of these two resources will provide opportunities for significant decreases in energy pricing, decreases in greenhouse gases and increases in the overall efficiency of energy delivery. As the world transitions away from fossil fuels to renewable energy sources, there is a need for both high-capacity storage units that will allow power generated through renewable energy to be available for use when it is most expensive to produce, and also means of transitioning from internal combustion engine vehicles to electric vehicles to help reduce greenhouse gas emissions from the transportation sector [12].

While Oman already has a competitive advantage of utilising renewable energy for commercial purposes, including solar and wind power, the country has large potential in the future to create jobs in these sectors due to the likely increasing costs associated with these technologies. As Oman's use of these technologies progresses, the need for a higher skill level of employment related to the manufacture of these technologies will also increase. The expansion and diversification of both the economy and energy sources, both of which are key goals of Oman Vision 2020. Through establishing a centre of excellence in this energy field, Oman will develop into a leader in this sector by establishing a robust capability to demonstrate and monitor these technologies for technology manufacturers and help develop future relevant technologies [13].

Jordan:

Due to globalization of the economy and rising quality of life; energy security has become an extreme priority for government administrators throughout the globe. Jordan is experiencing a particularly challenging time in this area, due to the lack of natural resources in the country and the impact of regional instability on the availability of energy resources. Based on desk research and expert interviews, this report outlines the current state of the Jordanian Energy Sector, identifies the major obstacles to achieving energy independence for Jordan, and discusses the anticipated future direction of the Energy Sector in Jordan. The findings of this report will contribute to the ongoing discourse regarding Jordan's ability to achieve environmental, economic, social, and political sustainability of the Jordanian energy sector. The historical correlation between Jordanian Energy Security and its relationships with its immediate neighbours has made Jordan's energy security vulnerable to external forces, including external political events [14].

Egypt:

The demand for electricity in Egypt is growing rapidly as Egypt's population exceeds 100 million people. The increase in Egypt's energy demand occurs due to the increase in Egypt's number of people living there (Population Growth) and the expansion of the Industrial Sector (Development). Due to Increased Energy

Demand in both areas, the need for alternatives to conventional energy sources will have to be considered to prevent an energy crisis. Therefore, the Egyptian Government has initiated a process of exploring renewable sources of Energy, including Wind and Solar, which have already provided some of its required amount of Renewable Energy. Additionally, Egypt's Government has recently moved towards Nuclear Power [15].

In its 2016 Integrated Sustainable Energy Strategy, Egypt set targets of 20% RE in the electricity generation mix by 2022 and 42% by 2035. However, the actual amount of installed RE capacity (6.3 GW) is only approximately 11% of Egypt's total electricity generation capacity (59 GW), and the amount of energy generated from RE sources (24 TWh) is only about 12% of Egypt's total energy production (200 TWh). Egypt currently has 4 - 5 years remaining before it will need to achieve the target of 42% RE in the total electricity generation mix (63 GW). Thus, Egypt needs to increase its RE capacity from 6.3 GW to at least 63 GW, averaging 4 - 5 GW of additional RE capacity each year from now until 2035. Since Egypt's total hydropower energy generation capacity is currently fully utilized (approximately 2.8 GW), the combined generating capacity of solar and wind sources (approximately 3.5 GW) represents the total amount of NEW RE generation that can be developed for immediate use prior to 2035. Challenges to achieving RE target in Egypt include [16]:

- High capital costs of renewables—Slow increase in the demand due to energy efficiency and COVID-19, combined with presence of surplus generating capacities.
- Recent natural gas discoveries will lead to increased dependence on domestic, relatively cheap natural gas—Agreements to build nuclear power plants will decelerate RE.
- The share of hydropower energy will decline during the filling of the Ethiopian Dam Opportunities for boosting.

RE in Egypt include [16]:

- Abundance of land, sunny weather and high wind speeds, with published solar and wind atlases.
- Egypt's environmental commitments to sustainable future—Initiatives of green hydrogen resulting from water electrolysis by RE.
- Introducing electric mobility and the need to charge it from RE—New policies and regulations that support the deployment of RE.

In conclusion, Egypt's energy strategy should be revised, updated, and SMART action plans should be applied. Several recommendations for mass deployment of RE in Egypt are presented.

***Iraq*:**

According to Al-Ghabera and colleagues [17], renewable energy is a viable approach to addressing the infrastructure challenges that follow a period of conflict in Iraq, with evidence suggesting that areas such as Basra's solar resources (5.5 $kW/m^2/day$) and Erbil/Sulaimaniyah's wind energy potential. The research high-

lights the need for considerable attention to be paid to addressing several barriers impeding success: *i.e.*, lack of technical expertise, insufficient resources, and limited availability of trained personnel. Recognizing the overall multitude of barriers to the transition to renewable energy system, the authors conclude by stating that while Iraq faces numerous barriers, with appropriate policy development, financial incentives, and collaboration with the international community, the potential to utilize renewable energy sources can be completely realised. Additionally, the comparison of countries like Morocco and Tunisia demonstrates that while Iraq has some very specific barriers, the successful implementation of renewable energy in other nations with similar demographic and economic characteristics serves to establish a clear path for Iraq's development of renewable energy infrastructure. Many of these countries have undergone substantial transformation through policy changes, workforce training, and financial incentives, which are examples that Iraq may wish to adopt to aid in overcoming its energy infrastructure challenges. Moreover, cultural and economic contexts should be considered for successful implementation. The study finds that a comprehensive and inclusive national strategy is crucial for incorporating renewable energy into Iraq's energy ecosystem. Additional research is recommended to evaluate project-specific viability, policy frameworks, and the effects of global collaboration on speeding up Iraq's shift to renewable energy [18].

***Iran*:**

Iran has a lot of potential in terms of the use of renewable energy. Iran has access to a variety of abundant natural resources to help develop renewable energy in Iran, including solar, hydro and biomass resources from agricultural waste and municipal waste. Therefore, renewable energy represents a viable solution for reducing dependence on fossil fuels, enhancing energy security, and promoting long-term sustainability. Furthermore, the Iranian government's efforts to diversify energy sources and increase the use of renewable energy, as well as the geographical characteristics of Iran, provide a strong basis for developing new renewable technologies and creating additional electric generation capacity from renewable sources. In addition, there is a positive relationship between economic growth and energy consumption, so the investment in renewable energy will help meet both the goals of improving environmental performance and enhancing economic growth. Iran has many challenges that will make it difficult for it to take advantage of its potential regards renewable energy sources. Even after all of the policy initiatives, only a very small percentage of total energy consumed in the country comes from renewables while the remainder will be fossil fuel related. This is the result of restrictions on building out the necessary related infrastructure, restrictions on dissemination of technology, and limitations on the rate of technology adoption. Iran's continued reliance on fossil fuels for internal use and exports causes the economy and policymaking to be affected by the continuation of that reliance. Iran's problems of reducing air pollution, climate change, and protecting its energy security are all problematic as they add to the complexity of transitioning to

a low-carbon energy system [19].

***Türkiye*:**

Türkiye has pledged to achieve net-carbon free emissions by 2053 but maintains a considerable dependence on imported fossil fuels, which constitute over seven percent of its total energy consumption. The energy section is Türkiye's greatest contributor to national carbon dioxide emissions, providing approximately seventy-two percent of the country's total emissions during 2022. Renewables accounted for fifty-nine percent of installed capacity in 2024 by category of energy source and supplied forty-six percent of the nation's electricity. Türkiye has an estimated 380 trillion watt-hours potential for solar generation yet produces only 25 trillion watt-hours. Türkiye has installed only 13 GW of approximately 48 GW capacity for wind generation. The capacity installed for geothermal generation is only 4.5 GWe, and it utilises only 38 percent of the available capacity for geothermal resources. Since 2010, several hydropower reservoirs have declined in level due to climate change and over-extraction. For example, Gediz Basin has had a decline of 45 percent of its storage since 2010. As a result of these trends, the availability of water for hydropower generation in areas where water reliability has decreased has been adversely affected by climate variability and overuse. Additionally, geographical mismatches between demand and supply for energy means that most energy demand centers in Türkiye are located in the industrial northwest part of the country, whereas the best locations for generating energy from renewable sources (particularly hydropower) are located in remote areas of the country. This geographical separation requires considerable infrastructure investment [20].

***Morocco*:**

Morocco has experienced a rapid growth in its Power Sector as evidenced by rising electricity consumption levels, a continued reliance on imported sources of energy, and a primary generation mix using fossil fuels. In 2022, over 43 TWh of electricity were generated by Morocco; however, due to inefficiencies in storage and distribution, only approximately 38 TWh were made available for final consumption. Another behaviour related to Morocco's energy sector is that approximately 83% of electricity produced in Morocco comes from fossil fuels and is responsible for approximately 48% of total GHG emissions from Morocco's energy sector. Morocco, guided by the international commitment to effectuate decarbonization on a national basis, has created a very stringent goal to reach a significant portion of its total energy needs through the use of renewable energy. Under Conv. 51 Program, Morocco's goal is to achieve a minimum of 52% of the electricity mix coming from renewable sources by 2030 and a minimum of 70% by 2050.

We will systematically assess the renewable energy sector in Morocco using the PRISMA methodology, which includes a thorough review of 1328 published works sourced through Scopus, Web of Science, and Google Scholar. The review found that as of November 2021, Morocco has completed the construction and installation of over 5.0 GWh of solar power (1.6 GWh = 4.14 TWh/year), over 4.0

GWh of wind power (1.28 GWh = 4.29 TWh/year), and approximately 2.5 GWh of hydropower (1.1 GWh = 1.70 TWh/year). Improvement in solar energy generation is expected to be at least 28% better than it currently is by 2050, for wind energy at least 55% better than it currently is, and for hydropower generators will be about 90% - 94% more efficient. The major contributing factors to the cost reductions in the solar, wind, and hydropower industry are expected to drop to $37, $41, and $26, respectively. The development of an integrated energy sector has produced emissions reductions of approximately 41 Mt-CO_2e, and renewable energy systems have already produced approximately 125 MW of solar-powered irrigation, approximately 480 MW of industrial-grade electric power, and about 91 MW of electric vehicles. Although Morocco's existing regulatory framework, primarily composed of Laws 57-09, 37-16, 13-09, and 48-15, enabled the development of renewable energy systems, the institutional structure's effectiveness needs to be improved and private investments of $1-2 billion are required [21].

Lebanon:

Lebanon faces a persistent energy crisis, characterized by chronic electricity shortages and an over-reliance on polluting self-generation methods, particularly in urban areas like Beirut. Despite a lack of sufficient political support, the use of solar energy has increased significantly since 2020. This rise is primarily attributed to widespread distrust of the state-owned electricity company and the government, decreasing costs, and growing public awareness of the risks of pollution and health. These studies propose simplifying import procedures and exempting solar panels and their accessories from customs duties and value-added tax. This initiative aims to encourage the adoption of renewable energy solutions, reduce pollution, alleviate the electricity supply crisis, and thus contribute to building a more sustainable and resilient energy future for Lebanon. By implementing these measures, Lebanon can promote a comprehensive and equitable energy transition, improve the quality of life for its citizens, and reduce the environmental impact of its energy consumption [22].

Yemen:

The National Renewable Energy and Energy Efficiency Strategy of Yemen is the main guide for developing renewable energy in Yemen. This strategy has set high targets for enlarging and improving the energy mix of Yemen, including reaching 15% of the energy mix as renewable energy by 2025, providing solar electricity to rural regions, and enhancing the entire electric power system's efficiency. Unfortunately, as a result of ongoing conflict and the fragmentation of institutions, the Yemen Renewable Energy and Energy Efficiency Strategy is now outdated and missing its means of implementation. Although the future of renewable energy in Yemen looks promising, it heavily relies on the support of policies, institutions, and financing. Therefore, the future of photovoltaic electricity in Yemen can be a major success if the necessary financing and institutional stability exist along with the implementation of policies that are adaptive. A phased approach to establishing supportive policies, instituting networks for both support and funding, pilot-

ing and scaling up successful models, and incorporating resilience into national recovery efforts will yield a much stronger and brighter future for photovoltaic electricity in Yemen [23].

As per research Yemen is capable of using renewable energy as clean energy and for other energy needs. Fossil fuels can yield much manipulation and creating bigger advantages than heating and lighting. Even with Yemen having a large crude supplier and discovering and creating new oil resources, Yemen's advantages to pursue renewable and sustainable energy sources is sufficient to make it an attractive form of energy. Due to the current conflict, skyrocketing gas prices have had a tremendous effect on food prices and other macroeconomic factors, the government must begin to address some of these attempts to ease public frustration. While it is necessary for the Yemeni government to commit to CO_2 reduction as part of international climate agreements like the Kyoto and Paris Agreements, it must also make a commitment to the establishment of clean energy infrastructure in Yemen. Yemen's future vitality regarding renewables and renewable energy will greatly vary depending on the efficiency of its government. Certain strategies might seem to have been more successful for some people than for others depending on where they live (e.g., some people have benefited from solar panels in isolated areas). Still, the majority of people do not see any practical benefits from these approaches. In fact, at present, renewable energy technologies are neither practical nor significant components of Yemen's energy supply. Moreover, we also are witnessing similar trends in countries with substantial energy resources (e.g., Saudi Arabia). Yemen's major barriers to successful renewable energy development include a lack of effective, well-established government policies that support the growth of the renewable energy sector, an ongoing presence of international trade embargoes against Yemen, and low levels of public awareness [24].

3.2. Opportunities and Challenges

The challenges associated with developing renewable energy sources include financial and technical issues as well as limited market penetration. The installation of renewable technologies; operation and maintenance of these technologies; and training employees to operate, maintain, and utilize these technologies, are significantly more costly than conventional energy sources. Together these factors resulted in the fact that worldwide, only 12% of all energy consumed was derived from renewable sources in 2017, while only 9% of the energy consumed in the United States was renewable in that same year. The efficiency of photovoltaic systems decreases as surrounding temperatures rise, and dust impacts the efficiency of Inverter systems found in many Concentrated Solar Power (CSP) plants. These problems may be resolved by implementing cooling and cleaning systems to support PV and CSP projects, respectively. These issues aside, there are several hurdles for the development of renewable energy, including: Technical Challenges; High Initial Investment; Low Efficiency; and Lack of Access to Financial Capital.

However, Supporting Investments in Renewable Energy Projects creates many new job opportunities within Communities and increases activity within Local Economies. In addition, by investing in Renewable Energy, we can, at a minimum, partially reduce our Pollution Footprint and Improve Environmental Quality [5].

Over half of the world's fossil fuel reserves are located in the Middle East, which meets approximately 31% of the world's oil needs and 18% of the world's natural gas needs (68,410). In addition, the Middle East is situated at a geographic crossroads between Europe, Asia, and Africa; thus providing a prime location providing fossil fuel supplies to other parts of the world. Recently some Middle Eastern nations have begun moving away from their dependence on crude oil and natural gas to export for the purposes of becoming economically diversified, with methods to secure their future sustainable development through the development and utilization of renewable energy sources. Renewable energy sources provide a viable means of satisfying the energy needs of various Middle Eastern nations while allowing them to decrease their overall dependency on fossil fuels. Solar energy is viewed as the best option for future development of renewable energy sources within the Middle East because of its potential to satisfy the energy needs of the region's nations. As of 2021, the total installed capacity of solar power in the Middle East was approximately 8.4GW (approximately 8.5 times greater than the 2015 installed capacity). By 2030 it is predicted that 92% of the projected renewable energy installations of the Middle East will be completed, with most of the installations focused upon solar and wind, thus providing an estimated increase of 200% of installed capacity by 2030 [25].

A large number of obstacles to the development of renewable energy production in the ME exist due to both political and economic factors. The primary economic challenge of developing renewable energy production in the ME is the significantly lower cost of fossil fuels versus renewable energy sources. To meet the price disparity, coherent development plans for renewable energy production, as well as educating the public on renewable energy sources, are recommended in order to reduce the costs associated with renewable energy in the ME. The most complete and coherent renewable energy development plans in the UAE and Saudi Arabia have been implemented. A similar constraint in the development of renewable energy sources in part results from the political instability and/or conflicts of some ME nations. The challenges being encountered with the development and harvesting of renewable energy in the ME, along with recommendations on how to circumvent these problems, can be found in **Table 1**. Some countries such as Iraq and Iran were unable to achieve a consistent increase in their renewable energy contributions to total energy consumption from 1990-2020, due to a variety of technology-based (technical) and social (non-technical) difficulties encountered while trying to develop renewable energy systems. The specific problems included a dearth of advanced infrastructure, difficulties integrating other power systems into the existing electrical grids, and instability in the region, as well as the existence of inconsistent government policies regarding renewable en-

ergy development. Conversely, countries using renewable energy have shown significant annual growth of varying rates during the same time period [26].

Table 1. The main challenges of renewable energy development and production in the Middle East and some proposed solutions [26].

Challenge	Proposed solution
High production cost compared to fossil fuels	• Localization/domestication of knowledge associated with development and harvesting of renewable energy in the fields of process design, equipment, simulation, and optimization. • Revising the current production techniques and improving them toward new strategies.
Lack of precise and reliable framework/policies for developing renewable energies	• Forming an expert committee to review and establish applicable policies in each country. • Prioritizing the design and developing framework/policies in each country. • Using the experience of developed countries in designing new policies.
Disinclination and reluctance of investors for activity in the renewable energy area	• Offering constant tariffs for national and international investors.

4. Discussion

From the comparative findings, it is evident that the development of renewable energy in the Middle East is influenced by not only the economic structures of the individual nations but also by regional-level factors that are subject to different levels of institutionalization and policy coherence. As the preceding sections have highlighted the individual country-level findings, the following discussion aims to present a synthesized view of the structural dynamics that either drive or hinder the attainment of the United Nations' Sustainable Development Goals (SDGs).

One of the most significant cross-cutting technological challenges identified in the region involves the effects of extreme weather, dust, and arid weather conditions on solar photovoltaic (PV) efficiency. This challenge was specifically identified in the Saudi Arabian context [5] but is more generally applicable across the region as a whole. The effects of dust storms, in particular, have significant implications for the cost of maintenance as well as the quantity of water used to clean solar panels. Nevertheless, the strategies employed to address this challenge vary significantly across the region in line with differences in research, development, and financial capacity. For instance, hydrocarbon-rich Gulf Cooperation Council (GCC) states such as Saudi Arabia and Qatar have the financial capacity to invest in cooling systems as well as innovation ecosystems that are specifically linked to their broader national agendas of economic diversification. The innovation strategy in Qatar, for instance, specifically reflects the capacity of the government to link its energy transition strategy with research funding [8]. The investment in green hydrogen solutions in Oman [11], on the other hand, specifically reflects

the capacity of the government to link the intermittency of solar power with energy storage solutions.

On the contrary, in conflict-affected countries such as Iraq and Yemen, the climatic conditions are the same, but they do not have the institutional and financial means to respond to these conditions technologically. Research done in Iraq [17] [18] indicates that the solar potential in these countries is good, but there is a lack of technological know-how. In Yemen, the expansion of renewable energy is fragmented owing to institutional instability and outdated strategies [23]. The common climatic condition in these countries, *i.e.*, hot weather and dust, thus becomes a distinguishing factor.

Another cross-cutting theme is that of grid integration and storage limitations. All countries, namely Kuwait, Türkiye, Egypt, and Oman, face technical issues of mismatches between renewable resources and peak demand structures. For Kuwait, renewable resources require matching peak summer demand for cooling [8]. Türkiye has geographical mismatches in renewable resources and industrial demand [20]. Egypt has an abundance of surplus renewable capacity, which is being offset by natural gas discoveries [16]. All of this shows that renewable resources are not limited by scarcity of resources but by matching their capacity to existing infrastructure.

A third cross-country linkage is that of economic diversification incentives. For hydrocarbon-exporting countries like Saudi Arabia and Qatar, renewable energy is seen as a means to an end for long-term economic restructuring and post-oil visions. The economic gains that Saudi Arabia is likely to make from renewable investments, as reflected by their GDP and employment projections [5], are an example of how this country is working towards achieving SDG 8 on decent work and economic growth. For countries that import hydrocarbons, such as Jordan and Morocco, renewable energy is more likely to be seen as an energy security policy. For instance, Morocco is an example of how a stable regulatory framework can be used to support scaling, even when it is a fossil fuel-dependent country [21].

Lastly, governance capacity consistently mediates outcomes in all country groups. Lebanon's solar expansion post-2020, which was mainly driven by citizenry distrust of the state's utilities [22], stands in sharp contrast to the centralized strategic planning model of Qatar. Iraq and Yemen also underscore the limitations of institutional strength in leveraging resource potential. Meanwhile, Morocco and Oman underscore the impact of relatively coherent regulatory systems in attracting private sector investment in renewable energy development in the face of structural constraints.

In terms of regional-level findings, International Energy Agency and World Bank reports cite the paradox of the Middle East boasting some of the world's most favorable solar irradiance conditions but also boasting relatively low penetration of renewable energy. The above comparative study's findings underscore, however, that the paradox is not technological in nature. The region's shared tech-

nical challenges of heat, dust, and intermittency with grid management can all be addressed. The question, however, remains to what extent these factors can be addressed.

On the whole, the cases provide support for the central argument that the transition to renewable energy sources in the Middle East is influenced by an interplay of three layers: 1) shared environmental and technological conditions, 2) economic conditions and incentives for diversification, and 3) institutional conditions and stability. Countries with financial, policy, and innovation capacities can capitalize on shared environmental challenges as opportunities for technological advancement, while those with fragmented governance structures and unstable politics cannot capitalize on their abundant renewable energy resources.

On the whole, the inter-case findings provide additional robustness to the overarching argument that renewable energy transitions in the Middle Eastern region can be explained by the three-tiered interplay between shared environmental/technological factors, economic factors/economic diversification needs, and institutional factors/institutional stability. Countries with economic capabilities, along with appropriate institutional mechanisms, can successfully transform shared environmental challenges into opportunities for technological advancements. Countries with institutional fragmentation and political volatility, however, continue to underutilize their renewable wealth.

Therefore, in the Middle Eastern region, the renewable energy transition is not just a matter of capital investments but also of R&D efforts geared toward desert conditions, institutional strengthening, and knowledge-sharing between regions. Learning between countries, especially in the domains of regulatory mechanisms in Morocco and system planning in Oman, can go a long way in addressing common challenges faced in the region, such as dust management, storage development, and climate resilience, in the quest for inclusive development in line with the SDGs.

5. Results

Analysis of renewable energy opportunity for Middle Eastern countries differ according to factors of country economic structure, and political stability. Gulf countries (*i.e.*, Saudi Arabia, Qatar, & Oman) with a high level of resources available to them, and who are relatively politically stable, are positioned to have greater success investing in renewable energy (the finance available supports the development), whereas countries impacted by conflict/insecurity/governance (*i.e.*, Iraq, Yemen, Lebanon) have significant solar/wind potential, but do not appear to be able to translate that into successful outcomes. Countries facing political instability, lack of confidence in institutions, limited access to finance are typically not able to leverage their renewable energy potential to develop the renewable energy sector as a means to diversify the economy or create jobs.

A second key finding is that ambitious targets alone do not guarantee effective implementation. Countries, like Egypt, Türkiye and Jordan, share similar experi-

ences where there is a significant gap between their ambitious goals outlined in government policies and the actual progress made toward those goals. Although they have good planning with regard to renewables, they still face significant hurdles to overcome. These hurdles include high costs of renewable technologies, limitations in the grid to accommodate more renewables, current capacity from fossil fuels being underutilised, and the economic incentive for a large majority of the population not to invest in renewables because abundant amounts of fossil fuel remain on the market at very low prices. Morocco demonstrates a way to mitigate many of these same hurdles through a consistent regulatory framework, long-term planning and engagement of the private sector. This comparison highlights that the quality of governance, clarity of regulatory framework, and availability of the physical infrastructure needed to support renewable energy development are as important as the physical availability of renewable energy resources in determining success.

The results reveal that shared regional challenges exist alongside differentiated national opportunities. High upfront investment costs, grid integration and energy storage limitations, as well as environmental impacts (e.g., heat and dust), restrict the growth of renewable energy across all participating countries; however, there are differing opportunities for different groups of countries: Gulf states have the opportunity to use renewable energy for a post-oil economic transformation; energy importing nations (*i.e.*, Jordan) can strengthen their energy security; and fragile countries can use decentralized, solar-based systems to increase resilience and access. Overall, this study provides evidence that a one-size-fits-all approach to renewable energy in the Middle East is not effective; therefore, renewable energy strategies in the Middle East need to be developed based on the specific economic structure, institutional capacity, and socio-political context of each nation in order to take advantage of the opportunities available and address the challenges faced.

6. Recommendation

The findings of this study indicate that the countries of the Middle-East will benefit from adopting renewable energy strategies, which are inclusive of all of the country specific characteristics, instead of taking a "one size fits all" regional approach. In doing so, Middle Eastern Governments should work towards ensuring consistency between their renewable energy policies and their existing oil and gas sector policies. In addition, they should put in place a consistent regulatory framework for the renewable energy sector, as well as establish long-term plans for the development of renewables in their countries to provide certainty to potential investors and speed up their country's implementation of renewable energy sources. Governments of hydrocarbon rich countries should have a stronger link between their renewable energy policies and the development of economies to diversify away from reliance on oil and gas, as well as create opportunities for local manufacturing and workforce development.

Governments in energy importing countries and low and middle income countries should work to upgrade their grid infrastructure, develop more advanced energy storage systems, and improve energy efficiency in order to meet their renewable energy goals. In fragile and conflict affected countries, the focus should be on deploying decentralised and off-grid renewable systems, which will require the support of the international community in the areas of funding, capacity building, and regulatory reform. Finally, many of the technology related costs associated with climate conditions will require more investments in research and development, regional cooperation to share knowledge, and partnerships between the public and private sectors in order to reduce costs and support renewable energy solutions linked to the goals of sustainable development.

7. Conclusion

In conclusion, this research illustrates that there are significant disparities between countries throughout the Middle East in their ability to transition to renewable energy sources and achieve sustainable development goals. While the region possesses substantial quantities of renewable resources, particularly solar and wind, a comparative analysis shows that only in countries where there is political stability, institutional capability, and coherent policy frameworks, are there opportunities for maximum utilization of these resources. In the Gulf States, the economies of these countries are better equipped to take advantage of renewables to support economic diversification. In contrast, middle-income and energy-importing nations have barriers, including the lack of infrastructure required to implement renewables, while fragile states continue to experience challenges to effective governance and access to financing. Therefore, these results emphasize that the challenges associated with renewable energy in the region are not merely technical, but rather are multi-faceted issues related to development. Ultimately, the degree of success achieved in this energy transition will depend upon the extent to which each country aligns its renewable energy initiatives with its existing economic system, the extent to which the state is capable of governing itself effectively, and its long-term development objectives, thereby ensuring that the transition to cleaner energy provides a meaningful contribution to the promotion of sustainable and inclusive growth.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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