KAPSARC
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King Abdullah Petroleum Studies and Research Center

Changing Energy Supply Economics in Saudi Arabia in the Context of Global Transitions

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

This publication is also available in Arabic.

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Key Points

Some global industrial organizations posit that energy demand could peak in the mid-2030s based on expected efficiency gains in transportation, manufacturing and buildings sectors.

Global energy companies such as Shell, Equinor and Total are investing in energy storage, utilities, and renewables, but these efforts alone will not halt climate change. Falling costs of renewable technologies, in terms of levelized cost of energy (LCOE), is partially working against inviting additional investments as the returns are not attractive enough.

By 2030, Saudi Arabia aims to deploy significant renewable energy capacity. To promote regional development, these projects will be spread over several locations, and rolled out gradually to mitigate technology risk.

The Renewable Energy Project Development Office (REPDO) has devised a pre-development process that significantly reduces execution risks by ensuring that bidding contractors can successfully deliver projects. This has enabled recent projects to set new world records for LCOE. The REPDO model shows how central management of renewable deployment can reduce transaction costs.

Energy policy should take into account that industries vary widely in energy intensity, and that this does not necessarily correspond with labor intensity. The food industry is labor-intensive but not energy-intensive, while the plastic industry is the opposite. Others, such as the pharmaceutical and automotive industries, are neither energy- nor labor-intensive.

The National Saudi Energy Services Company (TARSHID) has upgraded more than 1 million streetlights and 123,000 chillers, saving 1.5 terawatthours (TWh) of electricity annually with these relatively inexpensive enhancements. While a significant efficiency gain, this represents less than 1% of total annual consumption in the Kingdom. In the future, more costly and complex projects can bring greater efficiency improvements.

The power sector can easily supply the electricity needed for Saudi Arabia to expand desalination operations. The Saudi Water Partnership Company estimates that by 2025, it will require 2 GW of additional power generation capacity.

The solar power industry is unlikely to reduce electricity generation costs by directly improving module efficiency. Instead, it will focus on bifacial modules that increase energy yield, and lighter modules that lessen balance of system (BOS) costs. In the wind industry, cost reductions will be attained via higher hub heights and longer blade lengths.

Summary

Many factors, local and global, will impact Saudi Arabia's electricity sector and energy markets. The Kingdom has committed to deploying a significant share of renewable energy by 2030 and is considering plans to add nuclear power to its energy mix. At the same time, Saudi Arabia is investing to increase its non-associated gas supply. Globally, oil prices and energy dynamics will be affected by many climate-related initiatives and regulations, such as the new International Maritime Organization (IMO) rules that impose switching to low-sulfur fuels to reduce sulfur emissions by over 80%. Accurate supply modeling also requires understanding and projecting demand. The Kingdom has only recently embarked on its energy price reform journey, and initiatives related to industry electrification, distributed generation deployment, and energy efficiency will greatly affect future energy consumption.

On the other side of the spectrum, the energy price reform journey that the Kingdom has embarked on is still ongoing. Furthermore, initiatives relating to industry electrification, distributed generation deployment, and energy efficiency will affect energy demand. Understanding demand and projecting it is considered a crucial step if any supply modeling is to be accurate.

The above represents only a sample of the numerous aspects that would affect energy transitions within Saudi Arabia. Hence, this workshop was arranged and convened to discuss these factors and assess the extent to which they will impact the energy landscape in the Kingdom.

Background to the Workshop

KAPSARC held this workshop in Riyadh on November 19, 2019 as part of the center's research on the energy transition and its implications for Saudi Arabia. The event comprised a roundtable discussion focused around four themes—Global Transitions, Supply, Demand and Industry—which this briefing summarizes in the corresponding sections below.

Under its strategic partnership with the Saudi Electricity Company, KAPSARC is building a detailed power system model for the Kingdom that can help inform policy discussions in areas such as long-term capacity planning, reliability challenges brought by renewable energy adoption, and the impact of energy price reform on electricity generation costs. While existing KAPSARC models can partially address such issues, the forthcoming model will be more granular and apply a mixed-integer approach, which is more accurate than classic linear optimization. This endeavor will be carried out with close collaboration with the Saudi Electricity Company (SEC) as part of the strategic partnership between KAPSARC and SEC.

Global Transitions

Most major energy organizations, whether involved in research or in services, agree that global energy demand will rise substantially by 2050. The electricity generation sector in particular will experience significant growth as the global population expands, developing economies become wealthier, and electric vehicles are widely deployed. On the other hand, some industrial organizations posit that final energy demand could peak in the mid-2030s, based on expected efficiency gains in the transportation, manufacturing, and buildings sectors. In other words, economic growth will partly, or even fully, decouple from key parameters such as primary energy supply and carbon emissions. It is worth noting how difficult it is to project these future developments, which are sensitive to myriad underlying assumptions and expectations.

The worldwide transition to renewable energy is occurring at a rapid pace. However, the current rate of adoption will be insufficient to limit global warming to the well-known 2 degree Celsius scenario. While dozens of countries have set renewable energy targets, many others continue to commission new fossil-fuel plants. Coal, the most carbon-emitting fuel, will still satisfy a significant share of the global energy demand in 2050. Countries that heavily rely on coal for power generation, such as India, Indonesia and Australia, must radically change their energy systems in order to retire their coal fleets. The proliferation of core renewable technologies, namely solar and wind, also encourages increased natural gas generation to ensure ample ramping capability to offset the intermittent nature of renewables generation.

Driven by falling production costs, greater demand for renewable energy technologies has attracted strong interest from traditional fossil fuel companies. Firms such as Shell, Equinor and Total are investing large sums in storage technologies, utilities, and renewables. However, these efforts alone will not halt climate change. The falling cost of renewable technologies, in terms of levelized cost of energy (LCOE), is partially deterring additional investments by big fossil fuel players because the diminished returns are less appealing.

Solar and wind power have already become the least expensive electricity generation technologies; further cost reductions will therefore make the case for renewables even more compelling. However, they are competing against a moving target. Conventional fossil fuel companies continue to refine technologies, achieve efficiency gains and improve business strategies.

As the energy transition unfolds, political and cyber security risks warrant special attention from the perspective of the energy sector. While these types of risks are not necessarily limited to a certain sector, they deserve additional attention in the field of energy for a number of reasons. Investments in energy are generally large with long-term horizons, and therefore have greater exposure to political stability than do shorter-term ventures. At the same time, the energy sector underpins political stability, economic growth, and industrial developments. Thus, disruption to a country’s energy system can quickly spread to the wider economy and result in severe consequences.

Supply

In line with global trends, Saudi Arabia has embarked on a domestic energy transition. The Kingdom has set ambitious targets to raise the shares of renewable energy and gas in its energy mix by 2030, and is also considering developing nuclear energy.

By 2030, Saudi Arabia aims to deploy significant renewable energy capacity. To promote regional development, these projects will be spread over several locations, and rolled out gradually to mitigate technology risk.

The potential energy yield of any solar or wind project depends heavily on its location. Hence, REPDO adopts a GIS-assisted process to aid in site selection, screening and prioritization. Other factors relevant to project location include benefits to economic development and potential displacement of existing liquid-fuel generation. Further, REPDO has implemented a nine-step pre-development procedure to reduce project execution risk. The framework evaluates bidders during tender processes to ensure that they can successfully deliver projects. This also relaxes some financial commitments that the bidders had to otherwise bear themselves. REPDO's pre-development screening has enabled projects to set new world records for LCOE, demonstrating how a central body managing renewable deployment can substantially reduce transaction costs.

However, regulatory challenges remain and may increase with the number of renewable projects. The system operator will face dispatch conflicts while trying to simultaneously satisfy a greater volume of power purchase agreements and maintain grid stability. Further, technical transmission issues will become more pronounced as the system expands, and the costs associated with network congestion must be calculated so that retail price of electricity reflects these operational expenses.

Effective January 1, 2020, the International Maritime Organization (IMO) announced that it will reduce the maximum sulfur content allowed for fuel used in the maritime industry to 0.5% from 3.5%. Assuming the regulation is enforced, global demand for heavy fuel oil (HFO), which is generally high in sulfur content, will likely decrease. This may result in Saudi Arabia having excess HFO available with no immediate use except in power generation. Numerical modeling has shown that Saudi Arabia's power sector can save tens of millions of dollars annually if the prices of HFO fall or additional HFO becomes available, but the resulting change in the energy mix would have negative implications for emissions.

The above-mentioned developments in the Kingdom's electricity generation mix, fuel supply, and network constraints should not be studied in isolation. Rather, they must be considered simultaneously and within the context of long-term policy objectives. To this end, KAPSARC, with the aid of SEC, is developing a mathematical representation of Saudi Arabia's power sector to serve as a test-bed for different scenarios.

Demand

In the near to medium term, energy demand will be driven largely by three areas: industry, water, and energy efficiency. Saudi Vision 2030 (SV2030), the government's strategic roadmap for national development, aims to diversify the economy away from reliance on oil by expanding other industries, thereby raising energy use in non-oil sectors. The Kingdom's growing population will increase not only direct demand for electricity but also for energy-intensive desalination and other water-related services. At the same time, energy efficiency initiatives will help offset this rising demand and boost productivity.

According to Saudi Arabia's Electricity and Cogeneration Regulatory Authority, the industrial sector accounted for 20% of national electricity consumption in 2018, led by the chemicals and chemical products (fertilizers and other chemicals) industry. The three other most energy-intensive industries are basic metals (steel, aluminum and copper), non-metallic products (cement, glass and ceramics), and fabricated metals (construction metal products). These industries vary in terms of revenue, labor intensity, and contribution to gross domestic product.

To this end, policymakers should note that energy-intensive industries are not necessarily labor-intensive, and carefully assess both dimensions to best support growth. For example, the food industry is labor-intensive but not energy-intensive while the plastic industry is the opposite. Others, such as the pharmaceutical and automotive industries, are neither energy- nor labor-intensive.

The source of energy is another factor that will have implications for the industry's competitiveness. In the GCC, gas is a main energy source. However, Europe is mainly reliant on hydro-power and China is mainly reliant on coal. It is difficult to predict the growth rates for Saudi Arabia's key industries or how fundamental shifts in their business models or market reach could impact their energy requirements — or what new industries may be introduced into the Kingdom. Hence, evaluating sector- and industry-level energy demand growth, while challenging, presents a fertile area for future research.

Important changes are taking place in the water sector, which will play a central role in energy consumption in Saudi Arabia over the next decade. The authorities intend to fully privatize the sector, which is currently 25% privately held, by 2030. Recently, the government expanded the responsibilities of the Saudi Water Partnership Company (SWPC) to include purchase of desalinated water, purification, sewage treatment, cogeneration, and all relevant tendering. SWPC essentially serves as the principal off-taker for the water sector, similar to the role of the principal buyer in the electricity sector.

To meet the projected rise in water demand, SWPC plans to increase its supply capacity from around 8 million cubic meters per day (MMcm/d) to around 13 MMcm/d by 2030, and the number of storage days from 1.3 to 7. These targets require expanding both the desalination capacity and water transmission infrastructure. SWPC estimates that its planned desalination expansion will demand around 2 GW of additional electricity generation capacity by 2025; the power sector can easily meet this requirement.

On the energy efficiency front, the National Energy Services Company (TARSHID) has been active. Government and commercial buildings account for around 35% of Saudi's consumption, and TARSHID enables the effective implementation of energy efficiency initiatives.

TARSHID was created as a super ESCO to conduct large scale retrofit projects that derive energy savings. Their roles encompass legal, financial and operational facets. Among the successful projects that TARSHID has implemented was retrofitting more than 1 million street lights and 123,000 chillers. Combined, these retrofits attained 1.5 TWh of savings. This latter figure is considerable in its own right; however, it represents less than 1% of the total consumption of the Kingdom. Greater efficiency gains can be accumulated at the expense of more costly and complex projects.

Industry

Solar PV and wind technologies are being rapidly deployed worldwide. The global installed capacity of solar PV and wind totaled 505 GW and 591 GW, respectively, at the end of 2018. The falling costs of these technologies have been central to their success. By comparison, just 5 GW of more expensive CSP has been installed worldwide.

Past experience suggests that solar PV and wind technologies could see their prices continue to fall. However, as a technology matures, additional cost reduction generally becomes more difficult, regardless of the industry. Moreover, the learning curve in the solar PV industry, for example, applies to the module cost only — in other words, not to LCOE. This misconception appears to be widespread among non-experts in the field.

Further cost reductions for solar PV are unlikely to come from module efficiency enhancements. Instead, they will be attained through other means including: bifacial modules which increase energy yield, lighter modules, which reduce balance of system costs (BOS) and mounting structure requirements and lower panel degradation rates. In the wind industry, cost reductions will be attained mainly via higher hub heights and longer blade lengths. Currently, wind turbines can be installed on hubs as high as 166 meters and possess blade diameters that are as long as 162 meters. This contrasts with hub heights of 40-86 meters and blade diameters of 52 meters in the year 2000. Economics of scale and innovative financing mechanisms can help reduce costs across all technologies. With additional cost reductions achieved, the competition between different players intensifies and the margins become tighter. As such, it is expected to see consolidation in several industries.

The LCOE has been, typically, used to assess the competitiveness of different generation technologies. It provides a relatively fair basis of comparison and is useful for high-level and initial screening. However, LCOE has limitations. For example, it does not capture the value of reliability from adding storage capacity to a system, nor does it quantify cost/benefit implications that stem from network congestion and/or peak shaving. Although LCOE can be informative for simple cases, such as a single solar farm providing energy to a single customer, it becomes less relevant for measuring overall system costs for a portfolio of generation technologies.

About the Workshop

KAPSARC organized this workshop, Changing Energy Supply Economics in Saudi Arabia in the Context of Global Transitions, in Riyadh on November 19, 2019. It brought together around 30 regional and international experts from government, industry, think tanks and academia to discuss key factors that will impact the economics of energy supply in Saudi Arabia. The workshop was held under a modified version of the Chatham House Rule, under which participants consented to be listed below. However, none of the content in this briefing is attributable to any individual.

List of participants

Essam Al-Ammar – Associate Professor, King Saud University

Abdulaziz Al-Arifi – Head of Special Projects, Renewable Energy Program Development Office

Hamed Al-Jadaani – Renewable Energy Engineer, King Abdullah City for Atomic and Renewable Energy

Turki Al-Aqeel – Senior Research Associate, KAPSARC

Hatem Al-Atawi – Senior Research Analyst, KAPSARC

Ali Al-Awami – Assistant Professor, King Fahd University of Petroleum and Minerals

Osamah Al-Hamadi – Project Manager, Renewable Energy Program Development Office

Abdulmajeed Al-Maymoon – VP Industrial Enabling, Industrial Clusters

Amer Al-Rajiba – VP Capacity Planning and Analysis, Saudi Water Partner Company

Abdullah Alsubaie – Director, King Abdulaziz City for Science and Technology

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About the Team

Nawaz Peerbocus

Nawaz is KAPSARC's program director for Energy Transitions and Electric Power. Before joining KAPSARC, he was chief economist at the Saudi Electricity Company (SEC) where he led the strategic transformation project and advised on strategic planning issues. Prior to SEC, Nawaz was director of market strategy at Enbala, and senior economist at the Ontario Independent Electricity System Operator in Canada.

Amro Elshurafa

Amro is a KAPSARC Research Fellow working on energy transitions. His research interests include power system modeling, solar PV techno-economics, and hybrid microgrid design and optimization. The author of 40+ papers and reports and inventor of several patented technologies, Amro holds a Ph.D. in electrical engineering complemented thereafter with an MBA in finance.

Turki Al-Aqeel

Turki is a Senior Research Associate at KAPSARC focusing on energy transitions, electricity market regulations and policy, digitalization, power system modeling, and renewable energy policy. He has worked for several multinational companies including ABB and Woodward. Turki holds a Ph.D. in Electrical Engineering and an MBA from Colorado State University. He is a Senior Member of IEEE.

Hatem Al-Atawi

Hatem is a researcher at KAPSARC. Previously, he worked at ABB Västerås in Sweden conducting asset management studies of electric vehicles under the Swedish transport administration's electric road systems project. Hatem also modeled speed governors and prime movers for hydro and gas turbines at Schweitzer Engineering Laboratories in Washington State. He holds a master's degree in Power System Economics with a concentration on Electricity Markets from KTH Royal Institute of Technology in Sweden, and a bachelor's degree in Electrical Engineering from the University of Idaho.

About the Project

KAPSARC's Energy Transitions project seeks to develop insights into how the ongoing shift to low-carbon electricity generation will impact energy markets. It focuses on the rise of renewable energy and the related increase in natural gas-based electricity production. The intermittency of core renewable technologies, especially solar and wind, creates complementary demand for more flexible electricity production that today is met primarily by gas-fired generation. The resulting growth in gas consumption pushes up global gas prices and in turn affects the markets for other fuels. Future advancements in battery technology could also solve the problem of intermittency: this would reverse the surge in gas-powered generation and create greater ripple effects on energy markets.

The energy transition has particularly significant implications for Saudi Arabia, where power is generated mainly by crude oil, heavy fuel oil, and natural gas. This project is therefore timely and relevant for the Kingdom's policymakers and energy authorities such as the Saudi Electricity Company and the Ministry of Energy.

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