Analyzing Feasible Renewable Energy Policies : UAE Electricity Authorities

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Abstract

Over the past few decades, the impact of energy demand on the environment has increased global nations focus on sustainability efforts to reduce greenhouse gas (GHG) emissions that required intervention and a shared sense of responsibility. The need for a long-term sustainable energy policy became of high importance due to the increasing CO_2 emissions and the rising marginal cost of natural gas supply, which is the primary backbone of the UAE domestic energy system. The UAE government recognized the need to deploy renewable energy to address climate change and CO_2 emission problem by diversifying their energy resources, but the critical challenge is to minimize the gap between RE policy formulation and actual implementation. This study conducts intensive research to support solar energy deployment in the UAE by introducing a framework to promote feasible RE policy mechanisms that can be implemented to break up the monopoly. Therefore, the research intends to assist UAE electricity authorities in considering RE policies to meet the energy demand by taking advantage of UAE's abundant solar irradiance, which reduces the dependence on fossil fuels. However, the paper's main findings indicate RE policies to promote sustainability deployment, including feed-in-tariffs (FIT), net metering, RE auctions (tendering), quotas, and tax credits. In contrast, a mixed FIT policy and quota policy is recommended for the UAE's electricity sector whereas the significant factors influencing RE development are geographical, economic, technological, environmental, and political factors.

Keywords
Greenhouse gas emissions, Energy demand, Sustainability, Energy policy

1. Introduction

The rapid economic growth combined with the increasing energy demand is a continuous driving force for economic development, social advancement, and improved quality of life. Studies revealed that the role of rapid population growth, urbanization, and high energy consumption led to increasing the GHG emissions level. As the energy sector alone accounts for two-thirds of GHG emissions as more than 80% of energy needs are satisfied using hydrocarbon-based resources. The United Arab Emirates (UAE) ranked among the world's highest CO_2 emitters from fuel consumption around 18 tCO2/capita*year in the past few years. Besides, the UAE ranked in the 25th place of CO_2 emission, which is about 0.7% of the annual worldwide emissions due to fossil fuel consumption. After its independence in 1971, UAE has undergone rapid economic growth and overall development, leading to a remarkable increase in energy consumption and a growing responsibility toward environmental protection (Said et al. 2018, Mehmood 2018).

The UAE is among the largest oil producers globally, with approximately 2.8 million barrels per day and is considered the world's third-largest net exporter. Upon looking into the UAE case, it was found that due to the rapid economic growth in the past few decades, it is pushing the country's electricity grid to its limits, whereas in 2010, the electricity consumption was estimated to be 85.2 billion kWh 8.5% higher compared with 2009. This demand caused the natural gas reserves to be no longer sufficient to meet the UAE demand, which forced the government to import natural gas from the neighbouring countries to resolve this issue. However, the UAE's power sector is highly dependent on natural gas as initial efforts are mandatory to diversify the UAE economy capitalized on energy availability (Sgouridis et al. 2016). The need for a long-term sustainable energy policy became of high importance due to the increasing CO_2 emissions and the rising marginal cost of natural gas supply, which is the primary backbone of the UAE domestic

energy system. The emergent worldwide commitment to sustainable development placed responsibility on technology policy, which created a challenge for UAE due to the reliance on conventional energy resources for its survival. It is an alarming to start using alternative energy resources before the traditional reserve of energy runs out. The UAE federal government recognized that diversifying its economy plays a vital role in maintaining its growth. The GCC countries, including the UAE, can take advantage of solar energy generation as they lie within the solar belt, a region with high solar radiation and a clear sky throughout the year. For instance, the GCC countries receive a quarter of the solar energy striking the earth, whereas solar energy can meet the current electricity demand (Jamil et.al 2016, Jeon 2016). This research therefore, focuses on the importance of having an energy balance by implementing RE policy mechanisms, which aligns with UAE's 2030 vision to have an energy mix by increasing RE and reducing energy subsidies.

Solar energy is one of the promising RE resources for a sustainable deployment due to its low environmental impact compared to conventional resources. Thus, after viewing the UAE's energy sector, solar energy can be adopted for electricity generation to meet the electricity demand effectively. The utilization of RE sources can help sustain the future of the UAE's electricity needs by harnessing abundant natural energy resources. This study intends to introduce renewable energy policy mechanisms by promoting the most feasible policy that can be implemented in the UAE to encourage RE deployment. However, the study is aligned with the UAE government strategy in attaining sustainable growth to meet the local demand. The electricity generated in UAE is provided by four different authorities ADWEA (Abu Dhabi Water and Electricity Authority), DEWA (Dubai Water and Electricity Authority), SEWA (Sharjah Water and Electricity Authority), and FEWA (Federal Electricity and Water Authority). These four authorities operate to meet the demand as the UAE government estimated the annual peak demand for electricity to rise to more than 450,000 MW by 2023 (Jamil et.al 2016, Jeon 2016). The anticipated high energy demand due to the increase in the UAE population requires implementing new power plants. Throughout this research, grid-tied solar energy is proposed to satisfy the consumer's demand, aligning with the government target to reduce CO_2 emissions.

However, to support solar energy development in UAE, new renewable energy policies are needed to achieve a significant share of RE in the national energy mix. Energy policies that promote RE energy deployment include feed-in-tariffs, net metering, RE auctions (tendering), quotas, and tax credits. Thus, the decision to adopt such policies in GCC is based on scientific analysis as RE policies deployment tends to break up the monopoly. This paper intends to assist electricity authorities in considering feasible RE policies to meet the energy demand by taking advantage of the UAE's high solar irradiance, which reduces the dependence on fossil fuels. This would also contribute to sustaining UAE's economic development for the long-term and reduce GHG emissions by attaining environmental protection.

2. Renewable Energy

In a modern world, life would not be possible without energy as energy plays a significant role in the development of nations. Such a development can be estimated in terms of the amount of energy consumed per person, whereas energy cannot be seen; it can be utilized efficiently. Energy is categorized into two types renewable energy (RE) and non-renewable energy; in fact, RE is not new as humans have used hydropower, solar thermal, geothermal, and wind energy for thousands of years (Jamil et.al 2016, Jeon 2016). Although the concept of RE existed for several decades recently, it gained profound global concerns owed to energy security and environmental sustainability. Renewable energy is cleaner, safer, and more secure than fossil fuel-based energy resources as it can generate clean energy, which tends to reduce energy-related problems such as CO_2 and other pollutants contributing to global warming.

However, by complying with the UN World Energy Summit, Kyoto protocol, Paris agreement, and other national agreements on climate change, several developed countries considered implementing renewable energy as an alternative energy source. Ellabban et al. (2014) defined renewable energy as the abundant energy sources continually replenished by nature, which can be derived directly or indirectly from the sun. Solar energy, thermal energy, and photo-chemical energy are derived directly from the sun, whereas wind, hydropower, and biomass are derived indirectly. Thus, renewable energy stems from natural resources such as rain, wave, sunlight, and geothermal heat. It tends to sustain its resources without contaminating the environment by turning the natural energy sources into applicable forms of energy, such as electricity, heat, and biofuels.

Besides, the benefits of using natural energy resources reduce the reliance on conventional resources such as fossil fuels, which increase energy security. It also decreases the impact of fossil fuels and hydrocarbons on the environment by reducing GHG emissions. Since the environmental concerns are increasing, it is clear that shifting towards

renewable energy can help in meeting the goal of reducing CO_2, whereas investing in clean energy can have a significant impact on the UAE energy sector. Thus, the deployment of RE would positively impact the countries sustainability by providing a wide variety of socio-economic benefits such as diversification of energy supply, enhance regional development, and creating opportunities for domestic industries. Therefore, in the past few years, UAE has taken some crucial steps in establishing the RE sector by diversifying its energy supply to address the problem of CO_2. In 2009, the UAE government announced the first RE policy, which stated that by the year 2020, 7% of the power sector's energy would come from RE (Al-Amir and Abu-Hijleh 2013).

2.1 Worldwide Renewable Energy Trends and it's Evolution in GCC

By 2050, the increase of RE deployment in electricity generation is expected to contribute to CO_2 reduction between 9% and 16%. According to Dilek et al. (2010), in 2003, renewable energy supplied 18% of the global electricity production as it was estimated to have a capacity of 880 GW. Thus, the worldwide generation from RE varies each year due to the weather conditions and other local conditions. The largest hydropower producers are China, Canada, Brazil, Russia, and the United States. Countries with geothermal capacity are France, Kenya, Indonesia, Mexico, Philippines, and Russia. The energy production from biomass is expanding in Europe, mainly in Finland, Austria, Germany, and the United Kingdom. As biomass uses solid waste for electricity production, it can be significant in countries with the large sugar industry, including Colombia, Cuba, India, Brazil, Thailand, and the Philippines. Germany, Spain, Portugal, India, Denmark, Italy, and the United States have led the wind energy growth. Besides, the grid-connected solar photovoltaics is deployed mostly in China, Japan, Germany, and the United States. Therefore, by examining the global renewable capacity for electricity generation in six different renewable resources, including hydropower, biomass, geothermal, wind, tidal, and solar. Hence, by using the data of accredited worldwide organizations such as Renewable Energy Policy Network (REN21), International Energy Agency (IEA), U.S Department of Energy, IRENA, and Korea Energy Economics Institute. China is found to be the leading country in the RE implementation, followed by the United States, Germany, India, and Italy.

However, the Gulf Cooperation Council (GCC) Countries have a high vulnerability to affect climate change due to the rapidly increasing population and industry, which tends to contribute to environmental problems. The energy generation in GCC grows by 8% each year due to the rapid population increase; it is expected to result in electricity demand growth. According to (Waheeb Alnaser and Naser Alnaser 2011), the social and economic impacts of climate change are higher in GCC than in other countries, as the rise in domestic energy demand depends on fossil fuels as the primary source of energy in GCC. The total energy consumption in GCC has doubled since 2000, as shown in figure1, whereas the extraordinary increase makes GCC the fastest-growing energy market in the world. (Mondal et al. 2016, Mezher 2016) stated by considering the overall trend; all GCC countries are experiencing significant growth in electricity demand as the peak electricity demand in Saudi Arabia is expected to double in 2030 compared to 2016.

For instance, in the UAE, the rising demand requires significant upgrades and extensions in the existing electricity grid. However, GCC countries might face multiple environmental challenges, including biodiversity loss, desertification, water pollution, air pollution, and water scarcity. To overcome the environmental threats, GCC has the potential to take advantage of its immense potential in RE sources such as solar, wind, and geothermal energy generations as it is a unique opportunity to enhance future energy security.

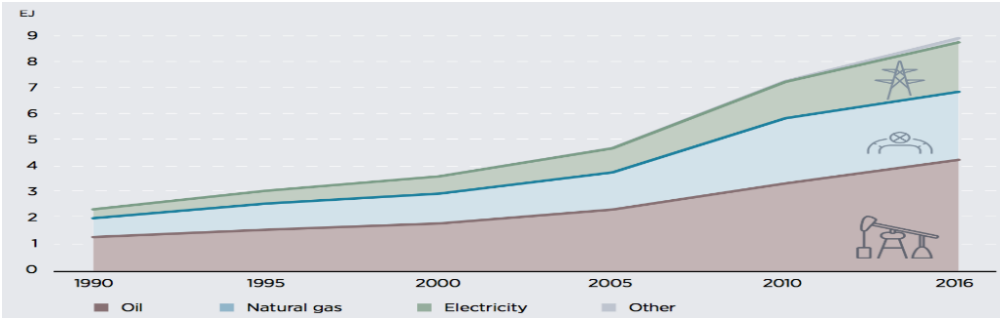

Figure 1: Total Final Energy Consumption by Source in GCC, 1999 - 2016

The GCC countries started a process of environmental evolution, which started by complying with UNFCCC and the Kyoto protocol in 2005 as they were obligated to reduce GHG emissions. Also, GCC countries are motivated to comply with the Paris agreement by keeping the global rise of temperature below 2 °C. While in 2012, Qatar organized the 18th United Nations Climate Change Conference to address environmental challenges in GCC countries by adopting a multi-disciplinary approach that combines energy production by considering policies to ensure sustainable development. Besides, the RE plans and targets are being translated into concrete projects in GCC's energy markets, mainly in Saudi Arabia and the United Arab Emirates (IRENA 2019). By the end of 2018, the region had 867MW of installed renewable capacity, whereas UAE accounted for 68% of the total capacity followed by Saudi Arabia 16% and Kuwait 9%. Solar PV is the dominant RE technology, followed by CSP, about 10% and Wind energy, about 9%, mainly in Saudi Arabia and Oman. Furthermore, after considering the importance of alternative energy deployment, shifting towards renewable energy tends to reduce fossil fuels. GCC countries should promote continuous strategies for investing in alternative energy sources that will help in prolonging fossil fuels and CO_2 footprint in the region. Thus, by looking into the global renewable energy trends, GCC countries were not among the leading countries: China, the United States, Germany, India, and Italy. However, GCC countries have a unique advantage in deploying solar and wind energy resources, whereas having an energy mix would meet the energy demand without impacting the environment.

3. UAE Sustainability Deployment

In the present world, commitment to sustainability development places a particular responsibility on the countries technological policies as the power industry affects the social and economic life by directly influencing the countries technological advancement. Energy is considered the driving force for economic development as the growing population depletes fossil fuel reserves, which encourages countries to pursue RE deployment. The United Arab Emirates (UAE), is located in the Middle East, consists of seven emirates Abu Dhabi, Dubai, Sharjah, Ajman, Ras Al-Khaimah, Fujairah, and Umm Al-Quwain, each of which has its energy sector. In the past few years, UAE took essential steps in RE deployment to address CO_2 emission and diversify its economy. The GCC countries, including the UAE, have the highest CO_2 emissions, whereas UAE contributes to 0.4%. In 2016, UAE used about 80% of natural gas, 18% of oil, and 2% other resources to supply energy. Thus, based on IRENA's report as the GCC capacity in generating electricity has expanded dramatically, UAE is the second country with an installed capacity of 29,958 MW in 2017 (IRENA 2019). Upon looking at figure 2, it is observed that in 2010 UAE CO_2 emissions increased tremendously due to the rapid economic and population growth by 8%, which increased the energy demands by pushing the electricity grids to its limits.

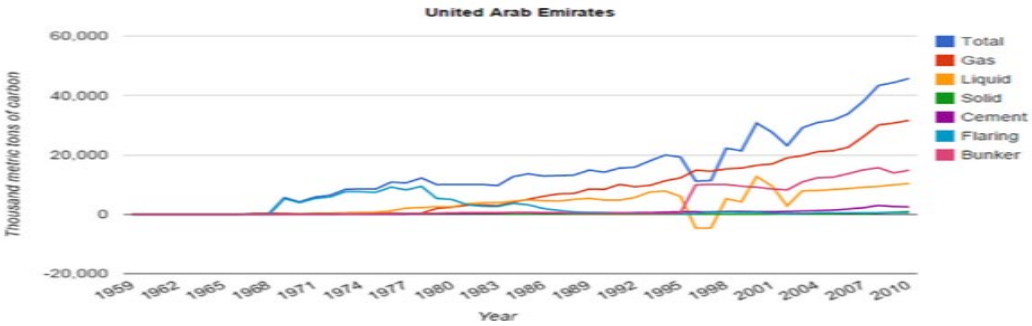

Figure 2: The Historical CO_2 Emission in UAE, 2014

UAE has two primary sources of energy, oil, and natural gas, while other sources such as coal and solar energy contribute around 0.1% to meet the increasing demand. The UAE is considered the world's 7th largest oil reserve and the 4th largest oil-producing country with about 3.65 million barrels per day, about 4% of the world's total production. The electricity generation increased dramatically in the UAE in the past few years to 5.4 TWh each year, more than 13.5% compared to 2002. Besides, the UAE has four utility companies Abu Dhabi Water and Electricity Authority (ADWEA), Dubai Electricity and Water Authority (DEWA), Sharjah Electricity and Water Authority (SEWA), and the Federal Electricity and Water Authority (FEWA). While FEWA supply the emirates of Ajman, Ras Al-Khaimah, Fujairah, and Umm Al-Quwain. Based on the electricity consumption from 2003 to 2013, ADWEA contributed to a total energy generation capacity of about 50%, whereas DEWA contributed around 30%, while SEWA and FEWA

together contributed to 20% (kumetat 2015). The gross generation capacity share of these utility companies is estimated to be 27,374 MW in 2013, with the following distribution; ADWEA 13,899 MW (50.75%), DEWA 9,656 MW (35.27%), SEWA 2,895 MW (10.57%), and FEWA 924 MW (3.38%). Abu Dhabi and Dubai had relatively high populations also high industrial and commercial activities, which explains the high energy generation.

To maintain such growth, UAE leadership is promoted to diversify electricity production by foreseeing the energy mix of conventional and renewable energy sources. In 2009, the UAE government announced the first RE policy, which stated that by the year 2021, about 27% of the energy sector would be supplied by renewable energy. UAE took the lead in RE deployment after signing the Paris Agreement in 2016; they pledged to pursue and adopt an energy mix. As a part of UAE's efforts, a Ministry of Climate Change and Environment was created to make climate change of its top priorities. In 2017, the ministry introduced the National Climate Change Plan, which serves as a road map for the UAE sustainability adaptation up to 2050 (Ayu et al. 2015, Nicholas 2015).

3.1 Solar Energy Potential

The United Arab Emirates is a country located in the southeast of the Arabian Peninsula on the Arabian Gulf, and it is known for its hot climate with high temperatures during summer, reaching 48C and relative humidity reaching 100%. Thus, due to the geographical location between latitudes 40 North and 40 South, the UAE is blessed with abundant solar energy exposure as it is located across the solar belt. Solar energy is the most promising RE resource in UAE, with an average of 10 sunlight hours and 300 clear days a year. While the total solar energy received is about 6.5 kWh/m2/day, whereas the direct normal solar radiation (DNI) is between 1900 and 2100 kWh/m2/day. The diffused horizontal radiation (DHI) and the global horizontal irradiance (GHI) vary between 1800 and 2300 kWh/m2/day. The best solar energy implementation location should receive GHI about 1600 kWh/m2/day for PV applications and DNI about 2100 kWh/m2/day for CSP applications. Therefore, based on the DHI and DNI, the UAE is a country with a high potential for solar implementation (Mas'ud et al. 2018).

However, solar (PV), concentrated solar power (CSP) and solar thermal heat are all renewable energy options successfully deployed in the GCC region. According to a study by (Gherboudj and Ghedira 2016) on the assessment of solar energy potential in UAE using weather forecast and remote sensing, it was observed that PV power plants are more applicable in UAE than CSP power plants. The most suitable areas for PV power plant installation are located on the eastern side of the country, whereas for CSP power plants, it is ideal for the cost near Abu Dhabi and the southern side of the country. The scalability of solar PV, including the simple operation, the ability to utilize diffuse light, and low unit cost make solar energy ideal for UAE's RE deployment. Depending on the technology used, solar energy implementation requires specific areas controlled by several characteristics such as land use, land constraints, and land accessibility, such as the distance from the solar and electricity transmission grid.

3.2 Implemented Solar Energy Projects

Renewable energy development has come a long way in the GCC region as the efforts focused on exploiting solar energy potential; the UAE took the lead in RE implemented projects as the electricity demand in UAE is expected to be more than double, rising from 16,000 MW to 40,000 MW by the end of 2020. Thus, to meet the UAE's increasing demand, many RE projects were made and planned to bridge the gap between UAE supply of fossil fuels and electricity demand. In 2006, Masdar Company was established as it is the UAE's renewable arm; the company invested $250 million in clean technology companies worldwide. Also, Masdar took the following steps; during the future energy summit, Masdar announced a deal with British Petroleum and Rio Tinto to build one of the world's largest commercial hydrogen power plants with a 500MW operation and cost around $2 billion. However, Masdar City, a 6km2 community, is designed to be car-free and served by magnetic trains, whereas a desalination water plant operates by solar power. Shams 1 is a 100 MW solar power facility that will be built near UAE's capital. Masdar would collaborate with the companies Abengoa of Spain and Total of France to create Shams 1 by installing 768 solar parabolic mirrors known as CSP (Mezher et al. 2011, Choucri 2011). The concentrated solar power (CSP) focuses the sunlight, which is concentrated by the mirrors to heat a coolant that generates high-pressure steam to drive a steam turbine by generating green electricity. Masdar City would be solar-powered by using rooftop PV panels and 20MW from a wind farm.

The emirate of Abu Dhabi created the Shams Tower project at Yas Marina circuit to produce 450 MWh PV electricity, whereas Noor 1 is a 100 MW power plant built in Al Ain city as the project is still under development phase. Also, the Abu Dhabi government sponsored the solar roof plan, which is a financial incentive to take advantage of the solar PV on rooftops. Masdar leads this project in collaboration with Abu Dhabi Water and Electricity Authority (ADWEA) as it is a step to reach Abu Dhabi's target for achieving 7% by 2020, whereas this program aims to achieve 500 MW PV rooftop installation within 20 years. In this context, 11 government-building fixed PV modules with an installed capacity of 2.3 MW and electricity generation of 4.024 GWh/yr (Mezher et al. 2011, Choucri 2011). Besides, the Supreme Council of Energy in Dubai aims to ensure reliable energy resources by preserving natural resources to address climate change and the development of RE technologies. For this purpose, Dubai's Supreme Council integrated energy strategy 2030 to ensure sustainable energy deployment by supporting economic growth, whereas the strategy included diversifying energy resources. As a part of Dubai's energy diversification strategy, Mohammed Bin Rashid (MBR) solar park was created to meet the renewable energy target (DEWA 2019). The solar park is located in Seih Al-Dahal as it would be the largest in the region with an installed capacity of 1000 MW by 2030, as it would include PV and CSP applications.

Although the UAE has sufficient solar energy resources for electricity generation, it is vital to identify its limitations in promoting RE deployment in UAE. The main limitation is that the electricity industry is individually controlled by each of the seven emirates, which leads to defragmentation and discrepancies in regulation between the emirates. Another limitation is the low cost of electricity due to extensive government subsidies. Also, there is no provision for the feedback excess energy to the electricity grid, and there is no direct taxation system to support RE implementation. Lack of transparent regulation and provisions in controlling private and independent power providers. Besides, there is no regulation to the mandatory use of renewable energy to decrease GHG and CO_2 emissions (Reiche 2010).

Therefore, after viewing the limitations, it is observed that UAE needs the policy to unlock the RE market and encourage development in the RE sector, aligning with the research intension in introducing feasible RE policies to assess electricity generation using solar energy as a part of UAE's energy mix strategy. These policies would contribute to sustainable economic development in the short and long term by reducing GHG emissions and contributing to them to protect the environment. Also, the UAE would achieve environmentally sustainable power development.

4. Renewable Energy Drivers and Challenges

The need to ensure energy security and enhance economic development by mitigating climate change is a primary renewable energy driver. In the GCC countries, the significant drivers toward RE deployment include concerns over the long-run due to instability of fossil fuel markets, fading hydrocarbons reserves, loss of exporting revenue due to the falling price of hydrocarbons, rapidly dropping cost of renewables, an abundance of solar energy and environmental sustainability concerns. Thus, the UAE became aware of the risk of climate change that could affect the region. According to Malik et al. (2019) , there is also a global pressure on countries to reduce carbon emissions to exhibit their commitment to the Paris Agreement and Kyoto Protocol. Furthermore, the domestic energy demand increases in the UAE, which provides a need for alternative energy generation. GCC countries have abundant solar energy resources, which serve as a wake-up call for these countries to integrate strategies and policies towards implementing RE technologies in the region. Although hydrocarbons richly endow in GCC countries, they are almost equal to renewables. GCC countries have a clear potential to play a leading role in RE industries due to the abundant solar resources and vast deserts. Also, GCC countries can meet the domestic demand from RE resources and become a significant exporter of renewable energy. Besides, the member countries realized diverting the revenues from oil exports by investing in renewable energy could yield tremendous economic benefit. As the shift towards sustainability accelerates, GCC countries can create new industries by having a new income source. Al Mulla (2015) stated that the factors that spur renewable energy development in GCC have similarities with other countries.

The significant factors inhibiting renewable energy deployment in many countries are the high cost of electricity generated from RE, the availability of conventional resources with lower prices, and lack of public awareness about the benefits of implementing renewable energy. Besides, for GCC countries, the barriers are unique; according to Patt and Lilliestem (2015), there are two main obstacles inefficient bureaucracy and dependence on non-renewable subsides with lack of RE support. Thus, RE implementation's initial cost is an essential barrier to GCC; insufficient RE infrastructure, market conditions, and regulatory frameworks hamper RE diffusion in the region. However, RE deployment has a weak legal framework to attract investors, lack of incentives for private investors, and lack of

stakeholder awareness from the customer's viewpoint. Another challenge to GCC countries is the harsh weather condition, resource insecurity, and bureaucratic process associated with RE project deployment. Delivering efficient targets depends on appropriate policies, financing, and technology. Other barriers include high costs of retrofit, fragmented ownership, and mismatched incentives. The mismatch incentive is a barrier in the region due to the resident population's predominance, limiting the incentives for efficiency improvements as the pay-out period is a year or two.

A laudable commitment to RE has been made in the UAE, specifically in the emirates Abu Dhabi and Dubai, to increase RE penetration in achieving UAE's sustainability target. By taking advantage of the abundant solar resource, wind, and waste to energy, geothermal resources are an alternative to fossil fuels to meet the increasing domestic consumption. The critical challenges to UAE include cost awareness as the stakeholders are not aware of the comparative energy costs; another challenge is maintaining grid reliability with high penetration due to the energy variability. However, UAE RE deployment's primary challenge is the inconsistent regulatory framework that lacks economically optimal choices and legacy contracts, which inhibits alternative energy resource utilization. According to Ferrouki et al. (2013), despite the UAE's transition towards renewable energy, barriers include policy framework, legislation, financial, market, and technology. The market and technological barriers are due to the short experience in the renewable energy field as the solar industry existed a few years ago, whereas the technological limitations such as intermittency of solar radiation and the need for storage for full-time operation.

While the policy and legislation barriers lacked policy framework in promoting sustainability in UAE and solar in particular, whereas such a framework would attract investors and developers in the local market, Ferrouki et al. (2013), stated that the primary two factors for delaying the sustainability framework in UAE are that not all entities would benefit from implementing solar energy. The second factor is the accessibility of interconnecting solar energy generation to the existing electricity grid as the PV systems can experience a variation in the output. Thus, the financial barriers included the high capital cost of implementing solar energy at a large scale and the lack of financing mechanisms to make solar energy competitive with other conventional energy sources. The UAE had RE implementation limitations as the electricity industry is controlled by different entities, which leads to discrepancies in setting sustainability regulations between the other emirates. Another limitation is that the low electricity cost due to government subsidies; an example, the electricity in the emirate of Abu Dhabi costs approximately 4 US cents per kWh.

To overcome the RE deployment barriers in UAE, economic and political intervention are crucial as some effective interventions include providing incentives for investing in renewable energy technologies, appropriate legislation, strategies, and RE diffusion guidelines. Makki and Mosly (2018) stated that among these interventions, economic factors are the most influential for overcoming the barriers and promoting RE adoption. The economic incentives can help overcome RE implementation impediments, such as RE subsidy and the initial investments to develop the RE infrastructure. Thus, extending the RE infrastructure would increase renewable energy capability by enhancing the grid to distribute and transmit energy generated by RE resources. GCC countries can also collaborate by installing an advanced grid system to transmit electricity generated by RE, remove subsidies and government intervention to ensure cost-effective prices, and establish regulations to reform the power sectors by deploying RE in the region. Therefore, UAE political transformation that moderate energy consumption is an indispensable method for ensuring sustainable revenues in the long-term.

5. Renewable Energy Deployment Policies

Energy policy is a manner and a strategy by which governmental entities address energy development issues to sustain growth, including energy production, distribution, and consumption. According to Assman et al. (2007), energy policy attributes include international treaties, incentives for investment, legislation, energy generation target, energy conservation guidelines, taxation, and energy simulation strategies. Increasing RE in the national energy mix is considered a fundamental strategy for a more sustainable energy regime. In the past decade, the developed countries embraced several effective policies to utilize RE significantly as an example, the target of green labeling, procurement setting, and target setting. However, the aspects that affect RE integration include accessibility, affordability, and policy deregulation. Many policy mechanisms have been established worldwide, but the most used is the fixed tariff, contract bidding, quota (RPS), and Tax credit mechanisms.

The feed-in-tariff (FIT) is one of the widely used RE mechanisms as it offers a long-term pricing scheme to RE producers and aims to compensate costs as well as risk-related issues. FIT is defined by the Renewable Energy Policy Network (2017) as a renewable energy policy that pays a guaranteed price for power generated by a RE source for each unit of electricity fed into the grid and usually for a long term period of about 20 years. In support mechanisms like FITs, the difference between the designated price and the wholesale market price is not only financial support to investors but also enhances environmental benefits, supply security, and diversification. In 1970, PURPA was the first in introducing FIT policies in the US, whereas the second implementation of FIT was in Denmark and Germany, which was in mid-1990. Tariffs mechanisms were successfully applied in 73 countries such as China, Canada, India, Australia, Spain, Germany, Denmark, and the US. The advantage of using the FIT mechanism is to allow non-traditional developers to participate in the RE market by installing solar panels to generate electricity. Another advantage is that FIT reduces investor's risks as generators guarantee a fixed energy price with a fixed duration. However, three types of PV microgeneration FITs are distinguished; each is related to a different metering arrangement (Ayompe and Duffy 2013). In gross metering, the meter records the total kWh of the electricity produced by the PV systems, whereas in net metering, the meter recording is based on the difference between the amount of electricity produced and the portion used on-site. When the PV system's output exceeds the consumption on-site, the utility customers receive credit for the excess generation fed into the grid. The third type of metering, known as the smart meter, has been introduced as it includes the total quantity of electricity generated, used on-site, and exported to the grid. Thus, figure 3 shows the three grid-connected PV system metering configurations gross metering, net metering, and smart metering, whereas table 1 summarizes the difference between the meter arrangements.

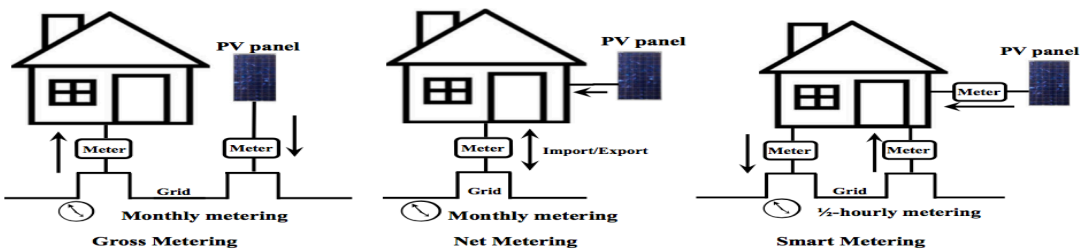

Figure 3: Grid-connected PV System Metering Configurations

Table1: Metering arrangements comparison

Type	Characteristic	Advantage
Net metering	Importing and exporting electricity at the same cost	Easy implementation by using a simple meter
Gross metering	Offering high FIT for all electricity generated	1. Straightforward design and implementation 2. Predefined rate of return on investment for the targeted PV installation
Smart metering	High FIT for electricity generated and low FIT for electricity spilled	1. Predefined rate of return on investment for the targeted PV installation 2. Real- time historical metering data

Besides, FIT's feasibility depends on several characteristics as the public opinion is an essential factor that explains the feasibility of RE innovations and FITS in particular. This is because the economic burden of FIT is reflected in bill payers, and the absence of such acceptance can act as a barrier at the implementation level. Therefore, to have a successful FIT mechanism, the following characteristics are substantial conditions: public awareness and consent, supplier-friendly pricing and cost distribution, and active institutional structures. Another RE policy is the quota mechanism or renewable portfolio standards (RPS); it is one of the quantities driven mechanisms where the government sets a framework or quota for the companies to produce, distribute or sell a specific quantity of energy-driven from RE sources. The companies that fail in meeting the law will be forced to pay the penalty, whereas this mechanism creates a market competition between electricity generating companies, resulting in attaining the best lowest price for RE electricity.

Thus, auctioning, tendering, or biding is another form of quantity driven energy policy in which the energy producers tend to bid to produce certain energy quantity at a specific cost per unit of energy. However, according to Atalay et al. (2017), auctions are classified into different forms, such as sealed-bid, descending-bid, or hybrid bid based on the

nature of the bid, the type of RE resource the site of energy generation. Thus, auctions are crucial elements for RE policy as it fosters the RE market's growth and strength. Also, auctions tend to reduce investors' risk as they offer guaranteed revenues for fixed periods, improve cost efficiency due to price competition, foster budget control, and increase energy supply predictability from RE resources. Since the first introduction, the auction yielded several positive developments, including great RE capacity at a lower price and the wind energy industry's growth due to the local content requirement . Auctions can be part of FITs, whereas the main difference is in terms of how they make use of the local content requirement as in FITs, the requirement is used as a bonus for increasing the applied tariff once they meet the designated percentages.

Also, investment tax credits are another RE mechanism, which means lowering RE's costs through market compensation. Mainly it includes two types of tax investments and production tax credits. Different tax-related incentives are provided by many governments to promote RE investments; such incentives include capital, vat reductions, tax reductions, and property tax incentives. Such mechanisms are used worldwide, but they are used mainly in Europe, the USA, Japan, and India. Thus, the investment tax credit can cover the cost of RE systems and the total installation costs as they are useful at the early stages of deployment, where there are high costs. According to Darghouth et al. (2011), investment tax credit helps reduce the risk level and the costs of investing in RE technologies. The high investment cost of renewables makes them unattractive investors' choices, whereas this barrier can be removed by reducing the initial capital costs for consumers through subsidies or rebates. However, subsidies are used to share the system's initial capital cost, such that consumers see it at a lower price.

To ensure successful policy implementation, several requirements should be attained for the feed-in-tariffs guaranteed grid access, developers' availability, high tariffs to cover RE generation costs, and long-term contracts. Therefore, RE policies are mostly applied in combinations to foster RE's share in the power generation sector. Over the past years, both FITs and quotas emerged as the dominant RE policy mechanisms. While the bidding, tendering, or auctions have also been applied in many countries. Together FITs, quotas, and bidding are called the major for RE promotion policies. However, tax incentives and subsidies help the RE developing market when applied in conjunction with one of the significant policies such as quotas, FIT, or bidding.

5.1 Worldwide Renewable Energy Policies Comparative Analysis

Mezher et al. (2012) conducted a comparative analysis of the current RE state to identify the policy trends in 61 countries, mainly focused on capacities, technologies, and policies. However, it was found that approximately 70% of the countries applied the feed-in-tariffs mechanism, which indicates it is an effective mechanism to encourage RE adoption. This widespread use of FIT is due to the advantage of offering investment security and market stability by increasing electricity generated mainly from wind and solar RE resources. Comparative analysis main findings are that Europe took the lead since more than 50% of RE projects are European, followed by the Asians, Americans, and Africans. Therefore, after reviewing RE policies in different countries, the most commonly used are FIT, quotas, contract bidding, and tax credit mechanisms.

5.2 UAE Renewable Energy Policies

Viewing the international comparative RE policies, the UAE is far behind the world's RE leading countries. Introducing RE initiatives in the region might play a role in setting the stage for similar policies to be implemented. However, UAE's leadership initiated a defined energy strategy where; launching such a strategy is considered a systematic approach for establishing the UAE's renewable energy sector. Hence, the policy sets the goal of attaining at least 7% of RE sources' power production. In UAE, energy is an emirate level matter until recently, long-term plans and targets were issued on the country level. The UAE launched several economic plans which attest to the country's commitment to sustainable development goals. Such strategies included UAE 2021 vision, UAE green growth vision centennial plan 2071, and UAE future strategy. While in 2017, UAE launched the energy strategy in 2050 as the first unified energy strategy in the country that became law (Choucri et al. 2010,Mezher 2010). The importance of sustainability is recognized, but the critical challenge is to minimize the gap between RE policies and the actual implementation. UAE aims to attain sustainable growth to diversify its economy from an oil-based to RE by effectively increasing electricity demand.

Therefore, attracting foreign investments in RE electricity generation is one of the globally used policies for enhancing the RE energy market that can be done through the feed-in-tariffs policy. The other policy option is the quota, where

the government sets a percentage of electricity to be produced by each emirate and imposes on the electricity consumers. A mixed policy between FIT and quota is recommended for the UAE's solar energy sector (Choucri et al. 2010,Mezher 2010). In early 2010, Dubai announced keeping the energy prices fixed but increasing the government's pressure by introducing FITs to help deploy RE in the region. To ensure FIT's feasibility, a competitive financial setting is required and public awareness and consent. Thus, the extent of applying such mechanisms depends on the legal and institutional capabilities, whereas in this context, there is a lack of taxation system that prevents companies' overall willingness to comply with auctions penalties. Richie (2010) stated that as UAE has ratified the United Nations Framework Convention on Climate Change (UNFCCC), Paris Agreement, and the Kyoto Protocol, these are the drivers for implementing effective policies to encourage solar energy. The UAE has committed to contributing to global environmental issues by driving initiatives that reduce the usage of fossil fuels. UAE is the largest growing solar market in the GCC, whereas solar PV is the leading technology accounting for 83% of the installed RE capacity. Thus, UAE is taking the lead in rooftop solar installations as in 2014, Dubai launched the Shams Dubai initiative, which enabled customers to generate power using PV panels as the excess energy is fed back to the grid.

The legislation and guidelines for connecting solar to the grid is operated by Dubai Electricity and Water Authority (DEWA). A net meter is installed to calculate the amount of clean energy generated, whereas a slab rate was used such that the customer's consumption reduces based on their energy generation. According to shams Dubai regulations, DEWA will not pay back the surplus of energy produced; instead, it would be transferred to next month's bill. As of 2020, 208.28 MW of solar PV rooftop projects has been installed under the net metering mechanism. Thus, the Shams Dubai initiative benefits from the unsubsidized electricity rates in Dubai (DEWA 2019). Abu Dhabi started rooftop solar installations; for instance, Masdar installed rooftop solar on 11 governmental buildings. In 2017, Abu Dhabi implemented a net metering policy similar to Dubai. Besides, Abu Dhabi and Dubai emirates started rapid steps toward climate change issues and becoming among the top ten sustainable cities. Thus, UAE's capital created a local green rating scheme called the Pearl Rating System (PRS) to evaluate resource depletion, water, energy consumption, and waste management in buildings. Another critical policy for a clean environment is the Green Building Codes and Regulations developed to eliminate the negative environmental impact by adopting sustainable standards during construction, operation, and demolition. In 2012, green building regulation became mandatory for all buildings to obtain the building permit by Dubai's Municipality (Sundus and Hasim 2019).

Therefore, to ensure successful policy implementation in the UAE electricity authorities several factors should be taken into account to ensure sustainability deployment. These factors includes geographical factors, which depends on the amount of rainfall, sunshine intensity, and fossil fuel resources' unavailability. While, the economic factors depend on the cost of oil and gas and subsidies for fossil fuels, whereas the technological factors include technological development of RE and grid capacity. Besides, the cognitive environment factors depend on public awareness and the RE installation efficiency whereas political factors depend on international obligations and targets.

6 Conclusion

This research focused on the UAE's need to deploy RE resources to address climate change and CO_2 emission problem by diversifying their energy resources. Thus, after viewing the UAE's energy sector, solar energy can be adopted for electricity generation to meet the electricity demand effectively. The UAE has the potential to take advantage of the abundant solar energy as it lies within the solar belt. The utilization of RE sources can help sustain the future of the UAE's electricity needs by harnessing abundant natural energy resources. Thus, to efficiently utilize grid-tied solar energy, feasible renewable energy policies are needed to address energy development to sustain its growth, including energy production, distribution, and consumption. The worldwide comparative RE analysis listed the RE policy mechanisms for many countries that were successfully implemented in meeting the national targets, whereas FITs are the most deployed. Throughout this study, a set of factors, policy mechanisms, drivers, and challenges to RE deployment are developed. The main research findings are summarized in table 2 to outline the research intension in assisting UAE electricity authorities in considering RE policies to meet the increasing demand by taking advantage of the abundant solar irradiance to reduce the dependence on fossil fuels. Also, table 2 summarizes the main challenges tackled from literature and ways to overcome them. Having examined the main RE challenges and barriers, the need for formulating energy policy in UAE is mandatory to encourage the transition of renewable energy development by ensuring that policies would overcome the existing structural weakness.

Table 2: Literature Review Findings

RE Development Factors	RE Drivers	RE Challenges/ Barriers	Ways to overcome them	UAE Implemented RE Policy Mechanisms
Geography	Energy security	High installation cost	Provide invectives for investing in RE	FIT (Net Metering) for small-scale grid connected-projects: -Implemented in 2014, by DEWA -Implemented in 2017. By ADWEA.
Economic	Environmental pressure and competitive energy markets	Availability of conventional resources	Formulate energy policy Appropriate legislation for RE diffusion	
Environmental	Instability of fossil fuels	Lack of public awareness	Develop RE infrastructure by enhancing electricity grid	
Technology	Fading hydrocarbons resources	Regulatory and policy framework	Promote appropriate technologies & awareness	
Political	Loss of exporting revenue due to falling prices of hydrocarbons	Unfavorable weather conditions		Tendring for large-scale projects such as: -Masdar 10 MW power plant -MBR Solar Park
	Dropping costs of renewable	Insufficient infrastructure		
	Abundance of solar energy	Resource insecurity		
	Job creation	Maintain grid reliability		

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