



upstream operations

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Our upstream strategy: Leveraging advantages to maximize value Designed to maximize longterm value, our upstream strategy focuses on leveraging our competitive advantages in production and scale. By tempering production from mature fields, accelerating younger fields and secondary reservoirs, and developing fresh reserves from new increments, we plan to create and sustain value for generations to come. To maintain our standing in the

upstream sector, we seek to:

- Maintain our position as the world's leading crude oil producer by production volume, and provide consistent, reliable, and competitive crude oil supply to customers
- Further diversify operations to capture value from strategic integration
- Expand natural gas activities to supply the Kingdom's natural gas market

For 85 years, we have been entrusted with the stewardship of the Kingdom's oil and gas reserves.

In this time, we have grown to become the world's leading producer of crude oil and condensate.

Over the decades, we have matured our understanding of the Kingdom's geology and built an integrated network of oil and gas production and processing facilities. By combining technologies developed in-house with leading industry practices, we enhance our reserves base and optimize production from Saudi Arabia's reservoirs.

Exploration: Adding to our resource base

Exploration has been the cornerstone of Saudi Aramco since the Kingdom first granted a concession to our predecessor, Standard Oil of California, in 1933. Decades of onshore and offshore exploration in Saudi Arabia have resulted in an extensive portfolio of oil and gas fields that includes the world's largest onshore and offshore oil fields (Ghawar and Safaniyah, respectively). This accumulated knowledge and expertise enables us to replace reserves through new discoveries, the delineation and reassessment of existing fields, and revisions of reserve estimates in producing reservoirs and fields.

Throughout 2017, we remained committed to discovering new conventional and unconventional hydrocarbon resources across the Kingdom, aided by the development and deployment of data acquisition and processing technologies.

Our unconventional gas exploration program targeted three areas: Northern Arabia, the South Ghawar area, and the Jafurah Basin east of Ghawar.

In the Red Sea, using an autonomous system that deploys seismic nodes on the seabed via reinforced armored rope, we reduced the costs of 3-D seismic data acquisition in our survey of two blocks measuring 800 square kilometers (km) and 900 square km. The choice of locations for the 3-D seismic survey was informed by a large-scale hydrographic survey — a first for these waters. We anticipate the results of the survey will help optimize field operations and facilities, including rig movements, laying of pipelines, and supply vessel routes.



The Kingdom ended 2017 with proved reserves in the fields we operate of 332.9 billion barrels of oil equivalent.

New discoveries

Crude oil and gas exploration activities during 2017 resulted in the discovery of two new oil fields and one new gas reservoir. The new oil fields discovered in 2017 were: **Sakab**, southeast of Haradh, and **Zumul**, in the Rub' al-Khali. The new gas reservoir discovered in 2017 was **Jauf**, in the Sahba field.

Oil production: Investing to meet demand

The International Energy Agency's (IEA) *World Energy Outlook 2017* New Policies Scenario estimates that global energy needs will expand by 30% between today and 2040. With petroleum energy resources expected to form a key component of the world's energy mix for the foreseeable future, we continue to invest in our capability to meet current and projected future demand.

We have consistently produced five grades of Arabian crude oil. These grades, and the wide range of blends that can This laser technology tool, developed in-house, is designed to be multifunctional — able to drill, frac, and perforate wells.





In support of our drive to sustain value from the Kingdom's resource base for generations to come, we are working to increase the production capacity of our Khurais facility.

be produced using them, are compatible with most refineries around the world. This compatibility, combined with our flexible crude oil production capacity, enables us to quickly respond to increases in market demand for crude oil in general and to fluctuations in demand for specific grades.

In 2017, we produced an average of 10.2 million barrels per day (bpd) of crude oil, including blended condensate.

Our production strategy is guided by four interlinked considerations:

- The crude oil grades available
- The long-run value of different crude oil slates
- Our ability to sell the crude oil grades in strategic markets
- The near-term requirements based on a long-term assessment of future performance

To execute our production strategy, we focus on completing technical assessments for producing fields and exploiting potential synergies through the integration of subsurface computational models with surface facility networks. And because our principal oil fields are linked with our extensive network of integrated facilities, we have the flexibility to send crude oil to multiple plants for processing, stabilization, and shipping.

Given the scale of our reserves, even small percentage increases in recovery rates and production efficiency can significantly boost long-term supply. In 2017, we pursued a host of initiatives to maximize oil recovery, including advanced well completion technologies, artificial lift optimization, and debottlenecking of production systems.

We continued efforts to develop secondary reservoirs, such as 'Ain Dar and Lower Fadhili, and to optimize surface facilities. For example, we upgraded offshore platforms, installed new tie-in platforms, and replaced key trunk lines in our **Safaniyah** field. We also stayed on course to increase the plant capacity of our **Khurais** facility by 300,000 bpd in 2018.

We completed a major project to de-mothball one of the gas-oil separation plants (GOSPs) at our offshore **Zuluf** field. Production from GOSP-3 was suspended in 1995. During a six-month program, we inspected, repaired, and installed new equipment and utilities to bring GOSP-3 safely back online to sustain the field production capacity at 800,000 bpd of crude oil.

Gas processing: Powering growth

The expanding industrialization of Saudi Arabia, and the increasing use of cleaner burning natural gas for power generation and seawater desalination, and as feedstock for the petrochemicals sector, provide opportunities for us to create significant additional value beyond crude oil.



Crude oil production (million bpd)

We are the sole supplier of natural gas in the Kingdom, the seventh largest natural gas market in the world.

> This year, we made progress on several new gas processing plants. Designed to boost supplies of natural gas, the plants are expected to enable increased exports of higher value liquids, provide feedstock to the petrochemical industry, and reduce domestic reliance on liquid fuels for power generation. Additionally, the increased use of gas is expected to help lower greenhouse gas emissions and improve air quality.

> In 2017, we processed an average of 12.4 billion standard cubic feet per day (scfd) of raw gas and supplied 8.7 billion scfd of natural gas with an energy content of 1,080 Btu per standard cubic feet (scf).

Improving production, expanding capacity

In 2017, we readied our **Midyan** nonassociated gas field in northwestern Saudi Arabia. The facilities in the field are designed to produce 75 million scfd of natural gas and 4,500 bpd of condensate. This gas will be used to displace liquid fuels for power generation.

We completed wells toward the development of the Hasbah-Khursaniyah increment designed to feed the **Fadhili Gas Plant**, which is designed to process 2.5 billion scfd of raw gas. The gas from the Khursaniyah field is planned to feed the specially designed cogeneration plant that can handle low Btu gas.

We made significant commitments to improve production from existing gas fields and expand gas processing capacity, including:

- Expansion of the gas processing capacity of our Hawiyah Gas Plant by 1.1 billion scfd. The new gas processing facilities, expected to be on-stream in 2021, are anticipated to raise total production capacity of the plant to approximately 3.6 billion scfd, making it one of the largest gas processing facilities in the world.
- Commencement of engineering, procurement, and construction of a natural gas liquids (NGL) deep recovery train at our 'Uthmaniyah Gas Plant to recover ethane and other NGLs from the natural gas produced from the 'Uthmaniyah plant and from the Hawiyah Gas Plant expansion.

In 2017, we achieved the following in our three **unconventional gas** exploration focus areas:

- In northern Arabia, we achieved raw gas production while reducing drilling costs through optimized well design and drilling practices, and made available 55 million scfd of natural gas to the Wa'ad al-Shamal Industrial Complex.
- In South Ghawar, we completed wells that showed high gas and condensate flows while also reducing drilling costs through well design optimization and the application of fit-for-purpose technologies.
- In the Jafurah Basin, we completed a number of wells and reduced drilling costs through improved well design and execution.





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Upstream R&D highlights: Enhancing discovery, boosting recovery

At Saudi Aramco, we are dedicated to achieving technology breakthroughs that enable us to meet the needs of our customers more efficiently and costeffectively while helping to minimize the environmental impact of our activities.

We are harnessing the power of the Fourth Industrial Revolution through our use of Big Data and supercomputing, and through ongoing investigations into nanotechnology applications. Our upstream R&D addresses key oil and gas challenges: Improving seismic processing and analysis, increasing the effectiveness and efficiency of gas exploration, optimizing enhanced crude oil recovery methods, raising crude oil recovery rates, enhancing oil well productivity, and lowering production costs.

Our upstream research activities are primarily performed in-house, with support from our Global Research Network research centers in Houston, Boston, and Beijing, and from our technology offices in Aberdeen,



Researchers at our Houston R&D Center explore the use of seawater as a fracturing fluid to minimize the use of freshwater, a scarce commodity in the Kingdom.

"Advanced technology will continue to play a pivotal role in helping us improve oil well productivity, increase recovery, and deliver better cost efficiency."

Mohammed Y. Al-Qahtani, Senior Vice President, Upstream

Scotland and Delft, the Netherlands.

Highlights from our upstream R&D programs in 2017 include the following:

Enhancing discovery

We continued to increase the power and speed of **GigaPOWERS**, our parallel oil and water enhanced reservoir simulator, and **TeraPOWERS**, our next-generation reservoir and basin simulator, to improve our computational modeling. These enhancements improve the resolution of the models, giving our petroleum engineers a better understanding of reservoir mechanics to enable maximum recovery and sustainable production for the long term.

We developed GeoDRIVE, our nextgeneration, integrated seismic imaging platform that enables ultra-high resolution subsurface mapping and characterization, and tested the platform in collaboration with the King Abdullah University of Science and Technology (KAUST). Our geophysical expertise, integrated with the power of Shaheen II, a KAUST supercomputer, successfully produced a 3-D image of subsurface geologic layers at a record resolution of 7.5 meters. This capability will enhance our understanding of challenging subsurface environments and help optimize drilling for exploration and production.

Boosting recovery

We continued monitoring the performance of our multi-well

demonstration project in 'Uthmaniyah, with the goals of sequestering carbon dioxide (CO_2) , developing related technologies, and **enhancing oil recovery**. To assess the effectiveness of the field pilot, the migration of the subsurface plume from the injected CO_2 is being tracked through 4-D geophysical monitoring, interwell tracer tests, geochemical sampling, and timelapse logging. The crude oil production response due to CO_2 injection continued to show positive results.

Our state-of-the-art Advanced Geosteering Center in Dhahran enables real-time monitoring of drilling rigs hundreds of kilometers away to achieve precise, optimal well placement. Live drilling and downhole data is transmitted by satellite from rigs to the Advanced Geosteering Center where teams of experts analyze the data to make realtime decisions. Geosteering allows us to position wells for maximum reservoir contact, resulting in enhanced well productivity and reduced development costs. In 2017, our Geosteering program achieved 93% reservoir contact efficiency.

Smart Flood uses injected seawater with ionic compositions that have been optimized to enhance the "sweep" of oil in carbonate reservoirs and improve recovery rates. In 2017, we completed tie-in activities and commissioned multiphase flow meters at our 'Uthmaniyah Smart Flood demonstration project.



Natural gas supplied (billion scfd)

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At a glance: Oil and gas mega-projects Maintaining our reputation as a reliable producer of crude oil, and as a leading producer of natural gas, requires ongoing investment in our production capacity. In 2017, we continued to plan and execute a slate of . mega-projects:

- Khurais field: Planned increase of crude oil production capacity by 300,000 bpd in 2018
- Fazran field: Planned increase of crude oil production capacity by 75,000 bpd in 2020
- Dammam field: Expected start up of 25,000 bpd in

2021, increasing to 75,000 bpd in 2026

- Fadhili Gas Plant: Designed to process up to 2.5 billion scfd of gas, with start up planned in 2019
- Hawiyah Gas Plant: Planned processing capacity expansion of 1.1 billion scfd

We are exploring the use of **seawater** for fracturing operations to minimize the use of freshwater resources. We completed a field trial in Haradh and three more field trials are planned for 2018.

Targeting improved well site safety, as well as significantly reduced field operation costs and downtime, we continued our field trials of a cable deployed electric submersible pump

(ESP). This technique enables the rapid deployment of ESPs using the pump's power cable, rather than a workover rig. In 2017, we completed two installations, with a third planned for 2018. We also progressed preparations for a field trial of a slimmer version of the technology.

To improve recovery rates and longterm reservoir management, we are conducting a suite of nanotechnology research projects. Nanotechnology shows the potential to enable the monitoring and analysis of reservoir performance — and possibly intervention — directly from within the reservoir. In 2017, we identified scalable formulations of surface nanoparticles, which we plan to use in a single well chemical tracer field test in 2018.





Using cameras and sensors to document geological features, our GeoDrone solution improves safety and the accuracy of field data while also reducing costs, since geologists can conduct virtual field trips from their desktops.