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ENERGY SECURITY IN SAUDI ARABIA: CHALLENGES, THREATS AND SOLUTIONS

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ABSTRACT

Energy security is a major concern for many countries, given worries over peak oil and recent spikes in oil and gas prices. This has been made worse by growing concerns over the environmental implications associated with the extensive use and reliance on hydrocarbons. Saudi Arabia is hugely dependent on the revenues from oil exports for its economic security. More immediately, Saudi Arabia is facing a rapid growth in domestic energy demand. If left unchecked, this could undermine Saudi Arabia's ability to maintain oil exports at prevailing levels. As a result, there is an urgent need to investigate the issue of energy security in Saudi Arabia. In order to answer the research questions, data were collected by semi-structured interviews. These data were analysed using a thematic analysis. Findings suggest that Saudi Arabia experiences distinct aspects of the energy security problem. The country could be at extremely high risk in the future, because oil seems to be the valve for the country's energy and economic security. Saudi Arabia considers that renewable energy and energy efficiency could be the best solutions for energy security concerns. This research project argues that there are important overlaps with these two areas. Moreover, the renewable energy sector in

the country is in the early stages of development; and is lagging behind even other neighbouring Middle Eastern oil exporting-countries. This research, therefore, seeks to expand the available knowledge related to renewable energy barriers in an oil-dependent economy. It is apparent that in order to allow Saudi Arabia to maintain its position in the future as the largest oil exporter in the world, whilst improving its energy and economic security, the country requires major changes in its existing energy structure. Therefore, this research seeks to provide a clear understanding of the impact and role played by the government policy in the energy sector, cultural awareness about energy efficiency and renewable energy, and effective administration in the energy organisations in helping to ease energy security concerns in the Kingdom via a significant expansion in the capacity for renewable energy generation.

INTRODUCTION

Energy is the most important element in contemporary life, without fossil fuel, "societies would crumble" [1]. Fossil fuel has become a vital commodity for all modern human societies, both to generate electricity and propel transportation. However, it is hard to avoid the fact that oil is a non-renewable resource, the product of millions of years of solar energy, photosynthesis and geological pressure and cannot be regenerated after use [2]. Klare [3] claims that currently, "we are seeking more, but the finding is less". At the same time, renewable energy resources are playing a more significant role in sustaining people's lifestyles, saving the environment by reducing carbon emissions and most importantly, slowing the depletion of fossil-fuel resources [4]. Although the term 'energy security' first came to the fore after the oil embargo in 1973, there is now a renewed focus on energy security driven by a number of factors including fluctuations in oil prices, the issue of peak oil and the environmental concerns embodied in carbon emissions, and green energy demand. Energy security is now the subject of intense debate in policy circles around the world and forms part of the "high politics" of national security [5].

The available literature has revealed that the subject of energy security challenges, threats and solutions in Saudi Arabia has not been widely investigated, due to the widespread availability of oil in the Kingdom and its status as the world's leading producer and exporter of oil. It is notable also that there has been little previous research examining the prospects of peak oil in major oil-producing countries, particularly in heavily oil-reliant economies such as Saudi Arabia. However, as the Kingdom aims to maintain oil resources for future generations by diversifying energy sources and entering the renewable energy and nuclear energy market, there is now an ambition to invest and develop further renewable energy resources in the country to tackle any future energy crises.

Saudi Arabia is not only the largest oil producer and exporter in the world; the country is also among the top oil-consuming countries per capita in the world. This makes the Kingdom particularly vulnerable to changes in the global energy market, which could affect the economic, political and energy security in countries across the world as the Kingdom is the biggest global energy supplier, condensate reserves of 260 billion barrels of oil [6]. Saudi Arabia is currently encountering some problems with its energy sector, both internally and externally. Internal problems arise from the fact that Saudi Arabia

continues to depend on oil as its main source of income [7]. The country's dominant role in the supply of oil could be affected by two main factors. Firstly, the growth of domestic energy consumption could impact the country's ability to meet international oil demand [8]. Addressing this issue would require significant structural changes in energy prices and improvements in energy productivity in all sectors - industrial, transportation and buildings [9]. Secondly, the problem of peak oil production and/or peak oil demand might become a significant factor in the Kingdom as it indicates that oil resources are limited and may eventually run out [10]. External problems, including those associated with carbon emissions, and green energy demand, have raised interest in the potential of renewable energy across the world in recent years [11]. Furthermore, international interest in improving energy efficiency, especially in transport sectors, may reduce oil imports globally due to the strong relationship between oil consumption and carbon dioxide (CO2) emissions [12]. This will probably lead oil-importing countries to reduce their reliance on fossil fuel, and encourage international energy demand to shift to cleaner energy. This shift in energy demand from fossil fuels to renewable energy threatens the economic security of the Kingdom due to its reliance on oil exports as a main source of income.

Therefore, this research attempts to investigate the seriousness of a policy concern is energy security in Saudi Arabia, as well as the potential of renewable energy to ease energy security concerns in Saudi Arabia.

METHODOLOGY

Qualitative methods have been adopted in this research as the aim to generate a rich dataset that can be subjected to qualitative analysis. This process will conclude with an analytical commentary that intertwines participants' extracts with a body of literature and a range of theoretical perspectives that relate to renewable energy in Saudi Arabia. This research is exploratory. Using a qualitative approach helps to explore new phenomena and investigate a little-known or poorly-understood phenomenon that has not yet received much attention in the literature [13, 14].

This research aims to investigate energy security challenges and threats in Saudi Arabia. Despite growing concern, the issue of energy security in Saudi Arabia has received insufficient research attention. Additionally, peak oil theory is a sensitive topic in Saudi Arabia that is still the subject of widespread debate for Saudi policymakers and energy experts. With regards to renewable energy, this research represents an opportunity to explore a new area of study which has a clear social impact, but which needs a clear steer from policymakers.

This research focuses on participants' perceptions and attitudes, applying a qualitative approach help to analyse their views, freely expressed. Additionally, using this approach permits the researchers to contrast and compare the various perspectives of participants [15]. This point is crucial, as part of this research involves different sets of participants who play different roles according to their employment status (government employees, private

sector employees or retired). Therefore, using qualitative research aids in understanding the similarities and differences in their viewpoints.

Data Collection Tools

The main source of primary data collection in this project is interviews. Interviews can be defined as "situated, face-to-face interactions in which researchers typically pose questions that respondents answer" [16]. Semi-structured interviews provide the researchers with the opportunity to discover more detailed information about subject or event by asking the participants to give more detail or clarification to their answer [17]. It has been determined that semi-structured interviews will be the only method used in this research, for the following reasons:

I. This research study has adopted a phenomenological approach.
II. Semi-structured interviewing gives the ability to dig deeper into a participant's answers, and investigate them in more depth to find new insights.
III. This research has an interpretive nature.
IV. Semi-structured interviews involve open-ended questions and the answers from the participant are unpredictable, this kind of interview allows the participants to expand on their answers and gives them an option to take a different path and explore different thoughts and ideas.
V. Semi-structured interviews give the researcher the chance to ask further questions in response to what is seen as significant replies to important questions.

Interview Approach

For this research, face-to-face interviews were conducted with all participants with the exception of one, who preferred to conduct the interview by phone. The interviews in this research have been conducted at five different places: at work, in restaurants, in hotels, at a participant's home, and at the researcher's home. Interviews in this research lasted between 60 to 120 minutes, allowing for as rich a set of information as possible from the participants without losing concentration.

Interview Questions

In line with suggestions from Arksey and Knight [18], the interview questions in this research were designed followed a number of recommendations such as:

I. Vocabulary: In this research, clear and easily understood language was chosen by the researcher for the Saudi cultural and social sample. The researcher ensured that the participants were aware of all of the concepts used in the questions.
II. Prejudicial language: This research has avoided reinforcing particular beliefs or prejudices.

III. Ambiguity: The researcher avoided the misunderstanding of words that can lead to different interpretation. Face-to-face interviews can address any misunderstanding of questions during the interviews.
IV. Leading questions: This research avoided using questions that suggest or lead participants towards a specific answer.
V. Double-barrelled questions: These types of questions committed when the researcher, for example, asks a question that touches upon more than one concern, however allows only for one answer. This could result in inaccuracies in the answers for the question. In this research, there were no double-barrelled questions.

Regarding the sequence of the interview questions, the researcher listed general questions in the beginning, and moved gradually into more specific, detailed questions. These questions addressed the first aim of this research, which is to examine the severity of energy security concerns in Saudi Arabia and to uncover the drivers of these concerns. Then, which is to investigate the feasibility and usefulness of utilizing renewable energy alternatives as a solution to energy security issues in Saudi Arabia as perceived by research participants.

Ethical Consideration

According to Easterby-Smith et al. [19] qualitative research usually provokes discussion about ethics because of the nature of qualitative research and the view that it tends to be more 'sensitive' and 'receptive' to participants feelings and emotions. This research has obtained ethical clearance from the College of Business, Law and Social Sciences (BLSS) Research Ethics Committee.

Sampling Methods

Interviews were conducted with 23 participants. 21 Saudi, one is British and one is French. All interviews in Saudi Arabia were conducted in the three main cities namely Riyadh, Jeddah and Dammam. Ten interviews were conducted in Riyadh city, seven interviews were conducted in Jeddah city, five interviews were conducted in Dammam city and one interview was conducted in Nottingham city in the UK.

The sample includes Saudi Arabian policy-makers, managers, specialists and researchers of organizations in order to collect information about the research topic. The criteria used to choose the research sample for this study was based on diversification of organisations and sectors within the Kingdom.

Data Analysis Procedures

In this research, the Thematic Analysis has been used to derive, consolidate and interpret the qualitative data obtained through interviews.

Thematic analysis has been chosen in this research study for the following reasons. Firstly, as qualitative interviews are the main method in this research, it allows the participants to reflect on a variety of subjects relating to energy security and renewable energy in a different way [20], and gives a new insight

into a social phenomenon. Therefore, thematic analysis gives the researcher the flexibility and possibility to link between peak oil, energy security, the renewable energy sector and the views of the participants. In addition, it allows the researcher to perceive the differences and similarities that accrue before and after data collection [21]. Secondly, as this research was inductive in nature and aimed to generate understanding of a poorly understood phenomenon, thematic analysis was used. Braun and Clarke [22] outline thematic analysis as a method that minimally organises data via the identification and reporting of patterns within the discourse.

Document Analysis

In respect of the present research study, the use of triangulation methods assisted in obtaining reliable and meaningful information. This has been asserted by a comparative exercise of the primary and secondary data collected for this research study. It was also an effective way to overcome most of the weaknesses of the semi-structured interviewing tool used in this research [23].

Quality Criteria

This research study attempts to meet validity, reliability, conformability and triangulation criteria in a number of ways. In terms of this research, validity was achieved by using several different methods to investigate the problem from different angles and strengthen the validity of the results. Such as transcriptions were validated and rechecked with English language specialists to ensure the accuracy of the data, involvement of energy specialists in Saudi Arabia for the validation process.

The reliability was achieved by taking a number of precautions. The interviews were recorded to present fairly and reasonably reliable evidence and avoid possible bias. All the questions were formulated clearly and asked in a natural tone of voice. Also, the interview questions were provided to participants in print form to enable participants to understand what they were being asked and to ensure that there was no misunderstanding or confusion.

Conformability refers to the objectivity of the researcher when conducting the research. The present research is concerned with objectivity and not overshadowing the views of the participants through the biases of the researcher.

Triangulation in qualitative research is a strategy for improving the validity and reliability of the study's findings. In terms of this research, data triangulation was achieved through using two different sources; semi-structured interviews and document analysis. The use of these sources helped with data triangulation.

RESULT AND DISCUSSION

ENERGY SECURITY CHALLENGES AND THREATS

Energy Security

The issue of energy security first emerged in 1973 when the Arab oil embargo raised concerns about the use of an "oil weapon" by oil exporters [24]. Recent years have seen increasing consideration being paid to energy security, because of a number of concerns such as peak oil, environmental issues (climate change in particular), world population growth and the political uncertainty in many oil-exporting countries around the world. One of the emerging concerns for oil exporters is the direction of many oil-importing countries towards renewable energies, rather than relying on oil and gas imports. This reduction in demand for oil and gas has become a real concern for oil and gas producing nations on the demand side.

Conceptualizing Energy Security in Saudi Arabia: Challenges and Threats

A number of energy scholars indicate that the concept of energy security is vague [25] and has no commonly accepted definition [26]. A number of participants in this study agreed that the term is not clearly defined in the context of Saudi Arabia, which makes it hard to identify the difficulties that could affect the country's energy position in the future. Initial analysis of participants' interviews indicated that there are several reasons behind the difficulty in measuring and defining energy security in the country. Firstly, "*the non-democratic structure in Saudi Arabia might prevent Saudis from discussing and debating this matter*" as indicated by participant V. Participant M added "*actual numbers and accurate statistics about oil revenue and reserves could be difficult to ascertain in the Kingdom*". Participant R also pointed out that "i*t could be hard to identify matters relating to energy security in Saudi Arabia because it may negatively affect the political and economic position of the country*".

Despite these difficulties, the present research was able to identify a number of themes related to energy security challenges and threats in Saudi Arabia (Table 1).

Table 1. Quantifying the Frequency Of Sub Themes

Main Theme	**Sub Themes**	**Number of participants who cited these themes**	**Percentage of participants who cited these themes**
Energy Security Challenges and Threats	The rapid growth of domestic energy consumption (Challenge)	23	100%

	Complete reliance on oil revenue (Challenge)	22	95%
	Peak oil (Threat)	16	69%

The Rapid Growth of Domestic Energy Consumption

The theme 'domestic energy consumption' was mentioned by all participants. This reveals the anxiety of participants about the dramatic increase in energy demand in the country. This concern has become important because the Kingdom's demand for its own oil and gas is growing at around 7% per year [27], leading to fears that this might affect the country's ability to meet both domestic and international oil demand in the future.

When assessing the reasons behind the strong growth of domestic energy demand in Saudi Arabia, four associated themes emerge namely (1) lack of energy efficiency awareness, (2) energy subsidies, (3) population growth and (4) energy efficiency barriers. Table 2 shows the number and percentage of participants who cited these themes.

Table 2. Quantifying the Frequency Of Associated Themes

Sub Theme	**Associated Themes**	**Number of participants who cited these theme**	**Percentage of participants who cited these theme**
Increase domestic oil consumption	Lack of awareness	23	100%
	Energy subsidies	21	91%
	Population growth	19	82%
	Energy efficiency barriers	18	78%

Khan [28] revealed that "whilst most developed countries are starting to increase consumer awareness about energy efficiency, people in Saudi Arabia still believe that their country floats on a river of oil". This is something that most participants agreed upon. The residential sector is the biggest consumer

of electricity in the Kingdom, using 50% of the electricity generated in the country [29]. Several participants argued that, despite the gradual reform of electricity prices in 2010 for the government, commercial and industrial sectors, prices in the residential sector remain very low. While there are ambitious objectives to reduce demand for energy consumption among residential consumers [30], all participants asserted that there is a close relationship between the growth in domestic energy consumption and the lack of consumers' awareness.

It is difficult to discuss the Kingdom's energy consumption without discussing the energy subsidies policy, as for many years, domestic energy prices have been heavily subsidised by the government [31] and, thus, "*Saudi consumers enjoy the cheapest prices in the world*" (Participant J). Several participants believed that the country's policy-makers are worried that low energy prices could stifle the country's ability to balance domestic energy consumption and exports, and that this would have serious consequences for government revenue and GDP in the future. As a result, twenty-one participants agreed that continued energy subsidies at current levels in Saudi Arabia could pose a huge risk to national economic stability.

The Kingdom's population could reach 40,388 million by the year 2050, based on the average annual growth rate in previous years [32]. Saudi Arabia's population is one of the fastest growing in the world, with 50% of citizens under 25 years old [33]. 'The effect of population growth' theme addresses the impact of population growth on domestic energy consumption in Saudi Arabia, and discusses the consequent impact on energy security in the country. About 82% of participants linked the issue of population growth and increased energy demand. Participants also agreed that the population problem is not just a matter of the number of people that will be added in the future; it is also a matter of consuming more food, water, electricity, minerals, and other forms of energy. Overall "*the population is continuing to grow, so there is a mismatch between energy demand and supply*" (Participant C).

Energy efficiency barriers are considered to be one of the main reasons behind the strong growth in domestic energy demand in Saudi Arabia [9]. This associated theme provides an overview of energy intensity concerns in three sectors namely industry, buildings and transport. As the Kingdom attempts to diversify its economy beyond oil exports, energy intensity within the economy has grown in these key sectors and they now represent over 90% of the energy consumption in the country [29]. However, the Kingdom faces particular constraints that are rooted in significant barriers to its energy efficiency initiatives. According to eighteen participants, increasing energy efficiency in Saudi Arabia is a considerable challenge. As participant B explains, "*The Saudi government should be aware of the enormous waste in hydrocarbon utilization in all three sectors in the country; this waste will not only affect Saudi Arabia, but the oil market globally*", given the role the country plays on the world energy market.

Complete Reliance on Oil Revenues

In this context, 22 participants believed that the country needs to reduce its reliance on oil and unleash the potential of non-oil sectors. Economic diversification is one of the most significant aspects of sustainable economic growth. The Kingdom's economy is currently highly reliant on revenues from oil and risks danger and instability if oil prices continue to decrease on the international market (Participant I). According to Callen et al. [34], there are three main incentives for economic diversification. Firstly, diversification limits an economy's exposure to volatility in global markets and therefore reduces uncertainty. Secondly, it creates jobs in the private sector, reducing youth unemployment and bringing more of the working-age population into the workforce. Thirdly, it increases productivity and sustainable growth. In the case of Saudi Arabia, economic diversification would help the country to develop the non-oil economy that it will need in the future.

The massive oil revenues generated in the last decade allowed the Kingdom to make massive investments in the education sector, in social programmes and in the country's infrastructure [7, 35]. However, several participants agreed that the country failed to decrease its reliance on oil, as the country's 2014 budget was still 90% dependent on oil revenues. Furthermore, several participants agreed that a fall in crude oil prices for any reasons, or the appearance of viable energy alternatives, could threaten Saudi Arabia as the country has no other source of income that could substitute oil revenue, which was estimated at $274 billion in 2013.

Accordingly, it can be argued that a number of oil importing countries have made some success in diversifying their sources of energy and reducing their dependency on oil. Al Sabban [36] indicates that there has been a huge structural change in the energy market, on both the supply and demand side. High oil prices in the last few years have encouraged more energy efficiency measures to be taken, more switching to other sources of energy. Therefore, Saudi policy-makers need to look afresh at the new energy landscape in order to secure the country's economic and energy security in the future. SEEC was established by the Saudi government in order to develop energy efficiency and conservation policies in the country [30], whilst K.A. CARE was created to develop substantial alternative energy capacity [37]. Although these two initiatives have not yet achieved their aims completely, they are signs that the Saudi government is increasingly aware of the crises that the country could face in the future.

The non-oil private sector plays an important role in economic diversification. However, several participants indicated that the complete reliance on oil revenues hinders growth in the non-oil sector in the Kingdom, particularly for SMEs. According to a recent Saudi Arabian Monetary Agency report (2014) [38], "the private sector accounted for 35% of the GDP in 2010–2013, which is not different from its share in earlier development plan periods". According to several participants, the underdevelopment of the non-oil private Sector-SMEs could be one of the major obstacles to the Kingdom's economic progress.

Both the literature and the research participants agree that the drop in oil revenues in the short term would not have a detrimental effect on the economic and/or financial positions of the country. Participant E explains, "*The Kingdom will not be badly affected; Saudi Arabia can survive if oil revenue decreases for a few years because the country has financial reserves that could protect the economy in the short term*". According to the data available in recent literature, the country has "$654.5 billion in foreign reserves" [39]. However, evidence to contradict this statement may be found in the IMF's recent prediction, made after the 2015 oil crisis, that Saudi Arabia might be bankrupt within five years [7].

In the medium term, participant I believed that "*Saudi Arabia's national budget could be cropped*". As previously mentioned, the Kingdom's economy has benefited from high oil revenues, due to increases in oil prices over the past decade, which in turn has created an environment of luxury consumption within the country [40]. However, as things stand at this stage, the luxurious lifestyles enjoyed by many Saudi citizens' might be coming to an end earlier than anticipated.

In the long term, most participants agreed that continuing to depend on oil as the main source of revenue for another 10 years will be a disaster for the Kingdom's economic security in the future. Further evidence to support their claim can be found in Saudi Arabia's situation in 2015. According to the Ministry of Finance [41], the country's budgeted expenditure last year was a record $229 billion while the total revenues were estimated to be $190.7 billion, resulting in a fiscal deficit of $38.6 billion. Any further drop in oil revenues is likely to increase this deficit, which in turn will negatively impact the country's economic growth and security.

On the whole, notable progress towards economic diversification has been made in Saudi Arabia, particularly since the recent decrease in oil prices in 2015, and it now forms a key part of the country's vision [42]. As Prince Mohammed bin Salman stated: "What is left now is to diversify investments, so that, within 20 years, we will be an economy or state that no longer depends mainly on oil" [43]. However, most participants agree that economic diversification will not occur overnight: There needs to be an enabling environment, increased government support, and the right investment and fiscal policies in order to make diversification possible in the future.

Peak Oil

The results of the present research study suggest that the debate over "peak oil" in Saudi Arabia revolves around four separate views or associated themes. These can be categorized as (1) optimists, (2) pessimists, (3) believers in peak oil demand and (4) reticent participants who do not offer clear opinions about peak oil. Table 3 shows how frequently ideas associated with these themes were mentioned by participants.

Table 3. Quantifying the Frequency Of Associated Themes

Sub Theme	Associated Themes	Number of participants who cited these theme	Percentage of participants who cited these theme
Peak Oil	Pessimists	8	34%
	Optimists	6	26%
	Believers in peak oil demand	4	17%
	Reticent participants	4	17%

The high percentage of participants expressing pessimistic views came as quite a surprise. Contrary to the literature which indicates that "there seems to be a widely-held disbelief among Saudis with regard to the notion of peak oil" [44], the present research shows that 34% of participants predict a dark future for oil production and argue that the oil production capacity peak is imminent. Pessimist participants agreed that fewer new oil fields are being discovered and that as opportunities to develop new oil fields diminish, so extraction will become more difficult and thus more costly. As participant P explained, "*Oil is an impoverished substance, whether we like it or not – new technology will keep oil around for a little longer but it will never create new oil fields*". This statement supports the work of Simmons [45], who revealed that Saudi Arabian oil production depends on a small number of 'super-giant' fields, with little production capacity in other smaller fields.

Despite strong evidence indicates that oil fields do not magically re-fill [46], optimists believe that the peak oil theory is completely false and that Saudi Arabia will continue to enjoy plentiful supplies of oil because of the impact of technological advancements in finding new oil fields. Participant G mentioned the impact of new developments such as "*deep-water drilling, tar-sands extraction and the recent fracturing techniques*" on oil production capacity; while participant R expressed the belief that "*more and more resources will be discovered and improvements in technology will enable Saudi Arabia to produce even more oil than it does now*". However, The Al-Ghawar field, established in 1948, is still the world's largest onshore oil field and there has been no new exploration of giant fields in the Kingdom [47]. In addition to this problem, the observations from this associated theme did not capture any potential of the unsustainable domestic increase in energy demand in the country, which could challenge the country's ability to export its oil in the future [27].

Although optimists believe that there is still plenty of oil left under the ground and that business will continue as usual in the world energy markets, economists remain unconvinced. They argue that this view fails to take account of several factors which impact oil demand, notably the international

increase in renewable energy investment. The oil-importing countries seek to reduce their dependency on foreign energy, so international energy demand and renewable energy sources become ever more important issues [48]. Participants were asked whether they thought this move towards renewable energy would affect Saudi Arabia as an oil exporter. Participant K stated: "*The answer depends on what Saudi Arabia will do with its economy in these circumstances. Technology will inevitably reach a point where electricity and the renewable energy alternatives will be cheaper than energy produced from oil and gas. The costs of battery technology will be reduced, and 'solar' and 'wind' technology will be cheaper too – they will all continue to become cheaper and the world's change of direction towards clean energy will also affect the demand for oil and gas*". However, it was evident that the majority of participants did not feel that the move towards renewable energy in oil-importing countries would negatively affect Saudi Arabia; only a few participants said it would affect the country's status in the future, whilst others did not provide a specific answer at all. These findings are presented in Figure 1.

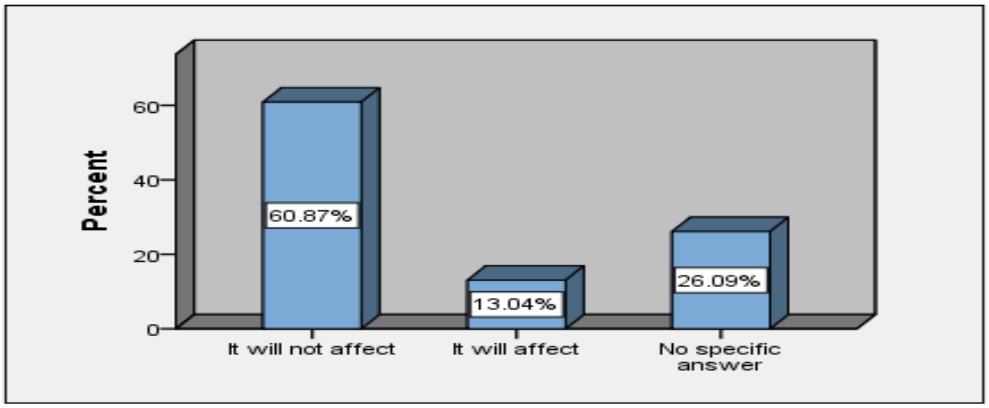

Figure 1. Will the Move Towards Renewable Energy in Oil Importing Countries Affect Saudi Arabia?

Several participants agreed that the only uncertainty about peak oil is the time scale; however, they believed that peak oil will definitely happen. Based on the current statistics of proven crude oil reserves (266,578 million barrels) and crude oil production (9,713 [1,000 b/d]), a simple calculation suggests that the country's oil will last for 75 years:

266,57,8000 ÷ 9,713 = 27,445.485431895 (days)

27,445.485431895 ÷ 365 (days) = 75 (years)

Despite the fact that Saudi Arabia is the world's central bank of oil, the country could face an energy crisis in a couple of decades. Although it may seem strange to say this to the world's largest oil producer, data collected through interviews and data provided in the literature suggest that it is feasible.

RENEWABLE ENERGY

Renewable Energy Development In Saudi Arabia

Although Saudi Arabia possesses 18% of the world's proven petroleum reserves and ranks as the largest exporter in the world [49], the country is looking to invest in renewable energy [50]. This was reflected in the data collected in this study, as 22 of the 23 participants asserted that renewable energy has the potential to ease the problems caused by the rapid growth in domestic energy demand. They also agreed solar and wind energies are the most promising renewable energy resources for the GCC region, based on a number of studies [51-53]. About 22 participants seemed to prefer solar energy technologies, supporting claims that they have greater potential for application in Saudi Arabia [54].

Almost all participants agreed that renewable energy resources offer Saudi Arabia an opportunity to preserve fossil fuels to supply the next generation and to increase exports by helping to meet domestic demand. However, they indicated that although the Kingdom's geographical location makes it an almost ideal environment for renewable energies; it lags behind other countries in the region, in terms of alternative energy development.

Common Challenges Facing the Saudi Renewable Energy Sector

Both the literature and the participants in this study agree that the Kingdom's renewable energy sector is facing challenges and difficulties. The participants identified a number of these challenges, and these form five sub-themes namely (1) a lack of regulatory framework, (2) limited coordination and collaboration between different agencies, (3) limited public awareness about renewable energy, (4) climate conditions and technical challenges, and (5) insufficient qualified domestic consultants and experts. These sub-themes are presented in Table 4 below according to the frequency with which they featured in the interviews.

Table 4. Quantifying the Frequency of Sub-Themes

Main Theme	**Sub-Themes**	**Number of interviewees who cited these theme**	**Percentage of interviewees who cited these theme**
Challenges Facing Renewable Energy in Saudi Arabia	Lack of policy framework	14	60%
	Limited coordination and collaborati	10	43%

	ve between different agencies		
	Limited public awareness about Renewable energy	8	34%
	Climate conditions and technical challenges	8	34%
	Few qualified domestic consultants and experts	5	21%

Lack of Policy Framework

According to Bhutto et al. [55], any energy policy should include certain elements, including "legislation, international treaties, incentives for investment, targeted energy generation, guidelines for energy conservation, strategies to stimulate the energy industry, taxation and other public policy measures as well as a focus on new (usually renewable) energy sources".

The lack of a renewable energy policy framework in Saudi Arabia was discussed at length in the interviews. Reflecting its importance and its influence on other energy and economic issues in the country, fourteen participants stated that the Kingdom's renewable energy sector might not survive unless a clear policy framework is introduced. Saudi Arabia has allocated $109 billion for the development of renewable energy and plans to introduce utility-scale solar energy into the power system [37]. This plan was developed in a White Paper16 issued by K.A. CARE in 2013; it sets the framework for three tendering rounds: "an introductory round of 500-800MW; a first round of 2000-3000MW; and, a second round of 3000-4000MW" [37]. However, Saudi Arabia has not approved a national renewable energy policy to date.

The current situation in Saudi Arabia is complex. There are several government authorities responsible for the activation of renewable energy regulations that will create new industries. These include K.A. CARE, the Ministries of Finance and Petrol, ECRA, KACST, Aramco and SEC. As participant C indicates, even though ECRA is the body responsible for regulating the electricity and water desalination industries in the Kingdom, it has not approved a national renewable energy policy to date. Even K.A.

CARE, which has a significant role to play in shaping the overall energy policy of the Kingdom and defining the nuclear and renewable energy policy, has not yet approved any policy relating to renewable energy.

In terms of the consequences of not having a renewables policy, several participants agreed that the lack of a regulatory framework discourages investment in renewable energy projects in the Kingdom. It is a challenge to convince investors to invest in renewable energy without an established regulatory framework. Participant H indicated that the only way investors would consider entering the Saudi market for renewables is if they had a customer commitment to guarantee renewable projects that would support the business case for entering the market. Three participants also indicated that one of the major deterrents for renewable energy investors in Saudi Arabia is the lack of subsidies for renewables even though fossil-fuels are heavily subsidised. Indeed, research has shown that "it is almost impossible for renewable energy to compete in the Saudi electricity sector with the current artificially low electricity prices" [56].

Participant E makes clear, high fossil fuel subsidies make renewable energy appear uncompetitive and this both discourages investors and complicates attempts to establish renewables policies. According to Beck and Martinot [57], one of the most important elements in incorporating renewable energy within a power sector is the reduction of subsidies to fossil fuels; therefore, if the Kingdom is serious in its intention to encourage investors to enter the renewables market, fossil fuels subsidies must be reduced. Accordingly, all participants agreed that fossil fuel subsidy reform could encourage the development of renewable energy by motivating investors to enter the renewables market.

Limited Collaboration and Coordination Between Different Agencies

Within the context of Saudi Arabia, Melton [58] found that collaboration and coordination help agencies in addressing their common objectives by working together in an effort to achieve the Kingdom's common goals whilst Masini and Menichetti [59] discuss their significance in relation to renewable energy policy and projects.

Based on comments made by these participants, it appears that the establishment of KACARE as a new independent entity caused some confusion amongst energy stakeholders in the Kingdom. This has led to each entity operating without adequate reference to any other. Participant C added that KACST and ECRA were asked to transfer all renewable energy initiatives related to developing clean-energy policy and regulatory frameworks to K.A. CARE; however, this seems to have resulted in blurred accountability between different agencies, leading some organizations to operate in silos.

The literature reports that "agencies are most likely to be willing to collaborate and network when they agree on common objectives, [and] operate under the same laws and regulations" [60]. It seems apparent that the lack of clear and decisive renewable energy regulation has damaged relationships between the

different agencies. As participant C noted, the Saudi government has an important role to play in changing the quality of relations between agencies. In his view: "*To achieve our renewables objectives, it is critical for the Saudi government to encourage collaboration between agencies; we do not need to establish another ministry or another agency in renewables – rather we need only to collaborate and work together*". Such intervention by the government would encourage agencies to share relevant information and to coordinate their activities. However, this might also require managerial changes within those organisations.

Besides that, the co-ordination between research centres, academic institutions and scholars in Saudi Arabia is important. The pioneering research institutes in the Kingdom such as KAUST and KACST are failing to appreciate the full potential of working collaboratively to advance applied research efforts that would help jumpstart renewable energy development. Participants agree with this point when it comes to streamlining renewables research findings. For instance, data collected from three participants at KAUST and KACST revealed that although they are working on similar solar projects, neither institution collaborates with the other because they see no value in doing so. Therefore, as existing literature about R&D institutions in the Kingdom has indicated, the contribution of these institutions towards renewable energy development has been limited [56].

It can be concluded that K.A. CARE's plans to turn Saudi Arabia into the Kingdom of sustainable energy cannot be achieved in isolation. As several participants indicated, in order for renewable energy projects to be implemented successfully in the Kingdom, there must be closer collaboration between different agencies and within each agency itself. This should be governed by clear rules and overseen by a defined governance body. The impetus to closer collaboration and coordination must come from the Saudi government, directing agencies to work with each other on stated objectives and to share relevant information.

Limited Public Awareness of Renewable Energy Technologies

In addition to the legal and managerial barriers confronting the renewable energy sector, limited public awareness of renewable energy is also hindering the development of the sector in Saudi Arabia. Eight participants asserted that limited public awareness and acceptance of renewable energy technologies could be a challenge during the country's transition away from fossil fuels towards renewables. This lack of widespread acceptance might also threaten the development of this sector for the foreseeable future. According to Ekins [61], public acceptance is one of the most important factors in the successful implementation of renewable technologies, and it could play a key role in accelerating the development of the renewables sector in Saudi Arabia.

There was agreement amongst participants that economic considerations play a large part in shaping public attitudes towards renewable energy. Participant N identified a relationship between the high costs of renewable energy technologies and the willingness of consumers to shift towards renewable

electricity. He explained "*the cost of conventional energy is cheaper than renewable energy resources. As a consumer, I care only about the cheapest price*". According to El-Katiri [62], the "key to determining any technology's deployment is its comparative cost advantage vis-à-vis existing technologies". Although the costs of renewable energy technologies continued to drop in 2013 and 2014 [63], multiple participants confirmed that unless current domestic oil and gas prices increase considerably, renewables will remain economically unattractive, in comparison with fossil fuel-based technologies. Participant P suggested that lessons might be learned from the experiences of some European countries, which have succeeded in encouraging consumers to adopt renewable technologies in their homes: "*The governments of some European countries have provided financial incentives to promote renewable energy implementation, which has encouraged consumers to install solar panels on their rooftops*". According to Randolph and Masters [64], the evolution of the renewable energy industry in Germany was successful largely because of increases in public awareness. The German case shows the importance of citizens' acceptance and willingness to participate in the development of a country's renewable energy sector, and, therefore, in transforming its energy systems. According to several participants, a Saudi-style FiT policy would bring a number of benefits to the Kingdom, including a significant reduction in CO2 emissions and a more secure domestic energy supply, which could reduce the problem of power cuts in the country. The evidence gathered here suggests that the introduction of such a scheme would help to accelerate the development of the renewable energy sector in Saudi Arabia, and therefore decrease energy insecurity in the country.

In terms of educational barriers to public acceptance of renewable energy, several participants indicated that many Saudi citizens are not fully aware of the need for renewable energy technologies and have little understanding of climate change and other environmental issues. Participants further believed that the concept of renewable energy does not receive sufficient attention in the media or within educational curricula in the country. Participant R highlighted education as an important element in efforts to overcome the limited public awareness about the subject in the Kingdom. He said: "*If Saudi Arabia wants to accelerate renewables' growth, the government needs to increase the awareness of renewable energy technology amongst people at schools and in universities*". According to Zografakis et al. [65], raising young people's awareness about renewable energy through education is instrumental in securing a future energy-responsible consumer culture.

Participant O indicates that the Saudi Education system has limited reference to concepts such as renewable energy and energy efficiency. He also expressed the view that the Ministry of Education needs to take serious steps towards updating the educational system in the country by including an 'environmentally-friendly' curriculum that encourages renewable energy implementation and application by promoting green culture among young people. Participant S also commented on the need to adapt the education system in order to develop a 'post-oil' society at ease with renewable technology: "*We want a responsible society for the after-oil-era, a society that will create alternative resources other than oil, a society that will enable*

Saudi Arabia to retain the same economic level as it has right now, and this society will depend on knowledge, so the better the educational system this society has, the more innovate and creative it will be". There seems to be general agreement that in many developing countries, interest in "solar energy applications is limited as they pay very little attention to solar-energy education" [66]. Therefore, based on the participants' interviews and the information gathered, the lack of public awareness of renewable energy constitutes a barrier to the development of renewable energy in the Kingdom.

Climate Conditions and Technical Challenges

In recent years, considerable attention has been paid to renewable energy in Saudi Arabia. K.A. CARE began to develop the regulatory framework necessary to produce one third of the nation's electricity from solar panels by 2032, alongside energy from wind, geothermal, and nuclear reactors [50]. Although the extreme climatic conditions in the Kingdom pose a challenge to several renewable energy technologies (extreme heat during the day, a drop in temperature at night, and very low annual rainfall) [67], the participants focused principally on the challenges to solar technology in view of its significant role in the country's energy plans.

In 2013, K.A. CARE announced its intention to build 41 gigawatts of solar capacity [50]. However, according to the current literature, it seems that this aim has proven hard to achieve. Five participants agreed that significant technical and environmental challenges have caused delays in launching solar projects. Besides that, five participants claimed that the Kingdom's desert environment (in particular dust) is one of the main challenges hindering solar initiatives and projects in the country. Conversely, three participants argued that dust accumulation on solar panels and its effects on performance is an overrated problem and not as severe as sometimes described.

Saudi Arabia is planning to deploy both PV and CSP in order to achieve its mixed energy objectives and conserve hydrocarbon resources whilst delivering on energy security goals. Based on the information gathered from the literature, PV technology's reliability and efficiency depends on many factors, including "geographical, (latitude, longitude and solar intensity) and environmental (temperature, wind, humidity, pollution, dust, rain, etc.)" factors [68]. It was clear from the interview data that Saudi Arabia's climate, which includes both humid and arid regions and features frequent dust storms and dusty conditions, could have a significant impact on power output and the PV modules' overall performance and degradation rate. This view is consistent with a broad range of research published in the area of climate conditions and their impact on solar performance [69-71]. As participant F explained: "*High solar potential areas with high solar irradiation can be unproductive due to the high soiling rates. Additionally, dust particles vary in size and compositions depending on the location, which makes dust mitigation a challenge. Furthermore, soiling parameters such as gravitational effect, particle size, and wind speed and direction can lead to varying transmittance of light into the module, leading to small areas with partial shading from solar*

radiation which impacts performance". These technical challenges appear to be affecting the Kingdom's solar energy plans.

Despite the environmental and technical challenges affecting solar project deployment in the Kingdom, participant C indicates that neither SEC nor KACST were prepared to consider climate conditions as a major obstacle to renewable energy projects in the country. Instead, they have continued with the implementation of a range of solar projects to meet the Kingdom's ever growing energy demand. The project is intended to produce clean energy on a small-scale, with the intention to scale-up the implementation of solar rooftop panels to other larger-scale deployment projects. As of November 2015, the project has produced the predicted energy output while using old-fashioned cleaning strategies to eradicate dust from solar panel surfaces, using water for cleaning [72]. While it is practical to use conventional cleaning methods for small-scale solar rooftop systems, cleaning dirty panels using precious desalinated water on a large-scale can prove to be resource inefficient [73] especially in Saudi Arabia, a desert country with no permanent rivers or lakes and very little rainfall. This is something that several participants agreed upon.

Participant N was sceptical about certain climatic challenges, arguing that dust should be treated only as a minor nascent problem in Saudi Arabia's solar industry. He also maintained that whilst some people think that dusty weather conditions affect all parts of Saudi Arabia, this was not actually the case. In reality, he argued, "*there are many regions in the Kingdom such as Jeddah, Madinah, and Tabuk where solar radiation is high and where there are few dusty days or no dust at all*". It would therefore appear that the Kingdom's climatic conditions give rise to a range of differential weather challenges that require consideration when determining the best locations for solar panels.

Limited Qualified Domestic Experts in Renewable Energy

Shediac and Samman [74] indicate that "in addition to physical capital and technology, human capital is a key determinant of economic growth". While Saudi Arabia has the financial ability to establish renewable energy projects, it seems that the country's reliance on foreign professionals is detrimental to its long-term success. Limited domestic capabilities in renewable energy could also impede the development of the renewable energy sector in the country. Although there are many skilled jobs in the industry, these are usually filled by foreign workers because the Kingdom has a severe shortage of skilled domestic specialists and trained scientists in its renewable energy sector [75, 76].

According to a K.A. CARE report (2013) [50], renewable energy development will not only improve the environment and enhance energy security, but also create jobs for Saudis. According to four participants, this 'Saudization' policy may prove detrimental to the development of the country's renewable energy sector, on both the technical and administrative sides. Firstly, two participants indicated that the education system and labour market in the Kingdom are not well aligned with the renewable energy sector. The strict religious character of the education system means that some important sciences subjects, such as

renewable energy and energy efficiency, are sometimes neglected [77]. Only a few universities offer courses or research programmes in renewable energy technologies. Therefore, young Saudis are not being equipped with the skills necessary to meet the demands of the renewable energy sector. Secondly, the Saudization policy may slow the development of renewable projects because the sector itself is still underdeveloped, and needs highly experienced workers to grow and develop. Al-Saleh [78] indicated that "to establish an industry that is as highly technical and as innovative as renewable energy, it is necessary to recruit highly-qualified individuals who are equipped with the relevant sets of professional skills". These professional skills include expertise in mechanical and electrical engineering, economics, finance and risk assessment, as well as electrical and grid connection design. Therefore, participant U asserted, in order to ensure that the renewable industry is properly established in the Kingdom, "*Saudi Arabia needs to collaborate with international experts, as previously done with Aramco*".

In order to reinforce the Saudization policy whilst addressing the lack of suitably-qualified Saudis, in 2005 the Saudi government launched a large-scale scholarship programme: KASP [79]. This programme has given many Saudi men and women the opportunity to study and major in renewable energy fields in the world's best universities. However, interview participants could not agree on whether KASP could achieve the strategic plan for developing human resources in critical majors, including renewable energy and other energy-related fields. It seems that KASP does not yet provide significant support to the renewable energy sector because, as participant P indicated, Saudi graduates are still failing to obtain the necessary renewable energy skills. The reason behind this may go back to the lack of interest in renewable energy specialisations amongst students because the renewable industry in the Kingdom is still new and, therefore, not yet well defined.

With regards to renewable energy, the Ministry and the President of K.A. CARE have also created a scholarship partnership to encourage students to specialise in renewable energy disciplines [80]. It was evident that interview participants believed that the next group of KASP graduates might benefit the renewable energy industry directly by increasing the number of local experts with renewable technologies skills. As participant O put it, "*A proper education system and KASP will lead the Kingdom to discover the most talented and creative people*". The research in this area seems to support the view that the low number of qualified domestic consultants and experts in renewable energy presents a major concern, not only in Saudi Arabia but throughout the GCC [53].

Participant P acknowledged that shortages of experienced workers could slow down renewables progress in Saudi Arabia. When asked why there is not more local renewable energy expertise in the Kingdom, he suggested that "*the public sector – the renewable energy sector in particular – is not offering attractive job opportunities, career advancement, and, more importantly, is not motivating employees to challenge themselves*". This view is consistent with Al-Jibreen [81], who describes the public sector in Saudi Arabia as a

'graveyard' for talented Saudi professionals or for those who want to challenge themselves.

Participant P, an engineer in the public renewable energy sector, described his own experiences of seeing capable young Saudi colleagues, with great potential in the field of renewable energy, leaving to work in the private sector, due in large to financial incentives. He reported that "*more than 40 engineers resign for salary increases of between three and four thousand Saudi Riyals, which could be only found in the private sector*". However, Participant N, who recently left the public renewable energy sector for the private sector, indicated that participant P's experience was not widely representative. He added that the renewable energy expertise encompasses a variety of people besides engineers, from those who draft regulations to those involved in designing incentives regimes. Moreover, there are engineers who design renewable energy systems, researchers who work on developing new solar cells as well as technicians who work on the installation of renewable energy projects.

Data generated by the team of Evidence for Policy Design (EPoD) has previously indicated that despite the high private sector demand for technical skills, there is low enrolment among Saudis [82]. They also reported that "Job security makes government jobs particularly attractive to Saudis. Saudi nationals earn an average annual salary of Saudi Arabian Riyal (SAR) 4,800 in the private sector, versus SAR 7,000 in the public sector" [82].

CONCLUSION

The existing literature and semi-structured interviews inform the belief that Saudi Arabia does not face serious threats to its energy security in the short term, because of the widespread availability of fossil-fuels. However, there are already signs of energy insecurity in the Kingdom, in terms of electricity shortages and distribution problems. In the medium to long term, the country could face greater energy insecurity issues physically, politically and economically. Therefore, despite the fact that Saudi Arabia is currently the world's largest producer of oil, the country could face an energy crisis. What is clear is that Saudi Arabia cannot sustain its current position in the international energy market by continuing to rely on its conventional energy resources.

The renewable energy has the potential to ease energy security concerns in Saudi Arabia. However, the renewable energy sector in the Kingdom is still in its infancy and faces a number of challenges. These include a lack of renewable energy policy and investment framework, lack of skills and experience in the domestic workforce, and a lack of renewable energy awareness and acceptance amongst consumers. If Saudi Arabia wants to maintain its position as the largest oil producer and exporter in the world and transform itself from the Kingdom of oil into the Kingdom of sustainable energy, the country is in urgent need of a comprehensive renewable energy strategy.

The results of this research are important to policy makers and other government organisations as they implement a new policy and framework to

ease energy security concerns in Saudi Arabia. This research has provided local and international investors with insights into the challenges which impede the development of renewable energy in Saudi Arabia. Most significantly, the research addresses the obstacles that prevent these investors from investing in the renewable energy sector in the country. The results of this research are important in highlighting the issues of energy security and renewable energy to the general public. Once the term 'energy security' is defined clearly within the Saudi context, consumers are more likely to be aware of its impact on their own lives.

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