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Middle East energy consumption and potential renewable sources: An overview

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ABSTRACT

Despite having enormous fossil fuel resources, the Middle East is susceptible to drops in oil and gas prices, which hurts the country budget. Even while the Middle Eastern countries that import energy enjoy cheaper energy costs, several of these nations have experienced war, social disorder, and political upheaval, which has made the position of the energy of the region very difficult. Water shortages are another significant issue in the Middle East. This region might be classified as a desert. The management of water resources is becoming more and more important in the area as water shortages become a serious problem. To address the current energy crisis and strengthen energy security, the Middle Eastern governments have established commendable renewable energy projects over the years. However, there is still a sizable gap between the potential of renewable energy and production that can be exploited due to rising demand and population growth. This research reported a description of the energy consumption of the Middle East and the viability of the potential renewable energy. The predicted technical result shows that the Middle East region is rich in potential solar and wind, which is the most probable option to satisfy future energy demands via a regional transmission system owing to the severe intermittent nature of renewable energy resources. In the end, it has been shown that, especially in the Middle East, which depends heavily on fossil fuels for its gross domestic product, several policy options need to be studied and put into place for renewable energy goals to be met.

1. Introduction

Energy transitions have a substantial effect on the environment, economy, and society, but the pace and extent of these changes would be reliant on a widespread move toward renewable sources of energy and energy efficiency (Dall-Orsoletta et al., 2022). To transition from carbon-intensive energy technologies to a more environmentally friendly future, it is crucial to continue to increase expenditures on both renewable energy sources and energy efficiency. According to the International Energy Agency, the electrical industry is expected to have the fastest increase in the area of renewable energy sources, which could set the stage for a sustainable future. Since the power industry is recognized as a significant contributor to global climate change, there has been much discussion on the high utilisation of renewable energy sources for electricity production globally (Gielen et al., 2019a,b). However, a significant shift in favour of renewable energy sources could require a number of ambitious goals and adjustments to the energy policies of existing administrations. According to a recent assessment from the International Renewable Energy Agency, 45 million jobs could exist in the renewable energy sector by 2050. Jobs related to energy efficiency were also expected to grow by 25% over the next few years (Heffron, 2021).

The six areas of emphasis defended where policy and decision-makers should take action toward a sustainable future are shown in Fig. 1. In the first focus area outlined in Fig. 1, for example, it is suggested that to achieve a more affordable and environmentally friendly

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pathway that is also focused on the other two central tenets of decarbonisation and the so-called energy transition, it is necessary to take advantage of the complementarities between energy efficiency and sustainable energy sources (Stevis and Felli, 2015).

Recent developments have taken place in the global electrical business during the last few years. For example, the growth of a wide variety of alternative solutions, for instance, is creating a number of issues for the power industry. This also implies that in order to handle the issues raised by this cutting-edge and intelligent power system architecture, new approaches and strategies must be used to run and plan power sources (Narayan and Kumar, 2016). Several changes in legislation, planning, investments, and cognitive processes would be necessary to implement the energy transition (Xu, 2021). Due to the disturbances in the electrical industry, new difficulties have emerged in recent years for authorities, companies, and system integrators. To handle the intermittent production from renewable energy sources while simultaneously achieving the goals of the global environment, for example, new strategies are needed (Prideaux et al., 2020). Additionally, given the high ability to contribute to emissions of carbon dioxide from the perspective of the energy sector, and in light of the Paris Agreement efforts to keep the average world temperature rise below 2 °C in this century, a comprehensive approach is needed to address the challenging problem of reducing the total level of greenhouse gases (Liu et al., 2019).

Many countries have deemed climate change to be their most urgent issue. The importance of having energy resources distributed has become more apparent in the aftermath of the climate change discussion and the just decarbonisation idea as a possible contribution to resolving these issues (Nordhaus, 2019; Carton, 2019). Distributed sources of renewable energy have gained popularity recently for two key reasons:

(i) the costs of technology are declining,
(ii) an increasing demand for greater energy adaptability in energy systems (Koirala et al., 2019).

A comprehensive and integrated strategy is necessary to achieve these objectives at the same time, and the adoption of energy supply distribution has the ability to handle the three main conflicting factors encountered by governments, municipalities, companies, and general communities (Barrows et al., 2021). Despite all the advantages associated with the growth of distributed energy resources, the increasing use of these technologies means more uncertainty in estimates of power consumption and, as a result, in the ideal future country energy distribution. (Roundtable et al., 2014) emphasise that the need to alter how the grid is controlled is being driven by the distribution of energy supplies. Therefore, the distribution of energy supplies has a high chance of causing problems. It could help the power system in big and important ways, but it could also make the system much more difficult to understand (Hu et al., 2021).

However, to fully benefit from the systemic advantages, changes in current intervention and growth planning practices are still necessary, including new contextual influences and market modelling techniques that accurately value the institutional, ecological, and social advantages (Hassan, 2022). The ability of storage solutions to absorb generated from renewable energy production from variable sources of energy and to produce electricity at a lower cost during peak periods appears to be a feasible solution. This may significantly aid in the assimilation of intermittent renewable energy into power systems (Abbas et al., 2022). Emerging tactics have also been acknowledged as one of the main contributors to overcoming the aforementioned difficulties and have the potential to provide important benefits in the development of future power supply systems. Combining energy efficiency and requirement techniques may have major positive effects on the functioning of the power system and postpone investments in the transmission and distribution infrastructure. It is important to look at the short-term and long-term effects of energy resource policies to find synergies and opportunities on the demand side (Ceran et al., 2021; Hassan and Jaszczur, 2021).

This study advances past research on renewable energy development in the Middle East by assessing the existing and future structure of energy systems. This research focuses attention on the power supply in the Middle East, and it is also relevant in terms of the conventional energy consumed, given that the renewable energy resource in the region is dependent on the energy consumption sectors. Determining feasible potential renewable resources (solar and wind) is thus a way to decarbonize the energy industry and minimize carbon emissions associated with the generation of renewable energy. The researchers will explore the technological and economic possibilities of renewable energy integration in the Middle East, as well as the policies that would facilitate their incorporation into the power grid and other sectors of energy consumption.

2. Middle East region

The bulk of Egypt and Western Asia are often included in the area known as the Middle East. More than 5.5 million square miles constitute the Middle East region. The unique physical terrain generally restricts habitation to areas along the Mediterranean coast and in Egypt forms the east, Arab sea along the south and the Arab gulf form the south east. There are mountains all around the area, some peaks reaching heights of 18,000 feet. In these mountainous regions, snow is a frequent occurrence. High plateaus are typical between the mountains (Kardaş, 2010). Fig. 2 shows the map of the Middle East region with the main locations

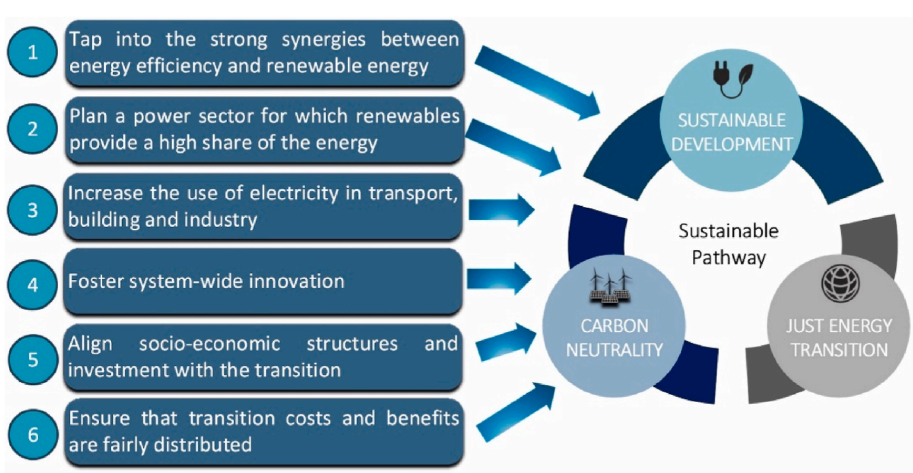

Fig. 1. The key areas where policymakers need focus their efforts for sustainable future creation (Gielen et al., 2019).

Fig. 2. Middle East region map with the red color countries evaluated in this study.

that are described in this study.

In the worldwide oil and gas sector, the Middle East plays a significant role (Rana et al., 2017). The main source of revenue for nations in the Middle East comes from the natural gas and oil resources in this area. Strategically, the area is located in the middle of Europe, Asia and Africa. The abundance of oil and gas has been a godsend for every nation in the area. Security, independence, and wise use of this money for the future are the main problems (Khatib, 2014). Due to the proximity of the Middle East to the equatorial and Northern Stream, new and sustainable energy sources such as solar and wind power are used as a significant alternative. So that they may become independent of energy demand in the future, the emerging nations in this area can invest in infrastructure for renewable energy. From the standpoint of sustainable energy, it is vital to remember that oil independence is crucial to a nation economy. However, there has been an increasing demand for the integration of the development and planning of sustainable energy and infrastructure in recent decades due to the rapid population increase that is occurring, as well as changes in zonal climate and the water cycle.

The majority of fossil fuels used around the world are found here. For example, Fig. 3 shows the Middle East has more than 58% of world oil resources (Anser et al., 2020). Although the Middle East only produces 9.6% of the world natural gas, it has 37% of the world reserves (Nathaniel et al., 2020). This study was associated with the evaluation of renewable energy sources. They thus appear to be a suitable alternative to both alternative energy sources instead of fossil fuels, the technology to use these resources is still being developed, but it is more advanced rapidly.

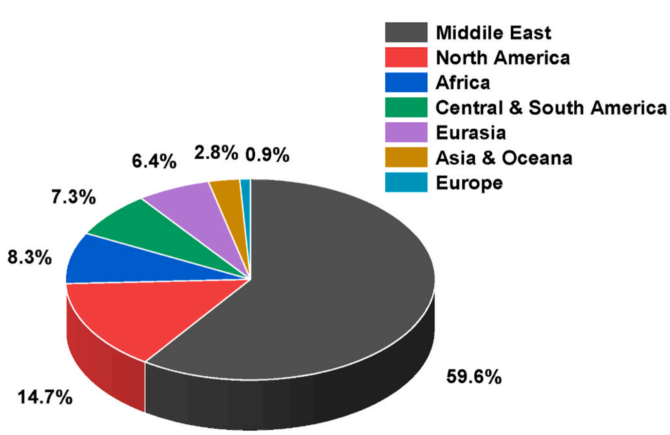

Fig. 3. The oil reserves in the Middle East (Anser et al., 2020).

As mentioned above, climate and geographic characteristics of the Middle East has a considerable potential for renewable energy sources. The characteristics of the region include strong breezes throughout the year and significant amount of solar radiation.

3. Middel East energy consumption

Due to enormous advances in economic development and energy demand, the Middle East is a crucial area of the globe to examine in terms of electricity consumption and the future of energy (Salimi and Al-Ghamdi, 2020). The real gross domestic product increased in the Middle East, Europe, and South America at average annual rates of 5.1%, 4.9%, and 4.3%, respectively, between 2010 and 2020 (Maliszewska et al., 2020). In most Middle Eastern countries, the amount of electrical power used per person has been increasing.

For example, Saudi Arbia and Iran, are the largest Middle Eastern countries, have significant oil and gas reserves 18%, 12%, between 2015 and 2021, of the world oil resources respectively (Tagliapietra, 2019; Xiaoguang et al., 2018). However, as a result of its population expansion, economic development, and improved living standards, its internal usage of fossil fuels (oil and gas) for electrical energy has expanded dramatically. This trend may soon result in a reduction in its oil exports. The use of electricity in Saudi Arabia and Iran increased by 33%, and 20% between 2015 and 2021 (Ebrahimi and Bagheri, 2022). Fig. 4 shows the energy consumption for electricity in the Middle Eastern countries for the year 2020 (Kahouli et al., 2022; Norouzi et al., 2021).

3.1. Saudi Arabia

By 2020, the consumption per capita was 5.9 toe (tone of oil equivalent), with 8.9 MWh of energy included (Mahmood et al., 2018). Due to subsidy reductions and the slowing economy, overall energy consumption has stopped rising since 2015 and decreased by almost 5% to 209 Mtoe (megaton of oil equivalent) in 2020 (Al-Homoud and Krarti, 2021). Before 2015, it had grown quickly (3% from 2020 to 2021), driven by strong, persistent economic and social development and cheap energy costs, as presented in Fig. 5 in ktoe (kiloton of oil equivalent).

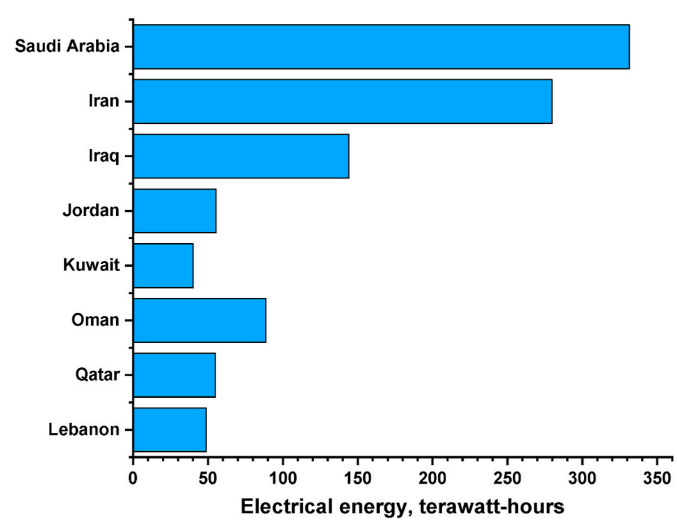

Fig. 4. Energy consumption for electricity in Middle Eastern countries (Kahouli et al., 2022; Norouzi et al., 2021).

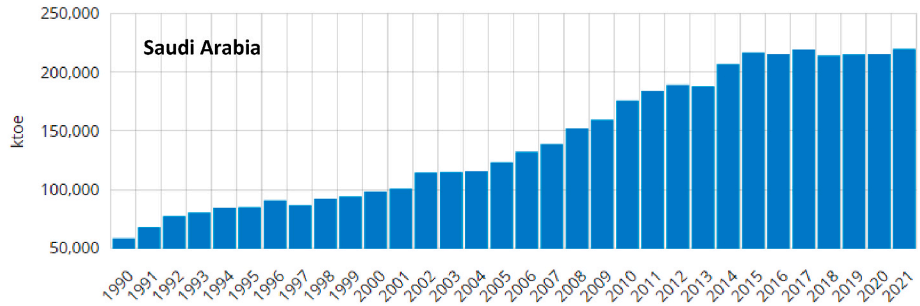

Fig. 5. Total energy consumption for Saudi Arabia (Al-Homoud and Krarti, 2021).

The Saudi national renewable energy program is managed by the renewable energy programme operations centre, which reports to the Ministry of Energy (Amran et al., 2020). Saudi Arabia share of renewable energy in electricity production as presented in Fig. 6.

3.2. Iran

Since 2019, the energy demand in Iran has maintained its level, reaching 282 Mtoe in 2021. Between 2012 and 2019, it increased by 3.9% annually (Mardani et al., 2022). In 2021, natural gas will account for 77% of all energy used, an increase of 11 percentage points since 2010. Since 2000, the proportion of oil in overall consumption has decreased by half, from 58% to 29% by 2021 (Taghvaee et al., 2022). Only 2% of primary power is produced as presented in Fig. 7 and Fig. 8.

The governing agency in charge of approving renewable energy projects, developing renewable energy policies and obtaining agreements for power purchase agreements with renewable energy providers was the Iran Renewable Energy Organization (REO). According to the country plan, the nation sought to achieve 4.5 GW of wind and 0.5 GW of solar capabilities by 2021, with an additional 2.5 GW by 2030 reaches with renewable energy providers, the Iran REO. According to the country plan, the nation sought to achieve 4.8 GW of wind and 0.6 GW of solar capabilities by 2023, with an additional 2.8 GW by 2030 (Solaymani, 2021). Only 320 MW of wind and 460 MW of solar energy have been built, as presented in Fig. 8.

3.3. Iraq

In 2021, the Iraq energy consumption per person was 1.3 toe/person. About 1030 kWh of electricity were used per person in 2021 in Iraq. Compared to the neighboring country, it remains substantially lower (3350 kWh in Turkey and 1920 kWh in Jordan) (Istepanian, 2020). The total energy usage increase by 12%–50 Mtoe in 2021 (Hassan et al., 2022a). From 2015 (8%/year), it has been observed rapidly increase till 2020. In Iraq, about 77% of the total energy use in 2021 come from oil; the remaining 23% come from gas and 4% come from renewables. Energy consumption in Iraq has been presented in Fig. 9.

In October 2021, the Iraqi energy government stated the country intention to expand the proportion of renewable energy in its mix of energy generation to 35% by 2030, owing to a significant growth in solar energy (a target of 13 GW). Before 2017, the Iraqi power ministry announced the renewable energy infrastructure plan with a 2020 goal of 2671 MW (Hassan et al., 2022b). The goal was not achieved as the output reached 220 MW in 2020 what is presented in Fig. 10.

3.4. Jordan

In 2021, including 1890 kWh of electricity, Jordan per capita usage is 0.8 toe/cap. Since 2018, the total country consumption about 8 Mtoe has decreased by 3.6% (Alawneh et al., 2018). About 53% of the total energy consumption comes from oil, followed by 39% from natural gas as shown in Fig. 11.

The Jordanian policy targeted having 10% of the country electricity sector come from renewable sources by 2021, equivalent to a capacity of 1850 MW, primarily from solar 650 MW and wind 1250 MW. This objective was achieved in 2021, when around 2 GW of solar and wind energy was built and made up 25% of the energy mix (Alawneh et al., 2018). Jordan plans to increase its participation to 33% by 2030. In 2014, the country established a feed-in tariff system for smart meters. This system reduces energy use and allows any extra energy to be sold back into the national grid. Fig. 12 the percentage of renewable energy consumption form total energy consumption in Jordan.

3.5. Kuwait

Kuwait per capita consumption in 2011 has fluctuated approximately 8.5 tons (among the ten highest in the world), while electricity usage has fluctuated around 15 MWh/capita during 2008. From 2014 to 2016, overall energy usage increased rapidly and ranged from 36 Mtoe until 2019. In 2020, it decreased by 17% to approximately 30 Mtoe. It remained relatively steady throughout 2008 and 2013 (about 28 Mtoe) and grew fast throughout 2000 and 2008 (a mean of 5.4% each year) Fig. 13.

In accordance of Kuwait vision of the future of Kuwait 2035, the government has set an ambitious aim to produce 57% of its power from renewable sources by 2030 (Alsayegh, 2021). Several photovoltaic

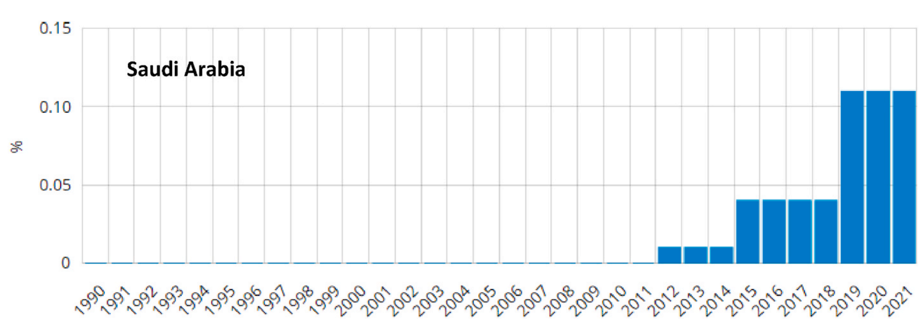

Fig. 6. Renewable energy consumption in total energy consumption in Saudi Arabia (Amran et al., 2020).

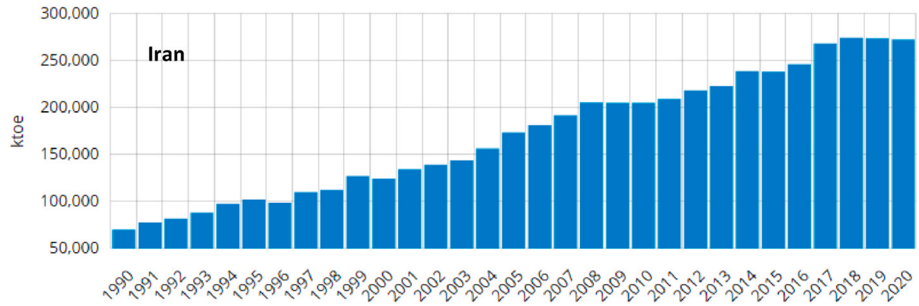

Fig. 7. Total energy consumption for Iran (Taghvaee et al., 2022).

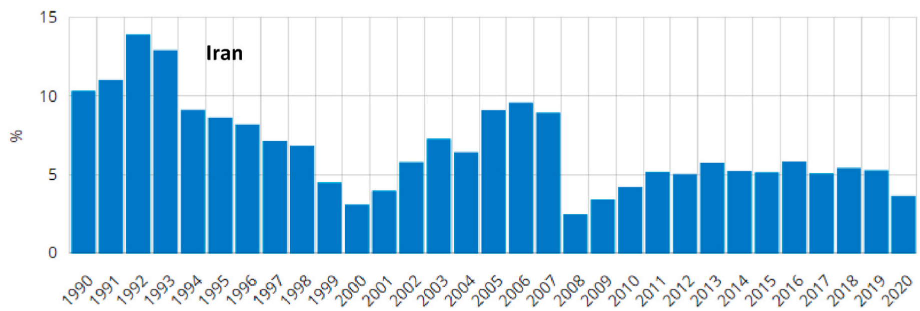

Fig. 8. Renewable energy consumption percentage in total energy consumption for Iran (Solaymani, 2021).

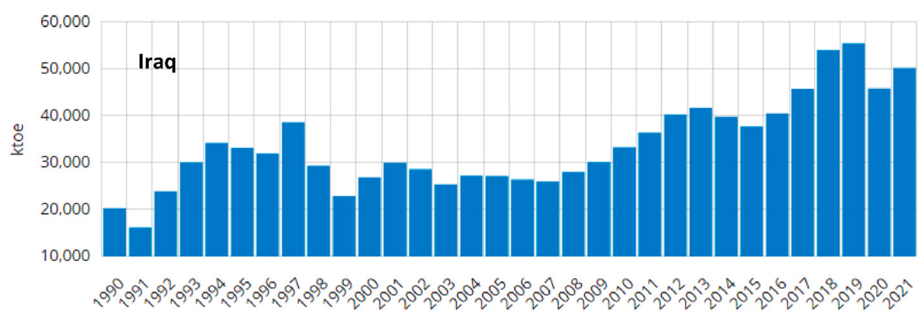

Fig. 9. Total energy consumption for Iraq (Hassan et al., 2022a).

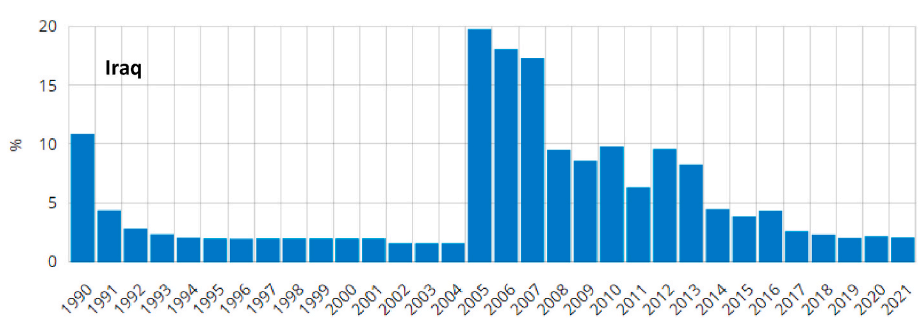

Fig. 10. Renewable energy consumption percentage in total energy consumption for Iraq (Hassan et al., 2022b).

installations are progressing, but no flagship programmes to accelerate the growth of renewables has yet been established, as shown in Fig. 14.

3.6. Oman

The per capita energy demand in Oman is 4.5 toes in 2020, which is three times the world average (Al-Saadi and Shaaban, 2019). In 2020, the per capita electricity usage reached 6,3 MWh, as presented in Fig. 15.

In accordance of Kuwait vision of the future of Kuwait 2035, the government has set an ambitious aim of producing 157% of its power from renewable sources by 2030 (Al-Badi and Al-Saadi, 2020). Several photovoltaic installations are progressing, but no flagship programme to accelerate the growth of renewables has yet been established, as shown in Fig. 16.

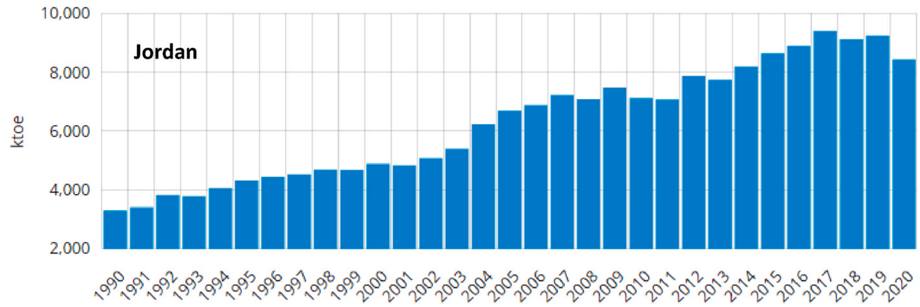

Fig. 11. Total energy consumption for Jordan (Alawneh et al., 2018).

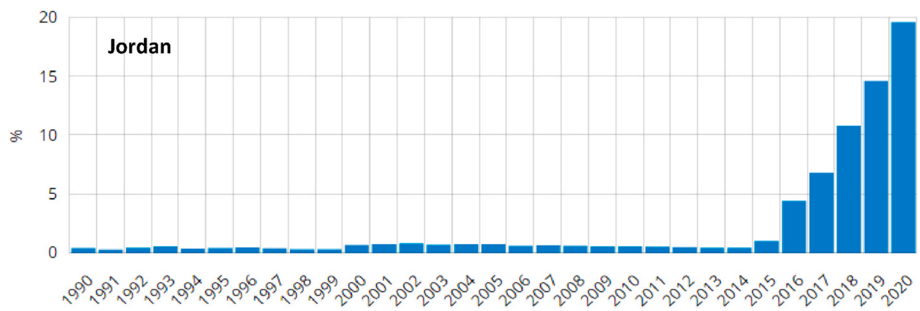

Fig. 12. Renewable energy consumption percentage in total energy consumption for Jordan (Alawneh et al., 2018).

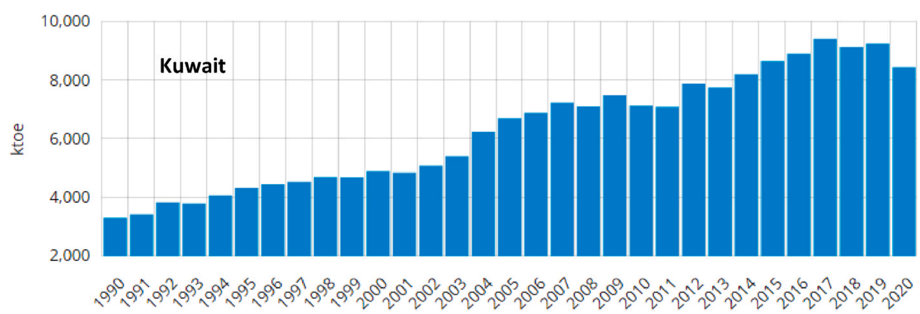

Fig. 13. Total energy consumption for Kuwait (Alshuraiaan, 2021).

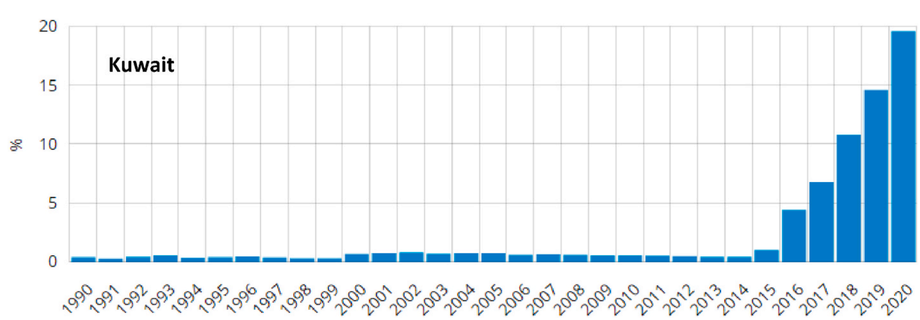

Fig. 14. Renewable energy consumption percentage in total energy consumption for Kuwait (Alsayegh, 2021).

3.7. *Qatar*

The total energy usage per capita in Qatar is approximately 16 tons, comprising 14,300 kWh of electricity (Kamal et al., 2019). After an extremely strong increase throughout 1999 and 2012 (11%/year), the overall consumption expanded more slowly throughout 2012 and 2018 (1.6%/year). In 2020, it declined by 3.5%–46 Mtoe, as presented in Fig. 17 (Khalifa et al., 2019). It is divided between natural gas (82%) and crude oil (18%) 17 (Khalifa et al., 2019).

Qatar aims to meet 20% of its energy needs from renewable sources by 2030. Its original goal was to reach a solar capacity of 1800 MW by 2020 at a cost of between $10 billion and $20 billion (Abdmouleh et al., 2018). However, this goal was not met, since the complete 900 MW power plant is slated to be commissioned and linked to the grid in 2022. Fig. 18 show the renewable energy percentage from total energy consumption in Qatar (Abdmouleh et al., 2018).

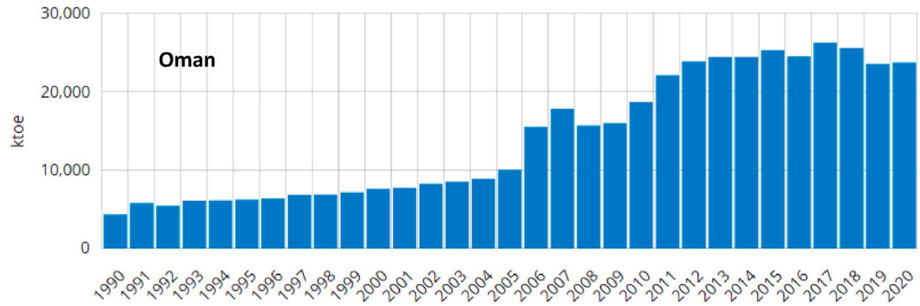

Fig. 15. Total energy consumption for Oman (Al-Saadi and Shaaban, 2019).

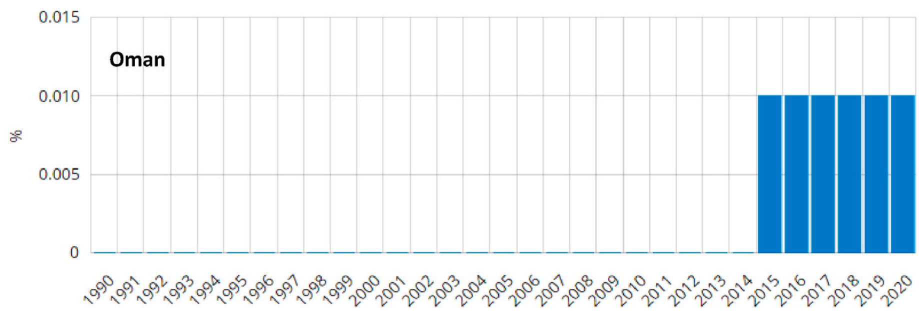

Fig. 16. Renewable energy consumption percentage in total energy consumption for Oman (Al-Badi and Al-Saadi, 2020).

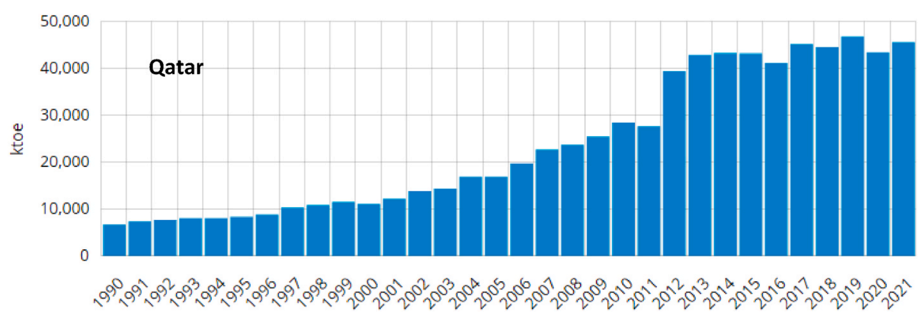

Fig. 17. Total energy consumption for Qatar 17 (Khalifa et al., 2019).

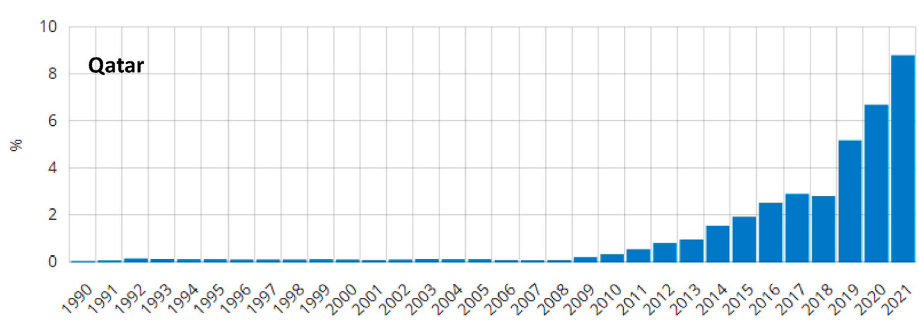

Fig. 18. Renewable energy consumption percentage in total energy consumption for Qatar (Abdmouleh et al., 2018).

3.8. Lebanon

In 2020, the per capita energy demand in Lebanon was 0.9 toe/cap. In 2020, the per capita power usage was 2100 kWh. In 2020, overall energy usage decreased by 14% to 7.5 Mtoe, after a 7% decrease in 2019 (Moore and Collins, 2020). Historically, it increased substantially throughout 2011 and 2017 (about 6% annually), as presented in Fig. 19.

Lebanon has planned to produce 17% of its electricity consumption and 12% of its heat needs from renewable sources by 2030 (Ahmad, 2020). With foreign cooperation, these renewable energy objectives could be potentially extended to 32% of the country electricity consumption and 17% of its heat needs, as shown in Fig. 20.

3.9. United Arab Emirates

In 2020, the overall energy consumption per capita throughout the country account for 7.3 toe. Due to air ventilation in buildings and electro-intensive sectors, the 2020 per-person energy consumption is

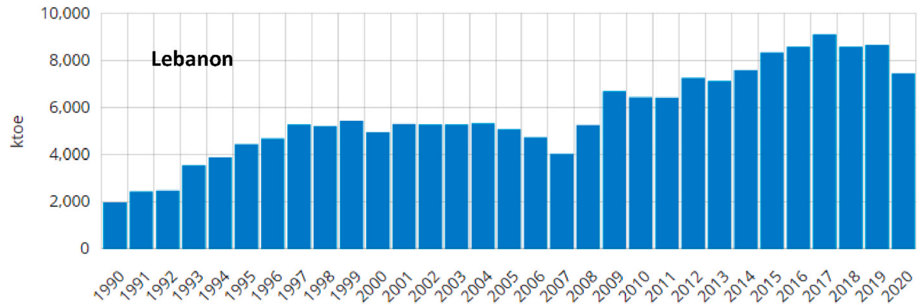

Fig. 19. Total energy consumption for Lebanon (Moore and Collins, 2020).

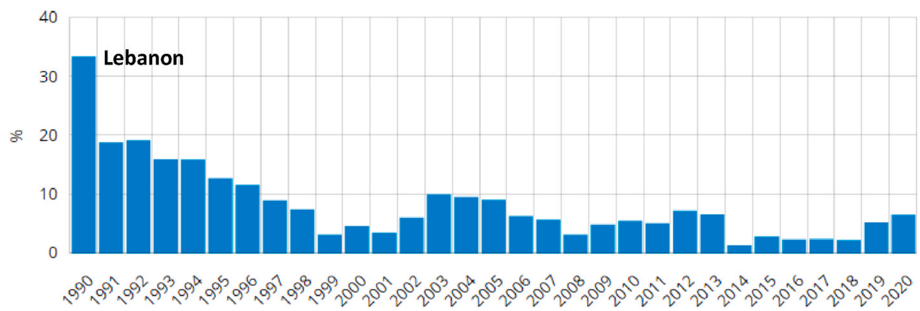

Fig. 20. Renewable energy consumption percentage in total energy consumption for Lebanon (Ahmad, 2020).

also quite high, approx. 13 MWh, ranking ninth in the world. Since 2017, total energy use has fallen, however, between 2001 and 2017, it has more than doubled (Almasri and Narayan, 2021). The United Arab Emirates aims to achieve 25% of installed capacity using renewables by 2025 and 45% in energy consumption by 2050. Dubai has also set a goal to generate 30% of its electricity from renewable sources by 2030, and 70% by 2050 (Krarti and Dubey, 2018).

4. Potential renewable energy

Currently, most of the energy in the Middle East is produced by steam-based power plants powered by natural gas or oil, some of which provide both electricity and heat. The cumulative use of renewables in the Middle East is minimal at the moment, but a growing number of countries within the region are examining alternatives to relying on indigenous oil and natural gas supplies for power production, due to environmental and economic advantages. The projected potential for photovoltaics and concentrated solar power in Saudi Arabia during the next two decades is approximately 28 GW (Boretti and Castelletto 2021; Boretti, 2021). The Energy Information Agency anticipates 15–25 GW by 2035 in the Middle East from each of the three primary renewable energy sources: wind, photovoltaics and concentrated solar power.

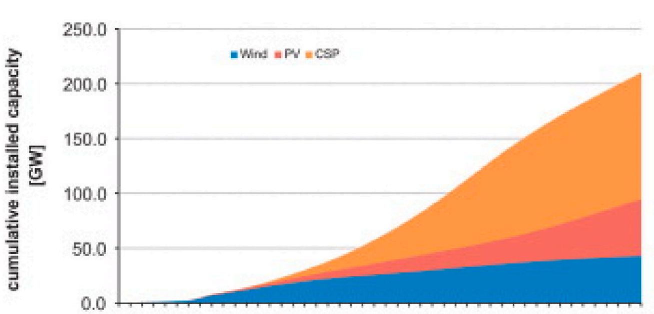

Fig. 21. Capacity for three renewable energy technologies in the Middle East till 2050 (Jendar et al., 2022).

Fig. 21 shows the capacity of three renewable energy capacities in the Middle East region till 2050.

Performance measurement and management frameworks are often used to construct regional and national predictions for prospective energy demand and supply or to motivate their development. For this investigation, we employ the renewable technology needed in the Middle East region to implement a rigorous global climate change policy that stabilises atmospheric carbon dioxide accumulation with a minimum extra solar irradiance of 2,8 W/m^2 (He et al., 2018; Al-Jiboory et al., 2016; Hassan et al., 2021). In this concept for combating climate change, which differentiates between long-term and short-term climate change policies. In the short future, through 2020, we anticipate that global nations will take national steps to meet local objectives for greenhouse gas emission reduction, sustainable energy deployment, and energy conservation implementations (Hassan et al., 2019; Jendar et al., 2022). In light of the apparent lack of Copenhagen commitments from Middle Eastern nations, no climate policy managerial measures will be adopted until 2020, with the exception of the announced targets for the deployment of renewable energy in several countries across the region, including Saudi Arabia, Iraq and the United Arab Emirates (Jaszczur and Hassan, 2020; Jaszczur et al., 2020).

Long-term, after 2020, we assume a globally concerted response to reduce climate change, which can be interpreted as the emergence of a carbon pollution tax system as well as a credential market, to ensure that by the end of the century, as a direct consequence of deep greenhouse gas emission cuts.

4.1. Potential wind energy

Wind energy is the conversion of renewable energy into a form of energy that can be used. As a replacement for fossil fuels, wind energy is plentiful, renewable, widely available, clean, does not release greenhouse gases when it is made, and only needs a small amount of land (Hassan, 2020). The intensity of the wind fluctuates, therefore, an average number for numerous places in the Middle East does not reflect the amount of electricity a wind turbine may generate anywhere. Frequently, a probability density curve is fitted to observable data to determine the frequency of wind speeds in a given place. Wind speed distributions at various sites are very different (Jaszczur et al., 2019). Typically, winds near the ground are used to generate electricity, winds at higher elevations are faster and steadier, and their is worldwide potential. In recent times, major advancements have been made in the technology used to produce power from high-altitude winds.

Wind energy is the potential energy associated with mass movement. Wind energy systems transform this kinetic energy into more practical kinds of energy. Compared to conventional fuels, the electricity generated by wind power systems emits less carbon dioxide. Consequently, it has a lower greenhouse impact. In addition, wind energy creates numerous employments.

It should be emphasised that comparing the wind direction across several locations simultaneously is quite challenging. In this study, data mapping software (GIS) was used to make more informed decisions on wind feasibility studies. Since there were no wind data for any of the relevant possible sites, constant wind data and wind power densities were used to estimate the potential for renewable energy in areas without wind speed data. Three GIS maps are produced for the Middle East, using the average wind speed and wind battery capacity at two different heights. Different colors on the GIS map represent the wind velocity and specific power at each place. On the other hand, the various categories of wind speed and specific power could be highlighted in red for better conditions. Additionally, locations with low wind speed and power density are highlighted in green.

Notice that the wind data throughput is at a height of 10 m. To facilitate a more accurate comparison of wind data from different stations and to account for wind shear, wind data have been estimated at a height of 50 m. As seen in Fig. 22 and 23, the eastern, southern and southeast parts of the Middle East have a high potential for the installation of wind turbines. These locations are known for their strong wind speeds. According to these maps, the central parts of Iran and the southern parts of Saudi Arabia have significant promise. Some of these areas are better suited for restricted applications, such as wind-powered cooling systems. ArcGIS can be used to locate potential locations for wind turbine installation, taking into account aspects such as proximity to cities, highways, and other needs.

Fig. 22 reveal that the power density at a height of 10 m is about 188 W/m^2. From these numbers, the regions with the highest density of wind energy at a height of 10 m include central Iran and parts of Oman. Other nations, including Iraq, Kuwait, Jordan, and Lebanon, have a lower energy density. There is a significant potential value of energy output, modest wind turbines may be used, and smaller turbines can offer energy to rural regions with relative ease. Although this number climbs to around 520 W/m^2 at a height of 50 m, which is considered an excellent wind location as presented in Fig. 23.

There is a significant power concentration capacity at 50 m; consequently, large wind turbines can be constructed to supply energy to rural and urban regions and link to regional power systems.

4.2. Potential solar energy

Solar energy is the direct or indirect conversion of irradiance into energy using photovoltaic or concentrating solar energy. Concentrated solar energy systems employ mirrors or lenses and tracking systems to condense radiation from a vast region into a narrow beam (Kabir et al., 2018). Solar energy is clean, renewable, and globally accessible. Solar energy may be used in several ways, including (Jaszczur et al., 2018; Hassan et al., 2022c): Produce energy with the use of photovoltaic solar cells; produce hydrogen using fuel cells; Produce hot and cold air using solar chimneys; Produce hot water using solar geysers.

In addition to the benefits of renewable energy, solar energy has the following additional advantages (Hassan et al., 2022d). Restoration of degraded lands; less focus on the national electricity grid; Improve water quality throughout the country; and expand remote area electricity.

The daily total worldwide horizontal radiation GIS map for the Middle East is displayed in Fig. 24. Solar radiation intensity is color-coded on GIS maps. Thus, regions with superior circumstances are indicated by hues that are closer to the color red. As places approach low levels of radiation, the color of the marker changes to green. According to the GIS maps shown in Fig. 24, the quantity of radiation generally increases as one moves from north to south. This is because the latitude decreases on this route, bringing it closer to the equator.

5. Middle East towards renewable energy

The Middle East has benefited greatly from its large oil and gas deposits for many years. Fossil fuels have been the most affordable

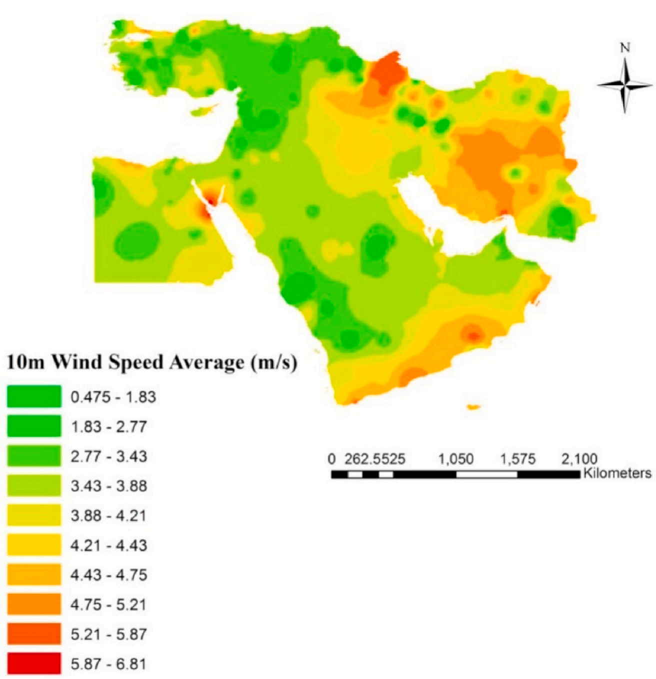

Fig. 22. Potential wind speed at 10 m (GIS map).

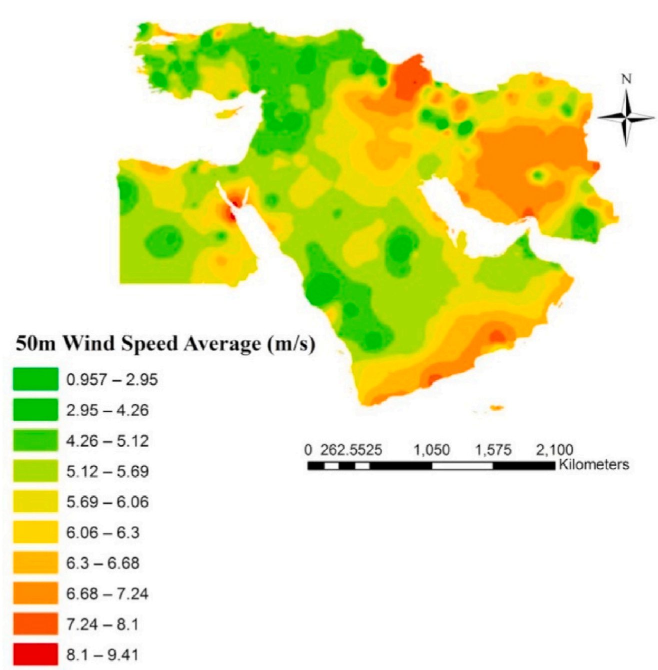

Fig. 23. Potential wind speed at 50m (GIS map).

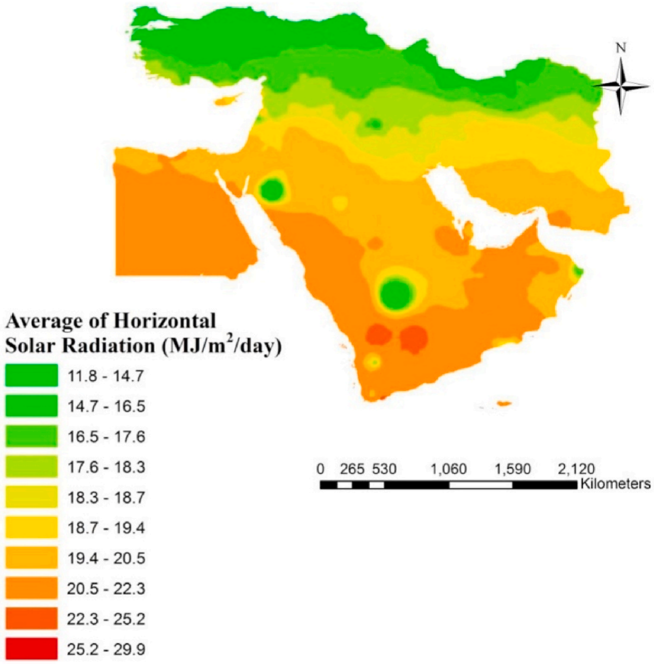

Fig. 24. Potential solar radiation (GIS map).

alternative for many due to their low cost of production and a lack of regulations to encourage the use of other sources of energy, which explains the region delayed adoption of sustainable energy. In recent years, there have been more projects to boost renewable energy, which shows that the countries in the area are moving toward more sustainable options. An increase in initiatives to encourage renewable energy sources indicates that the area is progressively moving toward sustainable options.

According to the most recent survey on the Middle East energy transition, thermal power dominates the regional power mix and will account for more than 90% of all energy consumption in 2021 (Sharma et al., 2021). Natural gas is the main fuel source in this Region. Despite recent initiatives to progressively reduce dependency on fossil fuels, outside forces like Russia and Ukraine wars have worked to stymie any notable advancement. The sanctions placed on Russia, the second largest natural gas provider in the world after North America, have caused the rest of the World to look for other supplies, which is expected to lead to an increase in Middle Eastern natural gas output in the next ten years. In contrast, a 30% reduction in oil-fired power capacity is expected in 2030 (Alqaed et al., 2021). The growing preference for lower-carbon fuels, which favors natural gas over oil and coal, is to blame for this gap.

6. Conclusions

The most important reasons for research attention to the advancement of renewable energy, in addition to the regional possibilities, are the restrictions, dangers, and negative environmental effects of fossil fuel energy. Despite the Middle East abundance of competent renewable sources, progress in renewable energy is seen as modest or even stagnant because of the region over-concentration on fossil fuels. The future of the energy sector and its revenues will face further problems in light of the strong economic development in this area caused by fossil fuel exports and the rise in regional consumption. This requires more attention to the production of energy from renewable energy sources. It is necessary to be competitive and non-governmental in order to make the use of renewable sources of energy more affordable. Consequently, it is economically crucial that the private sector participate as a stimulant engine. However, studies show that the financial sector is consistently reticent about making investments in a particularly emerging industry. In this article, a collection of seven necessary variables for the spread of renewable energy has been identified, which focuses on the requirements for private sector investment. Then, these aspects have been classified and graded into three distinct parts, including technology, the environment, and the economy and politics.

From the perspective of the investor, Middle Eastern politics and commerce seem to be the main obstacles or possibly the root of the likely market risk. Researchers determined that investors are now uncertain about the sustainability of this business and the associated marketplaces after collecting the necessary data. The accurate, transparent, and well-classified facts and information that are the subject of this article should be provided to them in order to set the stage for the private sector engagement and alleviate their uncertainty. Following validation and updating, for example, good knowledge and segmentation of the renewable energy consumption market have been shown to be critical. This component helps investors recognize the consumer market and have a thorough understanding of it. This study also shows that some of the most obvious things that academics may overlook are very important for investors.

Some of the factors that are considered in this study are the identification of the regional potential for the development of renewable energy and the appropriate exploitation time. They might be used to support and direct a wide range of upcoming research projects. In a similar vein, future studies in this field will need to examine the crucial study required for the creation of a non-governmental industrial organization. It could lead to the participants sharing information and doing more research to come up with better choices. It could also lead to a market analysis and an analysis of operational challenges and the risks they pose.

Data availability

No data was used for the research described in the article.

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