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King Abdullah Petroleum Studies and Research Center

Commentary

Overview of Saudi Electricity Demand (1970–2018)

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Context

Saudi Arabia's demand for electricity is undergoing unprecedented changes. In recent years, the government has implemented several efficiency measures and pricing reforms to curb demand growth. These measures started delivering concrete results in 2016. After decades of rapid growth, the Kingdom's electricity demand started flattening and eventually fell for the first time on record in 2019 (Soummane 2020). This commentary traces the evolution of Saudi electricity demand over the past half-century. Section 1 of this document provides an overview of demand patterns since 1970, and Section 2 focuses on the post-2015 period. This commentary intends to provide a foundation for a prospective study by Soummane and Ghersi (2021) that will project sectoral electricity demand up to 2030.

Retrospective analysis (1970–2018)

Surging Saudi electricity demand has been driven by a combination of fast population growth, dynamic economic growth, and low regulated energy prices for both electricity generation and final consumers.

The Saudi electricity sector's development began in the early 1970s. The oil price boom during that decade provided the government with a large fiscal surplus, and the Kingdom's population was relatively small. The government therefore encouraged investment in power generation capacity. It provided oil feedstocks, refined products and natural gas to producers at low regulated prices to supply electricity and improve the population's living standards.

Over the following decades, Saudi Arabia's electricity demand surged rapidly. This surge was driven by a combination of fast population growth, dynamic economic development, and low regulated energy prices for both electricity generation and final consumers. The Saudi population has grown at an average annual rate of almost 4% from 1970 onward, reaching 34.2 million in 2019 (SAMA 2019). In parallel, Saudi Arabia's real gross domestic product (GDP) has also grown at an average rate of almost 4% annually since 1970. Saudi Arabia is currently the nineteenth largest economy in the world, with a real GDP of $703.9 billion.[1] This rapid economic growth has contributed to a rapid increase in its electricity demand since 1970, although the pace of this growth has slowed significantly in recent decades (Table 1).

The electricity demand growth rate greatly exceeds that of GDP, demonstrating that low regulated electricity prices result in excessive consumption. Demand has therefore been on an unsustainable path (Lahn and Stevens 2011, Alyousef and Abu-Ebid 2012). Furthermore, Saudi Arabia's low energy prices have not only caused high energy consumption but also social inequality. The pricing scheme has primarily benefited large energy consumers, which are often high-income households. Richer consumers have benefited more from the tariffs, capturing 70% of energy financial incentives. In comparison, lower-income households, which account for 40% of the population, have captured only 30% of the incentives (Kingdom of Saudi Arabia 2017).

Table 1. Growth rates of Saudi economic and electricity indicators.

Period	Real GDP	Population	GDP per capita	Electricity demand	Electricity consumption per capita
1970–1979	11.2%	4.8%	6.2%	25.9%	20.2%
1980–1989	-2.7%	5.0%	-7.4%	15.8%	10.2%
1990–1999	3.5%	3.3%	0.2%	6.4%	3.0%
2000–2009	3.4%	2.9%	0.5%	6.0%	2.9%
2010–2019	3.4%	2.5%	0.9%	4.1%	1.5%

Sources: Author's computation based on data from ECRA database and SAMA (2019).

Note: The growth rates are compound average growth rates over the indicated periods.

In 2018, total Saudi electricity demand reached 299.2 terawatthours (TWh),[2] making Saudi Arabia the fourteenth-largest electricity consumer in the world. Its consumption matches those of more populated countries such as Mexico, which had a population of 127.5 million in 2019, or more advanced economies such as Italy, which had a real GDP of $2,147.4 billion in 2019 (World Bank 2020).[3] Saudi Arabia's distinct climatic conditions have contributed to the rapid growth of electricity consumption, with buildings comprising up to 76% of the Kingdom's total electricity demand (Krarti et al. 2017, Howarth et al. 2020).

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Residential demand is the largest segment of electricity consumption in Saudi Arabia. This demand has more than doubled since 2000, reaching 130.4 TWh in 2018 (43.6% of total demand). Given the Kingdom's climatic conditions, around 70% of Saudi residential electricity demand is attributed to air conditioning (ECRA 2015). Industrial electricity demand has also doubled since 2000, and was 58.2 TWh (19.4% of total demand) in 2018. Commercial electricity demand increased fourfold since 2000, and demand from government services increased threefold. In 2018, commercial demand was 61.8 TWh (20.6% of total demand), and government demand was 43.9 TWh (14.7% of aggregate demand).[4] Finally, demand from the agriculture sector was marginal, accounting for 4.9 TWh in 2018, although it also has doubled since 2000 (Figure 1).

Saudi peak load has increased threefold since 2000, reaching 61.7 gigawatts (GW) in 2018. At that time, the country's installed capacity was 76.9 GW (ECRA 2018). In 2017, the Saudi power sector used almost one-third of the Kingdom's total primary energy consumption (IEA 2017).[5] Saudi Arabia's surging electricity demand has heavily burdened the government budget, as the financial and opportunity costs of using fuel for power generation have escalated. Saudi Arabia's cost of producing oil and natural gas is among the lowest in the world (Alyousef and Stevens 2011). Nevertheless, burning large quantities of fossil fuels for domestic consumption results in significant foregone government revenues.[6] Between 2010 and 2018, Saudi Arabia allocated around $120 billion (around 450 billion SAR) in financial support to the electricity sector (IEA 2019).[7]

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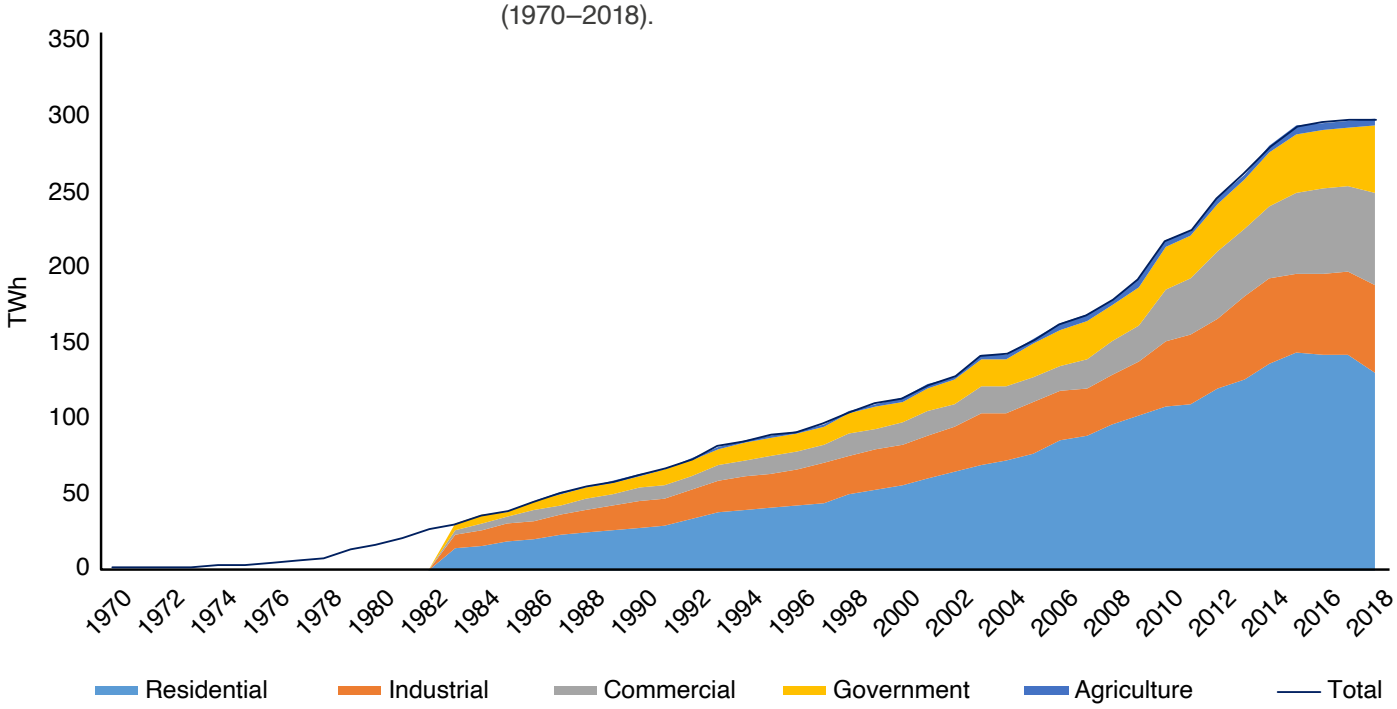
Figure 1. Evolution of total Saudi electricity demand and demand by sector (1970–2018).



Sources: SAMA (2019), ECRA (2018), IEA database. Data on sectoral demand before 2005 come from the IEA World Energy Balances. From 1983 to 2004, data for commercial and government uses correspond to the IEA's "Commercial and Public Services" category. The total for this category is split evenly across the two sectors based on their average shares for years with disaggregated data (i.e., 2005–2018).

Moreover, because Saudi Arabia's production capacity is almost exclusively fossil-fuel-based, the environmental cost of power generation is a pressing issue.[8] In 2018, the Saudi power sector was responsible for 40% of the country's total carbon dioxide emissions (i.e., 247.0 megatonnes [Mt] out of 624.9 Mt) (Crippa et al. 2019).

Successive Saudi policymakers have explored ways of reforming the power sector (Fattouh and El-Katiri 2013). However, such reforms are sensitive for any government. Indeed, any potential energy price reform must overcome several cultural, economic and institutional barriers. These barriers have delayed broad electricity sector reforms (Alyousef and Varnham 2010).

Focus on the post-2015 period

In 2015, international oil prices fell by almost 50% year-on-year. Oil revenues are a primary source of income for the Saudi government, and this price contraction severely impacted its public finances.[9] The government's budget deficit was 15.8% of GDP in 2015 (SAMA 2019). The low oil prices negatively impacted the government's fiscal outlook, and optimizing expenditures and broadening the government's revenue base became urgent tasks (Kingdom of Saudi Arabia 2017). This fiscal situation drove Saudi policymakers to make fundamental changes to curb

inefficient financial incentives for the energy and water sectors. Previously, these incentives were the dominant components of government aid. Other Gulf countries took similar steps to reform electricity prices and curb wasteful electricity use (Krane and Hung 2016).

In 2016, the Saudi government implemented the first phase of its energy price reform (EPR). This reform aims to gradually align domestic energy prices with international reference prices (Kingdom of Saudi Arabia 2017) to accurately reflect energy supply costs and initiate a structural change in consumption patterns.

For electricity tariffs, residential prices for all consumption brackets increased from 0.05–0.26 Saudi riyals per kilowatthour (SAR/kWh) to 0.05–0.30 SAR/kWh (Kingdom of Saudi Arabia 2017).[10] Residential electricity demand fell by 0.6% in 2016 (ECRA 2018). Prices for the commercial segment rose more, from 0.14–0.26 SAR/kWh to 0.18–0.30 SAR/kWh, causing the segment's demand growth to fall from 12% in 2015 to just 4% in 2016. The prices for government services increased by 23% from 0.26 SAR/kWh to 0.32 SAR/kWh, causing demand to decrease by 3%. By comparison, demand increased by 10% in 2015. Finally, prices for industrial uses increased by 20% from 0.15 SAR/kWh to 0.18 SAR/kWh. Nevertheless, industrial electricity demand grew by 3% in 2016, having decreased by 8% in 2015, owing to the industrial slowdown following the oil price collapse. However, this growth rate was half of the 6% annual growth recorded over the previous decade (ECRA 2018).

In addition to curbing the rapid increase in energy demand, the government intended to provide Saudi families with social protection from the expected direct and indirect impacts of the various economic reforms. This protection was provided through direct cash transfers under the Citizen's Account Program. The handouts to compensate for energy price hikes varied according to the sizes, incomes and ages of the family members of eligible households. The first round of the program was launched in December 2017 and reached 10 million beneficiaries, representing a total cost of around 2 billion SAR (around $0.53 billion) (APICORP 2018).

In 2018, the Saudi government approved the second round of its EPR. This phase included a significant tariff increase of 260% for the first segment of household electricity use. Specifically, residential electricity prices increased from 0.05 SAR/kWh to 0.18 SAR/kWh for monthly consumption of 1–6,000 kWh. In the same year, residential electricity demand decreased by 9.1%. Two recent decomposition analyses of the factors driving this decline in residential demand both show that the price hike is the primary driver (Aldubyan and Gasim 2020, Mikayilov et al. 2020). The industrial, commercial and government tariffs remained the same as in the first round of the EPR, causing their consumption growth to recover in 2018. Nevertheless, the EPR had a significant overall effect on total demand. For the first time since 1970, the first year for which data are available, Saudi electricity demand flattened (Table 2). Furthermore, the available data for 2019 show that, during this year, total demand contracted for the first time on record (Soummane 2020).

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Table 2. Overview of Saudi electricity demand and average prices for 2014–2018.

	Electricity demand by sector (in TWh)			Average price by sector (SAR/kWh)			Δ (2014–2018)	
	2014	2016	2018	2014	2016	2018	Demand	Price
Total	281.2	296.7	299.2	0.13	0.17	0.22	+6%	+69%
Residential	136.4	143.7	130.4	0.08	0.09	0.19	-4%	+138%
Industrial	56.6	53.6	58.2	0.15	0.18	0.18	+3%	+20%
Commercial	47.7	55.5	61.8	0.22	0.26	0.26	+30%	+20%
Government	35.9	38.5	43.9	0.26	0.32	0.32	+22%	+23%
Agriculture	4.6	5.4	4.9	0.11	0.17	0.17	+7%	+55%

Sources: ECRA (2018). Author's price computations are based on data from Nachet and Aoun (2015), Kingdom of Saudi Arabia (2017), APICORP (2018), and Hasanov (2019).

Note: The SAR exchange rate is fixed at 1 US$ = 3.75 SAR.

Along with the pricing reforms, Saudi Arabia has accelerated its implementation of efficiency measures. The government expanded the Saudi Energy Efficiency Center's (SEEC's) mandate. SEEC designs, implements and monitors efficiency measures for transportation, industry and buildings. To address electricity demand, it targets buildings, focusing in particular on air conditioning, which is responsible for 50% of the Kingdom's electricity consumption (SEEC 2018).

Several studies point to significant savings from improving energy efficiency in buildings. Krarti et al. (2017) estimate that some cost-free actions, such as thermostat adjustments, can reduce buildings' total electricity consumption by around 8%. Taking such actions in the residential, commercial and government sectors could have abated Saudi Arabia's total electricity demand by around 20 TWh in 2018. Investments in retrofitting can also provide greater savings. For instance, replacing air-conditioning units, building insulation and installation control systems could abate buildings' electricity use by more than 50%. Krarti et al. (2020) assess the cost-effectiveness of retrofitting in the residential segment and confirm this finding. Retrofitting across the Kingdom can reduce the country's residential electricity demand by up to 50%. Had it been fully implemented in 2018, this adjustment could have saved 65 TWh of electricity.

What lies ahead?

Regardless of whether the current efficiency measures and pricing reforms have initiated a structural shift in consumer behavior or will have only temporary effects, it is important to disentangle the underlying factors. The drivers of future electricity demand include potential future price increases, and the responses to price variations, energy efficiency measures and income dynamics.[11] In the context of structural changes, methodologies must be strengthened to account for shifts in demand patterns. The general equilibrium approach offers a suitable framework for modeling long-term energy demand scenarios in the context of significant transformations. In a forthcoming study, we use the computable general equilibrium model developed by Soummane et al. (2020). This model is adapted to the Saudi economy's specific features and has an improved representation of electricity demand.

Using that framework, Soummane and Ghersi (2021) project three scenarios for future Saudi electricity demand by sector. The reference scenario assumes that no additional tariff increases occur and the intensity of electricity use stabilizes. The price reform scenario tests the potential electricity demand savings if domestic prices are aligned with international benchmarks by 2030. Finally, an efficiency scenario based on improvements to the electricity intensity of production is used to test electricity demand abatements. The results provide valuable insights for policymakers regarding the probable outcomes of policies aiming to curb electricity demand growth.

Endnotes

[1] This statistic comes from 2019 World Bank data (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD) and is equivalent to 2,639 billion Saudi riyals (SAR). Since 1986, the SAR has been pegged to the U.S. dollar at a fixed rate of 1 USD = 3.75 SAR.

[2] This amount corresponds to billed final consumption; it does not include in-plant power uses or transmission and distribution losses.

[3] https://databank.worldbank.org/source/world-development-indicators

[4] Commercial uses include uses labelled as "Other" in ECRA statistics, which correspond to "Private Hospitals and Schools, and Other Categories."

[5] Power sector fuels' consumption includes consumption by both "main activity producer electricity plants" and "autoproducer electricity plants" in the IEA nomenclature.

[6] The average efficiency rate of Saudi power plants is 32.4%, whereas the world average is 43.3% (Enerdata).

[7] For fossil-fuel exporters, such as Saudi Arabia, IEA data comprise actual financial aid, which has direct budgetary implications, in addition to opportunity costs. Opportunity costs are defined as the rent that could be recovered if consumers paid world prices (see https://www.iea.org/topics/energy-subsidies#methodology-and-assumptions). That said, estimating financial support energy consumption in Saudi Arabia remains a complex and debatable process (Alyousef and Stevens 2011).

[8] Saudi Arabia's installed capacity in 2018 included 22.5 GW in steam generators, 17.5 GW in gas generators, 0.19 GW in diesel generators and 23.4 GW in other capacities. The latter category is mainly comprised of desalination and cogeneration plants (ECRA 2018). However, Saudi Arabia is planning to develop renewable energy, mainly based on solar and wind. The first utility-scale photovoltaic project (300 megawatts [MW]) in the Sakaka region was connected to the grid at the end of 2019. The project achieved an internationally competitive price of $0.0234 per kilowatthour (kWh).

[9] Between 2010 and 2018, oil revenues comprised, on average, 80% of total Saudi government revenues (SAMA 2019).

[10] As this commentary focuses on electricity, we do not report the price changes for other energy products. APICORP (2018) offers a comprehensive overview of the EPR.

[11] Several large-scale projects are expected to emerge over the coming years in Saudi Arabia. However, their impacts on demand are not directly modeled and remain beyond the scope of our forthcoming prospective study. Future electricity consumption projects can be assessed at the project level and then incorporated into our analysis of the fundamental drivers as incremental demand.

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About the project

Evolution of Electricity Demand

The electricity sector is at the heart of the energy transition in many countries. Both the demand and the supply side of the electricity market require rigorous assessments to identify the appropriate policy options that can yield the maximum benefit for stakeholders. This project focuses on the demand side of the Saudi market. The supply side, including the evolution of the power mix and the integration of the domestic electricity market with regional markets, is assessed in other projects.

Electricity demand in Saudi Arabia has grown consistently over the past decades. Since 2016, Saudi Arabia has initiated price reforms, and launched rationalization campaigns for energy use, to curb electricity demand and inefficient use. As a result, Saudi electricity demand flattened between 2016 and 2018, eventually dropping for the first time on record in 2019. The various factors determining potential demand growth or decline and the impact of energy efficiency on electricity demand growth in developing economies is not well understood. Understanding electricity demand growth is critical for public policy development. Uncertainty regarding electricity demand growth rates directly impacts investment needs.

This project disentangles the primary driving factors of Saudi electricity demand. We analyze potential future trends of electricity demand by sector in Saudi Arabia. We also investigate the impacts of disruptive factors such as electric vehicles and the production of green hydrogen.

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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.

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