

## Unconventional Gas Reserves in Saudi Arabia

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**Abstract.** Since the 1970s, Saudi Arabia has been capturing the natural gas that is released from its reservoirs as a byproduct of oil production. Besides that, Saudi Arabia is working on an extensive exploration and development program for unconventional gas reserves (gas reserves locked underground within shale and tight sandstones). This effort has been established to fulfill the surge in local and worldwide demand for oil and natural gas.

Jafurah unconventional gas field is an excellent example in this program; it is the kingdom's largest unconventional non-oil-associated gas field, and it is potentially the biggest shale gas development outside of the United States. Jafurah has reserves of 229 trillion cubic feet of gas and 75 billion barrels of condensates.

Extracting commercial quantities of natural gas from shale gas reservoirs requires advanced drilling techniques; such as horizontal drilling; and the use of hydraulic fracturing techniques to increase the flow of gas through the rock formations. This is why gas fields found within shale rock formations are classified as unconventional.

This work outlines the key properties of the main sources of unconventional natural gas in Saudi Arabia, with some emphasis on the development techniques required to exploit these resources.

**Keywords:** Unconventional gas, Oil, Saudi Arabia, Jafurah, Ghawar Oil Field, Safaniya Oil Field, Oil and Gas Supply and Demand, Pipeline

### 1 Study Objectives

The objectives of this study are:

1. Outline the global importance of conventional and unconventional oil and gas reserves in Saudi Arabia.
2. Emphasize the development techniques required to exploit unconventional oil and gas resources.
3. Outline the key properties of the main unconventional natural gas resources in Saudi Arabia.

## 2 Conventional Oil and Gas Resources in Saudi Arabia

In 1938, oil was discovered in well no. 7 in Dammam, in the eastern province of Saudi Arabia, at commercial quantities at 4717 ft below sea level (Figure 1) [1]. After that, six oil fields were discovered, as follows: Ain Dar oil field, 1948; Haradh oil field, 1949; Uthmaniyah oil field, 1951; Shedgum oil field, 1952; Hawiyah oil field, 1953; and Fazran oil field, 1957. Later, these six oil fields proved to be part of a giant oil field called Ghawar (Figure 2), which covered an area of 280 km long and 25 km average width [2]. Now, the total number of discovered oil and gas fields in Saudi Arabia is more than 125. The Ghawar oil field is the world's largest (super-giant) onshore oil field, with a proven reserve of 58.32 billion barrels of oil equivalent and a daily production of 1.3 MMbbl/day [3]. Safaniya is the world's largest (super-giant) offshore oil field, with a proven reserve of 34.03 billion barrels of oil equivalent and daily production of 3.8 MMbbl/day [3]. These discoveries have put Saudi Arabia in first place in proved conventional oil reserves with 297.5 Bbbls and in fifth place in proved conventional gas reserves at 294.3 Tcf. In 2013, Saudi Arabia discovered the super giant unconventional gas field Jafurah, close to the super giant conventional oil field Ghawar. The discovered oil fields in Saudi Arabia accumulate all types of known crude oil. Table 1 shows the Saudi crude oil grades.

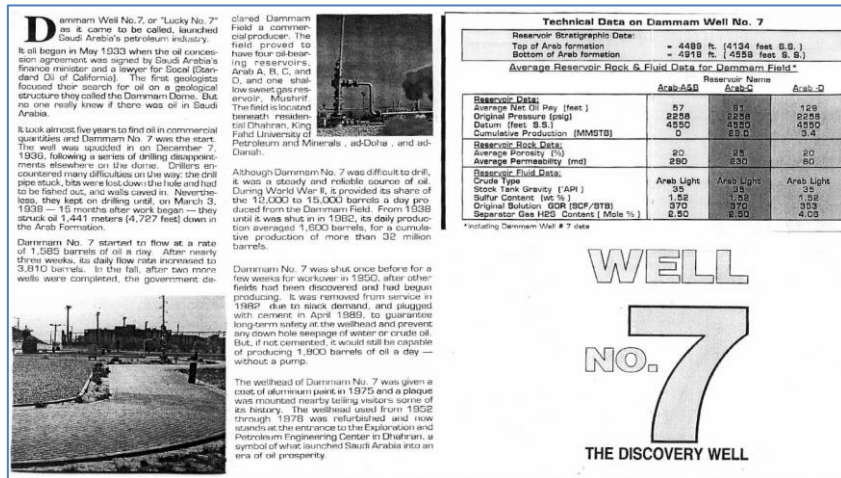


Fig. 1. Dammam well no. 7 - the discovery well [1].

Table 1. Saudi crude oil grades [4].

Crude oil type	API gravity index	Sulfur content	Percentage of crude oil reserves
Arabian Heavy	API < 29	more than 2.9%	35%
Arabian Medium	29 ≤ API < 33	2.2% to 2.9%	17%
Arabian Light	33 ≤ API < 37	1.3% to 2.2%	34%
Arabian Extra Light	37 ≤ API < 40	0.5% to 1.3%	13%
Arabian Super Light	API ≥ 40	less than 0.5%	1%

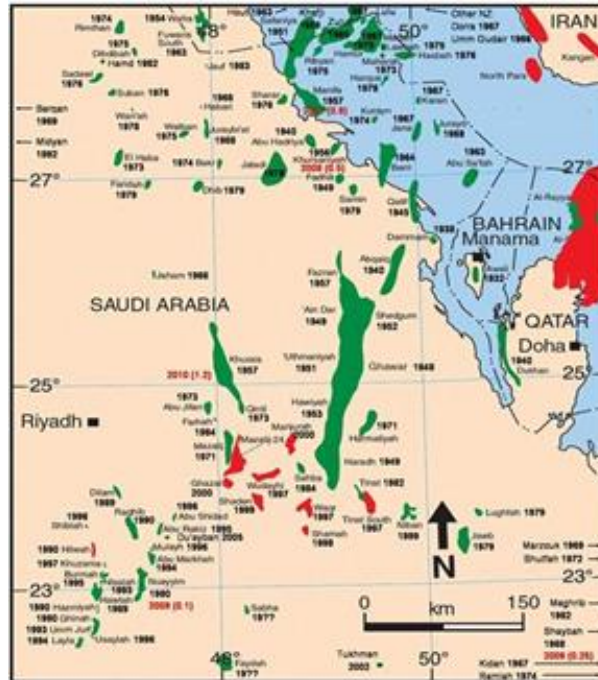


Fig. 2. Saudi Arabia oil and gas fields map [3].

### 3 The Importance of Oil and Gas Reserves in Saudi Arabia

The importance of conventional oil reserves in Saudi Arabia comes from several important capabilities accumulated over a long period, including:

1. Huge conventional oil and gas reserves.
2. Huge unconventional oil and gas reserves.
3. Excellent oil and gas pipeline network connecting oil and gas fields, treatment and storage facilities, and east (Arabian Gulf) and west (Red Sea) exporting ports (Figure 3).
4. Huge reserves and production capability at low cost (Figures 4 and 5).
5. Relatively low domestic oil consumption.
6. Excellent geographic location for oil and gas global supply.
7. Environmentally and politically stable country.

### 4 Global Surge in Oil and Gas Demand

Worldwide demand for oil and gas is surging, as shown in Figures 6 and 7. As shown in Figure 4, OPEC is the only source that has spare production to fulfilling the global increasing oil demand. Since then, Saudi Arabia, the main OPEC oil producer, has recognized its responsibility to supply the world with oil and acted as follows:

1. Continuing in developing its proven reserves and searching for new resources.
2. Reducing Saudi high domestic oil consumption (see Figures 8 and 9).
3. Increasing Saudi domestic gas utilization.
4. Increasing clean and renewable energy generation.
5. Utilizing CO<sub>2</sub> capture, storage, and utilization.

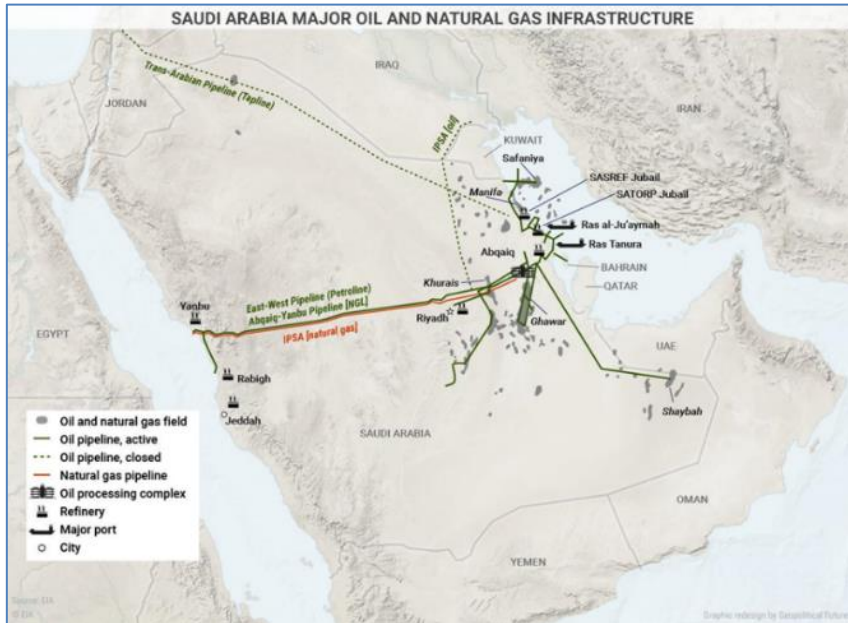


Fig. 3. Saudi Arabia oil and gas pipeline network [5].

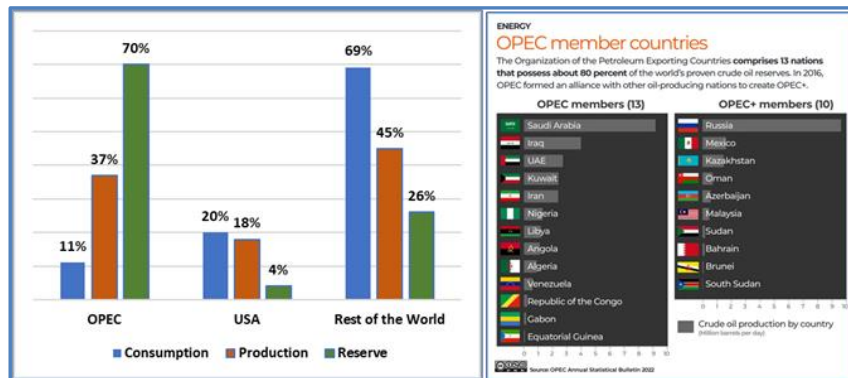


Fig. 4. OPEC and Saudi Arabia oil demand capability [6, 7].

Since the 1970s, Saudi Arabia has been capturing the natural gas that is released from its reservoirs as a byproduct of oil production and utilizing it in power generation and as a feedstock for domestic industry. Besides that, Saudi Arabia is working on an extensive exploration and development program for shale gas reserves to increase

domestic oil consumption and oil exports. Currently, Saudi Arabia meets its local natural gas consumption with domestic production and does not import or export natural gas.

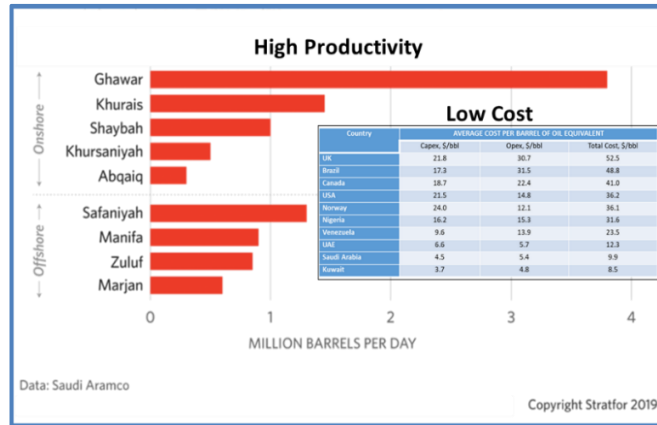


Fig. 5. Saudi Arabia oil demand and cost [8].

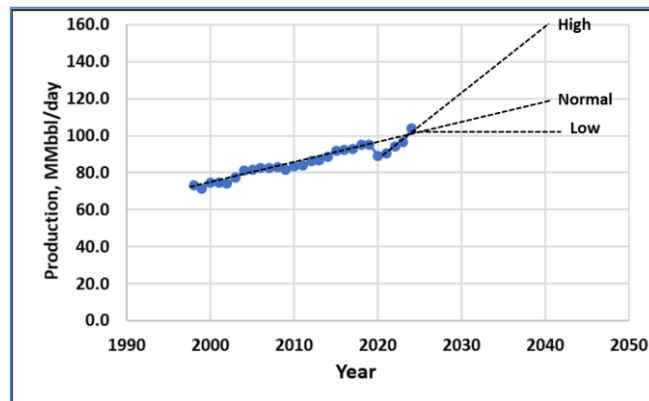


Fig. 6. Global oil demand forecasting.

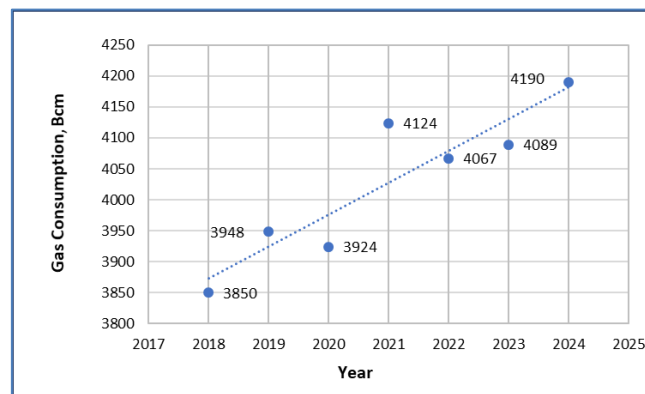


Fig. 7. Global gas demand forecasting.

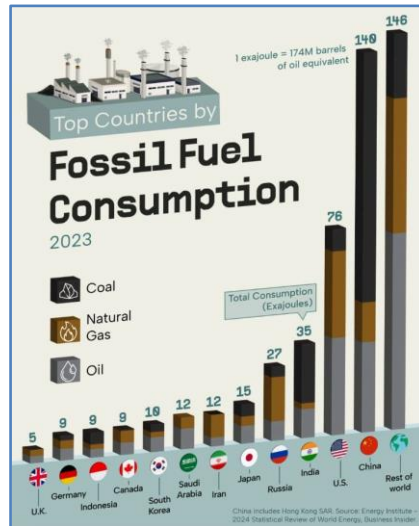


Fig. 8. Global Fuel consumption [9].

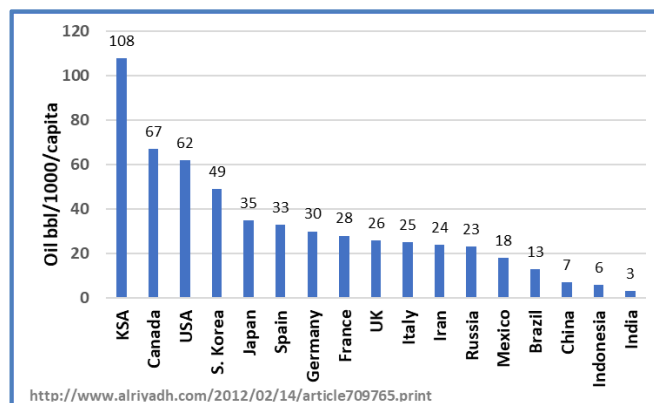


Fig. 9. Global oil consumption per 1000 capita [10].

## 5 Unconventional Gas Resources in Saudi Arabia

The term “unconventional oil” is synonymous with oil that cannot be produced, transported, or refined using traditional techniques. Within this definition, the North American unconventional resources include US oil shale, Canadian oil sands, Canadian heavy oil, US oil sands, and Canadian and US tight oil. Unconventional heavy oil occurs throughout the world, with the largest resources being the extra-heavy oil-bearing deposits in Canada and Venezuela. The US also has oil sand deposits containing extra-heavy oil. These extra-heavy oils (also called bitumen) are extremely viscous, sometimes nearly solid. These properties make them difficult to produce and process. However, not all unconventional oils are heavy. A growing source of unconventional supply is tight oil which is produced from low-permeability shale, siltstones, sandstones, and

carbonates. The produced oil has the same properties (density, sulfur content, etc.) as conventional oil. Historically, the oil was locked in the formations and could not flow through the tight formation rock. However, recent advancements in horizontal drilling and well fracturing technologies are now enabling the production of tight oil; notable plays include the Bakken, the Eagle Ford play in Texas, the Cardium play in Alberta, and the Miocene Monterey play in California. Oil produced from the previously mentioned fields is considered unconventional oil [11]. Saudi Arabia holds as much as 645 Tcf of technically recoverable shale gas resources [12]. Saudi Arabia is estimated to be sitting on the fifth largest shale gas reserves in the world [13].

Saudi Arabia's unconventional potential is also estimated to be 10 times the volume of the conventional oil and gas in the ground. For Saudi Arabia, a current business focus is tight sand, tight carbonate and shale gas recovery. With strong indications of substantial shale and tight gas deposits, Saudi Aramco is currently exploring and appraising several prospects for unconventional gas within the Kingdom [14].

As exploration and development of unconventional gas in Saudi Arabia are accelerating, the following fields have been recently discovered in Saudi Arabia: Jafurah unconventional gas field, 2013, Awatad unconventional gas field at 10 MMSCF gas and 740 bbls of gas condensate, 2022, Addahna unconventional gas field, 2023 at 17.5 MMSCF gas and 362 bbls of gas condensate, Samnah unconventional gas field, 2023 at 508 MMSCF gas, Alladam unconventional gas field, 2024, Alfrooq unconventional oil field at 4557 bbl/day plus 3.8 MMSCF gas, Alladdam, unconventional oil field, 2024 at 5100 bbl/day plus 4.9 MMSCF gas, Umkhonser conventional gas field, 2022 at 26.6 MMSCF gas, Ashorfah conventional gas field, 2022, Shehab conventional gas field, 2022, Alheran gas field, 2023, Almhakeek gas field, 2023 at 0.85 MMSCF, Shadon conventional gas field, 2022 at 27 MMSCF gas and 3300 bbls of gas condensate, Aljahak conventional gas field, 2024 at 5.3 MMSCF, Alktoof conventional gas field, 2024 at 7.7 MMSCF gas, Osakrah conventional gas field, 2024 at 4.9 MMSCF gas, and Onyiah conventional oil field at 1780 bbl/day plus 0.7 MMSCF gas, 2024 [15]. Saudi Arabia will soon (2025) be one of the main natural gas producers in the world using its combined conventional and unconventional gas resources as shown in Figures 9 and 10.

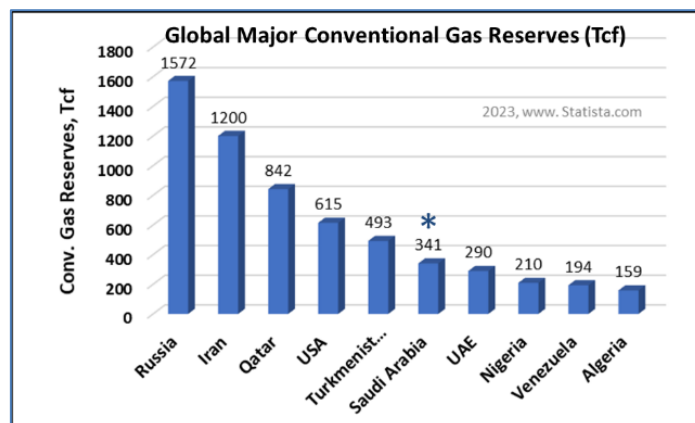
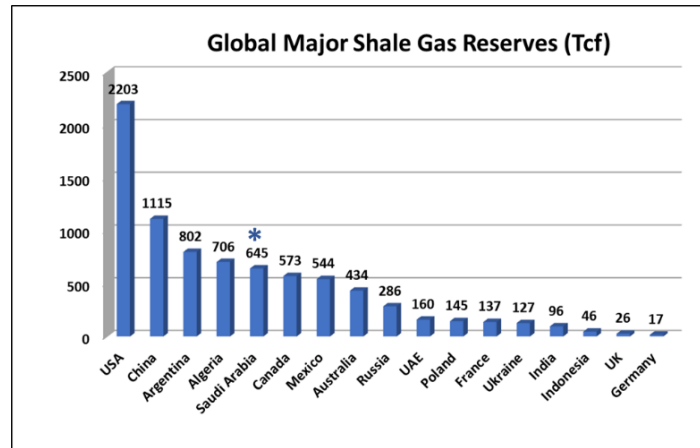


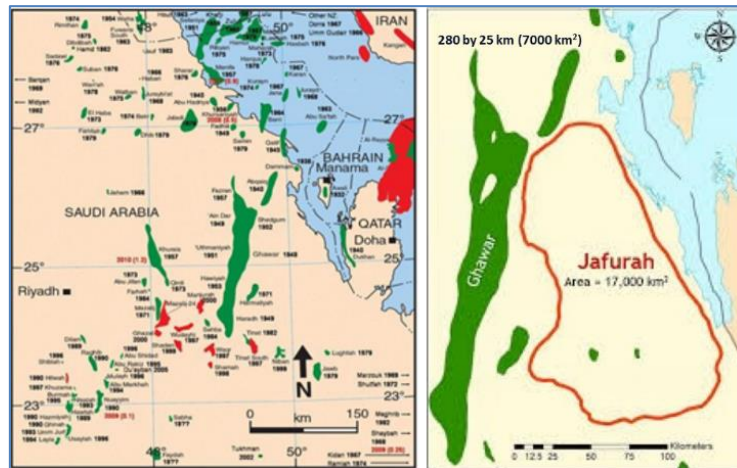
Fig. 9. Global conventional gas reserves [16].





**Fig. 10.** Global unconventional gas reserves [12].

The Jafurah field (discovered in 2013) measures 170 km long and 100 km wide and is reportedly similar in size to Eagle Ford, the second-largest shale gas field in the US (Figure 11). Jafurah's reserves reach 229 trillion cubic feet of gas and 75 billion barrels of condensate. \$110 billion overall investment in various Jafurah development stages. The middle-upper Jurassic organic-rich carbonate mudrocks of the Tuwaiq Mountain Formation (Figure 12) in the Jafurah sub-basin of the central Arabian basin have long been recognized as the source of hydrocarbons trapped primarily in upper Jurassic carbonate reservoirs of Saudi Arabia [17].



**Fig. 11.** Jafurah super giant unconventional gas field [3, 18].

Gas production at Jafurah is expected to begin in 2025. The projected Jafurah production capacity is 3.1 billion standard cubic feet per day. Jafurah could generate \$9 billion a year in revenue. Saudi Energy Minister Prince Abdulaziz bin Salman earlier said the Jafurah gas field will place the Kingdom third in the world in natural gas production by 2030 [13].



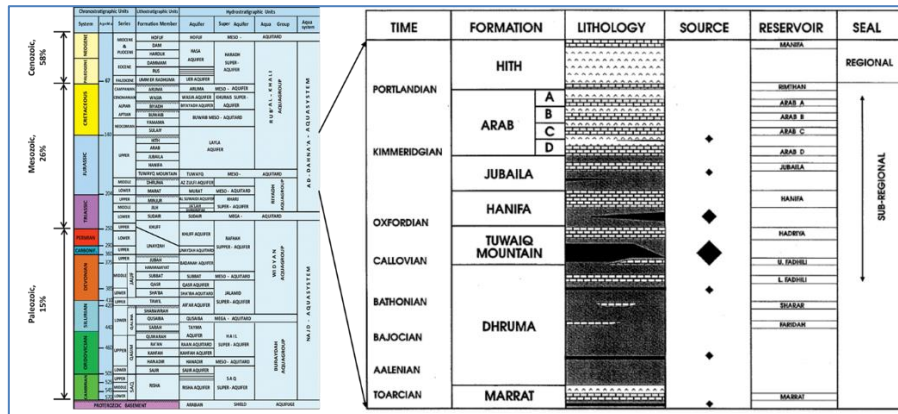


Fig. 12. Generalized and Jurassic stratigraphic column of Saudi Arabia [6, 19].

Gas fields found within shale rock formations are classified as unconventional. Extracting commercial quantities of natural gas from shale gas reservoirs requires:

1. Advanced hydraulic fracturing which requires huge amounts of fresh water.
2. Drilling deep (9000 to 1000 ft) horizontal and geo-steered wells.
3. Installation of smart completion and monitoring.
4. Enormous financial resources.

Saudi Aramco has routinely used the previously mentioned technologies in its former oil and gas conventional projects. Additionally, Saudi Arabia has the financial potential to support exploration and development activities. Saudi Arabia is currently ranked among the major 20 economies worldwide.

According to Saudi Aramco chief executive Amin Nasser, Saudi Aramco managed to reduce drilling cost by 70 percent and stimulation cost by 90 percent since the 2014 cost benchmark, while increasing well productivity six-fold compared with the start of the program. The water issue was resolved years ago, since the Saudi oil industry has a long history of using saline water for drilling [13].

According to Saudi Aramco, unconventional gas is the preferred fuel for power generation and water desalination because of its increased efficiency and cleaner burning qualities compared to other fossil fuels, where Saudi Arabia plans to be among the first countries outside North America to use shale gas for domestic power generation. The utilization of natural gas and renewable energy locally will support Saudi Arabia record in protecting the environment and its sustainability. Jafurah is expected to contribute to Saudi Arabia's goal of producing half of its electricity from gas and half from renewables (50%:50%) as it pursues its 2060 net-zero target [14].

## 6 Conclusions

Based on the previously mentioned information, the following conclusions are drawn:

1. Saudi Arabia is the past, current and future reliable source for energy supply.

2. With its conventional and unconventional gas resources, Saudi Arabia will move forward in the global gas reserves and gas production ranking.
3. Saudi Arabia has the technological, financial means, and skilled man power to expedite exploration and development of its unconventional oil and gas resources.
4. The huge discovered shale gas resources in Saudi Arabia will satisfy domestic needs and help supply the world with more oil and gas for a longer time.
5. Saudi Arabia will utilize its shale gas in conjunction with renewable energy (50%:50%) to pursue its 2060 net-zero target for environment protection and sustainability.

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