

Renewable energy and GCC States energy challenges in the 21st century: A review

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Abstract— Gulf States characterized by its strategic geographical location and huge reserves of oil and natural gas. It is also characterized by a high potential for the production of power from renewable energies such as wind, solar and wave energy. However, these capabilities were untapped in previous decades due to the cheap oil and gas energy production for the region because these countries are the oil and gas producers. In recent years, because of the high rise in oil prices in world markets, and its coincided with the plight of the deterioration of the financial markets in 2008 and its consequences with the Arab Spring incidents and ended up regionally and globally. Each of these variables has made the attention of decision-makers heading to the Gulf renewable energy, especially after the Gulf environment began to suffer from pollutants emitted from the exploration, production and transportation of oil and gas field as well as burning it in power stations. The steps taken by the Gulf Cooperation Council (GCC) is a shy at regional and global levels but nonetheless it is the first step of a thousand miles.

This study shows the steps undertaken by the GCC countries to improve the environment and reduce the damage that has beset them, and the plans to move to the stage of optimal use of renewable energy. The biggest and most important obstacle in the face of the spread of renewable energy is to the high government support for electricity and fuel prices. As the citizens of the region need to educate the evils of environment pollution and the pros of using renewable energy.

Index Terms— Renewable Energy, GCC, Energy profile.

I. INTRODUCTION

It became well known that the economic factor become a high priority constitute due to its high quality and many other advantages. This factor is characterized by its high flexibility as it can be used in a positive way or negative to inflict the desired influence [1]. Also, this factor features by its quick results due to its severity and impact on others. Economic factor provides new ways to express the national interest and protection from internal and external threats and ways away from the direct use of military force and armed

conflict [2]. The economic conglomerates have emerged as a new mechanism to compete in the distribution of power between the various forces candidate as it is an active and influential in the twentieth century [3]. These conglomerates accompanied by a severe tendency to bloc and assembly of individuals in structures more conducive to the demand of defense of the interests and development gains in the face of others [4]. The importance of economic power has increased under the new international changes and has become a target of many states, which the current strength and at the same time a tool of many coefficients owned by a State to enter and exercise of the international game. Countries have become dependent on the economic capacity more than its military capability in the game of international powers [5]. The economic pressures exercised by the major world countries on the developing countries relatively more effective than military interventions.

The Arab Gulf is a vital region due to its natural resources and huge oil reserves. Its geographical location made its countries an important focal point of contact between East and West countries. This region enjoys an importance of geopolitical, economic and security as the Strait of Hormuz is the safety valve for more than 50% of the world's oil exports as shown in table 1 [6]. Also, it represent approximately 30% of the world oil reservoir. The highest producer is Saudi Arabia and the lowest is Bahrain. As the Gulf region is located in one of the most important regions of the world in terms of its strategist vital, they are at the same time located in the most volatile areas in the world lacks to stability. This region has been the scene of three major wars fought during the past three decades, besides it is today the major field of the current war on terror [7]. The Arab Gulf states understand the needs to agree on security strategies, defense, and economic to face the internal and external regional threats. The experience of the GCC is one from the best experiences that have been able to continue and strengthen the steps convergence and coordination in the economic, defense and security fields [8].

The rise of the oil age can define the era of modern development in the Gulf region more than anywhere else worldwide. The six members of the GCC (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE)) is the source of about a third of the world's known reserves, and about a quarter of its natural gas needs [9]. Saudi Arabia is still considered to this day the most important source of oil in the world as it contains the world's highest reserves of this material. Qatar has become the largest producer of liquefied natural gas (LNG) in the world. GCC is still considered a major center for petroleum supplies in the world, which have a pivotal role in the global energy markets [10].

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The GCC has become a major economic center because of the demand for energy and the growth in numbers of oil importers. The large Gulf companies embarked on a high-investment and expansion, and the growth of the private sector began to exceed growth in government sectors. The estimated size of the private wealth in the GCC is evaluated by about US\$ 1.5 trillion dollars [11]. Moreover, large parts of the Gulf private sector independent of the state for decades. Although the Gulf region has not experienced industrial development on the same scale of the Asian industrial countries and Latin America, the two-way trade has become more diverse than it was 20 years ago [12]. The medium-sized industries grew

rapidly in the region and variable sectors such as steel and aluminum, machinery, plastics, and food industries have been established. It is worth mentioning that the reduction in oil prices in 2014-2015 and continuous in 2016, where it fluctuated in the range of US\$ 40/ barrel, have negative impact on the economics of GCC countries. In addition, the instability in the oil prices makes economy oil dependence is not secure, which represent positive point to shift toward renewable energy. Furthermore, the territories interest in the oil sources and the market they created make this field dangerous and high risky source [13].

Table 1, the proved oil reserves and production in the Arabian Gulf economies at the end of 2011.

	Proved reserves (bbl)	Share of world reserves (%)	R/P ratio	Production ('000 b/d)	Share in world production (%)	Ratio export: consumption
The GCC States	495.0	29.9	69.5	19,505	23.3	58
Bahrain	0.1	<0.05	7.0	47	0.1	5.0
Kuwait	101.5	6.1	97.0	2,682	3.2	7.7
Oman	5.5	0.3	16.9	889	1.1	6.7
Qatar	24.7	1.5	39.3	1,638	2.0	6.0
Saudi Arabia	265.4	16.1	65.2	11,153	13.3	3.8
UAE	97.8	5.9	80.7	3,096	3.7	5.3

Saudi Arabia is the largest exports into the region, where the six Arab countries send more than a fifth of their regional exports to Saudi Arabia. The existing Gulf's investment in the other Arab countries is considerably deepened in recent years, covering many sectors like industrial projects, tourism and real estate projects, telecoms and finance [14].

The paradigm of the GCC state-directed towards economic integration has become an absolute need for better life. The Gulf developed to become the pivot of the regional political economy. The GCC will be able to play a more assertive role based on its economic resources. The Gulf money helped significantly in consolidation the world economy after the 2008 financial obstacle. The Gulf can play a significant role in the international relations due to its economic power [15]. In this study a review of the energy outlook in the GCC region is presented. The oil and natural gas impact on economic in term of production, consumption and prices have been discussed. The opportunities, challenges and barriers to utilize renewable energy in GCC and moving in this direction are presented [16].

II. THE ENERGY CHALLENGES FOR GCC IN THE 21ST CENTURY

As the GCC States continue altering into a significant centre of energy demand growth, while oil and natural gas played a

primary role in its development. Gulf States need to departure to alternatives of power in their domestic needs. The Gulf energy sector increasingly depends on oil and natural gas production to meet regional demand [17]. The renewable energy sources in the region can form an important part of the region's supply side solution for the growing electricity demand. The values of renewable energy in the GCC region cost needs investments, particularly in solar power. This will make the GCC states save their valuable crude oil resources for export and next generations. The efforts of GCC states must focus on the demand management through the energy efficiency improvements [18].

Taking Saudi Arabia as a case, many valuable studies indicated a lack of environmental and technological awareness among the public with a comprehensive and clear failure in education on sustainable energy systems [19]. In the same time, Masdar City in UAE can be considered as the largest source of experience in the region in the field of sustainable energy so far. It is classified as the first city in the world free of carbon emissions. Masdar City has the opportunity to become a model for sustainable cities in the region and the world and the most widely accepted example since it survived after the obstacles caused by the financial crisis in 2008 and started to become an acceptable model all over the world [20]. The GCC could become a key player in increasing the use of carbon captures and storage CCS. Thus, it makes an important contribution to the world towards sustainable use of fossil

fuels rise in the presence of the local and global demand for energy and the presence of climate change [21]. The fundamental rethinking of policy makers in the GCC to change economies from ones calculated on the most carbon-intensive economies in the world. Some of the governments of the Gulf States such as the United Arab Emirates has conducted a number of efforts in politics, and a project to mitigate the effects of climate change, and provided more valuable approach for low-emission development steps. These approaches integrate strategic goals of reducing emissions to a wider and economic efficiency, and sustainability, and resource security objectives [22].

A. How can renewable energies be an opportunity for the GCC economy?

The Gulf fundamentally shaped for eras as a single energy commodity. Today's with the huge wealth as a result of the region's unique gift of natural resources where the GCC are the leadership in these resources will promote the region's economic development. The GCC economies' demand has rapidly raised in the domestic energy needs. Renewable energy sources in the gulf region can form an important role in answering such obstacle if they are used in an intelligent way [23].

The GCC economics has tended to more profits from using their valuable natural resources to increase the economic developments. Natural gas entered GCC energy markets as a stage guest during the 1970s, and then it rapidly takes a primary portion in the energy sector during the 1980s and 1990s. Natural gas has become a major alternative to oil for power generation and petrochemical industry [24]. Now, Qatar, Abu Dhabi, and Oman export natural gas and this policy has transformed Qatar to be one of the largest gas reserves in the world. Qatar is also the largest producer of liquefied natural gas in the world. Natural gas exports helped in saving Qatar from the decline of state revenues associated with the limited oil reserves [25].

III. SHIFTING GLOBAL ENERGY DEMAND

Energy consumption in the GCC countries rose in a manner that does not exist only in the major industrial economies (see Figure 1). This increase was due to decades of rapid population growth, and the speed of improvement of living standards, and a focus on energy-consuming industries heavily. Kuwait, the United Arab Emirates, and Qatar consider among the largest consumers on the individual level in the world of power and energy today. The consumption rates in the GCC region are the complications of regional consumption rates in the Middle East and North Africa. Saudi Arabia is one of the largest six consumers of oil in the world [26].

The possibility of increasing domestic energy consumption in the GCC is a huge threat to strategic planners. The energy planning changes in the GCC over the coming years of the region is a dilemma due to rising domestic demand for energy. It is assumed the oil and gas resources that must help to improve the situation of the governments of the GCC through export earnings [27]. These governments are not prepared to reduce its support for a high level social welfare, which

include health, education, free of charge. In the same time, increasing the taxes on the citizens' income is considered an expensive option and harmful to these governments at this time of profound spasm relationship between the peoples and governments in the Arab region. Political stability in the GCC is associated since the Arab Spring in early 2010 to the ability of these governments to provide decent care for its citizens without interruption [28]. However, taxes has been increased on the domestic energy consumption lately 2015 and early 2016.

GCC States start to focus and take care to alternative energy, including nuclear energy and renewable energy. The growing domestic energy markets of these countries need a long-term supply of alternatives to the used fossil fuel. In addition, renewable energies provide additional benefits, such as the creation of new jobs of high quality and the reduction of carbon concentrations in the air. The optimal use of the benefits of renewable energy must concentrates in ensuring on encouraging their use because it is the correct procedure, but it is an enormous economic challenge [29].

The distorted domestic energy prices of the region are a primary key challenge. Indeed, the domestically produced energy by fossil fuels costs in GCC States limited the usage of alternative technologies. As the current solar technologies domestic market prices are uneconomically everywhere in the GCC, the fossil fuels prices against the costs of alternative energy technologies is raised significantly 30. As the solar thermal and photovoltaic power technology costs are continuing to decrease, the renewable energies will require reconsideration for domestic GCC markets. A domestic market pricing will introduce an economical efficient solution [31].

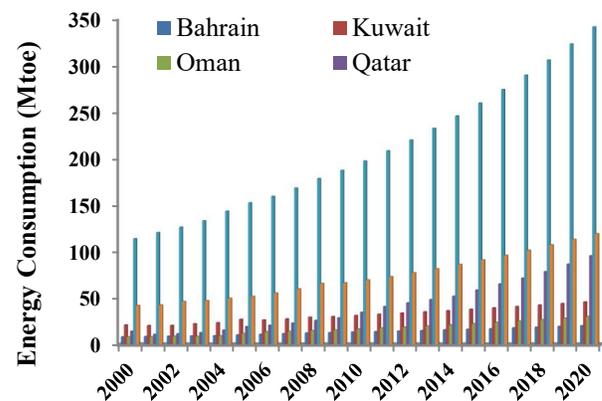


Fig. 1. GCC countries energy consumption projection for the period 2000-2020

IV. FACING THE ENERGY CHALLENGES OF THE GCC FOR THE 21ST CENTURY

Energy is the key to develop any country and for the prosperity of its economies. Gulf region is considered one of the highest energy consuming regions in the world since the 2000s. At the same time, the GCC has the most amazing

energy reserves in the world. Saudi Arabia holds the lion's share, 20 per cent of the total export of the world's oil [33]. These countries take advantage of the huge oil reserves, although domestic demand for energy is increasing, its population relatively limited compared to the massive oil reserves, this position enable it to export most of its produced oil. Also, this region contains about 23% of the natural gas reserves in the world. However, the GCC produces only about 8% of total global gas production. At current production rates, the estimates that oil reserves in the region will continue for another 70 years, while its natural gas reserves will last for another 118 years. Over the past three decades, the demand for the Gulf gas has been doubled at a rate of 100% of each decade [34].

Natural gas can play a unique role as an energy source that supports the development in the Gulf region. The natural gas sector suffers from nucleation in comparison with oil ones. However, due to energy crisis and the development of shale, tight, and sour gas, the GCC member states started to develop the natural gas sector as an alternative bridge fuel for continued regional industrialization. In the same time, due to the high consumption rates, the GCC governments in the last few years increasingly tend to produce fossil fuels for domestic consumption rather than to exportation [35]. These countries have to reduce its total energy consumption of natural gas, as the Gulf decision-makers should focus these days on two essential issues; reduce energy intensity and the production of new sources of natural gas to maintain the required supplies because of economic expansion [36].

On the other side, the GCC has crossed a long way since 2008 in the trend towards the use of sustainable energy in this area. It is clear today as part of the daily news in these countries that there is hot discussion on: efficient use of resources, alternative energy projects, programs, research and clean technology, and sustainable building codes, and public transport systems, and strategies for the green economy. In spite of the resources of fossil oil, the Gulf States begin to give a quota for turning sustainable energy that can play key roles as an engine of technology and to bring investors in this sector [37].

V. THE GULF IS MOVING

Starting in 2008, the Emirate of Abu Dhabi (United Arab Emirates) began to build Masdar City of sustainable source. This move reiterates with less size by at least three of the GCC. Emirate of Abu Dhabi is hosting the International Renewable Energy Agency now [38]. Qatar presided over the main United Nations climate conference, and Saudi Arabia began to implement a massive solar energy program. These are three examples of changes in the regional vision to the field of alternative energy. The research and development (R&D) of clean energy technologies is a primary concern for all governments of the GCC. Improving energy efficiency also became the target of numerous economic sectors [39].

The GCC members took a number of policies and projects, and extensive efforts in this sector. These projects will lead, if implemented, to a variety of business and its impact on the environment will be felt by even the ordinary citizen.

However, many of these policies and projects still exist only on paper. Solar and green building goals have become national symbols [40].

In a low-carbon world, the mentality of the usual Gulf businessmen will not have any opportunity to stand up and keep going. Over the past few years, the GCC has moved to build the foundations of renewable energies approach. In 2012, at the suggestion of the Kingdom of Saudi Arabia and the United Arab Emirates, Qatar, Bahrain, the parties agreed on the United Nations Convention on the climate [41]. The economies that rely on petroleum products can do effective procedures in the field of mitigation and the rest of the activities associated with the climate in cooperation with other countries on the international level. The GCC still till today haven't registered any action in this concept framework under the umbrella of economic diversification and development strategies sustainable, but may do so in the near future [42].

The economic changes cannot be regarded as the best way to increase the flexibility of the economy in the Gulf region, where the best solution for these countries lays its living in an economy based on low carbon environment. All sectors must be developed, such as solar and clean technology industry, energy service companies, and the buildings are all together. The policy should focus on increasing the efficiency of the economy through a variety in green sectors and increase employment opportunities. The Gulf countries will suffer if it remained only depends on the current style in using energy and consuming it, which will present many of the threats and risks in the future [43].

The increasing scopes of green and climate change in GCC States can be considered as a good start. Unburnable carbon is the billboard that the attention of the Gulf energy policymakers and oil and gas companies must turn to. The global financial crisis that began in 2008 drew attention to the division between economic growth and its impact on the environment. This resulted in the perception about the concept of the green economy, currently used by some United Nations organizations, as the Global Green Growth Institute (regional office in Abu Dhabi) [44]. The GCC increased the number of procedures and scopes of the "green" and climate that can be considered as a good start. This trend will intensify in the years and decades ahead. However, the development of the GCC countries and the current plans and actions taken may not lead to a reduction of carbon or a better future of climate change flexibility [45].

VI. THE NEXT FRONTIER OF RENEWABLE ENERGY IN GCC STATES

The Kingdom Saudi Arabia (KSA) established the King Abdullah City for Atomic and Renewable Energy (K.A.CARE) in 2010 to encourage alteration and the use of alternative energy technologies for power generation and water desalination, and to build a world-class alternative energy sector. The K.A.CARE program plans for a 54 GW renewable energy target, 41 GW of which is to come from solar energy (16 GW from PV and 25 GW from Concentrated Solar Power (CSP)), 9 GW from wind energy, 3 GW from

waste-to-energy, and 1 GW from geothermal – to generate 23–30 per cent of the Kingdom’s electricity through renewable resources by 2032 [46].

The renewable energies technologies R&D programs have been initiated by KSA scientific universities and centers, in collaboration with the top international research centers. KSA effort is focusing on localization and the human development integrated with buildings, education and training, technology development. The conjunction with the R&D and industrial investment can create jobs in the non-hydrocarbon sector [47]. KSA proved that it has an ambitious renewable energy strategy plans. UAE has surpassed KSA in renewable energy investment in the GCC region till today. Abu Dhabi adopted the production what is equivalent of 7% of the capacity of the necessary electrical energy from renewables as a target. The UAE is planning to produce what is equal to 1.5 GW by 2020. The Abu Dhabi Emirate hosted the International Renewable Energy Agency (IRENA) with 160 member states. The two organizations state-owned to government: Mubadala Development Company, and the Abu Dhabi Fund for Development (ADFD), is funding and development of renewable energy source in the city [48]. The list of contributors to the initiatives in the city source: source of Science and Technology Institute, the power source (that invest in renewable energy projects on the scope and utility), and Masdar City. The city supports sustainable energy through renewable energy with the installation of PV 10 MW as a source of energy, in a joint venture with Total and Obanjua. Also, Shams 1 CSP 100 MW plant in Madinat Zayed completed. Masdar city is a sponsorship for the installation of 30 MW of wind on Sir Bani Yas Island [49 & 50]. Besides, it has invested in parabolic trough CSP power plants in Spain, and LM -Fi facility for the production of thin PV modules in Germany. Masdar City contributed in the establishment of Noor 1 PV station of 100 MW, and 100 MW waste-to- energy power plant, while the program on solar surfaces of 500 MW are in the planning stage. The Emirate of Dubai plans to set up 5 per cent of its energy from renewable energy sources by the year 2030. There are 13 MW produced from thin film PV plant in operation, and will be bidding for an extension of 100 MW in the year 2015-2016. The most ambitious is a project of solar island floating scheme with (1 MW) and solar garden Mohammed bin Rashid of 1 GW by 2030 [51].

Kuwait announced its aims to generate 1 per cent of electricity from renewable energy sources by 2016, and 10 per cent by 2020 and 15 per cent by 2030 (the equivalent of 2 GW). The Kuwait Institute for Scientific Research (KISR) supervised many researches on solar energy systems, and developed a renewable energy strategy for the 2030 plan [52]. The process of bidding for 70 MW Shagaya renewable energy complexes began. It has been planned for this first project component of the wind plant capacity of 10 MW, and the ability of other station operates 10 MW PV, and 50 MW of thermal energy storage for 10 hours to assess the performance of the various renewable technologies under the Kuwaiti climatic conditions. In preparation to set up a plant with a capacity of 280 megawatts Integrated Solar Combined Cycle (ISCC) plant with enhanced solar field of 60 MW in Abdaliya area [53].

Oman has planned to produce up to 10 % of its electricity needs from renewable energy sources by 2020. It has put

several plans and is working to shift to renewables. Oman has completed Menbina plant capacity of 6 MW PV, 7 and 1024 MW trough CSP plant with Glass point for enhanced oil recovery (EOR) application. The Omani government has held several agreements for solar PV project in the rural areas in Mazyunah signed by Omani rural areas Electricity Company (RAECO) [54]. Also, 50 MW wind farm in collaboration with Masdar to be installed and operate southern Oman in 2017. Moreover, there is evidence that a number of steps waiting for the completion of a comprehensive strategy to generate electricity from renewable energy, which is expected to take shape in the coming years [55].

Qatar plans to generate at least 2%, which is equivalent to about 640 MW of electricity from solar energy resources by the year 2020. One of the current projects is a set of solar power plants to assist in cooling and supplying electricity for playgrounds and FIFA World Cup finals facilities that will be held in Qatar in 2022. Qatar is working to develop ambitious programs for the development and manufacturing of solar energy for building with a 3.5 GW plant and with 500 MW of PV solar power station [56].

Bahrain has announced its goal to generate 5% of its electricity from renewable energy resources by 2020, with a focus on mature technologies. The production of electricity by wind turbines is currently working on in the Bahrain World Trade Center. There are also plans and projects such as the construction of 25 MW waste-to- energy plant in the planning stage [57].

VII. THE DIFFICULTIES FACING RENEWABLES ENERGY IN GCC REGION

Typical transfer resettlement of any technology is relatively a mature technology and it need to establish national and international companies operate on the markets strategies demands. All of these conditions do not exist in the GCC to deploy the potential of renewable energy technologies. The energy companies entered the region, utilities and renewable energy equipment and space but still in the learning stage in the Gulf. Now, as this region still have limited experience in publishing and risk appetite, large and equity, and the obligations of the warranty [58]. Few developers in the field solar energy technology providers or owners of good financial strength are trying to gather themselves to transfer their international experience to these countries to become independent power producers [59]. The international renewable energy industry worldwide focuses on the GCC as a commercial center, which can fund further proliferation. There are many challenges facing the solar PV industry in the future of the GCC plan to install more than 20 GW of solar PV energy by the year 2032 [60]. GCC plans in the future are only a small part of the current and expected international market. PV market development for certain climatic conditions in the GCC requires contracting and R&D works correlated actual work with the manufacturers to establish a successful industry [61].

There are many difficulties facing the widespread use of renewable energy in the GCC: First, the government support for water and electricity charges, in addition to the cost of production based on fossil fuel prices. All of these standards

fail to provide price indices for the region's governments and consumers and producers. Through the application of direct and indirect support, and provides all the GCC in support of energy and local economies so that what the citizen is levied at a fraction of the real and the actual price [62]. Although these subsidies describe the important economic and social objectives, it also causes considerable expense on the budgets of governments in the region. These subsidies unwound become more difficult despite the presence of several justifications for any future strategy to fix this flaw, but will face public anger and condemnation, though it will be more painful of the economic development. The use of subsidy policy has a number of side effects that may void, in part or in full, the original purposes [63]. Many studies of these effects concluded that there is a need to reform the subsidies policy. The disadvantages of encouraging the reduction of energy prices are the increased demand for energy, which increases the total cost of support and pressure on the country's economy [64]. According to valuable studies that high-income households have a much larger share of the total utility support from poor families. Therefore, the use of support and subsidies to protect low-income families is shifting its benefits towards high-income families [65 & 66]. However, lately 2015 and recently 2016 the GCC countries reduced the subsidies on fossil fuel used domestically.

The conditioning of solar energy technologies in the GCC to suit the weather conditions are still in the stages of research and development. Changes are extreme in temperatures, dust, and humidity affects the efficiency levels, which require more R&D and financial costs. GCC has an experience and successful tradition in business for long years, so the investment in the energy and water sector will be at a great level of economic wisdom. The partnerships between the two public at the national and international levels and joint ventures is a natural issue for these governments. Thus, the competitive bidding process is the favorite to emerge renewable knowledge [67 & 68]. As the liberalization of the electricity market and renewable policy frameworks support similar to those available in the United States, Europe, and Japan is the early stage of deployment. Frameworks for renewable sources of energy policies vary widely among the GCC countries. It rose from the financial and organizational traditions of each country, and cannot be changed, according to budget constraints and political requirements [69]. Due to these variations between the GCC States the localization of proportion to adapt technologies to local conditions, the development of techniques and skills, and provide job opportunities along the entire value chain will vary between them as well [70 & 71]. However, it calls for policies that are related to local institutions and the public and private business environment in the state and structure of the industry. The renewables technologies in the GCC market age now is less than 20 years employed outdated power purchase policies, and contracted with expensive agreements. Today, the manufacturing facilities and development of solar energy technologies less cost and within a few years will be developed elsewhere if GCC countries are not interested [72 - 76].

VIII. CONCLUSIONS

In this paper energy outlook in the GCC countries has been reviewed. The oil and natural gas reservoir, production, consumption, and export of the six countries in GCC is presented. Also, shifting toward renewable energy and steps taken by these countries has discussed. It is found that there is an important opportunities for GCC countries to invest in renewable energy and plans and polices has been adopted. The challenge of renewable energy strategy in the GCC can be defined in:

- (A) The nature of the current renewable energy sources fragile and emerging unlike petrochemical and oil industries in the region.
- (B) The development and deploy of an early stage of solar energy technologies need time and effort and disbursement considerable budgets on this issue.

The decision of the GCC countries to join the United States, Europe, Japan and China in the financing and support of R&D, and learning, and raise the level of the process for renewable electricity both economically is warranted and welcome. It requires long-term commitment and flexibility to adjust policies and partners to change the circumstances. Finally, and not least, it requires a realistic assessment of the costs of building an international-class sector of alternative energy - not propaganda work, not green washing.

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