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King Abdullah Petroleum Studies and Research Center

Commentary

If Renewable Energy is Getting Cheaper, Why Are Electricity Prices Increasing?

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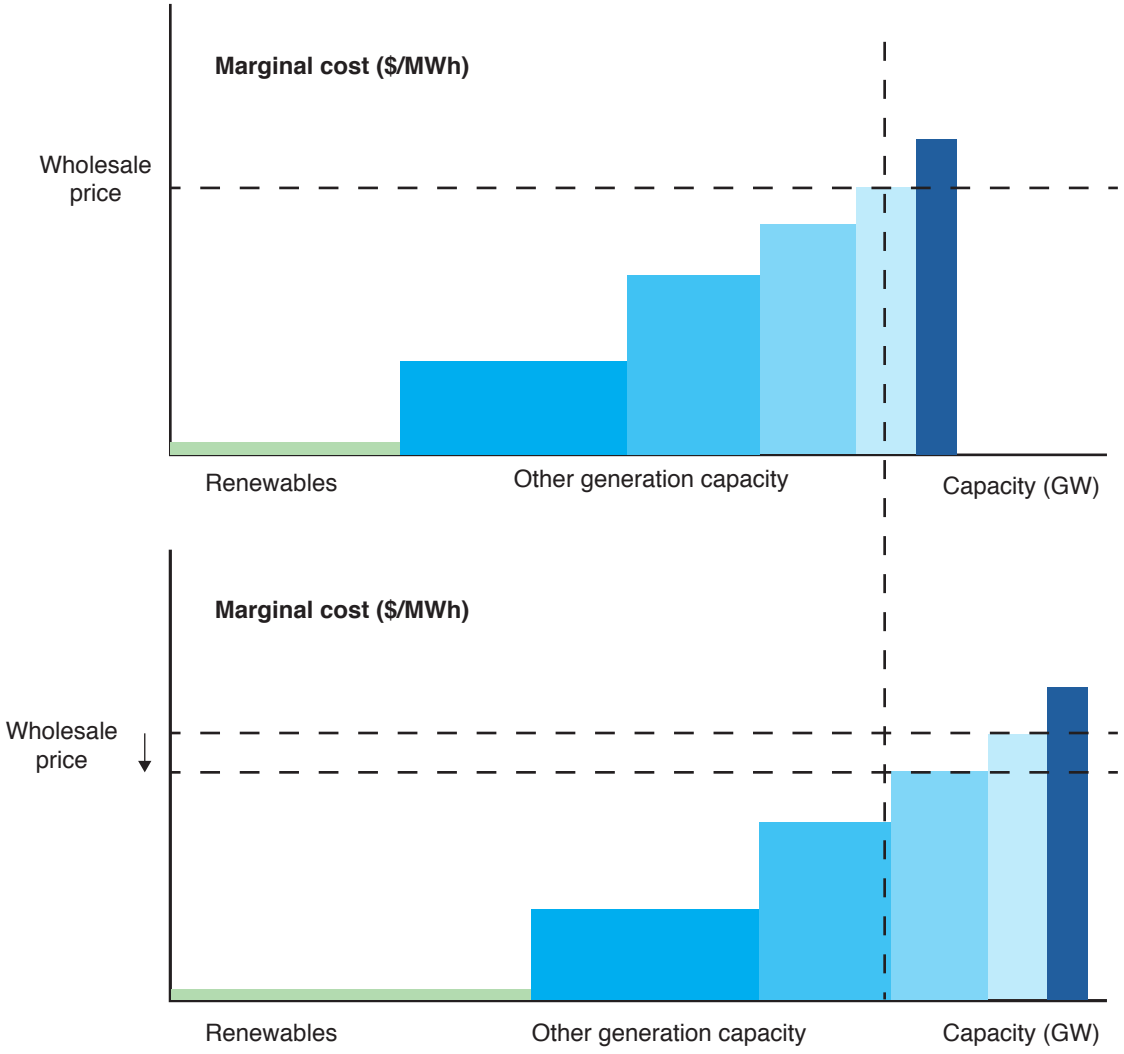
Context

Electricity policymakers are all familiar with the merit order figure below: To minimize the cost of providing electricity, prices are set according to the marginal cost (typically the fuel and variable maintenance costs) of the highest marginal cost operating unit (Figure 1). In a forthcoming paper, KAPSARC researchers assess several renewable energy penetration scenarios in the Saudi power mix over the next two decades. In this commentary, we discuss the impact of renewable energy penetration on end-user electricity prices driven by the observed development in European countries since 2000. We conclude with a discussion on how Saudi Arabia is benefiting from its development of renewable energy. We focus on the renewable generation from solar and wind since they have witnessed a large deployment in the power systems over the past years, and they are expected to increase their shares in the future electricity mix as policies to decarbonize the power sector take effect worldwide. Since solar and wind energy has a zero or near-zero marginal cost, they will be the first resources in the merit order.

Figure 1. The impact of merit order dispatch on wholesale electricity prices with increasing renewable resources.



Source: Author's illustration.

Renewable energy generation costs witnessed a significant decrease over the past decade. According to the International Renewable Energy Association (IRENA), the global weighted-average levelized cost of electricity (LCOE) of utility-scale solar photovoltaics decreased by 82% between 2010 and 2019, while the cost of wind declined by 39% and 29% for onshore and offshore projects, respectively (IRENA 2020). As solar and wind resources increase their share in electricity production globally, as they become more competitive due to technological advancements and economies of scale in production, one would expect electricity prices to decline.

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What does data from 55 countries tell us?

We compiled data from 55 countries for the years 2000, 2010, and 2019, as shown in Figure 2. The data tells a different story from what received wisdom would suggest. Surprisingly, there seems to be a positive correlation between the share of renewable energy generation from solar and wind and end-user electricity prices. We illustrate this point using residential prices (Figure 2). It can be observed that the more solar and wind production increases its share in a country's power generation, the higher electricity prices become. In 2000, the average share of solar and wind in total electricity production across the 55 countries was 0.4%, while the average rate of electricity prices (including taxes) amounted to 13.3 United States (U.S.) cents per kilowatthour (kWh) (in real 2015 U.S. dollars). By 2010, the share of renewable solar and wind in power generation increased to 2.4% on average, while real residential electricity prices reached 15.5 U.S. cents/kWh. In 2019, the average share of renewable jumped to almost 11%. In the same year, average real residential electricity prices stood at 16.4 U.S. cents/kWh, i.e., a 6% increase compared with 2010 and a 24% increase compared with 2000.[1] The magnitudes of these increases depend on myriad factors such as solar and wind availability, the amount of renewable resources installed, the renewable support mechanism, and labor and land costs, among others.

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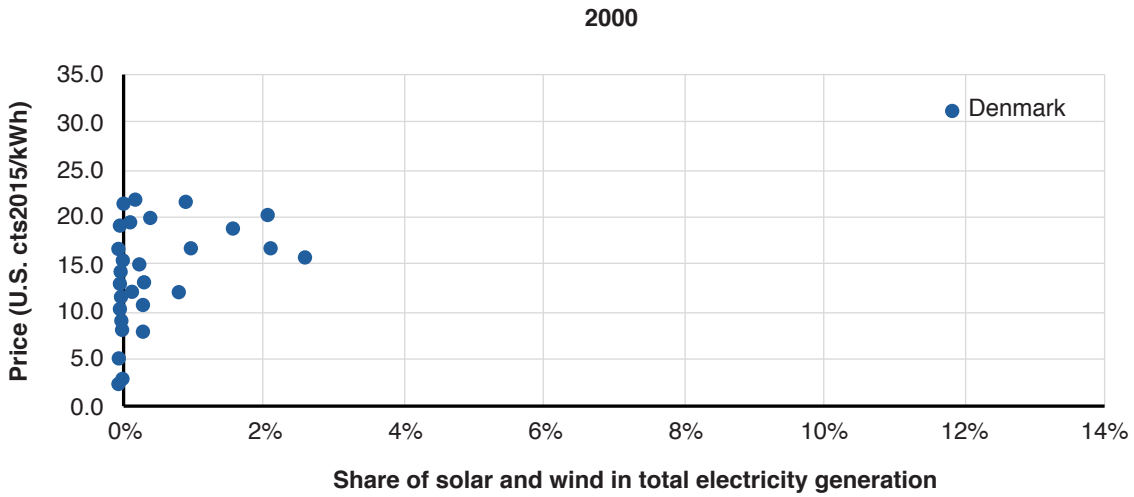
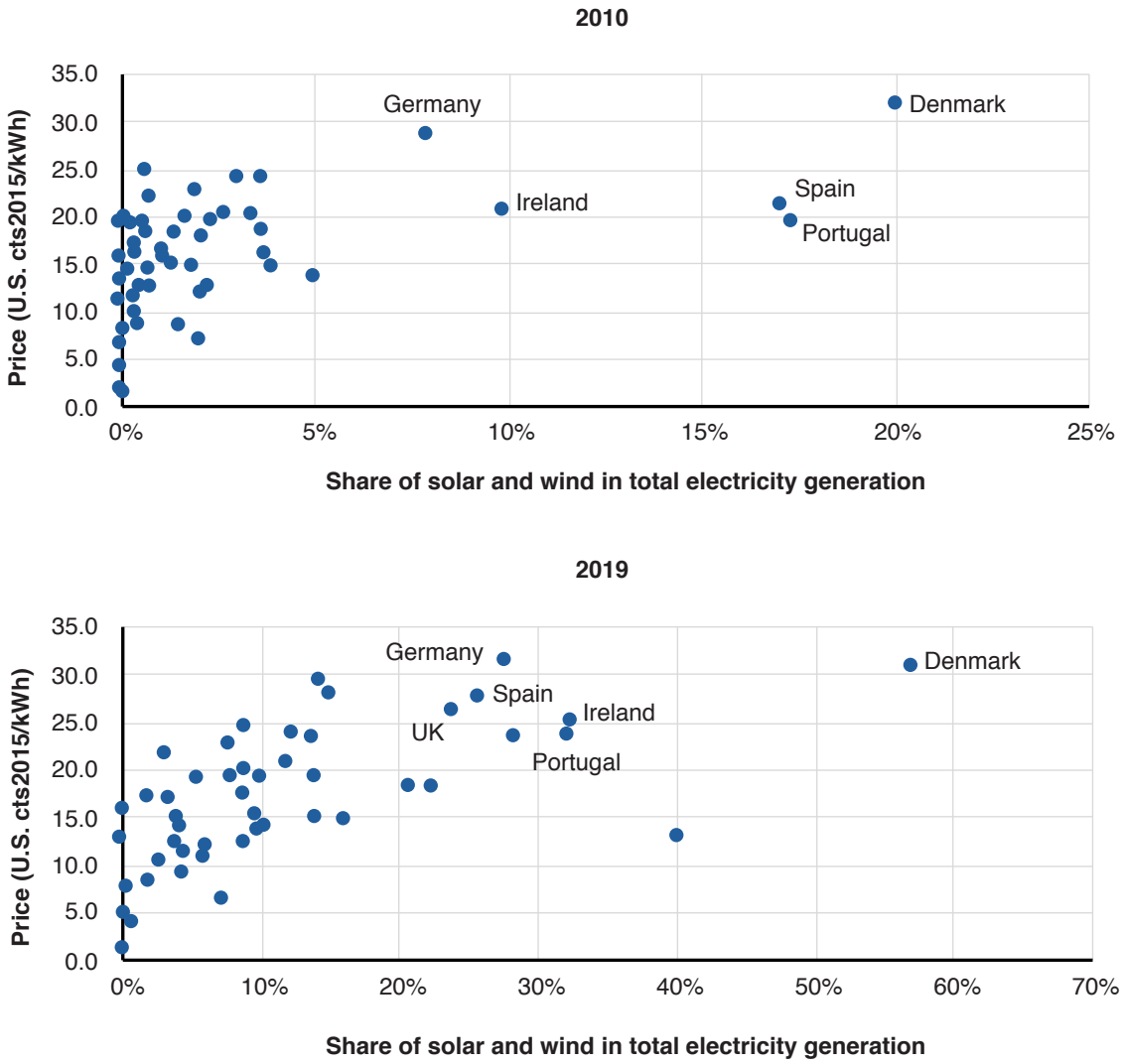
Figure 2. The evolution of real residential electricity prices with higher penetration of solar and wind production in 55 countries.



[1] Looking at industrial electricity prices shows a similar trend. Between 2000 and 2019, the average real industrial electricity price across the 55 countries increased 25%, i.e., from 9 to 11 cents/kWh.



Source: Enerdata (Energy and CO2 Global Data).

Several plausible overlapping factors could explain this renewable energy paradox of decreasing costs but increasing electricity prices, which could vary across countries depending on specificities

Several plausible overlapping factors could explain this renewable energy paradox of decreasing costs but increasing electricity prices, which could vary across countries depending on specificities. The first part of the answer lies in the composition of electricity prices. When we pay for a kWh of electricity, we pay for the energy, distribution fees, plus a significant amount of taxes and levies. The latter includes the value-added tax (VAT), contributions (such as local or federal taxes), transfers for social tariffs, in addition to mechanisms that support renewable generation. This can be achieved through, for instance, feed-in tariffs and the renewable portfolio standard, which have served to improve the economic viability of renewable energy projects in their early development stages.

Looking at a sample of 28 OECD countries, in 2000, the average share of taxes and levies in total electricity prices, including support mechanisms for renewable energy, was 16% (Figure 3). This share increased 8 percentage points by 2019, reaching 24%. Moreover, the share of taxes in total electricity prices show large disparities across the sample countries. In 2019, the smallest tax rate was 4% for the U.S., versus 59% for Denmark. Also, between 2000 and 2019, shares of taxes in total residential electricity prices increased in almost all countries (23 out of 28 countries), slightly decreased for three countries, while it remained stable for two.

Figure 3. Residential electricity prices composition.

Source: Enerdata (Energy and CO2 Global Data).

Another surprising observation is that even while isolating the tax component from residential electricity prices, the increasing trend in prices following solar and wind penetration does not change. Between 2000 and 2019, average real residential electricity prices excluding taxes in the 28 countries increased by 13%, i.e., from 12.7 cents/kWh to 14.3 cents/kWh. Likewise, over the same period, industrial electricity prices excluding taxes across the 28 countries increased 18%, i.e., from 7.9 cents/kWh to 9.3 cents/kWh.

The larger renewable plants get (the size of ongoing projects is several hundred megawatts and is moving increasingly toward gigawatts), the greater the need for managing their intermittency

The second possible explanation for the observed increase in final electricity prices with increasing shares of solar and wind is the intermittent nature of these resources. For example, a solar photovoltaic (PV) plant can lose a significant amount of its output (percentage-wise) due to cloud cover. Within minutes, this could amount to several megawatt hours (MWh) of energy that the grid must provide. Therefore, reserve margin requirements, i.e., regulation reserves and capacity reserves, increase. These investments are necessary to improve the grid's flexibility, i.e., its ability to handle the ramp-up or demand shifting on a large scale, and are reflected in the final electricity price. The larger renewable plants get (the size of ongoing projects is several hundred megawatts and is moving increasingly toward gigawatts), the greater the need for managing their intermittency (Elshurafa and Matar 2017; Aurora Energy 2016).

The third potential factor is the mismatch between the renewable energy supply and consumer behavior on the demand side. Indeed, the drop in the generation costs of solar and wind due to innovation, competition, support mechanisms and financial development is ahead of the adoption of factors on the demand-side that could make the integration of renewables drive electricity prices down. For example, the deployment of smart meters and the internet of things (IoT) has been slower than expected. These two factors can optimize, in real-time, the output of electricity from renewable sources to match end-user consumption. One way to ensure the responsiveness of solar and wind supply to demand is to develop innovative financial offers to make electricity prices cheaper. For example, earlier this year, the world's first energy offer linked to wind speed was launched in the United Kingdom. Customers near a wind farm located in Yorkshire now receive a 50% discount on their electricity tariff when the wind speed reaches 8 meters per second (Octopus Energy 2021).

Could the future Saudi power mix be an exception?

There are several factors, if appropriately capitalized on, that could benefit Saudi Arabia's strategy to increase the share of renewable energy while mitigating the impact on final consumer prices

Saudi Arabia is planning to increase the share of renewable in its future generation mix. By 2030, solar and wind are expected to represent around half of Saudi electricity generation. Looking at experiences from countries discussed above, increasing the share of renewables in the Saudi power mix would inevitably increase electricity bills, as observed in other (mostly European) countries. However, there are several factors, if appropriately capitalized on, that could benefit Saudi Arabia's strategy to increase the share of renewable energy while mitigating the impact on final consumer prices.

First, the Kingdom has remarkable renewable energy potential, primarily solar. Saudi Arabia has one of the highest solar radiation rates worldwide, which makes solar energy more efficient compared with other countries

(Zell et al. 2015; AlYahya and Irfan 2016). Moreover, the Kingdom's potential for distributed solar systems is significant (Elshurafa and Muhsen 2019; Ramli et al. 2017), which could mitigate the impacts of disruption occurring at large-scale plants mentioned above and contributing to price spikes.[2]

Second, Saudi renewable potential output, mainly solar, is concomitant with the load curve patterns. Saudi power demand mainly consists of buildings (around 75%), with 70% of this power used for air-conditioning in the residential sector (Howarth et al. 2020). Therefore, most demand occurs during the summer months, i.e., between April and October. Awam et al. (2018) and Alotaibi et al. (2020) show that solar radiation patterns across the Kingdom match its load curve. Solar PV deployment can thus reduce the need for marginal units and push electricity prices down, as illustrated in Figure 1.

Third, Saudi Arabia's institutional framework for developing renewable energy is based on a transparent and competitive tendering process led by the National Renewable Energy Program. The bidding process is designed to fully capture and disclose advances in the cost-effectiveness of renewable energy. Given its large potential for renewable energy, the Kingdom has already received world-record bids for its first solar PV and onshore wind projects (NREP 2018, 2019). In April 2021, Saudi Arabia achieved another world breaking record bid for the Al Shuaiba 600 MW solar PV project, reported at $0.0104/kWh (Emiliano, 2021).

Fourth, Saudi Arabia launched an ambitious program for the digitization of its power sector. The Kingdom is deploying 10 million smart meters, which are expected to cover all customers (SEC 2021). Smart meters will allow for the real-time reading and billing of electricity consumption with a high degree of granularity. Therefore, a large deployment of smart meters will allow customers to optimize their demand to match times when renewable energy generation is most efficient. Ultimately, fully automated processes (decentralized generation, smart meters, IoT) will enable customers to benefit from the cost-effectiveness of renewable sources.

To conclude, solar and wind are increasingly gaining shares in the power mix as they become cost-competitive compared with conventional fuels. They also provide environmental and economic benefits. However, to take advantage of the falling costs of renewable energy, policymakers must set adequate frameworks in place to allow electricity prices to fall as renewables increase their shares in the power mix. Deploying technologies such as smart meters, and tariff innovations such as dynamic pricing, could help lower energy bills for end consumers. Indeed, these factors would trigger energy efficiency investments and demand, both helping to increase the share of renewable energy in the energy mix while addressing its intermittency.

[2] Saudi Water and Electricity Regulation Authority recently launched the "Shamsi" portal to incentivize the development of rooftop solar https://shamsi.gov.sa/en/Pages/Default.aspx.

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About the Project

Saudi Arabia’s policymakers aim to transform the country’s electricity sector by pursuing a dual agenda of electricity reform and decarbonization, supported by an ambitious deployment of renewable technologies. The Kingdom is pursuing this agenda in the context of a rapidly changing global electricity sector, with emerging renewable and distributed technologies testing the limits of existing market, business and regulatory frameworks.

This commentary series is part of KAPSARC’s continuing effort to disseminate its work on Electricity Market Analysis within the Energy Transitions and Electric Power research group.

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.

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