Innovative Systems Design and Engineering
ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol.9, No.3, 2018

Alternative Energy System

Firas J. Khusaifan
Saudi Arabia

Abstract
The population of Saudi Arabia has jumped from 3.2 Million in 1950 to 31.7 Million in 2015; approximately 10 times more, therefore, the energy demands have been increasing to meet the need of the nation. As a result, the domestic oil demand is increasing to respond to the population growth. There are several reasons beyond the huge domestic energy demands for Saudi Arabia. Saudi Arabia is well known of its lack of fresh water sources; since there is no rivers and not much rain fall. Consequently the Saudi government built many desalination plants to supply its nation with the water and some of them are still under contracture (Bloomberg.com, 2014). As a sequence, the energy demands will increase to operate and maintain those desalination plants beside transportation, industrial and residential sectors. Saudi Arabia is ranked as the biggest producer of desalinated water worldwide through 27 desalination plants nationwide with a capacity of 1.06 Billion Cubic meters of water associated with using 240,000 barrels of oil. The kingdom produces % 18 of the total global production of the desalinated water (Alyaum.com, 2015). Furthermore, Saudi Arabia is ranked as the third-largest global producer of basic petrochemical ethylene (hydrant.co.uk, 2014); which requires a lot of energy to produce the material.
Keywords: energy demands, domestic oil demand, petrochemical ethylene

Introduction

The hydrocarbon (Fossil fuel) has been deposited beneath the Earth's surface since thousands of years. It is considered to be non-renewable energy because it's production rate is too long compared to the consumption rate. The hydrocarbon fuel is providing around 84% of the total energy demands worldwide (Fig.1).

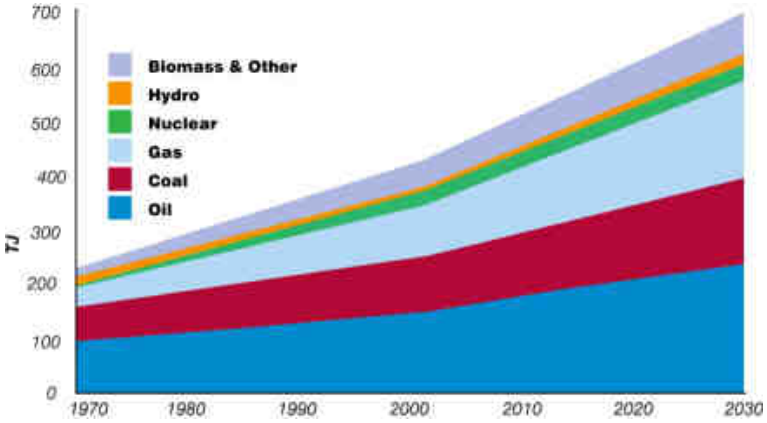


Fig. 1: Fossil fuel is accounting for 84% of the energy demands into the world. (Source: Estefani, 2013

The energy demands have doubled from 230 in 1970 to 550 (Estefani, 2013) in 2015 and world oil consumption has jumped from 500 Million Tons in 1950 to 3800 Million Tons in 2004 (Fig.2) (Worldwatch.org, 2015). The reason beyond increasing the demands is that the world population has almost tripled from 1950 to 2010 (Fig.3) and the industrial era has been dramatically developed for the last few decades (Mother Earth News, 2015).

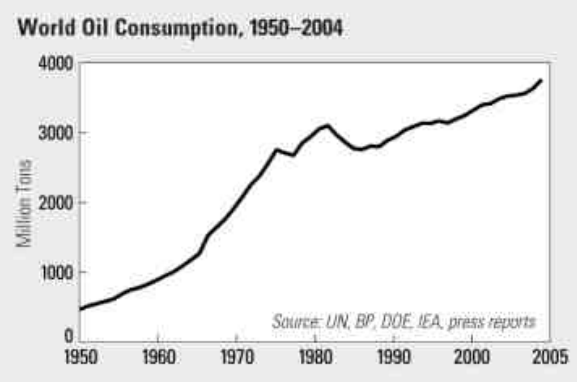


Fig.2: World oil consumption

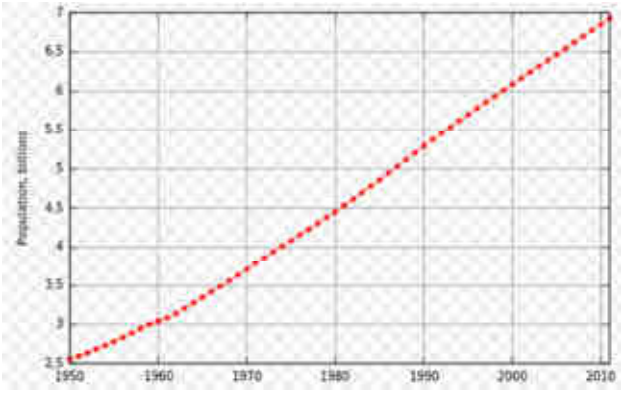


Fig.3: World Population (Source: Worldwatch.org, 2015)
(Source: Mother Earth News, 2015)

Based on the previous facts, the oil demands have been greatly increased for the last few decades and as a sequence some problems have been developing along with it such as global warming, public health concerns and hydrocarbon inadequacy in the future.
Some countries have already shifted to use renewable energy to be a major source to produce power in the near future. The drive beyond that are 1) oil prices has been 3 times costly since 2003, 2) to help reducing greenhouse gas emissions to the atmosphere because the alternative energy machineries are considered to be clean source of energy and would have significantly smaller environmental impacts than energy sources coming from fossil fuel, and 3) reduce public health concerns associated with the air pollution.
This study focuses on Saudi Arabia and what is the possible alternative energy solution that can be taken to help conserving the fossil fuel and saving our precious environment from degrading. I will start with a brief essay and to be followed with a feasibility study of deploying a wind farm at one of the locations in Saudi Arabia.

Background, current and future plans
Despite the fact that Saudi Arabia is considered to be one of the biggest oil producers to the world, it might lose this tanking in the near future due to the high domestic oil demand. Saudi Arabia consumes 3.4 Millions barrels of oil per day in 2010 and it is expected to reach 8.3 Millions barrels of oil per day by 2028 (Fig.5) (Kacare.gov.sa, 2015). Thus, it is essential to focus on the renewable energy, not just to save the fossil fuel but also to reduce CO2 emissions to the atmosphere, which contributes significantly in causing the global warming and increasing greenhouse gases. Currently, Saudi Arabia capacity of generating electricity is 58 gigawatts(GW)- all the power comes from fossil fuel- and the expected demands might take it up to 120 (GW) in 2032. Accordingly, Saudi government has considered evolving solar energy, wind farms and nuclear power generations to take its share in providing the nation with the needed power for their needs (Kacare.gov.sa, 2015), (Eia.gov, 2014).

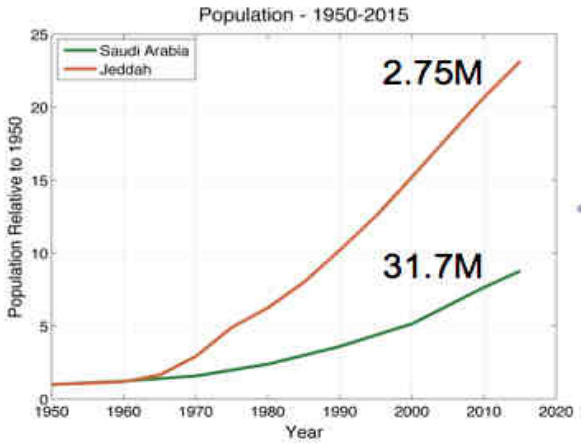


Fig.4: Saudi Population

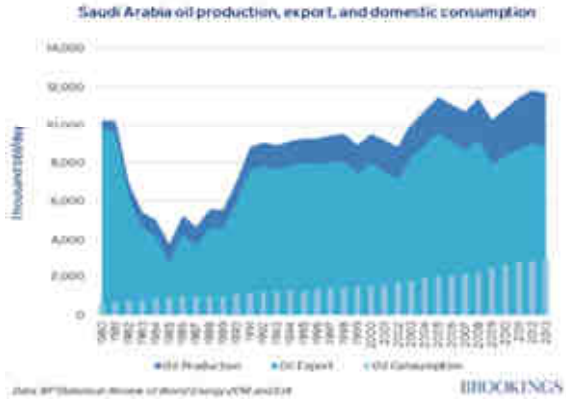


Fig.5: Saudi Arabia oil production, export, and domestic consumption (Source Hino, 2015)

In a brief, the current hydrocarbon power capacity generation of Saudi Arabia is 58 GW. By 2032, the expectation would be 120 GW; 71 GW would be coming from alternative energy and 49 GW would be generated from hydrocarbon fuel. (Table.1). The fossil fuel would still be the major supply for energy at least for the upcoming four decades (Kacare.gov.sa, 2015).

Table.1: The expected alternative energy power generation in Saudi Arabia by 2032 (Kacare.gov.sa, 2015)

Alternative Energy	Anticipated Capacity	Nation Demand Coverage Percentage %
Solar Energy	41 GW	34.1 %
Wind Farms	9 GW	7.5 %
Geothermal and Waste	4 GW	3.33 %
Atomic	17 GW	14.61 %
Total	71 GW	59 %

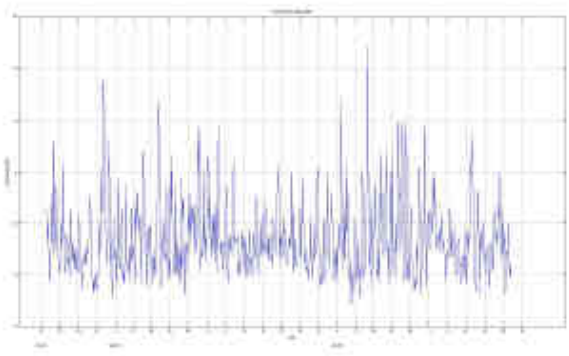
Duba wind farm Feasibility Study

One of the future plans to use alternative energy in Saudi Arabia is to utilize the wind to generate energy; the wind share will cover 7.5 % of the total energy demands by 2032. Duba location was chosen due to the fact that the data was available to conduct the study. The data includes the following parameters: air temperature, wind speed, and wind direction.

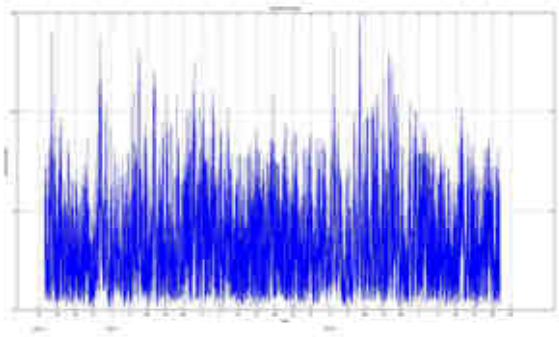
Study Area

The coordinates of the study area are 27°19'23.31"N 35°43'51.73"E.

Data analysis and results



Hourly Wind Speed (m/s) (Source Environmental Scientist Saudi Aramco,2015)



Daily Wind Speed (m/s) (Source Environmental Scientist Saudi Aramco,2015)

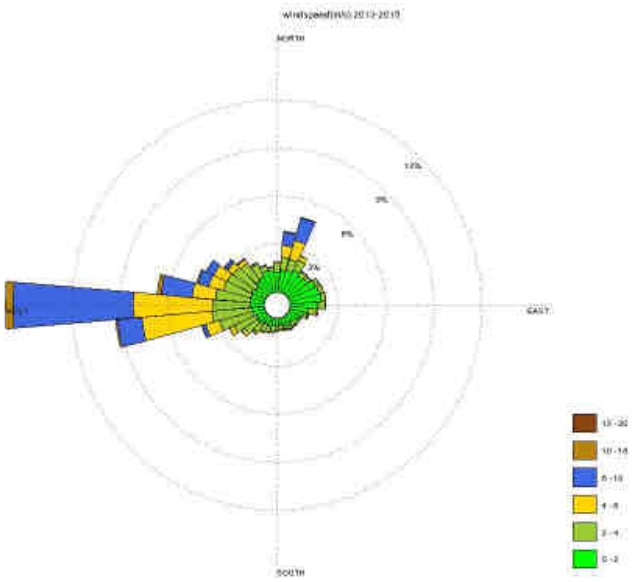


Fig.6: Wind speed & wind direction (Wind rose) for Duba Metrological station between September 2013 and October 2015 (Source Environmental Scientist Saudi Aramco, 2015)

This wind rose shows the speed and direction of the wind. The figure shows that the majority of the wind comes from the west (% 17) with a different average wind speed that varies between 3 m/s to 10 m/s.

One of the feasibility study about deploying a wind farm in Saudi Arabia that was conducted by (Martin, 1985) illustrates that the best two locations to deploy a wind farm in Saudi Arabia are allocated in Yanbu and Dhahran cities, the wind speed averages are 4.1 m/s and 4.4 m/s respectively (Martin, 1985). Duba site has an average of 3.41 m/s which makes it feasible (Table.2). Therefore, Duba location it can be utilized to generate energy that can serve the local residents, especially, the population of Duba is too small considered to other cities.

Usually, a good quality wind turbine starts spinning at 5km/h breeze and starts producing power at 8km/h (Solarelectricityhandbook.com, 2015). Therefore, building a wind farm at Duba Coastal area is feasible because its average wind speed guarantees its operation most of the year.

Table2. Annual mean wind speeds, and annual mean wind powers for Duba station in Saudi Arabia as a height of 10 m Above Ground Level (AGL).
(Source Environmental Scientist Saudi Aramco,2015)

Location	Annual mean wind speed (m/s)	Annual mean wind power (W/m2)	Observation years
Duba	3.41	41.7	Sep. 2013 – Oct. 2015

The Wind Farm Characteristics
Since the Duba site does not have an extreme wind speed condition, choosing a large blade would ease and enhance capturing the wind to be utilized perfectly for energy generation, therefore, a set of twelve (12) wind turbines were chosen with a capacity of 2 MW each to be deployed to be able to generate a total of 24 MW; working at their full capacity.

According to the wind rose, the turbines should face the West (W), west-northwest (WNW), and west-southwest (WSW), four-wind turbines at each direction. Since the wind directions chances to hit the W, WSW and WNW is % 32, the capacity factor will be set as 0.32 and the total capacities of the 12 wind turbines would be around

7.68 MW with a total cost of $ US 48 Millions. The average electricity use in a household in Saudi Arabia is 8.23 MWh, which means it is as twice as the average global household (Alriyadh Magazine, 2015), as a sequence, the generated energy by the wind farm will be sufficient to provide energy for more than 8000 household in Duba region.

Wind Turbines	Capacity of each turbine	Maximum generating capacity for Duba	Expected generating capacity (0.32 capacity factor)	Total cost
12	2 MW	24 MW	7.68 MW	US $ 48 Millions

Conclusion

Shifting to the alternative energy for Saudi Arabia is not an option as it is a necessity, the country has the resources and it is location gives it an advantage to enormously use the solar energy, by 2032 the solar energy might produce 34.1% of nation energy demand. Wind speed all over Saudi Arabia is not as great as other countries; however, it will cover 7.5 % of the total energy consumption by 2032. Personally, I am surprised that solar energy would be generating the double energy quantity than atomic. The alternative energy will cover 59 % of the total energy demand in Saudi Arabia by 2032 and the hydrocarbon will still a major source of providing energy as much as % 41.

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