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King Abdullah Petroleum Studies and Research Center

Commentary

What Happened to Residential Electricity Consumption in Saudi Arabia Between 2015 and 2018?

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Between 2015 and 2018, residential electricity consumption in Saudi Arabia started to flatten, before declining, falling from a peak of 144 TWh in 2015 to 130 TWh in 2018.

Saudi residential electricity consumption

Between 2007 and 2018, residential electricity consumption in Saudi Arabia increased by 45%, from around 89 terawatthours (TWh) to 130 TWh (SAMA 2019), as shown in Figure 1. Population and gross domestic product (GDP) are two key factors that influence residential electricity consumption. According to the Saudi Arabian Monetary Authority (SAMA) (2019), between 2007 and 2018, the total population of Saudi Arabia increased by 34%, while real GDP increased by 45%. The number of residential electricity subscribers (indicative of the number of residential housing units) also increased by 74% (SAMA 2019), implying a similar increase in installed appliances such as air conditioners (ACs), which consume roughly two-thirds of electricity consumption in residential buildings in the Kingdom.

However, between 2015 and 2018, residential electricity consumption in Saudi Arabia started to flatten, before declining, falling from a peak of 144 TWh in 2015 to 130 TWh in 2018. In this commentary, we look at the factors behind this decline.

Factors that likely did not contribute to the decline in electricity consumption include the weather, the number of housing units in the country, and the number of appliances used. Saudi Arabia has been getting warmer (Peerbocus et al. 2020), while the number of residential electricity subscribers grew by 4.9% annually on average between 2015 and 2018 (SAMA 2019).

It is likely that energy price reform and improved energy efficiency were the key factors behind the decline in residential electricity consumption. Furthermore, the country also experienced a slowdown in economic growth between 2016 and 2018 due to low international oil prices, which might have also played a role in reducing electricity consumption. Additionally, between 2017 and 2018, many non-Saudis left the Kingdom, following the implementation of the expatriate levies. The list below details factors that may have contributed to the recent decline in the country's residential electricity consumption.

- **Higher electricity prices:** Electricity price reforms were implemented at the start of 2016 and 2018. The 2018 electricity price reform was much larger than the 2016 reform; electricity prices in the lowest consumption segment increased by 260% in 2018.

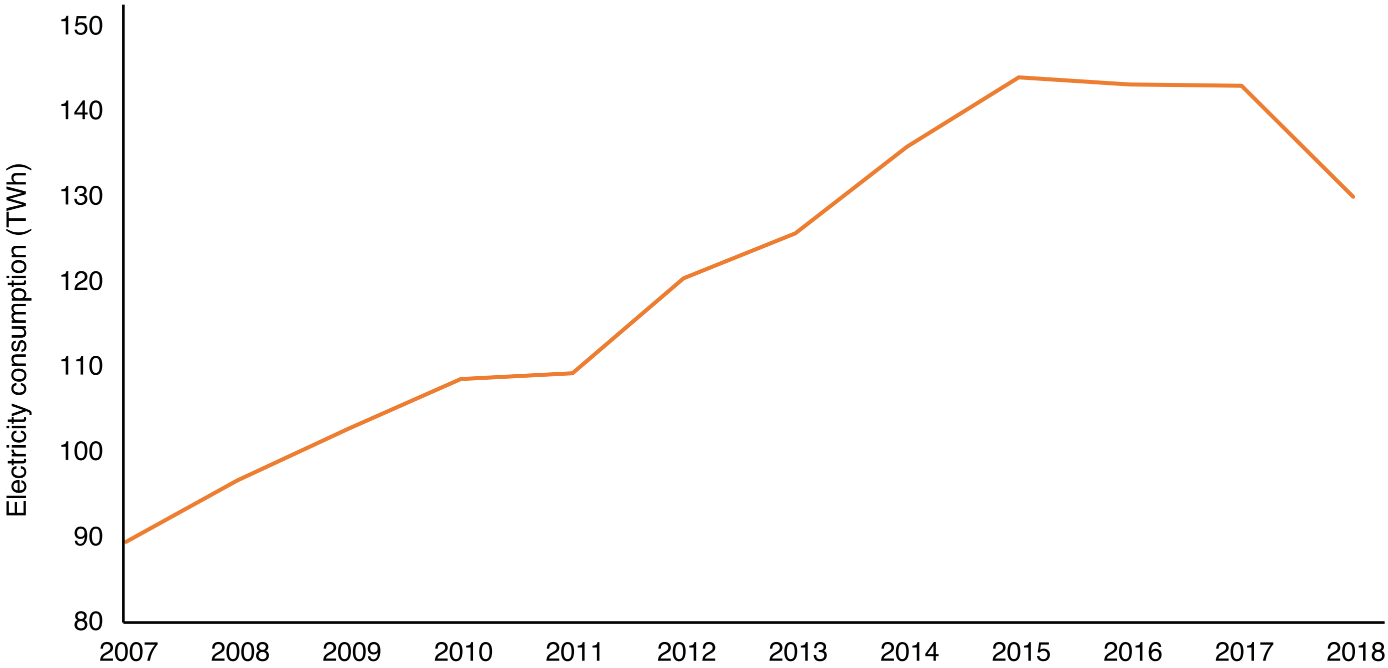
- **Improved energy efficiency:** A wide range of energy efficiency measures was launched, following the establishment of the Saudi Energy Efficiency Center (SEEC) in 2010. They included mandatory thermal insulation for new units in 2014, higher minimum energy efficiency standards for appliances, and energy efficiency labeling, among others.

- **A decrease in the non-Saudi population:** The expatriate levies that were first implemented in mid-2017 caused over a million non-Saudis to leave the Kingdom between 2017 and 2018 (GASTAT 2019).

- **A decrease in real income:** Real GDP growth in Saudi Arabia slowed from 2016-2018, and fell by 0.7% in 2017 (GaStat), due to the fall in oil GDP by 3.1%. Growth was negative in per capita terms in 2016 and 2017, with real GDP per capita falling by 1% and 3%, respectively (SAMA 2019).

In this commentary, we quantify the contributions of all these factors by combining econometrics with a decomposition analysis.

Figure 1. Residential electricity consumption in Saudi Arabia (2007-2018).



Source: SAMA.

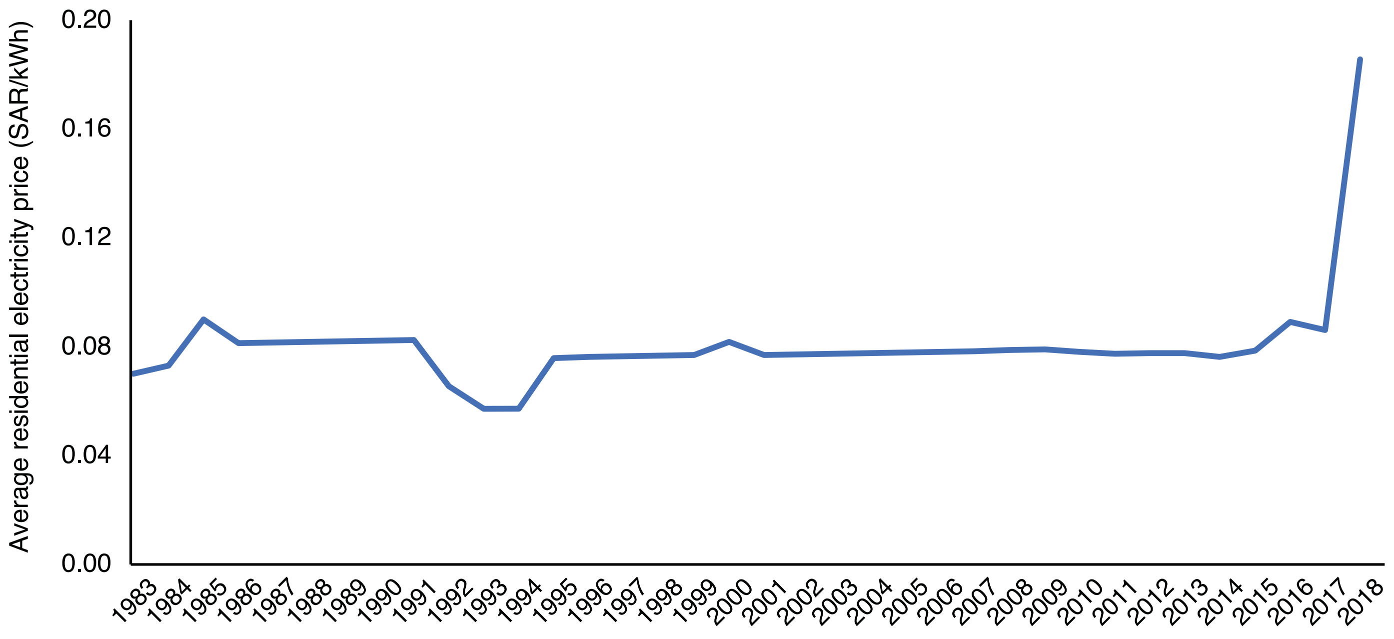
Electricity price reform in Saudi Arabia

Saudi Arabia has been regulating domestic energy prices for decades, setting them at levels far below international market prices. Governments around the world often underprice energy to make it affordable domestically. This provides important support for lower-income households. However, underpriced energy encourages high energy demand growth, wasteful consumption, and disincentivizes investments in energy efficiency, causing environmental damage and contributing to climate change. Furthermore, higher-income households, which often consume more energy, benefit more from underpriced energy. For Saudi Arabia, low domestic energy prices also represent foregone revenues for the government, as the fuels could have been sold internationally at higher prices. Raising energy prices is thus a cost-effective way to manage the rapid growth in domestic energy consumption, promote energy conservation behaviors, encourage greater investment in energy efficiency, reduce environmental damage, and increase government revenues. Furthermore, some of the additional revenues from higher energy prices can be used to support targeted programs that compensate lower- to middle-income households, such as Saudi Arabia's Citizens' Account Program.

Between 1983 and 2017, residential electricity prices in Saudi Arabia underwent only a handful of minor revisions, with the average price hovering around 0.08 Saudi Arabian riyals (SAR) per kilowatthour (kWh), as shown in Figure 2. We illustrate only the average residential electricity price because electricity prices in Saudi Arabia vary according to the amount of electricity consumed. For example, between 2001 and 2015, the first 2,000 kWh of monthly electricity consumption was priced at 0.05 SAR/kWh for households, while the next 2,000 kWh was priced at 0.10 SAR/kWh. To be more specific, the average price presented in Figure 2 is a weighted average of residential electricity prices at different segments of consumption, where the weight given to each segment's price is equal to the percentage of invoices issued at each segment.

Saudi Arabia began implementing an energy price reform program to realize the economic and environmental benefits of higher energy prices. The first wave of energy price reform was implemented at the start of 2016, during which time the weighted average electricity price for the residential sector increased from 0.08 SAR/kWh to 0.09 SAR/kWh. During the second wave of energy price reform, at the start of 2018, electricity prices increased much more. The weighted average electricity price for the residential sector jumped from 0.09 SAR/kWh to 0.19 SAR/kWh. Table 1 summarizes the electricity price changes for the residential sector following both waves of energy price reform.

Figure 2. The weighted average electricity price for the residential sector in Saudi Arabia.



Sources: Aramco (N.D.); ECRA (2008-2017); ECRA (2013b); KAPSARC analysis.

Table 1. Changes in residential electricity prices.

Electricity prices (residential)	Prices before January 1, 2016		Prices starting January 1, 2016		Percentage change	Prices starting January 1, 2018		Percentage change
Segment of consumption:	**SAR/kWh**	**US$/kWh**	**SAR/kWh**	**US$/kWh**		**SAR/kWh**	**US$/kWh**	
0-2,000 kWh	0.05	0.01	0.05	0.01	0%	0.18	0.05	260%
2,001-4,000 kWh	0.10	0.03	0.10	0.03	0%	0.18	0.05	80%
4,001-6,000 kWh	0.12	0.03	0.20	0.05	67%	0.18	0.05	-10%
6,001+ kWh	0.15 to 0.26	0.04 to 0.07	0.30	0.08	15% to 100%	0.30	0.08	0%

Sources: Akhbaar24 (2015); Alriyadh (2015); ECRA (2013b, 2019).

Energy efficiency in the Saudi residential buildings sector

In 2010 Saudi Arabia established the Saudi Energy Efficiency Center (SEEC) to enhance energy efficiency, thereby supporting the sustainability of the Kingdom's natural resources. The SEEC developed and launched a range of energy efficiency initiatives for the residential sector. For example, in 2014 it introduced mandatory thermal insulation for all new buildings (Aleqt 2016) while encouraging existing buildings' owners to invest in thermal insulation. The SEEC and the Saudi Standards, Metrology and Quality Organization (SASO) also implemented energy efficiency labeling and have been lifting the minimum energy efficiency standards for ACs and other appliances. The SEEC has also regularly launched energy awareness campaigns for the public. These are just a few examples of measures being taken in the Kingdom; there are many more initiatives that have and are being implemented in the Kingdom's residential buildings sector.

It is difficult to measure the combined impact of these energy efficiency measures on the average level of energy efficiency. Doing so requires detailed data on the energy efficiencies of all the appliances used by the millions of households in Saudi Arabia. Instead, we follow an alternative approach that measures energy efficiency indirectly by controlling for other factors in an econometric model. Our econometric model controls for the effects of income, population, electricity prices, and weather on residential electricity consumption. This leaves behind two key factors: appliance use and energy efficiency – both of which we have no data for. The impact of both time-varying factors on residential electricity consumption is indirectly captured by a non-linear trend generated by the econometric model. This trend is known as the underlying energy demand trend (UEDT) and is shown in Figure 3. More details on the econometric model we used can be found in Harvey (1990).

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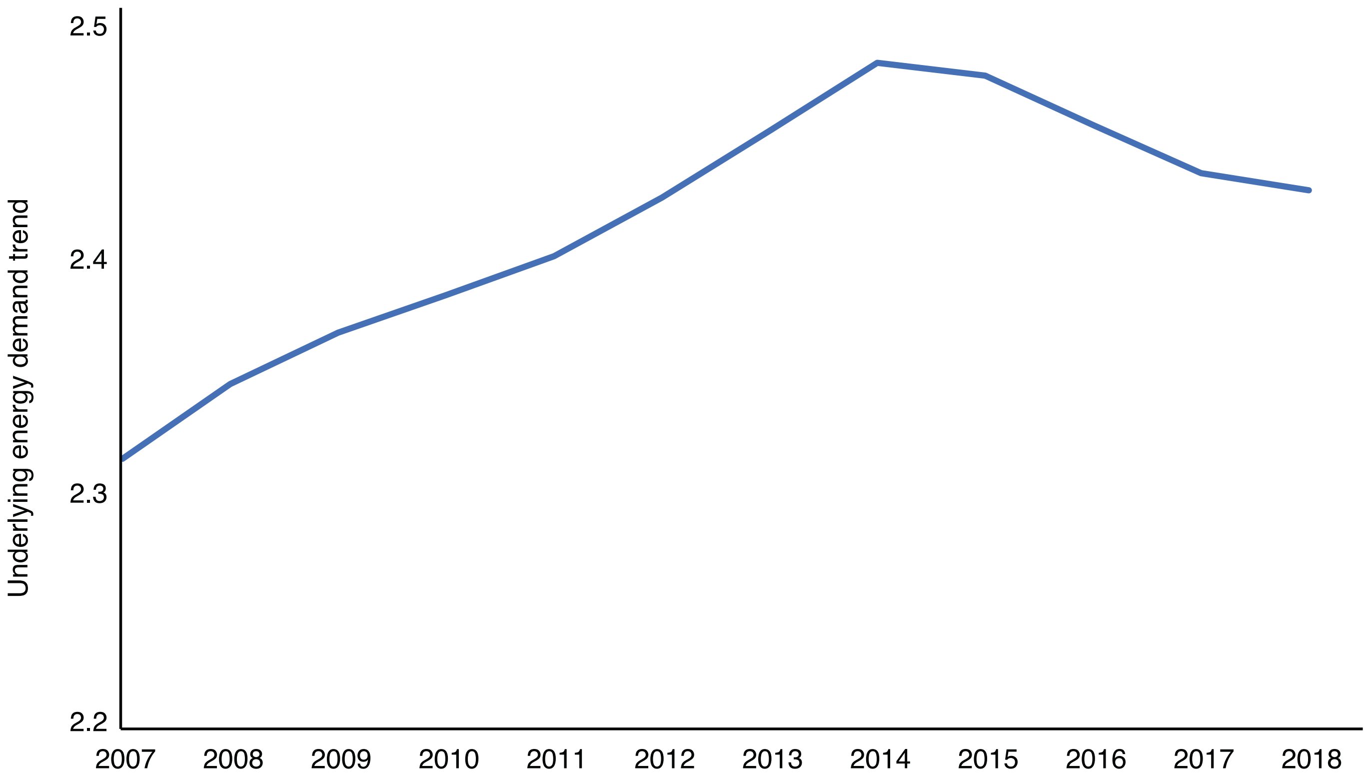
An upward-sloping UEDT suggests that if we hold income, population, electricity prices, and weather fixed over time, then there is an external factor that is increasing residential electricity consumption over time. Between 2007 and 2013, the UEDT was largely upward sloping. This was likely due to the increasing use of appliances during this period. Starting from 2014, the UEDT became downward sloping. A downward-sloping UEDT suggests that if we hold income, population, electricity prices, and weather fixed over time, then there is an external factor that is reducing residential electricity consumption. A downward-sloping UEDT is generally indicative of energy efficiency improvements. The UEDT in our model therefore captures the impact of recent improvements in energy efficiency in the residential buildings sector between 2014 and 2018. If appliance use continued to increase between 2014 and 2018, then it is likely that the energy efficiency improvements were even larger, and that the trend in Figure 3 would have been more downward sloping if not for the continued increase in appliance use.

Figure 3. The UEDT for the residential electricity sector generated by the econometric model.



Source: KAPSARC analysis.

Why did residential electricity consumption decline between 2015 and 2018?

Above, we listed factors that may have contributed to the decline in residential electricity consumption between 2015 and 2018. By applying decomposition analysis to our estimated econometric model, we were able to quantify the contribution of each factor. The net change in residential electricity consumption between 2015 and 2018 was **-14.0 TWh**, which was decomposed as follows:

- **+3.0 TWh** because of a **net increase in population** between 2015 and 2018, even though many expatriates left the country between 2017 and 2018.

- **+1.6 TWh** because of **hotter weather** in 2018 compared with 2015.

- **-10.1 TWh** due to **electricity price reform**, which led to markedly higher residential electricity prices in 2018 compared with 2015.

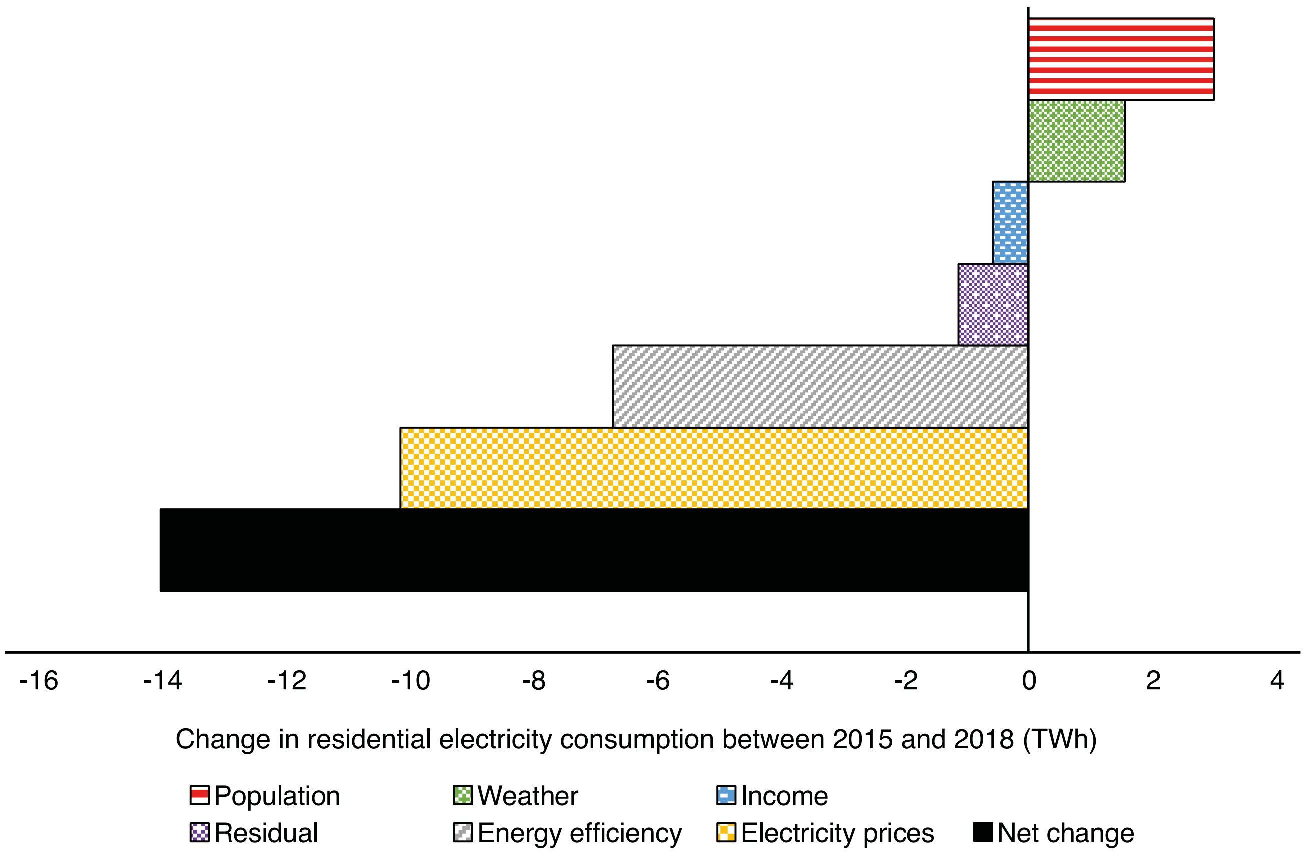
- **-6.7 TWh** due to **energy efficiency improvements**, indirectly captured by the UEDT. It is likely that the 'true' impact of energy efficiency is larger, since appliance use likely increased between 2015 and 2018, offsetting some of the energy efficiency improvements captured by the UEDT.

- **-0.6 TWh** because of a slight **fall in real income (real GDP per capita)** between 2015 and 2018.

- **-1.1 TWh** due to **other factors** that may not have been accounted for in the econometric model and/or **statistical noise in the data**, which is captured by the econometric residuals.

These results are illustrated in Figure 4.

Figure 4. The net change in residential electricity consumption decomposed into six contributing factors.



Source: KAPSARC analysis.

The economic and environmental benefits from electricity price reform in 2018

Using the electricity demand curve from the estimated econometric model, it is possible to measure the economic benefits of electricity price reform in 2018, which had the biggest impact on consumption in that year. The analysis shows that electricity price reform in 2018 increased total surplus in the economy by 3.4 billion SAR (around 0.2% of nominal non-oil GDP in 2018). Focusing on the government, we find that electricity price reform in 2018 increased its revenues by 14.4 billion SAR (around 1.6% of total government revenue in 2018). Part of this revenue uplift was redirected to low- and middle-income households through the Citizens' Account Program to compensate them for the higher energy prices.

The model also allows us to measure the environmental benefits of price reform. Using the electricity demand curve, we find that residential electricity consumption in 2018 would have been 9.3 TWh higher in a counterfactual scenario in which prices did not increase at the start of 2018. Assuming each kWh of electricity savings avoids roughly 0.6 kilograms of carbon dioxide (CO_2) emissions, then the electricity price reform in 2018 resulted in around 5.6 million tonnes of avoided CO_2 emissions in that year (roughly 1% of total CO_2 emissions in 2018). These avoided emissions are measured on an annual basis and would likely accumulate over the following years, delivering larger cumulative reductions in emissions when compared with a business-as-usual scenario in which electricity prices did not change. A monetary value can be assigned to the reductions in CO_2 emissions and air pollution that occur as a result of electricity price reform. Our analysis reveals that the net monetary gain from reducing CO_2 emissions and air pollution was 0.4 billion SAR.

The total welfare gain for the Saudi economy, resulting from the 2018 electricity price reform, was 3.8 billion SAR.

Thus, the total welfare gain for the Saudi economy, resulting from the 2018 electricity price reform, was 3.8 billion SAR (a 3.4 billion SAR gain in total surplus, plus a 0.4 billion SAR gain due to reduced CO_2 emissions and air pollution). In conclusion, the Kingdom's electricity price reforms have helped mitigate the rapid growth in the country's residential electricity consumption, increased government revenues, generated welfare gains for the economy, reduced its CO_2 emissions in support of climate change mitigation efforts, and reduced the country's air pollution.

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About the Project

This commentary is part of the project titled ‘Modeling Final Energy Demand,’ which examines how factors such as economic growth, income, energy prices, economic structure, and energy efficiency influence the demand for energy at national, sectoral and household levels. This project also measures the impact of policies such as energy price reform on energy demand, the economy, the environment, and social welfare in the Kingdom of Saudi Arabia.

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