Roadmap for Future: Vision 2030 and its Impact on Saudi Arabia's Energy Sector

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Abstract: The energy consumption of Saudi Arabia is at a record high due to growing population and increasing industrialization. The electricity consumption is also growing rapidly and is expected to double by 2032. Currently, Saudi's electricity generation depends entirely on fossil fuels. However, the Kingdom's energy sector is shifting towards renewable energy since the announcement of Vision 2030. The purpose of this paper is to investigate the effects of Vision 2030 on Saudi's energy sector and assess its impact on the Kingdom's economy. Vision 2030 calls for a renewable energy capacity of 71.6 GW by the year 2040. The majority of development will be done in solar, nuclear, wind, geothermal and waste-to-energy fields. Saudi Arabia is willing to spend well over $100 billion to facilitate this growth, and is also changing several policies such as encouraging public-private partnerships in energy field, privatizing the renewable sector and removing the subsidy on electricity and gasoline. After going through several researches, a few results, analysis and predictions are presented in this paper. Vision 2030 can help Saudi Arabia save nearly 250 million barrels of oil, 300 million tons of carbon dioxide and approximately $25 billion annually from the year 2040 onwards, provided all the policies and strategies are implemented efficiently by the government of Saudi Arabia.

Key words: Saudi Arabia, Vision 2030, sustainability, solar, nuclear, waste-to-energy

INTRODUCTION

World Bank data informs that 100% of Saudi's population has access to electricity at all times. British Petroleum Statistical Review of World Energy reported that in 2017, 375.4TWh of electricity was generated in Saudi Arabia, out of which 0.1TWh was generated from renewables, while 221.1TWh and 154.3TWh was generated from natural gas and oil respectively. KSA also ranks 3rd in terms of average household electricity consumption, nearly 24MWh per house hold (Anwer & Matar, 2017). KSA is the 4th largest energy producer in the world, producing a total energy of 652Mtoe in 2017 (Yearbook , 2018). A major portion of this energy is generated from oil, making Saudi the 5th largest oil consumer with a daily consumption of 172.4 million tons. Annually, Saudi consumes a massive 1.43 billion barrels of oil, leading to an extremely high annual per capita consumption of 42 barrels. This extensive use of oil and natural gas results in higher amounts of carbon dioxide emissions. Saudi Arabia is the 9th largest CO2 emitter in the world, emitting a total of 594.7 million tons of carbon dioxide in the year 2017, resulting in a massive per capita total of 17.6 tons of carbon dioxide emission in 2017 (BP, 2018).

RESEARCH METHODOLOGY

This paper is a quantitative research based on secondary data retrieved from various authentic global reports and published research works. This research provides a case study of KSA's attempt to promote sustainability under the Vision 2030 program. It investigates the current and the future of Saudi's renewable energy sector and primarily focuses on solar, nuclear and waste-to-energy, giving the readers a basic idea of the advantages of this transition. This change leads Saudi Arabia to a more efficient, environment friendly and cost effective energy system, hence, it is important to evaluate and discuss the transition in detail. The researchers also present a considerable view of the different initiatives undertaken and the policies diversified by the government in order to facilitate this shift towards sustainability. The collected data is evaluated to analyze the present and forecast the future of the Kingdom's renewable energy sector. The data analysis presented in this research includes direct or indirect impact on the environment and the country's economy.

TRANSFORMATIONS IN THE ENERGY SECTOR OF SAUDI ARABIA

The total electricity consumption is expected to double by 2025 and the energy consumption is expected to triple by 2030 (Kingdom of Saudi Arabia, 2016). Completing the plans of Vision 2030 requires energy generation from renewable sources and the government has put great emphasis on developing the renewable energy sector of the Kingdom (Salam & Khan, 2018). Initially, KSA targets 9.5GW by 2023 under National Renewable Energy Program (NREP) with an interim target of 3.45GW by 2020 under the National Transformation Program (NTP) (Renewable Energy Project Development Office, 2017). National Renewable Energy Program also aims by 2021 to increase the energy efficiency by reducing the peak demand nearly 14% and reducing the electricity consumption by almost 8% (Wogan, Pradhan, & Albardi, 2017). By 2040, King Abdullah City for Atomic and Renewable Energy (K.A.CARE) plans on generating 71.6GW of energy from renewable sources. K.A.CARE aims that by 2032, 30% of electricity generation and by 2040, almost 50% of the total generated electricity will be from a non-fossil fuel source (Chite & Ahmad, 2017). A breakdown of KACARE's plan is shown in the Table 1:

Table 1: Energy Generation from Renewable Sources by 2040

Source of Energy	Combined Energy Generation (GWh)
Solar Energy	41
Nuclear Energy	17.6
Wind Energy	9
Wastes	3
Geothermal Energy	1
Total	**71.6**

Source: General Authority for Statistics (2016).

Solar Energy

The location of Saudi Arabia makes solar the best option for renewable energy generation. In 2017, the total renewable capacity of Saudi Arabia was 92MW, with 89MW of this energy being solar, while the remaining 3MW being wind (IRENA, 2018). But this number is set to increase as Saudi's solar industry is striving to achieve 41GW of solar capacity by the year 2040. In this solar capacity, 25GW is from Concentrated Solar Power (CSP) and the remaining 16GW is of Photovoltaic (PV). Additionally, the government plans on investing more than $108.9 billion in the solar industry and has also announced incentives that include financing 50% of the project cost and even promised a generous tax break (Alyahya & Irfan, 2016).

Since the introduction of Vision 2030, the solar industry of Saudi Arabia has been expanding relentlessly. A few mega projects witnessed by the Kingdom include Makkah Solar Energy Project, Duba I ISCC, Waad Al-Shamal ISCC, Taiba ISCC and Sakaka IPP PV. A representation of this growth and a prediction of the future growth is presented in Figure 1 below:

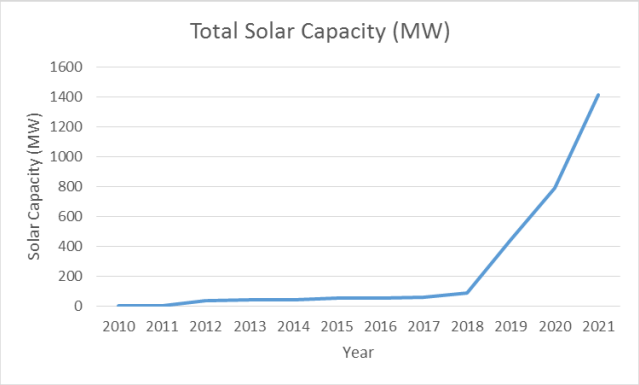

Figure 1: Growing Solar Capacity of Saudi Arabia

The growing solar industry of Saudi Arabia has achieved some milestones already.

- Duba 1 and Waad Al Shamal have the cheapest cost per installed kW, which is lesser than $1,600 per kW (Hashem, 2016).
- The solar thermal water heater installed at Princess Noura University is the world's largest district solar water heater (Power Technology, n.d.).
- Sakaka IPP plant will harness solar energy at the lowest global tariff of US Cents 2.3417/kWh (ACWA Power, 2018).
- Al-Khafji desalination plant will be one of the world's first huge-scale solar-powered desalination plant upon (Water Technology, 2017), (Laursen, 2018).

Nuclear Energy

In the year 2017, nearly 11% of the global electricity was produced from nuclear energy, which is more than double of solar, wind, geothermal and tidal combined (World Nuclear Association, 2018). Due to its high efficiency and lower fuel requirement, Saudi Arabia plans to invest in the nuclear industry. K.A.CARE plans on generating a total of 17.6GW of power from atomic energy.

Saudi Arabia has been closely working with a few countries in order to develop nuclear energy in the Kingdom. The most prominent countries are China, France, Russia and South Korea. In January 2012, China National Nuclear Corporation (CNNC) agreed with K.A.CARE to develop and maintain nuclear research reactors. In 2016, China Nuclear Engineering Corporation signed an agreement for building a high temperature reactor. CNNC has also been working with Saudi Geological Survey for the exploration of uranium in the Kingdom. In 2015, France agreed to undertake a feasibility study for constructing 2 EPR nuclear reactors. In 2016, Russian nuclear company Rosatom announced that it is ready to build 16 nuclear plant in Saudi Arabia for a total of $100 billion. In 2015, Korea Atomic Research Institute agreed to assess the building of multiple SMART reactors for integrated desalination (World Nuclear Association, 2018).

In 2015, International Atomic Energy Agency (IAEA) held a workshop in Riyadh to help Saudi Arabia establish a baseline for nuclear education and train its personnel using IAEA Education Capability Assessment and Planning Methodology (Ugochukwu, 2016). Later in 2017, IAEA officiated the first Country Program Framework (CPF) for the years 2017-2021 (IAEA, 2017). In July 2018, IAEA carried out the Integrated Nuclear Infrastructure Review (INIR) for Saudi Arabia and reviewed KSA's nuclear infrastructure development with Phase 2 criteria (IAEA, 2018). Phase 2 is the preparation for the contracting of a nuclear power plant. Upon the completion of Phase 2 comes Milestone 2 which proves that the member state has the adequate infrastructure for the construction of the nuclear power plant (IAEA, 2016).

The construction of nuclear power plants is very expensive and strict rules and policies laid down by IAEA are to be followed. IAEA safety standards include 20 essential safety elements and are referred to as IAEA's Specific Safety Guide (SSG) (IAEA, 2017). Saudi Arabia plans on constructing 2 large nuclear power reactors. This is scaled back from building 16 over the next 20-25 years at a cost of more than $80 billion. K.A.CARE projects nearly 17 GW of nuclear capacity by 2040 to accommodate 15% of the country's power consumption then (World Nuclear Association, 2018).

Waste-to-Energy

Saudi Arabia produces nearly 15 million tons of Municipal Solid Waste (MSW) each year (Nizami A. , 2018). Saudi is 9th in terms of daily MSW generation per capita with an average waste of 1.3 kg (Statista, 2018). This number is estimated to be doubled by the year 2033 due to industrialization (Nizami, et al., 2016). Currently, majority of MSW is collected and sent to landfills untreated, which results in several problems such as leachate and methane emissions (Nizami A. , 2018). However, this health and environmental hazard can be countered by proper waste management techniques or Solid Waste Management (SWM). One of which includes producing energy from waste, which is called Waste-to-Energy (WTE). By the year 2040, the Government of Saudi Arabia plans on generating 3GWh of electricity from waste. Waste-to-Energy (WTE) is a feasible source of producing energy in the Kingdom of Saudi Arabia.

A common and efficient WTE technology is the generation of Refuse Derived Fuel (RDF). RDF is produced from biodegradable waste materials and plastics (Clarity, 2018). RDF is an alternative fuel which can be used in power generation. The process of RDF production involves several phases that include reduction, separation, crushing, drying and pelletizing (Zafar, 2018). The primary advantage of using RDF pellet is its high calorific value of 0.145kW/kg (Gendebien, et al., 2003). The efficiency of generated power via RDF is around 18% with an energy recovery rate of 168kWh (Ouda, Raza, Al-Waked, Al-Asad, & Nizami, 2017). Another, commonly used WTE process is biomethanation. Biomethanation is the anaerobic conversion of organic materials into organic fertilizers and energy (Chakraborty, et al., 2013). The raw materials essential for biomethanation include food and vegetation wastes (Gotmare, Dhoble, & Pittule, 2011). Higher efficiency and minimum economic requirements are the advantages of biomethanation. However, larger area is required for this process as the waste needs to be stored and covered (Ouda, et al., 2016).

WTE technologies have massive potential in Saudi Arabia. However, unlike majority of the other renewable energy sources described in Table 1 that require minimal public participation for their success, the residents of KSA play a crucial role for the success of WTE. The government needs to educate the people and spread awareness regarding SWM. Spreading awareness includes making the public understand the concept of waste segregation. Segregating of waste is essential for WTE techniques such as biomethanation and RDF. For this, the authors recommend installation of at least 3 distinguishable, smaller waste containers for plastics, non-plastics and food wastes, instead of one huge waste container. This will allow the public to segregate their wastes. Segregation can also be facilitated by the introduction of third party contractors for door-to-door collection of wastes in a designated color-coded bin for easy recycling. This way, the government will save money, as the municipality will not go through the tedious and time-consuming process of separating the wastes.

CONCLUSION

The year 2016 marked the beginning of Vision 2030, a scheme that changed the outlook of the Kingdom. It mainly focused on reducing the country's dependence on oil and diversify the Nation's economy by changing several policies. The Ministry of Energy, Industry and Mineral Resources started Renewable Energy Project Development Office (REPDO) under the National Renewable Energy Program (NREP). In the start of 2018, Saudi announced its plans of reducing the subsidy on electric and gasoline prices. Within a year, nearly 71% of Saudi Arabian consumers are using electricity and 55% are using gasoline efficiently (Wald, 2018). The Kingdom also started privatizing companies such as SWCC, SEC, and Saudi Aramco. NREP encouraged private industries to invest in the renewable sector, resulting in the rise of companies such as ACWA Power. Additionally, the government announced incentives that include financing 50% of the project cost and a generous tax break (Alyahya & Irfan, 2016).

Vision 2030 sets forth the Kingdom's plan to generate 71.6GW of energy by the year 2032 from clearner sources. NREP's Vision 2023 targets to generate 10% of the Kingdom's total energy capacity of 9.5GW from renewable energy (Renewable Energy Project Development Office, 2017). National Transformation Program (NTP) will add 3.45GW that is approximately 4% of the total generation capacity from renewable energy by the year 2020, in three phases (Renewable Energy Project Development Office, 2017). NREP's plans are demonstrated in Figure 2 below:

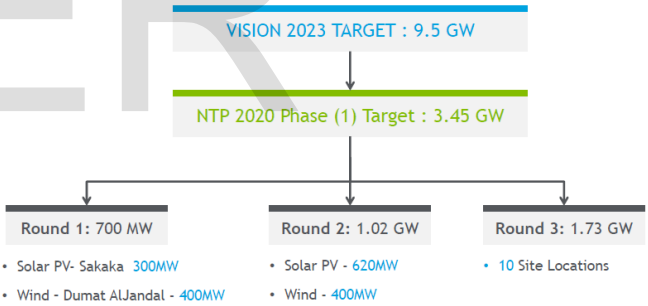

Figure 2: National Renewable Energy Project Vision 2023 schematic
Source: Renewable Energy Project Development Office (2017)

NTP 2020 and NREP's Vision 2023 provide information regarding the total renewable generation capacity. However, the breakdown of the generated energy is not completely determined. The authors predict that by the year 2020 nearly 2.5GW of solar capacity- 1.5GW CSP and 1GW PV and 950MW of wind capacity will be added. By 2023, out of the 9.5GW of renewable capacity, solar energy will be 7.2GW-4.3GW CSP and 2.9GW PV. The remaining will be shared by nuclear, wind, WTE and geothermal. A tabulation of the predicted benefits of this transition of energy sector is presented in Table 2 below:

Table 2: Predicted Benefits of the Transforming Energy Sector

Year	Renewable Capacity (GW)	Annual Generation (GWh)	CO_2 Emissions saved (Tons)	Oil saved (Barrels)	Predicted Oil Price ($/Barrel)	Money Saved ($)
2020	3.45	16,380	12,285,000	9,638,660	62.1[a]	589,560,786
2023	9.5	43,300	32,480,000	25,479,484	69.3[b]	1,765,728,241
2040	71.6	400,000	301,110,000	235,376,300	106.08[c]	24,968,717,900

[a]BBVA (2017) [b]Gusev (2018) [c]EIA (2018)

Table 2 clearly illustrates the positive impacts of Saudi Arabia's energy transformation on the environment as well as on its GDP. Saudi Arabia could end up reducing nearly 300 million tons of carbon dioxide emissions by the year 2040. Moreover, the Kingdom will end up saving a massive annual total of nearly $25 billion from the year 2040 as it will save nearly 650,000 barrels of oil a day.

The renewable energy sector is definitely being boosted and promoted by the Government of Saudi Arabia. This will benefit the Kingdom enormously provided the proposed strategies are implemented efficiently. The authors conclude by stating that Saudi Arabia's Vision 2030 is a giant leap forward for the Kingdom in terms of sustainability and economic development.

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