Discussion Paper

Renewable Energy Certificates in the Saudi Electricity System

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Summary

A renewable energy certificate (REC) is a tradable instrument that represents 1 megawatt-hour (MWh) of electricity generated from renewable sources. In addition to the electricity itself, a REC embodies the non-energy attributes of that generation, such as reductions in greenhouse gas emissions. RECs allow electricity users to track the quantity of renewable electricity supplied and consumed. They not only verify that the total amount of electricity used by consumers is matched by renewable generation but may also incentivize additional renewable electricity projects if increased demand raises REC prices.

Renewable power producers may issue these certificates for the electricity they generate and sell them to designated buyers under relevant agreements or market rules. In the end, electricity consumers would pay for RECs to certify that they are using renewable electricity.

Saudi Arabia is presently targeting that half of its electricity capacity will come from renewable technologies by the early 2030s. In this analysis, the KAPSARC Energy Model is used to estimate the value of a potential REC in the Saudi context. When the demand for RECs first exceeds the supply of targeted renewable electricity, the modeling analysis reveals that the expected REC price would be $25 per MWh. A nonzero REC price can generate sufficient revenue for renewable power producers to support the development of additional projects. A REC price ranging from $24.6 to $26.1 per MWh could encourage up to 17 GW of investment beyond the capacities already projected to come online under domestic policy. A price reaching up to $35.4 per MWh could incentivize as much as 51 GW of additional investment. RECs may be a viable option to stimulate further private sector investment in renewable electricity capacity beyond current targets.

Keywords: Renewable Energy, Solar, Wind, Energy System, Saudi Arabia

Introduction

01

Saudi Arabia aims to achieve equal levels of renewable and thermal power capacities domestically. The technologies could range from solar photovoltaics (PV), concentrating solar power (CSP), seawater pumped hydroelectricity, geothermal, or wind turbines. The Kingdom is making significant strides in deploying renewable electricity. According to the *Saudi Arabia Renewables Tracker* (KAPSARC 2025), solar PV accounts for 93.5% of the total renewable generation in KSA, which has 23 GW that is either online or under construction. There is an additional 28.5 GW of renewable capacity that is being tendered. This momentum toward achieving the Kingdom's ambitions could be reinforced by a market-based instrument that incentivizes further development of renewable power projects.

To elaborate, renewable electricity generation consists of both the electricity itself and its associated environmental, social, and other non-energy attributes. A renewable energy certificate (REC) is an instrument that conveys the property rights to these non-energy attributes of renewable electricity generation. RECs are issued when 1 megawatt-hour (MWh) of electricity is generated from a renewable energy source. Since the physical electricity delivered through the utility grid does not indicate its origin or how it was generated, RECs play a crucial role in accounting for, tracking, and assigning ownership of renewable electricity generation and use. On a shared grid, RECs are the instrument that electricity consumers must use to substantiate claims of renewable electricity use.

RECs may be of interest for Saudi policymakers for a couple of reasons: they can help local firms meet their CO_2 emissions targets by lowering their Scope 2 emissions,[1] and they can incentivize the installation of additional renewable electricity capacity. This would be the case if renewable electricity demand is in excess of the renewable energy targets set by the Saudi government. Otherwise, RECs would not incentivize additional renewable investments, as the extra demand could be fulfilled by the surplus renewable electricity already generated within the system. This statement is supported by Zhu et al. (2022), who find that higher demand for renewable electricity from firms, coupled with rising REC prices (e.g., due to limited supply), leads to increased investment in renewable energy.

Beyond their role in stimulating renewable deployment, RECs can be leveraged to achieve other strategic goals. For example, they can enhance the attractiveness of local firms to foreign investors or encourage foreign firms to establish operations in

Saudi Arabia. Supporting this claim, Chung, Kunene, and Chang (2024) find that energy-intensive firms that purchase renewable certificates experience a positive impact on their valuation. They argue that investors view such purchases favorably, as RECs enhance firms' competitiveness in the face of environmental regulations, such as an import tariff on CO_2-intensive products, and in the face of shifting consumer preferences. Firms that are not energy intensive, such as financial institutions, do not appear to gain a perceived benefit from purchasing RECs. Additionally, Eweade and Güngör (2024) find that the availability of renewable energy attracts foreign direct investment (FDI) into the United States. In the case of Saudi Arabia, Kerrouche and Zehri (2024) provide quantitative evidence that renewable energy has positively contributed to domestic FDI.

While Saudi Arabia does operate a voluntary carbon market (VCM n.d.), there is no prevailing price on the CO_2 emitted by firms. In any case, it is worth noting that renewable energy certificates are compatible with a CO_2 price. A CO_2 price makes renewable technologies more attractive relative to thermal power plants – increasing renewable electricity supply. Thus, the price of RECs needed to encourage the development of renewable projects becomes lower. In a similar certificate type to RECs, De Jonghe et al. (2009) show that prices of tradable green certificates decline as the CO_2 price rises, and vice versa. Wang et al. (2024) support this finding by showing the costs of both green certificates and carbon trading decline when both measures are combined.

We quantify a potential price for RECs in Saudi Arabia and explore their role in the Kingdom using an in-house energy system model. REC prices are estimated under scenarios both with and without renewable capacity targets. The year 2030 is chosen as it represents the approximate target date for achieving Saudi Arabia's renewable power capacity goals. However, in the scenario without renewable capacity targets, the year of analysis is less critical, as a nonzero REC price indicates that demand for RECs exceeds the prevailing supply of renewable generation. The modeling assessment identifies the conditions under which RECs become impactful and estimates their expected price. Part of the analysis also evaluates the feasibility of expanding renewable capacity beyond 2030.

The next section provides an overview of RECs and reviews relevant literature. This is followed by a description of the methods and data used to estimate the potential impact of RECs in Saudi Arabia. The paper then concludes with a presentation and discussion of the results.



02 Renewable Energy Certificates and Their Role in the Saudi Electricity System

As there are no wholesale or retail electricity markets in Saudi Arabia, power purchase agreements (PPAs) are the preferred means of operation for independent renewable power producers. PPAs are long-term contracts between an electricity generator and a purchaser. A key aspect of PPAs is that they may include the transfer of RECs, which are essential for making renewable electricity claims. In the case of Saudi Arabia, the purchaser is the Saudi Power Procurement Company (the principal buyer), which agrees to buy electricity at a prearranged price.

When a renewable energy project that is registered for RECs generates electricity under a PPA, it typically produces both electricity and a certificate for that electricity. The buyer of the PPA may receive both the electricity and the associated RECs, or in some cases, only the RECs. This depends on the structure of the agreement.

RECs serve as proof that electricity was generated from an eligible renewable resource. While the electricity itself is indistinguishable once it enters the power grid, RECs allow buyers to claim 1 MWh units of renewable electricity generated by renewable power producers. This is electricity that can no longer be claimed by another buyer. Consumers can purchase two types of RECs: voluntary and compliant. Each variant of RECs targets different participants.

Voluntary REC frameworks are driven by firms and individuals who choose to purchase RECs to meet internal sustainability goals or to demonstrate environmental responsibility. These purchases are not mandated by law, but are instead motivated by corporate social responsibility, consumer demand, or climate commitments. For instance, a business aiming to reduce its greenhouse gas (GHG) emissions may purchase RECs to match its electricity consumption with renewable energy generation in the power system, even if its actual electricity use has come from thermal power plants.

In contrast, compliance REC markets exist to meet legal or regulatory requirements, like a renewable portfolio standard (RPS). These mandates require electricity suppliers or consumers to procure a certain percentage of their energy from renewable sources. To demonstrate compliance, utilities must either generate renewable energy themselves or purchase RECs from other producers (DOE 2024). In this way, RECs serve as a flexible mechanism to ensure adherence to policy goals without obligating direct renewable energy use by all consumers. Compliance mechanisms are typically more regulated and structured, with set rules about which energy sources qualify, how RECs are tracked, and penalties for noncompliance.

The main difference between voluntary and compliance RECs lies in their purpose and the targeted participants. Voluntary RECs are usually less expensive without regulatory oversight, while more-expensive compliance RECs are subject to more

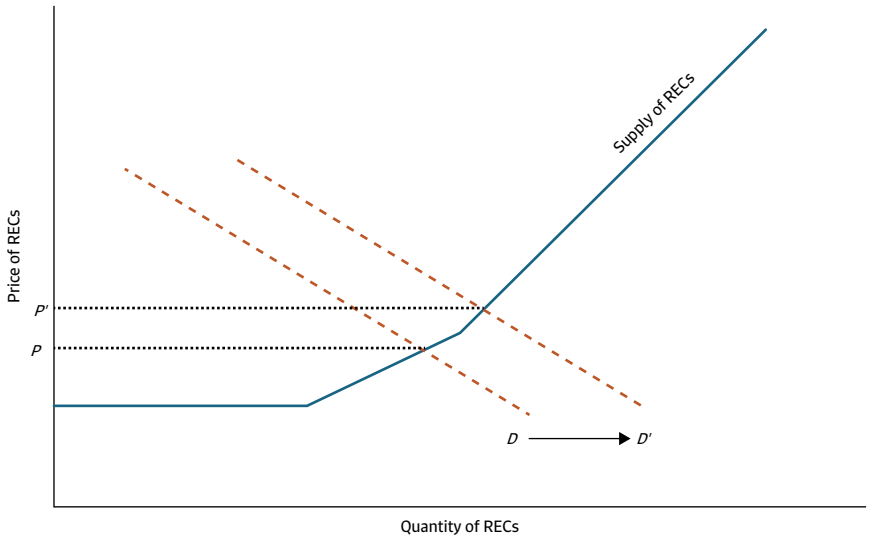
rigorous standards and regulation. However, both variants can complement each other by increasing demand for renewable energy. If demand pushes against supply, an emergent non-zero price for RECs would encourage the installation of additional renewable power generation technologies. Figure 1 shows that if demand were to increase from *D* to *D′* and supply is fixed, the equilibrium price of RECs increases, from *P* to *P′*, and the supply of renewable electricity would rise.

While sustainability goals may be the primary objective, it is worth noting that some analysts have cautioned that RECs may hinder genuine reductions in greenhouse gas emissions (Bjørn et al. 2022). For example, Bjørn et al. (2022) find that prevailing accounting guidelines for RECs have led to an overestimation of their efficacy. Essentially, the guidelines have allowed for double-counting the emissions reduction. On another front, Langer et al. (2024) find that voluntary RECs, where supply and demand are matched annually, may not lead to significant additional CO_2 emissions reduction compared to the absence of RECs. However, if supply and demand are matched on an hourly basis, they find substantial CO_2 emissions abatement.

Existing paradigms of the RECs markets around the globe are reviewed to ascertain implementation possibilities in Saudi Arabia. In the U.S., for example, RECs are offered as bundled and unbundled certificates. The certificates are bundled when they are bought along with the electricity that they represent. Certificates are unbundled when electricity is purchased separately. In regulated markets in the U.S., customers can purchase bundled RECs through their local utility company or energy provider through PPAs (DOE 2024). An energy provider like this is exemplified by the Saudi Power Procurement Company (principal buyer). RECs may be retired once they are bought or once they expire some time after issuance if no consumer buys them (DOE 2024). Each REC is assigned information about where, when, and what type of renewable electricity is generated to a tracking number. This tracking mechanism may warrant an administrative cost that is tacked onto the certificate.

As it relates to the exact mechanics of implementation, an example is provided by Chung, Kunene, and Chang (2024) for the trading system in Taiwan. The Taiwanese RECs market is administered and managed by the local commission. All renewable electricity producers and consumers must pay to participate in the market platform. One feature of the market is that renewable electricity generators that participate in other renewable energy incentive programs or carbon trading are not allowed to participate. The commission issues a REC for each MWh of electricity generated by a renewable energy producer. Demand for RECs is aggregated from the electricity consumers who purchase renewable energy in this market. Those consumers may be firms or households.

Figure 1. Stylistic supply-demand curves for a REC market.



Source: Authors.

The Taiwanese trading platform notifies renewable energy producers and electricity consumers of the trading day. Within one week after the announcement, generators wishing to participate must provide information on the type of energy, installed capacity, and available electricity. Meanwhile, electricity consumers must register the portion of their annual electricity demand to be matched with RECs. After verification, consumers must pay a deposit based on the amount of RECs that they requested. The trading platform notifies the renewable energy generators so that they can review the information submitted by the electricity consumers. Then, a renewable energy generator may correct the quantities and register its base price. Generators that do not register their base price before the deadline will have their participation revoked. After the generator's offering has been approved, it will be published on the platform and electricity consumers will be invited to submit bids. Once a bid is selected, both the generator and electricity consumer sign a PPA, which is submitted to the platform to complete the transfer of the REC (National Renewable Energy Certification Center 2025).

Methods and Data

03

This study applies the KAPSARC Energy Model (KEM), a multisector energy systems model developed for Saudi Arabia (Matar 2016). KEM is formulated as a mixed-complementarity problem, allowing for the seamless integration of intersectoral fuel prices set by the Saudi government. The model comprises seven core sectors, represented across the western, southern, central, and eastern regions of the country: (1) electricity, (2) oil refining, (3) petrochemicals and fertilizers, (4) water desalination, (5) cement production, (6) upstream iron and steel production, and (7) upstream oil and gas transshipment.

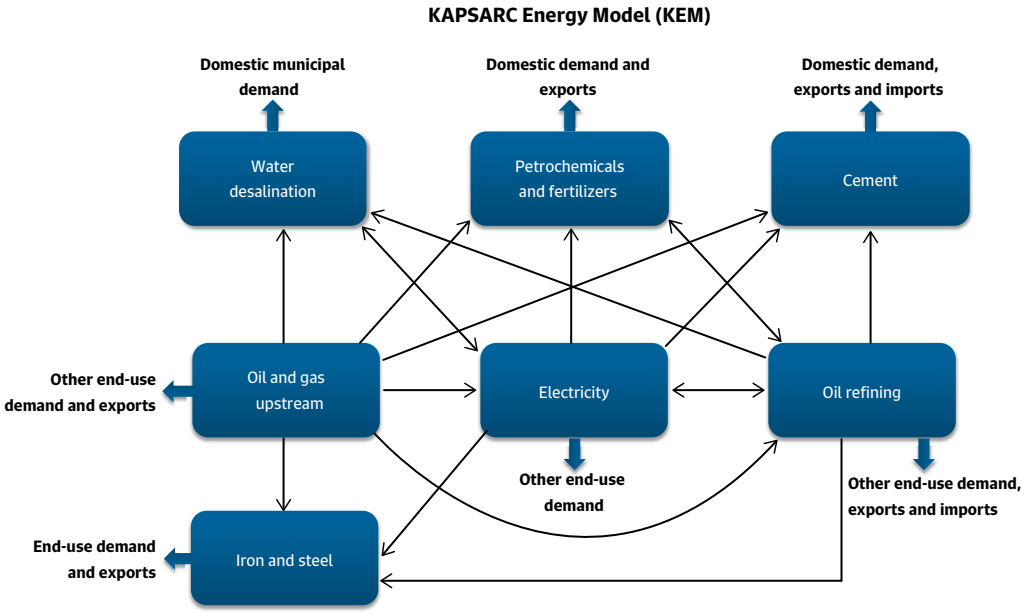
The energy flows among these sectors are illustrated in Figure 2. For example, fuel oil may flow from the oil refining sector to the electricity, cement, or petrochemicals and fertilizers sectors. Alternatively, those sectors may use natural gas from the upstream oil and gas sector.

Given the scarcity of natural gas in Saudi Arabia, allocating the fuel to each sector in the local energy system is crucial when performing energy policy analyses. For this paper, the projected natural gas supply and its allocated quantities for the electricity sector will play a role in determining the price of RECs. Using the full KEM framework allows us to consider how total natural gas supply from Saudi Arabia is allocated among the seven sectors. In general, a sector aims to maximize profits if it exports internationally and minimizes total costs when serving only domestic demand.

To further elaborate on the electricity sector, KEM models eight load segments for representative days in each season and for different day types (weekends and weekdays) in each region. This approximation is employed to manage the computational demands of modeling the other sectors. KEM distinguishes between oil- and natural gas-fired power generation technologies, with their cost and performance attributes shown in Table 1. These attributes are assumed to remain constant over the analysis period.

In the model, solar PV and wind turbines warrant the operation of spinning reserves. The spinning reserves back up intermittent capacities by using idling natural gas-fired turbines. Capital costs for key renewable technologies are presented in Figure 3 and are sourced from the International Renewable Energy Agency (IRENA 2024) and the National Renewable Energy Laboratory (NREL 2024a, 2024b, 2024c). Fixed operational costs are estimated as a small percentage of capital costs.

Figure 2. Sectors and their associated energy flows in the KAPSARC Energy Model.



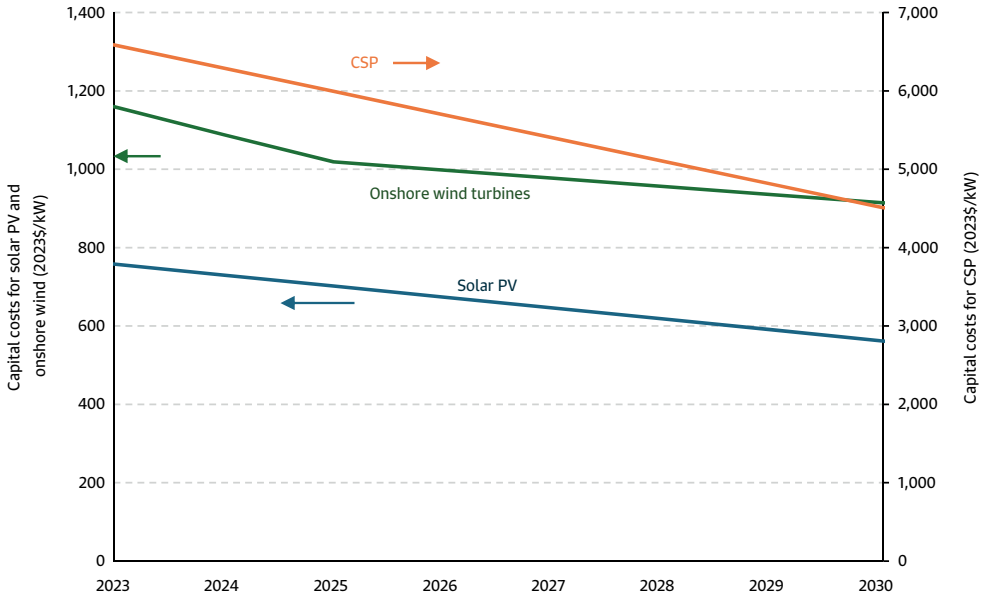
Source: Authors.

Table 1. Cost estimates for thermal power generation technologies and pumped seawater hydro.

Power generation technology	Fuel	Capital cost ($ per kW)	Fixed O&M cost ($ per kW per year)	Non-fuel variable O&M cost ($ per MWh)	Ramping costs ($ per ΔMW)	Designed lifetime (years)
Open-cycle gas turbines (OCGT)	Oil	1,226 to 1,337	10.1	4.0	0.92	30
	Natural gas	912 to 1,016				
Combined cycle (CC) plants	Oil	1,037 to 1,212	19.9	3.3	0.58	35
	Natural gas	943 to 1,102				
Conversion of OCGT to combined cycle plants*	Oil or natural gas	240	20.9	3.8	0.58	20
Steam turbine (ST) plants	Oil	1,584 to 1,680	36.5	1.64	1.61	40
	Natural gas	1,500 to 1,600				
Oil-fired ST plants with SO_2 scrubber	Oil		42.0	4.4	1.61	40
OCGT plants with CCS	Natural gas	1,050 to 1,168	11.6	4.0		
CC plants with CCS	Natural gas	1,192 to 1,394	22.9	3.3	0.58	35
ST plants with CCS	Natural gas	1,725 to 1840	42.0	1.64	1.61	40
Nuclear fission plants	Nuclear fuel	6,500	130.0	6.9	-	60
Pumped seawater storage hydro	-	552	18.0	0.5	-	70

Source: Authors' analysis; ramping costs from Van den Bergh and Delarue (2015).
*Note: * Conversion has a lower efficiency than new combined cycle plants and increases the capacity of OCGT by 50%.*

Figure 3. Capital costs of renewable electricity technologies until 2030.



Source: IRENA (2024); NREL (2024a, 2024b, 2024c).

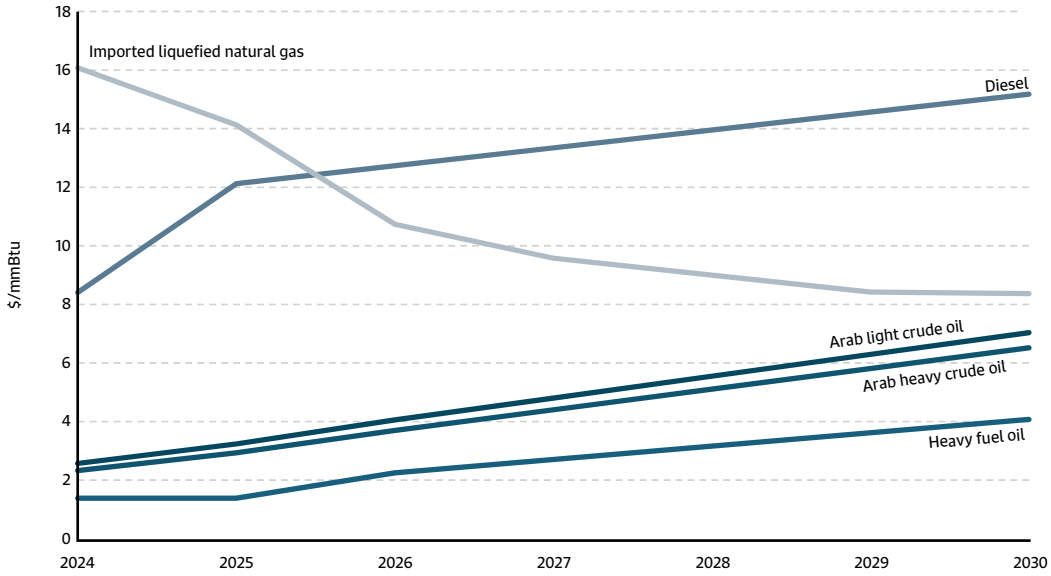
Renewable power installations can contribute to the reserve margin in KEM. The reserve margin is defined by the installed capacities that can address the peak power load in the electricity system. Solar PV capacity contributes 15%, CSP contributes 60% due to the accompanying eight hours of thermal energy storage, and onshore wind turbines can contribute 10% (percentages are authors' assumptions). Battery storage systems have not been considered as part of this analysis. Saudi Arabia aims to achieve up to 48 GWh of battery electricity storage by 2030 (Saudi Electricity Company 2025).[2]

The electricity sector has also been equipped with the ability to make investments in carbon capture and sequestration (CCS) technologies. The CCS technology in the model is characterized by a 90% capture rate (Budinis et al. 2018; Brandl et al. 2021). CCS is available for new natural gas-fired power plants. The representation of CCS in KEM considers the capital and fixed operational costs of a post-combustion technology. The addition of CCS imposes a penalty on the thermal efficiency of the power plants due to higher parasitic loads within the plant.

KEM is run from 2023 to 2030. The equilibrium among the seven sectors is found over a one-year moving window throughout the eight-year time horizon. The data used to parameterize the latest version of KEM have been detailed by Matar (2025). The most pertinent data inputs for this exercise are the projected fuel price and the government renewable electricity capacity targets by 2030.

For the former, model runs consider domestic fuel price reforms. Domestic prices of natural gas and oil products consider the prevailing administered values in 2023 to 2025. The domestic natural gas price was $1.25 per mmBtu in 2023, $1.75 per mmBtu in 2024, and $2.15 per mmBtu in 2025. Beyond 2025, the natural gas prices are generally determined by KEM as the marginal value at which supply clears demand. While this is the general rule, we run one case that takes fixed natural gas prices over time. Domestic natural gas supply is projected factoring in the production growth targeted by Saudi Aramco (2024). The growth in natural gas production is planned to come from non-associated and unconventional sources, like the Jafurah Gas Field. Domestic prices of oil products and liquefied natural gas (LNG) that are input in KEM are shown in Figure 4. The option to import LNG is availed to the power sector in case domestic natural gas supply becomes constraining.

Figure 4. Domestic prices of oil products and imported liquefied natural gas until 2040.



Source: Authors' estimation; liquefied natural gas prices from Nexant World Gas Model.

Two cases of renewable electricity capacity additions are considered. In one, the model is mandated to meet the renewable capacity targets. The annual renewable capacity additions are estimated to take place linearly, reaching ≈100 GW by 2030. While the actual capacity additions may not be linear, these additions are purely used to facilitate this analysis. The mandated capacity additions are input in the model as lower bounds for renewable capacity over time. These lower bounds are defined as the "baseline." In the other case, no capacity targets are enforced in the model.

KEM uses the projected renewable electricity capacity additions as lower bounds of total renewable capacity built. Then, the framework considers that the demand for RECs, defined exogenously, gradually rises from 0 TWh to 461 TWh in 2030. A constraint, shown in Equation (1), has been added to KEM to link REC demand and renewable electricity supply. In Equation (1), the demand and renewable supply of RECs are matched annually to produce a single price for RECs for each year. Once the demand for RECs (D) rises to the supply of renewable electricity from the mandated lower bounds, then a non-zero price for RECs may be calculated as the constraint's dual variable. This dual variable is the marginal value of introducing RECs in the Saudi electric power landscape. In other words, it represents the economic benefit or cost to the power system that one more REC would garner in Saudi Arabia. This value may then encourage the installation of additional renewable capacity above the renewable capacity targets. It considers the regional solar irradiance and wind profile characteristics, the cost projections of power generation technologies, and fuel prices, to name only a few. More detail on these parameters is described by Matar (2025).

$$\sum_{(v,\,l,\,s,\,d,\,r)} (PV_{v,\,l,\,s,\,d,\,r,\,t} + CSP_{v,\,l,\,s,\,d,\,r,\,t} + W_{v,\,l,\,s,\,d,\,r,\,t}) \geq D_t \qquad (1)$$

In Equation (1), $PV_{v,\,l,\,s,\,d,\,r,\,t}$, $CSP_{v,\,l,\,s,\,d,\,r,\,t}$, and $W_{v,\,l,\,s,\,d,\,r,\,t}$ are the amounts of electricity generated in TWh by solar PV, CSP, and wind turbines, respectively. The three variables are indexed by vintage (v), load segment in which electricity is produced (l), season (s), type of day (d), region (r), and yearly time periods (t).

Results

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4.1. Varying Demand for Renewable Energy Certificates

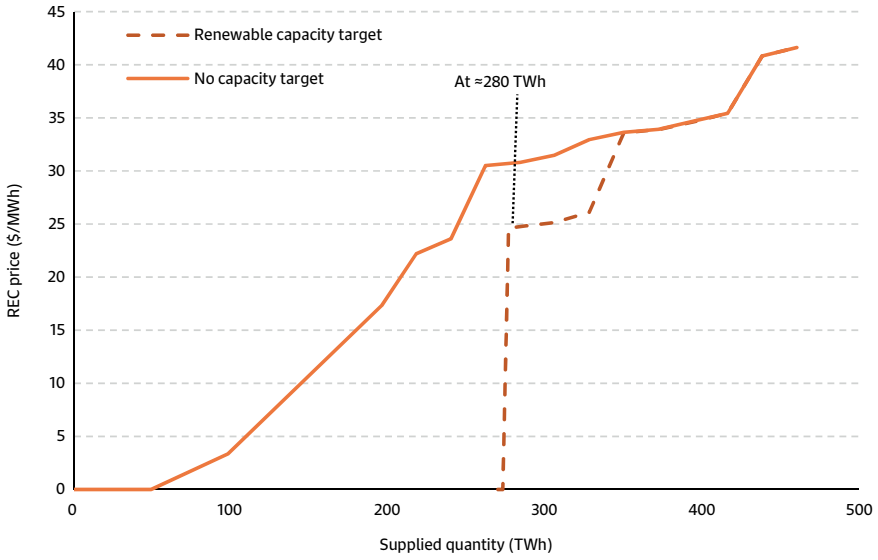
Figure 5 shows the dual prices of RECs versus renewable electricity that is generated in 2030. The prices are shown for the two cases where renewable capacity targets are imposed (dashed line) and where they are not (solid line). The expected base annual generation in 2030, due to the renewable energy policy the Saudi government has put in place, is around 275 TWh. When demand for RECs is below the base generation, that means the constraint shown by Equation (1) is not binding. Therefore, it will not produce a dual price above $0 per MWh. In practice, there could be some non-trivial costs, like administrative charges, which may make the certificates hold a non-zero value, but we consider the dual price as the price.

The REC price becomes greater than $0 per MWh once demand reaches supply. The price jumps to $24.6 per MWh when the demand is at 277 TWh, and 277 TWh is when domestic renewable capacity is at ≈100 GW. It gradually rises to $26.1 per MWh before experiencing a sudden rise to $33.6 per MWh when the demand for RECs reaches 350 TWh. It jumps again to just above $40 per MWh at around 440 TWh. These jumps in the price represent different regional investments in renewable generation capacity across Saudi Arabia. When the capacity targets are not enforced, the REC price that would be needed to reach the targeted capacities would be around $30 per MWh.

With no renewable capacity targets or a REC, the model only builds 27 GW of renewable capacity by 2030, or 76 TWh of electricity generation. The lower capacity here results from overlooking broader policy objectives behind the renewable targets, such as reducing emissions to meet Saudi Arabia's nationally determined contribution (NDC), or attracting foreign direct investments in pursuit of economic diversification. Without imposing these targets, emissions reduction goals are not internalized in the model in the absence of an emission cap or a carbon price. Additionally, capturing wider economic benefits beyond the energy system transcends the boundaries of a partial equilibrium energy model.

The lower addition of renewable technologies compared to past analyses[3] using KEM is due to the higher natural gas supply projections that are input. For instance, Matar and Shabaneh (2020) find that higher domestic natural gas supply tends to lower renewable capacity deployment.

Figure 5. The prices of RECs as a function of quantity of electricity supply in 2030.



Source: Authors' analysis.

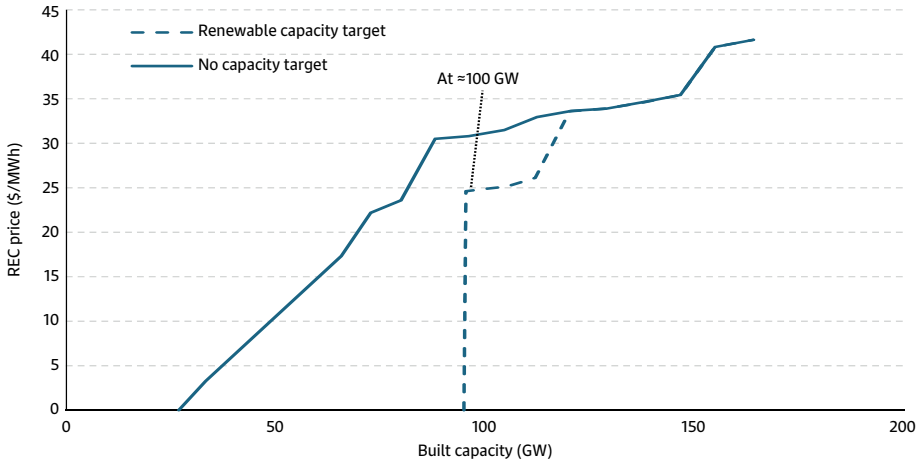
In the case where no renewable capacity targets are enforced, the price of RECs would be contingent on the exogenous demand we set in the model and on the endogenous renewable energy capacity deployed to meet the demand. At a REC demand of 284 TWh, the REC price is $30.8 per MWh. That is roughly $5 per MWh more than the case when the renewable targets are met. This difference in the price of RECs between both cases stems from the varying regional distribution of renewable generation. Different regions have different levels of available renewable resources, like solar insolation. In the case where the model is mandated to meet the renewable targets, more renewable capacity is installed in the western region of Saudi Arabia. In the case here, the renewable targets are not met, and more renewable capacity is built in the central region of the country, meaning that the marginal renewable generation would come from different regions. Because each region has a different renewable resource profile, this would result in a difference in benefit that an additional REC would bring. The prices of RECs converge once the demand for RECs exceeds 350 TWh because at that point, substantial renewable electricity is available in every region of Saudi Arabia.

Moreover, the results when the capacity targets are not enforced may be used as a proxy for years prior to 2030. This is because the modeled price is for a situation where the demand for RECs outstrips renewable generation, regardless of year. Then, the prices of RECs become non-trivial at around 50 TWh of renewable generation. Given the 23 GW of renewable generation capacity that is either installed or under construction in Saudi Arabia (KAPSARC 2025), and if we consider demand slightly exceeds the amount generated by this capacity,[4] the price of RECs may be between $3 per MWh and $5 per MWh, plus any administrative charges.

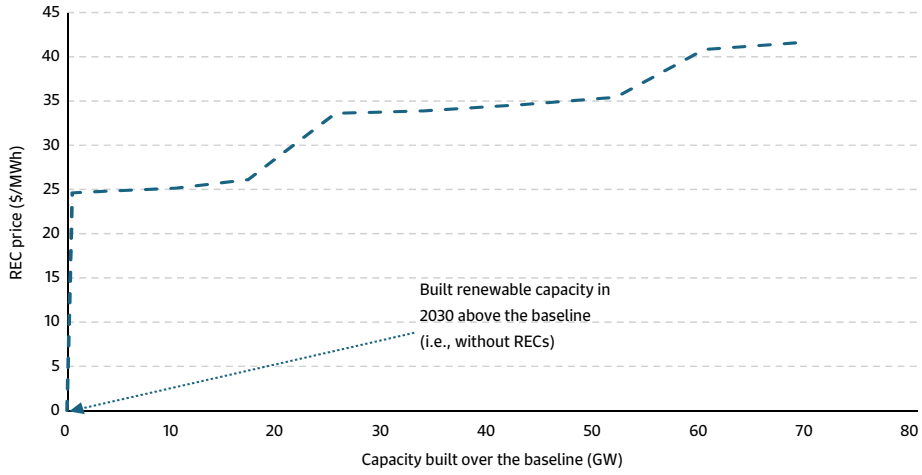
The corresponding capacities that would generate the electricity annually and the related prices of RECs are shown in Figure 6. Similar to the electricity generation figures, a dashed line represents the case with the renewable capacity targets met, and the case where they are not mandated is shown by a solid line. The top portion (a) shows the absolute capacity built, and the bottom portion (b) shows the capacity built relative to the baseline. Similar to electricity generation quantity, the price of RECs below the targeted capacity is $0 per MWh. Moreover, the REC price that would be needed for renewable energy to reach 50% of the power capacity mix if renewable capacity targets were not enforced is around $30 per MWh.

Figure 6. The prices of RECs as a function of electricity capacity in 2030.

(a) Absolute capacity that is built.



(b) Built capacity relative to the baseline in the case of the renewable capacity targets.



Source: Authors' analysis.

The REC price rises to the initial non-zero value of $24.6 per MWh at an incrementally higher capacity than is expected to be in place in 2030. The sudden jumps take place at the corresponding electricity generation, as shown in Figure 5. A non-zero price for these certificates may produce enough revenue for the renewable power producers such that more renewable power projects are built. Similar to Figure 5, there is a $5 per MWh difference at the 100 GW mark between the cases due to the renewable mandates.

Figure 6b highlights the incremental capacity relative to a situation where there are no RECs. In such a situation, the supply of RECs in 2030 is higher than their demand. A REC price ranging from $24.6 per MWh to $26.1 per MWh encourages up to 17 GW of additional investment. A price ranging up to $35.4 per MWh may incentivize up to 51 GW of incremental investment. If the Saudi government were to create incentives for private project developers to build more renewable electricity capacity beyond 2030 or beyond the targets, enacting a REC mechanism may be one option to explore.

To summarize and contrast, the prices of RECs that we find in our analysis are compared to values from other countries in Table 2. Renewable generation of 98 TWh and 277 TWh are

selected to present our results. To recap, 277 TWh is chosen as it is the first instance where a non-zero REC price appears with the renewable capacity targets enforced. In other words, any REC demand below this level would result in a zero price in the model due to excess supply associated with the 2030 targets, effectively covering only administrative costs. The REC price of $24.6 per MWh when the 2030 renewable targets are enforced is the price required to allow for additional investment. If no renewable targets are enforced, Figure 5 shows that the price of RECs at 277 TWh would be $30.8 per MWh in 2030. We also report the price of RECs at 98 TWh, which is $3.4 per MWh, to ensure that we show the prices at a different equilibrium point with a lower installed capacity of renewables. It is useful to show these different prices, as the REC prices for the countries listed in Table 2 may not necessarily be sufficient to encourage additional renewable investments.

Table 2. REC prices in this analysis compared to those of other countries.

This analysis for Saudi Arabia at renewable electricity generation of								
277 TWh in 2030		98 TWh* in 2025-2030	Japan	Australia	Taiwan	India	South Korea	China
Renewable capacity target	No capacity target	No capacity target	In 2023:					
24.6	30.8	3.4	≈4	≈35	≈175	<10	≈52	≈4

Source: Authors; Wood Mackenzie (2024)
*Note: *At 98 TWh, there would not be price for RECs in the case of the 2030 renewable capacity targets. Units in $ per MWh.*

In 2023, Wood Mackenzie (2024) reported REC prices for six countries that range from $4 per MWh to $175 per MWh. The REC prices we find for Saudi Arabia are within the bounds of this range. Globally, renewable electricity generation is projected to rise sharply in the coming decades (Wood Mackenzie 2024; IEA 2025). In turn, REC prices are expected to fall. Wood Mackenzie (2024) anticipates a 76% reduction in the average REC price for the six countries it covers between 2023 and 2050.

4.2. The Effects of Fuel Pricing on the Value of RECs

It has been shown that higher demand for RECs in the excess of its existing supply allows for additional renewable capacity deployment. Now, we explore how different the marginal value of RECs is with or without fuel price reform by running a counterfactual case where the fuel prices are those in Saudi Arabia in 2015. We chose 2015 because 2016 was the unofficial start of the energy price reforms program. Listed in Table 3, we take the nominal prices in 2015 as inputs in the model. Table 4 shows the power generation mix in 2030 without imposing either a lower bound for renewable capacity targets or a demand for RECs with the 2015 fuel prices and the input fuel price reforms. Input reforms include actual fuel price adjustments until 2025 and those projected by 2030. Naturally, higher fuel prices for power generation make renewable technologies more competitive and economically viable.[5] In Table 4, almost three times more renewable capacity is installed in the case with fuel price reforms.

Table 3. Fuel prices in Saudi Arabia in 2015.

Fuel	Price
Natural gas	$0.75 per mmBtu
Arab light crude oil	$4.24 per barrel
Diesel	$3.60 per barrel
Heavy fuel oil (360cSt)	$2.08 per barrel

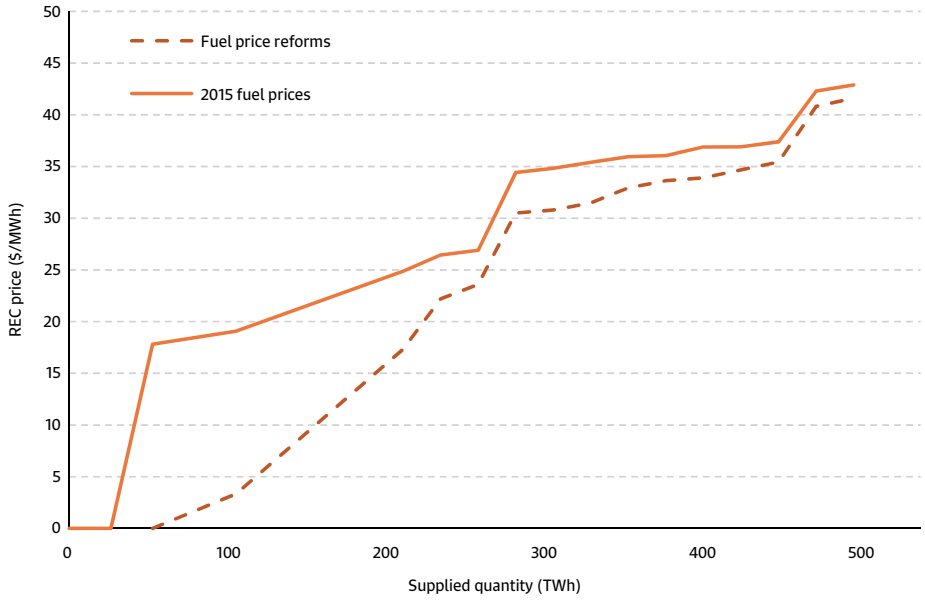
Source: Matar et al. (2015).

Table 4. Model results for installed renewable power capacity with 2015 fuel prices and fuel price reforms without renewable mandates in Saudi Arabia by 2030, including capacity that is already under construction as of 2025.

	2030
Fuel price reforms	26.9 GW
2015 fuel prices	9.8 GW

Source: Authors' analysis.

Figure 7. REC prices with fuel prices before and after fuel price reform in 2030.



Source: Authors' analysis.

Figure 7 shows that under 2015 fuel prices, the REC prices would need to be significantly higher compared to those under current fuel prices. For example, if the demand for RECs were 100 TWh, the REC price would need to be $19 per MWh with 2015 fuel prices, compared to $4 per MWh under the reformed fuel prices. However, as the demand for RECs increases, the price difference narrows. For instance, when demand reaches 400 TWh, REC prices are $37 per MWh and $35 per MWh under the 2015 and the reformed fuel prices, respectively. These results suggest that the effect of fuel prices on the marginal value of RECs becomes less significant as more renewable technologies are integrated into the system. This finding makes sense because as more renewable capacity is operational, fuel costs have a lesser role in power generation costs.

It is worth noting that our framework assumes an exogenous demand for RECs, as we aim to explore how such external demand could incentivize additional renewable energy deployment. Our analysis focuses on the cost of meeting that demand and the corresponding REC prices, which are represented by the shadow prices of the imposed constraints. We find that, without price reforms, REC prices would need to be much higher to influence the electricity generation mix at lower renewable capacity additions. In contrast, with reformed fuel prices, a significantly lower REC price would be sufficient to encourage additional renewable investments. In practice, REC demand is sensitive to its price, as it raises the effective electricity prices that consumers face. While access to renewable electricity (claimable via RECs) can attract industries, higher effective electricity prices can negatively affect them. Lower REC prices play a critical role in meeting industrial demand for renewable electricity without causing a significant increase in effective electricity prices.

Conclusion

05

Saudi Arabia plans to build enough renewable electricity capacity to account for approximately half of its total installed capacity by around 2030. The Kingdom has made steady progress toward this goal in recent years. As of May 2025, 23 GW of renewable capacity has either become operational or is under construction. An additional 28.5 GW is currently in the bidding stage and is expected to come online over the next few years.

As Saudi Arabia approaches the final stages of its renewable energy plans, it may seek to encourage further private investment in renewable projects. Renewable electricity generation also produces a non-energy attribute, represented by a REC. This certificate signifies the CO_2-free nature of the electricity generated by the renewable plant. A REC is a tradable instrument that represents 1 MWh of electricity generated from renewable sources.

Once electricity from a renewable source is transmitted on the grid, it becomes indistinguishable from thermally generated electricity. RECs enable electricity users to track and account for the amount of renewable electricity generated and consumed. RECs not only verify that the amount of renewable electricity used matches what has been generated but can also incentivize further renewable development if rising demand increases the value of RECs. Renewable power producers may issue RECs for the electricity they generate and sell them to designated buyers under relevant agreements or market rules.

RECs can potentially incentivize further renewable development if RECs prices are high enough. This paper looks at different cases for renewable capacity deployment. One case does not enforce the renewable capacity targets for Saudi Arabia by 2030. In the other case, the targets are achieved.

When the capacity targets are not enforced, the REC price that would be needed to reach the targeted capacities would be around $30 per MWh. In the case where the government's renewable targets are achieved, and if the demand for RECs matches the expected supply, the equilibrium price for RECs is $25 per MWh. A non-zero REC price can generate additional revenue for renewable power producers, potentially encouraging the development of more renewable energy projects. A REC price ranging from $24.6 per MWh to $26.1 per MWh could incentivize up to 17 GW of investment beyond the renewable energy capacity already anticipated to come online under existing domestic policies. If REC prices rise to as much as $35.4 per MWh, they could support up to 51 GW of

additional investment. If the Saudi government is looking for ways to encourage private project developers to build more renewable electricity capacity beyond 2030 or beyond the targets, enforcing a mechanism for RECs may be one option to explore. Battery storage systems have not been considered as part of this analysis. Future analyses may incorporate batteries to quantify their impact on RECs.

Our findings also show that fuel price reforms lower the prices of the RECs needed to deploy additional investments. Under 2015 fuel prices, REC prices would need to be much higher to incentivize renewable deployment, while reformed fuel prices enable the same outcome at substantially lower REC prices. However, once a significant share of renewable electricity generation is deployed, the influence of fuel costs on REC pricing diminishes considerably.

Endnotes

[1] Scope 2 emissions refers to the indirect greenhouse gas emissions resulting from the purchase of electricity, steam, or heat.

[2] This suggests batteries will mainly play a balancing role in the grid, rather than be used for dispatch to meet demand. Thus, batteries would have minimal effects on the REC price.

[3] For instance, the papers by Matar et al. (2017) and Matar and Shabaneh (2020).

[4] We may only move along the supply cost curve at any particular demand level. Although unknown, the shape of the demand curve would help us ascertain the dynamics between supply and demand.

[5] Higher fuel prices have also induced investment in more energy-efficient power plants (Matar et al. 2017; Saudi Electricity Company 2025).

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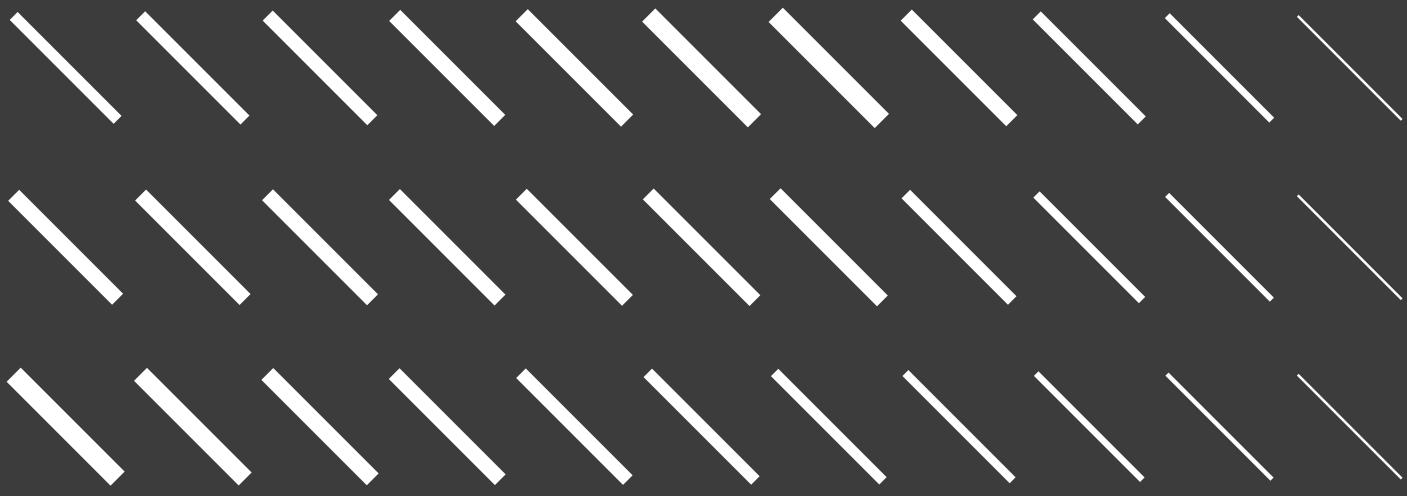
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About the Project

We developed the KAPSARC Energy Model (KEM) for Saudi Arabia to understand the dynamics of the country's energy system. It is a partial equilibrium model formulated as a mixed complementarity problem to capture the administered prices that permeate the local economy. KEM has been previously used to study the impacts of various industrial fuel pricing policies, improved residential energy efficiency on the energy economy, the feasibility of deploying power plant technologies in Saudi Arabia, natural gas storage, and a way to computationally analyze residential electricity prices.





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