NOTTINGHAM TRENT UNIVERSITY

Investigating Energy Demand and Renewable Energy Utilisation Strategies to Enhance Energy Policy and Sustainability in Kuwait

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BSc, MSc

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy from Nottingham Trent University

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Originality Statement

I hereby declare that this thesis is submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy (PhD) from Nottingham Trent University (NTU) and is entitled “Investigating Energy Demand and Renewable Energy Utilisation Strategies to Enhance Energy Policy and Sustainability in Kuwait”. Neither the whole, nor any part of the work, has been submitted before in order to qualify for any other academic degree or award at NTU, or any other university. I further declare that the work is original, except where shown by specific cited reference and acknowledged within the text, and represents the efforts of the author alone. The content of the thesis is the result of work that has been carried out since the date of approval of the research programme, and it has been prepared in accordance with the regulations for postgraduate research study set out by NTU. All ethics procedures and guidelines have been duly observed in the preparation of this thesis. Any views expressed in the thesis are those of the author and in no way represent those of the University. The University has permission to keep, lend, or copy this thesis, in whole or in part, on condition that any such use of the material is duly acknowledged.

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Dedication

الإهداء

أهدي ثمرة هذا الجهد ونجاح هذه الأطروحة إلى الأرواح الغالية والطاهرة إلى والدي ووالدتي، رحمهم الله رحمة الأبرار وأسكنهم فسيح جناته مع الصالحين والأخيار.

وإلى أخوتي وأخواتي وإلى أسرتي الصغيرة .. إلى زوجتي "مها العنزي" والتي كان لها الدور في مساعدتي، فجزاها الله كل خير، وإلى أبنائي الأحباء " علي ، علياء ، حوراء ، مريم ، أبيار" أسأل الله العلي القدير أن يجعلهم من أهل العلم وينفع بهم الإسلام والبلاد والعباد.

وإلى أصدقائي وأقربائي، وأساتذتي العلماء الكرام من المشرفين والمحكمين والعاملين بجامعة نوتنجهام ترنت في المملكة المتحدة، ولكل من ساهم في تقديم النصح والإرشاد لإتمام نجاح هذا العمل.

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List of Publications

- **Journal Articles**

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- **Conference Papers**

  Al-Fadhli, H, Al-Habaibeh, A (2020). SWOT Analysis of Solar Energy Source in Kuwait. International Conference on Applied Energy 2020. (Accepted)

- **Poster Presentations**

  Al-Fadhli, H. (2016). Strategy of Renewable Energy Utilization in Kuwait. The Low Carbon Future Cities Symposium. CADBE PhD Conference 14 June 2016. Nottingham, UK.

Abstract

In past decades, few oil-producing countries have paid significant attention to renewable energy utilization due to the widespread availability of fossil fuels with well-established production technologies. However, in recent years, it has become clear that this has adverse environmental, economic, and social effects, and may also threaten these nations' energy security. As a result, the State of Kuwait has declared its intention to meet 15% of its energy needs from renewable sources by 2030. This study explores the drivers of current and future energy demand in Kuwait, assesses the nation's progress towards its 15% target, and suggests a policy framework and medium and long-term strategies to enhance renewable energy utilisation within the oil-rich state.

Energy consumption and renewable energy utilisation data were obtained from the general public, government organisations, and private sector stakeholders in the country using a mixed-methods approach. Qualitative data was collected through semi-structured interviews with experts, legislators, and policymakers in governmental and non-governmental organisations with links to Kuwait's energy and renewable energy sector. Quantitative data was gathered using structured questionnaires targeting three groups of participants: members of the general public, official organisations, and academic organisations; these questionnaires sought to ascertain respondents' attitudes towards environmental issues, especially the positive effects of utilising renewable energy instead of fossil fuels. The collected data were coded and analysed, with a SWOT analysis used to examine the viability of solar energy as an alternative to conventional fossil-based fuels in Kuwait.

The results provided positive indications of belief in sustainability, the need to protect the environment, and the desire to achieve energy security in the long term for future generations. 75.7% of respondents were characterised as showing high to moderate levels of energy

conservation; however, the findings suggest that greater efforts must be made to encourage the rest of the population to become more energy aware and improve their consumption behaviour, ideally via more public-awareness campaigns and other initiatives by the Kuwaiti government. 91% of respondents believe that official (or government) organisations should support citizens who use renewable energy in their homes by, for example, providing financial benefits, including lower electricity bills or feed-in-tariffs.

87.5% of participants chose solar energy as the most suitable renewable energy source to invest in due to its widespread availability in Kuwait. However, most interviewees considered that the Kuwaiti government is in a precarious position in respect of its 15% goal. The research findings indicate that the economic viability of renewable energy is still a significant challenge, due in part to the ongoing subsidisation of fossil fuels, and this is exacerbated by over-consumption. In terms of energy supply and demand, findings from the questionnaires and interviews indicate that the State of Kuwait is currently struggling to meet rapidly rising demand. In order to achieve its 2030 target, the country needs to invest in several types of renewable energy generation, notably at the Al-Shagaya project, to overcome the barriers to private sector investment in the production of renewable energy technologies, and to develop coherent strategies to expand renewable energy utilisation.

This study proposes a National Policy Framework for Renewable Energy for Kuwaiti policymakers, focussing on energy demand, consumer efficiency, and renewable energy utilisation, and aiming to increase knowledge and awareness about renewable energy utilisation at the individual and governmental levels. The four areas targeted for policy and legislation are a) increasing awareness about energy consumption and renewable energy utilisation; b) monitoring and evaluating systems to improve user efficiency and encourage renewable energy use; c) introducing rewards and subsidies to promote energy efficiency and renewable energy utilisation; and d) boosting the portfolio of renewable energy projects. It also proposes a medium term (2030) and a longer term (2050) strategy for renewable energy utilisation. The Renewable Energy Strategy for 2030 involves developing the necessary policies and legal frameworks, creating the infrastructure for renewable energy sites and farms, and setting aside capital to acquire the necessary resources. The recommend strategies for 2050 are to invest in the production of renewable energy components, notably solar panels and storage mechanisms, and to diversify renewable energy sources to include wave and wind energy.

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List of Abbreviations

ANOVA	Analysis of Variance
BITs	Bilateral Investment Treaties
Btu	British Thermal Units
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Sequestration
CF	Capacity Factor
CSB	Central Statistical Bureau of Kuwait
CSP	Concentrated Solar Power
DNR	Direct Normal Radiation
EEA	European Environmental Agency
EIA	U.S. Energy Information Administration
EOR	Enhanced Oil Recovery
EPC	Engineering, Procurement and Construction
EU	European Union
EV	Electric Vehicle
FiT	Feed-in-Tariffs
GCC	Gulf Cooperation Council
GCCIA	Gulf Cooperation Council Interconnection Authority
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GW	Gigawatts
IEA	International Energy Agency
IRINA	International Renewable Energy Agency
ISCC	Integrated Solar Combined Cycle
KAPSARC	King Abdullah Petroleum Studies and Research Center
KFAS	Kuwait Foundation for the Advancement of Sciences
KISR	Kuwait Institute for Scientific Research
KNPC	Kuwait National Petroleum Company
KPC	Kuwait Petroleum Corporation

kV	KiloVolts
kW	Kilowatt
kWh	Kilowatts per Hour
kWh/m2	Kilowatt-hours per Square Meter
LCOE	Levelised Cost of Energy
MENA	Middle East and North Africa
MEW	Ministry of Electricity and Water
MOE	Ministry of Education
MW	Megawatts
MWh	Megawatt Hour
NDCs	Nationally Determined Contributions
NGOs	Non-Governmental Organisations
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
PAAET	Public Authority for Applied Education and Training
PACI	The Public Authority for Civil Information of Kuwait
PEF	Primary Energy Factor
PPPs	Public-private Partnerships
PV	Photovoltaic
RE	Renewable Energy
RETs	Renewable Energy Technologies
RES	Renewable Energy Sources
RPSs	Renewable Portfolio Standards
RR	Renewable Resources
R&D	Research and Development.
SCPD	General Secretariat of the Supreme Council for Planning and Development
SEOR	Solar Enhanced Oil Recovery
SMEs	Small and Medium-sized Enterprises
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering and Mathematics
SWOT	Strengths, Weaknesses, Opportunities and Threats (Analysis)

TEOR	Thermal Enhanced Oil Recovery
TOWS	Threats, Opportunities, Weaknesses, Strengths (Matrix)
TPED	Total Primary Energy Demand
TPES	Total Primary Energy Supply
TWh	Tera Watt Hour
UAE	United Arab Emirates
UN	United Nations
WDI	World Development Indicators
WMO	World Meteorological Organization

Chapter 1

Introduction

An effective energy sector is considered to be one of the essentials of life in modern day societies. It contributes to both social development and economic prosperity and, in many countries, it provides the cooling and heating necessary to sustain daily life. Without electrical energy to power air-conditioning and desalinate water, much of the Gulf region, for example, would be largely uninhabitable. However, as populations grow and standards of living rise, the enormous increase in demand for energy generated by burning fossil fuels is having negative effects on human health and damaging the natural ecosystems upon which we depend. As countries become more aware of the harmful effects of carbon dioxide (CO_2) emissions, resulting from fossil fuel consumption, many are turning towards renewable energy production as an alternative, utilising energy derived from inexhaustible natural resources that do not produce harmful gases. In Gulf states such as Kuwait, harnessing solar energy alongside other renewables, could provide a way to meet rising demand without damaging the environment or contributing to climate change.

1.1 Background

The amount of solar energy flowing to the Earth's surface could satisfy human demand for primary energy more than a thousandfold. The potential of this resource is massive and makes solar energy a vital component of any renewable energy portfolio aimed at reducing global emissions of greenhouse gases (GHGs). However, in 2018, the global electricity generation from renewable resources made up 26.2%, with expected to achieve up to 45 % by 2040 (C2ES, 2020). The world's dependence on fossil fuels began almost 200 years ago, but contemporary society is now confronting a "Perfect Energy Storm" due to unstable energy prices, increasing environmental problems, and rising energy insecurity. Kuwait is no exception: the country is largely dependent on fossil fuels for electricity generation, indeed, its energy-consumption from coal, oil, petroleum, and natural gas products was recorded at 100% in 2014, based on the World Bank Development Indicators (WDI) (Economics, 2019), but it faces environmental challenges as a result of climate change, including rising sea levels and rapid desertification (Al-Mutairi *et al.*, 2017). Domestic demand for energy is also increasing, threatening the nation's ability to meet its future energy needs (KISR, 2019). Although renewable energy could play an active role in supporting energy security (Foster *et al.*, 2010) and reducing environmental damage, the strategy for renewable energy utilisation in Kuwait is not clearly articulated in the open literature (IRENA, 2014a).

The potential for renewable energy in Kuwait is clear. The country's geographic location provides one of the highest solar irradiation levels in the world, with high value incidences of solar energy per square meter (MEED, 2014), and wind, geothermal, hydropower, and biofuels are also viable options. These resources have begun to be exploited commercially, with solar and wind the preferred options, and the nation already has higher rates of Concentrated Solar Power (CSP), Photovoltaic (PV), and wind energy technologies utilisation than other renewables (Jerath *et al.*, 2015). However, effective renewable energy use requires the development of sustainability strategies which involve energy savings to limit demand, increasing the efficiency of energy production, and replacing fossil fuels with renewable resources (Lund, 2007a). If Kuwait is to realise the full potential of renewable sources such as solar and wind in the coming years, effective strategies need to be put in place now to safeguard future generations.

1.2 Research Motivation

This research has been motivated by the need to address three primary concerns:

1- Energy security: Continuous increases in demand for electrical energy threaten Kuwait's energy security. Although the country aims to increase renewable energy utilisation, the sector is still weak, and renewables form only a small part of the energy portfolio.

2- Environmental concerns: High pollution rates due to emissions from fossil fuels are causing a deterioration in the environmental situation in Kuwait and this has a negative impact on the Kuwaiti community.

3- Economic concerns: Oil is the pillar of the economy of Kuwait, but its reserves are not infinite. As more of the nation's oil is used to generate electricity internally, less is available for export. Thus increasing domestic demand for energy has a negative effect on essential export revenues.

1.3 The Geography and Demographics of Kuwait

Before going on to define the research problem, it is important to provide a brief introduction to Kuwait's geography and demography, as these affect the country's ability to exploit renewable resources to meet rising domestic demand. Further geographic and demographic data is provided in Chapter 5, which explores energy demand and renewable energy developments in Kuwait.

1.3.1 The Geography of Kuwait

Kuwait is located in the Gulf region at the north-eastern end of the Arabian Peninsula and includes nine islands. It shares borders with the Kingdom of Saudi Arabia (to the south and south-west) and the Republic of Iraq (to the north and north-west) and covers an area of approximately 17,818 square kilometres (7000 square miles). The furthest distance between the northern and southern borders is about 200 kilometres (124 miles) and from east to west is about 170 kilometres (160 miles). Kuwait is located at latitude 28°.30' – 30°.06' to the north of the Equator and between longitudes 46°.30' – 48°.30' to the east of Greenwich. The western borderland is 270 meters above sea level. Much of the country consists of arid desert areas, and less than 6% of the total land area is inhabited (PACI, 2010). These vast tracts of uninhabited land suggest the country has the potential to benefit from the development of large scale solar and wind energy projects without disturbing local populations. In addition, the long coastline offers the option of utilising wave energy as an additional renewable resource (see Figure 1-1).

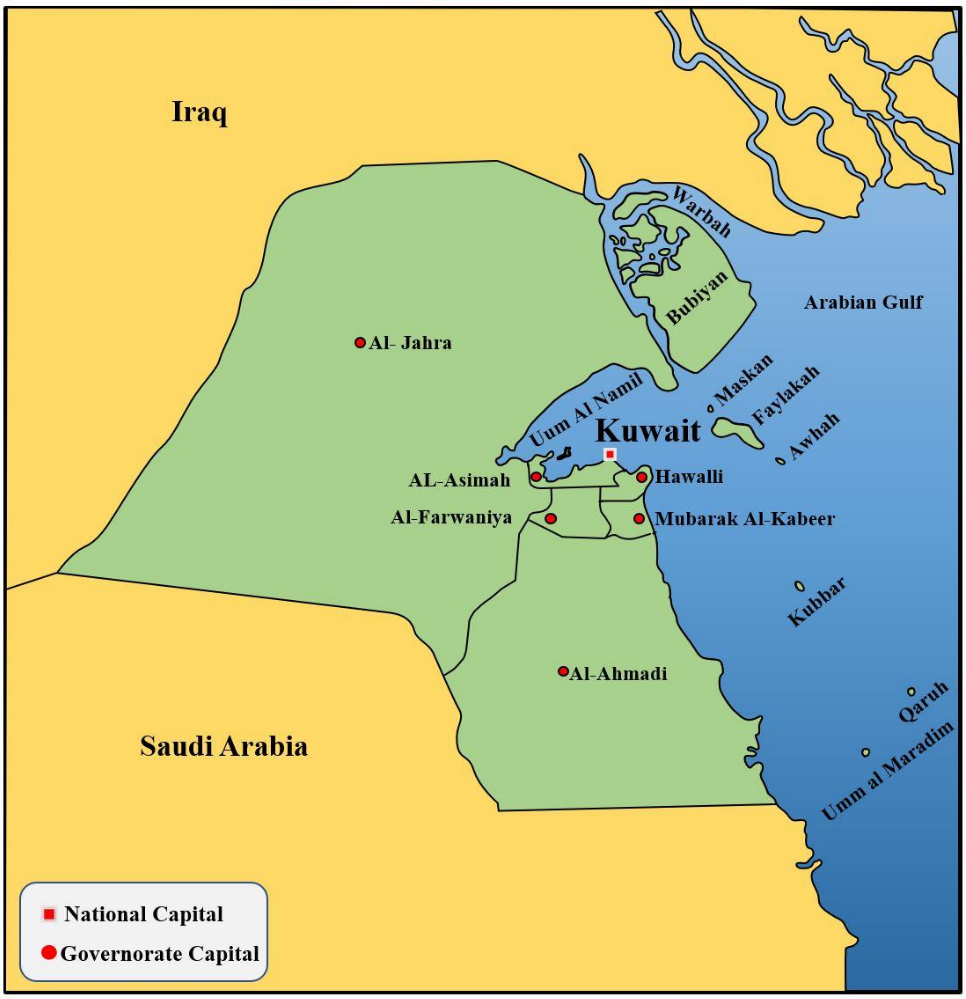


Figure 1-1: Map of the State of Kuwait

Source: Created by the Author

Kuwait's location means it frequently experiences extreme temperatures. The World Meteorological Organization (WMO) committee formally estimated the temperature in Mitribah in Kuwait at 54.0°C (129.2°F) on 21 July 2016, the highest temperature ever recorded for Asia, and the fourth highest temperature to have been recorded worldwide within the last 76 years (Merlone *et al.*, 2019). This indicates that Kuwait is rich in solar energy resources.

1.3.2 The Demography of Kuwait

According to demographic data issued by The Public Authority For Civil Information of Kuwait (PACI), Kuwait's population was estimated to be 2.26 million in 1998 and had almost doubled to reach 4.24 million by 2015, with an annual growth ratio of about 3.7% (Gulseven, 2016a). Kuwaiti citizens make up just over a third of the population, with the rest comprising expatriate and migrant workers. In 2019, the total population was 4,420,110, of which 1,335,712 were Kuwaitis and 3,084,398 non-Kuwaitis (C.S.B, 2019). Kuwait is divided into six Governorates, Al-Asimah (Capital), Al-Jahra, Hawalli, Al-Farwaniya, Mubarak Al-Kabeer and Al-Ahmadi.

1.4 Research Problem Definition

The countries of the Gulf Cooperation Council (GCC) are considered to have one of the highest rates of energy use in the world, and the Kuwaiti per capita average is ranked 3rd out of 140 countries (Baumert *et al.*, 2005). Moreover, demand for electricity in the country is rising, especially in the summer season when high temperatures make air conditioning and cooling systems essential. Although, the conventional power supply sector is considered a vital and developed national asset, when demand reaches the highest levels, it can be necessary to programme cuts in the electricity supply. Given that demand is forecast to double or triple by the year 2050, as the international population grows and the country's economy develops, this poses an increasingly significant threat to the nation's energy security (MEW, 2018a). Furthermore, there are international concerns that the increase in emissions from fossil fuels will exacerbate climate change (Foster *et al.*, 2010), and this poses a threat to Kuwait's environmental security.

Renewable energy is beginning to play a significant role in the energy policies of governments as enhancing utilisation supports national development plans and energy security. Kuwait has begun to develop its renewable energy sector, notably solar and wind energy, and aims to increase the percentage of renewable energy to 5% by 2020 and 15% by 2030 (IRENA, 2016a); however, the literature indicates that the country does not have an evidently articulated strategy for renewable energy resources utilisation (IRENA, 2014a). Without a clear strategy for implementing renewable energy projects, Kuwait is unlikely to meet its energy goals or keep up with the global energy market.

1.5 Research Questions

In light of the problem set out above, this study aims to answer the following questions:

1. What is the Importance of the RE, and What are the most effective strategies adopted by leading developed countries and by other Gulf states in relation to renewable energy utilisation?
2. What role could renewable energy play in meeting current and future energy demand in Kuwait?
3. Do the strengths, weaknesses, opportunities, and threats relating to solar energy in Kuwait make it a viable alternative to energy derived from fossil fuels?
4. What are the key ingredients required to implement an effective strategy for renewable energy utilisation in Kuwait?

1.6 Research Aim and Objectives

1.6.1 Research Aim

This study aims to examine current and future energy demand in Kuwait and suggest strategies to enhance renewable energy utilisation in the medium and long-term. By critically reviewing and investigating renewable energy strategies in leading developed countries and in the Middle East and North Africa (MENA) region, it will identify examples of best practice, and consider how these might be applied within a Kuwaiti context. It will also explore attitudes towards energy consumption, consumer efficiency, and renewable energy utilisation among the general public, energy experts, and public officials in Kuwait. As solar is the preferred renewable energy source in the country, it will examine the sector in detail to identify key issues and suggest possible solutions. These findings will be used to outline a medium-term strategy (to 2030) and a long-term strategy (to 2050), to develop a national policy framework of renewable energy for Kuwait, and to provide actionable recommendations for policymakers and legislators in Kuwait based on empirical investigation and analysis of best practice.

1.6.2 Research Objectives

To achieve the above aims, the research will perform the following objectives:

1. Critical understanding of RE technologies and strategies globally and in the MENA region, including Kuwait via literature review.
2. Assess the current and future situation relating to energy supply, demand, consumption and consumer efficiency of electricity consumption in Kuwait.
3. Investigate the viability of renewable energy utilisation in Kuwait and evaluate the effectiveness of current and future renewable energy projects.

4. Evaluate the levels of awareness, orientation and attitudes towards renewable energy utilisation and environmental issues among the general public, public officials, and key players in the renewable energy sector in Kuwait.
5. Identify barriers and obstacles facing the renewable energy sector in Kuwait and formulate a set of actionable solutions based on best practice for use by Kuwait legislators.
6. Propose a medium- and long-term strategy (for 2030 and 2050) for renewable energy utilisation in Kuwait.
7. Develop a national policy framework of renewable energy to support renewable energy investment and a set of recommendations to help policymakers in Kuwait develop efficient renewable energy strategies and programmes.

1.7 The Significance of the Study

This study focuses on the issue of energy security in the State of Kuwait and the need to generate energy from renewable sources instead of relying entirely on fossil fuels, a move which would create positive returns for Kuwait's society, its economy and its environment. Despite the need to find new ways to address rising energy demand while reducing harmful emissions, the country has yet to establish a clear strategy for renewable energy utilisation. Therefore, by identifying the key ingredients required for an effective strategy and suggesting how it could be implemented, this study makes a contribution to both knowledge and society as follows:

1.7.1 The Contribution to Knowledge

The research contributes to knowledge by investigating and proposing a renewable energy strategy for the State of Kuwait, a national policy framework of renewable energy, and a set of recommendations to support the future development of the renewable energy sector in the country. It does this through scientific methods of analysis and measurement, and findings will be shared with researchers and policy makers in order to contribute to current understanding of renewable energy policy and inform future research. In addition, this study can be considered as one of the first to identify and assess the strengths, weaknesses, opportunities and threats associated with the solar energy sector in Kuwait by means of a SWOT Analysis Tool in order to evaluate its viability as an alternative form of energy generation in the state.

1.7.2 The Contribution to Community

The study makes a community contribution by increasing awareness in society of the need to rationalise electricity consumption to reduce excessive demand and adopt renewable forms of energy generation. In economies driven by fossil fuel production, this will require significant changes at both the individual and government levels, so this study highlights the key advantages and benefits of renewable energy utilisation. Although this research is framed within a Kuwaiti context, its contribution is not limited to the State of Kuwait and it may benefit countries with similar cultural, environmental, climatic, geographic and demographic situations, notably fellow GCC members, Saudi Arabia, Oman, the United Arab Emirates, Qatar and Bahrain. At a broader level, communities across the world who aim to expand their energy portfolios through the development of renewable energy strategies may also benefit from this study.

1.8 The Thesis Structure

This thesis is structured into 12 chapters. In the introduction (Chapter 1), the author provides an overview of the study and sets out the research problem, the aim, the objectives and the research questions. The next four chapters provide an in-depth review of the literature relating to the study, namely the different types of renewable energy resources and technologies available (Chapter 2), global cases of energy demand and renewable energy leading strategies (Chapter 3), in the MENA region (Chapter 4), and in Kuwait (Chapter 5). Chapter 6 describes the methodology of the study, and an explanation of the content of this chapter is given below. The data analysis is divided into four chapters: Chapter 7 provides statistical analysis of the public questionnaire undertaken for this study, Chapter 8 examines the questionnaires directed at academics and official organisations, and Chapter 9 analyses the results of the interviews with renewable energy experts and policy-makers in Kuwait. As solar energy is the preferred form of renewable energy in Kuwait, Chapter 10 is devoted to a SWOT Analysis of the solar energy sector in the country. Chapter 11 discusses the findings in relation to the research questions and outlines a medium and long-term strategy (2030-2050) for renewable energy utilisation in Kuwait, supported by a national policy framework. Chapter 12 concludes the thesis and includes a set of recommendations for Kuwaiti legislators and policymakers along with suggested avenues for future work. A diagram showing the thesis structure is provided in Figure 1-2.

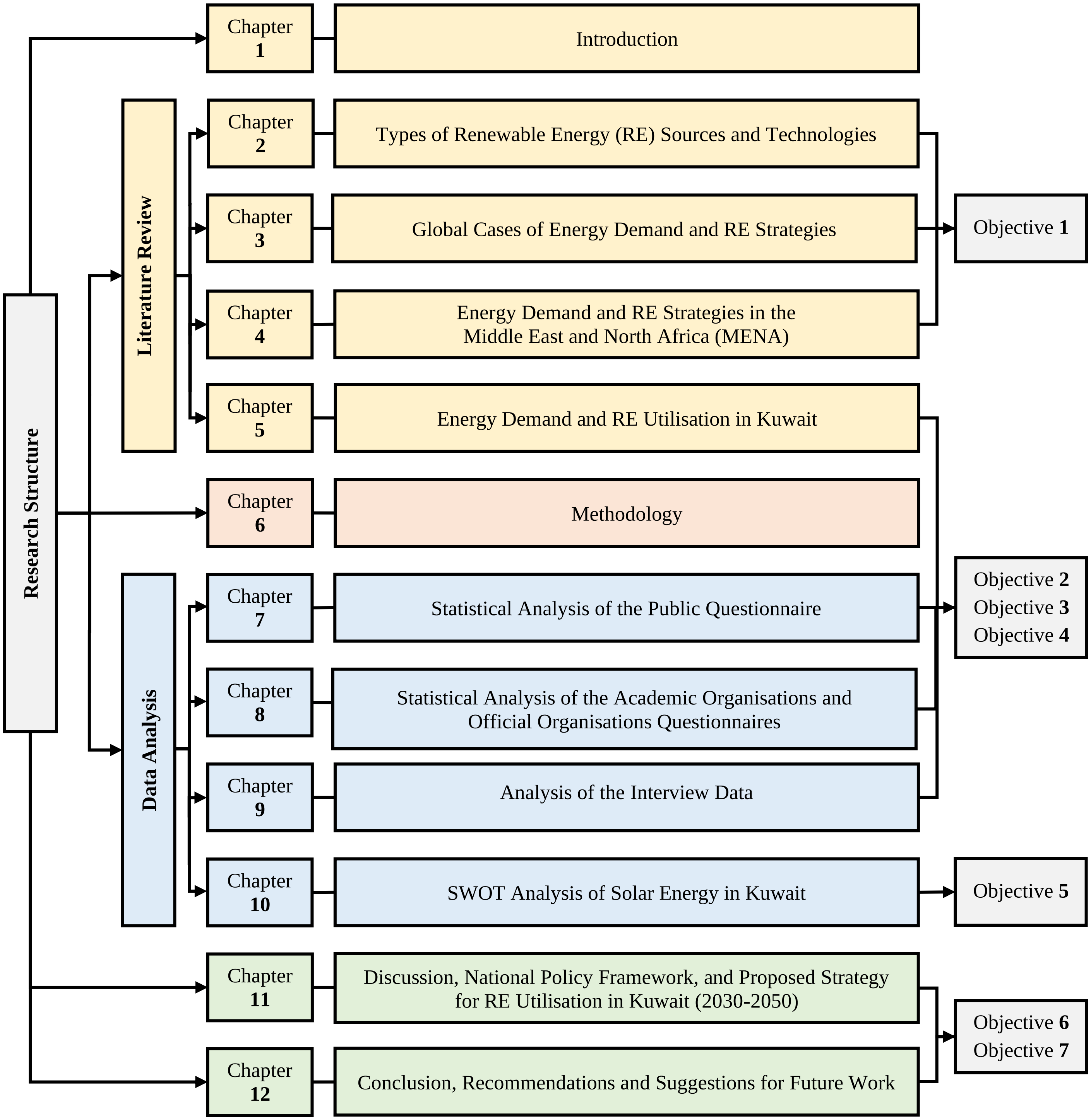


Figure 1-2: Thesis Structure
Source: Author's Own

1.9 Research Methodology Design

This research adopts an exploratory descriptive approach. The central pillars on which its methodology is based are a review of the literature regarding the subject of the research and the collection of data from three target groups in Kuwait: members of the public, experts in the energy sector, and policymakers. Quantitative data was gathered by means of two random surveys of members of the public, educators and officials, while quantitative data was collected through semi-structured interviews with experts and policy makers. The data collection phase also included a field visit to explore the general energy sector in Kuwait.

The analysis used for the questionnaires was statistical analysis using SPSS software while the interview data was analysed by coding analysis. It is significant to note that the total number of questionnaires collected from each group exceeded the required number for the research sample size, which led to more reliable results for the study. For example, the calculated research sample size was 385 questionnaires for the public group, but 1383 questionnaires were collected; the sample size for educational and official organisations was 100 questionnaires for each, but 232 and 102 questionnaires were collected respectively. The reliability of the questionnaires was tested through experimental samples (as shown in the data analysis chapters). In addition, data was collected from 20 interviewees, with results that supported the initiation of data collection.

As the study is both descriptive and exploratory, the methodology included a SWOT analysis of solar energy production within Kuwait in order to devise scenarios for the strategic development of renewable energy utilisation based on the findings of the research. The research process and methodology design of the study are summarised in Figure 1-3.

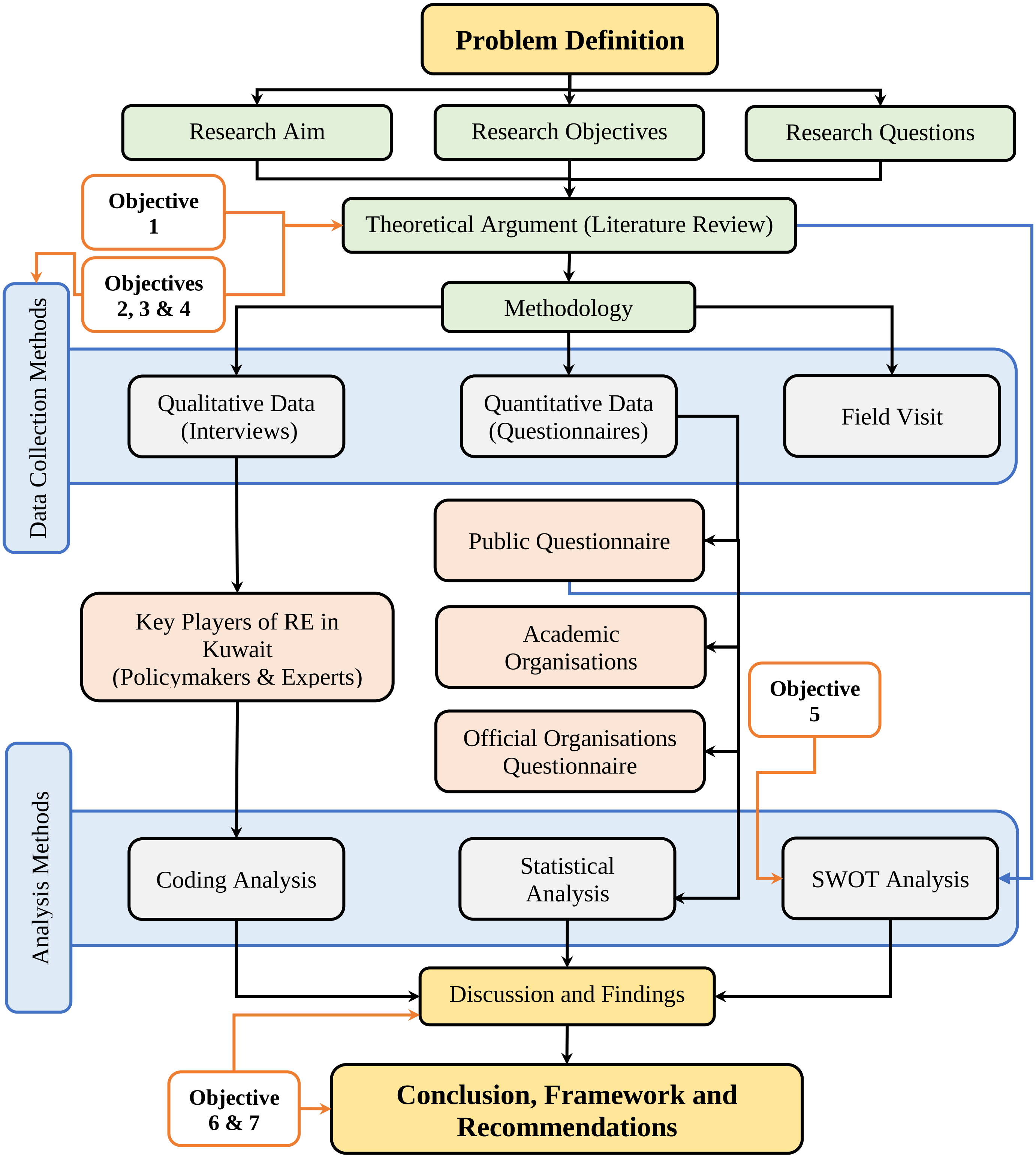


Figure 1-3: The Research Process and Methodology Design of the Thesis
Source: Author's Own

1.10 Recent Changes in Renewable Energy Projects in Kuwait due to COVID-19

The Coronavirus pandemic (COVID-19) is having a profound impact on the global financial and oil markets, and renewable energy projects in Kuwait have also been affected. In July 2020, the Kuwaiti Cabinet decided to cancel the proposed Al-Dabdaba solar energy plant project, which was intended to have a production capacity of 1500 MW. The project, located 100 km (62 miles) west of Kuwait City, with a total area of about 32 square kilometres (12.4 square miles), was considered the second and most crucial phase of the Al-Shagaya Renewable Energy Center project and was central to the country's aim of achieving 15% of electricity demand from renewables by 2030 (Reuters, 2020).

The Al-Dabdaba solar plant, which was to be developed by Kuwait National Petroleum Company (KNPC), was originally intended to start operating in February 2021, but the project was delayed due to bureaucratic procedures. While it has not been possible to consider the impact of this cancellation within this thesis, it is clear that it will weaken the renewable energy portfolio in Kuwait. This, along with the weaknesses identified in this research, indicate an increasingly urgent need to develop clear practical strategies to promote the renewable energy sector in Kuwait.

1.11 Summary

This chapter has given an overview of the contents of this thesis and provided geographic and demographic information about Kuwait, the site of the study. It has explained the motivation for the research, defined the research problem, set out the research aim and objectives, and introduced the research questions. It has also explained the significance of the study in terms of its contribution to knowledge and to the community in Kuwait. In addition to setting out the structure of the thesis and outlining the content of each chapter, it has also introduced the methodology of the study and described the key elements of the research process. The next chapter forms the first part of the literature review and examines renewable energy sources and their associated technologies.

Chapter 2

Literature Review

Types of Renewable Energy Sources and Technologies

2.1 Introduction

This chapter provides an overview of the types of renewable energy sources (REs) currently available and their associated technologies (RETs). It gives a brief historical profile of renewable energy and then focuses in particular on the renewable sources most relevant to this study. In addition, it defines the technologies related to each energy source, describing their characteristics and the advantages and disadvantages associated with them. It is important to consider these factors as RETs vary in terms of cost and lifecycle characteristics, and this influences the capital and revenue costs associated with investment in renewable energies.

2.2 A Historical Definition of Renewable Energy Sources (REs)

Renewable energy (RE) is defined as energy generated from sources that do not deplete, or which can be replenished within a human's lifetime. The term "Renewable Energy Sources" (REs) is now commonly used in place of the older name "Renewable Resources" (RR) to describe these energy sources. The latter term first came to prominence during the oil crisis in the mid-1970s when the Organization of Petroleum Exporting Countries (OPEC) increased the price of crude oil from approximately 2 US$/barrel to 30 US$/barrel or more. This prompted politicians, economists and industry leaders to begin to consider the potential benefits of renewable resource utilisation to supplement conventional energy sources. These benefits include unlimited regenerative availability, reduced CO_2 outputs, and positive economic impacts, including enhanced employment opportunities, especially in developing countries (Bollert *et al.*, 2001).

The energy we consume can be classified into two types:

1- **Renewable Energy:** The energy which is produced out of natural and consistent flows of energy in the instantaneous environment is referred to as 'renewable energy'; these include wind, solar, geothermal, biomass, and hydropower. "Green Energy", "Sustainable Energy" and "Alternative Energy" are terms commonly used to describe this type of energy.

2- **Non-Renewable Energy:** This can be defined as the energy which is acquired from static stores of energy which stay underground except when released by the involvement of humans, for instance, nuclear fuels and fossil fuels of oil, natural gas and coal.

Given the significance of solar resources in Kuwait, it is worth noting that some forms of stored solar energy, notably petroleum, natural gas, coal and shale, are classed as non-renewable (Sopian *et al.*, 2011) (See Figure 2-1).

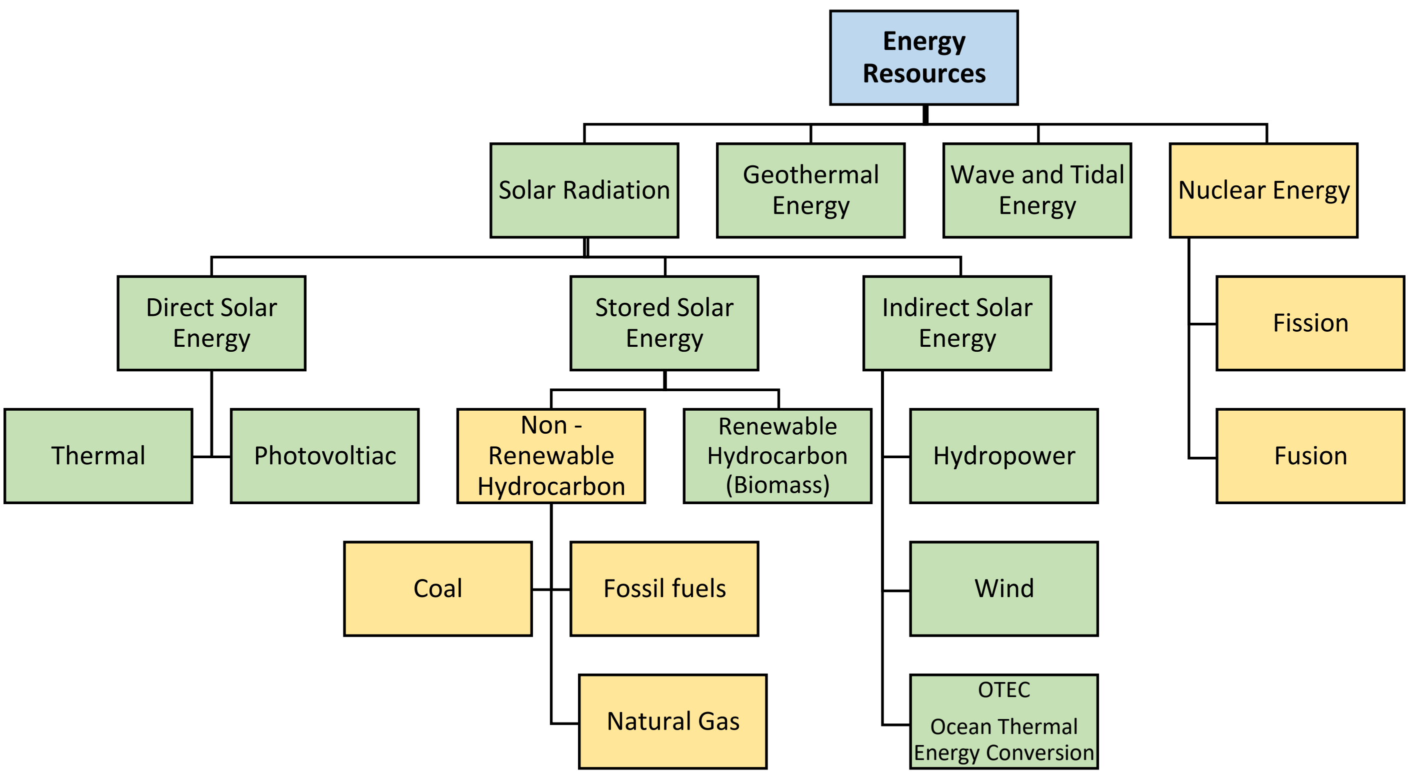


Figure 2-1: Categories of Solar Energy and Other Energy Sources
Source: Reproduced from (Sopian *et al.*, 2011)

2.3 Types of Renewable Energy Sources

2.3.1 Solar Energy

Solar energy sources include the mechanisms through which sunlight is harnessed into various energy sources. According to Bicen, Szczutkowski and Vardar, 2018, solar energy can be harnessed into thermal systems or solar electric/ photovoltaic (PV) systems which are designed to convert the solar rays directly into electrical energy. Solar energy is increasingly utilised in countries across the world, via both PV and thermal systems, and its most common uses are summarised below (See Table 2-1).

Table 2-1: Solar Energy Systems Categories

Category	System	Use
PV	**Stand-alone**	• Small household systems • Small community/ commercial systems • Telecommunications use, such as base stations • Navigation installations, such as radar systems • Water pumping and distribution systems • Commercial systems in remote locations • Micro- and mini-grids systems, such as fuel pumping for fuel stations.
	Grid-connected	Supplementing the mains supply for a commercial enterprise or residential area
Solar-Thermal	**Stand-alone**	• Water heaters for commercial establishments • Drying and desiccation purposes, such as grain storage facilities • Cooking and other household activities • Distillation and desalination of water • Cooling, especially in desert locations

	Connected to an existing space or water heating system	Supplementing water or space heating systems connecting to grids. Mostly used during the day, after which the system resets to grid-based energy

Source: Compiled from different sources

The advantages and disadvantage of solar energy sources are summarised in Table 2-2. These relate to both PV and thermal solar energy systems.

Table 2-2: Advantages and Disadvantages of Solar Energy

Advantages	**Disadvantages**
• The technology has matured to achieve long-term reliability, with energy output assurances for up to 25 years • Involves automatic operating systems that require low maintenance and interventions • Limited operating expenses due to no fuel costs • Sources are modular, thus allowing for phased improvement and expansion • Low environmental impact as compared to conventional energy systems • Reputable systems which are often associated with environmental awareness • Limited impact on the variations in the costs and prices of other energy sources due to the uniqueness of other energy systems	• Use of toxic substances in the solar energy systems, such as energy storage or solar panels • Installation and maintenance requires technical knowledge and training • High terminal costs, especially in the disposal of batteries and old solar panels • Huge capital requirements for the initial investments • Limited capacity for storage, hence most of the energy that is generated is lost through latent means • Performance is influenced by unpredictable sunlight patterns which vary daily, monthly and yearly

Source: Compiled by Author from different sources

2.3.2 Wind Energy

Wind energy, which can either be in the form of generated electricity or mechanical energy, is generated from wind. Kinetic energy from the force of air in motion (wind) is transformed into mechanical energy through the installation of rotating blades. This can either be channelled to a motor for the generation of electricity or used purely as mechanical energy to move machines. Electricity generated from wind energy can be used in many ways; however, the simplicity of the processes through which wind energy is transformed into mechanical energy for use in driving pistons and other installations, is preferred due to the cost-efficiency, particularly in terms of the capital and revenue costs and expenses. For instance, windmills and water pumping installations, which are widely utilized in developing countries, rely on mechanical energy from wind.

The advantages and disadvantage associated with wind energy are shown in Table 2-3.

Table 2-3: Advantages and Disadvantages of Wind Energy

Advantages	Disadvantages
• Systems rely on technologies that are robust yet simple, with lifetimes of over 15 years • Generation involves automated operations that require limited human intervention once installed • Ease of adaptability of the technologies for the various topologies, including onshore and offshore wind energy generation • Requires no fuel for operations, hence limited logistical expenses • Limited ecological impact as compared to conventional energy sources	• Technologies are site-specific and have certain requirements that cannot be substituted • Huge initial capital requirements which are a challenge for developing countries • Huge costs of transporting technologies, since sites for generation are often remote • Variability in the productivity of energy, with limited predictability of efficiency, hence the need for backups • Limited potential market, hence limited investment in innovation

• Increased maturity of the technologies to achieve higher levels of efficiency	

Source: Compiled by Author from different sources

2.3.3 Hydro-energy

Hydro-power is the energy extracted from water falling from a higher to a lower level through the use of devices which convert the kinetic energy into electricity or mechanical energy (Alrikabi, 2014). Hydropower has long been generated through the use of turbines or wheels; however, advances in technology have led to improvements in hydropower generation, with the installation of dams to enhance the kinetic energy, rather than relying on the natural flow from river currents. This has led to an increased ability to generate megawatts of energy which can be fed into grids. Hydropower has a higher level of reliability than many other renewable sources as it is not intermittent; it can generate energy at all times, except when water availability is limited due to depletion of resources upstream.

The advantages and disadvantages of hydropower are shown in Table 2-4.

Table 2-4: Advantages and Disadvantages of Hydropower

Advantages	**Disadvantages**
• The technology is robust and simple, with a lifetime spanning over 30 years • Overall costs of installation are low, especially for small hydropower systems • Automatic operations with limited maintenance costs • No fuel requirements for the generation of electricity and energy • Low environmental impact as compared to conventional energy sources	• The engineering and technical skills for large scale hydropower systems are not widely available • High capital investments required at the start • Technology is site-specific and can only be used in locations with suitable topography. • Variations in the availability of water limit utility, especially for grid-related purposes. • Systems are not modular so cannot easily be expanded as the need arises

• Availability of power is constant throughout the year unless upstream water resources are compromised • Ease of adaptability of the technologies for use in developing countries.	

Source: Compiled by Author from different sources

2.3.4 Nuclear Energy

Nuclear energy is generated by splitting atoms of particular elements (fission). The process produces massive amounts of heat, which is, in turn, channelled to heat water into steam to turn turbines (Kessler *et al.*, 2014). Nuclear power plants have a higher capacity factor (CF) as compared to other forms of energy, including fossil fuels and the renewable energies discussed above. As Boccard (2014) explains, CF is the proportion of time that an energy plant produces usable energy. Since the fissionable materials can be replaced and energy production is continuous, nuclear energy has often been viewed as a reliable source of energy. For instance, according to the United States Energy Information Administration (USEIA), nuclear power plants in the US, which supply around 20% of the energy demand, achieved an average CF of 91.22% between 2010 and 2019. These plants operated for 336 out of 365 days, with the remaining 29 days involving maintenance (USEIA, 2020). In comparison, hydropower systems only achieved their targeted productivity on 138 days during the year (with an average CF of 39.68 over the ten years), wind energy systems for 127 days (an average CF of 33.07%), while solar PV plants only delivered energy on 92 days during the year (an average CF of 23.54%). A comparison of the CFs of a rage of energy sources is provided in Table 2-5.

Table 2-5: Capacity Factor for Different REs

REs	Geothermal	Hydroelectric	Nuclear	Biomass	Gas	Solar PV	Solar Thermal	Wind	Wood
Year/Month	CF	CF	CF	CF	CF	CF	CF	CF	CF
2010	71.60%	37.50%	91.10%	64.20%	50.50%	20.20%	24.50%	29.70%	61.50%
2011	71.50%	45.80%	89.10%	64.20%	54.10%	19.00%	23.90%	32.10%	59.60%
2012	68.30%	39.60%	86.60%	63.30%	59.60%	20.40%	23.60%	31.80%	61.30%
2013	71.80%	38.80%	90.80%	62.30%	55.90%	24.50%	17.40%	32.40%	59.00%
2014	72.00%	37.20%	91.70%	62.70%	54.00%	25.60%	18.30%	34.00%	60.00%
2015	71.90%	35.70%	92.30%	62.60%	60.80%	25.50%	21.70%	32.20%	59.30%
2016	71.60%	38.20%	92.30%	62.70%	64.80%	25.00%	22.10%	34.50%	58.30%
2017	73.20%	43.00%	92.30%	61.80%	62.80%	25.60%	21.80%	34.60%	60.20%
2018	76.00%	41.90%	92.50%	61.80%	65.40%	25.10%	23.60%	34.60%	60.60%
2019	74.40%	39.10%	93.50%	59.20%	67.00%	24.50%	21.20%	34.80%	60.90%
Average	72.23%	39.68%	91.22%	62.48%	59.49%	23.54%	21.81%	33.07%	60.07%

Source: Reproduced from USEIA, 2020

2.4 Renewable Energy Technologies (RETs)

Renewable Energy Technologies (RETs) denote the various mechanisms through which energy is extracted from renewable energy sources and transformed into electricity, fuel, or heat. In some instances, the technologies facilitate the creation of mechanical energy, depending on the preferences of the users. The various RETs available differ in their utility, efficiency, and their effectiveness in the extraction of energy from nature, and these variations influence decisions about the adoption of a particular technology (IRENA, 2018a). With variations occurring across time and space, it is common for most end-users to select the most viable RET for a particular location at the time.

2.4.1 Solar energy technologies

Solar energy technologies include three main categories: Solar photovoltaic technologies (PV), which converge sunlight directly into electricity; concentrating solar power systems (CSP), that convert the sun rays into heat (thermal energy) to drive turbine; and solar heating and cooling systems, whereby sunlight is transformed into thermal energy for heating or other forms of conditioning.

2.4.1.1 PV systems

PV solar technologies rely on a chemical and electrical interaction between the radiation from sun-rays and the semi-conductors on the panels to create DC electricity (Bicen *et al*, 2018). 87% of the solar cells are developed using silicon as the base materials. In addition to its low volume to weight ratio, silicon is preferred due to its durability, robustness and resilience. As an effective semi-conductor, silicon can easily be modified to fit the requirements for converting solar rays into electricity (Anano, 2019).

There are over 28 types of silicon-based technologies in modern PV solar systems, with the primary differentiating characteristic being the conversion efficiency. According to (Nemet, 2019), the highest efficiency is reported from a four-junction multi-junction concentrator cell at 47.1%. However, the primary challenge in the efficiency of solar energy systems, in general, is the storage of the energy generated. A chronologically-detailed display of improvements in the efficiencies of the various PV technologies is provided in Figure 2-2.

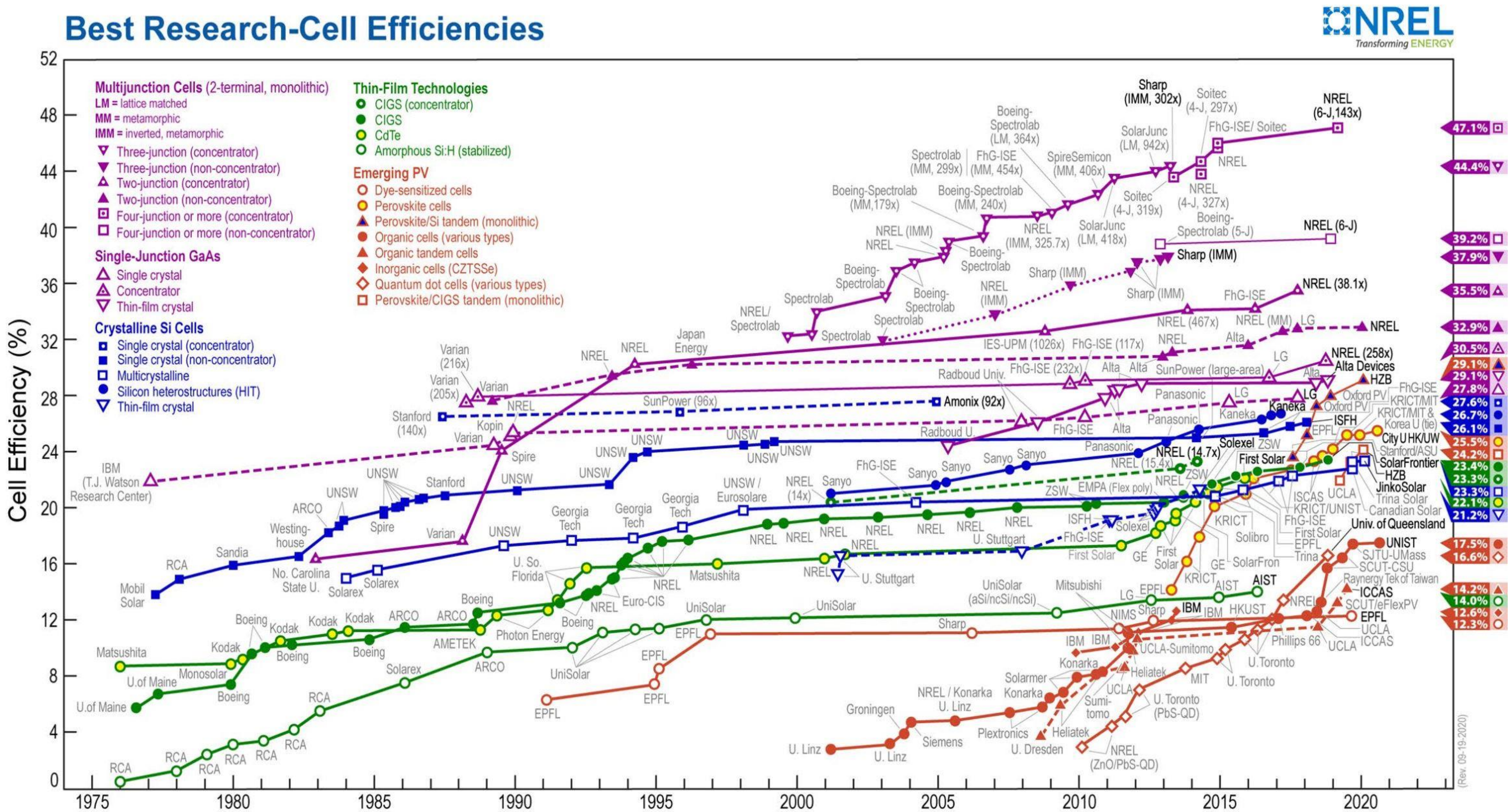


Figure 2-2: Best Research-Cell Technologies for PV Solar Energy

Source: (NREL, 2020)

2.4.1.2 CSP Technologies

CSP technologies use focused sun-rays which are concentrated onto a particular surface from where the energy can be converted into electricity (Chong *et al.*, 2016). By concentrating the sun-rays, CSP systems can generate high temperatures that can be used to generate electricity or other forms of energy. These technologies have been deployed in three main ways. Firstly in solar tower technologies, whereby a central receiver is installed with strategically placed mirrors to reflect the sun-rays to the receiver on the tower. Due to the potentially high temperature achieved at the receiver (over 1000^0 F), solar tower technologies use molten salts as the heat transfer fluid. Secondly, CSPs can be deployed through parabolic trough systems. Here long U-shaped troughs are lined with mirrors which reflect the sun-rays onto a pipe at the focal point at the centre (Xu *et al.*, 2015) (See Figure 2-3 below).

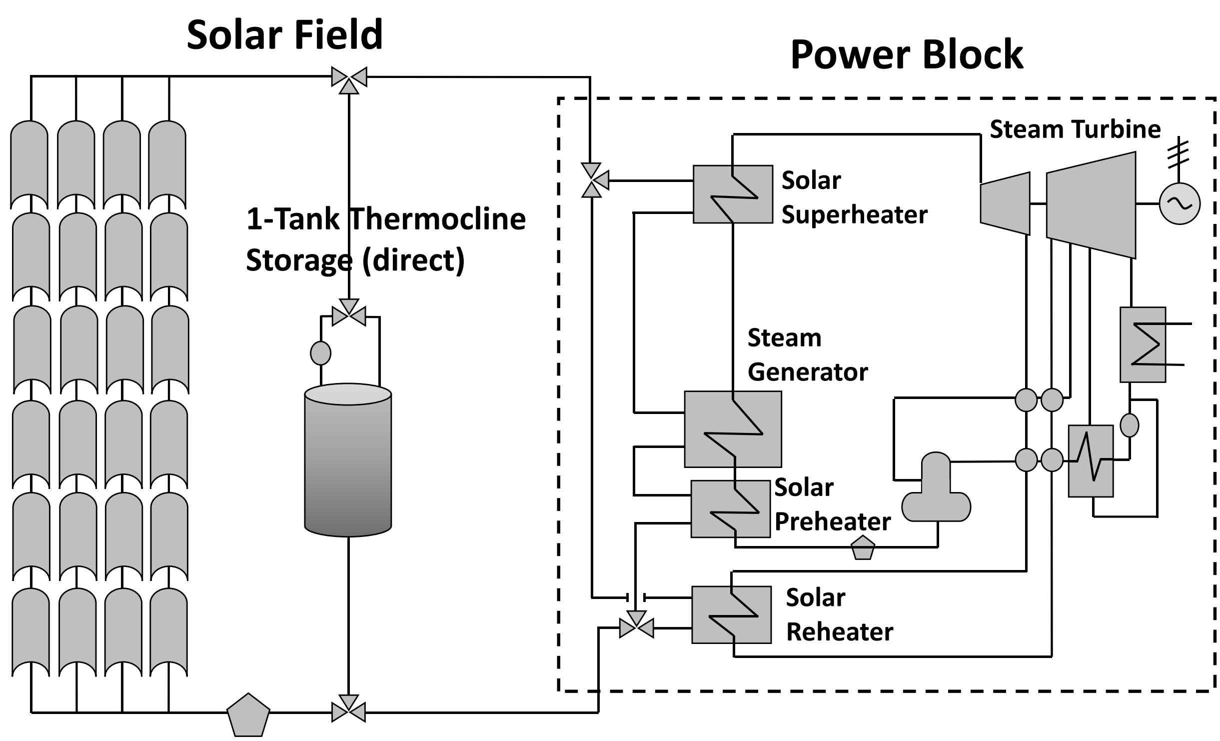


Figure 2-3: CSP Technologies

Source: Reproduced from (Nemet, 2019)

The reflectors in the solar field can be oriented to track the sunlight to ensure that the angle of incidence results in optimal exposure. This enables trough systems to achieve a temperature of 750^0F, which heats the transfer fluid that can then be used to generate electricity. As a result, oil, water, or gas could be used as the heat transfer fluid (Cipollone, Cinocca and Gualtieri, 2013). Finally, CSPs can be deployed through dish engine systems. Although dish systems have similar components to parabolic systems, the dish engines are designed to concentrate the sun-rays onto a central engine that generates electricity (See Figure 2-4).

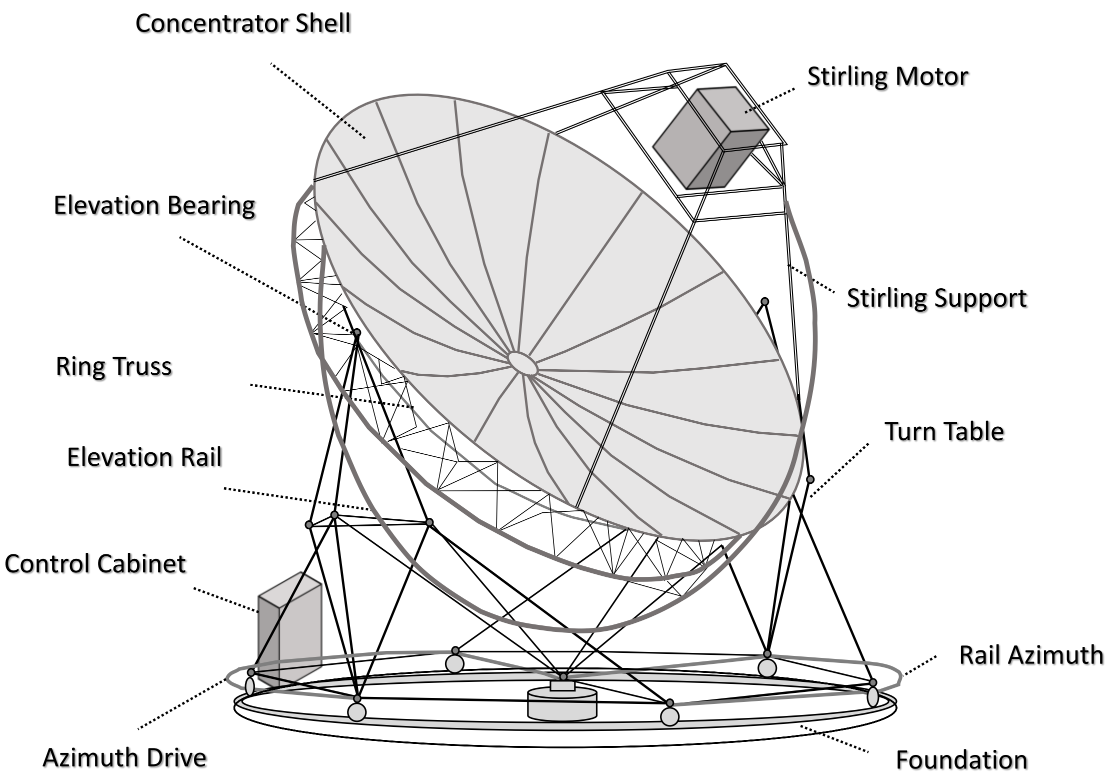


Figure 2-4: Dish Engine Solar Technology

Source: Reproduced from (Nemet, 2019)

The efficiency of a solar dish system is dependent on the “dish design features and factors such as the material of the reflector concentrators, the shape of the reflector concentrators and the receiver, solar radiation at the concentrator, diameter of the parabolic dish concentrator, sizing the aperture area of the concentrator, the focal length of the parabolic dish, the focal point diameter, sizing the aperture area of receiver, geometric concentration ratio, and rim angle." (Hafez *et al.*, 2016).

2.5 Summary

This chapter has provided an overview of the most common sources of renewable energy and the technologies associated with them. In addition, it has summarised their respective advantages and disadvantages, with a focus on the sources and technologies most relevant to this research, namely solar and wind energy. The next chapter will investigate the role renewable energy plays in pioneering countries across the world and review their utilisation strategies and plans in order to identify the requirements for a successful renewable energy strategy and their influencing factors.

Chapter 3

Global Cases of Energy Demand and Renewable Energy Strategies

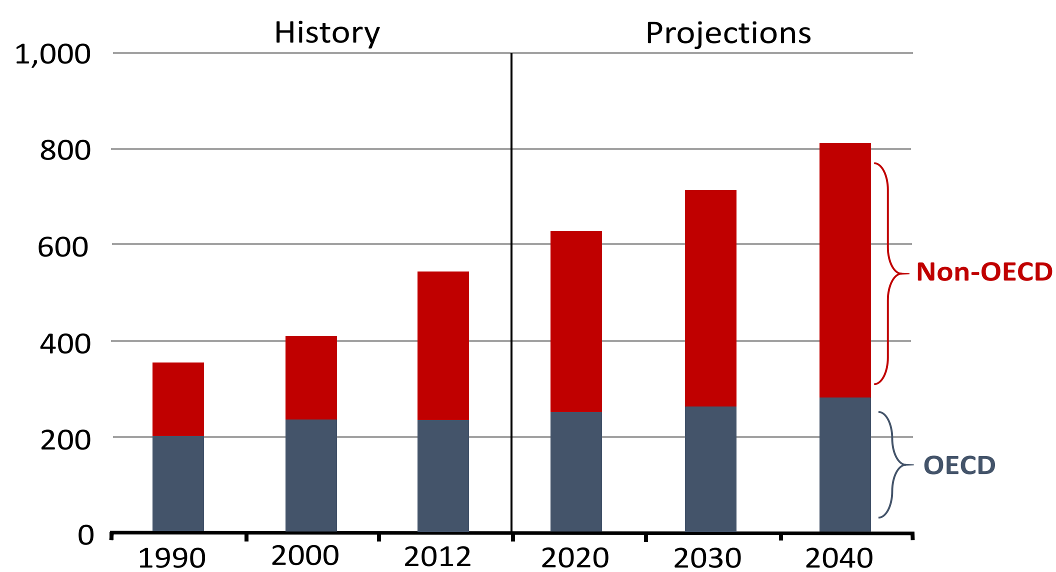
3.1 Introduction

The recent progress in renewable energy utilisation, mainly as distributed forms of energy, has the potential to make a positive difference to the global energy supply. As demand for energy rises, the complete depletion of non-renewable sources has become a major concern, as have the negative environmental and economic consequences of their consumption. As a result, much greater attention is being paid to the energy security implications, cost-effectiveness and the positive environmental impact of renewable energy sources, and many countries are adopting them to address concerns about climate change and the instability of fossil fuel prices. While most countries are motivated to take critical steps to shorten the gap between energy demand and supply, to contribute towards the resolution of environmental issues, and to maintenance resources for generations to come, some have developed clear strategies and roadmaps to enable them to plan and build a renewable energy future.

This chapter reviews energy demand across the world and examines some of the world's leading countries in renewable energy utilisation. It considers their plans and strategies for their renewable energy portfolios in the medium to long term (2030-2050) and identifies the key elements that contribute to promoting and achieving successful RE strategies, including choosing the optimal source of renewable energy, social acceptance, legislation and policies for the use of renewable energy, and the creation of essential infrastructure.

3.2 Energy Demand Across the World

The increase in energy demand in the decade since 2009 has been drastic. Although the European Union (EU) currently has the highest rates of energy consumption and greenhouse gas (GHG) emissions (Liobikien and Butkus, 2017), the primary driver of rising demand is associated with developing countries' growing energy needs. The International Energy Agency (IEA) reports that the growth rate for global energy demand will be approximately 1.5% annually until 2030, with highly populated countries such as China and India responsible for at least half the total increase over this period (World Energy Council, 2010). Substantial growth in global energy demand over a period of 28 years (2012-2040) is also forecast by the U.S. Energy Information Administration (EIA). According to their *International Energy Outlook 2016*, the total marketed energy consumed on a global level in 2012 was calculated to be 549 quadrillion British thermal units (Btu), and is predicted to be 629 quadrillions Btu in 2020 and around 815 quadrillion Btu in 2040, a 48% increase from 2012 (E.I.A., 2016) (See Figure 3-1).



*'OECD' denotes members of the Organisation for Economic Co-operation and Development (OECD)

Figure 3-1: World Energy Consumption Forecast, 1990–2040

Source: Reproduced from (E.I.A., 2016)

3.3 Demand for Renewable Energy Across the World

The systemic risks associated with the supply of fossil fuels, coupled with the realities of climate change and the fallout from the financial crisis of 2007–2008, has driven demand for renewables, and the amount of energy produced from RES has doubled in the past ten years (IRENA, 2020a). However, there are variations in the change, based on the region and the type of energy source. From an aggregate perspective, Asia is the most potent region in terms of renewable energy usage over the period. This can be attributed to the fact that it covers a wide geographical area and includes countries which are heavily involved in the invention and production of RETs; indeed IRENA estimates that 62% of RE jobs are in the Asian region (IRENA, 2017b). By contrast, Europe has experienced slower growth in the adoption of RES into its energy profiles in recent years. According to IRENA (2018b) and Zgajewski (2014), the plateauing of the growth in REs in the EU can be attributed to the fact that the region was one of the earliest adopters of REs, effectively achieving its targeted goals early. Any additional changes would involve a complete overhaul of the energy systems relying on fossil fuels, notably transport, and the technologies for such strategies are still at the research and development stage. Although the US has committed to the adoption of sustainable energy, it has failed to implement robust strategies due to the centrality of fossil fuels to its economy (Gross, 2020; Heal, 2009), and, as in Europe, growth is limited by the fact that emergent technologies have not yet been integrated into the energy systems. Africa has also experienced a plateauing in RE production, primarily due to the early widespread adoption of hydropower, coupled with limited adoption of the emergent technologies under solar and wind energy (IRENA, 2015b). Latin America has experienced an increase in the utilisation of RES, driven primarily by wind and solar, especially following the collapse of the fossil fuel markets in 2010 and 2011 (IRENA, 2016). Further details for a range of countries and renewable technologies are shown in Table 33-1.

Table 3-1: RE Demand for Various Regions Across the Globe 2010-2019 (MW)

Technology	Country/area	2 010	2 011	2 012	2 013	2 014	2 015	2 016	2 017	2 018	2 019
Total renewable energy	World	1 223 533	1 328 870	1 441 737	1 563 346	1 692 941	1 847 079	2 009 632	2 179 492	2 356 065	2 532 866
	Africa	27 330	27 776	28 748	30 945	32 965	35 287	37 950	42 729	46 466	48 446
	Asia	387 287	433 478	478 486	551 810	628 524	716 985	808 944	915 183	1 023 860	1 119 265
	C America + Carib	7 788	8 581	9 454	9 820	10 458	11 780	13 402	14 168	15 025	15 691
	Eurasia	69 699	71 493	76 692	80 878	84 326	88 140	91 219	96 160	100 302	103 337
	Europe	322 106	360 876	395 220	419 969	440 785	465 037	488 496	513 025	537 428	573 612
	N America	232 124	242 939	262 768	271 985	285 786	307 701	331 179	348 558	368 956	391 241
	Oceania	18 529	20 188	22 199	23 715	25 235	26 436	27 345	28 566	30 989	37 149
	S America	146 538	150 982	154 951	160 133	169 268	178 783	193 325	202 301	212 666	220 986
Hydropower	World	1 025 054	1 055 695	1 088 745	1 135 615	1 174 477	1 211 509	1 246 425	1 272 628	1 295 019	1 307 994
	Africa	26 883	27 021	27 680	28 875	28 965	29 490	31 414	34 845	35 691	35 887
	Asia	367 616	391 152	414 288	451 213	479 567	499 981	515 838	530 845	543 806	550 067
	C America + Carib	5 456	5 921	6 261	6 351	6 576	6 829	7 657	7 893	8 146	8 147
	Eurasia	68 082	69 466	74 036	77 500	79 736	82 133	83 029	84 105	85 359	85 776
	Europe	206 190	207 950	209 347	211 267	211 993	214 537	217 999	219 672	221 167	221 789
	N America	187 767	188 156	188 361	188 850	190 254	193 974	195 622	196 268	196 584	196 584
	Oceania	14 014	14 014	14 153	14 165	14 165	14 183	14 183	14 188	14 440	14 455
	S America	136 896	139 605	141 618	143 873	148 535	153 672	163 751	167 536	172 402	177 713
Wind	World	180 846	220 015	266 905	299 916	349 297	416 241	466 844	514 376	563 186	622 408
	Africa	861	992	1 125	1 739	2 398	3 318	3 830	4 582	5 470	5 770
	Asia	46 081	66 024	82 806	99 539	124 333	161 800	184 182	205 012	229 195	258 323
	C America + Carib	303	455	727	822	946	1 302	1 544	1 600	1 709	1 942
	Eurasia	1 335	1 742	2 274	2 775	3 645	4 525	5 801	6 566	7 147	7 783
	Europe	84 920	94 714	107 191	118 263	130 204	143 033	155 756	170 633	181 385	195 776
	N America	43 622	51 543	67 092	69 897	76 495	87 058	97 310	104 199	112 109	123 588
	Oceania	2 439	2 702	3 235	3 895	4 531	4 975	5 069	5 557	6 421	7 876
	S America	1 182	1 737	2 340	2 864	6 580	9 943	12 942	15 721	19 135	20 627
Solar	World	41 545	73 738	104 085	139 596	176 088	222 091	295 948	388 569	486 721	584 842
	Africa	239	331	411	724	1 722	2 248	3 397	4 248	6 171	7 441
	Asia	5 497	9 615	15 995	34 572	56 524	84 790	136 610	206 737	275 075	331 082
	C America + Carib	78	111	161	262	334	916	1 129	1 472	1 837	2 218
	Eurasia	6	8	13	21	48	316	936	3 678	5 651	7 147

	Europe	30 856	54 719	73 801	84 261	91 125	99 592	106 103	112 538	121 533	140 874
	N America	3 632	6 180	9 439	14 337	19 610	26 132	37 766	46 702	58 839	70 048
	Oceania	1 102	2 494	3 829	4 609	5 356	6 077	6 858	7 574	8 882	13 560
	S America	44	65	160	192	464	907	1 546	3 425	5 227	6 462
Bioenergy	World	65 603	71 777	76 629	83 848	90 004	96 764	104 576	110 539	117 738	124 026
	Africa	1 006	1 091	1 184	1 258	1 370	1 468	1 503	1 569	1 660	1 713
	Asia	13 754	15 207	16 252	18 533	21 204	24 596	29 941	32 767	36 411	40 517
	C America + Carib	1 425	1 514	1 649	1 744	1 966	2 093	2 442	2 538	2 667	2 663
	Eurasia	1 316	1 297	1 340	1 406	1 628	1 679	1 767	1 887	2 003	2 398
	Europe	25 282	28 539	30 043	31 344	33 053	34 471	35 491	36 850	39 813	41 603
	N America	12 402	12 511	13 279	14 312	15 030	16 109	16 219	17 194	17 192	16 835
	Oceania	1 000	1 004	1 009	1 001	1 012	1 013	1 047	1 058	1 058	1 069
	S America	9 390	10 549	11 807	14 178	14 662	15 235	16 060	16 568	16 827	17 118
Biogas	World	9 519	11 431	13 115	13 962	14 997	15 647	16 617	17 228	18 299	19 381
	Africa	8	10	10	11	11	22	30	34	39	50
	Asia	317	408	509	650	846	955	1 119	1 279	1 515	1 750
	C America + Carib	4	11	11	15	12	21	30	34	41	43
	Eurasia	72	90	133	162	204	253	298	378	440	535
	Europe	6 871	8 478	9 662	10 170	10 808	11 251	11 717	12 120	12 831	13 520
	N America	1 793	1 946	2 257	2 425	2 547	2 524	2 574	2 724	2 740	2 706
	Oceania	271	272	277	269	279	280	238	237	237	248
	S America	159	184	222	223	243	273	537	349	381	453
Geothermal	World	9 992	10 134	10 481	10 718	11 159	11 814	12 257	12 702	13 227	13 909
	Africa	205	205	213	213	373	626	670	680	670	830
	Asia	3 597	3 636	3 721	3 728	3 854	3 897	4 112	4 232	4 382	4 584
	C America + Carib	527	579	656	641	637	640	629	665	665	722
	Eurasia	175	195	243	390	483	702	899	1 138	1 357	1 589
	Europe	1 336	1 441	1 450	1 462	1 504	1 504	1 506	1 558	1 618	1 657
	N America	3 370	3 296	3 416	3 430	3 327	3 448	3 443	3 409	3 491	3 491
	Oceania	782	782	782	854	980	997	997	997	997	997
	S America	0	0	0	0	0	0	0	24	48	40

Source: Reproduced from (IRENA, 2020a)

As Table 3-1 shows, the share of REs has increased over time. According to IEA data, a gradual reduction in conventional energy sources has paved the way for the introduction and expansion of RES in the primary energy sectors across the globe (IEA, 2020). Solar PV technologies are the preferred RES, and are projected to overtake all other sources of energy by 2040 (See Figure 3-2).

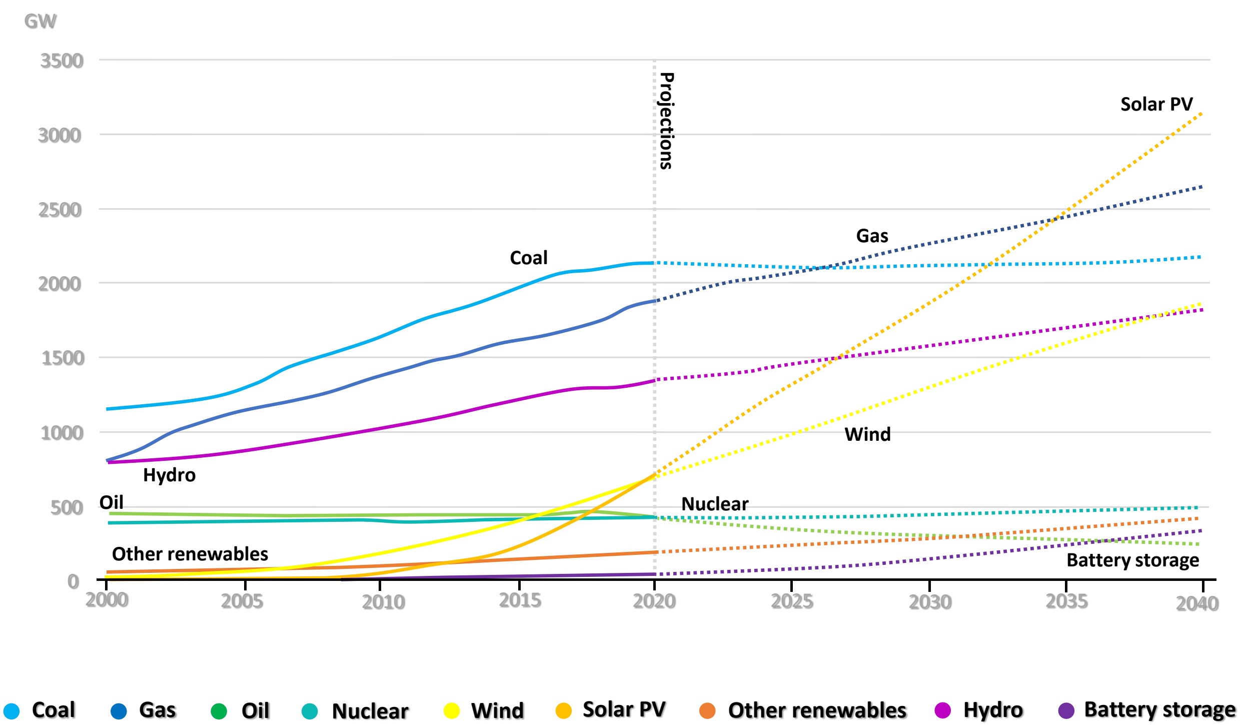


Figure 3-2: Projections for Total Energy Mixes (Global)

Source: Reproduced from (IEA, 2020)

3.4 Cost of Generation

As renewable energy use has increased and technologies have developed, the cost of generating energy has dropped significantly over time (IRENA, 2020a). The cost of generation is often reported as the 'levelised cost of energy' (LCOE), and the most significant drop in LCOE is reported in relation to solar PV, a scenario that can be attributed to the introduction of high-efficiency silicon-based technologies (See Figure 3-3).

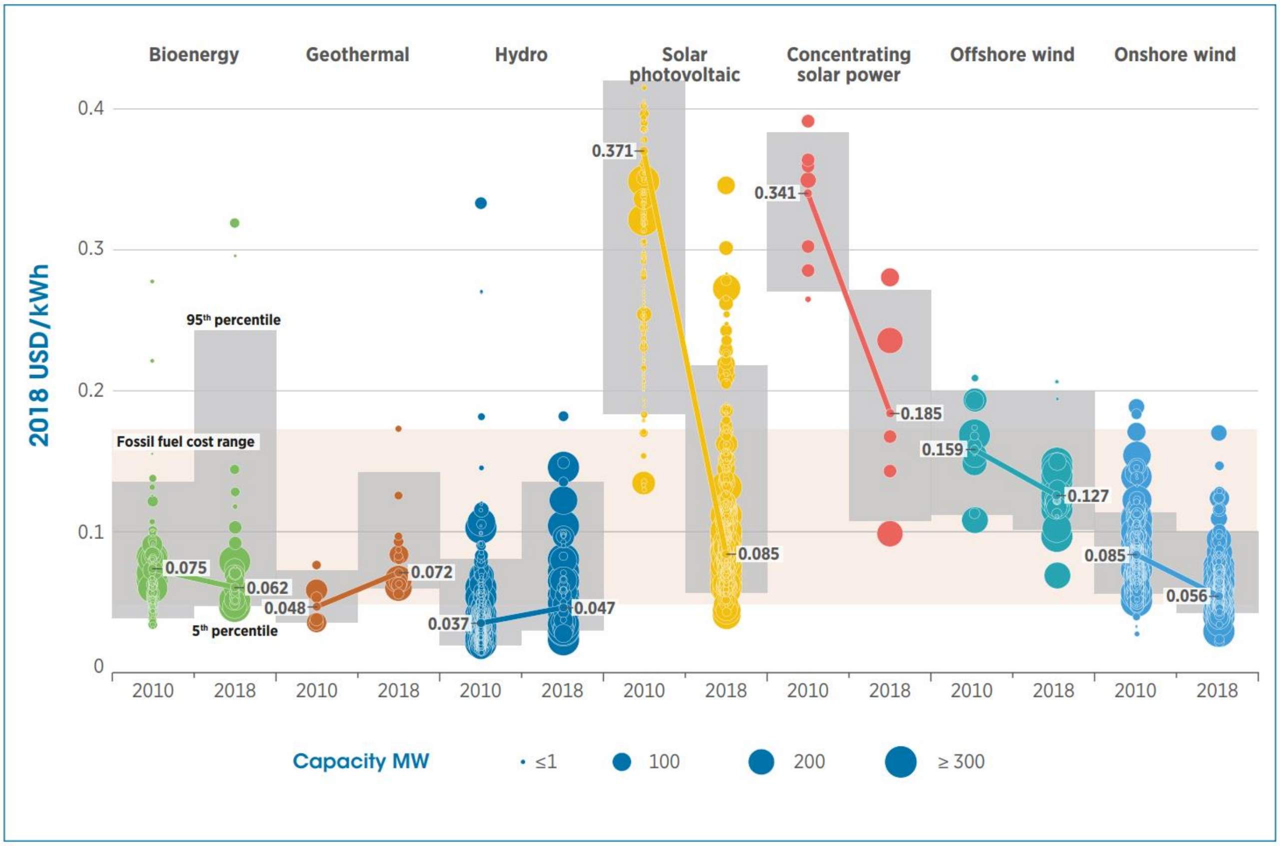


Figure 3-3: Global LCOE of Utility-Scale Renewable Power Generation Technologies, 2010–2018

Source: (IRENA, 2019a)

However, the LCOE depicts only the cost of generation of the electricity and fails to account for the cost of storage. In most medium and large-scale solar energy projects, storage of solar energy results in additional costs in the form of loss due to latency and the costs of acquiring the storage facilities. The Lazard's levelised cost of storage (LCOS)[1] provides an estimation of the total costs of storage for solar energy, and reveals that costs are inversely related to the storage capacity. It also indicates that while transmission of electricity often results in latent losses, large scale solar projects are more viable when storage facilities are included as compared to small scale solar project (See Figure 3-4).

[1] The analysis assumes a capital structure consisting of 20% debt at 8% cost of finance, and 80% equity capital at 12% cost of capital. The capital costs included relate to acquisition of storage modules, equipment for balancing the power, and power conversion equipment, all of which are collectively referred to as the 'Energy Storage System'.

Since renewable energy from wind has a similar intermittency profile as solar energy, the LCOS for solar are also applicable for wind energy.

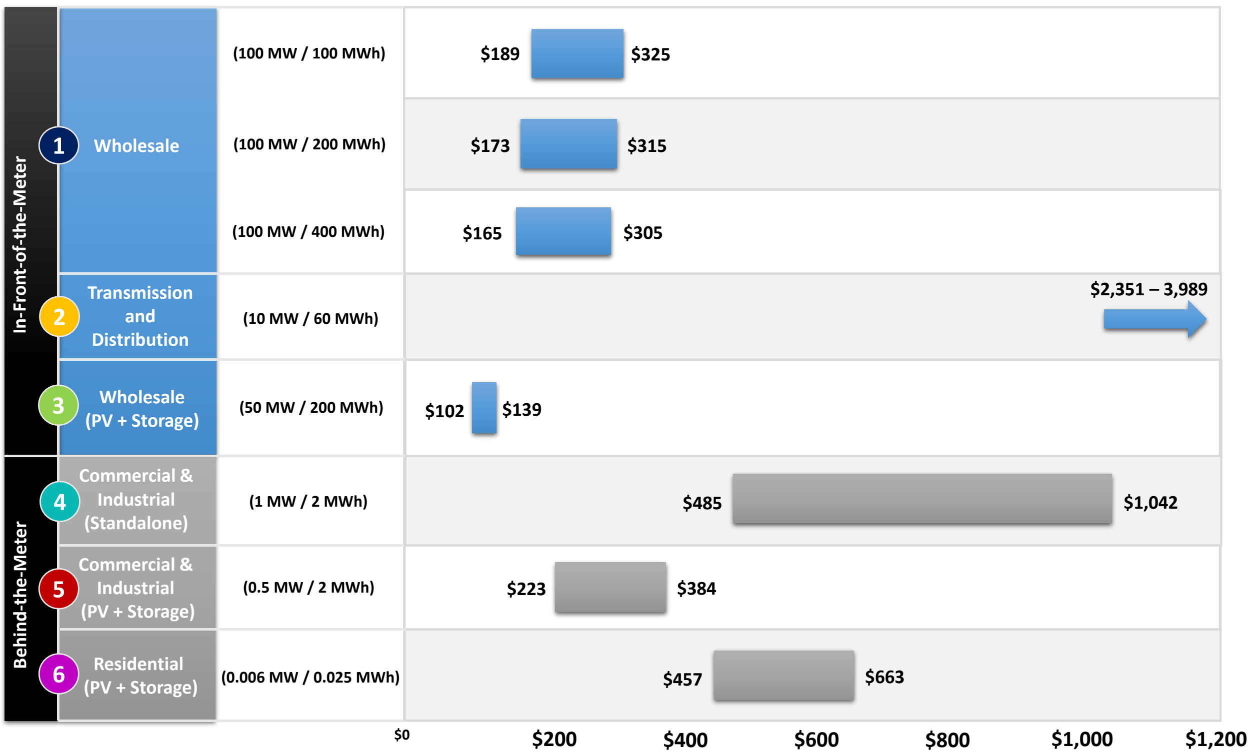


Figure 3-4: Unsubsidized Levelized Cost of Storage Comparison $/MWh

Source: Reproduced from (Lazard, 2019)

3.5 Plans and Strategies for Renewable Energy Portfolios (2030-2050)

By the end of 2018, most countries had some form of policy in place to support renewable energy development (REN21, 2019). Plans for achieving optimal energy use have often been presented in the form of scenarios; these facilitate the prediction of different outcomes, taking into account a diversity of variables (Ghanadan and Koomey, 2005). Most predictions by IRENA, IEA, and in empirical studies, focus on projecting energy demand in three scenarios: a Business as Usual (BAU) case; a best-case scenario, based on a particular set of strategies; and a worst-case scenario, in case the set of expectations are not met. This approach enables countries to estimate the direct and indirect costs and benefits of RES in order to enable regulatory institutions and entities in the energy sector to choose the most viable options (Ghanadan and Koomey, 2005; Sarmiento *et al.*, 2019).

The United States and China are the two biggest renewable energy players (IRENA, 2020a). The US has adopted the three scenarios model and, prior to Donald Trump's election, it had the target to increase REs from 7.5% of the primary energy mix to 10% under the 'business as usual' scenario, 27% under the most cost-effective plan, with savings of between US$30 and US$140B annually, and to 50% by 2030 under the most ambitious plan (IRENA, 2015a). More recent estimates by Yang *et al.*, (2016) pegged the goal at 80% RE by 2050. China, which has traditionally relied on coal for production of 73% of its electricity, is now a world leader in renewables and has invested heavily in RES since 2000. According to Yang *et al.* (2016), China reported an average annual growth in RE generation of 62.5% between 2006 and 2016, and current plans focus on generating at least 16% of its electricity from RES, with the possibility of achieving 26% under the most ambitious plans.

The countries of the EU also have ambitious aims to increase renewable energy utilisation. According to the European Environmental Agency (EEA), the EU is committed to transitioning to a low-carbon society by 2050, with intermediate energy mix and climate targets set for 2020 and 2030 (EEA, 2016). These include targets to generate 32% of final energy consumption from RES by 2030 (Meletiou *et al.*, 2019), and 55% by 2050 (Yang *et al.*, 2016a). To achieve these goals, the EU is committed to the reduction of reliance on fossil fuels, such as coal, and several EU member states have committed to getting rid of fossil fuels completely by 2050, including Denmark and Germany.

As a leading country in terms of renewable energy utilisation, Germany provides an instructive example of a successful renewable energy strategy. The German government has provided continuous support to renewable energy technologies to increase their contribution to the nation's energy mix. Renewable energy accounted for 12% of the total energy supply and 23% of the electricity supply in 2012, an increase from 16.8% of gross electricity production in 2010 and just 3.1% in 1990 (Klaus *et al.*, 2010a). The electricity is supplied mainly by wind power, with biomass, solar photovoltaic and hydropower close seconds (Sühlsen and Hisschemöller, 2014). Germany also reduced its thermal emissions by up to 23% in the 20 years between 1990 and 2010. The federal government introduced an integrated energy and climate programme in 2007 to ensure its climate targets could be achieved and the requisite measures organised cost-effectively. This provided the impetus for a range of domestic policies and measures which include, but are not limited to, a) priority grid access for power from renewable energy sources, b) feed-in tariffs, c) insulation standards for buildings, d) taxation of energy and e) the promotion of energy-efficient technologies. Its landmark Renewable Energy Sources Act, first introduced in 2000, is due to be updated again in 2021, and the country appears to be on track to reduce GHG emissions by up to 40% by 2020 and between 80-95% by 2050, with the proportion of renewables in its energy mix rising to at least 35% by 2020 and 80% by 2050 (Klaus *et al.*, 2010b).

While some plans for RE portfolios are plagued by overambitious goals, lack of commitment in the short-term, and limited mechanisms to account for the knock-on effects on the traditional energy sectors, Germany demonstrates that a comprehensive strategic approach can achieve significant growth in renewable use. This is supported by Ghazali and Ansari (2018) who investigated the influence of the Renewable Energy Act of 2011 in Malaysia and found that enhanced RE activities increased energy generation from 104.87 GWh to 521.95 GWh between 2012 and 2015.

3.5.1 Optimal Selection of the Appropriate Source of Renewable Energy

Research indicates that the most effective energy portfolios comprise a mix of energy sources, including RES and conventional sources (Aghahosseini, Bogdanov and Breyer, 2020; Bicen, Szczutkowski and Vardar, 2018; Demirbas and Demirbas, 2010). In addition to solving the challenge of intermittent productivity, the hybridisation of sources enables a country to achieve higher productivity and reliability while achieving cost-efficiency goals. However, as Yang, Solgaard and Haider (2016) note, an increase in the share of renewables introduces the risk of short-term shortages. This explains why some end consumers prefer certain energy sources over others, and in turn, why, while they may be willing to pay a premium for renewable energy, they may only be willing to do so if providers generate energy from different sources to ensure reliability.

3.5.2 Social Acceptance of RES

The extent to which communities and societies accept RE projects, as well as RE products and services, determines the extent to which a country can rely on them in its energy mix. The extent to which RES are preferred over conventional energy sources and the preferred types of REs have been widely investigated, with most studies concluding that RES are more popular than conventional energy sources. The findings from seven such studies are summarised in Table 3-2.

Table 3-2: Studies on Preferred RES

Author	Study setting	Energy sources compared	Analytical Model	Preferred energy source
Komarek et al., (2011)	US	Coal, Natural gas, Biomass, Wind, Solar, and Nuclear	Probit model	Wind energy
Cicia et al., (2012)	Italy	Biomass, solar power, natural gas, wind power	Probit model	Solar and Wind power
Kacnzig, et al., (2013)	Germany	Renewables, fossil fuels, nuclear energy	Mixed logit model	Renewables
Jang (2014)	Korea	Wind power, biomass, nuclear energy, fossil fuels, wind power, Solar power	Logit model	Solar power
Huh et al., (2015)	Korea	Nuclear energy, fossil fuels, renewable energy	Mixed logit model	Renewable energy
Murakami et al., (2015)	Japan, US.	Renewable energy, Nuclear energy	Mixed logit model	Renewables
Kim et al., (2018)	S. Korea	Nuclear energy, renewable energy, fossil fuels	Mixed logit model	Renewable energy

Source: Compiled by Author

However, Vargas Payera, (2018) found significant challenges to social acceptance of geothermal energy in Chile, linked to the obscurity of the technologies used in the extraction of energy resources. Based on in-depth analysis of interview data, a multiplicity of social barriers, including uncertainty about the ecological impacts, mistrust, and cultural sensitivities, were identified to explain the lack of social acceptance of this type of RES in this particular region. Although the widespread preference for renewable energy is encouraging, policy-makers cannot assume that social acceptance will follow.

Past studies, notably Simpson (2017) and Wustenhagen, Wolsink and Burer (2007), have used the Social Acceptance Model when discussing the factors which influence social acceptance. These are Socio-political acceptance, Community acceptance, and Market acceptance (See Figure 3-5).

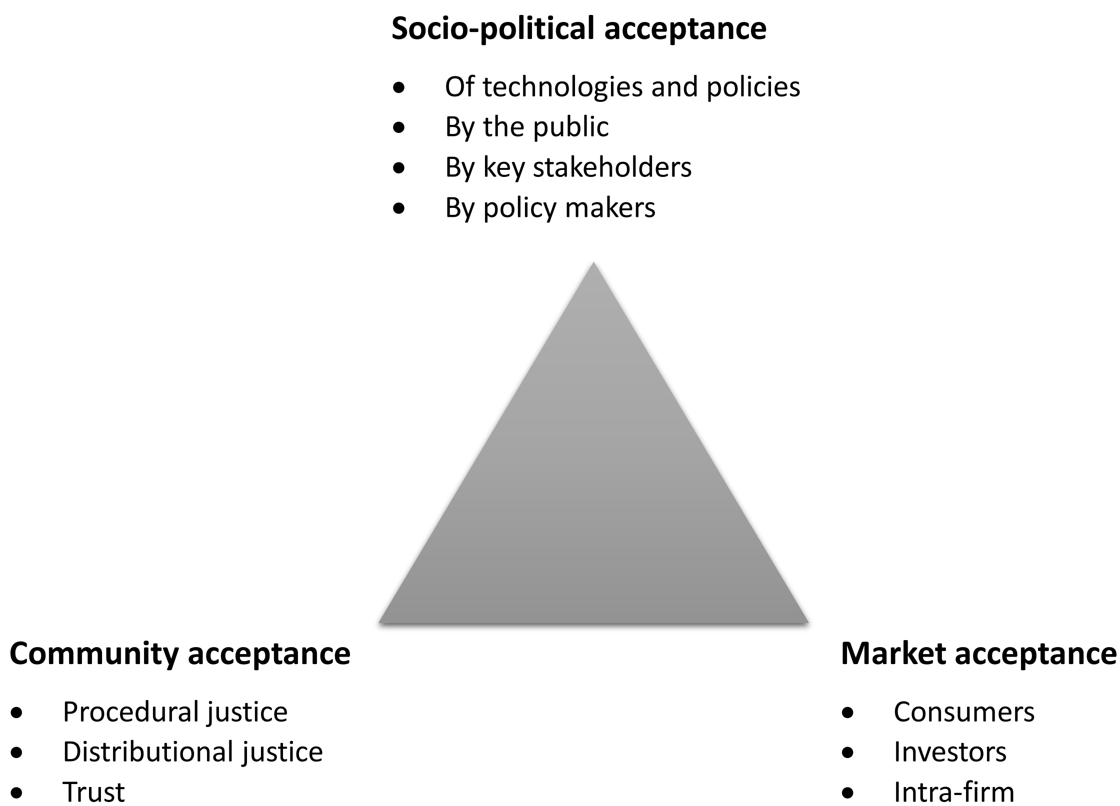


Figure 3-5: Social Acceptance Model

Source: Reproduced from (Wustenhagen, Wolsink and Burer, 2007)

These three dimensions determine the ease of adoption of renewable energies, as well as the extent to which societies are willing to accept the technologies. Although social acceptance has generally been seen as a pre-adoption concern, Hai (2019) discusses it from a multi-stage perspective on the basis that the views of communities change over time, specifically, before, during, and after the installation of the technologies. He developed a Willingness to Accept framework, which identifies different categories of willingness among individuals in any society (Hai, 2019) (See Figure 3-6).

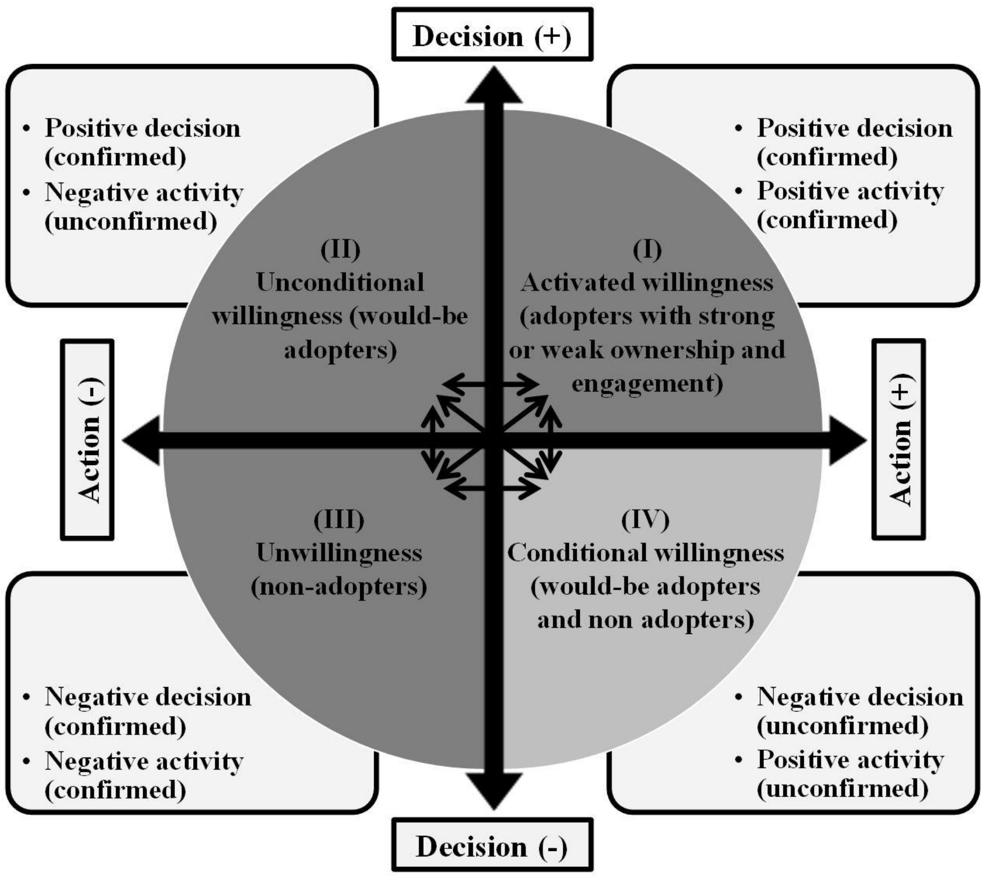


Figure 3-6: Typologies of the Willingness to Accept RES

Source: Reproduced from (Hai, 2019)

Although social acceptance is often relied upon in decisions to adopt one type of RE over another (or during the adoption of RE within a community), there are other considerations to be made. Woo *et al.* (2018) investigated the financial viability and social acceptance of nuclear energy vis-à-vis other emergent RES in South Korea, using two models, the cost-benefit analysis (CBA) and the contingent valuation method. The findings reveal that, based on the CBA, the yearly cost of replacing the energy from nuclear energies amounted to US$1.21B, which was found to be higher than the consumers were willing to pay. Based on the contingent valuation method, it was apparent that the consumers would only accept an additional cost of US$1.8 per month to replace nuclear energy, and this fell short of the sum required. These results indicate that if RES are to replace nuclear power in South Korea, it is necessary to improve consumers' willingness to bear the cost, as the Market dimension of the social acceptance model suggests.

3.5.3 Legislation and Policies for Optimal Utilisation

According to Hosseini *et al.* (2018), legislative policies aimed at regulating RE play an integral role in its adoption and utilisation across the globe. In addition to influencing social acceptance of RES, legislation can reduce the uncertainties associated with the adoption of RE. However, in order to achieve comprehensive oversight and responsibility for commitments, legislative frameworks and policies have to focus on mitigation of climate change, improvement of energy efficiency and enhancement of energy security (EEA, 2016).

Perhaps the most significant legislation in relation to renewable energy use is the Paris Agreement of 2015, which represents a commitment by 174 member states[2] and the EU (a total of 175 parties), towards the reduction of carbon emissions (IRENA, 2017a). Since these states account for 66% of global CO_2 emissions, they have agreed to invest in activities aimed at preventing average global temperatures exceeding 2˚C above pre-industrial standards (Alfredsson *et al.*, 2018). The agreement mandates a reduction in emissions while improving the abilities of all parties to achieve

[2] Under the Trump administration, the United States withdrew from the Paris Agreement on 4 November 2020; however, President-Elect Biden has committed to re-joining once he takes office.

climate-resilient socio-economic development, through consistent financial flows and climate management pathways (Gielen *et al.*, 2019) (See Figure 3-7).

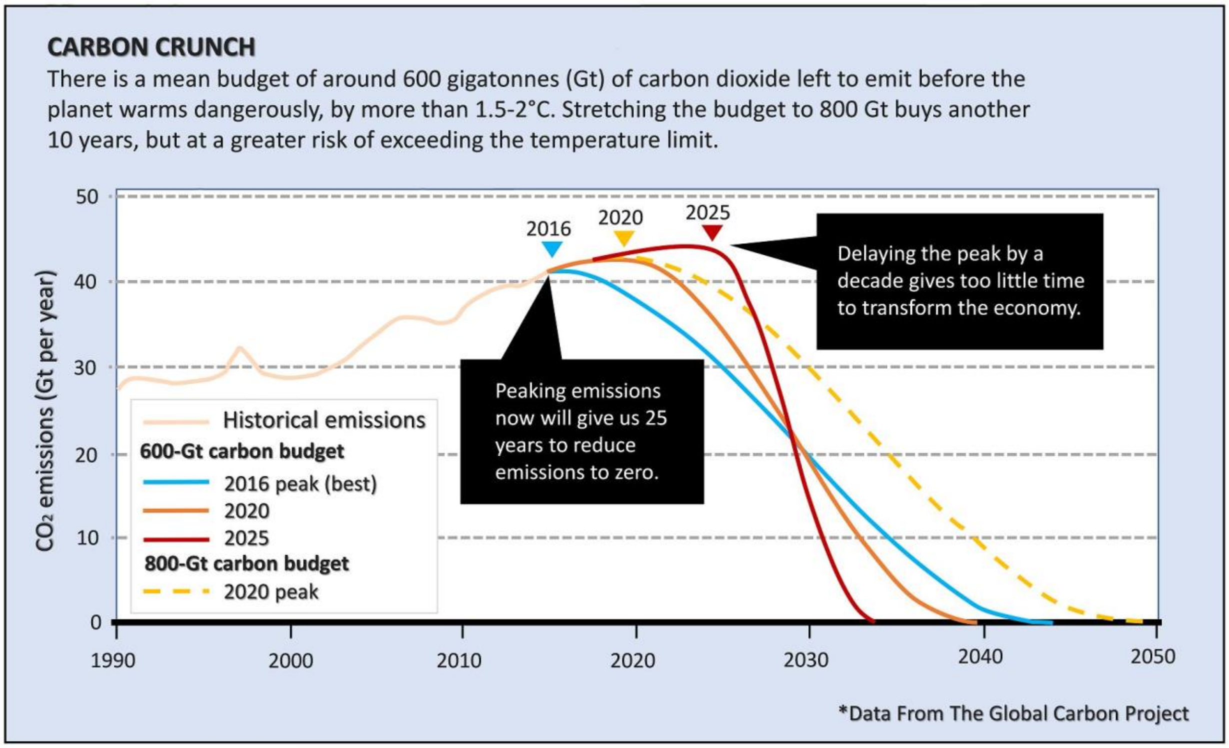


Figure 3-7: Strategies to Reduce Emissions under the Paris Agreement

Source: Reproduced from (Alfredsson *et al.*, 2018)

One of the most effective policy decisions concerning RE relates to feed-in tariffs (FiTs). FiTs are associated with the German energy model, having been introduced there in 1991. Under the model, policies mandate the creation of long-term contracts for energy generation companies to compensate small-scale domestic producers for electricity generated on-site (Böhringer *et al.*, 2017). An industry report by Cox and Esterly (2016) indicated that the number of countries that had adopted FiT schemes grew three-fold between 2004 and 2013, and FiTs have the potential to stimulate the uptake of RE and generate savings of up to US$21B by 2040 (Huenteler, 2014). However, poor FiT policy design has adverse effects on the adoption and utilisation of RES. In their study of FiT-schemes across 50 countries in Africa, Ndiritu and Engola (2020) found poor policy design was the primary weakness, evidenced by poor implementation processes, conflicts in the FiT schemes, lack of clarity in the provisions, and poor institutional infrastructure. Similar conclusions were drawn by Huenteler (2014) who found that a lack of specificity in FiT policies in Thailand led to stagnation in progress.

3.5.4 Creation of Infrastructure to Utilise RE

Increased social acceptance of RE coupled with the development of policies for their adoption and utilisation have resulted in improvements in associated infrastructure, including smart cities and the use of energy-efficient technologies. According to Eremia, Toma and Sanduleac (2017), smart cities depend on technology to improve sustainability, workability and ‘liveability’ by integrating critical infrastructure systems, including transportation, commercial and industrial components, to optimise service delivery to citizens. However, the conceptualisation of smart cities varies significantly across the globe (See Table 3-3). For the European Union (2016), smart cities entail the development of sustainable districts and construction, sustainability in urban mobility, and integrated processes and infrastructures. In Latin America, the focus is on the management of cities, improvements in urban services and businesses, the participation of citizens, and the introduction of new technologies (Telefonica, 2012). This approach can be viewed as the ‘first wave’ of smart cities (Smart City 1.0), in which the primary objective is the creation of a network of physical assets to achieve a ‘connected infrastructure’ environment. In the US, where the ‘second wave’ of smart cities (Smart City 2.0) is already happening, a combination of digital technological advances that rely on data, information and knowledge are driving initiatives to improve the utility of services.

Table 3-3: Different Conceptualisations of Smart Cities Across the World

Term	Trend	Regional popularity	Popularity in countries	Popularity in cities
Future cities	Stable	Global	India, USA, Canada, Australia, UK, Mexico, Brazil	Minneapolis, Singapore, Mumbai, New Delhi, Phoenix, London, San Francisco, Pune
Eco City	Stable	Asia	Philippine, Singapore, Malaysia, India	Chandigarh, Tianjin
Smart cities	Fluctuating interest	Europe, Northern America	Italy, Spain, Belgium, UK	Barcelona, Bologna, Torino, Roma
Intelligent cities	Stable	Northern America	USA, UK	London
Sustainable cities	Stable	Commonwealth	Australia, UK, Canada, USA, India	Vancouver, Singapore, Washington, Auckland, Portland, Dubai, London, Austin
Compact cities	Stable	Mixed	Australia, UK, USA	Salt Lake City, New York City
Liveable cities	Rarely used	Commonwealth	Australia, UK, Canada, Singapore	New York City, Singapore, Melbourne Pittsburgh, Vancouver
Digital cities	Stable, after a decreasing interest	Mixed	USA, Ireland, Philippine, UK	Kansas City, Oklahoma City, Dublin, Minneapolis
Innovative cities	Stable	Mixed	USA, UK, India	Bangalore
Green cities	Stable	Northern America	USA, Australia, Canada	New York City

Source: Reproduced from (Eremia, Toma and Sanduleac, 2017)

Smart cities are designed around sustainable energy microsystems, whereby different subsystems are combined in order to integrate and optimise the management of essential services (Brenna *et al.*, 202). This includes the integration of elements inside and outside the city to promote cogeneration of energy, for residential, commercial, and industrial use. As Maier (2016) points out, smart cities are dependent on the presence of sustainable and renewable energy systems, and sustainable and renewable energy strategies for the future are predicated on smart cities, given that most of the population will be living in urban centres by 2040 (Eremia, Toma and Sanduleac, 2017; Maier, 2016).

The attractiveness of energy efficiency in the design of sustainable energy policies arises from the fact that even though REs are ecologically-friendly, inefficient utilisation of energy introduces novel externalities and costs. This is why part of the innovations under smart cities is the creation of infrastructures for the efficient utilisation of the available REs.

3.6 Outcomes Required to Develop RES Utilisation Across the Globe

Based on the discourse, the following propositions represent the outcomes required in order to develop the utilisation of RES across the globe.

- First, create agreements to support the ambitious and challenging energy-capacity and climate change interventions aimed at achieving the overall goals
- Second, develop sustainability mechanisms and criteria to ensure the compatibility of the technologies and RE systems
- Third, introduce technological innovations at the national, regional and global level, through research and development to create efficient RES
- Fourth, invest in and provide capital resources for renewable, clean and sustainable energy, for all categories of uses
- Fifth, improve the accessibility of clean energy and promote sustainability in energy utilisation mechanisms through efficient technologies
- Sixth, establish grid systems to store, share and exchange clean energy through energy trade contracts and agreements to ensure that the available resources are utilised efficiently
- Seventh, promote the generation of clean energy over other options, to ensure availability for all by 2050.

3.7 Summary

This chapter has provided an overview of global demand for energy, both current and expected, and considered the role renewable energy is playing in meeting that demand. It has examined the costs associated with each RES and the mechanisms used to calculate them. In addition, it has explored the renewable strategies deployed by leading countries in RE, and identified key factors that contribute to the consolidation of renewable energy utilisation, namely social acceptance, legislation and policy, and the creation of essential infrastructure. The chapter concludes by listing the outcomes required to develop renewable energy utilisation effectively on the global scale. The next chapter presents the general state of energy demand and the use of renewable energy in the countries of the Middle East and North Africa, the region which includes Kuwait, the focus of this study.

Chapter 4

Energy Demand and Renewable Energy Strategies in the Middle East and North Africa (MENA)

4.1 Introduction

Given Kuwait's geographic location and its economic ties to other GCC members, this chapter examines energy demand in the MENA region and considers the role of renewable energy in countries whose economies have long been dominated by fossil fuels. It reviews the targets set for the region's renewable energy sectors in the years 2030-2050 and considers the legal and political frameworks in place to achieve them. As in Chapter 3, it focuses in particular on optimal selection of RES, legislative and policy requirements, and in the need to develop appropriate infrastructure; however, this chapter also considers the measures taken within the region to develop a knowledge economy and raise public awareness of renewable energy use.

4.2 Energy Demand in the MENA Region

Aghahosseini *et al*. (2020) attribute the increase in demand for energy in the MENA region to the growth in the population, increased urbanisation, and socio-economic growth driven by vast oil wealth and the introduction of growth-oriented policies, notably the Vision 2030 policies in place across the GCC. Secondary aspects include increased demand for water through desalination and an expansion in real estate development, hence the need for increased cooling and heating. This has led to high per capita demand for electricity in the MENA region, ranging from a low of 6.6MWh in Oman to a high of 20.2 MWh in Bahrain (Ali and Alsabbagh, 2018). The growth in demand, coupled with the disparities in energy generation capacities, has led to increased importation and exportation of energy among countries in the region (Zhang *et al.*, 2017).

Due to its climatic conditions, the MENA region holds considerable potential for RE, notably solar and wind energy. Furthermore, as the region is experiencing increased desertification due to climate change, it stands to benefit considerably from the use of more ecologically-friendly energy sources (Al-Mutairi *et al.*, 2017). However, as Jalilvand (2012) indicates, due to the prominence and availability of fossil fuels, REs only contribute to less than 1% of the region's basic energy mix. Although market dynamics in the oil sector, primarily the fluctuations in oil prices, have necessitated the adoption of REs by these countries (Zhang *et al.*, 2017), recent reports indicate that the proportion of RE has dropped to 0.4% of the total primary energy supply (TPES) (Aghahosseini *et al*., 2020). Nevertheless, the capacity to generate electricity from renewable sources has expanded significantly over the past decade, notably for solar and wind energy (See Table 4-1).

4.3 Plans and Strategies for Renewable Energy Development (2030-2050)

The availability of hydrocarbons has driven the economies of many MENA countries. As of 2011, the region held 42% of the global share of natural gas (88 trillion cubic metres) and 56% of the proven oil reserves (860 billion barrels) (Abdelrahim, 2019). As Abdelrahim's analysis of qualitative data concerning the UAE and Egypt indicates, in order for these countries to embrace RE in their energy portfolios, there is a need for policy changes in two areas. The first of these is the need to eliminate existing subsidies on fossil fuel products as these distort energy markets and encourage wastage and inefficiencies in the allocation of resources (Abdelrahim, 2019). The second involves reducing the financial burden on the energy sector from the international market to enable the private sectors in domestic markets to commit to the implementation of RE projects. Overall, governments and commercial enterprises in the region have to commit to improving their energy efficiency to reduce the levelised cost of energy in their countries. The steps being taken towards this are discussed below

Table 4-1: RE Capacity and Generation between 2009 and 2019

Indicator	Technology	2 009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electricity capacity (MW)	Total renewable energy	11 351	12 133	12 556	13 218	14 092	15 595	16 929	17 773	18 803	20 373	23 137
	Hydropower	11 429	12 151	12 410	13 001	13 521	14 685	16 709	16 931	17 277	17 423	17 576
	Wind	101	104	107	115	122	165	286	410	505	614	723
	Solar	42	91	215	275	618	905	1 113	1 604	2 193	3 507	6 009
	Bioenergy	19	27	65	67	72	80	101	108	108	108	109
	Biogas	16	24	32	34	39	47	67	74	75	75	76
Electricity generation (GWh)	Total renewable energy	13 373	18 294	21 194	22 268	24 532	21 233	20 899	26 683	26 340	26 605	
	Hydropower	12 997	17 813	20 372	21 340	23 346	19 399	18 346	22 437	20 853	18 721	
	Wind	240	222	226	217	228	216	382	670	786	1 337	
	Solar	62	156	365	471	696	1 303	1 803	3 202	4 326	6 163	
	Bioenergy	73	104	231	240	263	314	369	374	375	384	
	Biogas	67	98	148	157	180	232	286	291	292	301	

Source: Reproduced from (IRENA, 2020a)

4.3.1 RE Targets for Renewable Energy Utilisation in MENA Countries: 2030-2050

This section reviews the published renewable energy targets in the countries of the MENA region, from Morocco to the west and Iran to the east. This is a geographically and economically diverse area, and includes countries which have been, or are still beset by conflict, notably Syria, Iraq, Libya and Yemen. Rates of technological development vary significantly too, with some countries requiring more technological changes than others to achieve their goals. Despite the costs involved in bringing renewables into the energy mix, the highest targets are found in North Africa (Algeria, Egypt, Morocco and Tunisia) rather than the wealthy Gulf states, which are still economically dependent on fossil fuels. Details of the targets for 2030-2050 for each country in the region are set out in Table 4-2.

Table 4-2: RE Levels in the MENA Region and Future Goals

Country	Renewable Energy targets	Year/ Timeline
Algeria	Generate 27% from RES (22GW of generation capacity). Specific technological changes required: • Solar energy (PV): 3GW by 2020 and 13.6GW by 2030. • Wind energy: 1GW by 2020, 5GW by 2030 • Solar SCP 2GW by 2020, 4GW by 2030. • Biomass energy: 0.4GW by 2020, 2GW by 2030 • Geothermal: 15 MW by 2030	**2020 and 2030**
Bahrain	5% of gen. capacity from RE by 2024 and 10% by 2035 Specific technological changes required: • Solar PV energy: 300MW by 2025 • RE mix: 700MW by 2030	**2025 and 2030**
Egypt	20% of gen. capacity by 2022 and 42% by 2035 Specific technological changes required:	**2020 and 2030**

	• Solar PV energy: 200MW by 2020, and 700MW by 2027. • Wind energy: 7.2GW by 2020 • CSP energy: 1.1GW by 2020, 2.8 GW by 2030 • Hydropower: 2.8GW 2020	
Iran	Generate 10% (10GW) of energy mix from REs by 2025 Specific technological changes required: Increase solar and wind energy, no specified targets.	**2020 and 2030**
Iraq	10% of total energy mix by 2030 No specific targets for the short and medium term	**2020 and 2030**
Israel	10% of energy mix from REs from 2020, and 17% by 2030. Specific technological changes required: • Wind energy: 600MW to 1GW by 2020 • Solar energy (PV): 600MW to 1GW by 2020 • Recycled waste: 30-50 MW by 2020	**2020 and 2030**
Kuwait	5% of energy mix from REs by 2020 and 15% by 2030 (4.5GW) No specified targets for wind and solar energy	**2020 and 2030**
Lebanon	12% of total energy consumption from REs (9TWh), specifically for heating and electricity by 2020 from REs Specific technological changes required: • Solar energy (PV, CSP and Solar thermal): 4.2% of total energy mix by 2020 • Hydropower: 3.2% of the total energy mix • Biomass: 2.5% of the total energy mix by 2020 • Wind energy: 2.1% of the total energy mix by 2020	**2020**
Libya	10% of the generated electricity from RE by 2020, to be increased to 30% by 2030. Specific technological changes required: • Solar PV: 150MW in 2020, and 500MW by 2025	**2020 and 2025**

	• Solar CSP: 800MW in 2020 and 1200MW by 2025 • Wind power: 1.5GW in 2020, 2GW in 2025 • Biomass: 300MW in 2020 and 600MW in 2025	
Morocco	42% of the energy mix from REs by 2020 and 52% by 2030 Specific technological changes required: • Solar (PV and CSV): 2GW in 2020 • Hydropower: 2GW in 2020 • Wind energy: 2GW by 2020	**2020 and 2030**
Oman	10% of the energy mix by 2025 to be increased to 3GW by 2030 Specific technological changes required: • Solar and wind energy: No specific targets	**2025 and 2030**
Qatar	Increase RE share by 2030 Specific technological changes required: • Solar (CSP and PV): 16% of total energy mix (1.8GW) by 2020, and 10GW by 2030	**2020 and 2030**
Saudi Arabia	9.5GW of gen. capacity from RES by 2023, 200GW solar PV by 2030, in cooperation with SoftBank Group Specific technological changes required: • Solar PV, with no specified targets	**2020 and 2030**
Palestine	10% of energy mix from REs by 2020, up from 130MW of installed capacity Specific technological changes required: • Solar (PV): 34% of entire RE mix by 2020 • Solar (CSV): 15.4% of entire RE mix by 2020 • Wind: 33.8% of entire RE mix by 2020	**2020**
Syria	4.3% of the total energy mix from REs by 2030 Specific technological changes required: • Solar PV: 250MW by 2030 • Solar thermal: 11.6 TWh per year by 2030	**2030**

	• Wind 1.5 GW by 2030 • Biomass: 250 MW by 2030	
Tunisia	30% of total energy mix from RES by 2030 Specific technological changes required: • Solar PV: 1.5GW by 2030 • Solar CSP: 500MW by 2030 • Wind energy: 1.7GW by 2030 • Biomass energy: 300MW by 2030	**2030**
UAE	7% of total electricity generated from RES by 2030 to be increased to 30% by 2030. 7% of total installed capacity in Abu Dhabi and 5GW through Solar PV in Dubai by 2030 Specific technological changes required: • Solar (PV and CSP) the primary target • Additional options include energy from waste and wind energy	**2030**
Yemen	15% of the total installed capacity from RES by 2025 Specific technological changes required: • Solar PV: 0.6% of RES by 2025 • Solar CSP: 1.4% of RES by 2025 • Geothermal energy: 28.2% of total RES by 2025 • Wind energy: 56.3% of total RES by 2025 • Biomass energy: 0.8% of total RES by 2025	**2020 and 2025**

Source: Reproduced from (Aghahosseini *et al.*, 2020)

4.3.2 Optimal Selection of the Appropriate Source of Renewable Energy

As Table 4-2 shows, solar (PV and CSP) plays a dominant role in the energy mix and plans for REs targets. This can be attributed to the fact that the MENA region receives between 22% and 26% of all the solar radiation that reaches the earth (Zhang *et al.*, 2017). This translates to direct normal radiation (DNR) of 2000kWh/M^2 per year and a global horizontal irradiance of 2500kWh/M^2 per year. The potential for generation of wind energy, especially in countries like Morocco, Egypt and Oman, is also high, with estimates of at least 2400 hrs/ year of full load hours for wind turbines.

Despite the diversity of RES in the energy portfolios of the MENA countries, research indicates that the region could satisfy its electricity demand through solar PV alone. With increased penetration and improved efficiency to eliminate efficiency and storage challenges, it is possible to achieve 100% RE utilisation without compromising on energy reliability (Aghahosseini *et al.*, 2020). However, it is essential that appropriate policies are introduced to support the strategic development of RES within the region.

4.3.3 Legislation and Policies for Optimal Use of REs in the MENA Region

Several legislative frameworks and policies are in place in the MENA region to improve efficiency in the utilisation of RES and enhance RE development. However, as Zhang *et al.* (2017) note, domestic electricity markets in the MENA countries are vertically integrated, which creates institutional and structural challenges, and the fact that many RE energy policies are adapted from ones originally designed for conventional energy has led to the monopolisation of the sector. Three notable steps have been taken to address these issues, namely the creation of the MENA Super Grid, the introduction of Feed-in Tariffs (FiTs), and reductions in fossil fuel subsidies.

4.3.3.1 Integrating Regional Electricity Markets through the MENA Super Grid

A major step towards integration of the electricity markets in the region is the establishment of the Gulf Cooperation Council Interconnection Authority (GCCIA) and the creation of the MENA Super Grid, a high voltage direct current transmission grid system designed to enable participating countries to trade energy with each other (See Figure 4-1). According to data from the King Abdullah Petroleum Studies and Research Center (KAPSARC, 2018), power trading among these countries increased to 900GWh in 2017.

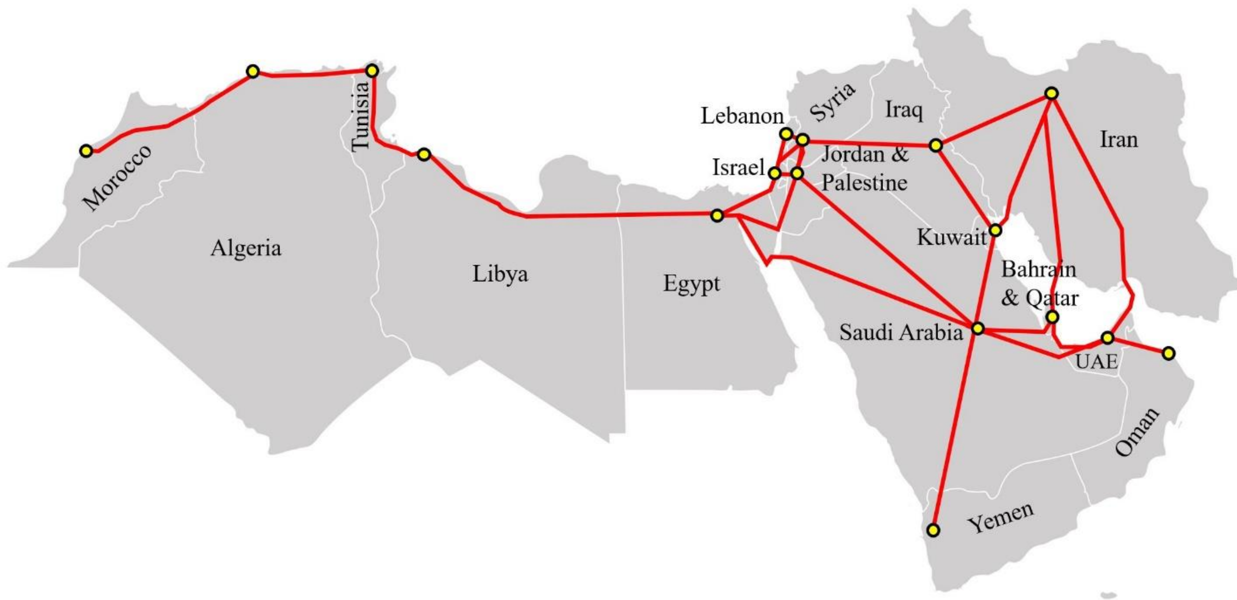


Figure 4-1: MENA Super Grid

Source: Reproduced from (Aghahosseini *et al.*, 2020)

As Aghahosseini *et al.* (2016) explain, the super grid lays down the foundation for a Pan-Arab electricity market within the MENA countries, whereby they can generate REs domestically, regionally, or through an integrated approach. While each scenario has an impact on the levelised cost of RE, as well as its availability, estimates reveal that a 100% RE-based system is viable in the region. The current success and future potential of the super grid has led to a diversification in import and export markets for energy, with interconnection now targeting other African countries, as well as Turkey, and EU electricity markets via Italy and Spain (See Figure 4-2).

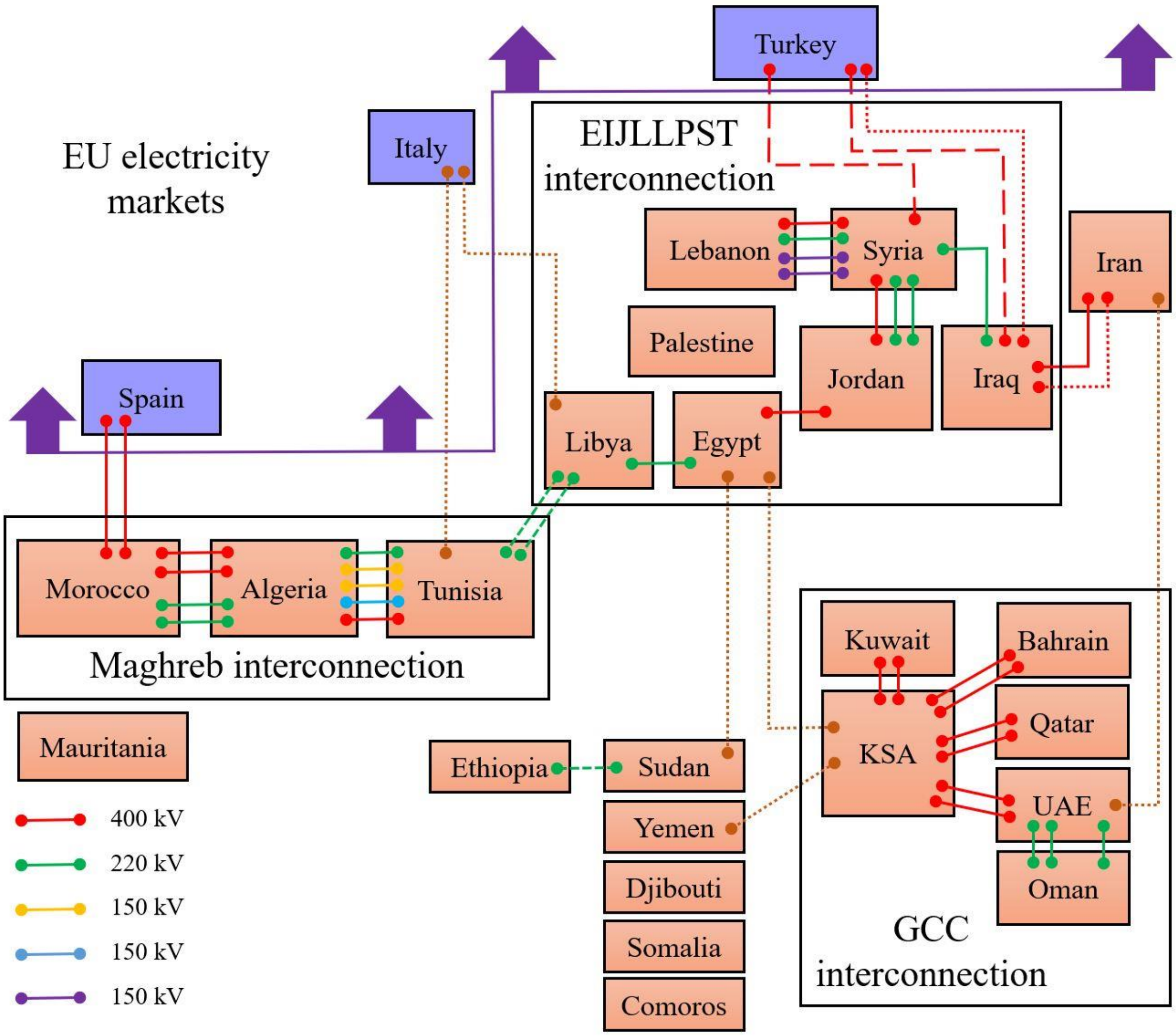


Figure 4-2:Infrastructure for International Energy Trade Beyond MENA Countries

Source: Reproduced from (Zhang *et al.*, 2017)

However, despite the huge potential for efficiency and financial viability of an interconnected energy system, there has only been modest trade in electricity in the past. For example, the Maghreb regional energy interconnection, which was conceptualised in the 1950s, has evolved slowly, with the harmonisation of the market rules and tariffs occurring as recently as 2010 (Zhang *et al.*, 2017). The Eight Countries regional energy interconnection, which was started in 1988 involving Palestine, Libya, Lebanon, Egypt, Iraq, Jordan, Turkey and Syria, has also faced similar challenges, due to limited development in total energy generation. The lack of synchronisation is magnified by the fact that most import and exchange activities are settled ‘in-kind’, making it difficult for emergent investments in RES to supply regional demand to achieve economic viability (KAPSARC, 2018).

According to KAPSARC (2018), effective market integration takes a long time to materialise and requires changes in governance structures, specifically liberalisation of markets. Equally, the integration of RE systems introduces administrative challenges that can only be solved through increased regionalisation among countries, many of which face governance challenges domestically. As a result, KAPSARC (2018) has identified the following measures without which regional integration of electricity markets cannot be realised:

- Effective price reforms to eliminate supply-side price distortions
- Elimination of discrimination against third party agents to improve competitiveness and liquidity, both domestically and regionally
- Introduction of a trade regime that recognises that short-term progress in long-term bilateral relationships is necessary, especially for effective mobilisation and utilisation of resources
- Greater adaptability in current and future market designs, to increase flexibility at both upstream and downstream levels, and prevent wealth transfer from the poorer to the richer countries.
- Increased compatibility in the regulatory frameworks and mechanisms in MENA countries, in order to standardise functions in integrated electricity markets. Furthermore, regulatory frameworks can enhance cost-reflectiveness in the trading of electricity, to ensure that cross-border trading benefits all countries equitably.

4.3.3.2 Introducing Feed-in Tariffs (FiTs)

Most countries in the MENA region have introduced some form of FiTs, although there is no standardised approach (KAPSARC, 2018). In Palestine, the introduction of FiTs in 2012 targeted RE from wind and solar energy to drive demand and adoption at the commercial and residential levels. Similarly, Algeria and Iran have introduced FiTs, which are fixed in nature, with differentiated rates for peak times and peak loads, and countries such as Egypt and Saudi Arabia are in the process of commissioning FiTs targeting small scale RE projects. According to Zhang *et al.* (2017), the primary objective is to increase the affordability of REs in the region. The costs associated with adopting RE are a particular issue in the MENA region due to the prevalence of energy subsidies on fossil fuels.

4.3.3.3 Reducing Energy Subsidies on Fossil Fuels

Countries in the MENA region have relied on energy subsidies to drive economic growth by providing low-cost energy resources to residential and industrial consumers (El-Katiri and Fattouh, 2017). According to Al-Saidi, (2020), the MENA region accounts for the largest proportion of pre-tax subsidies in the energy sector, estimated at US$ 237Trillion (48% of the global subsidies). However, these subsidies have led to a distortion of the energy markets in the Middle East, and the widespread availability of cheap energy has led to increased wastage and inefficiencies in the allocation of resources. Although subsidies are popular locally, they are also regressive, typically benefitting wealthier citizens more than poor neighbourhoods due to differences in demand (El-Katiri and Fattouh, 2017).

The withdrawal of subsidies on fossil fuels in countries such as Jordan, Morocco, Egypt and Iran has increased the relative attractiveness of REs in those countries (El-katiri, 2014). Equally, Aghahosseini *et al*. (2016) concur with KAPSARC (2018) that the removal of subsidies has the effect of reducing the level of vertical integration and monopolisation, thereby making the market attractive for independent power producers (IPPs). In support of this, Al-Saidi, (2020) also indicated that the withdrawal of subsidies in the MENA region could free up resources estimated at 18% of regional GDP.

As El-Katiri and Fattouh (2017) make clear, withdrawing fossil fuel subsidies is a politically sensitive issue, especially in the Gulf states, where they are often seen as part of the social contract. However, the full economic potential of renewable energy cannot be realised within the region without reform of domestic energy markets and their pricing schemes.

4.3.3.4 Creation of Infrastructure to Utilise REs

In addition to the MENA Super Grid, a variety of new infrastructures have been created in the region to drive the adoption of REs, including sustainable energy systems within the ‘smart city' framework. Dubai, for instance, has been conceptualised as a smart city since 2015, with a focus on improving energy efficiency, notably in the construction and transportation sector, and laying down the foundations for the integration of services (Efthymiopoulos, 2015). However, as Virtudes, Abbara and Sá (2017) note, the development of smart cities, such as Dubai, is part of wider urban transformation in Gulf countries, made possible by their extensive oil wealth, and countries elsewhere in the region have faced challenges in the establishment of smart cities. According to Efthymiopoulos (2015) and El-Kholei and Yassine (2019), key reasons for this include:

- Prevalence of illiteracy in the adult population, which affects strategic decisions at the national level
- Lack of technological capabilities, which compromises the efficiency and suitability of the smart cities, making them vulnerable to cyber-attacks.

Given the low levels of renewable energy use in the MENA region, some countries, notably Qatar and the UAE, have appointed ‘National Champions’ to spearhead the establishment of domestic energy policies. According to KISR (2019), these champions coordinate the various dimensions and resources for REs and provide an interface between stakeholder entities in order to address challenges in administrative, governance and technical abilities. The introduction of national champions is based on lessons from Nicaragua, which succeeded in transitioning from being a net energy-importer to generating sufficient electrical energy to meet over 50% of domestic demand in the decade between 2005 - 2015. As mechanisms for enhancing social acceptance have been found to revolve around information symmetry across all stakeholders (Alnaser and Alnaser, 2019), national champions have the potential to a significant role in promoting acceptance of RE. More details about their roles in Dubai (UAE) and Qatar are shown in Table 4-3.

Table 4-3: Utilisation of National Champions for REs in the MENA Region

Country	**National Champion**	**Objectives and Achievements**
Dubai	Dubai Supreme Council of Energy of 2009	**Objectives:** • Long-term growth in sustainable energy, including RES • Improving energy efficiency • Diversification of energy sources by 2030
Qatar	National Champion for the Environment	**Achievements:** Development of the 1st National Development Strategy for 2011-2016 for improvement in energy efficiency to support ecological awareness goals.

Source: Reproduced from (KISR, 2019)

4.3.4 Community Development and Awareness Creation

The adoption of national energy champions in Qatar and the UAE is part of broader efforts within the MENA region, specifically in the GCC countries, to create knowledge economies to drive their socio-economic development. This includes specific policies aimed at raising awareness of RE and developing the technical knowledge and skills required to support their use.

Alnaser and Alnaser (2019), who followed the development of RE across the GCC since 1970, found that one of the outcomes of their adoption was the "Establishment of new academic programs and courses in solar and other renewable energy technologies in the higher education institute and technical organizations" (p.3). The need for such programmes in schools, colleges and universities still exists. Aktamis (2011) used the 'Energy Saving and Energy Awareness Scale' to determine the level of awareness regarding REs among students. Based on data from 400 respondents in secondary schools in Turkey, the study revealed that while secondary school students showed a high degree of familiarity with RES and energy saving, they had limited interest in the particular solutions they offer.

By contrast, Zyadin *et al.* (2014), who investigated the perceptions of teachers towards REs in Jordan, found that teachers had limited knowledge about the subject and held neutral views on RE usage. However, the findings of a recent study by Rillero *et al.* (2020), which focused on education policies targeting awareness of solar energy in Palestinian schools, revealed that increased awareness among the teachers, coupled with measures to transfer their knowledge to the students, led to increased proficiency in RE-related knowledge.

In Jordan, changes to the curricula, specifically those related to engineering, were reviewed in a study by Alawin *et al.* (2016) in order to determine how institutions of higher learning oriented their pedagogical content to meet industry requirements. Data from 264 students from five institutions of higher learning was analysis through ANOVA and t-tests. The descriptive statistics revealed limited awareness about RETs among the engineering students. This lack of proficiency and knowledge explains why Jordan, like many other developing countries, continues to rely on imported RETs, rather than developing the technologies domestically.

4.4 Summary

This chapter has highlighted some of the issues which affect the development of renewable energy use within the MENA region. The widespread availability of fossil fuels means that energy policies in these countries are designed to promote easy access to electricity and energy, and this explains the high levels of subsidies that have led to distortions in the demand and supply structures. However, significant steps forward have been taken, notably in the creation of the MENA Super Grid, the introduction of FiTs, the establishment of RE infrastructure, and in moves to develop knowledge-based economies. If these countries are to achieve their published targets, considerable expansion in RE capacities will be required, supported by strategic policies and planning to liberalise energy markets and ease the transition away from heavily subsidised oil and gas. The next chapter considers the energy situation in Kuwait, the subject of this research, whose economy and population are heavily dependent upon fossil fuels for both export earnings and domestic use.

Chapter 5

Energy Demand and Renewable Energy Utilisation in Kuwait

5.1 Introduction

This chapter focuses on energy demand and the renewable energy sector in the State of Kuwait. It begins by presenting geographic and demographic data, and highlights both the significant oil reserves within the country, and the increases in population their exploitation has engendered. It goes on to describe current domestic energy demand and the capacity available to meet that demand. The second part of the chapter traces the development of renewable energy in Kuwait and explains how solar and wind have come to dominate the renewable energy mix. It details current solar and wind capacity, and then considers the policies and strategies in place to increase RE capacity. It concludes by considering future renewable energy development in Kuwait.

The significance of this chapter lies in highlighting the historical identity of the renewable energy sector in Kuwait, in clarifying the objectives of current RE policy in relation to current energy demand, and in establishing an evidence-based foundation for the data collection and analysis which is reported in the following chapters.

5.2 Kuwait Country Profile

Kuwait enjoys the status of gateway to the North-West Arabian Peninsula due to its strategic location between Iraq and Saudi Arabia. The country has the hot dry climatic conditions typical of the Sahara region, and more than 90% of its landmass is uninhabited (PACI, 2010). In addition, it has shallow coastal water with high and low tides and includes a number of islands in the Arabian

Gulf. While these elements suggest that RES, notably solar, wind, and wave power, are viable in Kuwait, the country's primary source of energy is its extensive oil fields (See Figure 5-1).

The population in Kuwait is largely urban and has grown significantly over the past two decades, rising by an average of 4.1% each year between 1994 and 2011 (E.P.A, 2012). It is worth noting that the largest population centre is not the capital, Kuwait City (pop. 60,064), but Al Ahmadi (pop. 637,411), the city which houses the headquarters of the Kuwait National Petroleum Company and the Kuwait Oil Company and neighbours Mina Al Ahmadi, the principal port for the export of crude oil products and gas. According to (KISR, 2019), Kuwait has the 6th largest confirmed oil reserve in the world, and the oil industry accounts for 90% of its revenues, and 40% of its GDP. Due to the country's relatively low population, the government has implemented policies aimed at ensuring the oil reserves are utilised for national development; these include nationalisation of the oil sector and the establishment of welfare systems to alleviate poverty.

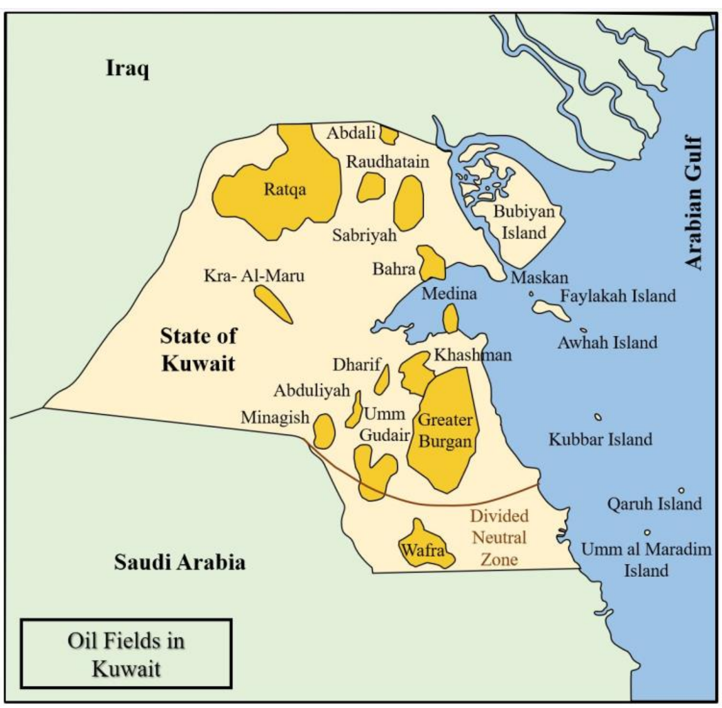


Figure 5-1: Map of Kuwaiti Oil Fields

Source: Reproduced from (E.I.A, 2016)

5.3 Energy Demand in Kuwait

As the population in Kuwait has increased, the demand for electrical energy has risen, notably in the summer season when temperatures reach 54˚C and air conditioning accounts for a considerable portion of residential and commercial energy use. During the 30 year period between 1987 and 2017, peak load consumption grew from 3740 MW to 13800 MW, with exponential growth in electricity usage (MEW, 2018b) (See Table 5-1). Furthermore, according to forecasts for the years 2019 to 2026, peak load demand will increase further, from 14049 MW in 2019 to 15063 MW in 2026 (See Table 5-2). Much of this growth has been ascribed to the new housing and commercial projects initiated in GCC countries in last few years, leading regional electricity consumption rates to rise by an average rate of 6% to 7% per annum between 2003 and 2013 (IRENA, 2016a). According to these stats, the increase in energy demand in the region is the highest in the world.

Table 5-1: Peak Load Growth Over a 30-Year Period

Year	Peak Demand (MW)	Installed Capacity (MW)	Mean Annual Rate of Peak Load Growth During 10 yrs (MW)
1987	3740	6696	-
1997	5360	6898	5.22 %
2007	9070	10481	5.42 %
2017	13800	18743	4.3 %

Source: Reproduced from (MEW, 2018b)

Table 5-2: Future Estimates of Peak Demand and Generation

MEW Networks Only		**Year**
Expected Electricity Energy Generation (M.kWh)	**Peak Load (M.W)**	
75426	14049	2019
76769	14190	2020
78135	14331	2021
79526	14475	2022
80942	14620	2023
82382	14766	2024
83849	14913	2025
85341	15063	2026

Source: Reproduced from (MEW, 2019)

According to (KISR, 2019), Kuwait has the highest per capita energy consumption in the world, estimated to be equivalent to 8.9 metric tonnes of oil per annum. To put this in context, average consumption in the OECD is estimated at 4.1 metric tonnes, while the average for the MENA region is estimated at 3.2 metric tonnes. The high demand in Kuwait can be attributed to subsidisation and poor allocation of energy resources leading to wastage. The greatest proportion of energy is used for industrial purposes, accounting for 31% of the total, mostly going to the oil extraction and processing sector (KISR, 2019). Meanwhile, the overreliance on private transport due to poorly developed mass public transportation system means transportation accounts for 25% of the total final consumption (Al-Saidi, 2020). However, like other oil-producing countries, the volatility in the supply and demand of oil, coupled with changes in technology, has precipitated the need to adopt REs to supplement and complement current energy and electricity production.

5.3.1 Stages of Growth Per Capita in Electricity Consumption

It is evident that the increase in energy demand and electricity consumption in Kuwait is associated with population growth. Those who study economics and energy dynamics have established a relationship between increasing population growth and an increase in per capita electricity consumption which is in turn related to an increase in the national income for the state (Demeny and McNicoll, 2003). Per capita consumption of electrical energy between 1986-2016 showed a dramatic shift: in 1986 the electricity per capita was recorded as 7910 KWh/person whereas by 2016 it had soared to 14036 KWh/person. Thus, in the past 30 years the per capita electricity consumption has increased at least two fold (See Figure 5-2). Energy production has increased significantly over this period to meet rising demand. According to studies conducted in 2017, in 1986 the power stations in Kuwait had the capacity to generate 5386 MW of electricity, whereas by 2016 this had risen to 18870 MW (MEW, 2017).

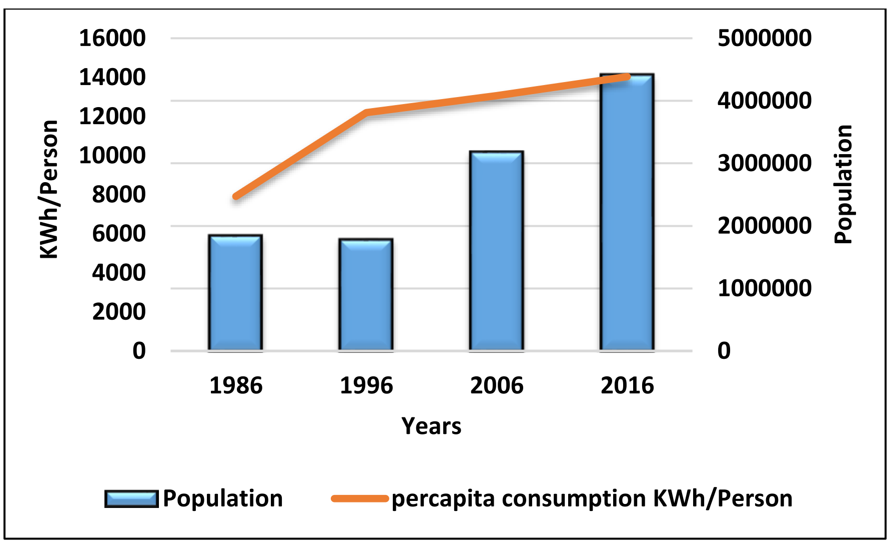


Figure 5-2: Per Capita Consumption of Electrical Energy

Source: Reproduced from (MEW, 2017)

5.3.2 Kuwait's Power Supply Capacity

The primary demand in Kuwait is for electrical energy, and the plants which produce electricity are considered as advanced utilities. There are currently eight conventional power stations in the country, with a total combined capacity of 19,353 MW, an almost four-fold increase since the mid-1980s. These operate by means of gas turbines, steam turbines and combined cycle turbines, and are driven by oil and natural gas. Just one power station uses renewable sources, providing a total additional capacity of 70 MW. This is part of the Al-Shagaya Renewable Energy Center project. Details of the available capacity of each individual power station are provided in Table 5-3

Table 5-3: The Available Capacity (MW) in Kuwait's Power Stations (on 30 June 2019)

Stations	**Current Available Capacity (From Fuel)**						**Current Available Capacity from Sustainable Energy**	**Current Available Capacity**
	Gas Turbines		**Steam Turbines**		**Combined Cycle Turbines**		**10 PV - 50 CSP 10 Wind**	
	Capacity of Each Unit	Total	Capacity of Each Unit	Total	Capacity of Each Unit	Total	-	
Shuwaikh Station	6 x 42	252	-	-			-	**252**
Shuaiba South Station	-	-	6 x 120	720			-	**720**
Shuaiba North Station	3 x 220	660			1 x 215.5	215.5	-	**875.5**
Doha East Station	4 x 18	72	7 x 150	1050			-	**1122**
Doha West Station	S x 28.2	141	8 x 300	2400			-	**2541**
Az-Zour South Station	8 x 130 4 x 27.7 5 x 165 2 x 250	1040 110.8 825 500	8 x 300	2400	2 x 280 2 x 185	560 370	-	**5805.8**
Sabiya Station	6 x 41.7 4 x 62.5 6 x 220 2 x 250 2 x 250 2 x 315	250.2 250 1320 500 500 630	8 x 300	2400	3 x 215.5	646.5	-	**6496.7**
Az-Zonr North Station	5 x 220	1100			2 x 220	440		**1540**
Shygaya Station							70	**70**
Total		**8151**		**8970**		**2232**	**70**	**19423.0**

Source: Reproduced from (MEW, 2019)

5.4 The Early Stages of Renewable Energy Development in Kuwait

The development of oil and natural gas resources has been central to the Kuwaiti economy for many years, both as the main source of income for the state and in the generation of electricity for domestic use (El-Katiri and Husain, 2014). However, the country has also been a regional pioneer in the development of renewable energy resources. The Kuwait Institute for Scientific Research (KISR), established in 1967, was first of its kind in the GCC area to study possible applications of these fuels and assess their cost-effectiveness with the aim including renewable energy in both Kuwait's and the GCC's energy mix. The establishment of this centre belied the popular belief, promoted by the international media, that the GCC states had no interest in renewables at this time.

Solar and wind technologies were the primary targets of investigation in relation to the energy sector in Kuwait, and experimental projects as well as economic modelling exercises were used to conducts studies. Early findings indicated that solar technologies tended to be more expensive when it came to the production of electrical energy and failed to serve the strategic interests of the country. These conclusions held throughout the late 1970s and early 1980s until they were finalized by KISR's original research team in 1986. It must be noted that the costs of concentrating solar power (CSP), photovoltaic (PV), and wind technologies at the time were very high in comparison with current costs.

In February 1980, the *New Scientist* Magazine published an article entitled 'Arabs Turn Their Eyes to the Sun' (Perera, 1980), which showcased Kuwait's role as the first country in the Arab region to start building a pilot solar power plant. Despite the concerns about solar's strategic value, this was developed for Kuwait by the German firm MBB and used 'farms' of collectors to produce up to 100 kW of electricity (See Figure 5-3). This joined the first solar thermal power plant in Kuwait, the Sulaibiyah plant, which operated from 1979-1986 (See Figure 5-4).

Figure 5-3: Solar Collector developed for Kuwait

Source: (New Scientist, 1980)

Figure 5-4: First Solar Thermal Power Plant in Kuwait 1979-1986

Source: (KISR, 2016)

5.5 Current Renewable Energy Resources in Kuwait

The early decisions to develop a renewable energy sector in Kuwait were driven by the potential of solar and wind energy, and these now form more than 60% of the energy portfolio, alongside geothermal, hydropower, and biofuel (See Figure 5-5). As a result, the formal adoption of REs, which can be traced back to 2013, mostly involved wind and solar energy (See Table 5-4). Although wind energy was introduced earlier, solar PV technology has become more widespread; this can be attributed to the fact that the deployment of solar energy technologies, at the small and medium scale, is easier than the installation of wind-farms (Nemet, 2019).

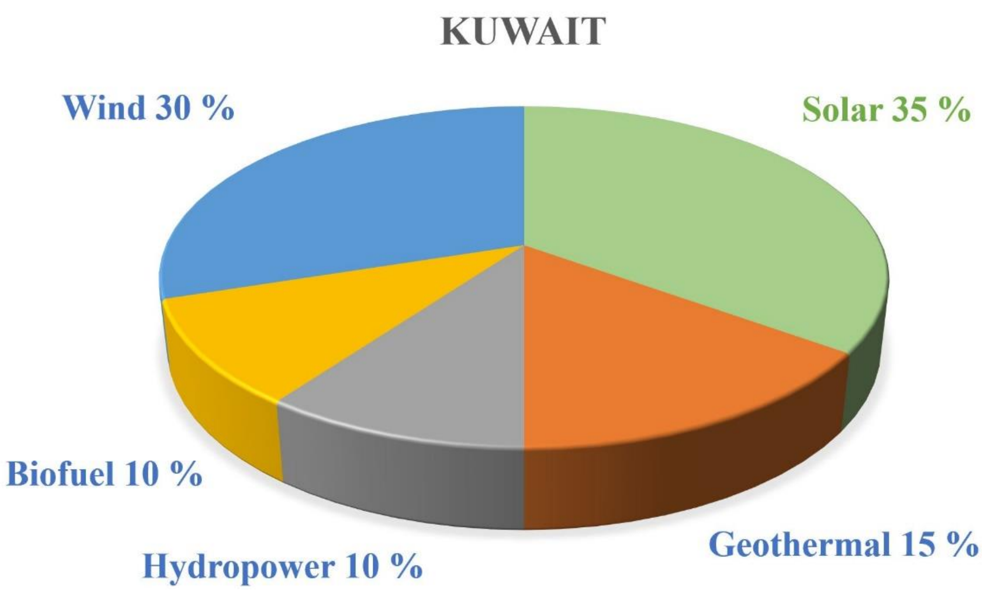


Figure 5-5: The Availability of Renewable Energy in Kuwait

Source: Reproduced from (Jerath *et al.*, 2015)

Table 5-4: Kuwait Energy RES (Solar and Wind)

Indicator	Technology	2013	2014	2015	2016	2017	2018
Electricity capacity (MW)	Total renewable energy	3	4	6	33	44	55
	Wind	2	2	2	2	12	12
	Onshore wind energy	2	2	2	2	12	12
	Offshore wind energy						
	Solar	0	2	3	31	32	43
	Solar photovoltaic	0	2	3	31	32	43
	Concentrated solar power	0	0	0	0	0	0
Electricity generation (GWh)	Total renewable energy	0	3	5	49	69	88
	Wind	0	0	0	0	18	18
	Onshore wind energy	0	0	0	0	18	18
	Offshore wind energy						
	Solar	0	3	5	49	51	71
	Solar photovoltaic	0	3	5	49	51	71
	Concentrated solar power	0	0	0	0	0	0

Source: Reproduced from (IRENA, 2020a)

5.6 Policies and Strategies for Renewable Energy Development

The adoption of REs in Kuwait has introduced several benefits, including improvements in end-user efficiency, as RE generation is not subsidised by the government in the same manner as fossil fuels. According to Jandal (2014), Kuwait's energy policy, which significantly informs its RE policy, is motivated by three outcomes: adaptation (to meet the increasing demand for electricity and energy), mitigation (to prevent or reduce high emission rates) and diversification (to identify new sources to meet emergent demands). The policies for RE are primarily aligned with the development of sustainable energy systems and include measures to enhance efficiency in both residential and industrial establishments (See Table 5-5). This focus on efficiency dates back to 1983, years before the widespread adoption of RE, when the Ministry of Electricity and Water established baseline standards for efficiency in residential energy use. The code, which was revised in 2010, provides stringent measures to ensure citizens adhere to energy efficiency requirements (Shehabi, 2017).

Table 5-5: Policy Reforms for Optimisation of Energy Efficiency in Kuwait

Energy Efficiency Measures	• Enforce and update building regulations and codes to reduce energy demand for air-conditioning. • Enhance the arrangement of windows in buildings to increase efficiency and install integrated photovoltaic systems. • Invest in building retrofits. • Invest in district cooling. • Implement a standardized labelling program for appliances and equipment. • Encourage energy service companies to market energy efficiency programs to consumers and support consumers in estimating energy savings.
Energy Policy reforms	• Gradually replace universal subsidies with targeted cash transfers or compensation schemes for eligible consumers. • Clearly define a price adjustment mechanism for future price movements. • Incorporate measures to protect energy-intensive firms from the inflationary effect of price increases. • Launch a sustained, long-term public awareness campaign ahead of energy price reforms.

Source: Reproduced from (KISR, 2019)

Kuwait has also entered into a number of Bilateral Investment Treaties (BITs) aimed at providing capital and technology for RES. According to a report by PWC (2016), the country has introduced two key features into its legal framework to enhance the attractiveness of treaties with foreign investment partners. Firstly, investment partners have a ‘cooling-off’ period after the negotiations, during which parties can withdraw from the agreement without consequences. Secondly, the use of ‘umbrella clauses’, designed to provide additional protection from risks associated with REs, including additional obligations by the State. Further provision is made in the following laws and decrees which are designed to reassure foreign investors, some of whom are wary of the investment climate in the Middle East (PWC, 2016).

Table 5-6: Laws and Decrees Facilitating Expansion of RE in Kuwait

Law/ Decree	Outline
Decree No. 55 of 2011	Ratification of the agreement between the government of Kuwait and France in the development of ecologically sustainable and renewable energy
Decree No. 194 of 2011	Ratification of the Memorandum of Understanding (MOU) for collaboration in the energy sector, specifically RES, between the government of Kuwait and Algeria
Decree No. 159 of 2011	Ratification of the MOU for electricity generation collaboration between the government of Kuwait and Egypt.

Source: Reproduced from (PWC, 2016)

According to KISR (2019), through political support from the General Secretariat of the Supreme Council for Planning and Development (GSSCPD), Kuwait has now developed a comprehensive energy policy, featuring in-depth projections showing different scenarios for development and analysis through to 2035. However, as of 2019, the country has only managed to supply 1% of its energy demands from RES. Further significant development is unlikely unless the country takes greater steps to reform current subsidies on fossil fuels.

5.6.1 Changes to Policies on Subsidies

The need for a change in Kuwait’s energy policies, specifically those designed to promote the adoption of RE, is evidenced by both empirical research and market reports. The distortionary and pervasive effect of subsidies in the country, which is aligned with economic theory, was reviewed by Plante (2014). Based on this study, the energy market in Kuwait has experienced extensive distortion, since subsidies tend to benefit consumers with high demand, rather than those with low incomes. This is one of the reasons why the country has started scaling back the subsidies, with the largest effects recorded between 2014 and 2015, when spending on subsidies fell from 11% of the GDP to 8%.

Subsidies also have an adverse effect on the national oil company. A study by Hartley and Medlock (2008) concluded that public entities experienced more inefficiencies than private energy companies, primarily due to access to subsidies. Similar conclusions were drawn by BuShehri and Wohlgenant (2012), who indicated that although the withdrawal of subsidies had the undesired effect of hurting welfare structures, it was necessary to align residential energy and electricity prices with free-market forces while using strategies such as cash transfer to alleviate welfare challenges. Kuwait’s subsidies were placed under review under Law No. 20, and, while (KISR, 2019) reports there is no absolute poverty in the country, policy-makers will need to consider the economic impact of further subsidy cuts if popular support for renewables is to be maintained.

5.6.2 Establishment of National Champions

Kuwait has followed the example of Qatar and the UAE and established a National Champion, the Higher Energy Committee of 2018, to drive its RE and sustainable energy objectives. The committee has been tasked with the following responsibilities:

- Spearheading the participation of Kuwait in international forums where decisions on REs are made
- Enhancing horizontal coordination between the energy ministry, regulatory institutions, and service providers, specifically those in the private sector
- Coordination between regional, central and local government entities and stakeholders

Findings from theoretical research by Shehabi (2017) concurs with industry reports by KISR (2019) which conclude that Kuwait's RE strategies cannot be effective without a separation of the regulatory frameworks from the policy-making entities. This would enable research institutions, such as KISR, to provide insights for the implementation of an RE strategy by the market players.

5.7 Future Renewable Energy Development in Kuwait.

Kuwait has employed the energy scenarios approach to projecting the future of RES in the country, as discussed by Ghanadan and Koomey (2005) and Sarmiento *et al.* (2019). As Jandal (2014) explains, Kuwait RES strategies are based on four potential scenarios, as shown in Table 5-7.

Table 5-7: Kuwait's RE Development Scenarios (2010-2035)

Energy scenario	Description
REF	The 'Reference' scenario, whereby the conventional fossil fuel energy development and utilisation achieved in 2008 is maintained into the future.
REF-RE$_{10}$	Target scenario, whereby the technologies under the REF Scenario for future energy are comprised of 10% renewable energies by the target date of 2030.
REF-RE$_{20}$	Target scenario, whereby the technologies under the REF Scenario for future energy are comprised of 20% renewable energies by the target date of 2030.
REF-ff	Policy-driven scenario, whereby the simulated energy portfolio is characterised by minimal reliance on fossil fuels, which are highly flexible (ff = flexible fossil

	fuels), while most industrial and commercial electricity is generated through RES, supplemented with fossil fuels.

Source: Reproduced from (Jandal, 2014)

By using the energy scenarios approach, Kuwait has adopted a conventional approach to modelling the future of RE, but the scenarios are tailored according to domestic needs. As Anano (2019) indicates, by customising these scenarios, Kuwait can enhance the utility of these forms of energy in its portfolio. However, the adoption of unique scenarios that differ from those utilised elsewhere in the region or across the globe, means Kuwait will be unable to compare its progress with that of its neighbours or other countries.

The scenarios used to predict the future composition of Kuwait's REs portfolios have differing outcomes concerning each RE. For example, a flexible fossil fuels scenario, whereby 20% of the energy in the country is sourced from RES, can only be achieved through the widespread use of nuclear energy due to the intermittency issues associated with other RES (See Figure 5-6). This is in line with the findings of USEIA (2020), which showed nuclear energy was reported to have the highest capacity factor (See Chapter 2, Table 2-5).

Despite the differences in the energy profiles under the four scenarios, KISR estimates that Kuwait may experience a drop in the cost efficiency of energy generation from renewable sources. Although the LCOE for RES have generally fallen with an increase in the scale of production (IRENA, 2020a), projections by Ali and Alsabbagh (2018) reveal a potential increase in the cost of energy generation systems relying on CCGT, which is often utilised to solve the challenges of intermittency in RE (See Table 5-8). This is supported by recent studies, notably Abdelrahim (2019) and Aghahosseini, Bogdanov and Breyer (2020).

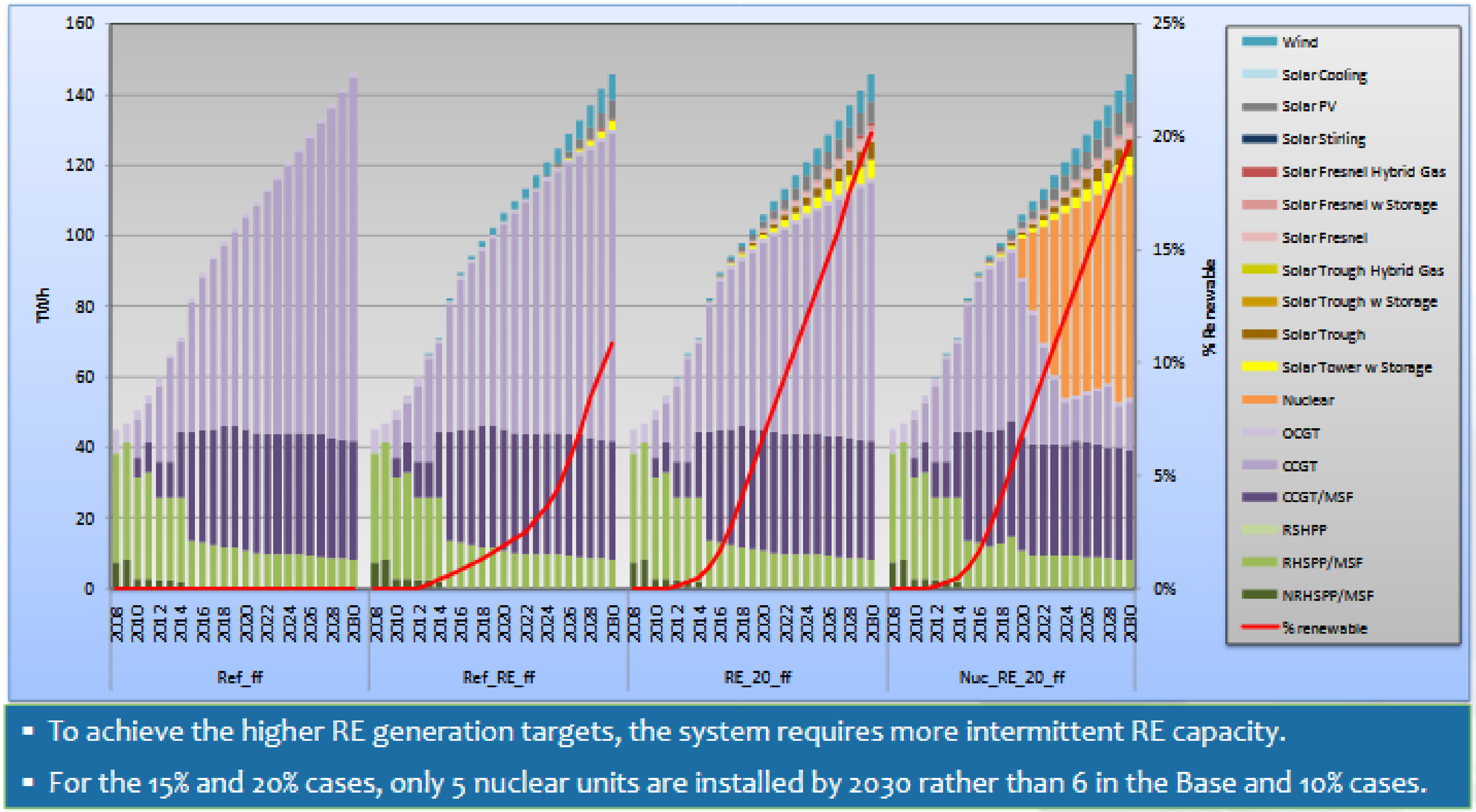


Figure 5-6: Energy Scenarios for Kuwait

Source: (Ali and Alsabbagh, 2018)

Table 5-8: Changes in LCOE for REs in Kuwait

Technology	LCOE ($/MWh)	
	2015	2030
Combined Cycle Gas Turbine (CCGT)	97	125
CCGT/Multi-Stage Flash	118	159
Reheat Steam Turbine	160	175
Solar CSP Trough	198	144
Solar CSP Trough + 6 hrs storage	293	217
Solar CSP Trough + 10 hrs storage	212	154
Solar PV Central	165	91
Solar PV Distributed	177	99
Wind	106	82

Source: Reproduced from (Ali and Alsabbagh, 2018)

5.8 Summary

This chapter has provided an overview of the status of renewable energy in the State of Kuwait, from its beginnings in the late 1960s until the present day. It has set out current energy usage and capacity in the country and considered how renewables could be developed to meet future demand. It has focused in particular on the policies in place to support the renewable energy sector, and highlighted the need for change in certain areas, notably the way energy is subsidised. Although Kuwait has been a regional pioneer in the introduction of renewable technologies and projects, current efforts to expand the sector are hamstrung by the fact that fossil fuels are deeply woven into the fabric of society. While positive measures have been introduced, including laws to facilitate foreign investment in renewables and the introduction of national champions, prevailing energy policies, particularly fossil fuel subsidies, do not encourage greater RE utilization in the country. To achieve better outcomes and fulfil the goal of generating 15% of its total energy mix from RES by 2030, Kuwait needs an overhaul of its energy policies, institutional frameworks, and a change in its culture towards the generation and utilisation of energy.

The next chapter explains the methodology and methods of data collection and analysis which underpin the research conducted for this study.

Chapter 6

Methodology

6.1 Introduction

This chapter moves on from the review of literature relating to energy demand and the adoption of RE to describe the methodology which underpins this investigation. It explains the philosophy behind the research, the target samples for the study, the research instruments used, the analysis methods adopted, and the ethical considerations addressed before the research was undertaken. Justification for the choices made in all phases of the study is also provided.

Since this research is concerned with investigating the renewable energy sector in Kuwait, it was essential to obtain energy consumption and renewable energy utilisation data from both the general public and the private sector in the country. As a result, a mixed-methods approach was adopted to obtain reliable and valid data. Quantitative data was gathered by means of structured questionnaires targeting three groups of participants: members of the public; official organisations participants; and academic organisations participants. Qualitative data was collected through semi-structured interviews with experts, legislators and policymakers in governmental and non-governmental organisations with links to the energy and renewable energy sector in Kuwait. Data collected was coded and analysed, with a SWOT analysis used to examine the viability of solar energy in Kuwait as an alternative to conventional fossil-based fuels. Further details of the research approach and the methods adopted are set out in the chapter below.

6.2 Research Philosophy

The philosophy of research is part of the investigative process and indicates how the researcher defines the reality regarding the research phenomenon (Saunders *et al.*, 2016). As an overriding paradigm, the research philosophy offers a generalist view of how the research data is gathered, processed, analysed and used in answering the research questions. Göran (2012) indicates that the research philosophy can generally be defined based on what is known to be true about the research subject, and what the researcher believes to be true. These two dimensions arise from the fact that, while some aspects of the research questions are clarified via the literature review, other aspects require further investigation.

Two primary research philosophies are applicable to this study; the positivist and the interpretivist perspectives. According to Saunders, Lewis and Thornhill (2016), the positivist perspective entails the definition of reality based on natural phenomena – the relations and properties that exist in the natural world. The exclusion of any speculation in defining reality implies that the views of all researchers about a particular phenomenon are identical, and the rigidity of the positivist perspective has been criticised for excluding the views of the researcher (Göran, 2012). The interpretivist perspective, by contrast, involves the definition and interpretation of reality based on the perceptions of the researcher (Saunders, Lewis & Thornhill, 2016). This perspective involves the knowledge, experience and background of the researcher; thus it is possible to achieve different outcomes from identical projects if different researchers are involved. The personalization of the processes introduces new forms of value to the research project. However, due to the lack of predictability in the outcomes, the interpretivist perspective is applied under strict guidelines.

Due to the limitations of these two perspectives, Lin (1998) indicates that researchers have the option of utilizing pragmatic philosophy, which involves the use of the available evidence in defining reality. Pragmatism draws on the positive aspects of positivism and interpretivism to construct a research paradigm that facilitates comprehensive investigation of a research topic, using the available evidence, to generate workable recommendations (Biesta and Burbules, 2002). In pragmatic studies, the researcher focuses on defining reality based on how it can be applied in a real-life scenario; this approach is of considerable value in research which aims to address problems in the real world, as is the case in this study.

6.3 Research Design

The choice of research design is influenced by a number of factors, primarily the overriding objective in analysing the findings from the study (Creswell, 2013). The objective can either be to confirm whether the findings fit into a particular expected scenario (confirmatory design), or to explore the findings to develop unique scenarios about the research topic (the exploratory design). The research design is also influenced by approaches to the development of theories about the study topic (Saunders, Lewis & Thornhill, 2016) and there are two main approaches: the deductive (which correlates to confirmatory research), and the inductive (which correlate to the exploratory design). Confirmatory research is typically utilised when the researcher has sufficient background information to form hypotheses about the relationships between the variables (Flick, 2015), while exploratory research is utilised when the researcher has limited knowledge and information. However, they both rely on the findings from the analysis to form theories and hypotheses about the research (Bell, 2014).

In this study, both the exploratory and confirmatory designs are adopted for the following reasons. Firstly, there is limited past research on the topic of renewable energy strategy, and almost no investigation of a similar kind in Kuwait. As a result, this research project can be considered as offering a pioneering perspective on the research topic. Secondly RE adoption in Kuwait is still in its infancy, and most of the progress identified in this study is based on plans for the future, and, while there are lessons to be learnt from other countries, as Chapters 3 and 4 suggest, the situation in Kuwait is unique. Thus, exploratory design is appropriate. However, Kuwait has already laid down targets for the development of REs, with articulate plans and institutional frameworks, so it is possible to use confirmatory design to determine the extent to which targeted outcomes have been achieved and to project whether the measures in place can deliver results.

6.4 Methodological Choice

Saunders, Lewis and Thornhill (2016) define the methodological choice as dependent on the type of data and analysis approaches that are selected for use in the study. There are two primary methodological choices: the quantitative and the qualitative methodologies. Bellamy (2012) defines quantitative methodologies as the approaches through which research into widely studied topics is performed in order to determine whether the data set fits into an expected outcome. Coolican (2013) further posits that quantitative research seeks to confirm whether the interactions and relationships between the variables are as expected. These highly structured approaches are facilitated through scientific models. By contrast, qualitative methodologies are best suited for investigations into research phenomena that have limited background research. This is because the lack of existing studies suggests that the researcher has to perform exploratory research to identify the variables and determine how they are related (Bellamy, 2012). In defining qualitative methods, Coolican (2013) indicates that the approach relies on the use of unstructured data collection and analysis to avoid limiting the research. Such data is in the form of text, images, audio, and audio-visual elements, and it facilitates exploration of the research topic from multiple dimensions.

In this study, both qualitative and quantitative approaches are used. When combined, the two approaches are applied as mixed methods. However, since they are used separately here, the methodology is best described as a sequential mixed-methods approach. As Saunders, Lewis and Thornhill (2016) indicate, the sequential mixed methods approach entails the utilisation of one methodology in sealing the gaps and weaknesses in the findings from the previous research process. As a result, rather than triangulate the findings, the sequential mixed methods approach enables the researcher to complement and supplement the findings under the first data analysis process through the subsequent activity. In addition, the mixed methods approach is a good fit for the present research design as it combines confirmatory and exploratory designs.

6.5 Research Data Collection

The process of data collection is selected based on the type of data involved. There are two main categories of data to be collected: primary and secondary data, and each has its own characteristics.

6.5.1 Primary Data Collection

According to Bell, Bryman and Harley (2018), primary data is collected directly from the sampled individuals. Its advantage exists in the fact that it is collected according to the parameters of the study; thus it is always relevant to that study. Furthermore, in cases where it is deemed insufficient, the researcher has the option of implementing a subsequent data collection run, a process that can involve changes to the sample size and the sampling approach. Two methods of collecting primary data were utilised for this research:

- **Interviews:** Conducting personal interviews, whether face to face, by phone or by e-mail.
- **Questionnaires:** Distributing questionnaires electronically through social media, apps and via e-mail.

6.5.2 Secondary Data Collection

Secondary data is data which has already been collected, often for another purpose. Much of the secondary data for this study was collected when the researcher visited Kuwait and obtained documents from ministerial and legislative authorities, research institutes and educational organisations, non-governmental institutions, and consulting companies in the private sector. These documents included annual reports, climate data, annual data for energy generated from photovoltaic (PV), ministerial procedures and decisions, and the plans and proposed strategies for current and future renewable energy projects. The collection and analysis of this secondary data informed the researcher’s understanding of the current status of renewable energy in Kuwait and the attitudes of policymakers and key organisations regarding its viability and effectiveness.

6.6 Research Instruments Design

The design of the research instruments is an integral step in laying down the foundation for the collection of data. The characteristics of the research instrument influence its suitability for the respondents, and these differs depending on whether it is an interview guide or a questionnaire.

6.6.1 Survey Questionnaires

The survey questionnaire is designed based on the variables identified in the literature review. The constructs, which are represented by the various questions about the research phenomenon, are framed in a manner that ensures the research questions are fully answered. According to Saunders, Lewis and Thornhill (2016), designing a questionnaire for a survey includes identification of the survey questions and development of a scale to measure the responses. Since the questionnaire is a self-administered instrument, it is necessary to provide articulated questions, with measurement scales to ensure predictability in the responses. The scales used for the survey questionnaire are known as Likert scales, which represent different levels of responses to the questions, based on the extent to which respondents ‘agree’ or ‘disagree’ with a statement.

6.6.2 Interview Guides

As Bell, Bryman and Harley (2018) note, interview guides can either be structured, unstructured or semi-structured. Structured interview guides are rigidly designed, covering all dimensions of the investigation, with limited options for adjustments by the researcher. Unstructured guides, on the other hand, are more general and loosely defined, and the researcher has the option to determine the direction of the investigation. The semi-structured interview falls somewhere between the two, entailing the predetermination of most of the interview questions, but leaving room for adjustments to the line of questioning (Flick, 2015). The option to make adjustments enables the researcher to confirm the responses and ask novel questions based on the responses provided by the interviewee. This is particularly important in situations where the researcher is aware that interviewees have some particular knowledge, so provision is made for them to contribute new ideas to the interview process (Creswell, 2013).

6.7 Quantitative Data Collection (Questionnaires)

Due to the large proportion of foreign nationals in Kuwait’s population, the questionnaires were designed in both English and Arabic. They were pretested on a sample of 100 respondents (comprising colleagues and friends) to determine their clarity with regards to the phrasing of the questions, and also, to test the overall responses of the participants. For reliability, the Cronbach’s alpha coefficient was calculated. This is discussed in more detail below (See 6.10.3).

6.7.1 Sample Size and Characteristics of the Questionnaires

The selection of a sample from a population is dependent on a variety of considerations. According to Coolican (2013), the most common approach to the selection of a sample in a survey study is the random sampling approach. Under this approach, each member of the population has an equal chance of being selected to provide data, thereby eliminating most forms of bias that the researcher might exhibit when selecting respondents. For this reason, random sampling was considered most appropriate for the questionnaires in this study

There were two categories of respondents to the questionnaires. The first questionnaire targeted members of the general public in Kuwait, hereafter referred to as the 'Public Questionnaire'. The sample size was calculated based on the population of Kuwait (4,082,704) as of November 2017, as estimated by the Central Statistical Bureau of Kuwait (C.S.B, 2017), using the formula set out in Figure 6-1. The sample size for the Public Questionnaire was calculated as 385 respondents, to be selected randomly. The calculation was determined with a confidence level of 95% and a margin of error of 5%.

$$\textit{Sample Size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Population Size = N | Margin of error = e | z-score = z

Figure 6-1: Sample Size Calculation

Source: (SurveyMonkey, 2019)

The Public Questionnaire was distributed electronically and ran online from 18 Nov 2017 until 17 Dec 2017. Respondents were asked to complete the questionnaire, but were free to choose whether to participate in the study and answer the questions (in either English or Arabic) or not. 1383 valid questionnaires (Arabic and English versions) were received from respondents and used in the analysis (See Figure 6-2 & Figure 6-3).

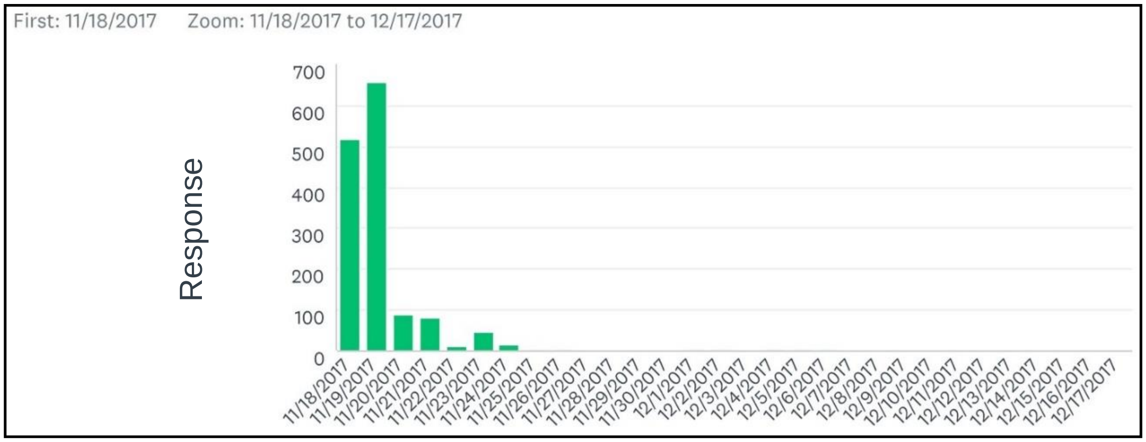


Figure 6-2: Responses Data for the Public Questionnaire (Arabic version)

Source: Author’s Own

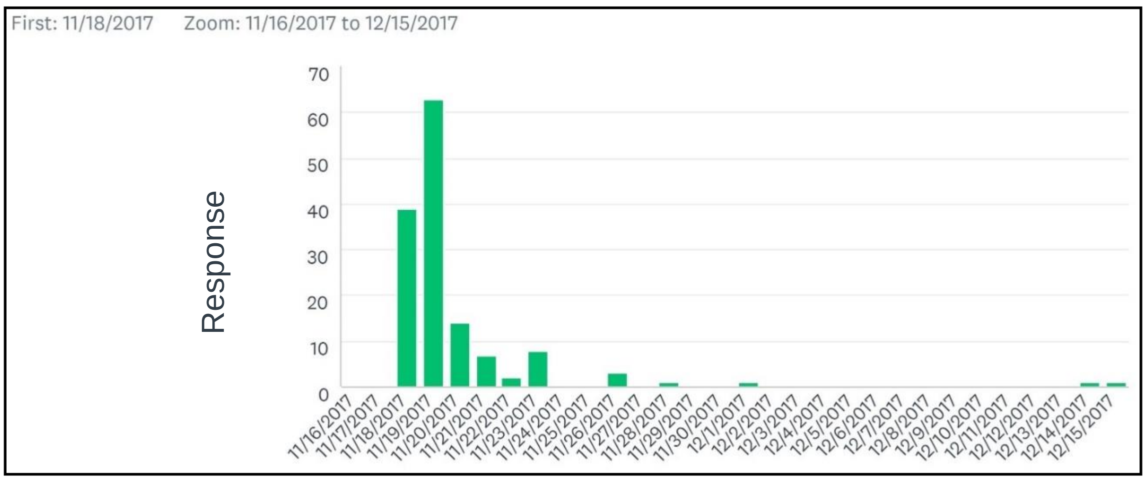


Figure 6-3: Responses Data for the Public Questionnaire (English version)

Source: Author’s Own

The second category of respondents completed the ‘Academic and Educational Organisations Questionnaire’ and the ‘Official Organisations Questionnaire’. These targeted much smaller populations and the study sample size was calculated to be 100 responses for each questionnaire. As with the Public Questionnaire, two versions of the questionnaires were designed in English and Arabic, and these were distributed randomly through electronic channels. The survey ran during

January 2019, and respondents were invited to complete the questionnaires, but were free to choose whether to do so or not. 105 Academic and Educational Organisations Questionnaires and 232 Official Organisations Questionnaires were received from respondents; all were valid, so all the questionnaires (n= 337) were used in the analysis.

6.7.2 Questionnaire Question Themes:

The questionnaires were organised in four parts (See Appendix I, II and III) and targeted the following themes:

- Background information of participants.
- User efficiency of electricity consumption.
- Knowledge and awareness of the advantages and challenges associated with Renewable Energy.
- Personal stance and attitudes towards Renewable Energy.

6.7.3 Questionnaire Data Analysis

The process of analysing the survey data involved three key stages to identify the relationships between the variables. Firstly, the measures of central tendency were used in analysing the demographic characteristics of the respondents; these indicate the nature of the respondents, based on their intrinsic characteristics, including personal and professional backgrounds. Secondly, the responses to the survey questions were analysed through descriptive statistics. Percentages and frequencies were used for the categorical variables, while mean and standard deviations were calculated for the continuous variables. These measures indicated the general inclinations of the responses and views of the sampled individuals regarding the questions in the survey instrument. Finally, non-parametric statistical tests were used according to the findings of the Normality Test. While Chi-squared test was used to test the association between the variables, Mann-Whitney U test and Kruskal-Wallis H test were used to test the differences in means of knowledge and awareness of the advantages and challenges of RE scores regarding demographic variables. Post-hoc test using Bonferroni Test was run to detect where the significant differences occurred within groups. Advanced statistical techniques, such as Factor analysis, were used to figure out the factors which characterise user efficiency of Electricity Consumption. All statistical analyses were performed in the latest version (v25) of Statistical Package for Social Sciences (SPSS). All the significance values were set at $p < 0.05$, while all the high significance values were set at $p < 0.01$. Statistical significance was used to test whether the relationship between the variables occurred by chance, or due to the characteristics of the variables (Pallant, 2016).

6.8 Qualitative Data Collection (Interviews)

The interviews were conducted via different approaches according to the availability of the interviewees. During the investigation phase, the researcher sought to determine the attitudes of a range of policymakers towards renewable energy utilisation in Kuwait, and the preferred approach was face-to-face contact. This preference is justified by Saunders, Lewis and Thornhill (2016), who noted that it enables the interviewer to observe visual responses from the interviewee, such as changes in demeanour following specific questions, or other forms of response. These visual cues were particularly significant in this study as the researcher relied on a semi-structured interview approach, with the flexibility to vary the line of questioning in light of the interviewees' responses, including seeking clarifications through follow up questions or adopting a different approach to see if the interviewee's views changed. As a result, the interviewer was able to make adjustments based on new information about the research topic from the professionals in the industry. In instances where face to face contact was not possible, the researcher relied on e-mail or telephone interviews.

The interviews were conducted in Arabic or English, according to preference of the interviewees. The data collected from the interviews were recorded in audio format and then transcribed and translated into English for discussion and analysis.

6.8.1 Sample Size and Characteristics of the Interviews

The interviews involved 18 individuals from 12 organisations, which were categorised into six different sectors (See Table 6-1). In order to collect adequate data for the study, interviewees in both the public and the private sector were targeted. Public sector interviewees included officials and leaders in governmental organisation and policymakers in the energy supply and renewable energy sector in Kuwait. The private sector interviewees included managers of renewable energy companies, private research institutions, and Kuwaiti associations.

Table 6-1: Sample Size and Characteristics of the Interviews

Classification	Interviewees List of Organizations	Interview Code	Number of Interviews	Interview Method
Renewable Energy Companies (Private Sector)	Smart Globe Company (SGC)	A	1	Face to Face
	Alternative Energy Projects Company (AEPC)	B	1	Face to Face
Research Institutes, Education Sector and Universities	Kuwait Institute for Scientific Research (KISR)	C1, C2	2	Email & Face to Face
	The Public Authority for Applied Education and Training (PAAET)	D1, D2	2	Email & Face to Face
	Ministry of Education (MOE)-Kuwait	F1, F2	2	Telephone
Governmental Organisations	Ministry of Electricity & Water (MEW)	G1, G2 & G3	3	Face to Face
	General Secretariat of the Supreme Council for Planning and Development (SCPD)	H	1	Face to Face
Policy Makers	Kuwait National Assembly (KNA)	I	1	Face to Face
Non-Governmental Organisations	United Nations Human Settlement Program-Kuwait (UNHSP)	J	1	Email
	Kuwait Society of Engineers	K	1	Face to Face &

	(KSE)			Telephone
Media	Kuwaiti Newspapers	L1, L2	2	Telephone
	Ministry of Information Kuwait (MOI)	M	1	Email & Face to Face
Total			**18**	

Source: Author's Own

6.8.2 Interview Question Themes

The interview questions focused on three areas: the current status of renewable energy in Kuwait, the state's plans for the future of renewable energy, and the obstacles it faces in achieving those plans. The interview form consisted of 26 questions (See Appendix VII & Appendix VIII), and these were classified under the following themes:

- Assessing the environmental situation of Kuwait.
- Validating the capacity and quantity of current and future renewable energy projects in the State of Kuwait.
- Exploring the role of government organisations in raising awareness of the need to rationalise electricity consumption.
- Exploring the role of government organisations in spreading awareness among consumers of the benefits of utilising renewable energy.
- Identifying the role of the government in selecting the most appropriate renewable energy sources and technologies.
- Identifying government procedures and legislation relating to renewable energy.
- Assessing the government's progress towards achieving the target of 15% renewable energy by 2030.
- Explore the obstacles faced by the government, and by private and public-sector consumers, in expanding the utilisation of renewable energy.

6.8.3 Coding the Interview Data

The process of coding the interview data, which is a precursor to data analysis, is aimed at transforming the data into information and observations that are meaningful (Saunders, Lewis and Thornhill, 2016). Coding is integral to the analysis of unstructured data, as the codes developed from the data establish cohesiveness in the data, by identifying relationships between the findings, and representing them as themes that can be linked and contrasted to form theoretical arguments. The classification of interview data into codes also facilitates the attachment of conceptual labels that shape the organization and interpretation of the findings within the research context, created through the problem statement, the research aims and the research questions.

In this study, coding was performed manually, using the following steps:

- Preparation and organization of the transcribed data. The data was then classified under each respondent.
- Formulating and translating the answers to the questions from Arabic and transcribing them into English (for those interviews which were conducted in Arabic).
- Review and exploration of the data, to determine sufficiency and relevance
- Creation of initial codes, based on the general characteristics of the content
- Review of codes and revision to combine the codes into themes. This included renaming and redefining the themes to make them representative of the data.
- Presentation of the themes coherently and cohesively.

6.9 Research Population and Sample

Saunders, Lewis and Thornhill (2016) define the research population as the collection of individuals who are sufficiently well-informed about the research topic to be able to respond to data collection activities. Any of these individuals can thus be selected to be part of the sampled individuals. The research population for this study was organised into seven groups, each of which plays an essential role in influencing renewable energy utilisation in Kuwait (See Figure 6-4).

Several entities within each group were targeted to collect data, whether by questionnaire or interview, or both. While members of the public received the Public Questionnaire, the type of questionnaire the other groups received was determined by the nature of the group (official or academic and educational organisation). Interviews were conducted with members of each group apart from members of the general public (See Figure 6-5).

Figure 6-4: Key Players in Renewable Energy in Kuwait

Source: Author’s Own

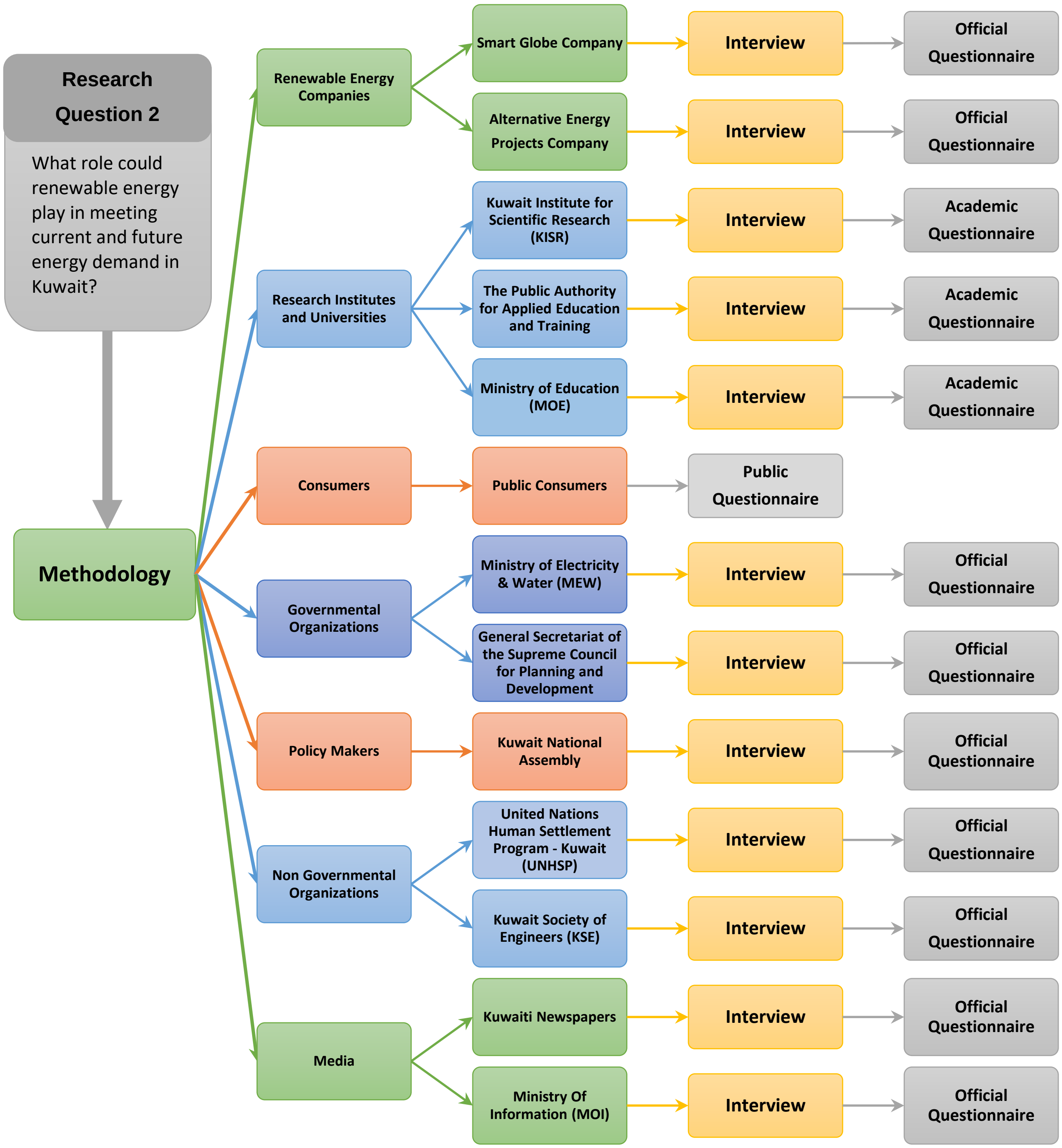


Figure 6-5: Research Population

Source: Author's Own

6.10 Research Data Analysis

Saunders, Lewis and Thornhill (2016) indicate that the process of analysing qualitative data involves an in-depth and unstructured methodology whereby the main objective is to identify the themes, the patterns of those themes, and establish how they can be formulated to develop theories. The process, which is referred to as exploration, involves identification of relevant content from the interview data. In this study, the process of analysing the data relied on two approaches: thematic analysis and content analysis. The use of two approaches enabled the researcher to triangulate some of the findings in order to ensure their validity.

6.10.1 Thematic Analysis

Thematic analysis was utilised in the identification of themes relating to strategies for renewable energy utilisation in Kuwait. According to Bell (2014), thematic analysis involves an intricate process of reviewing interview data to determine the relevant themes. The process is aimed at examining the content to determine which details are relevant to the research questions. Thematic analysis involves five main phases aimed at identifying, classifying and describing the themes and subthemes from the interview data; the stages followed in this study were as follows:

1. Transcription of the data from the original format into text format. According to Flick (2015), during this phase of the study, the researcher familiarises himself with the interview data in its entirety, to supplement and complement the knowledge acquired from the interviewees during the data collection.
2. Identification of themes relating to the utilisation of renewable energy were identified from the interview process, as well as during transcription. This phase was performed by determining the relevant views from the respondents and culminated in the naming of the themes. These were then merged or separated as necessary.

3. Classification of the various themes based on how they influence one another, in order to create linkages and relationships, (Jonker & Pennink, 2010). The relationships between the themes and sub-themes are integral to the findings, hence the need to categorise and link them accordingly.
4. Definition of the themes based on the orientation of the study. According to Fowler (2013), this phase entails identification of universal definitions for the themes to establish their value in answering the research questions or their utility in the research project. The definitions can be based on related information and knowledge from secondary sources.
5. Discussion and presentation of the themes. The themes are discussed in relation to evidence from the interview data to highlight the nature of the findings. This enables the researcher to create a narrative that can ultimately be used to establish hypotheses and models to show the relationships between the variables. The content is then presented coherently.

6.10.2 Content Analysis

Content analysis provides an additional perspective by indicating which themes are more prominent in the responses and which of them are unique. According to Bell (2014), the quantification of the themes and subthemes enables the researcher to highlight the validity and importance of the themes in answering the research questions and fulfilling the objectives of the study. Content analysis was applied in the second phase to quantify the views of the interview respondents; the process of quantifying the themes and subthemes was performed based on the relationships identified through thematic analysis, as well as the definition assigned to each theme.

6.10.3 Reliability Analysis

Saunders, Lewis and Thornhill (2016) define reliability analysis as the measures aimed at testing whether the research instrument facilitates the collection of the data which is targeted. Reliability is normally tested through internal consistency. Internal consistency is a measure of the correlation between the different items under the same test, scale or subscale. It tests whether the various items that measure the general construct have the potential to yield a similar score. Two constructs of this study, namely 'User Efficiency in Electricity Consumption' and 'Knowledge and Awareness of the Advantages and Challenges of Renewable Energy', of the primary sampled members (n=100) were tested for reliability. Table 6-2 summarises the results of the reliability analysis of the questionnaire used in the pilot study with the help of Cronbach's alpha. Cronbach's alpha is a reliable internal consistency measure and indicates the correlation at the inter-item level. Through the statistical tests under SPSS, it is possible to determine which items contribute to a low Cronbach's alpha; this enables the researcher to adjust the scale or eliminate the items.

Table 6-2: Cronbach's Alpha Value for the 'User Efficiency' and 'Knowledge and Awareness' Elements of the Survey

Variable Name	**No. of Questions**	**Cronbach's Alpha Values (n=100)**
User Efficiency in Electricity Consumption	11	0.75
Knowledge and Awareness of the Advantages and Challenges of Renewable Energy	5	0.81

Normally, A threshold of 0.7 is set for the Cronbach's alpha. As Table 6-2shows, the Cronbach's alpha value calculated to measure the reliability of the 'User Efficiency in Electricity Consumption' statements (11 statements measured on a 5-point Likert scale) was 0.75, which is considered to be good. Furthermore, the Cronbach's alpha value calculated for the 'Knowledge and Awareness of the Advantages and Challenges of Renewable Energy statements' (5 statements measured on a 5-point Likert scale) was 0.81 which is very good value (George & Mallery, 2003). Hence, the instrument was found to be valid and reliable in two important parts of the survey.

6.11 SWOT Analysis Methodology

Given the preference for solar energy in Kuwait, this study conducts a SWOT analysis to evaluate its viability as an alternative form of energy generation in the state. SWOT analyses are widely used in strategic planning processes to determine the strengths, weaknesses, opportunities and threats associated with a project or business activity, in both the internal and external environment. The analysis presented here considers the factors affecting the expansion of solar energy production in Kuwait, and draws on data from the literature review to identify the environmental factors in play at both the domestic and international level. Corroborating evidence is sourced for comparative purposes, especially for the factors that are relative, such as economic and ecological sustainability. Data collected from the ‘Public Questionnaire’’ is also used to represent the views of community members in Kuwait with different demographic and psychographic characteristics

The analysis includes the creation of a TOWS matrix to identify potential strategies to encourage the adoption of solar energy in Kuwait. The TOWS matrix is developed from the strengths, weaknesses, opportunities and threats identified via the SWOT analysis, and involves identification of strategic alternatives that address the following questions:

- How can the strengths be used in order to exploit the available opportunities (SO)?
- How can the strengths be exploited without the adverse effects of the threats (ST)?
- How can the opportunities be applied to overcome the weaknesses (WO)?
- How can the weaknesses be minimised in order to avoid the threats (WT)?

The analysis is performed in three phases: in the first phase, the dimensions of the SWOT analysis are identified; in the second phase, these dimensions are used to create a TOWS matrix. Finally, the strategic options identified via the TOWS matrix are discussed (See Figure 6-6).

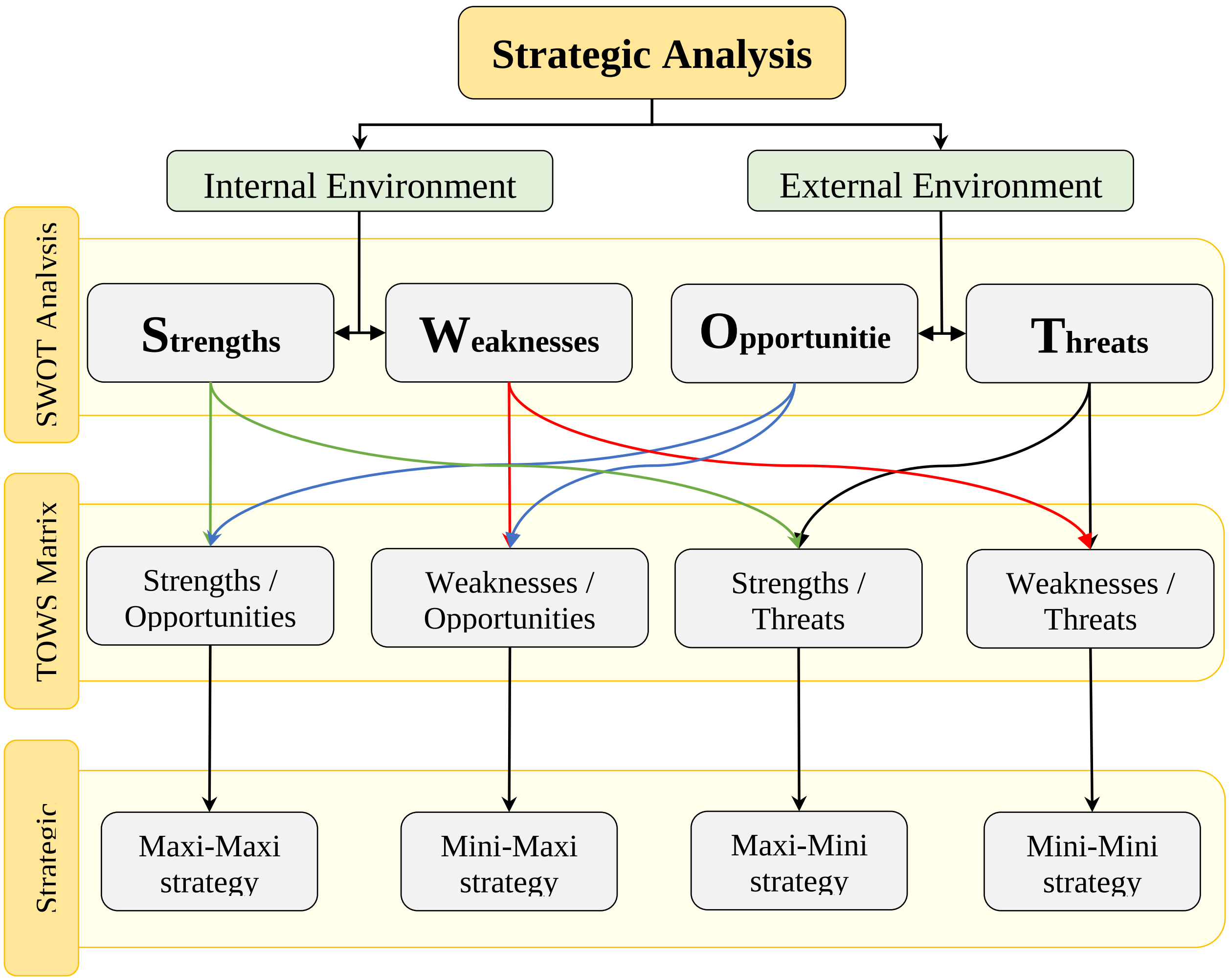


Figure 6-6: SWOT Analysis Model

Source :Author’s Own

6.12 Ethics in this Research

Saunders, Lewis and Thornhill (2016) define research ethics as those measures which a researcher must take into account in order to adhere to the established standards of morality and ethics. These measures govern the standards of conduct in any research project and are intended to protect the dignity, welfare and rights of the participants. For Creswell (2013), ethical issues are of upmost importance in research procedures, especially those which involve human participants. Indeed, as Flick (2015) notes, observing ethical standards is an integral aspect of the study, since they assist the researcher to comply with legal obligations, notably in the handling of personal data, and promote higher quality research since the researcher gains the trust of the human subjects. Finally, by observing research ethics, the researcher can avoid pitfalls that might limit the utility of the research findings, from the perspective of other researchers. After all, research projects that abide by the high standards of research ethics are viewed as meeting the best practices standards.

In this study, the ethical concerns included the following:

- **Informed consent**. According to Saunders, Lewis and Thornhill (2016), informed consent is employed in studies involving human subjects, and requires that participants are provided with enough information to make informed decisions about whether to participate in the research study. They should be informed that participation in the study is completely voluntarily, and they have the freedom to withdraw if they wish to do so. For those who decide to withdraw from the process, the data they had provided to that point is never used by the researcher.

Informed consent is normally acquired from adults of majority age, or individuals who are legally capable of giving that consent. As a result, Saunders, Lewis and Thornhill (2016) further indicate that to fulfil the requirements of informed consent, the researcher can only involve adults, or seek the approval of an adult chaperone if the research population is comprised of persons of minority age. Informed consents have to be explicitly acquired from the individuals. For face-to-face interviews, informed consent may be acquired verbally. In survey studies, informed consent is acquired through instructions included in the questionnaire, which advise the sampled individuals that their participation in the study is voluntary and may be withdrawn at any time.

- **Privacy**: Creswell (2012) defines privacy as the measures undertaken to protect the identities of the respondents. Research participants have the right to have their identity protected in order to mitigate the chance of any harm befalling them on account of their participation in the study. The ethical standards for this study involved adhering to standards and measures to protect the identity of the participants and using their participation for research purposes only. As a result, the researcher did not collect personal details, such as names, and no raw data is included in the study, except for summaries and excerpts. Where excerpts are used, care is taken to ensure anonymity is preserved.
- **Confidentiality**: According to Saunders, Lewis and Thornhill (2016), it is the responsibility of the researcher to ensure that access to the raw data from the respondents is restricted. In some instances, the data contains sensitive details about the entities referenced therein. Furthermore, the research conducted for this study is bound by the provisions of the General Data Protection Act of 2016 (GDPR). In line with these provisions, the data will be retained for up to ten years from the date of the successful completion of the research. The measures to limit access to the data collected from the respondents are defined under the confidentiality measures.
- **Benevolence**: Pimple (2017) defines benevolence as the measures undertaken by the researcher to ensure that no harm befalls the human subjects. These measures are generally

defined from a social and cultural perspective, in order to fit into the expectations and norms in the region. In this study, benevolence included respecting the culture of the people, and their social practices, including their religion.

Regarding the procedure for obtaining ethical approval to conduct the research, to collect the data and to analyse it, the researcher obtained ethical approval with a risk assessment for research from the Research Ethics Committee of Nottingham Trent University (NTU). In order to obtain approval, the researcher was obliged to demonstrate that the research complied with NTU's Research Ethics Policy and with due consideration given to the issues identifed above. This included ensuring that participants were able to provide informed consent, were notified that all participation data would be kept confidential and used for research purposes only, and that all the data in the researcher's custody would be retained until completion of the research, then destroyed within the requisite time frames.

6.13 Summary

This chapter has explained the philosophy which underpins this research, described the research design, and discussed the methodological choices made. It has identified the research population and the target groups for data collection, and explained how the sample sizes were calculated. It has provided a detailed description of the research instruments employed to collect both quantitative and qualitative data and the methods and processes of data collection and analysis used. It has also discussed the reliability of the study and the ethical issues involved in the research. The next chapter goes on to discuss the results of the "Public Questionnaire".

Chapter 7

Statistical Analysis of the ‘Public Questionnaire’

7.1 Introduction

This chapter provides statistical analysis of the data collected via the ‘Public Questionnaire’ in order to assess: a) participants’ user efficiency in electricity consumption; b) their personal attitudes towards renewable energy; b) their knowledge and awareness of the advantages and challenges associated with renewable energy utilisation; and c) their awareness of the need to preserve the environment in Kuwait. In addition, the analysis explores the obstacles faced by the renewable energy sector in Kuwait.

7.2 Results

This analysis begins by describing the demographic profile of the respondents and providing accompanying background information. It goes on to explore the responses given to questions exploring User Efficiency in Electricity Consumption and the Overall User Efficiency in Electricity Consumption, and details the Factor Analysis run for the User Efficiency in Electricity Consumption statements. It then assesses the respondents’ personal stances and attitude towards RE and their knowledge and awareness of the advantages and challenges associated with it. This chapter concludes by describing the results of the non-parametric statistical tests used to detect differences in means of the knowledge and awareness of the advantages and challenges of RE scores regarding the demographic variables.

7.3 Demographic Profile of the Respondents

7.3.1 Nationality

Table 7-1: Description of the Sample - Nationality

Nationality	n	Per cent
Kuwaiti	998	72.2%
Non-Kuwaiti	385	27.8%
Total	**1383**	**100%**

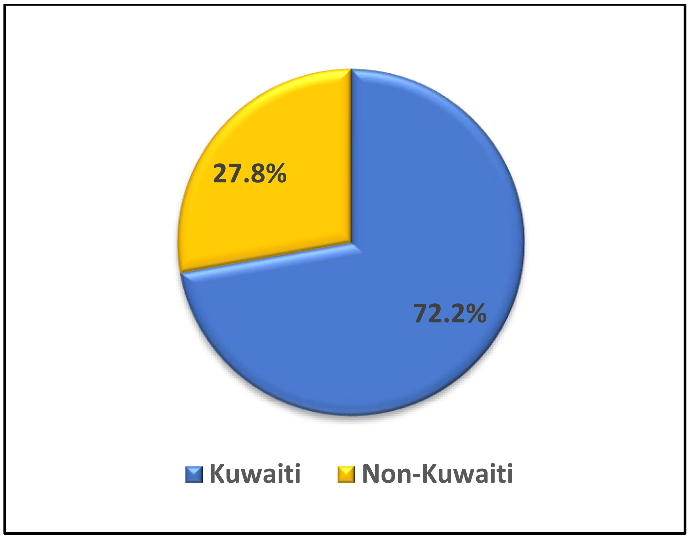


Figure 7-1: Distribution of the Sample Members According to Nationality

As Table 7-1 and Figure 7-1 show, the majority of the respondents (72.2%, n=998) were Kuwaiti, while non-Kuwaiti participants represented 27.8% (n= 385).

7.3.2 Gender

Table 7-2: Description of the Sample - Gender

Gender	n	Per cent
Male	1006	72.7%
Female	377	27.3%
Total	**1383**	**100%**

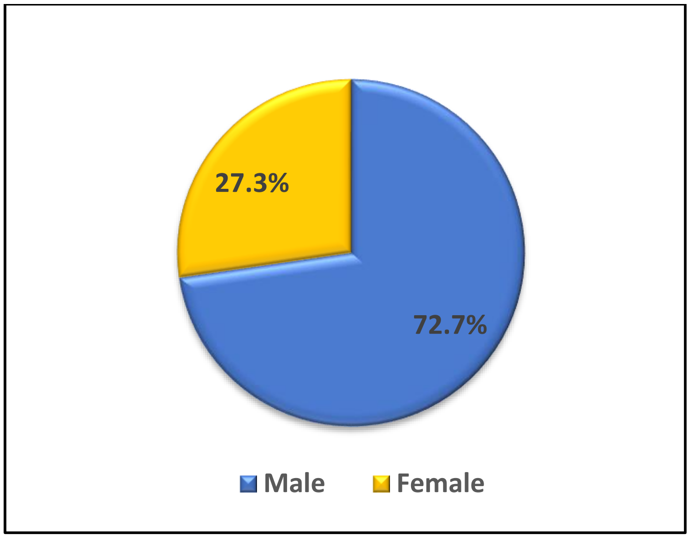


Figure 7-2: Distribution of the Sample Members According to Gender

|As Table 7-2 and show Figure 7-2, slightly less than three-quarters of the respondents were males (n=1006, 72.7%), while females represent 27.3% (n=377) of the sample.

7.3.3 Age

Table 7-3: Description of the Sample - Age

Age	n	Per cent
18-24	245	17.7%
25-34	322	23.3%
35-44	377	27.3%
45-54	304	22.0%
55-64	122	8.8%
65 and above	13	0.9%
Total	**1383**	**100%**

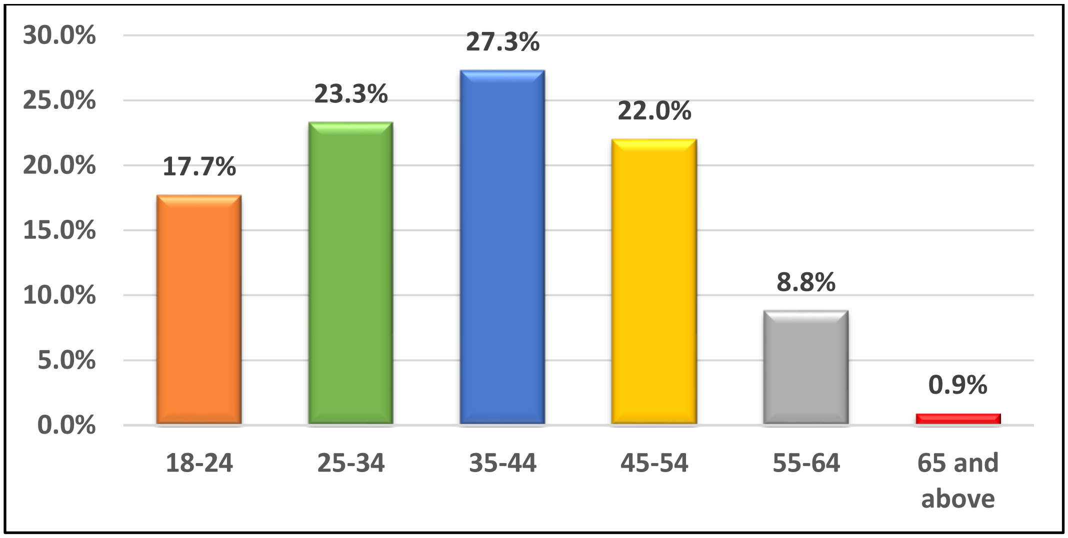


Figure 7-3: Distribution of the Sample Members According to Age

As we can see from Table 7-3 and show Figure 7-3, 27.3% (n=377) of respondents were aged between 35 to 44 years, while 23.3% (n=322) were between 25 to 34 years at the time of data collection, and 22.0% (n= 304) were between 45 to 54 years. However, only 9.7% of respondents were 55 years or older at the time of the survey.

7.3.4 Level of Education

Table 7-4: Description of the Sample - Level of Education

level of education	n	Per cent
PhD.	75	5.4%
Master	160	11.6%
Bachelor	584	42.2%
Diploma	269	19.5%
High School Certificate	246	17.8%
Primary School Certificate	49	3.5%
Total	**1383**	**100%**

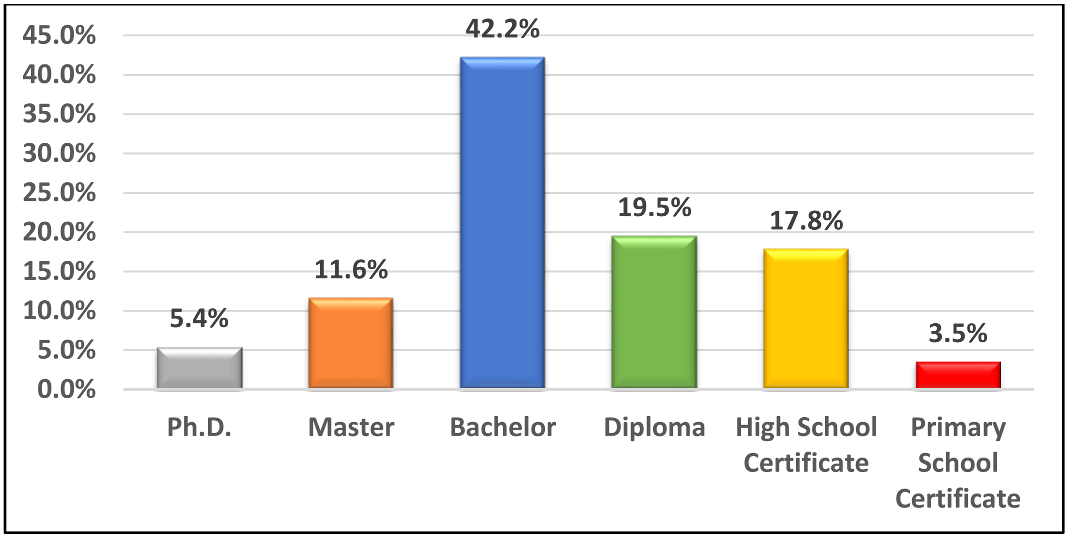


Figure 7-4: Distribution of the Sample Members According to their Level of Education

With regard to the level of education, as Table 7-4 and show Figure 7-4 show, there were 819 respondents in the degree-level category of education (i.e. with bachelors, masters or doctoral qualifications) which represents 59.2% of the respondents. In addition, close to one-fifth of respondents (19.5%, n=269) held a Diploma certificate.

7.3.5 Occupation

Table 7-5: Description of the Sample - Occupation

Occupation	n	Per cent
Student	233	16.8%
Employee	815	58.9%
Freelancers	112	8.1%
Retired	155	11.3%
Housewife	35	2.5%
Unemployed	33	2.4%
Total	**1383**	**100%**

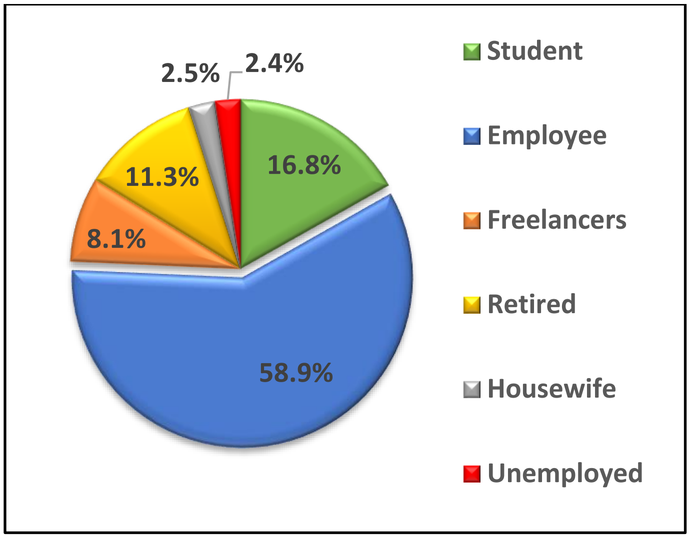


Figure 7-5: Distribution of the Sample Members According to their Occupations

As Table 7-5 and Figure 7-5 show, of the 1381 respondents, 58.9% (n= 815) reported that they were employees, while 16.8% of them were students. In addition, 11.3% (n=155) of the participants reported that they were retired.

7.3.6 Accommodation Type

Table 7-6: Description of the Sample - Accommodation type

Accommodation type	n	Per cent
Own accommodation (House)	876	63.3%
Own accommodation (Apartment)	159	11.5%
Rental accommodation (House)	124	9.0%
Rental accommodation (Apartment)	213	15.4%
Others	11	0.8%
Total	**1383**	**100%**

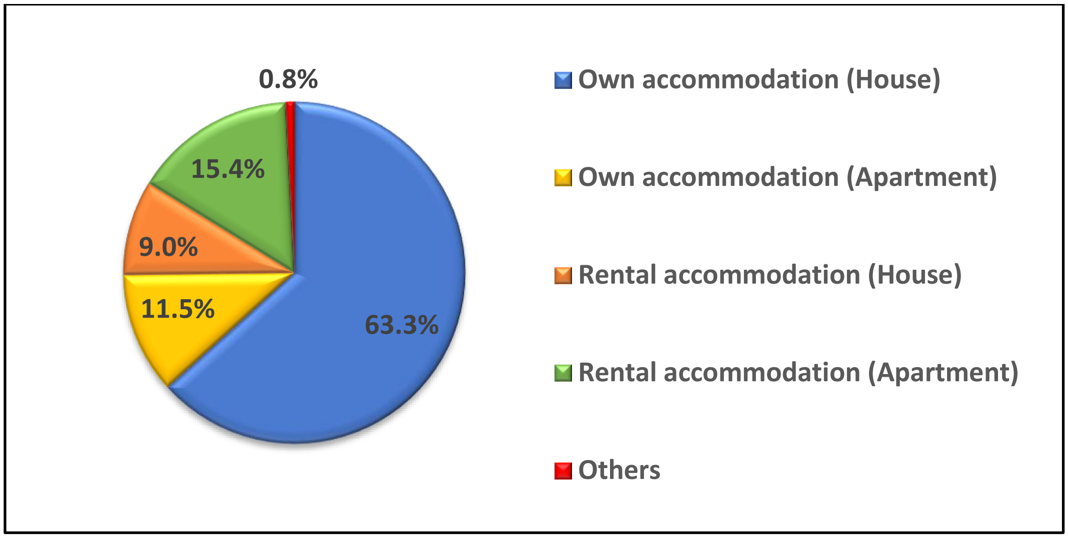


Figure 7-6: Distribution of the Sample Members According to Accommodation Type

With regard to the accommodation type, as Table 7-6 and Figure 7-6 show, the majority of respondents (n=876, 63.3%) owned their own house, followed by 15.4% (n=213) who rented an apartment, while 11.5% (n=159) owned their own apartment. However, just 0.8% percent of respondents (n=11) indicated that they live in 'Other' types of accommodation, such as company accommodation, the home of the husband's family, or their parents' house.

7.4 Background Information

Respondents were asked to report their opinions regarding the environment and renewable energy. Their responses are presented in Table 7-7 below.

Table 7-7: Respondents' Opinions Regarding the Environment and Renewable Energy

Statement		SD	D	N	A	SA
We must preserve the environment and the interests of environmental issues	n	0	2	11	215	1155
	%	0%	0.1%	0.8%	15.6%	83.5%
Recently, it has become necessary to start using renewable energy sources to generate	n	5	8	38	315	1017
	%	0.4%	0.6%	2.7%	22.8%	73.5%

electricity instead of generating it through fossil fuels which cause air pollution						
Increasing renewable energy utilisation is the best way to improve the environment and secure the future for new generations	n	3	5	36	366	973
	%	0.2%	0.4%	2.6%	26.4%	70.4%
Overall background		**0.2%**	**0.4%**	**2.0%**	**21.6%**	**75.8%**

SD= Strongly Disagree, D = Disagree, N= Neutral, A= Agree, SA=Strongly Agree.

As Table 7-7 shows, most of the participants (n=1155, 83.5%) strongly agreed that people must preserve the environment and the interests of environmental issues. In addition, slightly less than three-quarters of respondents (n=1017, 73.5%) strongly agreed that it has now become necessary to start using renewable energy sources to generate electricity instead of fossil fuels. Furthermore, 973 respondents (70.4%) strongly agreed that increasing renewable energy utilisation is the best way to improve the environment and secure the future for new generations.

Table 7-8: Respondents' Overall Background by Nationality

Nationality		**Respondents'Overall Background**					**Total**
		SD	**D**	**N**	**A**	**SA**	
Kuwaiti	n	6	12	63	638	2275	2994
	%	0.2%	0.4%	2.1%	21.3%	76.0%	100%
Non-Kuwaiti	n	2	3	22	258	870	1155
	%	0.2%	0.3%	1.9%	22.3%	75.3%	100%
Total	**n**	**8**	**15**	**85**	**896**	**3145**	**4149**

SD= Strongly Disagree, D = Disagree, N= Neutral, A= Agree, SA=Strongly Agree.
Note: Percentages and totals are based on responses.

As Table 7-8, shows 76.0% of Kuwaiti respondents and 75.3% of non-Kuwaiti respondents had a positive background regarding the environment and RE. The chi-square statistic is 1.11, the p-value is 0.8929, and this result is not significant at $p < 0.05$. Therefore, there was no significant association between nationality and the overall background of the respondents.

Table 7-9: Respondents' Overall Background by Gender

Gender		Respondent's opinion					Total
		SD	D	N	A	SA	
Male	n	7	11	63	624	2304	3009
	%	0.2%	0.4%	2.1%	20.7%	76.6%	100%
Female	n	1	4	22	272	841	1140
	%	0.1%	0.4%	1.9%	23.9%	73.8%	100%
Total	**n**	**8**	**15**	**85**	**896**	**3145**	**4149**

SD= Strongly Disagree, D = Disagree, N= Neutral, A= Agree, SA=Strongly Agree.
Note: Percentages and totals are based on responses.

As shown in Table 7-9, 76.6% of the males and 73.8% of the females had a positive background regarding the environment and RE. The chi-square statistic is 5.60, the p-value is 0.2312, and this result is not significant at $p < 0.05$. Therefore, there was no significant association between gender and the overall background of the respondents.

Table 7-10: Respondents' Overall Background by Age

Age		Respondent's opinion					Total
		SD	D	N	A	SA	
18-24 years	n	0	4	29	210	492	735
	%	0.0%	0.5%	3.9%	28.6%	66.9%	100%
25-34 years	n	2	7	23	217	717	966
	%	0.2%	0.7%	2.4%	22.5%	74.2%	100%
35-44 years	n	3	3	15	228	882	1131
	%	0.3%	0.3%	1.3%	20.2%	78.0%	100%
45-54 years	n	0	0	10	169	733	912
	%	0%	0%	1.1%	18.5%	80.4%	100%
55 and above	n	3	1	8	72	321	405
	%	0.7%	0.2%	2.0%	17.8%	79.3%	100%
Total	**n**	**8**	**15**	**85**	**896**	**3145**	**4149**

SD= Strongly Disagree, D = Disagree, N= Neutral, A= Agree, SA=Strongly Agree.
Note: Percentages and totals are based on responses.

The data presented in Table 7-10 shows that older respondents were more likely to hold positive attitudes towards the environment and RE than younger ones. 79.3% of respondents who were 55 years and above, followed by 80.4% of respondents between 45 to 54 years old had positive attitudes towards the environment and RE. However, only 66.9% of respondents between 18 to 24 years old, and 74.2% of those between 25 to 29 years old had positive attitudes. The chi-square statistic is 74.57, the p-value is 0.000, and this result is highly significant at $p < 0.01$. Therefore, there was a statistically significant association between age and the overall background of the respondents in relation to the environment and RE.

Table 7-11: Respondents' Overall Background by Level of Education

Level of Education		Respondent's opinion					Total
		SD	D	N	A	SA	
PhD.	n	0	0	3	24	198	225
	%	0%	0%	1.3%	10.7%	88.0%	100%
Master	n	0	3	9	109	359	480
	%	0.0%	0.6%	1.9%	22.7%	74.8%	100%
Bachelor	n	2	10	36	355	1349	1752
	%	0.1%	0.6%	2.1%	20.3%	77.0%	100%
Diploma	n	2	1	17	199	588	807
	%	0.2%	0.1%	2.1%	24.7%	72.9%	100%
High school Certificate or below	n	4	1	20	209	651	885
	%	0.5%	0.1%	2.3%	23.6%	73.6%	100%
Total	**n**	**8**	**15**	**85**	**896**	**3145**	**4149**

SD= Strongly Disagree, D = Disagree, N= Neutral, A= Agree, SA=Strongly Agree.
Note: Percentages and totals are based on responses.

The data illustrated in Table 7-11 shows that 88.0%, 74.8% and 77.0% of participants in the survey who had Ph.D., a Masters or a Bachelor's degree respectively, had positive attitudes towards the environment and RE. However, just 73.6% of the respondents who had a high school certificate or below followed by 72.9% of those with a Diploma had positive attitudes. The chi-square statistic is 1377.7, the p-value is 0.000, and this result is highly significant at $p < 0.01$. Therefore, there was a statistically significant association between level of education and the overall background of the respondents in relation to the environment and RE.

Table 7-12: Respondents' Overall Background by Occupation

Occupation		Respondent's opinion					Total
		SD	D	N	A	SA	
Employed	n	6	9	53	576	2137	2781
	%	0.2%	0.3%	1.9%	20.7%	76.8%	100%
Unemployed	n	2	6	32	320	1008	1368
	%	0.1%	0.4%	2.3%	23.4%	73.7%	100%
Total	**n**	**8**	**15**	**85**	**896**	**3145**	**4149**

SD= Strongly Disagree, D = Disagree, N= Neutral, A= Agree, SA=Strongly Agree.
Note: Percentages and totals are based on responses.

As Table 7-12 shows, 76.8% of the participants who were employed, and 73.7% of those who were unemployed had a positive background in relation to the environment and RE. The chi-square statistic is 5.66, the p-value is 0.2258, and this result is not significant at $p < 0.05$. Therefore, there was no significant association between occupation and the overall background of the respondents.

Table 7-13: Respondents' Overall Background by Accommodation Type

Occupation		Respondent's opinion					Total
		SD	D	N	A	SA	
Own accommodation (House)	n	5	9	53	521	2040	2628
	%	0.2%	0.3%	2.0%	19.8%	77.6%	100%
Own accommodation (Apartment)	n	0	1	5	126	345	477
	%	0%	0.2%	1.0%	26.4%	72.3%	100%
Rental accommodation (House)	n	0	1	10	108	253	372
	%	0%	0.3%	2.7%	29.0%	68.0%	100%
Rental accommodation (Apartment)	n	2	4	16	139	478	639
	%	0.3%	0.6%	2.5%	21.8%	74.8%	100%
Others	n	1	0	1	2	29	33
	%	3.0%	0%	3.0%	6.1%	87.9%	100%
Total	**n**	**8**	**15**	**85**	**896**	**3145**	**4149**

SD= Strongly Disagree, D = Disagree, N= Neutral, A= Agree, SA=Strongly Agree.
Note: Percentages and totals are based on responses.

The data presented in Table 7-13 shows that the majority of the respondents who live in their own house (77.6%) followed by 74.8% of those who live in a rental apartment had a positive background regarding the environment and RE, while 72.3% of those who live in their own apartment followed by 68.0% of those in a rental house had a positive background. The chi-square statistic is 38.61, the p-value is 0.0001, and this result is significant at $p < 0.05$ level of significance. Therefore, there was a statistically significant association between accommodation type and the overall background of the respondents regarding the environment and RE.

7.5 User Efficiency in Electricity Consumption

The respondents were asked a series of questions about their consumption habits in relation to electricity use. The distribution of their responses is shown in Table 7-14.

Table 7-14: Distribution of Responses Regarding 'User Efficiency in Electricity Consumption'

Statement		Yes	No	Sometimes	I do not know
Do you leave the lights on during the day even though there is daylight at home?	n	135	648	598	2
	%	9.8%	46.9%	43.2%	0.1%
When you are the last person to leave, do you switch off the lights before you go?	n	1110	40	229	4
	%	80.3%	2.9%	16.6%	0.3%
Do you turn off the electricity after using the TV, computer and other devices?	n	660	400	320	3
	%	47.7%	28.9%	23.1%	0.2%
Do you use LED (energy-saving) lighting in your home?	n	874	241	224	44
	%	63.2%	17.4%	16.2%	3.2%
Is your home supported by thermal insulation?	n	752	379	29	223
	%	54.4%	27.4%	2.1%	16.1%
Do you leave the air conditioning ON after you leave your home?	n	572	516	291	4
	%	41.4%	37.3%	21.0%	0.3%
Do you use power-saving controllers?	n	197	910	139	137
	%	14.2%	65.8%	10.1%	9.9%
Do you instruct your family members and maids to rationalise electricity consumption?	n	1032	96	249	6
	%	74.6%	6.9%	18.0%	0.4%
Do you think you want to use modern electric cars?	n	799	269	163	152
	%	57.8%	19.5%	11.8%	11.0%

Do you think that electric cars are a way to preserve the environment?	n	1032	72	137	142
	%	74.6%	5.2%	9.9%	10.3%
Are there charging points for electric vehicles provided by the government in public utilities, government organisations, commercial and residential complexes?	n	92	917	49	325
	%	6.7%	66.3%	3.5%	23.5%

Analysis of the data in Table 7-14 shows that:

- Up to 648 (46.9%) respondents reported that they did not leave the lights on during the day, while 598 (43.2%) said they did.
- Most respondents (80.3%, n= 1110) reported that they switch off the lights when they are the last person to leave a place.
- Just under 50% of participants (n=660, 47.7%) turn off the electricity after using the TV, computer, and other devices, while 400 (28.9%) do not.
- The majority of respondents (63.2%, n= 847) use LED (energy-saving) lighting in their homes.
- 752 (54.4%) respondents reported that their homes are supported by thermal insulation.
- 41.04% of participants (n=572) leave the air conditioning ON after they leave their homes while 516 (37.3%) of them do not.
- A majority of the respondents (65.8%, n= 910) do not use power-saving controllers.
- Close to three-quarters of the respondents (74.6%, n=1032) instruct their family members and maids to rationalise electricity consumption.
- Up to 799 (57.8%) of the respondents think they want to use modern electric cars.
- Almost three-quarters of respondents (74.6%, n=1032) think that electric cars are a way to preserve the environment.

- The majority of respondents (66.3%, n= 917) indicated that there are no charging points for electric vehicles provided by the government in public utilities, government organisations, commercial and residential complexes.

7.5.1 Overall Users' Efficiency of the Electricity Consumption

Table 7-15 describes the descriptive statistics for the scores of 'User Efficiency in Electricity Consumption'. The best score (the full mark) should be 22.

Table 7-15: Descriptive Statistics for the 'User Efficiency in Electricity Consumption' Scores

Measure	Value	Measure		Value
n	1383	Range		22
Mean	12.9	Minimum		0
Std. Error of Mean	0.09	Maximum		22
Median	13.0	Percentiles	25	11.00
Std. Deviation	3.35		50	13.00
Coefficient of variation	26.0%		75	15.00

The minimum score was 0.0, and the maximum was 22, with a range of 22, which indicates that there was a wide disparity between participants in terms of their user efficiency scores. The mean of the scores was 12.9 (SE = ± 0.09) with a median of 13, which indicates that the distribution of the scores is slightly skewed to the left (see Figure 7-7). The standard deviation of the scores was 3.35, suggesting that the coefficient variation of the scores was 26.0%. Finally, the 75th percentile indicates that 75% of the participants in the survey had a total score of 15 or below in relation to their user efficiency.

When the total scores for User Efficiency in Electricity Consumption were categorised using percentiles obtained from the analysis, slightly less than one quarter (n=336, 24.3%) of the participants had low user efficiency ($95\%\ C.I., 22.0\% - 26.6\%$), 43.2% (n=597) had moderate user efficiency ($95\%\ C.I., 40.6\% - 45.8\%$) and 32.5% (n=450) were categorized as high efficiency users ($95\%\ C.I., 30.0\% - 35.0\%$) (See Figure 7-7 and Table 7-16).

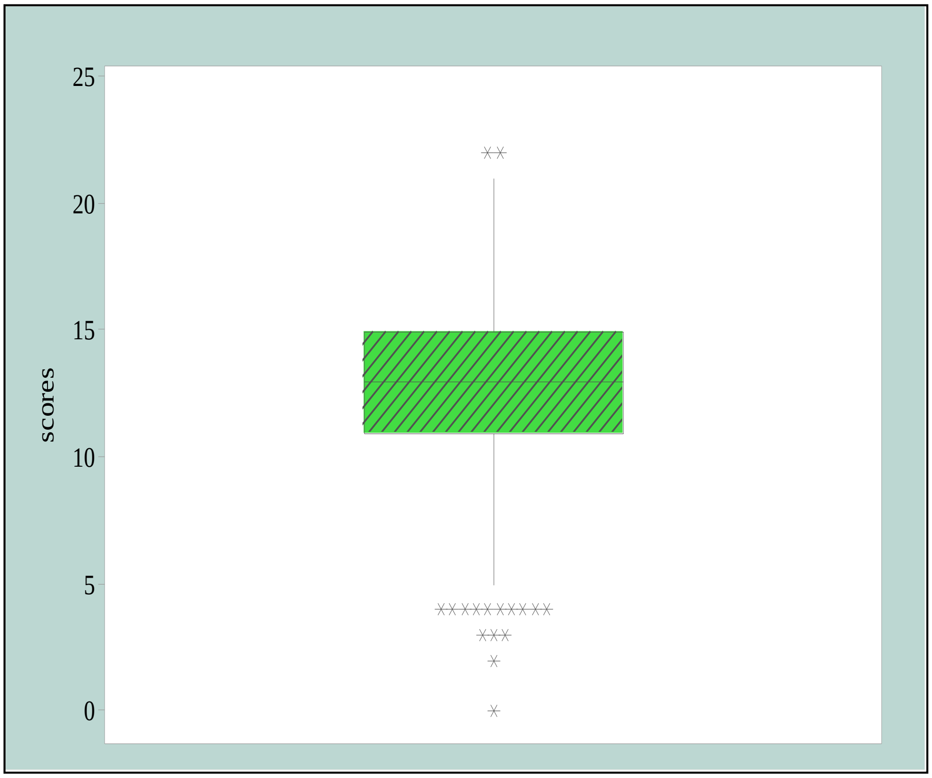


Figure 7-7: Boxplots for the Scores of User Efficiency in Electricity Consumption

* Indicates extreme values.

Table 7-16: Levels of User Efficiency in Electricity Consumption

Level of user efficiency	n	Per cent
Low user efficiency	336	24.3%
Moderate user efficiency	597	43.2%
High user efficiency	450	32.5%
Total	**1383**	**100%**

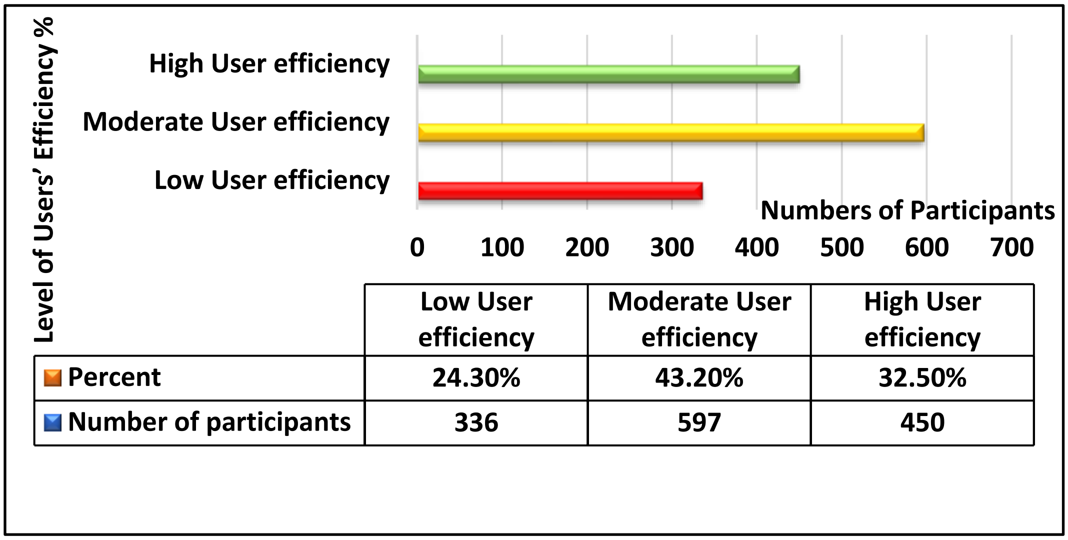


Figure 7-8: Level of User Efficiency in Electricity Consumption

The cross-tabulation shown in Table 7-17 indicated that 330 Kuwaiti respondents (33.1%) and 120 non-Kuwaiti respondents (31.2%) were classed as high efficiency consumers of electricity, while 418 (41.9%) Kuwaiti respondents and 179 non-Kuwaiti respondents (46.5%) were moderate efficiency users.

Table 7-17: Level of User Efficiency in Electricity Consumption by Nationality

Nationality		Level of user efficiency			Total
		Low User efficiency	Moderate User efficiency	High User efficiency	
Kuwaiti	n	250	418	330	998
	%	25.1%	41.9%	33.1%	100%
Non-Kuwaiti	n	86	179	120	385
	%	22.3%	46.5%	31.2%	100%
Total	**n**	**336**	**597**	**450**	**1383**
	%	**24.3%**	**43.2%**	**32.5%**	**100%**

The chi-square statistic is 2.51, the p-value is 0.284, and this result is not significant at $p < 0.05$ level of significance (See Table 7-18). Therefore, there was no statistically significant association between nationality and level of user efficiency.

Table 7-18: Chi-Square Tests for the Association between Nationality and Level of User Efficiency

	Value	**df**	**Sig.**
Pearson Chi-Square	2.51	2	0.284
No. of Valid Cases	1383		

Table 7-19: Level of User Efficiency in Electricity Consumption by Gender

Gender		**Level of user efficiency**			**Total**
		Low User efficiency	**Moderate User efficiency**	**High User efficiency**	
Male	n	210	434	359	1003
	%	20.9%	43.3%	35.8%	100%
Female	n	126	163	91	380
	%	33.2%	42.9%	23.9%	100%
Total	**n**	**336**	**597**	**450**	**1383**
	%	**24.3%**	**43.2%**	**32.5%**	**100%**

The cross-tabulation shown in Table 7-19 suggested that there might be a greater tendency for male participants rather than female participants to be high efficiency users (35.8% vs 23.9%). This proposition is supported by the chi-square result reported in Table 7-20($\chi^2 = 28.83, DF = 2, p < 0.01$). Therefore, there was a statistically significant association between gender and level of user efficiency in electricity consumption.

Table 7-20: Chi-Square Tests for the Association between Gender and Level of User Efficiency

	Value	**df**	**Sig.**
Pearson Chi-Square	28.83	2	0.000
No. of Valid Cases	1383		

Table 7-21: Level of User Efficiency in Electricity Consumption by Age

Age		Level of user efficiency			Total
		Low User efficiency	Moderate User efficiency	High User efficiency	
18-24 years	n	95	94	56	245
	%	38.8%	38.4%	22.9%	100%
25-34 years	n	92	141	89	322
	%	28.6%	43.8%	27.6%	100%
35-44 years	n	79	170	128	377
	%	21.0%	45.1%	34.0%	100%
45-54 years	n	51	134	119	304
	%	16.8%	44.1%	39.1%	100%
55 and above	n	19	58	58	135
	%	14.1%	43.0%	43.0%	100%
Total	**n**	**336**	**597**	**450**	**1383**
	%	**24.3%**	**43.2%**	**32.5%**	**100%**

The cross-tabulation shown in Table 7-21 suggested that there might be a greater tendency for elderly participants rather than younger participants to be high efficiency users. 43% (n=58) of those surveyed who were 55 years old or above and 39.1% (n=119) of those between 45 to 54 were classed as high efficiency users. Furthermore, 38.8% (n=95) of participants who were between 18 to 24 and 28.6% (n=92) of those between 25 to 34 years old were classified as low efficiency users. This proposition is supported by the Chi-Square result reported in Table 7-22 ($\chi^2 = 58.15, DF = 8, p < 0.01$). Therefore, there was a statistically significant association between age and level of user efficiency.

Table 7-22: Chi-Square Tests for an Association between Age and Level of User Efficiency

	Value	df	Sig.
Pearson Chi-Square	58.15	8	0.000
No. of Valid Cases	1383		

Table 7-23: Level of User Efficiency in Electricity Consumption by Level of Education

Qualification		Level of user efficiency			Total
		Low User efficiency	Moderate User efficiency	High User efficiency	
Ph.D.	n	10	33	32	75
	%	13.3%	44.0%	42.7%	100%
Master	n	44	68	48	160
	%	27.5%	42.5%	30.0%	100%
Bachelor	n	152	254	178	584
	%	26.0%	43.5%	30.5%	100%
Diploma	n	60	109	100	269
	%	22.3%	40.5%	37.2%	100%
High school Certificate or Below	n	70	133	92	295
	%	23.7%	45.1%	31.2%	100%
Total	**n**	**336**	**597**	**450**	**1383**
	%	**24.3%**	**43.2%**	**32.5%**	**100%**

As presented in Table 7-23, 42.7% (n=32) of those who had a PhD degree were high efficiency users of electricity, followed by 37.2% (n=100) of those who had a Diploma, and 31.2% (n=92) of those with a high school certificate or lower level qualification. However, 44 respondents who held a Master's degree (27.5%) and 152 respondents with a Bachelor's degree (26.0%) were classed as low efficiency users.

The chi-square statistic is 11.07, the p-value is 0.1651, and this result is not significant at $p < 0.05$ level of significance. Therefore, there was no statistically significant association between the education level of the respondents and the level of user efficiency (See Table 7-24).

Table 7-24: Chi-Square Tests for an Association between Level of Education and Level of User Efficiency

	Value	df	Sig.
Pearson Chi-Square	11.07	8	0.1651
No. of Valid Cases	1383		

Table 7-25: Level of User Efficiency in Electricity Consumption by Occupation

Occupation		**Level of user efficiency**			**Total**
		Low User efficiency	**Moderate User efficiency**	**High User efficiency**	
Working	n	203	404	320	927
	%	21.9%	43.6%	34.5%	100%
Not Working	n	133	193	130	456
	%	29.2%	42.3%	28.5%	100%
Total	**n**	**336**	**597**	**450**	**1383**
	%	**24.3%**	**43.2%**	**32.5%**	**100.0%**

The cross-tabulation shown in Table 7-25 suggested that there might be a greater tendency for working participants rather than non-working participants to be high efficiency users (34.5% vs 28.5%). This proposition is supported by the chi-square result reported in Table 7-26 ($\chi^2 = 10.15, DF = 2, p < 0.01$). Therefore, there was a statistically significant association between occupation and level of user efficiency.

Table 7-26: Chi-Square Tests for the Association between Occupation and Level of User Efficiency

	Value	**df**	**Sig.**
Pearson Chi-Square	10.15	2	0.0062
No. of Valid Cases	1383		

In respect of level of user efficiency by accommodation type, Table 7-27 shows that 36.8% (n=322) of those who owned their houses were high efficiency users, followed by 33.1% (n=41) of those who lived in rented houses. By contrast, 68 respondents who lived in rental houses (31.9%), and 4 respondents who lived in other types of accommodation (36.4%) were classed as low efficiency users.

Table 7-27: Level of User Efficiency in Electricity Consumption by Accommodation Type

Accommodation type		Level of user efficiency			Total
		Low User efficiency	Moderate User efficiency	High User efficiency	
Own accommodation (House)	n	190	364	322	876
	%	21.7%	41.6%	36.8%	100%
Own accommodation (Apartment)	n	41	79	39	159
	%	25.8%	49.7%	24.5%	100%
Rental accommodation (House)	n	33	50	41	124
	%	26.6%	40.3%	33.1%	100%
Rental accommodation (Apartment)	n	68	100	45	213
	%	31.9%	46.9%	21.1%	100%
Others	n	4	4	3	11
	%	36.4%	36.4%	27.3%	100%
Total	**n**	**336**	**597**	**450**	**1383**
	%	**24.3%**	**43.2%**	**32.5%**	**100%**

The chi-square statistic is 28.34, the p-value is 0.000, and this result is highly significant at $p < 0.01$ level of significance. Therefore, there was a statistically significant association between the accommodation type of the respondents and their levels of user efficiency (See Table 7-28).

Table 7-28: Chi-Square Tests for the Association between Accommodation Type and Level of User Efficiency

	Value	df	Sig.
Pearson Chi-Square	28.34	8	0.000
No. of Valid Cases	1383		

7.5.2 Factor Analysis

In this study, Exploratory Factor Analysis (EFA) was run for each item in the ‘User Efficiency in Electricity Consumption’ part of the survey (11 items). Variables in this part were examined using EFA to work out which factors characterise user efficiency in electricity consumption.

The results revealed that the KMO value was greater than 0.6 and Bartlett's test was significant ($p\ value < 0.001$) which satisfied the initial assumptions for the EFA (see Table 7-29). However, during eigenvalue's examination, four factors were extracted whose eigenvalue was greater than 1 (see Table 7-30).

Table 7-29: KMO and Bartlett's Test for Characteristic Items

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.604
Bartlett's Test of Sphericity	Chi-Square	892.39
	df	55
	Sig.	0.000

The Bartlett's Test of Sphericity is statistically significant (p-value <0.001) and, consequently, the correlation matrix of the variables of User Efficiency in Electricity Consumption was not the identity matrix. Therefore, it contains a minimum level of inter-variable relations. The Kaiser-Meyer-Olkin Measure of sampling adequacy is 0.604; therefore, this value is considered statistically good, according to Kaiser's classifications. Consequently, this result reinforces our confidence that the size of the sample for this study is adequate for carrying out Factor Analysis.

Table 7-30 shows the eigenvalues for each of the component items (in the second column entitled "Total"). There are four eigenvalues higher than integral 1. The table also shows the size of the variance extracted or explained by each factor and the total amount of the explained variance expressed in percentages. The value of the accumulated variance is 49.2, which means that these four factors explain 49.2% of the change occurring in the User Efficiency in Electricity Consumption of the surveyed respondents.

Table 7-30: Eigenvalues, Rotation Sums of Squared Loadings, and Total Variance for User Efficiency in Electricity Consumption Items

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.86	16.89	16.89	1.86	16.89	16.89	1.47	13.41	13.41
2	1.36	12.38	29.27	1.36	12.38	29.27	1.46	13.24	26.65
3	1.14	10.33	39.60	1.14	10.33	39.60	1.39	12.62	39.27
4	1.06	9.60	49.20	1.06	9.60	49.20	1.09	9.93	49.20
5	0.96	8.72	57.92						
6	0.93	8.43	66.34						
7	0.88	8.03	74.37						
8	0.80	7.29	81.66						
9	0.78	7.11	88.77						
10	0.66	6.00	94.77						
11	0.58	5.23	100.00						

Extraction Method: Principal Component Analysis.

In order to extract these four factors, it was essential to determine the minimum accepted level of variable saturation on the factor (i.e. the correlation intensity of the variable with the factor). For data reduction purposes, (0.3) was considered as a cut-off limit between adopted saturations and neglected saturations. A varimax rotation was used in order to extract the factors, an orthogonal rotation method commonly used in social science studies to identify which data belongs to which factor (Allen, 2017) Table 7-31 shows the rotated component matrix that was extracted:

Table 7-31: Rotated Component Matrix for User Efficiency of the Electricity Consumption

Variables/ Items	Factors			
	1	2	3	4
Do you think that electric cars are a way to preserve the environment?	0.817			
Do you think you want to use modern electric cars?	0.780			
Are there charging points for electric vehicles provided by the government in public utilities, government organisations, commercial and residential complexes?	0.408			
Is your home supported by thermal insulation?		0.720		
Do you use power-saving controllers?		0.634		
Do you use LED (energy-saving) lighting in your home?		0.514		
Do you instruct your family members and maids to rationalise electricity consumption?			0.737	
When you are the last person to leave a place, do you switch off the lights before you go?			0.734	
Do you leave the lights on during the day even though there is daylight at home?				0.801
Do you turn off the electricity after using the TV, computer and other devices?				0.462
Do you leave the air conditioning ON after you leave your home?				0.407

- Extraction Method: Principal Component Analysis.
- Rotation Method: Varimax with Kaiser Normalization.

As Table 7-31 shows, four factors describe User Efficiency in Electricity Consumption. A description of each factor is given below:

Factor (1): Personal Beliefs about Electric Vehicles

This factor describes the personal beliefs of the surveyed people about electric vehicles. It is composed of the following items:

- Do you think that electric cars are a way to preserve the environment?
- Do you think you want to use modern electric cars?
- Are there charging points for electric vehicles provided by the government in public utilities, government organisations, commercial and residential complexes?

Factor (2): Behaviour towards Saving Energy

This factor describes the behaviour of the surveyed people towards saving energy. It is composed of the following items:

- Is your home supported by thermal insulation?
- Do you use power-saving controllers?
- Do you use LED (energy-saving) lighting in your home?

Factor (3): Rationalising Electricity Consumption

This factor describes the behaviour of the surveyed people towards rationalisation of electricity consumption. It is composed of the following items:

- Do you instruct your family members and maids to rationalise electricity consumption?
- When you are the last person to leave the place, do you switch off the lights before you go?

Factor (4): Behaviour Towards Electric Devices

This factor describes the behaviour of the surveyed people towards electric Devices. It composed of the following items:

- Do you leave the lights lit during the day even though there is daylight at home?

- Do you turn off the electricity after using the TV, computer and other devices?
- Do you leave the air conditioning ON after you leave your home?

7.5.3 External Issues Which Affect User Efficiency in Electricity Consumption

While the questions discussed so far have focussed on individual actions in relation to energy efficiency, consumption behaviour is also influenced by external factors, notably the cost of electricity, the availability of the electricity supply, and the action of government agencies in promoting energy efficiency. As a result, the next three questions inquired about these areas.

Table 7-32: Responses Regarding Financial Burden Due to Electricity Bills

Responses	n	Per cent
Yes	842	60.9%
No	215	15.5%
Sometimes	326	23.6%
Total	**1383**	**100%**

Up to 60.9% (n=842) of the respondents replied in the affirmative when asked if their electricity bills were becoming a financial burden, with a further 326 (23.6%) saying they were sometimes a burden. Based on these results, it is clear that the cost of electricity is considered to be a burden by a significant proportion of the population in Kuwait (See Table and Figure 7-9).

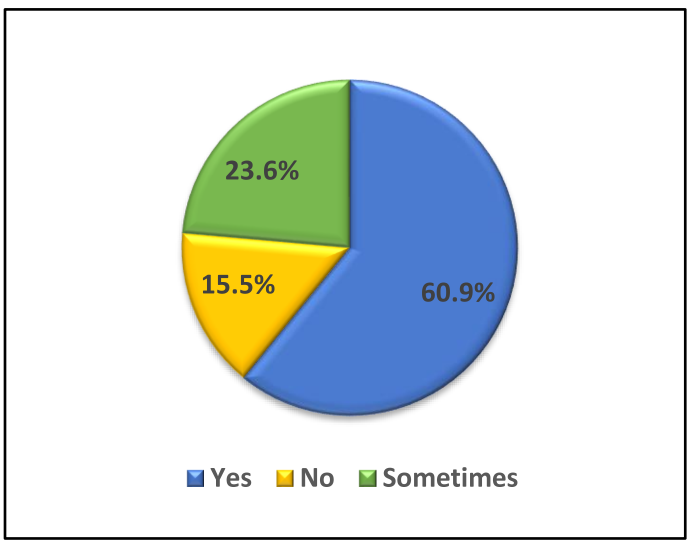


Figure 7-9: Responses Regarding Financial Burden Due to Electricity Bills

Furthermore, just under three-quarters of respondents (74.0%, n=1024) indicated that the programmed power cuts due to electrical loads in the summer had a negative effect on them at home, while only 10.3% (n=142) considered this issue had no effect on them (See Figure 7-10).

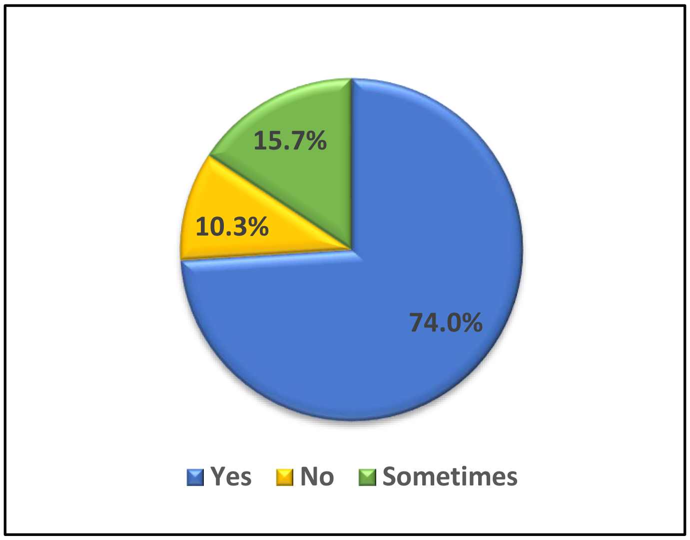


Figure 7-10: Responses Regarding the Negative Effects of the Programmed Power Cuts Due to Electrical Loads in the Summer

In addition, respondents were asked to rate the role of the Kuwaiti government in raising public awareness of the need to rationalise electricity consumption (See Table 7-33 and Figure 7-11).

Table 7-33: Evaluation of the Role of the Kuwaiti Government in Raising Public Awareness of the Need to Rationalise Electricity Consumption

Rate	n	Per cent
Excellent	103	7.4%
Very good	222	16.1%
Good	391	28.3%
Acceptable	297	21.5%
Weak	370	26.7%
Total	**1383**	**100%**

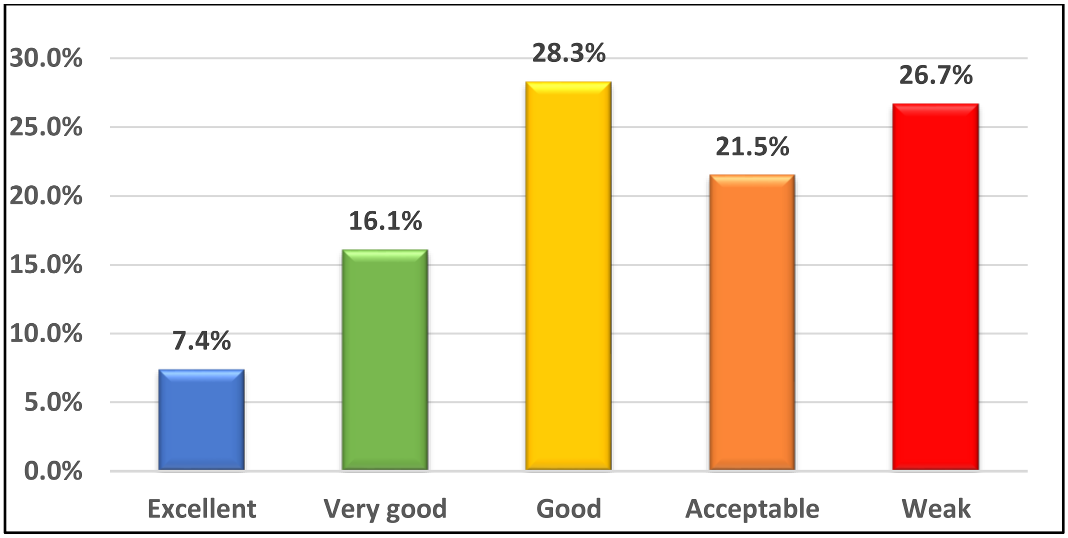


Figure 7-11: Evaluation of the Role of the Kuwaiti Government in Raising Public Awareness of the Need to Rationalise Electricity Consumption

As Table 7-33 and Figure 7-11 show, 28.3% (n=391) of the respondents considered that the role of the Kuwaiti government in raising public awareness of the need to rationalise electricity was good, while 21.5% (n=297) considered its role acceptable. However, 26.7% thought the government's role in this area was weak. Overall, 51.8% of respondents were satisfied with the government's role (rating it good, very good or excellent) while 48.2% were dissatisfied.

7.6 Personal Stance and Attitude towards Renewable Energy

The questions in the next section of the questionnaire moved away from energy consumption behaviour to ask respondents about their personal stances and attitudes towards renewable energy use in Kuwait. Respondents were encouraged to provide additional comments to explain their responses, and selected extracts from these responses are given below. (For details of all the comments made, see Appendix IX).

The first question asked respondents which sources of renewable energy they thought were most appropriate for development in Kuwait. As shown in Table 7-35 and Figure 7-14, most of the participants (87.5%, n= 1210) preferred solar energy, while the other sources received very low rates. This result could be explained by the fact that Kuwait is a hot, dry country, with average daily high temperatures range from 42 to 48 °C (108 to 118 °F) in the summer, so solar energy is in abundance and is widely seen as the best renewable energy solution.

Table 7-34: Description of the Respondents' Opinions Regarding the Most Appropriate Sources of Renewable Energy to Develop in Kuwait

Energy Sources	n	Per cent
Solar energy	1210	87.5%
Wind energy	34	2.5%
Nuclear energy	51	3.7%
Tidal energy	11	0.8%
I don't know	77	5.5%
Total	**1383**	**100%**

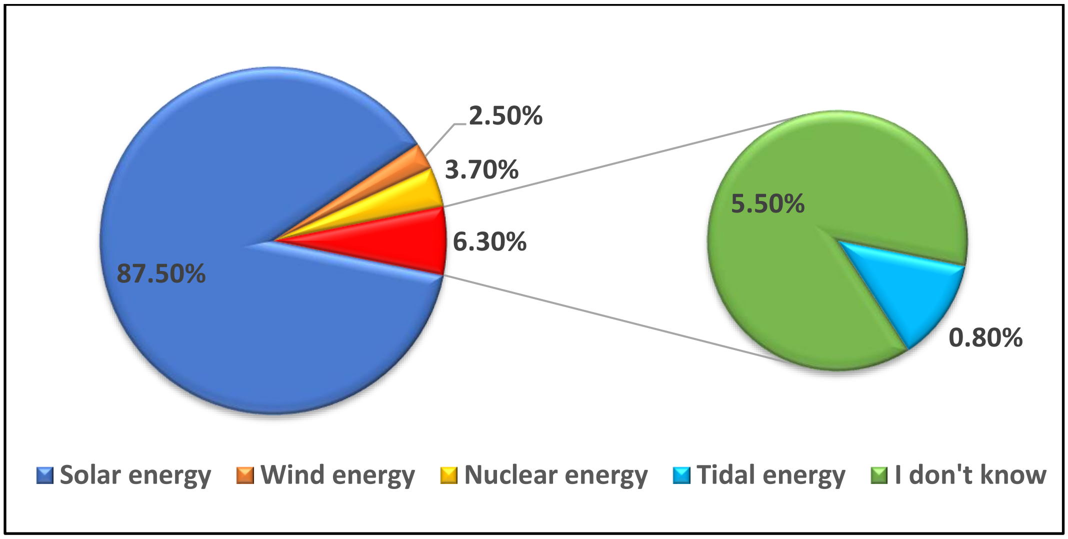


Figure 7-12: Respondents' Opinions Regarding the Most Appropriate Source of Renewable Energy to Invest in Kuwait

The comments section asked respondents "*In your personal opinion, please specify the most appropriate type of renewable energy or clean energy to invest in Kuwait*." The most significant comments are given below (See Appendix IX for all the comments made in this section).

Respondents offered a range of reasons for opting for solar energy, including Kuwait's climate, their personal experiences with solar technology, and the experience of neighbouring countries:

- *Kuwait is exposed to high temperatures. I think the most suitable sources to use are solar and thermal energy technologies.*
- *Kuwait is very hot in summer. Average daily high temperatures range from 42 to 48 °C (108 to 118 °F); the highest ever temperature recorded in Kuwait, so solar energy is the best solution.*
- *Kuwait is one of the highest countries for kWh/m of power generation from solar energy, the only issue is with the heat; if we can solve that issue then it'll be the best option.*
- *From personal experience of a facility in a desert area using solar panels which met the daily work requirement with high efficiency due to the constant availability of solar energy.*
- *Solar energy was chosen based on the UAE's successful experience as the climate is very close [to ours].*

With regard to wind energy, some respondents explained why they thought it was less attractive than solar:

- *Solar energy is more common in Arab countries, in particular in Arab Gulf countries, due to the favourable location, but wind energy much less applicable, because the wind speed is quite limited in Arab Gulf countries, between 4-6 me/m.*

Although some respondents saw nuclear energy as the most appropriate source, they mentioned the following concerns:

- *Nuclear power is the best, but there are regional conflicts that threaten it.*

- *The best is nuclear energy, but if government control is weak, it can cause disasters for the country.*

Some respondent provided impressive details regarding diversity in the exploitation of renewable energy sources and noted that:

- *After relying on solar energy, the trend should be to use wind and wave energy for the diversity of the use of renewable energy sources in Kuwait, as [it is] a desert country and the demand for electric power is constantly increasing. The use of renewable energy helps improve the environment and reduces current high pollution.*
- *A study needs to be conducted to select the best option. Natural we will say it is solar due to our climate, but we do not have sufficient data to neglect the tidal or wind energy. Other forms of energy might have good potential, depending on the field-testing location.*

The next question in the survey asked "*What are the most important elements associated with the use of renewable energy*?" and provided a list for respondents to choose from. A summary of their responses is provided in Table 7-35.

Table 7-35: Description of the Most Important Elements Associated with Renewable Energy

Important Elements	**Responses**		**Per cent of Cases**
	n	**%**	
Contributes to maintaining a clean environment.	1122	36.9%	81.7%
Contributes to the provision of the national economy.	748	24.6%	54.5%
Creates jobs.	397	13.0%	28.9%
Helps maintain oil resources and reduces their consumption	751	24.7%	54.7%
I think renewable energy is useless.	26	0.9%	1.9%
Total	**3044**	**100%**	

As Table 7-35 shows. the total number of responses across all elements was 3044. Of these, 1122 (81.7%) indicated that renewable energy contributes to maintaining a clean environment, and this choice represents the mode of the selections since it represents 36.9% of all the answers given to this question. Given the status of oil in Kuwait, it is significant to note that 751 (54.7%) of respondents indicated that renewable energy helps maintain oil resources and reduces their consumption and that 748 (54.5%) thought it contributed to the national economy. The fact that there were 3044 responses from a total of 1383 participants suggests that most people selected at least two options.

Likewise, regarding a question in the survey labelled*" Currently, where do you use renewable energy technologies?"* the total number of responses was 1525. While 751 respondents (54.7%) indicated they did not use renewable energy technologies currently, 338 (24.6%) indicated they used them in facilities in desert area with 259 (17.0%) using them at home (See Table 7-36).

Table 7-36: Description of Places Where Respondents Currently Use RE Technologies

Places where Renewable Energy technologies used	Responses		Per cent of Cases
	n	%	
Home	259	17.0%	18.9%
Facility in desert areas	338	22.2%	24.6%
Elsewhere	177	11.6%	12.9%
I do not use it	751	49.2%	54.7%
Total	**1525**	**100%**	**111%**

It is worth mentioning here that Photovoltaic (PV) cells was the most widely used technology among those respondents who said they currently used renewable energy technologies.

Participants were then asked to rate the role of official organisations in raising awareness of the benefits of renewable energy for the community. A summary of their responses is provided in Table 7-37 and 13.

Table 7-37. Evaluation of the Role of Official Organisations in Raising Awareness of the Benefits of Renewable Energy for the Community

Rate	n	Per cent
Excellent	76	5.5%
Very good	114	8.2%
Good	292	21.1%
Acceptable	243	17.6%
Weak	658	47.6%
Total	**1383**	**100%**

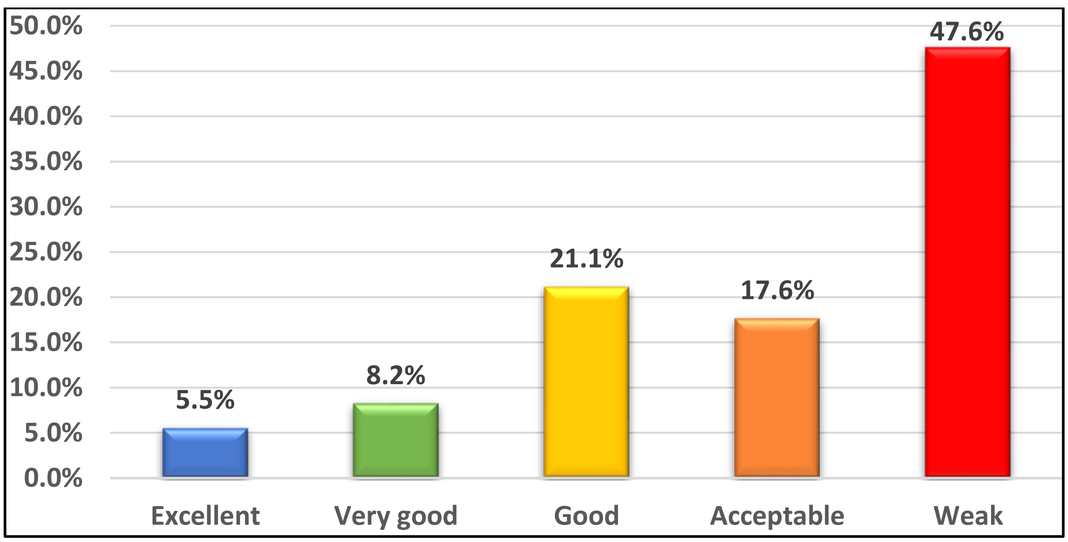


Figure 7-13: Evaluation of the Role of Official Organisations in Raising Awareness of the Benefits of Renewable Energy for the Community

As can be seen, a majority of the participants (n=658, 47.6%) rated the role of official organisations in raising awareness of the benefits of renewable energy for the community as 'weak', while 21.1% (n=292) of them rated it 'good', and just 5.5% (n=76) of respondents rated it 'excellent.'

The next question asked whether respondents thought it was important for householders to initiate the use of renewable energy in their homes. Most respondents (86.7%, n=1198) agreed that it was important, while only 1.2% (n=17) of them thought the opposite (See Table 7-38 and Figure 7-14).

Table 7-38: Responses Regarding Initiating the Utilisation of Renewable Energy in Private Homes

Responses	n	Per cent
Strongly Agree	669	48.4%
Agree	529	38.3%
Neutral	168	12.1%
Disagree	14	1.0%
Strongly Disagree	3	0.2%
Total	**1383**	**100%**

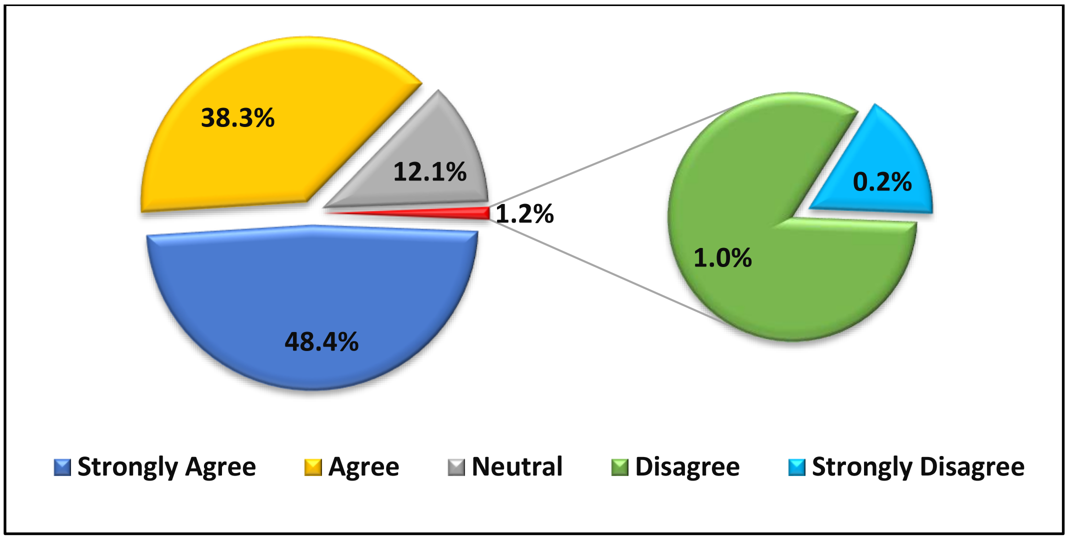


Figure 7-14: Responses Regarding Initiating the Utilisation of Renewable Energy in Private Homes

In addition, most of the respondents (91%, n=1258) agreed that official organisations should support citizens who use renewable energy in their homes by reducing their electricity tariff, while only 1.3% (n=19) of them disagreed (See Table 7-39 and Figure 7-15.

Table 7-39: Responses Regarding a Reduction in Electricity Tariffs for Domestic RE Users Supported by Official Organisations

Responses	n	Per cent
Strongly agree	774	56.0%
Agree	484	35.0%
Neutral	106	7.7%

Disagree	17	1.2%
Strongly disagree	2	0.1%
Total	**1383**	**100%**

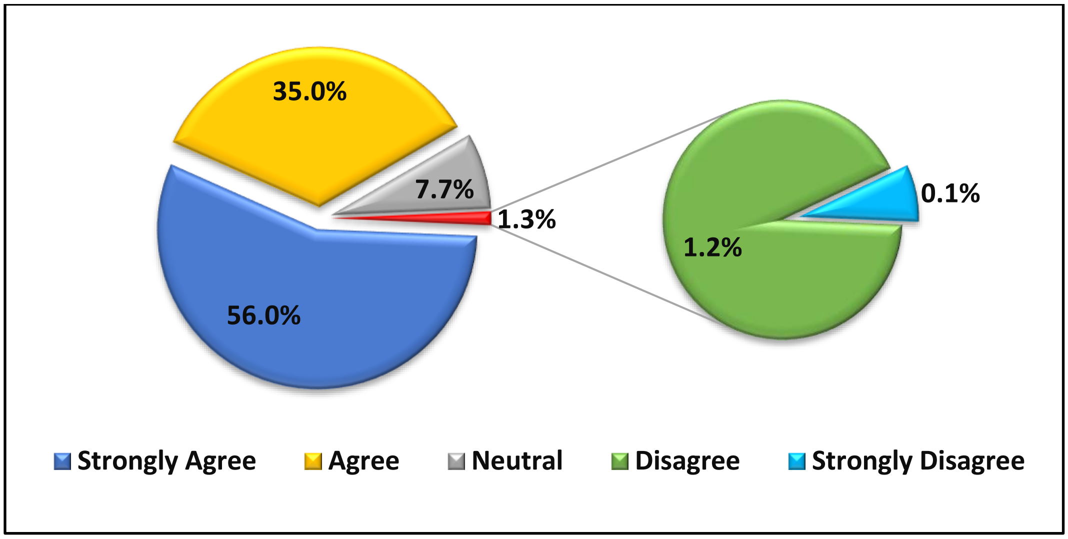


Figure 7-15: Responses Regarding a Reduction in Electricity Tariffs Supported by Official Organisations

Furthermore, the vast majority of respondents (96%, n= 1328) agreed that it was important for official organisations to increase the number of renewable energy projects to boost electric power generation (see Table 7-40 and Figure 7-16 below).

Table 7-40: Responses Regarding Official Organisations Increasing Renewable Energy Projects to Boost Electric Power Generation

Responses	n	Per cent
Strongly agree	900	65.1%
Agree	428	30.9%
Neutral	49	3.5%
Disagree	4	0.3%
Strongly disagree	2	0.1%
Total	**1383**	**100%**

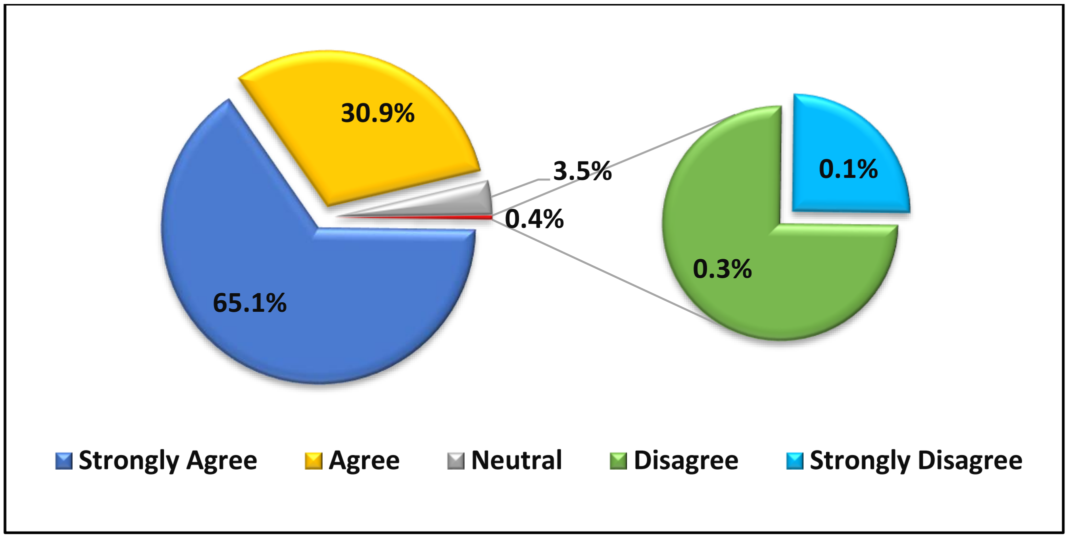


Figure 7-16: Responses Regarding Official Organisations Increasing Renewable Energy Projects to Boost Electric Power Generation

7.7 Knowledge and Awareness of the Advantages and Challenges of Renewable Energy

After exploring respondents' opinions about renewable energy, the next set of questions asked about their knowledge and awareness of the advantages and challenges associated with renewable energy. The first question asked respondents if they had background knowledge of renewable energy sources, acquired through reading or study, prior to completing the questionnaire. Their responses are summarised in Table 7-41 and Figure 7-17.

Table 7-41: Responses Regarding Participants' Background Knowledge of RE

Responses	n	Per cent
I don't know	99	7.2%
Strongly Agree	446	32.2%
Agree	672	48.6%
Neutral	141	10.2%
Disagree	17	1.2%
Strongly Disagree	8	0.6%
Total	**1383**	**100%**

As can be seen, 80.8% (n=1118) of respondents reported that they had some background knowledge, through reading or study, about renewable energy sources, such as solar, wind, and thermal energy.

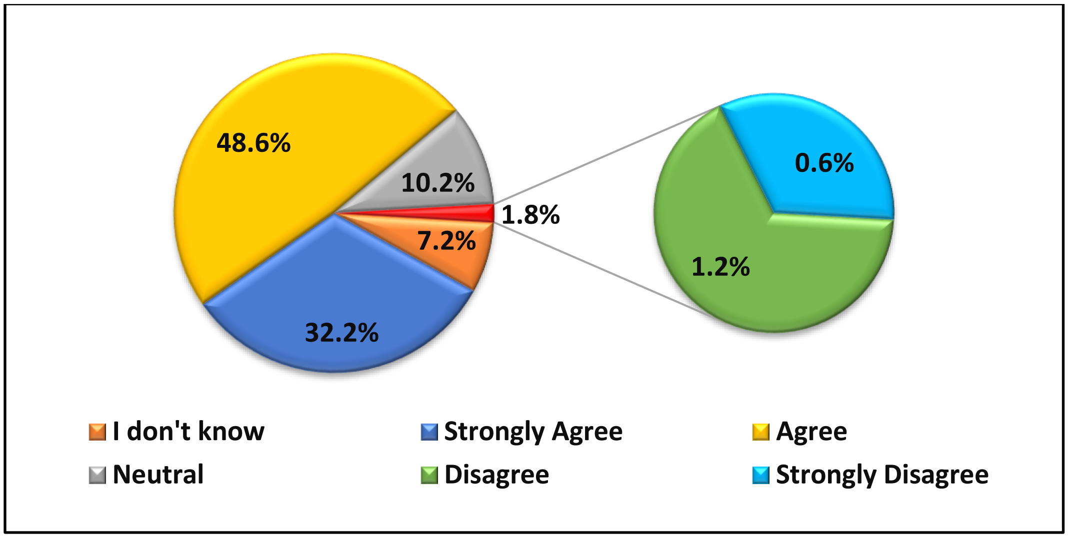


Figure 7-17: Responses Regarding Participants' Background Knowledge of RE

The next question asked respondents about the distribution of renewable energy technologies in Kuwait. Most of the participants (78.7%, n= 1088) agreed that renewable energy technologies were not widely distributed in the domestic market in Kuwait, while only 2% of them disagreed. Their responses are summarised in Table 7-42 and Figure 7-18.

Table 7-42: Responses Regarding the Distribution of Renewable Energy Technologies in Kuwait

Responses	n	Per cent
I don't know	139	10.1%
Strongly Agree	458	33.1%
Agree	630	45.6%
Neutral	128	9.3%
Disagree	24	1.7%
Strongly Disagree	4	0.3%
Total	**1383**	**100%**

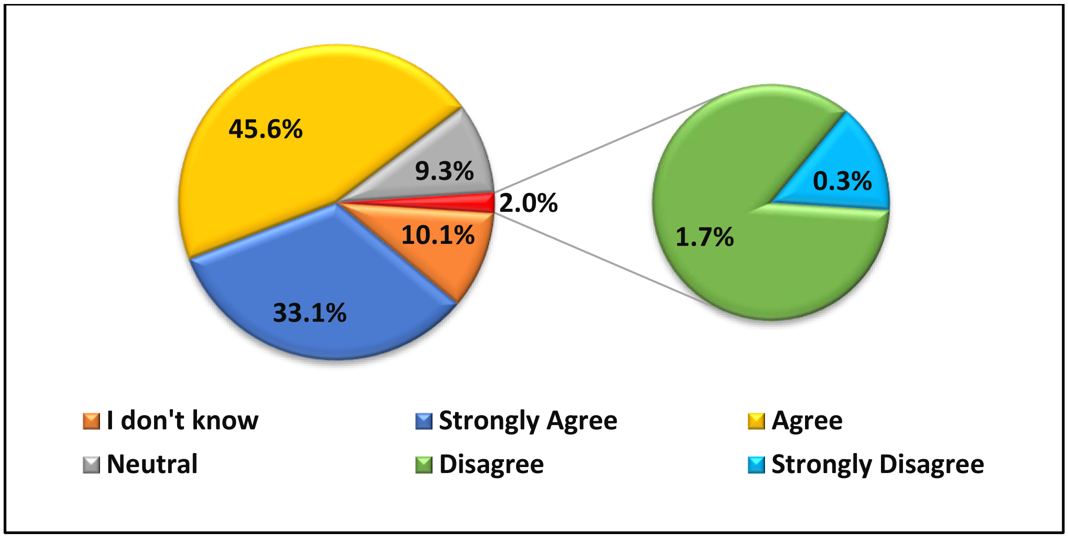


Figure 7-18: Responses Regarding the Distribution of Renewable Energy technologies in Kuwait

This was followed by a question about the costs associated with renewable energy technologies. A majority of the respondents (64.7%, n=895) agreed that renewable energy technologies in Kuwait have high prices due to the lack of government support to encourage their use. However, just under one-quarter of respondents reported that they had no idea about this issue (See Table 7-43 and Figure 7-19).

Table 7-43: Responses Regarding the Cost of Renewable Energy Technologies

Responses	n	Per cent
I don't know	338	24.4%
Strongly Agree	462	33.4%
Agree	433	31.3%
Neutral	127	9.2%
Disagree	16	1.2%
Strongly Disagree	7	0.5%
Total	**1383**	**100%**

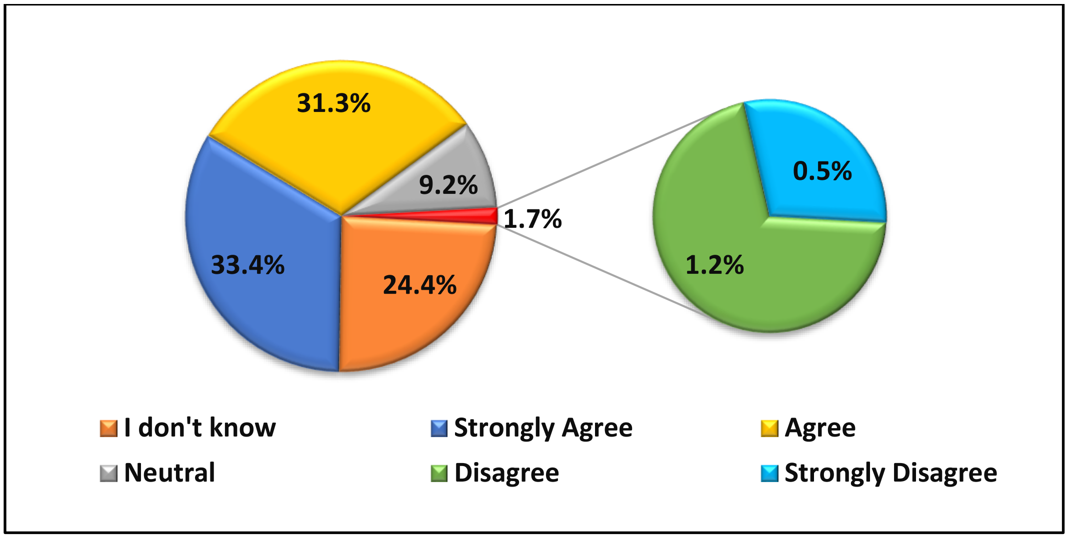


Figure 7-19: Responses Regarding the Cost of Renewable Energy Technologies

Respondents were then asked about the strength of the renewable energy sector in Kuwait. Most of them (83.3%, n= 1151) agreed that the sector is still weak. However, 149 (10.8%) respondents reported that they did not know about the situation of the RE sector in Kuwait (see Table 7-44 and Figure 7-20).

Table 7-44: Responses Regarding the Renewable Energy Sector in Kuwait

Responses	n	Per cent
I don't know	149	10.8%
Strongly Agree	633	45.8%
Agree	518	37.5%
Neutral	67	4.8%
Disagree	10	0.7%
Strongly Disagree	6	0.4%
Total	**1383**	**100%**

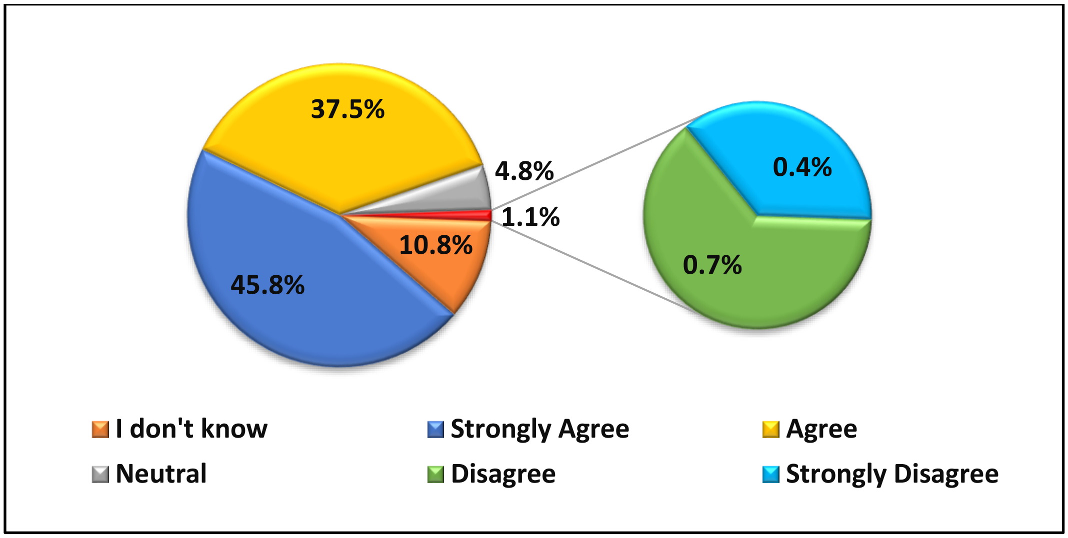


Figure 7-20: Responses Regarding the Renewable Energy Sector in Kuwait

The final question in this section asked respondents if they thought that the Kuwaiti community needed to increase its awareness of renewable energy. The vast majority of respondents (93.2%, n=1288) supported this view (See Table 7-45 and Figure 7-21).

Table 7-45: Responses Regarding Increasing Community Awareness of Renewable Energy in Kuwait

Responses	**n**	**Per cent**
I don't know	43	3.1%
Strongly Agree	890	64.4%
Agree	398	28.8%
Neutral	44	3.2%
Disagree	6	0.4%
Strongly Disagree	2	0.1%
Total	**1383**	**100%**

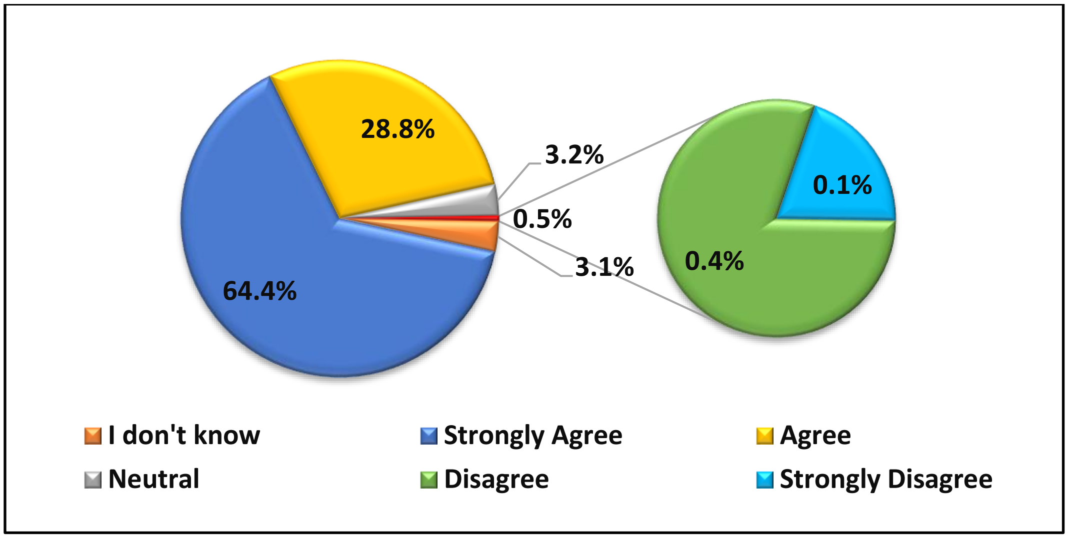


Figure 7-21: Responses - Increasing the Awareness of Renewable Energy in Kuwait

7.7.1 Descriptive Statistics for the Knowledge and Awareness Scores

Table 7-46 provides descriptive statistics for the scores of 'Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy'. The best score (the full mark) should be 25.

Table 7-46: Descriptive Statistics for the Scores of Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy

Measure	Value	Measure		Value
n	1383	Range		25
Mean	19.34	Minimum		0
Std. Error of Mean	0.14	Maximum		25
Median	20.0	Percentiles	25	17.00
Std. Deviation	5.09		50	20.00
Coefficient of variation	26.3%		75	23.00

The minimum score was 0.0, and the maximum was 57.0 with a range of 25, which indicates that there was a wide disparity between participants' scores. The mean of the scores was 19.34 (SE = ± 0.14) with a median of 20, which indicates that the distribution of the scores is slightly skewed to the left. The standard deviation of the scores was 5.09, suggesting that the coefficient variation of the scores was 26.3%. Finally, the 75th percentile indicates that 75% of the participants in the survey scored 23 or below for their knowledge and awareness of the advantages and challenges associated with RE.

7.7.2 Normality Test for the Knowledge and Awareness Scores

Table 7-47 shows the results of the Kolmogorov-Smirnov test for the scores for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy. These show that the scores were not normally distributed, as their distribution was statistically significant at 0.01 level of significant ($p < 0.01$). Therefore, these results validate the use of non-parametric tests, namely the Mann-Whitney U test and Kruskal-Wallis test when exploring the relationships between Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy and other variables.

Table 7-47: Tests of Normality of the Data Obtained in the Scores of Knowledge and Awareness of the Advantages and Challenges of Renewable Energy

Variable	Kolmogorov-Smirnov		
	Statistic	df	Sig.
Knowledge and Awareness of the Advantages and Challenges of Renewable Energy	0.179	1383	0.000

7.7.3 Mann-Whitney U Test

The results of the Mann-Whitney U test are set out in Table 7-48. This shows that there was a statistically significant difference in mean rank for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy attributed to Nationality ($Z=7.61$, $p < 0.01$). Kuwaiti citizens who participated in the survey were more likely to have a higher score for knowledge and awareness than non- Kuwaitis.

Likewise, Mann-Whitney U test showed that there was a statistically significant difference observed in mean rank attributed to Gender (Z=2.82, p < 0.01). Males who participated in the survey were more likely to have a higher score for knowledge and awareness than females.

However, there was no statistically significant difference observed in mean rank attributed to Work Status (Z=1.85, p > 0.05) as the total scores for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy were similar for both 'Working' and 'Not Working' respondents.

Table 7-48: Mann-Whitney U Test Results for Differences in Total Scores for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy According to Nationality, Gender, and Work Status

Variables	**Category**	**N**	**Mean Rank**	**Sum of Ranks**	**Test Statistics**	
Nationality	Kuwaiti	998	742.6	741069.0	Z	-7.61
	Non-Kuwaiti	385	561.0	215967.0	p value	0.000
	Total	**1383**				
Gender	Male	1003	710.6	712679.5	Z	-2.82
	Female	380	643.0	244356.5	p value	0.005
	Total	**1383**				
Work Status	Working	927	705.9	654322.5	Z	-1.85
	Not Working	456	663.9	302713.5	p value	0.065
	Total	**1383**				

7.7.4 Kruskal -Wallis Test

Kruskal-Wallis H test was also used to explore whether there were significant differences in mean rank for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy attributed to Age, Level of Education, and Accommodation type, since Kruskal -Wallis H test can be applied for independent variables which have more than two categories. The results are set out in Table 7-49.

Table 7-49: Analysis of Kruskal Wallis Test Results for Differences in Total Scores for Knowledge and Awareness According to Age, Level of Education, and Accommodation Type

Variables	Category	N	Mean Rank	Test Statistics	
Age	18-24 years	245	650.77		
	25-34 years	322	678.26		
	35-44 years	377	697.73	Kruskal-Wallis H	6.12
	45-54 years	304	725.29	df	5
	55-64 years	122	699.57	p value	0.295
	65 and above	13	793.62		
	Total	**1383**			
Level of Education	PhD.	75	675.75		
	Master	160	707.02		
	Bachelor	584	681.50	Kruskal-Wallis H	2.33
	Diploma	269	711.51	df	5
	High School Certificate	246	700.89	p value	0.802
	Primary School	49	641.17		
	Total	**1383**			
Accommodation type	Owned House	876	721.25		
	Owned Apartment	159	617.60		
	Rental House	124	611.75	Kruskal-Wallis H	23.79
	Rental Apartment	213	657.73	df	4
	Others	11	1006.09	p value	0.000
	Total				

As Table 7-49 shows, the H values calculated according to Age, Level of Education, and Accommodation type were 6.12, 2.33, and 23.79, respectively. Regarding Age and Level of Education of the respondents, there were no significant differences in mean scores for knowledge and awareness attributed to these two variables since their p values are greater than 0.05. However, there are significant differences in the mean scores attributed to Accommodation type (H=23.79, DF=4, p-value <0.01).

After examining the post-hoc test with the aid of Bonferroni Test (See Appendices IX) for the mean results for Accommodation type, it was observed that respondents who owned their house had a higher mean score compared with other respondents. Bonferroni Test indicated that there were highly significant differences in mean ratings for knowledge and awareness between the 'owned house' group and 'owned apartment' (p-value <0.01), 'rental house' (p-value <0.01), and 'rental apartment' (p-value <0.05).

7.7.5 Respondents' Suggestions for Increasing Renewable Energy Utilisation in Kuwait

The questionnaire concluded by asking respondents *"Do you have any other comments or suggestions?* Many respondents noted down their suggestions and comments, and the most prominent among them are listed below (The rest of the comments are provided in Appendix IX):

- *Kuwaiti and non-Kuwaiti people who live in the Gulf area, are used to being independent, being spoiled and being served; habits that need to be replaced if people who live in the Gulf area are to start feeling the damage they are causing to the environment due to overconsumption of all types of resources. "Humans who do not clean their surroundings cannot be responsible for saving their homes or nations." This is due to natural self-developmental psychology. It all starts deep within.*

- *We need to see articulated support by the government in the form of subsidy; laws and regulations; awareness; support networks and initiatives to see an increase in alternative renewable energy. Not smoke-screen one-off PR initiatives, but rather a strategic program that has clear goals, targets and follow-up as well as the right resources (investments, people, R&D) to succeed.*

- *The government must start a campaign by selecting random samples in villas under construction in the residential areas and installing PV panels to the walls of villas and installing external lights free of charge to increase the awareness of the community by making renewable energy part of the energy used in their homes, such as for external lights and operating central heaters and elevators.*
- *Adaptation to any topic needs a culture to ensure citizen awareness, and this culture must be cultivated and developed from a young age and be within the study programs and the media [should] have a significant and active role in spreading this culture so that the citizen realises the importance of renewable energy.*
- *Travelling a thousand miles begins with a single step, so let us start on a correct basis by identifying our requirements for renewable energy and benefiting from it without delay.*
- *In terms of solar energy and PV cells, these are limited in Arab Gulf countries, because of a lack of the evidence required to develop a strategic plan as a national framework under the concept of sustainability. Also, this technology needs support from international and local experts in order to implement solar cells with a method suitable for the climatic conditions. In other words, solar cells need to improve their efficiency to be applicable for hot, dry and arid countries such as Kuwait, because the efficiency of cells declines whenever the temperature exceeds 40 degrees, so it is necessary to minimise the furnace temperature of PV cells.*

7.7.6 Demography and Criteria Associations

One of the objectives of the 'Public Questionnaire' was to identify the demographic profile of the respondents in terms of nationality, gender, age, level of education, occupation and accommodation type, so that the relationship between these variables and the respondents' efficiency of energy consumption and knowledge and awareness of renewable energy could be evaluated. Table 7-50 presents the results of the analysis of these relationships.

Table 7-50: The Relationship Between the Respondents Demographics and their Background Knowledge, User Efficiency, and Knowledge and Awareness of Renewable Energy

Criteria	**Highly-Significant Association** ***$p < 0.01$***	**Significant Association** ***$p < 0.05$***	**Non-Significant Association** ***$p > 0.05$***
Background Knowledge of Environment and Energy	Age	Accommodation type	Nationality
	Level of Education	-	Gender
	-	-	Occupation
User Efficiency and Energy Conservation	Accommodation type	Gender	Nationality
	-	Age	Level of Education
	-	Occupation	-
Knowledge and Awareness of the Advantages and Challenges Associated with RE	Accommodation type	Nationality	Occupation
	-	Gender	Age
	-	-	Level of Education

Source: Author's Own

A highly-significant association was found between the background knowledge and the age and level of education of participants; this is to be expected and shows the significance of age and knowledge gained from education and life experience. A significant association was found with accommodation type of participants; this could be related to the fact that accommodation type denotes different income levels and therefore different levels of consumption. A non-significant association was found between nationality, gender and occupation of the participants and their background information and knowledge. This result comes as no surprise.

In relation to electricity consumption and efficiency of energy use, the results show that there is a highly-significant association between electricity consumption and efficiency of energy use and the accommodation type of the participants; this could again be related to income or family energy budget. The results also show a significant association with gender, age and occupation, which could also be related to financial income and who is responsible for paying energy bills.

In relation to participants' knowledge and awareness of the advantages and challenges associated with renewable energy, the association with accommodation type is found to be highly significant. The association of nationality and gender is also found to be significant. As previously discussed, these associations could be explained by linking the interest in renewable energy with the level of income and the responsibility for paying energy bills, but further work is needed to understand how nationality and gender might influence this aspect.

7.8 Summary

This chapter has provided statistical analysis of the data collected via the 'Public Questionnaire'. It has analysed the characteristics of the participants and their significant associations with the scores for 'User Efficiency and Energy Conservation' and 'Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy'. It has also determined the participants' attitudes and behaviours towards electrical energy saving and their evaluation of the role of governmental organisations in encouraging this. In addition, it has examined public attitudes towards renewable energy use, levels of awareness of the advantages and challenges associated with RE, and the role of official organisations in promoting its use. It has also assessed the extent to which renewable energy is currently used by members of the public. The next chapter goes on to provide analysis of the data collected via the 'Academics and Educational Organisations Questionnaire' and the 'Official Organisations Questionnaire".

Chapter 8

Statistical Analysis of the 'Academic and Educational Organisations Questionnaire' and the 'Official Organisations Questionnaire'

8.1 Introduction

This chapter provides statistical analysis of the data collected via the 'Academic and Educational Organisations Questionnaire' and the 'Official Organisations[3] Questionnaire' in order to assess: a) participants' awareness of the need to preserve the environment in Kuwait; b) their user efficiency in electricity consumption; c) their personal attitudes towards renewable energy; d) their knowledge and awareness of the advantages and challenges associated with renewable energy; and e) the role their organisations play in promoting energy efficiency and raising awareness of renewable energy utilisation.

In order to achieve the objectives of this phase of the study, two dedicated questionnaires were developed to assess levels of renewable energy awareness and attitudes towards energy efficiency among academics, officials and other stakeholders in Kuwait. These questionnaires, herein entitled the 'Academic and Educational Organisations Questionnaire' and the 'Official Organisations Questionnaire', also explored their views of the obstacles facing the renewable energy sector in Kuwait with a view to identifying possible solutions. These questionnaires were completed by academics, officials, and other stakeholders, including members of professional bodies, heads of media organisations, and NGOs, and business leaders.

[3] The term 'official organisations' is used here to refer to both governmental organisations and those which have received official authorisation to operate, including companies, newspapers, professional bodies and NGOs.

8.2 Methods of Data Analysis

As with the ‘Public Questionnaire’, descriptive statistics were used to describe participants’ baseline characteristics. Percentages and frequencies were used for the categorical variables, while mean and standard deviations were calculated for the continuous variables. Non-parametric statistical tests were used according to the findings of the Normality Test. While a Chi-squared Test was used to test associations between the variables, Mann-Whitney U Test and Kruskal-Wallis H Test were used to test the differences in means of ‘Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy’ scores regarding demographic variables. Post-hoc testing using Bonferroni Test was run to detect where the significant differences occurred within groups. Advanced statistical techniques, such as Factor Analysis, were used to determine which factors characterized ‘User Efficiency in Electricity Consumption’. All the statistical analyses were performed using SPSS (v25). Finally, all the significance values were set at $p < 0.05$, while all the high significance values were set at $p < 0.01$.

8.3 Results

The analysis begins by describing the baseline characteristics of the respondents, then investigating their background information. It then considers the role their organisations play in relation to environmental issues and their own attitudes towards the environment and renewable energy use. It goes on to explore the responses given to questions exploring User Efficiency in Electricity Consumption and the Overall User Efficiency in Electricity Consumption, and details the Factor Analysis run for the User Efficiency in Electricity Consumption statements. The next section examines the role the respondents’ organisations play in raising awareness of the need to curb excessive consumption and considers their own behaviour in this regard. The analysis then goes on to assess the extent of renewable energy utilisations in educational and official buildings, and the role the government might play in promoting this. The final section examines the respondents' personal stances and attitudes towards renewable energy and their knowledge and awareness of the advantages and challenges associated with it. This section concludes by describing the results of the non-parametric statistical tests used to detect differences in the means of the user efficiency and knowledge and awareness of the advantages and challenges of renewable energy scores regarding the demographic variables.

8.4 Baseline Characteristics of the Respondents (Academics, Officials and Stakeholders)

8.4.1 Nationality

As Table 8-1 and Figure 8-1 show, the majority of the academics (79%, n=83) and officials and stakeholders (82.8%, 192) were Kuwaiti citizens.

Table 8-1: Description of the Sample - Nationality

Nationality	**Academics**		**Officials**	
	n	**%**	**n**	**%**
Kuwaiti	83	79.0%	192	82.8%
Non-Kuwaiti	22	21.0%	40	17.2%
Total	**105**	**100%**	**232**	**100%**

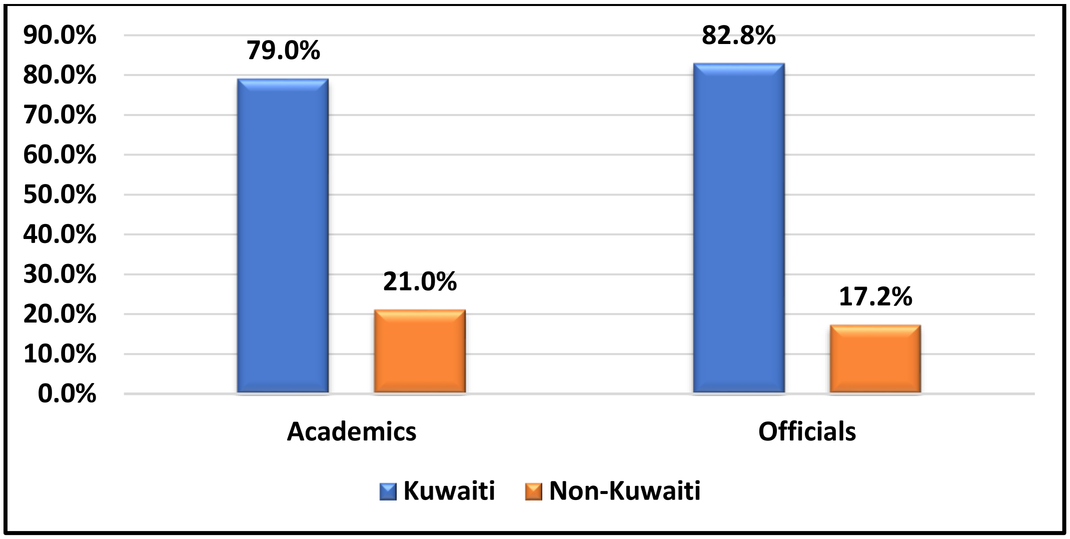


Figure 8-1: Distribution of the Sample Members According to Nationality

8.4.2 Gender

As can be seen in Table 8-2 and Figure 8-2, while gender ratios were distributed almost equally among the academics (50.5% males and 49.5% females), 71.6% (n=166) of the officials who participated in the survey were male.

Table 8-2: Description of the Sample - Gender

Gender	Academics		Officials	
	n	%	n	%
Male	53	50.5%	166	71.6%
Female	52	49.5%	66	28.4%
Total	**105**	**100%**	**232**	**100%**

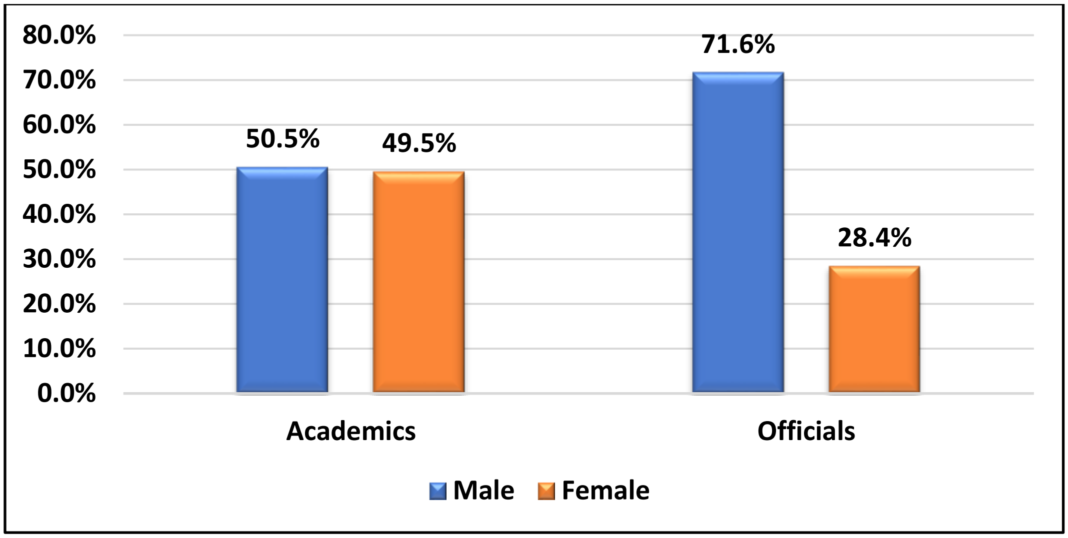


Figure 8-2: Distribution of the Sample Members According to Gender

8.4.3 Age

As Table 8-3 and Figure 8-3 show, 33.3% (n=35) of academics were in the age range 35 to 44 years, while 32.8% (n=76) of officials were in the age range 45-54 years at the time of data collection.

Table 8-3: Description of the Sample - Age

Age	Academics		Officials	
	n	Percent	n	Percent
18-24	3	2.9%	2	0.9%
25-34	30	28.6%	50	21.6%
35-44	35	33.3%	71	30.6%
45-54	30	28.6%	76	32.8%
55-64	7	6.6%	31	13.4%
65 and above	0	0%	2	0.9%
Total	**105**	**100%**	**232**	**100%**

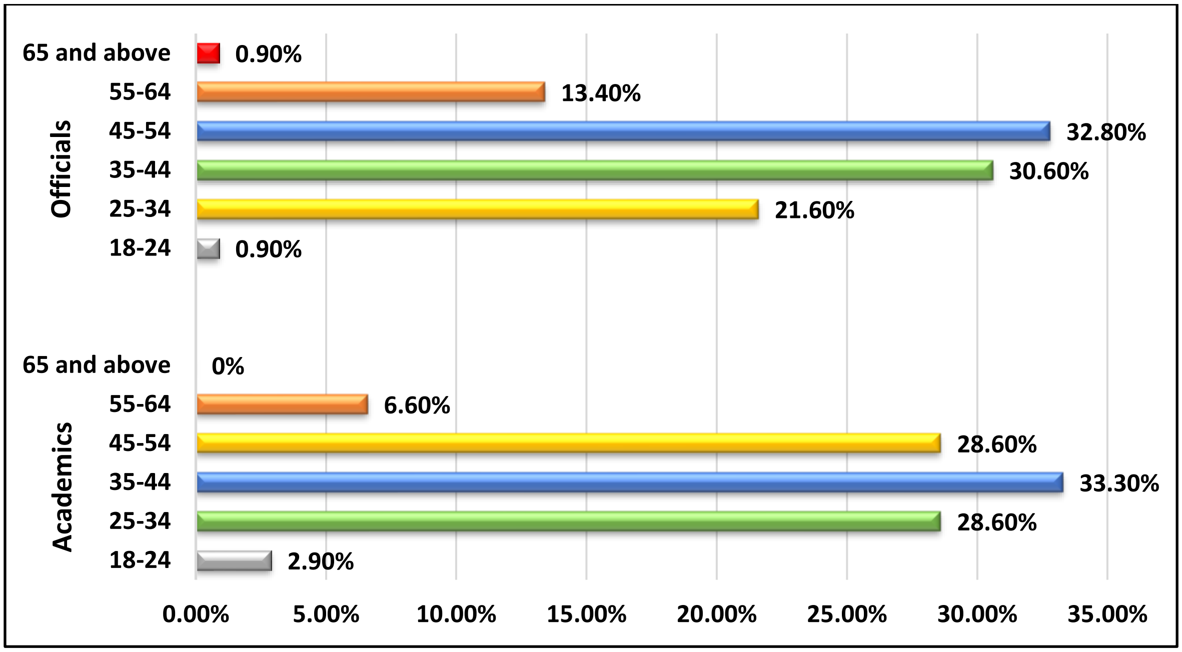


Figure 8-3: Description of the Sample - Age

8.4.4 Qualifications

With regard to qualifications, 88 academics (83.8%) held degree-level qualifications or above (i.e. Bachelor, Master, or Ph.D.), while 152 officials (65.6%) held them (See Table 8-4 and Figure 8-4).

Table 8-4: Description of the Sample - Qualifications

Qualification	Academics		Officials	
	n	Percent	n	Percent
Ph.D.	14	13.3%	12	5.2%
Master	13	12.4%	29	12.6%
Bachelor	61	58.1%	111	47.8%
Diploma	9	8.6%	46	19.8%
High School certificate	8	7.6%	30	12.9%
Primary School certificate	0	0.0%	4	1.7%

Total	**105**	**100%**	**232**	**100%**

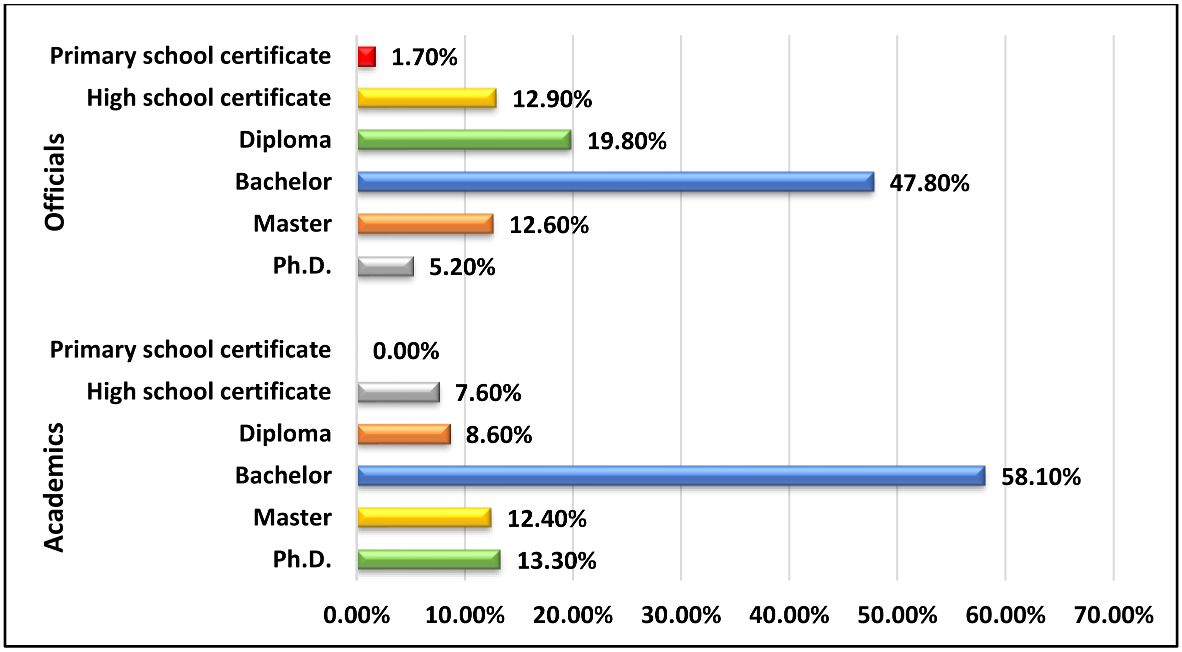


Figure 8-4: Description of the Sample – Qualifications

8.4.5 Occupation

As Table 8-5 and Figure 8-5 show, of the 105 respondents who were academics, 91.4% (n= 96) reported that they were employed, as opposed to 188 officials. 9 academics (8.6%) were retired, while 44 (19.0%) of officials reported they were retired.

Table 8-5: Description of the Sample - Occupation

Occupation	Academics		Officials	
	n	Percent	n	Percent
Employed	96	91.4%	188	81.0%
Retired	9	8.6%	44	19.0%

Total	**105**	**100%**	**232**	**100%**

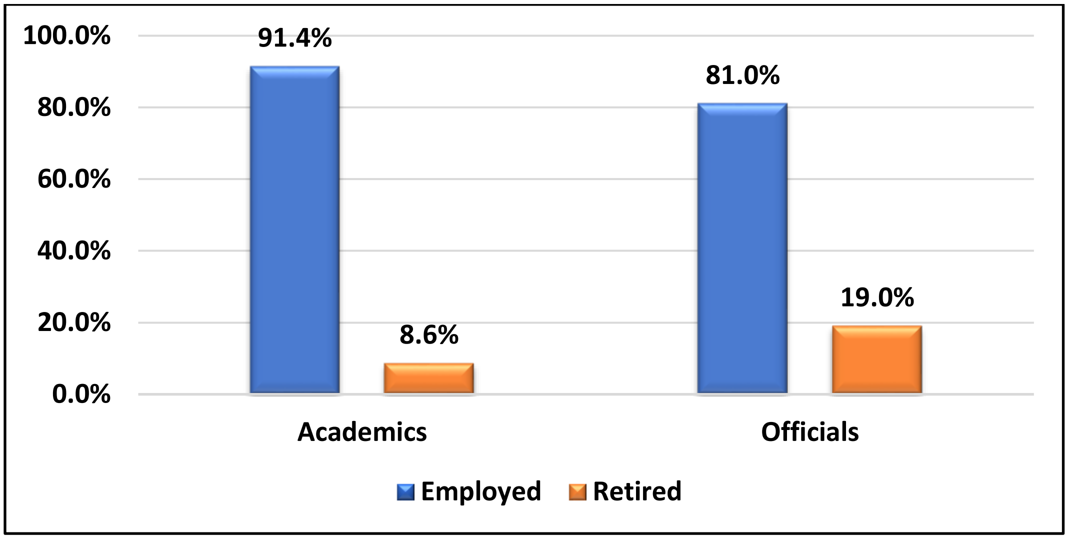


Figure 8-5: Distribution of the Sample Members According to Occupation

8.4.6 Sector – Academics

As shown in Table 8-6 and Figure 8-6, more than two fifths of respondents were working in state schools (n=46, 43.8%), followed by 23.8% working in public (state) universities.

Table 8-6: Distribution of the Academics According to Sector

Academic sector	n	Percent
Public (state) university	25	23.8%
Private university	8	7.6%
Public (state) college	12	11.4%
Private college	1	1.0%
Research institute	3	2.9%
State school	46	43.8%

Private school	2	1.9%
Ministry of Education	8	7.6%
Total	**105**	**100%**

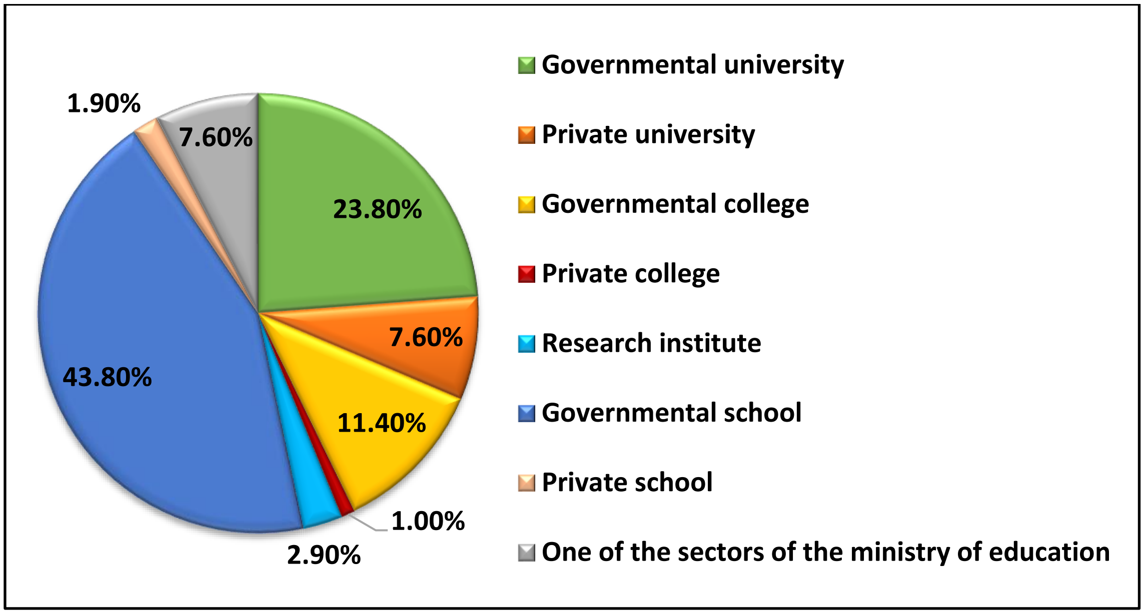


Figure 8-6: Distribution of the Academics According to Sector

8.4.7 Sector – Officials and Stakeholders

The overwhelming majority of the officials and stakeholders were working in the public sector (n=165, 71.1%), while just 67 (28.9%) were working in the private sector (See Table 8-7 and Figure 8-7).

Table 8-7: Distribution of the Officials According to Sector

Sector	n	Percent
Public sector	165	71.1%
Private sector	67	28.9%
Total	**232**	**100%**

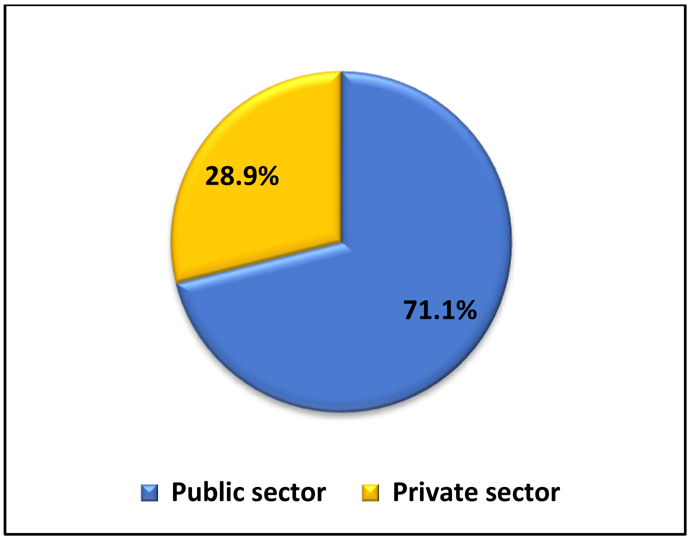


Figure 8-7: Distribution of the Officials According to Sector

8.4.8 Employment Field – Officials and Stakeholders

Almost half the officials who participated in the study worked in the Ministerial sector (49.1%, n=114), followed by (19.8%, n= 46) in the Companies sector, and 12.5% (n=29) in the Education sector (see Table 8-8 and Figure 8-8).

Table 8-8: Distribution of the Officials According to Employment Field

Employment Field	n	Percent
Ministerial sector	114	49.1%
Authorities sector	7	3.0%
Companies sector	46	19.8%

Industrial sector	14	6.0%
Services sector	8	3.4%
Health sector	14	6.0%
Education sector	29	12.5%
Total	**232**	**100%**

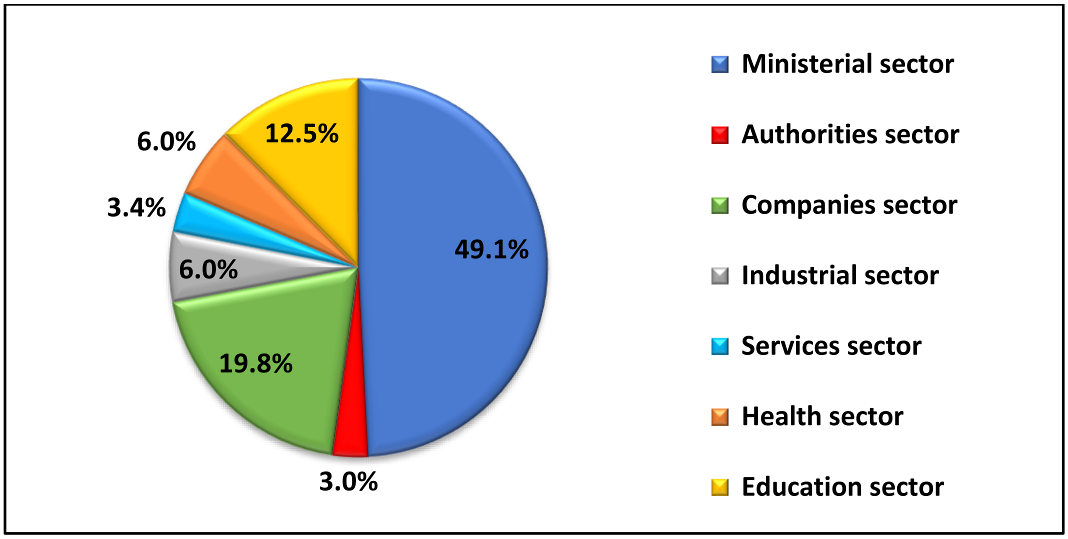


Figure 8-8: Distribution of the Officials According to Employment Field

8.5 Role of the Institutions in Environmental Issues

The next part of the survey asked a series of questions to gather background information about the roles the institutions targeted in the sample were playing in promoting environmental issues and the use of renewable energy.

8.5.1 Role of Organisations in Relation to Environmental Issues – Academics

The first of these questions asked academics: "Does your educational organisation teach students how to preserve the environment and to show an interest in environmental issues?" Slightly less than the half of the academics responded positively (47.6%, n=50), while close to one quarter (24.8%, n=26) responded negatively (=No) (See Table 8-9 and Figure 8-9).

Table 8-9: Role of Organisation in Relation to Environmental Issues – Academics

Responses	n	Percent
Yes	50	47.6%
No	26	24.8%
Sometimes	29	27.6%
Total	**105**	**100%**

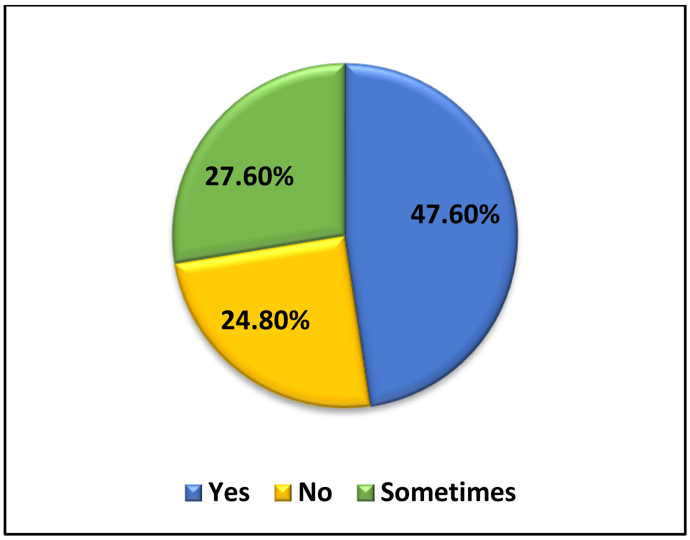


Figure 8-9: Role of Organisation in Environmental Issues - Academics views

8.5.2 Role of Organisation in Relation to Environmental Issues – Officials and Stakeholders

In addition, 103 officials (44.4%) reported that their organisations played an active role in preserving the environment and had an interest in environmental issue while 29.7% of them stated that their organisations did this sometimes (See Table 8-10 and Figure 8-10.)

Table 8-10: Role of Organisation in Relation to Environmental Issues - Officials

Responses	n	Percent
Yes	103	44.4%

No	56	24.1%
Sometimes	69	29.7%
Don't know	4	1.8%
Total	**232**	**100%**

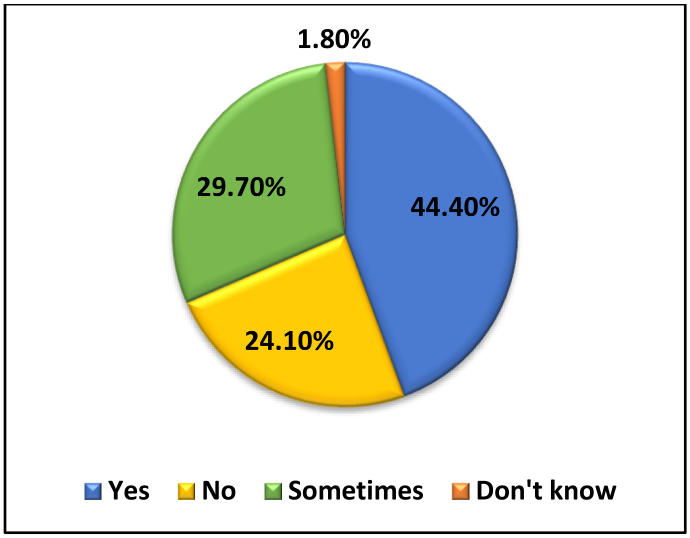


Figure 8-10: Role of Organisation in Relation to Environmental Issues - Officials

8.6 Respondents' Perceptions Regarding the Environment and Renewable Energy

The next question asked respondents to report the extent to which they agreed with two statements regarding the environment and renewable energy. The responses of the academics and the officials and experts are given below.

8.6.1 Academics' Perceptions

The responses provided by the academics are presented in Table 8-11.

Table 8-11: Academics' Perceptions Regarding the Environment and Renewable Energy

Statement		SA	A	N	D	SD
	n	69	29	6	1	0

Recently it has become necessary to start using renewable energy to generate electricity instead of fossil fuel which cause air pollution	%	65.7%	27.6%	5.7%	1.0%	0.0%
Moving towards the utilisation of renewable energy sources is the best way to improve the environment and secure the future for new generations	n	71	29	3	1	1
	%	67.6%	27.6%	2.8%	1.0%	1.0%
Overall perceptions		**66.7%**	**27.6%**	**4.2%**	**1.0%**	**0.5%**

SA=Strongly Agree, A= Agree, N= Neutral, D = Disagree, SD= Strongly Disagree.

As Table 8-11 shows, most of the academics (n=69, 65.7%) strongly agreed that it is now necessary to start using renewable energy sources to generate electricity instead of fossil fuels. In addition, 71 respondents (67.6%) strongly agreed that moving towards the utilisation of renewable energy sources is the best way to improve the environment and secure the future for new generations.

8.6.2 Officials' and Stakeholders' Perceptions

Equally, a majority of the officials (n=165, 71.2%) strongly agreed that it has become necessary to start using renewable energy sources to generate electricity instead of fossil fuels. In addition, 159 respondents (68.6%) strongly agreed that moving towards renewable energy utilisation is the best way to improve the environment and secure the future for new generations (See Table 8-12).

Table 8-12: Officials' Opinions Regarding the Environment and Renewable Energy

Statement		SA	A	N	D	SD
Recently it has become necessary to start using renewable energy to generate electricity instead of fossil fuels which cause air pollution	n	165	59	7	1	0
	%	71.2%	25.4%	3.0%	0.4%	0.0%
Moving towards the utilisation of renewable energy sources is the best way to improve the	n	159	69	4	0	0
	%	68.6%	29.7%	1.7%	0.0%	0.0%

environment and secure the future for new generations						
Overall perceptions		**69.8%**	**27.6%**	**2.4%**	**0.2%**	**0.0%**

SA=Strongly Agree, A= Agree, N= Neutral, D = Disagree, SD= Strongly Disagree.

8.7 User Efficiency in Electricity Consumption

The next section asked a series of questions designed to assess respondents' user efficiency in relation to electricity consumption. The responses provided by the academics and the officials and stakeholders are set out below.

8.7.1 Academics' User Efficiency in Electricity Consumption

Table 8-13 shows the distribution of responses received from the academics.

Table 8-13: Percentage Distribution of Responses Regarding User Efficiency in Electricity Consumption - Academics

Statement		**Yes**	**No**	**Sometimes**	**I don't know**
Do you leave the lights on during the day even though there is daylight at your place of work?	n	22	44	39	0
	%	21.0 %	41.9%	37.1%	0%
When you are the last person to leave your place of work, do you switch off the lights before you go?	n	77	8	18	2
	%	73.4 %	7.6%	17.1%	1.9%
Do you turn off the electricity after using the computer and other devices?	n	53	29	23	0
	%	50.5 %	27.6%	21.9%	0%
Does your organisation use LED (energy-saving) lights?	n	25	51	11	18
	%	23.8 %	48.6%	10.5%	17.1%
Is your organisation's building supported by thermal insulation?	n	28	36	3	38
	%	26.7 %	34.3%	2.9%	36.1%
Do you leave the air conditioning ON after leaving your place of work?	n	56	26	12	11
	%	53.3 %	24.8%	11.4%	10.5%
	n	13	47	6	39

Does your organisation use power-saving controllers?	%	12.4 %	44.8%	5.7%	37.1%
Does your organisation use electric cars?	n	4	87	4	10
	%	3.8%	82.9%	3.8%	9.5%
Do you think that electric cars are environmentally friendly?	n	76	3	16	10
	%	72.4 %	2.9%	15.2%	9.5%
Are there electric charging points provided by your organisation for employees and the community in your place of work?	n	10	76	1	18
	%	9.5%	72.4%	1.0%	17.1%

As Table 8-13 shows:

- 44 (41.9%) of the academics reported that they do not leave the lights on during the day, while 21.0% do.
- Most of the academics (73.4%, n= 77) reported that they switch off the lights before they go if they are the last person to leave.
- Close to 50% of the academics (n=53, 50.5%) turn off the electricity after using the TV, computer, and other devices while 29 (27.6%) do not.
- A majority of the academics (48.6%, n= 51) reported that their organisations do not use LED (energy-saving) lights.
- Close to a third of the academics reported that their organisation's building is not supported by thermal insulation, while 36.1% (n=-38) do not know.
- Just over half the academics (n=56, 53.3%) reported that they leave the air conditioning ON when they leave their place of work, while 26 (24.8%) of them do not do that.
- A majority of the academics (44.8%, n= 47) stated that their organisations do not use power-saving controllers, while 37.1% (n=39) do not know.

- Most of the academics (82.9%, n=87) reported that their organisations do not use electric cars.
- Almost three-quarters of the academics (72.4%, n=76) think that electric cars are environmentally friendly.
- A majority of the academics (72.4%, n= 76) indicated that there are no charging points for electric vehicles provided by their organizations for employees or students.

8.7.1.1 Overall User Efficiency - Academics

As with the ‘Public Questionnaire’, these responses were used to allocate scores for user efficiency in electricity consumption. Table 8-14 presents the descriptive statistics for the scores for user efficiency among the academics. The best score (the full mark) should be 20.

Table 8-14: Descriptive Statistics for the Scores for User Efficiency in Electricity Consumption - Academics

Measure	Value	Measure		Value
n	105	Range		19
Mean	8.05	Minimum		0
Std. Error of Mean	0.31	Maximum		19
Median	8.00	Percentiles	25	6.0
Std. Deviation	3.19		50	8.0
coefficient of variation	39.6%		75	10.0

The minimum score was 0.0 and the maximum was 19.0 with range of 19, which indicates that there was a wide disparity between academics in their user efficiency scores. The mean of the scores was 8.05 (S.E. = ± 0. 31) with a median of 8.0, which indicates that the distribution of the scores is symmetric (see Figure 8-11 below).

The standard deviation of the scores was 3.19, suggesting that the coefficient variation of the scores was 39.6%. Finally, the 75th percentile indicated that 75% of the academics in the survey achieved a total score of 10 or below in user efficiency in electricity consumption.

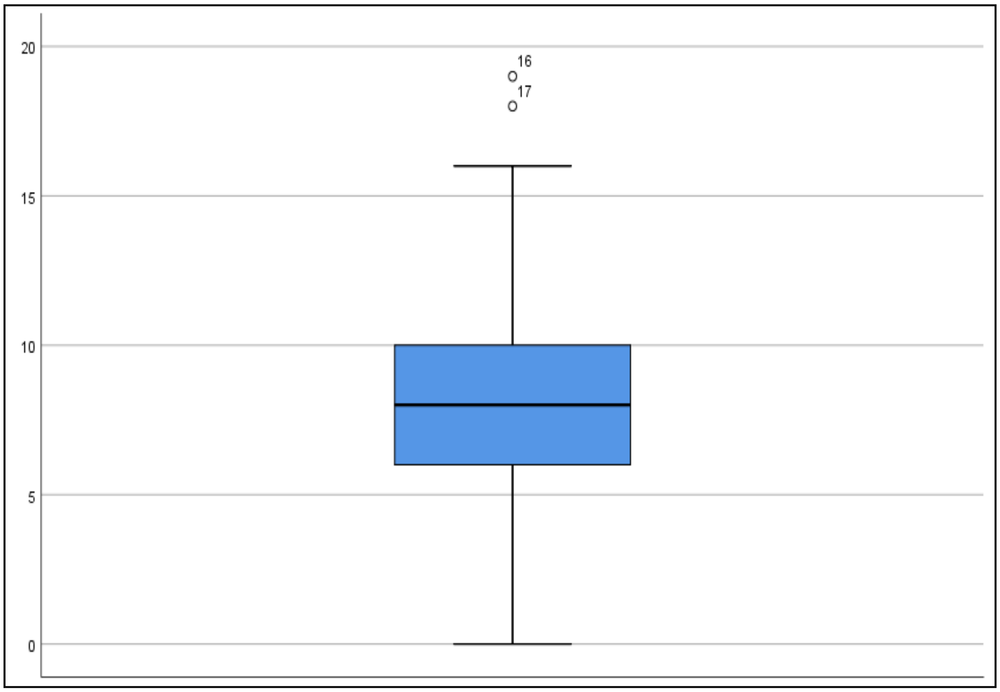


Figure 8-11: Boxplot for User Efficiency of the Electricity Consumption-Academics

○ Indicates extreme observation.

Categorization of the total scores for user efficiency in electricity consumption using percentiles indicated that more than one third (n=39, 37.1%) of the academics had low user efficiency. In addition, 38.1% of them (n=40) had moderate user efficiency, while close to a quarter of them (n=26, 24.8%) were categorized as high efficiency users (See Table 8-15 and Figure 8-12).

Table 8-15: Level of User Efficiency in Electricity Consumption - Academics

Level of user efficiency	n	Percent
Low efficiency	39	37.1%
Moderate efficiency	40	38.1%

High efficiency	26	24.8%
Total	**105**	**100%**

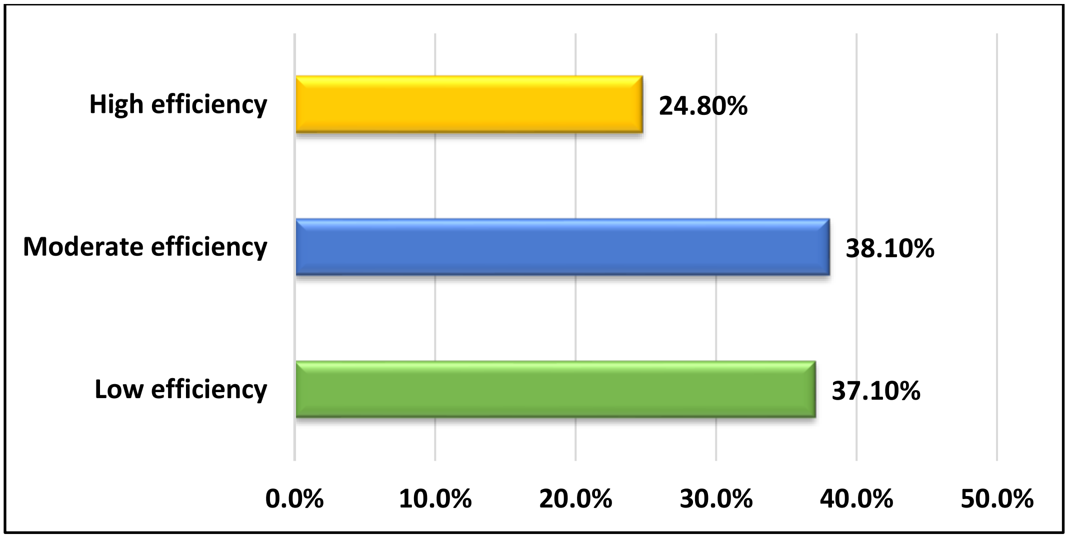


Figure 8-12: Levels of User Efficiency in Electricity Consumption - Academics

8.7.1.2 Factor Analysis for User Efficiency - Academics

As with the 'Public Questionnaire', Exploratory Factor Analysis (EFA) was run separately for each of the items in the User Efficiency in Electricity Consumption part of the questionnaire (n=10). Variables were examined using EFA to determine the factors that characterize user efficiency based on the academics' responses (n=105).

The results revealed that the KMO value was greater than 0.6 and Bartlett's Test was significant ($p\ value < 0.001$) which satisfied the initial assumptions for the EFA (see Table 8-16). However, during eigenvalue's examination, five factors were extracted whose eigenvalue was greater than 1 (see Table 8-17).

Table 8-16: KMO and Bartlett's Test for Items Relating to User Efficiency in Electricity Consumption Items – Academics' Responses

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.601
Bartlett's Test of Sphericity	Chi-Square	109.036

	df	45
	Sig.	0.000

As Table 8-16 shows, Kaiser-Meyer-Olkin Measure of sampling adequacy is 0.601; therefore, this value is considered statistically good according to Kaiser's classifications. This result creates confidence that the size of the sample for this study is adequate for carrying out Factor Analysis.

Table 8-17 shows the eigenvalues for each of the factors (in the second column entitled "Total"). There are 5 eigenvalues higher than integral 1. The table also shows the size of the variance extracted or explained by each factor and the amount of the total explained variance in terms of percentages. The value of the accumulated variance is 68.33, which means that these five factors explain 68.3% of the change occurring in user efficiency in electricity consumption of the surveyed respondents.

Table 8-17: Eigenvalues, Rotation Sums of Squared Loadings, and Total Variance Explained for User Efficiency in Electricity Consumption – Academics' Responses

Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	2.18	21.80	21.80	2.18	21.80	21.80	1.78	17.81	17.81
2	1.48	14.84	36.64	1.48	14.84	36.63	1.56	15.56	33.36
3	1.10	11.04	47.68	1.10	11.04	47.68	1.23	12.32	45.68
4	1.05	10.54	58.22	1.05	10.54	58.22	1.15	11.55	57.23
5	1.01	10.12	68.33	1.01	10.12	68.33	1.11	11.10	68.33
6	0.86	8.57	76.90						
7	0.74	7.39	84.30						

8	0.60	6.04	90.33						
9	0.54	5.41	95.74						
10	0.43	4.26	100.00						

Extraction Method: Principal Component Analysis.

In order to extract the five factors, it was essential to determine the minimum accepted level of variable saturation on the factor (i.e. the correlation intensity of the variable with the factor). For the data reduction purpose, (0.3) was considered as a cut-off limit between adopted saturations and neglected saturations. Again, A varimax rotation was used in order to extract the factors. Table 8-18 shows the rotated component matrix that was extracted.

Table 8-18: Rotated Component Matrix for User Efficiency in Electricity Consumption - Academic Responses

Statements	Factors				
	1	2	3	4	5
Is your organisation's building supported by thermal insulation?	0.829				
Does your organisation use power-saving controllers?	0.753				
Does your organisation use LED (energy-saving) lights?	0.665				
Are there electric charging points provided by your organisation for employees and students in your place of work?		0.787			
Does your organisation use electric cars?		0.703			
When you are the last person to leave your place of work, do you switch off the lights before you go?			0.819		

Do you leave the air conditioning ON after leaving work?			0.636		
Do you think electric cars are environmentally friendly?				0.866	
Do you turn off the electricity after using the computer and other devices?				0.405	
Do you leave the lights lit during the day even though there is daylight at your place of work?					0.934

- Extraction Method: Principal Component Analysis.
- Rotation Method: Varimax with Kaiser Normalization.

As Table 8-18 shows, five factors describe User Efficiency in Electricity Consumption. A description of each factor is given below:

Factor (1): Organisation's Behaviour Towards Saving Energy

This factor describes the organisation's behaviour in relation to energy saving. It is composed of the following items:

- Is your organisation's building supported by thermal insulation?
- Does your organisation use power-saving controllers?
- Does your organisation use LED (energy-saving) lights?

Factor (2): Acceptance of Electric Vehicles

This factor describes the acceptance of electric methods by organisations and electric charging points. It is composed of the following items:

- Are there electric charging points provided by your organisation for employees and students in your place of work?
- Does your organisation use electric cars?

Factor (3): Personal Behaviour Towards Saving Energy

This factor describes personal behaviour in saving energy. It composed of the following items:

- When you are the last person to leave your place of work, do you switch off the lights before you go?
- Do you leave the air conditioning ON after leaving work?

Factor (4): Personal Attitudes Towards Electric Devices

This factor describes personal attitudes towards electric devices. It is composed of the following items:

- Do you think the electric cars are environmentally friendly?
- Do you turn off the electricity after using the computer and other devices?

Factor (5): Saving Energy (Lighting)

This factor describes saving energy by turning lights off at the place of work. It is composed of one statement, namely "Do you leave the lights on during the day even though there is daylight in your place of work?"

8.7.2 Officials' and Stakeholders' User Efficiency in Electricity Consumption

The officials and stakeholders were asked to respond to the same statements, although the reference to students in relation to electric charging points was removed. Table 8-19 shows the distribution of responses received from the officials.

Table 8-19: Percentage Distribution of Responses Regarding User Efficiency in Electricity Consumption - Officials

Statement		Yes	No	Sometimes	I don't know
Do you leave the lights lit during the day even though there is daylight at your place of work?	n	48	97	83	4
	%	20.7 %	41.8%	35.8%	1.7%
When you are the last person to leave your place of work, do you switch off the lights before you go?	n	176	25	30	1
	%	75.9 %	10.8%	12.9%	0.4%
Do you turn off the electricity after using the computer and other devices?	n	107	66	58	1
	%	46.2 %	28.4%	25.0%	0.4%
Does your organisation use LED (energy-saving) lights?	n	85	85	30	32
	%	36.6 %	36.6%	13.0%	13.8%
Is your organisation's building supported by thermal insulation?	n	105	53	14	60
	%	45.3 %	22.8%	6.0%	25.9%
Do you leave the air conditioning ON after leaving your place of work?	n	122	59	37	14
	%	52.6 %	25.4%	16.0%	6.0%
Does your organisation use power-saving controllers?	n	33	112	16	71
	%	14.2 %	48.3%	6.9%	30.6%
Does your organisation use electric cars?	n	10	207	5	10
	%	4.3%	89.2%	2.2%	4.3%
Do you think electric cars are environmentally friendly?	n	158	11	41	22
	%	68.1 %	4.7%	17.7%	9.5%

Are there electric charging points provided by your organisation for employees and the community in your place of work?	n	13	194	6	19
	%	5.6%	83.6%	2.6%	8.2%

As Table 8-19 shows:

- 97 (41.9%) of the officials and stakeholders reported that they do not leave the lights on during the day, while 20.7% of them do.
- Most of the officials and stakeholders (75.9%, n= 176) reported that they switch off the lights before they go when they are the last person to leave.
- 46.2% of the officials and stakeholders (n=107) turn off the electricity after using the computer, and other devices, while 66 (28.4%) of them do not.
- More than a third of the officials and stakeholders (n= 85, 36.6%) reported that their organisations do not use LED (energy-saving) lights, while 85 (36.7%) reported that their organisations do use them.
- A majority of the officials and stakeholders reported that their organisation's building is supported by thermal insulation, while 25.9% (n=-60) did not know.
- Just over half of the officials and stakeholders (n=122, 52.6%) reported that they leave the air conditioning ON after they leave their place of work, while 59 (25.4%) do not.
- Almost half of the officials and stakeholders (48.3%, n=112) stated that their organisations do not use power-saving controllers, while 30.6% (n=71) do not know.

- Most of the officials and stakeholders (n=207, 89.2%) reported that their organisations do not use electric cars.
- A majority of the officials and stakeholders (68.1%, n=158) think that electric cars are environmentally friendly.
- Most of the officials and stakeholders (83.6%, n= 194) indicated that there are no charging points for electric vehicles provided by their organizations for employees and the community.

8.7.2.1 Overall Users' Efficiency – Officials and Stakeholders

As was the case with the academics, these responses were used to allocate scores for user efficiency in electricity consumption. Table 8-20 presents the descriptive statistics for the scores for user efficiency among the officials. The best score (the full mark) should be 20.

Table 8-20: Descriptive Statistics for the Scores for User Efficiency in Electricity Consumption - Officials

Measure	Value	Measure		Value
n	232	Range		16
Mean	8.65	Minimum		2
Std. Error of Mean	0.20	Maximum		18
Median	8.00	Percentiles	25	6.00
Std. Deviation	3.00		50	8.00
coefficient of variation	34.7%		75	11.00

The minimum score was 2.0 and the maximum was 18 with range of 16, which indicates that there was a wide disparity between officials and stakeholders in their scores for user efficiency. The mean of the scores was 8.65 (S.E. = ± 0.20) with a median of 8.0, which indicates that the distribution of the scores is skewed to the right (see Figure 8-13 below).

The standard deviation of the scores was 3.0, suggesting that the coefficient variation of the scores was 34.7%. Finally, the 75th percentile indicated that 75% of the officials and stakeholders achieved a total score of 11.0 or below for user efficiency in electricity consumption.

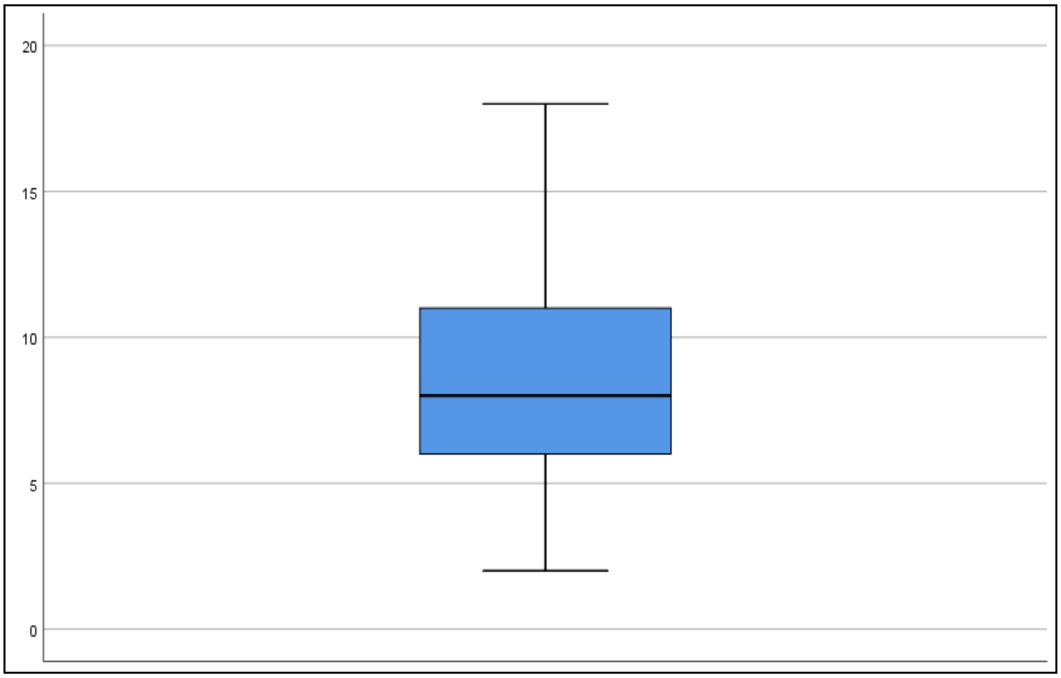


Figure 8-13: Boxplot for User Efficiency of the Electricity Consumption – Officials and Stakeholders

Categorization of the total scores for user efficiency using percentiles indicated that slightly more than one quarter (n=60, 25.9%) of the officials and stakeholders had low user efficiency. In addition, 48.7% of them (n=113) had moderate user efficiency, while 25.4% of them (n=59) were categorized as high efficiency users (See Table 8-21 and Figure 8-14).

Table 8-21: Level of User Efficiency in Electricity Consumption – Officials and Stakeholders

Level of user efficiency	n	Percent
Low efficiency	60	25.9%
Moderate efficiency	113	48.7%
High efficiency	59	25.4%
Total	**232**	**100%**

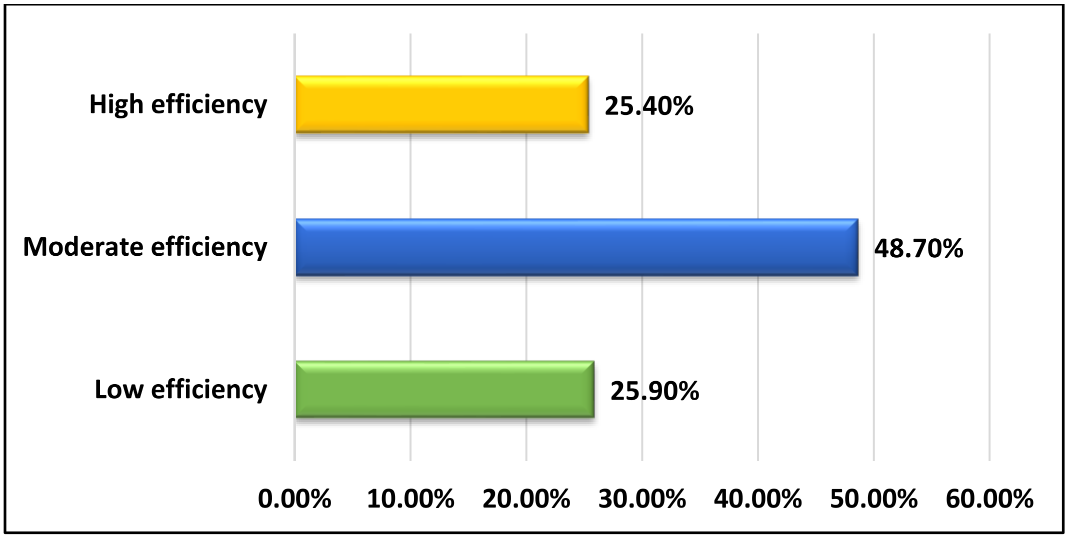


Figure 8-14: Level of Users' Efficiency in Electricity Consumption - Officials

8.7.2.2 Factor Analysis for User Efficiency – Officials and Stakeholders

Again, the variables in the User Efficiency in Electricity Consumption part of the questionnaire (n =10) were examined using EFA to determine the factors which characterize user efficiency based on the officials' responses (n=232).

The results revealed that the KMO value was greater than 0.6 and Bartlett's Test was significant ($p\ value < 0.001$) which satisfied the initial assumptions for the EFA (see Table 8-22). However, during eigenvalue's examination, three factors were extracted whose eigenvalue was greater than 1 (See Table 8-23).

Table 8-22: KMO and Bartlett's Test for User Efficiency in Electricity Consumption Items – Officials' and Experts' Responses

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.656
Bartlett's Test of Sphericity	Chi-Square	222.58
	df	45
	Sig.	0.000

As shown in Table 8-22, Kaiser-Meyer-Olkin Measure of sampling adequacy is 0.656, therefore, this value is considered statistically good according to Kaiser's classifications. This reinforces our confidence that the size of the sample for this study is adequate for carrying out Factor Analysis.

Table 8-23 shows the eigenvalues for the factors (in the second column entitled "Total"). There are three eigenvalues higher than integral 1. The table also shows the size of the variance extracted or explained by each factor and the amount of the total explained variance in terms of percentages. The value of the accumulated variance is 47.56, which means that these three factors explain 47.6% of change occurring in user efficiency in electricity consumption of the surveyed respondents.

Table 8-23: Eigenvalues, Rotation Sums of Squared Loadings, and Total Variance Explained for User Efficiency in Electricity Consumption – Officials' Responses

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.22	22.24	22.24	2.22	22.24	22.24	2.18	21.81	21.81
2	1.42	14.18	36.42	1.42	14.18	36.42	1.38	13.79	35.61
3	1.11	11.14	47.56	1.11	11.14	47.56	1.20	11.95	47.56
4	0.99	9.86	57.43						
5	0.95	9.50	66.92						
6	0.85	8.55	75.47						
7	0.77	7.74	83.21						
8	0.64	6.44	89.65						
9	0.54	5.41	95.06						
10	0.49	4.94	100.00						

Extraction Method: Principal Component Analysis.

Table 8-24 shows the rotated component matrix extracted using orthogonal rotation.

Table 8-24: Rotated Component Matrix for User Efficiency in Electricity Consumption – Officials' and Stakeholders' Responses

Statements	Factors		
	1	2	3
Is your organisation's building supported by thermal insulation?	0.706		
Does your organisation use power-saving controllers?	0.702		
Does your organisation use LED (energy-saving) lights?	0.702		
Does your organisation use electric cars?	0.515		
Are there electric charging points provided by your organisation for employees and the community in your place of work?	0.471		
Do you turn off the electricity after using the computer and other devices?		0.718	
When you are the last person to leave your place of work, do you switch off the lights before you go?		0.647	
Do you think the electric cars are environmentally friendly?			0.591
Do you leave the air conditioning ON after leaving your place of work?			-0.495
Do you leave the lights on during the day even though there is daylight at your place of work?			-0.470

- Extraction Method: Principal Component Analysis.
- Rotation Method: Varimax with Kaiser Normalization.

As Table 8-24 shows, three factors describe User Efficiency in Electricity Consumption. The description of each factor is given below:

Factor (1): Organisation's Behaviour Towards Energy Saving and Using Electric Devices

This factor describes the organisation's behaviour towards saving energy and using electric devices. It is composed of the following items:

- Is your organisation's building supported by thermal insulation?
- Does your organisation use power-saving controllers?
- Does your organisation use LED (energy-saving) lights?
- Does your organisation use electric cars?
- Are there electric charging points provided by your organisation for employees and the community in your place of work?

Factor (2): Personal behaviour towards saving energy

This factor describes personal behaviour in saving energy. It composed of the following items:

- Do you turn off the electricity after using the computer and other devices?
- When you are the last person to leave your place of work, do you switch off the lights before you go?

Factor (3): Personal attitudes towards electric devices

This factor describes personal attitudes towards electric devices. It is composed of the following items:

- Do you think the electric cars are environmentally friendly?
- Do you leave the air conditioning ON after leaving your place of work?
- Do you leave the lights on during the day even though there is daylight at your place of work?

8.8 Role of Organisations in Raising Awareness of the Need to Rationalise Electricity Consumption (Internally)

Respondents were then asked about their organisations efforts to raise awareness of the need to rationalise energy among their employees, and, for the educational institutions, their students. The responses of both the academics and the officials and stakeholders are set out below.

8.8.1 Academics' Views

In response to the question "Does your educational organisation raise awareness of the need to rationalise electricity consumption among employees and students?", just over two fifths of the academics responded positively (n=43, 41.0%), while close to a quarter (n=26, 24.8%) responded negatively (=No) (See Table 8-25 and Figure 8-15).

Table 8-25: Responses of the Academics Regarding the Role of the Organisation in Raising Awareness Internally

Responses	n	Percent
Yes	43	41.0%
No	26	24.8%
Sometimes	34	32.4%
I don't know	2	1.8%
Total	**105**	**100%**

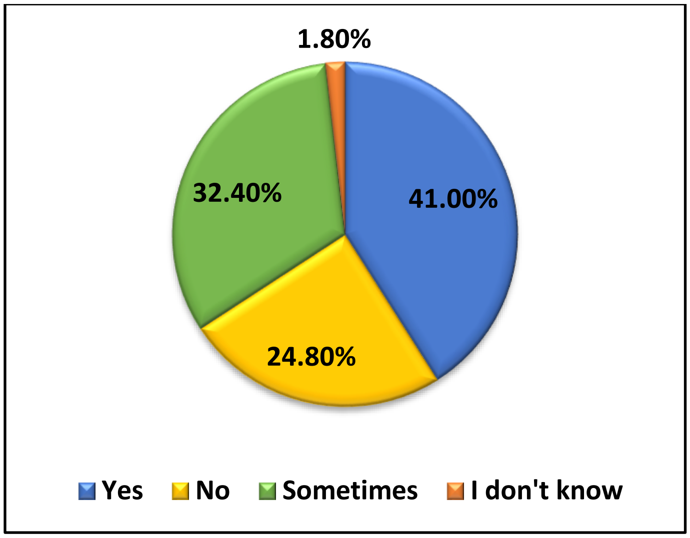


Figure 8-15: Responses of the Academics Regarding the Internal Role of the Organisation in Spreading Awareness

8.8.2 Officials' and Stakeholders' Views

When asked if their organisations made efforts to raise awareness of the need to rationalise electricity consumption among employees, 88 officials and stakeholders (37.9%) reported that their organisations do, while close to two fifths (n=92, 39.7%) stated that their organisation do not (See Table 8-26 and Figure 8-16).

Table 8-26: Responses of the Officials and Stakeholders Regarding the Role of the Organisation in Raising Awareness Internally

Responses	n	Percent
Yes	88	37.9%
No	92	39.7%
Sometimes	49	21.1%
I don't know	3	1.3%
Total	**232**	**100%**

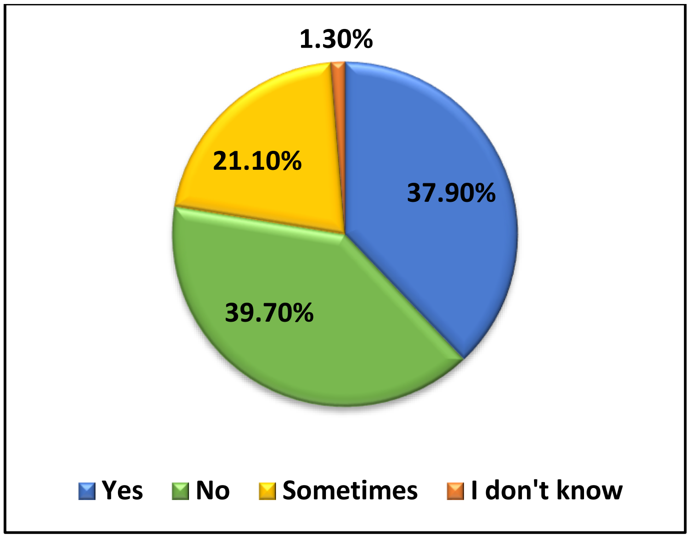


Figure 8-16: Responses of the Officials and Stakeholders Regarding the Role of the Organisation in Raising Awareness Internally

8.9 Role of Organisations in Raising Awareness (Externally)

Respondents were then asked about the role their organisations should play in raising awareness of the need to utilise renewable energy in their local communities. Their views are set out below.

8.9.1 Academics' Views

In response to the question "In your opinion, should educational and academic organisations increase awareness within the local community regarding utilizing renewable energy sources to generate electricity", a majority of the academics strongly agreed (n=73, 69.5%) (See Table 8-27 and Figure 8-17 below).

Table 8-27: Responses of the Academics Regarding the Role of the Organisation in Raising Awareness (Externally)

Responses	n	Percent
Strongly Agree	73	69.5%
Agree	28	26.7%
Neutral	3	2.8%
Strongly Disagree	1	1.0%

Total	**105**	**100%**

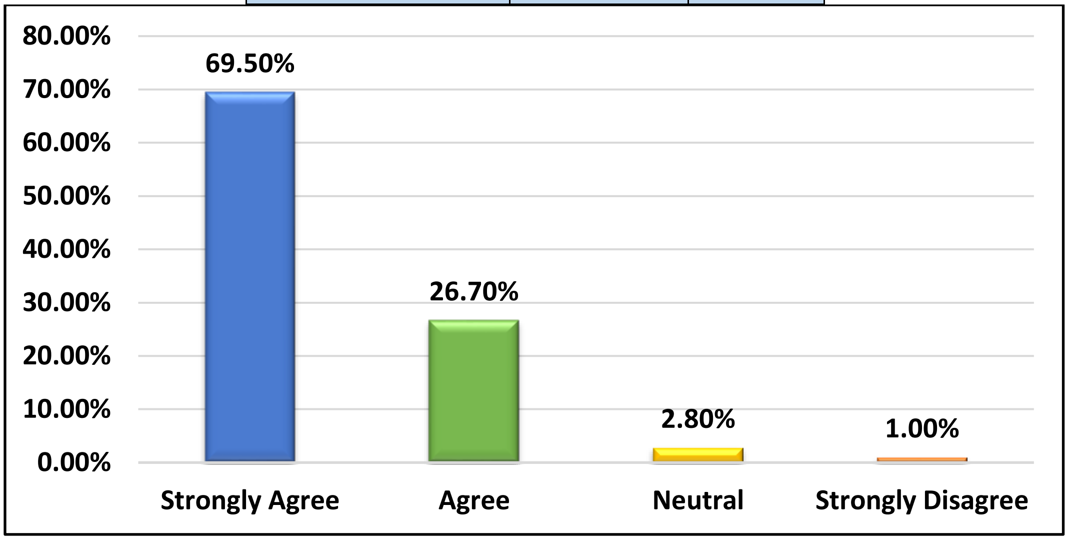


Figure 8-17: Responses of the Academics Regarding the External Role of the Organisation in Spreading Awareness

8.9.2 Officials' and Stakeholders' Views

When asked a similar question, 170 officials and stakeholders (73.3%) strongly agreed that governmental organisations and private institutions should increase awareness within the community regarding utilizing renewable energy sources to generate electricity (see Table 8-28 and Figure 8-18 below).

Table 8-28: Responses of the Officials and Stakeholders Regarding the Role of the Organisation in Raising Awareness (Externally)

Responses	n	Percent
Strongly Agree	170	73.3%
Agree	54	23.3%
Neutral	8	3.4%
Total	**232**	**100%**

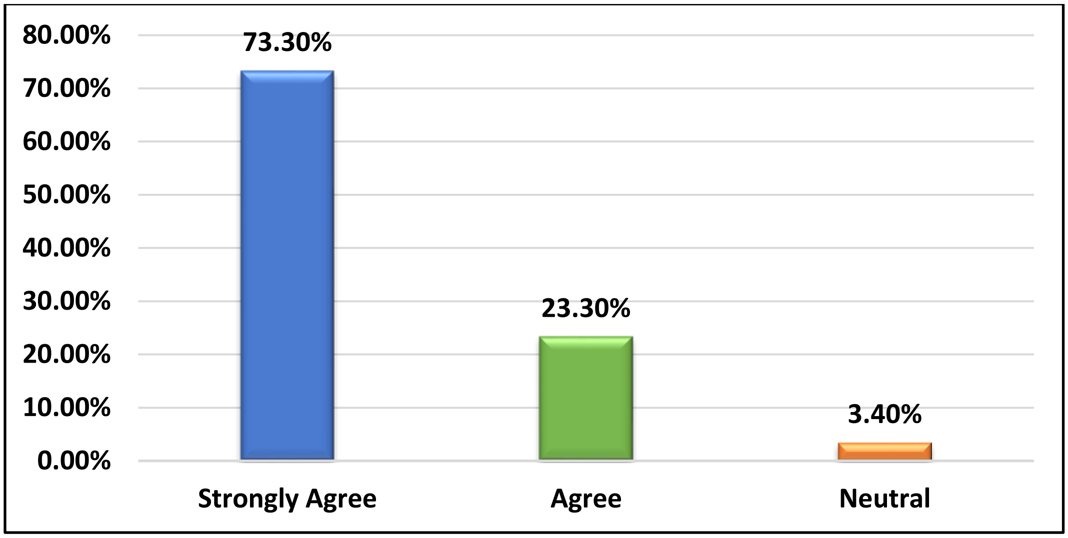


Figure 8-18: Responses of the Officials and Stakeholders Regarding the Role of the Organisation in Raising Awareness (Externally)

8.9.3 Actual Behaviour of Organisations in Raising Awareness (Externally)

Both sets of respondents were asked about the actual roles their organisations played in raising awareness within their local communities; however, the questions they were asked varied according to whether they were academics or officials and stakeholders.

8.9.3.1 Raising Awareness of the Need to Rationalise Electricity Consumption within the Community (Officials and Stakeholders)

Given the importance of official campaigns in raising community awareness, the officials and stakeholders were asked about the actual behaviour of their organisations in raising awareness of the need to rationalise electricity consumption within the community. 103 (44.4%) reported that, in general, their organisation does not do this; however, just over a quarter of them (n=64, 27.6%) responded positively (See Table 8-29 and Figure 8-19 below).

Table 8-29: Responses Regarding Behaviour of the Organisation in Raising Community Awareness of the Need to Rationalise Electricity Consumption - Officials and Stakeholders

Responses	n	Percent
Yes	64	27.6%
No	103	44.4%
Sometimes	55	23.7%
I don't know	10	4.3%
Total	**232**	**100%**

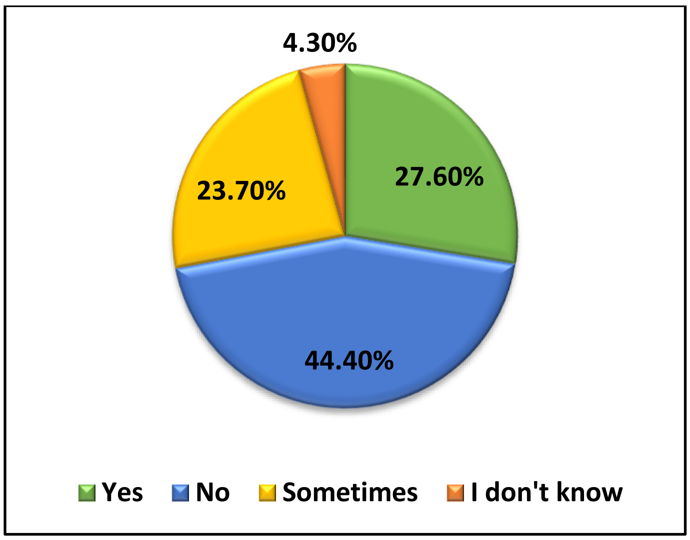


Figure 8-19: Responses Regarding Behaviour of the Organisation in Raising Community Awareness of the Need to Rationalise Electricity Consumption - Officials and Stakeholders

8.9.3.2 Raising Awareness of Renewable Energy and Sustainability (Academics)

Given their educational focus, academics were asked if their educational organisation takes steps to raise awareness of renewable energy and sustainability. 55 (52.4%) agreed, while only 18.1% (n=19) disagreed (see Table 8-30 and Figure 8-20 below).

Table 8-30: Responses Regarding Raising Awareness of Renewable Energy and Sustainability - Academics

Responses	n	Percent
Strongly Agree	27	25.7%
Agree	28	26.7%
Neutral	31	29.5%
Disagree	14	13.3%
Strongly Disagree	5	4.8%
Total	**105**	**100%**

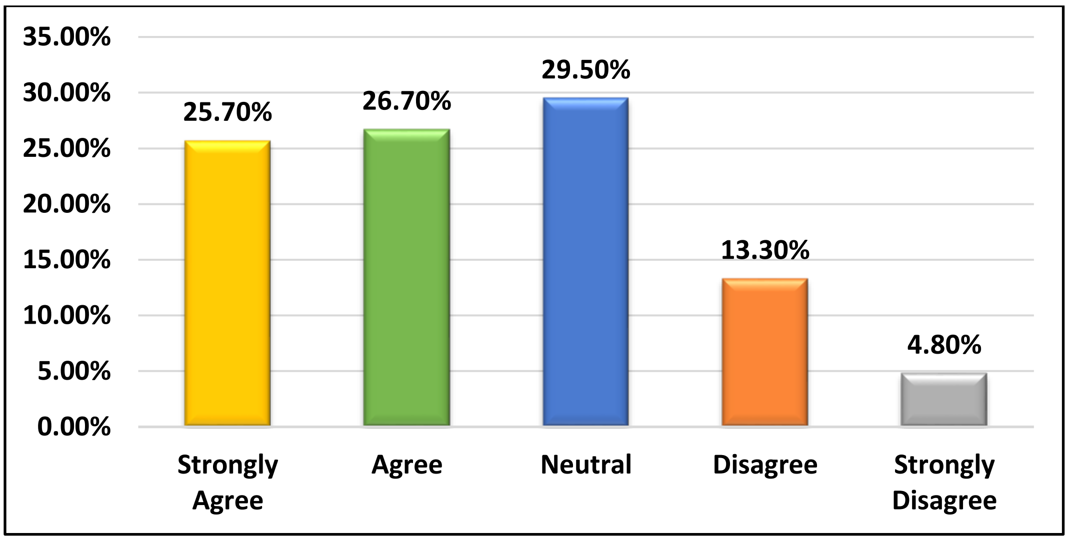


Figure 8-20: Responses Regarding Raising Awareness of Renewable Energy and Sustainability - Academics

8.10 Using Renewable Energy in Organisations (Academics, Officials and Stakeholders)

Both sets of respondents were asked: "Does your organisation use renewable energy?" and asked to specify which type was used. A majority of the academics (n=71, 67.6%) and the officials and stakeholders (n=138, 59.5%) responded negatively (=No) (See Table 8-31 and Figure 8-21 below). However, of those who responded positively, the sources used were solar and wind energy.

Table 8-31: Responses of the Surveyed Members Regarding Using Renewable Energy in the Organization

Responses	Academics		Officials	
	n	Percent	n	Percent
Yes	17	16.2%	42	18.1%
No	71	67.6%	138	59.5%
I don't know	17	16.2%	52	22.4%
Total	**105**	**100%**	**232**	**100%**

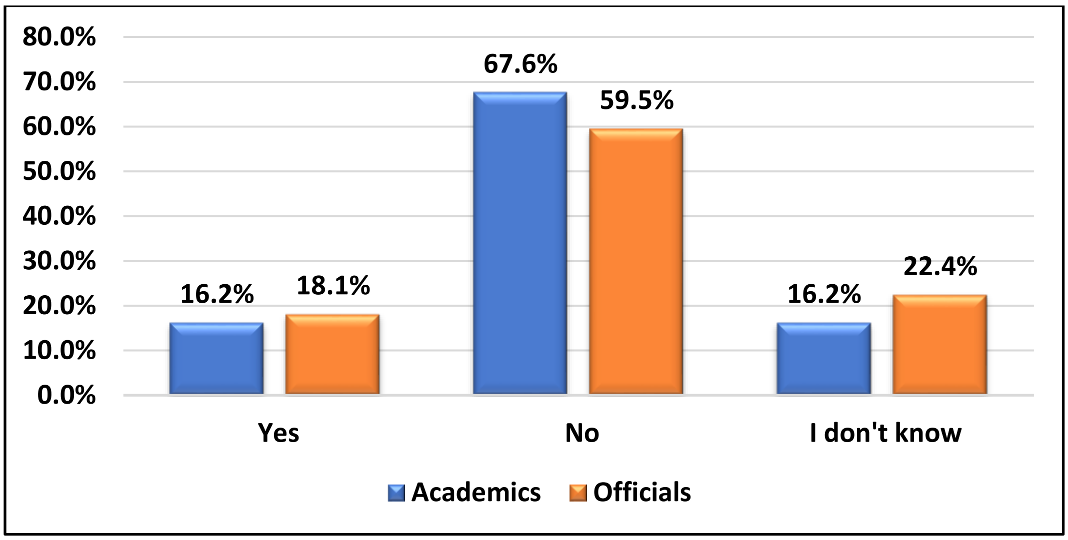


Figure 8-21: Responses of the Surveyed Members Regarding Using Renewable Energy in the Organization

8.11 Respondents' Evaluations of the Possibility of Using Renewable Energy Technologies in the Organisation (Academics, Officials and Stakeholders)

Both sets of respondents were asked about the possibility of starting to use renewable energy technologies in their organisations. While 30.5% (n= 32) of the academics reported that this would be difficult, 86 officials and stakeholders (37.1%) thought it would be easy. Overall, 43.5% of the respondents thought it would be easy to use renewable energy technologies in their organisations while 36.5% thought it would be difficult (See Table 8-32 and Figure 8-22).

Table 8-32: Respondents' Evaluations of the Possibility of using Renewable Energy Technologies (RETs) in their Organisation - Academics, Officials and Stakeholders

Evaluation	Academics		Officials		Overall
	n	Percent	n	Percent	
Very difficult	8	7.6%	19	8.2%	7.9%
Difficult	32	30.5%	62	26.7%	28.6%
Easy	27	25.7%	86	37.1%	31.4%
Very easy	14	13.3%	25	10.8%	12.1%
I don't know	24	22.9%	40	17.2%	20.0%
Total	**105**	**100%**	**232**	**100%**	**100%**

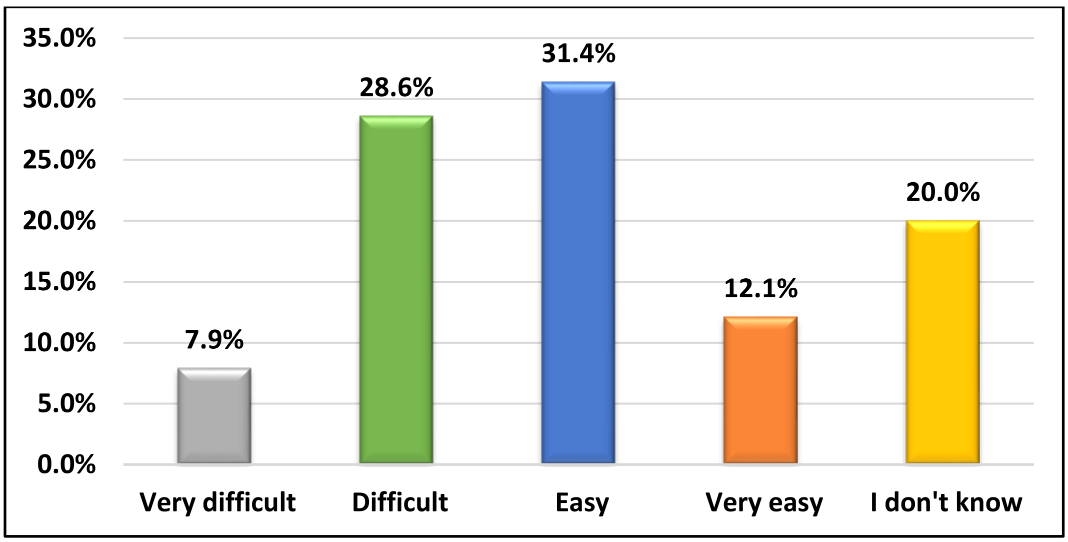


Figure 8-22: Overall Views Regarding using RETs in their Organisations - Academics, Officials and Stakeholders

8.12 Importance of Starting to Use Renewable Energy in Institutions' Buildings (Academics, Officials and Stakeholders)

Both sets of respondents were asked if it was important for their organisations to initiate the use of renewable energy in their buildings. Just under three fifths of the academics strongly agreed (n=61, 58.1%) that it is important for educational and academic organisations to initiate the use renewable energy in their buildings. In addition, 149 officials and stakeholders strongly agreed (64.2%) that it is important for governmental organisations and private institutions to do so (see Table 8-33 and Figure 8-23 below).

Table 8-33: Responses Regarding the Importance of Starting to Use Renewable Energy in Institutions' Buildings - Academics, Officials and Stakeholders

Responses	Academics		Officials		Overall
	n	Percent	n	Percent	
Strongly Agree	61	58.1%	149	64.2%	61.2%
Agree	39	37.1%	77	33.2%	35.1%
Neutral	4	3.8%	6	2.6%	3.2%
Strongly Disagree	1	1.0%	0	0%	0.5%
Total	**105**	**100%**	**232**	**100%**	**100%**

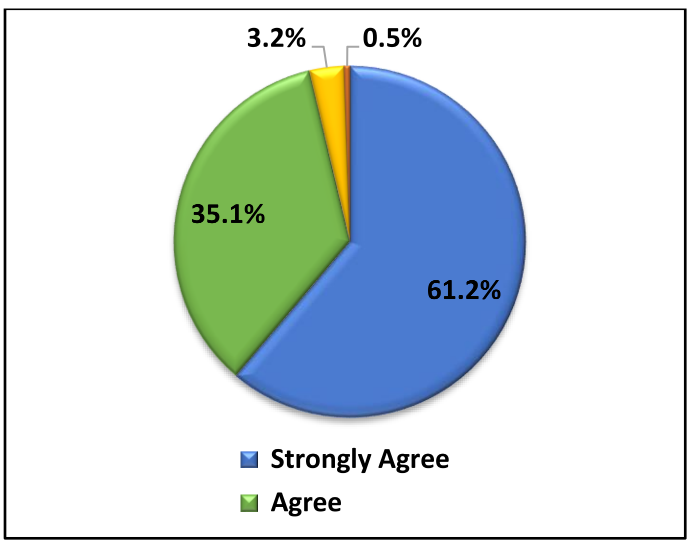


Figure 8-23: Overall Agreement on the Importance Starting to Use Renewable Energy in Institutions' Buildings - Academics, Officials and Stakeholders

However, when officials and stakeholders were asked "If your organisation has facilities in desert areas of Kuwait, do they use renewable energy technologies there?" and asked to specify which type was used, 97 (41.8%) did not know, while just 48 (20.7%) responded positively (See Table 8-34 and Figure 8-24).

Table 8-35: Responses Regarding Using RETs in Desert Areas of Kuwait - Officials and Stakeholders

Responses	n	Percent
Yes	48	20.7%
No	87	37.5%
I don't know	97	41.8%
Total	**232**	**100%**

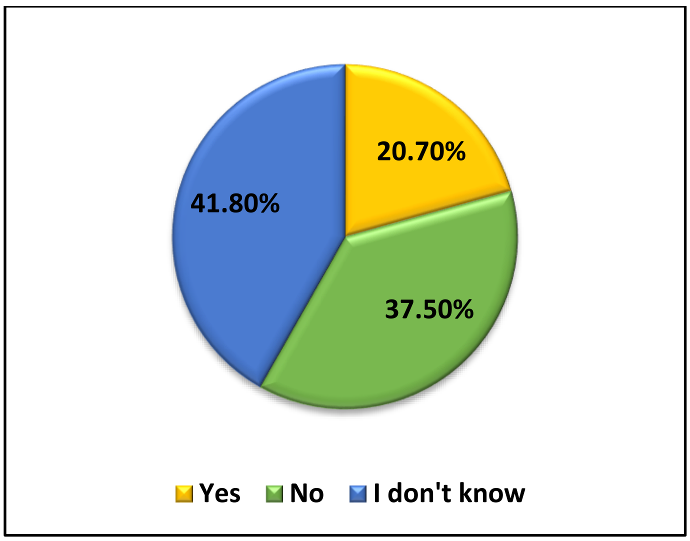


Figure 8-25: Responses Regarding Using RET in Desert Areas of Kuwait – Officials and Stakeholders

Those who responded positively reported that the type of RET used in desert areas of Kuwait was Photovoltaic (PV) cells.

8.13 Role of the Government in Utilizing Renewable Energy by Connecting Institutions to the Electrical Network Grid (Academics, Officials and Stakeholders)

The electricity power system in Kuwait is owned and operated by the Ministry of Electricity and Water (MEW), and is currently being expanded and developed (Alosaimi, 2019). As a result, both sets of respondents were asked if they thought that the government should encourage institutions to utilize renewable energy by connecting them to the electrical network grid.

A majority of the academics strongly agreed (n=66, 62.9%) that the government must support governmental educational buildings and private educational buildings to utilize renewable energy by connecting them to the electrical network grid. Moreover, 146 officials and stakeholders strongly agreed (62.9%) that the government must support governmental and private institutional buildings to utilize renewable energy by connecting them to the grid (See Table 8-34 and Figure 8-24 below).

Table 8-34: Responses Regarding the Role of the Government in Promoting the Use of Renewable Energy by Connecting Institutions to the Grid - Academics, Officials and Stakeholders

Responses	**Academics**		**Officials**		**Overall**
	n	**Percent**	**n**	**Percent**	
Strongly Agree	66	62.9%	146	62.9%	62.9%
Agree	33	31.4%	76	32.8%	32.1%
Neutral	6	5.7%	10	4.3%	5.0%
Total	**105**	**100%**	**232**	**100%**	**100%**

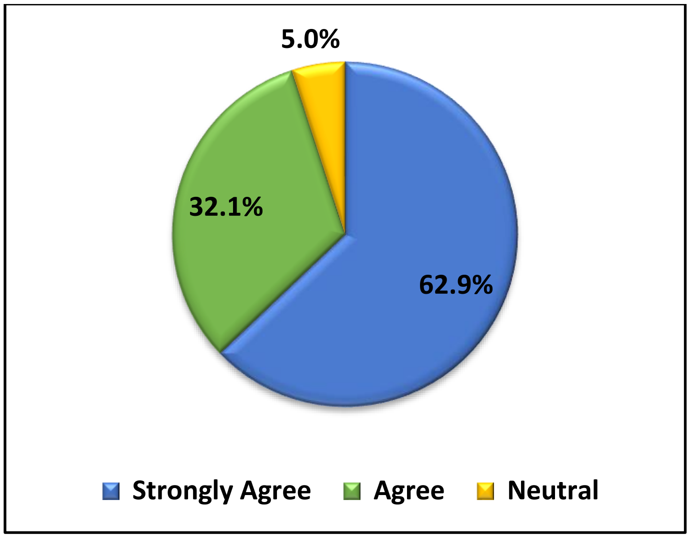


Figure 8-24: Overall Agreement on Role of the Government in Promoting the Use of Renewable Energy by Connecting Institutions to the Grid - Academics, Officials and Stakeholders

8.14 Personal Stance and Attitude Towards Renewable Energy (Academics, Officials and Stakeholders)

As was the case in the 'Public Questionnaire', both sets of respondents were asked "In your personal opinion, please specify the most appropriate type of renewable energy or clean energy for investment in Kuwait". Their responses are presented in Table 8-35 and Figure 8-25.

Table 8-35: Respondents' Opinions Regarding Appropriate Sources of Renewable Energy for Investment in Kuwait

Appropriate source of Renewable Energy	Academics		Officials		Overall
	n	Percent	n	Percent	
Solar energy	90	85.7%	208	89.7%	87.5%
Wind energy	4	3.8%	4	1.7%	2.8%
Nuclear energy	3	2.9%	7	3.0%	3.0%
Tidal energy	4	3.8%	3	1.3%	2.6%
I don't know	4	3.8%	10	4.3%	4.1%
Total	**105**	**100%**	**232**	**100%**	**100%**

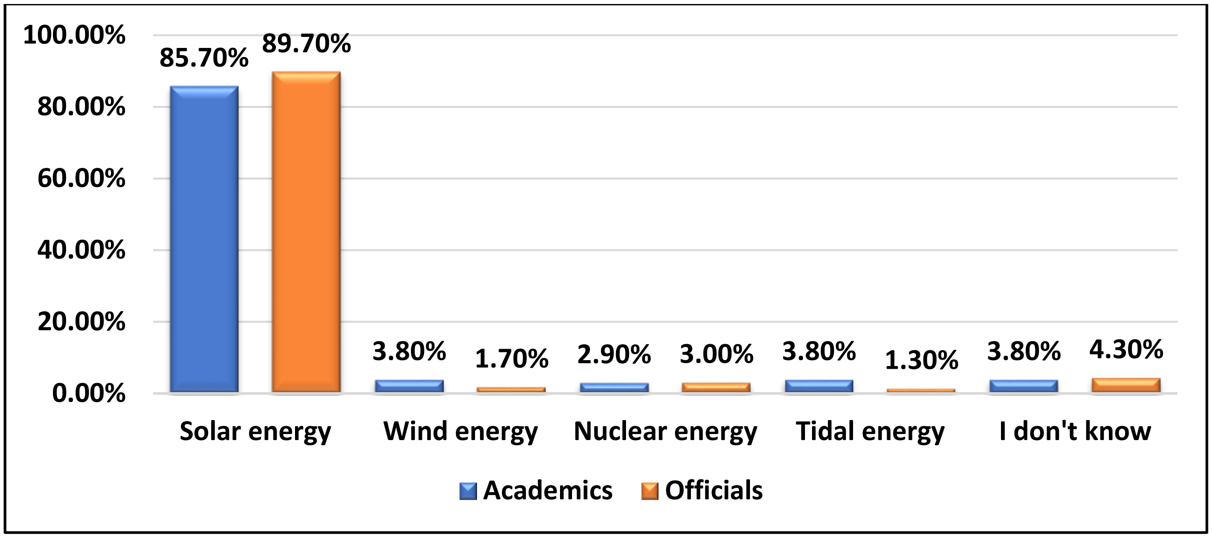


Figure 8-25: Respondents' Opinions Regarding Appropriate Sources of Renewable Energy for Investment in Kuwait

Most of the participants (85.7%, n=90 for academics and 89.7%, n=208 for officials and stakeholders) considered that solar energy is the most appropriate source of renewable energy for investment in Kuwait, while the other sources received very low rates. This result could be explained by the fact that the Kuwaiti summer is very hot, so the perception is that clean, safe, cheap, solar energy is available throughout the year.

Both sets of respondents were invited to provide comments to explain their choices. The most noteworthy of these are set out below (For details of all the comments made, see Appendix IX). These were similar to the comments made in the 'Public Questionnaire', with solar, wind and nuclear highlighted, and at least one academic respondent voicing concerns about the security implications associated with nuclear energy.

Academic Respondents

- *Due to the availability and the enormous potential of the solar energy source. It is considered the most suitable source in Kuwait because of its geographical location and the presence of vast desert areas and it is possible to benefit from solar energy throughout* *the year for the intensity of sunlight with the temperature which can reach 54°C when the weather is sunny and clear in the majority of the four seasons. And it is also possible to use wind energy as a second source in Kuwait but not like relying on solar energy, whose technologies are cheaper than other technologies.*

- *Nuclear power is more efficient to produce electric power and can provide a stable and predictable amount of electrical power in megawatts compared to solar, wind or tidal energy. Whereas solar panels can be affected by the weather, for example, dust and the accident angle. Moreover, wind power can be very fluctuating, and tidal energy may be an obstacle to tidal power due to the nature of behaviour in the Gulf Sea.*
- *Solar energy is the best because Kuwait is not windy enough to use wind energy and does not have enough availability for tidal energy. As for nuclear energy, is the best and most appropriate, but one of the most critical obstacles is the situation of the country… not to have confidence in the possibility of adequate management and responsibility to activate nuclear energy.*

Official and Stakeholder Respondents

- *Solar energy is suitable because of the long duration of the sunshine during the day, especially in the summer season, also the location and climate conditions of Kuwait are suitable for the utilise of solar energy. Nuclear power is no less critical than solar energy, despite the high cost to build it.*
- *The solar energy is appropriate as well as the wind at this present moment because they have shown a preliminary success. Nuclear should be heavily investigated for potential baseload in Kuwait.*

8.15 Advantages of Using Renewable Energy

Both sets of respondents were asked to select the main advantages associated with renewable energy from a list of options. Their responses are set out below.

8.15.1 Academics' Views

240 responses were received for this question and the total number of academics who participated was 105, so almost everyone selected at least two options. 93 (88.6%) academics indicated that renewable energy contributes to maintaining a clean environment, and this choice represents the mode of the selections since it represents 38.8% of all the answers given to this question. Moreover, 62 (59.0%) indicated that renewable energy helps maintain oil resources and reduces their consumption, while 59 (56.2%) indicated that renewable energy contributes to the provision of the national economy. (see Table 8-36 and Figure 8-26 below). Just two respondent (1.9%) thought renewable energy was useless.

Table 8-36: Main Advantages Associated with Renewable Energy - Academics

Important Elements	**Responses**		**Percent of Cases**
	n	**%**	
Contributes to maintaining a clean environment.	93	38.8%	88.6%
Contributes to the provision of the national economy.	59	24.6%	56.2%
Creating jobs.	24	10.0%	22.9%
Helps maintain the oil resources and reduces their consumption	62	25.8%	59.0%
I think renewable energy is useless.	2	0.8%	1.9%
Total	**240**	**100.0%**	

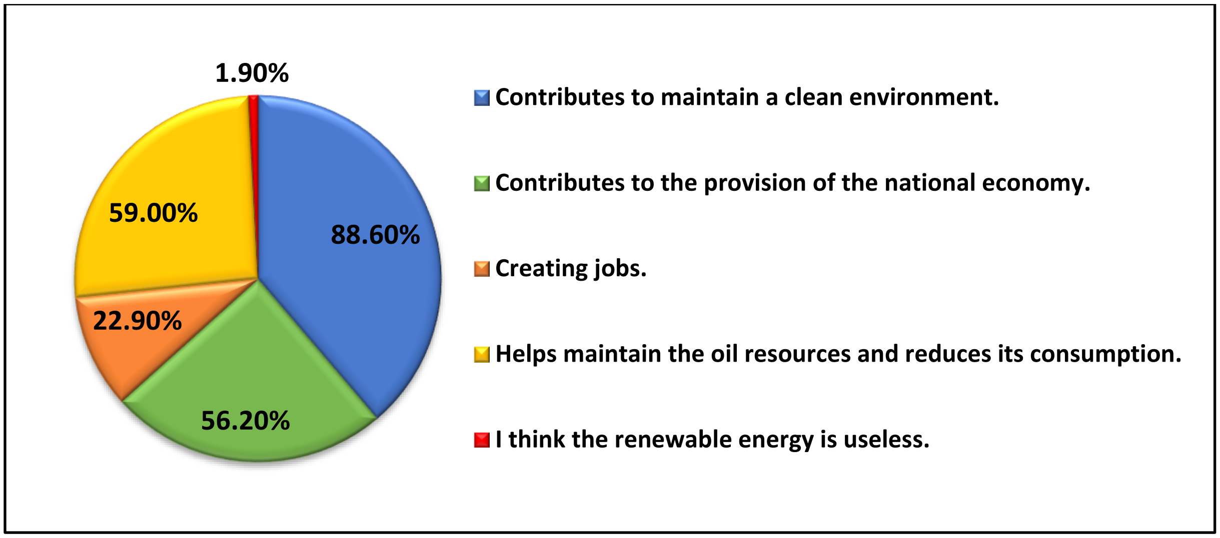


Figure 8-26: Main Advantages Associated with Renewable Energy - Academics

8.15.2 Officials' and Stakeholders' Views

Likewise, the total number of responses obtained from officials and stakeholders was 555 and the total number who participated was 232, so almost everyone selected at least two options. 190 (81.9%) officials and stakeholders indicated that renewable energy contributes to maintaining a clean environment, and, again, this represents the mode of the selections since it represents 34.2% of all the answers given to this question. 146 (62.9%) indicated that renewable energy contributes to the provision of the national economy, while 142 (61.2%) indicated that it helps maintain the oil resources and reduces their consumption. Just two respondent (0.9%) thought renewable energy was useless (See Table 8-37 and Figure 8-27 below).

Table 8-37: Main Advantages Associated with Renewable Energy - Officials and Stakeholders

Important Elements	Responses		Percent of Cases
	n	%	
Contributes to maintain a clean environment.	190	34.2%	81.9%

Contributes to the provision of the national economy.	146	26.3%	62.9%
Creating jobs.	75	13.5%	32.3%
Helps maintain the oil resources and reduces its consumption	142	25.6%	61.2%
I think the renewable energy is useless.	2	0.4%	0.9%
Total	**555**	**100%**	

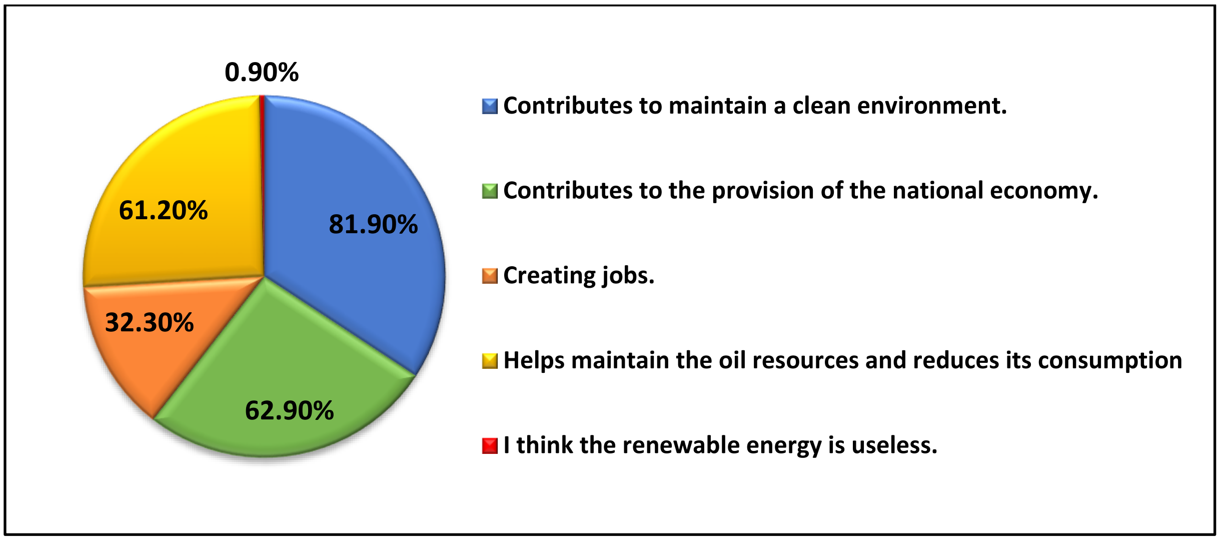


Figure 8-27: Main Advantages Associated with Renewable Energy - Officials and Stakeholders

8.16 Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy

Both sets of respondents were then asked to respond to a series of statements relating to their knowledge and awareness of the advantages and disadvantages associated with renewable energy.

8.16.1 Academics' Views

The responses received from the academics are set out below, and a mean, standard deviation, and rank for each statement is provided (See Table 8-38 and Table 8-39).

Table 8-38: Percentage Distribution of Responses Relating to Knowledge and Awareness of the Advantages and Challenges of RE - Academics

Statement		SA	A	N	D	SD
I have some background knowledge, through reading or study, about renewable energy sources including solar, wind and thermal energy.	n	32	56	14	3	0
	%	30.5%	53.3%	13.3%	2.9%	0%
Renewable energy technologies are not widely distributed in Kuwait’s domestic market due to a lack of investment support.	n	31	61	9	2	2
	%	29.5%	58.1%	8.6%	1.9%	1.9%
There is a shortage of knowledge and skills concerning renewable energy technologies in Kuwait.	n	29	64	6	4	2
	%	27.6%	61.0%	5.7%	3.8%	1.9%
The location and weather of Kuwait are suitable for renewable energy investment.	n	61	38	5	1	0
	%	58.1%	36.2%	4.8%	1.0%	0%
Renewable energy technology is facing a slow social uptake in Kuwait.	n	30	59	11	4	1
	%	28.6%	56.2%	10.5%	3.8%	1%
The private sector should be encouraged to participate in renewable energy investment in Kuwait.	n	56	45	4	0	0
	%	53.3%	42.9%	3.8%	0%	0%
There is insufficient information in Kuwait on renewable energy technologies, their efficiency, advantages and disadvantages.	n	29	50	18	8	0
	%	27.6%	47.6%	17.1%	7.6%	0%
There is a shortage of educational programmes on renewable energy in the educational curriculum (schools, colleges, universities and other educational institutions) in Kuwait.	n	36	47	14	8	0
	%	34.3%	44.8%	13.3%	7.6%	0%
The Kuwaiti community needs to increase its awareness of renewable energy.	n	55	45	5	0	0
	%	52.4%	42.9%	4.8%	0%	0%

SA=Strongly Agree, A= Agree, N= Neutral, D = Disagree, SD= Strongly Disagree.

Table 8-39: Mean, Standard Deviation, and Rank for Each Statement Relating to Knowledge and Awareness of the Advantages and Challenges of RE – Academics

Statement (N=105)	Mean	Std. Deviation	Rank
I have some background knowledge, through reading or study, about renewable energy sources including solar, wind, and thermal energy.	4.11	0.74	4
Renewable energy technologies are not widely distributed in Kuwait's domestic market due to a lack of investment support.	4.11	0.79	5
There is a shortage of knowledge and skills concerning renewable energy technologies in Kuwait.	4.09	0.81	6
The location and weather of Kuwait are suitable for renewable energy investment.	4.50	0.68	2
Renewable energy technology is facing a slow social uptake in Kuwait.	4.08	0.79	7
The private sector should be encouraged to participate in renewable energy investment in Kuwait.	4.50	0.57	1
There is insufficient information on renewable energy technologies, their efficiency, advantages and disadvantages in Kuwait.	3.95	0.87	9
There is a shortage of educational programmes on renewable energy in the curriculum (schools, colleges, universities and other educational institutions) in Kuwait.	4.06	0.89	8
The Kuwaiti community needs to increase its awareness of renewable energy.	4.48	0.59	3
Overall Knowledge and Awareness	**4.21**	**0.78**	**High**

Std. Deviation= Standard Deviation.

From Table 8-38 and Table 8-39 , the following can be deduced:

a) The statement “The private sector should be encouraged to participate in renewable energy investment in Kuwait” came in the first rank, since the overall agreement was (96.2%, n=101), with mean responses of (4.50) and standard deviation of (0.57). In addition, the statement “The location and weather of Kuwait are suitable for renewable energy investment” came in the second rank, since the overall agreement was (94.3%, n=99), with mean responses of (4.50) and standard deviation of (0.68). Moreover, the statement “The Kuwaiti community needs to increase its awareness of renewable energy” came in the third rank, since the overall agreement was (95.3%, n=100), with mean responses of (4.48) and standard deviation of (0.59).

b) Three statements gained very low response means. The statement “Renewable energy technology is facing a slow social uptake in Kuwait” came in the seventh rank, since the overall agreement was (84.8%, n=89), with mean responses of (4.08) and standard deviation of (0.79). In addition, the statement “There is a shortage of educational programmes on renewable energy in the curriculum (schools, colleges, universities and other educational institutions) in Kuwait.” came in the eighth rank, as the overall agreement was (79.1%, n=83), with mean responses of (4.06) and standard deviation of (0.89). The statement “There is insufficient information on renewable energy technologies, their efficiency, advantages and disadvantages in Kuwait” came last, as the overall agreement was (75.2%, n=79), with mean responses of (3.95) and standard deviation of (0.87).

The overall mean (4.21, SD= 0.78) of responses for all the statements indicated that the level of knowledge and awareness of the advantages and challenges of RE among academics is high. Categorization of the total scores of the statements indicated that most of the academics (n=94, 89.5%) were categorized as having a high level of knowledge and awareness of the advantages and challenges associated with RE. Only 11.5% (n=11) had a moderate level of knowledge and awareness (See Table 8-40).

Table 8-40: Level of Knowledge and Awareness of the Advantages and Challenges Associated with RE - Academics

Level of knowledge	n	Percent
Moderate knowledge	11	10.5%
High knowledge	94	89.5%
Total	**105**	**100%**

8.16.2 Officials' and Stakeholders' Views

The responses received from the officials and stakeholders are set out below, and a mean, standard deviation, and rank for each statement is provided (See Table 8-41 and Table 8-42).

Table 8-41: Percentage Distribution of Responses Relating to Knowledge and Awareness of the Advantages and Challenges of RE – Officials and Stakeholders

Statement		SA	A	N	D	SD
I have some background knowledge, through reading or study, about renewable energy sources including solar, wind, and thermal energy.	n	83	123	24	1	1
	%	35.9%	53.0%	10.3%	0.4 %	0.4 %
Renewable energy technologies are not widely distributed in Kuwait's domestic market due to a lack of investment support.	n	94	104	28	6	0
	%	40.5%	44.8%	12.1%	2.6 %	0%
There is a shortage of knowledge and skills concerning renewable energy technologies in Kuwait.	n	92	110	26	4	0
	%	39.7%	47.4%	11.2%	1.7 %	0%
	n	161	59	10	2	0

The location and weather of Kuwait are suitable for renewable energy investment.	%	69.4%	25.4%	4.3%	0.9 %	0%
Renewable energy technology is facing a slow social uptake in Kuwait.	n	81	123	19	9	0
	%	34.9%	53.0%	8.2%	3.9 %	0%
The private sector should be encouraged to participate in renewable energy investment in Kuwait.	n	138	84	8	2	0
	%	59.5%	36.2%	3.4%	0.9 %	0
There is insufficient information on renewable energy technologies, their efficiency, advantages and disadvantages in Kuwait.	n	85	109	23	12	3
	%	36.6%	47.0%	9.9%	5.2 %	1.3 %
There is a shortage of programme on renewable energy in the educational curriculum (schools, colleges, universities and other educational institutions) in Kuwait.	n	111	97	18	6	0
	%	47.8%	41.8%	7.8%	2.6 %	0%
The Kuwaiti community needs to increase its awareness of renewable energy.	n	150	77	5	0	0
	%	64.6%	33.2%	2.2%	0%	0%

SA=Strongly Agree, A= Agree, N= Neutral, D = Disagree, SD= Strongly Disagree.

Table 8-42: Mean, Standard Deviation, and Rank for Each Statement Relating to Knowledge and Awareness of the Advantages and Challenges of RE – Officials and Stakeholders

Statement (N=232)	Mean	Std. Deviation	Rank
I have some background knowledge, through reading or study, about renewable energy sources including solar, wind, and thermal energy.	4.23	0.68	6
Renewable energy technologies are not widely distributed in Kuwait's domestic market due to a lack of investment support.	4.23	0.76	7

There is a shortage of knowledge and skills concerning renewable energy technologies in Kuwait.	4.25	0.72	5
The location and weather of Kuwait are suitable for renewable energy investment.	4.63	0.61	2
Renewable energy technology is facing a slow social uptake in Kuwait.	4.19	0.74	8
The private sector should be encouraged to participate in renewable energy investment in Kuwait.	4.54	0.61	3
There is insufficient information on renewable energy technologies, their efficiency, advantages and disadvantages in Kuwait.	4.13	0.88	9
There is a shortage of programmes on renewable energy in the educational curriculum (schools, colleges, universities and other educational institutions) in Kuwait.	4.35	0.73	4
The Kuwaiti community needs to increase its awareness of renewable energy.	4.63	0.53	1
Overall Knowledge and Awareness	**4.35**	**0.73**	**High**

Std. Deviation= Standard Deviation.

From Table 8-41 and Table 8-42, the following can be deduced:

- The statement “The Kuwaiti community needs to increase the awareness of renewable energy” came in the first rank, since the overall agreement was (97.8%, n=222), with mean responses of (4.63) and standard deviation of (0.53). In addition, the statement “The location and weather of Kuwait are suitable for renewable energy investment” came in the second rank, since the overall agreement was (94.8%, n=220), with mean responses of (4.63) and standard deviation of (0.61). Moreover, the statement “The private sector should be encouraged to participate in renewable energy investment in Kuwait” came in the third rank, since the overall agreement was (95.7%, n=222), with mean responses of (4.54) and standard deviation of (0.61).

- Three statements gained low response means. The statement "Renewable energy technologies are not widely distributed in Kuwait domestic market due to lack of support for their investment" came in the seventh rank, since the overall agreement was (85.3%, n=198), with mean responses of (4.23) and standard deviation of (0.76). In addition, the statement "Renewable energy technology is facing a slow social uptake in Kuwait" came in the eighth rank, since the overall agreement was (87.9%, n=204), with mean responses of (4.19) and standard deviation of (0.74). The statement "There is insufficient information on renewable energy technologies, their efficiency, advantages and disadvantages in Kuwait" came last, since the overall agreement was (83.6%, n=194), with mean responses of (4.13) and standard deviation of (0.88).

The overall mean (4.21, SD= 0.78) of responses for all statements indicated that the level of knowledge and awareness of the advantages and challenges of RE among academics is high. Categorization of the total scores for knowledge and awareness of the advantages and challenges of RE indicated that most of the officials and stakeholders (n=221, 95.3%) were categorized as having a high level of knowledge and awareness. Only 4.7% (n=11) had moderate levels of knowledge and awareness (See Table 8-43).

Table 8-43: Level of Knowledge and Awareness of the Advantages and Challenges of RE – Officials and Stakeholders

Level of knowledge	n	Percent
Moderate knowledge	11	4.7%
High knowledge	221	95.3%
Total	**232**	**100%**

8.17 Normality Test (Academics)

As Table 8-44 shows, the results of the Kolmogorov-Smirnov test statistics for continuous variables (i.e. the scores for User Efficiency in Electricity Consumption and for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy). The results showed that the scores were not normally distributed, as their distribution was statistically significant at 0.01 level of significance ($p < 0.01$). Therefore, these results validate the use of non-parametric tests, namely Mann-Whitney U test and Kruskal-Wallis test, when exploring them with demographic characteristics.

Table 8-44: Tests of Normality of the Continuous Variables - Academics

Variable	Kolmogorov-Smirnov		
	Statistic	df	Sig.
Scores for User Efficiency in Electricity Consumption	0.115	105	0.002
Scores for Knowledge and Awareness of the Advantages and Challenges of Renewable Energy	0.107	105	0.005

8.18 Normality Test (Officials and Stakeholders)

Likewise, the results of Kolmogorov-Smirnov test showed that the scores of the continuous variables for the second group (i.e. Officials and Stakeholders) were not normally distributed, as their distribution was statistically significant at 0.01 level of significance ($p < 0.01$). Again, these results validate the use of non-parametric tests, namely Mann-Whitney U test and Kruskal-Wallis test, when exploring them with demographic characteristics (see Table 8-45).

Table 8-45: Tests of Normality of the Continuous Variables - Officials and Stakeholders

Variable	Kolmogorov-Smirnov		
	Statistic	df	Sig.

Scores for User Efficiency in Electricity Consumption	0.128	232	0.000
Scores for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy	0.090	232	0.000

8.19 Scores for User Efficiency in Electricity Consumption (Academics)

8.19.1 Mann-Whitney U Test (Academics)

Table 8-46: Results of Mann-Whitney U Test Results for Differences in Total Scores for User Efficiency According to Nationality, Gender, and Occupation (Academics)

Variables	Category	N	Mean Rank	Sum of Ranks	Test Statistics	
Nationality	Kuwaiti	83	53.26	4420.50	Z	0.170
	Non-Kuwaiti	22	52.02	1144.50	p value	0.865
	Total	**105**				
Gender	Male	53	58.82	3117.50	Z	2.00
	Female	52	47.07	2447.50	p value	0.047
	Total	**105**				
Occupation	Employee	96	53.26	5113.00	Z	0.288
	Retired	9	50.22	452.00	p value	0.773
	Total	**105**				

As shown in Table 8-46, Mann-Whitney U test showed that there was no statistically significant difference observed in mean rank of scores for user efficiency attributed to the nationality of the academics ($Z=0.170$, $p > 0.05$). It can be said that user efficiency remains the same among nationality categories.

However, Mann-Whitney U test showed that a statistically significant difference was observed in mean rank of scores for user efficiency attributed to gender ($Z=2.00$, $p < 0.05$). Males who participated in the survey were more likely to have high efficiency than females.

Moreover, Mann-Whitney U test showed there was no statistically significant difference observed in mean rank in scores for user efficiency attributed to occupation (Z=0.288, p > 0.05). It can be said that user efficiency remains the same among the occupation categories.

8.19.2 Kruskal-Wallis Test (Academics)

Kruskal-Wallis H test was also used to see if there were significant differences in mean rank of user efficiency attributed to age, qualifications, and academic sector, since Kruskal-Wallis H test is suitable for independent variables with more than two categories (see Table 8-47 below).

Table 8-47: Results of Kruskal-Wallis Test for Differences in Total Scores for User Efficiency According to Age, Qualification, and Academic Sector - Academics.

Variables	Category	N	Mean Rank	Test Statistics	
Age	18-24	3	41.50		
	25-34	30	47.15		
	35-44	35	53.16	Kruskal-Wallis H	2.85
	45-54	30	59.12	df	4
	55-64	7	56.00	p value	0.583
	Total	**105**			
Qualification	PhD	14	63.14		
	MA	13	41.35		
	BSc	61	50.60	Kruskal-Wallis H	5.45
	Diploma	9	61.78	df	4
	High school	8	62.63	p value	0.244
	Total	**105**			
Academic sector	State university	25	55.26		
	Private university	8	54.00		
	State college	12	63.67	Kruskal-Wallis H	5.26
	Private college / school	3	70.17	df	6

	Research institute	3	30.33	p value	0.511
	State school	46	50.75		
	One of the sectors of the Ministry of Education	8	43.94		
	Total	**105**			

As shown in Table 8-47, the Kruskal-Wallis H values corresponding with Age, Qualification, and Academic sector are 2.85 (DF=4, sig.>0.05), 5.54 (DF=4, sig.>0.05), and 5.26 (DF=6, sig.>0.05) respectively. Based on these findings, there are no significant differences in means of user efficiency attributed to age, qualifications, or academic sector of the academics. It can be said that user efficiency remains the same across the different categories of age, qualifications, and academic sector.

8.20 Scores for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy (Academics)

8.20.1 Mann-Whitney U Test (Academics)

Table 8-48: Results of Mann-Whitney U Test Results for Differences in Total Scores for Knowledge and Awareness According to Nationality, Gender, and Occupation - Academics

Variables	Category	N	Mean Rank	Sum of Ranks	Test Statistics	
Nationality	Kuwaiti	83	55.60	4615.00	Z	1.71
	Non-Kuwaiti	22	43.18	950.00	p value	0.087
	Total	**105**				
Gender	Male	53	58.06	3077.00	Z	1.73
	Female	52	47.85	2488.00	p value	0.084
	Total	**105**				
Occupation	Employee	96	52.36	5026.50	Z	0.708

	Retired	9	59.83	538.50	p value	0.479
	Total	**105**				

As shown in Table 8-48, Mann-Whitney U test results corresponding with nationality, gender, and occupation are (Z=1.71, Sig.>0.05), (Z=1.73, Sig.>0.05), and (Z=0.708, Sig.>0.05) respectively. Based on these findings, there are no significant differences in means of knowledge and awareness attributed to nationality, gender, or the occupation of the academics. It can be said that knowledge and awareness of the advantages and challenges associated with renewable energy remain the same across the different categories of nationality, gender, and occupation.

8.20.2 Kruskal-Wallis Test (Academics)

Table 8-49: Results of Kruskal-Wallis Test for Differences in Total Scores for Knowledge and Awareness According to Age, Qualification, and Academic Sector - Academics

Variables	Category	N	Mean Rank	Test Statistics	
Age	18-24	3	61.33		
	25-34	30	52.13		
	35-44	35	48.30	Kruskal-Wallis H	2.03
	45-54	30	56.62	df	4
	55-64	7	61.14	p value	0.731
	Total	**105**			
Qualification	PhD	14	56.71		
	MA	13	55.31		
	BSc	61	50.82	Kruskal-Wallis H	1.664
	Diploma	9	62.56	df	4
	High school	8	48.63	p value	0.797
	Total	**105**			
Academic sector	State university	25	51.02		

	Private university	8	53.94		
	State college	12	72.83	Kruskal-Wallis H	7.23
	Private college/ school	3	63.00	df	6
	Research institute	3	38.83	p value	0.301
	State school	46	48.65		
	One of the sectors of the Ministry of Education	8	55.06		
	Total	**105**			

As shown in Table 8-49, Kruskal-Wallis H values corresponding with Age, Qualification, and Academic Sector are 2. 03(DF=4, sig.>0.05), 1.66(DF=4, sig.>0.05), and 7.23(DF=6, sig.>0.05) respectively. Based on these findings, there are no significant differences in means of knowledge and awareness attributed to age, qualifications, or academic sector of the academics. It can be said that knowledge and awareness of the advantages and challenges associated with renewable energy remain the same across the different categories of age, qualifications, and academic sector.

8.21 Scores for User Efficiency in Electricity Consumption (Officials and Stakeholders)

8.21.1 Mann-Whitney U Test (Officials and Stakeholders)

Table 8-50: Results of Mann-Whitney U Test for Differences in Total Scores for User Efficiency According to Nationality, Gender, Occupation and Sector - Officials and Stakeholders

Variables	Category	N	Mean Rank	Sum of Ranks	Test Statistics	
Nationality	Kuwaiti	192	113.64	21819.00	Z	1.430
	Non-Kuwaiti	40	130.23	5209.00	p value	0.153
	Total	**232**				
Gender	Male	166	122.17	20279.50	Z	2.051
	Female	66	102.25	6748.50	p value	0.040

	Total	**232**				
Occupation	Employee	188	121.55	22850.50	Z	2.380
	Retired	44	94.94	4177.50	p value	0.017
	Total	**232**				
Sector	Public sector	165	113.07	18656.50	Z	1.229
	Private sector	67	124.95	8371.50	p value	0.219
	Total	**232**				

As shown in Table 8-50, Mann-Whitney U test showed that there was no statistically significant difference observed in mean rank of scores of user efficiency attributed to nationality (Z=1.430, $p > 0.05$) or sector (Z=1.229, $p > 0.05$). It can be said that user efficiency in electricity consumption remains the same across nationality and sector categories.

However, Mann-Whitney U test showed there was a statistically significant difference observed in mean rank of scores for user efficiency attributed to gender (Z=2.051, $p < 0.05$) and occupation (Z=2.380, $p < 0.05$). Males who participated in the survey were more likely to have high efficiency in electricity consumption rather than females, while employed respondents were more likely to have high efficiency than retired respondents.

8.21.2 Kruskal-Wallis Test (Officials and Stakeholders)

Kruskal-Wallis H test was also used to see if there were significant differences in mean rank of user efficiency in electricity consumption attributed to age, qualifications, or employment field.

Table 8-51: Results of Kruskal-Wallis Test for Differences in Total Scores for User Efficiency According to Age, Qualification, or Employment Field – Officials and Stakeholders

Variables	Category	N	Mean Rank	Test Statistics
Age	18-24	2	107.75	

	25-34	50	100.65		
	35-44	71	122.87	Kruskal-Wallis H	3.87
	45-54	76	118.41	df	4
	55-64	33	122.94	p value	0.424
	Total	**232**			
Qualification	PhD	12	133.17		
	MA	29	103.16		
	BSc	111	118.06	Kruskal-Wallis H	6.71
	Diploma	46	114.53	df	5
	High school	30	110.57	p value	0.243
	Primary school	4	187.00		
	Total	**232**			
Employment field	Ministerial sector	114	109.04		
	Authorities sector	7	154.07		
	Companies sector	46	128.30	Kruskal-Wallis H	7.67
	Industrial sector	14	112.86	df	6
	Services sector	8	151.19	p value	0.263
	Health sector	14	119.04		
	Education sector	29	109.02		
	Total	**232**			

As shown in Table 8-51, Kruskal-Wallis H values corresponding with age, qualifications, and employment field are 3.87 (DF=4, sig.>0.05), 6.71 (DF=5, sig.>0.05), and 7.67 (DF=6, sig.>0.05) respectively. Based on these findings, there are no significant differences in means of user efficiency attributed to age, qualifications, or employment field. It can be said that user efficiency in electricity consumption remains the same across the different categories of age, qualifications, and academic employment field.

8.22 Scores for Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy (Officials and Stakeholders)

8.22.1 Mann-Whitney U Test (Officials and Stakeholders)

Table 8-52: Results of Mann-Whitney U Test for Differences in Total Scores for Knowledge and Awareness According to Nationality, Gender, Occupation and Sector Officials and Stakeholders

Variables	Category	N	Mean Rank	Sum of Ranks	Test Statistics	
Nationality	Kuwaiti	192	117.20	22503.00	Z	0.351
	Non-Kuwaiti	40	113.13	4525.00	p value	0.726
	Total	**232**				
Gender	Male	166	117.51	19506.00	Z	0.363
	Female	66	113.97	7522.00	p value	0.716
	Total	**232**				
Occupation	Employee	188	113.69	21373.50	Z	1.324
	Retired	44	128.51	5654.50	p value	0.186
	Total	232				
Sector	Public sector	165	116.62	19243.00	Z	0.044
	Private sector	67	116.19	7785.00	p value	0.965
	Total	**232**				

As shown in Table 8-52, Mann-Whitney U test results corresponding with nationality, gender, occupation, and sector are (Z=0.351, Sig.>0.05), (Z=0.363, Sig.>0.05), (Z=1.324, Sig.>0.05), and (Z=0.044, Sig.>0.05) respectively. Based on these findings, there are no significant differences in means of knowledge and awareness attributed to nationality, gender, occupation, or sector. It can be said that knowledge and awareness of the advantages and challenges of renewable energy remain the same across the different categories of nationality, gender, occupation, and sector.

8.22.2 Kruskal-Wallis Test (Officials and Stakeholders)

Table 8-53: Results of Kruskal-Wallis Test for Differences in Total Scores for Knowledge and Awareness According to Age, Qualification, and Employment Field - Officials and Stakeholders

Variables	Category	N	Mean Rank	Test Statistics	
Age	18-24	2	151.50		
	25-34	50	106.14		
	35-44	71	120.76	Kruskal-Wallis H	2.341
	45-54	76	115.68	df	4
	55-64	33	122.80	p value	0.673
	Total	**232**			
Qualification	PhD	12	113.63		
	MA	29	100.33		
	BSc	111	115.88	Kruskal-Wallis H	3.115
	Diploma	46	120.07	df	5
	High school	30	130.18	p value	0.682
	Primary school	4	116.00		
	Total	**232**			
Employment field	Ministerial sector	114	122.28		
	Authorities sector	7	99.64		
	Companies sector	46	118.49	Kruskal-Wallis H	3.402
	Industrial sector	14	110.50	df	6
	Services sector	8	123.00	p value	0.757
	Health sector	14	103.64		
	Education sector	29	102.02		
	Total	**232**			

As shown in Table 8-53, Kruskal-Wallis H values corresponding with age, qualification, and employment field are 2. 341(DF=4, sig.>0.05), 3.115(DF=5, sig.>0.05), and 3.402(DF=6, sig.>0.05) respectively. Based on these findings, there are no significant differences in means of knowledge and awareness attributed to age, qualification, or employment field. It can be said that knowledge and awareness of the advantages and challenges of renewable energy remain the same across the different categories of age, qualification, and employment field.

The final question in both invited respondents to provide any other comments or suggestions. Many people noted down their suggestions and comments, and the most prominent one are listed below (For details of all the comments made, see Appendix IX).

Academic respondents

- *The government should increase the use of renewable energy and its application in state institutions and at the individual level by supporting citizens in using renewable energy technologies in addition to spreading adequate awareness of the use of renewable energy through the curriculum and by publishing massive media campaigns on the use of renewable energy to reduce the consumption of the oil supply.*

Official and Stakeholder respondents

- *The media sector in Kuwait, whether visual or audio media or newspapers and social media, should contribute to raising awareness through programmes and media messages about the importance and benefits of renewable energy to motivate society to use it.*
- *The development of nations depends on the progress of studies and research which go beyond traditional pattern to deal with the needs of life; we must keep pace with global developments in the use of renewable energy and benefit from the experiences of other countries.*

- *Renewable energy - to succeed quickly in Kuwait [we] need to start with government institutions first and then the private sector, and develop future plans supported by decisions and financial support which encourages consumers to use renewable energy.*
- *The local market lacks opportunities for effective participation in the deployment of renewable energy technologies by not focusing on local investors [and helping them] to invest in renewable energy by providing support and encouragement.*
- *In terms of community awareness, I believe that renewable energy awareness is necessary but not as important as 'energy conservation' awareness. It is important for people within the community to start developing that energy conservation mindset and mentality before forcing them to learn about renewables. Renewable energy awareness and enforcement have to be the government's role; it is crucial for them to be aware of these solutions while changing the consumer's energy consumption mentality to make these technologies work.*

8.22.3 Demography of the Respondents and Criteria Association

One of the aims of the questionnaires was to identify baseline characteristics of the respondents in terms of nationality, gender, age, occupation, qualifications, and employment field, so that the relationship between these variables and the respondents' user efficiency in energy consumption and knowledge and awareness of renewable energy could be evaluated (See Table 8-54 and Table 8-55).

Table 8-54: The Relationship Between Respondents' Characteristics and their User Efficiency and Knowledge and Awareness of Renewable Energy - Academics

Criteria (Academics)	**Highly Significant Differences** $p < 0.01$	**Significant Differences** $p < 0.05$	**Non-Significant Differences** $p < 0.05$

User Efficiency and Energy Conservation	-	Gender	Nationality
	-	-	Occupation
	-	-	Age
	-	-	Qualifications
	-	-	Academic Sector
Knowledge and Awareness of the Advantages and Challenges of Renewable Energy	-	-	Nationality
	-	-	Gender
	-	-	Occupation
	-	-	Age
	-	-	Qualifications
	-	-	Academic Sector

Table 8-55: The Relationship Between Respondents' Characteristics and their User Efficiency and Knowledge and Awareness of Renewable Energy - Officials and Stakeholders

Criteria (Officials and Stakeholders)	**Highly Significant Differences** $p < 0.01$	**Significant Differences** $p < 0.05$	**Non-Significant Differences** $p < 0.05$
User Efficiency and Energy Conservation	-	Gender	Nationality
	-	Occupation	Age
	-	-	Qualifications
	-	-	Employment field
	-	-	Sector
Knowledge and Awareness of the Advantages and Challenges Associated with Renewable Energy	-	-	Nationality
	-	-	Gender
	-	-	Occupation
	-	-	Age
	-	-	Qualifications
	-	-	Employment field

			Sector

Analysis of the results of the ‘Academic and Educational Organisations’ questionnaire identified a significant association between the participant’s gender and their user efficiency and energy conservation behaviour (as shown in Table 8-54). In addition, the ‘Official Organisations’ questionnaire found a significant association between gender and occupation and user efficiency and energy conservation behaviour (as shown in Table 8-55). The majority of the significant association relates to the male and employee categories. These results match those of the ‘Public Questionnaire’ and were to be expected due to the fact that men typically assume responsibility for paying household energy bills in Kuwait so may be more conscious of the need to regulate electrical energy consumption. The findings here suggest that energy-saving behaviour exhibited at home may also be reflected in the participants’ workplaces. However, no other statistically significant relationships between the respondents’ characteristics and their user efficiency and knowledge and awareness of renewable energy was identified, so further work may be needed to understand how differences in nationality, age, qualifications, employment field and sector type affect energy consumption behaviour and awareness of renewable energy.

8.23 Summary

This chapter has provided statistical analysis of the data collected from officials and stakeholders, with a particular focus on efficiency of energy consumption and knowledge and awareness of the utilisation of renewable energy. It has identified the participants’ attitudes and behaviour towards energy saving and their evaluation of the role of their organizations in this respect and determined their personal attitudes towards renewable energy and the roles of their organisations in this regard. Their responses have revealed some of the most important obstacles facing renewable energy in

Kuwait, notably low levels of energy efficiency, a lack of appropriate infrastructure, and insufficient knowledge and awareness of the advantages and challenges associated with renewable energy use. The next chapter goes on to provide analysis of the data collected via interviews with renewable energy experts and officials

Chapter 9

Analysis of the Interviews with Academics, Officials and Stakeholders

9.1 Introduction

This chapter discusses the data collected through semi-structured interviews with experts, legislators and policymakers with links to the renewable energy (RE) sector in Kuwait. It begins by identifying the factors driving the emergence of an environmental conscience in the oil-rich state and goes on to assess the roles of both public and private entities in promoting awareness of energy efficiency and renewable energy use. It reviews the government's plans and targets for RE and identifies the key measures required to achieve its stated aim of supplying 15% of energy from renewable sources by 2030. It also discusses the most significant RE projects in the country. While the interviewees express divergent views, clear reservations about the effectiveness of the government's actions emerge, and a number of significant challenges are identified. The chapter concludes by assessing the extent to which these threaten the long-term viability of RE in Kuwait.,

18 interviews with senior figures in key public and private sector organisations were conducted by the researcher during the field visit to Kuwait. Policymakers and experts were targeted in order to determine their attitudes toward the utilisation of renewable energy in Kuwait and to obtain data on electricity consumption, the environmental situation, and current and future renewable energy projects in Kuwait (See Table 9-1).

Table 9-1: Sample Size and Characteristics of the Interviews

Classification	Interviewees List of Organizations	Interview Code	Number of Interviews	Interview Method
Renewable Energy Companies (Private Sector)	Smart Globe Company (SGC)	A	1	Face to Face
	Alternative Energy Projects Company (AEPC)	B	1	Face to Face
Research Institutes, Education Sector and Universities	Kuwait Institute for Scientific Research (KISR)	C1, C2	2	Email & Face to Face
	The Public Authority for Applied Education and Training (PAAET)	D1, D2	2	Email & Face to Face
	Ministry of Education (MOE)	F1, F2	2	Telephone
Governmental Organisations	Ministry of Electricity & Water (MEW)	G1, G2 & G3	3	Face to Face
	General Secretariat of the Supreme Council for Planning and Development (SCPD)	H	1	Face to Face
Policy Makers	Kuwait National Assembly (KNA)	I	1	Face to Face
Non-Governmental Organisations	United Nations Human Settlement Program - Kuwait (UNHSP)	J	1	Email
	Kuwait Society of Engineers (KSE)	K	1	Face to Face & Telephone
Media	Kuwaiti Newspapers	L1, L2	2	Telephone
	Ministry of Information (MOI)	M	1	Email & Face to Face
Total			**18**	

9.2 The Rationales for Environmental Consciousness

Environmental consciousness in Kuwait is attributable to several rationales, some emergent and other extant. Among the extant rationales identified by the interviewees is the fact that the environmental conditions in Kuwait have been compromised in the past, leading to negative impacts on the health of the citizens. According to A1, the most apparent evidence of this is the effects of global warming, which can be attributed to "*the increase in emission at very high rates; this will threaten the continuity of the life of humans and beings, which we must research effectively to protect the environment.*". B1 concurs, indicating that "*Global warming is an issue that affects us all! When the environment is affected, so is our life, through the impact on our health linked to the preservation and quality of the environment*!". These views are also shared by J, who cites the unprecedented change in environmental conditions as part of the reasons for the increased pollution. J states that "*Because environmental pollution escalated in an unprecedented way, it became a life-threatening hazard and degraded the fauna and flora of Kuwait,[…] affecting Kuwait's economy in many ways."*

Among the emergent factors identified, C1 cites the increased involvement of Kuwait in international affairs through international agreements. In support of this, D2 indicates that Kuwait has adopted a globalised approach to decision making, including "*advocacy for the preservation of the environment linked to human health for the continuation of life on planet earth*." Similar views are shared by G1, who cites the case of Kuwait joining the United Nations Framework Convention on Climate Change as evidence of the emergent changes in Kuwait's approach to environmental awareness. The fact that Kuwait is subject to a cultural shift, which is part of a global phenomenon, is also mentioned. According to H, "*The new generation of Kuwaiti citizens have a greater understanding of the implications the environment plays with regards to their lifestyle, health and future*". This cultural shift has led to an increased focus on clean energy and protection of the environment. In support, F1 indicates that "*global interest in environmental affairs has increased over the past years*", concerning the protection of environments.

Government policies are also identified as playing an integral role in shaping environmental consciousness in the country. These include sustainable development policies, notably those under Kuwait Vision 2035, which includes environmental protection as part one of its pillars. According to F1, "*the environment is one of the pillars of sustainable development, and therefore any deficiency in preserving it reflects negatively on sustainable development and threatens the stability of life on the surface of the earth*."

9.3 Role of Institutions in Raising Awareness of Energy Efficiency and Renewable Energy

9.3.1 Role of Public Entities, Government Agencies and NGOs in Raising Awareness

The successful adoption of renewable energy (RE) in Kuwait will require the participation of both public and private entities. Among the public entities, the Kuwait Institute for Scientific Research (KISR) provides research and information on RE based on data collected from the industry. This research-based approach provides qualitative and quantitative propositions, rooted in evidence and technical elements, which is intended for governmental, industrial and public consumption. According to C1, KISR "*conducts research activities that comes up with results to be shared with the public*". As a research entity, KISR also conducts training and workshops for members of the public who are interested in getting specific technical information about RE. Another institution, the Public Authority for Applied Education and Training (PAAET), plays a similar role in the domain of research and public education, but lacks the infrastructure for training. Most of its information disbursement activities occur at the College of Technology Studies, which is a localised entity. A similar approach is adopted by the Ministry of Education (MOE); by targeting learners at different levels, it can establish the foundations for orienting learners, and young people in general, towards adopting RE in the country. As F2 reports, "*The Ministry of Education raises awareness among students about the use of renewable energy through relevant competitions, and some curricula emphasize the importance of renewable energy*".

According to G2, government institutions, such as the MEW, contribute to raising awareness by providing technologies for use in RE generation and training on how to use them, commenting that "*the Ministry of Electricity and Water has a system of photovoltaic panels (PV), as they may contribute to highlighting its importance to society*". However, the ministry has not dedicated specific resources to spreading awareness in the society. M indicated that the Ministry of Information is involved in the delivery of messages directly to the citizens through mass media. According to M, messages are delivered "*through television news broadcasts such as public news and may include news about renewable energy at the local and international levels, according to the media message addressed to us from state institutions*". L1 and L2 report that their newspapers play a similar role in aggregating news and publishing findings to the members of public. L1 focuses more on publishing for "*for researchers and those interested in the environment and renewable energy"*, while L2 focuses on providing commercial advertisement, "*because we are a privately-owned for-profit newspaper, but we compete with the other newspapers by publishing news or commercial advertising about renewable energy."* The differences in the type of messages contained in the awareness campaigns thus vary depending on the nature of the organisation and its operations.

The General Secretariat of the Supreme Council for Planning and Development (SCPD) is also involved in raising awareness by entrenching government policies towards Vision 2035 in Kuwait (commonly referred to as 'New Kuwait'). According to H, "*we oversee the implementation of the Sustainable Development Goals since the country committed to them in 2015 and SCPD approved the inclusion of a renewable energy programme [in Vision 2035]."* The involvement of the SCPD in awareness-raising is viewed as the reason why the MEW has taken a secondary role in these activities. However, this has its advantages, since the SCPD has a broader mandate than MEW and promotes a more diverse range of knowledge and information, including halting the expansion of *"fossil fuel-based power stations and focusing on rationalisation and the use of clean technology to counter emission. SCPD [also] supported the Clean Fuel Project that aims to provide power stations with low-sulphur fuel"* (H). These portfolio of responsibilities are highly correlated, leading to synergistic and symbiotic outcomes concerning the use of RE. A similar yet unique approach is adopted by the United Nations Human Settlement Program – Kuwait. According to J, their objective for raising awareness is "*capacity building at different levels, sharing information, developing reports on consumption levels and types in Kuwait, providing expertise and many other activities."*

The forms of specialisation evident in these institutions establishes a trajectory for the value of awareness campaigns since it is apparent each entity occupies a different area of the awareness-creation continuum. While some institutions are involved in the generation of information, others create the foundation for the utilisation of that information.

9.3.2 Role of Private Companies in Raising Awareness

Private organisations also have a role to play in spreading awareness of efficient energy utilisation, based on their specialisation, the available resources, and their special interests. As corporate entities, organisations have a bigger mandate than citizens regarding the use of energy (Nemet, 2019); however, their decisions are based on corporate strategies whose scope is mandated by owners and investors (Gonzalez *et al.*, 2016). Based on the findings from these interviews, RE companies have focused primarily on informing their customers through marketing materials. For instance, Smart Globe Company (SGC) has implemented programmes to inform customers about renewable energy technologies (RETs), through a multiplicity of offline and online media. According to A1, "*We have a programme for our company, being in the private sector, [and] for our customers concerning everything new about renewable energy technologies through brochures, emails, social media* *channels, and the company's website*." Meanwhile, AEPC has integrated information about its disbursement agenda into its corporate social responsibility program. B2 indicates that "*It is part of our CSR program to educate the public and stakeholders about the importance of this issue*". The company considers the programme a foundation for the spread of information about renewable energies and views the strategy as part of the mechanisms through which it can extract benefits from members of the public following a change in their views about RETs.

9.3.3 Role of Government in Raising Awareness

Although the interviewees describe the steps individual ministries are taking, the overall role played by the government is key to improving consumption behaviour and promoting RE use. While both C2 and F1 indicate that it is the mandate of the government to "*make advertisement campaigns to promote water and electricity saving by using efficient electrical equipment and to stop wasting water",* A2 and B1 report that the government has taken a 'weak stance' in these areas. They attribute the lack of public awareness to limited outreach through campaigns deployed via mass media, including "*Radio channels, television, newspapers, conferences, events, and social media to communicate the message of rationalisation and energy conservation to all segments of society*".

There is some acknowledgment of actions already taken. According to J, the government has launched successful campaigns aimed at increasing awareness of what members of the public can do, and F1 recognises the role of the Ministry of Endowments and the Ministry of Finance in promoting environmental protection, stating that "*the Ministry of Endowments has achieved distinguished results in the field of rationalizing water and electricity consumption and the Ministry of Finance took care of implementing energy and water rationalization programmes*." This comment, from a member of the MOE, suggests that government institutions have identified the potential value in these resources, as well as the need for an integrated approach across ministries.

However, there is also evidence that the campaigns by the government have received weak levels of responses and are viewed as ineffective. The responses of D1 reflect those of A2, B1 and C2 by indicating that the government has failed in its role since it has not prevented the excessive consumption of electricity. According to D2, the government "*assumed that we have an intensification of continuous awareness-raising media programmes that explain the danger of waste in increasing consumption.*" This assumption however is far from reality, and it has adverse effects due to the fact that members of the public justify their wasteful consumption on the grounds that the government has not taken specific measures to prevent it. Essentially, the failure by the government is viewed as a ratification of the wasteful actions of the public.

A2 also concurs with B1 that the government has failed in the implementation of regulatory mechanisms though a lack of required laws and guidelines. As a result, rather than the government failing to play a role, where it has failed is in implementing the necessary measures. According to G3, "*There is a role […] through the rationalisation campaign (Tarsheed) carried out by the Ministry of Electricity and Water [and] through awareness campaigns for the community,*" but this is "*ineffective*". G3 reiterates the fact that it is the role of the government to publicise the measures and mandates; however, this can only be achieved through "*continuous measurement to achieve the goal of the campaign to rationalise electrical energy, as it is said, "If you cannot measure, you will not be able to manage*."

H offers a summative view of what respondents such as D1, A2, B1 and C2 indicated, by stating that the government's role spans information disbursement as an educator to regulatory mandate as an oversight institution and "*promoting good habits, sustainable solutions and providing varied alternative solutions to its citizens and residents*". Although several campaigns have been deployed by the government, mainly focussed on educating citizens about rationalising electricity and water consumption, H believes there "*is still a lot to be done with regards to educating citizens;*

one of the major problems I believe is that the government heavily subsidises water and electricity. Thus the citizens and residents take it for granted". This reference to the role of subsidies in the activities of government reveals how this particular economic tool works as a double-edged sword. As H observes, while "*the benefit of the subsidy works nationwide – meaning, manufacturing companies and residents get cheap energy and water"* citizens and residents *"take it for granted, […] and thus also abuse this blessing".* This highlights the position that the government of Kuwait is in vis-à-vis the use of subsidies to drive its economy.

In line with the assertions by Alnaser and Alnaser, 2019, these outcomes can be attributed to the fact that government entities tend to base their decisions on political influence and long-term planning at a national scale, even when the policies are transmitted to the local level.

9.3.4 Role of Government in Using the Media to Raise Awareness

The use of media by government agencies to raise awareness in the country is judged as 'Weak' by 12 of the 18 respondents. Just six interviewees rated it as 'Acceptable', 'Good' or 'Very Good', with none rating it 'Excellent' (See Figure 9-1). According to A1, the measures taken are "*too weak and not properly activated*", while B2 can only cite the Tarsheed campaign and finds "*the performance is weak*". C2 , D2 and G2 also agree that measures are weak, with G2 indicating that the role is "*very weak" and "rests with the responsible media authorities, which must spread awareness on a large scale".* H attributes the weak state of the measures to the fact that there is a widespread lack of incentives, and states that "*it requires the legislature to implement [them]. Any awareness campaign requires incentivising the public as well."*

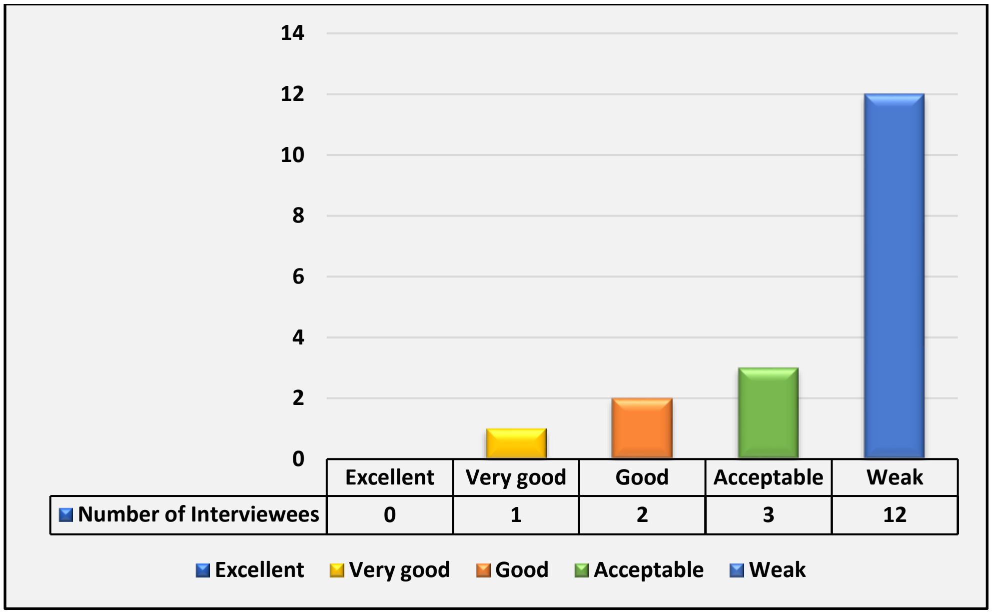


Figure 9-1: Effectiveness of Government Media Campaigns

9.4 Governmental Plans and Visions for Renewable Energy Utilisation

The government's plans and visions for RE utilisation in the country play an integral role in the achievement of the short- and long-term goals. However, based on the views of the majority of interviewees, the Kuwaiti government lacks clarity in its plans and visions. According to A2, there are "*not clear plans and strategies*", and G3 concurs by indicating that, where plans exist, they are "*not at the level of large renewable energy projects, for example lighting pedestrian roads in some areas or installing photovoltaic panels on the roofs of the water towers of the Ministry of Electricity and Water*". A different view is held by B2, who indicates that, based on the scope, "*The plans are to release EPC and PPP (mega-scale) projects to cover their target*". D1 also finds the scale of plans limited, given that the government aims to achieve 15% RE by 2030, but H views this aim as realistic, since there are "*different projects spread around the country.*"

9.5 Role of Private Sector in Investing in Renewable Energy in Kuwait

The private sector generally introduces a high level of efficiency into industries, due to the high level of objectivity in their operations. Their role in RE in Kuwait, which intersects with that of external investors, is generally limited but includes some active involvement. According to A, the private sector is primarily a guest in the industry, since "*the private sector and the external investor face difficulties, challenges, and obstacles in dealing with government agencies regarding the work of renewable energy projects [as they create barriers] by imposing impossible conditions*." These views are shared by B, C2, D1, G1 and J who all indicate that the private sector plays a minimal, and largely ineffective role, due to a lack of incentives or regulatory mandate. The weak-level of participation is explained by K, who states that "*the private sector is considering itself as a cash gainer from the government without a sense of participating in the field of making a success of a [long-term] investment*." Their primary focus on short-term benefits has limited the participation of the private sector, since most of the projects have long payback periods.

However, H sees SMEs and entrepreneurs as playing an integral role in the energy sector. He reports that one SMEs, Kuwait National Petroleum Company (KNPC), is already participating and *"its subsidies are implementing the use of renewable energy in remote sites. KNPC is been responsible to build 1000 MW solar plant"*. Ultimately, the participation of the private sector and external investors will be necessary, since it provides new sources of capital into the RE sector. Indeed, according to F2 , "*The private sector and foreign investor should play a greater role in investing in renewable energy in Kuwait".* The advantage of perceiving foreign investors as part of the private sector is that it eliminates many of the legal bottlenecks that limit the introduction of foreign direct capital into the country, as well as the sharing of technologies with entities from other locations.

9.6 Renewable Energy Projects in Kuwait

The discussion of RE projects in Kuwait in the interviews focused on the investments made for the production of energy, the relative significance of particular projects, and the manufacture of RE technologies. A comparative assessment of the RE investment in Kuwait vis-a-vis the rest of the world reveals that most of the interviewees view Kuwait as being in a relatively weak position in this respect (See Figure 9-2). G2 refers to the position of Kuwait as being "*Weak to acceptable to some extent*", while H indicates that the limited proportion of investment in RE by Kuwait, compared to its economic standing, accounts for its weak position. Although US$3B has been invested, H comments "*Bear in mind that Kuwait is an oil-rich country with an environmental conscience and a global commitment to climate change*". J also views Kuwait's position as weak, saying that it "*cannot compete and [is] without a promising future*"; however, F1 views the steps taken so far as a good starting point, but adds that the country must increase investment to catch up with the global renewable energy market.

Figure 9-2: Situation of RE Investments in Kuwait Compared to the Global RE Market

RE projects differ in their relative importance to the energy mix within Kuwait. Even when productivity and efficiency are identical, Heal (2009) indicated that, based on the economics of RE, there are some projects whose utility and importance is unique. Based on the interview responses, the utility of energy projects in Kuwait is dependent on their size and energy output. According to A2, the Al-Shagaya Renewable Energy Project is the most important project, because it is a "*mixture of renewable energy technologies PV panels, Wind turbine and CSP system.*" The project caters to the needs of telecom companies, remote environmental monitoring sites, oil exploration sites, and energy-consuming projects that are not connected to the national grid, such as lighting projects. C2, D2, G1 and J share this view of Al-Shagaya, adding that the fact the government has implemented two additional phases to the original project indicates its importance to the RE strategies in the country. According to C2, "*Phase 1 has a capacity of 70 MW of installed capacity (executed by KISR), phase 2 is expected to be around 1400 MW installed capacity (executed by KNPC), and phase 3 is still not determined*". Essentially, Al-Shagaya's importance is dependent on the fact that the government has plans to extend its scale and scope into the future,[4] although G1 states that it has also furthered the adoption of REs for rooftop use. B1 also views Al-Shagaya Project as the most prominent, but comments that "*There is no such thing as 'Most important' as all of them are equally as important"*. The prominence of the Al-Shagaya Project can perhaps be attributed to the fact that it was the first large-scale RE project in the country.

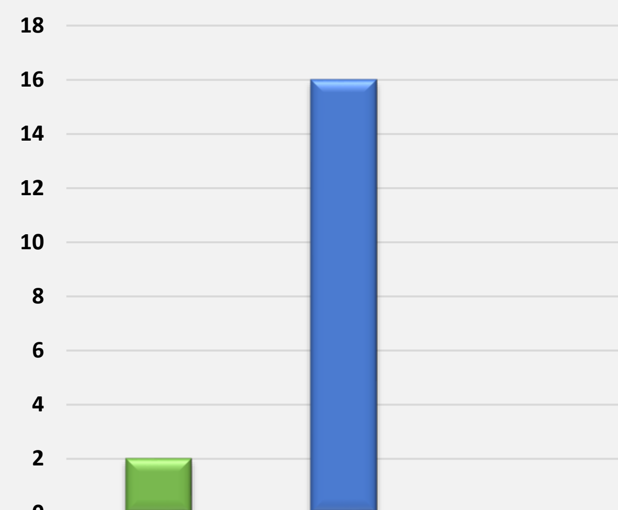
For G3, the Al-Abdilyah Station is the most important, since it combines RE (solar energy) and fossil fuels in an Integrated Solar Combined Cycle (ISCC). As a result, it is not affected by the intermittency of REs, and its carbon footprint is lower than that of dedicated fossil fuel projects. G3 describes the project as a "*common cycle between the gas station turbines and steam station turbines to enhance the production efficiency and production capacity of this station to 280 MW […] divided into two sections, with 60 MW capacity for the Concentrated Solar Power (CSP) system and 220 MW throughput using the combined cycle".* The combination of the two systems has also contributed to efficiency in the utilisation of land, with the project covering only $2KM^2$. G3 also considers Al-Shagaya Project is an important part of the RE projects in the country for similar reasons. In line with the views of C2, G3 states that the multiphase project is comprised of different RES, including 50MW output capacity from Concentrated Solar Power (CSP), 10MW production capacity from Photovoltaic Cells (PV) and 10 MW production capacity from the Wind Energy system. G3 expects the proposed phase 2 to have an optimal production capacity of 1930MW, making a total of 2GW from the entire project.

H and F1 view the Al-Shagaya Project as the most important RE project in the country due to its efficiency and the savings in carbon emissions it brings. Of importance is the fact that the project will "*produce 180GWh/year with a total area of 250 hectares and reduce emissions by more than*

[4] The Kuwaiti Cabinet decided to cancel the second phase of the project in July 2020 due to the financial effects of the pandemic (See Chapter 1, 1.19).

81,000 tons of CO_2/year" (H). However, F1 argues that the prominence of some projects means that other green energy projects can be overlooked. F1 identifies the Sidra 500 project in Umm Qadir, west of Kuwait, which "*would generate 10 megawatts of electricity from solar energy, half of which would enter the public electricity grid*". However, since it is privately owned, it has not received as much publicity as the other projects.

With respect to the manufacture of RE technologies, the interviewees concur on the fact that there were almost no such manufacturers in Kuwait at the time (See Figure 9-3).



	Yes	No	I don't know
Number of Interviewees	2	16	0

Figure 9-3: Has Kuwait Invested in the Manufacture of RE Technologies?

Of those who said 'Yes', H mentioned that the country has invested in the manufacture of "*the mounting frames for the solar panel. Some industrial facilities [also] provide ancillaries and accessories for the solar industry in the country."*, and F1 indicated that "*Kuwait has set up the first photovoltaic plant with the support of the National Fund for Small Projects, [as part of] the Shagaya Pilot Project for Renewable Energy*". However, this is a recent investment which might not have received sufficient publicity. B said 'No' but indicated that there is manufacture through an assembly line for small PV modules. However, both K and J stated that Kuwait has made no investment in manufacturing RE in the country, and J attributes this lack of investment to the poor investment climate in the country.

9.7 Government Procedures to Promote the Use of Renewable Energy Technologies

The Kuwait government, through its agencies, has implemented a variety of strategies to encourage consumers to adopt RETs. The measures reflect the priorities of the government, as well as the role of citizens in the adoption of REs in the country. However, the interviewees questioned whether there are adequate measures to enforce the prioritisation of REs over other energy sources among the different categories of users.

Concerning mandates for regular citizens to use REs, both A1 and F2 state that the government has promoted the adoption of solar PV technologies, notably for street lighting. A1 notes that "*some government agencies use solar panels in the positions of cooperative societies and in lighting pedestrian paths in some residential areas, which may contribute to drawing the attention of society to the importance of renewable energy.*" The use of solar energy for lighting is a viable approach to supplementing the use of fossil fuels. However, as indicated by A1, the strategy has not been supported by follow up maintenance activities, and this has led to failings in the project. Similar views are held by C2, who indicates that the government, through KISR, has installed "*PV panels on the roof tops of houses in order to promote the usage of renewable energy and educate the people."* Equally, D1, from PAAET, indicates that they have made "*an effective step on renewable energy by implementing a solar energy generation project on the roofs of the complex of basic education colleges buildings in Al-Ardiya area in Kuwait, and operating all of these PV panels and linking it to the public national electrical grid"*. As the institution is designed for training purposes, PAAET offers students the ability to learn from the available data to enable them to design proposals for effective RE systems. The measures in place also include grid-level connections for power buyback to the National Grid; a strategy which enables investors in REs to generate revenue by selling power to the government. Finally, H indicates that the government has taken measures to enhance the legislative frameworks that control the use of RE. Once approved by the government, these regulations will mandate the installation of RETs in parking lots across the country, following the successful implementation of two prototype projects. These respondents further indicate that these measures are accompanied by campaigns for increased use of REs from the installations.

By contrast, B2 and G2 have a different opinion, claiming that the government has failed to include the citizens in its REs policies. B2 states that "*Government is taking the role of the implementers and executor of projects with hardly any roles left or even enabled for the consumers".* According to G2, "*There are no procedures to encourage citizens to use renewable energy*". These views are based on the fact that the government treats the state-owned energy companies as tools for delivering services and sees no need to involve citizens in the process. These views are reflected by C2, who indicates that even under the rooftop solar projects, KISR has failed to properly regulate the policy.

Concerning the commercial use of RE, only one respondent indicates that the government has taken measures to force contractors to use it, with the rest signifying that no such efforts had been made (See Figure 9-4). A1 indicated that there was no such legislation, but stated that "*there are some requirements for contractors in some workplaces not to use the main network, which obliges the contractor to use solar panels for lighting".* This view is shared by B1, who indicates that there is some regulation for preferential use of RE but only for construction in government facilities. C1 categorically states that there no such measures, while H indicated that companies in the oil sector in remote locations are mandated to use RES. However, in the case of H, this arises from the fact that such remote locations are not connected to the national grid.

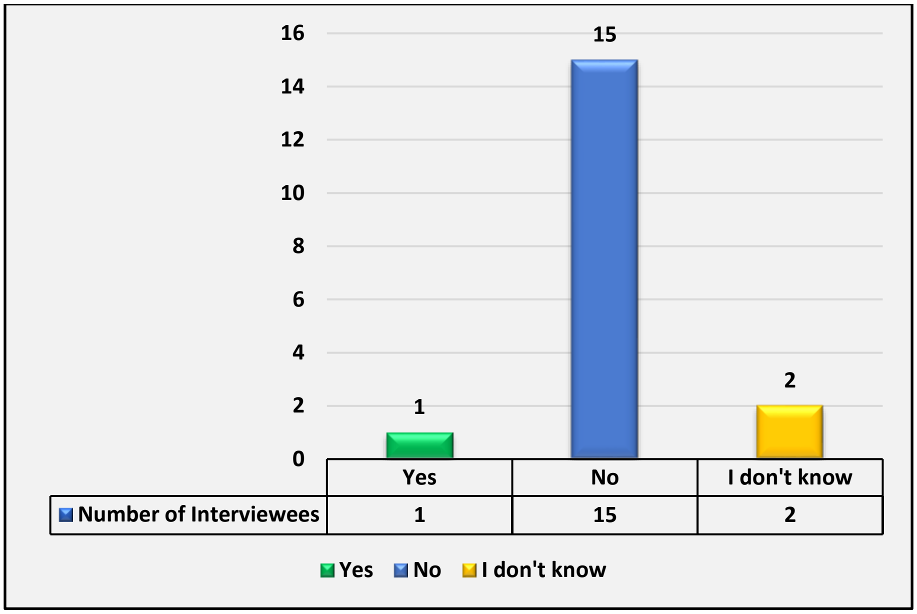


Figure 9-4: Are There Procedures or Laws to Mandate the Use of Renewable Energy Sources?

9.8 Government Performance Towards Achieving 15% Renewable Energy by 2030

According to KISR (2019), Kuwait is committed to supplying 15% of its energy demand from RES by 2030, up from 1% currently. The plan involves sector-wide transformation, coupled with increased penetration of RE into areas where such sources are not currently available. This process also involves the use of different RES (Jandal, 2014). Based on the interview results, views on the likelihood of such an achievement are widely divergent, with those who support the possibility of achieving such an outcome citing the fact that the government is committed to it.

C2 views the plan as viable, stating that although Phase 1 and 2 of Al-Shagaya project were government-funded, plans for Phase 3 include public-private partnerships to tap into the benefits of private funding and the efficiency associated with private entities. Similar views are shared by D1, who indicates that with an increase in the number of high-capacity RE projects, "it *can achieve that 15% or perhaps more than that*". However, G2 indicates that to achieve 15% RE by 2030, the country needs to both increase the amount of RE produced *and* replace fossil fuels with RE. Similarly, greater efforts need to be made to enhance efficiency in the use of energy sources. According to G2, there is a need to *"increase the efficiency of buildings and increase the share of renewable energy projects, and […]reduce the consumption of electrical energy in several ways, including improving consumer behaviour towards electric energy*". In support of this, G3 highlights measures that the government has taken, through the MEW, to "*achieve renewable energy and solar energy projects in particular, based on His Highness the Emir of Kuwait's desire for his country regarding the production of 15% renewable energy by 2030*". MEW's plans also include energy efficiency, reduction in pollution, and a reduction in the use of fossil fuels. F2 also considers that the government's efforts have been fairly successful, but states that "*more effort must be made to achieve this goal",* while J indicates that the government has a long way to go, since *"so much is needed to be done"* to achieve the goal.

These views suggest that although the 15% target is viable, the government has not shown commitment commensurate with the task ahead. According to A2, the strategy can only be achieved through the development of clear strategies and sound planning for RES projects. However, currently, "*there is no room for small and medium companies working on renewable energy projects, but a monopoly only for large construction companies, or to attract companies.*" (A2) The lack of appropriate resources is also a significant limitation. A2 argues that although Kuwait has sufficient human capital, the country still relies on foreign technologies, whereas other MENA countries, "*such as the UAE, have 3 factories for solar panels, and the Kingdom of Saudi Arabia has 4 factories for solar panels and the Republic of Egypt has one factory".* The challenges associated with access to human capital limit the potential auxiliary benefits, such as employment, which would make RE projects more economically viable. B1 concurs with A2, observing that the fact that the government has retained sole responsibility for the success of the project, and limited the ability of private entities and citizens to contribute, is part of the reason why it may fail. As B1 states, participation is "*only through government released projects! And it seems that they are falling short on their planning to achieve this target*." H also highlights the extent to which the government is unprepared for the 15%

RE target by 2030, based on the fact that the country has not yet started doing the groundwork. Although the government has sufficient resources, there is a need for more collaboration among entities such as the Kuwait Foundation for the Advancement of Sciences (KFAS), Kuwait Petroleum Corporation (KPC) and KISR.

9.9 Government Measures to Promote Renewable Energy

9.9.1 Choosing the Right Renewable Energy Technologies

Variations mechanisms have been applied by the government in the selection of the most suitable RETs. However some interviewees raised concerns about the lack of clear methodology in the selection and suggested that the government has not taken cost performance into account. This was identified as an issue by A1, who cited the case of the second phase of the Al Shagaya Project, and also by B1. The lack of effective mechanisms may be due to the wide-spread presumption that solar energy technologies are the most suitable. According to G1, "*There is no effective mechanism, but in my view, solar energy source are the most appropriate and the ideal system of renewable energy technologies is the use of CSP as it suits the climate of the State of Kuwait*".

In some instances, the government relies on a subjective approach, whereby the RETs are selected based on the perceptions and aims of the stakeholders. According to C1:

> "*Technologies are selected based on the need and type of power supply[…] the selection of technologies was made to achieve peak shaving in the summertime, especially when power consumption is highest. PV (photovoltaic) panels can provide direct power supply during the day, but there is no storage because it is very expensive for this technology.*"

Based on this notion, it is common for RE projects, such as the 2nd phase of Al-Shagaya, to utilise a combination of PV and CSP technology to enable them to deliver energy throughout the 24-hour cycle. Similar views are expressed by D2, who indicates that the adoption of RETs is based on a "*mechanism for diversifying the renewable energy technologies in the Al Shagaya Project, such as solar energy, PV and CSP, and wind turbines, I believe each technology will prove effective over time to prove that it is the most appropriate for the State of Kuwait".* The mechanism is hinged on the belief that by investing in different types of technologies now, the country can diversify later when it comes viable. K identifies two mechanisms for choosing the right RETs, depending on the scale of the project: for a "*large-scale project that will be specified in the tender by the owner and the consultant. The small-scale projects can be done between the contractor and the owner"* (K).

There is also evidence that the government follows an objective approach, whereby government entities, such as KISR, perform a cost analysis. For example, H states that "*KISR has been carrying out studies since the seventies. Hence, government entities rely on KISR's assessment."* Meanwhile, F2 adds that, rather than leaving the process to chance, the government has established mechanisms for customising the technologies through the MOE: "*The Educational Facilities Sector in the Ministry of Education has included the solar energy project within the government development program projects, which includes the establishment of solar cells in schools".* By so doing, the government aims to reduce the costs associated with acquiring the technologies from overseas, while also establishing additional benefits, such as the creation of job opportunities for citizens.

9.9.2 Promoting Technical Expertise in Operations and Investment in Renewable Energy

The operations surrounding RES, as well as the investments in these technologies, rely on particular knowledge. The government of Kuwait has an integral role in the acquisition of technical expertise among Kuwaitis; however, according to A1, "*the current role is considered somewhat weak, as we must have a quota of scholarships for students to study renewable energy at all educational levels and pave the way for renewable energy projects upon their return to the country to verify this by investing in national competencies".* D2 and G2 also call for improvements in the creation and transmission of evidence-based knowledge, through articulate curricula, research and development programmes, as well as promoting academic programmes. Further propositions are provided by B1, C1, and J, who argues that incentives and disincentives should be deployed in a manner that promotes the adoption of RE. H indicates that the responsibilities of the government include "*training, financing through the SME fund and licensing land through the Public Authority of Industries.*" According to G3, the failures of the government can be attributed to the "*lack of adequate expertise of technical cadres in renewable energy generation systems, the lack of administrative and legal legislation regulating work in the field of renewable energy and the absence of an administrative sector specialised in the ministry.*" Overall, these comments suggest that significant administrative and technical challenges, due to poor institutional frameworks and competence, must be overcome if Kuwaitis are to acquire the requisite expertise.

9.9.3 Developing Educational Programmes on Renewable Energy in Learning Institutions

The development of educational programmes in learning institutions increases awareness of the importance of energy efficiency and the various options under RETs (Aktamis, 2011; Alawin *et al.*, 2016). Targeted training orients learners to the importance of RE, thereby increasing their willingness to implement RE policies later in life. The existing educational programmes in Kuwait are designed by government institutions, including KISR (C1), the Ministry of Electricity and Water (G3), the Ministry of Education (F2), and Kuwait Society of Engineering (K). Some private institutions and civil society entities are also involved in the process, including PAAET (D1), SCPD (H), and the UN through their UN-Habitat online facilities (See www.unhabitat.org) (J).

However, in the views of several interviewees, Kuwait's curricula are judged as weak, leaving it unable to stimulate the responses required to drive a culture of RE adoption in the country. According to A1, "*the subject matter in Science regarding renewable energy for educational and educational curricula is very weak, and it needs to be reviewed and revised extensively in order to achieve increased awareness and knowledge, especially at the early stages of education.*" B1, C2, D1, G1 and F2 concur on this fact. The weaknesses in the curricula arise from the fact that the MOE has not provided a clear and accurate curriculum at all levels to generate and maintain interest in RES (B1). Although there are programmes through Science Clubs, C2 indicates that there is a complete lack of "*materials for promoting the use of renewable energy*" in the curricula, and D1 also perceives the curricula as being weak regarding RE.

H observes that "*the MoE sets up several environmental and renewable energy centres in many public schools to carry out annual competitions*", and J perceives the education system as providing good knowledge, though he states that it is "*inapplicable. The curricula content is good to a certain extent".* In response, F1 argues that it is the responsibility of the government to provide technical training to enhance the parity in skills across the country, commenting that the government has a role to play by "*conducting training courses [...] on how to operate and invest in renewable energy in Kuwait, and exchange experiences with developed countries in this field through foreign missions".* However, these are not sufficient in solving the challenges facing the industry (F1). Either way, it is apparent that there is a need for change since, as F2 indicates, we "*will witness a major shift towards its [RE] use, which requires spreading awareness of renewable energy, its importance and areas of use."* and education programmes will have to respond.

9.9.4 Introducing Energy Efficient Building Standards

The introduction of energy-efficiency regulations into building standards, including a requirement to incorporate thermal insulation, reduces the amount of energy required for residential purposes, as well as in some commercial and industrial establishments. Such policies increase the utility of RES in supplying energy, as quantities required are lower (Wang *et al.*, 2018). Since construction decisions are long-term decisions, with effects lasting decades, mandating the use of RES is one of the key determinants of the viability of new renewable energy policies (Lund, 2007; Papapostolou *et al.*, 2019). However, based on the responses provided by the interviewees, it appears that Kuwait has few such mandates, and enforcement is weak. A1 claims that "*There is no severe mandatory legislation regarding generalisation of thermal insulation specifications*", but B1 contradicts this, indicating that although such policies exist, they have not been effectively enforced. Meanwhile, G1 and H, go further, stating that such policies do exist and that the MEW has generalised their application within the building codes. According to the specifications under R6 Code, "*the development increases the building insulation of new construction by raising the insulation for building blocks from the insulation ratio of 0.1 for the brick size 20 cm to the insulation ratio of 0.08 for the size of the 25 cm brick*." However, according to G1, these codes are only applicable to government buildings, which may account for the divergence in responses. J indicates that this lack of universality means the codes have a limited chance of succeeding as they "*do not contain such procedures and standards for the private sector, although public sector buildings are mandated to do that. Mega projects follow international standards".* The lack of standardization has led to missed opportunities, considering that construction projects are long-term commitments.

9.9.5 Mandating the Use of Energy Efficient Devices

The use of energy-efficient devices has similar effects as energy-efficient buildings on the utility of RES. However, the interviewees again either indicated that the government had made no such mandates, or that they existed but were weakly implemented. J indicated that the matter of whether measures were introduced "*depends on the government's level of interest in implementing such procedures and using the mentioned devices."* H mentions that policies have been introduced, specifically "*power saving/rationalisation mechanism in our building at the General Secretariat of The Supreme Council for Planning and Development*", and C2 states that "*It is very highly to happened soon since MEW is working on implementing a role to use power saver equipment."* In support, F2 indicates that the government promotes these measures since they enable institutions to continue to operate even if power outages persist. However, since these policies are only implemented in some government offices, their effectiveness is limited.

J highlights the integral nature of adopting new building codes that are *"related to energy efficiency and implement them"*, and F1 suggests that the government can also increase awareness of the utility of rationalising energy consumption among the citizens, using incentives such as *"taxation on non-efficient energy machines and tools, [or] raising electricity tariff."* Based on the responses, rather than relying on one approach, the government should identify multiple integrated strategies in order to achieve better results.

9.9.6 Activating the Use of Electric Cars

The use of electric cars is part of the mechanisms for increasing energy efficiency, reducing pollution, and advancing the smart city models to promote the effectiveness of RE strategies. Kuwait has already explored the possibility of adopting electric cars to replace fuel combustion engines; however, most of the interviewees indicate that no particular measures have been introduced. Only three report that Kuwait has some measures to facilitate and mandate the use of electric cars. According to H, the installation of electric charging stations has laid down the foundation for this type of improvement, noting that "*There is an electric charging station at Al Shaheed Park (Government-owned) that was donated by a private citizen to support a growing EV community".* In support, F1 indicates that the country has imported some electric cars. However, a single electric car charging station cannot serve the entire country. The fact that the charging station was funded privately explains why K indicates that there are no government measures to support the utilisation of electric cars: "*We saw some private movement toward this technology; furthermore the Kuwait Society of Engineers installed the first public charging points of electric cars."* F1 further indicates that "*there are no procedures in government agencies to activate the use of these cars. There are only two experimental charging* *stations at the Kuwait Institute for Scientific Research".* The responses received are shown in graphical form in Figure 9-5.

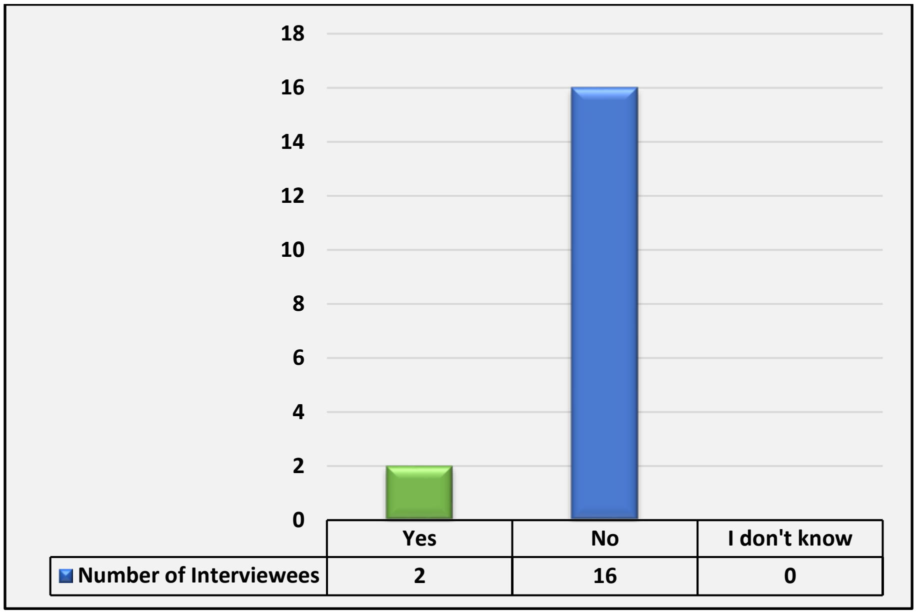


Figure 9-5: Has the Government Introduced Measures to Promote Electric Cars Utilisation and Charging Station Availability in Kuwait?

9.10 Challenges Associated with the Use of Renewable Energy in Kuwait

The interviewees identified a multiplicity of challenges associated with the adoption of RE, including high levels of pollution (mentioned by A, B, C1, D1, G2, H, F1 and J). The forms of pollution highlighted vary from air pollution. which reduces the effectiveness of PV panels and other solar technologies, (C1, G2, H, F1 and J), to marine pollution, which affects tidal technologies (B). As H puts it, Kuwait is "*one of the hottest countries in the world and faces harsh seasons; during summer we are constantly faced with sandstorms, and dry heat, and that affects the performance of PVs and increases maintenance costs in the long run."* In addition, K identifies a diversity of problems, including the lack of clear regulatory frameworks that specify the measures to protect the environment, and "*weaknesses in the infrastructure for the energy utility networks… lack of sufficient* *training and qualified employees in the private RE sector…and no third party that can test and inspect RE projects”.* The most significant challenges the interviewees identified are discussed below.

9.10.1 Economic Viability of RE

The economic viability of RE is one of the most prominent challenges. According to A1, “*The most important difficulties are the economic visibility (sic) for any project against the cost of the benefit of renewable energy; the State of Kuwait has subsidies for the tariff of electricity energy without effective rationalisation of electricity consumption”.* Economic viability challenges are worsened by the fact that the subsidies the government has long deployed for fossil fuels have not been implemented for RES. As a result, it is cheaper to produce energy and electricity from fossil fuels, and this limits the attractiveness of RE investment to the government and other private entities and individuals. J also identifies the impact of tariffs, stating that “*Cheap electricity tariffs mean the renewable energy tools are expensive with less feasibility.”* These economic challenges have led to long payback periods, limiting the attractiveness of committing capital to the industry. H also indicates that the cost of RE and efficiency in utilisation are key limitations. The comments suggest that, in the absence of measures to ensure efficient and affordable RE, Kuwait might not be able to benefit from RES.

9.10.2 Introducing and Enforcing Regulations

There are also challenges in introducing regulations targeting the RE sector and in enforcing adherence. According to B1, “*Setting up new regulation requires a change of law which is quite a hard procedure to apply*”. The regulatory mandates are worsened by the fact that they are highly dynamic, as the country finds the perfect combination of laws. G3 further highlights this issue, indicating that the government entities charged with regulating the industry have failed to establish a pathway for implementation. F1 also recognises the “*absence of a law requiring institutions and* *agencies to use renewable energy"* as *a key challenge, alongside "the lack of conviction among some individuals of the importance of renewable energy"* and the issue of *"how to store renewable energy sources such as wind and solar energy".* The absence of an articulate legal framework to guide the regulatory entities allows them to target different outcomes and provides limited impetus to act in a convergent manner.

9.10.3 Lack of Natural Resources

The lack of adequate natural resources, including tracts of land for large scale projects, was also highlighted. According to C2, for "*large scale projects, the limited area of land [is an issue]. For houses, still, there is no regulation".* Many of the large tracts of land in Kuwait are committed to oil energy production, so, in most instances, the country has to rely on small and medium scale projects. The lack of regulations for rooftop solar projects further complicates the lack of access to land. Residential construction techniques have also made rooftop solar projects unviable, which is why the government has preferred to install solar PV systems on parking lots instead. G3 further cites the issue of land, since "*most of the lands in the State of Kuwait are under the supervision of the Kuwait Ministry of Oil, the Ministry of Defence and the municipality of the State of Kuwait,"* and D1 mentions "*the failure to allocate private lands in renewable energy projects"*. The lack of water was also raised, as limited water resources make alternatives such as hydropower unviable in most of the country.

9.10.4 Reliance on Imported Technologies

Finally, the fact that Kuwait is a late adopter of RETs was mentioned by several interviewees. According to D1, the "*lack of trained national technical personnel in renewable technologies"* means Kuwait relies on the development trajectories of other countries. In some cases, before such technology can be imported into the country, it is mostly outdated or overtaken by more efficient technology. As a result, until Kuwait starts inventing its own systems, tailored to meet its specific needs, the country will always be lagging behind in terms of efficiency. This is evident from the fact that technical challenges continue to emerge due to the inability of project implementers to account for adverse local factors. For example, J cites the lack of measures against the frequent sandstorms and high temperatures in Kuwait which contribute to the rapid depreciation of solar farms. Failure to account for these challenges can be linked to the lack of customised technologies developed to withstand the conditions in the country.

9.10.5 Establishment of an Independent Oversight Body

An independent oversight institution has the power to guide other institutions and offer direction in the adoption of REs in the country. H, D1, C2 and B1 concur on the fact that such a body could introduce regulatory mandates to enhance effectiveness, while also creating short-, medium- and long-term plans. D1 added that any such institution must be backed by "*effective legislation and absolute powers to support its implementation mechanism for renewable energy projects*". These functions are deemed necessary for the committee approach to implementation of the various REs projects. However, 12 of the 18 respondents indicate that no such institution exists in Kuwait (See Figure 9-6). Among those who said 'Yes', K1 and F1 cited MEW, while only H1 identified two institutions which could be considered independent entities: The National Committee for Energy Policy Implementation and The Committee for Promoting Green and Renewable Energy Implementation; However, since these were established before the RE policies, they may not be perceived as being independent.

According to A1, the "*case is that the renewable energy sector in the State of Kuwait is under the diligences of multiple organisations, and this may cause conflicts of interests, specialisations and differences in attitudes, which may lead to obstruction and delaying the implementation of renewable energy projects."* This view is supported by G1, who states that the lack of an effective establishment to guide the process has led to the existence of conflicts of interest that limit progress.

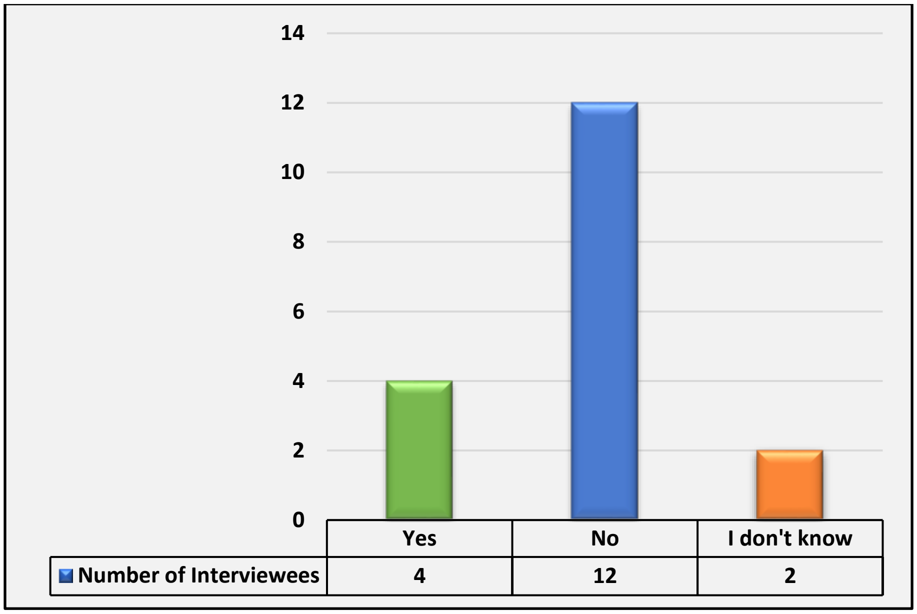


Figure 9-6: Does Kuwait Currently Have An Independent Oversight Body for RE?

F1 proposes the creation of an independent renewable energy authority for the country, which "*coordinates and monitors the performance of renewable energy projects, assesses these projects, identifies strengths and weaknesses, and helps them solve the problems they face, and determine the extent of their success in achieving the desired goals*". J also argues that an independent entity would be "*Very effective. Promoting, Monitoring, Encouraging, Collaborating with the Parliament in producing and registering new laws.*"

These responses suggest that establishment of an independent entity to spearhead the adoption of RE in Kuwait lacks a practical approach. However, such an oversight body could ensure independence from political influence, which tends to change over time. As a result, Kuwait could target long-term goals, without being affected by short-term political dynamics.

9.10.6 Synchronising Renewable Energy Project Plans with Population Growth

Consumer demand for energy is directly connected to population size. However, almost all the interviewees identified the lack of synchronisation between RE project plans and population growth as a challenge in the energy scenarios planning (See Figure 9-7). It also explains why most of them view the 15% RE plan for 2030 as unviable. However, H claims that the lack of synchronisation is not a challenge, since the rate of implementation of RE is "*lower than the rate of population growth,*" and C1 indicates that even, if there is no synchronisation, the effects of that weaknesses are off-set by the potential "*enhanced efficiencies of the technologies. It is expected that technologies will improve in time which will satisfy the demand*."

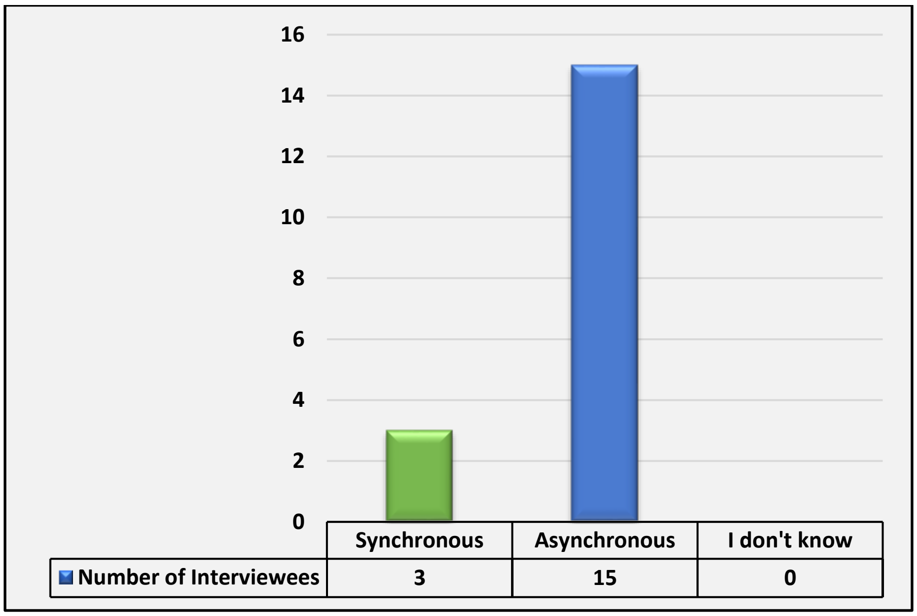


Figure 9-7: Synchronisation of RE Project Plans with Population Growth

9.11 Long-term Feasibility of Renewable Energy in Kuwait

The use of energy scenarios is widely discussed in the literature as they facilitate the presentation of possible outcomes based on a definite set of variables (See Chapter 3). When presented with a scenario in which all the challenges identified above were resolved, several interviewees (B2, C1, D2, G1 and G3) changed their view of the feasibility of RE in Kuwait from 'unviable' to 'viable'.

However, A1 gives a divergent view, observing that the greatest challenges lie in achieving economic viability, and stating that "*As an economic benefit, it is still not feasible at the level of* *individuals (consumers) due to the high rates of energy consumption, where the level of user efficiency is almost entirely medium to weak, and therefore the maximum benefit of investments will not be achieved."* However, G3 holds a different perspective about their economic viability, based on the operations at the Al-Abdilyah power-station project. In his view "*renewable energy stations will save the country economically by reducing the financial burden associated with the costs of producing electrical energy".* The inability to achieve economic feasibility arises from the fact that fossil fuels are subsidised, so, until such subsidies are withdrawn, it will be challenging for RES to achieve economic viability in Kuwait.

9.11.1 Assessing the Feasibility of RE Utilization in Kuwait

The assessment of the feasibility of RE utilisation is viewed as a determinant of the propensity of the government to proceed with its RE goals or to adjust its policies and strategies. However, the responses of the interviewees indicate that there is a lack of agreement on the most effective mechanisms to assess feasibility, as well as on whether REs are feasible.

From the narrow scope of economic viability, A and J consider that RE is not feasible in the absence of measures to enhance efficiency in energy utilisation, especially at the individual level. J states that "*Environmental wise, it will be very feasible, but economic wise, no,"* and A considers it will "*not be achieved at the level of individuals except when the energy consumption behaviour is improved for them."* However, these responses highlight the fact these interviewees only focus on the qualitative dimensions, because ultimately, it is possible to estimate the environmental benefits from an economic perspective.

A different view is held by B, CI, D2, G1 and F1 who indicate that RE utilisation is feasible in the country. G1 states that RE utilisation is highly feasible, "*provided that it is on a large scale and at a government level first, and then at the individual level after the government is successful in raising levels of knowledge and awareness and encouraging the use of renewable energy in Kuwaiti* *society".* This view is based on the fact that government-run RE projects enjoy the benefits of scale and scope, unlike RE installations by individuals. In support, F1 states that RE "*has great economic feasibility and will provide a radical solution to the problem of environmental pollution."* This is based on the fact that the government has long-term planning goals and massive capital resources, so it can achieve economic feasibility in the right circumstances.

Rather than viewing individual projects as being feasible or not-feasible, G3 states that over time, and with changes in circumstances, an RE project that is not currently economically feasible can become so. While it is common for projects such as Al-Abdilyah to incorporate fossil fuel at the start, to save on costs, G3 believes that, over time, renewable energy stations will both produce electrical energy and contribute to "*the preservation of national wealth."* The long-term perspective is also adopted by H, who explains that although the direct costs from renewable energy might not justify its feasibility, "*its indirect socio-economic feasibility is clear in the impact on the healthcare bill related to the quality of air*." Additional benefits identified by K include the fact that "*the local market will be so much more attractive to investors and that will lead to more positive competition toward successful projects with great feasibility*."

9.12 Summary

This chapter has discussed the data gathered from experts, officials and stakeholders in order to assess the role of government and private entities in promoting and developing the renewable energy industry in Kuwait. It has explained the rationale behind the emergence of an environmental conscience in the oil-rich state, and considered the actions taken by both groups to promote public awareness of energy efficiency and renewable energy use. It has focused in particular on the measures required to achieve the target of 15% renewable energy by 2030, and identified a number of serious challenges which must be addressed if this to be realised. It has revealed that many of the interviewees question the government's ability to achieve its aim in the absence of further measures to regulate energy efficiency, promote RE utilisation, and enhance cost-effectiveness, without which RE may not have a viable future in the country. The next chapter presents a SWOT analysis of the solar industry in Kuwait in order to assess the viability of the most popular RES.

Chapter 10

SWOT Analysis of Solar Energy in Kuwait

10.1 Introduction

As solar energy has emerged as the preferred source of renewable energy in Kuwait, this chapter presents a SWOT analysis in order to assess its viability within the country. A SWOT analysis involves the identification of the strengths and weaknesses of an entity (linked to its internal environment) (Evans, 2013), and the opportunities and threats existing in the external environment (Rumelt, 2011). It also considers the factors that create favourable conditions for the achievement of the goals associated with the entity, including strengths and opportunities, as well as those that create unfavourable circumstances, including weaknesses and threats (Rumelt, 2011). A comparison of the two, conducted through a TOWS matrix, facilitates the identification of strategies that could be utilised to take advantage of the favourable circumstances and mitigate the adverse circumstances.

This SWOT analysis of solar energy in Kuwait is performed in three phases: in the first phase, the Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T) are identified and discussed; in the second, these dimensions are used to create a TOWS matrix; and, in the third phase, the strategic options identified via the TOWS matrix are discussed. These options provide ways to capitalise on the strengths and opportunities while reducing the risks from the weaknesses and threats. This chapter ends by drawing some preliminary conclusions from the SWOT Analysis; however, the results are discussed in much greater detail in Chapter 11.

10.2 Aims and Objectives of the SWOT Analysis

The aim of the SWOT analysis presented here is to determine the strengths, weaknesses, opportunities and threats associated with the expansion of solar energy production within Kuwait. The objectives of the analysis are as follows:

- To identify the strengths, weaknesses, opportunities and threats associated with solar energy in order to determine the circumstances that influence adoption and utilisation.
- To identify potential strategies to encourage the adoption of solar energy in Kuwait by promoting the benefits of renewable energy (performed via a TOWS analysis).

10.3 Methodology of the SWOT Analysis

As discussed in the Methodology chapter (See Chapter 6), this analysis involves a bottom-up review of publications on solar energy in Kuwait, the GCC, and at the global level, in order to identify the environmental factors in play at both the domestic and international level. Corroborating evidence is sourced for comparative purposes, especially for factors of a relative nature, notably economic and ecological sustainability. Data collected from the 'Public Questionnaire' is also used in the analysis (See Chapter 7). For the TOWS analysis, identification of the components of the four strategies is based on the interactions between the relevant SWOT factors.

This analysis focuses on three key aspects of sustainability:

- **Energy Security**, which relates to the discovery of the strengths, weaknesses, opportunities and threats to the supply, demand, and consumption of energy in the country, and the possibility that renewable energy sources can be integrated into the energy systems in Kuwait. This represents the social dimension.
- **Economic Terms**, which focuses on ensuring that the benefits of utilising renewable energy outweigh those associated with fossil fuels (oil and gas sources).

- **Environmental Impact,** whereby the primary concern is whether it is possible to improve the environmental and ecological conditions in the country through the use of energy from environmentally friendly sources.

These guide the development of four strategies identified via the TOWS Matrix (See 10-1).

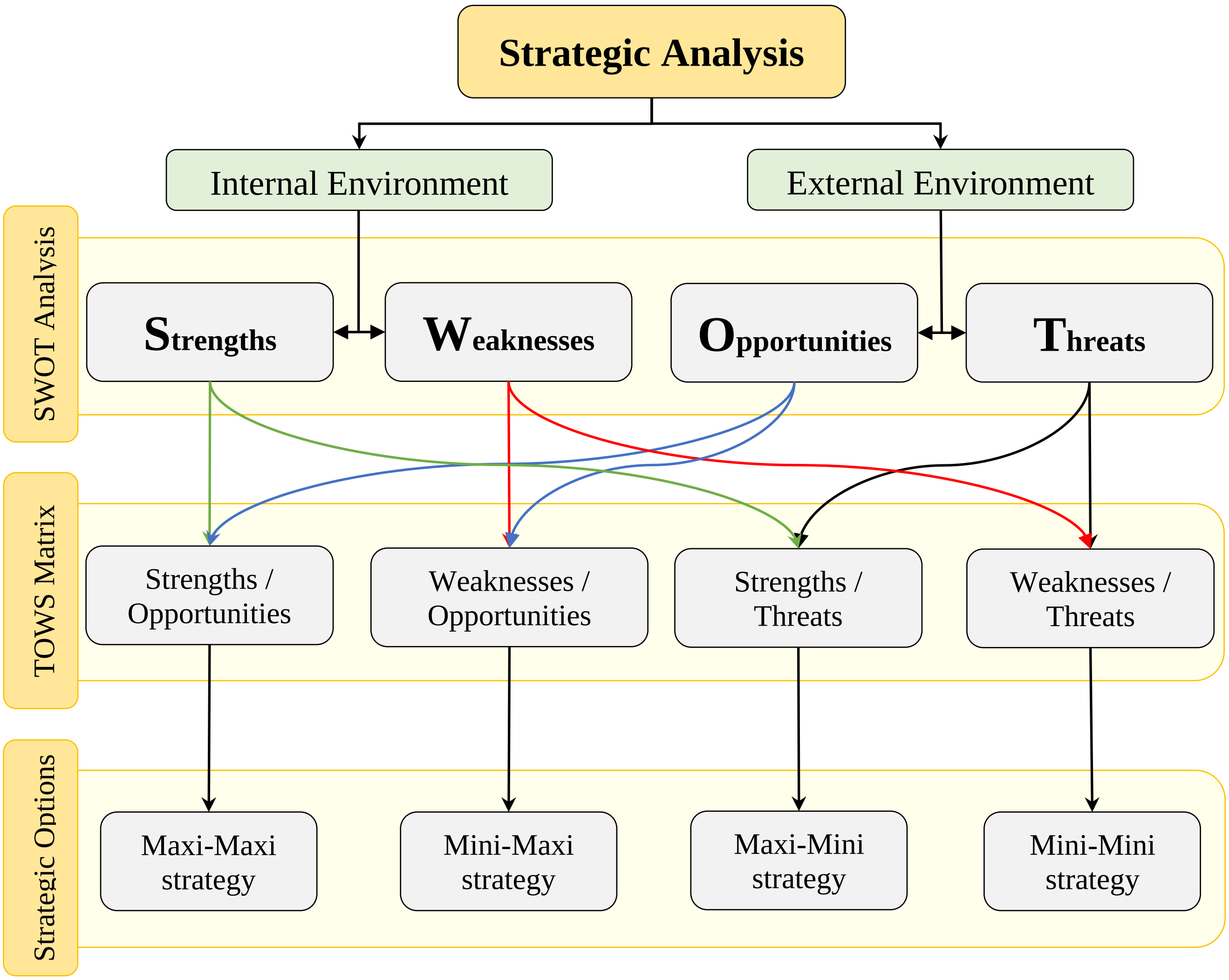


Figure 10-1: SWOT Analysis Model

Source: Author's Creation

10.4 The SWOT Analysis

This section sets out the strengths, weaknesses, opportunities and threats associated with solar energy in Kuwait. It involves identification of the elements under each of these dimensions and draws on supporting evidence from existing literature and from the research findings.

10.4.1 Strengths

These are elements that confer advantages to the use of solar energy within Kuwait. They indicate the ways in which solar energy is beneficial and a good ‘fit’ for the country (Saaty and Vargas, 2013).

10.4.1.1 An Ecologically Sustainable Energy Source

Concerns about the protection of the environment are at the forefront in Kuwait since most of the country is desert. The main concerns include access to water, protection of existing flora and fauna, and the prevention of increases in surface temperatures. This has prompted efforts to generate more energy from renewable sources as these typically have a much lower carbon footprint.

The process of reducing emissions involves the use of renewable energy sources (RES). While all the renewable energy sources preferred by respondents in the ‘Public Questionnaire’ have a low carbon footprint (See Figure 7-14), solar energy has been identified is an essential part of the renewable energy mix needed to achieve the goals set out in the Paris Agreement on Climate Change (Liobikien and Butkus, 2017). Based on the advantages associated with solar energy, the state-owned Kuwait Oil Company is currently developing new solar power facilities at the Shagaya Renewable Energy Park, with the aim of replacing over 285,000 barrels of oil each year. This plant is intended to minimise Kuwait’s carbon footprint by reducing CO_2 emissions by five million tons per annum, with the further aim of ensuring that the fossil fuels sector derives 20% of its energy needs from renewable energy sources.

Climate change is a stark reality for most countries in the Middle East, and 70.4% of the 'Public Questionnaire' respondents indicated they strongly agreed that greater use of renewable energies would result in a cleaner environment in Kuwait. Furthermore, 73.5% strongly agreed this would also reduce overreliance on oil (See Table 7-8). A reduction in the overreliance on oil would both help to protect the nation's ecosystems and encourage investment in other industries, thereby contributing to the diversification of the economy.

10.4.1.2 Offers Socially Sustainable Energy

There is a shift towards diversification away from fossil fuels and conservation of the environment across the GCC, as well as domestically in Kuwait. Although conservation efforts are concentrated among particular consumer and production segments, their impact in terms of changing perceptions in the region is already apparent. The introduction of solar energy in Kuwait is enabling the country to focus on social sustainability by eliminating the challenges associated with vertically integrated systems. According to the International Energy Agency (IEA) (IEA.Statistics., 2014), up to 12% of the electricity generated is lost due to the current monopoly in generation, transmission and distribution, in addition to the indirect losses. However, under a more sustainable deregulated system, where contracts are designed for users who also generate solar energy, it is possible for domestic producers to sell energy back to the grid, and generate revenues that improve the living standards within their households (See Figure 10-2).

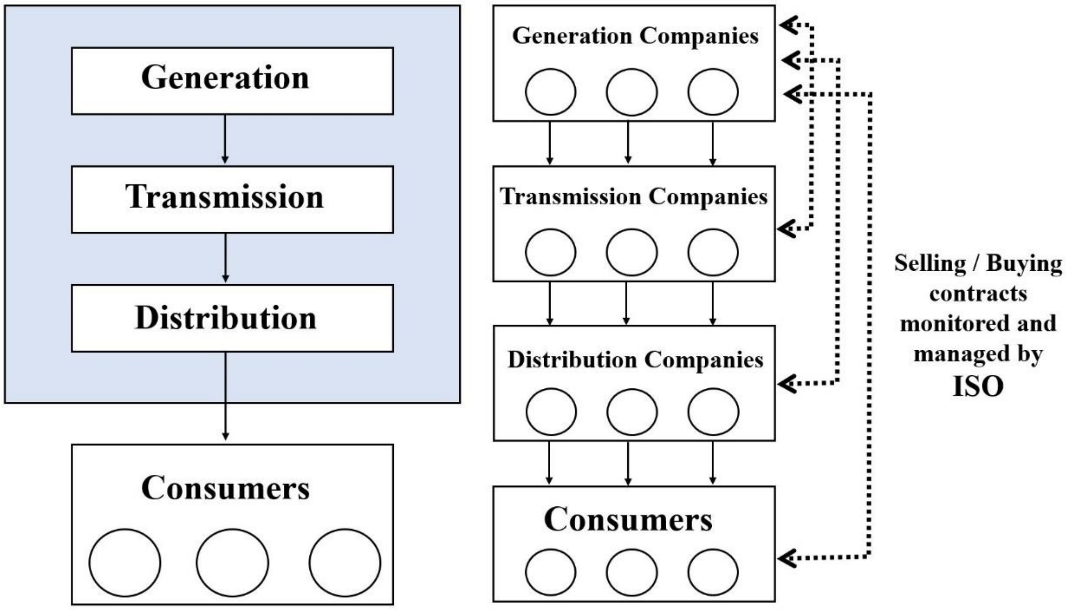


Figure 10-2: The Difference Between a Centralised and a Decentralised Energy System

Source: Reproduced from (Alsayegh, 2008)

Social sustainability also originates from the creation of job opportunities for local communities near solar farms, under both centralised and decentralised energy systems (Gerarden, 2018). By using more complex solar energy utilisation mechanisms, such as Solar Enhanced Oil Recovery (SEOR), Kuwait can achieve economic diversification, resulting in enhanced employment opportunities for local communities near the oil fields. Since the jobs available on these sites span various skill levels and categories, both skilled and unskilled, solar energy farms provide opportunities in locations where other economic activities are non-existent. It is noteworthy that 28.9% of respondents to the 'Public Questionnaire' view renewable energy as an important way of creating employment opportunities in the country (See Table 7-36).

10.4.1.3 Economically Sustainable in the Long Run

The economic sustainability of solar energy as part of the renewable energy portfolio is boosted by the fact that the cost of producing and using fossil fuels in Kuwait is increasing. The growth in population and changes in economic activities are increasing total primary energy demand

(TPED) in the region, and this is putting a strain on the national budgets of most GCC countries, including Kuwait. In recognition of this scenario, the questionnaire data reveals that 54.5% of respondents view renewable energy sources as contributing to the preservation of the national economy (See Table 7-36).

While recent estimates indicate that demand for energy from fossil fuels amounts to 40% of current supply and production (Jeon and Lee, 2019), production of energy from existing oil and gas reserves is predicted to drop by 60% by 2030 (IEA.Statistics., 2014). With the changing profile of fossil fuels, including the depletion of natural gas and the declining quality of heavy and crude oil, it has become necessary for most GCC countries to seek alternative energy sources to complement and supplement fossil fuels. Given the expenses associated with introducing new energy sources, including sources such as shale gas, or the discovery of new oil fields, renewable sources have become key components of Kuwait’s energy portfolio due to their economic sustainability.

10.4.1.4 An Alternative to Fossil Fuels

Renewable energy offers an effective means to complement and supplement fossil fuels. This is because the type of energy resources produced, including electricity, thermal energy, lighting and other mechanical categories, have proven to be suitable replacements for fossil fuels. Looking at solar energy in particular, it is possible to generate electricity through photovoltaic technologies and then utilise that energy in a multiplicity of ways. Solar energy can also be concentrated for the purposes of desalination, thereby reducing the need to transform it into electricity.

A prominent example of solar energy’s potential to replace fossil fuels is the use of Solar Enhanced Oil Recovery technology (SEOR). Enhanced Oil Recovery (EOR) is an integral part of the heavy oil extraction process, and most of Kuwait’s main oil fields, which have been active since the 1950s, now rely on EOR to amplify their productivity (Alhouli, 2017 and Moustafa and Al-Hamoud, 1981). The process involves injecting steam into the reservoir to heat the oil (making it easier to pump to the surface), and is highly energy intensive. SEOR harnesses solar energy to produce the steam required, thereby reducing the costs of EOR, the emissions produced, and the wider risks associated with the oil recovery process.

In general, solar energy is viewed as a viable alternative to fossil-fuel based electricity generation for a number of reasons:

- Kuwait has extensive experience in the utilisation of solar energy, with the earliest research into solar technologies recorded in 1981 (Moustafa and Al-Hamoud, 1981). Through the efforts of the Kuwait Institute for Scientific Research (KISR), this experience has played an important role in the effective implementation of a multiplicity of projects in the country.
- Kuwait, like most Gulf nations, relies on electricity for air-conditioning. This is the largest driver of demand for electricity in the country, and this increases significantly during the peak summer seasons. Research has shown that solar energy is best suited for cooling in residential and commercial locations (Alhaddad and Alsaad, 2016).
- Kuwait, like most other countries, is facing a decline in its fossil fuel reserves and the need to identify new sources of electricity in order to increase the longevity of its remaining reserves (Alazemi, 2017). Fossil fuels saved in this way could be exported to generate revenues for the country and fund investment in other industries.
- The accumulated wealth from oil revenues has placed Kuwait in a favourable fiscal position, with extensive capital resources. Utilising these reserves to explore the opportunities in renewable energy supplies would create positive spill overs for the economy.
- As the residential sector accounts for more than half of the demand for electricity, solar energy provides a viable alternative, especially if residential installations are introduced to localise the capture and utilisation of solar energy. This is supported by the fact that 48.4% of the

questionnaire respondents strongly agreed that local initiatives to encourage renewable energy use should focus on the use of solar panels (PV) in their homes (See Figure 7-16).

- Kuwait has recently invested natural gas production due to its diminishing oil reserves. Over time, the limited supply of oil to power the CCGTs will mean the country has to invest in systems to enable electricity production from other sources, including solar energy.

The utilisation of solar energy in the exploitation of fossil fuels resources is a significant step towards reducing the carbon footprint of the oil and gas sector in Kuwait. The various options it provides enable the country to meet the environmental goals under international treaties while promoting the adoption of renewable energy. The fact that it can be used in utility-scale solar power plants, to desalinate water, and to meet other routine energy requirements increases its potential.

10.4.1.5 High Solar Energy Potential Due to Climatic and Weather Patterns

Kuwait, which lies in the desert region and has clear skies throughout the year, has a high potential for solar thermal energy and solar power. One of the key advantages of solar energy in this context is its capacity to match seasonal variations in demand; energy use rises significantly during the hot summer months but this is when the highest solar irradiation is recorded. Solar energy can also introduce high nominal energy capacity, which can be stored to overcome the evening peak. Therefore, during peak seasons, solar energy offers an opportunity to supplement the baseload provided by fossil fuels and meet the increased demand (Bou-Rabee *et al.*, 2015). By investing in renewable energy, specifically solar energy, Kuwait can supply grid-level demands through renewable energy during the peak periods, then scale back to fossil fuel energy systems during the off-peak seasons (See Figure 10-3).

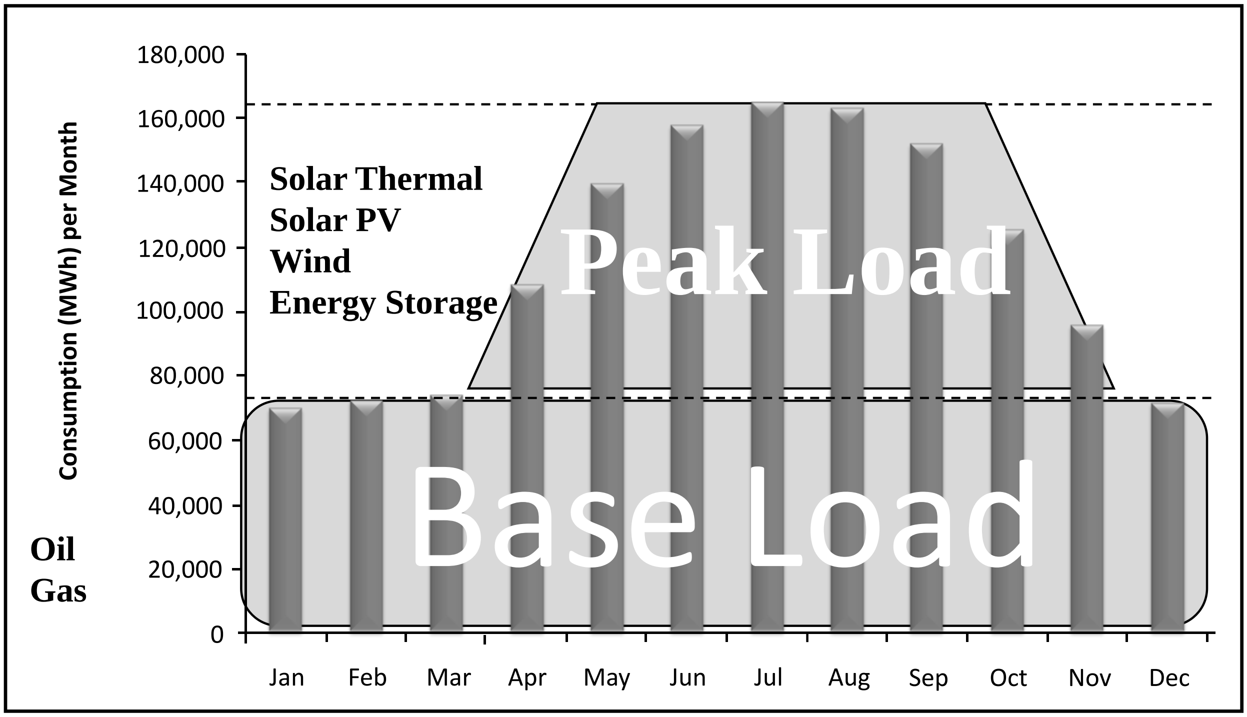


Figure 10-3: Monthly Variations in Solar Energy Potential in Kuwait

Source: Reproduced from (Bou-Rabee *et al.*, 2015)

The idea that Kuwait's climate and location are well-suited for investing in renewable energy was supported by the respondents to the 'Public Questionnaire'. When asked which renewable sources would be most appropriate for investment in Kuwait, 87.5% selected solar power over wind, wave, and nuclear energy (See Figure 7-14).

10.4.2 Weaknesses

The weaknesses involve aspects of solar energy that make it an unreliable source of energy within Kuwait based on the current status quo. They also represent the circumstances that limit the suitability or viability of solar energy within the country (Evans, 2013). Most GCC countries, including Kuwait, have long been politically and economically dominated by the exploitation of fossil fuels, and most of their policies and strategies are established around these energy systems (Munawwar and Ghedira, 2014). Kuwait's propensity and ability to transition to renewable energies is therefore laced with a multiplicity of challenges, some of which are associated with weaknesses in the solar energy industry in the country. However, in spite of the weaknesses identified below, only 1.9% of the respondents to the questionnaire regarded renewable energy as useless (See Table 7-36).

10.4.2.1 High Initial and Maintenance Costs

The cost of installing and maintaining renewable energy systems is one of the key weaknesses associated with the industry in Kuwait. Despite the range of options available, including solar, wind, wave and nuclear energy, most households and corporations lack the necessary resources to invest in fully-fledged renewable energy systems. Solar energy is most affordable in terms of initial investment and maintenance costs, and it can be scaled down to meet the needs of households, unlike nuclear or wave energy, but the production of solar energy still remains a costly venture.

The cost of installing solar energy is influenced by the amount of land required. Researchers refer to this as the ‘land-use footprint’ of solar energy, and this varies between locations depending on the type of technology used (See Table 10-1). While some have claimed that it is impossible to determine the actual land-use footprint of solar energy due to the multiplicity of variables that influence the productivity of solar farms (Horner and Clark, 2013), a report published in 2019 estimated that a 1MWh installation would require 5 acres, based on the most efficient solar technologies, at 18% production efficiency (Jeon and Lee, 2019). The report further specified that this can be reduced to 4 acres per MW of solar energy when crystalline technology is used in solar PV systems, a difference which is magnified in the large-scale projects. Although these outputs vary depending on the characteristics of solar irradiations on-site, they offer an indication of the average resources required and suggest that Kuwait would need to dedicate large tracts of land in order to establish solar farms with sufficient productivity to power the entire nation. Although much of the country is uninhabited desert, such areas are not ideal for the production of solar energy due to the problems associated with dust: thin crusts of carbonates or mud form on the panels, reducing their effectiveness, and this becomes worse in humid conditions.

Table 10-1. Land-use Footprint for Solar Energy Technologies

Technology	Direct Area		Total Area	
	Capacity-weighted average land use (acres/MWac)	Generation-weighted average land use (acres/GWh/yr)	Capacity-weighted average land use (acres/MWac)	Generation-weighted average land use (acres/GWh/yr)
Small PV (>1 MW, <20 MW)	5.9	3.1	8.3	4.1
Fixed	5.5	3.2	7.6	4.4
1-axis	6.3	2.9	8.7	3.8
2-axis flat panel	9.4	4.1	13	5.5
2-axis CPV	6.9	2.3	9.1	3.1
Large PV (>20MW)	7.2	3.1	7.9	3.4
Fixed	5.8	2.8	7.5	3.7
1-axis	9.0	3.5	8.3	3.3
2-axis CPV	6.1	2.0	8.1	2.8
CSP	7.7	2.7	10	3.5
Parabolic trough	6.2	2.5	9.5	3.9
Tower	8.9	2.8	10	3.2
Dish Stirling	2.8	1.5	10	5.3
Linear Fresnel	2.0	1.7	4.7	4.0

Source: Reproduced from (Jeon and Lee, 2019)

Additional research analysis reveals that it is possible to determine the generation-based and capacity-based land-use footprint from solar, giving planners more control over the decision making process. The capacity-based estimates are based on the potential productivity of the technologies and installation and consider the solar irradiation potential on-site (Hernandez *et al.*, 2015). The generation-based estimates focus on the actual productivity of the solar farm, which is a more practical but variable estimate. Regardless of the approach utilised, the land-use footprint represents one of the most frequently overlooked costs associated with the use of solar energy.

Looking beyond the explicit aspects of the land-use footprint, the costs associated with developing solar farms indicate that they have to rely on economies of scale in order to be effective (Turney and Fthenakis, 2011). Research has shown that smaller solar farms are less efficient in terms of productivity than larger farms, an assertion that is magnified when concerns about the land-use footprint are taken into account (Cheng and Hammond, 2017). This is why most solar farms are located in the desert and semi-arid regions, where access to large tracks of land is possible and land costs are low. This also helps to keep them away from activities that are considered incompatible with solar farms, notably farming, and human and animal habitation (Hernandez *et al.*, 2015). In reality, this means that countries like Kuwait have limited options in terms of locating utility-scale solar farms, especially when suitable sites need to be at least 5kms away from incompatible activities.

Generally, the economic sustainability of solar energy originates from the low maintenance costs across the lifecycle of the systems. Due to the complex nature of the technologies involved, the greatest costs are incurred in acquiring land and installing solar energy systems, and most members of the public are not currently aware of these costs.

10.4.2.2 Flat Learning Curve

The demand for electricity in Kuwait is changing significantly year on year, with increases in the population and in other determinants of demand. In order to respond to these changes, it is imperative that the country learns from previous experiences, mistakes and opportunities. A flat learning curve implies that an entity has not taken measures to improve efficiencies and take advantage of the market situation, based on previous experiences. By contrast, a steep learning curve implies that an entity is responsive and proactive in implementing change in order to improve efficiencies. It is therefore necessary for the country to adapt by increasing both the quantity of energy produced and the efficiency with which it is utilised. However, effective mechanisms to achieve this are currently unavailable. According to Gulseven (Gulseven, 2016b), although policy-based planning at the national level is done on a 5-year and 10-year basis, changes in the variables that affect the demand and supply of energy change at a more frequent rate. For instance, the growth in population (which determines residential demand for electricity) and changes in industrialisation (which determine commercial demand) are more dynamic and vigorous. These significant fluctuations are therefore commonly overlooked by government institutions. Another challenge to planning is the need to consider the high proportion of expatriate residents, a ratio which changes in neither a linear nor an exponential manner. As the planning process for solar farming has to accommodate potential changes in the long-term, the absence of reliable forecasting mechanisms means plans for solar energy systems inevitably raise questions about future viability.

The flat learning curve can also be attributed to the fact that most renewable energy projects take a long time to move from conceptualisation to completion. This means that by the time a project has been completed both energy demand and technologies have changed. For example, the Al-Shagaya concentrated solar plant was conceptualised as a 50MW plant in 2012, financing agreements were completed in 2015 and commercial operations started in 2018; however, there are reports that Phase 2 will not launch until 2026, a 14-year wait (Alnaser and Alnaser, 2019), and final plans have been changed to include an addition phase to boost the production potential from 2GW to 4GW. The fact that the Gulf region is a late adopter of technical innovations exacerbates this problem.

The lack of awareness of the applicability and utility of renewable energy systems in Kuwait also affects the learning curve. 64.4% of the questionnaire respondents felt that there was not enough information about renewable energy in the educational curricula (See Figure 7-23), and 47.6% expressed the view that the efforts of official organisations to raise awareness were weak (See Figure 7-15). This is attributable to the lack of educational programmes aimed at introducing the wider community to renewable energy technologies, and a lack of awareness campaigns spearheaded by the media. As a result, there are challenges in gaining popular support for measures to reduce energy wastage and the changes associated with the introduction of renewable energy solutions. These include using daylight instead of electric lighting, and introducing natural insulation and cooling mechanisms to reduce the need for artificial cooling and heating.

10.4.2.3 Preference for Combined Renewable Energy Systems

Most solar energy farms are composed of a combination of different technologies. Although solar is the most popular form of renewable energy in Kuwait, a proportion of the population recognise the value of other sources, such as wind energy, wave energy and nuclear energy. This strategy is justified due to the fact that each technology has unique characteristics that make the overall productivity sustainable. For instance, those living near the oceans are cognizant of the potential for wave energy, while those living inland can only rely on solar energy. There is a group which views nuclear energy as a viable alternative since its productivity does not fluctuate over time. Considering that the country has huge tracts of land that are uninhabited, it is possible to install nuclear power stations in the country.

By combining the different technologies, some argue that the country can take advantage of the various energy resources in place in order to improve the utilisation of renewable energies (Selmi *et al.*, 2014). For instance, the Shagaya solar energy plant is designed to house 56% concentrated solar energy production technologies, 35% photovoltaic energy production and 9% wind energy technologies. However, the downside to the strategy is the fact that with renewable energy technologies, the economies of scale outweigh those of scope. As Figure 10-4 shows, solar PV technologies are cheaper, deployment timelines are faster, and, as most companies have adequate dispatchable capacity, consumers can start utilising the energy from solar sources within shorter time frames.

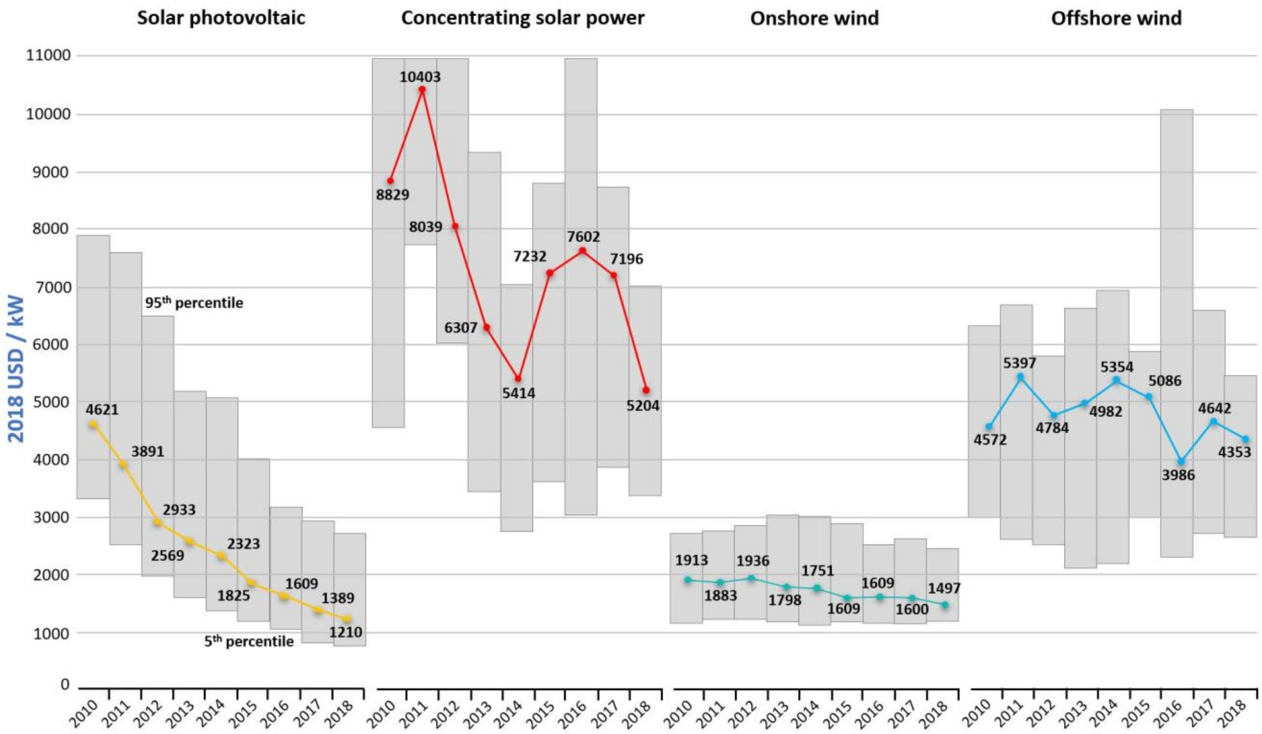


Figure 10-4: Levelised Cost of Different Renewable Energy Sources

Source: Reproduced from (IRENA, 2019b).

10.4.2.4 Limited Development in Terms of Technology

Kuwait still lags behind in terms of technological advancement, meaning it has to import most of the components for its solar farms. In order to develop economically viable solar energy systems, there is a need to adapt these technologies to local conditions to maximise cost efficiency and effectiveness. This customisation requires research and development activities to adapt materials, procedures and infrastructures, and is integral to the achievement of utility-scale solar energy plants that can be justified along sustainability lines, yet it attracts little investment in the Gulf region. As Alnaser and Alnaser (Alnaser and Alnaser, 2019) found recently, whereas China accounted for 45% of global investment in solar energy, the Middle East accounted for just 4%, among the lowest levels of commitment. Despite the country's extensive oil wealth, the government of Kuwait has dedicated just 0.1% of GDP to research and development, both in absolute and relative terms (Ramadhan, Hussain and Behbehani, 2013); by comparison, countries such as the US and China dedicate at least

2.5% of their budgets to research (Ball *et al.*, 2017), and Qatar, a fellow GCC member, has committed 2.8% of its budgets to research and development.

Moreover, the improvement of technologies involves the transfer of knowledge, as well as access to intellectual property systems that enable inventors to benefit from their creativity. The limited supply of these resources means that most local companies involved in the renewable energy sector lack the necessary inputs to develop customised energy systems. The lack of investment in research and development means that few Kuwaiti students are taught about renewable energy systems in schools, colleges or universities. As a result, they lack even basic knowledge about the economic, social and ecological benefits of energy efficiency, and the role renewable sources of energy can play in protecting the environment. Ultimately, this leads to limited considerations of the utilisation of renewable energy in domains such as engineering, construction and infrastructure development.

The financial barriers to research and development in Kuwait are magnified by overly bureaucratic procedures that originate from interference by the political class. In order to increase the potential for Kuwait to achieve its targeted potential for solar energy, it needs to rely on both local and overseas technologies and service providers, enabling domestic solar energy companies to benefit from the investments. For instance, reports reveal that the solar energy plant at Al-Dibdibah was required to secure 30% of its inputs domestically; this both supported local companies and established the basis for cooperation with foreign service providers, thereby laying the foundation for the sharing of technologies (Selmi *et al.*, 2014). This could provide a model for the future, but Kuwait has a long way to go to match countries such as Germany and China, and much greater investment will be needed if the ultimate goal of establishing competitive clean energy and technology industries in the country is to be achieved.

10.4.2.5 Variations in Productivity Between Peak and Off-Peak Periods

There is widespread agreement that Kuwait has the potential to generate solar energy all year round. Due to the nature of the winds in the desert and tidal movements, wave and wind energy are also viable across the year, and nuclear energy remains largely unaffected by climate or weather patterns. However, it is widely acknowledged that there are peak and off-peak periods with reference to renewable energy productivity, and these variations affect the reliability of the various types of renewable energy. For instance, the optimal production of solar energy occurs around noon when solar irradiation is highest. For some technologies, it is possible to ensure the generation of energy even during off-peak times; however, in the case of photovoltaic systems, energy can only be generated during the periods when solar irradiation is available (See Figure 10-6). This fact accounts for the difference in views between members of the general public and professionals in the country, some of whom advise the government on renewable solar systems. As the results of the questionnaire conducted for this study show, Kuwaiti society sees the country as a viable producer of renewable energy, specifically solar energy, due to its climate and location. However, with current technologies, the production of solar energy is limited by the variations in solar irradiation based on the time of the day and the month of the year. The efficiency of solar panels is also affected by wind speeds as solar energy installations typically only function when wind speeds are below 45m/s. This means that the productivity of large scale solar farms in the desert varies significantly depending on the speed of the wind. These considerations are outside the scope of most members of the public since they lack the technical knowledge of how existing solar systems functions.

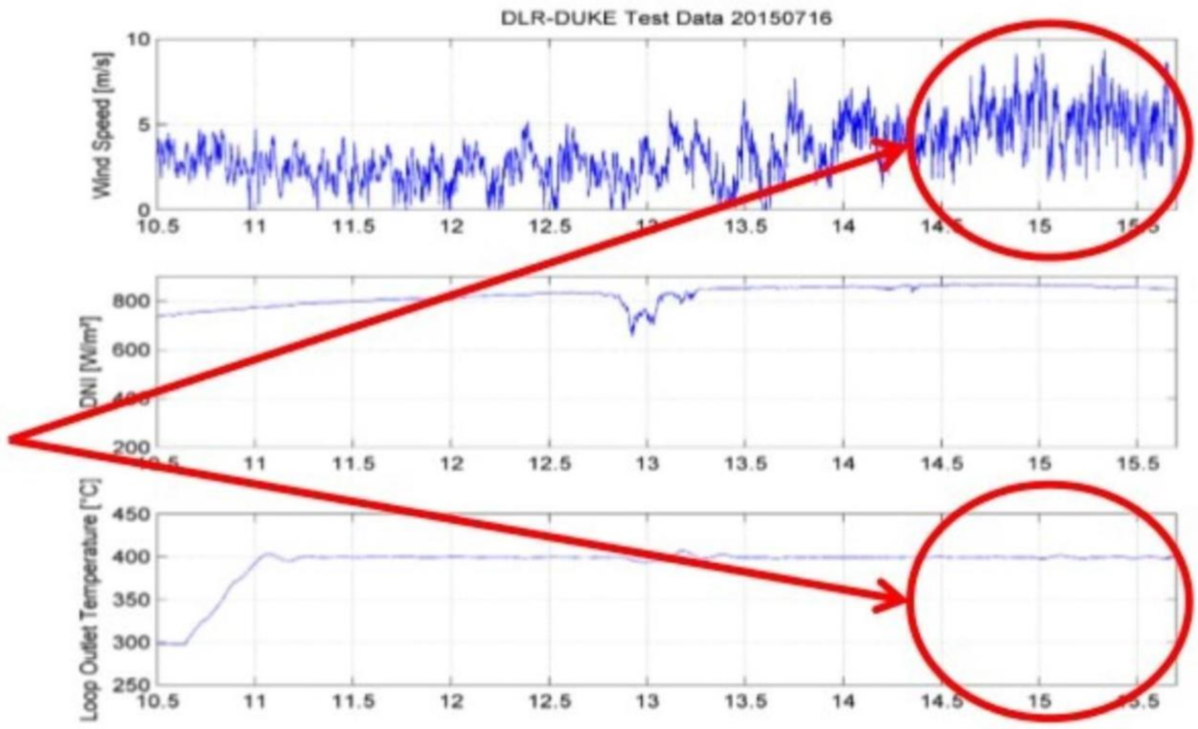


Figure 10-5: Variations in Productivity of Solar Systems Due to Shading

Source: (Geiger, 2017)

Variations in productivity can also be influenced by environmental factors. As mentioned above, the presence of dust on photovoltaic panels reduces the ability of solar irradiance to penetrate to the surfaces which transform light into energy (Maghami *et al.*, 2016). This process, known as hard shading, affects the performance of the solar energy system depending on which components are affected. By contrast, soft shading, when air pollution is caused by dust particles suspended in the air, affects the performance of the entire solar farm since it reduces the quality and quantity of solar radiation that reaches the solar panels. Research indicates that such reductions in the sensitivity of the solar energy capture mechanism can reduce the energy produced by up to 10% (Touati *et al.*, 2013). Although these effects are primarily discussed in the extant literature as causes of reduction in the efficiency of solar farms, they also affect maintenance costs and suggest that it is unviable to locate solar farms in remote locations.

10.4.3 Opportunities

These are the factors relating to solar energy that can be introduced into the industry in order to increase the utility value of solar energy to stakeholders. They represent the pathway to improvement in current levels of utilisation, efficiency, effectiveness and value to stakeholders (Zarkic-Joksimovic, N., and Marinkovic, 2018). A number of the opportunities identified here are derived from the literature review as well as from the findings of the questionnaire.

10.4.3.1 Developing New Technologies

The findings from the 'Public Questionnaire' reveal that renewable energy technologies are not widely distributed in the domestic market in Kuwait. This is supported by evidence of lacklustre adoption of renewable energy technologies over the last decade due to limited national policies and a lack of commitment by the necessary institutions. However, there are signs that the government and a number of private sector entities have now recognised the value of renewable energies and shown willingness to invest in new technologies. Perhaps the clearest evidence of this exists in the initial phases of the Shagaya Renewable Energy Park in Jahra (Munawwar and Ghedira, 2014). The inauguration of the 70MW solar energy plant as part of the national grid offers key stakeholders such as the Ministry of Electricity and Water and the Kuwait Institute for Scientific Research (KISR) the chance to participate in the customisation of solar energy technologies for the country. According to KISR, the energy plant is a combination of wind and solar (thermal and photovoltaic) energy, a unique combination designed to enable the park to optimise output by utilising all available energy sources rather than focusing on just one. The combination of the three technologies optimises production efficiency in the desert region, thereby achieving the plant's cost-efficiency goals.

Despite such innovations, 45.6% of the questionnaire respondents indicated that Kuwait's renewable energy industry are still lacking the necessary technical skills and knowledge (See Figure 7-20). One of the most imperative needs in terms of technological development is reliable storage systems for renewable energy. The rapid growth and widespread dissemination of solar electricity generation will require storage devices that are sufficient for the amounts generated. In the past, the production-driven solar energy developments have proven to be effective to an extent; however, the utility of renewable energy can only be optimised if it can be utilised during both peak and off-peak periods. The growth in demand for electricity across the entire Gulf region suggests that countries like Kuwait can monetise their investment in solar energies. If the country is instrumental in the development of new technologies which complement widely utilised systems and help meet this demand, Kuwait has an excellent opportunity to benefit from its investment in solar energy systems.

10.4.3.2 Adopting Sustainable Energy Models

The implementation of sustainable energy models depends on the contribution of both consumers and the institutions involved in the generation and distribution of energy resources. However, the findings of the ‘Public Questionnaire reveal that few consumers in Kuwait currently take steps to use energy in a more sustainable way. Wasteful utilisation behaviours include, for example, leaving lighting and air conditioners on when buildings are empty (See Table 7-15).

The adoption of sustainable energy models is integral to the achievement of the goals of the Kuwait Institute of Scientific Research (KISR), which spearheads the development of technologies for energy development (AlJandal, 2014). These goals include:

- Adaptation: meeting the growing demand for electricity
- Mitigation: reduction and prevention of high rates of emissions
- Diversification: meeting the increasing demand through new energy resources

Solar energy has the potential to fulfil these goals through end-user efficiency, especially when installations are well-placed. There is extensive popular support for the idea that Kuwait needs to start using renewable sources to generate energy instead of petroleum derivatives that pollute the air; indeed 73.5% of questionnaire respondents strongly agreed that this was necessary (See Table 7-8). However, achieving this in reality depends on the presence of measures to reduce the cost of energy, as well as to regulate and supervise the usage of electricity in order to reduce wastage. The lack of such functions under the Ministry of Energy adds to the challenge.

As previously discussed, there are opportunities for Kuwait to capitalise on investment in emergent technologies. The government has opened up to public-private partnerships (PPPs) in order to solve national supply-demand gaps in electricity, and these are designed to enable the country to utilise sustainable energy models in the growth of a renewable energy subsector.

10.4.3.3 Exporting Solar Energy to Neighbouring Countries

Based on evidence from the literature review, most countries that generate solar energy have established plans to export a proportion of their energy resources to neighbouring countries. By exporting energy to its neighbours who do not have renewable energy systems, Kuwait has an opportunity to capitalise on the emerging research-driven technology clusters in the region. Although the production potential for the Middle East is expected to double, the installed capacity is still below the existing demand. As a result, as an early regional adopter of solar technologies, Kuwait could generate revenue by exporting solar energy to neighbouring countries.

Although most of the countries in the region have different energy demands and supply characteristics, a number of common factors make it possible for Kuwait to export energy to its neighbours. These include:

- Rapid growth in the population, both local and expatriate, which drives the demand for energy resources.
- Improvements in living standards and increased utilisation of consumer electronics, which drives the demand for electricity at the commercial and domestic level.

- Harsh environmental conditions, including hot summers that necessitate cooling, cold nights requiring heating, air pollution necessitating air conditioning, and an increased demand for clean water (often involving desalination).
- Fluctuations in the price of fossil fuels. Since these countries export most of their own fossil fuel for foreign exchange, Kuwait could supply them with energy from renewable sources.

This is a unique opportunity for Kuwait, derived from the fact that it has extensive renewable energy potential and the ability to exploit those resources, unlike some of its neighbours who have not embraced this form of energy. As a result, any surplus energy over the national demand could be exported to earn the country foreign exchange.

10.4.3.4 Introducing Distributed Generation

According to Jeon and Lee (Jeon and Lee, 2019), decentralised and distributed ventures are expected to grow in the near future. This is significant for Kuwait because distributed energy production is best suited for off-grid installations, islands and desert regions. The findings of the ‘Public Questionnaire’ show that most respondents are aware of the potential for generating different types of renewable energy in different locations across the country (See Figure 7-14). Although the primary focus is directed towards the high levels of solar irradiation, there is also the potential for wind energy on some inland sites, as well as wave energy in coastal regions. This presents a potential incentive for self-generation, whereby households and companies invest in local solar energy generation. By enabling and empowering households and commercial establishments to generate energy on-site, Kuwait can offset most of their grid-based demand for energy, enabling grid-level production to be dedicated to specific large scale use. Such self-generation schemes would both reduce household energy costs and increase energy utilisation efficiency as a significant proportion of electricity supplied through the grid is currently lost during transmission.

There are numerous opportunities for distributed generation of renewable energy across the country. As the findings of this study indicate, most citizens are aware of the availability of solar irradiation all year round, and their preference for solar energy is founded on achievable goals. Distributed generation also enables the private sector to participate in the generation of solar energy, allowing the government to focus on more complex technologies, such as wind and wave energy.

10.4.3.5 Developing Grid Connected PV Systems

Grid-connected renewable energy systems offer additional production capacity and enhance the utility of solar energy since they solve the challenges of storage, distribution and fulfilment of demand at the household level. Grid-connected systems enable households and commercial entities that have installed renewable energy systems to sell excess energy back to the grid, as a way of earning returns from their investment. Solar energy systems are typically installed in consumers' homes with the primary purpose of meeting their domestic energy needs; this means that households can install systems based on the desired capacity, thereby reducing inefficiencies due to disparity in demand and supply. Given the fact that this research found that Kuwaitis generally believe that solar energy is worthiest of investment (See Figure 7-14), but that social uptake is currently slow (See Figure 7-20), the government could take steps to provide these grid-connected systems as a way of promoting the adoption of renewable energy in the country. The use of these systems would bring a number of advantages, most prominent of which is the fact that households and companies could reduce their overall energy costs due to the fact they are paid for their excess energy. The strategy would therefore provide an additional incentive to Kuwaitis while increasing the potential supply of energy from renewable sources.

10.4.4 Threats

The threats relate to the circumstances that limit the potential for utilisation or expansion of solar energy within the country. These might arise now, or in the future, but in either case, they have the potential to disrupt the entire solar energy industry (Abu-Ramman, Muslih and Barghash, 2007). The analysis presented here focuses on direct threats based on the findings from the questionnaire study, as well as threats identified in the literature, and findings from other locations that face similar circumstances to Kuwait.

10.4.4.1 Changes in Solar Energy Technologies

New developments in solar technologies pose a significant threat to the viability of the existing solar energy installations in the country. Although the speed with which the technologies for generation and storage of solar energy varies, newer technologies always offer the opportunity for increased productivity per unit. According to recent analysis of data from global solar systems, the cumulative installed capacity increase from 40GW to 321GW between 2010 and 2016 saw the price per watt at peak productivity drop from US$2 to US$0.56 (Abu-Ramman, Muslih and Barghash, 2017). This momentous drop suggests that, in light of the long-term payback period and lifespan of the systems, installations that were made in 2010 were four times costlier than those implemented in 2016, without taking into account the economies of scale. For a country like Kuwait, this has a major impact on the willingness of the government to commit resources to renewable energy, especially at a time when technologies are changing rapidly. This might explain why both the government and private sector investors have largely refrained from investing in this type of energy, at least in the short-term, as they wait to see where the markets go. These assertions are supported by the questionnaire most respondents, 78.7%, of whom indicate that, despite the popular support for investment in renewable energy technologies, social demand in the country is slow in (See Figure 7-20).

The impact of the change in technologies is further magnified by the fact that the initial costs of installation are high, thus change over costs is also high. These changes threaten the viability of renewable energy in general since the technologies for nuclear, wind and wave energy are also changing rapidly.

10.4.4.2 The Lack of Suitable Policies

The presence of proactive policy management is an integral step in accelerating the deployment of renewable energy systems. Government policies mandating the changeover to renewable energy have the power to motivate and even oblige institutions to utilise renewable energy sources. Indeed, 61.5% of questionnaire respondents strongly agreed that the government should require developers to incorporate renewable energy infrastructure in their buildings and a further 48.4% strongly agreed that academic institutions should initiate the use of renewable energies (See Figure 7-16). However, it is not clear whether corporations have begun to initiate the use of renewable energies in their buildings, and this has limited adoption of renewable energies at the household level. The introduction of targeted government policies would reduce the overall costs of solar energy, by establishing a market for solar energy products, and lay the foundations for the government assistance, in the form of subsidies and other incentives, that are necessary for the changeover to renewable energy.

Based on lessons learned within the GCC and across the globe, it is possible for Kuwait to invest in solar energy as long as the right policies are in place. However, the questionnaire findings indicate that the culture of responsibility in respect of the utilisation of renewable energies is still lacking in some dimensions. For example, although there is widespread awareness that electric cars can help to preserve the environment, only 57.8% of respondents said they would like to use them. Furthermore, 66.3% indicated that the government did not provide infrastructure for charging electric cars in public utilities, government organisations, or commercial and residential complexes (See Table 7-15). This suggests a lack of commitment at an institutional level towards the adoption of renewable energy sources.

The lack of policies and legal frameworks also indicates that there is limited commitment by the government and the institutions involved in the industry. Although KISR plays the role of the research agency for technologies and projects on renewable energy, it does not possess the mandate to create policy or legal frameworks. The lack of a dedicated agency to develop strategies for the implementation of renewable energy policies limits the viability of this type of energy source in Kuwait (Wogan, Murphy and Pierru, 2019). For instance, IRENA (IRENA, 2014b) indicates that whereas the official target for the generation of electricity from RES in Kuwait is 5% by 2020, the unofficial target is 1% by 2015, rising to just 15% by 2030. These disparities suggest that the country is ill-prepared for the long-term planning necessary for renewable energy technologies and the widespread adoption of solar energies.

10.5 TOWS Matrix

The TOWS matrix is a variant of the SWOT analysis, whereby the strengths, weaknesses, opportunities and threats are used in the design of strategies. The TOWS matrix involves identification of strategic alternatives that address the following questions (See Table 10-2):

- How can the strengths be used in order to exploit the available opportunities (SO)?

An SO strategy involves the utilisation of internal strengths in order to take advantage of the external opportunities. This is the most optimistic strategy.

- How can the strengths be exploited without the adverse effects of the threats (ST)?

An ST strategy involves the use of internal strengths in order to guard against threats from the external environment.

- How can the opportunities be applied to overcome the weaknesses (WO)?

A WO strategy focuses on improvements in the internal weaknesses in order to take advantage of external opportunities.

- How can the weaknesses be minimised in order to avoid the threats (WT)?

A WT strategy, which is the penultimate defensive strategy, aims at avoiding threats while minimising the weaknesses of the entity.

Table 10-2: TOWS Matrix

TOWS Matrix	**Strengths**	**Weaknesses**
	S1: Offers ecologically sustainable energy. **S2**: Offers socially sustainable energy. **S3**: Economically sustainable in the long run. **S4**: An alternative to fossil fuels. **S5**: High solar energy potential due to climatic and weather patterns.	**W1**: High initial and maintenance costs. **W2**: Flat learning curve. **W3**: Preference for combined renewable energy systems. **W4**: Limited technological development in Kuwait. **W5**: Variations in productivity between peak and off-peak periods.
Opportunities	**Maxi-Maxi-Strategies**	**Mini-Maxi Strategies**
O1: Developing new technologies. **O2**: Adopting sustainable energy models. **O3**: Exporting solar energy to neighbouring countries. **O4**: Introducing distributed generation. **O5**: Developing grid-connected PV systems.	**S3/O1&O3**: Generate revenues from Exports. **S1/O5**: Carbon trading and carbon finance. **S4/O5**: Utilise solar energy under SEOR.	**WI/O1**: Customise Solar Energy Systems for Domestic Circumstances. **W2/O4**: Focus on Research and Development.
Threats	**Maxi-Mini strategy**	**Mini-Mini-strategies**
T1: Rapid changes in solar energy technologies. **T2**: Lack of government policies.	**S3/T1**: Utilise private sector to increase efficiencies. **S4/T2**: Develop policies to promote the utilisation of renewable energy.	**W1/T2**: Implement government subsidies for solar energy products. **W3&W3/T2**: Invest in other renewable energy sources.

Source: Author's creation

10.5.1 The Maxi-Maxi Strategy

According to Zarkic-Joksimovic and Marinkovic (Zarkic-Joksimovic, N., and Marinkovic, 2018), the maxi-maxi strategy indicates how the strengths can be utilised in order to exploit the available opportunities (SO). In this analysis, the strategy for Kuwait revolves around the generation of revenues from renewable energies and the utilisation of solar energy to offset the demand for fossil fuel energy.

10.5.1.1 Generate Revenues from Exports

50% of Kuwait's GDP and 95% of its exports come from the oil and gas industry (Omar, 2019); however, as Omar (2019) notes, "Shifting supply, demand and technology trends have ushered in an energy world where oil-price volatility and market uncertainty are the defining features" (p. 8). The overreliance on this single sector exposes the economy to a number of risks, including the possibility of a drop in the price of oil, embargos and quotas by international regulatory entities, and the shift towards cleaner energy. The fact that 75% of oil and gas customers originate from the Asia Pacific region also exposes Kuwait to significant risks (EIA, 2016). This is why diversification of its revenue sources is necessary.

The proposition for the generation of revenues from solar energy systems is based on a number of rationales. The implementation of the GCC Interconnector, an electrical grid system between member states, means it is now possible for one country to trade energy resources with the rest. Since the costs of solar energy systems are expected to drop by half, Kuwait will have the ability to export energy to neighbouring countries, such as Saudi Arabia. Kuwait also borders Iraq to the north and west, a new and as yet untapped market for energy supplies.

Shehabi (2019) uses the example of the Mediterranean Solar Plan to explain how the exportation of solar energy to neighbouring countries functions. The plan is a collaboration between the EU and several Mediterranean partner countries to accelerate renewable energy production in order to meet growing regional demand. With a target of generating over 20GW of renewable energy through solar plants in remote and desert regions, notably in Morocco, the project will supply local needs and export energy to European countries. This will boost GDP growth in supplier countries while providing employment opportunities; in the case of Morocco, the project has the potential to generate at least 1.17% growth in GDP per annum and provide employment for 265,000 people, while the most optimistic projections forecast a growth rate of 1.91% with employment for over 482,000 people (Lorca, A., and Arce, 2012). Considering that some of Kuwait's neighbours, such as UAE have only achieved a 3% level in the utilisation of renewable energy, while others like Iraq do not have such policies, the market for clean energy generated in Kuwait is high.

10.5.1.2 Carbon Trading and Carbon Finance

Carbon trading and carbon finance are intended to reduce the amount of greenhouse gases entering the atmosphere, notably through the use of carbon capture and sequestration (CCS). CCS technologies enable carbon to be captured and then stored or utilised as a resource. Al-Hussaini (Al-Hussaini, 2016) has recently conducted research to determine the viability of carbon finance in Kuwait in order to promote sustainability, focusing in particular on the opportunities for public and private entities.

Considering that the Kuwaiti government is a signatory to the Kyoto Protocols, and the fact that the country has an Environmental Public Authority, the foundations for this strategy have already been laid. However, according to a report released by the International Carbon Reduction & Offset Alliance in 2017 (International Carbon Reduction & Offset Alliance, 2017), Kuwait had yet to implement economy wide national development contributions (NDCs) under the Paris

Agreement, meaning that climate targets and carbon finance policies were not yet in place. Furthermore, the introduction of carbon financing in Kuwait would involve the creation of a sovereign wealth fund to facilitate economic and social development. However, the country has taken extensive measures to enrol in programmes that promote carbon finance, such as ratification of the Paris Agreement, and increased adoption of renewable energy policies in preparation for a fully-fledged carbon trading strategy.

10.5.1.3 Utilising Solar Energy under SEOR

Existing literature indicates the pathway to achieving 100% renewable energy involves both end-user strategies (to promote savings and efficiency in use) and increased generation of renewable energy (to substitute for that generated from traditional sources) (See Figure 10-7).

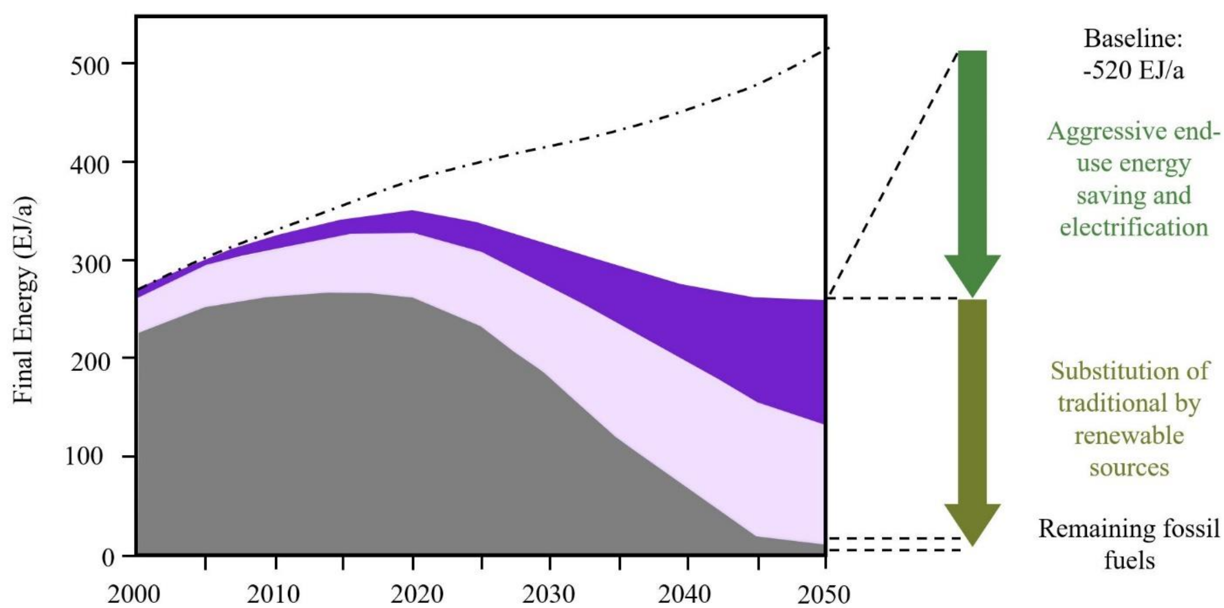


Figure 10-6: Utility of Solar Energy: Baseline and Substitution Goals

Source: Reproduced from (Leape, 2011)

Although Kuwait is not aiming to meet 100% of its energy needs from renewable sources by 2050, the country can utilise this model by targeting these two strategies, albeit in a less aggressive manner.

As outlined above (See 10.4.1.4), the utilisation of solar energy for enhanced oil recovery (SEOR) can play a major role in the reduction of reliance on traditional fossil fuels. Given the large tracts of uninhabited land which lie near the oil fields, developing solar farms to supply them with energy enables companies in the sector to reduce their use of fossil fuels across their supply and value chains. For instance, the Al-Dibdibah Solar Photovoltaic power plant, a US$1.2B installation owned by the Kuwait National Petroleum Company, will eventually have the ability to generate 1.5GW that can be used to offset some of the fossil fuel-based energy used in the plant. Indeed, according to recent reports, this 1.5GW will replace 5.2 million tonnes of fossil fuel energy, equivalent to 15% of the national energy needs by 2030 (IRENA, 2019b).

Current operations at the Al-Dibdibah plant demonstrate that techniques such as SEOR are a viable alternative to Thermal Enhanced Oil Recovery (TEOR). Indeed, reports on SEOR reveal that it is both economically and ecologically more sustainable than TEOR, and offers savings of up to $4 per million British Thermal Units (Geiger, 2017). As Figure 10-7 shows, it is possible to introduce an SEOR system into standard oilfields across Kuwait, and, as it is tethered to a fossil fuel energy source, the system can accommodate variations between peak and off-peak production without compromising operational efficiency. SEOR therefore provides an effective way to substitute renewable energies for traditional sources, primarily in the extraction of oil, and is integral to the achievement of Kuwait's renewable energy goals (Alhouli, 2017).

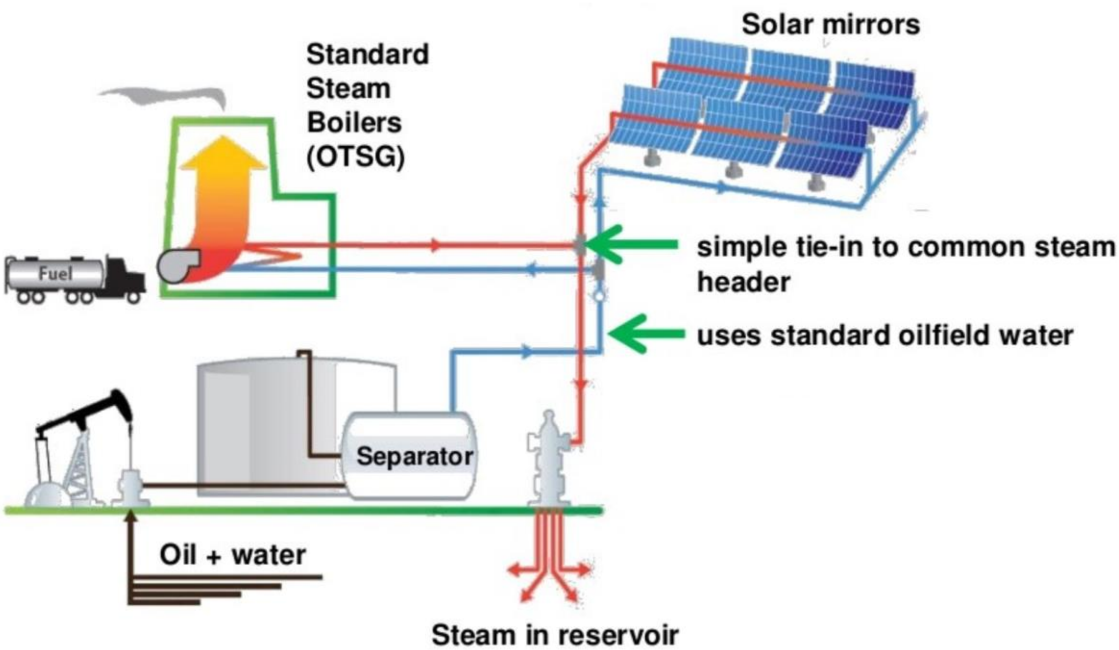


Figure 10-7: Sample SEOR System

Source: (Geiger, 2017)

The maxi-maxi strategy offers three ways through which Kuwait can amplify the utilisation of renewable energies in its energy mix, as well as the activities through which it can enhance the value of renewable energies within the country. This strategy focuses on the positive aspects of the internal and external environment, which have in the past been overlooked by the country.

10.5.2 The Maxi-Mini Strategy

Fleisher and Bensourssan (Fleisher, C. S., and Bensourssan, 2007) define this strategy as the product of utilising the strengths while overcoming the adverse effects of the threats (ST). In the analysis, the ST strategy seeks to indicate ways through which Kuwait can utilise the private sector in order to increase efficiencies in the utilisation of energy, as well as the development of policies that increase the utility of renewable energy in the country's energy mix.

10.5.2.1 Utilise the Private Sector to Increase Efficiencies

The dominance of the government in the energy sector, including the oil, gas, and electricity subsectors, has contributed to the affordability of its products and services. According to recent research (Ramadhan, Hussain and Behbehani, 2013), government subsidies of up to 95%, have yielded a multitude of benefits, including local affordability and the expansion of utilisation for industrial and commercial purposes. However, subsidisation has also had negative effects, notably those associated with the absence of market forces, including inefficiencies in utilisation. This suggests that the involvement of the private sector will be integral to increasing efficiency in the generation, distribution and utilisation of electricity from renewable sources. 45.8% of the 'Public Questionnaire' respondents supported the idea of increasing private sector participation as a means of creating new efficiencies, capital and demand (See Figure 7-22).

Research conducted in China (Yang *et al.*, 2016b) found that the involvement of the private sector contributed significantly in terms of capital and human resources, as well as in the transition to green energy. Based on the researcher's estimates, the contribution was pegged at 90% of what the government had achieved. If these levels were targeted in a country like Kuwait, a public-private partnership could drive efficiency without compromising the availability of energy as a public good. Furthermore, with advances in technologies which reduce wastage, such as smart grids, it becomes possible to create additional value from existing solar energy resources. The roles of the private sector and public entities in such a partnership are summarized in Table 10-3.

Table 10-3: Summary of the Roles of the Public and Private Sector Partners

Role of Public Entities	Role of Private Sector
• Create frameworks to enable the transition towards renewables in the energy sector • Invest in large scale infrastructure, notably transportation, power distribution grids, and research and development systems	• Adjust operational horizons from short- and medium-term to long-term to accommodate the lengthy payback periods associated with investments in renewable energy systems • Channel investments to the most viable renewable energy sources to increase allocative efficiency • Provide human resources and creative capacity to enable customisation of existing technologies and innovation of new systems

Source: Author's creation

10.5.2.2 Develop Policies that Promote the Utilisation of Renewable Energy

The utilisation of renewable energy is dependent on the characteristics of the policies adopted by the government. According to a recent study in France (Krakowski *et al.*, 2016), government policies are central to all the feasible pathways to the achievement of a 40-100% renewable energy share in the country, and the authors conclude that "high renewable energy penetration would need significant investments in new capacities, new flexibility options along with imports and demand-response" (p. 2). In addition, research from the USA (Ball *et al.*, 2017) and China (Lei *et al.*, 2019) makes clear that government policies are integral to orienting national resources and promoting receptiveness towards renewable sources. An industry report by the World Wildlife Fund (Leape, 2011) further indicates that it is imperative for policies to be utilised to prime the market place for these technologies. This is because the value streams associated with renewable sources differ from those of traditional sources, so the methodologies of financing and benefitting from renewable energy have to be driven by the right policies and legislative frameworks.

Research has indicated that most financial institutions view solar energy technologies as high-risk investments based on creditworthiness (Chaki, 2008). This is magnified by the short history of solar energies, as compared to other energy systems, the long payback periods, and the limited scope of revenue streams that focus mainly on cost savings and replacement of traditional energy sources. However, with the right policies, supported by clear goals, it is possible to establish a business environment that is supportive of renewable energy investments. Such an environment facilitates the availability of technological infrastructure, financing, and the elimination of obtrusive bureaucracy.

Specific policies would also help to increase awareness of the advantages of renewable energy among the Kuwaiti population and promote energy efficiency. This position is supported by the findings of the questionnaire conducted for this study: 47.6% of the respondents evaluated the role of Kuwaiti official organisations in spreading awareness about renewable energy as weak (See Figure 7-15), and 49.2% said they did not use any form of renewable energy technologies themselves (See Table 7-37). This widespread lack of knowledge about renewable energy is accompanied by a lack of a culture of efficient utilisation: 65.8% of respondents indicated they did not use power saving devices to control electricity consumption, and only 47.7% said they turned off the electricity after using TVs, computers and other devices (See Table 7-15).

Such policies would also bring other benefits. Kuwait currently has no institution dedicated to research and development in renewable energy sources, in particular, solar energy systems. The development of effective policies is integral to the creation of institutions that have clear mandates and transparent procedures, including for auctioning energy and tendering for new projects. These policies would also help industry benefit from long-term and sustainable management of the sector (Selmi *et al.*, 2014). Additional policies for management of demand should include smart grids and technologies for metering in order to ensure that utility tariffs are cost-reflective. Furthermore, as Omar (Omar, 2019) notes, such procedures would establish the basis for integrity and accountability, thereby reducing or eliminating the debilitating effects of corruption from the energy sector. These policies are necessary for encouraging private investors and enterprises to get involved in the sector.

The involvement of the private sector will introduce new dimensions of efficiency as well as new human and capital resources into the sector (Alsayegh, 2008). Therefore, policies will be needed to improve training, education and the development of human resources in order to prepare for the next phase in the growth of the industry. As research has shown (Long, Cui and Li, 2017), such policies are also integral to the localisation of jobs created in the renewable energy sector through maintenance activities. Involving the private sector will also bring cross-sectoral benefits, whereby renewable energy resources are utilised to improve development in other industries.

Kuwait's Five-Year Development Plan and the National Development Plan include some measures to promote the use of renewable resources in the future. Designed to position the country as a regional financial and trade hub, the plans focus on economic diversification and aim to increase investment in infrastructure, including the following:

- Resource efficiency programmes
- Green economy strategies
- Green building codes

- Clean technology research
- Alternative energy projects

Two policies have been designed to achieve these outcomes. The first of these involves withdrawing the subsidies on electricity prices in order to relieve some of the financial pressures that have caused inefficiencies in the economic systems in the country. As Shehabi (Shehabi, M., 2019) notes, reducing the subsidies by 83% would wipe out most of the US$15.3B budgetary deficits, thereby enabling the government to invest in new energy systems, including renewables. Saudi Arabia pioneered the withdrawal of some subsidies in 2016, increasing domestic gas prices by 77%, and the cost of crude oil to some companies by 50%, showing that radical cuts can be achieved (Wogan, Murphy and Pierru, 2019).

The second policy is the coordination of electricity generation across the GCC through the GCC Interconnection Authority (GCCIA). The GCCIA oversees the integration of electricity generation among six countries (Kuwait, Bahrain, Qatar, the UAE, Saudi Arabia and Oman), and brokers power exchange and trading agreements (Brownson, 2016). Four of the six (Kuwait, Bahrain, Qatar and UAE) are now part of the GCC Interconnector, a 400kV line managed by the GCCIA (Wogan, Murphy and Pierru, 2019), providing the means for countries with surplus supply to export to those with deficits. This integrated electricity market, which has the potential to reduce operating costs, provides Kuwait with the right context to transition its electricity supply systems to a market-based system.

A framework for the manner in which policies have been utilised by China to advance its solar PV industry is shown in Figure 10-9. These include guidance measures for newcomer entities, supporting measures for entities that incur costs and require resources, supervisory measures to ensure technical acuity, and specifications measures to ensure viability for custom needs. Adopting and customising the model into Kuwait can enable the country to learn from China, which has succeeded in the deployment of renewable energy sources in its energy mix.

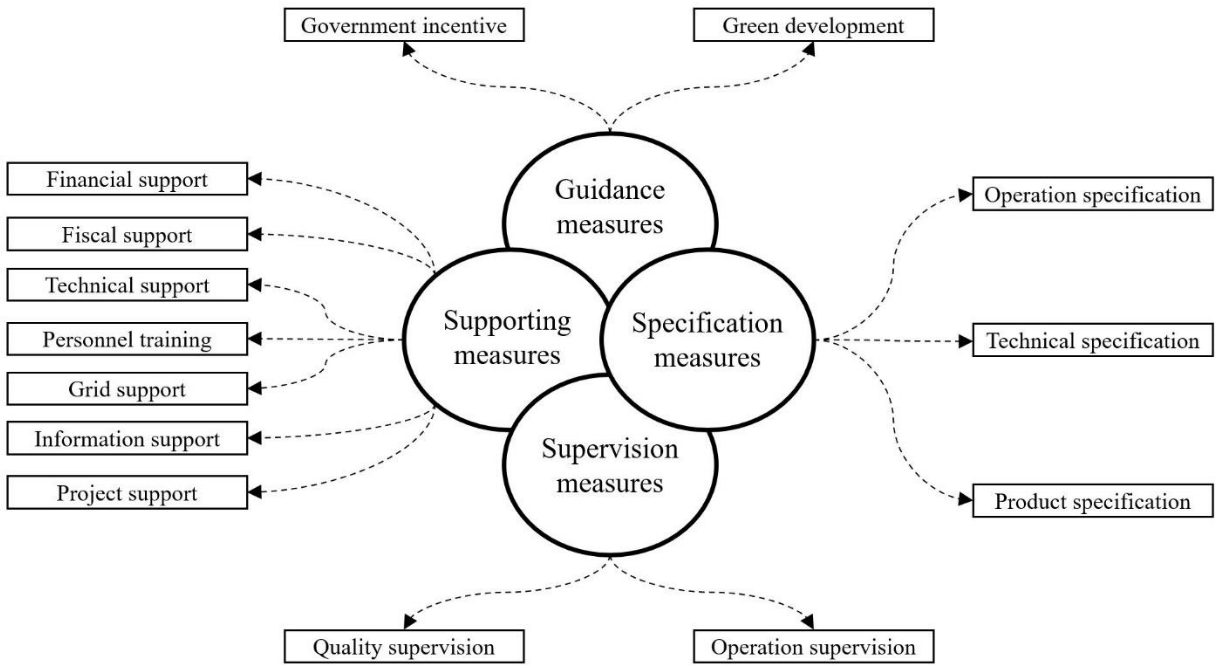


Figure 10-8: Policies Necessary to Drive the Implementation of a Solar Energy Subsector

Source: Reproduced from Adapted from (Long, Cui and Li, 2017).

Policies which should be considered in the context of Kuwait include the following:

- Feed-in-tariffs (FiT): this policy guarantees a premium payment to entities that produce energy from renewable energy sources. The compensation systems take into account the costs of producing electricity, as well as the need for a viable return on the investment, considering the non-financial benefits that arise from investment in renewable energy systems. FiTs have proven successful in over 75 countries across Asia, North America, Europe, and Africa, notably in Germany, where they have played a significant role in the expansion of renewable energy systems (Mendonca, M., Jacobs, D., and Sovacool, 2009). Payments for FiTs are calibrated to the scale of production and the technology used, and their applicability to all solar energy technologies has been established (Mendonca, M., Jacobs, D., and Sovacool, 2009). Therefore, Kuwait could adopt such as policy in order to encourage both household and utility-scale investment in solar energy.

- Investment tax credits: These are incentives that allow entities that invest in solar energy (or other renewable energy systems) to reduce the overall initial costs of investment. Research (Abu-Ramman, Muslih and Barghash, 2017) indicates that these credits encourage investors to overcome the barriers associated with the high initial capital costs which affect the industry. Although tax credits reduce the revenue available to the government, they encourage private investors to commit funds to renewable projects, thereby bringing benefits to the national economy.
- Renewable portfolio standards (RPSs): RPSs are designed for large scale energy suppliers and companies and mandate standards for the proportion of renewable energy sources that must be included in an energy supply for it to be authorised.

The adoption of this strategy will enable Kuwait to overcome a number of policy-oriented limitations that are widely considered to hamper the adoption and utilisation of renewable energy. The strategy is aimed at limiting the adverse effects of the policies, which essentially converge the activities and objectives of all stakeholders with reference to adoption and implementation of renewable energies.

10.5.3 The Mini-Maxi Strategy

Saaty and Vargas (Saaty and Vargas, 2013) describe this strategy as a way to limit the effects of the weaknesses through the utilisation of the opportunities (WO). Minimisation of the weaknesses is in recognition of the fact that Kuwait is still in its infancy concerning the adoption of renewable energy. The multiplicity of opportunities in the external market arise from countries that export technologies, as well as stakeholders who have past experiences in the small- and large-scale adoption of renewable energy sources.

10.5.3.1 Customise Solar Energy Systems for Domestic Circumstances

The globalisation of solar energy systems has led to the introduction of technologies that have generic features rather than being customised according to socio-cultural and economic needs. This limits their utility; however, through customisation, it is possible to increase uptake and improve the efficiency of solar energy systems. For instance, Tesla's Solar Roof products and services have been designed to fit into the residential market in the US. By replacing traditional roofing with solar energy capture mechanisms, they both increase real estate value and address energy demand and supply challenges in the US (Almuzel, M., Goudarznia, T., Daneshi, A., Saadatmand, M., and Yacoub, 2018). By customising solar energy systems according to market characteristics, Kuwait can incorporate solar energy utilisation into operations such as SEOR, whereby PV or CSP technologies are utilised when solar resources are available.

10.5.3.2 Focus on Research and Development

Inadequate research and development (R&D) is a fundamental challenge facing the country in terms of its ability to develop custom solutions for renewable energy systems. 64.4% of questionnaire respondents strongly agreed that there is a shortage of relevant academic and pedagogical curricula in educational institutions in Kuwait, and this leads to a lack of qualified human resources with the right technical and strategic knowledge (See Figure 7-23). Such expertise is needed to develop the fundamentals for the integration of renewable energy solutions in the country.

One of the primary areas for R&D within the country is the differences in the initial costs of the various technologies. Analysis (Alazemi, 2017) has identified the perfect mix of renewable energies needed to achieve Kuwait's cost efficiency goals, yet research into solar energy technologies in Qatar indicates that start-up costs vary significantly, especially when storage is included (See Table 10-4). Through greater R&D, Kuwait can find ways to bypass the challenges associated with high storage costs, including developing more efficient storage mechanisms or investing in high efficiency systems. Currently, the efficiency of PV solar is 23%, CSP systems have an efficiency of 32% while linear Fresnel systems have a 51% efficiency (Rehman *et al.*, 2019). Normally, the increased efficiency comes with higher costs (as evidenced in Table 10-4); however, through innovations under an intensive R&D environment, it is possible to reduce the costs of the technologies, without compromising their efficiency or their utility for various purposes. Indeed, China records lower LCOEs than Kuwait (IRENA, 2014c), due to the fact that it has invested extensively in research and development, and it has the potential to benefit from the economies of scale and scope in the production of the technologies. This is why the proposition for the acquisition of research and development capabilities is beneficial for Kuwait.

Table 10-4: Viability of Solar Energy Technologies in Qatar

Technology	Inv. Cost 2015 $/kw	Inv. Cost 2030 $/kw	O&M 2015-2030 $/kW/yr.	Annual Avail. %	Capacity Credit %	Start Year	Inv. Limit 2015-2030 MW/yr.	Cumulative Upper Limit MW
Tower w storage	5,044	3,783	73 - 44	37%	50%	2015	50-200	NA
Trough	3,929	3,056	58 – 44	23%	20%	2015	100-300	NA
Trough w storage	7,639	5,941	323 -251	37%	50%	2015	100-300	NA
Trough hybrid	4,273	3,487	249 – 194	23%	100%	2015	100-300	NA
Fresnel	3,570	2,677	58 – 44	23%	20%	2015	50-200	NA
Fresnel w storage	7,280	5,563	58 - 44	37%	50%	2015	50-200	NA
Fresnel hybrid	3,950	3,147	58 – 44	23%	100%	2015	50-200	NA
Stirling engine	4,656	3,492	58 - 44	23%	20%	2015	100-300	NA
PV centralized	2,178	1,188	15 - 6	17%	20%	2012	100-300	1558
PV rooftop (commercial & residential)	3,713	1,485	17 -10	17%	20%	2012	60-300	3115
Wind (onshore)	1,601	1,358	61 - 30	28%	20%	2012	100-300	NA

Source: Reproduced from (Yessian, K., DeLaquil, P., and Merven, 2016).

The development of R&D capabilities is reliant on the development of systems from the grassroots. As Alnaser and Alnaser (Alnaser and Alnaser, 2019) found, the establishment of new academic courses and programmes on solar energy and other renewable technologies, in both technical and institutions of high learning, has established the foundation for improvements in R&D activities. The accelerated utilisation of solar energies has also led to an increase in the number of students involved in the science, technology, engineering and mathematics (STEM) disciplines. In addition to boosting the level of knowledge and information about solar energy and other renewables, these institutions are central to the development of solutions that are customised to the region, especially if the level of long-term partnerships between learning institutions and companies involved in innovation increases.

In summary, this mini-maxi strategy plays an integral role in the increased utilisation of technology transfer, and the ability of the country to absorb knowledge and experiences from other countries, in order to solve the endemic challenges that limit the adoption and utilisation of renewable energies in the country.

10.5.4 Mini-Mini Strategy

These strategies are modelled around reducing the weaknesses in order to avoid the threats. For a country with low levels of renewable energy adoption, the strategies discussed here have the potential to play an important role in Kuwait.

10.5.4.1 Implement Government Subsidies for Solar Energy Products

The creation of subsidies is an integral step in promoting the adoption of solar energy as part of the renewable energy portfolio. Incentives increase the number of benefits that accrue to households and corporations that invest in renewable energy. The government should provide a broad range of incentives for households and corporations in order to reduce the initial costs of investing in renewable energy since this is one of the primary limiting factors. Incentives should also be provided for the processes of acquiring knowledge of solar technologies, as well as investments in the production of solar energy systems. Subsidies would also help to offset the costs of changing over from other forms of energy generation, specifically those based on fossil fuels. This includes subsidisation of electric cars as well as the technologies for renewable energy. The questionnaire findings reveal a strong preference for solar energy among Kuwaiti society; this suggests that the government can rely on economies of scale when subsidising these technologies (see Figure 7-14).

10.5.4.2 Invest in Other Renewable Energy Sources

The questionnaire findings reveal that 70.4% of respondents strongly agreed that the use of renewable energy sources is the best way to improve the environment and secure a sustainable future for Kuwait (See Table 7-8). While high levels of solar irradiation in the country make solar the preferred renewable energy source (Ramadhan, Hussain and Behbehani, 2013), there is evidence that other renewable sources, notably wind energy, are also viable. For example, research has shown that the average wind speeds in regions such as Al-Taweel and Al-Wafra, estimated at up to 5m/s, are viable for wind energy systems (Al-Nassar *et al.*, 2005). Furthermore, a study which examined the viability of this approach in the country concluded that the utilisation of 14 technologies at the 2GW Shagaya Renewable Energy Park, comprising 6 CSPs producing 1250MW, 3 wind power systems producing 136 MW, and 5 PV systems producing 614MW, offered the most optimal results in terms of efficiency and sustainability (Lude *et al.*, 2015). It also revealed that while economies of scale are viewed as being a key driver behind the adoption of solar energy, there are broader benefits under economies of scope for other renewable energy sources.

Further evidence of the need to utilise a blend of technologies to achieve renewable targets is provided by research in Macedonia (Cosic, Krajacic and Duic, 2012), in China (Yang *et al.*, 2016b) and in California (Walmsley, Walmsley and Atkins, 2015). In Macedonia it is seen as a way to achieve 100% renewable energy levels by 2050 despite unfavourable circumstances, notably a "high prevalence of lignite, a strong dependence on energy import, poor condition of the energy system and inefficiency in energy production and use." [58: p. 2]. In the case of China, more efficient wind energy systems have been proposed in order to complement the success in solar PV and CSP systems (Yang *et al.*, 2016b), and, in the US, "wind and solar PV collectively form an integral part of California reaching the 33% renewables target by 2020" [59: p. 2]. By combining different technologies in the renewable energy generation processes, the mini-mini strategy enables the country to counter the weaknesses of each renewable energy sources. Furthermore, it enables the country to lay down the foundation for future changes in a multiplicity of trajectories, based on which renewable energy system pans out to be the most efficient. For instance, by testing the viability of a combination of solar and wind energy, it is possible for Kuwait to determine which source is most viable, in order to make better decisions for the future.

The mini-mini strategy is designed with the knowledge that Kuwait is among those countries that are yet to fully adopt renewable energies due to a multiplicity of limitations. These limitations directly affect Kuwait's ability to create its own unique renewable energy pathway, especially as it relies on technologies imported from innovator countries. However, even if these technologies are suitable for use in Kuwait, their utility is dependent on the preparedness of the country for renewable energy, and that is perhaps the most significant challenge.

10.5.5 Model for Renewable Energy Investment in Kuwait

Given the importance of investor capital in generating growth within the renewable energy sector. The process of investing in renewable energy starts with the identification of a viable model which highlights the relationship between variables, stakeholders and other considerations, based on knowledge acquired from past experiences and expectations in the near future. Modelling the investment in renewable energy lays the foundation for commitment of resources, identification of opportunities, determination of strategies and deduction of possible outcomes.

The four strategies identified via the SWOT analysis provide the basis for the adapted model presented in Figure 10-2. This sets out the main considerations in respect of projects relating to renewable energy investment in Kuwait. The policy concerns are based on the key concerns raised in the SWOT analysis and the strategies developed under the TOWS matrix.

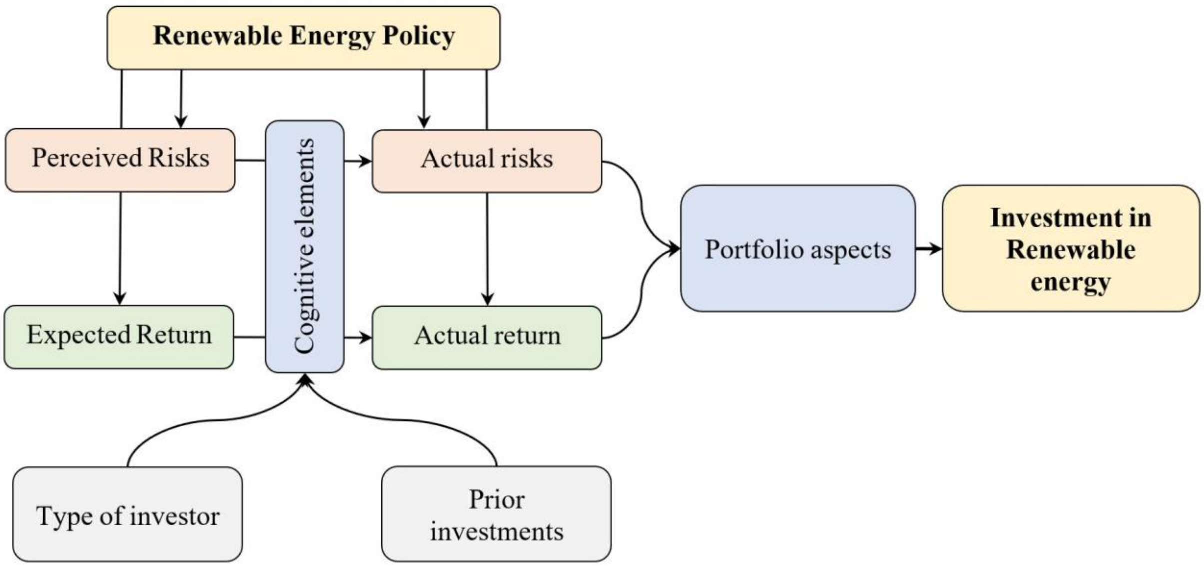


Figure 10-9: Model for Renewable Energy Policy and Investment

Source: Reproduced from (Wüstenhagen and Menichetti, 2012)

As Figure 10-2 shows, any model for the development of renewable energy investment has to take account of the risks and returns, based on the cognitive elements relevant to the environment. These are dependent on the type of investors (since they influence the availability of capital), and the choice of renewable energy system among the preferred alternatives (solar, wind, wave and nuclear). The main considerations which inform the cognitive elements include the fact that private sector investors have different stipulations as compared to government-based investors. Based on the actual risks and actual returns, the portfolio of investments is identified. The components of the portfolio are then selected from the different technologies under each category of renewable energy. For instance, under solar energy, the actual returns and risks will determine the proportion of energy produced from PV systems, CSP, and solar tower systems in the various solar farms.

The model focuses on the considerations during the provision of resources for investment in renewable energies in Kuwait. In most instances, limitation in capital resources has a similar effect in terms of limiting the adoption of renewable energy options as the relative efficiency of energy from these sources. This is why the model for investment is an integral consideration for the country. A number of other potential benefits arise from the introduction of renewable energy driven by policies that take into account the risks and returns from the investment. For example, although the framework presented here focuses on the economic dimensions of investment, it also has the potential to orient both public and private institutions towards efficiency and effectiveness in the activities designed to manage the energy sector.

10.6 Summary

This chapter has provided in-depth analysis of the strengths, weaknesses, threats and opportunities associated with the utilisation of solar energy in Kuwait. It has also set out four possible strategies to exploit the opportunities identified while reducing the risks from threats, building on the strengths whilst mitigating the effects of the weaknesses. The next chapter draws on the data presented in the previous chapters to answer the research questions, to present a national policy framework to support investment in renewable energy in Kuwait, and to propose two strategies for renewable energy use in the country (for 2030 and 2050).

Chapter 11

Discussion, Policy Framework, and Proposed Strategy for Renewable Energy Utilisation in Kuwait (2030-2050)

11.1 Introduction

In past decades, few oil-rich countries paid significant attention to renewable energy due to the wide-spread availability of fossil fuel with well-established production technology. However, the drive to reduce carbon emission, enhance air quality, and maintain reserves of oil for future generations, has led Kuwait to focus on renewable energy as the most sustainable approach to meeting its future energy needs. This chapter discusses the findings presented in the previous chapters in light of the research objectives in order to answer the research questions. It also proposes a national policy framework for renewable energy, a model for renewable energy investment, and two strategies for renewable energy utilisation in Kuwait, the first targeting 2030 and the second looking ahead to 2050.

As the study aims to examine current and future energy demand in Kuwait and suggest strategies to enhance renewable energy utilisation in the medium and long-term, the following research questions were formulated:

1. What are the most effective strategies adopted by leading developed countries and by other Gulf states in relation to renewable energy utilisation?
2. What role could renewable energy play in meeting current and future energy demand in Kuwait?

3. Do the strengths, weaknesses, opportunities, and threats relating to solar energy in Kuwait make it a viable alternative to energy derived from fossil fuels?
4. What are the key ingredients required to implement an effective strategy for renewable energy utilisation in Kuwait?

In order to answer these questions, the following objectives were established:

1. Critical understanding of RE technologies and strategies globally and in the MENA region, including Kuwait via literature review.
2. Assess the current and future situation relating to energy supply, demand, consumption and consumer efficiency of electricity consumption in Kuwait.
3. Investigate the viability of renewable energy utilisation in Kuwait and evaluate the effectiveness of current and future renewable energy projects.
4. Evaluate the levels of awareness, orientation and attitudes towards renewable energy utilisation and environmental issues among the general public, public officials, and key players in the renewable energy sector in Kuwait.
5. Identify barriers and obstacles facing the renewable energy sector in Kuwait and formulate a set of actionable solutions based on best practice for use by Kuwait legislators.
6. Develop a policy framework to support renewable energy investment and a set of recommendations to help policymakers in Kuwait develop efficient renewable energy strategies and programmes.
7. Propose a medium- and long-term strategy (for 2030 and 2050) for renewable energy utilisation in Kuwait.

The discussion section begins by considering the primary data collected for this study via the questionnaires and the interviews in order to a) assess current and future energy demand, b) to evaluate energy consumption behaviour c) to establish levels of renewable energy awareness and utilisation, and d) to identify barriers to renewable energy utilisation (Objectives 2, 3 and 4).

11.2 Findings of the Public Questionnaire

This questionnaire explored energy consumption behaviour and attitudes towards renewable energy use among the general population in Kuwait. It targeted both Kuwaiti citizens and non-Kuwaiti residents, was provided in Arabic and in English, and 1383 valid responses were received. As a result of the analysis presented in Chapter 7, a number of elements were identified which contribute to answering the research questions. These are discussed below.

11.2.1 Attitude and Behaviour of Participants Regarding Sustainable Consumption

The questionnaire sought to ascertain respondents' attitudes towards environmental issues, especially the positive effects of utilising renewable energy as opposed to fossil fuels. The results provided some positive indications showing the extent to which they believe in sustainability and protecting the environment, and their desire to achieve energy security in the long term for future generations. The answers to the questions regarding user behaviour and electricity consumption highlighted positive moves towards saving energy and reducing pollution by using power-saving electric controllers and the desire to use electric cars in the future. However, there is also evidence of a lack of infrastructure to support this desire, notably local charging stations for electric vehicles.

While the overall results of the analysis revealed that 75.7% of respondents were characterised as showing high to moderate levels of energy conservation, the remaining 24.3% indicate the need to raise levels of consumer efficiency and improve consumption behaviour, ideally via more awareness campaigns by the Kuwaiti government. As the analysis indicates, the majority of participants (65.8%) do not use power-saving controllers, and the use of electric cars is limited due to the lack of charging stations. This shows the need for improved infrastructure to support the use of electric cars, which should help to reduce pollution.

In relation to financial issues, 60.9% of participants indicated that electrical bills constitute a financial burden on them. This indicates the close link between income and affordability, which could influence people's consumption behaviour. Another factor which could play an important role in promoting energy efficiency is the inconvenience created by the programmed electricity cut-off periods in the summer when energy demand due to air conditioning exceeds the power generation capacity; 74% of participants reported this as negatively affecting their daily lives. While it could be argued that people's individual behaviour is a key issue in saving energy, there is scope for the Kuwaiti government to do more to promote the optimal use of electrical energy and enhance energy saving as 48.2% of respondents were dissatisfied with its role in this area.

11.2.2 Attitudes Towards Renewable Energy

When asked about the best renewable energy to invest in, 87.5% of participants chose solar energy due to its widespread availability in Kuwait. While a small proportion of respondents currently use PV solar panels in desert camping facilities, a high majority of participants (86.7%) believe that householders must begin to use renewable energy technologies in their homes. There is also a strong desire for greater government support to encourage renewable energy use. The results show that 91% of people believe that official (or government) organisations should support citizens who use renewable energy in their homes by, for example, providing financial benefits including reduced electricity bills or feed-in-tariffs. This would be an obvious way to address the concerns of the 64.7% of respondents who believe that renewable energy technology is still expensive.

Equally, almost half the respondents (47.6%) believe the performance of official organisations in raising awareness about the benefits of renewable energy for the community is weak; hence more efforts are needed from the government and other organisations to promote renewable energy use. This would address the problem identified via the questionnaire which showed that participants' awareness and knowledge of the advantages and challenges associated with renewable energy is still at a modest level. In addition, 96% of participants agree or strongly agree that it is important for official organisations in Kuwait to move towards enhancing the portfolio of renewable energy projects instead of relying on traditional power plants. This is supported by the finding that 78.7% of people believe that renewable energy technologies are not widely distributed in the domestic market in Kuwait.

11.2.3 Conclusions Drawn from the Public Questionnaire

Kuwait is rich in solar and wind energy, and that energy could be utilised to meet a high percentage of Kuwait's energy demand. The analysis of the results of this questionnaire has shown that both Kuwaitis and non-Kuwaitis are keen to utilise renewable energy to enhance sustainability in the country. In general, it is evident that education brings a more positive attitude towards sustainability and renewable energy and age also has a positive influence; perhaps this could be related to maturity and a better appreciation of the need to provide for future generations. Financial considerations also play a role. People who live in their own house have the highest sustainability awareness; this could be due to the cost of electricity required in a big house with many rooms, as is standard in extended, multi-generational family homes in Kuwait. When a dwelling is smaller, as in the case of rented flats, then energy costs may be cheaper, or included within the rent, hence the financial drive is less significant. Nationality was not found to be significant in people's behaviour (when Kuwaitis were compared with non-Kuwaitis), but male respondents were found to have slightly better energy efficiency awareness and conservation behaviour than female respondents. This might be related to the culture of who pay the bills, as in Kuwait, as in most

Arab countries, home bills are culturally the responsibility of the male spouse, and this could explain this trend. This, again, emphasises the financial and economic aspects and their relationship to sustainability.

It is clear that there is a need to provide greater support to enable people to improve their energy efficiency and make greater use of renewable resources. For example, a high proportion of participants (41.4%) leave their air conditioning systems on when they are not at home. While this may appear wasteful, it may be related to poor insulation of houses, meaning the interiors become excessively warm if the air conditioning is switched off in the summer months, causing damage to the décor and meaning it takes a long time for the indoor temperature to return to a normal level. As air-conditioning accounts for a significant proportion of energy demand in Kuwait, this suggests that subsidised provision of thermal insulation could play a significant role in reducing energy consumption. Equally, only 58% of people are interested in using electric cars despite the fact that almost three-quarters (74.6%) believe electric cars are better for the environment. This could be due to the initial higher costs and the lack of local maintenance and support facilities. While some countries have reduced tax on electric cars to stimulate demand, Kuwait enjoys a low tax economy and fuel is subsidised, so there is currently no financial advantage in adopting electric technology. There is also a lack of information about electric cars.

The same is true of renewable energy: knowledge and awareness of its benefits are not widespread and usage by Kuwaitis and non-Kuwaitis is still limited, occurring mainly in desert camps and farms rather than residential dwellings and driven mainly by being away from the grid, rather than other factors. Word-of-mouth is a very important way to influence consumer behaviour in Kuwait; therefore, the government should promote energy saving and renewable energy through awareness campaigns and by taking steps to provide physical infrastructure and financial incentives to enable people to experience the benefits of using renewable energy at first hand. If they then provide positive feedback on the technology, their families, friends and colleagues are more likely to adopt them, and this will have a ripple effect throughout the general population.

11.3 Findings of the Academic and Educational Organisations and Official Organisations Questionnaires

These questionnaires provided a wealth of data to draw on in answering the research questions. As with the ‘Public Questionnaire’, the discussion here focuses on the attitude and behaviour of the participants towards sustainable energy consumption and their attitude towards renewable energy.

11.3.1 Attitudes and Behaviour Regarding Sustainability and Energy Efficiency

The results of the questionnaires show that a majority of respondents have a positive attitude toward the preservation of the environment in Kuwait, with 69% of officials and stakeholders and 66.7% of academics agreeing on the need to promote renewable energy use to reduce environmental pollution and provide energy security for future generations. The current and future energy security results indicate the willingness and ability of educational and official agencies to promote sustainability in Kuwait through environmental conservation and renewable energy use.

As for energy consumption behaviour, the overall results of the analysis show that three-quarters of academic participants had moderate or low levels of user efficiency while a similar proportion of officials and stakeholders were low or moderate efficiency users. These results point to the need for organisations to provide infrastructure to facilitate behaviour which will support more sustainable consumption. For example, although a majority of respondents think that electric cars contribute to reducing pollution, most organisations do not use them, nor do they provide charging points to encourage their adoption. In addition, few organisations currently use energy-saving devices in their facilities, indicating that significant reductions in consumption could be achieved if their use was mandated in educational and official buildings. This would also help to solve the problem of electrical power wastage. The use of thermal insulation was also highlighted, with 34.3% of academic participants stating that their institutions did not use thermal insulation while 45.3% of the official and stakeholder participants said theirs did. This may be due to the fact that all governmental institutions, including educational institutions, must now incorporate thermal insulation into their buildings to increase their energy efficiency. Institutional buildings in Kuwait tend to be large and heavily dependent on air conditioning, especially in the summer, so the requirement to incorporate thermal insulation is a welcome move; however, extending it to cover a greater range of buildings could further reduce electricity consumption.

Nor should the importance of educating individuals and communities be neglected. As with the Public Questionnaire, these findings suggest there may be a need to increase levels of efficiency and enhance consumer behaviour by intensifying campaigns to raise awareness of electricity consumption and energy conservation, notably in official, academic and educational institutions. Educators can play an important role here, and three-quarters of the academic respondents reported that their institutions took steps to raise awareness of the need to rationalise electricity consumption among employees and students. However, almost 70% of them thought that their institutions' role in raising awareness about energy use in society was not sufficient. Equally, almost 40% of officials and stakeholders stated that their organisations were not concerned about increasing energy consumption awareness among their employees, and more than 70% described their institutions' roles in this respect as weak. In addition, a majority of officials and stakeholders participants reported that their organisations did not play an effective role in raising society's awareness of the need to rationalise electricity consumption. These findings may indicate that official authorities, notably the Ministry of Electricity and Water of Kuwait (MEW), should take an active role in raising awareness of energy conservation, as reducing pollution resulting from excessive energy consumption would be in the public interest.

11.3.2 Attitudes and Behaviour Regarding Renewable Energy

Both academic and official and stakeholder respondents expressed positive attitudes towards renewable energy, with just 1.9% of academics and 0.9% of officials and stakeholders stating that they thought it was useless. When asked to select the most significant advantages associated with renewable energy, they chose environmental conservation, promoting the national economy, contributing to the conservation of oil resources by reducing their consumption, and creating jobs. The analysis here indicates that levels of knowledge and awareness of the advantages, disadvantages, and challenges associated with renewable energy are higher among academics than the official and stakeholder respondents. This was to be expected, and indicates that these results are real and reliable, but it also suggests that greater interchange between educational, official, and stakeholder organisations may be required to strengthen the renewable energy portfolio in Kuwait.

While the overwhelming majority of respondents identified solar energy as the most appropriate renewable source for Kuwait due to its geography and climate, the results show that few educational buildings or official agencies use renewable energy technologies, despite having vast surface areas that could be used for photovoltaic panels to generate electricity. Equally, most participants stated that their institutions do not use renewable technologies, even in desert facilities. While respondents acknowledged that this may be difficult in some cases, the majority felt that it was important that organisations began to initiate the use of renewable energy in their buildings. They further agreed that the government could support them in these efforts by connecting them to the national electrical network.

There was also agreement across both sets of respondents that the community in Kuwait needed to increase its awareness of renewable energy, and that their organisations have a role to play in this. However, the analysis here suggests that the role played by both academic and official organisations must be stronger in future, as this is a key element in increasing knowledge and awareness of the advantages and benefits to be gained by using renewable energy sources.

11.4 Findings from the Interviews

The interviews with experts, officials and stakeholders addressed the role of the government and private entities in promoting public awareness of energy efficiency and developing the renewable energy sector in Kuwait. They focused in particular on the government's target of 15% renewable energy by 2030, and the serious obstacles which must be overcome if this is to be realised.

The findings reveal that the emergence of environmental consciousness in Kuwait originates from a realization that RE has the potential to provide both ecological and economic benefits. The possibility of benefitting from greater international cooperation on environmental issues is also appealing to the country. The government of Kuwait has set itself an ambitious target to achieve 15% of renewable energy by 2030, and is implementing strategies to promote consumer awareness, to adopt the right RE mix, to promote the quality of technical education in the country, to improve energy efficiency, and to activate the use of electric cars. These measures are intended to lay down the foundation for optimal RE utilisation as well as enhancing the ability of the country to achieve self-sufficiency in implementing RE technologies. However, as the interviewees make clear, these measures face numerous political, structural, administrative and technical challenges.

In the process of promoting RE adoption, it is apparent that the roles of institutions differ based on whether they are affiliated to the government or private entities. On the government side, there are measures to increase consumer awareness through media campaigns and other strategies, but the perception among the majority of interviewees is that these have been largely ineffective. The government has also mandated changes to certain practices to promote the adoption of RETs, notably the use of RE to provide street lighting in residential areas. However, the aims of these measures have not been fully realised due to the failure to involve citizens. Among the private entities, the measures taken to increase awareness can be attributed to the potential profits that arise from the marketability of the products and services they offer. This is partly due to organizational goals, but also because the participation of the private sector in Kuwait's renewable energy project is largely restricted to the provision of RE to the citizens.

In order to achieve the 2030 target, the country has invested in several projects to generate RE, primarily at the Al-Shagaya project, and there are limited investments in the production of RE technologies. However, most interviewees consider that the government is in a precarious position in terms of achieving the 15% RES goal. The economic viability of RE is still a major challenge, due in part to the ongoing subsidisation of fossil fuels, and this is exacerbated by over-consumption. The lack of an independent institution to regulate RE limits the attractiveness of the industry to investors and means decisions can be affected by short-term political dynamics. Finally, the country has failed to synchronise the adoption of RE with the growth in the population, leading to an increase in demand for fossil fuels, rather than achieving RE growth.

Based on an assessment of current and future scenarios, REs are viewed by most interviewees as having moderate economic viability, with elements of environmental viability. The challenges in feasibility can be attributed to a lack of awareness, as well as the fact that the country is still in its infancy in terms of implementing RE projects. However, there is a general consensus that further steps need to be taken to reduce over-consumption and enhance cost-effectiveness if the country is to achieve its 15% RE target within the next decade.

11.5 Research Question One: What is the importance of the RE, and What are the most effective strategies adopted by leading developed countries and by other Gulf states in relation to renewable energy utilisation?

One of the primary objectives of this research was to Critical understanding of RE technologies and strategies globally and in the MENA region, including Kuwait via literature review (Objective 1). Although renewable energy still suffers due to the dominance of fossil fuels, many countries are now establishing renewable energy programmes, and valuable lessons for Kuwait can be learned from their experiences. The literature review sources indicated the historical depth of renewable energy and explained the reasons behind the trend towards greater renewable energy use, including the disparity in oil prices, which has caused economic crises in some countries, and the environmental, economic and social benefits renewable energy brings (Bollert *et al.*, 2001). While a number of factors have made the wheel of renewable energy turn, perhaps the most notable are the environmental issues and climate change, which have prompted environmentalists, world leaders, and ordinary citizens to demand a move towards a renewable energy future.

The cornerstone of an effective renewable energy strategy is the selection of the most appropriate technologies, and this depends on time, place and the feasibility of investing in the right technology (IRENA, 2018a). The literature review therefore began by describing current renewable energy sources and their associated technologies and reviewing their relative advantages and disadvantages. Although several types of renewable energy are currently available, their utility varies according to their viability and potential, and the results of this research suggest that, in many regions, solar energy dominates. A majority of countries in the world benefit from high levels of solar energy, and light and heat from the sun is seen as a natural component of human life, generating high levels of social acceptance (See Chapter Three). In addition, solar energy technologies are relatively easy to use and can be deployed at the individual consumer, commercial or governmental level. The literature review further indicated that solar energy technologies, especially photovoltaics (PV), have expanded on an industrial scale, especially over the last ten years, and many countries are now adopting ‘CSP’ technology for large-scale solar power plants as it is considered a reliable technology. Wind energy is also gaining in popularity, but its availability rates vary for each country based on geographical location and climate. Nuclear energy also has a significant role to play, and nuclear power plants in the United States have already achieved 20% of energy demand (USEIA, 2020).

Perhaps the most significant impact of renewable energy utilisation is seen in the Global South. Although densely populated countries, such as China and India, are driving rising energy demand, the countries of Asia have become the most efficient in terms of using renewable energy. This can be attributed to the fact that they have embraced industrialisation and innovation in the field of renewable energy technologies, resulting in the creation of significant job opportunities (IRENA, 2017b). The use of solar energy, wind energy, and hydropower is increasing across the African continent, and Latin America has also witnessed a fundamental shift towards solar energy and wind energy. The diversity of renewable energy sources available means these countries can make optimal choices in terms of exploiting the available resources, strengthening their renewable energy portfolios and bringing economic and environmental returns, which ultimately contribute to their rise and development.

Although European countries were early pioneers in renewable energy utilisation, the EU has some of the highest rates of energy consumption and emissions in the world (Liobikien and

Butkus, 2017). As a result, many European countries have decided to take further steps to enhance their renewable energy portfolios, whether in the short-, medium- or long-term, in order to protect the environment, enhance energy security and meet international obligations in respect of climate change. The EU as a whole is moving towards a low-carbon society, or so-called 'Net Zero Emissions', by 2050, and a range of strategies are being implemented with the aim of achieving 32% renewable energy by 2030 and 55% by 2050 (Yang *et al.*, 2016a). There is tangible evidence that the EU is on track to achieve these goals, for example, between 2012 and 2013, a 13% decrease in dependence on fossil fuels (coal) was recorded along with a 0.8% increase in the use of renewable energy in the same period.

Germany in particular has achieved notable success in this area, reducing its greenhouse gas emissions by 23% between 1990 and 2010. Moreover, it has also made significant progress in using renewable energy sources to generate electric power, moving from just 3.1% of total electricity production in 1990 to 16.8% by 2010 (Klaus *et al.*, 2010a) This was achieved through concerted efforts, adherence to carefully targeted procedures, strategies and plans, and changes to German domestic policy to support and enhance renewable energy utilisation. The German government has played an effective role in providing support for renewable energy technologies, both in terms of industrialisation and innovations, and its landmark 'Renewable Energy Sources Act' (Erneuerbare-Energien-Gesetz [EEG]) created a legal framework for the growth in the share of electricity from renewable energy. Key measures taken in Germany include:

- Prioritizing network access: granting priority grid access for power from renewable energy sources (through the EEG).
- Implementing building insulation standards to increase building efficiency.
- Imposing taxes on energy.

- Promoting the deployment of high-efficiency renewable energy technologies.

Germany has claimed that it will achieve a 40% reduction in pollution rates by 2020 and 80% to 95% by 2050 and achieve 35% of energy from renewable energy sources by 2020 and 80% by 2050, The growth in renewable energy use Germany has already achieved suggests that it has a clear strategy, effective leadership, and is well-placed to achieve these goals, strengthening its renewable energy portfolio, adhering to international agreements on climate change, and reaping the economic and environmental benefits renewable energy brings.

The picture in the Middle East and North Africa (MENA) region is very different. Due to increases in population density and the architectural and civil expansion within the GCC countries, governments are now looking to develop renewable capacity as a way to safeguard energy security. However, the results of the critical literature review indicated that, despite the abundance of solar resources in the region, renewable energy still represents only 1% of total energy demand. This is due to several factors, including the dominance of oil resources in the Gulf states, the absence of effective legislative and political support for the consolidation and adoption of renewable energy, and the ongoing subsidisation of traditional energy tariffs. The MENA region has huge and potential for renewable energy, and countries have made progress in recent years to implement renewable energy projects and move towards sustainability, including the integration of energy markets via the MENA Super Grid and the development of smart cities. However, it is difficult to see how ambitious goals to boost renewable energy utilisation and enhance renewable portfolios can be realised without significant political, economic and behavioural changes backed by effective strategies, clear legislative frameworks.

In conclusion, it is clear that renewable energy is now seen as a viable alternative to fossil fuels, due to factors including the instability of global oil prices, the threat of resource depletion, concerns about pollution rates, and rising global energy demand. Although a variety of plans and strategies have been implemented across the world, the findings of the critical literature review indicated that three key factors drive the development of renewable energy utilisation:

1) Firstly, the selection of the most appropriate source of renewable energy according to geographic, economic and technological circumstances. Social acceptance must also be taken into account, as research indicates that it is often relied upon when making decisions to adopt one form of renewable energy over another.
2) Secondly, laws, legislation, and policies play a fundamental role in supporting the optimal development of renewable energy, providing comprehensive control mechanisms, assigning legal responsibility for commitments towards the implementation of strategies and plans, and ensuring goals are achieved.
3) Finally, the importance of developing the infrastructure to integrate and consolidate the use of renewable energy should not be underestimated, from charging points for electric vehicles to smart cities, as this plays a pivotal role in improving sustainability.

If Kuwait is to benefit from the experience of other countries, it would do well to examine the German experience, notably the comprehensive political and legal frameworks introduced to support the development of the country’s renewable energy portfolio. In addition, it should make use of the Asian experience regarding the exploitation of renewable energy to create job opportunities, thereby strengthening the national economy and promoting renewable energy as a valuable asset which contributes to the public good.

11.6 Research Question Two: What role could renewable energy play in meeting current and future energy demand in Kuwait?

The State of Kuwait appears to enjoy a strategic geographic location and a suitable climate for investment in renewable energy. High temperatures, clear skies, large tracts of uninhabited land, and a long coastline, with several marine islands, offer considerable scope for large-scale renewable energy projects, and solar, wind and wave energy technologies are already in use in the country. However, in order to assess the potential of renewable energy in the country, this study set out to achieve four specific objectives:

1. Assess the current and future situation relating to energy supply, demand, consumption and consumer efficiency of electricity consumption in Kuwait (Objective 2).
2. Investigate the viability of renewable energy utilisation in Kuwait and evaluate the effectiveness of current and future renewable energy projects (Objective 3).
3. Evaluate the levels of awareness, orientation and attitudes towards renewable energy utilisation and environmental issues among the general public, public officials, and key players in the renewable energy sector in Kuwait (Objective 4).
4. Identify barriers and obstacles facing the renewable energy sector in Kuwait and formulate a set of actionable solutions based on best practice for use by Kuwait legislators (Objective 5).

In terms of energy supply and demand, findings from the critical literature review, the questionnaires, and the interviews with experts, policy-makers and stakeholders indicate that the State of Kuwait is currently struggling to meet rapidly rising demand. Although the country has advanced power plants to meet its traditional energy supply needs, demand sometimes outstrips supply in the summer season, leading to programmed electricity cut-offs in some residential areas due to increased peak loads. The Ministry of Electricity and Water (MEW) has worked to secure the development of power stations to raise their production capacity, but energy demand continues to increase, due in part to wasteful energy consumption behaviour, the annual increase in population density, and the architectural and civic expansion in Kuwait.

Analysis of MEW's annual statistical reports indicated that demand is growing rapidly, with annual electrical demand jumping from 9070 MW in 2007 to 13,800 MW in 2017 (MEW, 2018b), and forecast to be 15, 063 MW by 2026 (MEW, 2019). The per capita share of electricity in Kuwait is also reported to be amongst the highest in the world, at an estimated 8.9 metric tonnes of oil per year. By contrast, the per capita share in the countries of the MENA region is estimated at 4.1 metric tonnes of oil per year. This high demand for energy is attributed to several reasons, including government subsidies for conventional energy, a lack of energy efficiency awareness among consumers, and a lack of effective measures to rationalise electricity consumption. Such measures could include mandating the use of energy-saving devices and requiring buildings to meet minimum efficiency standards in order to conserve energy.

With regard to the renewable energy sector in Kuwait, the literature review indicated that, despite its vast oil resources, the country was one of the first in the MENA region to research the possibility of benefiting from renewable energy. The pioneering Kuwait Institute for Scientific Research (KISR) was established in 1979 and the country inaugurated its first thermal power plant in Sulaibiyah, with capacity 100 KWh of electricity generation, in the same year (KISR, 2016). However, the operating life of the plant was short, and it closed in 1986, having failed to compete with energy produced from fossil fuels due to the high prices of renewable energy technologies at the time in addition to the operational costs. Although the costs associated with renewable energy have fallen considerably in the subsequent decades, the portfolio of renewable energy projects is still weak compared to projects based on fossil fuels, even though they are considered the main cause of environmental pollution.

The weakness of the renewable energy portfolio now threatens to place Kuwait in an embarrassing position in the face of its obligations under international agreements and cooperation treaties on promoting the use of renewable energy and environmental sustainability, As a result, although oil continues to be the cornerstone of the Kuwaiti economy, there are more opportunities to invest in renewable energy at the present time than there have been for many years. Given the economic risks caused by the instability of oil prices, the need to preserve dwindling oil reserves, and international commitments to reduce CO_2 emissions, the country is now looking to deploy low cost renewable energy technologies and explore the feasibility of investing in their development. With appropriate strategies in place to exploit the huge potential of solar energy and the other renewable sources in the country, it is possible for the State of Kuwait to become a regional pioneer in the field of renewable energy once again.

The government of Kuwait has committed itself to the goal of achieving 15% of energy from renewable sources by 2030, but the findings of this study suggest that it is unlikely to achieve this ambitious target without significantly expanding renewable energy production. The country has invested in several RE projects, primarily the Al-Shagaya project, and made some investment in the production of RE technologies; however, progress is still slow in terms of implementing renewable energy projects, and the total estimated outcomes for the renewable energy portfolio until 2020 are meagre by comparison with those of conventional power stations, with just 70 MW expected from the flagship Al-Shagaya project (as opposed to 19,353 MW from conventional sources). Based on this, it has become critical for the Kuwait government and the private sector to work together in order to strengthen the renewable energy sector and help the country compete on the regional and global renewable energy market. This study found that there is significant popular support for greater investment in renewable energy projects, with 96% of respondents to the ‘Public Questionnaire’ agreeing or strongly agreeing that it is important for official organisations in Kuwait to move towards renewable energy projects instead of relying on traditional power plants. Yet the interviews revealed that the participation of the private sector in Kuwait’s renewable energy projects is largely confined to the direct provision of RE to the citizens, and the lack of an independent regulatory institution limits the attractiveness of the RE industry to investors as decisions can be influenced by short-term political dynamics.

It is worth noting that the State of Kuwait has experienced bodies for political decision-making regarding development projects, notably the General Secretariat of the Supreme Council for Planning and Development (GSSCPD), and support studies and research on the feasibility of development projects is provided by KISR and other scientific research organisations. Furthermore, in 2018 the Kuwait Council of Ministers established a Higher Energy Committee to act as the government’s national champion and advocate for the renewable energy sector. However, this is primarily a coordination committee between central, regional and local government agencies with limited responsibility, and the findings of this research indicate that it may not meet the requirements for comprehensive management of renewable energy affairs. Many countries, including some in the MENA region, have sought to create a competent unified authority to manage their energy portfolio and projects; however, this study suggests that Kuwait would be better served by establishing an independent authority rather than a Department for Renewable Energy Affairs. One of the most important benefits of establishing such an authority would be the elimination of the conflict of competencies which currently arises, and the clear allocation of responsibilities. This would also facilitate greater flexibility in decision-making related to renewable energy policy and enhance cooperation and coordination between government organisations, research institutes, and the private sector in order to enhance the renewable energy portfolio and establish best practices to achieve the desired 15% renewable energy goal by 2030.

Another significant obstacle identified in this study is the lack of energy efficient behaviour and renewable energy awareness among the population in Kuwait. If renewable energy is to have a viable future in the country, much greater steps must be taken to reduce levels of demand due to wasteful consumption and to encourage people to use renewable energy in place of fossil fuels. This will require contributions from both the government and the private sector in terms of promoting awareness, providing infrastructure, and introducing and enforcing legislation. Among the government entities interviewed, for example, few have measures in place to raise energy awareness through public information programmes. This is why the government should publicise and use a comprehensive and diverse set of informational and educational tools to raise awareness of energy consumption and renewable energy utilisation within the Kuwaiti community. Measures mandating the use of energy-saving devices, the provision of infrastructure to support electric vehicles, and an extension of legislation to oblige buildings to meet minimum energy standards, notably by fitting thermal insulation, would also help to reduce energy demand in the residential and commercial sector. Although MEW has taken steps to revise and develop regulations and procedures to enhance the efficiency of residential and industrial buildings, this study suggests these currently have limited impact beyond the government sector. The government should also mandate changes to certain practices to promote the adoption of RETs, specifically the use of REs in residential areas. However, as this study has found, it is essential to involve and motivate citizens and provide ongoing maintenance support in order to ensure the success of such measures.

Among the private entities, the results of the interviews indicated that they are not currently involved with the government in intensifying public awareness-raising campaigns, and few take steps to encourage their own employees to exercise energy efficiency in their homes or workplaces. As their capacity to participate would vary based on the available resources and their own organisational goals, the government should invest in the private sector to support it to achieve increased awareness, both in terms of energy efficiency and renewable energy use. This would be particularly useful for private sector companies where measures taken to increase awareness can typically be attributed to the potential profits that arise from the marketability of the products and services they offer.

Kuwait aspires to achieve 15% of renewable energy by 2030. Its geographic location and the availability of land which could be used for large-scale energy projects indicates that renewable energy sources, notably solar energy, have the potential to make a significant contribution to meeting future energy needs. However, the findings of this study suggest that the government is in a precarious position in relation to its 2030 goal ; the country currently generates less than 1% of energy generation from renewable sources, and significant steps will need to be taken to overcome the obstacles identified here. The lack of awareness of renewable energy in Kuwait, the absence of effective legislation to mandate its utilisation, the slow pace of project implementation, and the limited role of the Higher Energy Committee indicate that the country urgently needs both a clear and comprehensive strategy for renewable energy development and a unified organisation with full responsibility for its implementation if the 15% target is to be achieved. While it is beyond the scope of this study to formulate detailed government policy, a set of actionable solutions to address the barriers to greater renewable energy utilisation, based on best practice, is presented in 11.8 below and in the Recommendations for Kuwaiti legislators in Chapter 12.

11.7 Research Question Three: Do the strengths, weaknesses, opportunities, and threats relating to solar energy in Kuwait make it a viable alternative to energy derived from fossil fuels?

Kuwait has high levels of solar irradiation across the year due to its geographic location and climatic conditions, and as the questionnaires demonstrated, there is a strong preference for solar energy in the country with 87.5% of participants selecting it as the most appropriate option for investment. In addition, solar energy technologies are relatively easy to use and can be deployed at all levels, from the individual consumer through to commercial or government-level deployment. Production of these technologies, notably photovoltaics (PV), has expanded significantly in recent years, and many countries now use 'CSP' technology for large-scale solar power plants due to its reliability. Kuwait appears to be well-placed to exploit the huge potential of solar energy; however, the SWOT analysis of the solar energy sector in the country conducted for this study revealed a more complex picture.

Table 11-1 provides a summary of the Strengths, Weaknesses, Opportunities and Threats identified via the analysis. The strengths reflect those common to most renewable sources in terms of ecological and social sustainability, but solar energy was also found to be economically sustainable in the long run, not least because of its widespread availability. This presents a number of opportunities for Kuwait, including developing its technological capacity, enhancing generation and connection models, moving away from fossil fuels to more sustainable energy models, and exporting both energy and expertise to neighbouring countries.

Table 11-1: SWOT Outcomes for Solar Energy in Kuwait

Strengths	Weaknesses
• Ecologically sustainable energy. • Socially sustainable energy. • Economically sustainable in the long run. • An alternative to fossil fuels. • High solar energy potential due to climatic and weather patterns.	• High initial and maintenance costs. • Flat learning curve. • Variations in productivity between peak and off-peak periods. • Preference for combined renewable energy systems. • Limited technological development in Kuwait.
Opportunities	**Threats**
• Developing new technologies. • Adopting sustainable energy models. • Exporting solar energy to neighbouring countries. • Introducing distributed generation. • Developing grid-connected PV systems.	• Rapid changes in solar energy technologies. • Lack of government policies.

However, as Table 11-1 demonstrates, the analysis reveals more weaknesses than strengths and the threats to the viability of solar energy in Kuwait are significant. Although the cost of solar technology has decreased considerably over time, high initial costs are one of the primary factors limiting investment in solar energy, especially when storage is included. Variations in productivity between peak and off-peak periods also present a problem given that efficient storage mechanisms are still expensive. This leads to a preference for combined renewable energy systems, and while this provides continuity of production, it limits the potential for cost-saving, as economies of scale typically outweigh those of scope with renewable energy technologies. Another significant issue is the flat learning curve in relation to solar energy and other renewable energy sources. This is due in part to the slow pace of renewable project implementation, which means that energy demand and technologies have often changed by the time a project is complete, but is also influenced by the widespread lack of knowledge and awareness. Due to limited educational opportunities, the local population lacks technical knowledge and skills relating to solar energy utilisation and has little awareness of the importance of conserving energy. While foreign expertise can be acquired, there is a need to develop academic and professional training programmes that will raise awareness across the social structures and establish a culture of responsible energy use among the citizens.

If nothing is done to improve energy efficiency and curb wasteful usage, any measures to introduce more solar energy into the energy portfolio are unlikely to address the emerging energy crisis in the country. One of the reasons these challenges have permeated Kuwaiti society is the lack of specific programmes to regulate energy usage, and this is symptomatic of the wider absence of legislation necessary to implement an energy policy built around renewable sources. The country currently lacks the necessary infrastructure for the utilisation of renewable energy and the frameworks required to implement effective renewable energy policies. This is due in part to the fact that the solar energy sector is still underdeveloped, both in Kuwait and within the region, but urgent action is required if the country is to meet its target of 15% renewable energy by 2030. The introduction of targeted government policies, for example, could reduce the high costs associated with solar energy by establishing a market for solar energy products and laying the foundations for government assistance in the form of subsidies and other incentives. The creation of a dedicated agency to develop strategies for renewable energy would also be a key milestone. While KISR plays the role of the research agency for technologies and projects on renewable energy, and the

Higher Energy Committee acts as national champion, neither possess the mandate to create legal or policy frameworks, and this limits the viability of solar energy production in Kuwait.

As this analysis demonstrates, the solar industry in Kuwait faces significant technical, political and economic challenges to achieving viability, especially in the short-term. However, in the face of dwindling oil resources, energy shortages, the pressure to meet international climate commitments, and increasing concerns about pollution in the country, the promise of unlimited, sustainable energy from the sun is one worth pursuing. If Kuwait can implement an effective renewable energy strategy which takes account of local conditions, it could resume its pioneering role and spread solar energy resources and technologies across the rest of the GCC and the wider MENA region.

11.8 Research Question Four: What are the key ingredients required to implement an effective strategy for renewable energy utilisation in Kuwait?

The overarching aim of this study was to contribute to the successful deployment of renewable energy in Kuwait. To this end, it has examined the renewable energy sector in the country in detail and identified a number of obstacles which currently limit its viability; these include a widespread lack of renewable energy awareness; excessive demand due to wasteful consumption; limited private sector engagement; and, most significantly, the lack of adequate political and legislative frameworks. In order to ensure that the study made a meaningful contribution to addressing the issues identified, the following objectives were established:

- Develop a policy framework to support renewable energy investment and a set of recommendations to help policymakers in Kuwait develop efficient renewable energy strategies and programmes (Objective 6).

- Propose a medium- and long-term strategy (for 2030 and 2050) for renewable energy utilisation in Kuwait (Objective 7).

Drawing on the findings of the literature review chapters, the analysis of the questionnaires and interviews, and the SWOT analysis, this study proposes a national policy framework for renewable energy utilisation in Kuwait and a model to promote renewable energy investment in the country. It also outlines two strategies for the development of renewable energy in Kuwait targeting 2030 and 2050 respectively and suggests a set of recommendations for policy-makers. The policy framework, investment model and strategies are set out below while the recommendations are proposed in Chapter 12. These are intended as a contribution and support to the legislators and policy-makers in the Kuwaiti government.

11.8.1 Proposed National Policy Framework for Renewable Energy in Kuwait

One of the main contributions of this study is the proposal of a National Policy Framework for Renewable Energy for policy-makers in the Kuwait Government. This arises from the outcomes of the literature review, and the questionnaires and interviews, and has the central objective of identifying the legislation required to strengthen the renewable energy sector in Kuwait and support the implementation of effective renewable energy strategies. The proposed framework focuses on two main issues, namely energy demand and consumer efficiency on the one hand, and renewable energy utilisation on the other hand, and aims to increase knowledge and awareness about renewable energy utilisation at the individual and governmental levels. The framework and recommendations (See Chapter 12) are intended to facilitate the implementation of the strategies for renewable energy development for 2030 and 2050 set out below.

The framework proposes four major areas in which legislation should be enacted and assigns roles and responsibilities in order to eliminate the issue of conflict of jurisdiction which currently hinders renewable energy development in the country. The four areas targeted for policy and legislation are: a) increasing awareness about energy consumption and renewable energy utilisation; b) monitoring and evaluating systems to improve user efficiency and encourage renewable energy use; c) introducing rewards and subsidies to promote energy efficiency and renewable energy utilisation; d) boosting the portfolio of renewable energy projects (See Figure 11-1). These are discussed in more detail below.

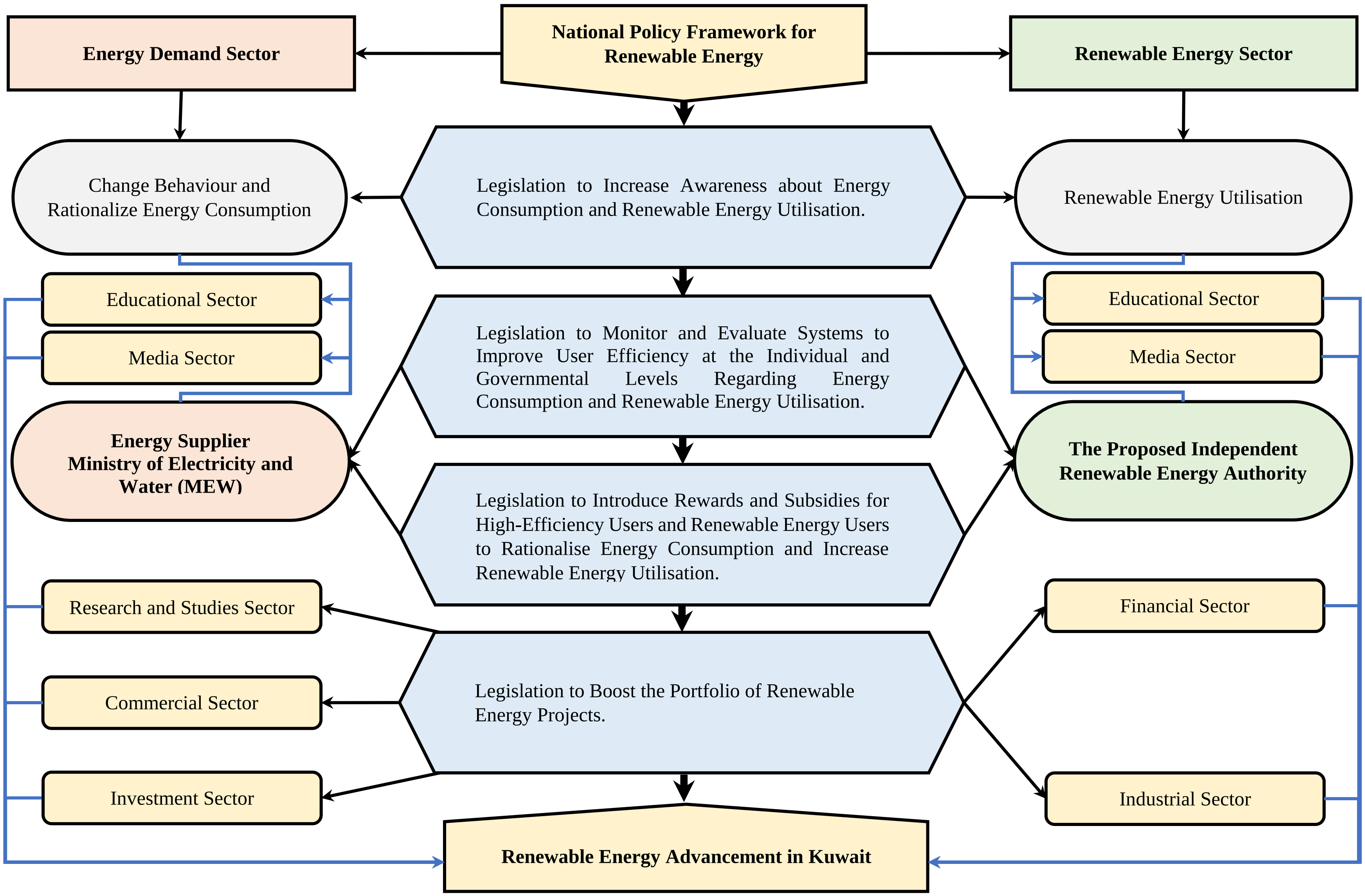


Figure 11-1: National Policy Framework for Renewable Energy (Source: Created by the Author)

The first area is concerned with the enactment of policy and laws designed to increase awareness of the need to rationalise energy consumption and promote renewable energy use. Roles related to raising awareness are assigned to the education sector, through educational and academic institutions, and the media sector, via television, radio channels, official newspapers and social media, in cooperation with the Ministry of Electricity and Water (MEW) and the proposed independent renewable energy authority. The second is concerned with monitoring and evaluating the effectiveness of systems to improve consumer efficiency and encourage the use of renewable energy at the individual and governmental levels. Responsibility for this is assigned to the relevant authorities in the MEW and the proposed independent authority.

The third area concerns the provision of rewards and incentives to promote consumer efficiency and reward renewable energy use, including the use of subsidies to reduce electricity tariffs for efficient users, and those who opt for renewable energy, and to mitigate the high set-up costs associated with renewable energy technologies. This would support the energy supply sector and enable MEW to meet demand more easily by reducing over-consumption. Responsibility for this is assigned to MEW and the proposed Independent Renewable Energy Authority.

The fourth and final area complements the others and addresses the urgent need to enhance the portfolio of renewable energy projects. It allocates roles to a range of relevant public and private sectors in order to strengthen the renewable energy portfolio in Kuwait and keep pace with the global energy market. These include the ‘research and studies’ sector, in order to provide feasibility studies for projects and research related to renewable energy and technology, the 'commercial’ sector, which includes private companies, to provide marketing and consultancy specialising in renewable energy, and the ‘investment’ sector, which is central to promoting the renewable energy portfolio through direct investment by local and foreign investors. Enhancing laws to guarantee the right to participate by all and the rights of profit and contracting would increase investor confidence, leading to greater investment in renewable energy projects. Equally, engaging the banking sector would also support local and international investors by providing specialist financial facilities for renewable energy investment, thereby strengthening the renewable energy market in Kuwait. However, perhaps the most significant aspect of this element is its involvement of the industrial sector, which could play a vital role in strengthening the renewable energy portfolio in terms of establishing factories to produce renewable energy technologies, creating job opportunities, and strengthening the national economy.

It is worth noting that the proposed national policy framework is premised on the establishment of an independent renewable energy authority with the authority to implement, monitor and manage renewable energy projects, and to oversee the activities of the aforementioned sectors. It also relies on MEW to feed the energy generated from renewables into the national grid for onward distribution. Along with the model for renewable energy investment described below, this proposed framework could ultimately strengthen the renewable energy portfolio in Kuwait, contributing to economic growth, environmental improvement, and enhancing energy security.

11.8.2 Proposed Energy Strategies for 2030 and 2050

Drawing from the SWOT and TOWS matrix discussed in Chapter Ten and the findings from the questionnaires and interviews, this study proposes two strategies for the development of renewable energy in Kuwait to be achieved by 2030 and 2050 respectively. Based on the investment timelines, the 2030 propositions are considered as short-term goals while the 2050 goals are considered in the long term. This is because the development of renewable energies requires considerable planning, and implementation periods in Kuwait are longer than would be desired, due to a number of factors, including the flat learning curve (See 10.5.2.2). Implementation of these strategies will be supported by the policy framework and investment model set out above.

11.8.2.1 Renewable Energy Strategies for 2030

- **Develop the necessary policies and legal frameworks**: These should include energy efficiency policies, as well as the mandates for on-site generation of renewable energy (specifically solar energy) in both households and commercial premises. The development of policies is dependent on political goodwill and the ability to justify the inclusion of renewable energy sources in the energy portfolio. A number of concerns about the presence of political goodwill in Kuwait arise, especially as the viability of renewable energy is predicated on changes to existing energy policies, notably those related to subsidies. The attractiveness of the fossil fuel subsidies currently in place, as well as the potential adverse outcomes presents a challenge to political goodwill towards renewable energy sources.
- **Develop the infrastructure for renewable energy sites and farms**: This is an essential step in expanding renewable energy production. It includes the development of roads and communication systems to the sites where installations will be situated as well as mechanisms for distribution of energy from them. It also includes installation of the foundations for renewable energy systems; in the case of solar farms, bases to hold the energy capture mechanisms can be constructed, since the solar panels can be installed later or changed as newer technologies emerge.
- **Set aside capital resources to acquire the necessary resources**: The government and private sector need to determine the risks and return profiles for the investments in order to establish the most viable way to supply the necessary capital. This includes determining the potential returns in terms of net present values and payback periods in order to decide

whether to invest through debt or equity capital. The government will also need to consider whether to rely on domestic capital or to seek external financing for the projects.

11.8.2.2 Renewable Energy Strategies for 2050

- **Invest in the production of renewable energy components, such as solar panels and storage mechanisms**: By investing in the capital and human resources required for the production of renewable energy capture mechanisms, Kuwait can create customised technologies that can be used domestically and exported to neighbouring countries.
- **Diversify renewable energy sources to include wave and wind energy**: The viability of solar energy in Kuwait has led to a marked preference for this type of renewable energy. However, it is necessary to diversify the range of energy sources in order to maximise productivity and efficiency and bridge some of the gaps between peak and off-peak productivity, both on a day-to-day and month-to-month basis.

11.9 Summary

This chapter has discussed the data gathered for this study in light of the research objectives in order to answer the research questions. It has drawn out the key finding from the literature review, the questionnaires and interviews, and the SWOT analysis, and used them to create a national policy framework for renewable energy, a model for renewable energy investment in Kuwait and two proposed renewable energy strategies, targeting 2030 and 2050 respectively. The next chapter concludes by providing a set of recommendations for policy makers, considering the limitations of the study, and outlining possible avenues for further study.

Chapter 12

Conclusion, Recommendations and Further Research

12.1 Introduction

This chapter concludes the study by providing an overview of each chapter and summarising its findings. It goes on to propose a set of recommendations for policymakers to promote the renewable energy sector and enhance sustainability in Kuwait and then sets out the study's contribution to knowledge. The final section describes the limitations of the study and suggests possible avenues for further research.

12.2 Thesis Overview

This study aimed to examine current and future energy demand in Kuwait and suggest strategies to enhance renewable energy utilisation in the medium and long-term. Chapter 1 provided geographic and demographic information about Kuwait, explained the research motivation, defined the research problem, set out the research aim and objectives, and introduced the research questions. It also introduced the methodology of the study and described the key elements of the research process. This was elaborated on in Chapter 6 which explained the philosophy behind the research, the target samples for the study, the research instruments used, the analysis methods adopted, and the ethical considerations addressed.

The literature review section began by providing an overview of the renewable energy sources currently available, and their associated technologies, and described their characteristics and the advantages and disadvantages associated with them (Chapter 2). It then examined energy demand and renewable energy strategies across the globe, with a particular focus on the MENA region, in order to identify examples of best practice which might be applied within the Kuwaiti context (Chapters 3 and 4). It found that selection of the optimal renewable energy source, social acceptance, legislation and policies for the use of renewable energy, and the creation of essential infrastructure were key to successful renewable energy implementation, and highlighted Germany as a model of good practice. It also identified a number of outcomes required to develop renewable energy utilisation effectively on the global scale. Within the MENA context, it considered the role of renewable energy in a region dominated by fossil fuels and the need to raise public awareness of renewable energy use and develop a knowledge economy. It found that positive steps had been taken to integrate regional energy markets, to reward domestic energy producers, to create renewable energy infrastructure, and to develop knowledge-based economies. However, it concluded that further strategic support was required to liberalise energy markets and end market-distorting subsidies on oil and gas.

The study then focussed on energy demand and renewable energy utilisation in the State of Kuwait. Chapter 5 set out current energy usage and capacity in the country and considered how renewables could be developed to meet future demand, with a particular focus on the policies in place to support renewable energy production. It found that, despite positive measures to facilitate foreign investment and introduce a national renewable energy champion, current energy policies, notably fossil fuel subsidies, hamper efforts to expand the renewable energy sector, and concluded that an overhaul of policies, institutional frameworks, and a change in culture would be required for the country to meet its target of generating 15% of energy from renewables by 2030.

As this study is concerned with investigating the renewable energy sector in Kuwait, Chapters 7 and 8 explored attitudes towards energy consumption, consumer efficiency, and renewable energy utilisation in the country. Analysis of the data gathered via questionnaires targeting members of the general public, energy experts, public officials and other stakeholders, revealed a desire to utilise renewable energy to enhance sustainability in the country and a strong preference for solar energy. However, it also identified a number of obstacles to the development of renewable energy, including low levels of energy efficiency, insufficient knowledge and awareness about renewable energy, and a lack of infrastructure to enable energy consumers to make greater use of renewable resources in their daily lives.

Chapter 9 discussed the data collected through semi-structured interviews with experts, legislators and policymakers, and stakeholders with links to the renewable energy sector in Kuwait. It began by identifying the factors driving the emergence of an environmental conscience in the oil-rich state and went on to assess the roles of public and private entities in promoting energy awareness and renewable energy use. It also discussed current renewable energy projects in light of the government's 15% target, and assessed the overall viability of renewable energy in the country. It found that the move towards renewable energy is driven by economic and ecological factors, and by international commitments to reduce carbon emissions and address climate change. However, findings indicated that government measures to promote energy efficiency and renewable energy use have had limited impacts due to a lack of financial and legislative support and the failure to engage citizens. The role of the private sector is also limited, and the lack of an independent regulatory institution reduces the attractiveness of the industry to investors. This, in turn, has a negative impact on renewable energy production: greater capacity is needed to meet the 2030 target, and the government has invested in several major projects, notably Al-Shagaya, but implementation is slow, and there is little investment in the production of renewable energy technologies. Overall, significant concerns about the economic viability of renewable energy were revealed in the absence of further significant measures to regulate energy consumption, promote renewable energy use, and enhance cost-effectiveness.

As solar emerged as the preferred renewable energy source in the country, Chapter 10 provided a detailed analysis of the strengths, weaknesses, threats and opportunities associated with its utilisation in Kuwait. It found that, while the country appears to be ideally located to benefit from solar resources, the weaknesses identified outnumbered the strengths; these include high initial and maintenance costs, limited technological development, and a flat learning curve in respect of solar and other renewable sources. In light of this, the chapter set out four possible strategies to exploit the opportunities identified while reducing the risks from threats, and proposed a model for renewable energy investment to boost private investment in the sector. It concluded that Kuwait should continue to develop its solar sector due to its long-term ecological and economic benefits, including the opportunity to export renewable energy, technology and expertise to neighbouring countries.

Chapter 11 discussed the findings in light of the research objectives in order to answer the research questions. It drew on the key finding from the literature review, the questionnaires and interviews, and the SWOT analysis, to create a national policy framework for renewable energy, and two proposed renewable energy strategies, targeting 2030 and 2050 respectively. These addressed the needs identified within the study, namely, the need to promote energy efficiency and raise awareness of renewable energy, to stimulate investment, to develop renewable infrastructure and boost technological know-how, to expand production capacity, to provide effective oversight, monitoring and regulation, and to establish specific policies and legal frameworks to facilitate this. Chapter 12 concludes the study by providing actionable recommendations for policymakers and legislators in Kuwait based on empirical investigation and analysis of best practices. It also considers the limitations of the study and suggests avenues for further study.

12.3 Recommendations for Policy Makers

Based on the findings of this study, the researcher offers the following recommendations for policymakers in the Kuwaiti Government to reduce energy demand, promote the renewable energy sector, and enhance sustainability in Kuwait. Together with the proposed strategies for 2030 and 2050 and the proposed national policy framework, they fulfil the primary aim of this study.

Further government investment in renewable energy is needed to enhance sustainability in the long term. This should be used to:

1. Provide further public campaigns to promote energy efficiency and the benefits of using renewable energy, and enhance the educational curricula to increase knowledge about renewable energy at all educational levels.
2. Enhance public engagement to reduce energy consumption and eliminate the need for programmed power cut-off during the summer season.
3. Develop plans to increase renewable energy infrastructure, notably charging points for electric vehicles, in residential dwellings, and government and public facilities.
4. Invest in building insulation and energy-saving technologies to reduce energy consumption in residential and commercial settings.
5. Implement a reward programme by reducing the cost of electricity tariffs for those who achieve rationalisation in consumption beyond a specific weighted average.
6. Develop a strategy to support the capital cost of renewable energy technologies for consumers to encourage distributed urban deployment.

7. Strengthen the role of the private sector in the domestic renewable energy market and encourage external investment in Kuwait's renewable energy sector.
8. Support the industrial sector to manufacture renewable energy technologies in Kuwait.
9. Establish an independent authority for renewable energy in Kuwait.
10. Create policies and legislations to boost the production and utilisation of renewable energy in Kuwait.
11. Expand the development of other renewable sources in addition to solar and wind.

12.4 Contribution to Knowledge

This study has focuses on energy demand and renewable energy use in Kuwait with the aim of identifying the obstacles to greater utilisation and then proposing actionable solutions. By identifying the issues at stake and devising a policy framework and two renewable energy strategies, this study has contributed to knowledge in the following ways:

1. Critically reviewing relevant literature on energy demand and renewable energy utilisation strategies across the globe and in the MENA region in particular.
2. Assessing the current and future situation relating to energy supply, energy demand, and consumer efficiency in Kuwait.
3. Evaluating attitudes towards renewable energy utilisation and environmental issues among the general public, officials, and key players in the renewable energy sector in Kuwait.
4. Investigating the viability of renewable energy in Kuwait based on current and future renewable energy projects and plans.
5. Identifying and assessing the strengths, weaknesses, opportunities and threats associated with solar energy utilisation in Kuwait by means of a SWOT analysis and proposing strategies to develop the sector.

6. Identifying the obstacles facing the renewable energy sector in Kuwait and formulating a set of actionable solutions based on best practices for use by Kuwait legislators.
7. Developing a policy framework to support renewable energy utilisation and help Kuwaiti policymakers develop efficient renewable energy strategies and programmes.
8. Proposing a medium- and long-term strategy (for 2030 and 2050) for renewable energy utilisation in Kuwait.

Although this research foregrounds Kuwait, the researcher anticipates that it will also serve countries with similar cultural, geographic and demographic circumstances, notably other countries in the MENA region. At a broader level, communities across the world who aim to develop their renewable energy strategies may also benefit from this study.

12.5 Limitations of the Research

It is unrealistic to expect any study to be devoid of flaws or limitations, especially as deficiencies may be due to factors beyond the control of the researcher, or occasioned by temporal, geographic or financial restrictions. Among the most significant limitations that the researcher faced in this study were:

- This study has focused primarily on solar energy as the preferred renewable source in Kuwait, with limited coverage of other sources, notably wind, geothermal, hydropower and biofuel. This is a limitation in the scope of the research, which can be addressed in future studies.
- Limitations during the interviews stage: the researcher had hoped to collect all the interview data through face-to-face interviews as this could have helped to expand the field of research by obtaining side data during the conversation. Limitations of time and geography

meant this was not possible; however, the researcher obtained sufficient data through in-person interviews and those conducted by phone or email to answer the research questions.

- A further limitation was the inability to collect environmental data related to pollution rates from official sources and to assess the impact on public health in Kuwait. This would have provided an extra dimension to the discussion of attitudes towards preserving the environment, which was explored in the questionnaires and interviews.
- The thesis did not include statistical hypotheses as the main aspect was the fact findings and the statistical validity of the information.
- Online surveys may encourage a specific group of people to respond, unlike a face-to-face survey.
- Fact findings to understand the current situation via suitable statistical analysis methods.
- Limited hypothetical statistical analysis was needed due to the nature of the objectives

12.6 Suggestions for Further Research

In light of the findings from this study and the limitations set out above, the researcher proposes the following avenues for further study:

1. An analytical study of the cost of electricity generation from one of the renewable energy sources suitable for the State of Kuwait. Solar energy is preferred because of its widespread availability, but further research is required to calculate the payback periods compared to electricity generation from fossil fuels in order to establish the economic benefits of investing in renewable energy in Kuwait.

2. A study to identify the most appropriate solar energy technologies based on cost-performance in Kuwait for both Photovoltaic systems (PV) and Concentrated Solar Power systems (CSP).
3. A study of the environmental situation with analytical measurements of pollution rates and their impact on public health in Kuwait in order to determine the size of renewable energy projects required to reduce pollution and achieve the highest levels of air quality.
4. A survey focusing on students at all levels of the educational and academic sectors in Kuwait to measure knowledge, awareness and attitudes towards renewable energy and assess their energy consumption behaviour.
5. An exploratory study on ways to enhance the role of the private sector in renewable energy and attract foreign and local investors to invest in renewable energy production in Kuwait.

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Appendices:

Appendix I: Public Questionnaire (English version)

NOTTINGHAM
TRENT UNIVERSITY

Public Questionnaire

For Research in Renewable Energy in Kuwait

Dear participant,

This questionnaire is part of an academic study of a PhD degree entitled Investigation in A strategy of renewable energy sources utilisation in Kuwait.In this voluntary questionnaire, questions will be reviewed to get some opinions that will contribute to support the research. Please do not hesitate to express your personal opinion to answer every question without the need to include your name in order to preserve your privacy. The aim of this research is to draw a roadmap in the field of renewable energy and develop a national framework to raise the awareness level of the consumers for the renewable energy utilisation and electricity consumption.It also aims to explore the obstacles faced by the renewable energy sector in Kuwait and find solutions to these obstacles which will, in turn, contribute to the conclusion of recommendations for policymakers in the field of renewable energy in the State of Kuwait.

PhD Student: Hassan Al Fadhli
Contact: hassan.alfadhli2015@my.ntu.ac.uk
University of Nottingham Trent-United Kingdom

Your help and support much appreciated

Please read the questions carefully and choose the suitable answer.

Part One: (Personal Details)

1. Nationality:

- ○ Kuwaiti
- ○ Non-Kuwaiti

1

2. Qualification:

- ◯ PhD
- ◯ MA
- ◯ BSc
- ◯ Diploma
- ◯ High school
- ◯ Primary school

3. Gender:

- ◯ Male
- ◯ Female

4. Age:

- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65 or over

5. Occupation:

- ◯ Employee
- ◯ Student
- ◯ Retired
- ◯ Housewife
- ◯ Unemployed
- ◯ Freelancers

6. Accommodation type:

- ◯ Own accommodation (House)
- ◯ Own accommodation (Apartment)
- ◯ Rental accommodation (House)
- ◯ Rental accommodation (Apartment)

Other :

Part Two: (Background Information)

What is your opinion on following phrases :

7. We must preserve the environment and the interest of the environmental issues.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

2

8. Recently, it has become necessary to start using renewable energy sources to generate electricity instead of generating it through fossil fuel which causes air pollution.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

9. Heading towards the utilisation of the renewable energy sources is the best way to improve the environment and secure the future of the new generations.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

Part Three: (User efficiency of the electricity consumption)

10. Please answer the following questions:

	Yes	No	Sometimes	I don't know
Do you leave the lights lit during the day even though there is daylight at home?	◯	◯	◯	◯
When you are the last person to leave the place, do you switch off the lights before you leave?	◯	◯	◯	◯
Do you turn off the electricity after using the TV, computer and other devices?	◯	◯	◯	◯
Do you use LED (Energy saving) lighting at your home?	◯	◯	◯	◯

3

	Yes	No	Sometimes	I don't know
Is your home supported by thermal insulation?				
Do you leave the air conditioning ON after you leave your home?				
Do you use power saving controllers?				
Do you instruct your family members and maids to rationalise electricity consumption?				
Do you think you want to use modern electric cars?				
Do you think that electric cars are a way to conserve the environment?				
Are there charging points for electric vehicles provided by the government in public utilities, government organisations, commercial and residential complexes?				

4

11. Are electricity bills becoming a financial burden on you?

- ◯ Yes
- ◯ No
- ◯ Sometimes

12. Does the programmed power cuts due to electrical loads in summer seasons have a negative effect on you at home?

- ◯ Yes
- ◯ No
- ◯ Sometimes

13. How do you rate the role of the Kuwaiti government in spreading awareness to rationalise the consumption of electricity for consumers?

- ◯ Excellent
- ◯ Very good
- ◯ Good
- ◯ Acceptable
- ◯ Weak

Part Four
Section One: (Personal stance and attitude towards renewable energy)

14. In your personal opinion, please specify the appropriate source of renewable energy sources to invest in Kuwait:

- ◯ Solar energy
- ◯ Nuclear energy
- ◯ Wind energy
- ◯ Tidal energy
- ◯ I don't know

Please add a comment why you chose this source or suggest a diffrent source.

[ ]

15. Please choose the most important elements which contribute to renewable energy:
(You can select One answer or more)

- ☐ Contributes to maintain a clean environment.
- ☐ Contributes to the provision of the national economy.
- ☐ Creating jobs.
- ☐ Helps maintain the oil resources and reduces its consumption.
- ☐ I think the renewable energy is useless.

5

16. How do you rate the role of official organisations in spreading the awareness about renewable energy for the community?

- ◯ Excellent
- ◯ Very good
- ◯ Good
- ◯ Acceptable
- ◯ Weak

17. It's important for official organisations to increase the renewable energy projects for electric power generation.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

18. It's important that householders initiate the utilisation of renewable energy in their homes.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

19. Currently, where do you use renewable energy technologies?
(One or more answers can be selected)

- ☐ Home
- ☐ Facility in desert areas
- ☐ Elsewhere
- ☐ I do not use

The used type is Photovoltaic (PV) cells or another type, what is the type?

____

20. The support of the official organisations in paying the cost of renewable energy technologies will encourage people to use it.

- ◯ Strongly agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly disagree

6

21. The official organisations should support citizens who use the renewable energy in their homes by connecting to the electricity grid to reduce their electricity tariff.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Part Four

Section Two: (Knowledge and awareness of the advantages and challenges of renewable energy)

7

22. What is your opinion on the following phrases :

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	I don't know
I have background knowledge, through reading or study, about renewable energy sources such as solar energy, wind energy, and thermal energy.	◯	◯	◯	◯	◯	◯
The renewable energy technologies are not widely distributed in the domestic market of Kuwait.	◯	◯	◯	◯	◯	◯
The renewable energy technologies in Kuwait have high prices due to the lack of government support to encourage its use.	◯	◯	◯	◯	◯	◯
The renewable energy sector is still weak in Kuwait.	◯	◯	◯	◯	◯	◯
You support that the Kuwaiti community needs to increase the awareness of renewable energy.	◯	◯	◯	◯	◯	◯

8

23. Do you have any comments or other suggestions :

Thank you for your support in participating to complete this questionnaire

9

Appendix II: Official Organisations Questionnaire (English version)

NOTTINGHAM TRENT UNIVERSITY

Official Organisations Questionnaire
For Research in Renewable Energy in Kuwait

Dear participant,

This questionnaire is part of an academic study for a PhD degree entitled "Investigating a strategy for utilising renewable energy sources in Kuwait". In this voluntary questionnaire, questions will be reviewed to obtain some opinions that will contribute to support the research. Please do not hesitate to express your personal opinions in answering these questions without the need to include your name in order to preserve your privacy. The aim of this research to draw a roadmap in the field of renewable energy and develop a national framework to raise the awareness level of the consumers for the renewable energy utilisation and electricity consumption. It also aims to explore the obstacles faced by the renewable energy sector in Kuwait and find solutions to these obstacles which will, in turn, contribute to the conclusion of recommendations for policymakers in the field of renewable energy in the State of Kuwait.

PhD Researcher: Hassan Al Fadhli
Contact: hassan.alfadhli2015@my.ntu.ac.uk
Nottingham Trent University - United Kingdom

Your help and support is much appreciated

Please read the questions carefully and choose the suitable answer.

Part One (Personal Details)

1. Nationality

- ◯ Kuwaiti
- ◯ Non-Kuwaiti

2. Gender

- ◯ Male
- ◯ Female

1

3. Age

- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65 or over

4. Qualification

- ◯ PhD
- ◯ MA
- ◯ BSc
- ◯ Diploma
- ◯ High school
- ◯ Primary school

5. Occupation

- ◯ Employee
- ◯ Retired

6. Organisation type

- ◯ Public sector
- ◯ Private sector

7. Employment field:

- ◯ Ministerial sector
- ◯ Authorities sector
- ◯ Companies sector
- ◯ Industrial sector
- ◯ Services sector
- ◯ Health sector
- ◯ Education sector

Part Two (Background Information)

What is your opinion on the following phrases :

8. Does your organisation plays an active role in preserving the environment and are interested in environmental issue?.

- ◯ Yes
- ◯ No
- ◯ Sometimes
- ◯ I don't know

2

9. Recently, it has become necessary to start using renewable energy sources to generate electricity instead of generating it through fossil fuel which causes air pollution.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

10. Heading towards the utilisation of renewable energy sources is the best way to improve the environment and secure the future of new generations.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Part Three (User efficiency of electricity consumption)

11.

Please answer the following questions :

	Yes	No	Sometimes	I don't know
Do you leave the lights lit during the day even though there is daylight at your place of work?	◯	◯	◯	◯
When you are the last person to leave your place of work, do you switch off the lights before you leave?	◯	◯	◯	◯
Do you turn off the electricity after using the computer and other devices?	◯	◯	◯	◯
Does your organisation use LED (Energy saving) lights?	◯	◯	◯	◯

3

	Yes	No	Sometimes	I don't know
Is your organisation building supported by thermal insulation?	◯	◯	◯	◯
Do you leave the air conditioning ON after leaving your place of work?	◯	◯	◯	◯
Does your organisation use power saving controllers?	◯	◯	◯	◯
Does your organisation use electric cars?	◯	◯	◯	◯
Do you think the electric cars are environmentally friendly?	◯	◯	◯	◯
Are there electric charging points provided by your organisation for employees and community in your place of work?	◯	◯	◯	◯

12. Does your organisation spread awareness to rationalise electricity consumption for employees?

◯ Yes

◯ No

◯ Sometimes

◯ I don't know

4

13. Does your organisation spread awareness to rationalise electricity consumption for the community in general?

- ◯ Yes
- ◯ No
- ◯ Sometimes
- ◯ I don't know

Part Four

Section One (Personal stance and attitude towards renewable energy)

14. In your opinion, should governmental organisations and private institutions increase the awareness for the community regarding utilising of renewable energy sources to generate electricity.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

15. Does your organisation use renewable energy?

- ◯ Yes
- ◯ No
- ◯ I don't know

16. If your answer is (Yes) to the above question, please indicate which is the type of renewable energy used:

- ☐ Solar Energy
- ☐ Wind energy

Other type:

____

17. In your personal opinion, please specify the appropriate type of renewable energy or clean energy to invest in Kuwait:

- ◯ Solar energy
- ◯ Wind energy
- ◯ Nuclear energy
- ◯ Tidal energy
- ◯ I don't know

Please add a comment as to why you choose this source or suggest a different source.

____

5

18. Your evaluation for the possibility of starting to apply and use renewable energy technologies in your organisation is:

- Very difficult
- Difficult
- Easy
- Very easy
- I don't know

19. It is important for the governmental organisations and private institutions to initiate the use the renewable energy in their buildings.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

20. If your organisation has facilities in desert areas of Kuwait, do they use renewable energy technologies?

- Yes
- No
- I don't know

Is it Photovoltaic (PV) cells or another type, what is the type?

21. The government must support governmental buildings and impose the private institutes buildings to utilise renewable energy by connecting them to the electrical network grid.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

22. Please choose the most important elements which contribute to renewable energy:
(You can select One answer or more)

- ☐ Contributes to maintain a clean environment.
- ☐ Contributes to the provision of the national economy.
- ☐ Creating jobs.
- ☐ Helps maintain the oil resources and reduces its consumption.
- ☐ I think the renewable energy is useless.

Part Four
Section Two: (Knowledge and Awareness of the advantages and challenges of renewable energy)

6

23. What is your opinion on the following phrases :

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	I don't know
I have some background knowledge, through reading or study, about renewable energy sources including solar energy, wind energy, and thermal energy.	○	○	○	○	○	○
Renewable energy technologies are not widely distributed in Kuwait domestic market due to lack of support for their investment.	○	○	○	○	○	○
There is a shortage of knowledge and skills with regards to renewable energy technologies in Kuwait.	○	○	○	○	○	○
The location and weather of Kuwait are suitable for renewable energy investment.	○	○	○	○	○	○
Renewable energy technologies is facing a slow social uptake in Kuwait.	○	○	○	○	○	○

7

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	I don't know
The private sector should be encouraged to participate in renewable energy investment in Kuwait.	◯	◯	◯	◯	◯	◯
There is insufficient information on renewable energy technologies, their efficiency, advantages and disadvantages in Kuwait.	◯	◯	◯	◯	◯	◯
There is a shortage in the educational program of renewable energy in the educational curriculum (schools, colleges, universities and other educational institutions) in Kuwait.	◯	◯	◯	◯	◯	◯
The Kuwaiti community needs to increase the awareness of renewable energy.	◯	◯	◯	◯	◯	◯

24. Do you have any other comments or suggestions :

Thank you for your support in participating to complete this questionnaire

8

Appendix III: Academic and Educational Organisations Questionnaire (English version)

NOTTINGHAM TRENT UNIVERSITY

Academic and Educational Organisations Questionnaire For Research in Renewable Energy in Kuwait

Dear participant,

This questionnaire is part of an academic study for a PhD degree entitled "Investigating a strategy for utilising renewable energy sources in Kuwait". In this voluntary questionnaire, questions will be reviewed to obtain some opinions that will contribute to support the research. Please do not hesitate to express your personal opinions in answering these questions without the need to include your name in order to preserve your privacy. The aim of this research to draw a roadmap in the field of renewable energy and develop a national framework to raise the awareness level of the consumers for the renewable energy utilisation and electricity consumption. It also aims to explore the obstacles faced by the renewable energy sector in Kuwait and find solutions to these obstacles which will, in turn, contribute to the conclusion of recommendations for policymakers in the field of renewable energy in the State of Kuwait.

PhD Researcher: Hassan Al Fadhli
Contact: hassan.alfadhli2015@my.ntu.ac.uk
Nottingham Trent University - United Kingdom

Your help and support is much appreciated

Please read the questions carefully and choose the suitable answer.

Part One: (Personal Details)

1. Nationality

- ◯ Kuwaiti
- ◯ Non-Kuwaiti

2. Gender

- ◯ Male
- ◯ Female

1

3. Age

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or over

4. Qualification:

- PhD
- MA
- BSc
- Diploma
- High school
- Primary school

5. Occupation

- Employee
- Retired

6. Type of educational or academic sector:

- Governmental university
- Private university
- Governmental college
- Private college
- Research institute
- Governmental school
- Private school
- One of the sectors of the ministry of education

Other:

Part Two: (Background Information)

What is your opinion on the following phrases :

7. Does your educational organisation teach how to preserve the environment and interest in environmental issues?

- Yes
- No
- Sometimes
- I don't know

2

8. Recently, it has become necessary to start using renewable energy sources to generate electricity instead of generating it through fossil fuel which causes air pollution.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

9. Heading towards the utilisation of renewable energy sources is the best way to improve the environment and secure the future of new generations.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

Part Three (User efficiency of electricity consumption)

10. Please answer the following questions :

	Yes	No	Sometimes	I don't know
Do you leave the lights lit during the day even though there is daylight at your place of work?	◯	◯	◯	◯
When you are the last person to leave your place of work, do you switch off the lights before you leave?	◯	◯	◯	◯
Do you turn off the electricity after using the computer and other devices?	◯	◯	◯	◯
Does your organisation use LED (Energy saving) lights?	◯	◯	◯	◯

3

	Yes	No	Sometimes	I don't know
Is your organisation building supported by thermal insulation?	◯	◯	◯	◯
Do you leave the air conditioning ON after leaving work?	◯	◯	◯	◯
Does your organisation use power saving controllers?	◯	◯	◯	◯
Does your organisation use electric cars?	◯	◯	◯	◯
Do you think the electric cars are environmentally friendly?	◯	◯	◯	◯
Are there electric charging points provided by your organisation for employees and students in your place of work?	◯	◯	◯	◯

11. Does your educational organisation spread awareness to rationalise electricity consumption for employees and students?

- ◯ Yes
- ◯ No
- ◯ Sometimes
- ◯ I don't know

Part Four

Section One: (Attitudes towards renewable energy)

4

12. In your opinion, should educational and academic organisations increase the awareness for the community regarding utilising of renewable energy sources to generate electricity.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

13. Does your organisation use renewable energy?

- ◯ Yes
- ◯ No
- ◯ I don't know

14. If your answer is (Yes) to the above, please indicate which type:

- ☐ Solar Energy
- ☐ Wind energy

Other:

[ ]

15. In your personal opinion, please specify the appropriate type of renewable energy or clean energy to invest in Kuwait:

- ◯ Solar energy
- ◯ Wind energy
- ◯ Nuclear energy
- ◯ Tidal energy
- ◯ I don't know

Please add a comment as to why you choose this source or suggest a different source.

[ ]

16. Your evaluation for the possibility of starting to apply and use renewable energy technologies in your educational organisation is:

- ◯ Very difficult
- ◯ Difficult
- ◯ Easy
- ◯ Very easy
- ◯ I don't know

5

17. It is important for educational and academic organisations to initiate the use renewable energy in their buildings.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

18. The government must support governmental educational buildings and impose private educational organisations buildings to utilise renewable energy by connecting them to the electrical network grid.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

19. Please choose the most important elements which contribute to renewable energy:
(You can select One answer or more)

- ☐ Contributes to maintain a clean environment.
- ☐ Contributes to the provision of the national economy.
- ☐ Creating jobs.
- ☐ Helps maintain the oil resources and reduces its consumption.
- ☐ I think the renewable energy is useless.

Part Four
Section Two: (Knowledge and Awareness of the advantages and challenges of renewable energy)

20. What is your opinion on the following phrases :

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	I don't know
Your educational organisation spreads awareness about renewable energy and sustainability.	◯	◯	◯	◯	◯	◯
I have some background knowledge, through reading or study, about renewable energy sources including solar energy, wind energy, and thermal energy.	◯	◯	◯	◯	◯	◯

6

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	I don't know
Renewable energy technologies are not widely distributed in Kuwait domestic market due to lack of support for their investment.	○	○	○	○	○	○
There is a shortage of knowledge and skills with regards to renewable energy technologies in Kuwait.	○	○	○	○	○	○
The location and weather of Kuwait are suitable for renewable energy investment.	○	○	○	○	○	○
Renewable energy technology is facing a slow social uptake in Kuwait.	○	○	○	○	○	○
The private sector should be encouraged to participate in renewable energy investment in Kuwait.	○	○	○	○	○	○
There is insufficient information on renewable energy technologies, their efficiency, advantages and disadvantages in Kuwait.	○	○	○	○	○	○
There is a shortage in the educational program of renewable energy in the educational curriculum (schools, colleges, universities and other educational institutions) in Kuwait.	○	○	○	○	○	○
The Kuwaiti community needs to increase the awareness of renewable energy.	○	○	○	○	○	○

21. Do you have any other comments or suggestions :

Thank you for your support in participating to complete this questionnaire

7

Appendix IV: Public Questionnaire (Arabic version)

NOTTINGHAM TRENT UNIVERSITY

إستبيان عام

لبحث أكاديمي في مجال الطاقة المتجددة لدولة الكويت

عزيزي المشارك ،

هـذا الإسـتبيان هو جزء متعلق بدراسـة أكاديميـة لدرجـة الدكتوراة بعنوان التحقيق في إستراتيجية إسـتخدام مصادر الطاقـة المتجـددة في دولـة الكويت وسـيتم الإسـتعراض في هذا الإسـتبيان التطوعي لبعض الأسـئلة للحصول على بعض الأراء التي من شأنها المساهمة في دعم البحث، فيرجى عدم التردد في التعبير عن رأيك الشخصـي للرد على كـل سؤال دون الحاجـة لإسم المشـارك وذلك للمحافظـة على خصوصـية المشاركـة , وهـدف هـذا البحث إسـتنتاج خارطـة طريق في مجال الطاقـة المتجـددة وتطوير إطار عمل وطني وذلك لرفع مسـتوى مفهوم الطاقـة المتجددة وإسـتهلاك الكهرباء لـدى المسـتهلكين و إسـتنتاج العوائق التي تواجهها الطاقـة المتجـددة في الكويت لإيجاد الحلول لتلك المعوقات والمساهمة في إستنتاج توصيات لصناع القرار بمجال الطاقة المتجددة في دولة الكويت.

طالب الدكتوراة : حسن الفضلي
للتواصل : hassan.alfadhli2015@my.ntu.ac.uk
جهة البحث: جامعة نوتنجهام ترنت – المملكة المتحدة

شكرا على تعاونك ولإتاحة الفرصة من وقتك

يرجى قراءة الإستبيان بعناية وتحديد الإجابات المناسبة

الجزء الاول (البيانات الشخصية)

الجنسية

- ○ كويتي
- ○ غير كويتي

الجنس

- ○ ذكر
- ○ أنثى

1

العمر

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- فما فوق 65

المؤهل العلمي

- دكتوراة
- ماجستير
- بكالوريوس
- دبلوم
- الثانوية العامة
- دون الثانوية العامة

الحالة الوظيفية

- طالب
- موظف
- أعمال حره
- متقاعد
- ربة منزل
- لا أعمل حاليا

نوع السكن

- سكن خاص (منزل)
- سكن خاص (شقة)
- سكن إيجار (منزل)
- سكن إيجار (شقة)

أخرى :

الجزء الثاني (خلفية المعلومات)

ماهو رأيك بالعبارات التالية :

يجب علينا المحافظة على البيئة والإهتمام بالقضايا البيئية.

- موافق بشدة
- موافق
- محايد
- معارض
- معارض بشدة

2

في الأونة الأخيرة،أصبح من الضروري البدء بإستخدام مصادر الطاقة المتجددة لتوليد الطاقة الكهربائية بدلا عن توليدها بواسطة المشتقات البترولية التي تلوث الهواء.

- معارض
- معارض بشدة
- موافق بشدة
- موافق
- محايد

التوجه نحو إستخدام مصادر الطاقة المتجددة هي الطريقة الأمثل لتحسين البيئة وتأمين مستقبل الأجيال القادمة.

- معارض
- معارض بشدة
- موافق بشدة
- موافق
- محايد

الجزء الثالث (كفاءة إستهلاك المستخدم للكهرباء)

يرجى الإجابة على الأسئلة التالية :

لا أعلم	أحيانا	لا	نعم	
○	○	○	○	هل تترك الإنارة مضاءة بفترة النهار على الرغم من وجود ضوء النهار في المنزل؟
○	○	○	○	عندما تكون أخر شخص يغادر المكان هل تغلق الإضاءة قبل المغادرة ؟
○	○	○	○	هل تقطع التيار الكهربائي كليا بعد إنتهائك من مشاهدة التلفاز وإستخدامك للحاسوب وغيره من الأجهزة ؟
○	○	○	○	هل تستخدم مصابيح LED الموفرة للطاقة لإضاءة المنزل؟

3

	نعم	لا	أحيانا	لا أعلم
هل منزلك مدعم بالعازل الحراري ؟	○	○	○	○
هل تترك أجهزة التكييف تعمل بعد مغادرتك المنزل ؟	○	○	○	○
هل تستخدم أجهزة تحكم حفظ الطاقة الكهربائية ؟	○	○	○	○
هل تقوم بتوجيه أفراد أسرتك والخدم بترشيد إستهلاك الكهرباء ؟	○	○	○	○
هل تعتقد بأن لديك الرغبة بإستخدام السيارات الكهربائية الحديثة ؟	○	○	○	○
هل تعتقد أن السيارات الكهربائية هي وسيلة للمحافظة على البيئة ؟	○	○	○	○
هل توجد نقاط شحن للسيارات الكهربائية توفرها الحكومة في المرافق العامة والجهات الحكومية والمجمعات التجارية والسكنية ؟	○	○	○	○

هل فواتير الكهرباء أصبحت تشكل أعباء مادية عليك ؟

○ أحيانا
○ نعم
○ لا

4

هل القطع المبرمج للتيار الكهربائي بسبب زيادة الأحمال في فصل الصيف له تأثير سلبي عليك في المنزل ؟

- نعم
- أحيانا
- لا

كيف تقيم دور الجهات الحكومية بنشر الوعي لترشيد إستهلاك الكهرباء للمستهلكين ؟

- ممتاز
- مقبول
- جيد جدا
- ضعيف
- جيد

الجزء الرابع
الفصل الأول: (توجهك الشخصي وموقفك من الطاقة المتجددة)

برأيك الشخصي ، يرجي تحديد المصدر الأنسب من مصادر الطاقة المتجددة لإستثمارة في دولة الكويت :

- الطاقة الشمسية
- طاقة الأمواج
- طاقة الرياح
- لا أعلم
- الطاقة النووية

يرجي إضافة تعليق سبب إختيار المصدرأو إقتراح مصدر أخر

يرجي إختيار أهم العناصر التي تساهم فيها الطاقة المتجددة :
(يمكن إختيار إجابة أو أكثر)

- تساهم بالمحافظة على بيئة نظيفة
- تساهم بالمحافظة على مورد النفط بتقليل إستهلاكة
- تساهم في المحافظة على الإقتصاد الوطني
- أعتقد ان الطاقة المتجددة عديمة الفائدة
- تساهم في خلق فرص عمل

حاليا أين تستخدم تكنولوجيات الطاقة المتجددة ؟
(يمكن إختيار إجابة أو أكثر)

- المنزل
- أماكن أخرى
- بمنشأه في المناطق الصحراوية
- لا أستخدم

هل النوع المستخدم الألواح الضوئية أو نوع أخر، وما هو النوع ؟

5

ماهو تقييمك في دور الجهات الحكومية بنشر الوعي للمجتمع بإستخدام الطاقة المتجددة ؟

- مقبول
- ممتاز
- ضعيف
- جيد جدا
- جيد

من المهم على أصحاب المنازل المبادرة بإستخدام تكنولوجيا الطاقة المتجددة في منازلهم.

- معارض
- موافق بشدة
- معارض بشدة
- موافق
- محايد

المساهمة من الجهات الحكومية في دعم تكاليف تكنولوجيات الطاقة المتجددة سوف تشجع المواطنين على إستخدامها.

- معارض
- موافق بشدة
- معارض بشدة
- موافق
- محايد

الجهات الحكومية يجب عليها أن تدعم المستخدمين للطاقة المتجددة بتقليل تعرفة الكهرباء عليهم من خلال الربط بالشبكة الكهرباء الرئيسية.

- معارض
- موافق بشدة
- معارض بشدة
- موافق
- محايد

من المهم بأن تقوم الجهات الحكومية بزيادة بناء منشئات للطاقة المتجددة لتوليد الطاقة الكهربائية.

- معارض
- موافق بشدة
- معارض بشدة
- موافق
- محايد

الجزء الرابع

الفصل الثاني: (الوعي والمعرفة بفوائد الطاقة المتجددة والمعوقات التي تواجهها)

6

ما هو رأيك في العبارات التالية :

	لا أعلم	معارض بشدة	معارض	محايد	موافق	موافق بشدة
لدي المعرفة من خلال المطالعة أو الدراسة حول مصادر الطاقة المتجددة كالطاقة الشمسية، طاقة الرياح أو الطاقة الحرارية.						
تكنولوجيات الطاقة المتجددة غير منتشرة بشكل واسع بالسوق المحلي لدولة الكويت.						
تكنولوجيات الطاقة المتجددة في الكويت أسعارها مرتفعة لغياب الدعم الحكومي لها بالتشجيع علي إستخدامها.						
قطاع الطاقة المتجددة لازال ضعيفا في دولة الكويت.						
تؤيد بأن المجتمع الكويتي يحتاج زيادة المعرفة والوعي بالطاقة المتجددة.						

هل لديك تعليقات أو أقتراحات أخرى :

شكرا لدعمك في المشاركة بإستكمال هذا الإستبيان

Appendix V: Official Organisations Questionnaire (Arabic version)

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إستبيان الجهات الرسمية

لبحث أكاديمي في مجال الطاقة المتجددة لدولة الكويت

عزيزي المشارك ،

هذا الإستبيان هو جزء متعلق بدراسة أكاديمية لدرجة الدكتوراة بعنوان التحقيق في إستراتيجية إستخدام مصادر الطاقة المتجددة في دولة الكويت وسيتم الإستعراض في هذا الإستبيان التطوعي لبعض الأسئلة للحصول على بعض الأراء التي من شأنها المساهمة في دعم البحث، فيرجى عدم التردد في التعبير عن رأيك الشخصي للرد على كل سؤال دون الحاجة لإسم المشارك وذلك للمحافظة على خصوصية المشاركة , وهدف هذا البحث إستنتاج خارطة طريق في مجال الطاقة المتجددة وتطوير إطار عمل وطني وذلك لرفع مستوى مفهوم الطاقة المتجددة وإستهلاك الكهرباء لدى المستهلكين و إستنتاج العوائق التي تواجهها الطاقة المتجددة في الكويت لإيجاد الحلول لتلك المعوقات والمساهمة في إستنتاج توصيات لصناع القرار بمجال الطاقة المتجددة في دولة الكويت.

طالب الدكتوراة : حسن الفضلي
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جهة البحث: جامعة نوتنجهام ترنت – المملكة المتحدة

شكرا على تعاونك ولإتاحة الفرصة من وقتك

يرجى قراءة الإستبيان بعناية وتحديد الإجابات المناسبة

الجزء الاول (البيانات الشخصية)

1. الجنسية

- ○ كويتي
- ○ غير كويتي

1

2. الجنس

- ذكر
- أنثى

3. العمر

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- فما فوق 65

4. المؤهل العلمي

- دكتوراة
- ماجستير
- بكالوريوس
- دبلوم
- الثانوية العامة
- دون الثانوية العامة

5. الحالة الوظيفية

- أعمل حاليا
- متقاعد عن العمل

6. جهة العمل

- القطاع العام
- القطاع الخاص

7. مجال العمل

- قطاع وزاري
- قطاع الهيئات
- قطاع الشركات
- قطاع صناعي
- قطاع خدمات
- قطاع صحي
- قطاع التعليم

الجزء الثاني (خلفية المعلومات)

ماهو رأيك بالعبارات التالية :

8.
هل جهة عملك تقوم بدور فعال بالمحافظة على البيئة والإهتمام في القضايا البيئية ؟

- نعم
- لا
- أحيانا
- لا أعلم

2

9.

في الأونة الأخيرة، أصبح من الضروري البدء بإستخدام مصادر الطاقة المتجددة لتوليد الطاقة الكهربائية بدلا عن توليدها بواسطة المشتقات البترولية التي تلوث الهواء.

- معارض
- معارض بشدة
- موافق بشدة
- موافق
- محايد

10.

التوجه نحو إستخدام مصادر الطاقة المتجددة هي الطريقة الأمثل لتحسين البيئة وتأمين مستقبل الأجيال القادمة.

- معارض
- معارض بشدة
- موافق بشدة
- موافق
- محايد

الجزء الثالث (كفاءة المستخدم لإستهلاك الكهرباء)

11.

يرجى الإجابة على الأسئلة التالية :

	نعم	لا	أحيانا	لا أعلم
هل تترك الإنارة مضاءة بفترة النهار على الرغم من وجود ضوء النهار في مكان عملك؟	○	○	○	○
عندما تكون أخر شخص يغادر مكان عملك هل تغلق الإضاءة قبل المغادرة ؟	○	○	○	○
هل تقوم بفصل التيار الكهربائي كليا بعد إنتهائك من إستخدام الحاسوب وغيره من الأجهزة ؟	○	○	○	○
هل جهة عملك تستخدم مصابيح LED الموفرة للطاقة للإضاءة؟	○	○	○	○

3

	نعم	لا	أحيانا	لا أعلم
هل مبنى جهة عملك مدعم بالعازل الحراري ؟	◯	◯	◯	◯
هل تترك أجهزة التكييف تعمل بعد مغادرتك مكان عملك؟	◯	◯	◯	◯
هل جهة عملك تستخدم أجهزة تحكم حفظ الطاقة الكهربائية ؟	◯	◯	◯	◯
هل جهة عملك تستخدم السيارات الكهربائية ؟	◯	◯	◯	◯
هل تعتقد أن السيارات الكهربائية هي وسيلة للمحافظة على البيئة ؟	◯	◯	◯	◯
هل توجد نقاط شحن للسيارات الكهربائية توفرها جهة عملك للموظفين والمراجعين في مبنى مقر عملك ؟	◯	◯	◯	◯

12.

هل المؤسسة التي تعمل بها تقوم بنشر الوعي لترشيد إستهلاك الكهرباء للموظفين؟

◯ نعم ◯ أحيانا

◯ لا ◯ لا أعلم

4

13.

هل المؤسسة التي تعمل بها تقوم بنشر الوعي لترشيد إستهلاك الكهرباء للمجتمع بشكل عام ؟

- نعم
- أحيانا
- لا
- لا أعلم

الجزء الرابع

الفصل الأول (توجهك الشخصي وموقفك من الطاقة المتجددة)

14.

برأيك، على الجهات الحكومية والمؤسسات الخاصة زيادة نشر الوعي في المجتمع عن إستخدام مصادر الطاقة المتجددة لتوليد الكهرباء.

- موافق بشدة
- معارض
- موافق
- معارض بشدة
- محايد

15.

هل المؤسسة التي تعمل بها تستخدم نوع من أنواع الطاقة المتجددة ؟

- نعم
- لا
- لا أعلم

16.

إذا كانت الإجابة (نعم) على السؤال السابق يرجى تحديد نوع الطاقة المتجددة المستخدمة من الأنواع التالية :

- ☐ الطاقة الشمسية
- ☐ طاقة الرياح

طاقة أخري:

5

17.

برأيك الشخصي ، يرجى تحديد المصدر الأنسب من مصادر الطاقة المتجددة أوالنظيفة لإستثماره في دولة الكويت :

- طاقة الأمواج
- الطاقة الشمسية
- لا أعلم
- طاقة الرياح
- الطاقة النووية

يرجى إضافة تعليق سبب إختيار المصدر أو إقتراح مصدر أخر

18.

تقييمك لإمكانية البدء في تطبيق وإستخدام تكنولوجيات الطاقة المتجددة في المؤسسة التي تعمل بها هو :

- سهل جدا
- صعب جدا
- لا أعلم
- صعب
- سهل

19.

من المهم على الجهات الحكومية والمؤسسات الخاصة المبادرة بإستخدام الطاقة المتجددة في مبانيهم.

- معارض
- موافق بشدة
- معارض بشدة
- موافق
- محايد

20.

إذا كانت جهة عملك لديها منشئات في المناطق الصحراوية، هل تستخدم إحدى أنواع تكنولوجيات الطاقة المتجددة ؟

- لا أعلم
- نعم
- لا

هل النوع المستخدم الألواح الضوئية أو نوع أخر، وما هو النوع ؟

6

21.

الحكومة يجب عليها دعم المباني الحكومية وإلزام مباني المؤسسات الخاصة بإستخدام الطاقة المتجددة للإستفادة من خلال الربط بالشبكة الكهربائية.

- معارض
- معارض بشدة
- موافق بشدة
- موافق
- محايد

22.

يرجي إختيار أهم العناصر التي تساهم فيها الطاقة المتجددة :

(يمكن إختيار إجابة أو أكثر)

- ☐ تساهم بالمحافظة على مورد النفط بتقليل إستهلاكة
- ☐ أعتقد ان الطاقة المتجددة عديمة الفائدة
- ☐ تساهم بالمحافظة على بيئة نظيفة
- ☐ تساهم في المحافظة على الإقتصاد الوطني
- ☐ تساهم في خلق فرص عمل

الجزء الرابع

الفصل الثاني (الوعي والمعرفة بفوائد الطاقة المتجددة والمعوقات التي تواجهها)

23.

ما هو رأيك في العبارات التالية :

	موافق بشدة	موافق	محايد	معارض	معارض بشدة	لا أعلم
لدي المعرفة من خلال المطالعة أو الدراسة حول مصادر الطاقة المتجددة كالطاقة الشمسية، طاقة الرياح أو الطاقة الحرارية.	○	○	○	○	○	○
تكنولوجيات الطاقة المتجددة غير منتشرة بشكل واسع بالسوق المحلي لدولة الكويت لغياب الدعم في إستثمارها.	○	○	○	○	○	○

7

	موافق بشدة	موافق	محايد	معارض	معارض بشدة	لا أعلم
تكنولوجيات الطاقة المتجددة في الكويت لا زالت تعاني من إفتقار بالمهارات والمعرفة اللازمة.						
موقع ومناخ دولة الكويت مناسبان تماما لإستثمار الطاقة المتجددة.						
تعاني تكنولوجيات الطاقة المتجددة من بطء الإقبال الإجتماعي على إستخدامها في الكويت.						
ينبغي تحفيز القطاع الخاص بالمشاركة في إستثمار الطاقة المتجددة في الكويت.						
لا توجد البيانات الكافيه عن جميع تكنولوجيات الطاقة المتجددة بشأن كفاءتها ومميزاتها وعيوبها.						
يوجد نقص في البرامج والمناهج التعليمية للطاقة المتجددة في قطاع المدارس والهيئات التعليمية في الكويت.						

8

	موافق بشدة	موافق	محايد	معارض	معارض بشدة	لا أعلم
تؤيد بأن المجتمع الكويتي يحتاج زيادة المعرفة والوعي بالطاقة المتجددة.	◯	◯	◯	◯	◯	◯

24.

هل لديك تعليقات أو أقتراحات أخرى :

شكرا لدعمك في المشاركة بإستكمال هذا الإستبيان

9

Appendix VI: Academic and Educational Organisations Questionnaire (Arabic version)

NOTTINGHAM TRENT UNIVERSITY

إستبيان الجهات التعليمية والأكاديمية

لبحث أكاديمي في مجال الطاقة المتجددة لدولة الكويت

عزيزي المشارك ،

هـذا الإسـتبيان هو جزء متعلق بدراسـة أكاديميـة لدرجـة الـدكتوراة بعنوان التحقيق في إستراتيجية إسـتخدام مصادر الطاقـة المتجـددة في دولـة الكويت وسـيتم الإسـتعراض في هـذا الإسـتبيان التطوعي لبعض الأسـئلة للحصول على بعض الأراء التي من شأنها المساهمـة في دعم البحث، فيرجى عدم التردد في التعبير عن رأيك الشخصـي للرد على كـل سؤال دون الحاجـة لإسم المشـارك وذلـك للمحافظـة على خصوصـية المشاركـة , وهـدف هـذا البحث إسـتنتاج خارطـة طريق في مجال الطاقـة المتجـددة وتطوير إطار عمل وطني وذلك لرفع مسـتوى مفهوم الطاقـة المتجـددة وإسـتهلاك الكهربـاء لـدى المسـتهلكين و إسـتنتاج العوائق التي تواجهها الطاقـة المتجـددة في الكويت لإيجاد الحلول لتلك المعوقات والمساهمة في إستنتاج توصيات لصناع القرار بمجال الطاقة المتجددة في دولة الكويت.

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جهة البحث: جامعة نوتنجهام ترنت – المملكة المتحدة

شكرا على تعاونك ولإتاحة الفرصة من وقتك

يرجي قراءة الإستبيان بعناية وتحديد الإجابات المناسبة

الجزء الاول (البيانات الشخصية)

1. الجنسية

- ○ كويتي
- ○ غير كويتي

1

2. الجنس

- ذكر
- أنثى

3. العمر

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- فما فوق 65

4. المؤهل العلمي

- دكتوراة
- ماجستير
- بكالوريوس
- دبلوم
- الثانوية العامة
- دون الثانوية العامة

5. الحالة الوظيفية

- أعمل حاليا
- متقاعد عن العمل

6. نوع القطاع التعليمي أو الأكاديمي

- جامعة حكومية
- جامعة خاصة
- معهد حكومي
- معهد خاص
- مؤسسة أبحاث
- مدرسة حكومية
- مدرسة خاصة
- إحدى قطاعات وزارة التربية والتعليم

الجزء الثاني (خلفية المعلومات)

ماهو رأيك بالعبارات التالية :

7.
هل جهة عملك تقوم بتعليم طرق المحافظة على البيئة والإهتمام في القضايا البيئية ؟

- نعم
- لا
- أحيانا
- لا أعلم

2

8.

في الأونة الأخيرة، أصبح من الضروري البدء بإستخدام مصادر الطاقة المتجددة لتوليد الطاقة الكهربائية بدلا عن توليدها بواسطة المشتقات البترولية التي تلوث الهواء.

- ◯ موافق بشدة
- ◯ موافق
- ◯ محايد
- ◯ معارض
- ◯ معارض بشدة

9.

التوجه نحو إستخدام مصادر الطاقة المتجددة هي الطريقة الأمثل لتحسين البيئة وتأمين مستقبل الأجيال القادمة.

- ◯ موافق بشدة
- ◯ موافق
- ◯ محايد
- ◯ معارض
- ◯ معارض بشدة

الجزء الثالث (كفاءة المستخدم لإستهلاك الكهرباء)

10.

يرجي الأجابة علي الأسئلة التالية :

	نعم	لا	أحيانا	لا أعلم
هل تترك الإنارة مضاءة بفترة النهار على الرغم من وجود ضوء النهار في مكان عملك؟	◯	◯	◯	◯
عندما تكون أخر شخص يغادر مكان عملك هل تغلق الإضاءة قبل المغادرة ؟	◯	◯	◯	◯
هل تقوم بفصل التيار الكهربائي كليا بعد إنتهائك من إستخدام الحاسوب وغيره من الأجهزة ؟	◯	◯	◯	◯
هل جهة عملك تستخدم مصابيح LED الموفرة للطاقة للإضاءة؟	◯	◯	◯	◯

3

	نعم	لا	أحيانا	لا أعلم
هل مبنى جهة عملك مدعم بالعازل الحراري ؟	◯	◯	◯	◯
هل تترك أجهزة التكييف تعمل بعد مغادرتك مكان عملك؟	◯	◯	◯	◯
هل جهة عملك تستخدم أجهزة تحكم حفظ الطاقة الكهربائية ؟	◯	◯	◯	◯
هل جهة عملك تستخدم السيارات الكهربائية ؟	◯	◯	◯	◯
هل تعتقد أن السيارات الكهربائية هي وسيلة للمحافظة على البيئة ؟	◯	◯	◯	◯
هل توجد نقاط شحن للسيارات الكهربائية توفرها جهة عملك للطلبة والموظفين في مبنى مقر عملك ؟	◯	◯	◯	◯

11.

هل المؤسسة التعليمية التي تعمل بها تقوم بنشر الوعي لترشيد إستهلاك الكهرباء للطلبة والموظفين ؟

◯ نعم ◯ أحيانا

◯ لا ◯ لا أعلم

الجزء الرابع

الفصل الأول: (توجهاتك وموقفك من الطاقة المتجددة)

4

12.
برأيك، على الجهات التعليمية زيادة نشر الوعي في المجتمع عن إستخدام مصادر الطاقة المتجددة لتوليد الكهرباء.

- معارض
- معارض بشدة
- موافق بشدة
- موافق
- محايد

13.
هل المؤسسة التعليمية التي تعمل بها تستخدم نوع من أنواع الطاقة المتجددة ؟

- لا أعلم
- نعم
- لا

14.
إذا كانت الإجابة (نعم) للسؤال السابق يرجى تحديد نوع الطاقة من الأنواع التالية :

- ☐ طاقة الرياح
- ☐ الطاقة الشمسية

طاقة أخري:

15.
برأيك الشخصي، يرجى تحديد المصدر الأنسب من مصادر الطاقة المتجددة أوالنظيفة لإستثمارها في دولة الكويت :

- طاقة الأمواج
- لا أعلم
- الطاقة الشمسية
- طاقة الرياح
- الطاقة النووية

يرجى إضافة تعليق سبب إختيار النوع أو إقتراح نوع أخر

16.
تقييمك لإمكانية البدء في تطبيق وإستخدام تكنولوجيات الطاقة المتجددة في المؤسسة التعليمية التي تعمل بها هو :

- سهل جدا
- لا أعلم
- صعب جدا
- صعب
- سهل

5

17.

من المهم على المؤسسات التعليمية والاكاديمية المبادرة باستخدام الطاقة المتجددة في مبانيهم.

- ◯ معارض
- ◯ معارض بشدة
- ◯ موافق بشدة
- ◯ موافق
- ◯ محايد

18.

الحكومة يجب عليها دعم المباني التعليمية الحكومية وإلزام مباني المؤسسات التعليمية الخاصة بإستخدام الطاقة المتجددة للإستفادة من خلال الربط بالشبكة الكهربائية.

- ◯ معارض
- ◯ معارض بشدة
- ◯ موافق بشدة
- ◯ موافق
- ◯ محايد

19.

يرجي إختيار أهم العناصر التي تساهم فيها الطاقة المتجددة :

(يمكن إختيار إجابة أو أكثر)

- ☐ تساهم بالمحافظة على مورد النفط بتقليل إستهلاكة
- ☐ أعتقد ان الطاقة المتجددة عديمة الفائدة
- ☐ تساهم بالمحافظة على بيئة نظيفة
- ☐ تساهم في المحافظة على الإقتصاد الوطني
- ☐ تساهم في خلق فرص عمل

الجزء الرابع

الفصل الثاني: (الوعي والمعرفة بفوائد الطاقة المتجددة والمعوقات التي تواجهها)

20.

ما هو رأيك في العبارات التالية :

	موافق بشدة	موافق	محايد	معارض	معارض بشدة	لا أعلم
تقوم مؤسستك التعليمية بنشر الوعي عن الطاقة المتجددة والأستدامة.	◯	◯	◯	◯	◯	◯

6

	موافق بشدة	موافق	محايد	معارض	معارض بشدة	لا أعلم
لدي المعرفة من خلال المطالعة أو الدراسة حول مصادر الطاقة المتجددة كالطاقة الشمسية، طاقة الرياح أو الطاقة الحرارية.	○	○	○	○	○	○
تكنولوجيات الطاقة المتجددة غير منتشرة بشكل واسع بالسوق المحلي لدولة الكويت لغياب الدعم في إستثمارها.	○	○	○	○	○	○
تكنولوجيات الطاقة المتجددة في الكويت لا زالت تعاني من افتقار بالمهارات والمعرفة اللازمة.	○	○	○	○	○	○
موقع ومناخ دولة الكويت مناسبان تماما لاستثمار الطاقة المتجددة.	○	○	○	○	○	○
تعاني تكنولوجيات الطاقة المتجددة من بطىء الاقبال الاجتماعي على استخدامها.	○	○	○	○	○	○
ينبغي تحفيز القطاع الخاص بالمشاركة في استثمار الطاقة المتجددة في الكويت.	○	○	○	○	○	○

7

	موافق بشدة	موافق	محايد	معارض	معارض بشدة	لا أعلم
لا توجد البيانات الكافيه عن جميع تكنولوجيات الطاقة المتجددة بشأن كفاءتها ومميزاتها وعيوبها.	○	○	○	○	○	○
يوجد نقص في البرامج والمناهج التعليمية للطاقة المتجددة في قطاع المدارس والهيئات التعليمية في الكويت.	○	○	○	○	○	○
تؤيد بأن المجتمع الكويتي يحتاج زيادة المعرفة والوعي بالطاقة المتجددة.	○	○	○	○	○	○

21.

هل لديك تعليقات أو أقتراحات أخرى :

شكرا لدعمك في المشاركة بإستكمال هذا الإستبيان

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Appendix VII: The Interview Form (English version)

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The Interview Form for Research in:

Renewable Energy in Kuwait

PhD Researcher : Hassan Mutni Al-Fadhli

Nottingham Trent University – United Kingdom

The form content

A set of questions about the field of Renewable Energy in Kuwait.

The purpose of the interview

The purpose of the interview is to gather information and data to help the researcher with a project that will ultimately lead to acquiring a PhD degree.

The aim of the interview

To promote the renewable energy field in Kuwait through the field experts' participation that enables the researcher to conclude the recommendations of the experts and the policy makers of Renewable Energy in Kuwait.

The Researcher's ID

Researcher's name: Hassan Al-Fadhli

Nottingham Trent University - United Kingdom

Research Title: "Investigating in the strategy of renewable energy sources utilisation in Kuwait"

Phone: +965-55556020 / +44-778666996

Email: hassan.alfadhli2015@my.ntu.ac.uk / Quester.h@hotmail.com

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Consent Letter

Dear Participant,

This interview is part of a PhD study entitled " Investigating in the strategy of renewable energy sources utilisation in Kuwait ". In this voluntary interview, some questions will be presented to give opinions and answers which will contribute to support the research. The aim of this research is to draw a road map in the field of renewable energy and develop a national framework to raise the awareness level of renewable energy utilisation and energy efficiency of the electricity consumption for the consumers in Kuwait. Furthermore, the research aims to present the obstacles faced by renewable energy and to find solutions to those obstacles and contribute to the conclusion of recommendations for decision makers in the field of renewable energy in the State of Kuwait. All data is documented and used for the research and will be eliminated once the research is completed and you have the free choice to mention your name or not. The answers to the interview form depend on your general background and personal experience on renewable energy in Kuwait through your leadership position at the academic or practical level.

I appreciate your help and support

The consent conformation

I would like to take part in this research and I will give answers to the interview questions based on my experience in the field of the Renewable Energy in Kuwait.

Participant's name:……………………………

Signature:……………………………………....

Interview date:…………………………………

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Part One: (Participant Personal Information & Organisation Information)

<u>Participants Personal Information:</u>

Participant Name (Optional) :…………………………………...

Qualification:……………………………

Career:…………………………………..

Phone number:…………………………..

Email address:…………………………...

Please attach CV if available: ☐ Yes ☐ No

<u>Organisation Information:</u>

Organisation name :…………….

Organisation type: ☐ Public Sector ☐ Private Sector

Organisation field:

☐ Ministerial sector ☐ Authorities sector

☐ Companies sector ☐ Industrial sector

☐ Services sector ☐ Education sector

Documents attached related to organisation information:

☐ Annual reports

☐ Annual statistics

☐ Agenda

☐ Evaluation Reports

☐ Other information:………………

Part Two: (Interview questions)

1. In your opinion, why has it become important to pay attention to the environment in Kuwait in terms of seeking ways to preserve it?

2. What is the role of the government agencies in enhancing consumers' awareness to rationalize the electricity consumption?

3. What is your organisation's role in spreading the awareness for the community about renewable energy utilisation?

4. What are the most important renewable energy projects in Kuwait?

5. What are the procedures being taken by government agencies to activate the utilisation of the renewable energy technologies in order to encourage the consumers to use it?

6. Are there procedures or laws that force contractors and households to use renewable energy sources in Kuwait?

7. What is your point of view on current governmental organisations' performance for achieving 15% of renewable energy sources utilisation by 2030?

8. What is the mechanism used by government agencies to choose the most appropriate renewable energy technologies in terms of cost performance?

9. What are the biggest difficulties faced by the State in applying and using the renewable energy in Kuwait?

10. What is the role of government agencies in promoting national competencies and expertise in the operation and investment of the renewable energy in Kuwait?

11. How do you assess the educational programmes of renewable energy in educational curriculums in schools, universities and educational institutions in Kuwait?

12. Which agency is responsible for coordinating and monitoring the performance of all renewable energy projects in Kuwait?

13. How effective would it be to establish an independent authority for the renewable energy in Kuwait? And what roles should this independent authority have to play if established?

14. In your opinion, is the plan of the Kuwaiti government concerning renewable energy projects coinciding with population growth?

15. How effective is the role of private sectors and external investors in the investment of renewable energy in Kuwait?

16. How do you assess the renewable energy investment in Kuwait compared to global renewable energy market?

17. Are there training courses on renewable energy in your organisation? What is the most important one?

18. Are there governmental procedures and standards for the construction of new buildings by using thermal insulation?

19. What is the possibility of government agencies to activate and generalise the use of electric power saver devices?

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20. What procedures have been followed by government agencies to activate the use of electric cars? Are there charging stations in state facilities?

21. What is the role of government agencies in raising awareness of the community for utilising the renewable energy through media in Kuwait?

22. Is there any manufacturer of renewable energy technologies in Kuwait?

23. What are the Kuwaiti government plans and visions to activate the renewable energy utilisation?

24. What are the most significant environmental problems facing Kuwait which push it to move towards renewable energy utilisation as soon as possible?

25. How can the government agencies improve the energy efficiency of consumers and develop renewable energy utilisation for contributing to the strengthening of the national economy in Kuwait?

26. How do you assess the feasibility of renewable energy utilisation in Kuwait if all difficulties are solved?

Do you like to add any comments or notes before the end of this interview:

…………………………………………………………………………………………………
…………………………………………………………………………………………………

Thank you for your time and your cooperation

Appendix VIII: The Interview Form (Arabic version)

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استمارة مقابلة شخصية لمشاركة علمية في مجال:

الطاقة المتجددة في دولة الكويت

لباحث درجة الدكتوراه: حسن مطني الفضلي

جامعة نوتنجهام ترنت – المملكة المتحدة

محتوى استمارة المقابلة:

مجموعة من الأسئلة متعلقة بشأن مجال الطاقة المتجددة في دولة الكويت.

الغرض من استمارة المقابلة:

من أجل الحصول على بعض النتائج التحليلية المبنية على إجابات المقابلات والآراء التي من شأنها أن تساهم في دعم دراسة البحث للحصول على درجة الدكتوراه المناطة فيها تلك الاستمارة.

الهدف من استمارة المقابلة:

لتعزيز وتقويم مجال الطاقة المتجددة في دولة الكويت من خلال المشاركة العلمية والعملية لذوي الاختصاص بقطاع الطاقة المتجددة ليستنتج الباحث علي مجموعة من التوصيات لذوي الاختصاص ذاتهم ولصانعي القرار والمشرعين لسياسات مجال الطاقة المتجددة في دولة الكويت.

تعريف بالباحث:

أسم باحث الدكتوراه: حسن مطني الفضلي

جهة البحث: جامعة نوتنغهام ترنت – المملكة المتحدة

عنوان البحث: التحقيق في استراتيجية استخدام مصادر الطاقة المتجددة في دولة الكويت

رقم الهاتف: +965-55556020 / +44-7786669967

البريد الإلكتروني: hassan.alfadhli2015@my.ntu.ac.uk / Quester.h@hotmail.com

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نموذج الموافقة

عزيزي المشارك،

هذه المقابلة هي جزء متعلق بدراسة أكاديمية لدرجة الدكتوراه بعنوان "التحقيق في استراتيجية استخدام مصادر الطاقة المتجددة في دولة الكويت" وسيتم الاستعراض في هذه المقابلة التطوعية لبعض الأسئلة ونقاط جانبية للحوار للحصول على بعض الإجابات و الآراء التي من شأنها المساهمة في دعم البحث، فيرجى عدم التردد في التعبير عن رأيك الشخصي للرد على أسئلة المقابلة، وهدف هذا البحث هو استنتاج خارطة طريق في مجال الطاقة المتجددة وتطوير إطار عمل وطني وذلك لرفع مستوى مفهوم الطاقة المتجددة وكفاءة الطاقة لاستهلاك الكهرباء لدى المستهلكين. بالإضافة إلى استنتاج العوائق التي تواجهها الطاقة المتجددة في الكويت لإيجاد الحلول لتلك المعوقات والمساهمة في استنتاج توصيات لصناع القرار بمجال الطاقة المتجددة في دولة الكويت،على ان جميع البيانات موثقة واستخدامها لغرض البحث وسيتم التخلص منها بمجرد الانتهاء من البحث، ولك حرية الاختيار بذكر أسمك او من عدمه، الأجوبة علي استمارة المقابلة تعتمد علي الخلفية العامة والخبرة الشخصية لديك بشأن الطاقة المتجددة في الكويت من خلال وظيفتك القيادية علي المستوي الأكاديمي أو العملي.

شكرا لك مع التقدير للتعاون والدعم ولإتاحة الفرصة من وقتك

- **الموافقة على أجراء المقابلة**

أرغب في التطوع في المشاركة بالبحث وذلك بأدلاء البيانات والمعلومات من خلال الاجابة على أسئلة المقابلة وأبداء بعض التوصيات والمقترحات بناء على الخبرة لدي.

الاسم: ....

التوقيع: ....

تاريخ المقابلة: ....

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- **<u>الجزء الأول (البيانات الشخصية للمشارك وبيانات المؤسسة) :</u>**

<u>البيانات الشخصية للمشارك:</u>

أسم المشارك (اختياري): ....

المؤهل العلمي: ....

المسمى الوظيفي: ....

رقم الهاتف: ....

البريد الإلكتروني: ....

يرجي أرفاق السيرة الذاتية : ☐ يوجد ☐ لا يوجد

<u>بيانات المؤسسة:</u>

جهة العمل: ....

نوع جهة العمل: ☐ قطاع عام ☐ قطاع خاص

مجال العمل:

☐ قطاع وزاري ☐ قطاع الهيئات

☐ قطاع الشركات ☐ قطاع صناعي

☐ قطاع الخدمات ☐ قطاع التعليم

المستندات المرفقة عن بيانات المؤسسة:

☐ تقارير سنوية

☐ احصائيات سنوية

☐ جدول اعمال

☐ تقارير تقييم

☐ بيانات أخري ....

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- **<u>الجزء الثانى (أسئلة المقابلة) :</u>**

1) **برأيك لماذا أصبح من المهم الاهتمام بشأن البيئة في الكويت بالبحث عن طرق المحافظة عليها؟**

2) **ما هو الدور الذي قامت به الجهات الحكومية في نشر وتعزيز الوعي لترشيد استهلاك الطاقة الكهربائية للمستهلكين؟**

3) **ما هو الدور المناط بكم في نشر الوعي للمجتمع بشأن استخدام الطاقة المتجددة؟**

4) **ما هي أهم مشاريع الطاقة المتجددة في دولة الكويت؟**

5) **ما هي الإجراءات التي تتخذها الجهات الحكومية في تفعيل استخدام تكنولوجيات الطاقة المتجددة لتشجيع المواطنين على استخدامها؟**

6) **هل هناك إجراءات أو قوانين اعتمدتها الحكومة تجبر المقاولين وأصحاب المنازل على استخدام مصادر الطاقة المتجددة في الكويت؟**

7) **ما هي وجهة نظرك بشأن الأداء الحالي للجهات الحكومية لهدف عام 2030 لتحقيق نسبة 15% من استخدام مصادر الطاقة المتجددة في الكويت؟**

8) **ما هي الألية المتبعة التي قامت بها الجهات الحكومية بالاعتماد على انسب تكنولوجيات الطاقة المتجددة من حيث تكلفة الأداء؟**

9) **ما هي أهم الصعوبات التي تواجهها الدولة في تطبيق واستخدام تكنولوجيات الطاقة المتجددة؟**

10) **ما هو دور الجهات الحكومية في تعزيز الكفاءات والخبرات الوطنية في تشغيل واستثمار الطاقة المتجددة في الكويت؟**

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11) كيف تقيم البرامج التعليمية للطاقة المتجددة في المناهج التعليمية للمدارس والجامعات والهيئات التعليمية في الكويت؟

12) من هي الجهة المسؤولة عن التنسيق والرقابة لأداء مشاريع الطاقة المتجددة في الكويت؟

13) ما هي فعالية استحداث هيئة مستقلة بالطاقة المتجددة في دولة الكويت؟ وماهي الأدوار المناطة فيها في حال استحداثها؟

14) هل برأيك أن خطة الحكومة الكويتية لمشاريع الطاقة المتجددة متزامنة مع النمو السكاني؟

15) ما هي فعالية دور القطاع الخاص والمستثمر الخارجي في استثمار الطاقة المتجددة في الكويت؟

16) كيف تقيم استثمار الطاقة المتجددة في الكويت مقارنة مع سوق الطاقة المتجددة العالمي؟

17) هل يتم عقد دورات تدريبية في مجال الطاقة المتجددة لدي الجهة التي تعملون بها؟ وما أهمها؟

18) هل توجد إجراءات ومعايير متبعة من الجهات الحكومية بشأن أنشاء المباني الجديدة باستخدام العزل الحراري؟

19) ما هي إمكانية الجهات الحكومية من تفعيل وتعميم استخدام أجهزة حفظ الطاقة الكهربائية؟

20) ما هي الإجراءات التي اتبعتها الجهات الحكومية لتفعيل استخدام السيارات الكهربائية؟ وهل توجد محطات شحن في مرافق الدولة؟

21) ما هو دور الجهات الحكومية من التوعية الإعلامية لنشر استخدام الطاقة المتجددة؟

22) هل توجد مصانع لإنتاج تكنولوجيات الطاقة المتجددة في الكويت؟

23) ماهي الخطط والرؤى للحكومة الكويتية بشأن تفعيل استخدام الطاقة المتجددة؟

24) ما هي أهم المشاكل البيئية التي تواجه الكويت والتي تدفعها للتحرك نحو استخدام الطاقة المتجددة في أقرب وقت ممكن؟

25) كيف يمكن للجهات الحكومية تحسين كفاءة الطاقة لدى المستهلكين وتطوير استخدام الطاقة المتجددة للمساهمة في تعزيز الاقتصاد الوطني الكويتي؟

26) ما هو تقييمك بجدوى استخدام الطاقة المتجددة في حال قامت الحكومة الكويتية بحل كافة الصعوبات التي تواجهها؟

- هل لديك أي تعليق أو ملاحظة للإضافة من خلال هذه المقابلة؟

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شكرا لتعاونك ولأتاحه الفرصة من وقتك

Appendix IX: Questionnaires Respondents Comments

Public Questionnaire Respondents Comments:

In the comments section of the question ***"In your personal opinion, please specify the appropriate type of the renewable energy or clean energy to invest in Kuwait"*** The most essential and prominent comments that were written by respondents to stated that as follows:

Some respondents indicated that they only chose solar energy without selecting other renewable energy sources in the following:

- *This is because the Middle East region, especially Kuwait, is characterised by high percentages of solar energy.*
- *The State of Kuwait shines the sun from morning to sunset, and there are no clouds that block the sunlight.*
- *Solar energy is the best, and it is a natural source that costs nothing, and we must rationalise the current electricity consumption and start using solar energy to secure future generations.*
- *Development in Kuwait is supposed to be exported to other countries, not just reliance on domestic consumption.*
- *Solar panels are better, but you need to periodically clean the dust, and you should choose a type that carries high temperatures.*
- *Solar energy in Kuwait is hugely available and does not require costs to extract it, unlike other energies.*
- *Solar energy the best, and we can reduce our energy consumption by implementing energy efficiency methods.*

- *Solar energy because Kuwait is very close to the equator.*
- *Solar energy is a natural and renewable daily source and the intensity of solar radiation most days of the year in Kuwait is a positive factor for supply Energy, and high temperatures are a contributing factor in heating water and taking advantage of the heating output for energy conversion.*
- *Solar energy is best suited because there is a direct relationship between its power and our electricity consumption.*
- *Solar energy for its availability and the rapid development of the solar technology industry.*
- *We have high Solar radiation in Kuwait also we have a lot of unused rooftop spaces.*
- *Our extreme sun and heat must be utilised constructively as it is a great opportunity to wean off a reliance on fossil fuel.*
- *In Kuwait there is sun all over the year almost so using it as an electricity source would make a huge change.*
- *Because in Kuwait there are at least 8 hours of sunshine and a lack of rain.*
- *This source of energy -solar energy- will help provide backup power and help reduce the usage of fuel in power stations.*
- *The sun is shining year-round and without any clouds, add to that the extended hours of daylight in the summertime.*
- *But need fully maintains due to frequent dust storms.*
- *High availability of Solar Energy in Kuwait, in addition, due to wide desert.*
- *I choose solar energy as a source of renewable energy because as everyone knows that in the middle east like Kuwait is not surrounded by trees. We all feel the heat of the sun during*

the summer season, instead of using fuel energy why don't use solar energy during the day and some alternative during the night-time.

With regard to Wind Energy, some of the respondents stated the reasons for not favouring wind energy over solar energy, and stated in the following:

- *There are no continuous high winds in Kuwait to depend on, and there are no continuous high sea waves for the same reason it is more likely to use solar energy.*
- *We have limited wind power potential, unlike solar power available throughout the year.*

Although some respondents see Nuclear Energy as the most appropriate source, they state the following:

Yet some respondent provided impressive details Regarding diversity in the exploitation of renewable energy sources and noted that:

- *Solar and Tidal because Kuwait is a gulf country, and the possibility of using wave energy is available.*
- *Olfactory solar, wind and waves are the most likely energy models available in the Kuwaiti environment.*
- *I chose Solar Energy. I would also choose wind, for our country is very hot in summer, so we can use solar energy. And in winter, we can use the wind.*

Finally, Regarding the last question in the Public questionnaire labelled" ***Do you have any other comments or suggestions?*** *"*, as many respondents noted down their suggestions and comments listed as follows:

- *The social media needs more talking about renewable technologies.*
- *Improving education and increasing awareness through community events is vital to make the largely ignorant Kuwaiti community aware of the dangers of waste and the benefits of maintaining a clean environment, renewable energy, and efficient solar power use.*

- *Our whole lives depend on our only economical source, which is oil or petrol. It won't last forever, so why don't we improve solar energy and use it? It will make a good change we, the coming generation can make a difference, but we can't make it without the government support.*

- *The topic of renewable energy is highly important and could very well benefit Kuwait; however, no matter how much you raise awareness about this matter, it will feel like you're jogging in one place. You need to convince consumers in this part of the region why renewable energy is beneficial to them financially, and environmentally. In addition, you need to convince the government why it should invest in this source, without having an impact on the oil market. Governments and people alike are hesitant to invest in a source that might diminish the oil source, which is an integral part of the country's economy. You need to convince them that renewable energy will not get in the way of oil. In general, people, even if aware, will hold no regard for the impact on the environment, so you need to lure them by explaining the incentives if they choose to go the renewable energy route.*

- *Energy conservation is a GLOBAL issue, and we must all work together to help sustain our planet and the whole of the human race.*

- *I suggest starting using renewable energy sources, not as a primary source but secondary in order to get the users familiar with it so in the next 5-10 years. The transition phase is much more productive.*

- *The government needs to strongly encourage investment projects on renewable energy.*

- *The government organisations should be starting to increase the spread the awareness about renewable energy utilisation in every single individual of the Kuwait community.*

- *In order for any community to be encouraged to use Renewable Energy, awareness should be obtained through proper education and especially in early learning.*

- *In my opinion, solar energy more suitable than wind energy, especially that wind energy still under development in term of wind turbines doesn't store energy to use it later.*

- *The oil will spend out on the day; it is important to our nation to find alternative sources for power, such as solar power.*

- *The use of renewable energy is very important for all societies. Kuwait can benefit by using RE such as reducing using fossil files can clean the environment, can save our main resources and become a member of the world society in a clean environment friendly.*

- *Kuwait is already hot. If we consume more fossil fuels, more CO2 will be released. Global warming will become harm to world society.*

- *Due to the low cost of electricity for domestic households, there is no point in household owners to install solar panels since they won't be saving money. Due to the highly subsidised electrical cost, the government should have re-plan of the cost for the high consumption of households.*

- *Solar energy is more environment-friendly and with less cost, especially in Kuwait weather.*

- *Nowadays, energy becomes more important, especially solar power. While in Kuwait the summer season is the longest season during a year about eight months so it can use the solar power to produce electricity for homes on that time. As a result, the environment becomes clean and depend on electricity generator decrease with time. Eventually, for the best time of the year, it can be stored the electricity in summer and use it on other seasons.*

- *Power energy generation is cursorial subject, but the topic adds the limitations of renewable energy, specifically the storage energy.*

- *Should start to teach the positive of using renewable energy in all school stages.*

- *As technology has been developed and more inventions are coming, plus the global climate change becomes hazardous, so the need for renewable energy sources is imminent.*

- *Increase the awareness of how to use and how is it effective.*
- *Nuclear energy should be the last consideration, Due to the fact of using old technologies to operate nuclear power plants and the growing issues of safety and isolation.*
- *I think we must start using renewable energy in government buildings, schools and shopping centres. The second step should be private homes.*
- *Renewable energy must be used in Kuwait for so many reasons, the first is to have a clean environment, and the second is to save our natural resources such as oil & gas.*
- *By improving the environment using renewable energy, this will positively affect the public health of the community by reducing the diseases and health problems resulting from air pollution.*
- *Many Kuwaiti citizens who are about to build their new homes have a desire to use solar panels if there is government support for renewable energy technologies, as is the case with support for building materials.*
- *The municipality must impose new building permits by supplying at least two power lines, renewable energy and conventional electric power, in order to reduce the loads on conventional stations and to boost the economy to reduce the consumption of the oil resource in Kuwait.*
- *The aspirations of the people always remain for what is new and beneficial. Renewable energy has a pivotal role in that. However, the basis on which it depends is the efficiency of what it provides, so what is the benefit of filling the desert with solar panels may not achieve the desired goal of it or its cost may be higher than the benefit. At the same time, one nuclear power station covers Less space, reasonable cost and higher production capacity.*
- *I believe that renewable energy is no longer an option among the options presented, but rather an inevitable and urgent alternative to benefit from its utilisation.*

- *The utilisation of renewable energy has a positive impact on people's health. In addition to reducing the bills cost in the future. Alternative energy is a haven for humanity from diseases and adverse effects resulting from current energy consumption.*

- *There should be an active role through awareness television programs that show the types of renewable energy and the intended benefit of it, as well as allow the public to participate through their proposals on alternative energy.*

- *I suggest that there should be scholarships for youth to study renewable energy, especially solar and wind.*

- *Renewable energy is an essential source of diversification of national income, supports the national economy, supports the general health of the population and leads to reducing global warming.*

- *We should focus our efforts on reducing our consumption by implementing energy efficiency measures by doing energy audits on all buildings and manufacturing facilities.*

Respondents Comments of the Academic and Official Organisations Questionnaires:

Finally, Regarding the last question in the Academic and Official organisations questionnaire labelled" Do you have any other comments or suggestions? ", as many respondents noted down their suggestions and comments listed as follows:

☐ **Academic respondents stated:**

- *The government should increase the use of renewable energy and its application in state institutions and at the individual level by supporting citizens using renewable energy technologies in addition to spreading adequate awareness about the use of renewable energy through the curriculum and by publishing massive media campaigns on the use of renewable energy to reduce the consumption of the oil supplier.*

☐ **Official respondents stated:**

- *Renewable energy should be taken interest in and relied on an alternative source other than the source of oil because is of one of the main causes of environmental pollution.*

- *Awareness of renewable energy sources and how they are used and support in the prices of renewable energy technologies should be disseminated to encourage their use.*

- *There is a dereliction of government in applying renewable energy that must be treated seriously and quickly.*

- *The society is interested in the economic aspect and since the electricity tariff is still cheap and the weak of environmental awareness there is no reason to look for another source.*

- *By going to understand and know how to use renewable energy is a pillar of preserving the environment and the economy in general, the government and the people must cooperate constructively to start using renewable energy.*

- *The government and corporate support, as the UK does, should encourage the private sector to make alternative energy for homes free of charge and pay for the private sector the amount it saved from consumption. Annual An example of that is if Distracted Consumer Annual 1000 KD And alternative energy changes consumption 500 KD paying. Government 500 KD to the private sector for Reduce consumption and so be Government I saved. By consuming fuel and kept the environment.*

- *Renewable energy should be used effectively because it will contribute to the strengthening of the national economy and the expansion of the local market and a very important step towards environmental conservation.*

- *Kuwait government must study other countries renewable energy programs and finds out which one is suitable for Kuwait.*

Appendix X: Kruskal Wallis Test Results of the Public Questionnaire

Kruskal Wallis Test Results- Knowledge and Awareness of the Advantages and challenges of Renewable Energy

Descriptive Statistics

Category	N	Mean	Std. Dev. Deviation	Std. Error	Min.	Max.
Owned House	1001	19.82	4.640	0.147	0	25
Owned Apartment	176	18.45	5.512	0.416	0	25
Rental House	147	18.27	5.826	0.480	0	25
Rental Apartment	243	18.81	5.497	0.353	0	25
Others	13	21.54	4.390	1.217	10	25
Total	**1580**	**19.38**	**5.034**	**0.127**	**0**	**25**

Std. Dev. =Standard Deviation Min.= Minimum Max.=Maximum

Multiple Comparisons: Bonferroni Test

(I) Accommodation type		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Owned House	Owned Apartment	1.37	0.409	0.008	0.22	2.52
	Rental House	1.55	0.441	0.005	0.31	2.79
	Rental Apartment	1.02	0.357	0.045	0.01	2.02
	Others	-1.71	1.395	1.000	-5.64	2.21
Owned Apartment	Owned House	-1.37	0.409	0.008	-2.52	-0.22
	Rental House	0.18	0.558	1.000	-1.39	1.75
	Rental Apartment	-0.35	0.495	1.000	-1.74	1.04
	Others	-3.08	1.436	0.320	-7.12	0.95
Rental House	Owned House	-1.55	0.441	0.005	-2.79	-0.31
	Owned Apartment	-0.18	0.558	1.000	-1.75	1.39
	Rental Apartment	-0.53	0.522	1.000	-2.00	0.93
	Others	-3.27	1.446	0.240	-7.33	0.80
Rental Apartment	Owned House	-1.02	0.357	0.045	-2.02	-0.01
	Owned Apartment	0.35	0.495	1.000	-1.04	1.74
	Rental House	0.53	0.522	1.000	-0.93	2.00
	Others	-2.73	1.423	0.550	-6.73	1.27
Others	Owned House	1.71	1.395	1.000	-2.21	5.64
	Owned Apartment	3.08	1.436	0.320	-0.95	7.12
	Rental House	3.27	1.446	0.240	-0.80	7.33
	Rental Apartment	2.73	1.423	0.550	-1.27	6.73