

The Future of Saudi Arabia's Energy Supply: The Kingdom Navigates a Worrying Predicament.

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Opening Thoughts

Ali: CO₂ emissions have proven to be the leading cause of the global warming crisis -- a crisis that threatens everything we hold dear. The world is actively taking action through adopting numerous new sources of energy that are both "green" and renewable, supplying newly arising industries and the rapidly increasing population with sustainable, sufficient, and clean energy.

Hisham: Saudi Arabia, a nation long blessed with an abundance of petroleum and the biggest crude oil supplier in the world, produced over 11.8 million barrels a day in 2019 and exported over 7 million of those to the global community. Today, Saudi Arabia finds itself in a worrying predicament. With the world finally waking up to the climate change crisis (and the impact of fossil fuels in particular), alongside its diminishing supply of oil with no way to replenish, Saudi Arabia has to quickly find a clean and lasting alternative. Increasing pressure from the international community coupled with unstable oil prices have made this shift the greatest the kingdom has ever faced. Therefore, it is paramount that the kingdom does this right, with no room for costly mistakes.

Prologue

In this paper, we will compile and explain the energy sources we believe are best suited for

the kingdom and its challenging circumstances. We will consider the country's available resources, financial ability, economic stability, and other obstacles that it might encounter. We will explore the energy sources in greater detail and answer the question of how the nation can effectively capitalize on the issues it faces. We will also provide a comprehensive review and educated prediction for how Saudi Arabia may utilize modern renewable energy sources to cut off its extreme dependence on oil.

We chose mainly to display how current propositions, along with our own, which we shall reveal at the end of this paper, will aid in relieving these issues by reducing the heavy use of fossil fuel energy in the country and, instead, shifting to renewable and mostly green energy sources, which will, in turn, help grow Saudi's economy and terminate the country's complete dependence on fossil fuels, while providing renewability for the next generations to enjoy.

All information was gathered through our personal research obtained from reputable sources (listed at the end of this paper) alongside personal help and review from those specialized in the field. When enough information is provided, we will propose our own take on what we believe would be best for the Kingdom. Our opinions come with respect to what is mentioned in this paper, however, there could be further information

which we happen to be oblivious to. This project serves primarily as an instigator of country-wide debate on what we, as a nation, should do next. It is not a basic assertion of opinion that claims to have everything under control. Rather, we hope that institutions and individuals, especially the Saudi youth, benefit from reading this paper by receiving factual information summarized efficiently and in an easy-to-read manner. Our goal is to both notify and educate the public on the challenges we encounter and spur healthy discourse on how we should adequately face them.

The issues we will address:

High energy consumption and sole fossil fuel reliance:

Ali: The average household in Saudi Arabia consumes roughly 23.81 MWh of energy (Mega-watt per hour), an objectively excessive figure. For comparison, the United States' average energy consumption per household is only 914 KWh (kilo-watt per hour). The amount of energy required by a Saudi household to sustain basic living conditions in the country's geological standpoint, which includes constant AC usage, is totally unsustainable when exclusively provided by fossil fuels. As of now, fossil fuels are the only energy source supplying the Kingdom's households and facilities.

Additionally, Saudi Arabia's population density is rapidly increasing. The country's centralized government system makes it so that the population density of Riyadh, its capital, is at an especially high rate. Recently, the population density of the city reached a staggering 4,000 people/km². Thus, supplying sufficient and reliable power to the population requires exorbitant use of crude oil induced energy, which substantially harms the environment, and is totally unsustainable in future years.

Severe drought:

Hisham: Another issue the country faces is severe drought. The Kingdom has no rivers, little rain water, and drastically decreasing groundwater. Thus, the country is fully dependent on expensive and environmentally harmful seawater desalination. Desalination plants are powered solely by fossil fuel energy, consuming more than 1.5 million barrels of oil a day. The energy produced is used to desalinate thousands of gallons of seawater every day just to adequately support the Kingdom's growing population.

An incomplete electrical grid:

Ali: A notable issue that threatens the sustainability of Saudi Arabia's energy sources is the country's incomplete electrical grid. Since not all regions are connected to the same electrical grid, the nation wastes a lot of its produced energy. Lacking a complete grid will not allow a truly renewable and sustainable energy source, such as solar energy, to be used efficiently enough to partially or fully replace fossil fuels as a primary energy source.

We have listed four energy sources which would be the best for the Kingdom to adopt. Below are detailed explanations of each energy source and the circumstances surrounding its use:

Solar power:

Ali: Solar power is one of the cleanest and most renewable energy sources that exists today. The technology has developed greatly in the past few years, becoming more cost efficient, environmentally friendly, and easier to manufacture. With solar power, energy is produced through the use of photovoltaic cells on a solar panel that work to convert solar radiation into usable energy stored in special batteries.

Many practical applications for solar power exist that perfectly fit in line with Saudi Arabia's electrical needs. One of which is

known as “Solar Cooling”, an application that uses solar radiation to power refrigerants, providing cool air and water. This is an absolute necessity for most Saudi cities during the hot summer months, where temperatures can hit 50°C. Another application of solar power is known as “Concentrated Solar Power”. This technology uses a reflective surface to focus the sun’s rays onto a container of molten salts which store energy as heat. This energy is then used to heat water, producing steam. The steam then turns nearby turbines, generating massive amounts of energy (in the terawatt range). When that energy is connected to the nation’s electrical grid, it can be used to power facilities and even cities at the industrial level. This method of energy production is the most efficient and has nearly zero waste. The molten salts, which store the heat, are reused after they are cooled. Furthermore, the steam used to power the turbines simply condenses back to water, ready for reuse.

One of the largest and most efficient solar power plants, known as “Ivanpah Solar Power facility”, is located in California, USA. The facility uses only about 14 km² of public land yet produces roughly 940 GWh of solar energy. Issues regarding this energy source are linked to its heavy burning of natural gas. The plant has consumed over 5,790,000 Btu of natural gas since it began operation in 2014, achieving an efficiency of 87% in 2019. The relatively low efficiency resulted from an overestimation of the sun’s availability, which will not be the case in most Saudi cities where the sun stands vertically atop no clouds for most of the year.

Wind power:

Hisham: Wind power harnesses the wind to turn moving turbines, performing mechanical operations that produce electricity. The process has developed greatly in the last few years, seeing significant advancements in turbine technology and manufacture. Wind power is only feasible in areas that experience

strong and frequent winds (to the north of Saudi Arabia).

Nuclear energy :

Hisham: Nuclear energy involves the splitting of atoms to produce heat (nuclear fission), which most frequently is used to power turbines to produce electricity inside nuclear power plants. Nuclear power can guarantee generating energy with no greenhouse gas emissions during operation, and very minimal emissions throughout a nuclear plant’s lifetime. Nuclear power can be obtained from nuclear fission, nuclear decay, or nuclear fusion reactions, the latter of which is yet to be perfected.

This energy source comes with costs that are worthy of mention. Although safety measures have been incredibly improved over recent years, countries housing nuclear power plants will still need to deal with issues like storing nuclear waste and maintenance costs along with having to deal with potential accidents.

It was also proven that numerous political barriers stand before relying on nuclear energy as a primary energy source for the region of Saudi Arabia specifically.

Geothermal energy :

Ali: Geothermal energy utilizes earth’s underground heat to power turbines through steam. The more in depth process is more complicated than that. Regardless, the energy source is now used to power over 60% of the American Northern Carolina coast. This energy source could be used to add more diversity of sources to the energy mix. However, it is not to be relied on for completely clean, cost-efficient and high production of energy.

The technology needs development in order to manage some of its downsides such as its produced wastes and low efficiency compared to other renewable sources. It also cannot be used all around the nation of Saudi Arabia because plants must be placed in strategic remote and sensitive regions. The largest

geothermal plant named “The Geysers” which is located in California, United States uses about 78-square KM and produces 1,517 MWh.

Now, we will review what the Kingdom is currently working on and what is predicted to happen in the next few years.

For the use of solar energy :

Ali: Saudi Arabia has been trying out the adoption of solar energy as a source of renewable energy since the 70’s. Beginning in 2010 - due to a dramatic decrease in the price of solar power projects - numerous projects were initiated and began production of power such as the solar power plant located in King Abdullah University of Science and Technology in Thuwal, the Farasan solar power plant, and the North Park project in Dhahran which is to become one of the largest PV parking lots in the world, Al-Faisaliah solar photovoltaic independent power project to name a few.

For the use of wind energy :

Hisham: EDF Renewables and Masdar won a contract in January 2019 to build a 400-megawatt wind power facility which is to be fully operational by 2022. The facility “will be the biggest wind-power plant in the Middle East”, Masdar claims. The plant is to be built in the city of Dumat Al Jandal in northwestern Saudi Arabia, a region known for its strong winds. Still, as of late 2020, the Kingdom has no further plans or projects lined up.

For the use of Geothermal energy :

Ali: Saudi Arabia is among the most geothermally active areas in the region. However, there are no plants installed. Though this energy source is a promising one for The Kingdom, it remains widely “untouched” due to lack of supportive infrastructure.

There’s only low-grade direct usage that has been going on for the last few years.

For the use of nuclear energy:

Hisham: Saudi Arabia currently has no nuclear power plants in operation. However, the country hopes to create a strong nuclear industry to support its increasing energy needs. In 2010, the King Abdullah Center for Atomic and Renewable Energy (KAcare) was introduced to oversee Saudi Arabia's nuclear energy program, representing Saudi Arabia at the International Atomic Energy Agency (IAEA). KAcare aims to oversee nuclear power production and manage nuclear waste.

In 2010, a deal was signed with Toshiba and Shaw to build nuclear reactors in Saudi Arabia, and with Exelon to manage the nuclear facilities. In February 2011, Saudi Arabia signed a nuclear accord with France aimed to research peaceful applications of nuclear energy. In April 2019, the IAEA released a statement saying Saudi Arabia was likely to have a nuclear reactor in operation within a year, but that the kingdom had not agreed to any IAEA inspections.

It is clear that Saudi Arabia sees the value in nuclear energy and hopes to pursue it. However, political tensions and false promises have been stumbling blocks for any significant progress in the sector. For now, nuclear energy remains a source untapped for the kingdom.

The conversation :

Ali

After conducting comprehensive research, we have concluded that any new energy source the Kingdom will adopt must be renewable and not cause a significant financial burden on the nation. Even though Saudi is blessed with extravagant wealth, a rapid shift away from crude oil is already proving to be extremely strenuous on the economy. An economic shift of such magnitude would simply not be

feasible and plunge the country in economic turmoil if proposed without a sequential, well planned preposition.

We advocate for a plan which, if correctly executed, will allow for Saudi Arabia to transform much of its local energy supply to renewable, clean energy sources. The “correctly executed” condition must be emphasized since working on huge, economy-shifting projects without proper preparation for delays, accidents, and shortcomings will eventually lead to failure. An example of that is Saudi Arabia and Soft Bank’s failed “Largest Solar energy plant” project.

We deduced that our first step should be connecting the electrical grid to all of the country’s major cities and most of its minor regions. Hopes of expanding to nearby energetically almost self-sufficient countries (European countries, for example) could also be proposed; however, we need to avoid geo-political implications and simply focus on what we can effectively execute locally first.

The primary energy source should evidently be solar energy. Simply put, the energy source provides a high output value, great cost efficiency, and total renewability for the Kingdom. However, this does not mean that the country should not strive for an efficient energy mix. We can clearly see the great potentials of the aforementioned technologies and economic systems that the country may adopt.

Hisham

Nuclear energy is also a very suitable option for Saudi Arabia. A typical nuclear power plant has a capacity of producing one GWh (GW = one billion watt) meaning that a plant that works 90% of the time may produce up to 8 TWh (TW = 1 trillion Wh) per year. This amount of energy would be enough to make Saudi Arabia completely independent from the use of fossil fuel energy in the next few years following construction. In addition to

that, the kingdom has a very large land area, allowing for strategic placement of nuclear power plants far away from densely populated regions. Thus, fear of the risk of terrible consequences of an accident is increasingly minimized. Also, since Saudi Arabia can relatively easily provide finance for the construction and periodic maintenance of those plants, the cost of producing 1 KWh (the LCOE) will not bring financial burden to the nation in the long term.

However, with all that being said, political issues are in the way of Saudi Arabia ever becoming a member of the exclusive “nuclear energy producing club”. Doing so demands the country to resolve its large unemployment issue and employ exclusively Saudi citizens in those plants and agree to terms that will confine the kingdom to a limited production capacity.

In this example, we see that an energy source being the most promising, does not necessarily mean that it would be easily adopted or that it should be. Thus, for the nation’s energy mix, we must focus on ways of using those incredible technologies without having to deal with political or any other type of major issues.

However, if geo-political scenarios in the future could differ from today’s circumstance, a nuclear energy supply should most definitely be a considerable part of Saudi Arabia’s plans for its future.

Ali

Saudi Arabia must also begin “excavating” its untapped choices. Although research revealed that many geothermal hotspots in the kingdom, such as those previously mentioned in the western region of the country, exist, and has proven that Geothermal Energy is indeed a viable and fruitful option for the kingdom to utilize, not much effort has been exerted in adopting this energy source into Saudi Arabia’s energy mix.

Hisham

Now, when thinking about how the country can avoid its coming dystopian future, water desalination is among the main topics. As long as the country has enough energy to power water desalination facilities, its people may never have to face terrible water-shortages. That is, with the number of water desalination plants in the country remaining the same, the obstacle is that these facilities consume tremendous amounts of energy with low efficiency.

In order to deal with that need and provide efficient and sufficient energy to those facilities, appropriate renewable energy plants must be linked with them. A complete electrical grid is an essential infrastructural development when speaking of future highly efficient energy sources.

We thus prioritize developing a country-wide electrical grid connection in order to supply the general public's homes and those plants with efficient energy. This, for example, will mean that extra energy produced in one location will be usable by other regions where it may not be produced. Rather than having this type of energy that is produced in the country's north being exclusive to its northern regions, why not utilize it throughout the kingdom as a whole?

Ali

In addition to that we're also talking about unused energy of households which will not be benefitted from during the winter seasons when AC units are not as commonly used throughout the kingdom. If added up, that would be a lot of energy. That energy may not last enough to be exported internationally, and if it does, that just means extra income. Thus, a more practical use for that energy would most definitely be investing it in powering high-energy consuming facilities and other vital factories. The same applies for the example of solar energy harnessed from the most sunny areas in Saudi Arabia and geothermal energy.

Final statement:

Ali: Regardless of physical belonging to a specific land, we belong to the same globe and deal with the same crisis. The young, educated, and ambitious minds of our and all nations are those who will elevate the living conditions of man for years on-end without the expectation of a terrible crisis to fall upon that living condition. If one is to occur, we must at least ensure that it does not occur by our own accord. What has been mentioned in this project is how we (Hisham Bin Taleb and Ali Algain) fulfill a small yet impactful part of that promise. We hope you can use this project in a way to fulfill your part as well, as this is clearly a global effort.

For references, click [here](#).