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Saudi Arabian Energy: Evolution, Trends, and Outlook

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Independent Study

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Executive Summary

The energy sector of Saudi Arabia plays a critical role in the country's economy and socio-political well-being. The Kingdom is one of the leading players on the global scene of oil trade and ranks second in proven oil reserves, meaning that it has a substantial oil supply to continue exporting petroleum and other oil products. Nevertheless, there is a growing global trend toward the development of renewable energy sources in order to improve sustainability and prevent the exhaustion of the Earth's resources. The purpose of the independent study was to examine the energy sector of Saudi Arabia and the impact of global trends in energy on it. As part of the project, the current state of renewables and non-renewables in Saudi Arabia and the world was assessed, and the implications of green energy trends in the Kingdom were evaluated. National policies concerning renewables and fossil fuels were also taken into account since they shape the current state of the energy sector in the country.

As a result of the analysis, it was found that the Saudi Arabian economy relies heavily on oil exports, which contributed to its growth over the years. At present, oil exports constitute 90 percent of the Kingdom's revenues, thus playing a major role in its economic growth and stability (Salam & Khan, 2018). Oil production and sale also accounts for about 45% of the country's GDP, and a reduction in oil exports can push the economy into a recession (Salam & Khan, 2018). Therefore, fossil fuels and their sale have a direct impact on economic stability of Saudi Arabia.

Renewables, in contrast, play a minor role in the country's national policy and its energy sector, and planned improvements in this area are meager. For instance, the government substituted the goal of 54 GW of renewables by 2032 to just 9500 MW of renewable energy by 2023 (Bayomi & Fernandez, 2019). At the same time, there is a global trend toward the acceptance and development of renewables, which could damage the global demand for oil and oil prices, thus

impacting Saudi Arabia negatively.

Three potential scenarios for the future of the Saudi energy sector were formulated based on previous research findings. While the optimistic and the middle-ground scenarios would either benefit the country's economy and political stability or have no significant impact on them, the pessimistic scenario could force the Saudi Arabian economy into recession and cause political turmoil due to unemployment and other negative social consequences. Hence, it is advised that the country seeks to develop its capacity for renewable energy to protect against the pessimistic scenario and mitigate its potential negative effects.

Saudi Arabian Energy: Evolution, Trends, and Future Outlook

Introduction

The Kingdom of Saudi Arabia is a significant producer of oil in the contemporary world. According to Al-Saleh (2009), it is "the principal oil superpower," which makes the country dependent on trends in the global energy sector (p. 650). Other experts note that around one-fifth of the world's oil capital is located in Saudi Arabia, and the total reserves of natural gas in the Kingdom are estimated to be about 275 trillion cubic feet (Tlili, 2015). The country's economy is supported by the production and sale of oil and natural gas, and its growing population also results in increasing energy needs (Al-Saleh, 2009). Nevertheless, given that the natural reserves of fossil fuels are projected to exhaust in the next ten decades, developing a more sustainable energy sector and diversifying it to reduce the reliance on oil is an essential challenge for Saudi Arabia (Salam & Khan, 2018).

The government of Saudi Arabia seems to recognize the importance of renewable energy and its potential contribution to the country's future. As noted by Tlili (2015), the Kingdom invests in renewable energy research and has developed multiple initiatives to support renewable energy applications in the upcoming decades. The gradual deployment of alternative energy in Saudi Arabia aligns with global trends in the energy sector, which will likely continue impacting the country in the future.

The present independent research project focuses on the energy sector in Saudi Arabia and the shifts occurring in it. The paper aims to review the local and global trends in energy production and use while also studying the dynamics of renewable energy in Saudi Arabia and the implications of these developments. The first goal of the paper is to expand the current understanding of the effect that global energy trends have on the energy sector or Saudi Arabia. The second goal is to

examine the context for renewable energy both globally and in the Kingdom and explore the future outlook for clean energy in Saudi Arabia. By fulfilling these goals, the project expands scholarly knowledge and examines policy implications on the topic.

The research project is organized as follows. The first chapter focuses on the energy sector of Saudi Arabia, explaining its evolution, significant developments, and current state. The chapter also reviews the role that the industry plays in the country's national policy and economy and draws regional comparisons. The second chapter describes the key trends in global energy and their effects on energy production and use in the Middle East and Saudi Arabia. This includes an overview of the industry and a description of green energy trends and impacts. In connection with this information, the third chapter offers more details on renewable energy and fossil fuel in Saudi Arabia by looking at national policies, projects, future outlook, and potential scenarios. This is followed by an exploration of the impacts of renewable energy, the risks posed by it, and the effect of each scenario on the political and economic situation in Saudi Arabia in Chapter 4. Lastly, the Conclusion section overviews the results and implications and provides recommendations for national policies that could help to prevent the pessimistic scenario from unfolding. It is expected that the project provides essential information to support research and policy in the field of renewable energy in Saudi Arabia.

The Energy Sector of Saudi Arabia

Evolution of the Energy Sector of Saudi Arabia

Oil Discovery

The primary milestone in the evolution of the energy sector of Saudi Arabia was undoubtedly the discovery of oil. It began in 1933 when Standard Oil of California (SoCal) was awarded an oil concession for the province of Al-Hasa in Saudi Arabia (Morton, 2018). The introduction of structure drilling made a powerful impact on the progress in this area, allowing locating and accessing oil in the Kingdom. This technique was suggested as a way to identify subsurface structures, which could not be found with other methods (Morton, 2018). Consequently, giant oil fields were discovered in the Arabian desert toward the end of the decade. At the same time, the Rub al-Khali desert was also being explored (Morton, 2018). Once oil fields were located in the deserts, shallow wells began to be built, with deep strategic drills following them to gain more access to the areas (Morton, 2018).

The commercial production of crude oil in Saudi Arabia began in 1938 when conventional petroleum reserves were first located in the Kingdom (Aramco, 2020a). Since then, the production of oil was used both to sustain the country's growing demand for electricity and for export, causing Saudi Arabia to become one of the key players in the global oil market. National policy supported the developments in the oil sector since they contributed to the country's economic growth (Salam & Khan, 2018). Oil has a substantial impact on the country's GDP, accounting for 45 percent of it as of 2015 (Salam & Khan, 2018). Furthermore, 90 percent of Saudi Arabia's export earnings come from the sale of oil (Salam & Khan, 2018). Hence, the effect of oil discovery on the nation's economic development and growth over the past decades has been significant. It has also impacted society at large by providing enough power for infrastructure and businesses. According to Salam and Khan

(2018), 85% of Saudis live in urban areas, and the power consumption of the Kingdom is significant, with a compound growth rate of 6%, with the housing and commercial sectors being the main consumers of electricity. Thus, the discovery and subsequent use of oil played a crucial role in the evolution of the Saudi energy sector and its economy.

Energy Sector Development

Reviewing the development of the power infrastructure in the Kingdom can also shed light on the background of the energy sector since it increased the need for oil and other sources of energy. According to a technical report by Barad'ieh (2015), the history of power infrastructure in Saudi Arabia can be generally separated into two stages. In the first stage, electricity production and distribution was the duty of small local companies in Saudi towns and villages, which sold electricity generated primarily from oil to residents (Barad'ieh, 2015). Since then, the government's involvement in the energy sector became more and more prominent, with the subsequent establishment of the Department of Electricity Affairs and the Department of Electricity Services in 1961 and 1972, respectively (Barad'ieh, 2015). This began the second phase of power system development as energy production and distribution became more controlled.

In 1975, the Government of Saudi Arabia committed to an economic development plan that focused heavily on the expansion of the energy sector in the country. The goal was to sustain population growth through electrification while also developing the share of oil exports. Consequently, government control of power companies intensified further, and with the help of commercial-scale oil production, power networks were improved across the Kingdom (Barad'ieh, 2015). Consequently, between 1970 and 2006, the number of customers for electricity in Saudi Arabia grew more than twice. This increased the demand for oil and prompted other developments in the energy sector, including the exploration of natural gas reserves.

Natural Gas

As reported by Aramco (2020b), the production of natural gas in Saudi Arabia began in the 1970s as a way to generate additional revenue. However, at the time, the focus of gas production was mostly on associated gas, and the reserves of non-associated gas were not explored thoroughly. Toward the end of the decade, the Masted Gas System was developed. As noted by Shamma (2000), "the MGS made the kingdom self-sufficient in gas feedstocks for industry and fuel for electricity" (p. 7). The focus on non-associated gas was developed later when the Saudi company Aramco began developments in this area. The efforts were mostly focused on the Ghawar region and were supported by the government, which sought to develop the Kingdom's access to power further and reduce its dependence on oil (Shamma, 2000). As a result, natural gas became a prominent component of the country's energy sector, and its exploration led to its further development.

Long-Term Trends in the Saudi Energy Sector

As evident from the discussion, the growth of the energy sector in Saudi Arabia was prompted by three main factors: resource discovery, national policy, and growing population needs. In 1990, the total energy production in Saudi Arabia was 368.44 mtoe, and it increased by over 80% by 2018 (IEA, 2020a). Over time, oil has come to play a crucial role in the development of the country's economy. According to Alkhatlan (2013), the reduction in oil exports has an immediate negative impact on the country's GDP, while the increase in oil exports has a positive effect. Figure 1 presents a comparative graph of oil, non-oil, and real GDP. Based on the chart, the development of the Saudi economy was associated with greater oil exports as they increased the country's real GDP.

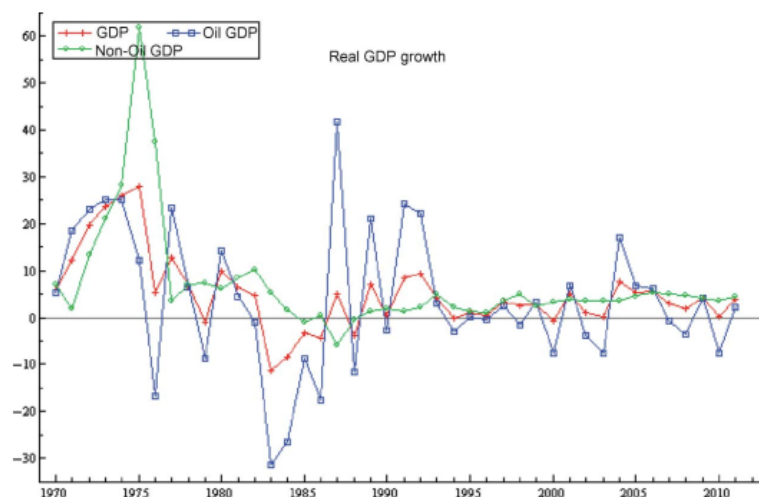


Figure 1. Economic growth by real GDP, oil GDP, and non-oil GDP (Alkhatlan, 2013, p. 344).

The country's oil reserves show positive long-term trends, having increased from 166 billion barrels in 1980 to 266,578,000,000 in 2016 (Saudi Arabia oil, 2020). Still, this growth was prompted by a significant increase in 1990, and since that time, the growth of oil reserves has been slow (Figure 2). The country currently occupies second place in oil reserves and in oil production but is also notable for its growing consumption (Salam & Khan, 2018; Saudi Arabia oil, 2020). Hence, long-term trends in energy show that fossil fuels play a critical role in the economy and that the country is committed to the exploration and use of its oil reserves.

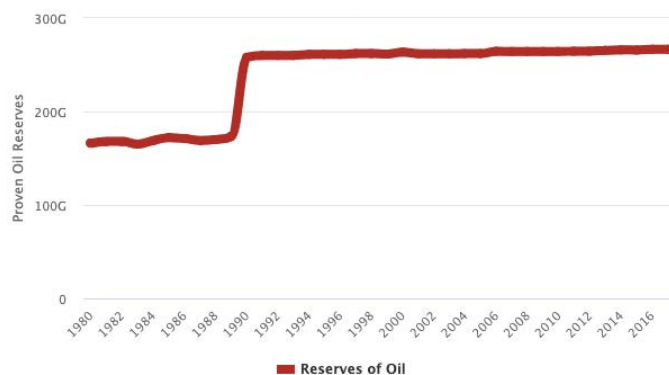


Figure 2. Proven oil reserves of Saudi Arabia (Saudi Arabia oil, 2020).

Current State of the Energy Sector

The current state of the energy sector in Saudi Arabia is characterized by considerable reliance on both oil and natural gas. Biofuels and waste, as well as alternative energy sources, represent a minimal share of the overall supply of energy in the Kingdom. In exploring energy production, it is possible to note critical improvements over the past 30 years, driven both by economic shifts and by population growth (IEA, 2020a). The total output of the country's energy sector equaled 665.38 mtoe in 2018, showing substantial growth from 572.97 mtoe in 2008 (IEA, 2020a). In comparison, the United States had a total energy output of 2172.52 in 2018, up from 1701 mtoe in 2008, and Russia, who is another leader in fossil fuels, produced 1484.13 mtoe of energy in 2018, up from 1254 mtoe in 2008 (IEA, 2020b). Based on these figures, the growth of energy production in Saudi Arabia is comparable to other major players in global energy, but production outputs are smaller than those of the United States and Russia.

The total primary energy supply in Saudi Arabia has also increased compared to global trends. In 2018, the total supply of domestic energy in the Kingdom was 213.64 mtoe, compared to 151.46 mtoe in 2008 (IEA, 2020a). In the United States, the total primary energy supply decreased from 2277 mtoe in 2008 to 2230 mtoe in 2018 and in Russia, it has grown from 688 mtoe to 759 mtoe over this period, but decreased by 13.65% from the 1990s (IEA, 2020b). These trends indicate that the energy sector of Saudi Arabia continues to develop rapidly and shows more robust trends than its key competitors, providing sources of energy both for domestic use and for export.

The export of Saudi Arabia is primarily centered on crude oil and oil products. According to the data by the IEA (2020a), out of the total 586 254 ktoe of crude oil produced in the country in 2018, over 370 000 were exported as crude oil and over 118 000 as oil products. Still, 10-year trends indicate that the growth in oil imports has been insignificant, as the total crude oil exports in 2008

were over 363 000 ktoe (IEA, 2020a). At the same time, natural gas is used mostly for domestic purposes, with no growth in imports or exports over the past decade (IEA, 2020a). In comparison, United States and Russia produce and export coal, which makes no contribution to the energy sector of Saudi Arabia (IEA, 2020b). The volume of crude oil production and exports in Russia and Saudi Arabia was comparable in 2018, with 558 165 ktoe produced by Russia and 261 856 ktoe exported (IEA, 2020b). The United States, maintaining comparable oil production levels (685 168 ktoe), exported less crude oil (125 202 ktoe) and imported more (431 899 ktoe), meaning that the country plays a less prominent role in the global oil sector (IEA, 2020b). Based on these trends, it is evident that oil is the primary product for Saudi Arabia in the global energy sector, and the reliance of the country's economy on its exports is firm. As a result, other sources of energy remain underdeveloped, despite efforts to gain more power and revenue from them.

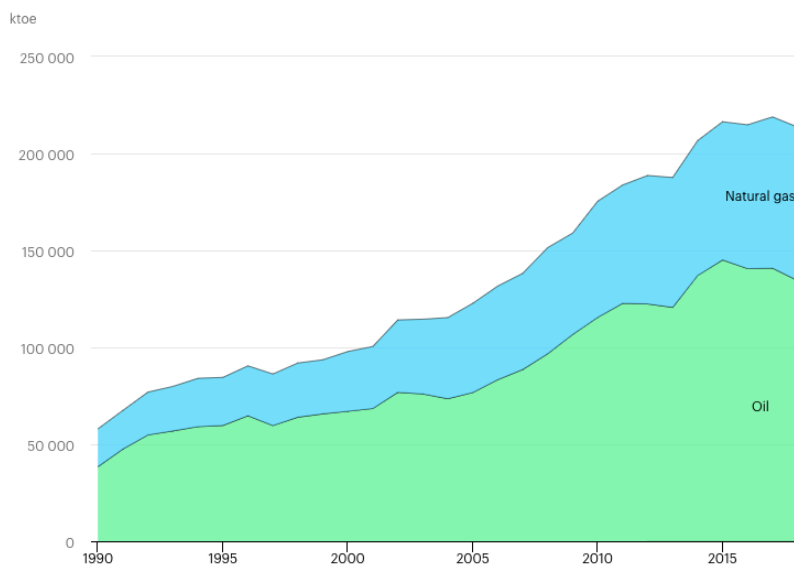


Figure 3. Supply of energy from different sources in Saudi Arabia (IEA, 2020a).

These trends are further illustrated in Figure 3, which shows the dynamics in the supply of different energy sources in Saudi Arabia. The growth in natural gas supply occurred mostly in the

past decade, which was associated with government's efforts to develop this aspect of the industry sector further (IEA, 2020a). Before that, the production of associated gas meant that the supply was tied to the production of oil, as seen in the figure. Renewable energy sources, including wind, solar, and others, saw only minor growth in the last few years and are yet to start to make vital contributions to the energy sector overall.

Consumption of energy in Saudi Arabia is an important topic that should be addressed since it has an impact on trends in the sector. According to Lahn and Stevens (2011), energy consumption in the country has been on the rise between the 1970s and 2010, and was not tied to oil prices, meaning that it is unlikely to change if oil prices become higher. Based on the reports, Saudi Arabia is one of the largest consumers of power in the world (Lahn & Stevens, 2011). The growth in power consumption has been associated with economic development and population growth, leading to a noticeable increase in the needs of individuals and businesses for power. Consequently, the change in energy consumption over the past years was most noticeable in the residential and commercial sectors of the economy (IEA, 2020a). The latter sector grew in its energy consumption in particular, from 4 173 ktoe in 2008 to 10 973 ktoe in 2018 (IEA, 2020a). Still, the primary users of energy in the Kingdom are the industry and the transport sector (Figure 4). Based on these findings, it is possible to suggest that the trends of the energy sector are significantly tied to the country's economy and infrastructure. On the one hand, the reduction in energy consumption of the industry sector would likely lead to a decrease in outputs, stalling economic development and non-energy exports. On the other hand, the use of oil and natural gas is also essential for supporting the country's vast infrastructure through adequate transportation.

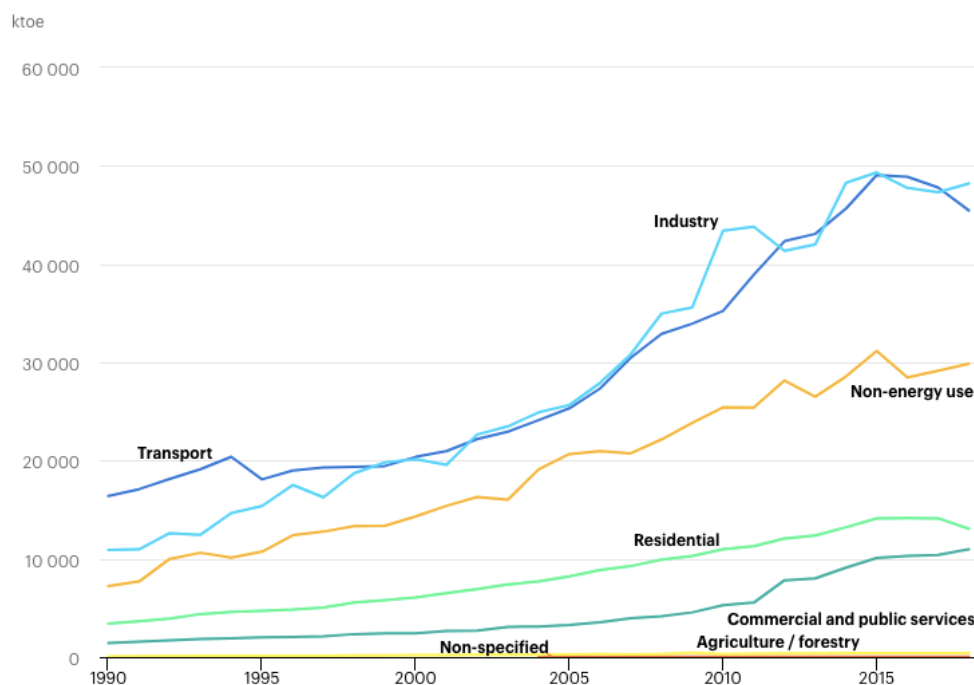


Figure 4. Oil consumption by sector in Saudi Arabia (IEA, 2020a).

The Role of the Energy Sector in National Policy and Economy

Over the years, the energy sector has come to occupy a considerable place in the government policy of Saudi Arabia. Firstly, the development of the energy sector was a crucial concern for the national policy due to the need to improve the infrastructure and quality of life in the Kingdom. Barad'ieh (2015) argues that, in order to sustain the growing population, the government had to develop power systems and spread them throughout the country. This entailed developments in the energy sector, including increased governmental control and investments into energy production.

In a similar way, the national economy of Saudi Arabia also came to depend significantly on oil production. Nachet and Aoun (2015) show that oil is a critical source of revenue to Saudi Arabia, which contributes a substantial share of its GDP every year. The economy also depends on the production of oil and natural gas indirectly. As reported by IEA (2020a), the industry sector of Saudi

Arabia is the largest consumer of energy in the country, and the commerce sector has also increased its energy consumption in recent years. Therefore, the ability of enterprises to produce goods and services to be turned into profits largely depends on their access to electricity. This makes energy a great contributor to the country's economy through the activity of unrelated businesses.

Vision 2030 is an essential policy document that highlights the key focus areas of the government for the upcoming decade. With respect to the energy sector, there are two central policies that should be noted. First of all, the government continues to develop its oil and natural gas production through formalized efforts. For example, it intends to "transform Aramco from an oil-producing company into a global industrial conglomerate" (*Vision 2030*, 2017, p. 7). Another example of a national policy referring to the oil and gas sector that is found in the document is the localization of oil and gas production. According to *Vision 2030* (2017), the goal of the Saudi government is to "increase the localization of oil and gas sectors from 40% to 75%" (p. 46). This will undoubtedly give the government even more control over the production and distribution of oil and gas on Saudi territory, potentially leading to other essential developments in the sector.

Secondly, the Vision also highlights the goal of the government to develop the Kingdom's renewable energy potential. The document confirms that the renewable energy sector remains underdeveloped and sets plans to begin generating 9.5 gigawatts of renewable energy and to localize a large portion of the renewable energy value chain in the Saudi economy (*Vision 2030*, 2017). This development in the national policy is crucial since it shows the government's commitment to developing the nation's sustainability and expanding alternative energy sources in the future.

When compared to its key global competitors, it is evident that Saudi Arabia places a similar emphasis on the development of its energy sector as Russia and the United States. For example, the Russian energy policy for the period from 2010 to 2030 focused less on diversification but more on

increasing the effectiveness of natural resource use through government investments in research, development, and technology (Ministry of Energy of the Russian Federation, 2010). Russia's main goals for the period were to modernize its energy infrastructure, improve the institutional infrastructure, and introduce green energy as a way of sustaining the growing energy needs of the population while exporting oil, gas, and coal actively (Ministry of Energy of the Russian Federation, 2010). In the United States, the energy policy focused on diversification and meeting the domestic demand while penetrating the global energy market through exports (National Energy Policy Development Group, 2001). Therefore, both competitors show similar trends in terms of national energy policy, although the focus on diversification and renewables is stronger in the United States.

Regional Energy Sector Comparisons

	Crude Oil (ktoe)	Wind, solar etc. (ktoe)	Natural gas (ktoe)	Biofuels and waste (ktoe)
UAE	181 887	153	49 909	-
Iraq	231 588	5	9 647	47
Yemen	1 544	39	86	127
Oman	49 070	-	32 752	-
Saudi Arabia	586 254	13	79 108	-

Table 1. Regional energy sector comparisons by energy production (IEA, 2020a).

United Arab Emirates

The United Arab Emirates differ significantly from Saudi Arabia in the scope of their energy production. As highlighted by the IEA (2020a), the total energy production of the UAE in 2018 was 231 949 ktoe, which is less than half the output of Saudi Arabia (Table 1). Moreover, the UAE produces more renewable energy from wind, solar, or other sources and has a higher share of natural gas in total oil production (IEA, 2020a). At the same time, the volume of crude oil imports is much

smaller, and some energy resources are imported. This suggests that the energy sector of the UAE is more diversified than that of Saudi Arabia and relies less on crude oil. There is also evidence that the country is developing its potential for renewable energy in response to global trends in energy.

Iraq

Iraq borders Saudi Arabia in the North and should thus also be included in the comparison. Similarly to the UAE, the country shows evidence of decreased energy output in comparison with Saudi Arabia. In 2018, the total production of energy in the country was 241 444 ktoe, which is significantly lower than in Saudi Arabia (Table 1). The vast part of this output, like in the Saudi energy sector, comes from crude oil. In 2018, it accounted for over 230 000 ktoe of outputs produced (IEA, 2020a). The country did not import any crude oil but imported some oil products. The share of these imports was similar to those of Saudi Arabia. Another point of similarity was the low production of renewable energy, which constituted only 5 ktoe in 2018 (IEA, 2020a). The exports of oil in Iraq were much lower than those of Saudi Arabia, showing that, while the country has a strong dependence on oil production, it occupies a less prominent position in the global energy market.

Yemen

Yemen has a smaller population than Saudi Arabia, which implies its lower energy needs. This is reflected in the cross-country comparison. In contrast to Saudi Arabia, Yemen's energy production is meager, standing at just 1796 ktoe in 2018 (IEA, 2020a). The vast part of the output is made up of crude oil, which constituted 1544 ktoe in 2018 (IEA, 2020a). However, the share of energy obtained from renewable sources or from biofuels and waste in Yemen is substantial (Table 1). Compared to Saudi Arabia, where renewable energy sources accounted for just 13 ktoe, Yemen produced 39 ktoe of wind and solar energy (IEA, 2020a). Biofuels and waste, in turn, created over

125 ktoe of energy in the country, compared to 0 in Saudi Arabia (IEA, 2020a). Similarly to Saudi Arabia, Yemen imported a relatively significant share of oil products from other countries, which was likely necessary to sustain population needs in energy. The exports of oil were absent in the 2018 report. On the whole, Yemen's energy sector appears to be much less developed than that of Saudi Arabia. Still, the country deserves recognition for the increased use of renewable energy sources and energy derived from biofuels and waste, as these trends make it more sustainable.

Oman

Among the countries reviewed in this section, Oman had the second smallest output of energy in 2018. The total amount of energy produced in the country that year was 81 822, which is over five times less than what Saudi Arabia made (IEA, 2020a). The differences between countries in energy production structure are also critical. In Oman, natural gas occupies a large share of the total energy output, with 32 753 ktoe produced in 2018 (IEA, 2020a). In terms of crude oil, the country's production reached 49 070 ktoe, with a vast portion of this amount exported (39 555 ktoe). Natural gas, however, was not exported as much, suggesting that the country relies more on it for electricity than on crude oil (IEA, 2020a). Like Saudi Arabia, Oman did not show evidence of renewable energy production and did not use biofuels and waste (IEA, 2020a). Hence, the energy sectors of these two countries have more differences than similarities.

Comparison to the California Energy Sector

With the United States currently occupying the leading position in the world by energy production, it is also essential to examine the energy profile of California and draw comparisons to Saudi Arabia where possible. According to the U.S. Energy Information Administration (EIA, 2020), California is the seventh-largest state by oil production and has a well-developed capacity for oil refinement, being the third in this ranking. Therefore, the state plays a significant role in energy

production in the United States, particularly with respect to oil. As of 2018, the state produced about 965.3 trillion Btu of oil but was also involved in the production of natural gas and nuclear power (228.9 trillion Btu and 190.4 trillion Btu, respectively).

California is also notable for the production and use of energy from renewable sources. The U.S. Energy Information Administration (EIA, 2020) notes that the state was ranked first in the U.S. in the production of energy from solar, geothermal, and biomass sources and fourth nationally for conventional hydroelectric power production. The United States is among the key global leaders in renewable energy, and this initiative is also evident in California, where renewables occupy a significant place in local policies. As of 2020, California obtains more than 30% of its electricity from renewable energy sources, meaning that it relies highly on solar, wind, and other green energy sources (Borunda, 2020). In particular, solar and wind power fulfill 20% of the state's energy needs, and California features a well-developed network of solar and wind power plants.

In comparing the state to Saudi Arabia, one similarity can be noted. Like the Kingdom of Saudi Arabia, California has a prominent role in oil production and utilizes its natural oil reserves effectively to provide for the population's energy needs. In the same way, Saudi Arabia focuses heavily on oil production both to satisfy population needs and to export oil to the global energy market. Thus, the two states are comparable in terms of their energy production strategy and reliance on oil.

Nevertheless, renewables play a much more prominent role in California's energy production and consumption than they do in Saudi Arabia. The Kingdom has just begun to develop its renewable energy and cannot use green energy to support the growing needs of the population. In California, the share of people benefitting from renewable energy is about 30%, which is higher than the Kingdom of Saudi Arabia could show. Hence, the analysis allows suggesting that it is possible

for Saudi Arabia to develop its green energy capacity and potential without harming the production of crude oil and oil products.

Drivers and Impediments to the Development of the Saudi Energy Sector

The above data in the literature review allow for identifying key drivers and impediments to the development of the Saudi energy sector. The two primary drivers that supported the increase in oil production and natural gas exploration are population growth and industrialization. On the one hand, population growth, along with the development of power systems throughout the country, contributed to the increase in the demand for electricity since the 1970s. With greater access to power and its higher use, people needed more energy to be produced in the country. On the one hand, the industry remained the most significant consumer of energy in the country over the years (IEA, 2020a). This suggests that technological developments and the growth in business activity necessitated a higher output of energy to be used in the production of goods and in other industry sectors. Hence, both of these trends created a need for higher energy production and drove the development of the Saudi energy sector.

At the same time, another critical driver here was the national policy by the government of Saudi Arabia. As noted by Barad'ieh (2015), the development of power infrastructure in the country was largely the government's initiative. The government also narrated the evolution of the sector through various policies, such as those necessitating an increase in the exploration and production of non-associated natural gas and others. For example, this year, the government announced plans to invest over \$110 billion into the development of the country's gas fields, thus generating more natural gas for exports (Saadi, 2020). State ownership also played a great role in the development of the energy sector in Saudi Arabia. The leading producer of energy and natural gas, Aramco, is state-owned, which means that the government invests heavily in its development (Pickard & van der

Burg, 2015). Therefore, the support granted by the government also assisted in the evolution of the Saudi energy sector.

Still, there are some obstacles faced by Saudi Arabia that could affect the future of energy production and distribution in the Kingdom. First and foremost, the country relies heavily on non-sustainable energy sources, including oil and natural gas (IEA, 2020a). Once these resources become exhausted, the country's energy sector will struggle to survive due to the inability to export oil and natural gas for profits. This will also endanger the country's economy, leading to severe consequences for Saudi Arabia and its people. Secondly, another critical obstacle for the Saudi energy sector comes in the form of fluctuating oil prices and the costs of producing more natural gas. As noted by Lahn and Stevens (2011), fluctuations in oil prices do not have a significant impact on the consumption of fuel in the Kingdom while harming the revenues derived from the export of oil and natural gas. At the same time, the price of natural gas on the global market is too low for its large-scale commercial production to be economically sustainable (Lahn & Stevens, 2011). This means that more and more investments will likely be required in order to sustain the energy sector, leading to more issues in the foreseeable future.

The third factor that could halt the development of the Saudi energy sector is the heavy reliance on oil both as a power source and as a way of generating revenue. As shown by the data from IEA (2020a), oil remains at the core of the country's energy consumption and exports, meaning that efforts to develop alternative energy sources are unlikely to grant the same economic benefits as government investments into oil production and refinement. This could cause energy policy challenges due to conflicting interests and the inability to shift from oil to other energy sources promptly to avoid exhausting oil reserves in the future.

Trends in Global Energy and Their Impacts on the Middle Eastern Region and Saudi Arabia

Global Energy Sector

Leaders in Energy Production

The global energy sector features a large number of players, supplying energy derived from a variety of resources. On the whole, world energy production was 14 421 Mtoe in 2018, an increase of 3.2% from the previous year (IEA, 2020b). Fossil fuels remain the core sources of global energy, with natural gas, coal, and oil production increased by over 370 mtoe in 2018 and the overall share of fossil fuels in global energy production reaching over 80% in 2018 (IEA, 2020b). However, nuclear energy and renewables both showed significant growth. Between 2017 and 2018, nuclear energy production increased by nearly 3%, compared to a 2% increase in oil (IEA, 2020b). Renewable energy grew more profoundly, at an overall rate of 11.2% in the same period (IEA, 2020b). These trends can be observed in Figure 5, which shows the share of various energy sources in the global energy supply from 1990 to 2018. Although fossil fuels form a significant share of global energy production at the moment, advances in other energy sources, particularly in renewable energy, are evident.

According to the report by British Petroleum (BP, 2020), the Middle East remained the leading producer of oil in the world, followed by North American and the Commonwealth of Independent States (CIS), which includes Russia, Belarus, Moldova, and six other states located in Eurasia. With natural gas, North America retained the leadership, followed by countries of the CIS, the Middle East, and Asia Pacific (BP, 2020). In coal production, Asia Pacific was a critical player for the past several decades, whereas the output of coal in other countries has slowed down (BP, 2020). Renewable energy production was primarily driven by countries of Europe, followed by the Americas (BP, 2020). Considering trends of the past 20 years, these countries developed their

renewable energy most significantly, whereas, in countries of the CIS and the Middle East, the development of renewables has been stalled. Still, the Middle East showed slight growth in renewable energy generation between 2018 and 2019, and future developments are anticipated.

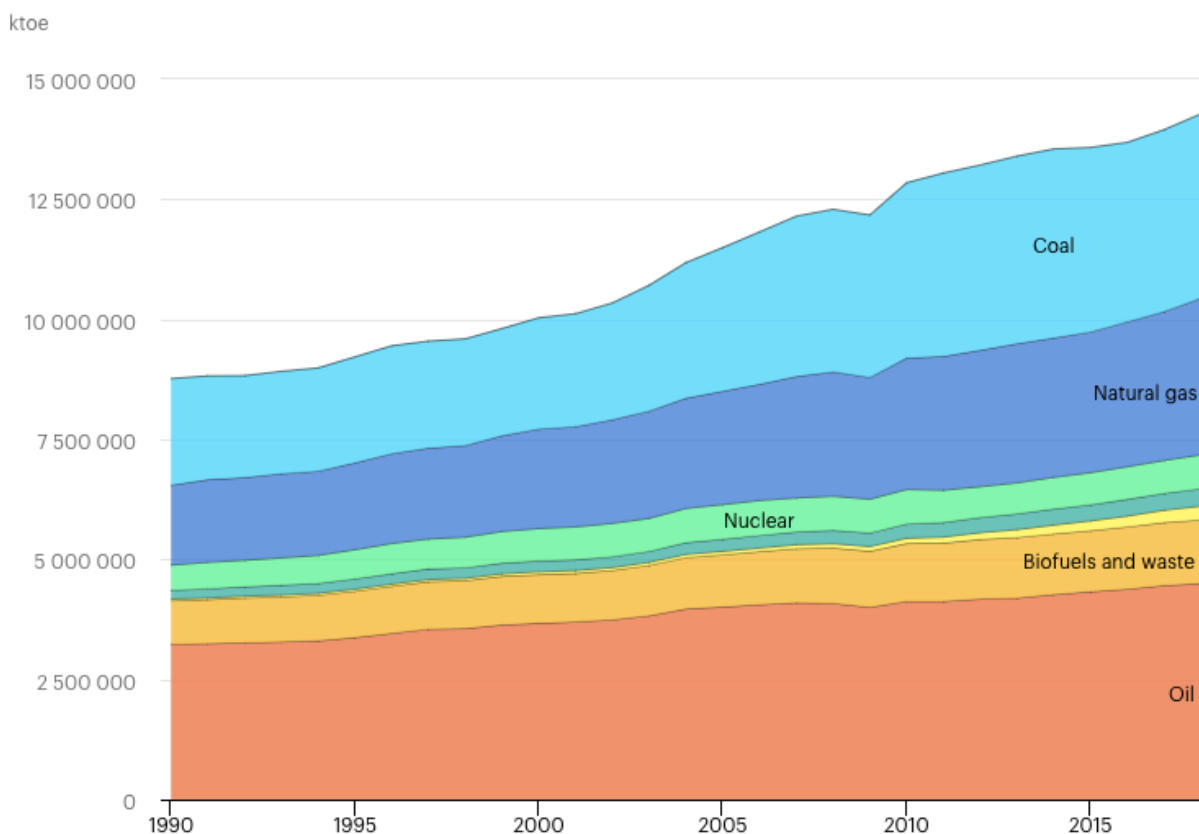


Figure 5. Global production of energy from various sources (IEA, 2020b).

Multinational Agreements and Collaboration – OPEC

The central multinational collaboration and agreement that is relevant to Saudi Arabia is the Organization of the Petroleum Exporting Countries (OPEC). The Organization of the Petroleum Exporting Countries is "a permanent, intergovernmental Organization, created at the Baghdad Conference on September 10–14, 1960, by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela" ("Brief History," 2020, par. 1). The primary purpose of the organization is to support the coordination of policies with regard to petroleum production with the end goal of offering a stable and efficient

supply of petroleum to the global energy industry and consumers ("Brief History," 2020). OPEC has seen some significant changes over the years regarding membership states, agreements between members, and other aspects of policy. One such change was the formation of OPEC+, which included OPEC countries, Russia, and nine other states, in 2016 (Kennedy, 2020).

Recently, OPEC has been in the spotlight of news coverage and expert publications due to the impact of the coronavirus and oil production. According to Reed (2020), the oil prices decreased into negative values in April, despite efforts by OPEC to cut the output in order to balance the demand. Furthermore, OPEC has been in conflict with Russia earlier this year as the country tried to escape the production cuts pushed by Saudi Arabia in March in response to the coronavirus outbreak (Kennedy, 2020). Based on these shifts, it is evident that OPEC is influenced dramatically by the overall global environment and the factors affecting the demand for petroleum. At the same time, the contribution of this agreement to the global energy sector also relies on the involvement of and relationships with non-member nations, and it is critical to balance to interests of multiple parties to avoid negative trends in global energy.

Recent Market Shifts

In recent years, the global energy market has been affected by numerous forces causing changes in production, supply, demand, and prices. First of all, the unstable political situation in some regions of the Middle East has affected the supply of oil and other fossil fuels to the global energy market (Butler, 2018). At the same time, the development of technology and the adoption of green energy policies by more and more states have led to a fall in the price of renewable energy (Butler, 2018). This explains the swift increase in the generation of energy from renewable sources, which has been noted by market reports.

Another critical shift that has occurred in recent years is the growing role of Asia in energy

production and consumption. According to Butler (2018), the region increased its energy consumption from 18% of the global total in the 1980s to 41% in 2018. The supply of fossil fuels from Asian countries has also grown over the past years, with China and India developing their oil exports (Butler, 2018). This shift had an effect on oil prices, but its long-term impact on global energy can also be prominent. If Asian countries' role in the market becomes more and more apparent, it will create competition for nations that rely heavily on fossil fuel exports, including Saudi Arabia. Furthermore, it might necessitate new multinational agreements and deals that would include new market players.

The growing role of the United States in global energy has also been noted as one of the fundamental forces that have influenced the market in recent years. Butler (2018) reports that oil exports in the United States have been declining for some time before the so-called "shale revolution" (par. 11). The development of oil extraction from shale formations in the United States resulted in its growing role in global energy. With the increased involvement of the United States in global energy, prices have also been impacted, and the geography of energy production has changed.

Green Energy: Genesis, Current Trends, and Outlook

Genesis: Stages in Critical Developments

The history of green energy began in the 20th century and was tightly associated with technological developments and the growing concerns with the environment. By the second half of the century, it became clear that the production and use of fossil fuels affected the environment negatively through pollution and other consequences (Mittlefehldt, 2018). Moreover, concerns about sustainability began to surface, as experts suggested that the continued use of fossil fuels will drive the global energy market into shortages over time (Mittlefehldt, 2018). In response to these concerns, developed economies began looking for ways to support energy production through the

use of renewable energy resources. There were also local motivations for countries to invest in green energy research. For example, the United States began exploring the opportunities of wind and solar power following the increased prices of oil set by OPEC in 1973 (Maczulak, 2010). The interest in renewable energy encouraged scientific developments to support large-scale green energy production.

As evident from the discussion in the previous section, Europe and North America are mainly responsible for the advancement of green energy. According to Maczulak (2010), developed nations began investing in green energy research in the second half of the 20th century, bringing new opportunities for energy generation. Innovations that are now responsible for the growth of green energy emerged as a result, including solar (parabolic troughs, solar dish-Stirling, solar towers, space-based solar panels, solar films, etc.), wind, and tidal power technologies (Maczulak, 2010). The technological shifts paralleled the growth of renewable energy production and consumption. In many cases, the demand for renewable energy was supported by governmental efforts to address pollution, climate change, and rising energy prices (Maczulak, 2010). Hence, the history of green energy relied heavily on environmental, political, and economic forces that affected research and demand.

Current Trends and the Role of Renewable Energy Sources in Global Energy

At this time, renewable energy is a growing sector of the global energy market, with production increasing significantly from one year to the next. Hydropower remains the leading renewable energy source today, with much of the worldwide supply produced by China, Brazil, Canada, the United States, and Russia (Nunez, 2019). However, wind energy has also been growing and is currently used by many countries. Nunez (2019) notes that the leading producers of wind energy in the world are China, the United States, and Germany. Between 2001 and 2017, the global

capacity for the production of wind power increased by 22 times and reached more than 539,000 megawatts (Figure 6). This development has been supported by governmental and private projects to develop large scale wind energy production. For example, in 2016, the United States began developing offshore wind farms, starting with a project in Rhode Island, and the country plans other improvements in this energy market niche (Nunez, 2019). At the same time, solar power is also a prominent source of green energy in the contemporary world. Between 2007 and 2017, the global solar energy capacity increased by 4,300%, mainly due to solar power programs of China, Japan, and the United States (Nunez, 2019).

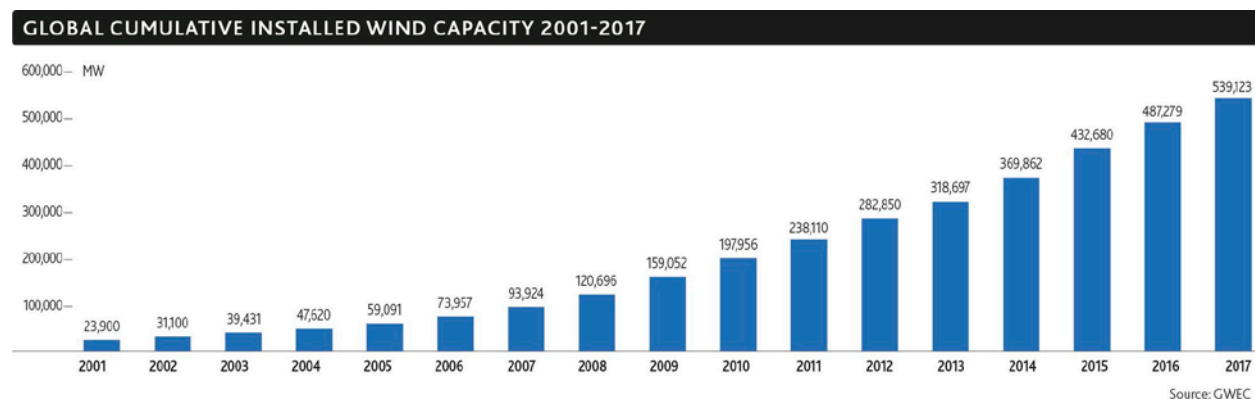


Figure 6. Global cumulative wind power capacity (Global Wind Energy Council, 2019).

On the whole, the green energy market is currently growing around the world, with more and more countries developing their capacity for the production of energy from renewable sources. Despite these improvements, green energy is still in the emergent stage, and fossil fuels lead the market in terms of both production and consumption. Despite the cumulative growth of 1,226% in consumption since 1990, renewable energy still accounts for just 0.4 billion tonnes of oil equivalent in consumption, compared to 4.3 of oil, 3.8 of coal, and 3.1 of natural gas (Clark, 2017). When it comes to government subsidies, fossil fuels receive more support in comparison to renewables, although subsidies for green energy increased twofold between 2008 and 2015 (Clark, 2017). Hence, although green energy is currently characterized by fast growth and high interest by

authorities and experts, more developments are necessary for it to reach the state of oil, coal, or gas energy.

Outlook

The outlook for green energy is generally positive, and global consumption and production is expected to increase further in the next decades. First of all, it is evident that governments of European countries and certain other states are interested in the development of green energy as a way of curbing the negative environmental effect of energy production while also becoming more sustainable in the long term (Clark, 2017). The support of governments has led to a decrease in the price of renewable energy, making it more cost-effective and allowing it to compete in prices with fossil fuels (Clark, 2017). Therefore, it is likely that investments in green energy will continue and spread across the world, along with sustainability efforts.

Secondly, the development of green energy is expected to be in line with technological advancements in the area. As shown by Maczulak (2010), innovations in wind and solar energy allowed making the process of generating energy from renewable sources quicker and cheaper. Future designs will likely focus on increasing the capacity of global renewable energy production, thus allowing renewable energy sources to increase their share in energy produced and consumed globally (Clark, 2017).

Based on these forces, experts predict the continuous growth of green energy in the following decades. For instance, the global solar capacity is expected to grow by 600 GW by 2024, and the overall development of renewable energy is projected to amount to 1200 GW by this time (Ambrose, 2019). As a result, the global supply of renewable energy will increase significantly, possibly reducing the reliance on fossil fuels and supporting the shift to green energy in power consumption.

The Impacts of Renewable Energy in the Middle East

The global reports show that countries of the Middle East are behind Europe, North America, and Asia in the deployment and use of green energy. The four largest consumers of power in the Middle East are Iran, Saudi Arabia, Kuwait, and the UAE, and out of these countries, the UAE has the most well-developed potential for green energy production and use. Based on the research by Bayomi and Fernandez (2019), Iran has the capacity to reach up to 40,000 MW in renewable energy production has committed to targets of reduced greenhouse gas (GHG) emissions and increased renewable energy output as part of its climate plan.

Saudi Arabia is characterized by high electricity consumption, and it is expected to grow further in the foreseeable future due to industry developments and population growth (Bayomi & Fernandez, 2019). Consequently, the country has been focusing on developing sustainability in order to be able to satisfy the domestic demand for electricity while continuing exporting oil. Local policies to support the development of renewable energy relate to government vision plans. For example, the initial target set for Saudi Arabia was to reach 54 GW of renewables by 2032, but it was later amended to account for the country's focus on the natural gas generation and use (Bayomi & Fernandez, 2019). As a result, the current target is to achieve 9500 MW of renewable energy production by 2023, and the primary sources of renewables in the country are wind and solar energy (Bayomi & Fernandez, 2019).

Kuwait is another country of interest that has taken some steps to improve renewable energy production. As reported by Bayomi and Fernandez (2019), Kuwait relies heavily on hydrocarbon resources. Moreover, the country also faces a growing demand for electrical power due to demographic and industry forces, which necessitate the production of more energy. Due to these forces, the country has developed a diversification plan aimed at improving the sustainability and

diversity of its energy sector. As part of the project, Kuwait is planning to increase the share of renewable energy in its total power outputs to 15% by 2030 (Bayomi & Fernandez, 2019). The main focus in Kuwait is on wind and solar energy generation, and these sources will likely prove to enhance the country's energy sector, making it more efficient and sustainable.

The UAE is famous for its innovative approach to the use of technology in infrastructure, and it is no surprise that it leads the Middle East in developing renewable energy. Similarly to other states, the UAE faced a growth in the demand for energy because of the population increase in the past few decades (Bayomi & Fernandez, 2019). Although the country still relies heavily on hydrocarbon, it has implemented policies to shift the focus of the energy sector to renewable power sources, including solar and wind. The government of the UAE has created policies to support the growth of renewable energy production through subsidies and programs while also defining two consecutive targets to reach 27% in power generation from renewable sources by 2020 and achieve 30% by 2030 (Bayomi & Fernandez, 2019). The country also supports the demand for renewable energy by shifting to green power use in public institutions and infrastructure.

The future outlook for green energy in the Middle East is similar to that in other developing areas. Firstly, population and industry growth results in continuously increasing energy consumption, prompting governments to consider sustainability in developing plans for local energy sectors (Nematollahi et al., 2016). This trend has already encouraged some countries to adopt green energy advancement programs since shifting to renewable energy promises to make energy more efficient and accessible to populations. Secondly, many countries of the Middle East export oil and natural gas, using these exports to support their economic development (Bayomi & Fernandez, 2019; Nematollahi et al., 2016). Given the overall global trend toward renewable energy, the over-reliance on fossil fuels threatens these countries by decreasing the world's demand for them. In this

environment, diversifying the energy sector can help to support it in the face of significant shifts and ensure long-term sustainability, both in society and in the economy. Thirdly, countries of the Middle East also benefit from regional and global collaborations that support energy production and technological development. This means that states of the Gulf Cooperation Council and those who are part of OPEC could use these collaborative opportunities in the future to raise their technological potential for renewables while also continuing trading fossil fuels. In this way, countries could find a balance between local improvements and economic needs, gradually shifting away from oil and gas to green energy.

The Impacts on Saudi Arabia

Saudi Arabia is a critical player in the global energy sector, mainly because of its high output of fossil fuels. The country produces and exports a significant share of worldwide oil and also seeks to enhance the production and trade of natural gas to improve its position in the global energy market further (Tilli, 2014). Nevertheless, the trends in global energy are already affecting local policies and will likely shape the energy sector of the Kingdom in the future, raising the importance of renewable energy sources. Tilli (2014) shows that there are at least two ways in which Saudi Arabia is affected by trends in global green energy. On the one hand, the country faces a threat of reduced demand for fossil fuels as more and more countries implement renewable energy policies and reduce the reliance on non-renewables. This has a direct impact on Saudi Arabia since the decreased demand could reduce the economic benefits derived from oil and natural gas exports. On the other hand, advancements in green energy have become a hallmark of development, with local leaders in the sector, encouraging others to improve renewable resource use to reduce climate damage and achieve sustainability. Therefore, Saudi Arabia, along with other Middle Eastern nations, sought to include renewable energy in its development plans, incorporating green power

into future infrastructure and industry advancements. Given the growing use of energy in Saudi Arabia and the role of oil exports in its economy, a complete shift to renewable energy is unlikely in the foreseeable future (Tilli, 2014). However, it is still likely that the country will gradually expand its potential for renewable energy in response to global and regional trends. For example, offering subsidies for renewable energy use or shifting public institutions to solar or wind power could be essential steps in promoting renewables on the local level. In this way, it will reduce the reliance on fossil fuels, protect its long-term sustainability, and satisfy the growing energy demands of the population.

The Dynamics of the Domestic Energy Sector in Saudi Arabia: Fossils vs. Renewables

Future Outlook for Renewable Energy in Saudi Arabia

The future outlook for renewable energy in Saudi Arabia is generally positive, which is justified by the benefits presented in Table 2. Firstly, the country experiences a high and growing demand for energy and would thus benefit from increased sustainability (Bayomi & Fernandez, 2019). Developing the renewable energy sector would help the country to ensure that the local demand for energy can be satisfied easily while retaining enough fossil fuels for exports.

Renewable Energy	Fossil Fuels
<ul style="list-style-type: none"> • Relies on renewable energy sources (e.g. wind, sun); • Offers an opportunity for economic diversification to reduce reliance on oil; • Produce minimal pollution; • Encouraged by environmental protection authorities. 	<ul style="list-style-type: none"> • Rely on oil and natural gas reserves that can be exhausted over time; • Volatile oil prices, dependent on other oil-producing nations; • Produce significant pollution and emissions; • Affected by environmental regulations.

Table 2. Renewable energy and fossil fuels: Economic and environmental comparisons.

In addition, the positive outlook for renewable energy development is shaped by the need to diversify the country's economy and its energy sector. As noted by experts, Saudi Arabia relies heavily on the production and exports of oil (Al-Saleh, 2009; Bayomi & Fernandez, 2019; Tlili, 2015). However, oil prices are highly volatile and depend on the activity of other oil-producing nations, including Russia and the United States. In this context, the over-reliance on oil can be dangerous for Saudi Arabia, while diversifying the energy sector could help to support the country in benefitting from exports even if oil prices decrease significantly (Salam & Khan, 2018).

Consequently, the government is likely to focus on economic diversification, including through

renewable energy use. Renewable energy is much less risky from the economic viewpoint since it is infinite and not restricted by the country's current reserves. The development of renewable energy would introduce more stability into the energy sector of Saudi Arabia, thus encouraging the government to invest in it.

Finally, environmental protection actions also enhance the outlook for the development of renewable energy in Saudi Arabia. According to Al-Saleh (2009), environmental concerns largely influence the growth of renewables throughout the world due to local regulations and international agreements for environmental protection. As a major exporter of fossil fuels, Saudi Arabia could achieve significant environmental benefits by reducing the share of oil and natural gas in its energy sector and expanding renewables. Hence, if the government acknowledges climate change, pollution, and other environmental issues surrounding the production of oil in the country, Saudi Arabia is likely to develop renewables faster. Renewable energy presents less environmental risks in comparison to non-renewable energy because it does not exhaust natural resources and is not associated with greenhouse gas emissions or other forms of pollution. Investments in renewable energy are favored by environmental protection agencies and organization, and Saudi Arabia is likely to recognize these concerns by enhancing its renewable energy production and use.

National Policies and Projects Concerning Renewable Energy

The government of Saudi Arabia appears to understand the trends reviewed above and shows commitment to developing its renewable energy sector. Based on Saudi *Vision 2030*, the Kingdom plans to reach an initial target of 9.5 gigawatts of renewable energy by the end of the decade (*Vision 2030*, 2017). At the same time, the country has also defined its plans for localizing the value chain of renewable energy production. According to the national plan, the Kingdom "will also seek to localize a significant portion of the renewable energy value chain in the Saudi economy, including

research and development, and manufacturing, among other stages" (*Vision 2030*, 2017, p. 49). This goal involves investing more in renewable energy research and production.

Another important policy that is highlighted in Saudi Vision with respect to renewable energy is the development of private-sector green energy initiatives. Saudi *Vision 2030* (2017) states the government's plans to review the regulatory framework enabling private sector companies to buy and invest in the renewable energy sector. As part of planned improvements in laws and regulations, the country could introduce programs that encourage private sector companies to use renewable energy and contribute to its development, such as tax cuts or subsidies. At the same time, governmental support of public-private partnerships in renewable can help to facilitate the development of local renewable energy capacity by supplying talents and resources (*Vision 2030*, 2017). For example, public-private partnerships could be used to build new renewable energy plans and shift certain cities' infrastructure to increase the reliance on renewable energy sources. Therefore, it is anticipated that the local capacity for renewable energy will increase substantially by 2030 in response to government's commitment to enhancing this sector.

National Policies and Projects Concerning Non-Renewable Energy

Despite potential developments in renewable energy, Saudi Arabia remains focused on the advancement of fossil fuel energy. The Kingdom possesses 16% of the global oil reserves and 4.4% of the global reserves of natural gas (Bayomi & Fernandez, 2019). In addition, the Kingdom's economy is centered around oil exports, which contribute significantly to its revenues and sustain economic development (Bayomi & Fernandez, 2019; Nchet & Aoun, 2015; Tlili, 2015). Therefore, national policies focus heavily on maintaining non-renewable energy production.

There are two major trends in national policies regarding non-renewable energy. The first trend is the continued investment in and regulatory support of Aramco, which is responsible for the

vast share of natural gas and oil production in the Kingdom (Vision, 2030). With support from the government, the company will be able to expand its efforts in the production of fossil fuels. For example, the company will be able to invest more in research, thus possibly identifying new opportunities for more efficient gas and oil production. Due to the major role of Aramco in Saudi exports of energy, it is likely that these improvements will have a positive effect on non-renewable energy in the Kingdom. At the same time, the government also seeks to develop the effectiveness of its energy sector by supporting competitiveness through business regulations and free-market opportunities (*Vision 2030*, 2017). This trend could also have a positive effect on the development of fossil fuels, particularly with respect to localization and export outcomes.

The second trend is the diversification of the energy section through a reformation of its structure. The Kingdom's government recognizes the potential risks of overreliance on oil and seeks to enhance the production of natural gas in order to address the issue and protect the economy from oil price volatility. The main goal for the Kingdom in these efforts is to improve the position of natural gas exports in the country's economy. As mentioned by Tlili (2015), the country has substantial reserves of natural gas, which are largely unexplored because this source of energy plays a minor role in the economy. Still, the government seeks to support natural gas production and sale through investments and enhanced regulations. For example, the country has recently invested over \$110 billion in the development of the Jafurah field, which is projected to become a major natural gas production site in Saudi Arabia (Saadi, 2020). Still, it is unlikely that natural gas will grow to occupy a significant share of the country's exports in comparison to oil. Besides investments in research and development of natural gas, the country does not mention this aspect of its energy sector in its Vision, meaning that the increased natural gas production is a minor goal. Still, it could help to reduce the domestic reliance on oil and provide resources for the development of other parts

of the energy sector.

Strategic Scenarios

Based on the trends and considerations described before, there are three critical forces that distinguish the potential scenarios of the development of the Saudi energy sector. The first force is the availability and beneficence of fossil fuel production. As noted in the analysis by Al-Saleh (2009), fossil fuels are a non-sustainable resource, so their production and role in the economy are largely defined by availability. At the same time, oil prices respond readily to a wide variety of environmental influences, as seen in recent issues with OPEC and the coronavirus pandemic (Kennedy, 2020; Reed, 2020). Therefore, the government's decisions affecting the energy sector will depend a lot on whether the continued reliance on fossil fuels will be perceived as beneficial and whether there will be sufficient resources to provide both for the local population and for exports into the global energy market.

The second force that should be taken into account is the commitment to environmental protection (Al-Saleh, 2009). At the moment, the government appears to recognize the negative impact of fossil fuels on the environment, but efforts to address the issue are minimal compared to the UAE, Europe, and the West, where renewable energy sources develop at a faster pace. However, if the environmental situation worsens, the government of Saudi Arabia might be pressured into reducing fossil fuel extraction and use, thus focusing more on the development of its potential for renewables. As a result, this will shape national policies for renewable energy and their real impacts in the sector. Finally, government's attitudes to renewable energy also play a role in defining the scenarios and future outlook of the energy sector. According to Al-Saleh (2009), governments of the world vary greatly in terms of how they perceive renewable energy. When perceptions of its potential and necessity are positive, the government is likely to invest more resources into

renewables, thus supporting their growth in the energy sector (Al-Saleh, 2009). The government of Saudi Arabia could also shift its attitudes to renewable energy, resulting in higher support of the sector or, on the contrary, its removal from the current list of priorities.

Overall, there is no doubt that the renewable energy sector in Saudi Arabia will witness major developments over the next decade. The most positive scenario, in this case, would be the gradual shift of focus from fossil fuels to renewables, but this would necessitate the government's conscious commitment to renewable energy and substantial financial investments in its research and development. The most pessimistic scenario, on the contrary, is that the government's attention will divert from renewables, and their development will be postponed until fossil fuel resources are fully exhausted. The realistic scenario draws from the current approach of the Saudi government to renewables and posits that the country will develop renewables minimally while still focusing heavily on fossil fuels, but when its reserves begin to deteriorate, or significant pressure is applied by international organizations or the Saudi people, it will shift its focus to renewables.

Transitioning to Renewable Energy in Saudi Arabia: Socio-Economic Implications

Impact of Renewable Energy on the Socio-Economic Development of Saudi Arabia

Renewable energy is a trend that has implications far beyond power generation and sustainability. Experts note that the transition to renewable energy has the potential to impact various areas of socio-economic development, such as infrastructure, employment, and economic stability (International Renewable Energy Agency, 2017). In the context of Saudi Arabia, there are three significant changes anticipated.

First of all, the emergence and continued development of renewable energy in the Kingdom will create more jobs. Even considering the potential job loss from reduced sourcing of fossil fuels, unemployment will likely decrease since more skilled and educated workers are necessary to operate renewable power plants (IRENA, 2017). A reduction in unemployment will result in higher average income, leading to increased buying and investment capacity and reduced economic inequality. Secondly, the improvements in the renewable energy sector will likely contribute to the power infrastructure in Saudi Arabia. As reported by IRENA (2017), renewable energy sources can be used in locations where traditional power grids cannot be situated, thus bringing electricity to remote areas. As a result of these improvements, social welfare is likely to rise because people will have easier access to heat, light, and transportation in remote areas.

Finally, renewable energy can also have a negative impact on Saudi Arabia's economy if the global trend toward renewables has a negative effect on the consumption of petroleum and other fossil fuel products (Al-Saleh, 2009; Tlili, 2015). Because the Saudi Arabian economy relies heavily on the export of oil, and major investments are planned into natural gas, the country will likely experience a reduction in export income if the global demand for fossil fuel products decreases due to renewables. This can harm the economy, affecting its stability and the Kingdom's economic

reserves.

Risks Posed by Renewable Energy to the Oil Sector

Because renewable energy poses challenges to the oil sector, it is critical to outline the potential scenarios of its development in Saudi Arabia. In the optimistic scenario, where the availability of fossil fuels remains high, and action on environmental protection is low, removing barriers to the global demand for oil, Saudi Arabia is likely to move slowly toward the use of renewable energy, using it primarily to serve its own energy needs (Al-Saleh, 2009). In this case, the impact on the oil sector will be positive because there will be more oil available for exports.

The pessimistic scenario, in turn, is where global action on sustainability is high and the availability of fossil fuels is low, forcing countries to invest more in renewable energy and dramatically reducing the demand for fossil fuels (Al-Saleh, 2009). If more countries become able to fulfill their energy needs without oil, Saudi Arabian exports of oil will decrease, and so will oil revenues. Consequently, the oil sector and the economy as a whole will be negatively affected.

The middle-ground scenario is where the global action on sustainability is moderate, while the availability of fossil fuels remains unchanged (Al-Saleh, 2009). In this case, Saudi Arabia will not experience any significant changes in the oil sector while developing renewables at the current pace. The main implications of this scenario are the future reduction in the availability of fossil fuels and the continued reliance on the economy on oil.

Impacts on the National Economy and Political Stability: Scenario Analysis

Each of the outlined scenarios has the potential to impact the political and economic stability of Saudi Arabia. The main factors that should be considered here are that Saudi Arabia relies heavily on oil exports for income and has a well-developed oil sector that employs tens of thousands of people (Tlili, 2015). Hence, the pessimistic scenario will likely drive many people into

unemployment while simultaneously reducing the income from exports and necessitating continued investments into renewables to sustain population needs (Al-Saleh, 2009). This will force the economy into a recession, while reduced welfare and rising unemployment could result in internal political unrest.

The other two scenarios would have minor or moderate positive effects on the politics and economy of the Kingdom. If the renewables develop along with rising or unchanged exports of oil, unemployment will likely decrease while people's access to electricity within Saudi Arabia will improve (IRENA, 2017). At the same time, the economy will remain stable due to the income from oil exports. The risk of political or economic instability in these scenarios would be low, and thus the Kingdom should seek to avoid the pessimistic scenario in favor of the optimistic or the middle-ground scenario.

Conclusion

Overview

The research focused on the energy sector of Saudi Arabia, the role of fossil fuels in it, and the potential developments resulting from the growth in renewable energy generation. The overview of the current state of the energy sector in Saudi Arabia revealed that fossil fuels are a significant contributor to the country's economy and power availability. While the country relies heavily on oil exports at the moment, the government also has plans to develop its natural gas reserves and enter the global market with gas exports. This could help to diversify the economy, although it would continue to be dependent on the global demand for fossil fuels. For example, issues concerning international oil trade agreements and fossil fuel prices would still have a major impact on Saudi Arabian income and economic stability.

In terms of renewable energy, the Kingdom lags behind global trends in renewable energy set by European and Western countries. This could pose a threat to the Saudi Arabian economy if the demand for fossil fuels decreases as a result of these changes. When compared to other Middle Eastern countries, the state of renewables in Saudi Arabia appears to be similar, as most of its neighboring economies are also dependent on oil or natural gas. However, some countries, such as the UAE, have already benefitted from projects concerning renewable energy, whereas Saudi Arabia aims for slow progress in the area.

Policy Implications

By developing a thorough overview of the energy market in Saudi Arabia and examining global trends in renewables and non-renewables, the study gathered the data to allow projecting possible implications of various scenarios on the Saudi Arabian energy sector, economy, and political stability. In general, it appears that a significant development in environmental protection,

coupled with the low availability of fossil fuels, could prompt countries all over the globe to enhance the role of renewables in energy generation, thus decreasing the demand for fossil fuel products significantly. This will damage the Saudi Arabian economy significantly while also forcing the country to invest more in renewables. As a result of the recession and unemployment resulting from this pessimistic scenario, the state could become less politically stable and face internal unrest. The other two potential scenarios, however, will not pose such significant risks and will likely benefit the country's socio-economic development by diversifying the economy, reducing unemployment, and improving infrastructure in remote areas.

National Policy

National policy concerning renewable and non-renewable energy should aim to avoid the pessimistic scenario to prevent economic damages and political instability. While the country cannot influence global trends in environmental protection and renewables significantly, it should seek to take gradual action on developing its renewable energy potential so that it could begin exporting green energy if the demand for fossil fuels becomes lower. Investing in renewable energy could also reduce unemployment and have a positive effect on oil exports as they would allow Saudi Arabia to fulfill population needs through green energy while using oil and natural gas mostly for exports. By avoiding over-reliance on fossil fuels and enhancing its capacity for renewable energy generation, Saudi Arabia would gain the opportunity to strengthen its energy sector and move along the optimistic or middle-ground scenarios, thus earning socio-economic benefits.

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