"An analytical study of environmental issues in the sustainable renewable energy development in the UAE"

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ABSTRACT

Sustainable development concept has been debated briefly in the literature since its idea promotes towards supreme aim of economic, social and environmental safeness. Sustainable energy development and the climate change play a great relationship in specific prominence towards the developing nations. The United Arab Emirates witnessed a rapid economic growth over the past several decades. This growth has resulted in increased energy consumption from the environmentally unstable conventional fossil fuels, hence resulting enormous amount of greenhouse gases emission annually.

The aim is to get an understanding and explore the suitable sustainable development in the UAE in order to mitigate the growing demand and to reduce the environmental concerns such as greenhouse gases. In addition to understand the public view in regards to sustainability and to improve the renewable energy schemes in UAE by providing various policy options.

The methodology involved developing sustainable indicators which assess the most suitable sustainable development for UAEs conditions, evaluating solar, wind and nuclear energy are the best options the UAEs rising demand and environmental issues. Using data collection from extensive range of literatures to support this decision, simulations and economic evaluations are carried out. Conclusively the results obtained shows an interesting figures that contributes widely towards sustainable development whether it's a small scale or a large scale process.

Keywords: Renewable Energy Development, CO_2 Emission Mitigation, Renewable Energy

Chapter I

Introduction

BACKGROUND:

Recently, a report by the Intergovernmental Panel on Climate Change stated that the amount of global greenhouse gas emissions (GHG) must be reduced by almost 60% by 2050. However, developed countries would have difficulty in combining strong emission reduction with fast economic growth. Because of the high dependency of transport systems on oil-derived fuels and internal combustion engines, reducing the amount of Green House Gases (GHG) emitted by transport systems by up to 60% seems impossible. Furthermore, the rapid increase in oil prices and the insecurity of oil supplies has worsened the situation. Therefore, the introduction of environmental sustainability and energy efficiency (i.e., an energy management system) is essential in the UAE.

In an article entitled "Sustainability Urban Mobility" Miranda, believes that a sustainable transport is defined as a system that contributes positively to economic and social welfare without having any negative effect on human health and the environment. She also indicates that in the present consideration of the social, economic and environmental aspects of energy management, the system should be integrated to achieve the following:

a) Satisfy the basic needs for access and movement of the entire society while maintaining compatibility with human health and the ecosystem.

b) Choose transport modes that have acceptable costs, function efficiently, and can support a dynamic economy and regional development.

c) Develop renewable resources at a rate below or equal to their regeneration, develop non-renewable resources at a rate below or equal to the utilization of renewable substitutes, and reduce sound emission and land use to the lowest possible minimum.

There is also a need for significant changes in current transportation systems to increase equity, economic efficiency and environmental safety. Moreover, individual transportation must take second place to long-term strategies that benefit the community.

According to Miranda, there are two factors in the energy demand of an integrated transport system. The first one concerns the type of energy source that should be used, and the second one concerns the amount of energy that should be consumed. According to her researches, the world's total transport energy consumption has increased in recent years, and it is now almost one-third of the total amount of energy consumed in developed countries. Of this total, road transport consumes almost 80%. Railway transport increased by the least amount by only 1.4 times because of the energy conversion of coal to diesel and electric power. According to statistics compiled in 2005, road transport occupied 79% of energy consumption and carbon dioxide emission, while railway transport, water transport, and air transport occupied only 7%, 8%, and 6%, respectively.

PROBLEM STATEMENT:

To ensure the efficient use of energy in the UAE by scrutinizing the environmental issues and constituting the strategies on the environment.

RESEARCH AIM:

To study the environmental issues affecting the sustainable renewable energy development in the UAE.

OBJECTIVES:

The main objective of this study is to analyse the environmental issues for sustainable renewable energy development in the UAE. This will be accomplished by the following research questions and objectives:

RESEARCH QUESTIONS:

1. **What are the factors influencing environmental issues in the sustainable renewable energy development in the UAE?**

(Literature Review- Secondary Data)

Here the literature will be collected by exploring the various research content/studies over the Internet on Google Scholar, Online databases i.e. EBSCO, SCOPUS, WEB OF SCIENCE etc. and Research Journals etc. as well. After this, Researcher will try to find out all the factors environmental issues in the sustainable renewable energy development in the UAE. It will be almost secondary data.

2. **What are the factors influencing in each emirate that affects environmental issues in the sustainable renewable energy development in the UAE?**

(Use of Secondary Data and Primary Data may be employed)

There might not be a lot of literature (Published data/Secondary data) available about the factors affecting in each emirate for sustainable Renewable Energy Development so the researcher would analyze the factors in each emirate in general & will try to find out the factors influencing environment that affect sustainable Renewable Energy Development in the UAE.

3. What are the criterions which facilitate the sustainable Renewable Energy Development in the UAE?

Here the researcher will try to find out criterions which facilitate sustainable Renewable Energy Development. Researcher will search the various databases and get the facts and figures about the criterion chosen for sustainable Renewable Energy Development. Researcher could also collect the primary data as well from the respondents.

4. How does it affect the development of the country if it has not been achieved?

Here the researcher will try to find out how it affects the development of the country if it has not been achieved. After identifying the above, the Researcher will try to arrive at the assessment of his own interpretation.

5. What are the key resources, facilities & support needed for sustainable renewable energy development in the UAE?

Here the Researcher will try to identify the key resources, facilities & support needed for sustainable renewable energy development in the UAE.

RESEARCH OBJECTIVE:

1. To study the factors influencing environmental issues in the sustainable renewable energy development in the UAE.
2. To study the factors influencing in each emirate that affects environmental issues in the sustainable renewable energy development in the UAE.

3. To find out the criterions which facilitate the sustainable Renewable Energy Development in the UAE.

4. To find out how it affects the development of the country if it has not been achieved.

5. To study the key resources, facilities & support needed for sustainable renewable energy development in the UAE.

RESEARCH HYPOTHESIS:

H0 1: There is no environmental issue that effects the Sustainable Renewable Energy Development in the UAE.

Research significance:

Many studies has shown the importance of integrating the energy management system in both transportation and construction sectors. Additionally, 16% of the total consumption of the energy in the world is typically attributed to consumption in public buildings. Considering Metro stations part of the research, many studies have been noticed for high traffic publically accessed buildings. Although, there are some energy management techniques that have been suggested to reduce the energy consumption in the UAE, there is no research work on comprehensive models for the optimal use of energy management systems in such facilities.

Moreover, several countries have applied various energy management systems and techniques, yet author has applied a blanket approach to measure and manage energy efficiency. For example, In Paris, the metro systems has installed the LED lightings and it is estimated the energy consumption should decrease by almost 50% of total consumption. Some countries such as United Stated, Germany, and Italy are using energy storage units to recover about 8% of lost energy. The UAE

installed platform screen doors in metro stations to enhance the safety of the passengers and also reduce the energy consumption by preventing the loss of air to the tunnel.

Research methodology:

The methodology involved developing sustainable indicators which assess the most suitable sustainable development for UAEs conditions, evaluating solar, wind and nuclear energy are the best options the UAEs rising demand and environmental issues. Using data collection from survey and extensive range of literatures to support sustainable renewable energy development, the questionnaire and secondary data has been used. At the final note, the research concludes that sustainable renewable energy development contributes widely whether it's a small scale or a large scale process.

PROPOSED DETAILED RESEARCH PROCESS

1) Proposed Research Methods & Methodology

i) Research Approach:

The research approach is Qualitative, Observational and survey. Here the researcher has conducted the survey among the prospective research population and observe the responses of that population. Here the researcher has observed some factors through secondary data as well. Along with it, he used qualitative analysis of the secondary & primary data.

ii) Data collection tools & techniques: Research Instrument

Research instrument is questionnaire by which the researcher has collected the data as well as recorded the responses. The questionnaire is based on demographic questions & research related

questions that we can say subjective question which has fulfilled the objective of the research & the questionnaire is close ended & follow the Likert scale as well. It involves mix of two points, three points, five points & seven points as well. The reliability & validity of the questionnaire has been checked by conducting the pilot test or manual calculations. Questionnaire has proper subjectivity which yield good results during the analysis & recording the responses.

iii) Sampling Design

Sampling frame is research population which indicates target population of the research. The sample size is 100. The sampling method is simple random sampling method.

2. Proposed Research Design:

The Design of the research is analytical. Here the researcher will try to identify out the environmental issues in the sustainable renewable energy development in the UAE.

The research design has developed keeping in mind all the positive and negative side of the research. The NP analysis has been carried out in order to come out with systematic research design.

CHAPTER II

LITERATURE REVIEW:
Sustainable Renewable Energy Development

Renewable Energy Development Evaluation

Indicators have been used worldwide for a very long time as a key tool for obtaining information, as well as identifying the related issues concerned with it. The electricity power generation of United Arab Emirates is highly dominated by the usage of conventional fossil fuel. The combustion of these fuel releases large amount of greenhouse gases in to the atmosphere, causing global warming and eventually climate change. According to **(A. Evans et al. 2009)** the worldwide electricity demand increased by 1.8% on an average every year from 1990 to 2004. However, As the demand for electricity increases the concerns about the impact of producing it also strengthens and vice versa. In order to meet this rising energy demand with minimal environmental impacts, new forms of sustainable energy developments should be taken into consideration. These developments include renewable energy and nuclear energy developments with carefully selected sustainable energy policies.

This study is conducted to identify the most effective sustainable energy development in the UAE probably by using 7 key sustainable indicators such as ***cost, greenhouse gas emission, efficiency, natural resources, storage, availability, and foot print***. To analyze the sustainable renewable energy development, these sustainable key indicators together could highlight the economical, ecological and social sustainability of various energy generation technologies. **(A. Evans et al. 2009)**

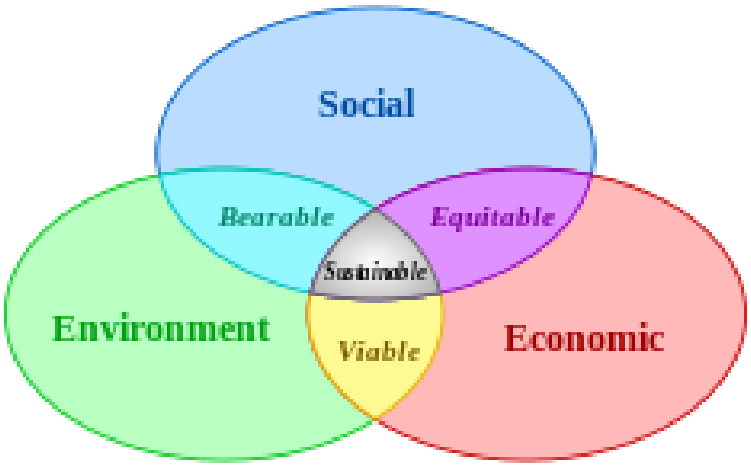


Figure (a) Sustainable indicators Key

Sustainable Indicators

One of the most important parameter in this study is the ***price***. Financial welfare is a significantly important figure in securing a sustainable development. ***Efficiency*** of the technology needs to be considered as it has a straight impact on the energy production, furthermore cost as well as the maturity of the technology can be improved by future R&D programs. As climate change and global warming are major concerns of the environment, the ***greenhouse gas emission*** of the technology should be determined which acts as a major indicator in sustainability. Since the UAE has insufficient water resources, it is important to identify the ***water usage*** of the technology (cleaning, cooling purposes etc.). Most of the renewable energy technologies operate efficiently only if their resource inputs are optimum (such as solar radiation, wind speed etc.), due to the intermittent nature of renewable energy resources, a proper ***storage*** system is required to meet the on-peak, off-peak and stabilize the power supply. As technologies compete for spacing, ***foot print*** is an important aspect to assess the technologies sustainability. Last but not least, the major key indicator is the ***availability*** of the technology, as the UAE's geographical location does not support all the available renewable energy technologies to generate electricity. Hence, an extensive data collection and literature review has been carried out and compared for

each energy generation technology.

I. Price

Average prices of the energy generation technologies are presented in US dollars per kWh. By analyzing the figure 3.2.1, the cheapest methods of electricity generation are gas, coal and nuclear costing an average 4.8c/kWh, 4.8c/kWh and 4.3 c/kWh respectively. However the renewable technologies such as hydro, biomass, wind and geothermal are slightly more expensive, costing on an average of 5.1 c/kWh, 8 c/kWh, 5.4 c/kWh, 6.8 c/kWh respectively but these costs are low when comparing to energy generation using photovoltaic which has a hefty price tag of 24c/kWh. (AEO 2011)

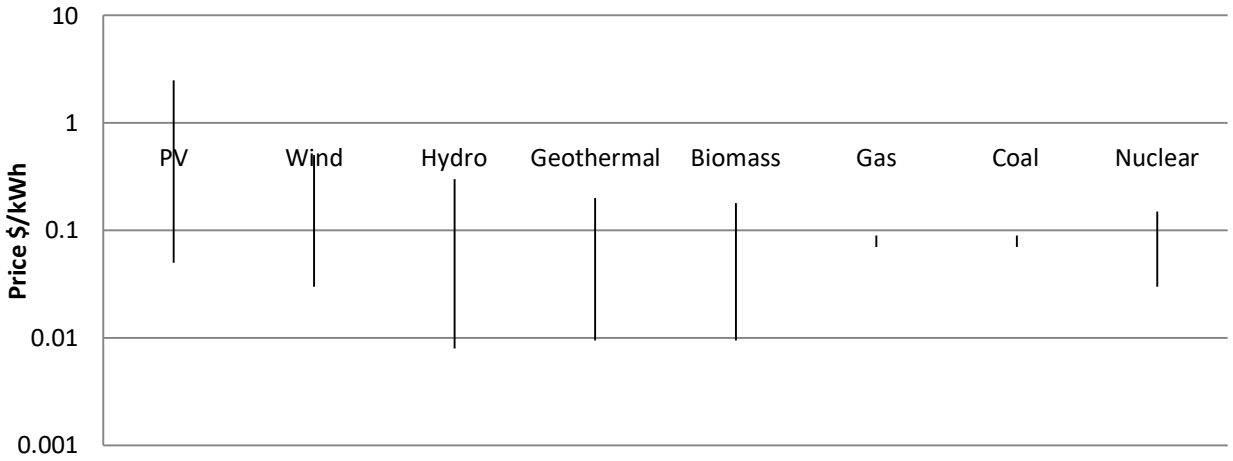


Figure (b) Cost various types of electricity generation

The above comparison now highlights the significance of a proper site preference and planning. The reason the prices of the conventional electricity such as coal and gas seem to be more stable in comparison to the RE is due to the well maturity of the technology and the reliability of the fuel products all across the globe.

II. Efficiency:

Efficiency plays an important parameter addressing the electricity generation technology when converting energy from fuel source to electricity. Sustainability and pricing are greatly influenced by efficiency as great amounts of wastes are related with inefficient products and processes are unsustainable. The following figure 3.2.2 below shows various technologies and the summary of their efficiencies.

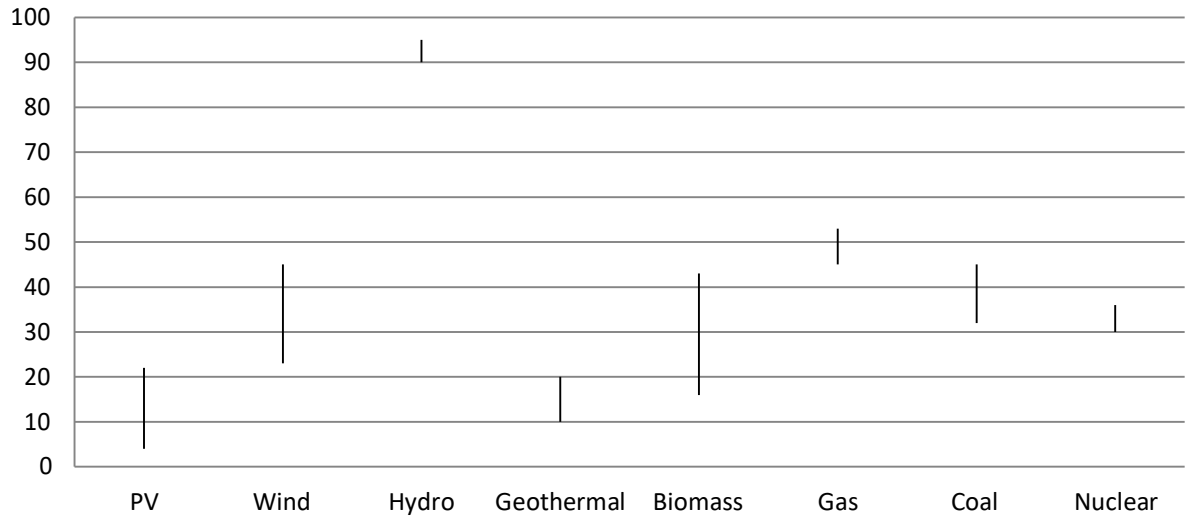


Figure (c) Electricity generation system efficiency

Comparing the technologies, hydro power has the highest efficiency, almost 3 times greater than other technologies. The latest wind turbines can hit up to an efficiency of 50%, when a proper site is selected with high quality of wind resource. The 2nd highest overall efficiency in the figure 3.2.2 is captured by natural gas which is known for the most efficient thermal system. Conversely, gas, coal and nuclear energy represent small ranges of efficiencies, differing up to 13%. However, looking at the case of wind energy, it is important to choose the right location to generate optimum, therefore the efficiency varies according to locations. Biomass has an even greater figures range, differing by up to 27%, with its maximum efficiency, biomass can be now compared with both coal and nuclear energy. The lowest efficiency is quoted for photovoltaic, and their efficiency seems to vary up to 22% due to difference in cell types. The geothermal energy efficiencies are dominant by the temperature of the geothermal source. Hotter geothermal sources are proportional to better efficiencies. (***A. Evans et al. 2009)***

III. Greenhouse gas emissions:

Electricity generations are the primary causes for greenhouse gas (GHG) emission. According to Evans 2009, world's electricity generation lead to in the release of over 10 billion tons of carbon dioxide to the atmosphere. RE technologies are considered as a solution for GHG emission. However there is no technology with completely zero greenhouse gas emission. Taking solar and wind energy as an example, these technologies do not emit greenhouse gas during operation, but during construction, recycling and installation of these technologies, there are GHG associated with it. Electricity from hydro dams, emit GHG through construction as well as operational stage where decay of organic materials within the dam is responsible for methane formation.

Following figure 3.2.3 shows the CO_2 emissions in grams for each associated technologies per kWh energy production.

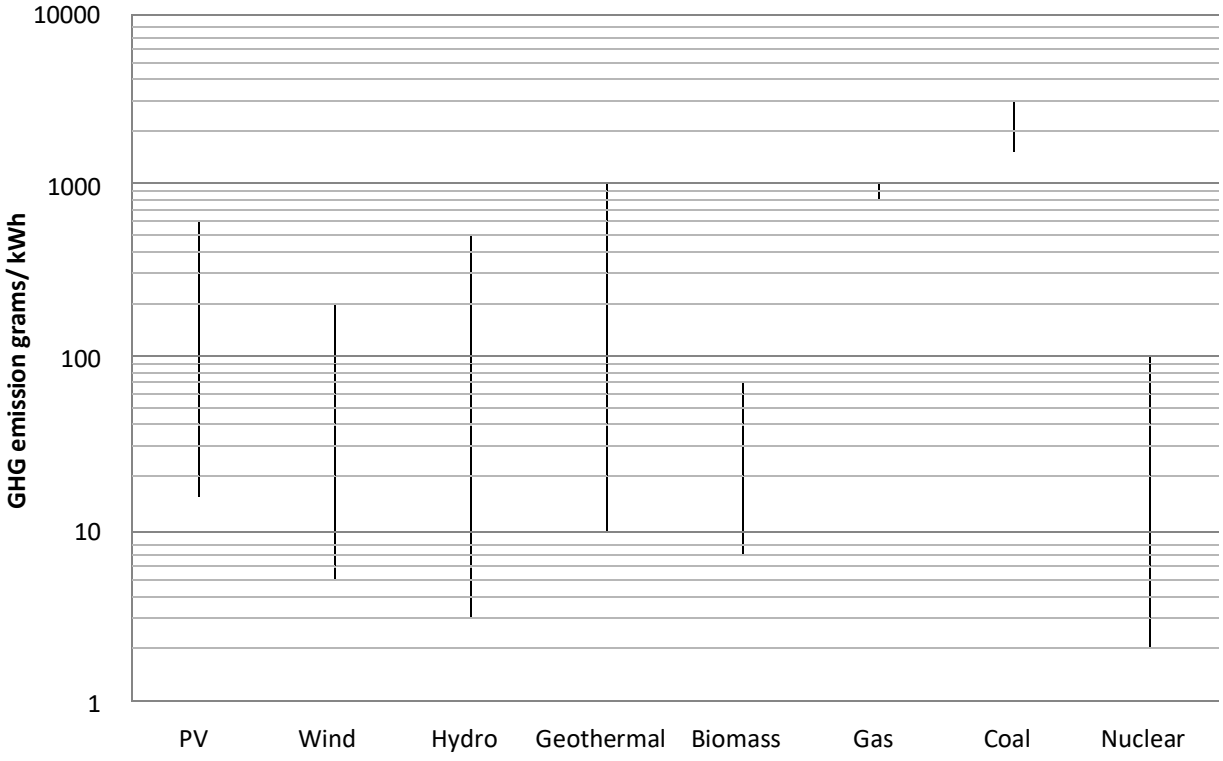


Figure (d) GHG emission from electricity production (g/kWh)

Nuclear energy has the bottommost average (16gCO_2e/kWh) and lowest range of emissions (1.8gCO_2e/kWh). Nuclear emission are highly based on enrichment of the ore, therefore great amount of nuclear energy can be produced by e

nrichment of uranium via diffusion **(A. Evans et al. 2009)**

IV. Usage of water:

As UAE has a dry climate, water is a significant resource which has to be sensibly preserved at all prospects. Many electricity generation technologies involve large amounts of water for c

ooling purpose. The usage of water can be categorized into two forms, consumption and withdrawal. Consumption is when the water is evaporated or lost from the system, which is impossible to be return to its resource. Withdrawal is when the water required to in order operating the system, in this case water can be recycled or returned to its source. Table 3.2.1 below shows the water consumption and the withdrawal of water of the electricity generation technologies.

	Consumption Kg water /kWh	Withdrawal Kg water /kWh
PV	0.01	_
Wind	0.001	_
Hydro	11 – 20	13600
Geothermal	0.3 – 300	_
Biomass	3.2	_
Gas	0.3 – 1.6	78
Coal	0.3 – 1.6	78
Nuclear	31 - 75	107

Table (a) Water consumption and withdrawal during electricity generation

Wind and solar have extremely low water consumption, 1g of water per kWh and 10g/kWh respectively. This negligible values make wind and solar more sustainable and preferable to UAE climate and resource availability. Geothermal has a wide range of water consumption; this due to the water capture, recycling efficiency and temperature of the geothermal resource, however applying close systems will reduce the water consumptions. Coal and gas are more matured technology compared to the rest, so they show equal consumption and withdrawal rate, 0.3 – 1.6 kg/kWh and 78 kg/kWh respectively. Biomass has a higher consumption than coal and gas this is primarily due to addition of water for crop growth and combustion. As nuclear plant requires large quantity of water for cooling the reactors it is obvious both consumption and withdrawal of water for nuclear power is high, however latest reactors and

technologies can be cooled down by sea water as well, which can be eventually returned back to the ocean.

As estimated hydro energy has the biggest water withdrawal, as it involves significant water storage volume. The availability of this resource as well as the UAEs insupportable climates make this renewable energy pointless all though hydro power tops the list of sustainability. As water is vital factor of UAE in identifying the technology, the most suitable technology according to this sustainable indicator will be solar, wind, geothermal and nuclear. (A. Evans et al. 2009)

V. Foot print:

UAE has a total land area of 83,600 km^2, and the rising populations have occupied most of the coastal regions of UAE therefore it is important to assess the foot print of the technology. Foot print is the direct and indirect measures of land occupancy required for the technology to operate, whether which land is been used, or the period of time it is used or how much damage has been done to the site due to the use of technology. Table 3.2.2 below shows the life cycle land occupation for electricity generation.

Technology	**Land occupation m^2/kWh**
PV	0.045
Wind	0.072
Hydro	0.152
Geothermal	0.05
Biomass	0.533
Gas	0.003
Coal	0.004
Nuclear	0.0005

Table (b) Electricity generation technology footprint

Exploring the data above, nuclear energy has the minimum land requirement in comparison to the rest of the technologies. PV, wind and geothermal energy also have low land

requirement. This makes these 4 technologies the most sustainable in regards to land occupation. Furthermore PV panels and micro wind turbines can be placed on top of a building roof, which will significantly reduce the foot print. . (A. Evans et al. 2009)

VI. Availability:

Fossil fuel and nuclear energy are finite resources. The availability is limited to the technologies applied. Fetter, S 2009, he states that "*According to the NEA, identified uranium resources total 5.5 million metric tons, and an additional 10.5 million metric tons remain undiscovered—a roughly 230-year supply at today's consumption rate in total*". Colorado River Commission (CRC) predicts the following reserves left shown in table 3.2.3. (CRC 2002)

	World Petroleum (Billion Barrels)	Natural Gas (Trillion Cubic Feet)	Coal (Billion Short Tons)
Annual World Consumption	27340	84196	4740
Years of reserves left	98	166	230

Table (c) Fossil fuel reserves

However to generate significant electricity using infinite renewable energy, it is important to assess the suitable renewable energy according to UAEs geographic and climate details. Since UAE has a limited access to water resources such as lakes, rivers etc. hydropower is not applicable. Similarly generating tidal energy is also problematic due to the insufficient speed of ocean currents. However other renewable energy technologies such as solar, wind, geothermal, bio energy may have some opportunities to build up.

Earth intercepts solar flux over 170 Pica Watt of sunlight every year and UAE has an abundant level of solar radiation. According to NASA meteorology centre UAE receives a radiation of 5-8

kWh/m^2/day during summer period and during winter 3-4 kWh/m^2/day. These values of radiations are optimum for operating solar energy.

As wind speeds are inconsistent, selection of a proper site is vital. In order to generate wind energy, wind speed has to be above 3m/s. By analyzing the data from NASA meteorology UAE has an annual wind speed of 4.78, 5.30, 5.64, 6.25 m/s at a height of 50,100, 150, 300m respectively. Although these wind speeds seems low comparison to other locations worldwide, certain areas such as top of a mountain, coastal area can expect higher wind speeds optimum for wind turbines.

High grade geothermal energy are available in over 80 countries globally, capable of a theoretically generating capacity around 400 PWh/year. In order to get an idea of this capacity, in 2009, the global energy consumption was 20.2 PWh. Currently, Masdar Abu Dhabi is investing 11 billion USD, on geothermal plant forward to produce 5MW power to power air conditioning system in Masdar city. (Renewable Energy World. 2010)

UAEs abundant climate makes bio-energy via extraction of crops out of the question. However Masdar institute plans for a jet fuel production from saltwater-tolerant crops grown in the desert. Masdar Institute scholars in the UAE are starting a 2 km^2 demonstration farm cultivating a suitable plant which can be converted into fuel known as mangrove trees and salicornia (see figure 3.2.4). Due to its immaturity, and experimental stage, bio energy solution for UAEs power generation will not be further discussed. (Bullis, K 2010)

Figure (f) Fuel crop: saltwater plant

VII. Storage:

Last but not least, as the renewable energy technologies are expected to take the lead in the forthcoming portfolio of energy generation. The major constrain about the renewable energy is availability and intermittency of their sources, for instance wind, solar, tidal energy unable to be stockpiled and they must be used as available or else they will be lost energy potentials. This issue now can be addressed by converting these energy sources into different form that can be stored. In transitioning to higher fractions of renewable electricity generation it is essential that adequate storage technologies are employed, allowing immediate resources to be captured and kept until they are required. The energy storage methods can be categorized in to four systems; Mechanical system, Electrical system, Thermal system and Chemical system as shown in the following figure 3.2.5 below. (A. Evans et al. 2012)

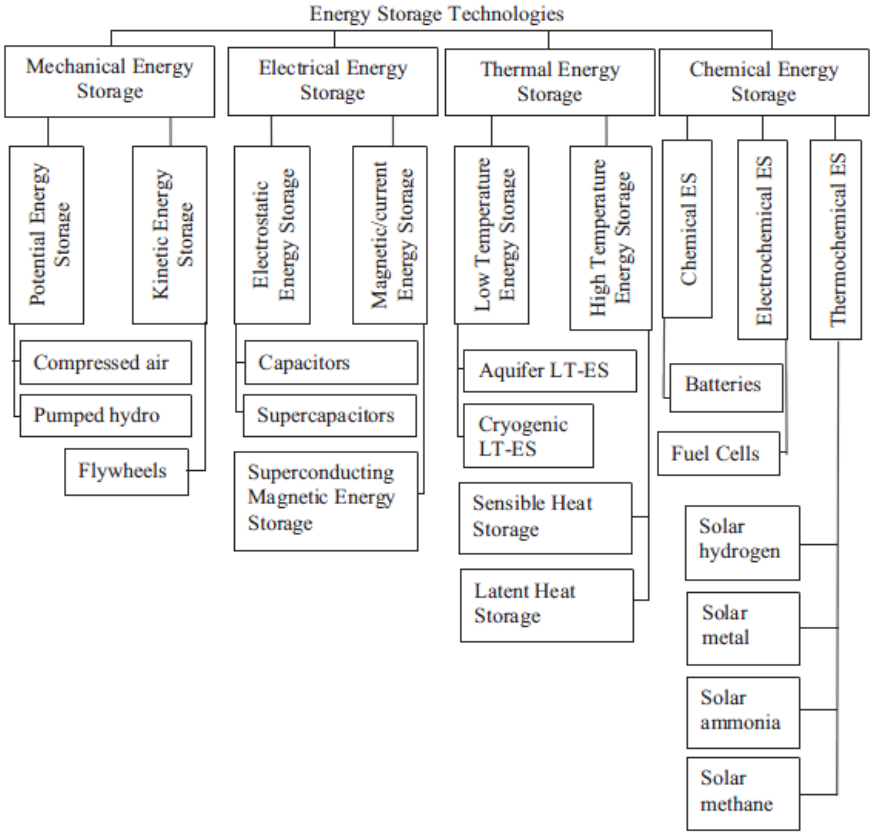


Figure (g) Types of energy storage systems

Overview

With an increase in the rate of energy generation through the use of conventional fossil fuel has resulted in an increased level of carbon emission in the environment. However if we continue this conventional practice, not only will we face the tragedy of extinction of the fossil fuels, but also the rise in environmentally related issues, as the carbon emissions are associated vice versa to the level of conventional energy consumption.

Renewable energy technology has continued to grow strongly in all end users, and global investment reached new highs. As with the new policies spread, the geography of renewables is also expanding worldwide. Therefore to assess the most effective sustainable energy technology developments for the UAE, 7 key sustainable indicators have been selected and discussed above which include cost, greenhouse gas emission, efficiency, natural resources, storage, limitations, and foot print respectively. Analyzing the provided seven key sustainable indicators for each energy generation technologies, it can be concluded that the **solar**, **wind** and **nuclear energy** generation technologies are the most suitable solutions for the UAEs arid climate conditions in order to overcome the growing demand and the rising climate change criticism. Executively supporting this selection, the UAE has ongoing and future developments in solar, wind and nuclear energy project, which indicates the potential.

The climate change and the fossil fuel exhaustion are the main factors for the recent interest on the alternative RE developments. However without sequences of associated policies, laws and regulations on the need for RE schemes, no agreement will be made on the development on RE technologies. Number of factors influences the elevation of RE schemes. These factors comprise the diversity of geographical circumstances and the energy policies and regulations within the country. The section 3.5 covers the existing UAE policies on sustainable development and a worldwide comparison of available renewable energy policy option for boosting RE

development in the UAE.

Renewable Energy Status in the United Arab Emirates

The electricity consumption in the UAE has accelerated consequent to the infrastructure developments and the increase in the energy investments. Taking into consideration the limited resources and the impact on the environment, specially the adverse effects of GHG emissions, the UAE has accepted that dependence on gas would not be a solution to the energy crisis faced by them. This directed their attention towards the usage of renewable sources of energy. In addition, the option of diversifying production of electricity encompassing nuclear energy has also been considered. Some of the renewable energy projects launched by the UAE are described below. (W. E. Alnaser & N. W. Alnaser 2011)

Shams 1

Shams 1 a pioneering project of Masdar, is expected to be the biggest Concentrated Solar Power (CSP) plant in the Middle Eastern region. The area covered by this vast project would be over 2.5km^2 and producing an enormous capacity of 100MW. In addition, it would have a solar field consisting of 768 parabolic trough collectors which would perform the task of producing clean and renewable electricity. 7% of the UAEs energy is proposed to generate by renewable energy by the year 2020, which would be supplied directly by Shams.

1. The plant will in addition be involved in the diversification of the energy production mix of the United Arab Emirates and also assist in the reduction of the UAE's carbon footprint. The aforementioned Shams 1 is a scheme which is under the United Nations' Clean Development Mechanism (CDM) and is a project which is qualified for carbon credits. It is noteworthy that Shams 1 is the first CSP unit to function under the CDM and furthermore it is the second

Masdar project. This plant will be capable of displacing around 175,000 tonnes of carbon dioxide annually .This in effect could be compared to the planting of 1.5 million trees or the withdrawal of 15,000 automobiles from the streets of Abu Dhabi. (Masdar 2010)

Figure (h) An artist's impression of Shams 1

Nour 1

In the third quarter of the 2013, Abu Dhabi Future Energy Co., referred to as Masdar expects to finalize the building of its second solar-power plant which has the capacity to generate energy up to 100 megawatts. This would enhance the output of green energy in the Persian Gulf Emirate. (DiPaola, A. 2011)

Plans for Nour 1 are based on the Emirate's goal of supplying 7% of its power utilizing renewable sources of energy by year 2020 as envisaged in year 2009. Masdar has already commenced the construction work on Shams 1, a plant which is to be completed in 2012. This is a $600 million venture which carries a concentrated 100 megawatt solar thermal power. Masdar, Abengoa SA of Spain and Total SA of France are the companies involved in this enterprise. The expenses incurred by Nour 1 plant would be comparatively less than the costs of Shams1 because efficiency has improved and due to the normal learning curve for the industry. (Yee, A. 2012)

Figure (i) Nour1 100 MW solar power plant

Sir Bani Yas Island

The construction of an onshore wind farm with a proposed capacity of 28.8 MW will be the initial stage of a program initiated by the Abu Dhabi's Tourism Development & Investment Company (TDIC) for the purpose of developing Renewable Energy on Sir BaniYas Island.

Sir BaniYas is a natural island situated 250 km southwest of the Abu Dhabi City and 9km offshore from Jebel Dhanna. Sir Bani Yas Island is the largest natural island in the UAE, measures up to 17.5 km north to south and 9 km from east to west. The project's planned designs and technical assessments were finalized in 2010 with the opening of the project fixed for early

2012. The island is promoted as an attractive place for tourists by the TDIC. **(Masdar 2012)**

Figure (j) Sir Bani Yas Island

Wind Stalk Energy:

Masdar city in Abu Dhabi, is currently studying a new form of technology to generate electricity via wind energy. This new phase is known as the "Wind Stalks", they are long pole shaped made out of carbon fibres, standing a height of 180 feet and a foot in diameter. As the wind stalks swing in the motion of wind, the piezo-electric discs present in the base of each pole generates electricity by converting mechanical energy into electrical energy. The main benefits of wind stalks in comparison with the traditional wind turbine is that they are way smaller in size giving benefits to land space and they cause no noise in comparison to wind turbines. Masdar proposed a wind stalk farm of 1203 wind stalks, covering up an area of 280,000 square feet.

As wind motion is not constant, a storage method is required to store the energy. Two large chambers below the site will operate like battery. This idea is based upon the technology PHES – Pumped Hydro Energy Storage. During off-peak period's water from lower chamber is pumped to the upper chamber & at on-peak period's water flows through the turbines to lower chamber, there by producing electricity. After the project completion, it is believed that each wind stalk will produce as much as energy as a convectional small scaled wind turbine. In addition to meet higher energy demand a dense rows of wind stalks can be planted to achieve the desired output. This is a major benefit in comparison with the convectional wind turbines. (Danigelis, A 2012)

Dubai Solar Park

A gigantic solar energy project is being launched by the Dubai Emirate authorities. A long name has been given in keeping with its lengthy proportions. Mohammed Bin Rashid Al Maktoum

Solar Park is founded by the UAE Vice President, Prime Minister and Ruler of Dubai, Mohammed Bin Rashid Al Maktoum. (Matters, E 2012)

The solar park would spread over an area of 48 square kilometres, and located at Sieh Al Dhal in Dubai. Billions of dollars will be invested in this project. Minor, privately controlled systems employing photovoltaic technology convert solar rays into electricity and produce 4.5 MW of solar power in Dubai. The new solar power park is also planning to use solar PV. In addition to this it is proposed to employ a new form of technology identified as concentrated solar power. The method followed is to project sunlight reflected from a long line of mirrors on to a confined area where the accumulated heat is converted into energy. The measures to be followed in order to increase the production from 4.5 MW to 1,000MW and the party who would finance the building of the plant has not yet been disclosed.. (Todorova, V 2012)

Solar Islands:

CSEM and its Emirates subsidiary were given a task of applying a project by the Ras Al-Khaimah Investment Authority (RAKIA). (Alpnach & Csem 2008)

A series of floating, rotating solar islands off the coast of Ras Al-Khaimah could be the solution to the Emirate's energy distresses. Heat produced from the solar panels produces steam in an underwater tank, piped to a turbine on shore. A prototype installation of these solar islands are situated in Ras Al Khaimah (RAK) in the UAE. Measuring 80 metres in diameter and weighing 250 tons, this facility generates 1.2 GWh of energy per year. Whereas this test installation has been built on dry land, in future significantly larger installations are possible which may also be built at sea. ***(SAIA-BURGESS 2008)***

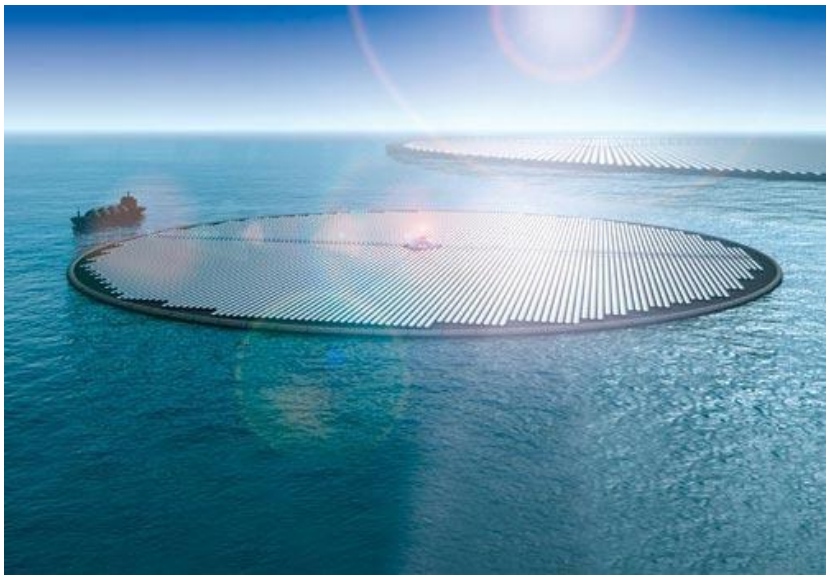


Figure (k) Concept solar Island

Energy policies in the United Arab Emirates

Today UAE faces a number of energy associated issues such as meeting the rising energy demand and increasing environmental pollution. As the consumption of fossil fuels over takes the production, the government recognizes the importance in generating power from non-conventional alternative energy structures. As a result, chain of supporting laws, policies and regulations have been delivered in order to enhance the sustainable energy opportunities in the UAE. The RE expansions are intensely associated with the declaration of appropriate policies and regulations. The following study offers an examination of the policy framework for the RE in UAE and comparing other available policies that could be obtain to make a better future to renewable energy development in the UAE. (Zhao et al. 2011)

UAE Laws on sustainable energy:

Federal Laws:

Federal Law No. 11 of 2006 – Environment Protection Law

Federal Law No. 30 of 2001 – Environmental Agency

Cabinet Resolution No. 37 of 2001 Regarding the Executive Regulation of the Federal Law No. of 1999 Concerning the Protection and Development of the Environment

Federal Decretal Law No. 7 of 2009 Abolishing Federal Law No. 7 of 1993 Establishing the Federal Environment Agency and the amendments thereto

Federal Law No. 6 of 2009 Concerning Peaceful Use of Nuclear Energy

Dubai Laws:

Law 19 of 2009 Establishing the Supreme Council of Energy

Abu Dhabi Laws:

Chairman of the Executive Council Resolution No. 42 of 2009 concerning Abu Dhabi Emirate Environment, Health and Safety Management System ***(Hadefpartners 2011)***

Further renewable energy policy options for UAE

RE Policy	Necessities for operation	Current status (presence)	Observations	Advantage	Disadvantage
Feed In Tariffs –FIT	▪ Grid connection guarantied ▪ High tariff to cover RE technology development ▪ Long term contract for electricity generation ▪ Different FITs according to location and technology	▪ Yes ▪ No ▪ No ▪ Still in progress	▪ 10 MW plant in Masdar city is connected to the grid. ▪ Need to restructure _ ▪ 10 MW PV plant is now built, and on-going construction on CSP	Successful development, Encourage project for both small and medium scale developers, Low financial risk, Stable investment	Overpriced renewable power, Involve restrain on RE trade due to domestic requirements.
Renewable Portfolio Standard/ Renewable Obligation/ Mandatory Market Share	▪ Target setting and following international regulations, carbon emission control, renewable energy job opportunities ▪ Assigning the actors and prepare market to function ▪ Review and monitoring ▪ Set tariff based on technology	▪ Yes ▪ Yes ▪ To be done ▪ Still in progress	▪ Target of 7% by 2030, retrieved the Kyoto protocol and contracted the UNFCC, Masdar being a government project. ▪ Masdar, RSB, ADNOC, ADWEA ▪ Masdar and RSB ▪ Solar PV (built) and CSP (under construction)	Constant pressure on cost reduction, Quotas establish guaranteed market, Allow trading of RE by green certificates which brings price down	Price fluctuate a lot, High transaction and licensing cost, Complex to design

	and location				
Bidding tendering	▪ Setting the RE electricity capacity ▪ Development of the infra-structure ▪ Bidding process take place	Yes To be done To be done	▪ By the year 2020, national RE target is set to be 7% ▪ Masdar is working with all stakeholders ▪ Sham1-CSP plant and Nour1-PV plant	Creates competition among developers therefor reducing the cost of RE electricity, Facilitated developing a solid service industry.	Drop of prices to unrealistic levels, Complications of permanency and steadiness.
Tax credit	▪ Reducing the cost of RE by means of market compensation by tax credits	No	_	Low levels of risk involved	Boom-bust cycles due to the time restrictions, No drive to rise performance.
Subsidies/ rebates	▪ Reducing the system cost of RE developments	No	_	Low operational and maintenance cost	High upfront investment cost.

Table (d) Available Renewable Energy Policies

(Mezher et al. 2012)

Most important fact is the way the government advocates the adoption of renewable energy. The pioneer in promoting the use of renewable resources is the Emirate of Abu Dhabi. Together with the Masdar project Abu Dhabi has strived to endorse RE in the Middle East region focusing mainly on the Gulf States which possess identical resources such as unlimited solar power, and oil based economies that can sustain such a step. The analysis recommended many policies and strategies for several countries while specifying their range of technologies and installed capacity. One notable feature is that while UAE (Abu Dhabi) anticipates that 7% of electricity generation will be catered by R.E by 2020, legislative enactments or strategies have not been stipulated for the promotion of power generation. (Mezher et al. 2012)

A number of countries have reached natural goals through FIT which was more reliable than Quota and Biddings. As a whole the implementation of the newly introduced RE policies must take into account the following points.

- Numerous countries have already established to renewal energy while legislation has been enacted to facilitate the adoption of the novel processes.
- Both the demand and supply should be taken into account when formulating policies.
- The importance of a feed in Tariff policy which gives weight to the different sources of energy as well as different scales should be considered.

Conclusively it will be a good idea if Abu Dhabi can get a mix of FIT system and Quota system to raise the share of renewable electricity generation. (Mezher et al. 2012)

CHAPTER III

LITERATURE REVIEW:
Economic Evaluations & Carbon Savings

Renewable energy and nuclear energy generations are receiving anincreased attention as a viable alternative to conventional fossil fuel based electricity generation. However, meeting the UAE electricity demands will require a more determined sustainable energy program than the present case. Although the UAE has invested millions of dollars on sustainable electricity generation such as solar, wind and nuclear energy, the objective of this chapter is to identify and analyse factors such as cost and carbon savings which are important for winning acceptance of sustainable energy both small scale and large scale project.

The study focused on four individual researches undertaken. In order to identify the potential impact of RE developments in the UAE, case study 1 and 2 are carried out regarding the implementation of solar energy and wind energy respectively in a small scale based. Case study 3 identifies the potential role of nuclear energy in the UAE (Emirates Nuclear Energy Cooperation) towards meeting the rising energy demand as well as mitigating the carbon emissions. Once identifying the economic evaluations and the carbon savings of the sustainable electricity generations, it is also important on the other hand to have a best practice on energy usage, consequently one of the best example to suit this matter is LED lighting, case study 4 is undertaken to analyse the beneficiaries of LED lighting in comparison to that of the conventional lighting systems.

It is a great challenge in promoting awareness and increasing relevant skills among related stakeholders and public. In this section, Key technologies and energy saving methods will be reviewed and the experiments illustrate the hierarchical pathway towards cost savings and zero-carbon refurbishment.

"Becoming carbon neutral is only the beginning. The climate problem will not be solved by one company reducing its emissions to zero, and it won't be solved by one government acting alone. The climate problem will not be solved without mass participation by the general public in countries around the globe" - Rupert Murdoch

Solar Energy

Solar energy global market:

When it comes to solar energy systems, most of the people imagine solar energy systems like the ones found on solar-powered calculators or the satellites. However photovoltaic systems are not the only way to convert solar radiation to electricity. Presently solar radiation can be converted into electricity by means of three different systems, Photovoltaic (PV), Solar Thermal and Concentrated Solar Power (CSP). As every day more solar power comes onto the grid, making integration and energy trading has reached to new heights, many countries are pushing themselves to play in the worldwide solar energy markets.

- *Solar Photovoltaic (PV):*

PV module price reductions continued in 2011, due to economies of scale associated with rising production capacities, technological innovations, competition among manufacturers, and a large drop in the price of silicon—and they outpaced cost reductions. The solar photovoltaic (PV) market saw another year of extraordinary growth, almost 30 GW of new solar PV capacity came into operation worldwide in 2011, increasing the global total to almost 70 GW. The number of countries adding more than 1 GW to their grids climbed from three to six, and the distribution of new installations continued to broaden. The top countries for total installed capacity at year-end were Germany, Italy, Japan, and Spain, followed closely by the United States. (Ahmed et al. 2012)

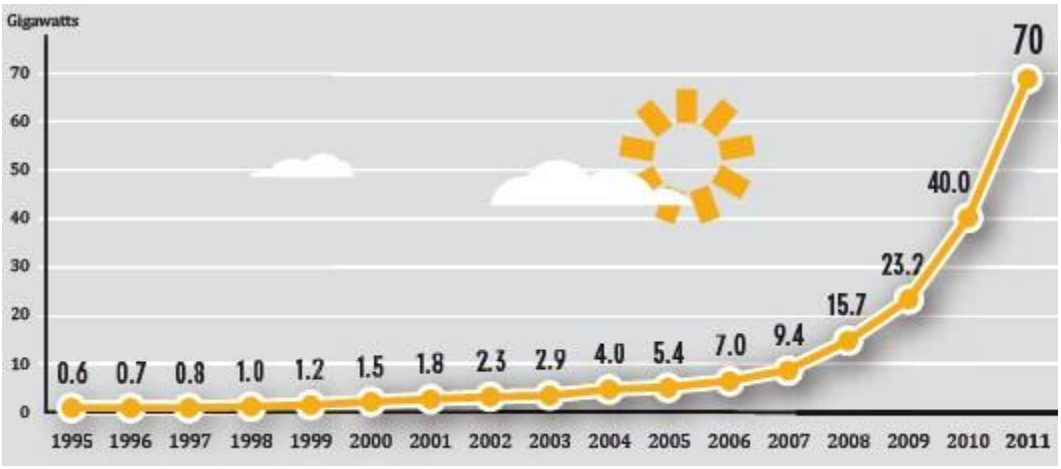


Figure (l) Solar PV total world capacity 95-11

The European Union again dominated the global PV market, thanks to Italy and Germany, which together accounted for 57% of new operational capacity in 2011. With a total of 51 GW by year-end, the EU accounted for almost three-quarters of the world's total installed solar PV capacity, and had enough solar PV in operation to meet the electricity demand of more than 15 million European households. Beyond Europe, the largest PV markets were China (2.1 GW), the United States (1.9 GW), Japan (1.3 GW), and Australia (0.8 GW). The vast majority of installed PV capacity today is grid-connected system, with the off-grid sector accounting for an estimated 2% of global capacity. Yet there is growing interest in off-grid and mostly small-scale systems, particularly in developing countries. (Ahmed et al. 2012)

- *Concentrated Solar Power CSP:*

Following the trend of the past few years, the concentrating solar thermal power (CSP) market continued its steady growth in 2011. More than 450 MW of CSP was installed, increasing total global capacity by 35% to nearly 1,760 MW. The market was down relative to 2010, but significant capacity was under construction at the year's end. Over the five-year period of 2006–2011, total global capacity grew at an average annual rate of almost 37%.

CSP growth is expected to accelerate internationally, with projects under construction or development in several countries, including Australia (250 MW), China (50 MW), India (470 MW), and Turkey, at least 100 MW of CSP capacity is under construction in the MENA region. South Africa completed an international tender in 2011 and awarded contracts to build 150 MW of capacity, and the national utility Eskom plans another 100 MW. Several other countries, including Chile, Israel, Italy, Mexico, and Saudi Arabia, have indicated intentions to install CSP plants or have begun work on legislation needed to support CSP development.

(Ahmed et al. 2012)

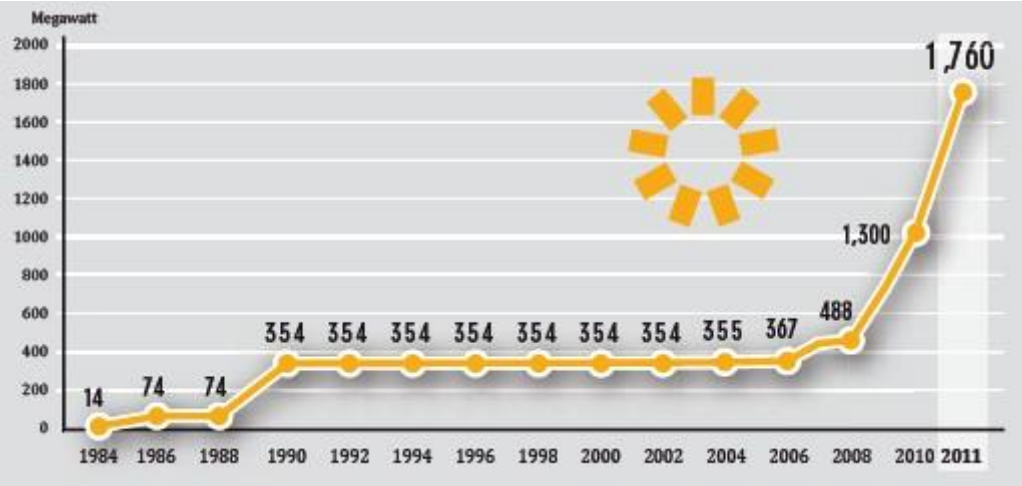


Figure (m) CSP world capacity 84-2011

- *Solar thermal:*

Solar thermal technologies contribute significantly to hot water production in several countries and increasingly also to cooling. In 2010, the world added an estimated 44.3 GWth of solar heat capacity, of which 42.4 GWth were glazed systems and the rest were unglazed systems for swimming pool heating. Glazed water collectors in operation by the end of 2010 provided an estimated 150 TWh (540 PJ) of heat annually.

By the end of 2011, total global solar water and heating capacity (glazed) reached an estimated 232 GWth, with net (less retirements) additions of more than 49 GWth. China again led the world for glazed installations, adding a net 18 GWth to end the year with a total capacity of 135.5 GWth—an estimated 58% of capacity in operation worldwide. While solar thermal heating is increasing around the country, its growth in China's urban markets is reported to have been considerable. The European Union accounted for most of the remaining added capacity, although lower rates of building renovation, due in large part to the economic crisis, have slowed growth in the region. The figure 4.1.1.3 below shows the worldwide solar thermal share. (Ahmed et al. 2012)

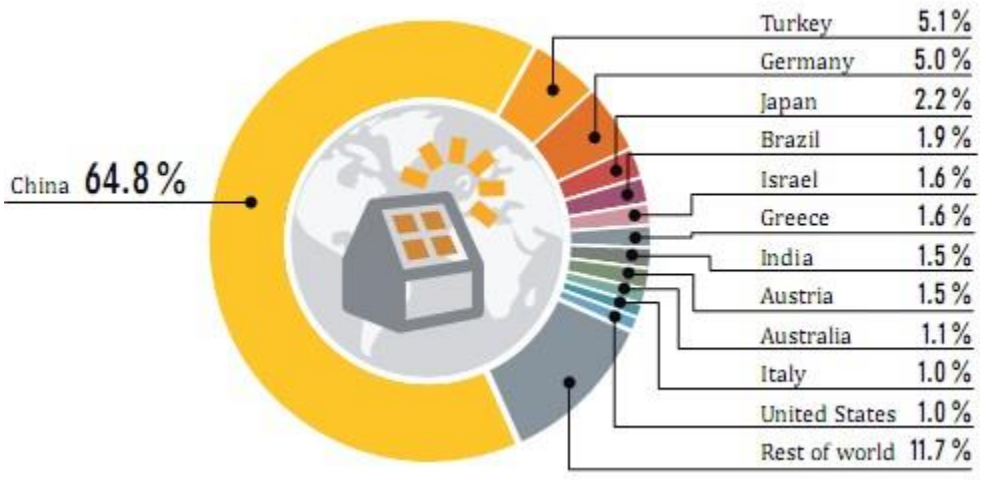


Figure (n) Solar thermal share worldwide

Solar energy in the UAE

Solar energy has been used for very long time, as the hydropower for applications such as heating dwellings, drying clothes etc. (ESA21 2012). Acceleration in the electricity usage is observed in the UAE during the period of 1980 and 2000. This consumption prevails to date. In

comparison, this increase in consumption is much higher than that of the world's average. The assessed increase is from 5.5 billion kWh in 1980 to around 36 billion kWh in 2000. The annual increase of 10% is high in comparison to the average world growth of 3%. This humongous rise in energy demand can be met by implementing solar energy, including the electrification in rural areas, obtaining water from wells, pipeline protection, desalination, telecommunication devices, buildings etc. could be covered by using photovoltaic technology. As solar power offers many opportunities, it is imperative to have a clear knowledge of distribution of global and direct solar power in the region. (Islam et al. 2010)

Certain renewable energy technologies are well favored to UAEs arid climate. To understand the potential promises solar energy holds in the UAE the following study has been carried out. The figure 4.1.2.1 below shows the blessed solar radiation of UAE acquired from the data provided by NASA meteorology. (NASA 2012)

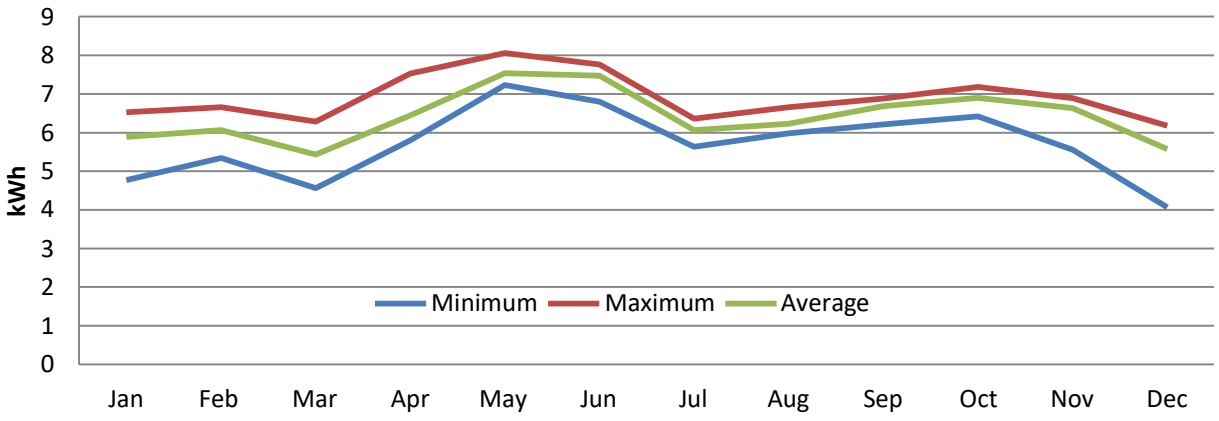


Figure (o) UAE Monthly average direct normal radiation kWh

In order to minimize the dependency on traditional fossil fuel based energy, the UAE government has diverted its investments towards renewable energy development, especially in the field of solar power. This step could be a definite solution to the energy crisis in UAE arising from the disparity between the demand for energy and the supply of non-renewable fossil fuel. There are several on-going projects which involve the planning, production, supply, setting up

and the commissioning of systems based on solar power and solar photovoltaic schemes. For example as mentioned in the earlier chapters, the Masdar PV holds the significance of major investments made in respect of solar power project as it has an investment of over $2 billion in the production of solar power. (Radhi 2010)

Case Study 1: Evaluating the potential of solar energy on UAE residential buildings

It has been established that generation of electricity, transportation sector, industrial sector and construction sector are mainly responsible for the rise in the carbon emissions. Hence research groups and the construction sector are especially compelled to deal with the problem of global warming and emission of greenhouse gases, especially CO_2. The UAE per capita energy consumption ranges among the highest in the world. The swift increase in the expenditure and population in conjunction with low energy cost has created this increase in energy consumption. A study has revealed that the greatest impact is felt by the residential sector. The rise in the electricity usage in residences is the result of several contributory factors. The growth in population levels and the usage of modern electrical devices which contribute towards comfortable living have directly increased electricity consumption among dwellers in buildings. (Radhi 2009)

- *Methodology*

To examine the electricity saving on buildings using solar panels, a case study on Abu Dhabi residential building was taken and the monthly loads are analysed. A typical villa was used to signify the residential building in Abu Dhabi city as shown in Figure 4.1.3.1. Factors which affect the energy consumption of dwelling can be divided into 3 classifications: climatic effects, design effects and people effects (Radhi 2009). The aim of this study is to achieve an acceptable level of renewable energy penetration towards energy saving as well as carbon emission

reduction.

Energy usage in buildings depends mostly on the prevailing climate. Temperature influences heating and cooling loads. Meanwhile cooling and lighting loads are controlled by solar radiation. Further, hours of daylight plays an important role on the lighting load. The usage of electricity within building is highly dominated by air conditioning. To examine the potential of solar energy on minimizing the electricity usage from conventional fossil fuel, a case study on a residential sector in UAE analysed as follows. (Radhi 2009)

Figure (p) Floor plan of the dwelling

- *Determining the load, sunlight availability, and selecting suitable PV and inverter sizes*

The statistical reports of Abu Dhabi already proved that the global warming have resulted due to the increased energy consumption. It is evitable that there is a major climate change, which reduces heating degree-days, but rising the cooling degree-days. This steady climbing in the cooling degree days suggests that higher quantity of electricity utilized by the air conditioners to achieve a comfortable internal environment during the hot summers of the Abu Dhabi city. A

residential building selected in this case study has an available area of 370 m^2 and an annual load of 99, 547 kWh/ year, figure 4.1.3.2 below shows the breakdown of monthly distributed loads. (Radhi 2009)

Impact of Geographical position for UAE:

As the UAEs geographical position lies on the solar belt, researches have proved that daylight exists about 4449 hours annually. Therefore the UAEs abundance of solar energy in addition to that of fossil fuel, gives a prospect to exploit this plenteousness of green energy successfully, thus encouraging towards clean environment. (Islam et al. 2010)

Following data presents the Abu Dhabi's (24.43 North, 54.45 East) actual measurements of solar radiation measured over a period of 20 years by NASA meteorological centre. Great resolution, real time solar radiation and other meteorological data such day light hours were collected and processed as shown in the figure 4.1.3.3 and figure 4.1.3.4 respectively. (NASA 2012)

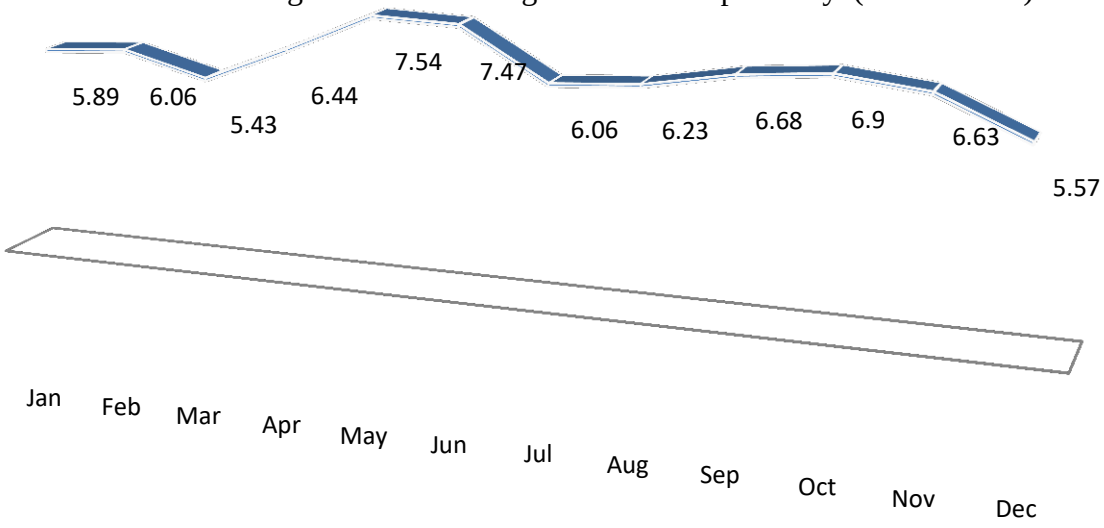


Figure (p) Abu Dhabi average monthly radiation kWh/m^2/day

Insolation Value can be defined as the quantity of useful sunshine obtainable for the solar panels on an average day (usually the day with least sunshine is undertaken, in order to perform safe

calculations). In most of Abu Dhabi, average solar insolation hours range from about 10.6 to 13.6 hours per day and with an average 82% clearness index annually, as shown in figure 4.1.3.4.

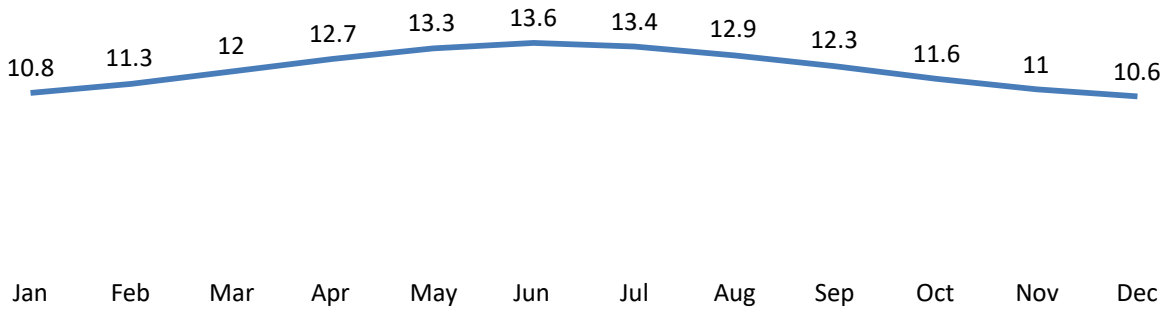


Figure (q) Abu Dhabi average monthly day light hours (NASA 2012)

For a PV system powering the building loads, the size of the PV array is determined by the daily energy necessity divided by the daylight hours. Generally, grid connected systems are designed to provide from 10 to 70% of the energy needs with the difference being supplied by utility power.

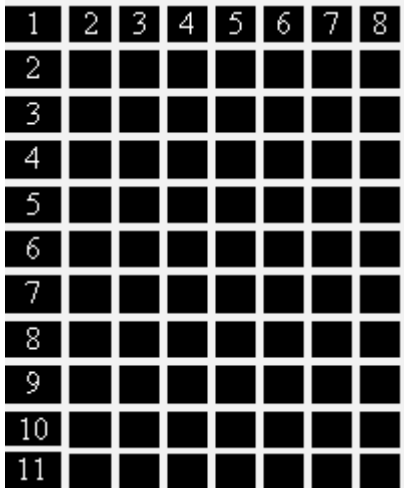


Figure (r) PV module arrangement

- ***Solar Simulation***

  Simulation modeling has become a huge part for technical improvement and investigation. A great number of simulation software's being used in engineering, medical, logistics etc. The simulation market consist a continuously increasing demand. Nowadays various technologies and studies have made simulation software's more accurate, user friendly, multi-language etc. to perform several fields of tasks. In the field of solar energy, PV software's are mainly used for designing, planning and monitoring. Today there are 12 foremost PV simulation software's are available in the market, as listed below in Table 4.1.3.1. (Lalwani et al. 2010)

Software Name	**Manufacturer/Developing Institution**	**Cost/ License**	**Website**
RETScreen	NaturalResourcesCanada	Free of Charge	www.retscreen.net

TRNSYS	University of Wisconsin, Madison, US	$2100 for educational Use	http://sel.me.wisc.edu/trnsys/
HOMER	National Renewable Energy Laboratory, USA	Free of Charge	www.nrel.gov/homer
INSEL	Insel Company, Germany	1700 Euro full version	www.insel.eu
PV F-CHART	University of Wisconsin, Madison, US	$400 for single user	www.fchart.com/
NREL Solar Advisor Model (SAM)	National Renewable Energy Laboratory, Washington	Free	www.nrel.gov/analysis/sam/background.html
PVSyst	Institute of Environmental Sciences (ISE)	900 CHF for one machine license	www.pvsyst.com/
Solar Design Tool	Verdiseno, Inc., Santa Cruz, USA	expert version with monthly fee	www.solardesigntool.com/
ESP-r 11.5	University of Strathclyde, Scotland	Free of Charge	www.esru.strath.ac.uk/Programs/ESPr.Htm
SolarPro	Laplace System Co., Ltd, Japan	$1,900 for educational Use	www.lapsys.co.jp/english/
PVDesignPro-G	Maui Solar Energy Software Corporation,	$249.00 for Solar Design Studio CDROM	www.mauisolarsoftware.com/
PV*SOL Expert	Dr. Valentin Energie Software, Germany	Euro 2456,00 for 20 licenses for educational	www.valentin.de

Table (e) Major Software's for PV Simulation in the world market (Lalwani et al. 2010)

Professional solar energy software designed to be used by various architectures, engineers and researchers. From the all 12 listed software's, PVsyst simulation program is favoured due to the free trial access and the detailed help option with various tutorial simulations which provides an understanding of various parameters and methodologies. (PVsyst: Software for Photovoltaic Systems. 2012)

PVsyst has an inbuilt 80 % of the countries worldwide & their geographical data. However due to the trial version been used certain countries were inaccessible, and unfortunately United Arab

Emirates was one of the inaccessible list. This matter can be solved by registering for a membership which involves additional cost. Since this study is a non-profitable education purpose only, a similar country to that of UAEs climate conditions is selected, in this case Jeddah, Saudi Arabia (Latitude: 21.4° N, Longitude: 39.1° E) matches more than 97% similar radiation to that of UAEs when compared and the study is proceeded. Albedo factor, tilt angle and the azimuth angle are important basic parameter needs to be identified. As the radiation from the sun falls on Earth surface, certain surfaces absorb this radiation while others reflect the radiation. The albedo factor ranges from 0 to 1, where 0 represent 100% absorption & 1 represent 100% reflection. According to NASA global albedo, UAE has an albedo factor of 0.2. Tilts angle and azimuth angle are entered by examining the optimization graph given by the software which is 20° and 0° respectively. Once identifying the basic background information, the component information and the design of the system has been entered. 88 units of 250Wp-41V solar modules from Canadian Solar Inc. arranged 8 units in series comprising 11 strings and 4 units of 5.5kW 246-480V inverter from SMA is used to convert the solar energy into consumable energy (see figure 4.1.3.6). Subsequently, identifying all the required components for the system, simulation has been carried out to identify the behavior of the solar energy system towards minimizing the use of electric load from the conventional grid.

Figure (s) Solar energy component details

- ***Results and the economic evaluation***

A residential building under taken for examination in Abu Dhabi has an annual load of 99,547 kWh with a total available area of 370m^2. A planned power of 40kWp solar energy system is designed using PVsyst software.

*Investment***:** Using the Solarbuzz fact sheets, and the Chinese solar market, the current market prices as of 2012 for modules, inverters etc. are archived and the initial cost of the setup is calculated and compared for the both markets (see table 4.1.3.2).

Product	**Units**	**Cost USD (Solarbuzz)**	**Cost USD (Chinese)**	**Total USD (Solarbuzz)**	**Total USD (Chinese)**
PV module 250Wp	*88*	*2.29 USD per Wp*	*0.65 USD per Wp*	*50,380 USD*	*14,300 USD*
Inverter 5.5kW	*4*	*0.711$ per Watt*	*1500 USD / set*	*15,642 USD*	*6000 USD*
Settings, wirings, installation etc. (1% of PV investment)				*504 USD*	*143 USD*
Total initial investment				***66,526 USD***	***20,443USD***

Table (f) Solar energy system economic comparison (Solarbuzz 2012) & (Alibaba 2012)

Findings: The proposed solar system produces 37,445 kWh annually, which is about 38% of the annual load. Since conventional energy cost 0.04 cents per kWh (15fils/kWh) according to ADWEA tariff, the total energy cost saving annually can be achieved. Analysing both markets, the Solarbuzz prices are relatively high due to the brand and the quality, therefore to be on the economical side and to avoid unachievable payback period, the Chinese module prices have been favoured.

According to (IEA 2011), CO2 emissions per kWh from electricity and heat generation in UAE is 0.694 Kg / kWh. Therefore a carbon savings can be saved annually.

Discussion:

The radiation on the horizontal surfaces of the Abu Dhabi was collected from NASA meteorology centre and the data was used to study the potential of PV technology. The minimum and maximum values solar radiation for each month was plotted, as well as the daylight hours were calculated and tabulated. The results obtained proved that the PV application in the UAE is a promising solution to minimize the conventional energy consumption. The land availability and the total annual solar radiation of Abu Dhabi indicate a strong potential for solar energy market in the Abu Dhabi. The residential sector in the UAE is the major reason for the growing energy consumption. Hence the case study has been examined in the residential sector of Abu Dhabi to identify the potential of the solar energy to minimize the dependency on the convention grid, hence contributing towards carbon savings.

Whether large-scale or small-scale, UAEs arid climate suits the best for solar energy potential. Three recent studies have examined by (Harder & Gibson 2011) the energy production potential, financial feasibility in Middle East using methods similar to those reported in this paper is shown in the figure 4.1.3.8. By analysing the results from multiple locations all three studies found the

PV projects to have a positive net present value (NPV), making all of the projects financially feasible. (Harder & Gibson 2011)

Therefore the use of solar energy in the United Arab Emirates holds the most promising, reliable and environmentally stable forms of RE technology which has the potential to contribute significantly on the current and future energy production.

	Saudi Arabia	Egypt	Jordan
Capacity (MW)	5 MW	10 MW	5 MW
Location	Bishah, S.A.	Wahat Kharga, Egypt	Talifa, Jordan
Global solar radiation	2.56 (MWh/m^2/year)	2.13 (MWh/m^2/year)	2.46 (MWh/m^2/year)
Daily sunshine duration	9.2 h	12.1 h	9.6 h
Tracking system	Fixed	Two-axis	Fixed
Module type	BP 90 W	Sanyo 205 W	BP 90 W
Internal rate of return	16.7%	24.9%	20.1%
Net present value	$74 million (US)	$144.3 million (US)	$40.5 million (US)
Cost of energy	20 cents/kWh	20 cents/kWh	123 cents/kWh
GHG reduction	10,007 tons/year	14,538 tons/year	9317 tons/year
Annual generation	12.4 GWh	29.5 GWh	11.9 GWh

Figure (t) Solar Energy Projects in Middle East

Wind Energy

Wind turbines installed capacity, efficiency and the visual design have improved immensely ever since the early 80s. The year 2010 was a huge turning point for wind energy, 39 GW of wind capacity have installed worldwide, more than any other renewable energy technologies. As a result total of 83 countries worldwide now use wind energy commercial basis, hitting an incredible capacity of 198 GW. (Ahmed et al. 2011)

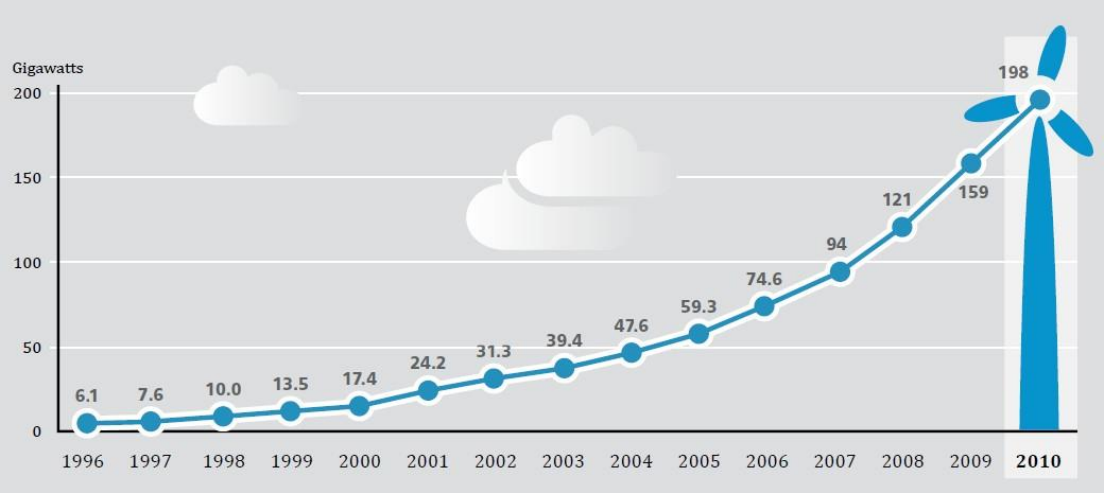


Figure (u) Existing World Capacity, 1996 - 2010

As the economic crisis continues slowing down the economies and energy demand in various developed nations, it is noticed that for the first time new wind turbines are taking the market in developing and emerging nations in compare to the traditional wind market. This growth is clearly seen in China, which is accountable for 50% of global capacity addition in 2010 as shown in the figure 4.2.0.2. In 2010 the European nations installed around 9.5 GW, which seems to be down in comparison to the year 2009. Although the shares of total wind capacity seems to be small, the offshore wind industry continued to pick up speed, increasing by 1.2 GW to 3.1 GW at the end of 2010, most of this capacity in Europe and the rest in China. Total present wind power capacity by the end of 2010 was sufficient to meet a projected 2.0–2.5% of global electricity consumption. (Ahmed et al. 2011)

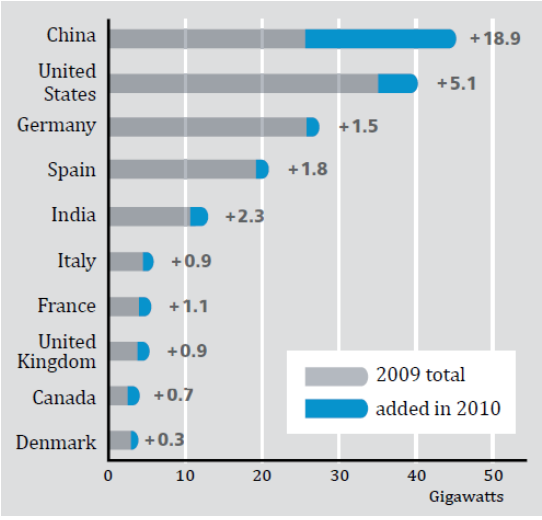


Figure (v) Top 10 wind power countries

Fundamentals of Wind turbine

Wind turbines are named in accordance to their constructional geometric & their aerodynamics. At present wind turbines can be classified into 3 machines; horizontal axis machines, vertical axis machines and concentrators. (John Twidell & Tony Weir 2006) Since the study focuses chiefly on Horizontal axis wind turbines (HAWT), the rest of the categories will not be further discussed. HAWT principally have 2 or 3 blades, and their diameter ranges from 10m up to several 100m according to their capacity. HAWT have the main rotor shaft, electrical generator, and other components at the top of the tower

see figure w.

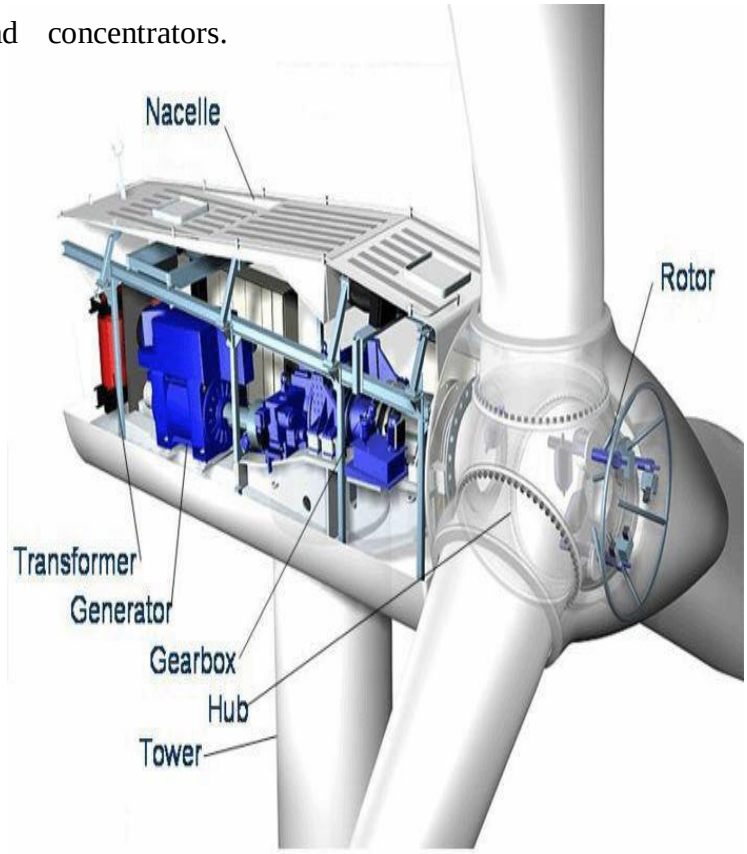


Figure (w) Components of wind turbine

Production of commercial wind turbines began during the 1980s. From sizes of 20-60 kW with rotor diameters up to 20 metres, since then wind turbine generators have increased in capacity up to 7 MW and above. Currently the largest machine being manufactured is the Enercon E-126 with a capacity of 7,580 kW having a rotor diameter of 127m. Frequent enhancements are carried out in order for the wind turbines to obtain as much as wind energy.

These enhancements include more powerful rotors, bigger blades, better power electronics, improved composite materials and taller towers. Since early 1980s, the wind turbine power has increased by a factor of more than 20 to the current date see figure 4.2.1.2. (EWEA 2010). Figure (x) The trend in rising wind turbine size

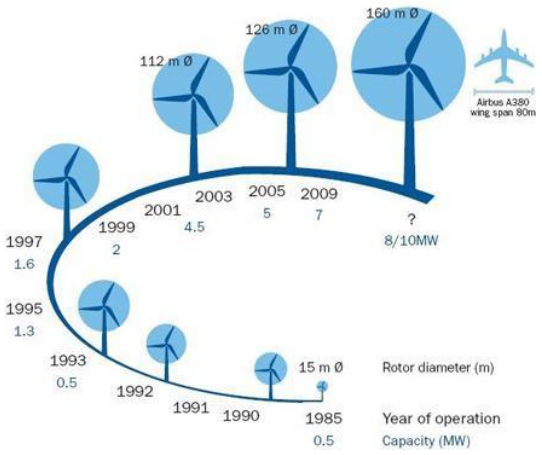


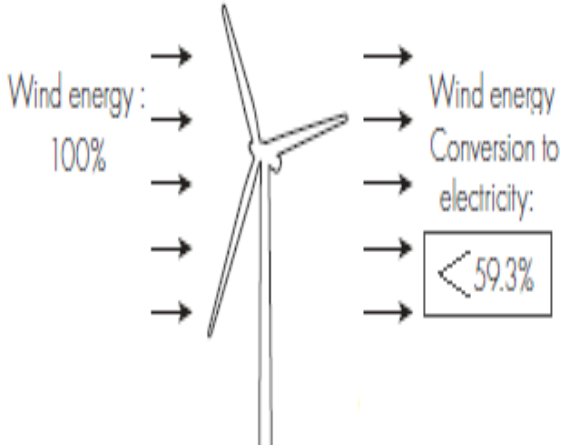
Figure (x) The trend in rising wind turbine size

Wind turbine power calculations

Kinetic energy in the wind is converted by the wind turbine into rotational kinetic energy which is then converted into electrical energy. The velocity of the wind and the swept area of the blades play a great role on extracting wind energy. When designing a wind farm, the expected power and energy output of the wind turbine should be analysed to calculate its economic feasibility. The kinetic energy present in an air mass m with unidirectional and uniform motion of speed V

is given by: (Mejía et al. 2006)

Albert Betz a German physicist stated in 1919 that "*no wind turbine can convert more than 16/27 (59.3%) of the kinetic energy of the*



wind into mechanical energy turning a rotor".

This is known as the **Betz Limit.** Therefore the maximum **efficiency** theoretically of any wind turbine is 0.59, this is known as "power coefficient"

Figure (y) Betz limit

No wind turbine operates at Betz limit. The *Cp* is a function of wind speed that the turbine is operating in. After analysing all the engineering requirements of a wind turbine, the turbines efficiency is well under than *Betz Limit* around 0.35-0.5%. By considering other factors in the wind turbine system such as gearbox, bearings, generator etc. only 10-40% of the winds power is eventually converted into usable energy due to the wind turbines efficiency. Therefore, the power produced by any given wind turbine is as follows; (RAENG 2012)

Wind Energy potential in UAE:

Wind farms can be operated in the coastal areas of Abu Dhabi, due to the favourable wind speeds and ground spacing. Researchers have evaluated the favourable ground spacing according to their energy generation capacities. Using geographical information system – GIS, it is found that the selected areas in the UAE has an average monthly wind speed ranging 4.18 m/s to 5.28 m/s as shown in the figure 4.2.3.1. (Kazmi, A and Chief, B. 2009)

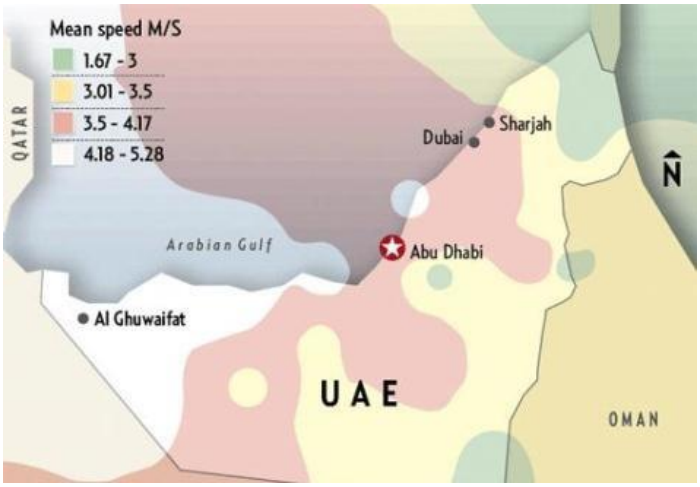


Figure (z) UAE average wind speed data

The wind speed in the UAE is relatively low, in comparison to other northern countries, however this wind speed can be utilized for generating small amount of energy for powering water pumps, high way lightings etc. In some period of the day in UAE, wind speeds can top up to 12m/s, these speeds can be taken into consideration, to design a wind turbine with an optimum cut in and cut out speed suitable for UAE weather conditions.

A study has been conducted in order to identify the potential opportunities of harvesting wind energy in Abu Dhabi, UAE, via wind turbine. The following theoretical calculations have made to identify annual energy production, carbon savings, and payback period using a selected wind turbine from Endurance Wind Power Company – Endurance E-3120 50KW wind turbine.

Theoretical examination of wind energy in Abu Dhabi, UAE:

The wind speed of the Abu Dhabi, UAE (Latitude 24.43, Longitude 54.45), is obtained from the NASA Meteorology site. (NASA 2012) By analysing the wind speeds in UAE, a proper wind turbine has to be chosen. Endurance E-3120 50kW Wind Turbine is one of the finest choices for UAE wind parameters. The following table 4.2.3.1 below shows details its specification Endurance E-3120.

SPECIFICATION SHEET	
Rotor Diameter	19.2 m
Swept Area	290 m^2
Hub Height	42.7 m
Max Power	50KW
Rated Wind Speed	8.5 m/s
Min Active Wind Speed	3.5 m/s
Cut Out Wind Speed	25 m/s
Max Rpm	60 RPM
Generator Efficiency	85%
Total Cost	330,000 USD

Table (g) Wind turbine specification sheet

Examining the specification sheet of the Endurance E-3120, annual output energy of the turbine is calculated using the fundamental wind power formula, as shown in the table 4.2.3.2 below;

Month	Wind speed m/s	Power Produced kW	Monthly kWh
Jan	4.57	8.55	6156
Feb	5.27	13.10	9432
Mar	4.95	10.86	7819.2
Apr	4.89	10.47	7538.4
May	5.41	14.18	10209.6
Jun	5.40	14.10	10152
Jul	5.01	11.26	8107.2
Aug	4.79	9.84	7084.8
Sep	4.54	8.38	6033.6
Oct	4.24	6.82	4910.4
Nov	3.90	5.31	3823.2
Dec	4.49	8.10	5832
Annual kWh			87098.4

Table (h) Wind power generation

Conclusion and Recommendation:

By the basic calculation, it is found that the Endurance E-3120 50kW wind turbine is capable of producing 87,098.4 kWh annually at mean wind speed of 4.8 m/s. However according to the Endurance E-3120 50kW wind turbine specification sheet, it states that at a rated wind speed of 8.5 to 10 m/s, it is capable of producing 462,095 kWh annually, this rated wind speed of 8.5 – 10 m/s is recommended in all the wind turbines worldwide. Therefore according to the UAEs available wind speed only a portion of 20% of the capable power is seen to be produced.

According to (IEA 2011), CO2 emissions per kWh from electricity and heat generation in UAE is 0.694 Kg / kWh.

Using this 20% power produced by Endurance E-3120 50kW Wind Turbine that is 87,098 kWh annually will save up to a significant amount of **60.45 tons** (0.694 * 87098) of CO_2 annually.

Though UAE seems to have relatively low wind speed in compare to other countries like Germany, Spain etc. by having a discussion with a wind turbine expert in UAE, it is suggested that the desired output can be archived by making some modifications to the wind turbine to perform optimally for UAE climate conditions. These modifications include;

- Choosing the appropriate location where the wind speed is optimum, as the output of the wind turbine rises by third of the exponential.
- Wind turbine generator size reduction, which allows the wind turbine to generate power at lower speed.
- Also wind turbine with larger blade diameter can be used to operate at lower wind speeds.
- Proper insulation and cooling is an important factor to consider, to minimize losses as well as to withstand UAEs harsh climate condition such as sand storm etc.

After understanding fundamental details of a horizontal axis wind turbine, it is now important to understand its potential on real life scenario. The following section highlights the potential of wind turbine in powering up remote areas where there is no grid access.

CASE STUDY 2: Hybrid renewable energy system for remote areas in UAE

The Wind Farm Simulation Software offers a real life simulation of the wind turbines behavior, aerodynamics, cost effectiveness etc. There are several wind simulation tools are available in the market, such as RETScreen, VirtualWind, WindPro, WAsP, HOMER etc. In order to identify the cost effectiveness of a wind turbine adding to a stand-alone or grid connected system comprising a diesel generator, a simulation is being carried out using the wind energy simulation software HOMER version 2.1, the micro power optimization model, simplifies the task of assessing designs of both off-grid and grid-connected power structures for a range of applications. When designing a power system, various decisions are made about the configuration of the system such as the ideal components in the system design, number of component and the accurate sizes etc. The great number of technology selections and the difference in technology costs and obtainability of energy resources makes decisions to be made. However **HOMER's optimization and sensitivity analysis procedures** make it easier to calculate the various potential system structures. A ***14 day trial version*** is downloaded which comes with the tools of hybrid power systems comprising

wind turbines, PV, batteries, diesel, micro turbines, fuel cells, hydro, grid connections and modular biomass is been used to assess the potential of wind turbine in a hybrid system coupled with a diesel generator, for a stand-alone system. (HOMER Energy 2012)

Most of the remote areas in the United Arab Emirates are fully powered using the diesel generators. However the rising operational costs and the concerns about pollutants and noise impacts are the key worries towards the desert landscape and the demography. Therefore the aim of this study is to provide the remote customers a viable solution by using hybrid system. This study is based on an existing safari camp in the Abu Dhabi. Coupled with the annual load measurements, and with the help of NASA meteorology for the annual average wind speeds of Abu Dhabi, simulation is carried out to provide a viable solution for remote customers using the software HOMER Energy.

Abu Dhabi Safari Camp:

UAEs beautiful desert landscape has cached the attraction of many tourist and the local residents. Safari camps are the primary attraction, as a result there are over a hundred safari camps are scattered in the deserts of UAE. Activities in the safari camps include camel riding, sand skiing, and dances. The camps are located in the deserts far from the civilization, this means electricity grids are far to reach. As a result UAEs safari camps are powered by standalone diesel generators. These generator capacities vary according to the load of the camps attraction. With the high operational cost conventional diesel generators have resulted emission of large amounts of CO_2, and also leakage of oil and diesel, which pollutes the underground water table, further more in the recent studies have also proven that the extreme vibration of the diesel generators are also seems to affect the layout of the sand dunes. The aim of the study is to provide a hybrid system to produce energy at low cost by using renewable energy system – wind turbine coupled

with diesel generator to match the load. The figure 4.2.4.1 shows the typical UAE safari camp. (Zoubeidi et al. 2012)

Figure (aa) Abu Dhabi Safari camp

Resources and Load Profile:

The safari camp in the Abu Dhabi is the case study under taken, located 22°11 N and 55°24 E. Abu Dhabi has the similar weather characteristic like the rest of the emirates in the UAE. The following figure 4.2.4.2 shows the average monthly wind speed acquired from NASA meteorological site. (NASA 2012)

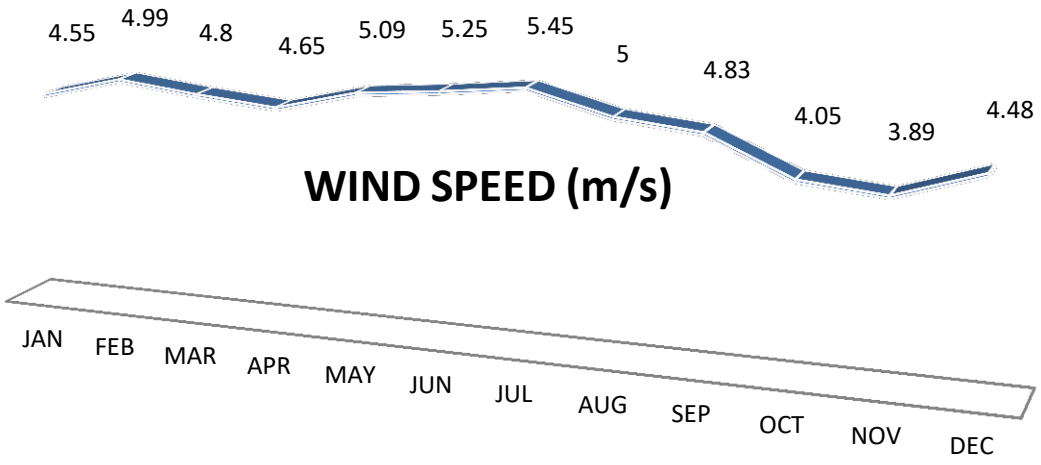


Figure (bb) Annual wind profile of Abu Dhabi (NASA 2012)

The Abu Dhabi safari camp timings are from 4pm to 1am, during this period load consumption can peek up to 35 kW, and has a daily load of 260kWh. Due to the high operational cost, the generators are usually turned off at off peak time from 1am to 4pm (Zoubeidi et al. 2012). Hence using a hybrid solution with a favourable load plan has been designed and this new load has scaled average of 278 kWh per day as shown in figure 4.2.4.3.

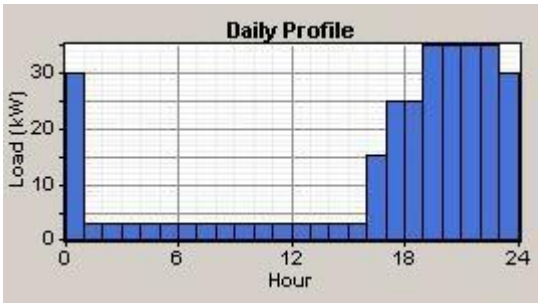


Figure (cc) Daily load profile

Methodology:

Once launching the HOMER simulation software, a new project is created, and the required components are selected as shown in the figure 4.2.4.4 below to analysis the effectiveness of wind turbine connected to a diesel generator system.

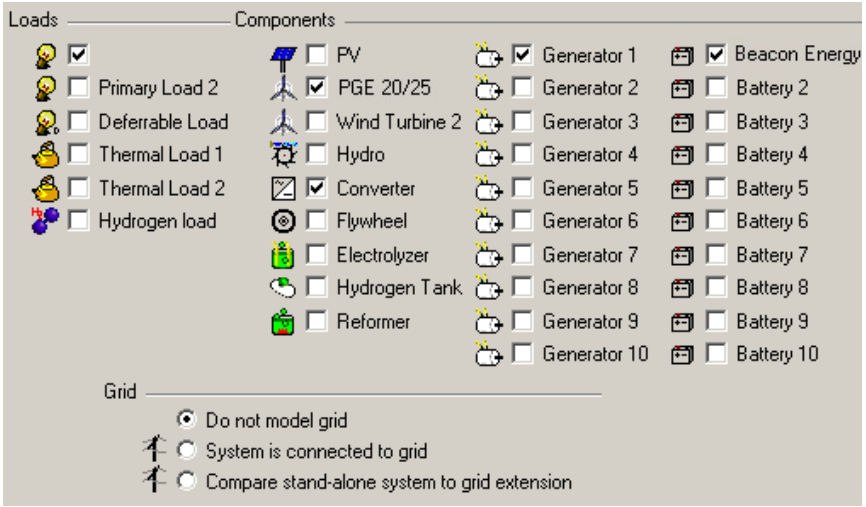


Figure (dd) Component selection

The electric demand, the annual load details of the system is now entered in the Primary Load 1, however during the month of Ramadan all of the safari camps are closed therefore according to 2012, the Holy Ramadan was on the month of August, therefore August is chosen and given an average of 2 kWh load for maintenance and other small activity purposes, as shown in the figure (ee) below.

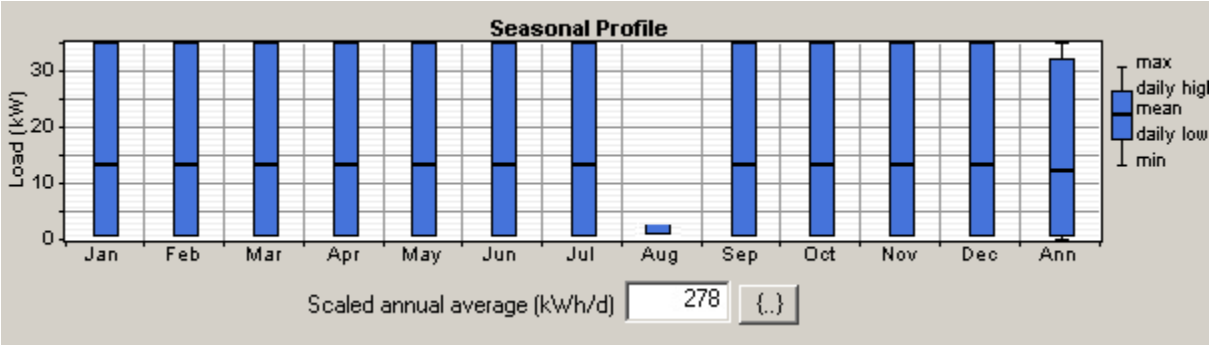


Figure (ee) Annual load profile

Resource details:

1. *Wind Resource:* Based on the wind resource details entered, HOMER automatically generates Diurnal Pattern Strength, Weibull-Shape, Autocorrelation Factor, and the hour when wind speed is at its peak. The Diurnal Pattern Strength uses the hour of peak wind speed to determine the scale and level of the typical daily pattern of wind speed. Weibull Shape is the circulation of wind velocity annually. Autocorrelation Factor relates to how much wind speed at a specific hour dependent is on the previous hour.

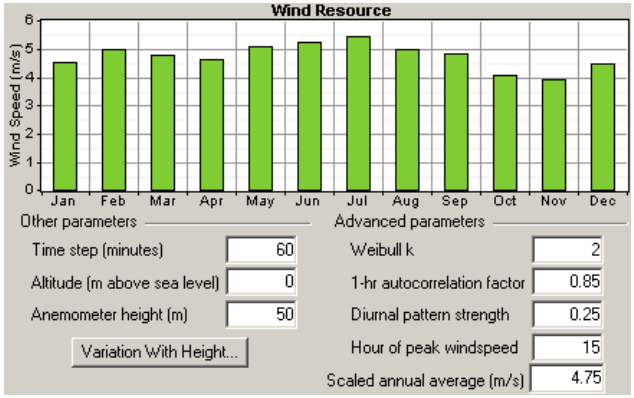


Figure (ff) Wind resource parameters

2. Diesel: Next resource is to enter the fuel price, the price of diesel according to the ADNOC petrol station 2012 is sold at 3.4 AED per litre, which is relatively high, due to this the operational cost of running a diesel generators are comparatively expensive in the UAE.

Component details:

Due to the prize inaccessibility of the components listed by HOMER energy software, an equivalent component from Alibaba.com has been used to quote the prices, without a surprise the low price quoted components are due to the Chinese market price.

1. Generator: 10500 USD worth of 35 KW Kohler Portable Hybrid Generator Set is chosen, which has maintenance cost of 0.05 $/hr. (Worldwide Power Products 2012)
2. Battery: plays a high role in energy storage in hybrid systems. Beacon Smart Energy 25 costing 2000 USD and maintenance cost of 50 $/year is a well know brand in the market, suitable for hybrid system. Numerous quantities of batteries are added for the HOMER to stimulate and chose the most cost effective configuration system. (Alibaba 2012)
3. Wind turbine: Suitable wind turbine is selected. In this case PGE 20/25, wind turbine with an estimated capital cost of 20,000 USD (Alibaba 2012) and the annual maintenance cost of a typical modern wind turbine is estimated around 1% to 1.5% of the original investment cost. (Wind Measurement International 2012) Figure 4.2.4.7 shows the power curve of the wind turbine PGE 20/25.

Figure (gg) PGE 20/25 power curve

Connection to the system:

Once identifying the appropriate wind turbine and the battery, to support the load, it is now required to add converter to connect the DC wind to turbine to the AC load. A converter converts AC to DC know as rectifier or DC to AC know as inverter. The figure 4.2.4.8 below shows the overall system schematic diagram. Finally simulation is carried out and HOMER will now simulate the most cost effective option for the system. The final scheme once completion of all the connection will look as show below in the figure (hh).

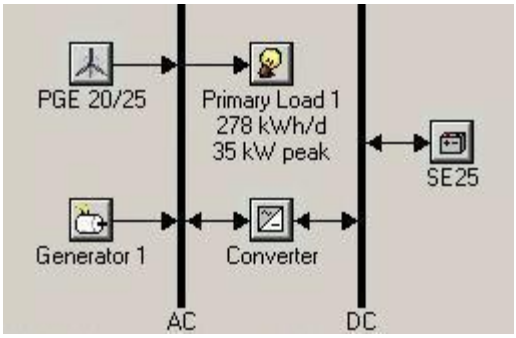


Figure (hh) overall system schematic diagram

Results and Conclusion:

The safari camps in the UAE uses convention diesel generator to power the load and running these conventional machines comes with a high operational price tag as well as ecological impact (oil leakage, vibration of generator affects desert sand dunes, carbon emissions etc.). However to minimize this issue, a hybrid system has been designed comprising wind turbine, diesel generator, battery, and converter using HOMER Energy software and a final report is generated.

Analysing the results, the wind turbine contributes to an astounding average of 47% of the load requirement, coupled with a generator producing up to 130277 kWh load annually. Although this amount of energy seems to be more than the required load (that is 101,470 kWh), the excess energy can be again stored via batteries or any other forms of storage systems. The figure 4.2.4.9 below shows the overall performance of the hybrid system.

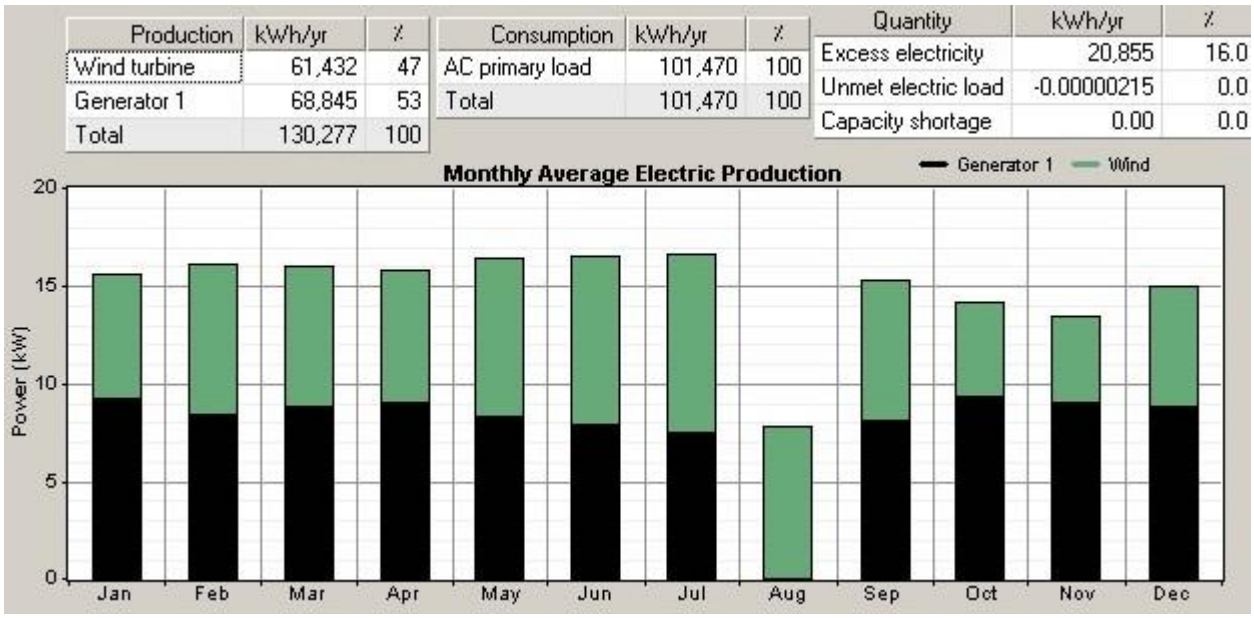


Figure (ii) Hybrid system overview

Reviewing the cost involvements and carbon emission in the table below, although hybrid system has tremendous 52,750 USD initial cost in comparison to that of 20500 USD conventional systems, the hybrid system pays great in annual operational cost than the conventional system that is 28251 USD and 35,879 USD respectively, which is about 7628 USD can be saved annually.

	Generator	Hybrid
Initial Cost	20,500 USD	52,750 USD
Annual Operational Cost	35,879 USD	28,251 USD
Cost of Energy	0.369 $/KWh	0.319 $/KWh
Fuel consumption	35,947 Litre/ year	26,832 Litre/ year
CO2 Emission	94,660 Kg/year	70,659 Kg/year

Table (i) Comparison between stand-alone generator and hybrid system

By means of this annual savings the payback period of the wind turbine can be estimated as following;

Since this study is for an educational purpose only the Original Equipment Manufactures OEMs refused to quote the component details, therefore most of the component prices are quoted according to the Chinese market, due to the inaccessibility of original cost of the product. Thus in real life, these price will be greater resulting a higher initial cost, extending the payback period to an estimated of up to 9 years. Wind generation systems have the disadvantage of an unstable power output, which can impact negatively on load operations. One means of solving this problem is to integrate battery energy storage system. However the objective of the present work is to estimate the optimal scopes of a stand-alone Wind/diesel generator hybrid system that promises the energy autonomy of a typical remote consumer. After comparing the performance for Abu Dhabi desert safari camp. It can be concluded that:

- The LCE is dominated by RE potential quality. For windy days, more than 70% of the total energy generation is supplied by the wind turbine, while for no-windy days the wind turbine influence represents only 30% of total production energy.
- The best option idealized in this case study is the hybrid system giving lower LCE, and

therefore provides higher system performance.

- The optimal hybrid wind system occurs at great energy excess. Therefore, the use of controllable diesel generator can bring benefit to the system.
- The duration of the payback period influenced by the turbine brand, the quality of wind speed, prevailing tariff rates, and available funding and motivations. Therefore with these provided factors, it usually takes 6 to 20 years to fully recover the cost of a small wind turbine.

Nuclear Energy

The industrialized countries empowered with required technology, finance and related institutions are seen to utilize nuclear power. It is observed that such industrialized countries which are in a position to use nuclear power are large scale consumers of energy. It is prudent for such nations to divert Uranium resources to productive use as they are supported by their technology and other assets. This practice could ensure the preservation of non-renewable resources for the other regions and future generations. Further, this utilization of nuclear power would apprise the future generations, even those in developing countries, that usage of nuclear power is an acceptable and an available option. (IAEA 2002)

There are currently 436 operational nuclear power plants in 31 different countries across the world. A further 63 were under construction. Their total output in 2010 was just over 2,600 TWh. This was 13.5% of global electricity generation. As of today there are three countries France, Slovak Republic and Belgium produce more than half of their electricity needs from nuclear power as shown in the figure (jj). (Bolton 2012)

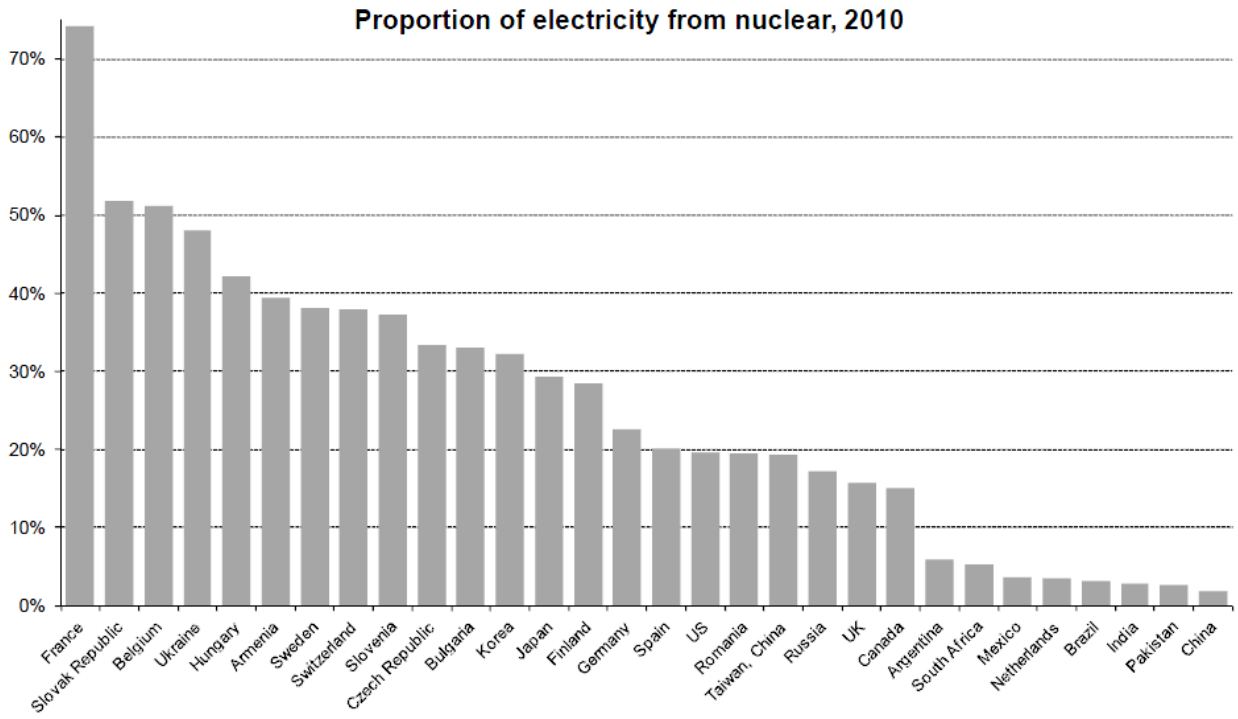


Figure (jj) Over view of worldwide nuclear energy generation

Nuclear energy workings:

If the term fission is to be defined, we could say that the vast amount of energy contained in an atom holds their nuclei together, and if isotopes of some elements split part of their energy is released as heat. This splitting process is known as fission. In power plants electricity could be generated by using the heat released in the process of fission. There are isotopes which fissions easily, such as Uranium-235 (U-235). What happens during fission is that loose neutrons are absorbed by U-235 atoms. Thereby U-235 loses its stability and splits into two light atoms, referred to as fission products. The mass of the original U-235 is higher than that of the combined mass of the fission products. As part of the matter is transformed into energy, the reduction of mass takes place. The energy is released in the form of heat. A series of fissions is referred to as a chain reaction. A chain reaction occurs when 2 or 3 neutrons released along with the heat strike other atoms and cause additional fission. The chain reaction creates a vast amount of heat, and could be used to produce electricity. The procedure followed to generate electricity in a nuclear power plant is similar to the procedure followed in other steam electric power plants. The procedure is as follows. Water is heated and turbines are turned by the power of the steam rising from the boiling water and thereby electricity is generated. (See figure 4.3.1.1). The source of heat is the principal difference between different models of steam electric plants. In a nuclear power plant a self- supporting chain reaction makes the water boil. The other plants use materials such as coal, oil or gas to heat the water. (U.S. Department of Energy 2012)

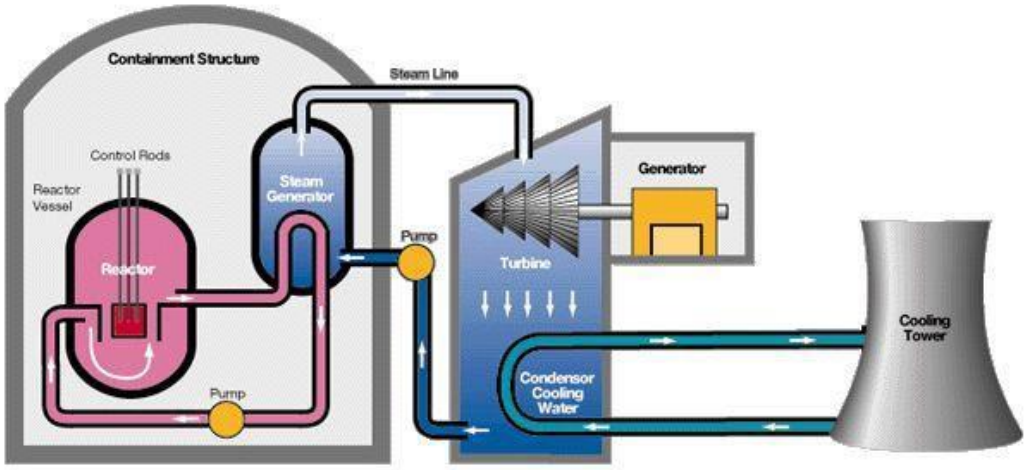


Figure (kk) schematic diagram of nuclear power plant (ESA21 2012)

Climate change and the need of meeting the rising energy are two major challenges faced by all the nations throughout the world. Concerning climate change and energy security have indicated a growing influence on the UAE energy policy and the nuclear power has suggested as a low-carbon technology by way of contributes widely towards sustainable energy developments. The following study discusses the on-going nuclear energy program and the related economic evaluations concerning towards it. (Corner et al. 2011)

Emirates Nuclear Energy Association

The UAE independently declared a comprehensive policy on Nuclear Power in April 2008.This policy assessed that the demand for electricity would rise from 15.5 in 2008 to over 40 GWe in 2020 and specified that natural gas would cover only half this quantity. The option of using imported coal was rejected due to environmental and energy security issues which may emerge. Renewable energy would provide only 7% of the required power by the year 2020. The UAE formulated a Nuclear Energy Program Implementation Organization following the advice extended by the IAEA. This organization founded the Emirates Nuclear Energy Corporation (ENEC) as an independent public authority of Abu Dhabi. (World Nuclear Association 2012)

The UAEs nuclear energy program is a joint venture between ENEC and Korea Electric Power Corp (KEPCO) costing about 30 billion USD. APR1400 nuclear reactor, with a capacity of generating 1400 MWe will be the first nuclear power plant of the UAE. The UAE plans to install four units APR1400 in the future. It is in 2017, unit one is expected to begin supplying electricity to the grid. UAE plans to complete the other 3 units in the years 2018, 2019 & 2020 and to provide a total capacity of 5600 MWe utilizing an accepted technology that complies with the highest international standards in respect of safety, production and effect on the environment. In South Korea four APR1400 units are under construction. The first unit will be connected to the grid by 2013. The units constructed by Korea will act as "reference plants" for the UAE. (ENEC 2012)

Nuclear energy policy for UAE:

The policy on the development of peaceful nuclear energy adopted by the United Arab Emirates was published in April 2008. Stringent levels of safety, transparency and security are essential features of this policy and this makes the UAE to be regarded as an exemplary model in the global development of nuclear energy. (ENEC 2012)

The policy highlights 6 key principles as follows:

- *Complete operational transparency*

- *The highest standards of non-proliferation*

- *The highest standards of safety and security*

- *Working directly with the IAEA and conforming to its standards*

- *Partnerships with responsible nations and appropriate experts*

- *Long-term sustainability*

Preferred site for nuclear power UAE:

Braka the Western Region of the Emirate of Abu Dhabi, located about 53 km west-southwest of the city of Ruwais, is the ENECs preferred site for the UAE nuclear energy program

Site selection contributing factors involved:

- Seismic activity history
- Isolation from populated areas
- Distance from water supply
- Distance from power grid
- Immediacy to transportation infrastructure
- Evacuation route and security circumstances
- Minimization of environmental impact

Figure (ll) ENEC proposed location

In July 2010, Federal Authority for Nuclear Regulation and the Environment Agency permitted the licenses for primary work to be processed at Braka. This License permits ENEC to begin the setting ups of the sites groundwork. It also permits construction other services such as roads, telecommunications networks and site administration buildings. For the meantime, the respective national license authorise the manufacture and assembly of parts such as nuclear reactor, pressure vessels, steam generators and coolant pumps which are important for safety reasons. (ENEC 2012)

The license for the construction of the UAEs first nuclear power plant has been provided by the country's safety regulator. Under the license, ENEC is authorized to import to the UAE equipment and technology exclusively for the construction of units 1 and 2 of the Braka plant, Korean-design APR-1400 design. (World Nuclear News 2012)

Economic evaluations:

According to (AlFarra & Abu-Hijleh 2012) the UAE's peaceful nuclear energy power program, is a joint venture between state owned Emirates Nuclear Energy Corporation and the Korea Electric Power Corporation, which will cost about $30 billion (Dh110 billion).

In order to find the cost per kWh, the capital cost is divided by the total capacity of the nuclear power plant, That is; This cost is the overnight construction, engineering, and procurement for producing per kWh energy from nuclear power plant. In comparing to other nuclear power plant project cost around the world this relatively lays in the same margin. By analysis this initial cost, it suggest that the UAE is in the same direction with other nuclear energy countries with regards to electricity production via nuclear energy. (AlFarra & Abu-Hijleh 2012)

Nuclear Energy generation cost: Following the estimated cost above, the Nuclear power plant

5600MWe will operate at efficiency of 90%, according to (AlFarra & Abu-Hijleh 2012) and the cost per kWh is calculated to be **3.2 cents/KWh**. This includes;

Amortized Cost	2.37 cents/kWh
Operating Cost	0.19 cents/kWh
Fuel Cost	0.64 cents/ kWh
Total	**3.2 cents/ KWh**

Table (j) Nuclear Cost break-down

(AlFarra & Abu-Hijleh 2012)

Convection Energy generation cost: Based on the statistical records provided by BP Statistical Review of World Energy June 2012, the total cost of generating electricity in UAE is **8.15cents/KWh.** This includes 66% gas and 34% oil. (Production et al. 2012)

Therefore the cost saving can be analysed by the following steps by reviewing (AlFarra & Abu-Hijleh 2012)

- ✓ ENEC plans to run 4 reactors of APR1400 by 2020 summing a total capacity of 5600MW.
- ✓ The Nuclear power plant will operate at a capacity factor of 90% which is equivalent to 5040MW producing;
- ✓ Thus the total annual cost of producing 44,150.4 GWh annually via nuclear energy;

Comparing this annual cost energy generation from nuclear to the convectional forms of energies is as follows;

Fuel	Price USD /KWh	Annual Cost of 44,150.4 GWh
Nuclear	0.0320	1.413 billion USD
Oil	0.1880	8.3 billion USD
Gas	0.0710	3.14 billion USD
Conventional (Gas 66% + Oil 34%)	0.0815	3.6 billion USD

Table (k) Energy generation costs

Annual Carbon savings:

According to CO2 Emissions from Fuel Combustion 2011 UAE has 0.694 Kg carbon emissions per kWh from electricity and heat generation. (Combustion 2011)

Since there is no carbon emission at operating stage of a nuclear power plant, carbon saving can be analyzed as following steps:

- ENEC Nuclear power plant produces enormous energy of / KWh = 0.694Kg
- Annual savings;

Carbon Emission:

Carbon dioxide is a primary greenhouse gas which causes global warming. It is ascertained that Carbon dioxide emissions in the UAE had more than doubled between the years 1990 and 2008. Therefore taking relevant factors into consideration the UAE has booked a decision to adopt nuclear energy as an acceptable low carbon source of energy in place of traditional sources of energy to cover the accelerating demand for energy and to minimize CO2 emissions. However the planned development and expansion of nuclear power utilization faces several challenges and certain standards have to be maintained to achieve the envisaged goals. These standards are as follows; (IAEA 2008)

- Safety and the dependability of nuclear plants have to be continuously monitored.
- Economic competitiveness should be ameliorated.
- The public should be persuaded of the benefits of nuclear power and the confidence thus gained should be retained.
- The skills and competence of workforces should be developed and maintained at acceptable levels.
- Spent fuels and radioactive waste matter should be under continuous surveillance and managed competently.
- Disposal of spent fuel and high level waste should be carried out diligently and meticulously.
- Transportation of nuclear fuel should be regulated and discharged in terms of accepted rules and regulations.
- Building up and maintaining reliability in respect of nuclear non-proliferation is imperative.
- Ensuring that reliable infrastructure facilities exist in countries where nuclear power is to be introduced.
- Ascertaining that the approved reactor designs are suitable for the country concerned.

- Attaining profitable and sustainable usage of resources.

As the environmental problems become more serious and the supply of fossil fuels become increasingly unstable, the importance of nuclear power as a possible source of energy in the next few decades, is rising progressively. The main reason is the innovative approach followed in nuclear energy which eschews technological obstacles and safety problems. Despite such innovations public response to nuclear energy is still negative and the situation remains unchanged. The lack of public conviction is the greatest obstacle which retards the progress and the establishment of nuclear energy. The absence of enthusiasm on the part of the society requires massive subsidies which are not founded on the social importance of nuclear energy. (Jun et al. 2010)

Energy Saving Solution – LED Lighting

The traditional light source, such as incandescent bulbs and fluorescent lamps, has disadvantages of low luminous efficiency, high power consumption, and short life and environment pollution although its price is cheaper. On the contrary, LED lighting is a newly developing light source and has many advantages of small size, long life, and low power consumption, pure colour light, safe, pollution-free, and so on. Along with the fast improvement of the luminous efficiency, LED has been widely used in indoor lighting, liquid crystal display (LCD), the backlight of portable electronic devices (PDA, mobile phone), headlights and lighting panels of cars, the buildings and plaza lighting, theatre

stage lights, etc. (Wu et al. 2011)

In the task of ensuring safe driving in the highway roads and tunnel lighting rates high in importance. Lighting systems which consume enormous quantities of electricity have been installed in the numerous long wide road and tunnels constructed as a part of the accelerated development of the UAEs Highway traffic system. Research studies disclose that 30% of the power utilized by the mechanical and electrical systems functioning in the highways and tunnels are consumed by the tunnel lighting system and consequently the tunnel management incurs a loss in respect of the tunnel lighting. The principle followed in the lighting system is to maintain the same illumination level inside the tunnels as outside to ensure excellent driver vision. This however, creates a conflict between safe driving and excessive lighting. This calls for an acceptable change which is to install a lighting system which conserves power instead of one which uses energy excessively. Further, discharges which tend to pollute the environment should be removed and steps should be taken to ensure safe driving. Sodium lamps with high voltage are the popular form of lighting used in tunnels. The power they emit is low; their energy consumption is high and has a narrow range of voltage. These factors combined with the fact that they take a long time to start make them totally unsuitable for energy conservation schemes. LED (light Emitting Diode) system is a novel green lighting method which has become increasingly popular during the recent years. This is considered suitable for street lights, lighting up buildings during night time and domestic lighting. In comparison with Sodium lamps the maintenance is less in LEDs. In addition security wise the LEDs are more reliable. Furthermore there is no flickering and they start faster than Sodium lamps. LED lamps are good for the vision and consume a lower amount of energy. LEDs have undergone much improvement especially with regard to its brightness and stability. These advantages have made LEDs a popular choice as lighting in highway and tunnels. (Zeng et al. 2011)

This section describes a case study taken in the UAE street lighting system. Abu Dhabi is experiencing a rapid growth and investment Emirate. Most of the roads in the Abu Dhabi are being equipped with conventional metal halide lamps, which have high energy consumption as well as annual operational cost. In order to find a solution for the high energy consumption a study is conducted (BetaLED 2012). The initial design for the Salam street development project considered conventional High pressure Sodium lamp, however, by the direction of executive council, Abu Dhabi, the street lighting design was redesigned in order to comply the Abu Dhabi Emirate as Green Street lighting Concept which will eventually reduce carbon emission and energy consumption. The figure 4.4.1 below shows the structure of Al Salam Street.

Figure (mm) Al Salam Street Project Abu Dhabi

- **Synopsis of fixtures used**

The study includes two types of application of LED lighting, Roadway – Surface Roads & Roadway – Tunnel interior Zone. The fixtures used in each cases are shown in the below table (l).

Application	Conventional Design (**Original Design**)	Quantity of conventional design	LED Design (**Revised Design**)	Quantity of LED design
Roadway – surface road	1000 W (1000*1.15= 1150 W System Wattage) HPSV 	330	240 LED (277 W System Wattage) 	660
Roadway – tunnel interior zone	2 x 58 W (116W System Wattage) Fluorescent Luminaires 	5016	48LED (48 W System Wattage) 	5016

Table (l) Synopsis of fixtures used in Salam street project

- **Capital Cost**

Cases	Conventional Design		Revised Design - LED	
Type of lamp	Street lighting (1000W HPS)	Tunnel(Florescent 2*58w)	Street lighting LED-277W	Tunnel Lighting LED-48W
Unit Cost	2200	1800	8000	3000
Number of unit	330	5016	660	5016
Initial cost	726,000	9,028,800	5,280,000	15,048,000
Total Excess cost			**10,573,200.00**	

Table (m) Capital costs

- **Energy Savings**

Energy loss in street lighting assumed 15% and tunnel lighting 10%

Cases	Conventional Design		Revised Design – LED	
Type of lamp	Street lighting (1000W HPS)	Tunnel(Florescent 2*58w)	Street lighting LED-277W	Tunnel Lighting LED-48W
Energy consumption	330 x 1000*1.15 = 379.5kWh	5016 x 116*1.1 = 637kWh	660 x 0.277 = 182.82kWh	5016 x 0.048 kWh = 240.7
Energy savings			379.5 – 182.82 = 196.68 kWh	637 – 240.7 = 396.3 kWh
% savings in energy consumption			52%	63%
nnual Energy saving			196.68*12*365= 861,459 kWh	396.3*24*365= 3,471,588 kWh
Annual Energy cost Savings(AED)			861,459*0.15 **129,218.85 kWh**	3,471,588*0.15 **520,738.20 kWh**
Total Energy Savings for 20 years			**12,999,140.00 kWh**	

Table (n) Energy savings

- Maintenance savings

HPS Luminaire

Average Rated life is when 50% of the lamps have failed. The department will not wait until such time to replace lamps since 50% of the roadway will not have light. Service life is around 16000 Hrs for HPS lamps.

Fluorescent Luminaire (Tunnel Interior Zone)

Service life is considered at 18,000

Hrs.

LED Luminaire Street Lighting

LED lifetimes are dependent on temperature. Thus lifetimes shall be considered only if the luminaire manufacturer is able to provide independently tested decay curves as per IESNA LM-79 and LM-80 standards. From certain existing manufacturers considering a high average annual temperature of 35 degree C the lifetime of LED is 80,000 Hrs.

LED Luminaire Tunnel Lighting

But for tunnel lighting application average annual temperature considered is 45 deg c. From IESNA LM-79 and LM80 decay curves at 45 deg C lifetime is 65000 hrs. This life will be even more considering that the dimming levels will reduce the drive current and thus increase life. Therefore the life is considered at 100,000 Hrs.

Based on the Cost data provided by the RUDD lighting Arabia, the component replacement cost are as follows; (BetaLED 2012)

Type of Lamp	Street lighting (1000W HPS)	Tunnel(Florescent 2*58w)	Street lighting LED-240W	Tunnel Lighting LED-40W

Lamp Cost	300	50	3000	500
Ballast	600	200	-	
Igniter	250	0	-	
Capacitor	100	0	-	
Driver	--	-	1500	1500
Manpower & Equipment	4800	3500	4800	3500
Traffic Lane Closure	200	200	100	100
Cost for 10 nos	6250	3950	9400	5600
Cost per Luminaire AED	**625**	**395**	**940**	**560**

Table (o) Component replacement cost

- Final Annual Maintenance Costs Savings

HPSV / FL Maintenance Cost per Year								
	Model	Lamp Life (Hours)	Lamp Life (in years)	Total units	Lamps to be replaced per year	Unit rate AED	Total rate AED	Operation
Street light	1000 W HPS	16000	3.7	330	90	625	56,250	12 hour operation
Tunnel light	58 W (2 Nos)	18000	2.056	10032	4877	395	1,926,415	24 hour operation
Total annual replacement cost for HPSV / FL luminaries							**1,982,665**	
LED Maintenance Cost per Year								
	Model	Lamp Life (Hours)	Lamp Life (in years)	Total units	Lamps to be replaced per year	Unit rate AED	Total rate AED	Operation
Street light	240 LED	80000	18	660	1	940	940	12 hour operation
Tunnel light	40 LED	100000	22	5016	1	560	560	24 hour operation
Total annual replacement cost for HPSV / FL luminaires							**1,500**	

Table (p) Final Annual Maintenance Costs Savings

- **Life Cycle Cost (considered for 20 years of life)**

Cost Elements	Conventional Design	Revised Design (with LED)	Excess cost/Savings
Initial Cost In Excess	**9,754,800.00**	**20,328,000.00**	**(10,573,200.00)**
Running Cost-Savings (Energy Tariff)	**21,726,990.00**	**8,727,850.00**	**12,999,140.00**
Maintenance Cost	**39,653,300.00 =(1,982,665*20)**	**30,000.0 =(1500*20)**	**39,623,300.00**
LCC	**71,135,090.00**	**29,085,850.00**	**42,049,240.00**

Table (q) Life Cycle Cost (considered for 20 years of life)

- **Payback period**

Extra Initial investment=10,573,200.00

Annual savings= (12,999,140+39,623,300)/20=2,631,122.00

- **Green House Gas Emission Reduction**

Annual Savings for the Project

Roadway = 196.68 kWh (Defined as an unit of power consumption per hour)

Tunnel = 396.30 kWh (Defined as an unit of power consumption per hour)

Annual Savings (Units / Annum)

Roadway = 196.68 x 12 hours x 365 days = 861,459 Units

Tunnel = 396.3 x 24 hours x 365 days = 3,471,588Units

Total No. of Units saved every year = 4,333,047 Units

Calculation of GHG Emissions Savings for Power units saved in Salaam Street Project using LEDs

Total Direct GHG	kgCO2e – 0.79398 / Unit
Total Indirect GHG	kgCO2e – 0.10617 / Unit
Grand Total GHG Savings	kgCO2e – 0.90015 / Unit

Table (r) GHG breakdown

Therefore for 2,597,253 Units per annum = 0.90015 x 4,333,047

$= 3{,}900{,}392.25\ kgCO_2$ OR 3,900.39 Tonnes CO_2 / Annum

Results and discussion

The Salam Street is one of the main roads in the city of Abu Dhabi, starting from Sheikh Zayed Bridge and curves its way around Abu Dhabi's and ends at the intersection with Corniche Road. The proposed project is given two options, the conventional High pressure Sodium lamp and the LED lamps to illuminate both the street and the tunnel. Due to the direction of executive council, Abu Dhabi, the street lighting design was redesigned in order to comply the Abu Dhabi Emirate as a Green Street lighting Concept which will eventually reduce carbon emission and energy consumption.

By analysing the results obtained it is evident that, using LED will not only reduce operational cost but also the CO_2 by the half or more, saving up to 3900 tons CO_2 per annum.

However the project helps to improve the following aspects;

- CO_2 Reduction for better environment improvement.
- Reduction of the consumption and the cost.
- Reduction of the maintenance cost.

(Salim, O. 2012)

The LEDs luminaries are a very promising technology for future development and deployment of photovoltaic lighting applications. (Fathi et al. 2011)

Review

Today it is seen that more than a billion people around the world lack access to the electricity, and more than a three quarter of them live in the rural areas. Exploiting energy efficiently plays an essential role to achieve sustainable developments. Thus nations across the world are determined to this end are in quest to re-evaluate their energy systems with an opinion towards planning energy programs and strategies in line with sustainable schematic goals and ideas. The aim of this dissertation was to examine the sustainable energy technologies for electricity generation in the UAE, and provide insights into the performance and functional patterns of various supporting policies, public views and examination of various sustainable energy technology performances in the UAE. More specifically, two main research questions have been addressed regarding the functional patterns within the UAEs energy sector, and the improvements to be made. In this research, the writer provides a summary of the key examination findings and a discussion of the implications for designing intervention strategies to support the development of sustainable electricity methods in the UAE.

UAEs electricity generation sector is highly dominated by the conventional finite fossil fuels, which is environmentally unsustainable source. In order to achieve sustainable development at comprehensive level will need a wise utilization of the resources and technology coupled with a proper economic inducements and strategic planning at both local and national levels. Firstly it is important to understand the energy and the economic sustainability of the country. Secondly, policy makers should comprehend the implications of designated energy, environment and economical programs, to plans and shape their development impacts on the feasibility to archive sustainability. Therefore, a proper

examination of economic, social and environment should be taken into account when choosing an energy fuel and its associated technology for production and utilization of its energy service.

Seven sustainable energy indicators were introduced to analyse the most suitable sustainable energy development for the UAE. Using these key indicators it was concluded that the most suitable sustainable energy development for the UAE is greatly reliant on the geographical location and the availability, thus resulting on Solar, Wind and Nuclear energy developments the most favoured solution for the UAEs continues rising demand and the growing criticism on climate change.

The emergence of RE industries is a complex process that is yet not fully understood. In this regard, this dissertation has contributed to an improved understanding of the formative results of solar and wind energy applications and their benefits. On the theoretical front, we have argued that when studying the emergence renewable technology it is possible to archive tremendous benefits by utilizing them. We are in early immature stage of renewable technology, however with future approaches, high efficient products, will end up defining an emerging reliable source of power for the UAE. To that end, we have argued that for an emerging renewable energy to develop and perform well, not only does it need favourable policies, but there is also a need to have all functions served.

The measurements of radiation on the Emirate of Abu Dhabi were obtained. The 20 years average collected data from NASA was used to study the possibilities of applying Photovoltaic technology. Analysing the results obtained from the case study 1 the potential of solar energy on residential buildings, it seen that solar power contributes perfectly according to the UAEs arid climate. Also, the booming PV market in the UAE is seen as feasible way to provide significant environmental benefits against conventional fossil fuel based energy. The

generated energy by PV technology minimizes CO_2 emissions from the conventional power plants, thus avoiding global warming effects. The trade-off between environmental welfares and economic cost give weight to the provision of the UAE policy for the adaptation of PV technology providing benefits beyond the price consideration. The results provided by this study indicate that PV technology application in Abu Dhabi and hence to the rest of UAE is a promising solution to meet the rising energy demand in the country.

Study on wind turbine is made in accordance to the Abu Dhabi weather condition highlights a clear result that the efficiency plays a high role in power generation. Abu Dhabi, UAE has a relatively low wind speed in comparison to other northern countries. However a turbine with low cut-in wind speed can be used to provide as much as possible of the wind power available. Based on the mathematical model and simulation performances undertaken it is recommended for further study on different locations in UAE to identify further improved potentials for wind energy. In moving forward, one need to assess and prioritize what are the most important issues to be tackled in the near term and what are the issues that need to be addressed in the medium and long term. The leading RE field countries, such as Germany, recommend that multiple aspects need to be addressed simultaneously rather than on a piecemeal basis.

GHG effect is highly contributed by the emission of CO_2, and the UAEs carbon emissions have double between periods of 1990 to 2008. Therefore to address this issue the UAE has come to the decision of approach peaceful nuclear energy development as a low carbon emission in comparison to that of conventional sources. By analysing the ENECs development, which specifies that the nuclear energy is the best competitive source of energy towards mitigating carbon emissions of electricity generation sector, resulting an ultimate drop down off global warming and climate change effects. The study has enabled to achieve the

understanding of the significance of nuclear energy in carbon mitigation. However the following recommendations are vital for future researches;

- A detail public survey can be measured to study the nuclear social impacts, which may help in decision making, awareness, site selection etc.
- Further cost evaluations has to be done, as there is a possibility of the actual signed capital cost contract to differ by the year 2020, which may result in estimation conflict.
- Measuring the carbon emissions locally using special tools will provide qualified results, than the available estimated data from Kyoto protocol and IEA.
- UAE transportation sector hold one of the major key on carbon emission, therefore investigations can be made to lessen this impact.
- Further reaches on the nuclear capacities can be investigated, to provide the optimum beneficiaries for long targeted periods.

While this dissertation has focused primarily on understanding the different sustainable electricity generation options for UAE, an alternative study has made to challenge the energy saving development of a thriving street lighting sector in the UAE. A case study in Abu Dhabi Salam Street project has enabled to set an experimental bench allowing the comparison of both conventional High pressure Sodium lamp and LED lighting. The experimental results provided not only a significant energy savings and carbon savings, but also a rapid payback period supporting the implementation of LED lights. In perspective, this experimental design and study will allow the development of a new energy saving technology. The LEDs luminaries are a very promising technology for future developments and further deployment of photovoltaic lighting applications.

It is noted that, in many countries, the development of a renewable and nuclear energy involves a political decision backed up by public support at the grass-roots level as well as fruitful collaboration and interaction between the government, academia and business. In the UAE, however, not only does policy-making favour top-down approaches, it also lacks a strong civil society and transparency. As the public questionnaire survey was taken, not only the people knowledge regarding sustainability and the required efforts was analysed, it is now also evident that the weaker impact of traditional educational system towards sustainable development is mainly due to lack of focus on community participation to achieve this cause. Hence to improve this situation more importance should be granted to the public participation in order to promote the concepts of sustainable development and awareness platform through RE. The following list some of the recommendations which can be implemented;

- Improved outcomes for sustainable energy development can be archived by applying national policies on regular basis.
- Sustainable energy development concepts can be effectively promoted via technical education infrastructure by covering subjects related to renewable energy technologies.
- Skilled sustainable energy policy makers must involve at all levels in policy making.
- The concept of public enlistment must be fused in order to establish awareness concerning sustainable energy development via renewable energy.

Convincingly it is found that the UAEs stated policy must recognize various differences, especially in concerning the supports for RE adoption. Abu Dhabi, stringed with the Masdar Initiative, is considered as an innovator to promote RE in the Middle East region

which is known for its abundance of solar potentials and oil rich markets. The reach undertaken has identified various renewable energy policy and mechanism across worldwide, in addition to their renewable energy technologies. Interestingly UAE has a policy target of 7% renewable energy share of electricity generation by the year 2020, however the further legislations and mechanisms to promote energy generation seems to be week. Several other countries have reached noticeably effective heights in meeting their targets through the use of FIT system, rather than Quota and Biddings. Conclusively, following facts should be taken into account when it comes to implementation of new renewable energy policies:

- Several countries have established RE into their grids with a supportive legislation to smoothen the adoption procedure. Hence, this a great lesson to be learned and various investigative case studies can be examined in the Abu Dhabi, UAE.
- The demand and supply aspect of electricity are the main principle that needed to be considered by policies.
- Implementation of FIT policy which takes into account the renewable energy source and their scales.

The sustainable electricity development concept has as an endless themes attached to it, therefore the writer has generally focused on the large scale existing projects in the UAE to support this dissertation. Given the short time period, further supporting data and public opinions were unable to be examined. Moreover, in the experimental procedures as discussed in the relative chapters, the writer has used trial based software due to this study is only for

non-profitable educational purpose only, furthermore quoting the similar component prices due to the inaccessibility of current market prices, has a potential to affect the payback periods calculated. Nevertheless the writer conclusively believes the UAE has a great potential of every sustainable technologies examined in this dissertation.

CHAPTER IV

RESEARCH METHODOLOGY

As per my research opinion, Research methodology is the way of deploying the research methods and other elements and analyzing systematically inline with the critical review of the literature which has shown in the below diagram ("Research Onion"). In other way around, research methodology combines the whole picture of conducting the research by setting the elements namely Research Process, Research Design, Research Methods, Research Questionnaire, Identification of variables & factors, Research Strategy at the outset and finally outfits the interpretation, findings, & conclusions.

The Research Onion brings out the clear picture of maintaining research direction & setting the pathway to arrive at an apt findings & conclusions.

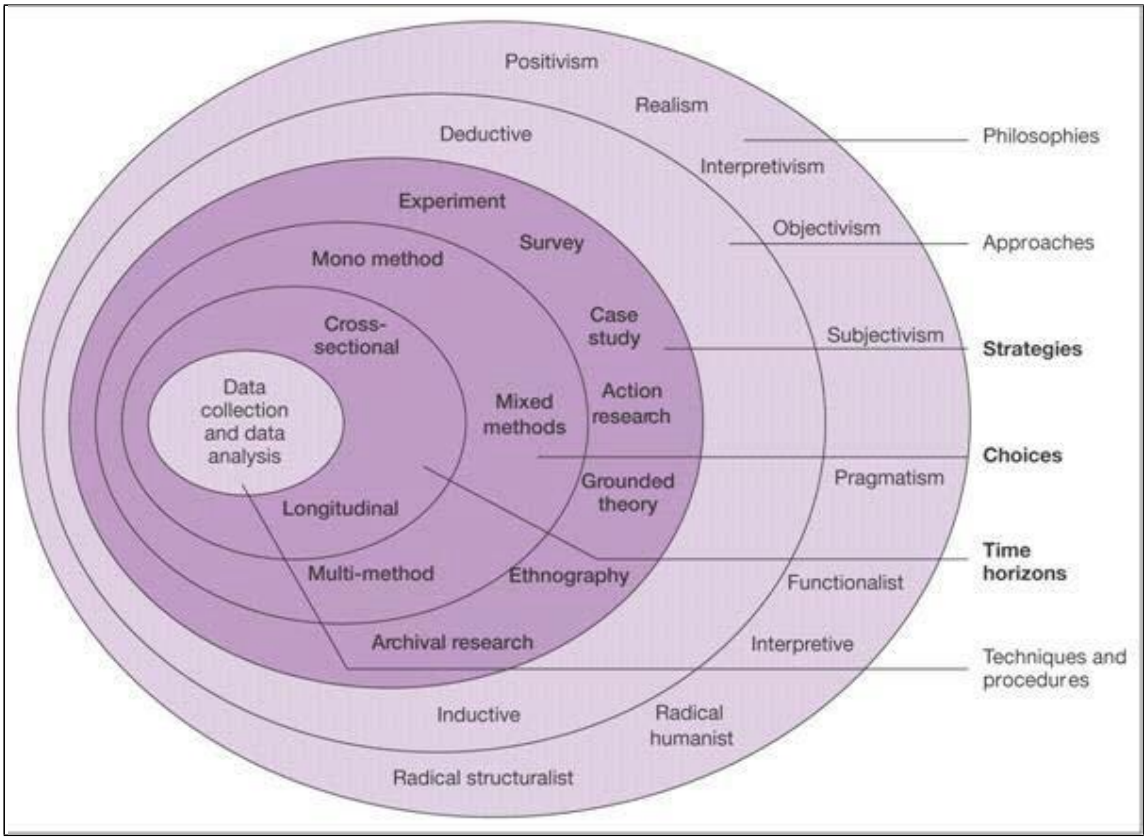


Figure: The research 'onion' (Saunders et.al, 2009)

Research Design:

The Research design depicts how the research has been carried out and shows the steps adopted by the researcher. The research design chosen is Quantitative and institutes the variables to arrive at the proper analysis. The quantitative measures like Normal Probabilistic Distribution etc. have taken into consideration to set up the outfit of the results which could be utilized for the industry decision making. At the outset, it has more flexi research approach which provides the way to analyse the environmental issues in Sustainable Renewable Energy Development in the UAE.

The following diagrammatic flow and representation brings out the clarity about how the flow of research process is being maintained.

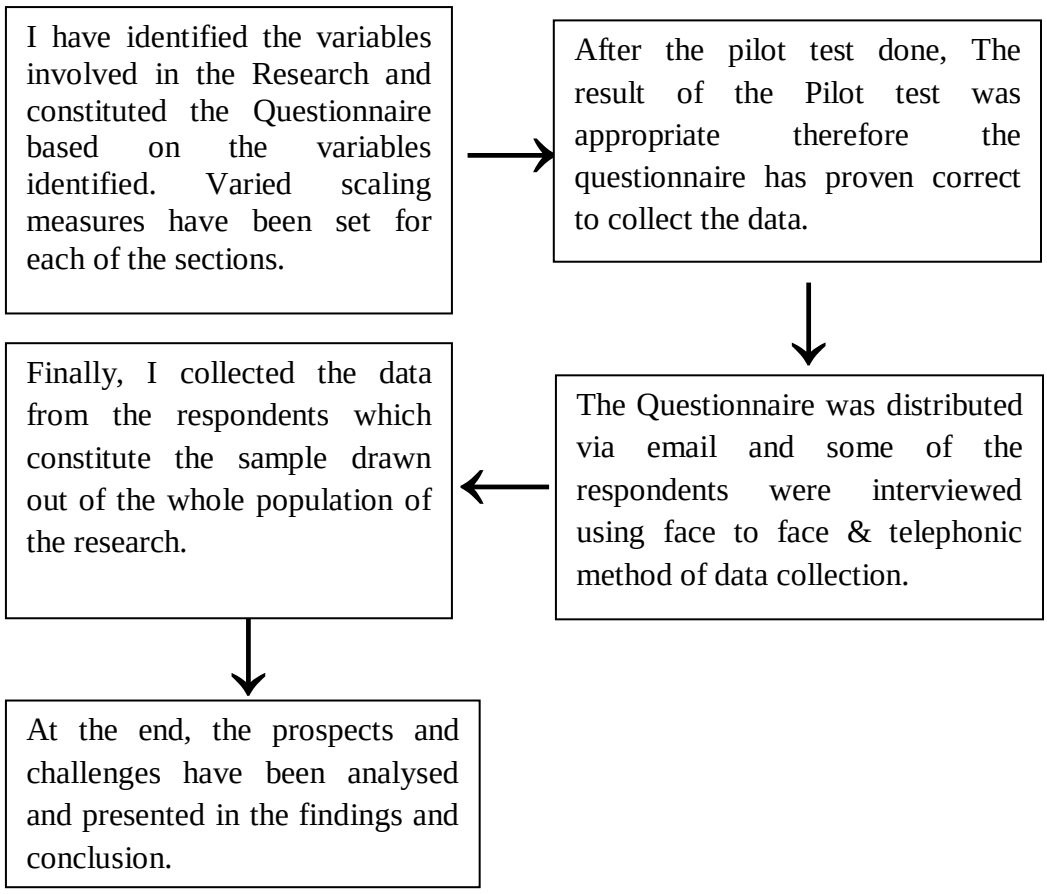


Figure: Research Design

The Design of the research is analytical. Here I have identified & explored about the Sustainable Renewable Energy Development in the UAE.

Research Population:

The population for the study consisted of various nationalities living in the UAE whether on rent or with their permanent residence in the UAE.

I have conducted the survey to collect the data about the Environmental issues about the sustainable renewable energy development in the UAE from the sample drawn out of the population assessed.

Research Sample:

A stratum of the population is made and Convenience Sampling Technique has used. The sample size is 100. Sampling has done as such it is at the comfort of the researcher in order to collect the responses however I have tried all the times for not to be biased and seemingly I successfully achieved it while collected all the responses.

Research Strategy:

Research Strategy shows out the way of how the objectives of the research are being set to achieve. Therefore I have adopted the strategies against each objective and set it out to achieve.

Strategy 1:

I have conducted the research using the literature search by exploring the various research content/studies over the Internet on Google Scholar & Online databases and Research Journals

etc. and found out issues affecting the Sustainable Renewable Energy Development in the UAE. It will be almost secondary data.

Strategy 2:

I have collected the data and analysed systematically using the questionnaire to understand the issues affecting the Sustainable Renewable Energy Development in the UAE.

Strategy 3:

I have cited the collective findings and conclusions in order to provide clear picture of what is happening in the current scenario of Sustainable Renewable Energy Development in the UAE.

Strategy of achieving the objectives:

1. I have achieved the objective 1 by conducting the review of literature on research online portals and questionnaire survey among 100 respondents wherein number of issues affecting the Sustainable Renewable Energy Development in the UAE has discussed.
2. I have achieved the objective 2 by conducting the review of literature on research online portals and questionnaire survey among 100 respondents wherein number of issues affecting the Sustainable Renewable Energy Development in the UAE has discussed.
3. I have achieved the objective 3 by conducting the review of literature on research online portals and questionnaire survey among 100 respondents wherein number of issues affecting the Sustainable Renewable Energy Development in the UAE has discussed.

Questionnaire:

Having considered the guidance & literature by Saunders et. al., **2009,** I have adopted the interpretive, positivism, realism & objectivism research philosophy, deductive research

approach, survey & archival research strategy, Mono research method & time horizons as a cross sectional research. Since the research design is quantitative therefore, I have set out the each question based upon the variables identified and therefore scaling techniques for each question is used based on the scope & intensity.

The Questionnaire has been divided into two sections namely demographic & psychographic. Both sections altogether consist of 50 questions following the variation of scale. Each question has been set based on the variable identified in the research. I have tried to maintain the consistency in the questionnaire by setting the flow of questions accordingly. The validity of the questionnaire has been checked by piloting the questionnaire and ensures the reliability of the questions & therefore the responses received.

Saunders et al. (2003)[44]emphasis on two aspects of data collection: validity and reliability. The validity and reliability of the data has been explained in SECTION. Saunders et al. (2007)[44] suggest that in case of a questionnaire pilot testing should be done to ensure the validity of the question and the reliability of the data subsequently collected. The questionnaire used for the survey has been tested on a group, to test the comprehensibility of the content and the logic of the questions. Bell (1999)[44] suggests that a trail run should never be compromised even if time is a constraint. While testing the questionnaire the respondent were asked regarding the time taken to complete, ambiguity of the questions, if any questions caused a uncomfortable feeling or awkward state of mind and the last was the structure. Validating the questionnaire ensures that the response for each question and the motive for the question are the relevant (Saunders et al. 2000)[44].

Reliability of the questionnaire depends on the consistency of the response to the same questions. To ensure this the questionnaire must be answered twice by the respondent at

differing time (Easterby-Smith, et al. 2002)[44]. This may be difficult due to time constraints but should be done. Mitchell (1996) [44] suggests that the responses of the questions should be checked for consistency within the subgroup. The results can be generalised to an extent due to the sample size and inferences are gathered based on the statistical analysis. Steps have been taken to ensure the anonymous nature of the questionnaire so that the responses are honest and unbiased.

Data Collection:

I have collected the data from 100 participants from the UAE. The data collected through the questionnaire from the sample of 100 respondents has been managed using the Microsoft Excel Program (.xls). I have recorded the 100 sampled responses against 24 questions formulated based on the variables & analysed purposefully.

Form & Process of the interview:

Having based in Dubai, I have conducted semi-structured e-interview using the email interaction, telephonic interaction, face to face interaction through one-on-one method over the skype.

The secondary data was obtained during the literature review and some additional reading in the form of journals, periodicals, magazines, newspapers, the Internet and books.

CHAPTER V

DATA ANALYSIS & INTERPRETATION

Data Analysis:

Research and Development lessons recommended a bright future for the use of the sustainable energy sources. To create such bright future, sustainable energy methods must be quickly and efficiently spread to current and the future generations. The aim of this survey study is to examine the level of awareness and fundamental attitudes of the community towards the sustainable solutions who are living in a country which is heavily reliant on fossil fuels despite having high renewable energy resources. Furthermore the study emphasis the need for a better understanding of knowledge in cultivating awareness of sustainable energy practice, which is necessary for the community of the UAE to become future responsible energy consumers. The following survey explores UAEs public levels of awareness, behaviour, attitudes, perceptions and acceptance towards UAEs sustainable energy initiatives. For this purpose, the following questionnaire was given to the community of UAE covering all seven Emirates. The data obtained from the questionnaire were evaluated using the Microsoft excel program and the associated charts are plotted for comparison.

Having recorded the data into Microsoft Excel software package, I have analysed the data systematically in order to arrive at proper reliable results. The software has provided the expected results and gives the needed flexibility. It also paves the way to visualized representations of the findings. The interpretation of responses and variables has been done

systematically as each of variables has been analyzed inline with 100 responses accordingly.

The Normal Probabilistic Distribution has been shown which has obtained after running the data through the software. The data is consistent which has shown during analysis. All graphs & tables have been numbered systematically and inferences have been drawn out.

I have arranged the findings systematically using the SMART *(Specific, Measurable, Achievable, Reliable & Time-bound or Time sensitive)* as it is a crucial elements of the research. I have cited the findings quite by following the Pipeline strategy & assessed the responses using *Root Cause Analysis & Cause-Effect Analysis*. Having the quantitative research design & approach, it is easy to understand the issues affecting the Sustainable Renewable Energy Development in the UAE has discussed.

I have cited the findings following the responses against each question or variable. Cause-and-effect analysis, which generates and sorts out usually the possible causes of problems. Cause & effect analysis can reflect either causes that Block the way to the desired state or Helpful factors needed to reach the desired state" (The Quality Assurance Project, 2008).

Causes can be clearly presented as aggregated missives of findings, and at the same time it can present an overall, broader picture of a problem.

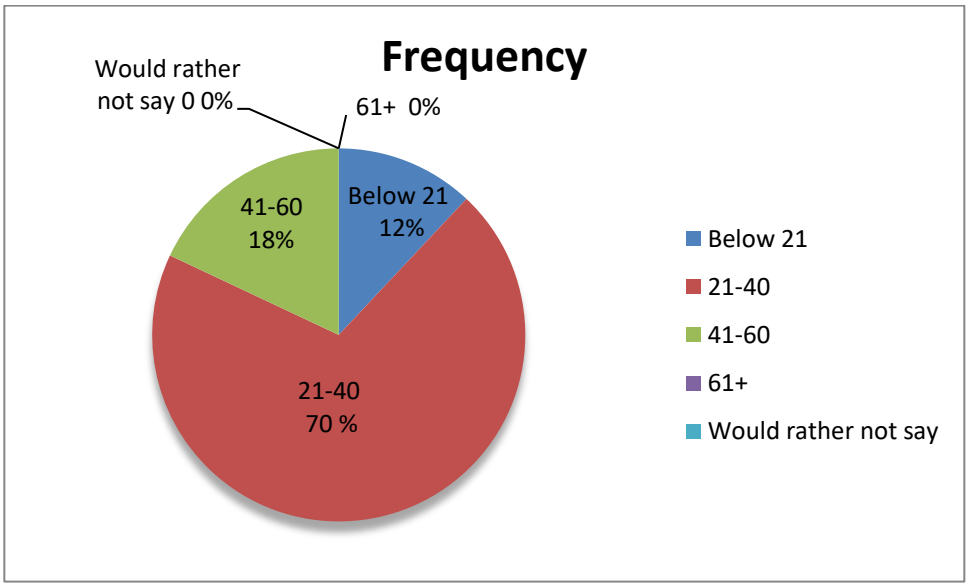
In this data analysis chapter, I am conducting the data analysis and its interpretation for the Questionnaire which is divided into 2 sections as follows:

Section 1: Demographic details:

Age:

Age	Frequency
Below 21	12

21-40	70
41-60	18
61+	0
Would rather not say	0



Interpretation:

Age wise if we look at the participants, there are higher number of respondents estimating 70% of the total and falling between the age ranges of 21-40. The second highest respondent falls into the age range of 41-60 bagging up 18% of the total & third highest respondent falls in the age below 21. However, rest of the age ranges contributes negligible.

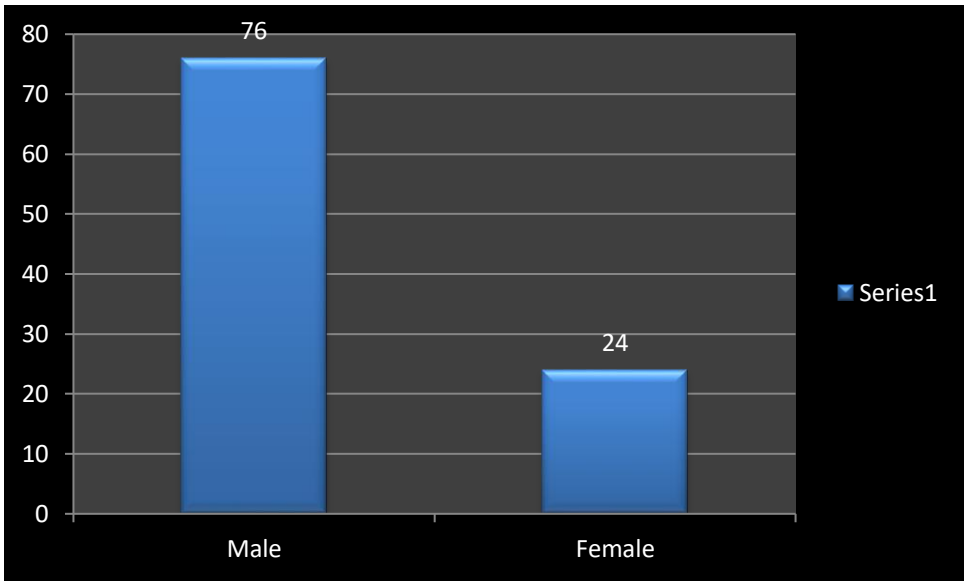
It shows that the age range 21-40 is more effectively need the implementation of sustainable renewable energy. This age group is more proactively handling the issues or looking forward to get the resolution in the country. Sustainable Renewable Energy development is totally societal safety oriented energy development which fosters the growth and overcomes the growth issues

within the country. It reduces the pollution upto the most and give environmental friendly culture to each of us.

In the modern world, Sustainable growth and culture is more likely to be taken care by the Government and Industries as it reduces the health issues and positions the healthcare to the human society at its behest.

Gender:

Gender	Frequency
Male	76
Female	24



Interpretation:

In this research, I have found that most of the participants are male when it comes to this research. As per the data trend observed in the above, it explains that only 24% participants are female. However, the male participation has estimated as 76% which reflects the level of participation of females in the Sustainable Renewable Energy Development.

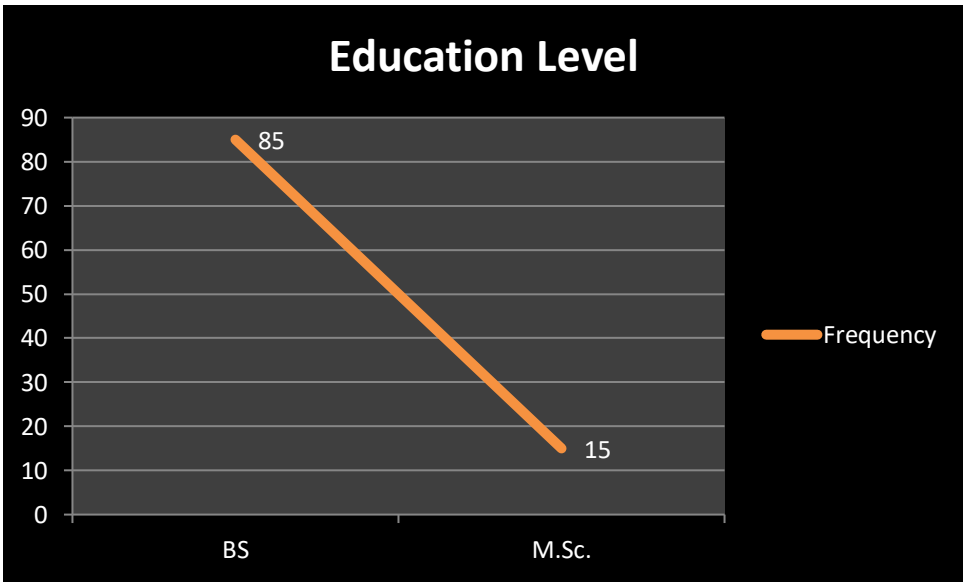
I have surveyed 100 participants, and out of that I received all responses. In these 100 respondents, 24 were females and rests of the 76 were males.

As far as Sustainable Renewable Energy Development Industry is concerned, it needs more mobility and requires outgoing attitude & behavior from the people and negotiation might also be the cause of concern for the least female participation.

As we know that In GCC, the women are now encouraged equally to men for participating in the events etc. therefore 24% participation is least but not the last. If we take a look in way back in 2000, it could be almost negligible. Finally, we see the womenpreneur era is coming up and no wonder it is closer to us when our women would be more active as equal as men.

Education Level:

Education Level	Frequency
BS	85
M.Sc.	15



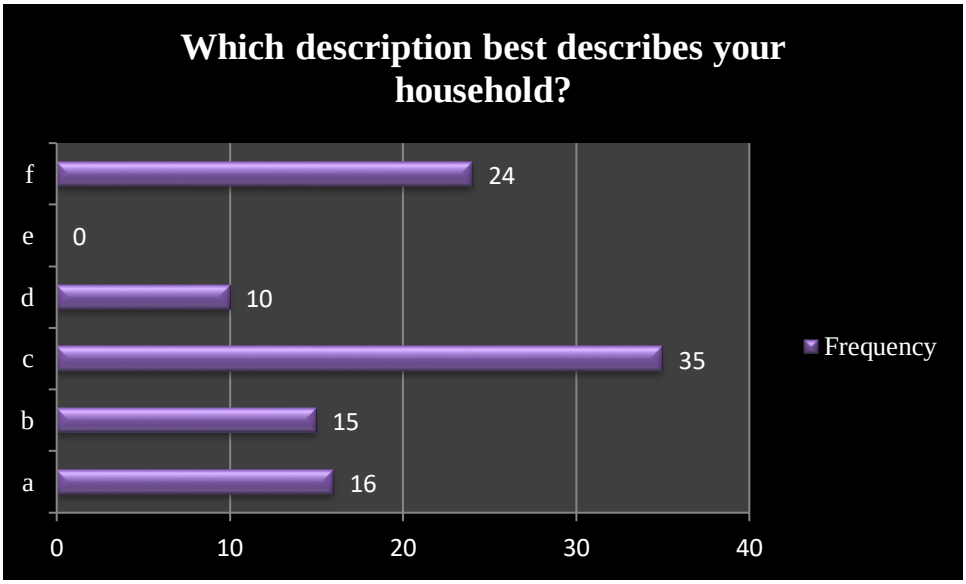
Interpretation:

As in the above graph, 85% respondents are BS education however only 15% respondents are withholding M.Sc. qualification.

Section 2: Business Related Factors:

Q1.Which description best describes your household:

Which description best describes your household?	Frequency
a	16
b	15
c	35
d	10
e	0
f	24



Coding:

“a” stands for “Yourself and your partner living together”,

“b” stands for “You living alone”,

“c” stands for “You living with your children”,

“d” stands for “You and your partner living with your children”,

“e” stands for “You living with friend(s)” &

“f” stands for “You living with your parent(s)”.

Interpretation:

As far as household is concerned, most of the respondents fall into the category “c” which estimates 35% of the total & that means they are living with their children in the UAE. Hopefully, they find the UAE as a place good for residence that’s why they are keeping their children in the UAE. Some of them are falling in the category “f” estimating 24% of the total living with their parents. Living with parents again proves the previous assessment as it says that they find the UAE as a good place to live due to its sustainable culture and growth and government thrives to do so with certain number of initiatives.

16% of the total falls into the category “a” which means that they and their partner both are living together and I can assess that this percentage is quite less than expected. However, in the UAE, most of the expats sometimes lives alone basing their income range.

Expectedly, only 15% respondents fall into the category “b” that means these people live alone in the UAE and perhaps they are meeting their needs by compromising in their family life.

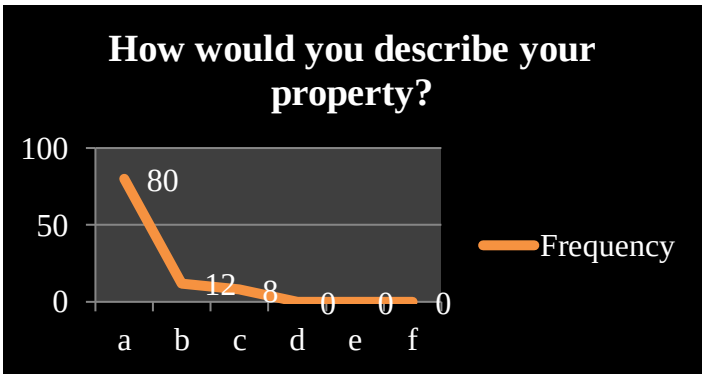
As it is least percentage in our survey, only 10% respondents fall into the category “d” that means they are living with their children and partner. It means these people are much inclined to live in the UAE. At the final note, Sustainable Renewable Energy development becomes vital element for building green environment in the UAE as these respondents are living in the UAE and the UAE must look forward to get their vested interest to live in the UAE. It will not

only increase the tourism but also provide way forward to the UAE growth.

Out of the above respondents, Surprisingly, I have recorded 0% respondents those who are living with their friends.

Q2. How would you describe your property?

How would you describe your property?	Frequency
a	80
b	12
c	8
d	0
e	0
F	0



Coding:

“a” stands for “Flat/Apartment”,

“b” stands for “Detached House”,

“c” stands for “Semi-detached House”,

“d” stands for “Bungalow”,

“e” stands for “Maisonette” &

“f” stands for “Other”.

Interpretation:

Nevertheless energy being sustainable becomes vital factor for human life survival, we are on our way to succinctly develop it and carve it to the right direction. Having living in Flat, Apartment, Bungalow etc. means a lot when it comes to look at the implementation of Sustainable Renewable Energy development in order to lead our human life effectively and environment friendly. In other way around we could say it a "Green Environment" or "Eco-Friendly life style".

The current research shows that 80% respondents are living in flats/apartments, 12% respondents says that they live in detached house & 8% respondents mentions that they live in semi-detached house however 0% respondents has no answer to Bungalow, Maisonette, & others.

I am trying to conduct this study and leading the edge to human lives in the world of UAE.

Q3. Do you know the difference between renewable and non-renewable energy?

a. Yes
b. No
c. Unsure
d. Unsure (please specify)

Coding:

"a" stands for "Yes",

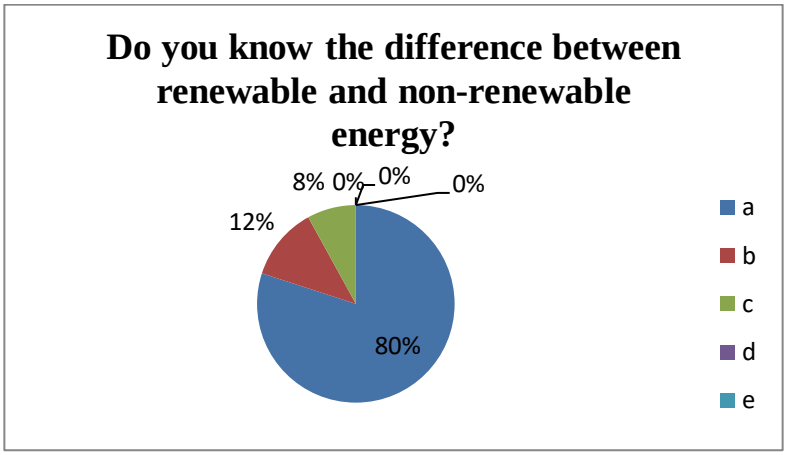
"b" stands for "No",

"c" stands for "Unsure",

"d" stands for "Unsure (please specify)

Do you know the difference between renewable and non-renewable energy?	Frequency
a	80
b	12

c	8
d	0
e	0
f	0



Interpretation:

Undoubtedly, each resident of the UAE expected to know the difference between the renewable and non renewable energy so far and perhaps the same has been observed in the research as 80% respondent answered that they are aware about the difference between the renewable and non-renewable energy. 12% says that they don't know and 8% says that they are not sure whether they know.

At the very onset, it is also part of corporate sustainability and green & eco-friendly environment therefore its awareness among the residents of the UAE matters the most and the same needs to be kept in the UAE's governance policies.

After this survey, I could estimate that most of the people around the country are aware of the sustainable development of energy and its reforms therefore it enlightening to me that the implementation in such cases becomes easy and curable. The paradigm shift can be seen among the people as their literacy and understanding with the modern world values has been put into place and the same adds value to the society which someway leads towards the corporate social

responsibility.

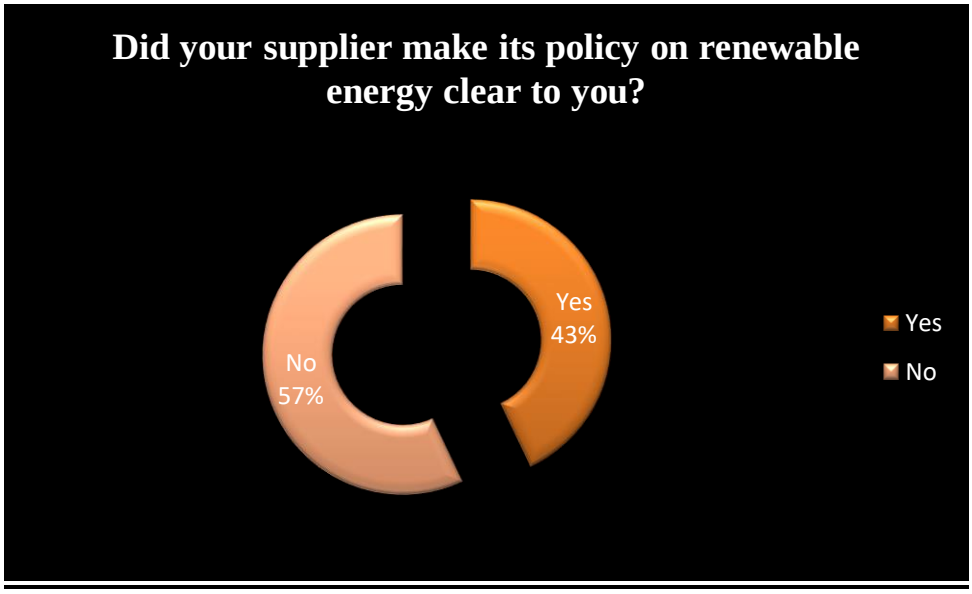
Q4. Did your supplier make its policy on renewable energy clear to you? (please write 'no' in box if not)

Coding:

"a" stands for "Yes",

"b" stands for "No",

Did your supplier make its policy on renewable energy clear to you?	Frequency
Yes	43
No	57



Interpretation:

Surprisingly, but not much, the policies of sustainable renewable energy are not clear to 57% respondents as they say that the supplier never provides this information which could be

focused core however 43% respondents said that they have been cleared systematically the policies by their supplier of sustainable renewable energy.

The knowledge about policies that we as residents never think of or takes into the consideration could be legally harmful to us therefore we as a part of the society must know the following factors at first:

[PESTLE] Political, Economical, Social, Technological, Legal, Environmental

This awareness adds value to the country in their development and grows more speedily as their residents are well informed about how the country is doing.

Q5. If you are aware of how much of their energy CURRENTLY comes from renewable sources please state (e.g. 50%)

If you are aware of how much of their energy CURRENTLY comes from renewable sources please state	**Frequency**
a	12
b	32
c	28
d	24

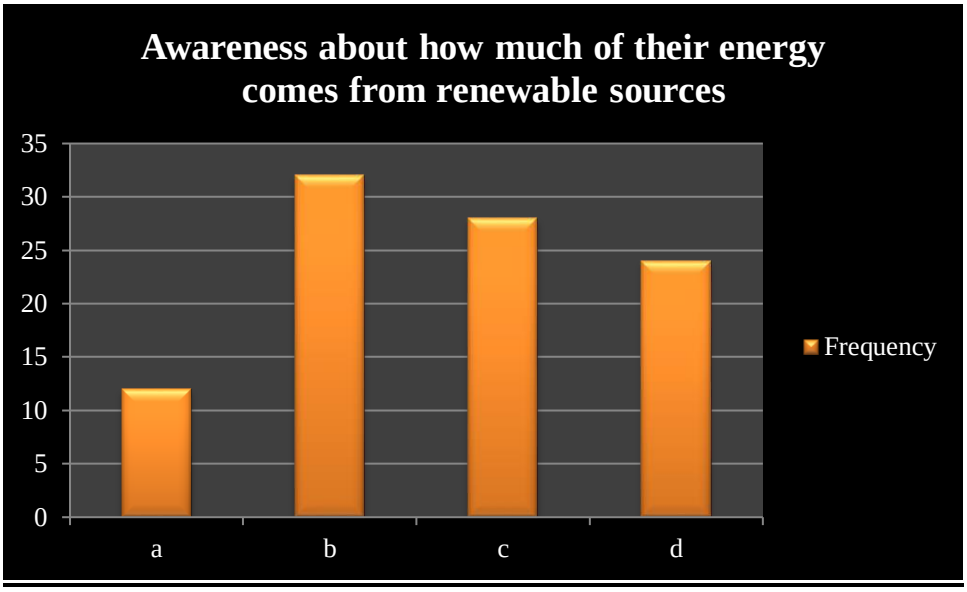
Coding:

"a" stands for "80%",

"b" stands for "70%",

"c" stands for "40%",

"d" stands for "30%",



Interpretation:

Despite of knowing the policies and its procedure, the awareness about how much of their energy comes from renewable sources is quite important to assess their own consumption from the source of renewable energy. Knowing the source of renewable energy can add value to the implementation and development part.

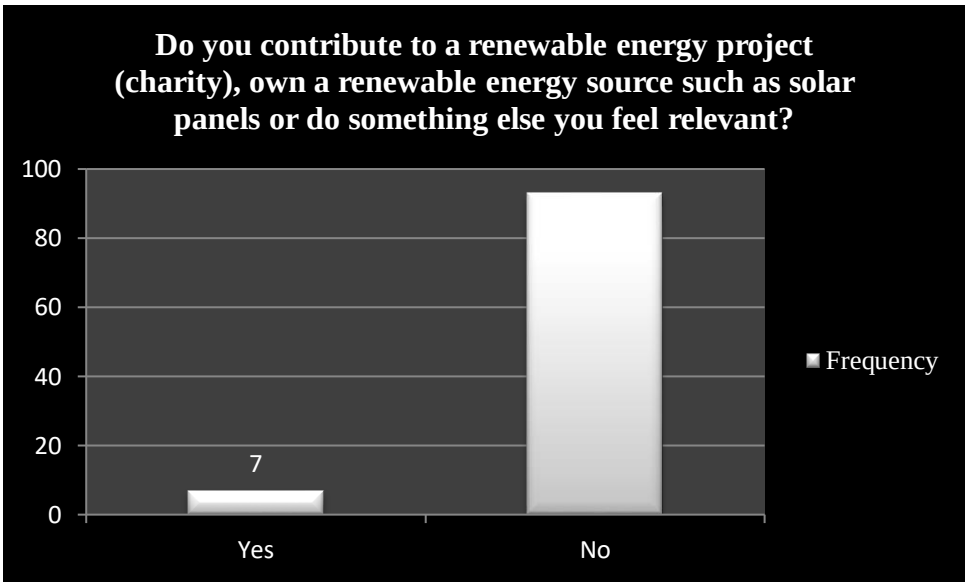
In this research, 12% respondents say that 80% energy supply to their house is from Renewable energy source, 32% respondents utters that 70% energy supply to their house is from Renewable energy source, 28% respondents mentions that 40% energy supply to their house is from Renewable energy source & 24% respondents worded that 30% energy supply to their house is from Renewable energy source.

Here its really quite encouraging statistics can be observed as all respondents in some way knows the %age of sustainable renewable energy source to their houses and that's great success for the UAE government.

Q7. What do you do around the house to help the environment?

Q8. Do you contribute to a renewable energy project (charity), own a renewable energy source such as solar panels or do something else you feel relevant?

Do you contribute to a renewable energy project (charity), own a renewable energy source such as solar panels or do something else you feel relevant?	Frequency
Yes	7
No	93



Interpretation:

As far as contribution to a renewable energy project by doing charity is concerned, it needs a person to know and understand the technical components of it. Moreover, they should be known of its harder side while working to build and develop the sustainable renewable energy

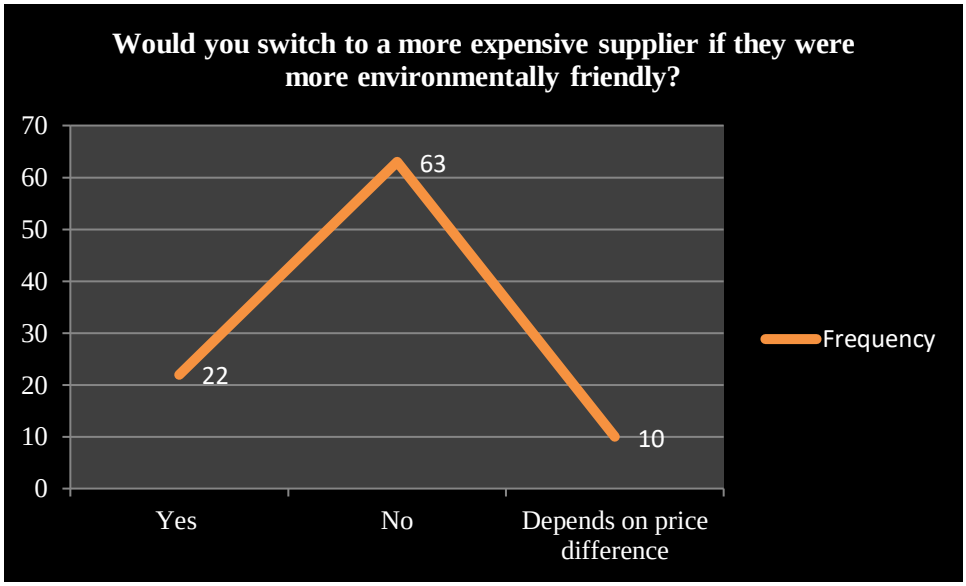
source. Once in a while, the knowledge has been build up among the society; it could be easier to look after the contribution from them.

Let's have a look into the result of the research, Only 7% respondents contributes to the sustainable renewable energy project or own a sustainable renewable energy source such as solar panels etc. while 93% doesn't contribute at all.

Q9. Would you switch to a more expensive supplier if they were more environmentally friendly? (More renewable energy)

a. Yes
b. No
c. Depends on price difference

Would you switch to a more expensive supplier if they were more environmentally friendly?	**Frequency**
Yes	22
No	63
Depends on price difference	10



Interpretation:

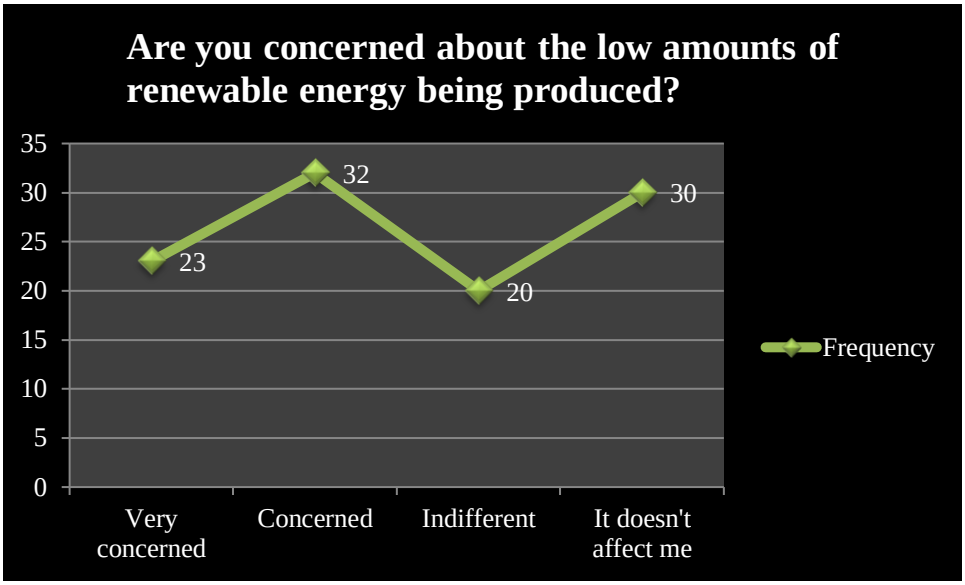
As the current research shows the statistics that only 22% respondents says **"Yes"** when it comes to switch to a more expensive supplier if they were more environmentally friendly, 63% which forms the majority says **"No"** to switch to a more expensive supplier if they were more environmentally friendly however the remaining 10% respondents says that the "**price difference"** is quite important for them while switching to a more expensive supplier if they were more environmentally friendly.

The society in general does not like to switch to a more expensive supplier even if they were more environmentally friendly but it may not be the reality as it could be the data which shows this trend yet there may be some other sort of data could show the different trend so finally, we agree to the facts observed but still need to look at other secondary researches that shows the interest towards more environmental friendly resources usage therefore we understand the results between the primary and secondary research.

Q10. Are you concerned about the low amounts of renewable energy being produced?

a. Very concerned
b. Concerned
c. Indifferent
d. It doesn't affect me

Are you concerned about the low amounts of renewable energy being produced?	**Frequency**
Very concerned	23
Concerned	32
Indifferent	20
It doesn't affect me	30



Interpretation:

In this research survey, the 23% respondents are very much concerned about the low amounts of renewable energy being produced, 32% respondents are just concerned about the low amounts of renewable energy being produced, 20% respondents are indifferent in their views about the low amounts of renewable energy being produced & 30% respondents says that low amounts of renewable energy being produced does not affect at all.

It indicates that the most of the respondents are concerned about the production of sustainable renewable energy development at low amount. It seems that they are futuristic and understands the positive and negative factors quite well.

Q11.If you were to consider purchasing a renewable energy system for your home, which are the TOP THREE difficulties you would be likely to experience?

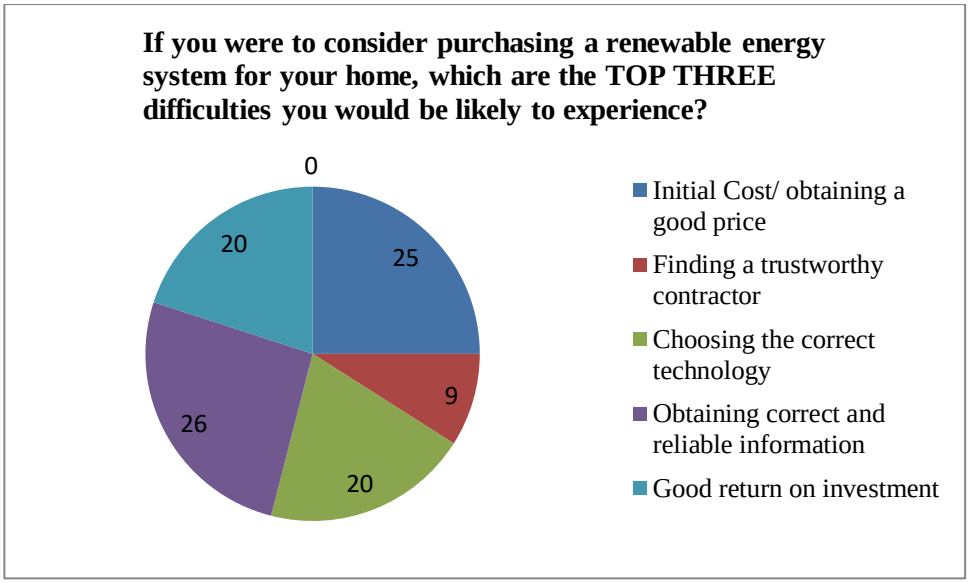
* The different possible answer choices are presented in random order.

a. Initial Cost/ obtaining a good price
b. Finding a trustworthy contractor
c. Choosing the correct technology
d. Obtaining correct and reliable information

e. Good return on investment

f. Technology may become obsolete too quickly

If you were to consider purchasing a renewable energy system for your home, which are the TOP THREE difficulties you would be likely to experience?	**Frequency**
Initial Cost/ obtaining a good price	25
Finding a trustworthy contractor	9
Choosing the correct technology	20
Obtaining correct and reliable information	26
Good return on investment	20
Technology may become obsolete too quickly	0



Interpretation:

In this research, most of the respondent answers are to consider the option *"Obtaining correct and reliable information"* for purchasing a renewable energy system for their home which

estimates to be 26% of the total. 25% considers *"Initial Cost/ obtaining a good price"* as a crucial factor for purchasing a renewable energy system for their home. 20% says to consider the option *"Choosing the correct technology" & "Good return on investment"* for purchasing a renewable energy system for their home. At least 9% agrees to consider the option *"Finding a trustworthy contractor"* however the option *"Technology may become obsolete too quickly"* has not been the consideration of anyone.

The TOP THREE difficulties have been experienced by the respondents are as follows while buying the sustainable renewable energy systems for themselves:

1. *25% considers "Initial Cost/ obtaining a good price"*
2. *20% considers "Choosing the correct technology"*
3. *26% considers "Obtaining correct and reliable information"*

Q12. Which of the following would you consider using in your home as a renewable source of energy?

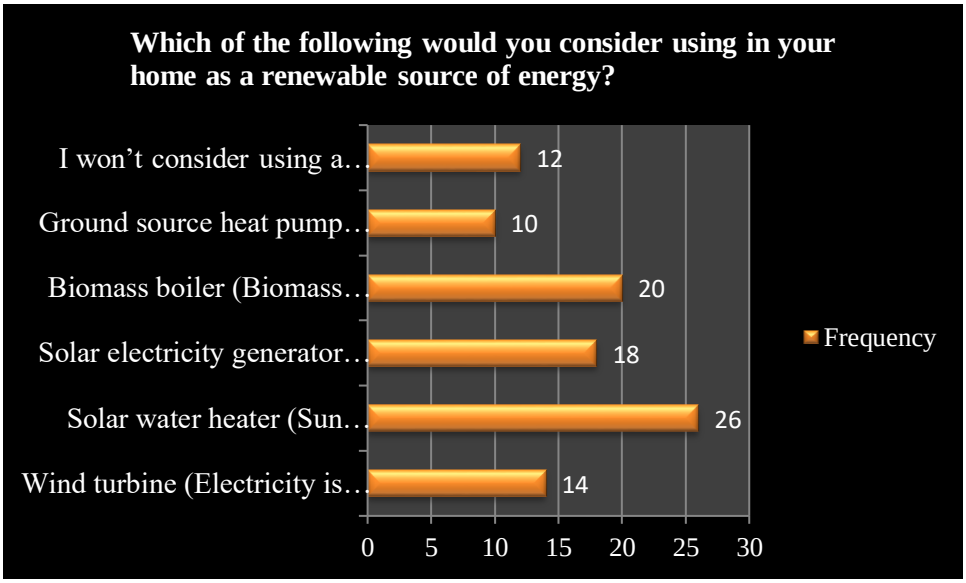
(Several answers possible)

* The different possible answer choices are presented in random order.

a. Wind turbine (Electricity is generated from the force of the wind through a rotor with attached blades)
b. Solar water heater (Sun energy is collected using a outdoor sunshine collector which heats household water or swimming pools)
c. Solar electricity generator (Creating electricity when sun light is absorbed into an outdoor panel)
d. Biomass boiler (Biomass boiler refers to the use of logs in log-burning stoves or cooker boilers in the home)
e. Ground source heat pump (Central heating and/or cooling system that pumps heat to or from the ground)

f. I won't consider using a renewable source of energy

Which of the following would you consider using in your home as a renewable source of energy?	**Frequency**
Wind turbine (Electricity is generated from the force of the wind through a rotor with attached blades)	14
Solar water heater (Sun energy is collected using a outdoor sunshine collector which heats household water or swimming pools)	26
Solar electricity generator (Creating electricity when sun light is absorbed into an outdoor panel)	18
Biomass boiler (Biomass boiler refers to the use of logs in log-burning stoves or cooker boilers in the home)	20
Ground source heat pump (Central heating and/or cooling system that pumps heat to or from the ground)	10
I won't consider using a renewable source of energy	12



Interpretation:

Here, at the very onset, 26% respondents consider the option "Solar water heater (Sun energy is collected using an outdoor sunshine collector which heats household water or swimming pools)" as a source of Renewable energy in their home, 20% likes the option "Biomass boiler (Biomass boiler refers to the use of logs in log-burning stoves or cooker boilers in the home)" as a source of Renewable energy in their home, 18% respondents consider the options "Solar electricity generator (Creating electricity when sun light is absorbed into an outdoor panel)" as a source of Renewable energy in their home, 14% respondents thinks of Wind turbine (Electricity is generated from the force of the wind through a rotor with attached blades) as a source of Renewable energy in their home. 10% respondent mentions about the Ground source heat pump (Central heating and/or cooling system that pumps heat to or from the ground) & 12% respondents say they won't consider using a renewable source of energy.

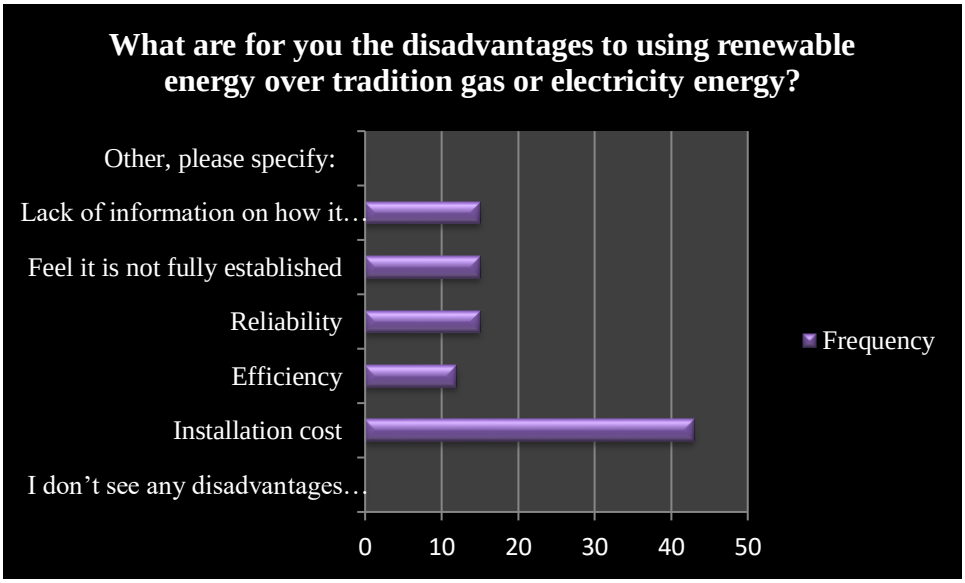
Q13.What are for you the disadvantages to using renewable energy over tradition gas or electricity energy?

(Several answers possible)

* The different possible answer choices are presented in random order.

a. I don’t see any disadvantages to using renewable energy
b. Installation cost
c. Efficiency
d. Reliability
e. Feel it is not fully established
f. Lack of information on how it works
g. Other, please specify:

What are for you the disadvantages to using renewable energy over tradition gas or electricity energy?	**Frequency**
I don’t see any disadvantages to using renewable energy	0
Installation cost	43
Efficiency	12
Reliability	15
Feel it is not fully established	15
Lack of information on how it works	15
Other, please specify:	0



Interpretation:

As far as the disadvantages of using renewable energy over tradition gas or electricity energy is concerned, 43% respondents say that *"installation cost"* is the disadvantage of using renewable energy over tradition gas or electricity energy.

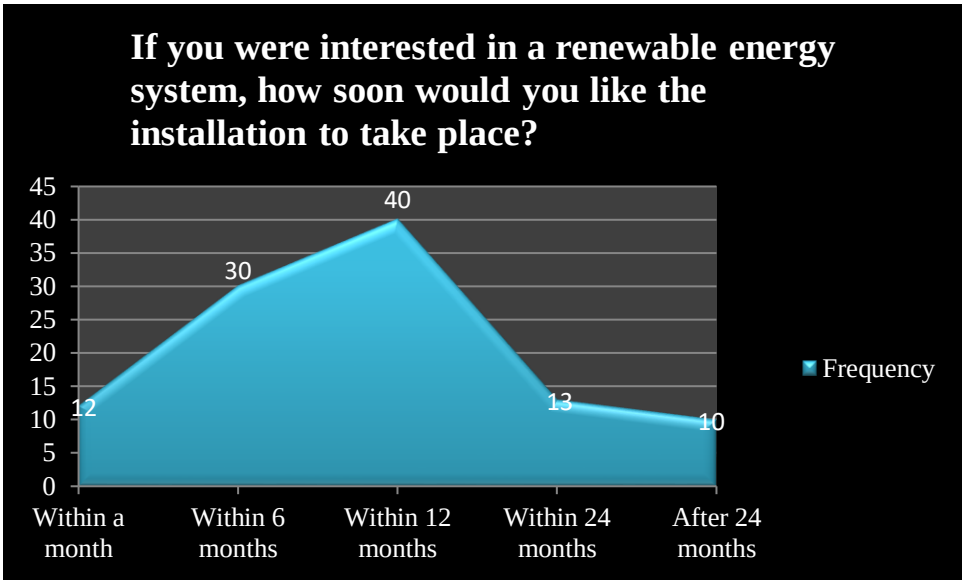
15% respondents agrees with the *"Reliability"*, *"Feel it is not fully established"* & *"Lack of information on how it works"* as a disadvantages of using renewable energy over tradition gas or electricity energy.

12% respondents accepts that *"efficiency"* is also disadvantages of using renewable energy over tradition gas or electricity energy however 0% agree with the last option *"others"*

Q14. If you were interested in a renewable energy system, how soon would you like the installation to take place?

a. Within a month
b. Within 6 months
c. Within 12 months
d. Within 24 months
e. After 24 months

If you were interested in a renewable energy system, how soon would you like the installation to take place?	**Frequency**
Within a month	12
Within 6 months	30
Within 12 months	40
Within 24 months	13
After 24 months	10



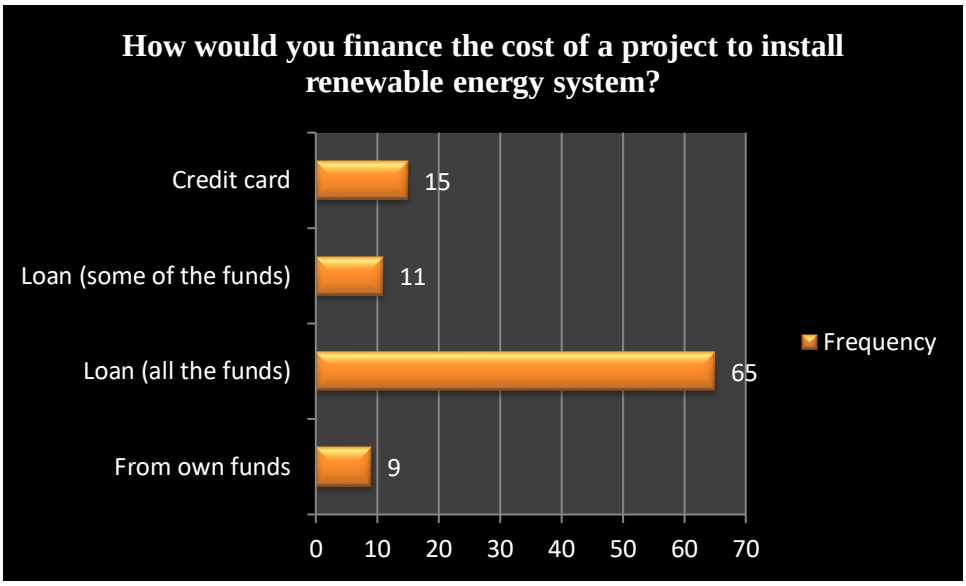
Interpretation:

At the helm of renewable energy system so far, access is one of the crucial steps and becomes the centre point for the consumers therefore the important paradigm is the access wherein most of the respondents who are interested in a renewable energy system, wants the installation to take place not later than 24 months collectively. 12% respondents agrees with that they want the installation to take place not later than a month, 30% respondents says that they are expecting the installation to be done not later than 6 months, 40% respondents look after for the installation of a renewable energy system to be done not later than 12 months, 13% respondents really want the installation of renewable energy system within 24 months and at the final note, only 10% respondents says the installation of the renewable energy system can be done after 24 months.

Q15. How would you finance the cost of a project to install renewable energy system?

a. From own funds
b. Loan (all the funds)
c. Loan (some of the funds)
d. Credit card

How would you finance the cost of a project to install renewable energy system?	Frequency
From own funds	9
Loan (all the funds)	65
Loan (some of the funds)	11
Credit card	15



Interpretation:

65% respondents needs the full loan for accessing the sustainable renewable energy system to be taken up for the installation in their houses which forms the base of most of the respondents and shows the attitude towards the installation of sustainable renewable energy system and it can be figure out that they put the importance of installation of sustainable renewable energy system as a priority at some level. 15% says the credit card to be used for the installation of sustainable renewable energy system, 11% respondents agrees with the partial funding from loan to install the sustainable renewable energy system in their houses however only 9% sounds

for from their own fund and does not want loan for the installation of sustainable renewable energy system in their houses.

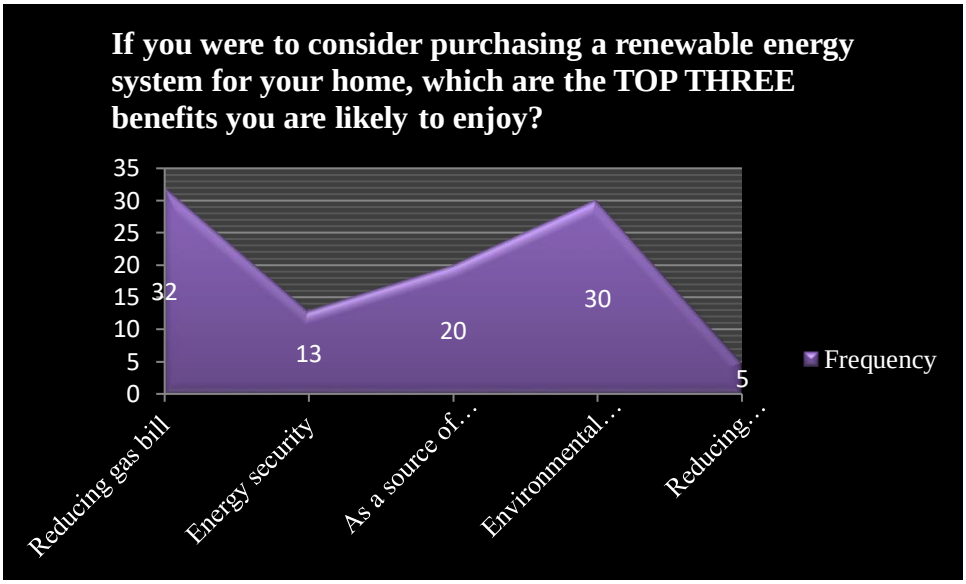
Q16.If you were to consider purchasing a renewable energy system for your home, which are the TOP THREE benefits you are likely to enjoy?

Please rank the top three: 1 being the most beneficial

* The different possible answer choices are presented in random order.

a. Reducing gas bill
b. Energy security
c. As a source of income from selling excess energy generated
d. Environmental responsibility
e. Reducing electricity bills

If you were to consider purchasing a renewable energy system for your home, which are the TOP THREE benefits you are likely to enjoy?	**Frequency**
Reducing gas bill	32
Energy security	13
As a source of income from selling excess energy generated	20
Environmental responsibility	30
Reducing electricity bills	5



Interpretation:

As a respondents for this research with no biasness has been observed in their answers, if they are to buy a renewable energy system for their home, only 32% respondents agrees with the factor "Reducing gas bill" for buying a renewable energy system for their home, 30% respondents accepts "Environmental responsibility" when it comes to buy a renewable energy system for their home, 20% respondents see it "As a source of income from selling excess energy generated" for buying a renewable energy system for their home, 13% respondents agree with "Energy security" for buying a renewable energy system for their home and only 5% considers "Reducing electricity bills" for buying a renewable energy system for their home.

The top three benefits has been identified, which are likely to enjoy by the respondents, are:

32% respondents for "Reducing gas bill"

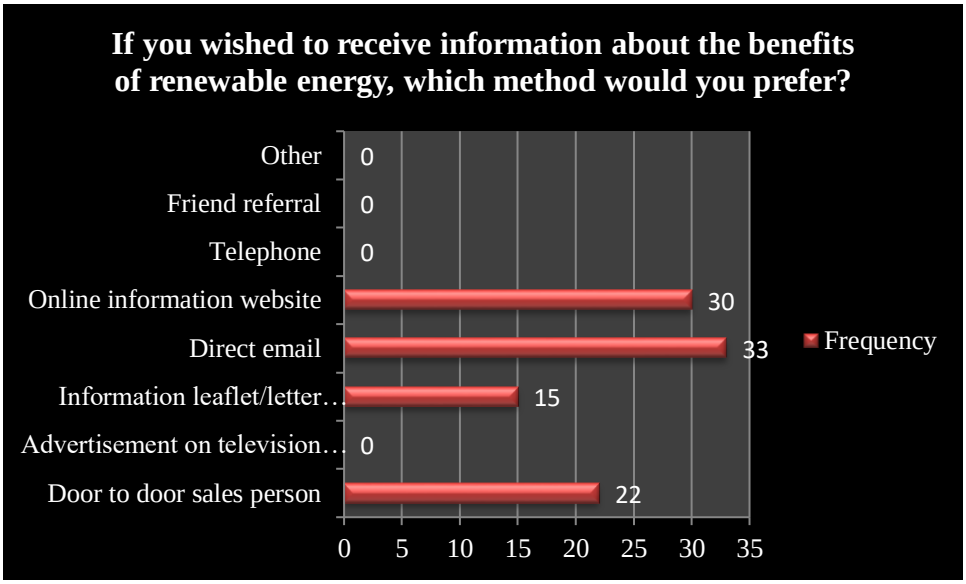
30% respondents for "Environmental responsibility"

20% respondents for "As a source of income from selling excess energy generated"

Q17.If you wished to receive information about the benefits of renewable energy, which method would you prefer?

a. Door to door sales person
b. Advertisement on television or radio
c. Information leaflet/letter through the post
d. Direct email
e. Online information website
f. Telephone
g. Friend referral
h. Other, please specify:

If you wished to receive information about the benefits of renewable energy, which method would you prefer?	**Frequency**
Door to door sales person	22
Advertisement on television or radio	0
Information leaflet/letter through the post	15
Direct email	33
Online information website	30
Telephone	0
Friend referral	0
Other	0



Interpretation:

As long as the information access related to benefits of renewable energy is concerned, the most preferred method has been seen is *"direct mail"* which has been answered by most of the respondents estimating the 33% of the total respondents yet another preferred method, which is chosen by the second highest number of respondents, is *"Online information website"* and the respondents estimated to be a 30% of the total. 22% respondents agrees with the option *"Door to door sales person"* for receiving the information about the benefits of renewable energy. However, only 15% respondents wish to receive information about the benefits of renewable energy via the traditional method of advertising as they prefer the option *"Information leaflet/letter through the post"*. Other three options *"Telephone", "Friend referral" & "other*" has been left unanswered and not considered by any respondents.

Q18.What type of promotions would encourage you to purchase a renewable energy system?

* The different possible answer choices are presented in random order.

a. Over time payments
b. Loan without interest

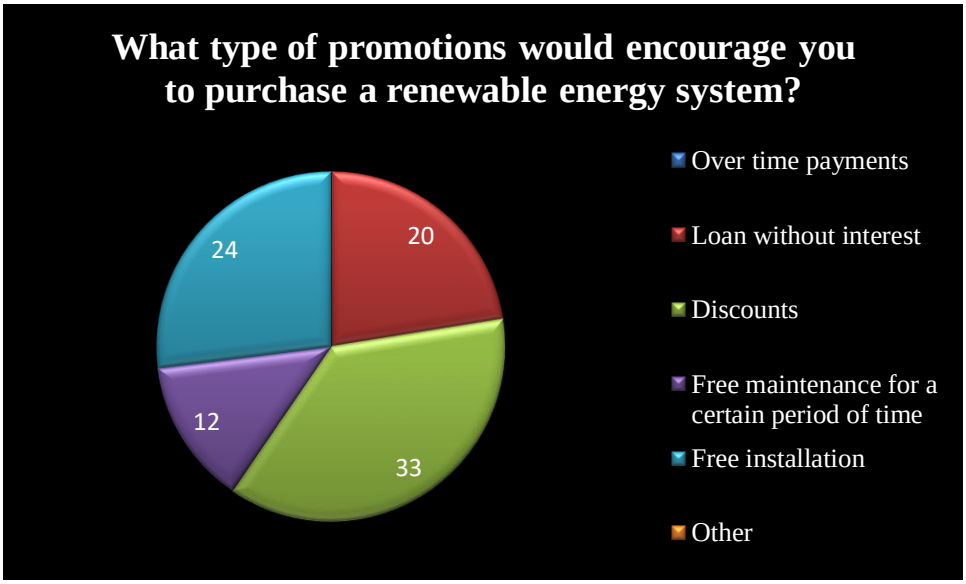
c. Discounts

d. Free maintenance for a certain period of time

e. Free installation

f. Other, please specify:

What type of promotions would encourage you to purchase a renewable energy system?	**Frequency**
Over time payments	0
Loan without interest	20
Discounts	33
Free maintenance for a certain period of time	12
Free installation	24
Other	0



Interpretation:

Type of promotions encourages everyone to make a decent purchase of a renewable energy

system for sure but that is limited to the level of priorities set out for the certain lifestyle. Adding more to it, 33% respondents say that they like the promotions using *"Discounts"*, 20% respondents look out for the *"Loan without interest"*, 24% respondent tries to search out the *"Free installation"*, 12% respondent always look for the *"Free maintenance for a certain period of time*". Only 0% respondent has chosen the options "over time payments" & "other" which estimates there inclination towards making a purchase.

Q19. What does the term Climate Change mean to you?

Q20. It is estimated that coal will run out within the next 110 years, and gas much earlier, in just 54 years. How do you feel about these statistics?

Q21. Please rate how strongly you feel each is responsible for reducing the carbon footprint, on a scale of 1-5. (5 being the strongest)

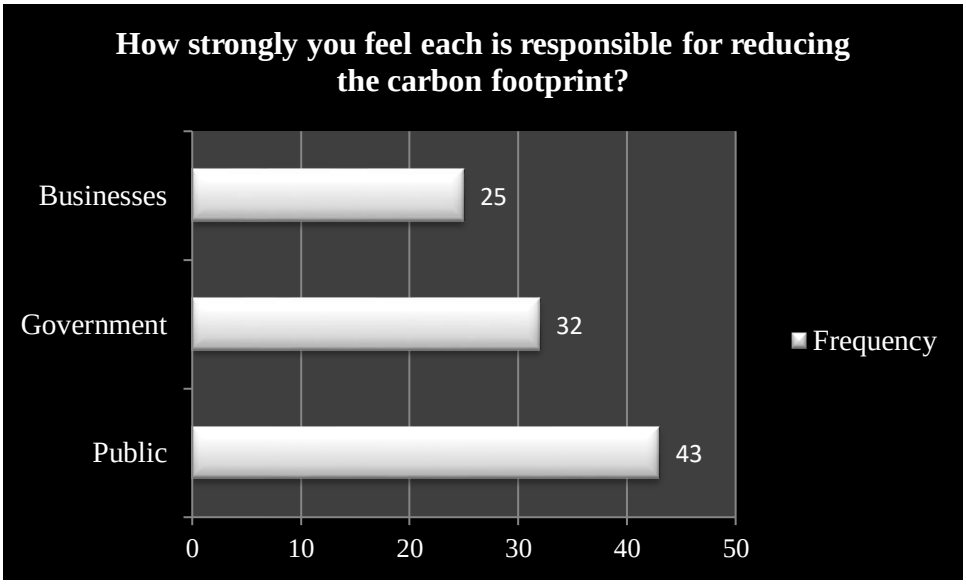
1 2 3 4 5

Public

Government

Businesses

How strongly you feel each is responsible for reducing the carbon footprint?	Frequency
Public	43
Government	32
Businesses	25



Interpretation:

43% respondents feel that *"Public"* is responsible for reducing the carbon footprint and 32% respondents feel that "*Government*" is responsible for reducing the carbon footprint and 25% respondents feel that *"Businesses*" are responsible for reducing the carbon footprint. Carbon reduction is the main forte of sustainable renewable energy implementation and its implementation leads the life with ***eco-friendly and green environmental*** and brings health care for the society which forms the base of ***corporate sustainability*** as well as ***corporate social responsibility***.

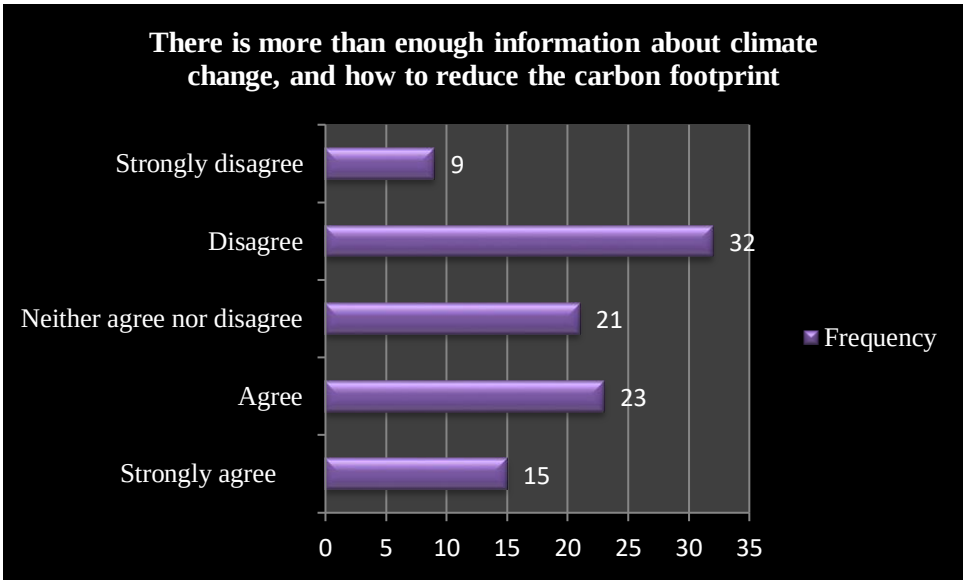
Q22. Please rate the following statements:

22.1 There is more than enough information about climate change, and how to reduce the carbon footprint.

i) Strongly agree ii) Agree iii) Neither agree nor disagree iv) Disagree v) Strongly disagree

There is more than enough information about climate change, and how to reduce the carbon footprint	**Frequency**

Strongly agree	15
Agree	23
Neither agree nor disagree	21
Disagree	32
Strongly disagree	9



Interpretation:

At the helm of bringing sustainability to the energy development, renewable energy plays a vital role and that leads to the reduction of carbon footprints as it is all totally dependent upon the climatic conditions such as wind whirl, sea access etc. Keeping in view the same and adding more to further, I have conducted a survey asking whether there is more than enough information about climate change, and how to reduce the carbon footprint, and that surprisingly estimates 32% respondents saying *"Disagree"*, 23% respondents says *"Agree"*, 21% respondents says *"Neither agree nor disagree"*, 15% respondents understands the topic of discussion quite well and heads off with *"Strongly agree"* however only 9% says *"Strongly disagree"*.

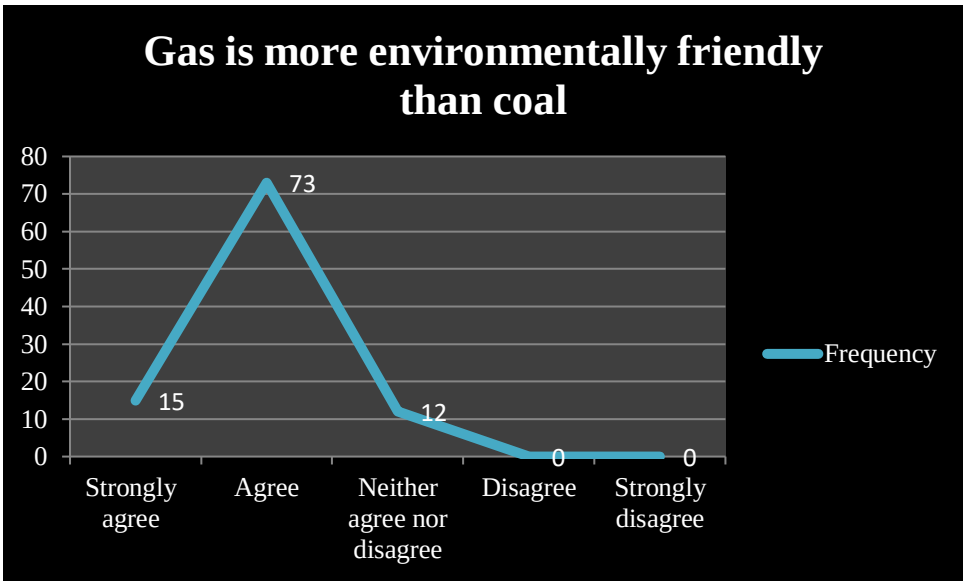
At the final note, I accept that most of the people understand the sustainable reforms

happening/taking place around the globe making it more popular and giving the edge.

22.2 Gas is more environmentally friendly than coal.

i) Strongly agree ii) Agree iii) Neither agree nor disagree iv) Disagree v) Strongly disagree

Gas is more environmentally friendly than coal	**Frequency**
Strongly agree	15
Agree	73
Neither agree nor disagree	12
Disagree	0
Strongly disagree	0



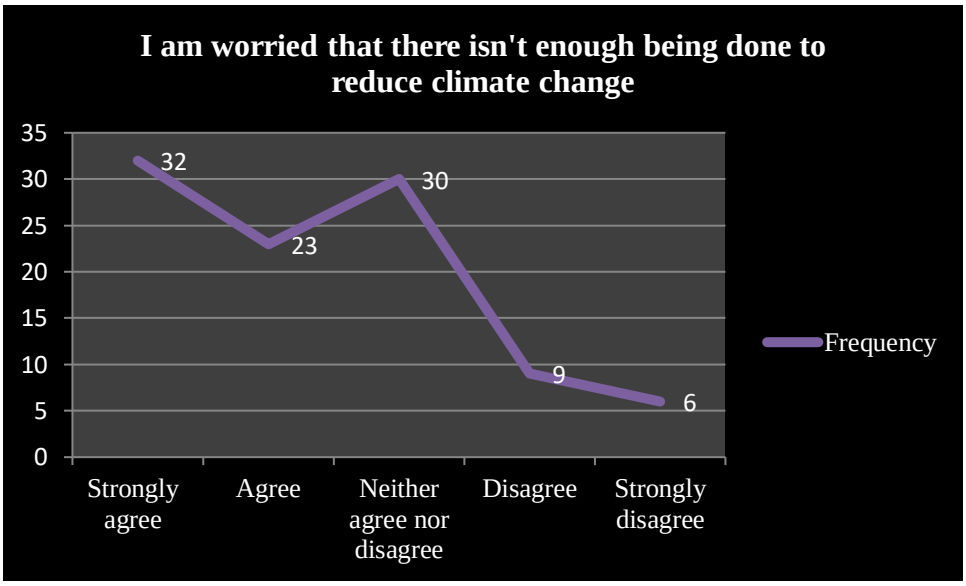
Interpretation:

Most of the respondents estimating 73% of the total says that they *"Agree"* with the statement ***Gas is more environmentally friendly than coal.*** Furthermore, 15% respondents *"Strongly agree*" with the same statement, and remaining 12% respondents says that they *"Neither agree nor disagree". No respondents have picked up the options "Disagree" and "Strongly disagree" and left un-chosen/unpicked.*

22.3 I am worried that there isn't enough being done to reduce climate change.

i) Strongly agree ii) Agree iii) Neither agree nor disagree iv) Disagree v) Strongly disagree

I am worried that there isn't enough being done to reduce climate change	**Frequency**
Strongly agree	32
Agree	23
Neither agree nor disagree	30
Disagree	9
Strongly disagree	6



Interpretation:

No sooner, there is a lot been done to reduce climate change around the Globe and no wonder the world will become the source of sustainable renewable energy wherein every country will be having their own sustainable renewable energy plants. The world must be aware of for those moments when all non-renewable sources such as fossil fuels etc. will get over and no source would be available.

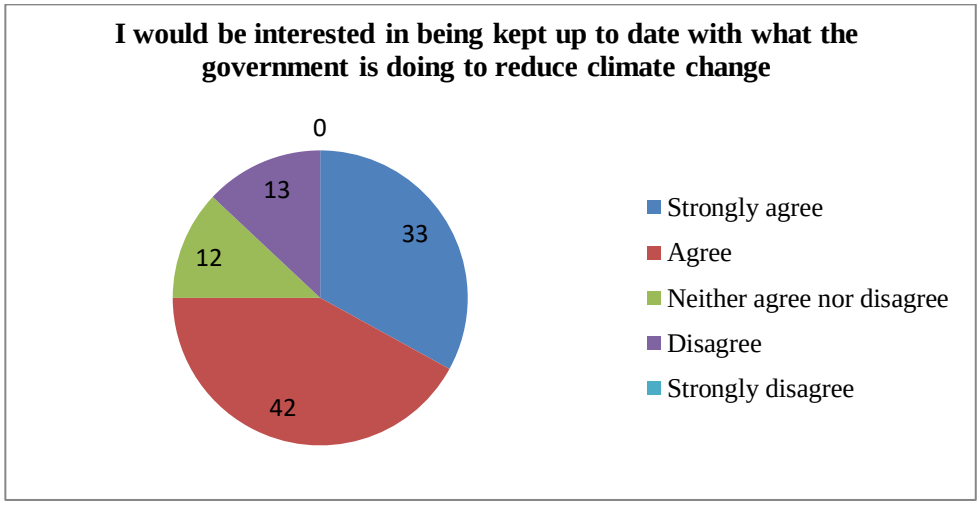
In this research, the question “I am worried that there isn’t enough being done to reduce climate

change" has been surveyed among 100 respondents and out of those 32% responded that they "strongly agree" with the statement, 30% responded that they "Neither agree nor disagree", 23% agrees with the option "Agree", 9% says they "Disagree" and 6% respondents "Strongly disagree" with the statements.

22.4 I would be interested in being kept up to date with what the government is doing to reduce climate change.

i) Strongly agree ii) Agree iii)Neither agree nor disagree iv)Disagree v)Strongly disagree

I would be interested in being kept up to date with what the government is doing to reduce climate change	**Frequency**
Strongly agree	33
Agree	42
Neither agree nor disagree	12
Disagree	13
Strongly disagree	0



Interpretation:

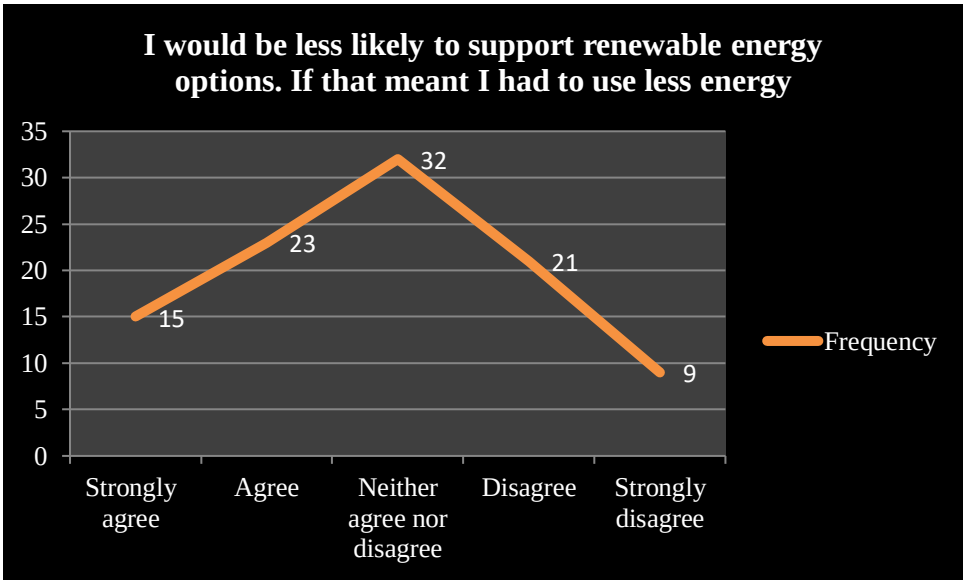
Nevertheless, the research has conducted the vast survey in order to understand the issues involved in sustainable renewable energy development yet the statement adds value to the

research and gives the edge. The statement “I would be interested in being kept up to date with what the government is doing to reduce climate change”. Most of the people choose the option “Agree” estimating it to be 42% of the total. 33% of total says that they “strongly agree” with the statement, 12% of the total responded that they “Neither agree nor disagree” with the statement, and on the other hand 13% of the total says that they “disagree” with the statement yet option “strongly disagree” nobody has chosen.

22.5 I would be less likely to support renewable energy options. If that meant I had to use less energy

i) Strongly agree ii) Agree iii) Neither agree nor disagree iv) Disagree v) Strongly disagree

I would be less likely to support renewable energy options. If that meant I had to use less energy	**Frequency**
Strongly agree	15
Agree	23
Neither agree nor disagree	32
Disagree	21
Strongly disagree	9



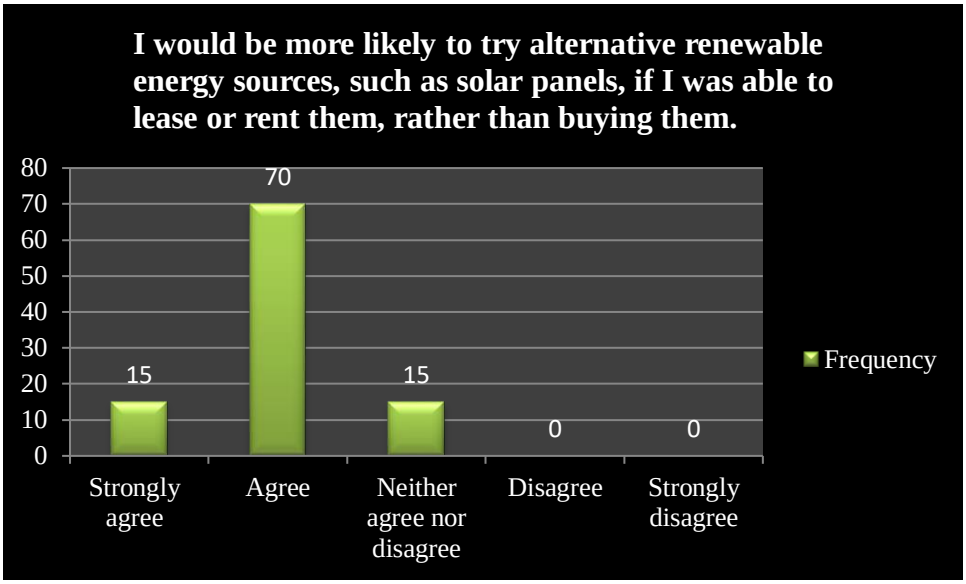
Interpretation:

Synoptically, this is the statement "I would be less likely to support renewable energy options. If that meant I had to use less energy" whose core focus is freedom of using the sustainable renewable energy. Most of the respondents says that they "Neither agree nor disagree" with the statement as it estimates to be 32% respondents of the total. 23% respondents of the total say that they "Agree" with the statement, 15% respondents of the total says that they "Strongly disagree" with the statement, and on the other hand 21% respondents of the total "disagree" with the statement, and remaining 9% respondents of the total fill up the option "Strongly disagree".

22.6 I would be more likely to try alternative renewable energy sources, such as solar panels, if I was able to lease or rent them, rather than buying them.

i) Strongly agree ii) Agree iii) Neither agree nor disagree iv) Disagree v) Strongly disagree

I would be more likely to try alternative renewable energy sources, such as solar panels, if I was able to lease or rent them, rather than buying them.	**Frequency**
Strongly agree	15
Agree	70
Neither agree nor disagree	15
Disagree	0
Strongly disagree	0



Interpretation:

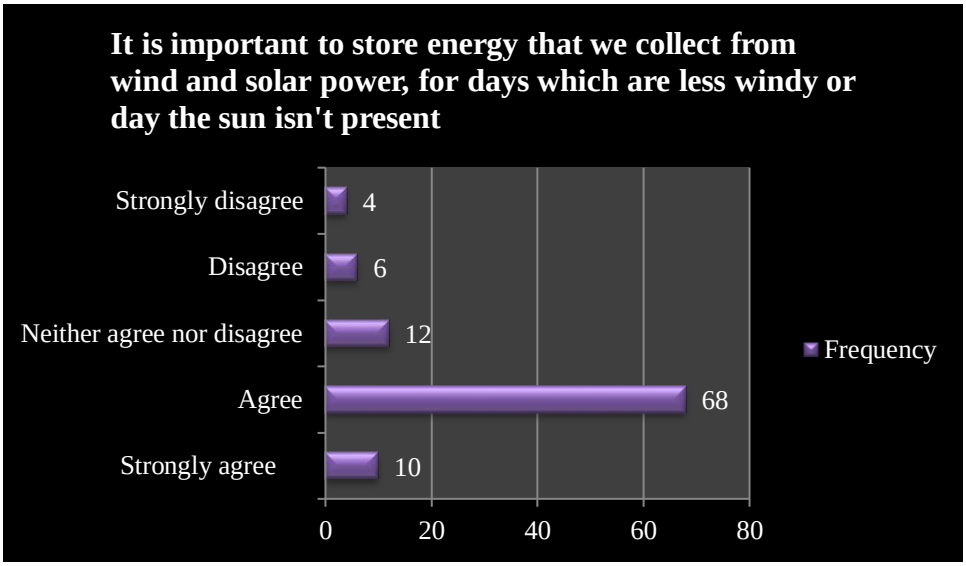
Holistically, the statement "I would be more likely to try alternative renewable energy sources, such as solar panels, if I was able to lease or rent them, rather than buying them" whose core focus is to use alternative renewable energy while leasing/renting the property. Most of the respondents say that they "Agree" with the statement as it estimates to be 70% respondents of the total. 15% respondents of the total say that they "Strongly agree" with the statement, 15% respondents of the total says that they "Neither agree nor disagree" with the statement, and on the other hand No respondents "disagree" & "Strongly disagree" with the statement.

22.7 It is important to store energy that we collect from wind and solar power, for days which are less windy or day the sun isn't present.

i) Strongly agree ii) Agree iii) Neither agree nor disagree iv) Disagree v) Strongly disagree

It is important to store energy that we collect from wind and solar power, for days which are less windy or day the sun isn't present	**Frequency**

Strongly agree	10
Agree	68
Neither agree nor disagree	12
Disagree	6
Strongly disagree	4



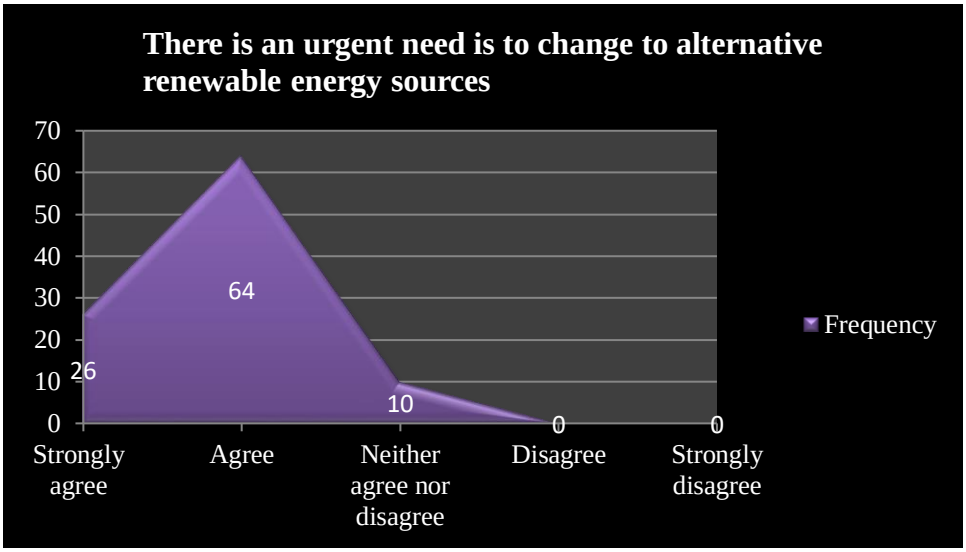
Interpretation:

Subsequently, the statement “It is important to store energy that we collect from wind and solar power, for days which are less windy or day the sun isn't present” presents the great response which amazingly supports the previous responses. Here the statement tries focusing on the preservation of energy whether windy or sun or both. Most of the respondents say that they “Agree” with the statement as it estimates to be 68% respondents of the total. 10% respondents of the total say that they “Strongly agree” with the statement, 12% respondents of the total says that they “Neither agree nor disagree” with the statement, and on the other hand 6% respondents of the total “disagree” & 4% respondents of the total “Strongly disagree” with the statement.

22.8 There is an urgent need is to change to alternative renewable energy sources

i) Strongly agree ii) Agree iii) Neither agree nor disagree iv) Disagree v) Strongly disagree

There is an urgent need is to change to alternative renewable energy sources	**Frequency**
Strongly agree	26
Agree	64
Neither agree nor disagree	10
Disagree	0
Strongly disagree	0



Interpretation:

Amazingly, the statement "There is an urgent need is to change to alternative renewable energy sources" shows the requirement of modern energy policies and its preservation that fits all the responses as it follows ***"One size fits all"***. Most of the respondents say that they "Agree" with the statement as it estimates to be 64% respondents of the total. 26% respondents of the total say that they "Strongly agree" with the statement, 10% respondents of the total say that they

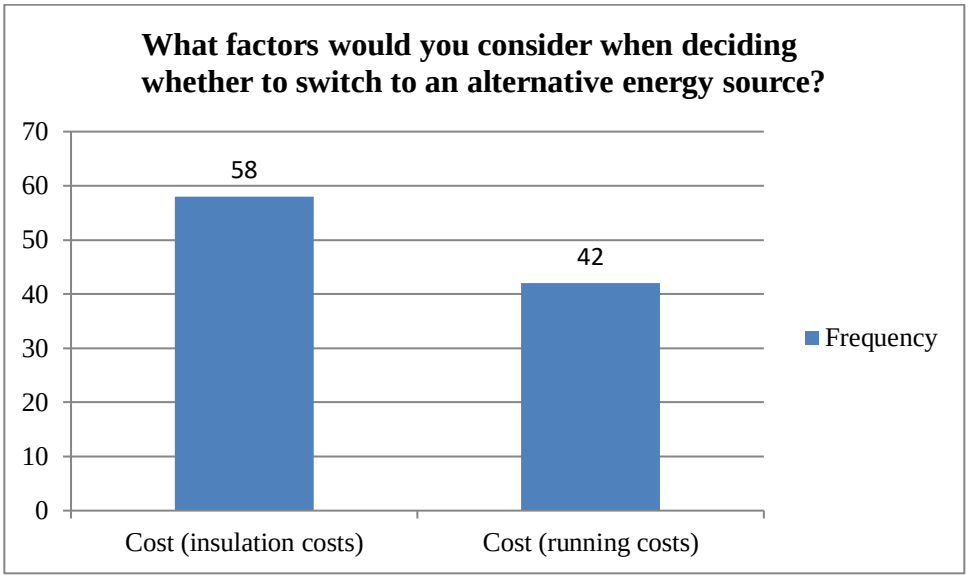
"Neither agree nor disagree" with the statement, and on the other hand, no respondents of the total choose the options "disagree" & "Strongly disagree" for the statement.

Q23. What factors would you consider when deciding whether to switch to an alternative energy source (please select all that apply).

a. Cost (insulation costs)

b. Cost (running costs)

What factors would you consider when deciding whether to switch to an alternative energy source?	Frequency
Cost (insulation costs)	58
Cost (running costs)	42



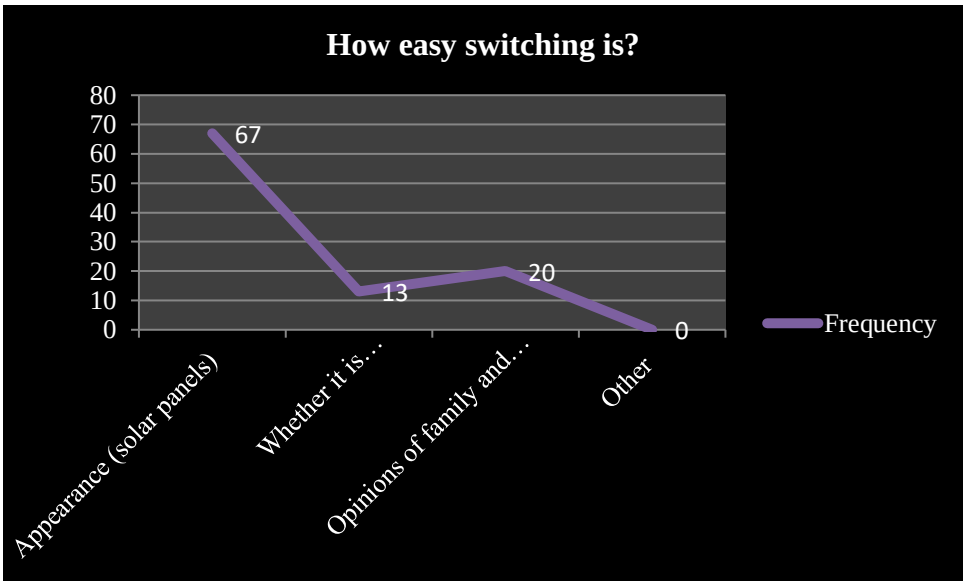
Interpretation:

In this research here I have found the factors that would be considered when deciding whether to switch to an alternative energy source as 58% respondents are saying that insulation cost matters the most however 42% respondents agrees with the running cost.

Q24. How easy switching is?

a. Appearance (solar panels)
b. Whether it is environmentally friendly
c. Opinions of family and friends
d. Other (please specify)

How easy switching is?	Frequency
Appearance (solar panels)	67
Whether it is environmentally friendly	13
Opinions of family and friends	20
Other	0



Interpretation:

Amicably, I have understood the easiness of switching the energy wherein 67% respondents says about the appearance of solar panels, 13% considers environmental friendly, 20% responds for opinions of family and friends.

CHAPTER VI

CONCLUSION

As far as conclusion out of whole large set of tables and charts accompanied with precise interpretation has concerned, it is really positive outcomes which have been observed during the data analysis.

At the very onset, I have conducted the literature review critically and unlocked/unfolded what the future lie for sustainable renewable energy in the Dubai nonetheless some factors which could take more crucial role to play may be left due to its very nature of the analysis. I have cited the interpretation of the primary data which has collected through the survey/questionnaire and analysed with research tool of MS excel package.

Here while citing the conclusion of my research, I have taken consideration of SMART targets; Specific, Measurable, Achievable, Reliable & Time-Sensitive; which would help me in setting the pace & tone of conclusion.

I have addressed the research objectives very clearly in the interpretation and stated with detailed explanation in order to avoid any misunderstanding. I have successfully achieved all the objectives and that serves the purpose at its fullest. Perhaps, I used more strict way of analysis in order to arrive at proper findings and tried to pick up the variables and factors and create good sync between them.

I have studies the factors in general influencing environmental issues in the sustainable renewable energy development in the UAE and specifically studied the factors influencing in each emirate that affects environmental issues in the sustainable renewable energy development

in the UAE. Taking it further, I have tried to set up the criterions which facilitate the sustainable Renewable Energy Development in the UAE which have been discussed in the literature review section. Not only this, I also understood the pros and cons in quite broader aspects which affect the development of the country if not achieved. And finally I examined the necessary key resources, facilities & support needed for sustainable renewable energy development in the UAE.

Probably, being cosmopolitan country the Dubai has seamless opportunities as far as business driven economy has concerned, therefore it is very need of proper implementation of sustainable renewable energy so as to facilitate the businesses the better environment within the UAE nonetheless much initiatives has been taken by the government of the UAE yet the management part which is formidable is missing sometimes and therefore cost goes high and restrict somewhere the further development within the country despite much vibrant growth has been observed yet recent oil crisis has brought so much changes which really impacted heavily the growth even hampered & still continued due to its own tourism driven infrastructure and that has put the Dubai on the list top tier country of the world.

CHAPTER VII

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Questionnaire

Myself, Mr. Zakaria Omran, Research Scholar, Charisma University, UK has designed and administered the questionnaire to assess the environmental issues Sustainable Renewable Energy Management in the UAE to understand better the UAE Energy market for Sustainable Renewable Energy Development. The elements of the questionnaire are already used by other researchers in their research as well as some industries to analyze the factors however I am using this questionnaire as a tool which is already developed by some other researchers in their researches. Questions in the questionnaire are taken partially by the researcher.

The researcher has divided the whole questionnaire in two sections:

1. Demographic factors

2. Business Related Factors

"Demographic factors"

Name:

Age: Under 21 21 to 40 41 to 60 61+ Would rather not say

Sex: Male Female Transgender

Income:

Marital status:

Location within the country: (Quality)

Experience (if any):

Education level:

"Business Related factors"

Q1.Which description best describes your household:

a. Yourself and your partner living together
b. You living alone

c. You living with your children
d. You and your partner living with your children
e. You living with friend(s)
f. You living with your parent(s)

Q2. How would you describe your property?

a. Flat/Apartment
b. Detached House
c. Semi-detached House
d. Bungalow
e. Maisonette
f. Other

Q3. Do you know the difference between renewable and non-renewable energy?

e. Yes
f. No
g. Unsure
h. Unsure (please specify)

Q4. Who supplies your energy?

a. EDF Energy
b. British Gas
c. Southern Electric
d. nPower
e. E.ON
f. Other
g. Unsure
h. Other (please specify)

Q5. Did your supplier make its policy on renewable energy clear to you? (please write 'no' in box if not)

Q6. If you are aware of how much of their energy CURRENTLY comes from renewable sources please state (e.g. 50%)

Q7. What do you do around the house to help the environment?

Q8. Do you contribute to a renewable energy project (charity), own a renewable energy source such as solar panels or do something else you feel relevant?

Q9. Would you switch to a more expensive supplier if they were more environmentally friendly? (More renewable energy)

d. Yes
e. No
f. Depends on price difference

Q10. Are you concerned about the low amounts of renewable energy being produced?

e. Very concerned
f. Concerned
g. Indifferent
h. It doesn't affect me

Q11.If you were to consider purchasing a renewable energy system for your home, which are the TOP THREE difficulties you would be likely to experience?

Please rank the top three: 1 being the most likely

* The different possible answer choices are presented in random order.

g. Initial Cost/ obtaining a good price
h. Finding a trustworthy contractor
i. Choosing the correct technology
j. Obtaining correct and reliable information
k. Good return on investment
l. Technology may become obsolete too quickly

Q12. Which of the following would you consider using in your home as a renewable source of energy?

(Several answers possible)

* The different possible answer choices are presented in random order.

g. Wind turbine (Electricity is generated from the force of the wind through a rotor with attached blades)
h. Solar water heater (Sun energy is collected using a outdoor sunshine collector which heats household water or swimming pools)
i. Solar electricity generator (Creating electricity when sun light is absorbed into an outdoor panel)
j. Biomass boiler (Biomass boiler refers to the use of logs in log-burning stoves or cooker boilers in the home)
k. Ground source heat pump (Central heating and/or cooling system that pumps heat to or from the ground)

l. I won't consider using a renewable source of energy

Q13.What are for you the disadvantages to using renewable energy over tradition gas or electricity energy?

(Several answers possible)

* The different possible answer choices are presented in random order.

h. I don't see any disadvantages to using renewable energy
i. Installation cost
j. Efficiency
k. Reliability
l. Feel it is not fully established
m. Lack of information on how it works
n. Other, please specify:

Q14. If you were interested in a renewable energy system, how soon would you like the installation to take place?

f. Within a month
g. Within 6 months
h. Within 12 months
i. Within 24 months
j. After 24 months

Q15.How would you finance the cost of a project to install renewable energy system?

e. From own funds
f. Loan (all the funds)
g. Loan (some of the funds)
h. Credit card

Q16.If you were to consider purchasing a renewable energy system for your home, which are the TOP THREE benefits you are likely to enjoy?

Please rank the top three: 1 being the most beneficial

* The different possible answer choices are presented in random order.

f. Reducing gas bill
g. Energy security
h. As a source of income from selling excess energy generated
i. Environmental responsibility
j. Reducing electricity bills

Q17.If you wished to receive information about the benefits of renewable energy, which method would you prefer?

i. Door to door sales person
j. Advertisement on television or radio
k. Information leaflet/letter through the post
l. Direct email
m. Online information website
n. Telephone
o. Friend referral
p. Other, please specify:

Q18.What type of promotions would encourage you to purchase a renewable energy system?

* The different possible answer choices are presented in random order.

g. Over time payments
h. Loan without interest
i. Discounts
j. Free maintenance for a certain period of time
k. Free installation
l. Other, please specify:

Q19. What does the term Climate Change mean to you?

Q20. It is estimated that coal will run out within the next 110 years, and gas much earlier, in just 54 years. How do you feel about these statistics?

Q21. Please rate how strongly you feel each is responsible for reducing the UK's carbon footprint, on a scale of 1-5. (5 being the strongest)

1 2 3 4 5

Public

Government

Businesses

Q22. Please rate the following statements:

22.1 There is more than enough information about climate change, and how to reduce the carbon footprint.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

22.2 Gas is more environmentally friendly than coal.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

22.3 I am worried that there isn't enough being done to reduce climate change.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

22.4 I would be interested in being kept up to date with what the government is doing to reduce climate change.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

22.5 I would be less likely to support renewable energy options. If that meant I had to use less energy

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

22.6 I would be more likely to try alternative renewable energy sources, such as solar panels, if I was able to lease or rent them, rather than buying them.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

22.7 It is important to store energy that we collect from wind and solar power, for days which are less windy or day the sun isn't present.

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

22.8 There is an urgent need is to change to alternative renewable energy sources

Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

Q23. What factors would you consider when deciding whether to switch to an alternative energy source (please select all that apply).

c. Cost (insulation costs)
d. Cost (running costs)

Q24. How easy switching is?

e. Appearance (solar panels)
f. Whether it is environmentally friendly
g. Opinions of family and friends
h. Other (please specify)

ZAKARIA OMRAN

Position : Technical Manager
Qualifications : (MSc. ASME, ASHRAE, EI)
Education : Heriot-Watt University-UK

Zakaria has more than 20 years of industry experience and has delivered sustainable and low energy solutions on many projects through varying contract types. He has acted as Technical Manager on large scale projects and has expertise in the fields of high rise, Airport, shopping Mall, district cooling plant design, MEP building services as well as active Energy and renewable energy systems such as power generation; water treatment plant: sewage treatment plant , and solar thermal.