# downstream operations

Our downstream business is one of the company's engines for growth and diversification.

## key figures

**seaborne crude oil exports**
6,879
thousand bpd

**NGL produced for sale**
993
thousand bpd

**refined products production**
657
million barrels

**pipeline network**
21,000+
km

unmatched

# Our downstream strategy: Integrating to add value

Our downstream strategy seeks to enhance the value of our resource base by targeting increased horizontal and vertical integration across the hydrocarbon value chain. The successful execution of our strategy would deliver a world leading, strategically integrated downstream network — one that maximizes the worth of the hydrocarbon molecules we produce — and a robust portfolio that is more resilient to market turbulence.

To achieve our strategic objectives in the downstream business, we continued to pursue the following key goals:

- Optimally meet the Kingdom's refined product needs, while building a world-scale global refining system
- Create a top-tier, globally integrated chemicals business
- Increase integration of downstream facilities
- Implement our crude oil placement strategy
- Maximize value creation from power and cogeneration integration opportunities

Our downstream business is one of the company's engines for growth and diversification.

We started building our first pipelines and shipping facilities in 1938, loaded the first tanker to ship Saudi Arabian crude oil in 1939, and commenced refining operations at our original Ras Tanura refinery in 1941.

Since then, we have built an extensive global downstream network that is designed to provide a diversified portfolio of non-crude oil revenue streams, create resilience in times of crude oil price volatility, secure dedicated outlets for our crude oil in strategic growth markets, and allow us to maximize value across the entire supply chain — from the wellhead to customers.

## Adding value through integration

In Saudi Arabia, our downstream operations encompass wholly owned and joint venture refineries and chemicals plants, and a Kingdomwide distribution network. The close integration of our upstream operations with our downstream system enables us to respond safely, reliably, and efficiently to meet the needs of our growing domestic and international customer base.

Our global downstream network supplies a diverse and expanding range of products. We are a major refiner and among the global leaders in base oils. Chemicals is the fastest growing demand sector for crude oil, and our ventures in this sector position us for future growth and long-term value creation.

We also seek innovative new routes to value. For example, our proprietary CONVERGE® technology transforms emissions by using captured $CO_2$ to make an array of high performance polyols with a broad range of applications.

## In-Kingdom downstream: Expanding opportunities

In Saudi Arabia, we manage a downstream network that encompasses gas fractionation, refining, distribution, and power generation that efficiently supports our operations. Within this system are the Sadara chemicals joint venture and Petro Rabigh (an integrated refining and chemicals company), eight refineries (three wholly owned), 23 bulk plants, two international airport refueling sites, more than 21,000 km of pipelines,

Our global downstream portfolio spans the hydrocarbon value chain and includes chemicals manufacturing, trading, refining, and marketing — creating greater value from our resource base.


and 20 export berths at six marine ports, including the Port of Ras Tanura — the world's largest group of crude oil export terminals.

We partner with world leading refining and chemicals companies in Saudi Arabia to produce a slate of products for domestic and international customers, generating greater value from our resource base and expanding market opportunities for our products with conversion industries and manufacturers. We are the sole supplier of refined products to the large and growing domestic market. And because our upstream operations supply crude oil directly to our domestic refining system through our extensive pipeline network, we optimize supply costs.

Our fourth wholly owned refinery, expected to be on-stream in 2018, is located in **Jazan** in the Kingdom's southwest region, and is designed to add 400,000 bpd of capacity to our domestic network.

### Optimizing supply and distribution

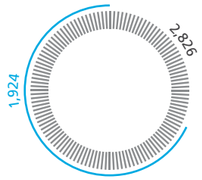
Our distribution system spans the Kingdom, cost-effectively connecting oil and gas facilities with refineries and terminals, and delivering fuel and feedstocks to industrial customers. From our **Operations Coordination Center** in Dhahran, operators can monitor and control our entire hydrocarbon production and distribution system, ensuring the safe, efficient, and reliable delivery of energy to Saudi Arabia and the world.

We own and operate the **Master Gas System** (MGS), an extensive linked network of pipelines, gas processing plants, and NGL recovery and fractionation plants. The MGS collects all associated and nonassociated gas produced in the Kingdom and connects key gas production sites with demand centers in the Kingdom.

To accommodate growing domestic demand, we are expanding the capacity of the MGS. The expanded system should deliver the twin benefits of reducing the use of liquids for power generation and enabling opportunities in energy consuming industries. Phase I of the expansion project was completed in January 2018, adding 1 billion scfd of capacity, raising the total capacity of the MGS to 9.6 billion scfd. The expanded system delivers increased supplies of natural gas to customers in the King Abdullah Economic City and the Rabigh area in the Western region.

Phase II of the expansion project — designed to raise capacity to 12.5 billion scfd — is in the engineering, procurement, and construction stage and is expected to be completed in late 2019. When complete, Phases I and II are planned to add more than 1,600 km of pipelines to the system, further enabling the growth of the high demand utility and industrial sectors in the Central and Western regions.

Work continued to de-mothball and integrate the **Yanbu' South Terminal** with the Yanbu' Crude Oil Terminal, with commissioning of the facility anticipated to begin in 2019. The additional capacity enables crude oil deliveries to the YASREF (Yanbu Aramco Sinopec Refining Company) and Jazan refineries while maintaining our West Coast export capability.




*Domestic refining capacity*

*(thousands of bpd)*

*Total capacity*
*Saudi Aramco share*

In support of our strategy to optimize supply and distribution of petroleum products in the Western region, we began a project to convert the industrial complex that includes our wholly owned **Jiddah Refinery** into a petroleum products distribution center, without refining operations. The conversion project also seeks to enhance safety and environmental performance. And the loss of the relatively low refining capacity of the 50-year-old Jiddah Refinery — 77,000 bpd — will be more than offset by our YASREF and SATORP (Saudi Aramco Total Refining and Petrochemical Co.) joint ventures in Yanbu' and Jubail, respectively, and by the start up of our Jazan Refinery.

### Toward a top-tier chemicals business

Our chemicals operations span the sector from the production of basic chemicals such as aromatics, olefins, and polyolefins, to more complex products, including polyols, elastomers, and advanced synthetic rubber.

In Saudi Arabia, our operations supply all of the feedstock required by our chemicals facilities and all of our domestic chemicals joint ventures. Most of our international joint ventures are integrated with refineries, providing production flexibility, and opportunities for cost competitiveness.

Our aspiration is to become a top-tier, globally integrated chemicals business. We are pursuing three routes to fulfill this aspiration: Leveraging existing assets, developing a global business platform, and seeking selective organic and inorganic growth. In 2017, we began work to launch a wholly owned subsidiary, **Aramco Chemicals Company**, to consolidate and manage the marketing of certain chemical products.

Our chemicals expansion strategy is supported by our expectation that the petrochemicals industry will be the fastest growing sector for crude oil, accounting for 15% of all crude oil demand by 2040. By increasing our participation in this market, we seek to create greater long-term value from our resource base and enhance our resilience to oil market fluctuations.

### Completing chemicals mega-projects: Sadara and Petro Rabigh

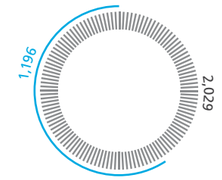
**Sadara,** our joint venture with The Dow Chemical Co. in Jubail Industrial City, began full operation of the last of its 26 plants during the year. The facility achieved reliable operations at full design feed capacity of 85 million scfd of ethane and 53,000 bpd of naphtha.

At our **Petro Rabigh** venture with Sumitomo Chemical on the Red Sea Coast, we achieved mechanical completion of the Rabigh Phase II project, which includes a new aromatics complex, an expanded cracking facility, and differentiated polymer units. Commissioning and start up of all units is expected in 2018.

### Transforming power

Our investments in power, which primarily support our upstream and downstream operations, seek to achieve economies of scale by considering adjacent demand centers and capturing opportunities for advantaged fuels. In addition, our strategy is to identify

We monitor and control our entire hydrocarbon production and distribution system from our Operations Coordination Center in Dhahran, ensuring the reliable delivery of energy to Saudi Arabia and the world.




*International refining capacity*

*(thousands of bpd)*

*Total capacity*
*Saudi Aramco share*


The world calls for energy at the Ju'aymah offshore terminal on the Arabian Gulf, where a supertanker loads crude oil from a single-point mooring.

opportunistic growth in the domestic power market.

We continued to transform our power business from dependency on third parties to self-sufficiency in electricity and cogenerated steam, while maintaining a steadfast concentration on safety, reliability, and energy efficiency. In 2017, we maintained self-sufficiency in power generation, with excess power exported to the national grid under a commercial agreement. Company power efficiency reached 67% by year-end, an improvement of 1% over the previous year.

In 2017, we created **Aramco Power.** Its establishment advances the transformation of the company's power business to a sustainable commercial business through the generation of service and trading revenues.

The joint venture power cogeneration facilities at our Hawiyah Gas Plant, Abqaiq Plants, and Ras Tanura Refinery were operational in 2017. In addition, the construction progress on the cogeneration facility integrated with our Fadhili Gas Plant reached 51% at year-end.

## Global downstream: Expanding integration

Worldwide, we participate in refining and marketing ventures in China, Japan, and South Korea, and are sole owners of the Motiva refining and marketing company in the United States. We also participate in a joint venture specialty chemicals company, ARLANXEO, headquartered in the Netherlands.

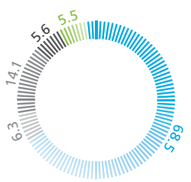
*In 2017, we continued to pursue opportunities to increase our refining and chemicals capacities in key strategic markets.*

In 2017, we continued to evaluate and pursue opportunities to increase our refining and chemicals capacities in key strategic markets. We also explored opportunities to integrate chemicals manufacturing with potential joint venture refineries, and to develop or expand chemicals production facilities at existing joint ventures.

In **Malaysia**, we executed Share Purchase Agreements with Petronas to participate in a grassroots full conversion refinery and integrated chemical cracker to be located in Johor Bahru, Malaysia. The project, known as RAPID (Refinery and Petrochemical Integrated Development), includes a 300,000 bpd refinery, 3 million tons per annum of olefins capacity, and downstream chemicals manufacturing units. Situated adjacent to Singapore, the refined trading products hub for Asia, the venture is planned to increase placement of our crude oil in the region, and add to our refining and chemicals manufacturing, and marketing capacity in strategic markets.

In **China**, we signed a Memorandum of Understanding with China North Industries Group Corp. (Norinco) to participate in its planned refinery expansion and a 300,000 bpd greenfield refinery in Panjin in Liaoning Province. Also in China, we marked the 10-year anniversary of our Fujian Refining and Petrochemical Company joint venture. Over the past decade, with our partners the Fujian Provincial government, Sinopec, and ExxonMobil, we have tripled the facility's crude oil production capacity, increased the capacity of its ethylene cracker, and added a new ethylene oxide/ethylene glycol unit.

In **Indonesia**, following the joint venture development agreement signed with Pertamina in 2016, we completed basic engineering for the upgrade and expansion of the Cilacap Refinery in Central Java.




*2017 crude oil exports by market*

*(percent)*

- *Asia*
- *Northwest Europe*
- *Mediterranean*
- *U.S.*
- *Other*

In New Delhi, **India**, we opened a new office for our Aramco Asia-India affiliate. The office will strengthen our presence in the country and potentially enable broader opportunities between Saudi Aramco and leading Indian entities.

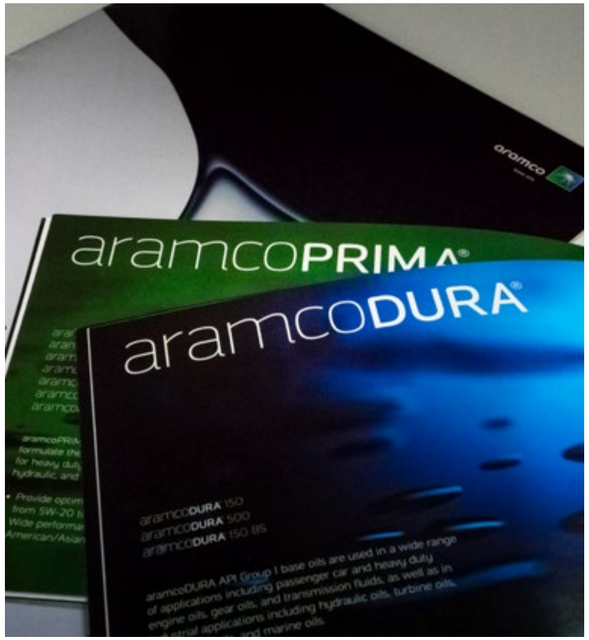
In the **United States,** the dissolution of the 18-year-long Motiva joint venture was finalized during the first half of the year. Saudi Aramco retained the Motiva name and assumed sole ownership of North America's largest single-site crude oil refinery, located in Port Arthur, Texas. In addition, Saudi Aramco retained 24 terminals and an exclusive license to sell fuel under the Shell brand in Texas and much of the U.S. Midwest and Southeast.

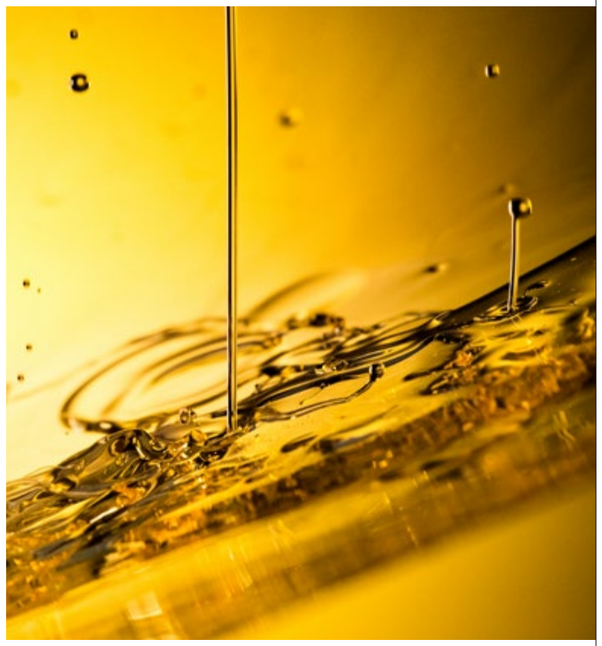
In the **Netherlands,** ARLANXEO is our specialty chemicals joint venture that produces, markets, and distributes synthetic rubber and elastomers. In 2017, we began design of a project to utilize crude C4 from Sadara to produce butadiene and related coproducts such as MTBE and high purity isobutylene as feedstock for ARLANXEO for a planned elastomers plant to be located in Saudi Arabia.

## Growing sales and marketing

In our drive to grow our **base oils business,** in 2017 we marked a number of milestones, including establishing a global interchangeable slate of Saudi Aramco branded base oils among our LUBEREF, S-Oil, and Motiva affiliates, and launching the brand at three major base oil and lubricants conferences. We also commenced domestic sales of aramcoDURA® and aramcoPRIMA® base oils. With the completion of the LUBEREF expansion project in Yanbu', we are aiming to become a leading supplier of global base oils, with gross production capacity of 4.7 million tons per year.

**Saudi Aramco Products Trading Company** (ATC) is our wholly owned subsidiary based in Dhahran, with a branch in Singapore. ATC is Saudi Aramco's trading arm and conducts trading activities in refined products, liquid chemicals, and polymers. ATC is also involved in chartering activities to deliver products to clients, and is the largest charterer in the Middle East region. In 2017, ATC continued to expand its market presence by entering new markets.



In pursuit of our aim to become a leading supplier of global base oils, we launched sales of our aramcoDURA® and aramcoPRIMA® base oils.



*"We capture value by integrating at the operational and geographical level — connecting oil and gas supply, refining, chemicals, and base oils in regions of high growth potential."*

*Abdulaziz M. Al-Judaimi, Senior Vice President, Downstream*

## Downstream R&D highlights: Leveraging technology to add value

Our investments in downstream R&D seek to maximize the value of our resource base through process improvement and enhanced production efficiencies while supporting integration across the hydrocarbon value chain. Our research includes the following key priorities:

- Oil and gas treatment: Crude oil separation and gas separation technologies
- Oil upgrading and refining: Supercritical upgrading of heavy oil, and production of novel catalysts for cracking low value refinery streams
- Chemicals: Converting lower value feedstocks and increasing the share of crude oil in chemicals production
- Oil and gas network integrity: Advanced sensing, prediction, and monitoring technologies

### Improving efficiency and performance: Oil and gas treatment

Technologies to upgrade and enhance oil and gas treatment show potential to improve production performance, increase the value of lower quality gas, and save water.

The use of **membrane-based technology** potentially offers a cost-effective approach to upgrade low Btu gas for use in cogeneration electrical power plants, helping minimize the use of liquids for power generation. In 2017, progress was made on the removal of acid gases through specialized membranes. We also completed a study that confirmed the capability of membranes to recover high levels of helium with a high enrichment factor, which could become a potential commercial opportunity.

### Upgrading oil, enhancing refining

We are investigating the feasibility of **upgrading heavy oil** for refining, petrochemical, and power generation applications. This research program could result in more flexibility in processing heavy crude oil grades and residue fractions of crude oil to create greater value. One focus area is our proprietary supercritical fluid technology for upgrading low value refining streams to distillates and chemicals. In addition, a number of evaluations were completed in 2017, including a process economy evaluation for lube oil and low-sulfur marine fuel oil.

Commercially available refining catalysts are designed for generic feedstock, and conversion processes can negatively impact product yields and quality. We are conducting research into specific **catalyst formulations and processes**

unmatched

## At a glance: Downstream projects

In 2017, we continued to make progress on projects across the hydrocarbon value chain to enhance our performance in the downstream sector. These projects include:

- Jazan Refinery, southwest Saudi Arabia: Continued progress on a 400,000 bpd grassroots refinery, terminal, and integrated gasification combined cycle power plant. Construction of the refinery was nearly 90% complete at year-end
- Sadara, Jubail, Saudi Arabia: Start up of all remaining plants achieved in first half of 2017
- Motiva, United States of America: Assumed sole ownership of North America's largest single-site crude oil refinery, retained 24 terminals, and an exclusive license to sell fuel at more than 5,000 service stations
- S-Oil, South Korea: Three refinery upgrade packages completed at the Ulsan refinery to improve refinery efficiency and productivity
- RAPID, Johor, Malaysia: Refining and chemicals joint ventures formed with Petronas

to enhance the performance of our refining conversion processes such as hydrocracking, fluid catalytic cracking, and hydrotreating. Key objectives of the research include increasing product yields and producing high quality feedstocks for production of propylene or base oils from heavier feedstocks. In 2017, we developed 15 new catalysts based on zeolite minerals, and completed pilot plant testing of 16 catalyst systems.

### Transforming the resource base

The conversion of advantaged liquid feedstock to chemical building blocks and the enhancement of lower value streams from refinery and petrochemical sources have the potential to create greater value from our resource base and strengthen our diversification and resilience as a business.

With our partner Sumitomo Chemical of Japan, we increased the throughput of our Petro Rabigh 1-Butene plant through the development of a **novel anti-fouling additive** technology (AFA).

Our **CAN-FCC** catalyst offers a high tolerance for heavy oil streams in fluid catalytic cracking processes and increases the yield of various distillates and chemicals. In 2017, we demonstrated an additional propylene yield improvement with this catalyst over the existing catalyst used in one of our joint venture refineries.

Our **SuperButol** technology targets the conversion of mixed low-value butenes streams for use as a gasoline blending component to improve fuel combustion and increase octane. In 2017, the technology was successfully scaled up and demonstrated, and the basic engineering package study was completed for potential commercial deployment.

### Maintaining reliability through network integrity

The safe and reliable delivery of our products to customers is paramount. With an emphasis on corrosion and materials, our R&D efforts seek to protect and enhance the integrity and performance of our oil and gas network. Our goals are to significantly reduce the annual cost of inspection and monitoring, and ultimately the cost of corrosion, through the use of autonomous robots and advanced sensing and prediction capabilities.

To achieve our goals, we are developing cost-effective **robotic sensing and inspection tools** to monitor shallow water and onshore pipelines. Additionally, we developed and released a storage tank calibration robot, improving inspection quality and reducing calibration time from 16 hours to four hours. To create additional value and enable greater opportunities for domestic businesses, a number of these technologies are being commercialized for local, regional, and global deployment.

An advanced materials researcher at our Boston R&D Center uses X-ray diffraction to determine properties critical for research programs ranging from corrosion to catalysts.