



## Natural Gas Potential And Energy Use In The GCC

Mohammed Saleh Al.Ansari <sup>a\*</sup>

<sup>a</sup>Department of Chemical Engineering, College of Engineering, University of Bahrain  
PO box 32038, Sukhair Campus, Kingdom of Bahrain  
<sup>a</sup>Email: malansari@uob.edu.bh Tel: +973-3944-1110

### ABSTRACT

The demand for natural gas within most countries throughout the GCC region, has, since the beginning of the new millennium, increased. The demand is actually growing faster, than the commodity can be given, which is resulting in a deficiency throughout the world. One of the main things that is affecting the cost and supply of natural gas, is the governments within the GCC region. The government is keeping the cost of natural gas, artificially low, which is increasing demand, yet, the supply is remaining stagnant.

The only way that the GCC region is going to be able to reach a point of sustainability, is to alter their pricing policies for natural gas. Unless the pricing policies go through a revision process, the GCC region will never reach a point of sustainability. The role that the GCC region plays when it comes to the international gas markets, within the future is going to be more than a simple growing demand, imports will be required in order to ensure that the region has enough natural gas for the domestic area. There are arguments coming from the government as well as the nationals within the GCC area that if something can be worked out then perhaps, the GCC region will be able to capitalize on the supply of natural gas that it has, and eventually, be able to supply the region and the international world with the commodity.

**Keywords:** Energy, Natural Gas, Gulf Cooperation Council(GCC)

### 1. Introduction

Natural gas is recognized as being the cleanest fossil fuel to burn. It produces lower emissions of carbon than oil and coal, and emits less pollutants. One fifth of the energy requirements of the world is able to be met by natural gas, in comparison to one fourth being met by coal, and one third being met by oil. Therefore, it is important that models are developed that will ensure that natural gas is priced accurately. This will help to determine what avenues regulatory channels will need to take when it comes to ensuring that the supply of natural gas is able to adhere to the demands for it. Natural gas is becoming a critical variable when it comes to generating electricity as well as analyzing what the benefits in comparison to the costs are. Natural gas is openly used in various programs that promote energy efficiency. Pollution within the urban communities throughout the world, has become a pressing problem. Pollutants affect the health of individuals, as well as adversely affects the environment, at the same time. Climate change concerns can be traced back to the industrial revolution, when activities that involved fuel combustion, began to increase the temperatures of areas all around the world[1].

-----  
\* Corresponding author. Tel.: Tel: +973-3944-1110

E-mail address: malansari@uob.edu.bh.

The United States Department of Energy, performed a test that estimated natural gas that was used as a fuel for vehicles. During this study, it was discovered that natural gas reduced the amount of toxic emissions by seventy to eighty five percent, in opposition to gasoline and oil. Also, vehicles that utilized natural gas to operate, did not emit as many harmful emissions into the air.

In order for the requirements of the public to be met, it is important that polluting emissions that are emitted by automobiles is reduced[1]. Specialized control systems and engine developments are being made in order to accomplish this feat. The regulation laws for emissions within developing countries are making attempts to be equivalent to those in developed areas. Due to its overwhelming abundance, natural gas is playing a major role when it comes to meeting the demands of the world, in regards to energy. This gas is abundant, versatile, and clean, when it is burned. Due to this fact, there are a lot of exploratory activities that are being carried out to assist with further developing the gas. New reservoirs are consistently being found in developing nations, due to the permeability in these areas being lower than in nations that have undergone an immense amount of developments.

During the recent years, the requirement for energy efficient as well as environmentally friendly purification techniques for gas, has forced further research efforts to be taken when it comes to separation gas technologies. Presently, this type of technology is used greatly to remove carbon dioxide from the raw natural gas components. A few challenges that are facing this feat are physical aging, poor balance as it relates to permeability, as well as poor conditioning. Further review is required in order to alleviate these issues[2].

There are different conventions that are used to price gas in varying regions. In some regions, gas is priced in varying spot markets. While in others, the pricing may be dominated by linking the prices of gas to the prices of other fossil fuel products, such as oil and crude oil products. Due to this fact, the price for gas can differ amongst the various regions[3]. The primary reason why the prices differ greatly is due to the fact that whenever changes within market structures occur, the profits can become larger than the cost of transporting the products. The magnitude of supply from nations abroad will depend greatly upon developing supply capacities by nations that already have a rich amount of resources, or perhaps by expanding the nonconventional resources, that are influenced by industry and national policies.

If efficient global markets develop, then there will be a substantial amount of flow amongst trading regions. The flows are consistent with demand, and being able to amply supply the demand for a specific product, in this case, natural gas[2&12].

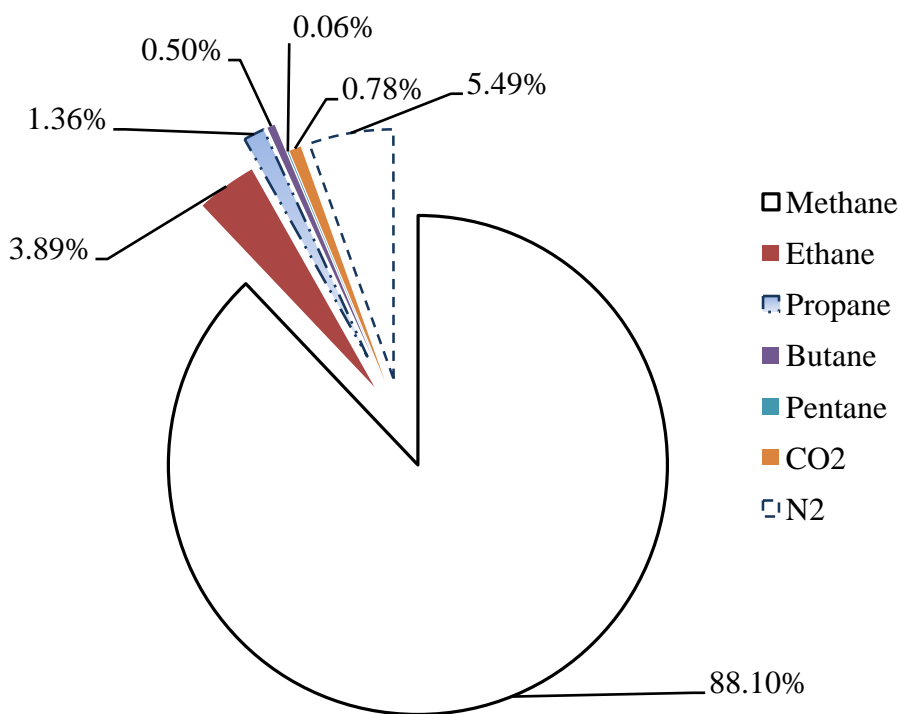
The energy crisis along with global warming, are the two biggest issues that threaten the existence of mankind. The adverse effects that these two issues have, are becoming more obvious throughout the present century, than they were ever before. There have not been any solutions introduced in order to eliminate the harmful effects that they are having on the planet. There are three different types of fossil fuels that exist. These three fuels are oil, coal, as well as natural gas. During the earlier part of existence, typically, before World War II, coal was the only fuel that was used, it quickly became replaced by oil following the war. The use of natural gas dates back to the middle portion of the twentieth century. These three basic fuels account for eighty five percent of the world's energy use. The consumption of these fuels is constantly on the rise, due to the growing population, and further developments being made to transportation and industries. The total amount of energy consumed in the world, has increased by thirty eight percent over the last decade. Also, energy consumption all around the world as increased by twenty five percent, in the span of one year, from 2010 to 2011[3].

When exploring what the future of natural gas is, it is apparent that the outlook for this type of fossil fuel to be used over the upcoming decades is favorable. Shale gas resources have been added to the United States, as a means to increase production, without these resources, production would decline, and sustainability for the fossil fuel would not be able to be obtained. The resource base for the gas, along with its costs are something that are uncertain. The uncertainty does not have as large of an impact on the domestic production levels, due to the mean estimates of resources and supply, that are used to meet the growing demands of moderate prices through till the year 2050. Even

analyzing these pessimistic estimates, if GHG mitigation was abandoned, the production of US gas and its use will be projected to be a lot higher in the year 2050, than it is today.

Natural gas is a colorless, characterless gas. It does not have any shape, and when it is in its purest form, is entirely odorless. It is intriguing, when thinking about the characteristics that this gas has. It is basically hidden from the naked eye, yet, when burned is extremely combustible and can give off large quantities of energy. In opposition to other types of fossil fuels, natural gas, is a clean burning fuel that emits lower levels of byproducts into the air that could inflict harm upon the masses[4]. Energy is required for daily living. It is used for cooking, heating, as well as for electricity. It is due to the increased need for energy that natural gas usage, has increased in importance.

Natural gas is a mixture of combustible hydrocarbon gases. Although the gas is generally made up of methane, other gases are also used to create the odorless fumes. Butane, propane, ethane, as well as pentane may be used to create this special type of gas. However, although, these are the prime substances that are combined to make natural gas, the composition of this gas can vary[2].

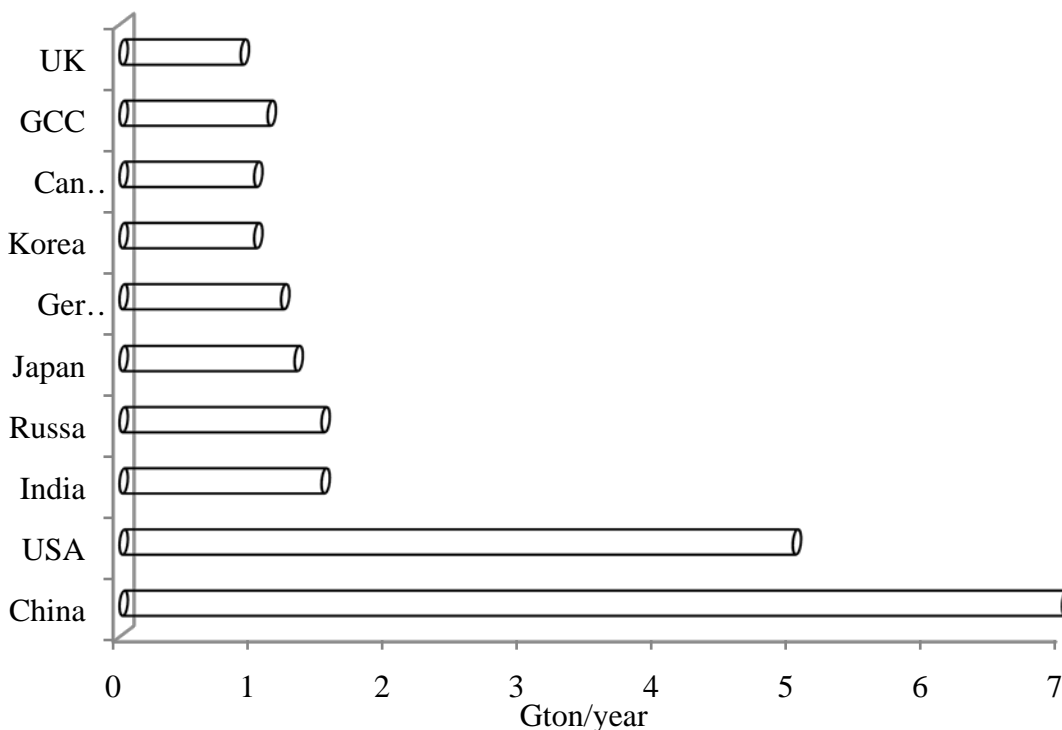


**Figure (1) Typical Natural Gas Composition by Volume in %**

It worth mentioning that around 20% of the globe’s energy needs is met from natural gas these days, compared approximately 33% from oil and one-fourth from coal. Therefore, developing models for accurate natural gas price forecasting and direction of price changes is important because these forecasts are generally exercised in decisive a range of regulatory decisions wrapping both supply and demand of natural gas or for market contestants; they are also regularly a crucial variable in electric generation capacity planning and in scrutinizing the benefit-cost relationship for demand-side and energy-efficiency plans. The natural gas is a mixture of combustible hydrocarbon gases. Although the gas is generally made up of methane, other gases are also used to create the odorless fumes. Butane, propane, ethane, as well as pentane may be used to create this special type of gas. However, although, these are the prime substances that are combined to make natural gas, the composition of this gas can vary[10]. The

natural gas fuelled vehicles reduced toxic emissions by 70–85%, in comparison with gasoline and diesel oil. Moreover, natural gas fuelled engines produce negligible emissions of the carcinogen mutagenic hydrocarbon. The emissions regulation laws and bylaws of developing countries are flattering equivalent to procedures assuming by developed countries. Figure (1) shows that the composition by volume of natural gas is 88.1% is methane and the CO<sub>2</sub> emissions from gaseous fuel consumption (kt) in Bahrain as example was stated in the year 2008 to be 17836.29 kt and in 2012 reached to 21300.89 kt[11]. This means that Carbon dioxide emissions from liquid fuel consumption refer mainly to emissions from use of natural gas as an energy source. Looking at carbon dioxide availability in the natural gas as percentage looks that the amount is subjected to accumulate one day.

When sampling was taken in figure (2) to compare the GCC emission of CO<sub>2</sub> as emitted sum of carbon dioxide then it shows that GCC is emitting hire than United Kingdom, Canada, Korea. Those are taken to be the highest area emitting the carbon dioxide as burnt gas emitted in the flue gas.



**Figure (2) sampling 10 emitting countries of CO<sub>2</sub> emission**

*1.1 Differences Between LPG and LNG*

LPG, which is an acronym used to express the term Liquid Petroleum Gas, is often times confused with the acronym term LNG. Although similar in the way they are written and expressed, these two terms mean entirely different things. The differences that exist between these two terms are fairly significant. The varieties of LPG that are purchased and sold, include mixes of various types of gases. The gases that are mixed together to create LPG are primarily composed of propane, butane, or mixtures that include both of these types of gases[12].

When comparing LPG to natural gas, the primary difference between the two, is that LPG heats at a higher value than natural gas does. LPG can also be stored and made into a liquid, by the gas having an excessive amount of pressure applied to it. LNG on the other hand, is different. LNG requires infrastructure investments to be made, in pipelines and other outside sources. LPG is a portable substance. The properties that LPG possesses makes it extremely valuable for developing countries, especially, those countries that are positioned within rural regions.

LPG has been utilized as a fuel in various heavy duty vehicles, for an elongated frame of time. It can be found in various petrol stations all around the world[11&12].

Comparative to oil, natural gas, is a sweet to sour type of gas. The amount of sweetness, as well as the amount of sourness that the gas possesses is dependent upon the amount of hydrogen sulphide that is found in the gas. Gases can also be characterized as being either dry or wet. This characterization greatly depends upon the present of liquids within the gas, along with other types of energy gases that mix with the gas to create the substance. Wet gases may be stripped of any NGL's which is an acronym used to describe natural gas liquids, so it can later be used within processing plants for gas. Natural gas is often times described as being either a non-associated or associated type of gas, based upon whether it is associated with the production of oil or not.

#### *Does LNG and GTL Share Any Similarities?*

Recently, there has been an increased demand for GTL, which is gas to liquids, all over the world. The demand for this type of substance is primarily in larger countries throughout the world. Larger cities are converting to GTL's in order to ensure that they are burning gases that are clean and environment friendly. However, contrary to popular belief, GTL and LNGs are not competing with one another. GTL is commonly used as a fuel for the transportation markets. LNG is usually utilized for industrial and utility markets, therefore, both fuels have their own specific markets that they are focused towards. Although, relatively different, there is some temptation that both GTLs and LNGs, may be able to be integrated, but this will more than likely be a difficult integration[10 &13].

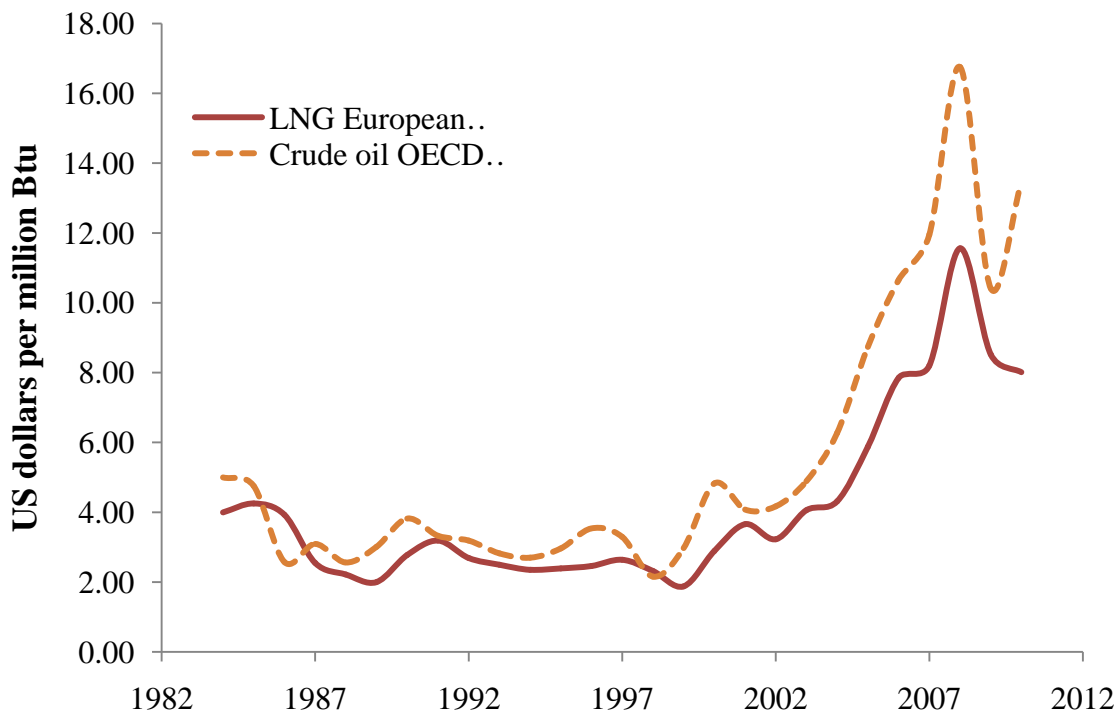
In opposition to LNG, GTL does not depend upon long-term contracts. This dependency may end up causing a reduction in LNG markets, as the market continues to develop and evolve. GTL and LNG is better positioned as being two different types of substances that are separate, but can come together, if need be, during production stages[14].

If GTL fuels are to be sold with refined products, they can easily become competition for former fuel products, due to the environment friendliness of the gas. LNG and GTL products, cover two different markets. One product takes care of the transport markets, while the other product, takes care of the industrial energy and commercial markets. These two markets are key focus areas for government entities that are searching for way to reduce the amount of emissions that are emitted into the air[7&8 and 12].

#### *1.2 Growing Demand versus Low Supply*

The demand for natural gas within the GCC region, grew faster than any other region in the world. The demand increased by almost nine percent, by the year 2011. Which caused the region to reach just a little bit under 490 Bcm. The prices of natural gas vary amongst the different countries that occupy the GCC region. In Saudi Arabia, the costs are \$0.75/ MMBtu, in Kuwait the price is \$0.8- 1.50/ MMBtu and in the country of Oman, the price is \$1 per MMBtu, the UAE and Qatar is experiencing the same costs for natural gas in their area, the cost for natural gas in these two regions is \$0.75 per MMBtu [2].

Issues relating to the prices for natural gas have been given an immense amount of attention, within various policy circles. The issue has become extremely concerning in countries that have short supplies, which has resulted in more petroleum products having to be used, which decreases the amount of exports for the country. Few countries have taken the proper steps to be able to address the issues that are arising, as it relates to natural gas. This is shown in Figure (3) when historical natural gas either in the form of LNG European or Crude oil in OECD price as \$ per million BTU is being used to demonstrate the price escalation in the form of time series[10&15]. Figure (4) shows billion of cubic meter of natural gases produced in GCC countries. For the sake of comparison. The Kingdom of Saudi Arabia is producing the highest after 1982 where Qatar is producing natural gas after 1992 and escalated to reach its existing level to be more than 120 billion cubic meter. United Arab Emirates reached to 55 billion cubic meter in 2012 and Kuwait, Bahrain, Oman reached 35,34,38 billion cubic meter per year in 2012[16&12].

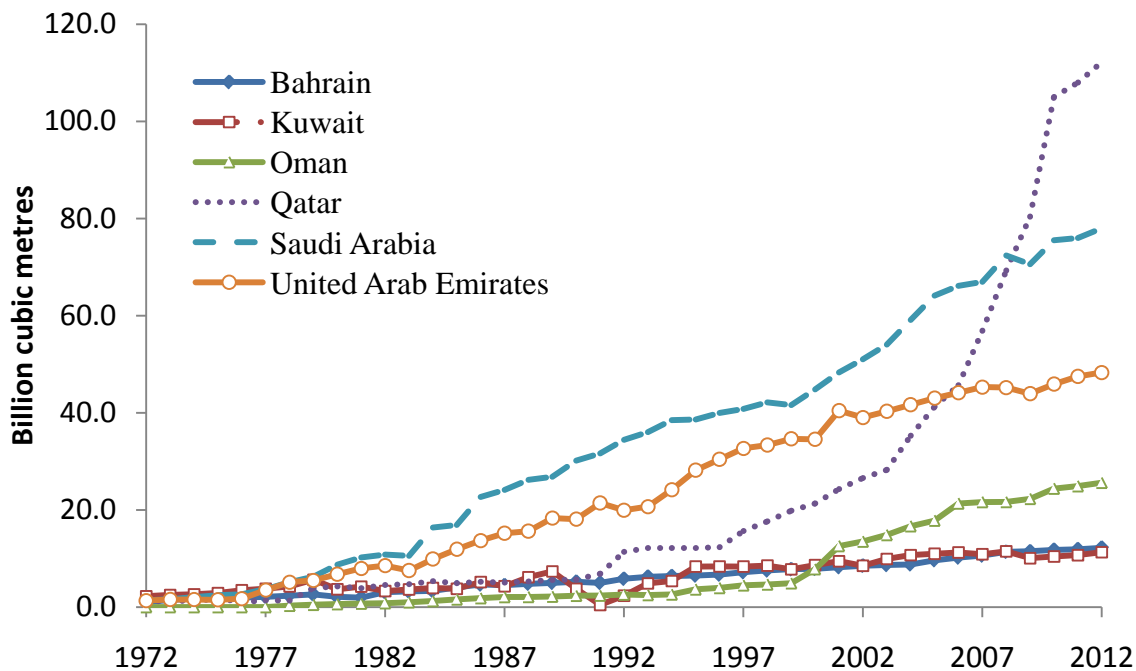


**Figure (3) historical natural gas either in the form of LNG European or Crude oil in OECD price as \$ per million BTU.**

Despite its marginal contribution of just 37 percent and 14 percent of world’s oil and gas demand, the GCC nations are the undisputed leaders on the supply side possessing an approximate share of 52 percent and 38 percent of global oil and gas reserves. The GCC nations are looking up to an increased bout of optimism in their fossil fuels sector. While global energy demand is forecasted to increase by as much as 59% by 2050, confidence on fossil fuels will continue to be escalated. The UAE has the seventh largest gas reserves in the world, with around 214.4 trillion cubic feet of proven reserves but capital costs and high sulphur content to the feasibility of the uses of the gas to be negative. The UAE's Abu Dhabi National Oil Company (ADNOC) and Occidental are developing the Sour Gas to meet the domestic energy requirement. UAE is also all counted to be one of the pioneering countries that search for alternative energy sources such as solar, wind and nuclear energy and has all the elements for developing a successful solar power industry with as many as 70 companies currently operating in solar power[12,13,14 & 18].

Qatar in terms of its established intrinsic worth in the gas sector where it has the global gas market is similar to what Saudi is to the global oil sector. Major development in the country’s gas sector includes the Qatar North Gas wells to be around 9000 billion cubic feet annually development. This project is so significant that the Qatari government located a freeze on additional natural gas development projects at the North Field to enable maximum optimization of the 450 trillion cubic feet of recoverable gas reserves found in this field[1,7 & ].

Saudi has turned its focus on to this immensely popular sector with its Karan Gas field developments in addition to other projects such as Shaybah NGL recovery program and Wasit gas development regarded as Saudi Aramco’s core gas projects thus aiming to exploit its massive proven[5,9 &11].



**Figure (4) showing the GCC countries Natural Gas Production since 1972**

Bahrain has the lower profile on the hydrocarbon sector in contend to its other GCC countries, is also charting ambitious plans for the development of its Oil and Gas sector. The Kingdom’s oil producing capability is approximately 32,000 barrels per day. The Kingdom of Bahrain want to produce 8 million cubic feet per day of gas from the offshore phased development project, apart from 65,000 barrels per day of oil from Bahrain Field. Looking at figure (5) that shows Carbon Dioxide emissions in selected countries and comparing the output of the emitted CO<sub>2</sub> amount in the graph, it shows that GCC have significant opportunity to set their economies on a path to lower-carbon growth through renewable energy economies and carbon capture sustained by carbon sequestering and energy efficiency[13, 17 & 20]. There are a number of potential near-term policy measures that are particular that are equivalent to study. In renewable energy, officials in GCC can move partially towards the technology through analyzing those technologies and start implementing it to sustain environmental and industrial circumstances. In carbon capture and CO<sub>2</sub> sequestration, The CCS adoption by the providing first mover incentives and by developing a regulations framework to administer land use in places should be the main target for the next few year. This should be associated with the liability and further by using monitoring and verification procedures that other nearby countries has adopted the methodology and gained such experience[18, 14 & 19].

In energy efficiency, an economy- wide energy audit would provide a support for any future action. However, there are also chances in both short and longer-term. Those chances can be grouped many cross-cutting topics. GCC have the chances to foster continued R&D at the basic and regionally-specific areas. In the field of renewable energy, the GCC countries have an prospect to build up materials-specific appropriate that meets the required type of material that works well with the GCC environment. Building and deployment expertise in applications that works properly with the GCC industries would be another aim for the region. In the field of CCS, the GCC have an incentive to develop applications in gas-fired power generation, LNG and GTL production. The petrochemical production is another subject that can be upgraded to meet such development and this serve both their own interests related to competitive advantage for future exports CCS technologies to other places [Ventures Report of March 2011 to August 2013].

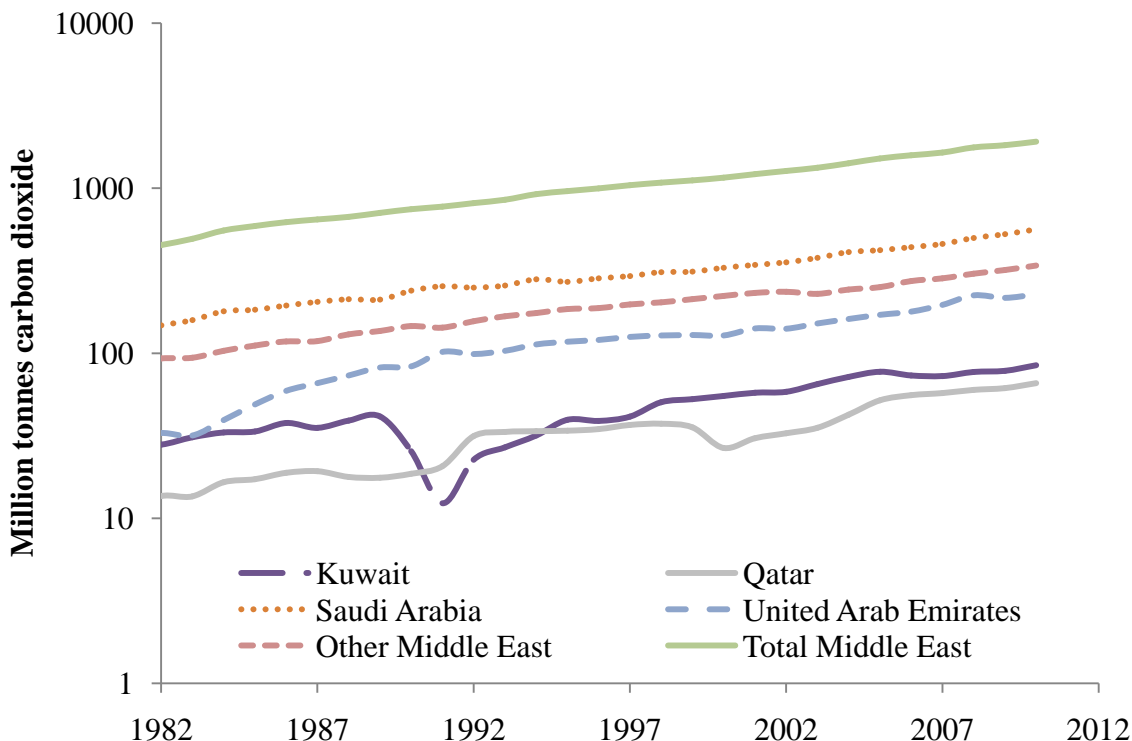


Figure (5) Carbon Dioxide emission in selected countries

## 2. Natural Gas In The Kingdom Of Bahrain

Bahrain’s natural gas reserves contain roughly 3.25 TCF of the gas. Much of the reserved amount of natural gas that Bahrain has comes from the oil field that is located in Awali. The output of the gas in Bahrain, has grown substantially since 2004. Bahrain has seen a ten percent increase in demand for natural gas[13].

In 2003, Bahrain produced 341 Bcf of natural gas. All of the gas that was produced at the time, was used by local residents. The responsibility of processing and producing natural gas for the kingdom of Bahrain, rests upon the Bapco Upstream department. The largest consumer that utilizes natural gas in the area, is Alba. They utilize the natural gas, in order to help keep their power plant, functional. In September of 2013, the government in Bahrain, signed an agreement with an American company that calls themselves Alcoa. The agreement was to allow the company to purchase twenty six percent equity within the company. The main supplier of natural gas in the region, Bapco Upstream, was given a contract from an engineering firm from the states, to make applicable upgrades on their primary processing facility for natural gas, within Awali.

The increased demand for energy within the kingdom of Bahrain is destined to make the area a primary natural gas importer, within the coming years. Back in 2002, Bahrain along with Qatar signed an agreement that would allow Bahrain to be able to purchase additional natural gas from the reserves that Qatar had. Bahrain has also entered into negotiations with Iran, to purchase any additional natural gas that they may be storing as well.

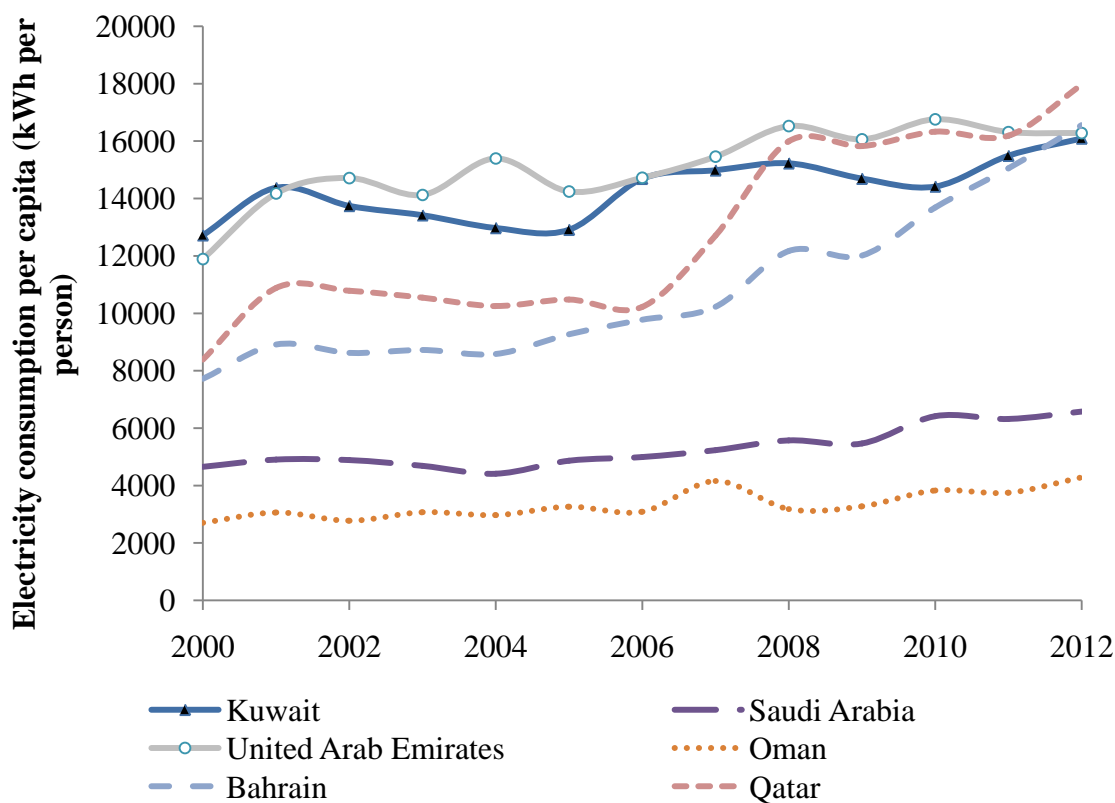
Bahrain is making plans to begin an upstream initiative that will enable them to restructure offshore blocks, allowing natural gas reserves within the area to be increased. This initiative is one of the first to emerge from the country. Bahrain is hoping that new oil discoveries can help them resolve their declining natural gas problems that they are experiencing within the area. Searching for new sources to pump natural gas from, has become a priority for the Kingdom. Making natural gas sustainable has proven to become an exhaustive feat[2].



**Table (1) Oil and Gas production figures 2012**

Crude Oil	69,452
Bahrain Field	15,516
Abu Saafa Field	53,936
Gas*	552,118
Refinery	96,026
Liquids of Gas	3,933
Petrochemical**	1,575

\*Million Cubic Feet \*\*Thousand Metric Tons - Source: National Oil & Gas Authority Annual Report OIL & GAS PRODUCTION (,000 barrels) for year 2012



**Figure (6) the Electricity consumption per capita in the form of Kwhr per person in GCC countries**

GCC countries' consumption is driven largely by home use, with almost 47% of the energy consumption siphoned into residential use as compared to a global average of around 25%. In 2011, each person in the GCC countries consumed on average 10300 GWh of electricity against a global average of 2852 GWh and a Middle East average of 3562 GWh. This consumption appears more reasonable when compared to the Europeans, North Americans who respectively consumed on average 7230, 14230 GWh of electricity during 2011. The per capita electricity consumption during the period 2011-2050 in the GCC is likely to increase at an annual rate of 2.7%. So in a matter of a few years, GCC residents may be absolute leaders in the per capita residential electricity use to race developed countries consumptions. Stemming information's of electricity consumption patterns of the industrialized and industrializing countries, the accomplishment of an economic diversification policies the GCC may be among other

attempts that requires a full shift in electricity consumption in terms of Gwhr from ‘Residential’ to ‘Industrial’ consumption figures.

### 3. Natural Gas In State Of Kuwait

The state of Kuwait produces a fairly modest amount of natural gas per year. During the last count of how much natural gas the state produced in a single year, the figures stated 396 Bcf. The natural gas produced in this region is associated gas. It is typically produced in conjunction with oil. Kuwait is the twentieth most plentiful producer of natural gas, and has an ample amount of natural gas reserves. The state contributes 56 Tcf, which is roughly 0.9 percent of the world’s total natural gas reserves[4].

The state of Kuwait has hopes to increase the amount of natural gas that is used within the area. They want to increase its usage on both an imported and domestic guideline. Kuwait is hoping it can utilize natural gas to assist with generating electricity, for petrochemicals, as well as for the desalination of water. Switching to natural gas, would free up the substantial amounts of oil that the state utilizes. Kuwait continuously searches for a large supply of non-associated and associated natural gas, while reducing the amount of natural gas that is flared in the area[6].

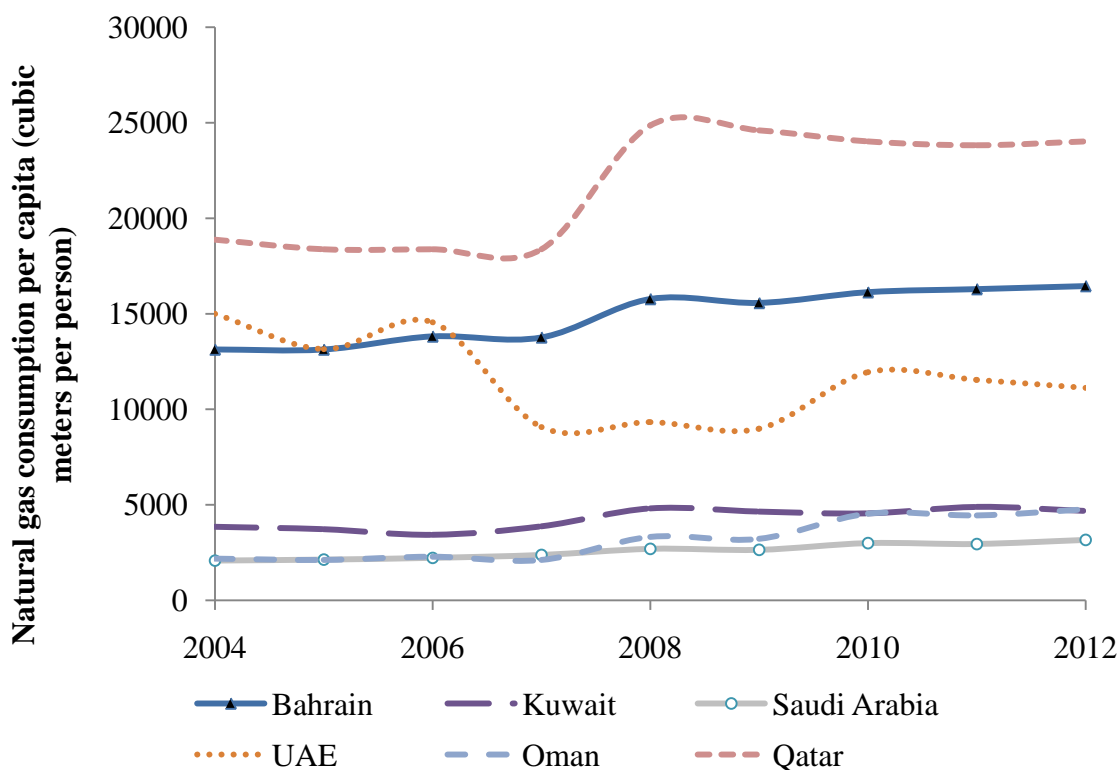


Figure (7) Natural Gas Consumption in GCC countries

Kuwait and Qatar signed an agreement amongst one another to start importing gas from Qatari lands. Qatar encompasses the largest offshore natural gas field that is non-associated. A \$2bn pipeline project was signed for that would enable a pipeline to run from Qatar to Kuwait.

Aside from doing business with Qatar, Kuwait is also attempting to enter into arrangements with Iran, when it comes to obtaining the natural gas that they have available. The countries signed a memorandum with one another

that will enable Kuwait to utilize some of the gas to be used for the desalination of water and the generation of power.

It is unclear if the gas demands that Kuwait has will be able to be supported by Iraqi, Iranian, and Qatari export projects. However, in any regard, the deal for natural gas that Kuwait struck with Iran is being upheld. Additional non-associated gas was discovered along the shore of Kuwait. With this discovery, Kuwait is hoping that they can become self-sufficient, and not have to rely upon the memorandums that they previously signed with other countries within the GCC[8].

#### **4. Natural Gas In The Kingdom Of Saudi Arabia**

The natural gas reserves that have been located in Saudi Arabia are ranked the fourth highest in the world, with 241 Tcf, they have increased by 5 Tcf, since 2002. Roughly sixty percent of the proven natural gas reserves that are located in Saudi Arabia are associated gases, they are taken from the shores of the Ghawar fields, as well as the offshore areas of the Zuluf and Safaniya fields. The Ghawar fields on their own, account for one third of the natural gas reserves within the country. However, only fifteen percent of the natural gas within Saudi Arabia has been explored adequately for this type of gas[11].

A lot of the natural gas reserves that are located in Saudi Arabia were discovered during the 1990s. Most of the non-associated reserves are located throughout the Khuff reservoir that is positioned underneath the Ghawar oil fields. Natural gases can be found in the northwestern part of the country, as well as within the southeastern deserts.

Another fairly large reserve can be found in an area that is known as Durra. This area is located offshore of the Khafji oil fields. Developing this area, has proven to be a controversial feat. The reason being is because a portion of the reserve belongs to Iran. The field borders Iran and Kuwait, who are both in agreements over the area. Saudi Arabia was able to reach an agreement with Kuwait, in order to be able to share the Durra area. At the present time, Iran is resistant to Saudi Arabia and Kuwait developing the open field on their own[6].

##### *4.1 Gas Find Is Reported In Saudi Arabia*

According to the oil minister within Saudi Arabia, there has been a new field that has gas in it, that has been discovered. The field is located along the Eastern Province, and is known as Zamlah. This new discovered gas field has the ability to produce natural gas at an alarming rate. The field can produce the required natural gas, at 20MMcf. 1400 barrels were tested back in June[3,8 &19].

Reports speculate that the area may have the ability to produce 80Mmcf every single day. There are additional tests that are being conducted, to determine if the area can feasibly be utilized as a primary site for a gas plant.

#### **5. Natural Gas In Sultanate Of Oman**

Even though oil continues to be the primary source of revenue in Oman, the country has decided to make natural gas a primary focus when it comes to growing its economy, and diversifying its resources. The growth strategy is sprung by exporting LNG and implementing gas based projects for the area. Through intense exploration, Oman has risen the amount of natural gas reserves that it has within its area from 12.3 Tcf back in 1992, to its present standing of 29 Tcf.

The government has plans to continue on with its aggressive exploratory campaigns. A lot of the reserves that Oman has are located in areas that are owned for petroleum developments. Which, the PDO, is the largest natural gas producer within Oman. Most of the natural gas that Oman produces is associated with oil in some way, even the natural gas that is non-associated, is typically located along the oil fields that are found within the country. Roughly 10 Tcf of natural gas within Oman that is non-associated, can be found in geological structures that are deep within the earth, many of which, are directly beneath oil fields that are actively producing oil. Back in 2003, Oman was able to produce 583 Bcfs of natural gas[3,4,7,&19].

The total production of natural gas, within Oman, continues to increase. In 2005, there was 917.7 Bcf of natural gas that Oman produced. This accounted for a 7.6 percent increase from the levels that the country was producing in 2004. During 2005, there were ten non-associated gas fields that were producing natural gas, and four of these fields, belonged to the PDO.

Natural gas within Oman is utilized for re-injection into oil reserves. The gases are used to help sustain oil production, as well as be used for LNG. The natural gas is also used in certain areas of Oman, as a fuel that powers desalination units, textiles, cement, and other types of industrial products throughout the country. Moving forward, natural gas utilization will continue to increase within the region, as more gas-based industrial products are introduced. Products such as cement, fertilizer, petrochemicals, and aluminum will require the utilization of natural gas[13&17].

### *5.1 Exporting LNG*

LNG is a big part of Oman's plans to develop their countries natural gas sector. Therefore, the country has chosen to invest heavily in their LNG project. In 2005, the exports for LNG within Oman, reached 7.06mn tons, in comparison to the 6.9mn tons that the country exported in 2004.

Production of LNG has been split between two different liquefaction plants. There have been some talks with India, about possibly allowing them to take a stake of equity within the plants that Oman uses for production. Allowing India to obtain a stake in equity, will greatly depend upon how viable the project is, and the amount of future customers that will require the utilization of natural gas, in the future.

Major desalination of the exports of LNG in the country, was sent to USA, South Korea, Spain, Japan, as well as France. Oman exported one hundred ninety eight thousand tons of the by-products of LNG to UAE, during 2005. Gas revenues revealed an improvement in the amount of money that Oman is bringing in from their contribution to the natural gas sector. Revenues increased by 8.6 percent, in the matter of one year. The increase in revenue, is a direct result of increased exploration within the country of Oman.

## **6. Natural Gas In United Arab Emirates**

According to the Oil and Gas Journal from January 1<sup>st</sup> of 2006, the amount of natural gas reserves within UAE is 214.4 Tcf. This makes the UAE, the fifth largest reserve area for natural gas, after Iran, Russia, Saudi Arabia, and Qatar. The largest reserves within the UAE were located in Abu Dhabi. Additional reserves were scattered throughout the area, with some appearing in Dubai, Sharjah, as well as Ras. The reserves within Abu Dhabi, are non-associated. These natural gas reserves can be found beneath Umm Shaif and the oil fields in Abu al-Bukhush, which rank as one of the largest reserves in the entire world.

Increased domestic consumption of energy, along with increased demands coming from the petrochemical industries has helped to provide incentives within UAE, in order to boost the amount of natural gas that is being used within the area. Over the past ten years, the amount of natural gas that is consumed in the UAE has doubled. The ever-growing development of natural gas fields has also caused an increase in production to occur.

Over the past few years, the UAE has made moves to embark upon a massive program that requires an investment of multi-billion dollars, within the natural gas sectors. The investments being made within the sector include, shifting towards natural-gas fired plants and transforming the commercial district located in Taweelah into a zone that only utilizes natural gas. A plan that has been given the name the Dolphin project is currently underway. This plan will allow the natural gas grids that are located in the UAE, Qatar, as well as Oman to interconnect with one another. Most of the natural gas needs that the UAE will face in the upcoming decade are going to be satisfied by importing natural gas from the country of Qatar. The development of the natural gas sector that is taking place in the UAE, is going to involve extracting NGLs and then re-injecting the gas in order to ensure that the oilfields remain under the right types of pressure.

The Dolphin Project is going to focus on developing links that exist between natural gas infrastructures in several GCC countries. This project is going to allow natural gas that is non-associated to be exported from the massive

shores of Qatar. Cost estimates have revealed that conducting this project is going to take anywhere from \$8 billion to \$10 billion throughout the next decade. The country of Oman, already has a pipeline that is shares with the UAE, until supplies from the country of Qatar are made available, importing of natural gas from Oman will continue, under the Dolphin Energy project.

## **7. Natural Gas In State Of Qatar**

With reserves that have proven to be 911 Tcf, the natural gas reserves located in Qatar, continue to rank third in size, just behind Iran and Russia. Most of the natural gas reserves within Qatar can be found along the offshore section of North Field. North Field is the largest non-associated gas field in the entire world. In addition to having this non-associated field, Qatar also possesses the Dukhan field. This field has an estimated amount of 5 Tcf along with 0.5 Tcf of non-associated natural gas as well. Smaller associated gas reserves are scattered throughout the country[7].

The government in Qatar, believes that the economic future of their country, is going to greatly rely upon developing the natural gas potential that the country possesses. There are presently two LNG exporters within Qatar. These exporters are the Ras Laffan LNG Company, as well as the Qatar LNG Company[3].

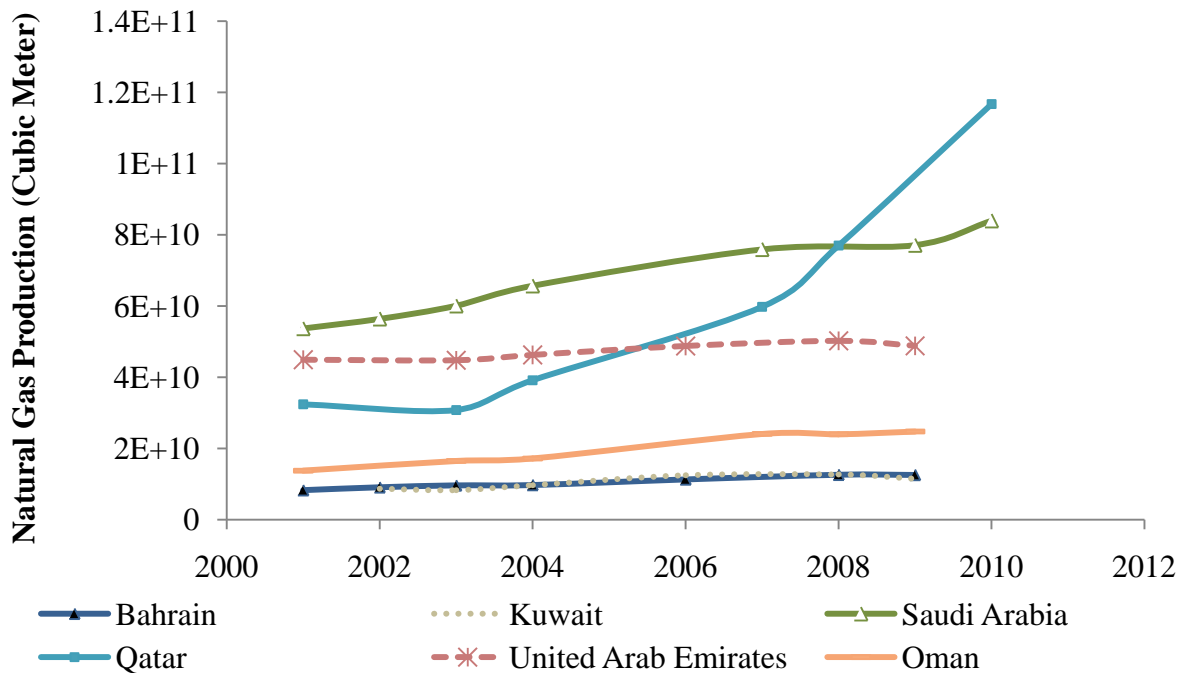
Rasgas is the second largest LNG project within Qatar. The two shareholders of this project are ExxonMobil and Qatar Petroleum. An agreement was signed between these two shareholders in October of 2003, to begin constructing Rasgas II, which would enable the LNG exporting company to add 756 Bcf to their liquefaction capacity[2].

The original markets that Qatar exported its LNG to were South Korea and Japan, which are the world's two largest LNG importers. India has more recently joined the market to obtain Qatari LNG projects. The proposed Dolphin project is in the works, which will help to tie the natural gas that is produced by Qatar together within the UAE. This project has caused an increased desire for the UAE and Oman to utilize more natural gas in order to assist with generation of power as well as industrial uses. This will also decline the amount of production that is going on in both of these countries consecutively. Pakistan has made some announcements about joining in on the project, however, their participation with the project, is still highly doubtful, due to the financial conditions that would have to be met, and the possibility that imports from Iran would be required.

## **8. Analysis The Natural Gas In Gcc Till 2050**

### *8.1 Strategy Options For Energy Transitioning In The GCC*

Many countries within the GCC have seen the benefits of consuming and exporting fossil fuels. However, diversification of fuel sources has become a growing concern for the region, due to security, economic, and environmental considerations being taken. The ability to address this concern, will be important if the GCC region is going to successfully transition their energy sector, it will also require additional investments to be made that will help to further the extraction of hydrocarbons, and their production. Aside from focusing on hydrocarbons, also nuclear and renewable will also need to be taken into consideration as the region opts to upgrade the various ways that they integrate upgrades to their electrical grids. Also, sharing equal importance, is the demand management initiatives that are being taken in order to slow down the speed that energy is being consumed, allowing the region to strive for energy efficient electrical utilization, and conserve fossil fuel resources. The ability to be able to provide energy that is cost effective, clean, and reliable, has become the driving force for the region, as it relates to diversifying the regions fuel source. Energy transition within the GCC, is also important to ensure that the region is able to continue building its economy, without inflicting a massive amount of costs onto the environment. Fossil fuel subsidies, may end up playing key roles, but will require proper modeling and further analysis to be conducted, in order to be able to fully understand what the political and economic impacts of the subsidies will be.



**Figure (8) Natural Gas Production in GCC countries**

The GCC energy transition initiative challenges will need to be taken into consideration, within regional environments, as well as within localized political chains, that are consistently evolving their relationships between national and international oil companies, concerns regarding the safety of the nuclear energy markets, as well as international commodity markets, and the uncertainties that exist regarding the reserves of hydrocarbons that are able to be extracted in an economical manner. Aside from these issues, economic expansion, along with rapid growth rates in population, coupled together with challenging climatic changes has placed an immense amount of pressure on the capacities of power generation, that are associated with distributing and transmitting networks. Strategies are required in order to be able to address the complex issues collectively.

Some studies [10&9] outlines that the GCC countries need to be able to develop economic, social, geopolitical, and environmental contexts that are suited for the region. He argues that even though the designed energy strategies that the GCC region is involved in are designed specifically for the area, that the strategies need to also take national concerns into consideration, as there is a lot of opportunity for coordinated actions to take place. Actions that are taken towards providing clean energy with an increased amount of efficiency is not only going to help to preserve the environment of the region, but it will also help to ensure that the fossil resources remain a core influential part to the various regional economies within the region. Taking some examples from the initiatives that have been made in the UAE, Dr Al Jaber has been able to show that the countries within the GCC, have the opportunity to be able to extend their leadership on a global level when it comes to energy. This extension will help the region, throughout the twenty first century and beyond[11].

### 8.2 Power and Water Sector

With the increased amounts of urbanization and the rapidly increasing population, combined with the large amounts of diversification programs taking place within the GCC region, by the governments, there has been a massive amount of demand surging within the power and water sectors, throughout the entire region. The GCC region, is already ranked as being the largest in terms of the amount of consumption that is taking place within these facilities. The large consumption is due in part, by the low amounts of tariffs within the region, along with climatic conditions, that encourage heavy utilization of valuable resources[5, 14 & 20].

In order to be able to adhere to the estimated gaps that are already being combated in the GCC region, when it comes to supply and demand, countries within the GCC, will have to individually, take the proper steps necessary, in order to invest in water and energy infrastructures in the upcoming years. There is a large amount of potential that is offered by the sea waters that surround the region. These waters can be used in terms of desalination, in order to adhere to the needs of water and electricity demands that has prompted these areas to make hefty investments of \$300 billion, during the time frames of 2012 thru to 2022, in the water and power desalination projects. Public private partnerships are continuing to drive the growth within this sector, the increased demand for pipelines is going to likely be fuelled by the increased amount of growth, as a feeder in the industry to supply the desalination sector between the time frame of 2012 to 2022 [12, 15 & 18].

### *8.3 Infrastructure Sectors*

In order to avert the spread of public unrest that is similar to that of its regional neighbors, and in an attempt to be able to shield the economy from the adverse effects that global economic slowdowns can have, to reduce the dependency on hydrocarbons as the main source of revenue generation within the economy, there are a lot of GCC governments that have taken it upon themselves, to embark on spending programs that will include vital spending for housing, utilities, and infrastructures[13, 17 & 20]. Infrastructures, such as air transport, surface transport, education, social housing, and hospitality have been given the utmost importance when it comes to the budgets that the GCC has. These investments are more than likely going to cause a spillover in increased demands for pipelines throughout the region, that will not only be adopted to be utilized for sewage and waste water reasons, but to also be used for cooling and heating, and other cross section applications, will possibly, increase due to this trend[6&9].

### *8.4 The Gas Sector*

It is well known that whenever pricing for anything is kept at an artificially low rate, that this will likely stimulate escalated consumption practices that do not correspond with the commodity being scarce. Gas consumption within the GCC has managed to double over the past few years. This increased demand for gas, has affected the prices of the commodity and investment decisions that are being made by companies that offer the commodity are having adverse effects on the way that the resources are being allocated across economic sectors, due to pricing signals, not correctly corresponding with the social costs of the utilization of energy[12&17].

### *8.5 Energy subsidies*

Energy subsidies that are being given in the GCC, have a lot to do with the consumption patterns of individuals within the areas. In Saudi Arabia, the government provides 43.5 bn in subsidies for gas, this equates to 9.8 percent of GDP within the area. The same occurs within Qatar, UAE, as well as Kuwait. In Qatar there are 4.2bn in subsidies given for gas, which equates to 3.2% of the country's GDP. In the UAE, 18.2BN is given in subsidies, equating for 6 percent of the country's GDP. While in Kuwait, 7.6bn is given in subsidies from the government, this equates for 5.8 percent of the GDP within the country[13, 12 & 20].

### *8.6 Hydrocarbon Shares in The GCC*

In Saudi Arabia, 40 percent of the GDP of hydrocarbons are shared, 85.7 percent of the hydrocarbons that come from the area are exported. The UAE has a 31.5 percent of GDP for hydrocarbons, of those 35 percent of the hydrocarbons are exported to other countries. Qatar has a 51.7 percent GDP for hydrocarbons, which of the amount of hydrocarbons that the area has, ninety two percent of them are exported[13]. Oman has 46.5 percent GDP of hydrocarbons, 68.9 percent of the hydrocarbons within the area of Oman are exported for other countries to utilize.

## **9. Energy Subsidies In Gcc**

Energy subsidies are often times defined as a diffuse concept. The definitions of these subsidies remain contested on different sides, which has been declared evident by the continuous inability of large international organizations such as the IEA and World Bank[13]. According to Calamai and De Moor, energy subsidies are better defined as being, any specific measure that will keep prices on specific commodities for consumers, below the market levels, or keeps prices for producers of the specific commodity, above the market levels that helps to reduce the costs associated

with the commodity for consumers and producers, by offering either indirect or direct support, for anyone that requires its use[18].

Clearly by the definition that is given for energy subsidies, it is safe to say that the definition defines that various governments taken actions when it comes to categories that involve assistance, credit subsidies, procurement subsidies, tax subsidies, and in-kind subsidies. These subsidies are for on-budget, as well as explicit subsidies that constitute transfers that are made by the government to either a consumer or a producer that is receiving subsidies that are registered within the state's general budgets[1&13]. The governments may mandate that a specific public utility is set to be sold below the selling price, as well as below the amount that it costs to produce the utility. The government, will then have the task upon themselves, to finance the losses that the utility incurs due to the subsidized prices that have been forced upon them[12].

Energy subsidies may also be cross-financed between different types of energy user groups. Cross-subsidies occur whenever tariffs are issued below the costs of production charges. For example, household users along with the revenue shortfalls for these types of offset tariffs will cause the commercial sectors to experience above the cost levels, for offering their specific commodity. There are other types of uniform cross subsidies that can be located within national uniform pricing systems, these are normally applied with single tariff structures, and then later applied to consumers, based on the locations that they reside in. However, in countries within the GCC, where the public utilities do not recover the costs of the subsidies, it is evident that this type of method is imperfect, with various sectors losing revenue, due to their enactment[13&19].

## **10 Conclusion**

Natural gas, which used to be an ignored commodity, has attracted the attention of oil majors all over the GCC region, and worldwide. Many oil majors are making it a focus of theirs to pour billions of dollars into projects, in order to adhere to the increased demand for the utilization of this environmentally friendly fuel. Oil is going to continue to remain supreme, within the transport industries. However, gas will soon find its way into the homes of power stations, replacing coal forever.

The demand for natural gas is steadily increasing. In fact, natural gas, comes in second right after coal, as the fastest growing energy source. The shares of natural gas, are expected to climb to twenty eight percent by 2030, from the 23.5 percent that it was at during 2005. This equates to an increase of 4.5 percent that can be justified by the environmental issues and high prices of oil, which will help to encourage customers to put their reliance in natural gas products. Technological developments, especially when it comes to the transport sector, will be a primary factor that will drive the world's demands for natural gas.

Moving forward, the utilization of natural gas within the GCC region, is expected to double between the time frame of 2003 and 2030, where various countries that export oil within the region, have sought out to expand their natural gas domestic sector use, in order to ensure that oil is readily available for exporting.

The future of natural gas, which is an efficient, environmentally friendly, and clean fossil fuel should enable it to be much brighter than the future of oil. However, there are still some uncertainties that surround the future of the demand of this type of gas. Gas has been put into direct competition with oil. Future trends in price, of the latter will not have any actual bearing on the consumption of natural gas. A decline in oil prices, does not favor natural gas. However, environmental concerns do, along with the expense of oil, and the tax policies that outside consumer countries have put on penalizing oil, in favor of utilizing natural gas, instead.

Presently, Oman, UAE, and Qatar are the largest exporters of LNG. They contribute twenty three percent of the world total amount of LNG exports, which is positively affecting their economies. However, there are beliefs that opening up this new type of energy sector to enable foreign investments to have a piece of the pie, is going to increase the production of natural gas, in the upcoming future. GCC governments are considering implementing foreign participation when it comes to their hydrocarbon sector. They are continuously constructing various expansion plans that are expected to come to a climax within the upcoming five years.



GCC countries presently possess twenty five percent of the world's natural gas reserves. Significant amounts of natural gas, in volumes have been discovered within the region. The amount of natural gas that has been undiscovered within the world is estimated to be 4221 trillion. Of the new natural gas resources that are expected to be added by the year 2025, reserve growth will account for 2347 Tcf. More than a half of the undiscovered natural gas is expected to come from the GCC region.

The private sector in the GCC region has the ability to be large enough to show resilience in order to be able to handle large projects in various sectors. It is expected that the energy sector will benefit by the entry of the private players, who possess knowledge and have skills that will help to add value, while still working alongside the public sectors.

The returns across the economic sectors are variable. Therefore, the countries located within the GCC are consistently looking for ways in order to be able to diversify their economies. Intra trading within the GCC is expected to increase the amount of major projects that are being constructed within the region.

## References

1. ABB, Trends in Global Energy Efficiency 2011(2011). Database available online at: <http://www.abb.com/cawp/db0003db002698/081f212da18596afc12579ba004babb9.aspx> (retrieved July 2011).
2. D.Z. Alge'rie, 'Contrebande d'essence entre l'Alge'rie et le Maroc', Alge'rie DZ (2 July 2008).
3. Arab Times, Subsidized fuel smuggling costs Kuwait KD 245m yrly, Arab Times (17 November 2011).
4. Arab Union of Electricity Producers, Statistical Bulletin 2009 (in Arabic) (2009). Available Online at: <http://www.auptde.org/Publications.aspx?lang%4ar&CID%440> (retrieved July 2012).
5. Arabian Business, Fuel Prices Skyrocket as Jordan Cuts Subsidies, Arabian Business, 9 February 2008.
6. Bloomberg, Syria to Raise Fuel-oil Price to Limit Smuggling, Bloomberg, 10 August 2011.
7. BP, Statistical Review of World Energy (June 2012). Available online at: <http://www.bp.com/sectionbodycopy.do?categoryId%47500&contentId%47068481> (retrieved July 2012).
8. C. Breisinger, W. Engelke, O. Ecker, Petroleum Subsidies in Yemen: Leveraging Reform for Development, International Food Policy Research Institute (IFPRI), March 2011.
9. F. Bressand, D. Farrell, P. Haas, F. Morin, S. Nyquist, J. Remes, S. Roemer, M. Rogers,
10. J. Rosenfeld, J. Woetzel, Curbing Global Energy Demand Growth: the Energy Productivity Opportunity, McKinsey Global Institute, May 2007.
11. B. Clements, R. Hugouneng, G. Schwartz, Government Subsidies: Concepts, International Trends, and Reform Options, IMF Working Paper, September 95/91, International Monetary Fund, Washington DC, 1995.
12. H. Darbouche, B. Fattouh, The Implications of the Arab Uprisings for Oil and Gas Markets. MEP 2,Oxford Institute for Energy Studies, Oxford, September 2011.
13. J. Dargin, The Gulf Natural Gas Dual Pricing Regime: WTO Rules and Economic Growth in the Gulf (August 2010). Dubai Initiative Working Paper.
14. De Moor, P. Calamai, Subsidizing Unsustainable Development, Earth Council and the Institute for Research on Public Expenditure, 1997, p. 1. Available at: <http://www.cbd.int/doc/case-studies/inc/cs-inc-earthcouncil-unsustainable-en.pdf> (retrieved July 2012).
15. J.A. Del Granado, D. Coady, D. Gillingham, The Unequal Benefits of Fuel Subsidies: a Review of Evidence for Developing Countries, IMF Working Paper, WP/10/202, The International Monetary Fund, Washington D.C., September 2010.
16. C. Ebinger, J. Banks, K. Massy, G. Avasarala, Models for Aspirant Civil Nuclear Energy Nations in the Middle East. Policy Brief 11-01, The Brookings Institution, Washington D.C., September 2011.
17. EIA, International Energy Outlook 2011, U.S. Energy Information Agency, Washington DC, 2011.
18. Al Jaber. Sultan; Opening Remarks Dr Sultan Ahmed Al Jaber IRENA General Assembly <http://www.huffingtonpost.com/dr-sultan-ahmed-al-jaber/> accessed August 2013 and <http://www.irena.org/DocumentDownloads/IRENA%20A1%20Jaber%20opening%20remarks%20jan%202013.pdf> accessed August 2013-08-24 Index Mundi, <http://www.indexmundi.com/g/g.aspx?v=137&c=ba&l=en>
19. Ventures Middle East Report, GCC Energy Sector – Quarterly Review, 2011, <http://www.pipelineme.com/media/797136/GCC-Energy-Industry-Mar-2011.pdf> accessed on 1 September 2013