King Abdullah Petroleum Studies and Research Center

The Prospect of Unconventional Gas Development in Saudi Arabia

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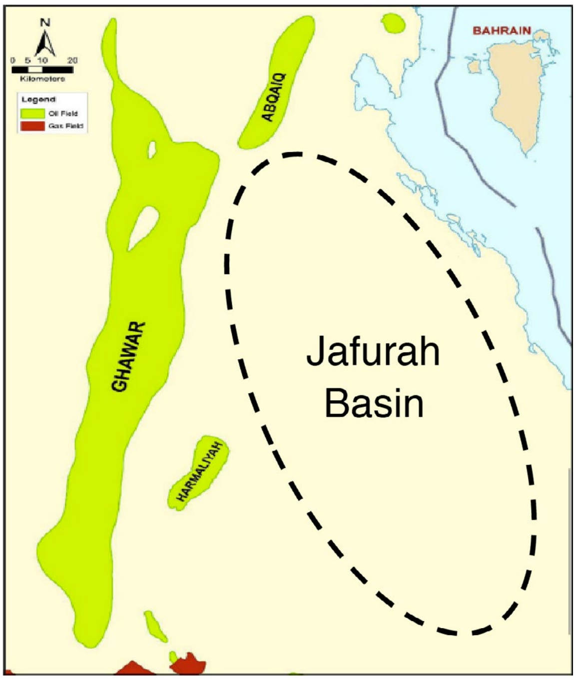
In February 2020, Saudi Aramco announced that it obtained regulatory approval to develop the Jafurah Basin, Saudi Arabia's largest unconventional natural gas field (Figure 1). Situated east of the giant Ghawar oilfield, it contains 200 trillion cubic feet (tcf) of gas resources.

Jafurah will be developed in stages, with the first gas deposits expected to be extracted in 2024. By 2036, production is expected to reach 2.2 billion cubic feet per day (Bcf/d) of natural gas, approximately 425 million cubic feet per day of ethane, and 550 thousand barrels per day (Kb/d) of other natural gas liquids and condensates.

The Jurassic Tuwaiq Mountain formation is the primary target within Jafurah. It has high total organic content, low clay content, low water saturation, and high gas saturation (Hakami et al. 2016).

Technical papers from Saudi Aramco suggest that these characteristics are similar to those of the Eagle Ford shale play in South Texas (Al-Mubarak et al. 2017). Results from appraisal wells at Jafurah indicate initial production rates similar to those of the Eagle Ford and that its well productivity and economics are likely to improve once operations move to the development phase (Hakami et al. 2016).

Figure 1. Location of the Jafurah Basin.



Source: Hakami et al. (2016).

Jafurah is one of three unconventional natural gas resources that Aramco has focused on since it began its Accelerated Transformation Program (ATP) in 2010. The ATP will expand Aramco's exploration and production activities into frontiers including the deep waters of the Red Sea. It will also facilitate Aramco's development of unconventional natural gas resources in tight sands and shale formations (Al-Falih 2011).

The ATP emerged after several unsuccessful attempts and joint ventures between Aramco and international oil companies (IOCs) to exploit the Kingdom's gas resources. The Saudi government signed an agreement in April 2001 with seven IOCs. It gave the IOCs a stake in any gas found in selected areas of the Kingdom, in exchange for their investment in projects ranging from exploration to the production of water and petrochemicals. However, the IOCs gradually exited the Kingdom due to technology challenges and the need for more fiscal incentives (MEED 2003). Meanwhile, the United States (U.S.) shale gas boom was taking place, led by independent producers who took advantage of high oil and gas prices to extended innovative solutions and technologies to exploit unconventional gas assets.

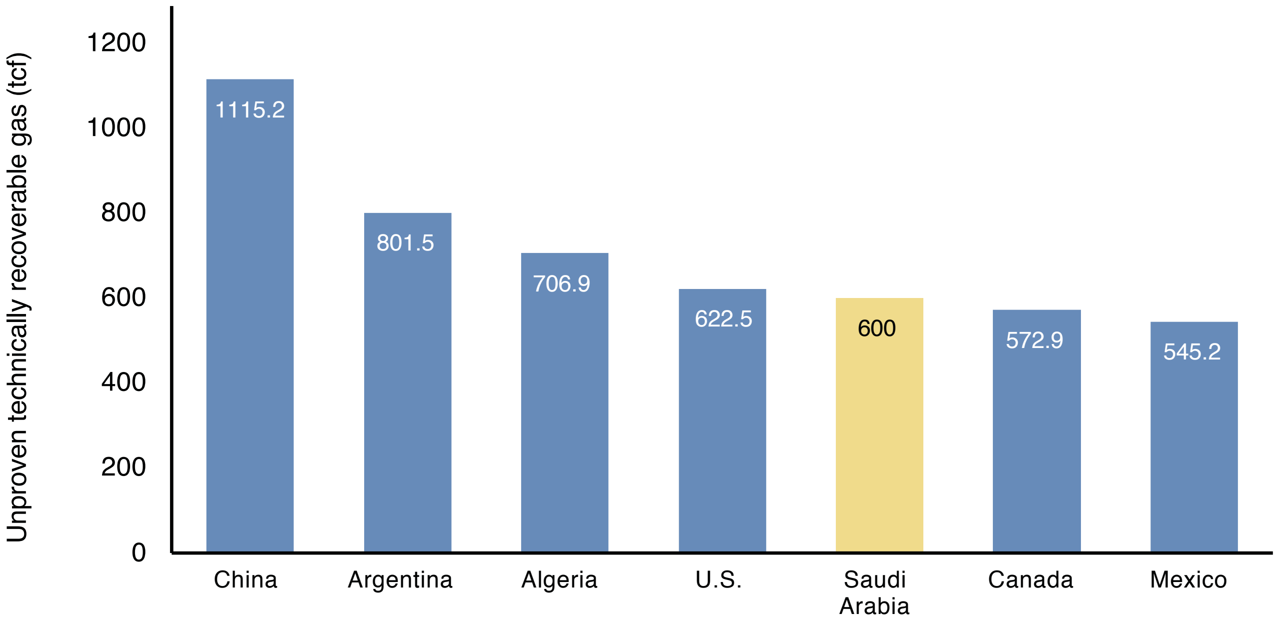
Debottlenecking the gas

According to OPEC's latest Annual Statistical Bulletin, Saudi Arabia holds the world's sixth-largest estimated proven gas reserves, totaling 320.3 tcf. It also has the world's ninth-largest marketable gas production (11.5 Bcf/d).

Historically, most of the Kingdom's gas was associated (gas dissolved in oil and separated once extracted). Associated gas production is directly linked to crude oil production. Ghawar is Saudi Arabia's largest source of associated gas. Due to the developments of new non-associated gas fields in the last several years, Aramco managed to increase the share of non-associated gas in natural gas production to nearly 60% as of 2019.

The Kingdom's heavy reliance on less efficient liquid fuels in power generation and seawater desalination could be replaced with more efficient and less carbon-intensive gas. Saudi Aramco expects natural gas demand to continue to grow from 2017 to 2030 at a compound annual growth rate of 3.7% (Saudi Aramco 2019). Gas production, on the other hand, grew by 4 Bcf/d in the past decade.

Figure 2. Unproven technically recoverable resources (wet gas).



Source: U.S. Energy Information Administration (EIA).

Unconventional gas has emerged as a solution to debottlenecking the system. In March 2013, the former Saudi oil minister Ali Al-Naimi announced that Saudi Arabia has over 600 tcf of unconventional gas resources (Fineren and Shamseddine 2013). This is almost twice the current proven gas reserves indicated above. If they are technically recoverable, the Kingdom would have the fifth-largest recoverable wet gas resources (Figure 2).

Nevertheless, drilling and completion costs, technical know-how, and water access pose significant challenges for tapping into and commercializing these resources.

- **Technical know-how**

Saudi Aramco has capitalized on many lessons the U.S. has learned from its shale gas development. Aramco established an unconventional gas department to oversee the development of unconventional resources across the Kingdom. It also hired a large number of unconventional development specialists to bridge the knowledge gap.

Aramco's approach to developing Jafurah is similar to that of its megaprojects, with significant capital investment placed upfront. The company pledged to invest $110 billion to develop the Jafurah basin.

The Karan offshore gas field was placed into production in mid-2011 and has a capacity of 1.8 bcf/d, with $8 billion of capital expenditures (capex). The high capital investment in Jafurah implies that most of the development cost is likely to be driven by high drilling and completion costs.

- **Drilling and completion**

Aramco plans to deploy an array of technologies in developing Jafurah, including horizontal multi-stage fracturing and underbalanced coiled tubing drilling (Al-Mubarak et al. 2017). To bridge the knowledge gap and optimize its development costs, the company awarded a lump sum turnkey stimulation services contract to Halliburton, which includes major hydraulic fracturing and well intervention operations (Saudi Aramco 2018).

Unconventional plays require more wells to be drilled and placed into production simultaneously than conventional wells, as the former have lower rates of productivity and rapid decline rates. However, technological improvements in horizontal drilling and fracking techniques have improved well productivity in the past several years.

U.S. shale gas development majors acknowledged the agility and volatility of the business. It will be interesting to observe how Aramco will tune its operations with respect to Jafurah.

Aramco's first tight gas sands development in the north of the country, North Arabia, has been successful. It reached commercial production in 2017, producing 55 million cubic feet per day, and currently feeds the industrial city of Wa'd Al-Shammal. However, the size of Jafurah's gas reserves and its liquids content within the gas field is unique. Its liquids content is integral to the economics of the project and is a much needed feedstock for Saudi Arabia's burgeoning petrochemical industry.

- **Water availability**

As with any shale or tight gas development, the extraction process for Jafurah will require significant volumes of water, which will most likely be derived from shallow aquifers close to its production sites. The drilling and hydraulic fracturing of a typical horizontal shale gas well in the Eagle Ford is estimated to consume around 4.3 million gallons (Arnett et al. 2014). This poses a challenge to Jafurah's development, as the number of producers and volumes of water they require are extremely high.

According to the latest research, Saudi Aramco is experimenting using seawater to fracture. Some of these wells may have up to 40 fracking stages. Up to 125,000 gallons of groundwater is currently being used for each stage. The company is prioritizing reducing groundwater use during fracturing treatments, and is exploring using seawater for fracturing applications, to significantly reduce groundwater use (Abdul Majid et al. 2017). Aramco's plan to use lightly treated seawater in Jafurah signals a technological improvement in hydraulic fracturing (CNBC 2020). The company is also piloting the use of local sand in its gas fracking treatments rather than imported sand (Alabbad et al. 2016). If Aramco succeeds in using seawater, it would be revolutionary and could provide a solution to many regions with shale resources but water availability constraints.

Opportunities for unlocking tight gas in Saudi Arabia

Gas from Jafurah is primarily reserved for domestic use to meet future energy demand for power, and water and petrochemical production. This is similar to the government of Oman's decision to develop the Khazzan tight gas field, one of the largest unconventional gas developments outside of North America. It began production in 2017 and now produces 1 Bcf/d. It is currently being expanded, with a second-phase development that will add 0.5 Bcf/d by 2021 (BP 2018). Initially, the gas from Khazzan was slated for domestic use to address the country's gas deficit. However, the gas from Khazzan has been able to satisfy Oman's domestic needs, leaving some available for export.

One reason for this excess supply was the slower growth of Oman's gas demand after the government took major steps to reform domestic gas and power prices. Between 2012 and 2015, the Omani government gradually increased domestic gas prices from $1.50 per million British thermal units (MMBtu) to $3/MMBtu for large industrial end-users (Corbeau, Shabaneh, and Six 2016). It then doubled gas prices for electric power utilities to $3/MMBtu in 2015. The increase in domestic gas prices is also likely to have played a role in improving the fiscal regimes of contracts between Oman and IOCs and incentivizing gas production in gas fields that are difficult to develop, such as Khazzan.

Saudi Arabia could see a similar scenario unfold. The country initiated domestic gas price reforms in 2016, with prices increased from $0.75/MMBtu to $1.25/MMBtu. However, the country still has one of the lowest domestic gas prices in the world, including among its Gulf Cooperation Council (GCC) peers.

The government aims to gradually remove energy subsidies and "to reach reference prices by 2025" (Kingdom of Saudi Arabia 2019).

In the meantime, the Kingdom still burns a significant amount of oil and oil products in its power generation and seawater desalination sectors, which it is trying to replace with gas and renewables in its energy mix. In 2018, the volume of oil and oil products used in these sectors averaged around 760 Kb/d (ECRA 2020). Displacing the volumes of oil used in power generation for exports will surely be taken into consideration when developing high-cost tight gas. In addition, how the costs of importing LNG and developing high-cost tight gas compare will depend on the long-term prices of LNG and oil. Nevertheless, there are other significant benefits in developing domestic gas, including that unconventional gas developments are major industrial projects that can enable the growth of local small and medium enterprises, foster job creation, and increase technical know-how in the Kingdom. This fits very well with the Saudi Vision 2030 goals of developing local industries and increasing local content, which would provide added value to the Kingdom.

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