Growing energy demand in the GCC countries

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\textbf{ABSTRACT}

The energy sector in GCC countries plays a vital role in achieving economic and social development and contributing to the Gross Domestic Product (GDP). Furthermore, the energy sector plays a major role in meeting the water and food needs in these countries that have harsh climate conditions and water scarcity. However, the consumption of energy is high in the GCC relative to other developed countries and this is one of the key challenges faced by the GCC. Growing energy consumption will threaten exports, affect the economic diversification and may increase the energy waste. A diversification of the energy mix by including renewable sources presents an opportunity as it would free up part of the energy production for export as well as would reduce carbon dioxide (CO\(_2\)) emission. Over the next ten years, it is expected that the population of the GCC countries will increase by more than 20%. This article provides estimate of demand for electricity and fuel used in the power plants for the next 25 years. The amount of carbon dioxide emission is estimated based on type and amount of fuel used. In order to reduce the dependency on the fossil fuel and reduce carbon emission a number of measures should be implemented that includes, utilization of renewable energy sources, adopting energy-efficient products and buildings, demand side management, and reforming the fuel prices. In fact, the GCC countries have already started implementing some of these measures toward a more sustainable energy future.

\section{1. Introduction}

The Gulf Cooperation Council (GCC) hold almost a third of proven global crude oil reserves and about a fifth of the world gas reserves (BP, 2019). The export of the hydrocarbon, in the form of crude oil, petroleum products and other liquids and natural gas, improved the economic growth and has brought impressive development and wealth to these countries. Rapid industrialization resulted in large percentage of labour migration. Furthermore, the high birth rate in the GCC coupled with improving living standards and increasing water desalination caused rise in the energy consumption.

The harsh climate in the region causes high cooling demand during the summer. Furthermore, huge energy waste due to lack of building codes and the use of low efficiency appliances, high living standard and energy intensive lifestyle resulted in making electricity consumption per capita in the GCC one of the highest rate in the world and even far above industrialized countries.

By 2025 it is expected that the total population will reach around 59 million while the total electrical energy consumption will jump to 1094 TWh (Almulla, 2014). Moreover, with the recent fall in global oil prices the contribution of oil exports to the economy of the GCC is affected. The main fuel that is used for electricity generation is natural gas followed by crude oil and the rest is divided between light oil, heavy fuel oil, diesel and renewable sources. Using 75% of natural gas in the energy mix in the region for electrical power generation power will raise the amount of gas required in year 2025, which is expected to increase to \(8.2 \times 10^{12}\) cubic feet. The remaining fuel in the energy mixed (25%) is assumed to be crude oil, used for electricity generation, the expected amount required will be 437 million barrels by year 2025. This definitely will affect the ability of GCC country to export the hydrocarbon fuel. The amount of CO\(_2\) emission that comes from natural gas will reach 453 \(\times 10^6\) tons whereas the CO\(_2\) emission from oil will reach 203 \(\times 10^6\) tons by year 2025.

Diversification of the energy mix by including renewable resources presents opportunities to this region as it would free up hydrocarbon production for export. With the reduction in price of solar and wind power in the world, GCC countries can utilize their promising solar and wind resources for power generation. Several GCC countries have announced target for deploying renewable energy technologies. Solar...
energy (photovoltaic cells) has received particular attention owing to resources availability and cost competitiveness compared with other technologies. Achieving renewable energy targets set by these countries will increase local economic diversification, can save 400 million barrels of oil, create around 210,000 jobs and reduce per capita carbon footprint by 8% in 2030 (International Renewable Energy Agency). A solar photovoltaic bid in Abu Dhabi in September 2016 resulted in the record-low electricity price of USD 0.0242 per kilowatt hour which is cheaper than gas-fired generation (http://fortune.com/2016/09/19/world-record-solar-price-abu-dhabi/).

In order to reduce the energy consumption and conserving of natural resources several measures by the GCC countries should be taken such as implementing policies, reducing energy subsidies, improving energy efficiency, increasing the share of renewable energy in the energy mixed, more trade of energy through the GCC grid. It is noteworthy that some GCC countries have already started implementing actions towards a more sustainable energy future.

2. Energy consumption in the GCC

Access to energy services is fundamental to human development and economic growth. The abundance of hydrocarbon resources in GCC countries has played a major role in the region’s social and economic development. Based on 2018 data (BP, 2019) the GCC countries has 30.6% of the total oil reserves in the world and about 19.8% of the total natural gas reserves. Economic developments and large industrial projects increased the immigration rates to this region causing the population jump rapidly from 21 million in 1990 to reach up to 53 million in 2015. The electrical energy consumption in the GCC between 1980 and 2040 is presented in Figure 1. These data are obtained by contacting official government institutions and the predication are based on the data obtained from reference (Almulla, 2014). The energy sector plays a major role in meeting the basic need of the region (water and food), and geographic factors such as water scarcity and harsh climate conditions have thus also contributed to the rise in energy demand.

The rapid demand growth in electrical energy in GCC countries is due to the region’s rapid economic growth. Large scale infrastructural development, heavy industry and petrochemicals all required substantial electrical power. High population growth as a result of labour migration and the high birth rate coupled with improving living standards led to the rise in residential and commercial energy consumption. Furthermore, the low pricing of electricity in the GCC countries plays an important role in increasing electrical power demand. Actually the electrical energy is sold below the economic cost, with the result the tariffs in GCC are among the lowest in the world. Moreover, waste due to inefficient buildings and equipment has contributed toward increase in power demand.

The major sector for electrical consumption is the residential sector. The peak demand during the summer, due to high level of air conditioning, can be twice the off-peak summer time, and three times the peak winter time. GCC countries continuous to build new electrical power stations to meet the peak power demand which, in the future, can make several GCC countries to be net importer for the natural gas for the business as usual scenario. Accordingly, the region’s generated electricity has grown from 51 TWh in the year 1990 to almost 536 TWh in the year 2015. The electricity use per capita in all GCC countries is considered one of the highest rates of energy consumption per capita, in 2010 ranges from 5340 kWh to 17610 kWh, comparing to the world average which reaches 2728 kWh and middle east average of 3378 kWh (International Renewable Energy Agency [IRENA], 2012).

The energy sector in GCC countries plays a vital role in achieving economic and social development, and contributing to the Gross Domestic Product (GDP). However, the sector has two main effects on the achievement of sustainable development; the first is the suffering from negligible contribution of renewable energy source in energy production and the high consumption pattern, the second adverse effect of the sector is on the environment. Consumption in GCC differs from most of developed countries, as the world obtains more economic growth from each barrel, the GCC are moving in the opposite direction (Wogan, Al-Mubarak, Al-Badi, & Shreekar Pradhan, 2018).

3. Drivers of energy demand growth in the GCC

There are several factors contribute to high energy demand in the GCC. These factors include geography
and available natural resources; population growth, urbanization and rising living standards; and economic development. Overall, the combination of available resources and current pricing schemes has particular impacts on demand patterns in the region, in both residential and industrial sectors.

3.1. Climate conditions and water scarcity

Extreme temperatures are the norm across the GCC region, especially during summer months when daytime highs can reach 50°C. Not surprisingly, harsh climate conditions have also led to a high demand for air conditioning, which accounts for 70% of annual peak electricity consumption in the GCC (Gelli).

The region also has one of the highest levels of water-scarcity in the world. Surface water resources are very limited, existing only along the east and west coasts. In terms of renewable water supply, the region has the world’s lowest availability, with only about 60 cubic metres (m³) to 370 m³ of annual freshwater available per capita (World Bank, 2005). Rapid population growth is putting pressure on the limited water resources, as is high per-capita consumption, which ranges between 300 litres per day (L/day) and 750 L/day. A clear trend of rising per-capita consumption is documented, with rates growing by 336% in Kuwait between 1992 and 2010, by 125% in the UAE from 2006 to 2008, and by 120% in Bahrain from 2000 to 2008. In Muscat, the capital of Oman, water consumption per capita increased by 120% between 2005 and 2009. If population increases as projected, the GCC renewable water supply is expected to drop to an average of 94 m³ by 2030 (World Bank, 2005). According to the United Nations World Water Development Report 2016, a country experiences “water stress” when annual renewable water resources decrease below 1700 m³ per person per year (The United Nations World Water Development Report, 2017).

Having so little fresh water and such high demand, GCC countries rely heavily on desalination, requiring substantial government investment in desalination facilities and distribution networks. Current water pricing schemes do not provide incentives for the citizens to reduce water consumption. Thus, the combination of necessary investments and subsidizing high levels of consumption place a heavy financial burden on GCC governments.

3.2. Population growth and urbanization

Since the discovery of hydrocarbon reserves, the GCC region has seen rapid economic and social development, as well as steep population growth. In just 60 years, total population in the region has increased tenfold, from approximately 5 million in 1960 to 53 million in 2015, with a particularly large surge between 1990 and 2015, when the population increased from 21 million to 53 million (GCC-Stat). Over the decade 2005 to 2015, the Compound Annual Growth Rate (CAGR) for the population was 4% (Innovatemedtec the Digital Health Network, 2014). At present, the population by country is largest in Saudi Arabia (34.3 million), followed by the UAE (9.8 million), Oman (4.6 million), Kuwait (4.2 million), Qatar (2.8 million), and Bahrain (1.6 million).

Two main factors have driven up population in the GCC region. The first factor is the high birth rates: between 1980 and 2000, the GCC average was six births per woman, compared with a global average of three (Michel, Beattie, & Walston, 2018). This rate recently halved (coming close to the global average) with increased standards of living, a higher age of marriage, and improved access to education and employment for women. Economic development and rapid industrialization (including large industrial projects) have also resulted in high rates of labour migration (the second factor). Across the GCC, foreign nationals represent 51% of the total population, with particularly high expatriate rates in Qatar (86%), UAE (89%), and Kuwait (70%) (GCC, 2010–2017).

Most of the GCC region is highly urbanized: on average, urban dwellers account for 80% of the population, while both Kuwait and Qatar are almost 100% urbanized. This has influenced GCC government spending to build road and public transportation networks, inter-city highways, and industrial and economic cities. Urban planning is an important factor that influences both land use and transportation energy demand. In this region, substantial opportunity exists to make urban expansion more efficient and environmentally friendly.

3.3. Economic development

The discovery of oil spurred economic development in the GCC. In 1980, when the oil price peaked at around $102 per barrel (bbl) in today’s value, GCC governments used the revenues resulting from exports to pursue aggressive economic and social development, including the development of large-scale infrastructure and the launch of heavy (i.e., energy-intensive) industries such as petrochemicals and cement production. This led to a staggering rate of energy consumption growth and high levels of energy intensity, an indicator of GDP output per unit of energy demand. This reflects that abundance of low-cost fossil fuels prompted development of energy-intensive industries (low-cost supply gives them a competitive advantage) but also that...
industry obtains electricity at subsidized prices. By 1986, reduced oil demand and increased production created a supply glut that pushed the oil price to less than $22/bbl in today’s prices. The consequence was a great loss in revenue for the GCC oil-producing economies.

The GCC economies have witnessed a similar boom and bust cycle in the past decade. Between 2002 and 2008, oil prices rose again to highs of $147/bbl which resulted in combined GCC economy tripled in size to $1.1 trillion (Setser & Ziemba, 2009). In line with the global economic crisis which began in 2009, the oil price dropped by 35% to $61/bbl. In 2014, the region reported slower growth with a combined GDP of just $1.6 trillion and total exports of around $861 billion, even as oil prices again peaked to $112/bbl. The subsequent decline in global oil prices (to around $30/bbl) shaved another $360 billion from export revenue in 2015. Overall, high dependence on a volatile commodity has created something of a vicious circle in which GCC economies are highly vulnerable to oil market cycles.

More recently, oil prices are recovering from a low of $30/bbl to a monthly average of $50/bbl to $60/bbl. These prices have again put more stress on GCC government budgets, as oil and gas exports accounts for 80% of fiscal revenues. The resulting lower public spending has slowed overall growth. With the recent decisions, in the 4th quarter of 2016, May 2017, and July 2019 to cut OPEC oil production, growth is now expected to stall (Meredith).

In response, GCC governments are increasing efforts to diversify their economies beyond hydrocarbons, and have introduced several reform initiatives that focus on improving the medium-term fiscal outlook. Several mega-projects that should support growth in the near term have been announced. Dubai has allocated $6.9 billion to infrastructure projects associated with hosting the World Expo 2020. Qatar has budgeted $200 billion for infrastructure upgrades in transportation, construction and service sectors in preparation for World Cup 2022. The free Zone in Duqm (Oman), which comprises an area of 1777 km² to be built up with a sea port, industrial areas, a town, a fishing harbour, a tourist zone, a logistics centre, and an education and training zone, is another mega-project expected to attract foreign investments and support economic development.

3.4. Energy pricing and consumption patterns

For the most part, governments control the energy assets underpinning GCC economic development. A long-held tradition is that the wealth generated through energy exports is “shared” in that domestic energy which is supplied to citizens and industries at very low cost with the dual aims of ensuring energy access and boosting economic development.

At present, electricity tariffs in the GCC are regulated and are among the lowest in the world, with substantial price subsidies offered to both utilities and consumers. In reality, such tariffs are well below the economic cost of production. Figure 2 shows gasoline and diesel prices after recent removal of subsidies, yet energy prices in the GCC are still among low comparatively with other producing countries.

At such low rates, citizens pay little attention to energy consumption—a factor contributing to the rapidly rising per-capita consumption rates. Inefficient pricing practices also lead to enormous energy waste in buildings, industry, and households. In total, energy subsidies currently cost GCC governments more than $160 billion annually in foregone revenues (McCulloch, 2017). Only recently, due to the decline in oil and gas revenues, the region’s governments have begun to gradually introduce energy price reforms. The amount of energy subsidies in the GCC compared with other Countries is presented in Table 1 and the recent energy price reform is presented in Table 2.

4. Future fuel needed for electricity generation and emission

In 2040, it is expected that the total world energy consumption will be raised by 48% and the world net electricity generation will increase by 69% compared with 2012 energy demand (U.S Energy Information Administration, 2016). Furthermore, the consumption of nonfossil fuels is expected to grow faster than consumption of fossil fuels, fossil fuels still will account for 78% of energy use in 2040 (U.S Energy Information Administration, 2016). The electricity generation is expected to account for 40% of all the world energy and the conventional hybrids cars to jump from about 2% of new-car sales in 2014 to more than 40% by 2040 (Meredith). The global carbon dioxide emissions are projected to rise by
29% in 2035, with all of the growth coming from the emerging economies. The emissions growth is expected to slow as natural gas and renewables gain market share from coal and oil; and emissions are expected to decline in some countries (Energy Outlook 2035, 2014).

As populations, economic and living standards in the GCC continue to rise, more energy will be required as a result the demand on fossil fuel is expected to increase. The amount of fuel used to generate electrical energy depends on the heat rate of generator and the fuel content of the fuel. The total amount of gas and oil that will be required can be calculated by the following equation (U.S Energy Information Administration, 2017a):

\[
\text{Natural gas demand in cubic feet} = \text{Energy(kWh)} \times 10.03
\]

\[
\text{Oil demand in barrels} = \text{Energy(kWh)} \times 0.0016
\]

The two constants in Equations (1) and (2) represent the heat rate for steam generator and the fuel heat contents for natural gas and petroleum products, respectively.

The total amount of carbon dioxide emission in the GCC when generating electrical energy using fossil fuel can be obtained using Equations (3) and (4) (U.S Energy Information Administration, 2017b):

\[
\text{Carbon emitted from natural gas in tons} = \text{Energy(kWh)} \times 0.55338/1000
\]

\[
\text{Carbon emitted from oil in tons} = \text{Energy(kWh)} \times 0.74389/1000
\]

The two constants in Equations (3) and (4) represent the heat rate for specific fuel and specific type of generator for natural gas and petroleum products (Distillate oil), respectively.

In terms of electrical energy generation mix in the GCC in year 2011, natural gas represents 75%, crude oil accounts for 14.4% and the rest 10% comes from light oil, heavy fuel oil and diesel (International Renewable Energy Agency).

| Table 1. Energy subsidies in the GCC compared with other countries (World Energy Outlook, 2019). |
|----------------------------------|-------------------|
| Country            | 2018 subsidies |
| Kuwait             | Oil 1743.4      |
| Kuwait             | Electricity 3739.8|
| Kuwait             | Gas 1976.7      |
| Saudi Arabia       | Oil 25,755.8    |
| Saudi Arabia       | Electricity 12,793.0 |
| Saudi Arabia       | Gas 6175.3      |
| Qatar              | Oil 325.8       |
| Qatar              | Electricity 973.0|
| Qatar              | Gas 881.8       |
| Oman               | Oil 122.3       |
| Oman               | Electricity -- |
| Bahrain            | Oil 324.3       |
| Bahrain            | Electricity 107.0|
| UAE                | Gas 196.1       |
| UAE                | Oil 2788.7      |
| UAE                | Electricity 8688.4|
| Algeria            | Oil 9564.2      |
| Algeria            | Electricity 3560.4|
| Algeria            | Gas 3956.0      |
| Russia             | Oil 14,333.7    |
| Russia             | Electricity 13,433.7|
| Russia             | Oil --          |
| China              | Oil 17,971.1    |
| China              | Electricity 24,857.3|
| China              | Gas 1611.6      |

| Table 2. Energy price reform in the GCC countries (Annual Meeting of Arab Ministers of Finance, 2017; http://www.argam.com/en/article/articledetail/id/404334; https://www.dewa.gov.ae/en/customer/services/consumption-services/tariff; http://nri-cafe.com/qatars-kahramaa-hikes-water-electricity-tariffs/). |
|------------------|-----------------|
| Country          | Energy          | Energy price reform |
| Bahrain          | Gas Increases of $ 0.25 per mbmht for industrial users until reach $4 per mbmht by April 2021. |                        |
| Bahrain          | Gasoline In January 2016, the price of regular gasoline was increased to about US$0.33 per L |                        |
| Bahrain          | Electricity In March 2016, the tariff will increase by 95% through phases until 2019. |                        |
| Kuwait           | Gasoline In September 2016, the price increase by 70%. The prices will be revised quarterly depending on international price. |                        |
| Kuwait           | Diesel In January 2015, price increases by 100% |                        |
| Kuwait           | Electricity Effective from 2017, increase in electricity and water prices for foreign residents |                        |
| Oman             | Gas In January 2015, the industrial price for natural gas has doubled ($3 per mbmht) |                        |
| Oman             | Gasoline In January 2016, the price was increased by 23%. The prices are revised monthly depending on international price. |                        |
| Oman             | Diesel In January 2016, the price was increased by 10%. The prices will be revised monthly depending on international price. |                        |
| Qatar            | Electricity The prices start to increase in January 2011. In August 2016, the price increases to US$ 0.45. |                        |
| Qatar            | Gasoline The prices start to increase in January 2011. In May 2014, the price increases by 50%. |                        |
| Qatar            | Diesel The prices start to increase in January 2011. |                        |
| Qatar            | Electricity In September 2015, electricity prices raised and tiered according to consumption level. |                        |
| Saudi Arabia     | Gas In December 2015, the price of methane and ethane gas raised to US$ 1.25 and US$ 1.75, respectively. |                        |
| Saudi Arabia     | Diesel In December 2015, regular gasoline price was increased to US$ 0.2 per L |                        |
| Saudi Arabia     | Electricity In December 2015, the price increases to $0.12 per L for the transportation sector and $0.09 per L for the industrial sector. |                        |
| UAE-Abu Dhabi    | Electricity On 11th January 2016, Electricity prices were adjusted on all sectors in accordance with consumption levels |                        |
| UAE-Dubai        | Fuel In August 205, fuel subsidies terminated. The prices are revised monthly depending on international price. |                        |
| UAE-Dubai        | Electricity In 2015, the electricity prices were adjusted on all sectors in accordance with consumption levels |                        |

A fuel surcharge is added to electricity & water consumption from 1st January 2011. The surcharges vary based on the rate of increase or decrease of the actual fuel cost.
Figure 3 presents the total demand of gas and oil for electrical power generation considering 75% of energy is coming from natural gas and 25% is coming from oil. It is clear from Figure 3 that more oil and gas will be required to meet the energy demand, in 2040 the total gas requirement in all GCC countries is expected to reach $1485 \times 10^7$ cubic feet, while the oil demand will be $792 \times 10^6$ barrels.

The total carbon dioxide emission in GCC countries, for the same period of time is presented in Figure 4. The CO$_2$ emission increases since more fossil fuels are used to meet the energy demand. More greenhouse emission is coming from gas compared with oil since the amount of oil used is one quarter of the total required fuel. The total CO$_2$ emission is expected to reach $119 \times 10^7$ tons by 2040.

5. Measures to address the GCC energy challenges
5.1. Implementing regulations and policies for energy efficiency

This could be codes and standard, appliance standards and import duties exemption, etc. The Saudi Energy Efficiency Center was established in 2010, which aims to help conserve national energy resources and improving energy efficiency (Saudi Energy Efficiency Center). Moreover, the Saudi Energy Building code was established in 2007 (Gelili). In Bahrain, they have established the Thermal Insulation implementation for building in 1999 (Electricity & Water Conservation Directorate). Energy Conservation Program, Code of Practice was approved in Kuwait in 2014 (Ministry of Electricity & Water, 2014). In UAE-Dubai, the Green Building Regulations and Specifications was approved in 2011 (Dubai Municipality, 2011). Qatar has mandatory green building rating that promotes sustainability of building on both construction and operation phases (Arab Future Energy Index, 2015). In 2016 Oman’s Supreme Council for Planning has set up a committee to develop a comprehensive green design code to meet the requirement of proposed unified GCC Building Code (Arabian Business). 10% contribution of renewable energy in electricity supply mix by 2025 is approved by the Council of Financial Affairs and Energy Resources in September 2017 (http://timesofoman.com/article/117249/Oman/).
5.2. Electrical energy prices reform

The pricing of electricity in the GCC countries plays a major role in increasing the consumption. There were no changes in the energy price and sold below the real cost since several decades, with the result the GCC countries tariffs are among the lowest in the world. The decline in oil prices in 2015 incentivized subsidy reform in the region. Recently, GCC countries issue regulations that will motivate the users to consume less energy. Subsidy structure can be reformed even further to reduce consumption and boost the development of renewables. Energy efficiency and saving strategy should be implemented on both generating and consumers’ sides. Electricity intensity can be reduced through increasing efficiency, especially in growth sectors.

5.3. Demand side management

Demand side management or Demand side response refers to initiatives that encourage consumers to optimize their energy. It is beneficial to consumers since this will reduce their energy bills and will be also beneficial to the utility since it reduces the peak electricity demand by load levelling and control. It has major role to play in deferring high investments in power system network. Implementing such measure in the GCC will reduce the yearly peak load growth which currently can reach 10% in some GCC countries. Additionally, electrification can reduce the total energy consumption if more efficient electric vehicle are used. Electric vehicles (EVs) can reduce peak power capacity since they may provide demand-side management to the power grid. Furthermore, they will increase penetration of renewable energy resources and reduce CO2 emission.

5.4. Utilization of renewable energy supplies

GCC countries are blessed with high level solar radiation, by utilizing renewable energy sources that will safe part of the energy production for export, reduce emissions, protect environment and improve public health. Recently, several GCC countries have announced plans and targets for conserving natural resources and deploying renewable technologies. Photovoltaic technology has received particular attention due to its resource availability and cost competitiveness (Al-Badi, 2018; Al-Badi et al., 2018; Al Busaidi, Kazem, Al Badi, & Khan, 2016). Renewable power can play a significant role in reducing regional carbon footprints. If the region renewable energy targets is achieved, it can reduce emissions by 1 Gt CO2 to 2030, leading to an 8% decrease in the per capita carbon footprint by 2030 (IRENA, 2016). GCC countries have set target for their renewable energy to contribute mainly in the electricity generation as presented in Table 3. The targets range from 5% in Bahrain to 30% in Oman by 2030.

GCC countries already took measures to increase energy security by initiating renewable energy projects. Nevertheless, renewable energy did not fulfil its potential at the expected pace. Governments can increase the adoption of these sources by specifying measurable binding policies, set clear regulations along with establishing independent regulatory bodies. Comprehensive energy mix policy must be identified and applied along with time-bound reasonable targets. Clear market structure coupled with transparent policies is vital to have the private sector participate actively in the energy transition.

Energy storage at large scale could provide flexibility to grid operator in managing the generation variability from intermittent wind and solar resources as well as to provide the required energy during the peak load demand. The storage can be in the form of pumped-hydro storage, compressed air storage or batteries. From the large load owner’s perspective, storage enables load shifting to reduce the demand charge and electricity cost during peak load periods. The storage system could be thermal energy storage or batteries.

5.5. Smart grid

The grid that integrates more penetration of renewable energy is a driver for a major infrastructure modernization project known as “Smart Grid.” The GCC should start developing a detailed Smart Grid Roadmap for the Electricity Sector owing to the increasing complexity of power systems, growing demand of electricity, requirement for greater reliability, security and efficiency, as well as the concern about the environmental and energy sustainability. Smart Grid is related to how to integrate advance

| Country      | Renewable energy targets                                                                 |
|--------------|------------------------------------------------------------------------------------------|
| Bahrain      | 5% by 2030 for electricity generation                                                    |
| Kuwait       | 15% by 2030 for electricity generation                                                    |
| Oman         | 10% by 2025 and 30% by 2030 for electricity generation                                    |
| Qatar        | 2% by 2020; 20% by 2030 for electricity generation                                        |
| Saudi Arabia | 4% by 2020 for final energy                                                              |
| UAE          | Abu Dhabi 7% by 2020; for electricity generation. Dubai 7% by 2020, 25% by 2030, and 75% by 2050 for electricity generation |
sensor, computer control and communication technologies with electricity that will offer unique flexibility and functionality required by digital society. For utilities, a grid that efficient, flexible, dynamic, can predict and heal power problems early. For consumer, a grid that provides lower energy bills, security and enhanced reliability, and new services that can add value but at reasonable cost.

5.6. Awareness about energy consumption and efficiency

Organizing awareness campaigns about energy saving, energy efficiency and demand side management program for governmental and nongovernmental institutions through public lectures, workshops, exhibitions, and cultural, artistic and sport activities.

7. Conduct a technical study on the impact of Electrical Vehicles on the GCC grid;
8. Increase natural gas in energy mix in Saudi and Kuwait.
9. Regional electricity trading instead of burning oil for generation.
10. Incentives and clear policies for increase the private sectors participation in clean power generation
11. Incentives and policies for residential solar installation (Charabi & Al-Badi, 2015). Oman finalized a new Standards that define the requirements to be fulfilled by residential solar PV which will operate in parallel with the distribution networks (http://aeroman.org/pdfs/press_releasesolar2017.pdf).

6. Conclusions

The gulf region have witness a jump in the domestic energy consumption over the past decade. Studies have shown that the GCC countries will face a rapid increase in electricity demand by 2025 to reach 1093 TWh. Kuwait, Saudi and Oman combined are expected to have a 679 TWh peak load, indicating a 57% jump from 2016. As the expected energy demand increases more fossil fuel is required and as a result more CO₂ emission. Hence, the model demand estimates was used to calculate future fossil fuel required to meet that projected demand for electricity in the region. CO₂ emissions caused by the hike in oil and gas usage for future electricity generation was also estimated. By 2025, CO₂ emission from oil and gas will reach 657 Mtons.

The Gulf States plan to invest $100 billion in renewable energy projects over the next 20 years. Additionally, the GCC countries have set renewables and clean energy targets. Saudi Arabia plans to generate 54 GW of renewable energy by 2040. Kuwait and Oman plan to increase the share of renewable in the energy mix to 15% by 2030 and 30% by 2030, respectively. In response to climate change at COP22, UAE raised its clean energy target from 24% to 27% by 2021 and by 2050 to 44%. Similarly, 20% of 1800 MW capacity is expected to be met by renewables in Qatar by 2030. In 2020, Bahrain would generate 5% of capacity by renewable energy.

UAE, Qatar, Bahrain and Oman use mostly natural gas for electricity generation. Some of these countries have already become importers of natural gas. Yet, Kuwait and Saudi Arabia burn more oil to generate electricity. In order to better utilize the latter’s crude oil resources, KSA has equipped new power plants to use natural gas. Nuclear energy projects are planned lead by the Emirates Nuclear Energy Corporation (NEC)’s four Advanced Power Reactor 1400 (APR-1400) where all are expected to be operating by 2020.

Beyond diversifying the energy mix, energy efficiency policies and targets were also announced. Kuwait intends to increase generation efficiency by 5% while decreasing 10% of energy consumption in buildings. Qatar also plans to decrease 20% in per capita electricity consumption. By 2030, Dubai is expected to lower its power consumption by 30% compared to the urban city business as usual case. Saudi Arabia set targets to reduce peak demand by 14% and 8% of electricity consumption in 2021.

The emissions of carbon dioxide are expected to slow if natural gas and renewables replace the oil fuel in power stations. Nonetheless, taxation on carbon emissions can be put on large industries.

Public awareness programs can help to manage the future electricity demand. People are accustomed to profligate energy usage. Thus, immediate awareness campaign might be put in place that leverage the use of all types of communication including social media. Additionally, long term learning must be integrated into the education system.

Disclosure statement

No potential conflict of interest was reported by the authors.

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