

# Estimation of the Oil Demand Domestically in Saudi Arabia in 2050

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**Abstract:** Saudi Arabia's distinctive place as the biggest crude oil exporter in world is menaced by rapid growth & uncontrolled local consumption of the fuel. In 2016, the domestic consumption of oil has reached to a very significant level approximately 30% of overall production of oil. The purpose of this paper is to study "Inflation in local fuel consumption in Saudi Arabia" in the power plants, transportation & desalination of Saudi Arabia, and how this influence may affect the overall production of oil of the Saudi Arabia in the next decades, that may generate a huge economic affect. There are many factors that affect the oil consumption which are annual electricity & water demand, population, expansion of transportation & industrial sector. Time Series analysis has been applied through Minitab software to forecast/projection of these factors to reach to the situation of the local consumption level in 2050. Many assumptions have been adopted to reach best scenario which are, no depletion is considered, Saudi Arabia can produce more than 12.5 mb/d (currently 10.4mb/d) & Saudi Arabia is increasing its production of oil consumption annually. The conclusion is that, the Saudi Arabia could be net oil importer by 2047. The recommendation was focus on applying solar energy immediately on the power plant to produce electricity and the same time fresh water, adopt the Distribution Generation System, stop importing the non-energy saving lamps, expand the public transportation, make the farms self-independent of electricity using bioenergy and get the benefit from the Dams through installing generators.

**Keywords:** Oil Demand, Saudi Arabia, Crude Oil, Inflation, Power, GDP

## I. INTRODUCTION

Crude oil known as the most natural valuable resource in the world, its actual value more expensive than any other material such as diamonds, where nobody can use diamonds for industrial purpose, electrical generation, transportations and so many others field unlike crude oil which is playing a major role in these fields among others. Saudi Arabia recorded as the largest crude oil exporter in 2016 with %20.1 of total crude oil exports, and the largest producer in 2016 Saudi Arabia currently is the world's second-largest holder of proved oil reserves which own % 17.9 (268 billion barrels), rating as second to Venezuela [1]. The economic benefit from the proceeds of sale of crude oil helped Saudi Arabia to become one of the developed countries in the period of last two decades as the country's infrastructure has developed quite dramatically during this period. Saudi Arabia's overall exports are mainly depending on oil as the other resources either natural or not, yet not reached to the level of the global market. Besides that, the country is still focusing on expand refining and oil extraction operations. During last two decades, it has observed that the domestic demand for oil has rapidly grown. Saudi Electricity Company in the recent 7 years recorded fictional figures in the process of burning the oil to generate the electricity to cover the local demand. This statement floating a question, Does Saudi Arabia have renewable energy?

In fact, Saudi Arabia generated approximately 0.001% (0.5 MW) of their total generated power in 2016 (61,162 MW) through solar cells [2], where no wind turbines, dam's turbines, or any other non-oil generation method participated in this generated amount of power. This, the huge consumption of electricity made Saudi Arabia the biggest consumer for electricity in the Middle East and Africa [3]. Saudi Arabia currently is suffering from the lack of renewable energy in its electrical network. This

rapid growth observed in the transportation and desalination sector as well. Saudi Arabia currently consuming approximately 30% of the entire produced crude oil with an average increase of %5 annually over the past 35 years<sup>(4)</sup>. Saudi Arabia is now the 6<sup>th</sup> largest oil consumer in the world, trailing just the US, China, India, Japan and Russia. Moreover, the consumption of gasoline in transportation is dramatically increased in the recent years and reached to the level that local production through refineries does not cover the domestic consumption, which led Saudi Arabia's government to import hundreds of thousands of gasoline barrels from global market to cover the domestic demand every year [5 & 6]. At first glance, it is beyond the imagination that country that swims over the biggest filed of crude oil in the world is importing the gasoline from global market.

In 07/06/2016, Saudi Arabia released an announcement for its vision of 2030, where the major goal of this vision is to reduce Saudi Arabia's dependence on oil, by creating and adopting other sources to rely on economically, such as increasing the non-oil industrial sector in order to have a significant share in the global market. Other goal of the vision is to increase the generation of clean energy in the electrical network of the kingdom. With no doubt, the launch of this vision is proving the knowledge of the huge economic dangers that could be resulted from the increasing of consumption of oil domestically soon in all fields of the kingdom. It also observed that, no any goal raised or proposed in this vision to reduce or control the increasing of local oil consumption, to be as an immediate solution as adding or construct green energy power plants to the network required very long years.

In this paper, we studied and forecast the impact of rapid growth of domestic consumption of oil to the overall production up to 2050 and list some suggestions & recommendations that must be implemented immediately to control the rapid consumption so positive results will be touched in the short & long term.

## **II. STATEMENT OF THE PROBLEM**

The Saudi Arabia's distinctive place as one of the top crude oil exporter in world is menaced by rapid growth & uncontrolled local consumption of the fuel. The domestic consumption of the crude oil is reached to more than %30 of the total produced oil in the year of 2016 [4], and by reference to the enormous rise in the electricity consumption in previous years, the electricity consumption grossly increased more than double in the last 10 years (61162 GW – 2016) with by annual average %7 of increasing in electricity demand over the same period [2]. Moreover, the gasoline domestic demand has also increased extremely rapidly due to the increase of imported vehicles in the kingdom, where in 2013 reached to (1006284) imported vehicles, which are more by %1033 comparing with imported vehicles in the year of 1995 [7]. Such consumption with no doubt will endanger Saudi Arabia capability to export oil to the global market in the future and this will cause serious economic disasters.

## **III. IMPORTANCE OF THE STUDY**

Recently, most of the developed countries around the world start legalized use of energy and rely on other sources/methods to generate the electricity and adopt transportation methods that not fully dependent on gasoline and diesel. These countries predicted that oil as a source for generating the electricity and source transportation is not sustainable source and in any period in the future, it may have disappeared. This step become through the knowledge and appreciation of the importance of natural resources and the need to use it carefully so that lasts for next generations. Therefore, these countries start implementing other method to generate the electricity such as but not limited to, solar, wind, bio, dams, etc. This study will enable us to evaluate the current situation in Saudi Arabia to follow alternates solutions that may help to not depend on oil.

## **IV. OBJECTIVE OF THE STUDY**

Study the impact of rapid growth of domestic consumption for oil to the overall production in the next

32 year and see what will be the situation in 2050, what the affects may happen to the production and consumption of oil in Saudi Arabia, this study will encourage us finding immediate & mandatory solutions as ignoring the current high consumption will results very economic problems in the future and reduce the export of oil, to find solutions that can be started to reduce the electrical consumption per capital and solutions that can limits the use of oil in general which will avoid burning the most valuable resource in the world as much as possible domestically, to predict the oil domestic consumption in 2050 we have to see the factors that play a major role in consuming the oil locally, which are as an example the electric demand, gasoline of motor, etc. In addition, see whether they will remain the same, increased or decreased and accordingly the reflection of these to the production of oil.

## **V. RESEARCH METHODOLOGY**

To be able to predict the future oil consumption, the major step is to know the consumed oil in the major sectors of Saudi Arabia, moreover ensure these sectors will never remain same through projection/forecast for the next 32 years so we can have an initial imagination about the consumption in the future whether will increase, decrease or remain the same, therefore collecting the following data:

- The consumed oil & gas in the power plant of Saudi Electricity Company (SEC), desalination plant of Saline Water Conversion Corporation (SWCC), MARAFIQ and other licensed companies for generation over the past 35 years, to forecast/predict the future need of oil.
- The electrical demand of the kingdom over the past 35 years to predict the future electrical demand.
- The imported vehicles in the past 20 years
- The domestic consumed gasoline & diesel inside kingdom for industrial and transportation sectors.
- The produced oil from ARAMCO.
- Review solutions to reduce the dependency on oil that other country made.

Usage of Reference & Computer Program

This report considers the book of Business Forecasting by John E. Hanke 9<sup>th</sup> edition. And using the computer software of Minitab Statistical Software version 17 for prediction/forecasting.

## **VI. LITERATURE REVIEW**

This section reviews literature/articles that related to many publishers who warned Saudi Arabia if the oil consumption remains following same pattern of rapid growth, some of the publisher predict that Saudi Arabia will be net importer soon due to the non-control of high consumption of oil domestically. The section highlights their views and suggested possible solution that can be adopt by the government of Saudi Arabia to control the high domestic demand.

*Sameer Said and Ahmed Alomran* (2015) wrote a journal discussed the raises of the domestic oil in kingdom, ability of Saudi ARAMCO production as output averaged 9.22 million barrels a day from 2006 to 2014 and how the challenge is increase year by year due to increasing in development and population that increased by 17% since 2005 faster than most developed countries. Total Saudi crude burned for domestic use more than 14% in 2014 over 2013. They also mentioned that Saudi officials have repeatedly warned that demand for energy, particularly electricity, has been rising to challenging levels, but the kingdom's plans for nuclear and solar power have made sluggish progress. They clarify on basic solution to compete this growth which is, the government could take, but has not, is eliminating subsidies for domestic energy products. Those subsidies keep gasoline prices at 50 cents a gallon and electricity costs for consumers as low as 1.3 cents a kilowatt-hour, far lower than U.S. prices

for both [8].

*Eckart Woertz* (2014) the writer started his article explaining how Saudi Arabia is faced with mounting problems in its domestic energy market which affect its ability to function as the global swing producer, as a result, its ability to export oil may dwindle or even disappear altogether. Consumes a quarter of its own production. Moreover, he mentioned that government failed (up to the Article was published) to find new sources of natural gas. He also highlighted that Saudi Arabia wants to build 16 nuclear reactors until 2030, but question marks remain over safety issues, cost overruns and a lack of available experts. He showed also that Saudi Arabia should use clean solution to generate the electricity as other countries adopted since many decades ago which as an example solar energy, where Saudi Arabia has only a paltry 12 MW of total installed solar capacity. Which means Saudi Arabia shall start immediately investing in the green energy to compete the domestic demand in energy since it has the financial ability [9].

*Saadallah Al Fathi* (2015) the publisher stats with clarifying that the fall in crude exports hides the rise in domestic refining and product exports in addition to the seasonal rise in direct crude oil burn for power generation. He is stating that Saudi Arabia's production in May stood at 10.333 million barrels a day (mbd) slightly higher than April's, its exports were 6.935 mbd, down from 7.737 mbd a month earlier, domestic refineries ran 2.4 mbd, up from 2.2 mbd in April and 20 per cent above a year earlier. According to "the American Energy Information Administration (EIA) said, "Saudi Arabia is the largest oil-consuming nation in the Middle East. Saudi Arabia consumed 2.9 million barrels per day of oil in 2013, almost double the consumption in 2000, because of strong industrial growth and subsidized prices." [10].

*Eric Reguly* (2014) the article writer was wondering how cheap the gasoline in kingdom is during his visit to Saudi Arabia, Jeddah in 2014, he was wondering that during his visit of six days in Saudi Arabia, in three cities on two coasts, he never saw a bicycle, a scooter or an electric car. Moreover, he was wondering also how the cars are very many and no one walk. "In my travels, I did not see a single solar panel or wind turbine. The extreme heat means that air conditioning is a necessity, ditto desalination plants to provide fresh water (a Saudi aquifer that was once the size of Lake Erie is 97 per cent drained). In the summer inferno, 800,000 barrels a day of oil is required for electricity generation alone. He also explains that the Citi group report, which was dismissed as fantasy in Saudi Arabia, is probably directionally right. It is hard to see Saudi exports rising from the current 7.7 million barrels a day when the domestic economy is getting ever thirstier for oil. At the of the article the writer was thinking that KAEC was built to create non-oil commerce and industry in Saudi Arabia, yet the city will be utterly dependent on oil to survive, and we warned if the government didn't start using renewable energy to limit the internal oil consumption, this will be reflected to become global problem [11].

*Yukari Hino* (2015) the article was explaining how Saudi Arabia the biggest oil exporter in the world may become net oil importer by 2030 or 203 through several studies predict this situation. The writer also mentioned how other regional energy exporters such as the United Arab Emirates, Kuwait, and Iran have worked to control their domestic consumption to address the skyrocketing costs, economic distortions, and potential vulnerabilities of high rates of internal energy utilization. He was wondering how Saudi Arabia the biggest energy consumer in the Middle East is currently. Energy demand in Saudi Arabia has increased annually by an average of 7.5 percent over the last five years. Moreover, the kingdom's energy intensity is four times that of energy efficient countries, such as Britain and Germany. The writer discusses how Saudi Energy Efficiency Center (SEEC) will play an important role in control the efficiency of residential users, the service sector, and the transport sector. He mentioned also positive step that the government has finished a renewable energy procurement plan, which aims to augment renewable energy capacity by 20 GW in 2020, 40 GW in 2025, and 54 GW in

2032. The writer warned and said the concerns (high domestic consumption of oil in Gulf countries) should be particularly acute in Asia, since many countries, including the Philippines, Korea, Japan, and Taiwan, are overwhelmingly dependent on Gulf oil exports. With the dependence of the United States predicted to drop by more than 20 percent between 2010 and 2020, governments in Asia should consider strategies to hedge against future supply disruptions resulting from unrestrained energy consumption at home in Saudi Arabia and other key Gulf oil exporters [12].

*Rebecca George* (2014) the writer shows that Saudi Arabia is one of a handful of countries that burn crude oil directly for power generation, according to the Joint Organizations Data Initiative (JODI). During the summer, Saudi Arabia typically experiences an increase in electricity consumption as domestic demand for air conditioning rises and how Saudi Arabia burned 0.9 million barrels per day (bbl/d) of crude oil in July, the highest ever recorded in JODI data for the month of July and the highest overall since August 2010. The gross domestic product (GDP) growth in Saudi Arabia in the first quarter of 2014 was 4.7% year-over-year compared to 3.8% growth in the first quarter of 2013. In addition, Saudi Arabia's Central Department of Statistics & Information estimates that the country's population will grow 2.6% in 2014 to more than 30 million residents, further increasing electricity demand. Finally, the writer stated that Saudi Arabia plans to diversify its power generation sources and improve overall energy efficiency. By 2032, Saudi Arabia is planning to more than double its available generating capacity from 58 gigawatts (GW) to 120 GW by developing solar and nuclear power generation [13].

*Ayesha Daya and Dana El Baltaji* (2012), discussing that the oil and its derivatives are used for about half of the kingdom's electricity production, which at peak rates is growing at about 8 percent a year. A quarter of the country's fuel production is used domestically, more per capita than other industrialized nations. "If Saudi Arabian oil consumption grows in line with peak power demand, the country could be a net oil importer by 2030," Heidi Rehman, they also mentioned that Saudi Arabia, which depends on oil for 86 percent of its annual revenue, is accelerating exploration for gas and is planning to develop solar and nuclear power to preserve more of its valuable crude for export. They also explain how the young population in Saudi Arabia playing a major role in the consumption of oil and how Saudi Arabian power providers pay \$5 to \$15 a barrel for its fuel from state-owned Saudi Arabian Oil Co., and because of its subsidies the calculation of 'lost' oil and gas revenues to Saudi Arabia in 2011 to be over \$80 billion. Therefore, they were saying that the only way to reduce the domestic consumption is to reduce subsidy levels to the oil [14].

*Glada Lahn and Paul Stevens* (2011), these analysts evaluate the kingdom oil consumption. They are examining the causes for concern. Chatham House simulations reveal that, on the current trajectory, Saudi Arabia's domestic energy consumption could limit its exports of oil within a decade. This would have a severe effect on government spending, over 80% of which is dependent on oil revenues. Ultimately, it may reduce Saudi Arabia's spare production capacity, causing greater volatility in the world oil markets [15].

*Dermot Gately, Nourah Al-Yousef and Hamad M. H. Al-Sheikh* (2011), They analyze the rapid growth of Saudi Arabia's domestic oil consumption, a nine-fold increase in 40 years, to nearly 3 million barrels per day, about one-fourth of production. Such rapid growth in consumption – 5.7% annually, which is 37% faster than its income growth of 4.2% – will challenge Saudi Arabia's ability to increase its oil exports, which are relied upon in long-term world oil projections by the International Energy Agency (IEA), US Department of Energy (DOE) and British Petroleum (BP). However, these institutions assume unprecedented slowdowns in Saudi oil consumption – from 5.7% annual growth historically to less than 2% in the future – allowing them to project increases in Saudi oil exports. Using 1971-2010 data, they estimate that the income responsiveness (elasticity) of oil consumption is at least 1.5 – using both Ordinary Least Squares regression and Cointegration methods. They believe that

continued high growth rates for domestic oil consumption are more likely than the dramatic slowdowns projected by IEA, DOE and BP [16].

*Andrew E. Hashim* (2014), They said Saudi Arabia is projected to become a net oil importer by the 2030s, a shift which threatens economic and social stability in the country, world energy market security, and U.S. interests in the Middle East. Saudi efforts to diversify energy consumption and increase natural gas production are insufficient to address their emerging energy problems. In the event a regional energy deal is not secured, Saudi Arabia should have the option of importing U.S. natural gas. The writers rely on IEA data and used the regression method of forecast [17].

## **VII. METHODOLOGY**

The section represents the methodology that used to gather and analyze data for the current study. As elaborated in the subsequent sections, the methodology section mainly demonstrates how the literature search was conducted, and how the information from the literature search was analyzed. Statistical method used to estimate the consumption in next 32 years, which is FORECASTING. The forecasting technique shall be used based on the data that need to be forecasted, there are many techniques to use such as but not limited to, Time Series Analysis, Regression Analysis, Moving average Analysis and other. More than one technique can be implemented but the technique that has less error shall be selected. So, the less error of the projection/forecasting the more accuracy of the result.

### *Research Approach:*

The researcher used a structured approach to determine the authenticity of the sources of materials that were reviewed and analyzed. Websites, peer-reviewed articles and official reports of companies were the key sources of general information. According to the objectives of this study, the researcher wants to analyze the effects of domestic consumption of oil to the overall production and measure whether if Saudi Arabia will reach to a critical situation that affect its export in the future.

### *Data collection:*

The researcher decided to collect the data of the factors that playing a major role in the oil consumption which are the electricity demand, desalination, number of vehicles that imported by Saudi Arabia, gasoline, diesel. These factors recorded a significant growth especially in the last decade. The data information is collected from many sources such but not limited to, the consumed oil and electricity annual reports of Saudi Electricity Company, the produced oil from Aramco annual report, the history of imported vehicles from Customs Department, the consumed gasoline & Diesel domestically for transportation & industries from Ministry of Petroleum and Mineral Resources, the consumed oil for generation purpose from Electricity and Cogeneration Regulatory Authority. These data will enable us to perform the forecast for future demand and consumption of oil in Saudi Arabia. It is very important that this information shall be taken from official sources, so the result will be accurate as much as possible.

## **VIII. RESULT & DISCUSSION**

In the beginning, we would like to give brief discussion, review and evaluate the Oil Production & Domestic Consumption in Saudi Arabia, we will forecast the production & consumption of crude oil up to 2050, and then we discuss and study the related factors that currently contribute to domestic high fuel consumption such as but not limited to population, vehicles, water demand, electricity consumption, etc., the review process include forecast some of these factors

### *Oil Production & Domestic Consumption:*

The story of the discovery of oil in Saudi Arabia took a huge historical curve as the Kingdom turned from an area whose economy is concentrated on livestock, agriculture, trade and simple industries. Its

main resource depended on Hajj and Umrah, a country that relies on 90% of its revenues from oil revenues. The Kingdom of Saudi Arabia is the largest oil exporter in the world according the annual report of 2016 of OPEC. It was first discovered in the Arabian Peninsula on the land of Saudi Arabia in 1925. Saudi Arabia has the second largest oil reserves in the world with 267 billion barrels and maintained the top oil reserves in the world until Venezuela announced that it has increased its proven reserves to 297 billion barrels in January 2011. From that date, Saudi Arabia is still in the second rank while Venezuela maintained its first rank. The amount of Saudi oil reserves is approximately one fifth of the world's conventional oil reserves, and a large part of this reserve comes from a small number of very large fields [1 &18].

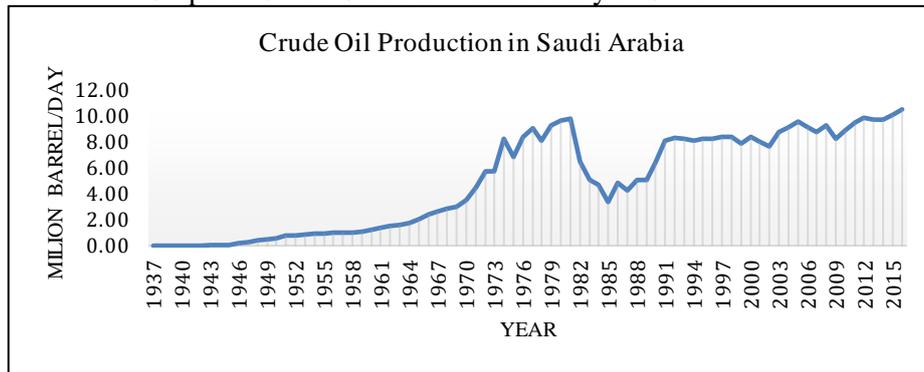
Because of the abundance of oil in Saudi Arabia, Saudi Arabia has dominated oil production in the world for decades. Domination of the oil markets helped Saudi Arabia to develop its infrastructure and transport it from a desert country based on livestock care and seasonal income to the pilgrimage to a developed country in the eyes of everyone. But this could become a mirage soon as domestic consumption of large quantities of oil could threaten the kingdom's top oil export to other countries and thus become a direct threat to the economy as the kingdom relies directly on oil sales. Recently, the Kingdom has implemented many reforms in its internal sectors such as applying VAT and increasing fees for some government and other services just to increase non-oil income. However, this is still not enough, hence, it is considering selling part of Aramco as a share capital to establish a sovereign fund to help the kingdom in supporting of developing the non-oil sectors according to the Vision of 2030.

The abundance of fuel in the Kingdom over the past decades as the highest producer of oil in the world made it addicted to oil significantly and clearly shown through amount of daily consumption of oil for the domestic purposes of generation, transportation, manufacturing and others. The biggest problem is that this domestic consumption increases annually by a frightening average of 5.4% growth rate versus %3 over the past of 28 years, directly threatening the economy and its future. Especially after the recent agreement in November 2016 for OPEC oil producers to stabilize/reduce crude oil production. Where the Kingdom renewed its desire to extend the stabilization/reduction of oil production in January of 2018 to continue until the middle of 2019 to control the amount of supply in the global market, which will promote and raise prices of oil. However, many journalists confirm that the same agreement would be also continued until 2022 as the prices of crude oil can be recover overnight. Stabilization of production with increasing domestic consumption may hasten the problem in the near term.

In this stage, the pattern of domestic oil consumption in Saudi Arabia could limit its exports of oil in the very near future, which will cause an economic problem as approximately 86% of Saudi Arabia revenue income is depending on oil export. The following graph (graph-1) shows the production of Oil in Saudi Arabia since 1937s until 2016s.

From previous graph we can see the increasing in production since the kingdom discover the oil and start production on 1936, and then the production start reducing sharply due the low demand and over-production created an abundance in the global market of oil during the 1980s as it was a surplus of crude oil formed by the decline in demand after the 1979 energy crisis, the world price of oil after peaking in 1979 in the United States and hit more than \$ 35 per barrel, collapsed in 1986 to nearly \$10 as a result of the slowdown in economic activity in industrialized countries which has been decided by kingdom in that time to reduce the production of crude oil. Then in 1986 the market was recover and the increase in production of crude oil started until these days.

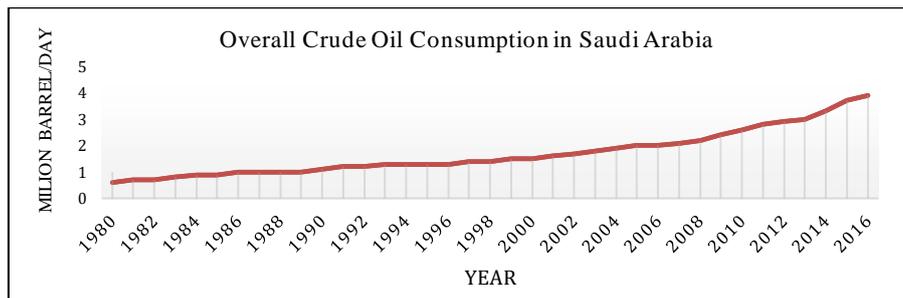
Graph-1: Crude Oil Production History of Saudi Arabia



Source: Saudi Aramco

The following graph (graph-2) shows the overall consumption of oil in Saudi Arabia, it is clearly shown the consumption is increased rapidly, the total consumption in 2016 (3.9 million barrel/day) is more than double the consumption of 2000 (1.5 million barrel/day) and more than triple the consumed oil in 1990 (1.1 million barrel/day). Which will ensure with no doubt the consumption in near future will reach to a disaster level. The results of the consumed oil seem adequate and reasonable because the factors that will be explained later in these papers are kept the increasing annually.

Graph-2: Overall Crude Oil Consumption History of Saudi Arabia



Source: Saudi Electricity Company & SWCC (in Barrel of Oil equivalent), the licensed power plant & industries & The Gasoline & Diesel from Ministry of Petroleum and Mineral Resources

The graph above shows the consumed crude oil, heavy oil & diesel by Saudi Electricity Company & SWCC in their power plant, the licensed power plant & industries, and the Gasoline & Diesel in transportation sector while the jet fuel and other minor consumption has been ignored due to very negligible effect on the study beside no availability data for them. Moreover, the consumption study started from 1980 due to the non-availability of consumed crude oil data before that year.

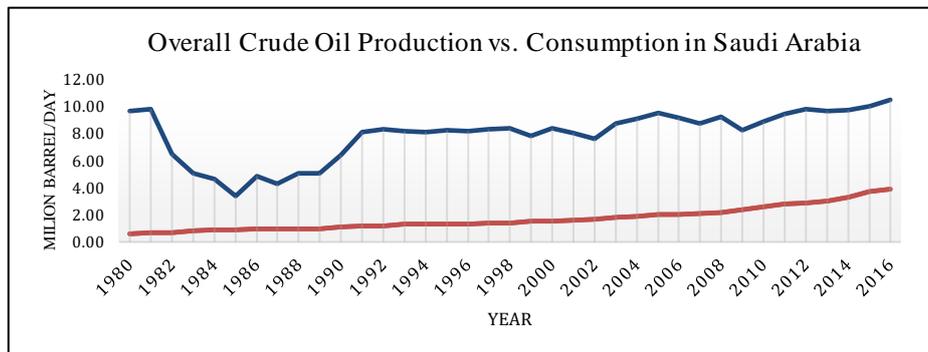
Now if we combined both, the crude oil production & consumption per million barrel per day in the following graph in Saudi Arabia we will get better understanding, we can see the growth between them, the production of oil seems having wobbling growth while the growth of the consumption almost sustainable growth, it can be more clear as the annual average growth for past 28 years for production is %3 and the annual average growth for consumption is %5.3 for the same period.

Well, these numbers of current production and consumption of crude oil based on the graph above will generate simple questions, what if the same growth of both continued in the coming years? What will be the situation and how it will be looks like? Is there a possibility to import crude in future?

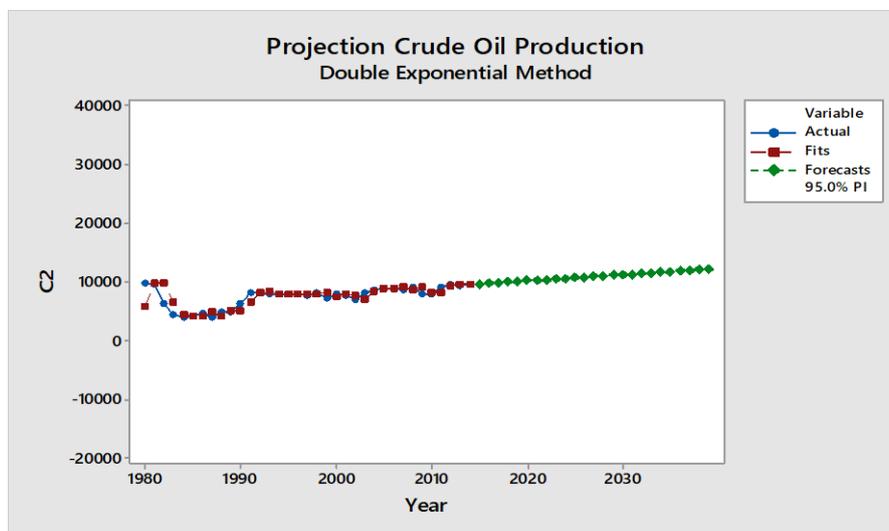
In following steps, we applied the forecast method to figure out the situation between the overall consumption of oil and overall production of oil, the below graphs show the projection of oil production and consumption in the future, it can be shown that the production is increasing with a fix

trend, while the consumption continue with growth like a curve.

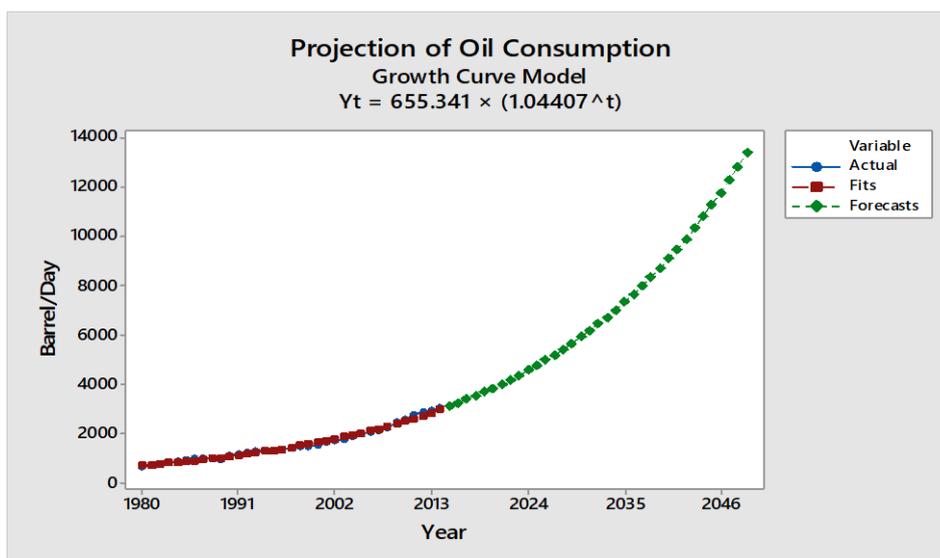
Graph-3: Overall Crude Oil Consumption vs Production in Saudi Arabia



Graph-4: Projection of Crude Oil Production in Saudi Arabia



Graph-5: Projection of Crude Oil Consumption in Saudi Arabia



In graph-4, we used Double Exponential Method in forecasting the future production, this method was the most suitable method due to the wobbling values of production which clearly shown going up and down many times, anyhow the fits values of forecast are almost matched with actual values of the

production which give us accuracy for this forecast about 95%, this prove us that the Double Exponential Method is the most suitable method for such wobbling data. Need to highlight that in this forecast we considered the production process is continued increasing yearly even though the production of the crude oil has been reduce by 0.5 million barrels per day due to the agreement of OPEC oil producers to stabilize/reduce crude oil production in 2017, moreover we assumed that a new field of oil discovered in future which allow Saudi Arabia to expand the process of oil extraction. We used the data from 1980s to 2014s, forecasted the amount of production up to 2050s including forecasting the production of 2015s & 2016s, and compare the forecasted results with official released production amount of 2015s & 2016s. As shown in the graph, we figured the amount of 2015s becomes (9.89 mbd) compare to the actual (10.05 mbd) & the amount of 2016s becomes (10.14 mbd) compare to the actual (10.5 mbd) which are representing %94 of accuracy.

While in the in the other graph of consumption (graph-5), we applied the Growth Curve Model in forecasting the future domestic consumption of crude oil, the reason for selecting this method is because it is giving us the most accuracy level more than %98 of accuracy for forecasting, and it can be verified through the fits values which almost exactly coming as the actual values. We also applied the same verification step, we used the data from 1980s to 2014s, forecasted the amount of production up to 2050s including forecasting the production of 2015s & 2016s, and compare the forecasted results with official released production amount of 2015s & 2016s. As shown in the graph, we figured the amount of 2015s becomes (3.6 mbd) compare to the actual (3.7 mbd) & the amount of 2016s becomes (3.7 mbd) compare to the actual (3.9 mbd) which are representing %98 of accuracy.

Glada Lahn and Paul Stevens, there are analysts who made a similar research about Saudi Arabia Consumption of oil locally in 2012, they reached to a conclusion that Saudi Arabia could import the oil by 2030 but they assumed factors we believe are not efficient, which are:

- No new reserves of oil are added,
- Crude production does not exceed 12.5 mb/d (million barrels per day) and maintains plateau production for 30 years before allowing a depletion rate of 3% per annum.
- A minimum of 1.5mb/d of crude spare capacity is maintained.

All of these assumptions are difficult to be happened in same period, Saudi Arabia since 80 years are expanding its production, spare capacity of oil is actually more than this, it is almost increasing annually as the projects of oil extraction are increasing annually as well, depletion is not confirmed to be started in 2041 as there is no factor can be consider for this assumption, and indeed a new reserve of oil has been discovered recently in the south region contains small amounts of oil, the possibility for discovering a new oil fields is also shall be taken into consideration.

Our assumptions that led us reach these results considered the best cases as follow:

- Saudi Arabia is increasing its production of oil consumption annually.
- Saudi Arabia shall not be bond to any specified limit of production.
- No depletion is considered, the increasing of production is increasing annually.

In fact, we must worry about production in the future, but first we must consider the consumption which coming from the back with unstoppable speed and big growing curve, this is the real danger that must be restrained.

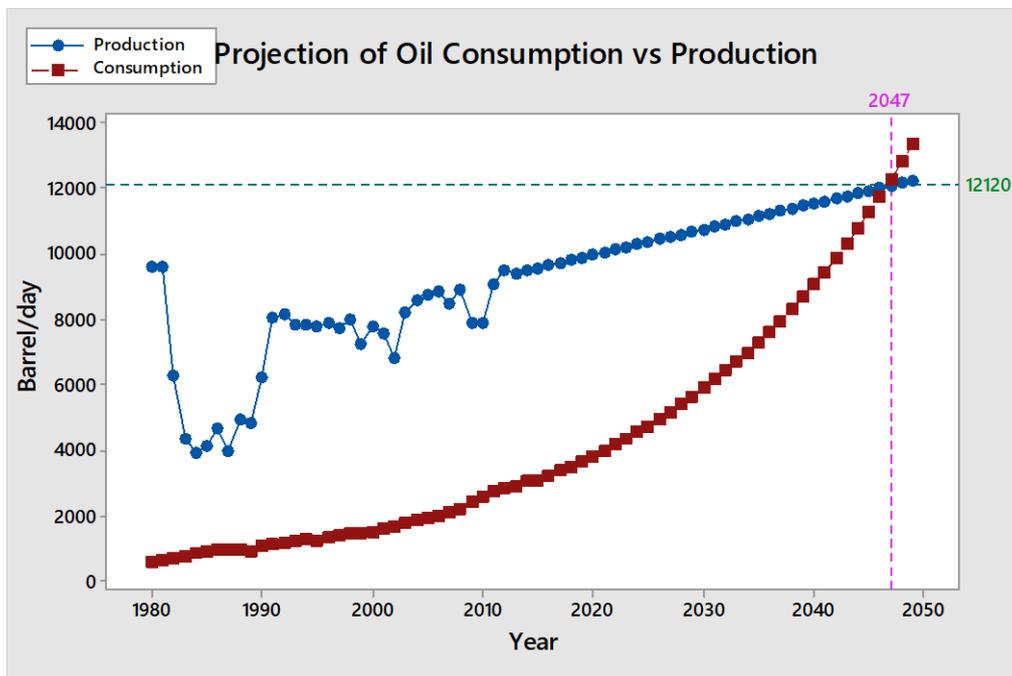
Accordingly, and as per the accuracy values of forecast, we can rely on the future amounts of both, the production and local consumption of crude oil in this study. If we combined the actual and the projection values of both, the production and local consumption of crude oil in one graph (graph-6),

we can conclude that Saudi Arabia may become net importer of oil by the year of 2047.

What an unexpected result, the biggest exporter of oil in the world and the country who has second biggest confirmed share of reserved oil in the world are a net oil importer by 2047. Saudi Arabia can be called as Addicted to oil consumption domestically.

In fact, Saudi Arabia economy may collapse before reaching to 2047 as billions of dollars needs to expand the investment in oil production soon, which allow Saudi Arabia to increase the production process of oil per day to avoid any effect, may happen to its global market share of oil sell. However, the more delay in adopting solution to reduce this scary consumption growth, the more difficulties and an ability to achieve the Vision of 2030s.

Graph-6: Projection of Crude Oil Consumption vs Production in Saudi Arabia



*Population:*

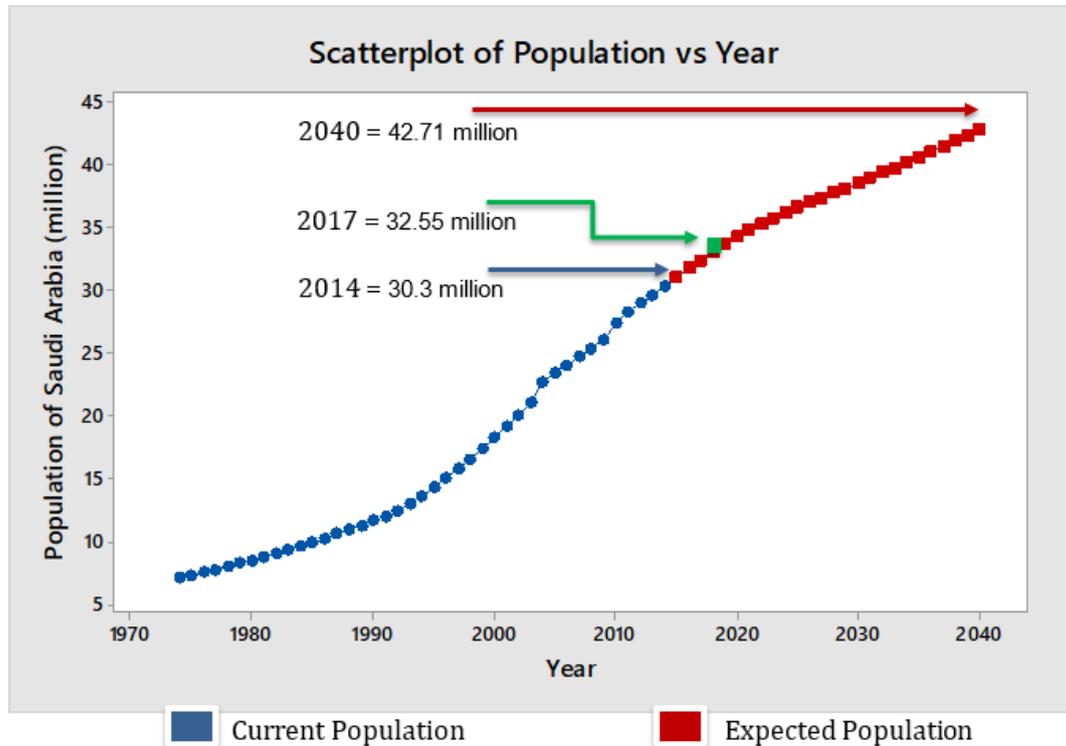
The total population in Saudi Arabia was estimated at (30.3 million) people in 2014s, (31.74 million) people in 2016s and in 2017s the population reached (32.55 million) people according to the latest statistical figures. Looking back, in the year of 1974s, Saudi Arabia had a population of 7.0 million people only, with an average annual population growth rate of (2.52%) it is expected that the population will reached to (42.71 million) people in 2040s, the graph (graph-7) below shows the population of Saudi Arabia since 1974s to 2014s and the expected population up to 2040s <sup>(19)</sup>. It is highly important to be noted that, to test the population, forecast, we decided to rely on the year from 1974s to 2014s and try to forecast the population up to 2040s including forecasting the population of 2016s & 2017s and compare the forecasted results with official released population number of 2016s & 2017s.

By looking to the graph below, we figure the population of 2017s becomes exactly (32.5 million) which is matching with official number (32.55 million) that released by General Authority for Statistics. This is give a confirmation that the overall forecast accuracy is reached to its optimum level.

All countries rely on the statistical population results, by this way any country can better arrange the launching of its future projects of hospitals, schools, infrastructure to new residential areas, electrical and desalination water, jobs, etc. in our case, the more population means more demand for energy

which lead to more burning of oil resource. Energy consumption exerts demands on energy resources making them scarcer, they become harder to extract.

(Graph-7): Population of Saudi Arabia since 1974 to 2014 and the expected population up to 2040



Recently, the kingdom of Saudi Arabia issued several resolutions concerning foreign employees in the country, one of these resolutions is to collect residence fees directly on the foreign workers' escorts in order to increase the non-oil revenues, but it seems the main hidden goal is to reduce the number of expatriates in order to reduce the high annual growth rate of population as after few years the expatriates numbers will be reduced significantly accordingly and this will no longer becomes as reliable source of non-oil revenue. In fact, this resolution will reduce the burden on government shoulder, many products and services subsidized by government such as but not limited to, electricity, desalination water, gas, gasoline & diesel (even though their prices increased recently but they still subsidized by government), Nutritional products such as rice and flour. Reducing the foreign workers' escorts will help the government to reduce the subsidization and drive the saved subsidization to other sectors.

#### Industrial Sector:

As we highlighted before, Saudi Arabia now days consumed a high amount of oil for its own domestic activities, these activities include the industrial sector. This growth came in conjunction with the growth of the overall economy of the country. Over the past of (40) years, Saudi Arabia made a progress in expanding its industrial environment, according to Saudi Industrial Development Fund, they stated that the kingdom made a significant progress in the operating industrial units in Saudi Arabia, the operating industrial units has increased from (208) industry in 1974s to (7741) industry in 2016s which is approximately 3721% more than the recorded industries number in 1974s [20]. Yet, this number of industries still represent approximately %11 of the national income now.

With the announced vision of 2030s, Saudi Arabia intend to expand its operating industrial units specially defense industries, industrial equipment, communications and information technology as

currently only %2 of military equipment are being manufactured locally. In only 12 years Saudi Arabia has a plan to increase the domestic defense industries so manufacturing of military equipment shall be increased from %2 to %50, in fact not only the defense industries being focused by the government but generally all the industries sectors where the petrochemical & mining industries coming in the first. The expected number of industries by the year of 2030s may cross (30,000) industries if we rely on the announced plan of increase and expand the industrial sector to make it equal to %40 ~ %50 of the national income. This is representing very difficult challenge comparing with the short period. The main objective of focusing on the huge expansion of the industrial sectors in this very short period is to reduce the dependence on oil income, create jobs and increase non-oil revenue, but this also means more consumption and burning of oil specially that the recent official statistical that released on 2011s clarified that the industrial sector in Saudi Arabia consumes 42% of total primary energy [21].

#### *Water Demand:*

The population growth, expansion of industrial & agriculture sectors contributed in the expansion of water consumption. Saudi Arabia represents for many the epitome in arid condition. It receives very little rain, has no rivers or lakes, and is endowed with only limited groundwater reservoirs, which are quickly depleting. With such conditions, one would think that we would come up with the best water conservation methods. Not so. We consume water at a rate twice the world average, using much more water than countries endowed with plentiful and replenishable resources. The Saudi minister of water and electricity raised the alarm on 2014 (now it is called as Ministry of Environment Water & Agriculture) about reaching a new threshold of water consumption, according to the Saudi Press Agency, which carried the minister's remarks, water consumption (by households) exceeded (7.8) million cubic meters per day (total 2874 million cubic meters in 2014), which means a new record for Saudi Arabia. Divided by a population of nearly (30.3) million, this amount gives us about (253) liters per person as a daily rate. Why we consider this as time bomb? Because the daily rate of water consumption per person was approximately about (231) liters in 2010s, which means increasing of (%9.5) in daily consumption for the same person 2014s [22].

Moreover, the industrial and agriculture sectors recorded also significant figures in domestic water consumption. According to the recorded statistical data, the industrial sector consumed (930) million cubic meters in 2014s which means increasing by (%25.3) comparing with consumed water in 2010s (753 million cubic meters), while the agriculture sector consumed (19,612) million cubic meters in same year, leading an increasing of (%36) comparing with consumed water in 2010s (14,410 million cubic meters) [22].

#### *Well, that was on 2014s, so what happened on 2016s?*

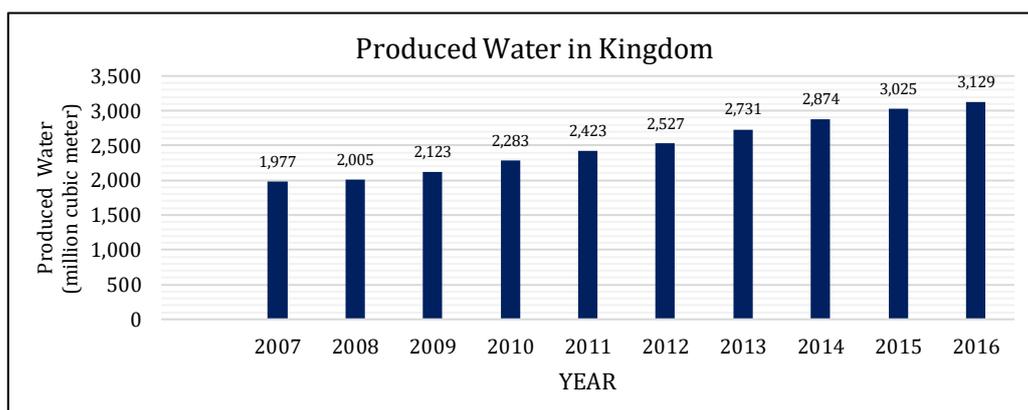
On 2016, the large consumption of desalinated water continued and led the production of desalinated water to reached (3129) million cubic meters in 2016s representing increase about (%37) in consumption comparing with the consumed water in 2010s, and accordingly the daily rate of water consumption increased to (270.6) liters per person, higher by (%16.9) than daily rate consumption per person in 2010s. the industrial and agriculture sectors also consumed high amount water, the industrial sector consumed (1,105) million cubic meters in 2016s leading increasing by (%34.8) comparing with consumed water in 2010s, while the agriculture sector consumed (19,789) million cubic meters in same year, recorded an increasing of (%37.3) comparing with consumed water in 2010s [23].

The high rate of water consumption in the agricultural sector is a surprise after the transformation of the Kingdom to a wheat importer since 2008 for all the needs of the Kingdom of wheat to rationalize the consumption of groundwater.

Studies have shown that continued consumption at large rates in the agricultural sector will affect the underground stocks, but the transformation of farmers to grow other agricultural products such as green fodder has exceeded the wheat consumption of water, which led to an increase in consumption rates.

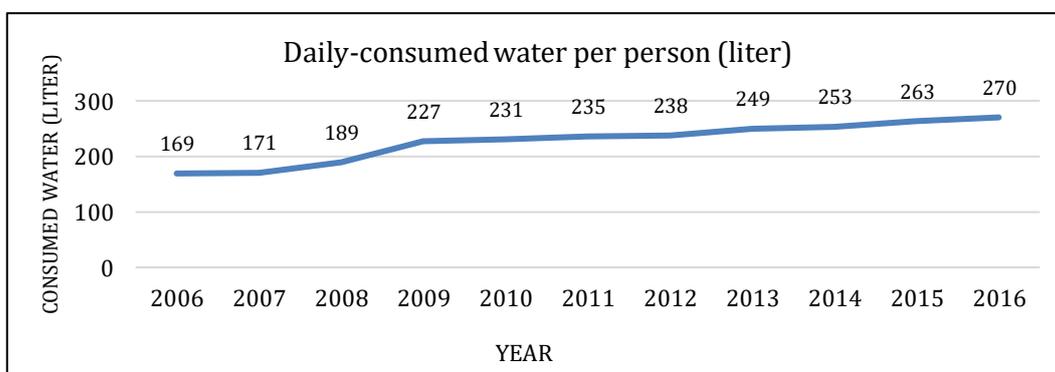
Demand for water by households, industrial & agriculture sectors is growing by (7%) annually, or nearly three times the Saudi population rate of growth. Population growth pushing the government to produce more & more of desalinated water, but increased water consumption rate for the individual in addition to the population growth will generate tremendous pressure on government. Back to the basic equation, the more desalinated water requires more energy. In addition, Saudi Arabia intended to achieve water and food security in the Kingdom and raise the percentage of agricultural sufficiency by supporting the agricultural sector and Saudi agricultural projects by the year of 2030s, which also considered a big challenge. In 2015s, Saudi Arabia leads the world in the production of desalinated water by producing over (1006.6 million cubic meters) of water annually, which equal to 18% of world produced in that year, in 2018s Saudi Arabia succeeded in increase the production to (5 million cubic meters) daily which will be (1825 million cubic meters) annually. This is considered as a new record; The Saline Water Conversion Corporation in Saudi Arabia continues to maintain its position as the world's largest producer of desalinated water [24]. This could be currently a great success, but it is also a serious indicator of the amount of consumption in the future.

Graph-8: The total produced desalinated water in Saudi Arabia



Source: SWCC annual reports

Graph-9: The daily-consumed water per person in Saudi Arabia.



Source: Open data of Saudi Arabia (www.data.gov.sa) & General Authority of Saudi Arabia for Statistics

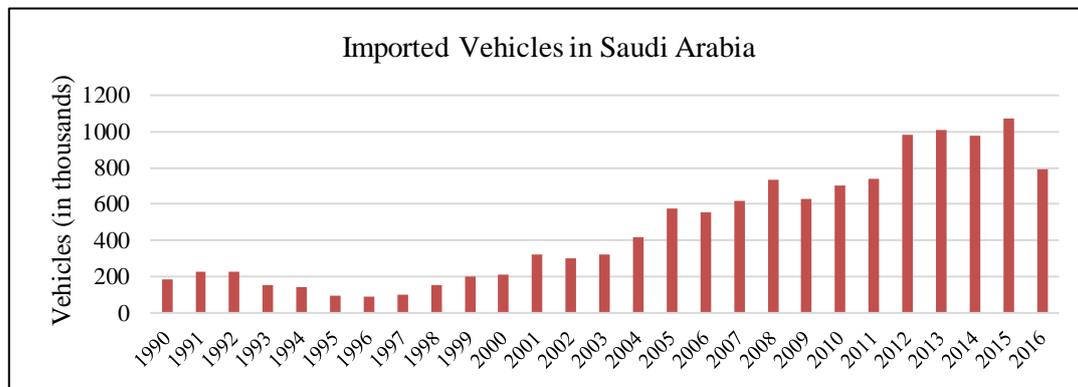
The following graph (Graph-8) show the total produced desalinated water in Saudi Arabia, while graph (Graph-9) show the amount of daily-consumed water per person.

Thus, with such amounts of daily consumed of water, Saudi Arabia ranked third in the world after America and Canada in per capita water consumption every day, despite the scarcity of water resources in the Kingdom and the difficulty in desalination and transfer to its beneficiaries [25].

*Automotive:*

Saudi Arabia recorded a significant figure in last decade as the largest importer for vehicles in Middle East. New car sales rising by 10% annually over the past 20 years, crossing one million cars imported in 2013, which are more by 1033% comparing with imported vehicles in the year of 1995. This demand is directly linked with population growth (specially 60% of them are in the range of 25 ±5 years old), income increase, facilities provided to own cars, low cost of gasoline even after reducing government’s subsidies partially recently, and the most important reason which is the lack of public transportations [26]. The following graph (Graph-10) shows the imported vehicles by Saudi Arabia in the period of 1990 to 2016.

Graph-10: The imported vehicles by Saudi Arabia



Source: Open data of Saudi Arabia ([www.data.gov.sa](http://www.data.gov.sa))

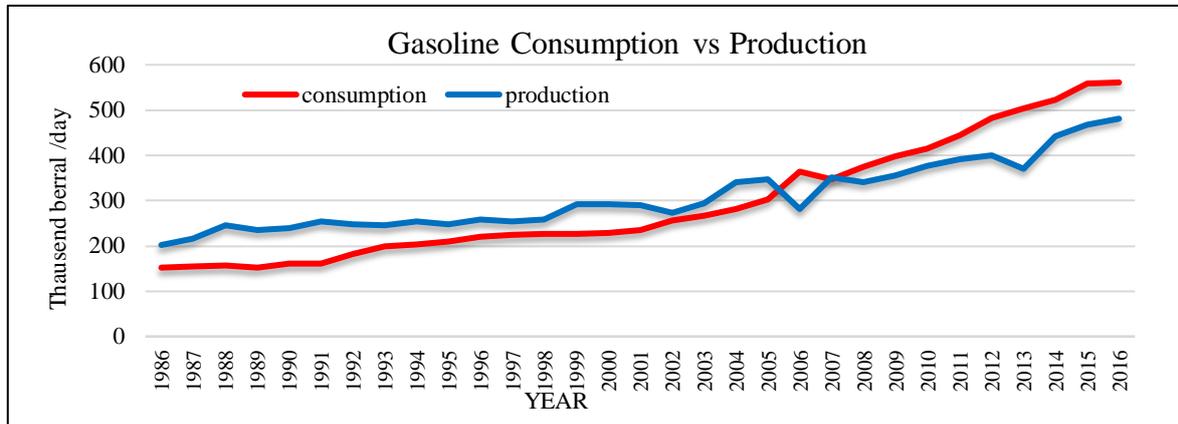
As noted above, the huge import of vehicles in the last decade was caused by economic recovery, lower interest on financing loans to own vehicles, the increase in the number of jobs and consequently the increase in income, which reflected in the purchasing ability of the individual. It is also noticed that the number of imported vehicles per year was increasing significantly until 2016 when imported vehicles began to decline due to the economic recession in the Kingdom, and as per unofficial sources the imported vehicles in 2017s is the same as 2016s. It is certain that in 2018/2019 the imported vehicles will rise again due to allowing the women in kingdom to drive and it will reach to significant record. The women in kingdom represent approximately %49 of the total population, this decision will help large part of women to own a car in the coming period. According to Statistical reports estimated in 2013 that the number of cars officially registered in the Saudi market about 16 million cars which we can say that there is a vehicle for every two persons in Saudi Arabia, and it is expected to reach more than 20 million by the year of 2020.

*Gasoline & Diesel:*

The consumption of these Petroleum products has reached to very significant levels in the previous years. In fact, they reached to the level that forced Saudi Arabia’s government to import 31.4 million of barrel in 2014 just to cover the domestic demand [27]. During Ramadan & Hajj specially, the domestic demand for the fuel is very highly. Well by referencing to the vision of 2030s, Saudi Arabia intended to increase the capacity to receive pilgrims from 8 million to 30 million pilgrims, which means more oil for services to achieve that. Moreover, Saudi Arabia has the biggest refinery in the world, which is Ras Tnoura Refinery, as well as many other big refineries distributed in the kingdom, but it seems it failed covering domestic demand and according to the record, the domestic demand

increasing year after year while the expansion production of Saudi Arabia are even not meet the consumption growth. Additionally, the demand for diesel has increased significantly in the recent years as it also used beside the automotive in the industrial sector and power plant of Saudi electricity Company, SWCC and other. The following graphs shows the relationship between the production and consumption of gasoline and diesel.

Graph-11: The Gasoline Consumption vs Production

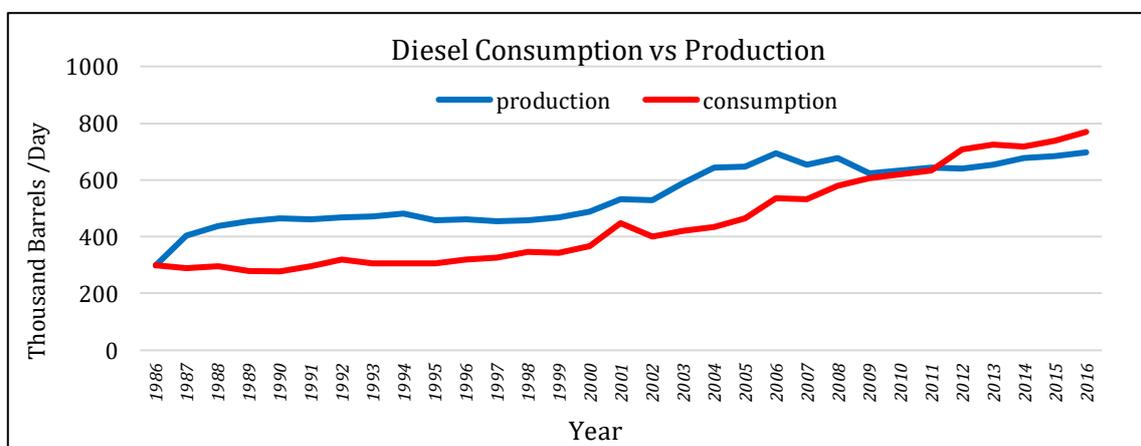


Saudi Arabia's Ministry of Energy, Industry and Mineral Resources recently unveiled the new prices for oil derivatives in Saudi Arabia, which came into effect from mid-January 1, 2018. The Ministry of Energy's decision on the fiscal balance program plan to correct the prices of energy products was "domestic oil derivatives" aimed at reducing the rapid growth in domestic consumption of energy products in the Kingdom and ensuring optimal use of national natural resources and enhancing their sustainability, but many opinions thinking this is not going to help reducing the rapid growth in domestic consumption of energy products in the Kingdom with the absent of effective public transportation as the only way to reach to your destination in Saudi Arabia is by using your vehicle.

The following graph shows the predicted Gasoline production and consumption in 2040. It seems a huge gap will be between both and that how the increase in the domestic demand will cause a pressure to the government in the coming years.

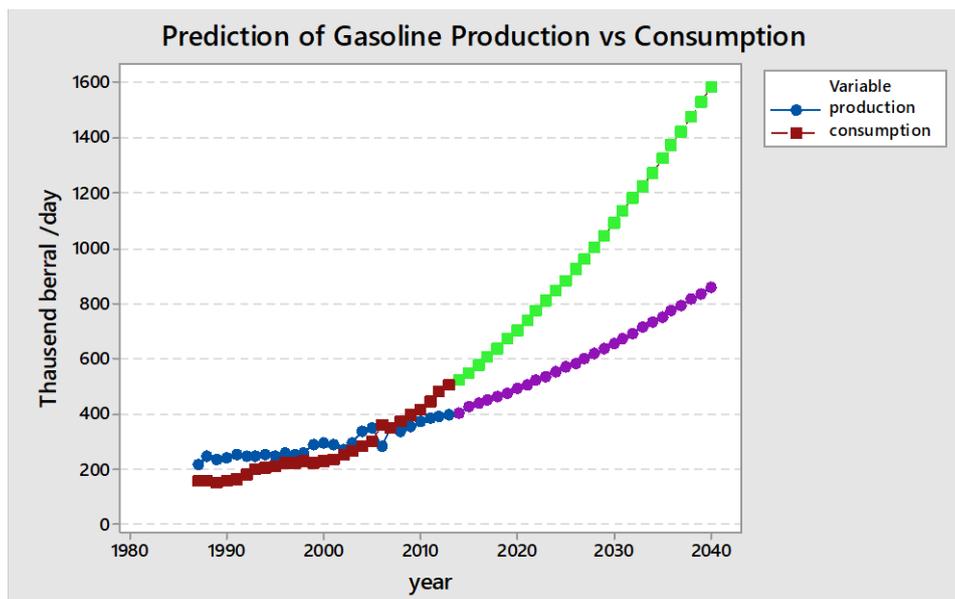
From previous graphs we can see that the local domestic consumption of energy products in the Kingdom is growing rapidly even beyond the kingdom ability to increase refineries to cover this demand.

Graph-12: The Diesel Consumption vs Production

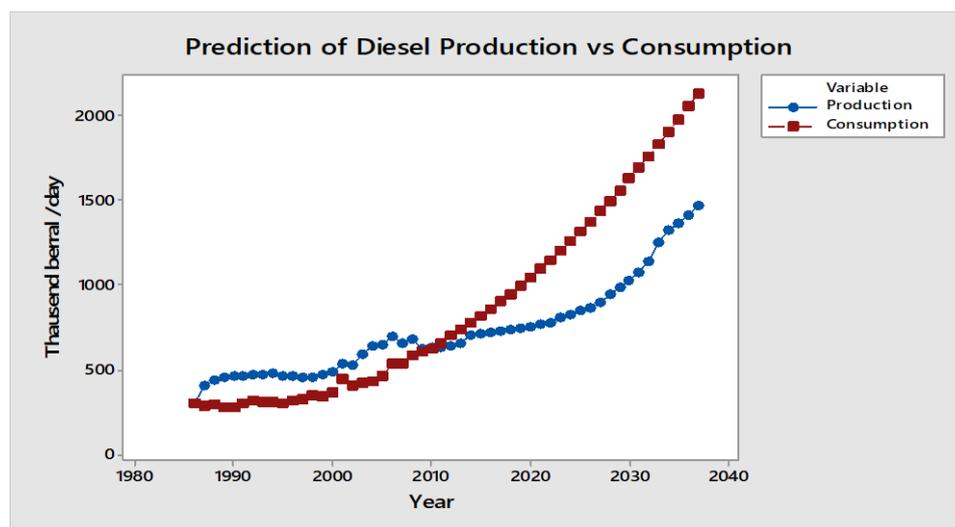


Source: Ministry of Petroleum and Mineral Resources

Graph-13: Predicted Gasoline Production vs Consumption



Graph-14: Predicted Diesel Production vs Consumption



*Generation & Demand of Electricity:*

Saudi Electricity Company faces many challenges every year related to the expansion the capacity of the generation as the demand increased rabidly. The generation activity performs a variety of tasks in the field of power generation, which include maintaining and operating power plants, strengthening their power generating capacity and establishing new power stations to meet the growing demand for electricity.

The efforts made by the Saudi Electricity Company have resulted in total sold energy of 296,673 GWH in 2016 vs. 114,161 GWH energy sold during 2000, recording an increase of 260%, in which the total actual capacity was 102 GW in 2016 vs. 25 GW in 2000, an increase of 400% [28]. There are other licensed companies contributing in the Electricity generation activity such as Saline Water Conversion Corporation (SWCC), MARAFIQ, ARAMCO and others. Some of these companies generate the electricity through gas, oil or by both. The generation capacity of Saudi Arabia in 2016 was 102,469 MW where Saudi Electricity Company Generation capacity share is 72% from the total capacity, the remaining generation capacity 28% has provided through these licensed companies.

According to the Arab Electricity Union, the Saudi Electricity Company is the largest producer of electric power in the Middle East and North Africa, and the Kingdom's production alone in energy accounts for more than %25 of the production of 18 Arab countries [29]. By the end of 2016, the generation capacity available from Saudi Electricity Company alone was 74 GW, up about %7 increase in capacity from 2016s (69 MW). Table 1 represents all the generation capacity for Saudi Arabia in 2016s. Also, the table 1 shows installed capacity of the electricity generation for all licensees.

The field of electricity Generation Electricity peak demand shows Saudi Arabia reached to 61,162 MW in 2017, with an average annual growth rate 6.3% over the last 15 years, the demand of electricity in 2017 has been increased by 600% since the recorded demand in 1985 [30]. This annual increase caused huge pressure on the government as well. The following graph (Graph-14) show the electricity demand since 1985 up to 2015.

These loads show us a very critical pattern of increase, the domestic consumption of electricity is growing rapidly and as we explain above, Saudi Electricity Company and other licensed company mainly depending on oil (mostly) to generate electricity in Saudi Arabia, without finding any solutions that may reduce burning more of oil, the rapid growth will help the consumption level to jump further in the very near future. Moreover, the increase in electricity consumption is due to the annual growth rate of new subscribers every year with an average %5.1 of annual increase per year. Over the past years, the company has expanded its network of power transmission, distribution networks and distribution stations to serve the yearly new subscribers, for better understanding, we will represent the number of subscribers for every year in the following graph (Graph-15). The consumed electricity per capital is a measurable indicator show whether the growth in consumption of electricity is in proportion with the increase in population. Electricity consumption per capita in Saudi Arabia has been growing very rapidly over the past 40 years with an annual average growth 8.56% considered one of the highest average growth in the world. The following graph (graph-16) shows the HYPERINFLATION of the consumed electricity per capita in Saudi Arabia and the annual average growth per capita among the other countries respectively.

Beginning in 2018, the Kingdom has decided to partially cut subsidies on electricity prices to raise economic efficiency, contribute to non-oil sectors as a sustainable economic development engine, and rationalize the consumption and sustainability of natural resources "energy products" for future generations. This decision will certainly contribute to the reduction of individual consumption and try to reduce the consumption of electricity for families in conjunction with the exit of many foreign workers' escorts out of the country due to issued fees that have been baptized recently, but most importantly is to repair the infrastructure of electrical appliances, which consume a lot of energy. Anyhow, this is temporary will help reducing the high growth rate of annual consumption, but it need to put into consideration the future of Saudi Arabia specially the vision of 2030s.

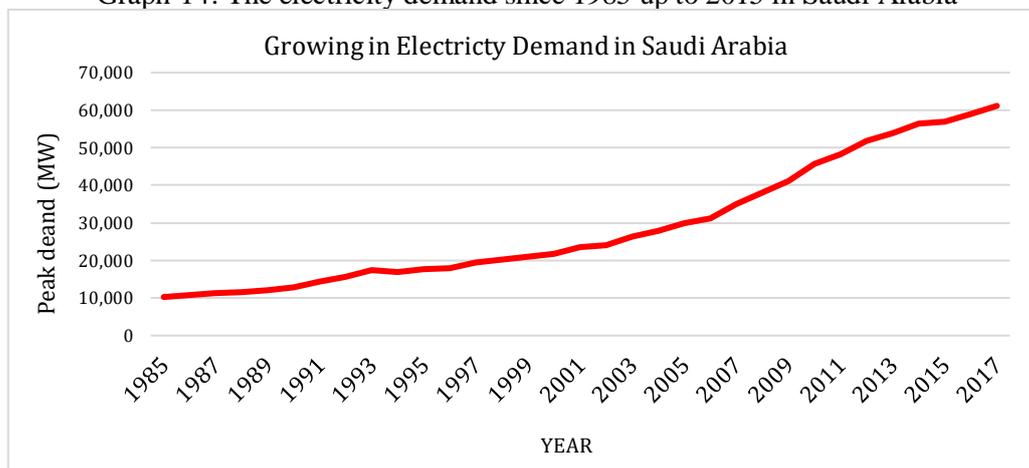
The Electrical services subscribers are for all sectors, not only for residential sector. Saudi Arabia is getting bigger than before, residential areas are getting expansion, new street means new lighting, hospitals, industries, malls, farms, and everything is getting growing due the high rate of population growth and the strong economy of the country. Besides that, soon, constructions of new cities will start such as NEOM and others according the future of Saudi Arabia which also required electrical infrastructure. This helping & giving us a clear Figure what the number of subscribers will be in 2040G. According to the graph below, the estimated electricity subscriber in 2040G will be 20.44 million, means 235% more comparing to 2016G as show in the forecasted graph below (graph-18).

Table-1: installed capacity of the electricity generation for all licensed companies in Saudi Arabia

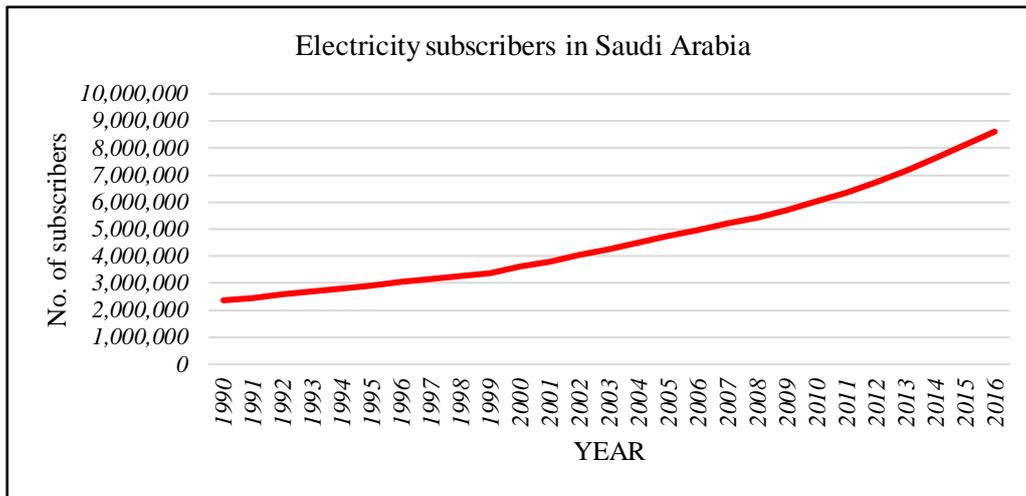
S.N.	Producer	No. of Plants	Capacity (MW)	%age
1	Saudi Electricity Company	44	74,313	72.52%
2	MARAFIQ	2	2,414	2.36%
3	Jubail Water & Power Company	1	2,875	2.81%
4	Shuaibah Water & Electricity Company	1	1,191	1.16%
5	Shuqaiq Water & Electricity Company	1	1,020	1.00%
6	Hajr for Electricity Production Company	1	4,098	4.00%
7	Durmah Electric Company	1	1,756	1.71%
8	Rabigh Electric Company	1	1,320	1.29%
9	SWCC	7	7,812	7.62%
10	Saudi ARAMCO	8	2,247	2.19%
11	Tihama Power Generation Company	4	1,643	1.60%
12	Rabigh Water & Electric Company	1	840	0.82%
13	Jubail Energy Company	1	250	0.24%
14	Saudi Cement Company	2	227	0.22%
15	Ma'aden Wa'ad Al-Shamal Phosphate	1	160	0.16%
16	Power Cogeneration Plant Company	1	160	0.16%
17	Tuwairqi Energy Company	1	78	0.08%
18	Saudi ARAMCO Shell Refinery	2	49	0.05%
19	Obeikan Paper Industries	1	16	0.02%
<b>Total Capacity (MW)</b>			<b>102,469</b>	

Source: Annual Statistical Booklet for Electricity, Seawater Desalination Industries & ECRA annual reports

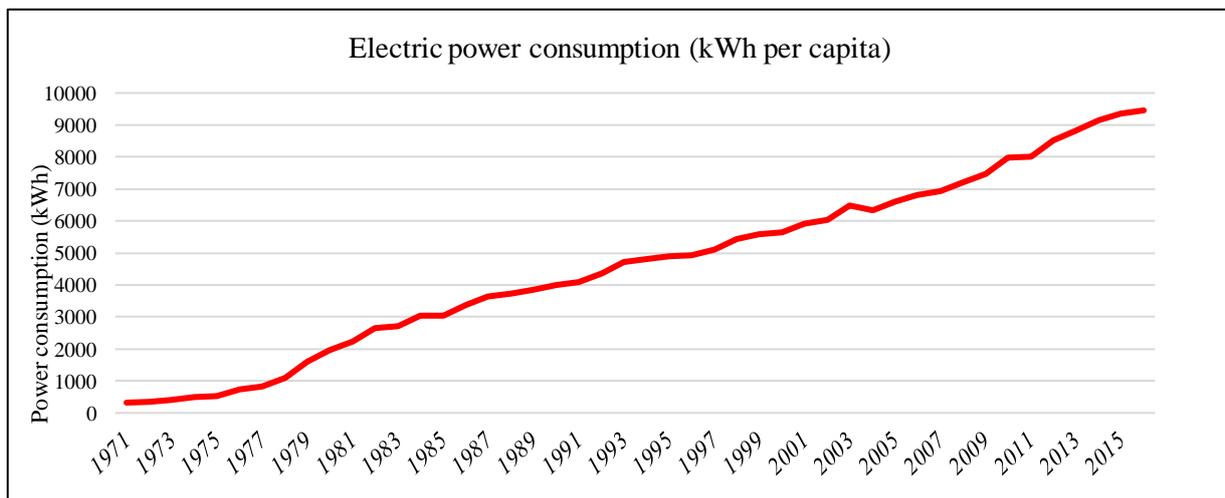
Graph-14: The electricity demand since 1985 up to 2015 in Saudi Arabia



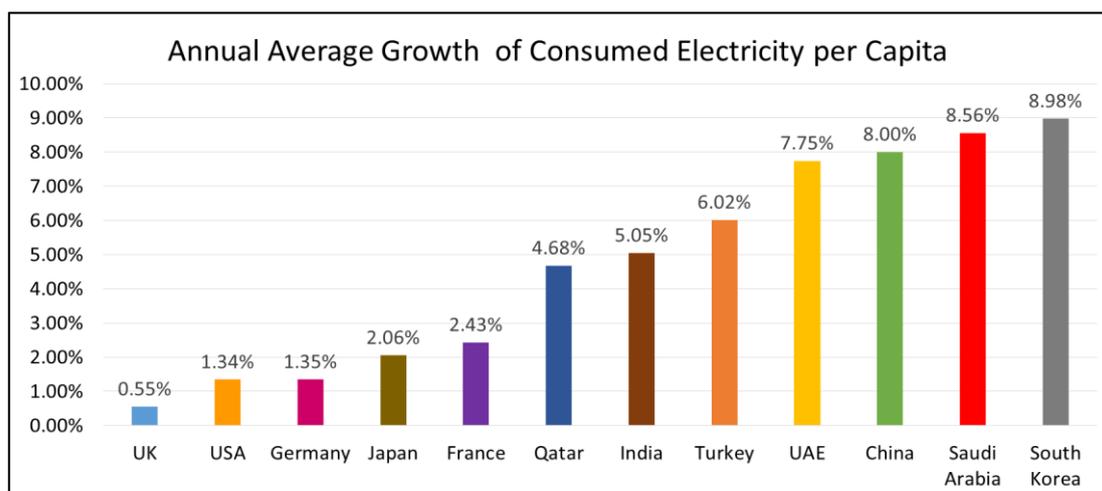
Graph-15: Electricity subscriber’s history in Saudi Arabia



Graph-16: Electric power consumption since 1971 up to 2016 in Saudi Arabia



Graph-17: Annual average growth per capita of Saudi Arabia compare to other countries



Source: World Bank

Note: The average for all has been estimated with same period (1971-2013)

To test the forecast of number of subscribers, we will use the data from 1985s to 2014s and try to forecast the number of subscribers up to 2040s including forecasting the subscribers of 2015s & 2016s and compare the forecasted results with official released number of 2016s & 2017s. As shown in the graph, we figured the number of subscribers of 2015s becomes (7.8 million) & the number of subscribers of 2016s becomes (8.3 million) which are representing %97 of accuracy.

No wonder the overall electrical demand of Saudi Arabia is getting significant increase annually, as the population, industrial sector is getting significant increase annually as well. Many Analysts expected that the overall electrical demand in Saudi Arabia may reach to double in 2030G which is almost true, according to the graph below, the expected demand of electricity in 2030G will be approximately (124037 MW) which means almost double the current demand and (182034 MW) in 2040G which means triple the current demand, the following Graph (graph-19) shows the expected electrical demand of Saudi Arabia in the future.

This will move the challenge of implementation of vision 2030s to a very high level, as the kingdom well must pay an immediate attention to the energy infrastructure and start adopting huge green generation projects. Currently Saudi Arabia generate approximately (0.5 MW) through solar cells out of (61,162 MW) generated energy in 2016s through oil. This small solar power plant located in Farasan Island in the south of the kingdom and the reason to build this solar power plant due the difficulties of delivering the oil across the Red Sea. Well, this sound weird because this technology is not new and it has been used since decades by many countries such as but not limited to, Germany, and the climate and location of Saudi Arabia considered one of the best sites in the world in the utilization of solar energy but yet that was not enough to encourage the government of Saudi Arabia to adopt more of green power plants in the past because the abundance of fuel and its low price encouraged the focus on oil generation plants, making the adoption of any green energy projects out of agendas. Recently Saudi Arabia start establishing the first solar power project for in “Skaka” in the northern region of generation capacity of 300 MW. It is a good start, but Saudi Arabia needs to establish several projects of solar and other green energy like wind in the very near future with capacity of at least 20GW to to compete and take a large share of electricity generation in the Kingdom specially that Sakaka Solar Project broke the world record low cost of solar energy.

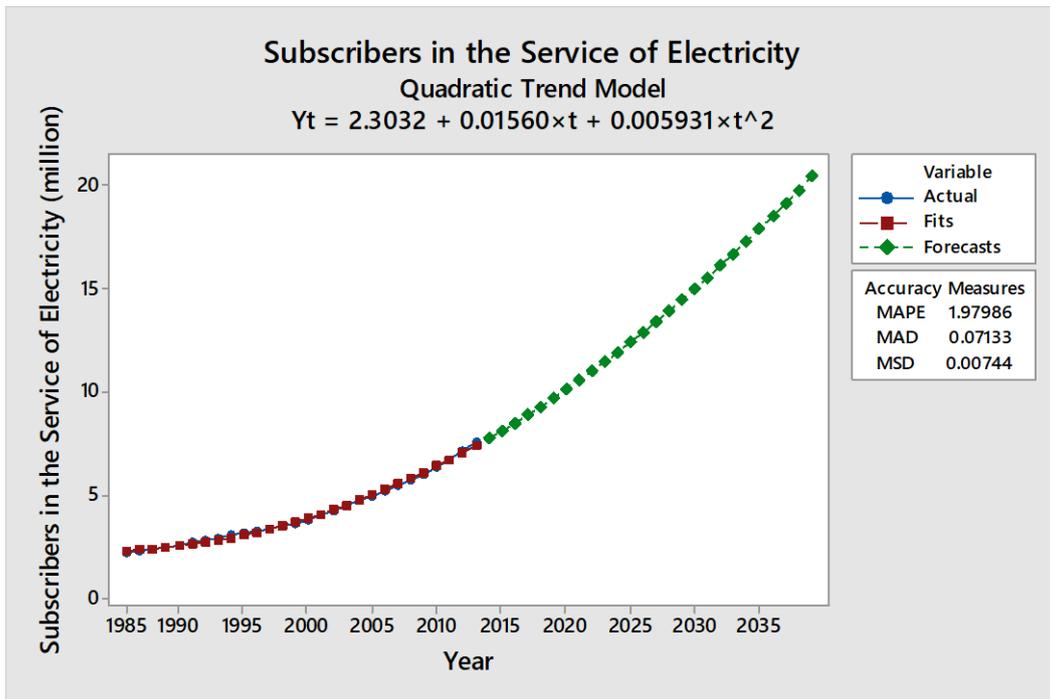
Where the offer by Masdar in partnership with Electricity de France to construct this power plant of the 300 MW power plant in Skaka \$1.79 cents per kilowatt-hour, the lowest price for a solar photovoltaic project in the world. Therefore, it is a good chance to establish several of similar projects immediately to gain the beneficial of this low cost and to enhance the plan to replace most of the Oil power plant with this green power plant as the cost to generate one kilowatt-hour through oil currently costing the government approximately \$3.28 cent.

From the above clarifications and future estimation for some factors, the necessity of more oil in the future is mandatory as growth of everything is related to consumption of oil. The affect is not only about consumption of oil but also the CO<sub>2</sub> emission that will be the outcome from burning of oil, the following Figure shows the relationship between oil consumption and growth of all related sectors.

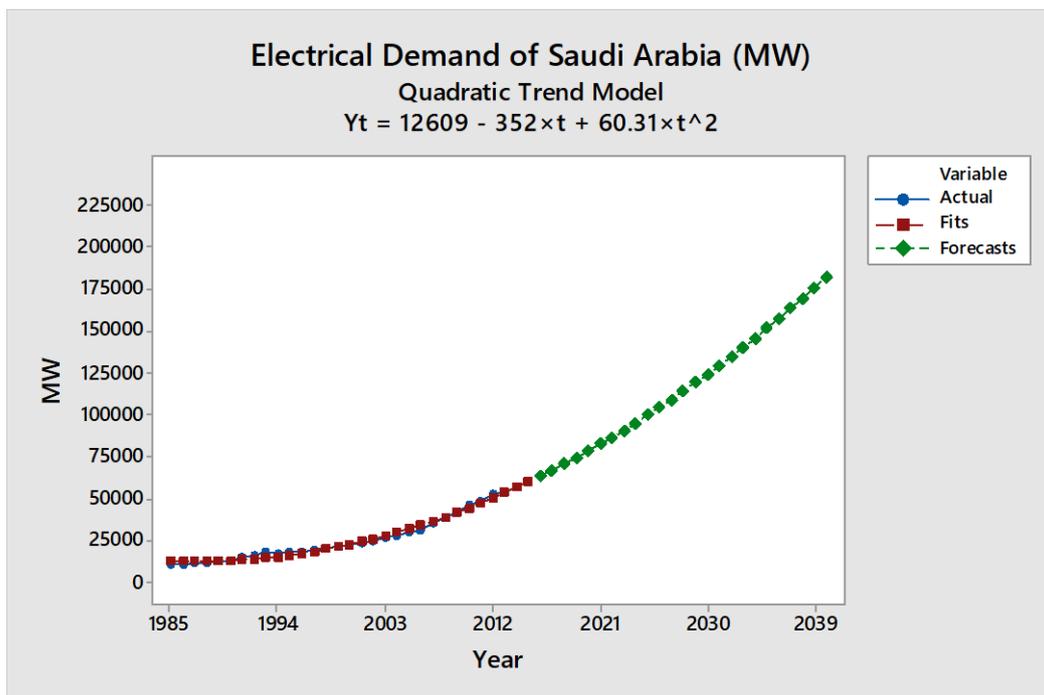
#### *CO<sub>2</sub> emission:*

There are both natural and human sources of carbon dioxide emissions. Natural sources include decomposition, ocean release and respiration. Human sources come from activities like cement production, deforestation as well as the burning of fossil fuels like oil and natural gas. Since the Industrial Revolution, human sources of carbon dioxide emissions have been growing. Human activities such as the burning of oil and gas are the primary cause of the increased carbon dioxide concentrations in the atmosphere.

Graph-18: Forecast of Electricity Services subscribers



Graph-19: Expected Electrical Demand of Saudi Arabia in the future



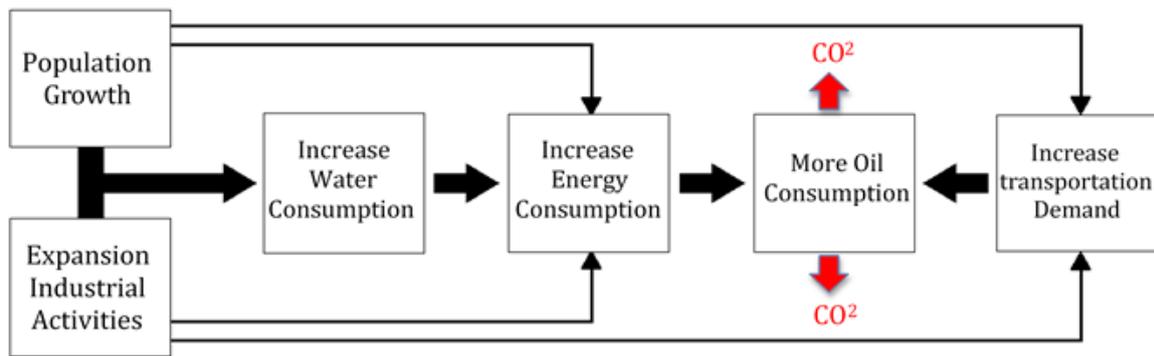


Figure 1: the relationship between oil consumption, CO<sup>2</sup> emission and growth of all related sectors.

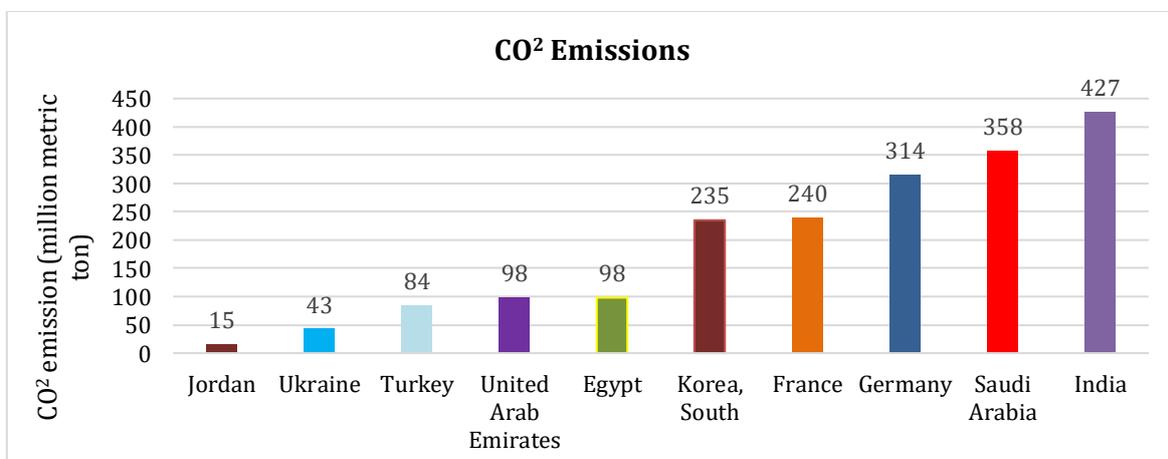
Almost 87% of all human-produced carbon dioxide emissions come from the burning of fossil fuels like natural gas and oil. The remainder results from the clearing of forests and other land use changes (9%), as well as some industrial processes such as cement manufacturing (4%).

The largest human source of carbon dioxide emissions is from the combustion of fossil fuels. This produces 87% of human carbon dioxide emissions. Burning these fuels releases energy which is most commonly turned into heat, electricity or power for transportation. Some examples of where they are used are in power plants, cars, planes and industrial facilities. In 2011, fossil fuel use created 33.2 billion tons of carbon dioxide emissions worldwide. anything involving fossil fuels has a carbon dioxide emission ticket attached. So, for example, burning these fuels releases energy but carbon dioxide also gets produced as a byproduct. This is because almost all the carbon that is stored in fossil fuels gets transformed to carbon dioxide during this process.

The three main economic sectors that use fossil fuels are electricity/heat, transportation and industry. The first two sectors, electricity/heat and transportation, produced nearly two-thirds of global carbon dioxide emissions in 2010 [31].

High depending on oil for electricity generation, high domestic demand for gasoline and diesel & growth of industrial sector in Saudi Arabia led the country to be recorded as the highest country in Middle East and Africa in CO<sub>2</sub> emission in 2013G. The following graph shows comparison of CO<sub>2</sub> emission of Saudi Arabia with other countries. Accordingly, high CO<sub>2</sub> emission will be reflected negatively on the overall health of citizens.

Graph-20: CO<sup>2</sup> emission from the Consumption of Petroleum for various countries



Source: World Bank

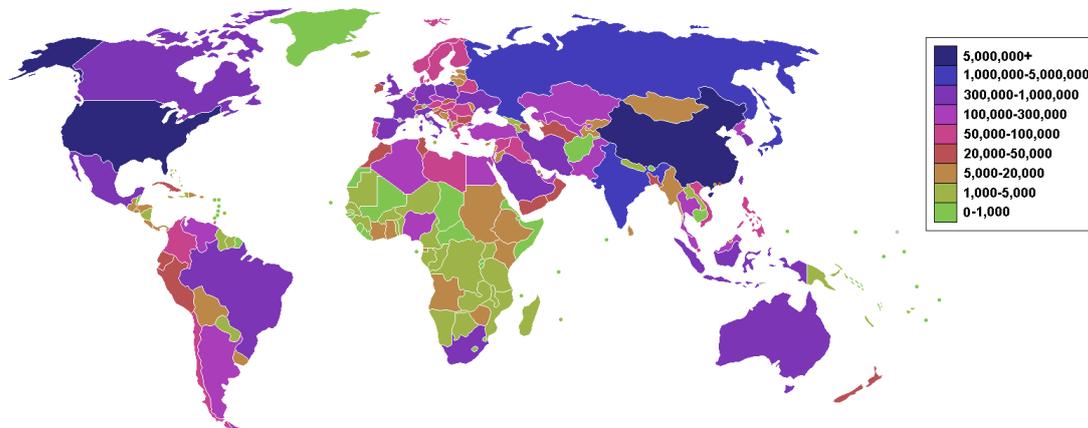


Figure 2: CO<sup>2</sup> emission globally (thousand metric ton)

## IX. CONCLUSION & RECOMMENDATION

This paper has discussed the problem of undue of oil consumption of Saudi Arabia. The biggest exporter of oil in the world, Saudi Arabia or the oil paradise, the country who has second biggest confirmed share of reserved oil in the world, or we can say the country which is swimming above biggest field of crude oil in the universe could be net importer of oil by 2047. The problem of oil consumption is not only related to Saudi Arabia but is being an international problem in the last decade. The low supported price of domestic oil consumption encourages people and industrial sector to consume more and more of oil, which will lead the rapid growth of oil consumption domestically increasing much faster soon, especially with rapid growth of population in Saudi Arabia. Energy prices in the Kingdom even after the reduction of government subsidies are still consider a low price compared to global energy prices.

Saudi Arabia could be oil importer by 2047 (after 30 years from now) but this is not the main problem, the main problem is the economy of the kingdom, this rabid growth of oil consumption will be reflected immediately to the economy of the country and the economic disaster will start appears and may collapse before this date if Saudi Arabia did not change its view about the diversification of income sources. And when we are taking about diversification of income sources, we mean Saudi Arabia should increase the sale of goods externally as the increase in the non-oil revenues of the country through taxes, recent government fees & other, consider as temporary anesthesia which will not help Saudi Arabia's contribute to the long-term renaissance of the country as desired, especially as the specter of domestic consumption of oil is increasing.

It was obvious even before made the projection of oil consumption, the factors that playing a major role in the oil consumption are rabidly increasing annually, population, industrial sector, Water demand, electricity demand, expansion of transportation and others will lead the oil consumption to increase to that limit.

Saudi Arabia started adopting many methodologies to reduce the energy consumption such as creation of Saudi Energy Efficiency Center (SEEC), which Support preserving the national energy resources to enhance the national development and economy through the rationalization of energy consumption and improving energy efficiency to achieve the lowest possible levels of energy intensity.

The followings are the recommendations and suggestions that need to implement to restrain the oil consumption in Saudi Arabia:

### *Solar Energy:*

To restraining the growth of domestic oil consumption Saudi Arabia must start relying on other sources to generate the electricity & water, and the best option is using the solar energy to produce the electricity and desalinate water in the power plant. Best move is to start construction of solar power plant with big volume. Signing a contract to construct one or two solar power plans with average generation capacity 500~300MW is not sufficient at all with the huge demand of electricity in Saudi Arabia. The only disadvantage of solar power plant regardless the big require space is the cost, it is very costly compare with oil power plant. The return on capital of solar power plant can be achieved within 20 years while the return on capital of oil power plant can be achieved in 7-years only. So, to start with many projects of solar power plant required huge funds, which can be solved if, facilitate the participation of giant's foreign companies in the energy industry from outside the Kingdom so that these solar generating plants are financed and constructed by these foreign companies. The profits may be distributed in certain percentages between the Kingdom and these companies or these companies generate the energy by their own and then sell it to the government. By this way, the government will have the ability to start many projects of green energy in very short period.

The current mainly method in any power plant in Saudi Arabia is burning the oil to heat up the water to make it reach to evaporation level that lead water molecules moving very fast and rotating the turbine for electricity generating. While in desalinate power plant the oil use to heat up the water until it becomes a vapor which helps to separate salt from water as initial process. Solar technology allowing heating up the water and evaporating it without burning any oil to generate electricity and to produce fresh water in same time. Solar panel to generate electricity became the first and prefer option for the countries in the last decade specially. Three years ago, Saudi Arabia start adopting this method in Duba Green Power plan, used the solar panels to desalinate the water and to generate the electricity as well. This method proved to be effective in the short term, but it is surprising that no any similar desalination projects by solar energy with same methodology has been established since then in the kingdom, and as we explained earlier that delay is not in the interest of the Kingdom. Saudi Arabia may start implementing the Distribution Generation System specially to compete peak period as many other countries such as but not limited to, Germany & UK. Distribution Generation System is an approach that employs small-scale technologies to produce electricity close to the end users of power. DG technologies often consist of modular (and sometimes renewable-energy) generators, and they offer many potential benefits. In many cases, distributed generators can provide lower-cost electricity and higher power reliability and security with fewer environmental consequences than can traditional power generators [28].

In fact, Saudi Aramco & KAUST start implementing this technology recently in Vehicle Park in Dhahran & Thuwal respectively. The parks have been covered with solar cells and it is producing the electricity to the building around it. The Saudi Aramco solar park project produce 10MW (Top Solar Project capacity in Saudi Arabia) that enable the four building that contains with 5000 employees self-dependent to any electricity from the general network of electricity. The following Figures shows the solar parks.

Recently, Saudi Electricity Company started to adopt DG technologies system by installing solar panels on the homes of the citizen like other countries who implemented this technology since long time ago, although this step came late, but it would change the compass of domestic electricity consumption. The installation process shall start in the middle of 2018. From our opinion, this step will not success as it is expected because of many reasons, firstly, Saudi Electricity Company will bear the installation cost only while the materials cost shall be paid by the customers. The material cost of solar panels system is very costly as we mentioned before, therefore for small system that generate 3 kilo-watts per hour it could cost approximately SR 20,000 which shall be paid at once by customers.

This is seeming difficult to the customers in respect to the economic situation of the country. Moreover, regardless the return years on capital the actual number of hours that solar energy can be used effectively is only seven hours at most. The second reason is that, most of the citizens living in rented houses which the ability to reject the installation of solar system by the owner of the building is very high due to the limitation in space. The third and last reason related to the design of houses itself. Most of the existing houses designs is not applicable to install the solar system.

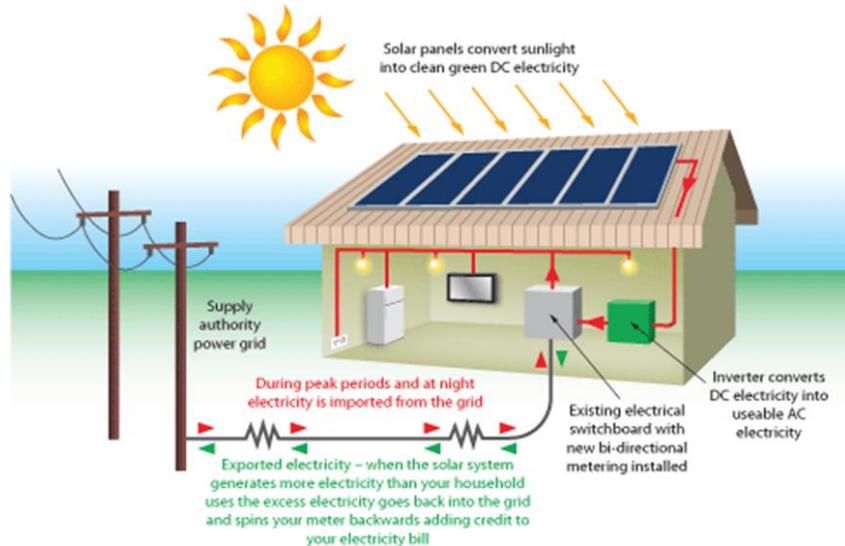


Figure 3: Distribution Generation System at end user unit



Figure 4: KAUST Solar Park (2MW)



Figure 5: Aramco North Solar Park (10MW)

The best way to ensure fast and big number of subscribers in this solar system is through directing local banks or government agencies such as Ministry of Housing and others to support the cost of purchasing the solar system's materials so that the costumers will pay the cost to these parties through monthly installments. In addition, forcing new commercial buildings, markets, malls, petrol station, schools and others onto certain designs that allow the installation of the solar system on a large scale. In general, a plan and facilities should be devised to exploit urban areas inside cities to benefit from solar energy effectively and ensure its widespread in short term.

#### *Public Transportation:*

Saudi Arabia suffering from the lack of the public transport until the registered vehicles in Saudi Arabia in 2016 reach to 20 million vehicles. Saudi Arabia started construction of public transportation in Riyadh but still not in the required range as other main cites still suffering from the lack of the public transportation such as Jeddah, Makkah & Dammam. Imaging 60 people can transfer in one-bus vs 60 people transfer in 60 cars daily to their work. But above of that we must imaging how much of Gasoline and Diesel can reduce.

The company (SAPTCO), a public shareholding company, has provided public service within cities and has certain positions within each city. However, this solution was not success. Old and worn buses that are not subject to any criteria of Safety and security are traveling inside cities and carry passengers from every street and pavement and cause hundreds of accidents. In addition, they offer cheaper prices than licensed buses. This is one of the important reasons that led to the failure of the public transport bus experiment in Saudi Arabia. Failure and delay in expanding the public transportation in the cites, this has led to a dramatic increase in the number of private cars on the Saudi roads, resulting in spectacular traffic jams, a significant increase in the consumption of roads and streets and a reduction in their life span. Of course, this contributed to increased traffic congestion Pollution and environmental pollution, and the most important reason among these, it causes huge domestic consumption of oil.

Railway, both in its traditional forms between cities or even between countries or even in other traditional forms within cities, whether underground metro or on roads or suspended, are all successful ways to help cities to get rid of their problems in transport and regulate the movement of transport in an important manner. The new project of railway that connect Jeddah, Makkah & Madinah is mainly built to serve the Hajj & Umerah to facilitate transfers to and from the airport and to these cities. It is a good start, but it is not enough. New York, Boston, Montreal, Paris, London, Prague, Moscow, St. Petersburg and even Pyongyang, the capital of North Korea, all have impressive subway networks that contribute and transfer of millions of people. On Arabian countries or cites level, there are Egypt and Dubai, and soon will join them Doha, Abu Dhabi & Riyadh, and we hope the public transportation will also available in other cities across the kingdom in near future.

The absence of public transportation led Saudi Arabia to be the world's first in traffic accident with 86 thousand death accident every year that causing 47 billion annually bleeding losses due to the accumulative increase in number of vehicles annually. Due to the Kingdom's lack of competition in this field, it is highly recommended that the expertise and foreign companies specialized in the field of public transport be allowed to enter and participate in tender's public transport projects. Energy saving Products: Saudi Arabia Market still drowned by products that consumed a lot of energy, and that include any product without energy saving feature, such as but not limited to, lamps and Electrical equipment of all kinds.

In last decade, Energy saving lamps start entering to the market of Saudi Arabia, which recorded a huge saving in the electricity consumption. I believe Saudi Arabia's government shall stop import the lamp that categorized as huge consumption of energy because same strength of light can have gained

by both but one consumed 400% energy more than other. Let us assume that if one person used only 10 energy saving lamps that consumed 80 watts for all in the same time, he could save around (220 watts) per hour if he used the non-saving type of lamp. Now imagine the population of Saudi Arabia is 32.3 million following the same, which will lead us saving more than 7000MW per hour, which is equal to 11% of the consumed electricity in 2017. What an energy amount that can be saved if every person can save more than 220 watts. It should also be noted that savings would have a significant impact on road lighting if energy-saving lamps were adopted in millions of poles around the Kingdom. Adopt and use awareness of the use of sunlight in our homes and offices by adopting modern designs that allow us to get benefit from daylight instead of using lamps, as this culture is totally lacking in our countries. When you walk in residential areas, windows are very small and can make up about 10% of the room's total wall space, as well as in schools, government facilities, and many other buildings designed to enmity with sunlight instead of making friendship with it. Unlike the exaggerated designs for the distribution of lighting in the room in the homes, you will always find a single operation button that lights multiple bulbs at the same time, which is significantly above the need.

The Kingdom has witnessed unprecedented economic and industrial development over the past decades, leading to an increase in domestic consumption of energy. Based on current patterns of domestic consumption of energy, it is estimated that this consumption will grow by between 4% and 5% annually, It is noticeable that there is a clear increase in the lighting used in shops and malls, where some use excessive use of incandescent lamps designed to attract customers, as is seen markedly the finite waste in many departments and government buildings in the use and operation of devices I would like to point out that there are manifestations of wasting electrical energy in all mosques, except, In regular prayers (other than Friday) there are few worshippers who do not exceed two or three ranks, yet a number of air conditioners (if not all) remain at times working without interruption, The majority of the electrical appliances in the Kingdom consume a very large amount of energy, which led the government to establish the Saudi Energy Efficiency Center years ago. To identify, consumption of each product for the buyers. But that is not enough, but that is not enough, as the government must ban the importation of electrical appliances that consume a large amount of energy.

Electrical/hybrid cars are the future car of choice. Being able to maintain fuel efficiency, meanwhile, produces only low levels of toxic fumes. Because of these benefits hybrid cars are becoming increasingly popular every day in many countries where people are now considering getting rid of their traditional cars and buying a hybrid car to help reduce the cost of fuel consumption. Hybrid cars have two engines and are designed to keep fuel-efficient. It has a traditional gasoline engine and has an electric motor and batteries. It has two engines working together to reduce fuel consumption. With this technology, people will be able to reduce fuel consumption by more than half. And if we can imagine, with a hybrid car, we will be able to go more than 100 km with 3 liters of Gasoline only. With this type of savings, hybrid cars are the future car. Unfortunately, the hybrid cars entered the Saudi market in 2016 through Toyota only and was not a great success due many reasons which as but not limited to, the low price of gasoline at that time and the high price of the hybrid car itself. However, let us agree that it is the future solution to reduce fuel consumption and carbon dioxide emissions. When you travel in many countries you find that the battery charging stations of these cars have begun to spread, which is a direct indication that the culture of the use of these cars have begun to spread as well.

Many countries have lunched long term plans to make all cars in cities electrical cars to meet the future challenges of fuel consumption and carbon dioxide emissions in cities. As of 2040, Britain will ban the sale of all types of conventional fuel vehicles (gasoline and diesel), including large transport vehicles, and only electric vehicles to preserve the environment and ensure pollution reduction. While Sweden is planning to completely dispense with gasoline and diesel cars and there are those who are

proposing a referendum to make it start in 2020. While the United States has put in place plans to encourage the use of electric vehicles, including the allocation of about 40,000 kilometers of major highways, where drivers throughout the United States can eventually get through them regularly to the charging stations. It should also be noted that electric charging stations raised from 500 stations in 2008 to more than 16 thousand stations in 2017. German Chancellor Angela Merkel also pointed out that her country's move towards banning sales of diesel and gasoline cars is only a matter of time, all this indicates that the future is for electric cars. India has decided that any car sold in the country must be operational on electricity as of 2030, and the Norwegian government plan has explicitly stated: all passenger cars and closed cars sold from 2025 must have zero emissions. And same is happening for many other countries such as Turkey, France and other. In Saudi Arabia, we must consider the inevitability of the dominance of these cars in the future on the market and start from now in facilitating the implementation of infrastructure and the development of incentives and facilities to own these vehicles. One of the proposals is to exempt them from customs fees, parking fees and give priority in many areas to any citizen owns this type of cars way.

The government should ban the import of electrical appliances that consume a lot of energy or at least increase the customs fees, which leads to make its prices higher in market, and in turn reduce customs fees on low energy consumption devices, leading to make its prices lower in the market to ensure fast spread of these devices. It is also proposed to create a Government support fund to support citizens by direct them to replace their old, high-energy appliances for low-energy devices, as for short term both will get the benefits. And the most important step to be taken immediately is that the government should start an expanded campaign to raise awareness of change and support energy-saving products through social media, awareness campaigns in public and other places, but above all of these, is to start with schools to raise a generation having to full responsibility of awareness of the importance of energy and the ways to preserve it.

#### *Bioenergy:*

Bioenergy is a form of renewable energy derived from biomass to generate electricity and heat or to produce liquid fuels for transport. Biomass is any organic matter of recently living plant or animal origin. It is available in many forms such as agricultural products, forestry products, and municipal and other waste [32].

Saudi Arabia has 4,577-customer subscriber in Agricultural sector in 2014. Agricultural sector is growing by an average growth 5.2% [33] and these farms can be easily use bioenergy to be self-independent of electricity. In Turkey 36% of the farms are using biomass to get energy. Bioenergy system can be easily implemented in most of these farms due to the many benefits that can be gain which are but not limited to:

- Reduction of pressure on finite natural resources.
- Reduction of greenhouse gas emissions via fossil fuel substitution.
- The removal of the need for specialist food crops.
- Reduction of landfill waste and associated issues.
- Provision of thermal, electrical and mechanical energy services.
- The ability to handle contaminated waste.
- The removal of carbon from waste. It is stored in the biochar produced which makes an excellent fertilizer.
- Increase of terrestrial carbon sinks and reservoirs.

- Protection of groundwater supplies and reduction of dry land salinity and erosion.
- Maintenance of logging sites in a clean state for reforestation.
- The return of land back into production with enhanced biodiversity.

*Economic Benefits:*

- The cost-effective supply of heat and electricity for your factory, office block, retail park, industrial estate or housing estate.
- Provision of thermal, electrical and mechanical energy services.
- Reduced waste management costs.
- Economic growth through business earnings and employment.
- A bioenergy plant can be installed quickly.
- Achieve additional value from products already in the economy.
- Farmers may improve returns as marginal crops become viable given an additional source of income from energy by-products.
- Import substitution with direct and indirect effects on GDP and trade balance.
- Security of energy supply and diversification.
- Support of traditional industries, rural diversification and the economic development of rural societies.
- Governmental support for renewable energy e.g. programmes and funding for cost-sharing research and development, demonstrations for new energy.
- technologies and tax incentives to encourage market penetration, informing the public about the merits of renewable energy, facilitating the development of standards and training tools.
- Flexible regulatory framework enabling formation of new start in the field of bioenergy.

*Dams:*

To exploit rain and flood waters as efficiently as possible, the Ministry has concentrated on building several dams in different areas. Before 1975 (1395 AH), there were 16 dams; the number had increased to 230 by end of 2006 (1426/27 AH), with a storage capacity of 850.33 million cubic meters. These dams contribute to the increase of subterranean water reserves and the provision of potable water, as well as helping to protect plantations and some villages against the flooding which previously threatened them as a result of sudden torrential rises in the level of water.

Among the major dams in the Kingdom is the dam of Wadi Najran with a storage capacity of 85 million cubic meters, the dam of Wadi Jizan with a storage capacity of 75 million cubic meters, the dam of Wadi Fatima on the outskirts of the Holy City of Makkah with a storage capacity of 20 million cubic meters, and the Wadi Bisha dam, the largest dam in the Kingdom and the second largest concrete dam in the Middle East [34].

The water dam considered as valuable source to generate electricity, as an example Hoover Dam in US with capacity of 2,080 MW which entire Las Vegas city depending on the power that generated for that dam, but unfortunately, none of any dam in Saudi Arabia is equipped with electrical generators.



Figure 6: Hoover Dam



Figure 7: King Fahad Dam

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