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King Abdullah Petroleum Studies and Research Center

Commentary

Natural Gas Strategies for the Saudi Energy System

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Power demand in Saudi Arabia is highly seasonal, with most of the load concentrated in the summer months to meet air conditioning demand.

Raising fuel prices will lead to the emergence of renewable generation technologies and the increased use of natural gas by power generators.

Fuel prices in the Kingdom of Saudi Arabia have historically been below international market values. This has stimulated rapid growth in primary energy demand. The Kingdom's natural gas demand has now outstripped its domestic production, forcing the government to impose rations on consuming sectors, and raising expectations that natural gas production and prices in Saudi Arabia will increase over the next decade.

Supply constraints in the Kingdom's natural gas market exist due to infrastructure bottlenecks in the Master Gas System (MGS). The MGS is a network of gas pipelines and processing facilities, operated by Saudi Aramco, that takes gas produced in the eastern fields and transports it across the country.

Power demand in Saudi Arabia is highly seasonal, with most of the load concentrated in the summer months to meet air conditioning demand. The MGS caps the daily transport of gas to power plants. The cap is reached in the high power load summer months but not during low-load periods such as in winter. Other industrial uses for natural gas could also constrain the domestic availability of gas for power generation year-round. The scarcity and daily transport limit of domestic natural gas mean that power utilities need to look for the next least-cost method to satisfy incremental electricity demand.

As fuel prices rise, renewable generation technologies become economically more attractive. Renewable technologies are characterized by low marginal costs once installed, which puts them first in the merit order, beating some natural gas plants. As Matar and Anwer (2017) show, raising fuel prices will lead to the emergence of renewable generation technologies and the increased use of natural gas by power generators. This further widens the variations in gas use beyond the impact of seasonal variations in electric power use alone.

There are plans to increase the pipeline capacity of the MGS to the western region (Saudi Aramco 2018). Even with this expansion, there is still a need to examine ways of optimizing gas use. This commentary looks at two possible options to mitigate the strong seasonal variability in gas demand and optimize the use of domestically produced natural gas in the Saudi energy system:

1. Utilizing underground gas storage (UGS) facilities to help alleviate the infrastructure constraints during the summer.

2. Importing liquefied natural gas (LNG) into the western region.

We combine these two options in the KAPSARC Energy Model (KEM), calibrated for Saudi Arabia.

Saudi Arabia does not presently store natural gas. The spare pipeline capacity in the winter could be used to transfer natural gas to UGS facilities. This may allow power plants more natural gas than they would otherwise have received in the summer due to the cap on gas transportation. Making more gas available to power plants in the summer may also reduce the amount of renewable generation deployed. Three types of UGS are used in practice: depleted oil and gas fields, aquifers and salt caverns.

This commentary looks at aquifers and salt caverns due to the geology of the Arabian Peninsula.

Complementing domestic natural gas supplies with LNG imports via a regasification terminal along the Red Sea coast may also be a viable solution. The flexibility of floating storage and regasification units can provide quick access to LNG.

The model used in this analysis can also divert gas to non-power related industries during the winter. There is currently high demand from these industries for natural gas, which will only be increased by the rise in domestic oil prices following the Kingdom's ongoing fuel price reforms.

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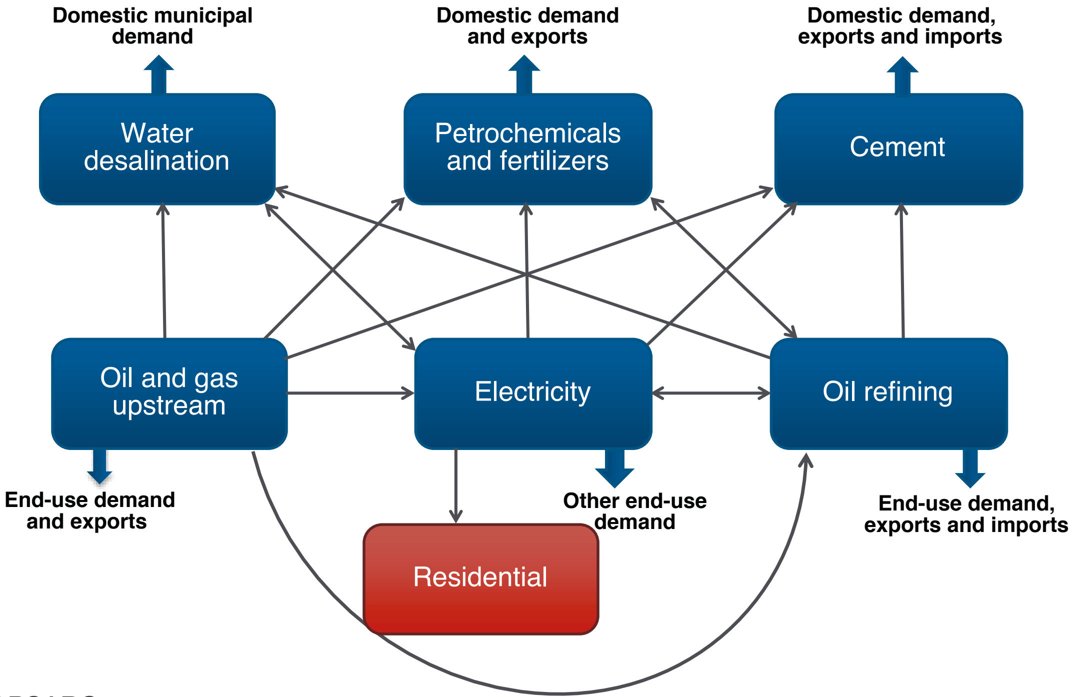
Method

This commentary uses KEM to assess the potential for natural gas storage in the Kingdom and the domestic effects of increased gas supplies. KEM was developed by KAPSARC (2016) to help assess the impacts of alternative policies on the Kingdom's energy production and consumption. This analysis uses additional features of the model that have not previously been documented:

- The ability to import LNG. The model assumes that potential imports are only used as fuel for power generation.
- The ability for the upstream oil and gas sector to invest in and build UGS.

KEM was developed by KAPSARC (2016) to help assess the impacts of alternative policies on the Kingdom's energy production and consumption.

Figure 1. The version of KEM used in this analysis.

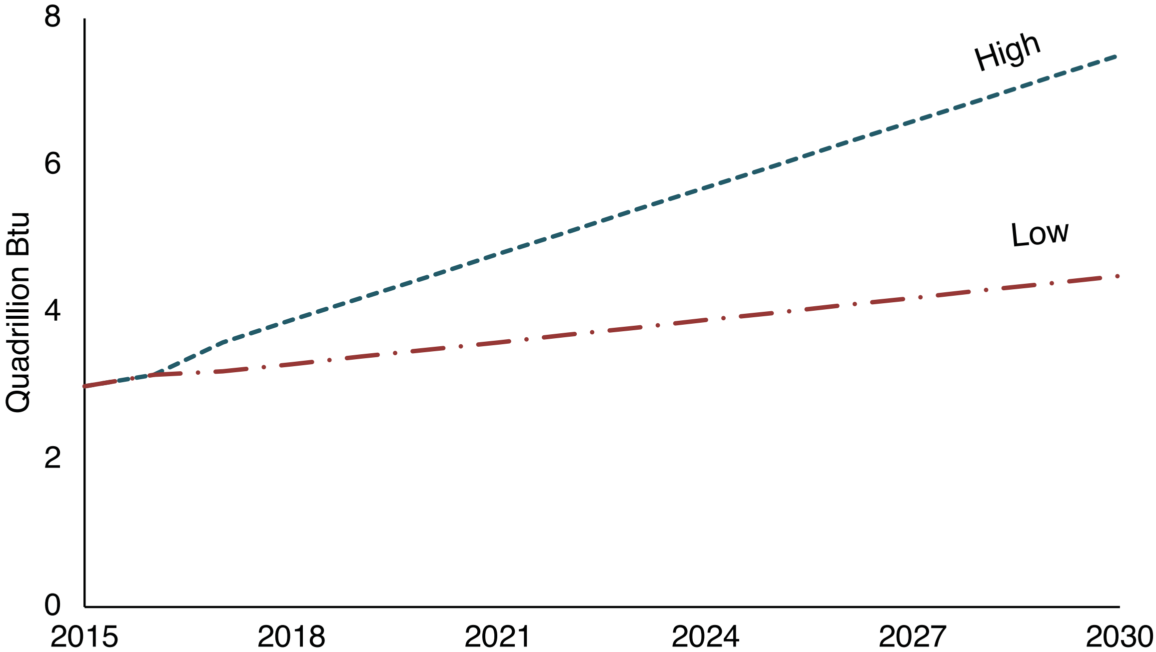


Source: KAPSARC.

Two domestic natural gas supply scenarios are considered.

Two scenarios, high and low domestic sales gas production, are used to assess the viability of the seasonal storage of domestically sourced natural gas (Figure 2). The model was calibrated to the most recent year for which all Saudi energy system data is available. According to Saudi Aramco (2017), around 3 quadrillion British thermal units (Btu) (7.9 billion cubic feet per day [Bcf/d]) of Saudi natural sales gas was produced in 2015, and 3.15 quadrillion Btu (8.3 Bcf/d) in 2016. In the high gas production scenario, we estimate that the supply of domestic sales gas will be 2.5 times the 2015 value by 2030, compared with 1.5 times the 2015 value by 2030 in the low production scenario. Saudi Aramco's MGS expansion plan (12.5 Bcf/d by 2020) would be consistent with our high gas production scenario.

Figure 2. Projections for domestic natural sales gas production.



Sources: KAPSARC estimates; Saudi Aramco (2017).

We examine four policy options for each scenario, shown in Table 1. These options combine two policy levers: power utilities are allowed to import LNG, and the oil and gas upstream sector is allowed to invest in gas storage facilities. For each policy, the reference case to which the three other policies are compared has no natural gas storage and no LNG imports.

Table 1. Policies considered in the high and low domestic natural gas production scenarios.

	Allowing imports of LNG for power plants	Option to invest in storage facilities for domestic natural gas
LNG and storage	√	√
No LNG with storage	-	√
LNG without storage	√	-
No LNG or storage	-	-

Both sets consider fuel price increases that are consistent with the Kingdom's planned price reforms. Industrial fuel prices were last raised in 2016. As Figure 3 shows, fuel prices are assumed to gradually rise again from 2019. We also assume that the prices of crude oil and refined petroleum products will reach global benchmarks by 2023, consistent with the aims of Saudi Vision 2030 (SV2030 2017).

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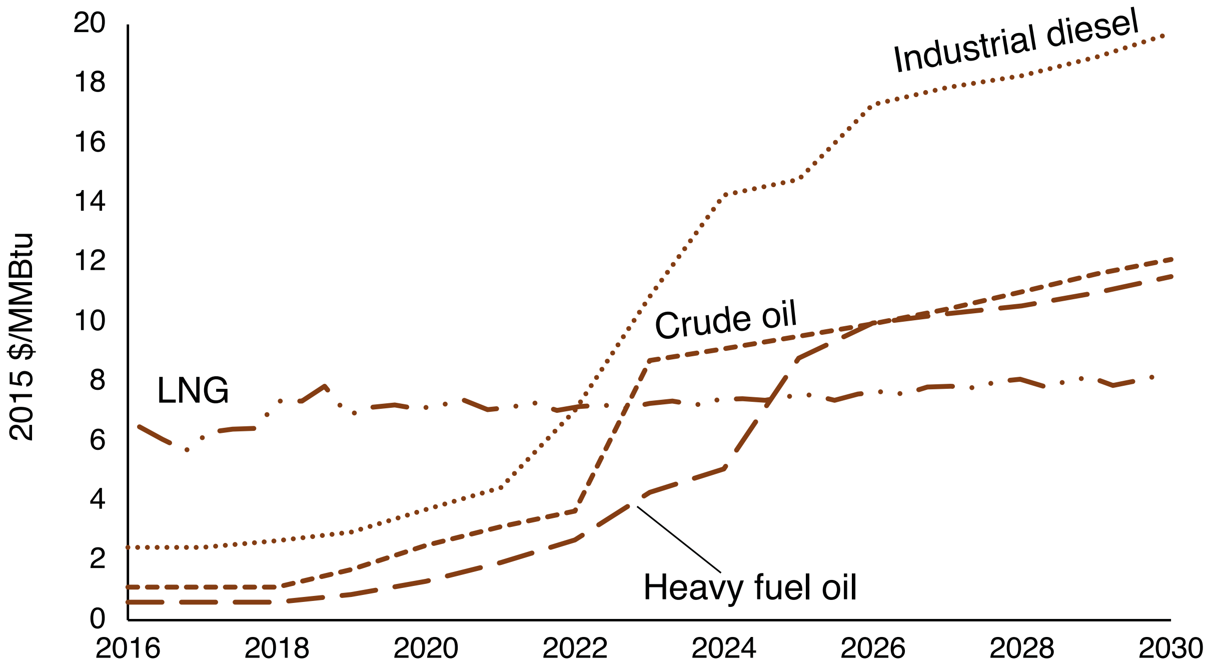
Figure 3. Prices of oil products and LNG offered to Saudi Arabia's power and water utilities and industrial sectors.



Source: KAPSARC analysis.

The prices of domestic natural gas and ethane between 2015 and 2017 are specified at their government-set levels. In 2015, the price of methane and ethane was $0.75 per million British thermal units (MMBtu). Their prices were raised in 2016 to $1.25/MMBtu and $1.75/MMBtu, respectively. This analysis uses their corresponding market-clearing prices from 2018 onward; they are an output of KEM.

The scenarios do not require the enforcement of government-sanctioned sectoral quotas, or rations, as the model will allocate the available resources optimally to each sector.

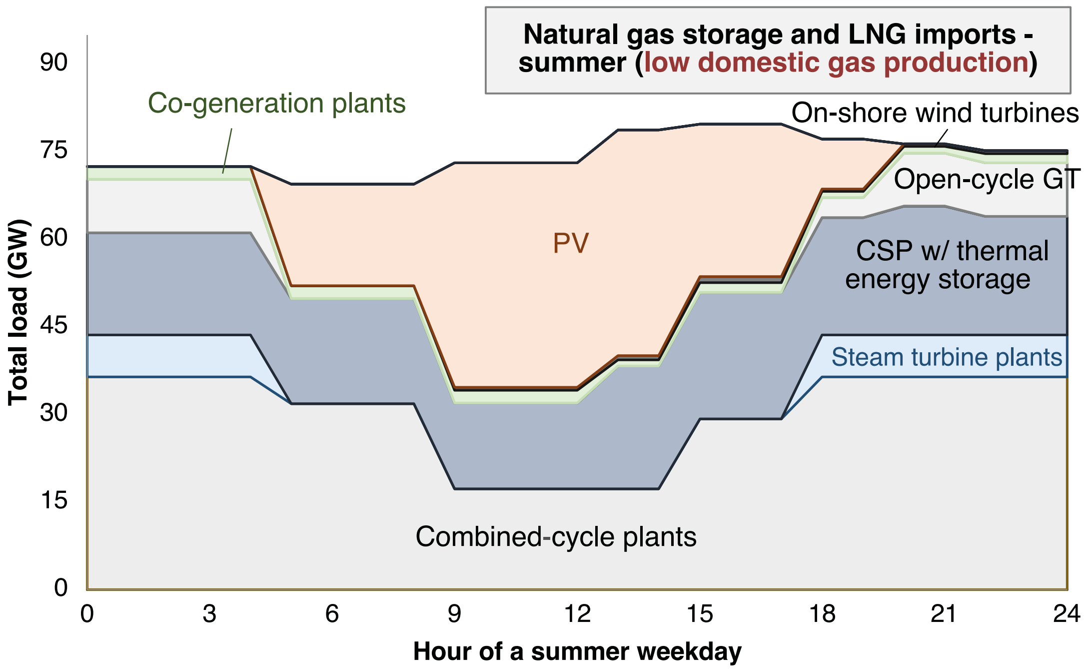
We use quarterly LNG prices, as we expect that LNG would be primarily imported in the summer months to meet the high power loads. If this turns out to be true, we want the model to consider lower LNG prices in the summer. LNG prices would be lower outside the winter months, as global natural gas demand for heating peaks during this period. The price of LNG imports is approximated on a net back basis to Henry Hub using quarterly real Henry Hub projections from Nexant's World Gas Model (WGM). The WGM was also used to calculate the liquefaction cost, a toll cost to pass through the Suez Canal, and a shipping cost that varies over time as a result of rising projected oil prices.

The real international price and domestic production of crude oil, and the real gross outputs of the cement, petrochemical, and fertilizer industries are taken from Oxford Economics' Global Economy Model and Global Industry Model.

The impact of increased natural gas supply on the power system

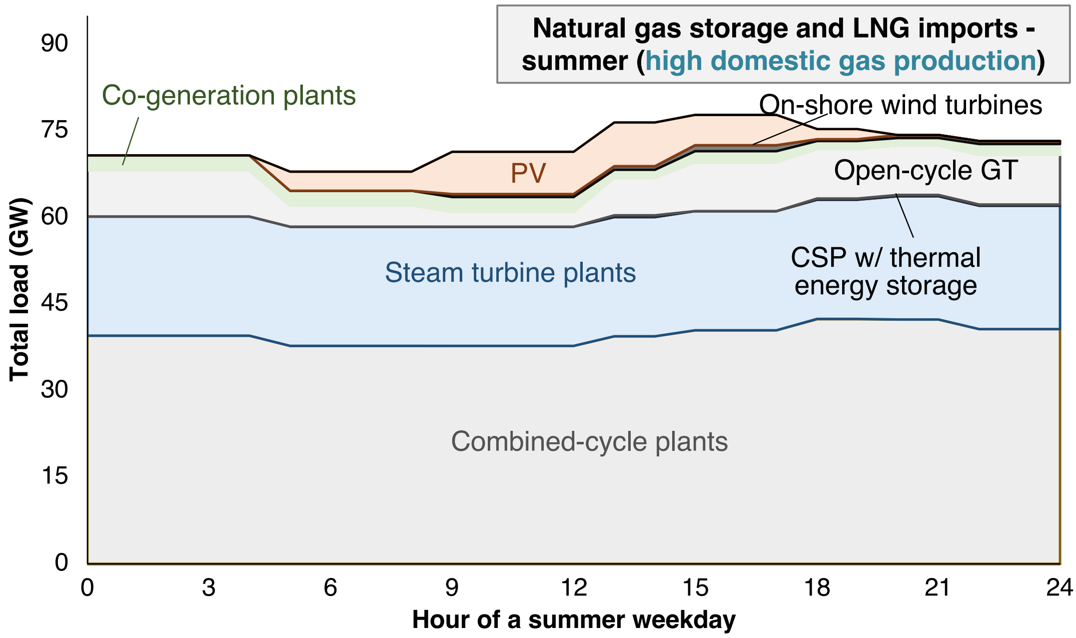
As a side output of the analysis, a higher domestic natural gas supply would reduce the domestic market-clearing price compared with lower supply. It was further shown by the model that a higher domestic natural gas supply will suppress the deployment of renewable generation technologies. Figures 4 and 5 show the electricity generation mix for summer 2030 for both gas production scenarios.

Figure 4. Power generation profiles by plant technology on a summer 2030 weekday with gas storage, for the low gas production scenario.



Source: KAPSARC Energy Model.

Figure 5. Power generation profiles by plant technology on a summer 2030 weekday with gas storage, for the high gas production scenario.



Source: KAPSARC Energy Model.

The economic viability of natural gas storage and policy conclusions

The real annual economic gain of the policy options examined in this study is the annual value of the netted export revenue of all sectors in the energy system minus the netted total costs incurred, relative to the reference scenarios. The revenues and costs considered for the energy system are cash flows that 'cross the boundary' of the energy system, as defined by KEM. In other words, they would be revenues from additional oil exports due to the domestic displacement of oil minus the costs of LNG procurement. We only consider export revenues because all exogenous domestic demands are fixed. Therefore, the difference in revenues accrued domestically between reference and alternative scenarios is zero.

We further define the net present value for the economic gain in 2018 as the discounted sum of the annual gain values until 2030. This metric may be used to assess the viability of storage facilities. For example, if the net present value is highest with gas storage, this option would be worth pursuing.

Under the high production scenario, utilizing UGS yields a net present economic gain of almost $900 million relative to the reference case with no storage and no LNG import option, as shown in Table 2. The results also show that LNG would never be imported in the high domestic supply scenario, making its inclusion in the analysis moot.

Under the high gas production scenario, utilizing UGS yields a net present economic gain of almost $900 million relative to the reference case with no storage and no LNG import option.

Table 2 also shows the net present economic gain for all low gas production policy options. The highest net benefit in the low gas production scenario is one that allows for LNG imports alone. Adding the possibility of gas storage provides a negative measure. In the low production case, the construction of storage facilities is economically unattractive for the whole energy system.

Table 2. Net present economic gains for the energy system between 2018 and 2030 (in real $).

	High domestic natural gas production	Low domestic natural gas production
LNG and storage	+0.9	-8.6
No LNG with storage	+0.9	-8.5
LNG without storage	0.0	+1.5
No LNG or storage	Reference high supply scenario	Reference low supply scenario

Source: KAPSARC Energy Model.

Note: the highlighted cells show the greatest net present economic gain(s) in each gas production case.

In the low gas production scenario, the storage option generates the largest gain for the power sector as it helps lower the price of natural gas and reduces the need for investment in renewable generation.

In the low gas supply scenario, the electric power sector would face lower natural gas prices with gas storage than without because it would reduce the scarcity of gas in the summer. The storage option generates the largest gain for the power sector as it helps lower the price of natural gas and reduces the need for investment in renewable generation. The net present gain for the power system with UGS in the low production scenario is nearly $4 billion, against around -$8.5 billion for the entire energy system. The power sector's net present gain using storage in the high gas production scenario is not as great as in the low gas production scenario.

The difference between the system-wide and sectoral-level economic gain reveals the benefit of a system-wide analysis. With low domestic gas supply, the power sector would benefit the most from having both gas storage and LNG imports, whereas the entire energy system would benefit the most from having LNG imports alone. This is because the upstream sector would bear the investment and operational costs of gas storage.

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