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Energy to the World

THE STORY OF SAUDI ARAMCO

VOLUME 2

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SECOND EDITION

Supertankers load crude oil at Ras Tanura Sea Island Terminal in 2003.

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ISBN
978-1-882771-14-1

Library of Congress Control Number
2023909954

Written by
Scott McMurray

Produced by
History Factory, Washington, D.C., USA

Project Team
Aramco:
Jamsheed M. Din, Christopher S. Baldauf, Michael J. Ives, Husam A. Nasr, Abdulrahman S. Abuljadayel, Maytham Al-Musawi, Shatha Alotaibi, and Musherf Alamri, *with special thanks to* Mohammad S. Abu Al-Makarem.

History Factory:
Theodore J. Brockish, Alden Hathaway, Michael Leland, and Kyle L. Pakka

Published by
Aramco Americas, Houston, Texas, USA;
www.americas.aramco.com

Designed by
Dan Saal, Wonderfull Design

Printed by
Al-Mutawa Press Co.
Dammam, Saudi Arabia

First Edition: Printed in 2011

Second Edition: Printed in 2024

NOTES

• Saudi Aramco/Aramco

In November 1988, the Saudi government took full control of the company, and the Arabian American Oil Company became known as the Saudi Arabian Oil Company, or Saudi Aramco. In this book, Saudi Aramco and Aramco are used interchangeably to refer to this company.

• King Abdulaziz Al-Saud

Abdulaziz bin Abdulrahman Al-Saud, more commonly known in the West as Ibn Saud, assumed more than one title: Amir, Imam, Sultan, and finally King. For easy reference, the text of this book will consistently refer to him as King Abdulaziz.

• Aramco Senior Executives

Volume 2 uses Aramco senior executive titles correct as of July 1, 2024. All job titles referenced in this book are specific to the chapter and time frame in which they appeared.

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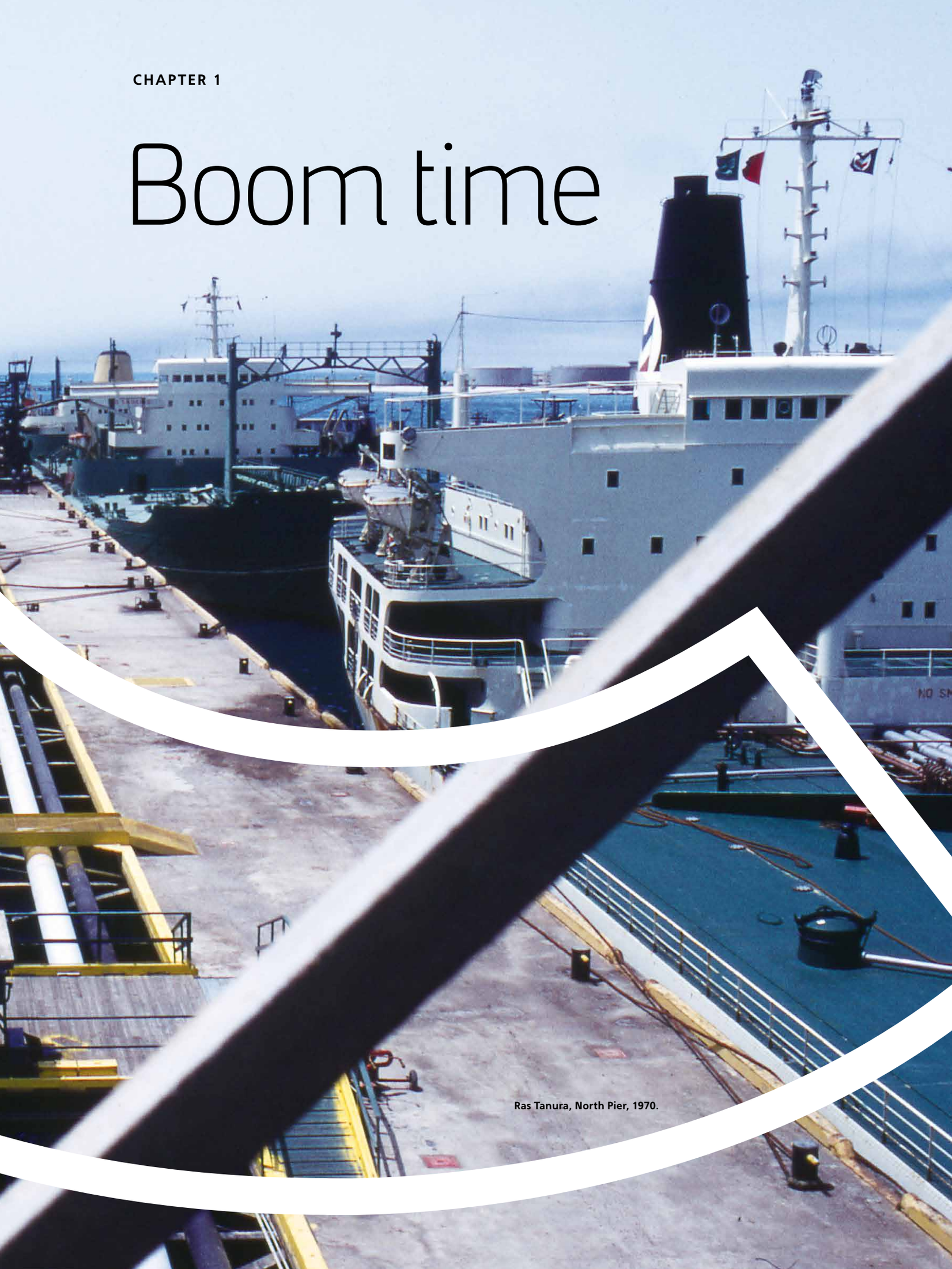
CHAPTER 1

Boom time



Ras Tanura, North Pier, 1970.

The early 1970s saw global oil demand turn sharply upward, prompting Aramco to increase its crude oil processing capacity, including that of Abqaiq, shown here.

The 1970s proved to be a time when Aramco's ability to serve the interests of both its shareholders and the Saudi government was strained almost to the breaking point. A booming oil market put more money in the hands of both entities, yet left both eager for more.

One of Aramco's most influential executives, Frank Jungers served as board chairman and CEO from 1973 to 1978. Throughout his 30 years with the company, he was a staunch advocate for development of the Saudi workforce, and the policies he implemented reflected those beliefs.

Saudi Arabia sought to use its bounty to intensify development plans for the country. The boom also prompted every Middle Eastern oil-producing country to seek ways to shift control of global oil markets from Western oil companies to the countries that owned the commodity. Both of these movements severely tested Aramco's ability to deliver on its promises to its shareholders as well as the government.

Frank Jungers, Aramco's CEO from 1973 to 1978, was intimately involved in some of the most dramatic events to shape Aramco as well as Saudi Arabia. Jungers was at the center of the decision making and implementation process, from the Saudi government's push to obtain an ownership stake in the oil company to operations during the oil embargo stemming from the October 1973 Arab-Israeli war. Jungers was also at the helm during the development of a system to capture, rather than flare off, natural gas produced with crude oil and use it to fuel domestic industrialization, as well as the drive to integrate and enhance electric power generation in the Eastern Province. In fact, he was so deeply imbedded in the integration of Aramco and Saudi Arabia that at times his actions were at odds with the wishes of Aramco's American shareholders. The mounting tension between the CEO and the shareholder-controlled board of directors played a major part in his decision to resign at the relatively young age of 51. While Jungers had a role in many events with a truly global impact, he saw his tenure at the top of Aramco in more personal terms. "The development of Saudis was my major accomplishment," he said, "because that had a lasting impact."

"RIGHT THROUGH THE ROOF"

R.W. "Brock" Powers, manager of exploration in the early 1960s, was sure he had made a mistake. He was in Aramco's New York office in late 1969, serving as liaison with the four shareholding companies. Occasionally, Powers must have felt his full-time job was tracking the shareholders' changing monikers, as The Texas Oil Company was renamed Texaco (1959), Socony Vacuum started calling itself Mobil (1966), and Standard Oil of New Jersey became Exxon (1972). If he had stayed long enough, he could have been on hand for the creation of Chevron (1984), formerly Standard Oil of California. But part of his actual job was to gather the advanced two-year "nominations," or projections of the amount of crude oil each company required per calendar quarter. For U.S. antitrust reasons, each shareholder had to submit its sealed numbers directly to Aramco. When Powers totaled the 1969 numbers, the result was astonishing: "I couldn't believe it. The nominations were right through the roof. They were astronomical, compared to the base we were operating on … so I called everybody back and they all confirmed them, and that's what they wanted."

As the 1970s began, Aramco's administration buildings and adjoining residential areas in Dhahran rapidly filled to bursting with workers and their families as an oil production and building boom gathered momentum. In 1975, the year this photo of the company's headquarters in Dhahran was taken, the workforce had expanded more than 21% over the previous year.

For the previous few years, Aramco's annual capital budget (spending on equipment and construction projects) had been roughly $40 million. Powers was among the first of Aramco's executives to realize that the company was about to enter a new boom era. But he knew that an extraordinary increase in demand could not be met by a few simple turns of the global oil spigot. This would not be a spike, a mere hiccup along an otherwise comfortably modest incline in demand. If the news on Powers' desk was right, this "spike" might last for decades. And long before Aramco could enjoy its swelling coffers, there would be more immediate consequences, and they would be painful. He made his case at the next Aramco executive committee meeting:

> *I laid out what it meant in terms of [the] cost that was going to come about as a result of this, and do you guys really want us to gear up to do this? It means hiring lots of people. It means building lots of facilities that we don't have on the ground now. It means a capital budget of billions of dollars a year. And they all agreed they were going to go ahead with it, because they were very parsimonious, and they weren't going to build anything that they didn't need.*

Just how unexpected was the demand surge represented by the shareholder nominations can be seen by comparing them to corporate studies prepared for Aramco management. The 1970 forecasts estimated a rise in production, albeit a gradual one — gradual enough, in fact, to be easily handled while continuing the company's plans to reduce its in-country payroll. These forecasts predicted that over the next 10 to 15 years, Aramco could cut its workforce by at least 40%, due mainly to automation and better training. The report predicted the number of workers would fall from the already low level of nearly 11,000 in 1970 to just 6,000 a decade later, with a mere 400 Americans on the payroll.

Powers was right: The corporate studies were, for the most part, wrong. Global demand for crude oil in the early 1970s was triggered by relatively robust economic growth in the United States, Europe, and Japan, following years of limited investment or even underinvestment by Aramco and most other oil companies. That combination resulted in the biggest oil boom since the postwar surge in the late 1940s. A Gulf Oil memo written in March 1970 noted that Gulf's 1968 estimates of oil demand in the West were running 8% below actual consumption. The memo warned, "If once again our estimates of future free world demand prove low, then a strain on productive capacity may be approached before 1980."

In 1970, U.S. oil production reached its highest level to date at 9.63 million barrels per day (bpd), nearly three times Aramco's average daily production of 3.5 million bpd. At the same time, U.S. oil consumption was 14.7 million bpd, accounting for 31.4% of global oil consumption. In response to the domestic supply-demand gap, U.S. President Richard M. Nixon relaxed import controls. Nixon's advisers determined that the need for additional oil trumped concerns about political instability in the Middle East, despite mounting Israeli-Palestinian tensions and the administration's widely perceived pro-Israel slant.

EXPANSION MODE

The company shifted into expansion mode in a manner of months, marking its most dramatic commitment of resources since the end of World War II. In 1971, Aramco production jumped 27% from the previous year, to 4.5 million bpd. Adding or expanding gas oil separation plants (GOSPs) increased production capacity by 700,000 bpd. Two GOSPs were completed in the Shedgum area and one in the 'Ain Dar area. The second million barrel crude oil storage tank was completed in Ras Tanura. And delivery capacity at the Ras Tanura Terminal increased 18% with the installation of another loading system between the tank farm and Sea Island.

A supertanker loads crude oil at Ras Tanura's offshore Sea Island Terminal in 1967. The terminal began operations with two berths in 1966, opened two more berths the following year, and added another two berths in 1969.

A gas-oil separation plant (GOSP) is lifted into position in the Marjan offshore oil field in 1973, part of Aramco's capital projects program that increased offshore oil processing capacity by 1 million bpd. In addition, eight onshore GOSPs, with a combined capacity of more than 2 million bpd, were constructed in the first nine months of the year.

Walter Dell'Oro, a superintendent in Exploration and Operations at the time, recalled that the crash building program of the 1970s led directly to Saudi Arabia's serving as the "swing producer" in world oil markets from that period onward:

> *Since Aramco had a superabundance of oil in the ground with more than adequate oil pressure, the bottleneck was in the surface facilities. If someday Aramco wanted to double production for a month or two to offset a disruption in the world oil supply in some other part of the world, it could be done in a matter of days if the surface facilities were in place.*

A company with enough spare capacity to dramatically increase production to meet a shortfall is called a "swing producer." The extra investment in surface oil facilities can be paid off rapidly as oil prices tend to skyrocket when there is a shortage.

Oil industry experts estimated in 1972 that there was a "cushion" of only a scant half-million barrels of oil between global supply and demand. Over the next few years, Saudi Arabia assumed the de facto role once held by the United States as the world's swing producer of oil — a position the country retains to this day. The Saudi share of world oil exports rose from 13% in 1970 to 21% by 1973.

The construction and production surge continued unabated. Aramco laid nearly 1,300 kilometers of pipeline, drilled roughly 1,000 wells, and built 24 GOSPs, and by 1974, average crude oil production had soared to 8.2 million bpd.

HELP WANTED

To support this increase in production, Aramco's employment effort shifted into overdrive. The company opened employment offices across Saudi Arabia and in several other countries. Mustafa Abuahmad, director of the Employee Relations Department during the early 1970s, was exaggerating only slightly when he said, "We were hiring everybody, everywhere. Americans, Filipinos, Indians, many Saudis." The demand

for qualified labor can be seen in the company's size and demographics from the period. In 1971, Aramco had 10,107 employees, 82% (8,324) of whom were Saudis; five years later, the number of employees had almost doubled to 20,067, but only 74% (14,837) were nationals.

With the oil boom, working for Aramco suddenly took on greater prestige among ambitious high school and college-aged Saudis. When he was entering high school in Dammam in the late 1960s, Abdulaziz F. Al-Khayyal, who retired from Aramco as a senior vice president in 2014, assumed he would follow in his father's footsteps and pursue a career in government service. That was where the prestigious jobs were for ambitious Saudis, he reasoned. By the time he was in college at the University of California, Irvine, where he earned a bachelor's degree in mechanical engineering in 1977 and a master's degree in business administration in 1979, that notion was beginning to change:

> *The transformation happened in about '73 or '74 with the first energy crisis and then the expansion, the big expansion. … Aramco went out trying to recruit, and the story began to change. But up to that point Aramco was viewed as having limited employment opportunities. They were not viewed as terribly excited about paying professional salaries. They had a program for professional Saudis, but it was limited in scope and most of the people said that Aramco was not the place to go work.*

Farewell to Tapline

Tapline once played a critical role in Aramco's oil infrastructure, transporting half a million barrels of oil a day from the oil fields of Saudi Arabia's Eastern Province to the shores of the Mediterranean, thereby avoiding both the circuitous route around the Cape of Good Hope and the expense of the Suez Canal. Advances in technology in the 1950s and '60s made possible the construction of larger ships capable of carrying substantially more oil, however, making the seaways more economical and causing Tapline to fall out of favor.

Tapline's use further declined as repeated conflicts wracked the region and left the pipeline vulnerable to sabotage and jeopardized its reliability. In addition to these problems, Tapline also had to contend with the Syrian government, which occasionally demanded higher fees to allow oil to flow through the pipeline within its territories.

In 1975, the Lebanese civil war forced the evacuation of Tapline personnel from its corporate headquarters in Beirut. With no sign of stability in Lebanon on the horizon, in 1978, Aramco decided to terminate the Tapline operational agreements. Tapline officials began termination negotiations with Lebanon, Syria, Jordan, and Saudi Arabia. By 1983, oil no longer flowed through the pipeline to Sidon. A small amount of oil continued to flow to a refinery in Zarka, Jordan, but with the advent of the Gulf War in 1990, that, too, was stopped. That was, in effect, the end of Tapline. Today, all of Aramco's oil exports flow through marine terminals on the Arabian Gulf and the Red Sea to tankers that travel either east to Asian markets or west through the Suez Canal or around the Cape.

On December 18, 2020, in recognition of the historical and economic significance of the pipeline and the progress associated with its contribution to the start of the oil industry, it was announced that the Saudi Heritage Commission had registered Tapline in the national register of industrial heritage. The pipeline is the first officially registered industrial heritage site in the Kingdom.

A combined crew of Tapline and oil tanker personnel hoist submarine crude oil loading lines aboard ship in July 1961, an action repeated thousands of times over the life of the Tapline terminal at Sidon, Lebanon.

Aramco's computers, such as the Project Management Department's IBM shown in this 1970 photograph, were used for numerous tasks, from processing complex seismic data to tracking basic payroll information.

Additional training programs were put in place for Aramco and its ancillary contractors, but both struggled to keep up with the flood of new hires. From 1970 to 1975, the number of trainees in Aramco's Industrial Training Centers jumped from 1,000 to 5,500, while the number of instructors merely doubled. Some locations ran double shifts of classes, and teachers found themselves on their feet for 10 hours a day without relief. Ali Dialdin, then staff adviser for Aramco's out-of-Kingdom training and later general manager of Training and Career Development, opened two temporary training centers in Egypt, historically one of the Middle East's biggest exporters of educators. But Dialdin soon discovered that even in other countries Aramco's demand for teachers could not be met.

UNIMAGINABLE SCALE

The scale of Aramco oil operations, already enormous by any measure, increased almost exponentially. Frank Fugate, who oversaw company construction projects in the early 1970s and eventually rose to become a senior vice president in the company, recalled that "the capital program went from $40 million to $450 million, and it got up to about $5 billion a year with a backlog, as I recollect, of about $7 billion. We had to get the people in and get the construction camps going. We went to suppliers and bought space in their shops for a year. We went to pump shops and bought their entire capacity for a year."

To take just one example, the production capacity of the giant Safaniyah offshore field grew dramatically, from 200,000 bpd to 1.5 million bpd. On this and similar jobs, everything the engineers and construction crews thought they knew about the scale of oil industry work was tossed out the window. Barges were laying pipelines to the offshore field at the same time offshore rigs were drilling new wells. Giant pumps were installed to move the oil onshore for processing. The installation was bigger than anything

Project management

With capital budgets soaring in the early 1970s, Aramco management saw the need for greater coordination among departments working on major projects. Project design was being done in The Hague in the Netherlands, or London in the United Kingdom, while construction was going on in Saudi Arabia. Officials involved in each activity tended to blame the other when a project slipped behind schedule or over budget or both. Ed Zinola, senior vice president of Engineering Services, embraced the concept of centralized project management, which was becoming increasingly popular in the United States. In 1972, he named Henry "Hank" Barracano, supervisor of the Electric Power Unit, Aramco's first project manager.

The appointment of a project manager did not stop the arguing, "but they would go through me … then I could kick these guys" to get them to take corrective action when necessary to keep projects on track, Barracano said. The first project completed on his watch was the 600,000-bpd Berri crude project in 1970. "I moved to London, where the design was being done by Fluor, to oversee design and procurement. Then when that was fairly well done, I moved back to Arabia. Even though that was the first one, it came in on time and in the money. I've always been proud of that," Barracano added. Project management played an increasingly vital role in the ensuing decades as the company took on and successfully completed construction of several oil and gas facilities that set new standards for the industry.

Aramco's implementation of centralized project management in the 1970s allowed it to more efficiently complete numerous capital improvement projects, including the Qurayyah Seawater Treatment Plant, shown here in 1979.

ever done in the oil business. For economies of scale, two giant pumps took the place of 10. To avoid maintenance shutdowns, a third giant pump was ordered and kept on standby.

Aramco was redefining the state-of-the-art in oil field facilities on a real-time basis. In most cases, the only limitation on the company was availability of materials in the market — what it could find and whether manufacturers were willing to rethink their production processes to accommodate Aramco's specifications regarding size and quantity. The company also kept several computers busy running "what if" scenarios to ensure that construction stayed on schedule if, for example, the shipment of a particular component was delayed.

The limited capacity of Dammam Port became a bottleneck for the inflow of additional equipment and supplies, especially as the revenue generated by the oil boom spurred rapid development of other Saudi industrial and construction projects. To avoid congestion, Aramco adapted by lightering (the process of transferring cargo between vessels of different sizes, usually from a larger to a smaller one) in material from outside the existing port areas, and using heavy cranes to lift the equipment onto waiting trucks for delivery.

The *F.A. Davies*

With the Zuluf offshore field entering production in 1973, the *F. A. Davies*, a converted oil tanker, served as a floating storage vessel.

Aramco had discovered the Marjan and Zuluf offshore fields prior to the oil boom of the early 1970s, but the company had not fully determined the fields' size. Rather than commit to building an expensive offshore pipeline or wait until additional survey work helped delineate the fields, Aramco engineers decided to adapt an approach that one of the company's shareholders, Exxon, had used in the offshore oil fields of Nigeria. In this system, as adapted by Aramco, oil from the new offshore Zuluf GOSP would move through underwater lines to a floating storage vessel 64 kilometers offshore, where tankers could then take on crude oil.

Robert Luttrell, superintendent of the Safaniyah Producing Division, was put in charge of the project, which, as was typical of such large-scale affairs, involved Aramco staff and contractors around the world. He visited the Exxon facility in Nigeria, met with Aramco's engineering and design staff in The Hague, and then flew to Japan with an Exxon maritime captain to purchase a tanker. The vessel they bought in Nagasaki had a capacity of 1.8 million barrels of oil — far larger than the tanker Exxon had used in Nigeria. The ship had to be modified for its new role, and its living quarters were enlarged. The project also required two single-point moorings: one to deliver oil to the floating storage vessel and another, 1.6 kilometers offshore, for tankers taking on oil. (Single-point moorings were also used at the Ju'aymah Offshore Terminal, which opened in 1974 north of Ras Tanura with an initial capacity of 1 million bpd.)

Finding a crew to operate such a novel craft proved to be more difficult than Aramco officials had expected. They eventually retained a British crew from well-regarded providers Common Brothers to run the vessel, but not without having to modify the typical Aramco operating contract. The crew demanded an "out" clause after a certain period in case Aramco's floating storage vessel proved to be a failure. "They didn't want to ruin their reputation [by] being involved in something that didn't work," Luttrell recalled with a chuckle.

Common Brothers need not have worried. The *F.A. Davies* (named after Fred Davies, Aramco's influential early CEO) worked flawlessly. In 1976, Aramco began building a second offshore GOSP in the Zuluf field to process increased production. By the 1980s, Aramco decided the size of the Marjan and Zuluf fields warranted the construction of a pipeline connecting them to onshore oil processing facilities. The *F.A. Davies* was then reconfigured and added to Aramco's tanker fleet.

King Khalid, left, cuts the ribbon on October 29, 1977, to open the Berri NGL Center while Minister of Petroleum and Mineral Resources Ahmed Zaki Yamani and Aramco CEO Frank Jungers look on. The first of the Master Gas System plants to open, the Berri NGL Center supplied treated gases as fuel and chemical feedstock to the industrial complex at Jubail and natural gas liquids for export.

Barge 136, nicknamed the "Queen Mary," supplies a drilling platform in the Safaniya field with power and drilling mud in 1971. Between 1970 and 1971, crude oil production rose 27%, propelling Saudi Arabia into third place among oil-producing nations behind the United States and Russia. The following year, crude oil production increased another 27.5%.

"THE BUYER'S MARKET FOR OIL IS OVER"

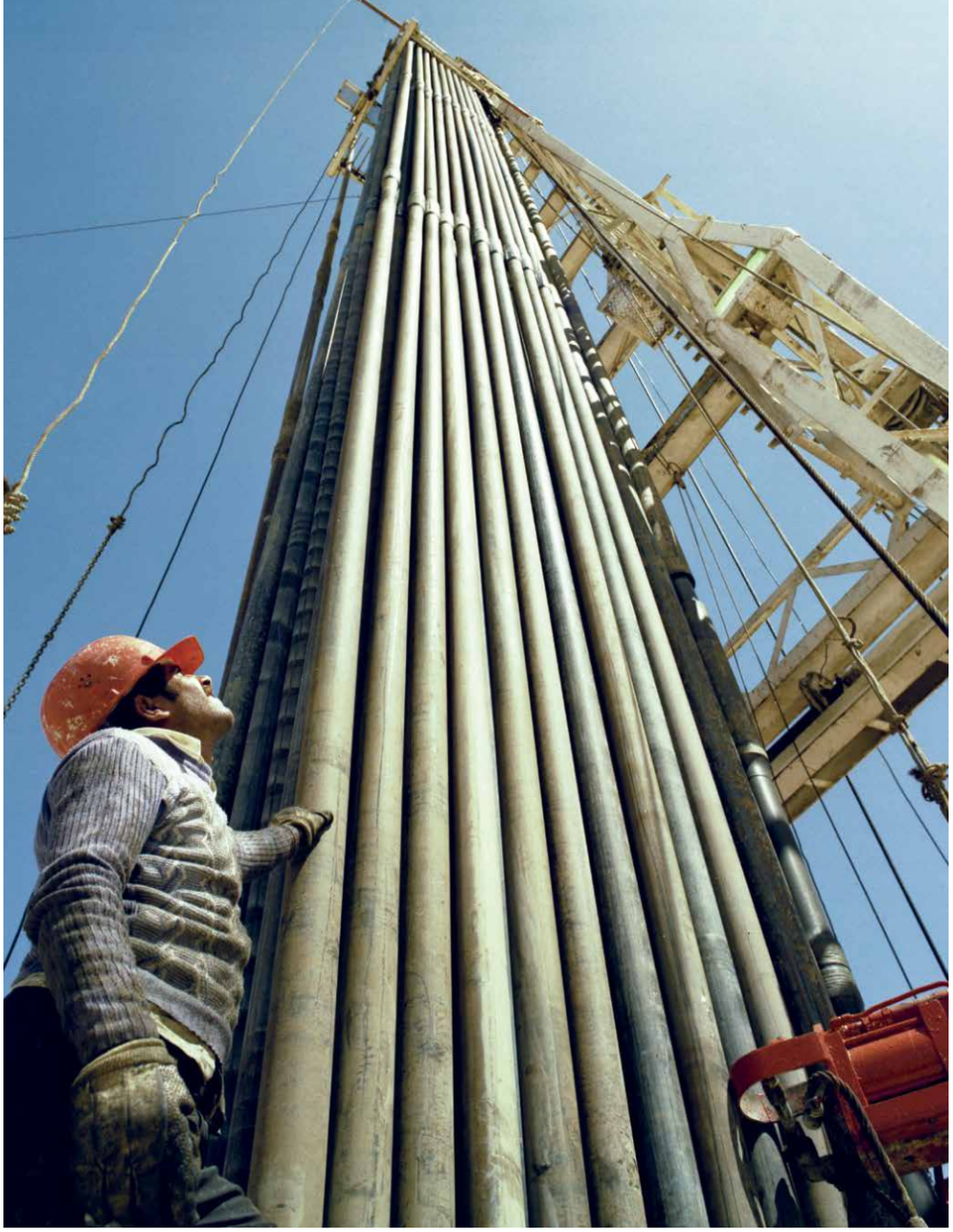
As the 1970s began, Aramco's shareholders and the other major global oil companies held to the position that they remained in control of oil prices. OPEC had been in existence for a decade, and had little to show for its speeches and conferences. Saudi Minister Zaki Yamani was frustrated with OPEC's lack of cohesion and in 1968 led the formation of the Organization of Arab Petroleum Exporting Countries (OAPEC), which initially included Saudi Arabia, Kuwait, and Libya. The purpose of OAPEC was to give leading Arab oil producers more control over their fate.

Jungers, Aramco's chief negotiator with the government since 1965, recalled riding on a plane with Yamani in early 1970. The price of oil was $1.80 a barrel, almost the exact price it had been a decade earlier. However, when adjusted for a decade of inflation (which averaged 2.75% annually), the $1.80 barrel of crude in 1970 was worth much less than its 1960 equivalent. For members of OPEC, Yamani complained, real income had actually declined over that period.

With the demand for oil rising sharply, Yamani argued for a 9-cent-a-barrel increase, saying that he could get the rest of OPEC to hold prices at that level if Aramco's shareholders went along. If the other countries raised prices first, there might be no controlling the rate of increase, Yamani warned. Jungers personally agreed with him but had to pass along the request to the shareholding companies. The Aramco shareholders refused, and months of meetings followed. Nerves frayed and tempers flared occasionally on both sides as the standoff continued.

The first OPEC country to initiate a price hike was Libya, which began pressing for higher prices in early 1970. It argued these were justified because of the low sulfur content of its oil, which made it easier and less expensive to refine than many other grades of crude oil. A further argument was its proximity to Europe, a factor that became all the more pertinent when, in May 1970, Aramco was forced to halt all shipments of oil through Tapline temporarily, after it was damaged in Syria, thereby increasing European reliance on Libyan oil. In June and August

Japanese brokers signal "buy" at the Tokyo Stock Exchange on December 27, 1973, as reports circulate that the Arab oil supply cutbacks against Japan will ease.



Strings of drill pipe stand ready on a drilling rig at Tamayshah in the Rub' al-Khali in March 1979. This was a test well in the Khuff zone at 3,471 meters and part of Aramco's accelerated gas exploration program in the 1970s.

of 1970, Libya imposed output restrictions on foreign oil producers, and by September, American-owned Occidental Petroleum Company had agreed to higher prices, breaking the oil industry's united front. Other independent oil companies and the major producers followed suit, raising the posted price of Libyan crude 30 cents a barrel to $2.53 a barrel and paying higher taxes as well.

The Aramco shareholders and other international oil companies felt the world shifting beneath their feet. They began meeting in groups (joined by a U.S. government representative to avoid antitrust concerns) to discuss options and hammer out common policies. Meanwhile, the Shah of Iran hosted a showdown of sorts between oil-producing countries and the oil companies themselves in early 1971. Representing the Arab producer states were Yamani of Saudi Arabia, Iraqi Oil Minister Sa'doun Hammadi and Iran's Finance Minister Jamshid Amouzegar. Representing the other side was the Group of 23, consisting of 16 U.S. companies, six Western European firms and one Japanese concern. Speaking for the Group of 23 was George Piercy, Exxon's director responsible for the Middle East, and William Fraser, a director and attorney for British Petroleum.

After weeks of negotiations, representatives from the two sides finally signed the Tehran Agreement on Feb. 14, 1971. It stipulated an increase of 35 cents a barrel for light crude and 40 cents a barrel for heavy crude from the Arabian Gulf. (Crude oil is classified according to density, or specific gravity. The lighter the crude oil, the more valuable products it yields when refined.) Furthermore, to account for inflation, the price of a barrel of oil would increase by 5 cents a year for the following four years, as well as another increase of 2.5% a year for the four years after that. Finally, the oil-producing countries' percentage of company profits would increase from 50% to 55%. The accord raised the price of Arabian Light to $2.17 a barrel and the price of Arabian Heavy to $2.125 a barrel.

This agreement has been interpreted in many ways over the years, but one thing is certain: Oil-producing countries gave the oil companies a very fair deal. The oil-producing countries needed this hefty adjustment to counter years of rapidly increasing inflation, which averaged 5.92% in 1970. Furthermore, even setting inflation aside, these countries simply needed to play catch-up with price developments elsewhere in the world. For example, the price of a barrel of American domestic crude, which was protected from cheaper foreign oil by U.S. import quotas, increased by 45 cents in 1969-1970 alone.

While the Shah of Iran and others hailed the agreement as ushering in a new era of price stability, few oil company executives shared their enthusiasm. As Shell Oil Company Chairman David Barran remarked following the Tehran meetings, "There is no doubt that the buyer's market for oil is over."

PARTICIPATION

Even while negotiating with the oil-producing states over raising prices, the oil companies in 1971 continued to resist discussing an even more daunting matter: the groundswell among producing nations in favor of direct participation in the ownership of the oil companies themselves, if not outright nationalization.

Since the late 1960s, Yamani in particular had advocated the Saudi government's position of participation, with producing nations acquiring ownership while preserving the oil trading and marketing structures. That stance enabled him to better resist calls for nationalization by aggressive oil-producing states. Jungers recalled: "Participation was Yamani's avowed idea that the government would buy into Aramco and become a true participant and thereby get to know the shareholders' problems intimately. Through this method, the Saudis would become a shareholder and fight off the rest of the producing governments, who were hell bent to nationalize."

Japanese-made cars bound for world markets crowd a pier in the port of Yokohama in March 1975. One aftereffect of the 1973 oil embargo was the rise of smaller, more fuel-efficient cars. The United States set fuel efficiency standards for new cars, mandating a doubling of average mileage from 13 miles per gallon to 27.5 within a 10-year period.

Aramco tried to control the participation debate, with Jungers at one point in 1971 floating the idea that the Saudi government could participate in 50% of the profits from new fields developed after that point, rather than take an ownership stake in the entire company. Yet while Aramco was dragging its heels on participation, varied forms of nationalization were gaining traction elsewhere. In 1971, Algeria dispensed with further negotiations and took 51% ownership of the French oil operations in its country. The following year, Libya nationalized British Petroleum's holdings and later took 51% control of other foreign operators, including Occidental. Iraq also nationalized the Kirkuk concession, the last remaining holding of IPC.

Yamani seemed to despair, feeling the Aramco shareholders were not getting the message. "There is a worldwide trend toward nationalization, and Saudis cannot stand against it alone," he warned. "The industry should realize this and come to terms so that they can save as much as possible under the circumstances."

By 1972, the Saudi Minister had finally convinced some members of OPEC to push for a united front on participation. Yamani described it as the best way to give oil-producing countries ownership interests while maintaining a strong pricing structure for OPEC. He argued that widespread nationalization would inevitably lead to cutthroat price competition, as countries gave in to domestic pressures to maximize oil revenues as soon as possible. As early as 1969, he had argued that nationalization would trigger a "dramatic collapse in the pricing structure" as producing nations pumped more oil to meet revenue targets in the face of declining prices.

The major foreign oil companies operating in the Arabian Gulf, seeing no alternative by early 1972, reluctantly agreed to engage in serious participation talks with governments in the region. Aramco's legal staff decided to get out in front of other companies and draft a participation agreement. Aramco General Counsel Bill Owen turned to one of his assistants who specialized in tax law, Leslie Lewis, with what would be one of the biggest assignments of his life. "Les," Owen said as he walked into Lewis' Dhahran office one day in early 1972, "I've chosen you to be my right arm, and you and I are going to produce the first draft of the agreement relating to participation. … At the first meeting with the shareholder company counsel we will table the first draft, and you're going to write it."

The negotiations took place during the spring and summer of 1972. A group of 100 to 150 attorneys, accountants, and oil industry experts followed the globe-trotting Yamani as he convened meetings at hotels and conference centers around the world to thrash out the details of participation. The longest sustained set of negotiations occurred at Beit Meri, a summer resort in the mountains of Lebanon.

By October 1972, the negotiations had borne fruit. The General Agreement on Participation, which was based on Lewis' draft, granted 25% participation to the countries. The pact was agreed to by the oil companies and signed by Saudi Arabia and Abu Dhabi in Riyadh on Dec. 20, 1972 (with Saudi television capturing the moment), effective Jan. 1, 1973. Kuwait and Qatar signed the agreement the following month.

Saudi ownership reduced the percentage held by the four existing shareholders, with Exxon, Texaco, and Chevron now owning 22.5% and Mobil 7.5%. Ownership participation was supposed to incrementally increase to 51% by 1982, in what both sides anticipated would be a relatively stable process in terms of maintaining prices and transferring ownership. That, at least, was the plan.

THE PRODUCERS TAKE CONTROL

Arab-Israeli antagonism seemed to intensify week by week in the early months of 1973. Arab spokesmen — particularly Palestinians — pressed Israel to relinquish territory gained in the 1967 war. Ever-tighter supplies in the West drove oil prices higher, highlighting Western reliance on imported oil, especially Middle Eastern oil. Understanding their obvious advantage, some oil-producing countries increasingly threatened to use the "oil weapon" — an embargo. The Saudi government made it clear to Aramco officials and American politicians that the situation was making it increasingly difficult to moderate the influence of other regional governments indefinitely. As spring gave way to summer, the situation grew progressively worse, as recounted by noted Arab authors M.S. Al-Dajani Al-Daoudi in his book, *Economic Diplomacy: Embargo Leverage and World Politics*:

> *On May 3 [King] Faisal confided to Aramco president Jungers that only in Saudi Arabia were US interests relatively safe, but that even in his Kingdom it would be more and more difficult to hold off the tide of opinion. And in August meetings with Aramco executives, the King began requesting that the US government pressure the Israelis to withdraw from the bulk of Arab territories occupied in the 1967 war.*

In the meantime, the participation agreement was already looking shaky, as the more radical Arab governments began to scoff at the 25% participation rate championed by Yamani. Libya acted first and in early September 1973 nationalized 51% of Exxon's Esso Libya operations. More uncertainty meant higher prices in the spot market for immediate delivery of crude oil. (The spot market at the time reflected the small amount of oil trading that existed outside the long-term agreements between oil producers and oil distributors.) On Sept. 11, 1973, a barrel of Arabian Light was $3.06 a barrel, up from the $2.17 per barrel price set by the Tehran Agreement the previous February.

Jungers, with the blessing of Aramco's four shareholding companies, made a whirlwind tour of the United States to promote a more balanced approach by America to the Arab-Israeli crisis. The conflict continued to fuel hostility toward America and American companies in the region. Jungers' focus was the broader U.S. business community, not just those industries directly tied to energy. Crisscrossing the country in a matter of days to press his case, he met with 38 CEOs of major U.S. companies. After hearing his argument, a number of major companies backed his position.

Several oil company executives spoke out against American and Western support for Israel. At an address before the Independent Natural Gas Association of America in Scottsdale, Arizona, Maurice Granville, chairman and CEO of Texaco, called for a "more even-handed policy" regarding the Arab-Israeli dispute: "We must feel concern when those who have been so close to us urge us to review our policies. When such long-time friends assert that we are not being fair and even-handed, it seems only sensible to pause and examine the actions about which they express concern. … To dismiss without some concern the viewpoint of those who feel wronged is to neglect a significant aspect of the nation's energy policy." Granville was not alone; Mobil Oil took out a series of advertisements in *The New York Times* to press the matter. Otto N. Miller, Socal's chairman, had denounced America's stance six weeks earlier in his July 26, 1973, letter to shareholders, calling for a greater understanding of "… the aspirations of the Arab people, and more positive support of their efforts toward peace in the Middle East." Miller and his company received a lot of flak from the American media, and protests took place outside Socal's headquarters, with some protestors even attempting to storm the building. But Socal stood its ground.

Jungers returned to Saudi Arabia after his trip and was debriefed by King Faisal. The King wanted to know every detail, especially the response from the American business leaders. Both of them expected the issue to be taken up again at the next OPEC meeting, scheduled for early October in Vienna, Austria.

Drivers in the United States, such as this motorist in Connecticut, faced shortages of gasoline in the wake of the OPEC oil embargo. The embargo also impacted consumers in Western Europe and Japan, and was a pivotal moment in the relationship between oil companies and producing nations.

As oil company executives arrived there on Oct. 6, 1973, they heard the news: Egypt and Syria had launched a coordinated surprise attack on Israel during the Jewish holiday of Yom Kippur and had scored impressive early gains. What the oil executives had hoped might be amicable price negotiations were inflamed by war fever. OPEC was demanding a 100% increase, from roughly $3 to $6 a barrel, in the posted price of crude oil. The companies were offering what, until the outbreak of war, had sounded to them like a more than fair 15% increase of 45 cents a barrel.

After no acceptable counteroffers came out of the Vienna meeting, negotiators from Arab OPEC countries and Iran reconvened in Kuwait City on October 16. There, they unilaterally raised the posted price 70% to $5.11, which was roughly in line with the panicked spot market prices. Despite the ongoing war, the significance of the OPEC price hike — and the bold unilateralism reflected in the manner in which it was presented — were felt around the world. The oil producers were clearly in control.

The following day, the oil-producer representatives rejected a call from the Iraqi representative to nationalize all American businesses in the Arab world. After Iraq's representative stormed out in protest, those remaining agreed to an embargo, the first since the 1967 war. They agreed to cut production 5% from September levels and to continue to cut output by 5% a month until major oil-consuming countries stopped supporting Israel. Some countries immediately doubled their first month's cut to 10%.

President Nixon's announcement of a $2.2 billion military aid package to Israel on October 19, following resupply shipments by the Soviets to Egypt and Syria, led the Arab oil producers and Iran to declare a total embargo on oil shipments to the United States. The Netherlands, also an active supporter of Israel, received the same treatment. Shipments to other countries in Western Europe and to Japan were also reduced in response to their support for Israel.

As the embargo took effect, Jungers and other Americans working for Aramco faced the most crucial decision of their professional lives. Critics in the United States were calling them traitors for complying with the embargo that was contrary to the interests of their country. Several members of the U.S. Senate Subcommittee on Multinational Corporations blasted Aramco. Senator Henry M. Jackson of Washington state claimed Aramco's adherence to the embargo was a "flagrant case of corporate disloyalty."

Senator Jacob K. Javits of New York accused the oil company of cooperating with the Saudis to increase the profits of its shareholder companies: "Obviously, it is to their [the Arabs'] interest to raise prices. They determine even your profit. They determine how much of the deal you may own. And yet what they are doing imperils this country and this world. … The only persons talking to these governments are companies who have their own profits, their own stockholders and their own private interests to protect. That is an impossible situation."

Aramco denied all the charges. The company declared that its actions were motivated by potential decisions by the Saudi government. Aramco was obviously worried that it would be cut off from its only source of crude oil. According to its statement, Aramco "had no choice but to follow instructions regarding cutoff on deliveries to the U.S. military of products manufactured from Saudi Arabian crude. … The embargo action was taken by a sovereign state and Aramco's compliance came as the result of a direct order and had nothing to do with 'patriotism.'"

Jungers was convinced that if Aramco did not cooperate with the Saudi government, nationalization of the oil company was a foregone conclusion. Furthermore, he feared nationalization would remove any American influence on Saudi oil policies, putting American security on even shakier ground: "We knew exactly where every barrel of oil that was exported went, and monitored it. This was under threat of complete nationalization. There was no doubt about this. And we did it in lieu of being nationalized. We had no choice."

While some in the United States raised the possibility of military intervention if the embargo turned into a stranglehold on the U.S. economy, cooler heads prevailed behind the scenes. The embargo, while relatively short-lived, reverberated through world economies and politics for years to come. From Oct. 1, 1973, to Jan. 1, 1974, the price of a barrel of Arabian Light crude soared from $3.01 to $11.65. That previously unimaginable $8 jump in oil prices followed three decades of oil price fluctuations in a relatively narrow band above or below $2 a barrel. The U.S. role in brokering peace talks among Israel, Egypt, and Syria contributed to the decision to lift the embargo in March 17, 1974.

As its payroll grew to fill the manpower needs of the Master Gas System, Aramco built new communities and revived older ones, such as 'Udhailiyah. Shown here in February 1977, the isolated camp, located 100 kilometers southwest of Abqaiq, had been mothballed since 1959.

Students gather in the courtyard of the women's campus of Jiddah's King Abdulaziz University in 1973. Founded in 1967 by a group of businessmen, the university was absorbed into the Kingdom's university system in 1971. The school opened with a handful of students, but by the time this photo was taken, total student enrollment was around 2,500.

A science lab experiment commands the attention of students at King Abdulaziz University in 1973. A donation in 1973 from Aramco helped finance the construction of a library on the women's campus.

MAJORITY STAKES

The embargo also sounded the death knell for the participation agreement, even though it was less than a year old. In December 1973, Kuwait, whose parliament had never ratified the 25% participation agreement, announced plans to assume 60% ownership of Kuwait Oil Company, which was jointly owned by Gulf Oil and British Petroleum. That same month, Yamani, at a meeting in New York, was quoted in *BusinessWeek* as saying that 51% participation was "not satisfactory." The magazine added, "In London, the center for Middle East oil watchers, the betting is that Faisal will eventually demand 100% ownership."

Saudi government participation in Aramco under an OPEC agreement went to 60% the following year, in 1974. The government thought it was a reasonable compromise under the circumstances, as other OPEC members were pressing for complete nationalization immediately.

The Saudi government's majority stake in Aramco as of 1974 made little if any immediately noticeable impact on the lives or careers of expatriate workers. Despite false scare stories that cropped up periodically in the U.S. media during the next few years warning that mass firings of Americans by Aramco were imminent, the expatriate communities worked and lived much as they had before. The government, and Yamani in particular, made it clear Saudi Arabia valued the expertise that expatriate workers brought to Aramco and that they were a key ingredient in the company's success.

In 1974, Faysal M. Al-Bassam became the first Saudi to be named a vice president of Aramco.

"TRUE SAUDIZATION"

When Jungers was named chairman and CEO in late 1973, he quickly realized the pace of training Saudis for progressively more senior positions at the company had fallen behind expectations he and others had set at the departmental level in the 1960s. A 1972 study delivered to Aramco management concluded that at the then-current rate, just 28% of Aramco executive and department head positions would be held by Saudis by 1990.

The study also predicted that unless something changed, Saudis, who held a mere 12% of management jobs in 1972, would hold only 54% of the managerial and professional jobs at Aramco by 1990. As of 1972, only four of the company's 44 departments were led by Saudis: Mustafa Abuahmad, director of Employee Relations; Faysal M. Al-Bassam, manager of Public Relations; Ali I. Al-Naimi, manager of Southern Area Producing; and Sa'id M. Tahir, manager of Local Industrial Development.

This rate of advancement was unacceptable, Jungers reasoned, especially in light of the participation agreement giving the Saudi government a direct ownership stake in Aramco: "This was not so much because percentage increases in Saudi government ownership demanded automatic corresponding increases in Saudi management. … We wanted to be sure that Saudis would be ready to move up. Realistically, we had to expect that participation could accelerate demands for Saudi management."

One of the biggest bottlenecks preventing Saudis from advancing to senior positions was the Saudi Development Committee, which as of 1973 seemed to be a contradiction in terms. Saudis attending colleges or universities were divided into two groups. The A-group members were in their junior or senior year and working toward a four-year degree. The B-group students were in their first two years of studies and came up for review after their second year. Whether they would be allowed to continue with their college educations at the company's expense was usually left up to the managers who had sponsored them.

In the early 1970s, the unsettling fact was that these managers denied permission to as many as 60% to 70% of the B-group students to continue their schooling and earn a degree. It was a simple but shortsighted decision: The managers benefited most by getting their employees back on the job. Dialdin, the general manager of Training and Career Development, termed the B-group students "victims, because without a four-year degree they had no hope of advancing into management positions."

Jungers demanded that the committee act in the company's best interest and support the deserving B-group students. As a first step, the Saudi Development Committee set about finding sponsors from its major departments who understood the long-term objective of the program: to build the next generation of Aramco leaders. As a result, word quickly spread throughout the company that Jungers was serious about promoting capable Saudis to management positions.

By the end of Jungers' first full year at the Aramco helm, the number of Saudis holding supervisor positions — the starting rung on the management ladder — had jumped by 23% to 366 out of 820 positions. In August 1974, Al-Bassam was named vice president of Public Affairs, the first Saudi to be appointed vice president. "The foresight was not there until Jungers became chairman," said Dialdin. "True Saudization began to take place after that."

Pressure for change came from the Saudi workforce, too. Ali Al-Baluchi, who had been a B-group student and had fought successfully to continue his education, recalled: "In the mid-1970s, a group of senior Saudis met with Shaikh Ahmed Zaki Yamani in House 17 in Dhahran and discussed with him the unjustified slowness in promoting Saudis to higher positions. Soon after that, more actions began taking place."

Sharing success

Khalid Ali Alturki rose to become one of the most successful businessmen in Saudi Arabia, but when he grew up in al-Khobar it was in a family of only modest means. He joined Aramco as an office boy in 1948 because it was, he explained, "the only place in Dhahran to get any schooling. … But you had to be an Aramco employee." When he showed promise in his part-time classes, Aramco sent him to the International College in Beirut. From there, he went to the United States, where in 1965 he earned undergraduate and graduate degrees in international relations from the American University in Washington, D.C. In 1968, he returned to the United States and received an MBA from Stanford University.

After three more years at Aramco, Alturki left the company and went into business for himself. In 1973, this was an unusual choice. As he recalled, "I think I was the first and only one in my generation, with my education at Aramco, that left … just at the time when all the Saudis were starting to take big positions in executive management."

Although he did not rise through Aramco's ranks with his former Saudi colleagues, Alturki shared in their success. His first business was an electrical contracting company, but he expanded into the construction, construction materials and oil and gas sectors during the 1970s and early 1980s in time to benefit from the oil boom. Alturki, and many Saudis like him, were beneficiaries of Aramco's training and support.

Khalid Ali Alturki, back row, far right, departed Saudi Arabia in July 1960 on an Aramco scholarship to an out-of-Kingdom college. The 10 other students pictured are, front row, left to right, Ibrahim A. Al-Afaleq, Salah A. W. Ghanim, Abdulaziz Al-'Abid, Saleh A. Al-Tu'aimi, and Abdullah Al-Faisal, and back row, left to right, Nassir M. Ajmi, Abdul Rahim Framarzi, Ni'mah S. M. Al-'Awwami, Abdulrahman Al-Bubshait, and Abdulaziz D. Al-Falih.

Ambitious Saudis found that by the mid-1970s new career opportunities were open to them, and that more and more expatriates were willing to act as mentors. While still a student at the College of Petroleum and Minerals in Dhahran in the early 1970s, Hamed T. Al-Saadoun worked for nine months in the Inspection Division at the Ras Tanura Refinery. His supervisor, Ralph Echezuria, who was fluent in Arabic, took the young Saudi in tow and gave him a solid grounding in the business.

He invited Al-Saadoun to his home after hours. "He was like a father figure to me," said Al-Saadoun. After graduation, Al-Saadoun joined Aramco and progressed quickly through the management ranks at the refinery. "All you needed to be was a Saudi with a college degree and a love to work and take charge of things," said Al-Saadoun, who served as vice president for four company organizations before retiring in 2009.

As Saudis rose through the ranks, they also felt the responsibility to help promote other qualified Saudis to follow in their footsteps. Sa'ud Abdulrahman Al-Ashgar, who retired as senior vice president of International Operations in 1997, was a plant superintendent in Ras Tanura in the early 1970s. "I saw part of my role was to look at potential shift coordinators and potential replacements for myself. Because we had three additional LPG [liquefied petroleum gas] plants and a new reformer, and each one needed a foreman … I would plan ahead and say, 'OK, we'll take shift coordinators and make them foremen and then develop some supervising operators to be shift coordinators." One of the early Saudis he helped promote to management roles was Ibrahim M. Al-Rebdi, who became the superintendent of a newly created Refinery NGL (natural gas liquids) Division in 1977, and then left the company to start his own business in the Eastern Province.

THE "GREENING OF ARAMCO"

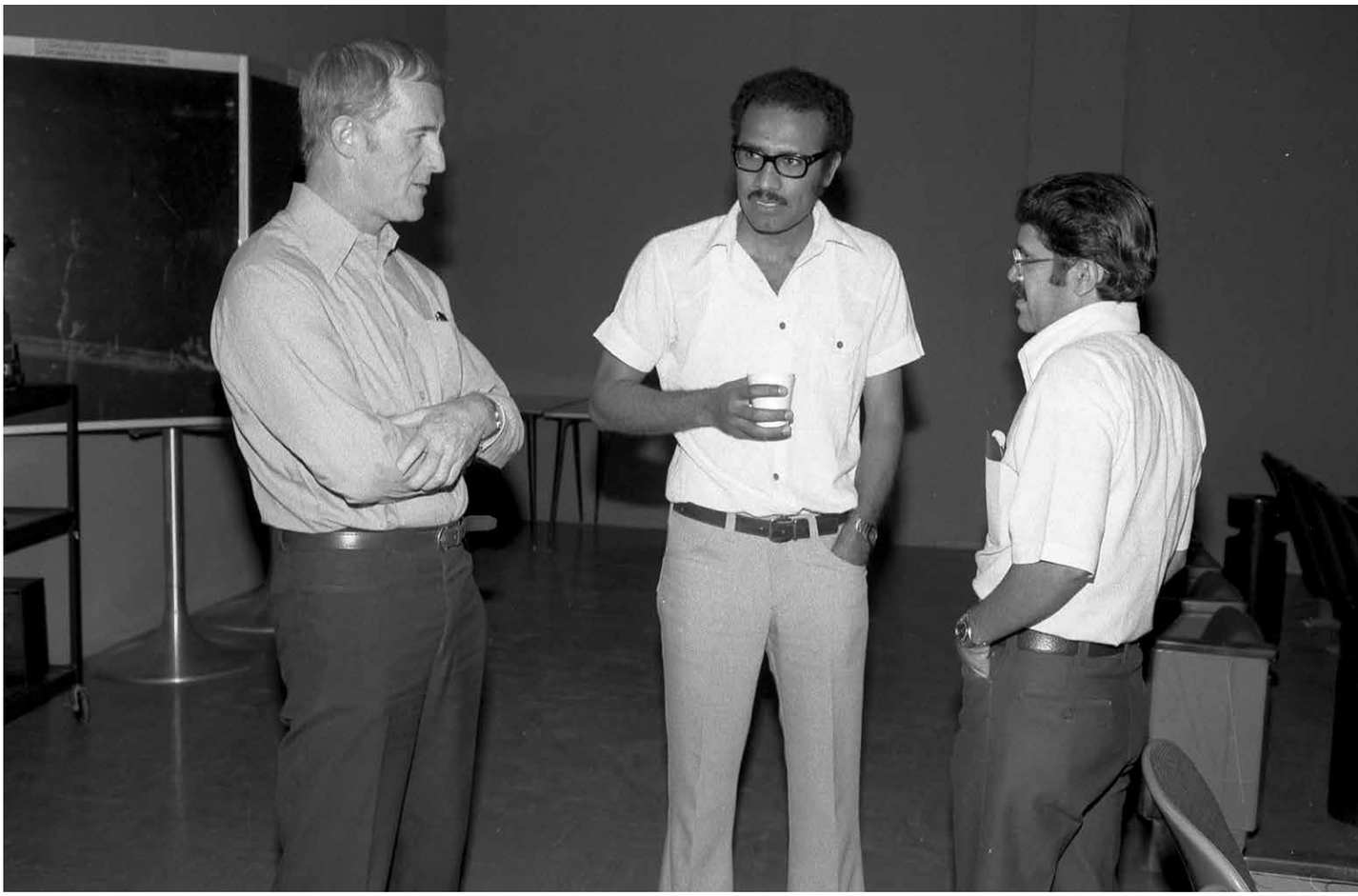
Over the years Aramco developed a succession planning system for Saudi and expatriate employees. Every management job — supervisor through senior vice president — had to have three candidates listed as having the potential to fill the job. The charts specified the training or experience each candidate needed, and how much time that would require.

The government generally avoided interfering in company personnel matters. Minister Yamani, however, as the person with responsibility for overseeing the development of the Saudi petroleum industry, monitored the trend of senior Saudis progressing through the management ranks. As Baldo Marinovic, appointed head of the Management Development Department in 1978, recalled, Yamani requested that the department develop a highly confidential chart for tracking Saudi candidates at the general manager level and above. On what came to be known as the "greening of Aramco" chart, a box representing an executive position held by a Saudi was colored green; a box where a Saudi candidate was considered ready to assume the position within two years was striped green; and boxes representing the positions for which there were potential Saudi candidates but no specific time frame for their promotions were outlined in green.

Only a handful of department executives ever saw the chart, which was carried by hand to and from meetings in Riyadh and otherwise kept locked in an Aramco safe. Given the high visibility and prestige attached to Saudis who reached senior positions in the company, the chart "was dynamite," said Marinovic.

One of the most closely tracked candidates was Al-Naimi. When Jungers asked him to go for a ride around Dhahran on May 1, 1975, Al-Naimi did not think anything special was in store. Jungers often sought Al-Naimi's opinion on a variety of topics. The 40-year-old Saudi had been promoted just the previous fall to manager of Northern Area Producing, which gave him oversight responsibility for 11 of the company's 15 producing oil fields. He would not be in line for another promotion for years. Or so he thought.

Jungers pulled to a stop in front of the Administration Building and turned toward Al-Naimi. "Ali, I want to congratulate you. The board just elected you a vice president of the corporation." Al-Naimi had high hopes for his career, but he was completely taken by surprise when he was named to the new post of vice president of Producing and Water Injection, making him just the second Saudi vice president.



Ali Al-Naimi, right, vice president of Producing and Water Injection, chats with Manager of Public Relations Abdallah S. Jum'ah, center, and filmmaker and photographer John Feeney, left, in Dhahran in 1976. As the company workforce expanded, greater numbers of Saudis rose higher in the ranks. By 1976, Saudis held 46% of Aramco's supervisory positions.

"MOST AMBITIOUS ENERGY PROJECT IN HISTORY"

A few years before the 1973-74 oil price rise brought unprecedented wealth to Saudi Arabia, King Faisal had implemented a program to achieve the Kingdom's First Five-Year Development Plan in 1970. It was created when annual oil-related revenue topped $1 billion for the first time. The plan predicted a modest 9.5% annual increase in oil revenue. Drawn up with the help of the Stanford Research Institute, the plan amounted to a somewhat cautious listing of projects, reflecting the relatively slack oil market conditions in 1968 and 1969 when the plan was formulated. In two years, surging oil revenue, which hit $2.7 billion in 1972, poured into government accounts, even before the spike in oil prices triggered by the 1973-74 embargo.

Aramco and its oil processing facilities provided roughly 90% of Saudi Arabia's revenue as the 1970s began. Government experts and outside advisers had been debating for years the best way to spur further industrialization in the country. Their goal was to diversify the economy and provide employment opportunities for Saudis coming of age, including the increasing number of college graduates. An obvious solution was to tap the huge amount of natural gas, produced along with crude oil, and use it as a low-cost fuel for industrialization. With the oil boom well under way, the country could afford such a massive undertaking.

At the time, most but not all natural gas was flared. Since 1955, Aramco had been reinjecting gas separated from crude oil back into oil fields to maintain reservoir pressure, starting with a plant in Abqaiq. Al-Naimi, who had been named a superintendent of operations in 1969, recalled that this plant was used to inject about 200 million standard cubic feet per day (scfd) of gas "to maintain the reservoir pressure at Abqaiq field. In [the] late fifties and early sixties, another plant was constructed at 'Ain Dar for similar purposes, the injection of 200 million cubic feet approximately of associated gas to maintain the pressure at 'Ain Dar and Shedgum [in the Ghawar field]."

"Bulldozers were going twenty-four hours a day"

Before the 1930s, Saudi Arabia was virtually unknown in non-Muslim countries. The discovery of oil brought the country greater international attention and increased the pace of modernization. At the time of discovery, most of the population resided along the coasts or in oases in villages of mud-brick huts. Riyadh had only 30,000 residents. Today, more than 83% of the population lives in cities, and Riyadh has blossomed into a metropolis of more than 6.5 million. Hospitals, universities, paved roads, and suburban communities, developed by a combination of Saudi and foreign labor, now stand in what once was empty desert.

Baldo Marinovic, former assistant to the chairman of the board, recalled the rapid growth of the 1970s: "That boom was something incredible. Roads were being built, bridges, ports, hospitals, oil facilities, gas facilities — I mean, bulldozers were going twenty-four hours a day, cement mixers. Every big construction company in the world was there. ... And they all had to work with local partners, of course, which made the local partners very rich."

Aramco's technical assistance to Saudi farmers helped 25 farms produce more than 18 million eggs in 1966. Saudi farmers in turn helped Aramco, supplying vegetables and other vital foodstuffs to its dining halls and commissaries that the company would otherwise have needed to import from abroad.

The Aluminum Products Company, or ALUPCO, began operations in Dammam in 1975. As the Saudi economy expanded in the 1970s, Aramco increasingly turned to domestic enterprises for goods and services. In 1975, Aramco awarded some 400 major contracts, worth roughly $250 million, to Saudi businesses for construction and other services, and purchased more than $700 million worth of goods from local suppliers.

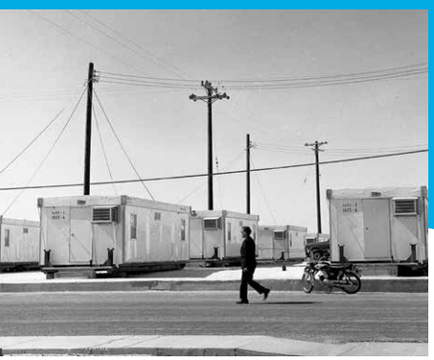
Aramco played a key role in this surge of development, providing technical and financial assistance to a host of services and industries, from health and dental care to a soft drink bottle factory. In al-Khobar, Aramco paved streets and constructed curbs and sidewalks, while in neighborhoods where Saudi employees built homes under the company's Home Ownership Program, Aramco did site preparation; paved streets; and built curbs, sidewalks, and playgrounds. The company's local Industrial Development organization supported a variety of businesses, including paper, plastics, and paint manufacturing; cold storage and meat processing; a hollow-glass factory; and service shops for valve repair, electronic maintenance, air conditioning, water well drilling, heavy equipment overhaul, and others.

On an experimental farm in al-Hasa and at other venues, company agricultural experts transferred knowledge and technology to Saudi farmers and agricultural technicians about the dairy and poultry industries, vegetable and fruit production, weed control, mechanization, modern packing, and beekeeping. One of Aramco's most significant contributions was its support behind the creation of the Kingdom's industrial standards for safety, the environment, materials, design, and construction.

The company's scholarship and training programs supplemented government efforts to provide every interested citizen with a free education through a constantly expanding school system. Today, 95% of Saudi children receive their primary through secondary education in government schools, and 29% go on to college. Many of these students will eventually apply their skills at Aramco, the largest employer in the Kingdom today behind the government.

"Lest we forget"

Many of the thousands of expatriate professionals who joined Aramco in the 1970s found themselves living in somewhat less than ideal conditions, such as these trailers in Dhahran in 1976, as the company expanded its ranks of employees faster than it could build permanent housing.



A lot of new employees among the expatriates in the 1970s did not work directly in the oil fields or in the processing plants, which were more than 90% Saudi-operated by that point. Thorn Snyder, Aramco's chief economist for many years, was known for an orientation talk he gave to new expatriate hires. William Laney Littlejohn, who joined the company as an economist in 1972, recalled:

> *Thorn … explained to the new employees what the world energy market looked like, what the oil market looked like, what Saudi Arabia's role was and what Aramco's role was in the international oil markets. He recognized that after a little while, wherever you worked in Aramco you could forget what it was you were really over there doing — say if you worked in data processing, or accounting, or in the hospital. Thorn would wind up this talk holding a lab jar of Arabian Light crude oil and say, 'Lest we forget.'*

Since the early 1960s, Aramco had also been capturing a modest amount of heavier natural gas liquids, or NGL — propane and butane — while processing oil at Abqaiq. This byproduct was shipped by pipeline to Ras Tanura. There, the NGL was processed and stored in refrigerated tanks. Some NGL was sold locally, and some was shipped to overseas buyers, mostly in Japan. That left the lighter natural gas, methane, to power the industrialization of the country.

In 1962, the government created the General Petroleum and Minerals Organization, better known as Petromin, which between 1964 and 1968 purchased all of Aramco's product distribution facilities in the Kingdom. Petromin had been studying industrial applications for the country's natural gas even before the government acquired a 60% stake in Aramco in 1974. Petromin hired Texas Eastern Engineering Ltd. to do a feasibility study. As Aramco economist William Laney Littlejohn recalled, Petromin delivered the multivolume study to Aramco in 1975 and said, "Build it."

The Master Gas plan was one of the cornerstones of the Kingdom's Second Five-Year Development Plan, which was unveiled in February 1975. Its release marked one of the last official acts of King Faisal, who was tragically assassinated a few months later. He was succeeded by Crown Prince Khalid.

The Master Gas plan was unprecedented in scope, as well as cost. The government asked Aramco to design, develop, and operate a gas-gathering and processing system to fuel the industrial network that was being developed on a parallel track. In June 1976, after conducting its own feasibility studies, Aramco estimated the Master Gas System (MGS) would cost between $12 billion and $14 billion. The company described it as "the most ambitious energy project in history."

By 1975, even before the hiring tied to the MGS project started, the Aramco workforce had nearly doubled in five years to 19,500 workers. That demand for workers was driven by two Aramco projects, which were the largest of their kind in the world: the offshore Zuluf GOSP-2 and the Qurayyah Seawater Treatment Plant. Aramco scrambled to build and operate construction worker camps at eight sites in the Eastern Province to support the crude oil expansion projects as well as the MGS. By 1977, the camps had the capacity to house 37,900 bachelors and 875 families. When it could not find or build sites fast enough on land, the company towed in five-story accommodation barges from Singapore and Japan, each with its own generators, desalination facilities, air conditioning, dining halls, and recreation areas. These "floating hotels," as the company called them, were anchored offshore at Ju'aymah and near Dhahran and housed another 4,500 workers.

In 1980, five years after the government requested Aramco to design, build, and operate the Master Gas System (MGS), the massive project was 75% complete. Key components of the MGS began operations or were completed that year, including the Shedgum Gas Plant, shown here.

The MGS had a dramatic impact on Saudi contractors as well as on industries and businesses ranging from earth moving to construction, steel, cement, and welding. In 1975, Aramco awarded roughly 400 contracts for MGS work valued at $250 million to Saudi firms. The following year, the amount of gas-related construction business directed toward Saudi firms jumped to 620 major contracts valued at $1.7 billion, and in 1977, the value of 730 gas system contracts for Saudi firms reached nearly $2 billion.

Aramco's American shareholders were ambivalent at best about the gas program. From their perspective, there was little profit in selling Saudi gas. Committing Aramco to the MGS was a distraction, even if it did not directly divert Aramco resources from the oil business. Jungers seized on the gas initiative as a new vehicle for making Aramco, and its American shareholders and management, increasingly important to the Kingdom's development. Other Aramco employees concluded that Jungers was

A residential barge was moored near Half Moon Bay, down the coast from Dhahran, evidence of the housing crunch Aramco faced in the mid-to-late 1970s. By 1978, the year after this photo was taken, Aramco was using six such vessels to house contractor employees.

not about to let any other company elbow its way into the Kingdom and run the gas program if he could avoid it. The shareholders acquiesced, especially since the Saudi government was paying the bills out of its oil revenues, not Aramco profits.

The MGS was designed to provide fuel or feedstock for domestic electrical power, cement, and desalination plants, and for petrochemical, fertilizer, and steel-making facilities. Two of the largest proposed users for the gas were the sprawling industrial cities being constructed at Yanbu' on the Red Sea and Jubail on the Gulf. Aramco also used the gas to power many of its own facilities.

At the heart of the system were gas-gathering facilities in four oil fields in the Eastern Province, gas-processing plants in the Eastern Province and on the Red Sea coast, and export terminals at Ras Tanura, Ju'aymah and Yanbu'. By the time the initial system was completed in 1982, it could process about 3.5 billion scfd of gas — the energy equivalent of 750,000 barrels of crude oil.

Aramco had used associated gas to maintain pressure in oil reservoirs, but that gas was now slated for industrial use. The company turned to a more efficient alternative for maintaining reservoir pressure: injecting treated seawater. In 1978, the Qurayyah Seawater Treatment Plant began pumping 3.7 million bpd of seawater from the Gulf. The plant removed impurities (but not salt), and huge pipelines carried the water to injection facilities in the Ghawar field. It was a massive undertaking and involved several technical hurdles, including engineering the metallurgy of the pipes to withstand the corrosive effect of the extremely salty water from the Gulf. The seawater injection system also replaced the use of water drawn from onshore saline aquifers for reservoir pressure maintenance.

The Port of Jubail, shown here in 1978, grew rapidly following a 1975 Royal Decree to create two industrial cities, Jubail and Yanbu', linked by pipeline to Aramco's Master Gas System for a ready and low-cost supply of fuel and feedstock.

Operators in the control room of the Qurayyah Seawater Treatment Plant in 1979 monitor the processing and delivery of 4.2 million bpd of seawater for injection into oil fields to maintain reservoir pressure.

Construction of the East-West NGL Pipeline reached Banban, a small town near Riyadh, in September 1979. The pipeline linked Aramco's Shedgum Gas Plant to the industrial city of Yanbu', 1,170 kilometers across the Arabian Peninsula on the Red Sea coast. Aramco also built an NGL fractionation plant and a marine terminal at Yanbu'.

As work on Qurayyah was wrapping up in 1978, Aramco embarked on another major aspect of the MGS: building an NGL pipeline across the country from the Shedgum Gas Plant in the Eastern Province to Yanbu' on the Red Sea. It ran parallel to Petroline, a crude oil pipeline Petromin was building, and went into service in July 1981.

The 1,170-kilometer pipeline crossed some of the roughest terrain on the Arabian Peninsula, from sand dunes to lava fields and mountains. As Saleh Al-Redaini, the senior engineer on the project, recalled, "Going across Saudi Arabia we had to drill our own wells for water supplies and build our own roads for transportation, especially in the west." The NGL pipeline represented state-of-the-art technology unimaginable a generation earlier. "The electronic survey work was unique and the pipeline design too had many unique features, such as electronic welding," said Al-Redaini.

Electronic welding involved suspending two 12-meter lengths of pipe over the pipeline trench by side loaders, where they were joined by automatic welders: one moving through the pipes and the other along the outside. In the course of the project, these remarkable machines made 45,000 welds. On July 28, 1980, the final section was lowered into a shallow trench 1,082 meters high in the Hijaz Mountains.

POWER PLAY

Despite the country's increasing public and private wealth, the electrical power grid in the Eastern Province, and the power systems covering most of Saudi Arabia, remained inadequate, restricting business development and limiting the opportunities for average Saudis to improve their quality of life.

Zuluf GOSP-2 came on-stream in July 1977 with a design capacity of 540,000 bpd, making it Aramco's largest offshore GOSP to date and one of the largest in the world. The main platform was connected by a 46-meter bridge to the auxiliary platform with living quarters for 80 men topped by a helipad.

Modest beginnings

Although it was not the first time Aramco had hired Saudi women, the worsening personnel shortage at Aramco by the mid-1970s prompted the company to seek government approval to train Saudi women for office and clerical jobs that until then had been filled by men. After five years of on-again, off-again planning and negotiations, Aramco opened the Special Clerical Training Center, its first training facility for Saudi women, on Jan. 24, 1976. The center was located in a one-story building across the street from the Administration Building in Dhahran. It opened with 10 young women as students.

Samia Al-Edrisi, front row, third from left and in the center of the group, was the first Saudi director of the Special Clerical Training Center. Shown here with the center's teachers and staff, including Masha'el Mo'ammar, back row, far left, a Saudi instructor of English, Al-Edrisi oversaw the growth of the center from 40 students in 1977 to 150 in 1981.

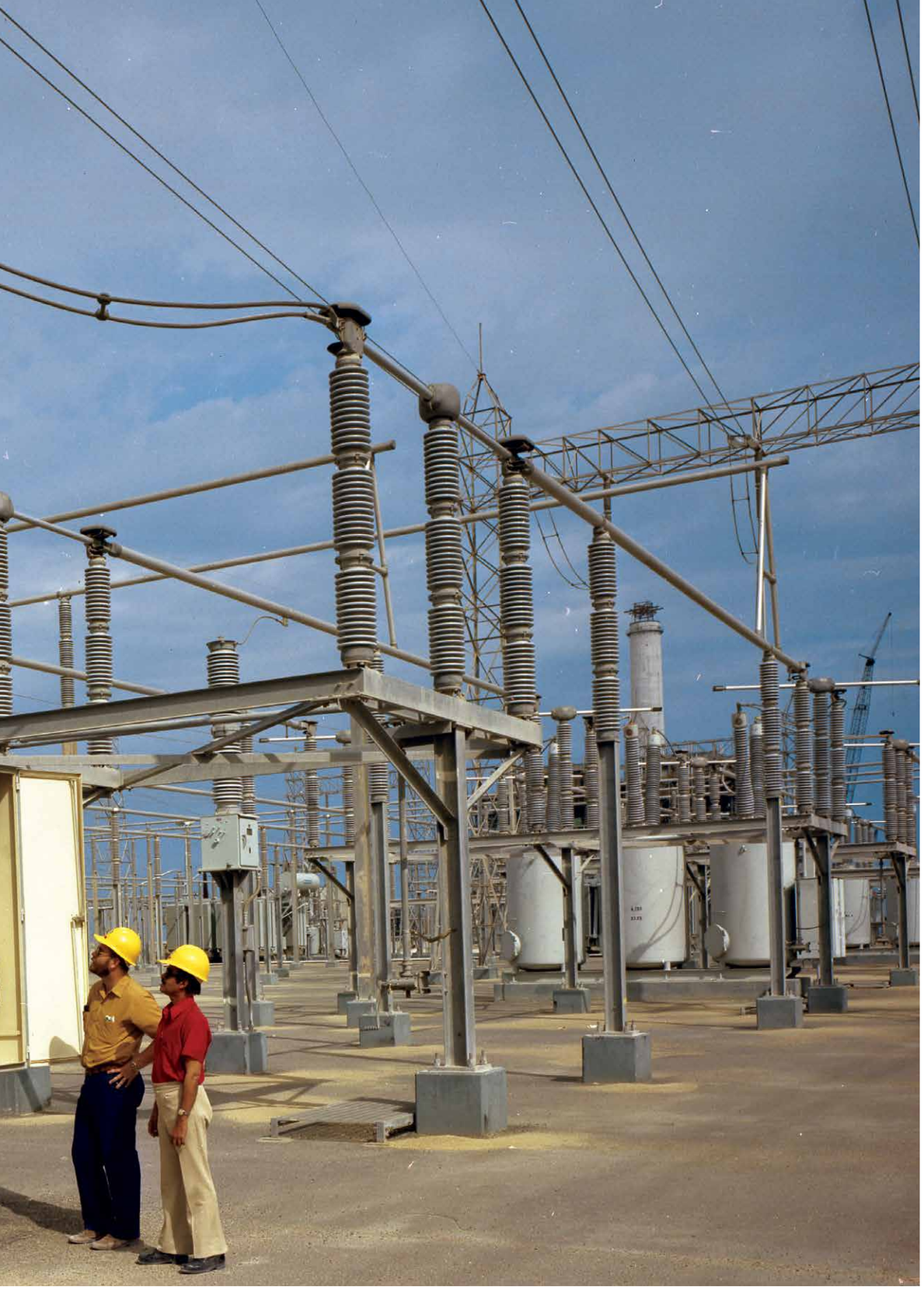
The staff, comprising Arab and American women, included three instructors and a supervisor who also was a part-time instructor. The only Saudi on the original teaching staff was Khalidah Al-Khayyal, the daughter of a Saudi diplomat and holder of a college degree in psychology. In 1977, another Saudi woman, Samia Al-Edrisi, was named to run the center. She had been a translation specialist in Government Affairs, and had graduated from the American University in Cairo with a major in political science and economics.

The center trained Saudi women to take over jobs from a list of 231 clerical positions, such as correspondence classifier, typist, receptionist, medical clerk, and library assistant. Within a few years, the program expanded to include chemistry and science courses. Additional subjects were added later. In 1980, the company provided scholarships to attend colleges in the United States to three of the program's highest achievers: Nadia Al-Shihabi, Badria Al-Sindi, and Haifa Al-Taifi. By the early 1980s, the women's program had outgrown its original location and a new two-story women's training center was completed in May 1982.

Since that time, women have gradually assumed increasingly complex and sophisticated responsibilities at Aramco, including positions in petroleum engineering, reservoir management, information technology, and human resources administration.

By the mid-1970s, the situation had improved somewhat, but the insufficient infrastructure Jungers had observed was stretched to the breaking point: "The power that the local power companies had was outdated, old diesel generator sets that they tried to hook together. They weren't integrated, all localized power, and it was going off all the time, and the transmission facilities were terrible. So, we thought of the idea of forming a consolidated power system."

If embracing the gas project was a reactive move on the part of Aramco and Jungers, the other major project that Aramco took on in the mid-1970s — creating a unified electrical power grid in the Eastern Province — demonstrated that Aramco's characteristic determination could solve some of the toughest problems in the Kingdom. The Saudi Consolidated Electrical Company (SCECO) became a key part of Aramco's and Jungers' legacy.



One of Aramco's most challenging projects in the 1970s was unrelated to oil: the creation of a unified electrical power grid in the Eastern Province. The facility in this 1979 photo, one of a pair located near Ju'aymah, began operations that year, increasing the total capacity of the Saudi Consolidated Electrical Company (SCECO) to almost 1,900 megawatts.

While solving a serious problem for the government, however, Jungers may have further eroded his support among the American shareholders by championing yet another major project that was only tangentially related to the oil business. As Powers, who served as president under Jungers, recalled, "The owner companies were dead set against it. … They saw it would diffuse our efforts from the oil and gas business, because here we were building power lines, whole substations, whole power plants, everything."

Years later, Jungers described the events that led up to the creation of SCECO:

> *It again was in that period when we were moving ahead with the gas program that it occurred to me primarily that we had to do something with our power system. Aramco had its own power company, its own power. All of our communities were run by our own power plants, and they were as reliable as any power plants are anywhere.*

Sometimes we went to the local towns at night for dinner with our Saudi friends, and all of a sudden the power would go off, and it would be hot because the AC would be off. And still Aramco's community nearby was lit up and functioning. These people are there damning their own power system, which was only going to end up with discontent and wondering why only the "Aramco foreigners" had power.

Over the course of several months, a group of Aramco officials worked out the details of how the 26 local power companies would be combined with Aramco's power plants. In August 1976, King Khalid issued a Royal Decree creating SCECO. Aramco built, operated, and managed the utility during its first five years of operation, "seconding," or lending, employees to run the utility and train Saudis in the industry. This mandate was later extended to 1983, when the management agreement was replaced with an agreement for loaned employees and services to be provided by Aramco.

SCECO's original service area included approximately 90,000 people in about 200 communities and covered an area roughly the size of New Zealand, as well as the industrial city under development at Jubail. Within five years, the utility's customer base more than doubled to 195,000, many of whom lived in remote villages that previously lacked electricity. The SCECO experience was later copied in other regions of the Kingdom, and eventually all of the regional power companies merged into a single Saudi Electricity Company power grid.

Being assigned to a power company that Aramco was going to operate on behalf of the government may have sounded like a questionable career move, but several future senior Aramco executives made their mark at SCECO. John Kelberer, who had worked on Tapline issues in New York in the mid-1970s and earlier had worked as an engineer on Tapline in Beirut and in Saudi Arabia, came to Dhahran and succeeded Jungers to become the last American chairman of the board and CEO of Aramco. Initially for a short period, though, Kelberer was a member of the board of SCECO and its managing director. One of the first staffers assigned to SCECO was a Saudi from Aramco's Public Relations Department who had recently returned from a management training course at Harvard. His name was Abdallah S. Jum'ah, manager of Power Systems Public and Customer Affairs from 1977 to 1979.

Aramco insiders universally credit Jum'ah with outstanding people skills and cite this ability as among the most important factors in his eventual rise to the positions of president and CEO. Jum'ah himself credits his time spent in the field with SCECO in the late 1970s as one of the most influential assignments in his career. One of his responsibilities was to act as the liaison with the 26 power companies and with the remote villages around the province that were to be included in the SCECO grid. He listened to the villagers' concerns and convinced them that connectivity to the grid could not happen instantly. One story Jum'ah told illustrated the knowledge and cultural gaps he had to bridge as part of his assignment:

We had a line of 10 villages, and we ran the 115 kV [kilovolt] line to the end where we put a big substation to drop the voltage to the usage voltage. Then, as part of our value engineering, we said, '… Why don't we put the substation in the village before last, and run a cheaper line to the other village.' I had a delegation coming from the last Bedouin village saying, 'We don't want the leftovers,' because they felt that electricity coming in on a smaller line was leftovers.

I've seen hundreds of people in my office, from all walks of life; someone concerned about a problem, a representative from a village asking about progress on the distribution network. I love dealing with people, and it's been the most rewarding experience of my career so far.

PLANT SAFETY

The huge increase in the amount of oil being processed by the mid-1970s made the potential for loss of production, and loss of life, all the more significant. A handful of accidents at Abqaiq during the 1970s, beginning with an August 1972 fire that led to the deaths of 13 workers and injured 13 others, prompted the company to overhaul safety procedures. The turning point came in 1977.

Despite the tremendous demand for personnel during the mid-1970s expansion, Aramco continued to sponsor out-of-Kingdom education for Saudi employees. In 1976, a total of 54 personnel were sent to high schools and universities in the United States. This group of young men composed the second batch to be sent that year.

Larry Tanner, vice president of Plants and Pipeline, was flying with a group of reporters to different Aramco sites in early May 1977 when he spotted a pillar of smoke rising from the direction of Abqaiq. His worst fears were confirmed minutes later when he received a call on the plane radio requesting him to return to Abqaiq as quickly as possible. A buried crude oil pipeline had ruptured, and flames were engulfing entire sections of the world's largest oil-processing plant, as he later described: "The fire had burned up most of the [gas-oil separation] spheroid area. Shedgum [oil field] was [at an elevation] 600 feet above Abqaiq with 100,000 barrels of oil in the pipeline. We could not close the valves to keep the additional oil from feeding the fire. They were starting to close one valve and it took hours. … We had basically [to] shut Abqaiq down." At that time, 10 million bpd of oil were being processed at Abqaiq.

As they stood amid the smoking ruins of the plant on the afternoon of the fire, Jungers and Yamani bombarded Tanner with questions. The fire had killed a Saudi foreman, Muhammad Al-Sunayyin, injured 13 workers, and caused $100 million in damage. Tanner and Jungers estimated they could get the plant back to full capacity in one month. Lying awake that night, Tanner blamed himself for making such an aggressive estimate, but Aramco rose to the occasion. Working under tremendous pressure, repair crews had the facility producing at more than 50% of capacity in less than a week. Thirty-four days after the fire, Abqaiq was operating at full capacity, though with a temporarily diminished gas separation process.

A lengthy safety review led to company-wide changes in the treating of buried pipelines, including gas pipelines, following another fire caused by a ruptured gas pipeline in 1978 in the Abqaiq oil field. Substantially more firefighting equipment and concrete dikes and trenches between processing plants were also installed throughout the company. Dhaifallah A.F. Al-Utaibi, who retired as senior vice president of Gas Operations in 2004, was head of maintenance in Abqaiq at the time of the fire. He recalled that "it took time and money [but] the outcome transformed the facilities from where they were to first-class facilities, and kept them that way."

REFOCUS ON SAUDIZATION

With the massive buildup of projects and personnel during the mid-1970s, Saudization — the term used to describe the development of Saudis to assume company positions — slowed down considerably. It was all the company could do to bring in bodies to fill positions; individual career development, with certain key exceptions, took a backseat. In addition, by late 1977, it was widely rumored that Jungers was on his way out, and he left the company in January 1978. (Powers, president under Jungers, was moved to the newly created position of vice

Aramco CEO Frank Jungers, right, hosts a press conference with journalists from Saudi newspapers to discuss the May 1977 Abqaiq fire, which killed one worker and injured 13 others. Those present include Hamid Mutawi', Abdullah Manna', Muhammad Al-Jihian, Jihad Al-Khazin, Khidr al-'Ali, Muhammad Al-Atiq, Fahd Al-Dossary, Bob Crew, Ahmad Muhammad Mahmud, and 'Abd Al-Majid Shubukshi.

chairman in 1978. He retired in March 1979. Replacing him as president in 1978 was Hugh H. Goerner, a senior official from Exxon.) While the Saudization process had lost its most high-profile champion in Jungers, this crucial initiative was taken over by a new advocate, and this time he was himself a Saudi.

Al-Naimi had risen to the level of senior vice president of Oil Operations in 1978 and was the highest ranking Saudi in the company. When John Kelberer succeeded Jungers as chairman and CEO of Aramco in 1978, he ordered a review of Saudization, which generated several recommendations. A key to his plan was to form a Saudi Arab Manpower Committee (SAMCOM) and make Al-Naimi its first chairman.

The committee's goal, Al-Naimi later said, "Was to seek, track and make sure that Saudi manpower was developed at all levels … coming from high school or going to college [or] coming back as a professional development [program] employee, and also seeing to it that after they finish these so-called PDP programs, they are pursuing their career." He noted that "Saudization had been through many tracks … 1979 was really a formalization … we were able to track every Saudi who exhibited potential for further development."

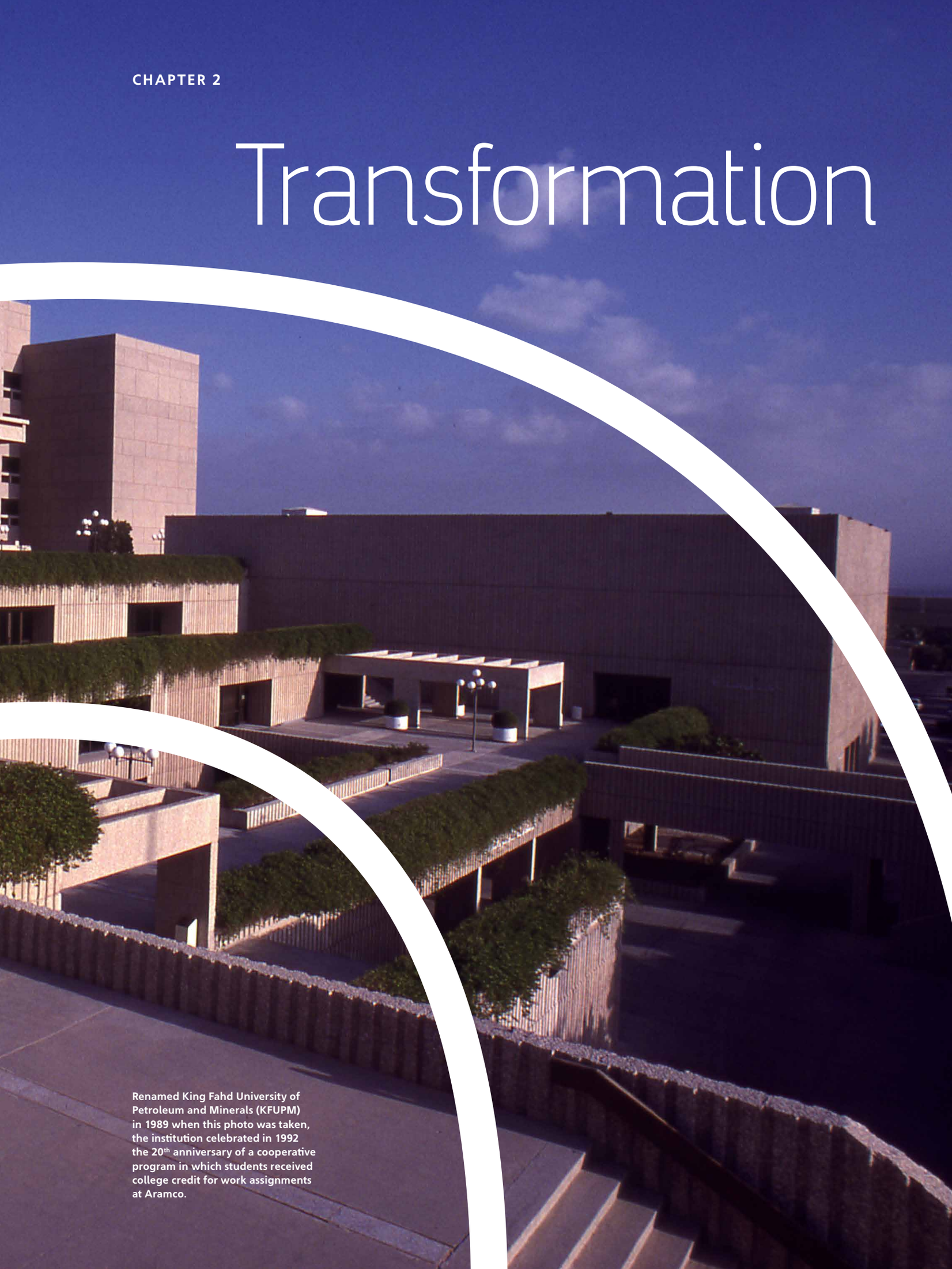
Following months of negotiations, the government announced in February 1979 an agreement to buy the remaining shares in Aramco and assume full ownership of the company. This surprised no one. Aramco officials and the four American shareholding companies had for some years assumed the inevitability of such a step. The agreement was signed in 1980 and on a financial basis was retroactive to 1976.

Fully owned by the Saudi government and refocused on developing and promoting qualified Saudis through the ranks, Aramco had helped engineer the smoothest and most effective transition to national ownership the world had ever seen. Rather than acrimoniously severing ties with the Western companies that had developed its oil industry — as had been the case elsewhere — the now Saudi-owned Aramco maintained close commercial and technical ties to its former American shareholders. Indeed, the government retained Aramco to manage the company on its behalf for a number of years. King Khalid and Minister Yamani recognized the need to maintain access to expatriate technical expertise as the government continued to groom Saudis for more senior roles.

Symbolic of the rapid growth occurring in the major metropolitan areas in the Kingdom in the 1970s and 1980s, Jiddah, seen here in 1974, grew upward and outward.

CHAPTER 2

Transformation



Renamed King Fahd University of Petroleum and Minerals (KFUPM) in 1989 when this photo was taken, the institution celebrated in 1992 the 20th anniversary of a cooperative program in which students received college credit for work assignments at Aramco.

A field geologist examines rock in October 1989, part of an exploration campaign that surveyed new prospect areas. In the years following the original 1933 concession and the supplemental 1939 concession, Aramco's exploration area had been reduced through a series of relinquishments. In 1986, the government requested that Aramco expand its exploration activities to include areas it had previously relinquished. In 1988, a Royal Decree approved company exploration activities Kingdomwide.

On May 16, 1983, Saudi royalty and dignitaries, led by King Fahd, celebrated with company officials and employees in the recently completed Exploration and Petroleum Engineering Center — commonly known as EXPEC — at the center of the Aramco office complex in Dhahran. The event marked the 50th anniversary of the signing of the Concession Agreement by which the Kingdom granted Socal the right to explore for oil in eastern Saudi Arabia.

King Fahd, accompanied by Crown Prince Abdullah, waves to the crowd during Aramco's 50th anniversary celebration in May 1983 after inaugurating Aramco's Exploration and Petroleum Engineering Center (EXPEC).

King Fahd, who had succeeded his brother King Khalid when he died in 1982, honored the "Saudis and non-Saudis who have exerted themselves so greatly, and contributed to making Aramco what it is today."

Though the event rightly honored those who had transformed the Kingdom through its oil industry, the speeches that day focused not just on an illustrious past but also on a promising future. Minister Yamani told the crowd, "Aramco is now a Saudi Arabian institution that 'speaks our language.'" He added, "We hope that the sun of this year will not set until a Saudi has become president of this company." His prediction became reality that November when the Aramco board of directors appointed Ali Al-Naimi the company's first Saudi president, effective January 1984.

The 1980s were a crucial period in the transformation of Aramco, as the Saudi government assumed full ownership of the company in the first year of the decade. The creation of EXPEC reflected this major shift in that EXPEC enabled Aramco to consolidate all of its high-tech exploration and petroleum engineering functions in Dhahran, work that had previously been performed in the United States or Europe by the four former owner companies.

This transformation continued when Al-Naimi assumed his duties as president in 1984. Al-Naimi was a product of the company's career development and Saudization programs and proof of their success. A Saudi national, he was elected because he was the most qualified due to his extensive training and years of service with the company. Al-Naimi, said Yamani, was not selected to be president "because he is Saudi to satisfy national

On November 8, 1983, the Aramco board of directors selected Ali Al-Naimi, seated right, as the company's first Saudi president. His appointment took effect January 1, 1984.

sentiment, but because he earned the office through sweat and hard work, and because he has built himself and helped build others."

PLANNING FOR PROSPERITY

Aramco had been caught short-staffed when the 1970s oil boom began. Company planners were determined not to make that mistake again in the 1980s. Extrapolating from trends at the end of the previous decade indicating strong global demand for oil, Aramco's corporate planners predicted the company needed to hire 30,000 more Saudis by 1985, more than doubling its Saudi workforce, to reach an anticipated total payroll of 75,000 employees.

To help train these new employees, the company approved a training budget of nearly $300 million for 1980. New programs were introduced, training facilities built, and staff added. "Developing people is time-consuming and expensive, but it pays off in the long run — both from the individual's and the country's point of view," noted Abdulaziz M. Al-Hokail, senior vice president of Industrial Relations in the early 1980s who retired in 2002 as executive vice president of Manufacturing Operations.

Fortunately, Aramco could afford to foot the training bill. The company's revenues ballooned by 1980 to more than $84.5 billion. In the wake of the Iranian Revolution in the late 1970s, global oil prices soared once again. Arabian Light crude oil climbed from $12.70 a barrel in 1978 to $26 a barrel by January 1980. Aramco, making up for lost Iranian oil output, produced a record 9.6 million bpd during 1980, an increase of 1.5 million bpd over 1978. Saudi Arabia was now the world's second-largest oil producer, after the Soviet Union's 11.7 million bpd. (The United States was third at 8.6 million bpd. No other country was close to the top three. Iraq was fourth largest with 2.6 million bpd.)

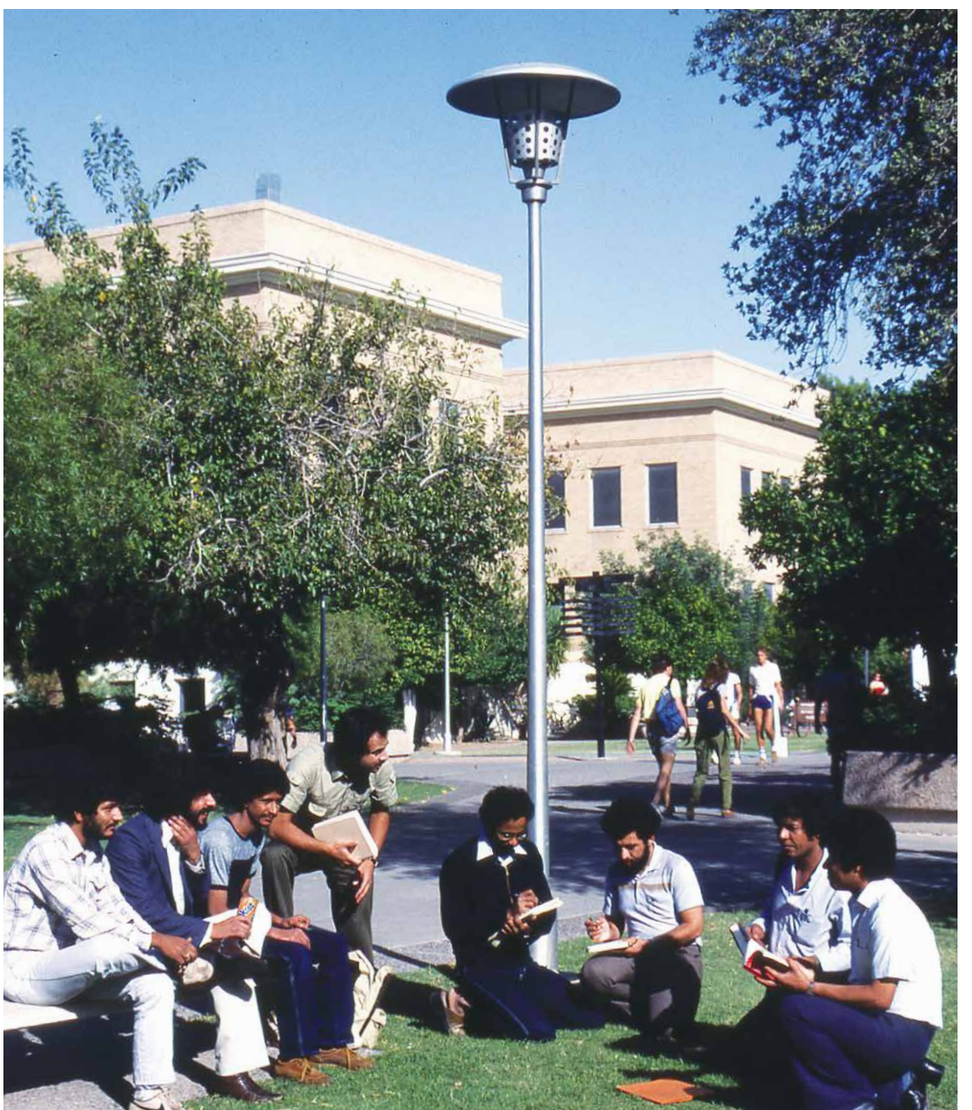
THE FAST TRACK PROGRAM

During this period, Aramco significantly stepped up the hiring of Saudi high school students in anticipation of sharply higher staffing needs. In the decade prior to 1979, the company hired an annual average of only 90 high school graduates; that year the number expanded enormously, to 796. In 1980, the figure jumped again, to 1,281.

The College Fast Track Program, instituted in 1979, attracted a great deal of interest among Saudi high school students. High school graduates with a grade average of 85 (out of 100) or better who agreed to join Aramco were sent to the United States for up to one year of intensive training in English. Those who achieved a 500 or better (out of 677) on the Test of English as a Foreign Language (TOEFL) proficiency exam qualified for an Aramco college scholarship. Even though only 57 high school graduates, including 13 women, qualified in 1979, many high school students joined Aramco after being initially attracted by the College Fast Track Program.

Aramco also intensified its pursuit of Saudi college graduates. In 1979, the company hired 124; in 1980, it hired 203. The two-year total exceeded the number of Saudi college graduates hired by Aramco in the previous two decades. These robust numbers, however, hardly put a dent in demand. Kelberer wrote to members of executive management on Dec. 14, 1981, demanding additional hiring. "Every Saudi college graduate should be hired and developed," he said, adding that the matter was "of utmost importance."

The story of Al-Naimi's rise from Bedouin shepherd boy to president and CEO of Aramco, and later Minister of Petroleum and Mineral Resources, is perhaps the best known example of the company's contribution to the extraordinary transformation of Saudi Arabia and its people, but thousands of Saudis experienced similar journeys.



Aramco-sponsored students gather on the campus of Arizona State University in Tempe, Arizona, in 1982. More than 1,200 Saudi employees were enrolled in university-level programs in Saudi Arabia and abroad that year, emblematic of the company's increased effort to develop Saudis.

The transformation of Saudi Arabia from desert kingdom to modern nation was mirrored in the personal journeys of thousands of Saudis who came of age in the 1950s and rose to high positions in Aramco in the 1970s and 1980s. Some of these accomplished men are shown in this November 1988 photo, including, left to right, Ahmed S. Al-Humaid, vice president of Government Affairs; Douhan Al-Douhan, executive director of Management Services; Sa'ud Al-Ashgar, vice president of Planning; Ismail I. Nawwab, general manager of Public Affairs; and Faysal M. Al-Bassam, vice president of Public Affairs. Standing behind Al-Ashgar and Nawwab is John Duke Anthony, president of the National Council on U.S.-Arab Affairs.

Douhan Al-Douhan, for example, as a teenager in the 1950s made the three-day journey across the roadless desert from Najran to Abqaiq in the back of a truck with more than 20 other passengers. Al-Douhan was "looking for a future" with Aramco. "In the United States, people said 'Go west, young man, go west.' Here, they said 'Go east,'" to Aramco, Al-Douhan recalled. He was not hired on his first application, but later, after working with a local contractor as a welder's helper, he was hired by Aramco and trained as an auto mechanic. In 1965, he was part of a group sent to Temple University High School in Philadelphia to earn secondary school diplomas. Al-Douhan went on to earn a bachelor of science degree in engineering technology from Memphis State University in Tennessee, and after a series of assignments, became executive director of Management Services. He retired in 1995.

Many Saudis who were sent abroad for higher education compiled impressive records. Jaber S. Jum'ah, for instance, was awarded the International Students Award each of the four years he attended Youngstown State University in Ohio. He ranked in the top 1% of his class during all four years, was elected to the national Phi Kappa Phi honor society, and graduated summa cum laude in 1973 with a degree in business administration. He rose in the company to manager level before retiring in 1992.

As coordinator of out-of-Kingdom training in the United States from the late 1950s through 1977, Bob Brautovich oversaw the development of many young Saudis. "I have the greatest respect in the world for those Saudis who came to school here [in the United States]. I don't think I could go to Saudi Arabia and do what they did when they came here," he said.

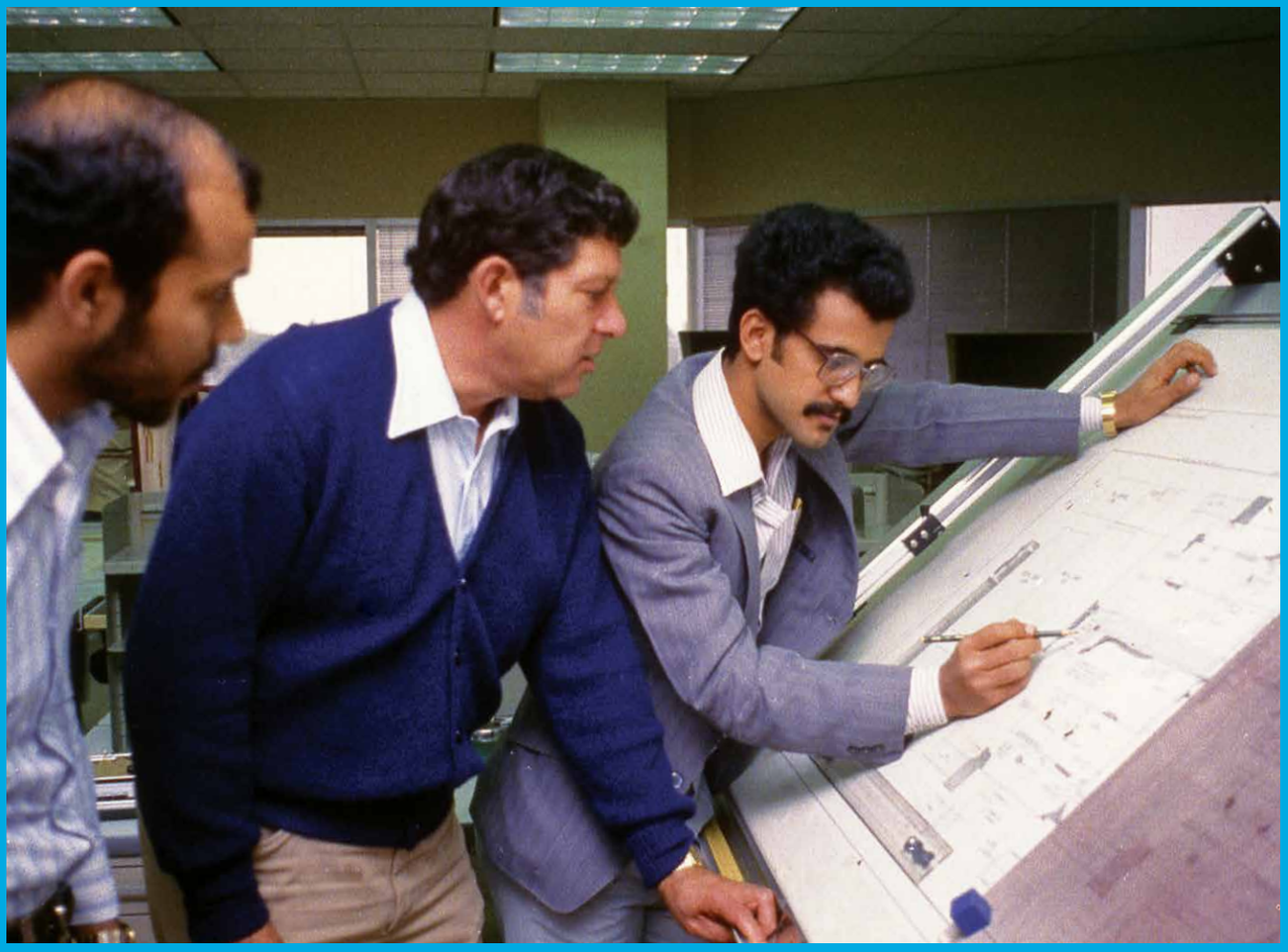
The Saudi college graduates who joined Aramco during this period as professionals were proud that Aramco actively recruited them. At the same time, they faced resentment from some of their countrymen who had worked for Aramco for years but had not had the same educational opportunities. Riyadh University graduate Khalid Nassir Al-Maghlouth joined Aramco in 1980, entering its Professional Development Program. He was sensitive to the fact that among the older generation "many of them had worked day and night for 20 to 25 years to reach grade code 10." He and his fellow college graduates started their careers at grade code 11, the initial professional level. For every complaint, however, there were plenty of Saudi veterans who took pride in the college graduates as representatives of a "bright, new generation" of Saudis, Al-Maghlouth said.

By 1984, Aramco had 55,819 employees. The Saudi workforce totaled 34,226, of which 3,343 held supervisory positions — nearly 62% of the supervisory jobs available. Training these recruits was a top priority for Aramco, which by then had assembled one of the largest industrial training organizations in the world.

Professional Development Program

Aramco's commitment to helping new college graduates integrate themselves into the professional world intensified in 1974, when it established its Associate Professional Program (APP). Initially, the program suffered from high attrition. When the late 1970s brought increased Saudization, Aramco executives reworked the program to hire as many new Saudi college graduates as possible.

In 1980, APP was developed into the Professional Development Program (PDP). The revised curriculum retained the three years of rotating job assignments that had characterized APP, but added written and oral English language courses, a variety of basic training programs, and a stronger individual counseling element. Those with weak English skills spent an additional nine months in a language immersion program.



The work of a young enrollee in the Professional Development Program is checked by a senior staffer in the program's design room. Enrollment in the program fluctuated throughout the decade, peaking at 910 in 1987.

In its first year, PDP enrolled 400 employees, 203 of whom were newly graduated Saudis. This total included new employees with fewer than three years of previous employment, although the program allowed them to follow a different course of study from the recent graduates. Abdullatif A. Al-Othman, who entered the PDP in 1981 after working for two years outside the company and eventually became the senior vice president of Finance and later Governor of the Saudi Arabian General Investment Authority, was relieved to find that the company was "actually very aware of the need for flexibility" for those with prior work experience. The program initially enrolled some expatriates but soon shifted its focus to encompass only Saudis. By 2021, more than 35,000 employees had benefited from the program.

Prosperity Well

The second wellhead from Dammam Well No. 7, which controlled the well's pressure between 1952 and 1978, stood for years outside the Exploration and Petroleum Engineering Center. Today it's displayed at the King Abdulaziz Center for World Culture.

Dammam Well No. 7, the original discovery well that set the stage for the modern era in Saudi Arabia, was finally shut down in 1982 because of slack demand for oil, even though it was still capable of turning out about 1,800 bpd under natural pressure. The well, also known as "Lucky No. 7," had produced nearly 32.5 million barrels of oil. In 1999, King Abdullah, then Crown Prince, visited Well No. 7 during a tour of company facilities and gave it the name "Prosperity Well."

Twenty-five years after the well was shut down, company geologists analyzed newly acquired 3D seismic readings of the Dammam Dome in anticipation of once again producing oil from the structure, but not from Well No. 7. To avoid disrupting life in the Dhahran community, plans were drawn up to use horizontal wells that, from a safe distance, could tap the estimated 1 billion barrels of crude remaining in the reservoir.

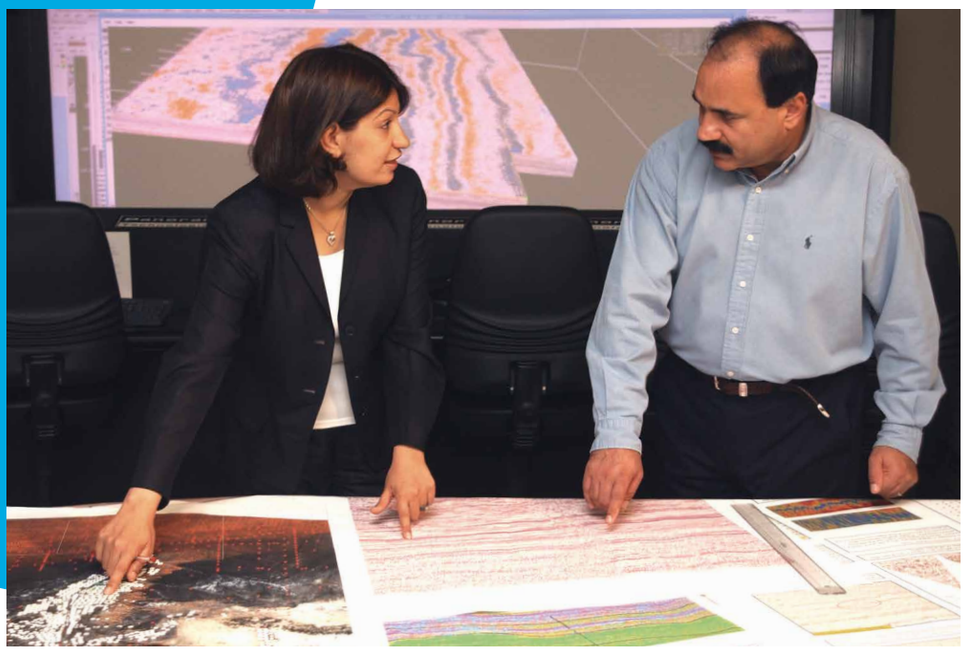
"I SEE A CHALLENGE"

By the 1980s, young Saudis who had witnessed the phenomenal growth of the oil industry and the Kingdom during the 1970s were flocking to Aramco. They were not simply looking for a paycheck or status; many wanted to make a difference in their country's future, and they wanted a challenge. As Haider Al-'Awwami, production supervisor at Safaniyah in the mid-1980s, explained, "If it was money I wanted, I would go and open a supermarket in al-Khobar. If I wanted a name and prestige I would go into government. I see a challenge in what I am doing here."

Many young professionals jumped at the opportunity to demonstrate that Saudis could run their own oil company. Salim Abu Khamsin graduated from the College of Petroleum and Minerals in 1973, and after a stint with another oil company and earning a master's degree in petroleum engineering, joined Aramco in 1978. By 1984, he was superintendent of Safaniyah Offshore Producing. He conceded that the isolation of offshore work was sometimes difficult, "but some Saudi has to do the job; we don't want to be spoon-fed by expatriates."

Other Saudis realized that a job with Aramco gave them the opportunity to make an impact on the company and in some cases the oil industry itself. One example was Hesham Al-Musaiid, who joined Aramco after graduating with a degree in civil engineering from the University of Petroleum and Minerals. After reviewing the American Petroleum Institute (API) standard for design of storage tanks during the course of work on a project, he concluded that two of the assumptions on which the standard was based were incorrect. He recommended changes that would result in a more conservative and safer standard. The API Standards Committee accepted his proposal, and the standard was revised accordingly in the late 1980s.

The consolidation of computer-intensive work at EXPEC in the early 1980s opened up a new field of endeavor for ambitious Saudis. Ibrahim S. Mishari joined the company in 1974 after earning a doctorate in computer science from Leeds University in the United Kingdom, and became manager of the Computing Technology Department in 1984. He was attracted to the oil industry by "the scope of the work and the challenge," he said. "I was becoming more aware of oil and its future importance." He saw Aramco as representing the future of computer applications in the petroleum industry. Mishari advanced through the ranks, leading the company through successive waves of computer modernization and information technology advances. He retired as vice president of Marketing and Supply Planning in 2007.



Ameera A. Al-Mustafa, left, a senior geophysical consultant, discusses reservoir diagrams with colleague Hashim Hussein. The company's efforts to sponsor the education and training of Saudi women began paying dividends in the late 1980s as more women joined the professional ranks of the company in fields such as petroleum engineering and computer science.

Nabilah M. Al-Tunisi, shown here in 2009 in her office at Aramco Services Company in Houston, Texas, was director of engineering on a proposed integrated refining and petrochemical project. She got her start with Aramco in 1982 as a computer systems engineer and eventually served as the company's chief engineer.

PROFESSIONAL WOMEN

While the 1980s opened new career opportunities in information technology and other areas for women, as early as the 1960s and 1970s, a handful of professional women set precedents in other fields. They included Na'ilah Mousli of Reservoir Engineering, Aramco's first female petroleum engineer and first female department manager. Another pioneer, Samia Al-Edrisi, joined Translation in 1974 and retired in 1996 as a planning and programs analyst in Public Affairs. The early 1980s witnessed an exceptional influx of professional Saudi women at Aramco. Many serve as role models for current women employees.

Few professional opportunities in the field or at production facilities were open to Saudi women in the early 1980s. The establishment of EXPEC and the expanding use of computers in general, however, provided them with additional career opportunities. Nabilah Al-Tunisi's career benefited greatly from what EXPEC offered. She recalled: "They needed … people with engineering backgrounds, computer backgrounds, all of these technical types — petroleum engineers and so forth. … And they made me an offer, and they told me about this computer center and what they were planning to do. … "

Petroleum sleuths

EXPEC brought together under one roof the equipment and expertise to enable Aramco to move to the forefront of world-class technology in exploration, drilling, and reservoir engineering. Company personnel — from headquarters in Dhahran, rather than outside consultants — could now conduct their search for hydrocarbons and determine the best means of producing them.

Within the company's exploration and production organizations, a variety of geoscientists and petroleum engineers today consider a host of clues gathered from seismic surveys, core samples, wireline logs, and other means, and employ tools ranging from satellite surveys to scanning electron microscopes. The overall goal of all this data analysis, explained Dave Cantrell, former chief geologist and chief technologist in the EXPEC Advanced Research Center who retired from Aramco in 2017, is "to characterize the reservoir, its internal stratigraphy or architecture."

Aramco's Exploration and Petroleum Engineering Center (EXPEC), on the left, and the adjacent EXPEC Computer Center and Engineering buildings bustle with activity in December 1982, five months before the official inauguration ceremony. EXPEC enabled Aramco to consolidate its exploration and petroleum engineering activities in one center.

A hydrocarbon reservoir is more like a sponge soaked with oil and gas, rather than an underground lake, and two key factors in how productive a reservoir might be are how big the holes are in the sponge and how they connect, known as porosity and permeability. Some reservoirs might contain a lot of hydrocarbons in the pore spaces within the rocks, but unless the rock is permeable, the hydrocarbons will likely remain trapped in the stone. Porosity and permeability are therefore vitally important for petroleum engineers to know.

Therefore, in one sense, petroleum engineers in EXPEC see hydrocarbon reservoirs as a giant plumbing problem: What is the best way to drain the fluids from the reservoir? "With multilateral wells and horizontal drilling, understanding the inner structure is even more important," Cantrell noted.

After earning a master's degree in electrical engineering from Oregon State University, Al-Tunisi declined several job offers from companies in California's Silicon Valley to return to Saudi Arabia in late 1982 and work in EXPEC. She immediately began writing petroleum engineering computer applications on a state-of-the-art IBM mainframe. Within a few years, Al-Tunisi was working in project management, on assignment in Houston, Texas, overseeing multimillion-dollar contracts. In 2005, she was promoted to manager of the Project Support and Controls Department, overseeing a staff of more than 380 employees. The following year, she returned to the United States and earned an executive MBA from Stanford, and then was called on to serve as the company's director of engineering on a proposed petrochemicals project with Dow Chemical Co. In 2006, Al-Tunisi was included on a list of 25 influential women from around the world in project management by *PM Network* magazine. Al-Tunisi eventually became Aramco's chief engineer before retiring from the company in 2018.

Thuraya Al-Arrayed, who joined Aramco in 1980 and retired in 2006, obtained her doctorate in educational planning and administration from the University of North Carolina in 1976. The company had wanted her to start immediately in Corporate Planning, but she insisted that she preferred to get a good overview of the company's range of activities first, and that Public Affairs was a better starting point. One of her first projects was to start a mobile library program as community outreach to local schools. She worked with a designer to retrofit two used vehicles as mobile libraries to carry books to schools across the Eastern Province.

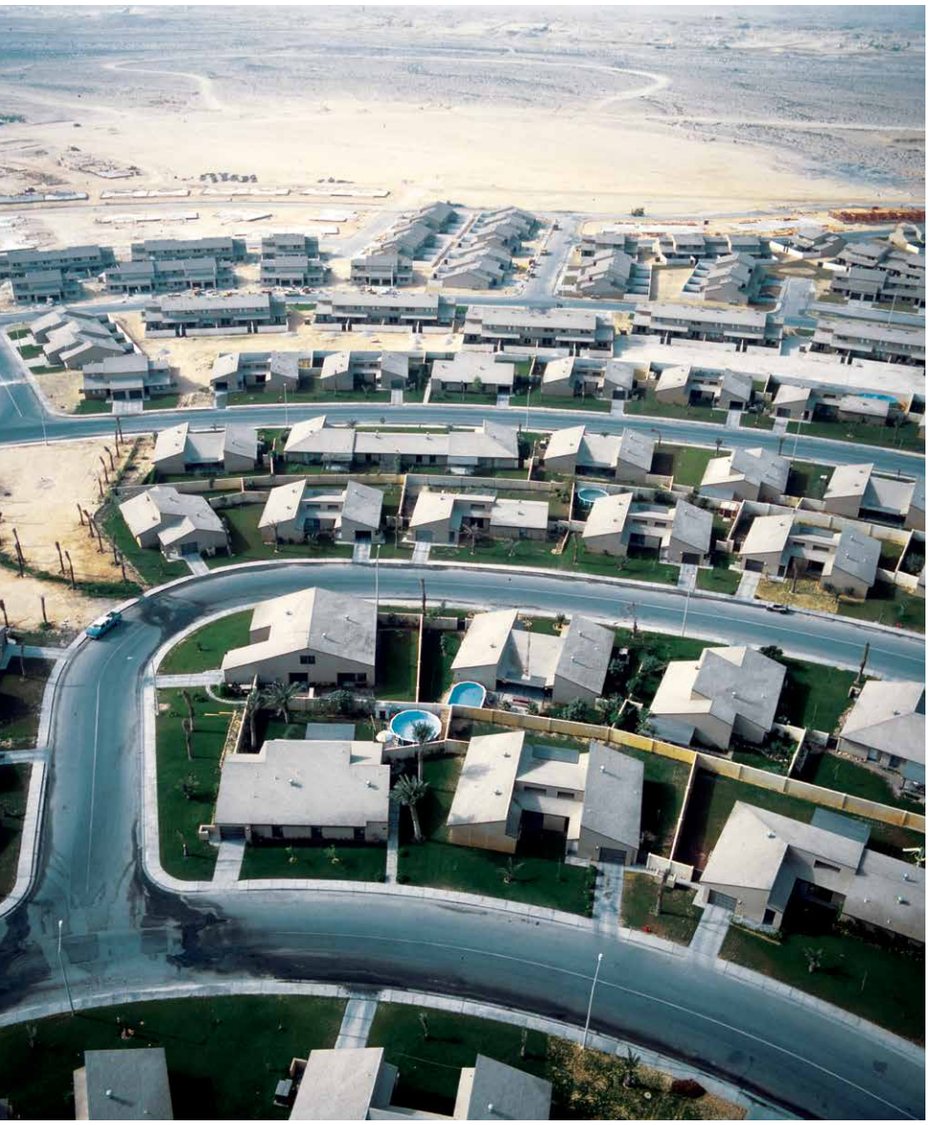
In another project, Al-Arrayed wrote Public Affairs' first guidebook for implementing the then new Personal Development Program, which became the seed for the Professional Development Program guidebook that for decades was used throughout the company. In 1981, she joined Corporate Planning as its first permanent Saudi employee. Upon her request, one of her first assignments was to assist in coordinating the company's five-year planning process with that of the Kingdom's plans for the energy sector.

Fatema H. Al-Awami was among the handful of Saudi women to receive college scholarships from the company in the early 1980s. She attended the University of Southern California and graduated in 1984 with a degree in petroleum engineering. She put her skills to good use in reservoir simulation, contributing to work on the Safaniyah, Shaybah, and Manifa projects, among many others. Al-Awami was one of the developers of the Event Solution, an innovative multidisciplinary approach to resolving reservoir management issues. She retired as a senior petroleum engineering consultant in 2014.

Huda M. Al-Ghoson received an undergraduate degree in English literature from Riyadh's King Saud University (then known as Riyadh University) before joining Aramco's Medical Services organization in April 1981 as a patient relations representative. A few years later, the company granted her a leave of absence to complete her master's degree in business administration at the American University in Washington, D.C. Shortly after receiving her master's degree in 1986, she transferred to Industrial Relations, where she completed various assignments of progressive responsibility until becoming the first woman in a corporate adviser position. In 2007, Al-Ghoson was the first woman named to the board of directors of a company subsidiary when she joined the board of Vela International Marine Limited. Two years later, Al-Ghoson was appointed general manager of Training and Career Development, and among other accomplishments, helped to improve the training and development programs available to women in the company's workforce.

In 2012 Al-Ghoson was named executive director of Human Resources, the first woman in company history to permanently hold an executive director position. In that role, she was instrumental in transforming Human Relations into a more participative and approachable organization within the company, responsible for the implementation and execution of policies affecting more than 65,000 employees of more than 80 nationalities in nearly 50 locations around the globe. After 37 years with the company, she retired in 2018.

Fatema H. Al-Awami, who retired as a senior petroleum engineering consultant in 2014, earned a degree in engineering in the early 1980s from the University of Southern California in Los Angeles.



The rapid pace of construction is evident in this 1980 photograph of Dhahran. Aramco built 780 new family residences in its four main company communities and started building 1,200 new bachelor units and other facilities, but temporary residential camps still housed 11,000 company bachelors and 700 families.

NEW NEIGHBORS

The dramatic increase in hiring beginning in 1980 caught Aramco without enough housing, reminding company veterans of similar situations during the 1950s. New housing units were constructed as quickly as possible, but the company could not keep up with the stream of new recruits — expatriates as well as Saudis. New employees often found themselves living in trailers or other temporary housing while permanent accommodations were built.

James R. Tracy, a member of the Tracy family mentioned earlier, lived in Ras Tanura from age 3 until he went away to high school. He was recruited by Aramco in 1980 after serving in the U.S. Army, earning a master's degree in international management and working in banking. He had fond memories of a spacious house and a grassy yard in Ras Tanura. But when he returned to Saudi Arabia to assume the first of several financial positions with the company, he and his wife, Claudia, were greeted by a slightly different prospect: "It was boom times. We lived in a place called North Camp, which was basically a big trailer park out in the desert. … It was just awful." Despite the harsh conditions, the couple persevered and soon moved into a comfortable home in Dhahran. He retired in 2003, ending his family's 58-year work history with Aramco, a service record not uncommon in a company with many third- and fourth-generation employees, expatriate and Saudi alike.

As more Saudis achieved professional status in the late 1970s and early 1980s, the number of Saudi families moving into Aramco communities increased. It was not unusual for a young Saudi couple to move in next door to an American or other expatriate family who might have been living there for 10 or 20 years. Many close relationships developed among new neighbors.

Ali A. Al-Muhareb, who retired in 2011 as vice president of Corporate Planning, and his wife moved into the Ras Tanura community in the late 1970s when he was a young engineer. Their next door neighbors were an older, childless American couple who treated the Al-Muharebs' first child as if he were their own grandson. The American woman presented the Saudi mother with needlepoint garments and a baby blanket, among other gifts. After the couple retired and moved back to the United States, the Al-Muharebs visited them during vacations and exchanged presents with them for years. As the expatriate population of Aramco has grown more internationally diverse in recent years, such cross-cultural encounters regularly include South Africans, Colombians, Venezuelans, Chinese, Britons, and Filipinos, among many others.

LEAN TIMES

Saudi Arabia has often been one of the few voices of oil market stabilization at OPEC. When revolution temporarily halted the flow of Iranian oil in the late 1970s, many OPEC members raised prices in response to the shortage. Saudi Arabia stood by the official price, however, and strove to persuade other OPEC members to choose stability over short-term profit. However, the combination of reduced demand stemming from energy conservation measures enacted in the West and Japan following the price hikes of the 1970s, the continuation of high production levels by OPEC, and increased production from Alaska, the Gulf of Mexico, and the North Sea, resulted in lower oil prices in the 1980s. Oil on the spot market peaked in 1981 at $42 a barrel. In October 1981, OPEC finally agreed to stabilize the price of oil at $34 a barrel if Saudi Arabia would lower its output.

The compromise, however, came too late to prevent a crash. While Saudi Arabia again struggled to maintain the official price, other OPEC countries dropped their prices to stay competitive with oil from the North Sea and other new fields. When prices started declining,

Jeffrey of Arabia

Quick, describe Saudi Arabia!

Most people think of sand dunes, camels, oil wells in the desert. Oil prices, too.

Few would think of Little League baseball or 11-year-old Jeff Jaszczak of the Dhahran Steelers. But to people who work for us, Little League is an ordinary part of Saudi Arabian life.

We're Aramco, the Arabian American Oil Company. There are 13,000 North Americans in Saudi Arabia with us. And even though you hear a lot of news about Saudi Arabia, there are things that might surprise you about our lives there.

1. We're doing something important. Aramco produces more oil than any other company. Badly needed oil. Including about 15 percent of the oil America imports.
2. The Saudi Government and Aramco are working together on some *incredibly* large energy projects. And on huge communication networks, electric utilities, and more.
3. Our people are glad to be in Saudi Arabia with Aramco. They came for excellent pay and professional challenge.
4. Aramco is growing. We need more good people, and few companies can match the hundreds of interesting, rewarding jobs we can offer.
5. Jeff made the all-star team.

ARAMCO
SERVICES COMPANY
1100 Milam Building, FS • JPS
Houston, Texas 77002
(713) 750-6965

Aramco's hiring initiatives during the 1980s targeted not only Saudis but also expatriates. This 1981 ad highlights the quality of life available to expatriates and their families in Saudi Arabia.

OPEC countries agreed to production cutbacks to stabilize the market. Despite the reductions, prices continued to fall through 1982, shaving approximately $39 billion off Saudi Arabia's 1982 income from oil revenues compared with the previous year.

In 1983, OPEC attempted another unified response. In addition to tightening the quotas and dropping the official price to $29 a barrel, it explicitly assigned Saudi Arabia the role of swing producer. By having one country vary its production with world demand, OPEC hoped to keep the price of oil stable. Saudi Arabia soon found its new role difficult, however, as some OPEC countries still did not abide by the agreement.

In the summer of 1985, the Saudi government abandoned the quota strategy. By producing large quantities of crude oil, Saudi Arabia hoped to regain market share from non-OPEC sources with higher production costs. Crude oil prices plunged to levels not seen since before the 1973-1974 price hikes. In 1986, oil prices dropped more than 50% before bottoming out at less than $10 a barrel. Faced with tumbling oil prices, OPEC members returned to the negotiating table in 1986. While not wholly satisfactory to anyone, the resulting revised quota system successfully stabilized oil at between $15 and $18 a barrel through the end of the 1980s — the same price it had sold for in 1979.

Aramco planners had based estimates of the company's output and staffing needs for the 1980s on late 1970s trends that had been wildly optimistic, as had planners at most major oil companies. Indeed, the boom-and-bust trend in oil prices had frustrated industry executives since the early 1970s and continued to do so through the decade that followed. Aramco's average daily production hit a record high of 9.63 million bpd in 1980. Four years later, production at times dipped as low as 2 million bpd as demand contracted. In 1985, Aramco's average daily production stood at 3 million bpd, the lowest since 1969.

The personal toll was dramatic. The company's 1980 estimate that it would employ 75,000 workers by 1985 proved off the mark. Instead, the total was slightly more than 50,000 by mid-decade, about 15% below its peak in 1982 of 61,227. At Aramco Services Company in Houston, whose employees were not included in Aramco's total employment figures for Saudi Arabia, the payroll was cut from 2,500 to 800 during this period.

One aftereffect of the oil embargoes was increased exploration in places such as the North Sea. This Mobil Oil drilling rig was built in 1982 to work the Statfjord oil field, one of the largest North Sea fields.

The ripple effect

The drop-off in demand for crude oil in the early 1980s was not just the result of a recession that hit much of the industrialized world. The high prices and threats of oil embargoes like those of the 1960s and '70s prompted increased exploration and production elsewhere, especially in Alaska, the Gulf of Mexico, and the North Sea. This increased production put even more oil into an already saturated market, lowering prices even further.

The lessons learned by the developed world in the wake of the dramatic spike in oil prices in 1973 and 1974 also contributed to a reduction in demand. Many industries switched to other energy sources and installed more energy efficient processes. In addition, individuals and governments took measures to conserve energy, including everything from improving home insulation to boosting auto mileage requirements to enacting lower traffic speed limits. By 1984, the United States was using approximately 10% less oil than in 1973, despite the fact that the U.S. gross domestic product, adjusted for inflation, had grown by 34%.

In Saudi Arabia, expatriate ranks were thinned significantly by the time the overall payroll hit its low point of about 43,500 employees in 1987. More than 14,000 of the 17,000 positions eliminated since 1982 had been held by expatriates. Among Saudis, many longtime employees were encouraged to take early retirement. With so many expatriates leaving or taking early retirement, by 1985 the Saudi component of the workforce had increased to 65%.

The impact of the downturn on the smaller Aramco housing compounds was especially striking. Aramco began a phased withdrawal of families from 'Udhailiyah in 1985 in anticipation of shuttering the entire community. The size of employee populations at Tanajib, Khurais, Abu 'Ali, Shedgum, and Berri was slashed by 60%. In addition, from the end of 1984 through the end of 1985, the number of contractors with living quarters assigned by Aramco plunged from 6,400 to 1,600.

It was a tough period for those who remained at the company as well as those who were let go or took early retirement. For many who had joined during the booming 1970s, it was their first lesson in coping with lean times. Khalid A. Al-Falih, Aramco former president and CEO and Chairman, worked as a project engineer during the early to mid-1980s: "The company went through a painful period. There were layoffs, there were cutbacks in budgets, there were a lot of adjustments that we had to make. … That period also taught us as individuals as well as an institution a lot in dealing with the upside, which we did in the 1970s, but also managing to work under more austere financial conditions in the 1980s."

"THE BIG PICTURE"

Saudi industry received a dramatic boost from the new sources of power and feedstocks provided by the Master Gas System (MGS) and other projects that originated with the second Five-Year Development Plan. By 1986, after the MGS had been expanded to include offshore fields, Aramco had the capacity to produce up to 2 billion scfd of gas.

Harbor pilot Mohammed Younis guides an oil tanker to its berth at Ras Tanura's Sea Island in 1989, a year in which more than half of Aramco's exports were destined for Asia, followed by 25% for North America, 21% for Europe, and the remainder shared between South America and Africa.

Saudi contractors and other companies that supplied goods and services to Aramco also benefited from the construction prompted by Aramco's expansive budgets of the early 1980s. In a number of locations, the company trained contractors in tandem with its own new employees to ensure there was adequate manpower to complete its ambitious roster of projects. The dramatic growth among contractors and other Saudi companies led to a considerable amount of poaching of Aramco's talent.

Some promising trainees were recruited by Saudi companies, which often offered higher starting salaries than Aramco. But that was the price Aramco paid for running a quality training program, said Abdulaziz Al-Hokail in 1984. "They are stars that shine in any company they go to," he noted. "If you have been working with Aramco you are recognized. We have discipline and experience."

Hamad A. Juraifani, vice president of Northern Area Manufacturing at the time, lamented the departure of these young Saudis, but was able to see the contribution of the program in broader terms: "Although we have lost a lot of experienced Saudis to the private sector, we Saudis [at Aramco] look at the big picture: what is good for the Kingdom."

The plunging oil prices of the mid-1980s impacted the Saudi private sector as much as Aramco. Contractors saw their list of future projects shrivel dramatically as Aramco — and the government — slashed construction budgets and canceled or delayed major projects. The ripple effect was felt in virtually every corner of the Saudi economy.

"MOTHBALLING"

Aramco shuttered some facilities as crude oil production fell in the 1980s. That made economic sense for some older operations, such as an oil-processing plant in Manifa, where the company was facing hefty maintenance and repair costs. However, for others it proved extremely costly: A planned refinery in Qasim in central Saudi Arabia was canceled, but the cost of terminating construction contracts and other costs made dropping the project roughly as expensive as completing it. There had to be a better way.

While a group of executives and engineers responsible for major offshore facilities in the company's Northern Area Operations was exploring cost-cutting ideas, some of the group came across an engineering journal that described the "mothballing" of U.S. Navy warships after World War II. The executives began thinking: If it worked for warships, why not oil processing plants? Sadad Al-Husseini, then vice president of Northern Area Operations, put a team together to study the issue and create a mothballing plan.

The concept was simple, but the scale was very large: Clean and store everything so that it would not corrode or deform, and provide enough maintenance so facilities could be reactivated quickly. Crews lifted huge rotors and turbines out of their moorings, put them in cases and stood them on end — if left horizontal while not rotating, they would deform under their own weight. They pumped diesel fuel through pipelines to displace all the corrosive sour crude. Likewise, nitrogen, an inert gas, was pumped though sensitive systems and equipment to displace corrosive oxygen-containing air. A minimal amount of power directed to instrument systems in control rooms kept them dry. Three or four guards provided security on each major offshore facility, minimizing personnel costs.

Facilities in the Marjan, Zuluf, and Safaniyah offshore fields were all mothballed using this approach. Oil from the offshore wells served by these facilities was piped at reduced volumes to facilities onshore for processing. GOSPs at Hawiyah, Haradh, and 'Uthmaniyah were also mothballed. Similar mothballing was applied to facilities in Khurais, Abu Sa'fah, Harmaliyah, and Mazalij, the community at 'Udhailiyah, and the 152-centimeter pipeline running from the Qurayyah Seawater Treatment Plant to the Ghawar field.

Saad A. Turaiki, a production engineer in 'Udhailiyah during the early 1980s who later became vice president of Southern Area Oil Operations, recalled that the mothballing process did not just look at the aboveground impact of shutting in facilities. Petroleum engineers also analyzed the impact on the oil reservoirs. "We had to go and conduct studies to find out exactly what are the most critical areas to mothball and shut down those that will have no effect on the reservoir," he said.

The sails

Aramco formed its own shipping subsidiary, Vela International Marine Limited, in 1984. Vela took its name from the constellation Vela, part of a much larger constellation known in ancient times as Argo Navis, the ship of the mythical Jason and the Argonauts. Argo Navis was split up into four smaller constellations: the sails (Vela), the keel (Carina), the stern (Puppis), and the compass (Pyxis); the ships in the Vela fleet were named after stars in Argo Navis. Arabs had long used the stars to help them navigate their vast desert and sea expanses; now these "stars" would lead Aramco's expanding fleet of oceangoing tankers for almost three decades. In 2012, Aramco merged Vela with the National Shipping Co. of Saudi Arabia, Bahri, transferring Aramco's fleet to Bahri and creating one of the world's largest shipping companies.

The 290,000-deadweight-ton supertanker *Phoenix Star* is launched in November 1993 from the Nagasaki shipyard in Japan, the second very large crude carrier (VLCC) to join Vela's fleet that year. Two years later, Vela, which started in 1984 with four secondhand tankers, completed its three-year construction program to build 15 VLCCs when it took delivery of the *Alphard Star*.

A drilling crew works in the Safaniya oil field in 1982. Even though world demand for oil was dropping, resulting in a concurrent drop in Aramco's production from more than 9.6 million bpd in 1981 to a low point of 3 million bpd in 1985, the company kept building production capacity in anticipation of future demand. The strategy proved to be prescient at the end of the decade.

The costs associated with mothballing were significant. They were paid back several times over, however, when global demand rebounded, along with prices, beginning in the late 1980s and continuing into the early 1990s. Mothballing expenses paled when compared to the cost and time involved in building new facilities after demand had already started to increase. In this manner, the mothballing program dovetailed with the company's approach to maintaining spare production capacity to help stabilize global energy markets.

NONASSOCIATED GAS

The overly optimistic projections that drove planning for crude oil production as the 1980s began also impacted plans to utilize natural gas to fuel economic growth in the Kingdom. When the MGS was designed in the mid-1970s, it was based on the assumption that Saudi crude oil production would climb steadily to a level of 12 million to 15 million bpd by the mid-to-late 1980s. That amount of crude oil would yield a corresponding amount of associated gas to meet much of the Kingdom's estimated gas requirements. The rapid decrease in oil production in the early 1980s clearly indicated that unless drastic steps were taken, Aramco would not be able to produce enough gas to meet the country's projected needs.

With little if any commercial demand for Saudi gas in the early decades of oil exploration, Aramco engineers had not focused on locating potential nonassociated gas reservoirs. (Nonassociated gas is free gas, or gas not associated with crude oil in a reservoir.) However, they had inadvertently found a large nonassociated gas reservoir in the late 1940s in the Dammam Dome, where oil had first been discovered. Dammam Well No. 43 was deepened significantly after World War II as the company searched for additional sources of oil. At a depth of between 3,350 and 3,660 meters, the drilling crew hit what would become known as the Khuff formation, which contains nonassociated gas.

Tanajib, where a gas-oil separation plant (GOSP) and other facilities were completed in 1985, became the new hub for expanded offshore activities, including work on new GOSPs in the Zuluf and Marjan fields. World oil markets remained weak throughout the mid-1980s, leading Aramco to mothball the Zuluf and Marjan GOSPs, among others.

Aramco has expanded offshore operations in its giant offshore oil field, Zuluf, in order to meet growing global demand. Here, a marine drilling rig operates in the Zuluf field shortly after operations began in the 1980s.

The crew was unprepared when it struck the reservoir, and sour gas laced with toxic hydrogen sulfide escaped to the surface under very high pressure. Fearing it might drift into Dhahran and threaten the lives of the hundreds of workers and residents, the crew plugged the well. Drilling shifted to other areas of the concession, and the gas well was largely forgotten.

That well may have marked the discovery of a gas-containing formation that extends through the entire Gulf region. Khuff gas has subsequently been found in several locations in the Kingdom, including the Haradh, Hawiyah, Shedgum, and 'Uthmaniyah areas of the Ghawar field, as well as in the Abqaiq, Berri, Dammam, Qatif, Khursaniyah, and Hawtah fields. The Khuff formation is relatively old and deep compared with oil and gas reservoirs in the region. Most Saudi oil reservoirs are in the Arab Zone of sedimentary deposits from the younger Jurassic Period, deeper than the shallower reservoirs tapped in Iran, Iraq, and Bahrain. Deeper, and older still, lies the Khuff gas formation.

Na'ilah Mousli, Aramco's first female petroleum engineer, was also the company's first female manager, of Reservoir Engineering, in the 1980s. Mousli received a master's degree in petroleum engineering from the University of Tulsa in Oklahoma and was a mentor to many other Saudi women in Aramco.

A team, including Na'ilah Mousli, manager of Reservoir Engineering, petroleum engineer Martes Yushatly, and vice president of Petroleum Engineering and Development Ed Price, developed a program to revisit existing oil wells and drill deeper in search of Khuff gas. There was one problem, however: They did not have a budget to drill for gas, and with Aramco trying to cut costs wherever possible during the mid-1980s, they were not likely to secure funding anytime soon. However, with crude oil production plummeting, the team needed to do something fast. As Sadad Al-Husseini recalled:

> *Whenever we had a well that was located at a promising location, I would get the engineers to change the program to deepen it two, three thousand feet and say we're doing this for structural delineation … just to tap into the gas and find it. … The oil would be at about 7,000 feet, and we'd get down to maybe 9,000 feet to find the Khuff [gas]. So, by the time we were running out of gas because oil production was coming down, we had enough information on the Khuff in North Ghawar to be able to concoct a program where we would produce some of the wells as gas wells.*

The Khuff gas project officially commenced in 1983. The gas, after passing through a pressure reducing and processing system, was sent into the MGS. By 1985, Aramco's capacity for nonassociated gas reached 1 billion scfd. As Al-Husseini recalled, "We never made as much [nonassociated] gas as we had designed the system for, but it was enough to see the Kingdom through many years of low oil production."

"SELL MY QUOTA"

Since the 1973-74 price shock and embargo, OPEC countries, for the most part, had wrested control of prices out of the hands of the major oil companies and tried to set member country production quotas. The system worked to varying degrees, subject to geopolitical events and each country's willingness to adhere to its agreed production caps.

Today's pricing methods, however, were born out of the chaos of the mid-1980s price collapse. In 1985, OPEC members adopted "net-back" contracts to try to stabilize prices. Such contracts pegged the price of crude oil to the value of a refined product, after subtracting refining costs, margins, and freight.

Molten steel provides the fireworks in the Hadeed steel plant in Jubail, one of many industries powered by the Master Gas System (MGS), completed by Aramco in 1982. Initially, the MGS harnessed about 3.5 billion standard cubic feet of gas per day, the energy equivalent of 750,000 bpd of crude oil.

The smokeless flare

In 1986, as part of Aramco's ongoing effort to reduce the flaring of natural gas, the company completed the installation of a new, modified safety flare system in Abqaiq, which dramatically reduced the amount of gas flared at such facilities. Flares are needed as emergency means of burning excess gas, which occurs at times during the production process or in the case of a plant malfunction or regular maintenance shutdown. The new flare consumed eight times less gas than the flare it replaced. In addition, its atmospheric emissions were nearly 10 times less than its predecessor.

In 1999, a young Saudi engineer named Mazen M. Mashour invented a smokeless flare system technology that uses nonconventional methods of operation and won a Gold Award at the International Inventors Conference in Geneva in 2006. Mashour discovered that injecting a relatively small amount of high-pressure air into the flare all but eliminated smoke from the flares, with significant savings over larger, complex systems. His invention, known as the High-Pressure Air Assist System (HPAAS) smokeless flare tip, delivers air, under high pressure, into an air distribution ring. Jets, contained in a wind shield, create the turbulence needed for smokeless operation.

The increased airflow creates a much hotter flame, which burns off the impurities rather than releasing them into the environment. The technology was shown to be cost-effective and easy to retrofit, with an average installation time of three days — a significant factor when the entire plant must shut down for safety reasons. Mashour's smokeless flare was first installed at Shaybah in June 2000, eventually followed by 29 large-scale operations that were upgraded as part of Saudi Aramco's Southern Area Smokeless Flare Project.

Mazen M. Mashour's invention, shown in prototype, was designed to reduce atmospheric emissions from gas flares without the expense of more complex machinery. The system injects compressed air into the flare, increasing the burn temperature.

In May 2008, a joint venture agreement to produce Mashour's invention on a commercial scale was signed between the Al-Rushaid Group of Saudi Arabia and Zeeco, a U.S. combustion technology company based near Tulsa, Oklahoma. The HPAAS proved a success: Its suitability for retrofitting, its low air requirements, and its quick installation time gave it advantages over other technologies. Mashour's invention — now designed, manufactured, and sold exclusively from within the Kingdom — reflected the success of Saudi Aramco's In-Kingdom Total Value Add (iktva) program to grow a localized manufacturing sector.

Mashour's smokeless flare system was an important step in Saudi Aramco's larger efforts to minimize flaring and reduce emissions. In 2021, Saudi Aramco's gas flaring intensity was less than 1%, and the company's Flare Minimization Program was progressing toward zero routine flaring. These results were made possible by various initiatives and Fourth Industrial Revolution (IR 4.0) technology to monitor and mitigate flaring in real time. In 2015, the World Bank recognized Saudi Aramco as having one of the lowest flaring intensities in the industry, and in November 2019, Saudi Aramco joined the World Bank initiative Zero Routine Flaring 2030.

A new crude oil pipeline snakes its way toward a notch more than 1,000 meters high in the Hijaz Mountains in 1986. Aramco, which assumed operation of the existing 1,200-kilometer East-West Crude Oil Pipeline from a subsidiary of Petromin in 1984, nearly doubled the pipeline's carrying capacity by laying a parallel line.

Aramco's Operations Coordination Center (OCC), seen here in the 1980s, is the central control room for the company's vast and complex oil and gas operations. The display panels on the OCC's walls monitor terminal scheduling, electric power generation, and distribution, and the production and distribution of oil, gas, and NGL, and refined product.

The jarring downturn in crude oil prices in 1986 sent oil producers in search of a new pricing mechanism. In December 1986, OPEC created the basket of prices, which quoted amounts for several grades of crude from different member countries, setting the price of Arabian Light crude oil at $17.52 a barrel. Production levels by some OPEC members, however, drove prices down, making it impossible for Saudi Arabia — through Aramco as its major producer — to sell oil at the official price. Nevertheless, Minister Hisham Nazer, who had succeeded Yamani as Minister of Petroleum and Mineral Resources earlier that year, came to Aramco chairman and CEO John Kelberer in September 1987, and said, "Sell my quota." He did not specify a price at which he wanted the 3.3 million bpd sold. Kelberer met with Aramco senior economist William Laney Littlejohn and said, "OK, we have to sell the quota. We can't use net-back contracts. How do we do it?"

Littlejohn's solution, which went into effect the following month, was used as the basis for pricing Saudi crude oil for more than two decades. Beginning in October 1987, Aramco priced its crude oil based on the prices for crude oil produced from a particular region, minus a certain differential based on several factors, including the quality of the oil, the distance from Saudi Arabia, and related shipping costs. The company sold Saudi crude oil in the United States based on the price for West Texas Intermediate oil; in Europe, based on the Brent Weighted Average price for North Sea oil; and in the Far East, based on the average price quoted in Dubai and Oman.

By 1987, rebounding industrialized economies had increased demand for oil, and prices reversed a five-year decline. Late that year, OPEC set a reference price of $18 a barrel, far from the $7 a barrel or less for which many types of Arabian Gulf crude oil had been selling in July 1986. Aramco's 1988 average daily production of 4.93 million barrels was the highest in six years. Rising employment levels reflected this increase. While still well below its peak of 61,227 employees in 1982, the number began to trend upward, with 43,822 employees on the payroll by 1988.

Expanded production prompted a modernization of the Ras Tanura Refinery, including construction of a new 250,000-bpd crude oil distillation unit and a major upgrade of Saudi Arabia's East-West Crude Oil Pipeline. The pipeline, 122 centimeters in diameter, at the time delivered 1.85 million bpd to Yanbu' for refining or export. Aramco took over operation of the crude oil pipeline from Petromin's Petroline in 1984, and began implementing a major expansion by laying a parallel 142-centimeter pipeline connecting to the existing pump stations, which were required to pump oil across Saudi Arabia and lift it over the Kingdom's western mountains. The second line boosted capacity to 3.2 million bpd. An additional pump station completed in 1992 increased total crude oil capacity to 5 million bpd.

QUICK RESPONSE

On the evening of Aug. 15, 1987, Abdallah S. Jum'ah, then vice president of Government Affairs, found himself managing a crisis. Malfunctioning equipment at the company's Ju'aymah Gas Plant had resulted in a serious fire, catching the company's operating crews by surprise. The only injuries were burns sustained by four workers. By responding quickly to minimize damage and utilizing backup resources, the operating crews at Ju'aymah managed to maintain a continuous flow of ethane feedstock to the industrial city in nearby Jubail and elsewhere, and a flow of NGL for export. With Aramco president Al-Naimi out of the country on vacation, Jum'ah became company spokesman and chief liaison officer with the government.

Jum'ah's task involved careful communication with government officials to allay fears that the accident might have been the result of a deliberate attack and to reassure customers that supplies of feedstock and fuel would not be interrupted. He worked closely with one of Aramco's leading in-Kingdom customers, Saudi Arabia Basic Industries Corporation (SABIC), communicating critical information in the crucial period after the accident occurred. In a subsequent meeting with Al-Naimi, then Aramco executive vice president Nassir Ajmi praised Jum'ah's performance as well as that of the entire Aramco response team.

Khalid A. Al-Falih was a lead project engineer on the team that rebuilt the Ju'aymah Gas Plant. Team members drew on years of training — and plenty of adrenaline, he recalled — getting the crucial facility back up to speed as soon as possible: "We put parts of the plant in service right away, and others were rebuilt in record time. So that was a highlight in terms of the intensity of the work, the long hours, the criticality of the project for the local industry."

Aramco also reviewed the accident from fire and safety perspectives to absorb lessons that could be applied systemwide. "Accidents like this, as unfortunate and bad as they are, always force you to go back and reexamine your safety systems to determine what really went wrong," Al-Falih noted. "In that case it was a hardware problem. Sometimes there are people issues, but these accidents, we learn from them, and we improve our facilities, our systems, and our human resource practices to make sure we avoid repetition of such incidents."

A NEW NAME

Saudi Arabia's Council of Ministers met in November 1988 and approved the charter of a new national oil firm — the Saudi Arabian Oil Company, or Saudi Aramco — to assume the responsibilities previously carried out by Aramco on behalf of the government. While the name "Aramco" no longer accurately reflected ownership of the company, it was retained to ensure continued name recognition as well as preserve a link to the company's rich heritage. The transition was seamless.

The company marked another milestone in April of that year — following the retirement of John J. Kelberer — when then-president Al-Naimi was also named the first Saudi CEO of Saudi Aramco, and Minister of Petroleum and Mineral Resources Hisham Nazer was named the first Saudi chairman of the company's board of directors.

As early as 1986, Al-Naimi had been advocating, in conversations with the Ministry of Petroleum and Mineral Resources, that the company should become more of an integrated petroleum company. Rather than limiting itself mostly to the "upstream" part of the industry, which includes exploring for and producing petroleum, Aramco should diversify, Al-Naimi believed, into what the industry terms "downstream" activities, which include international refining, distribution, and marketing of petroleum products.

Fin-fan coolers stretch into the distance atop one of the two fractionation modules of the Ju'aymah Gas Plant, which was rebuilt in the wake of a 1987 fire. Aramco responded quickly to ensure the flow of ethane feedstock and NGL to customers by adjusting pipeline flow, reactivating a mothballed plant, and increasing production at other active plants.

Children's art contest

For nearly three decades, Aramco sponsored a nationwide children's art contest, one of the first in the Muslim world. It was open to all children in the Kingdom ages 5 through 14. "The aim of the contest is to encourage our youth to continue [their] artistic journey, climbing new peaks of beauty, imagination and creativity," said Ismail I. Nawwab, former general manager of Public Affairs and founder of the competition.

The contest sparked the imaginations of thousands of Saudi children and inspired many to pursue their dreams of being an artist or working in graphic arts. For others, the contest raised their awareness of what is possible. Nasser M. Al-Dowayan, a former supervisor in Project Management, was among the contest winners in 1991 when he was a fourth-grader in the Dhahran Ahliyyah School. "Winning the contest was an amazing experience," he said. "It helped me understand the concept of 'challenge' and made me always want to set higher goals for myself, achieve more and be a step ahead."

Three oryx graze near a water hole in Nasser Mohammed Al-Dowayan's winning entry in the 1991 Aramco Children's Art Contest. The contest sparked children's imaginations, Saudi and expatriate alike, for more than 32 years. The contest migrated to Ithra after 2014.

The winning artworks were selected by a committee of independent judges comprising artists, teachers, and specialists in children's art. These works were honored in different ways. They were displayed in permanent exhibits in company buildings, in-Kingdom and internationally, and reproduced in company publications. The company also donated a selection of the contest's artworks to royal embassies of Saudi Arabia around the world, and many were included in local children's art exhibitions sponsored by the Youth Welfare Presidency.

King Fahd, center, comes to Ras Tanura in December 1986 to inaugurate the Aramco Training Center there. Joining him are Ali Al-Naimi, company president, on his right; Hisham Nazer, Minister of Petroleum and Mineral Resources, on his left; along with members of the Saudi government and Aramco management. Standing behind King Fahd is John Kelberer, company CEO.

The company proposed the forging of joint ventures with other international petroleum companies to increase the Kingdom's revenue from its oil. With the green light from Riyadh, Kelberer led a team that entered into negotiations with several international downstream companies. In 1988, a company subsidiary formed a joint venture with Texaco in the United States called Star Enterprise.

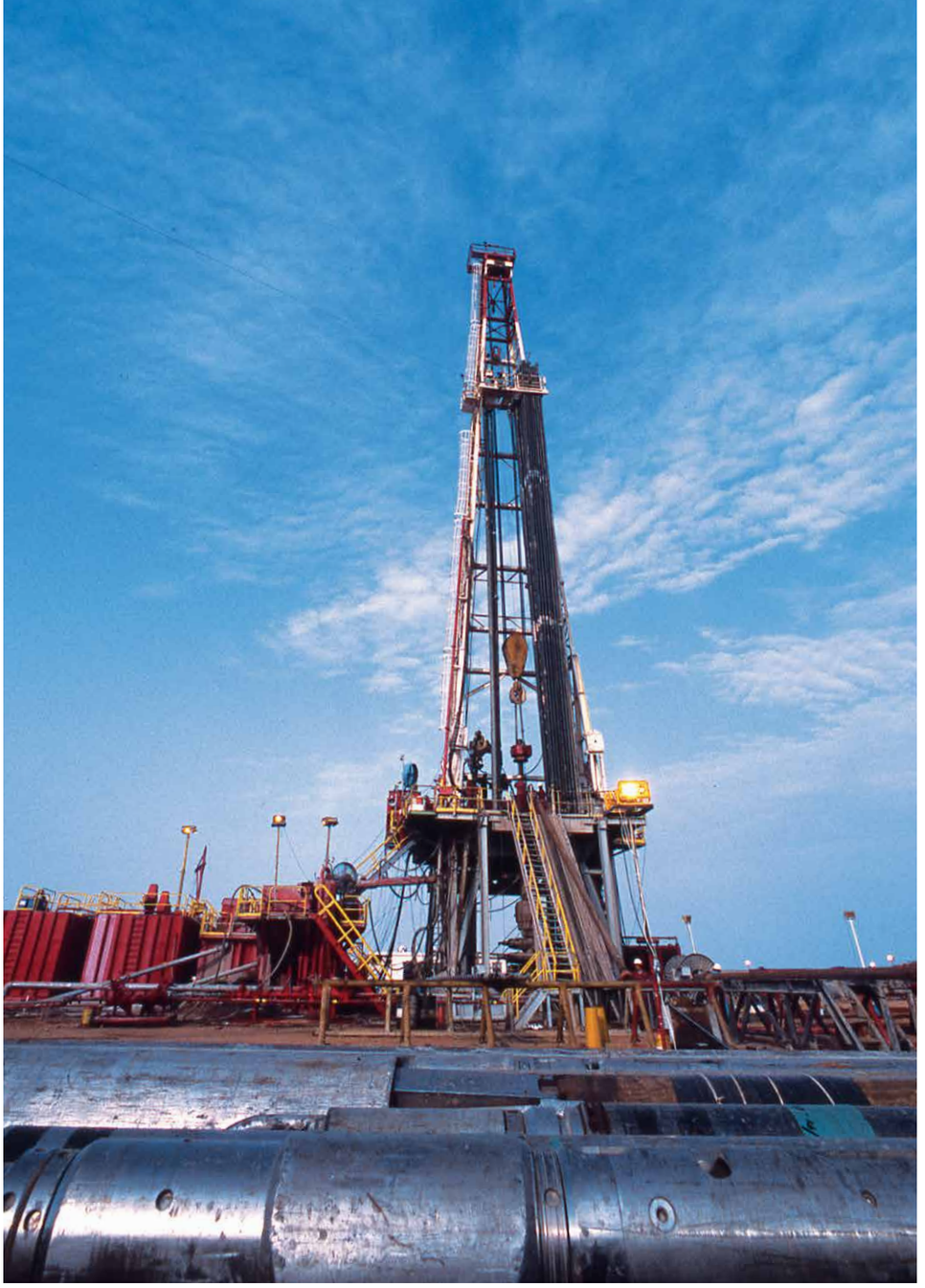
Star Enterprise began operations on Jan. 1, 1989, with assets that included major refineries in Delaware City, Delaware; Convent, Louisiana; and Port Arthur, Texas. With nearly 4,000 employees, the joint venture also included four marketing divisions in the United States, 48 product distribution terminals, and more than 10,000 Texaco branded service stations.

While the company gained added value through its share of the profits from the refining, distribution, and marketing of crude oil products in prominent or growing markets, its efforts to enter and expand into international downstream operations were part of a higher strategic goal. As it secured a share of downstream operations, the company could also secure a long-term agreement to regularly supply the operation with Saudi crude oil. By doing so, the company secured an outlet for its oil and reduced its vulnerability to market changes.

NEW FRONTIERS

The rebounding global oil market in the late 1980s added urgency to existing plans for more aggressive exploration. In 1986, Saudi Arabia had reassigned Aramco its original oil exploration rights to areas that had been relinquished from both the 1933 concession agreement and the 1939 supplementary agreement. This enlarged exploration area amounted to about two-thirds of the Kingdom — approximately 1.5 million square kilometers — an area larger than Germany, France, and Spain combined. In 1988, a Royal Decree approved company exploration activities Kingdomwide.

Aramco began its transformation from an oil-producing and -exporting company to a fully integrated petroleum enterprise in 1989 with the formation of Star Enterprise, a joint venture with Texaco in the United States.



Exploration efforts along the Red Sea coastal plain yielded results in 1992 with the discovery, in the well shown here, of sweet gas and condensate at Midyan, near the Gulf of Aqaba.

In 1989, Aramco geologists and drilling teams made headway in this new exploration campaign when they found oil in previously unexplored areas. Premium value Arabian Super Light crude oil (which is extremely low in sulfur) was struck at a depth of about 1,900 meters at Hawtah in central Arabia, south of Riyadh.

In the five years from 1989 to 1994, Aramco discovered 15 oil and gas fields in the central, western, and northwestern regions of the Kingdom. Found by using increasingly sophisticated technology to peer into previously uncharted regions, these discoveries heralded a new era of hydrocarbon exploration.

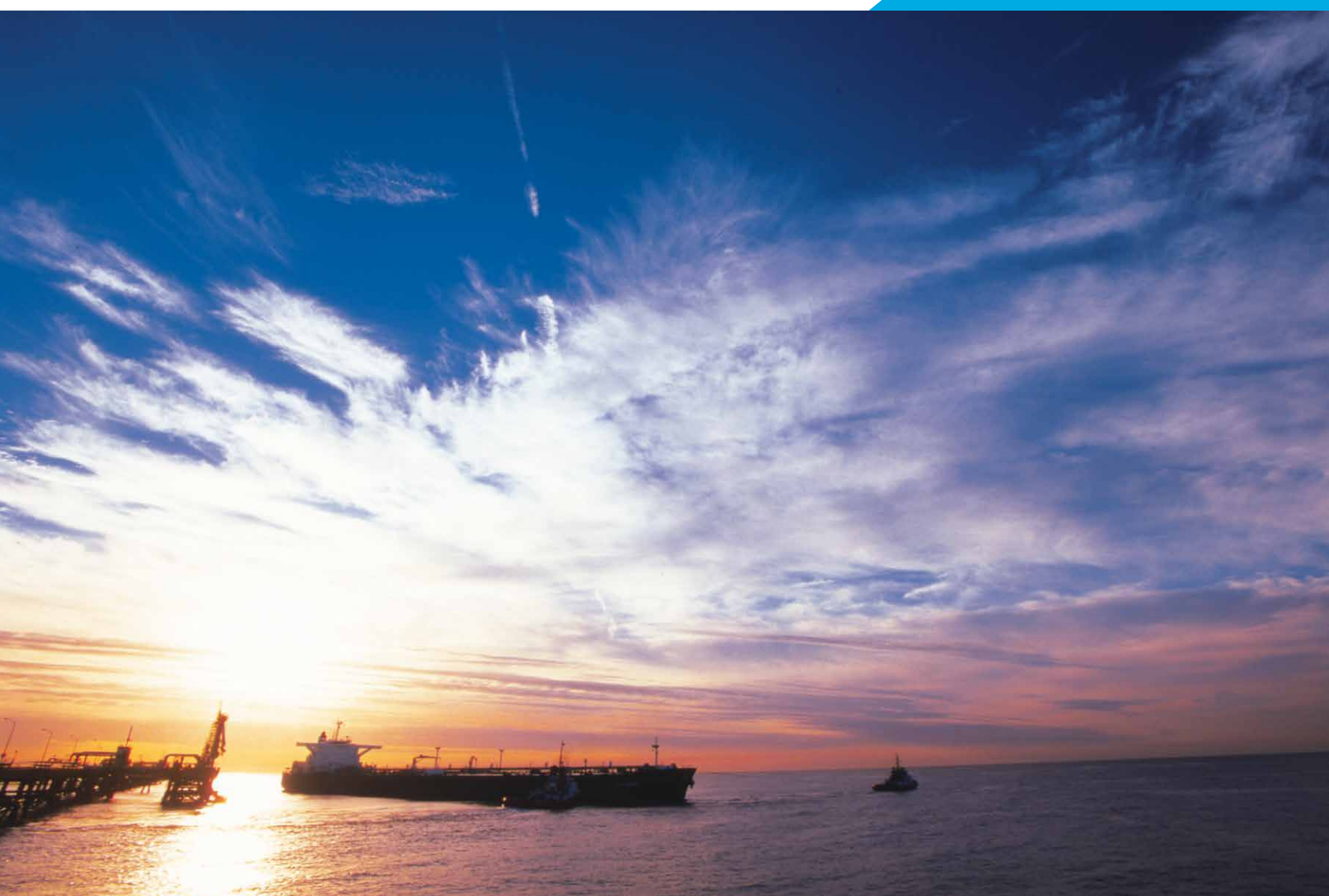
The Star Enterprise joint venture and the exploration successes, coming after Saudis had taken over management of the company, signified a renewed vitality at Aramco. The company continued to look internationally to increase its business over the coming years. In response to mounting global demand for crude oil, Aramco began reactivating numerous facilities that had been mothballed early in the 1980s. New plants and facilities were slated for construction. Little did Aramco officials realize how fortuitous their expansion plans would prove to be.

To help educate the public about the oil industry, the company has had a permanent exhibit in Dhahran since the early 1950s. This young Saudi works on a globe in 1990 at the Aramco Energy Exhibit, which opened in 1986. In recent years, the facility has been renovated and is now part of the King Abdulaziz Center for World Culture.

CHAPTER 3

Rising to the challenge

Shaybah, 2003.



A supertanker pulls away from the crude oil terminal at Yanbu'. In 1993, Aramco added a fourth berth, part of a larger project to raise the terminal's capacity from 2.6 million bpd to 4.2 million bpd.

The increasingly global role played by the Kingdom, and consequently the company, in the 1990s was marked by the international conflict that convulsed the Gulf region early in the decade. At the same time, the company continued to forge international ties to strengthen its business while coping with some of the most dramatic swings in world oil prices in a generation.

At home, Aramco assumed greater responsibilities for helping develop the Saudi economy. A new generation of Saudis assumed leadership of the enterprise and fine-tuned operations as the company launched a new round of mammoth oil and gas facility construction projects — a harbinger of the building boom to come in the opening decade of the new millennium.

THE GULF WAR

The decade began with a shock, and an extraordinary challenge for Aramco. On Aug. 2, 1990, Iraq invaded neighboring Kuwait, putting the Saudi government — and Aramco itself — on a crisis footing. While the government coordinated security measures both internally and with coalition forces from around the world, the company focused on its role in helping to stabilize world energy markets, now thrown into chaos by the invasion and subsequent international embargo on crude oil from Iraq and occupied Kuwait.

The sudden loss of 4.8 million bpd of oil from the world's oil markets put great pressure on all producing countries, and both producing and consuming countries looked toward Saudi Arabia and Aramco. With the world's largest oil reserves at the time, along with the highest production level and highest sustainable production capacity — and a spotless record of reliability — the Kingdom and the company were expected to come to the rescue as quickly as possible.

Before it could do so, however, the company had a more immediate concern: the security of its workers, their families, and the company's facilities. No one knew whether the Iraqi advance would stop in Kuwait. In the wake of the invasion, hundreds of employee dependents — mostly expatriates' families — were flown out of the country at Aramco's expense. Many families who were on vacation that August delayed their return to Saudi Arabia for weeks or even months. For employees and dependents who remained, the company implemented emergency plans, including the later distribution of gas masks.

A technician in the Abqaiq Mechanical Shops works on a job for the project to demothball a Khurais gas-oil separation plant in the latter half of 1990. Facilities mothballed in the mid-1980s were rapidly brought back online, reaffirming Saudi Arabia's commitment to providing reliable supplies of crude oil by quickly ramping up production to meet global shortfalls.

Early in September, Minister Nazer and other Ministry officials visited Dhahran and Aramco's facilities in a public show of government support for the company's employees. In private meetings with senior Aramco executives, Nazer articulated the government's most pressing question: Would the company be able to boost crude oil production enough to offset lost Iraqi and Kuwaiti production?

WARTIME EFFORTS INCREASE PRODUCTION

To help compensate for the loss of production from Iraq and Kuwait, company leadership decided to demothball production facilities that had been taken offline in the 1980s. M. Yusof Rafie, then vice president of Petroleum Engineering, was appointed to head the committee responsible for the massive demothballing effort. The most critical challenge was finding sufficient manpower to get the plants not only back in running order but also operating at near capacity levels.

One obvious pool of potential manpower was a group of about 800 trainees who had been recently recruited to work on the second major enhancement of the East-West Crude Oil Pipeline's capacity. That project was more than a year away from completion. Although some officials were reluctant to have the pipeline fall behind schedule, then executive vice president Nassir Ajmi decided the recruits would be temporarily reassigned.

Aramco made the most of its experienced workforce. By mixing the newcomers with seasoned operators, foremen, and superintendents, the company was able to recommission 146 oil wells and 12 GOSPs in the Harmaliyah, Khurais, and Ghawar fields, as well as the 152-centimeter water pipeline running from the Qurayyah Seawater Treatment Plant to the north 'Uthmaniyah area of the Ghawar field, all by the end of 1990. The advantage of having such an experienced workforce — the average Saudi had been with the company more than 10 years by the end of the decade — was never more apparent than that fall. Many of those who had participated in the 1980s mothballing work were still on the payroll in 1990 and knew firsthand the steps to take to get the machinery working again. Increased supplies of oil flowed to world markets faster than most outside observers thought possible.

The demothballing was an enormous success, accounting for 2.8 million bpd of additional production capacity achieved during 1990. By year's end, Aramco's average daily production was running at an astonishing 8.5 million bpd, up from 5.4 million bpd in July. While the average monthly price of a barrel of Arabian Light spiked to $35 a barrel during select days in September and October 1990, Aramco's quick response successfully helped counter this price hike. By March 1991, the price of Arabian Light was quoted at nearly $16 a barrel, approximately the same price it had been in July 1990 before Iraq's invasion.

ESPRIT DE CORPS

The war months were a nerve-jangling experience for many employees and residents living in or near company facilities. In February 1991, an Iraqi missile demolished a barracks housing U.S. troops near Dhahran, killing 28 and wounding 99. Although pieces of Iraqi missiles fell on company property in Dhahran, there were no casualties or significant property damage.

Esprit de corps remained high among management and the hundreds of operators at onshore and offshore plants, including those near the Kuwait border. Bryan Bartlett, who served as superintendent at the Safaniyah onshore plant during the war, recalled the commitment shown by employees during the conflict: "The operators worked 14 days on, seven days off. When the bombing started, the crew that was on their seven days off were gone. … Everything was kind of going crazy. Every single Saudi operator that I had came back to work on time. Not one single time did a man not come back to work. … And all of our American expatriate support stayed there. Nobody left."

The Iraqis had placed hundreds of mines in the Gulf in an attempt to disrupt shipping and sink the vessels of the nations arrayed against them. Several mines broke loose from their moorings and drifted into the Zuluf, Safaniyah, and Marjan fields, as well as off the coast of Ju'aymah. Most of these mines were detected while still far enough away that measures could be taken to avoid damage. Not all of these mines, however, were detected in time. Beginning in late December 1990, three such mines exploded under offshore platforms, causing more than $700,000 in damage, but no loss of life.

"NO SHUTDOWN, NO SLOWDOWN"

In addition to the ongoing security concerns, Aramco faced other unprecedented challenges from the war — protecting the fragile ecosystem of the Arabian Gulf and the major industry-related operations located on the coast. In January 1991, Saudi and coalition military officials detected oil drifting south in the Gulf — most of which had been discharged by Iraqi troops from the al-Ahmadi Sea Island loading terminal 21 kilometers off the coast of Kuwait. Earlier in the month, the Iraqi Army had dumped the contents of several oil tankers docked at the terminal and opened the taps at the terminal. Due to the circumstances, accurate accounting of the extent of oil spilled was obviously very difficult. Minister Nazer, however, estimated at the time that Iraqi forces dumped as much as 11 million barrels of crude oil into the Gulf.

Offshore facilities, such as these in the Zuluf oil field in 1991, were threatened by mines that had broken free of their moorings. Several mines caused damage to Aramco offshore facilities, but no lives were lost and oil production continued unabated.

A Saudi tank crew pauses for a photograph on January 19, 1991, two days after the air campaign phase of the battle to liberate Kuwait began. A cease-fire took effect a little more than a month later, on February 28.

Prince Abdulaziz bin Salman, then adviser to the Minister of Petroleum and Mineral Resources, noted during a late January press conference in Riyadh that the government and Aramco were working closely to deal with the effects of the massive oil slick. Nearly 70 tons of booms and skimmers alone were airlifted from England to the Gulf Coast. In many locations, three or more lines of booms were deployed to protect the water intake channels of company facilities and critical government utilities such as water desalination and power generation plants.

Much of the additional equipment was sent by the Southampton, England-based Oil Spill Service Center. The company was initially created by British Petroleum, but by the time of the Gulf War, the center was jointly owned by 13 oil companies, including Aramco. The governments of Japan, Germany, New Zealand, France, the United Kingdom, Canada, the United States, and the Netherlands also contributed equipment to help combat the oil spill.

Aramco's oil spill response team was well prepared to combat the advancing slick. Drills conducted in 1989 by the team, which numbered more than 450 workers at its peak, led to the adoption of the company's Oil Spill Contingency Plan in 1990. The team went to work under the direction of Dhaifallah A.F. Al-Utaibi, then vice president of Supply and Transportation and chairman of the company's Oil Spill Committee. While closely following the contingency plan, team members also quickly applied lessons learned on the job, such as which type of boom was most effective at blocking the flow of oil in a given circumstance. Al-Utaibi spoke at the time about the challenges created by the oil spill: "It is tough, expensive, and stressful fighting the elements, but so far we're holding the line. All our facilities have been in operation since day one. … There has been no shutdown, no slowdown of production as a result of the oil slick. Everything is intact. We're working hard to keep it together. … All conventional steps have been taken. Now we are trying to think what else we can do."

Saudi fishing vessels sink in an oil slick near Manifa on the northern Gulf coast in March 1991, the result of a massive oil spill moving south from Kuwait.

One of hundreds of personnel combating the oil spill faces a seemingly insurmountable task near Jubail in late March 1991. Aramco ultimately recovered more than 1 million barrels of oil from the spill and managed to protect all coastal installations from damage and operational interruption.

As comprehensive and thorough as the 1990 Oil Spill Contingency Plan was, the possibility of facing an oil slick in a combat zone during wartime had not been anticipated. The extent of the spill required that workers begin recovering oil before hostilities had ceased, making it impossible to adhere to some major provisions of the 1990 plan. For example, because the spill originated in a combat zone, there was no way to get to, and stop, the spill at its source — a primary goal of any spill response effort. Even as Aramco workers were attacking the slick farther down the Gulf, oil continued to flow at reduced rates from damaged Kuwaiti facilities until early May 1991, when it was finally stopped. Shifting winds and rough weather only made the team's task more difficult.

Much of the oil that might have threatened coastal facilities and communities in the Eastern Province was trapped in two bays south of Tanajib, well north of most coastal development. The Aramco team recovered several hundred thousand barrels of oil from these areas alone. Nearby, the company recovered another 100,000 or so barrels that had drifted near the onshore Safaniyah oil processing plant.

None of the government's or Aramco's coastal facilities that depended on water from the Gulf for operations such as water treatment or power generation or other facilities had to be shut down as a result of the unprecedented oil spill.

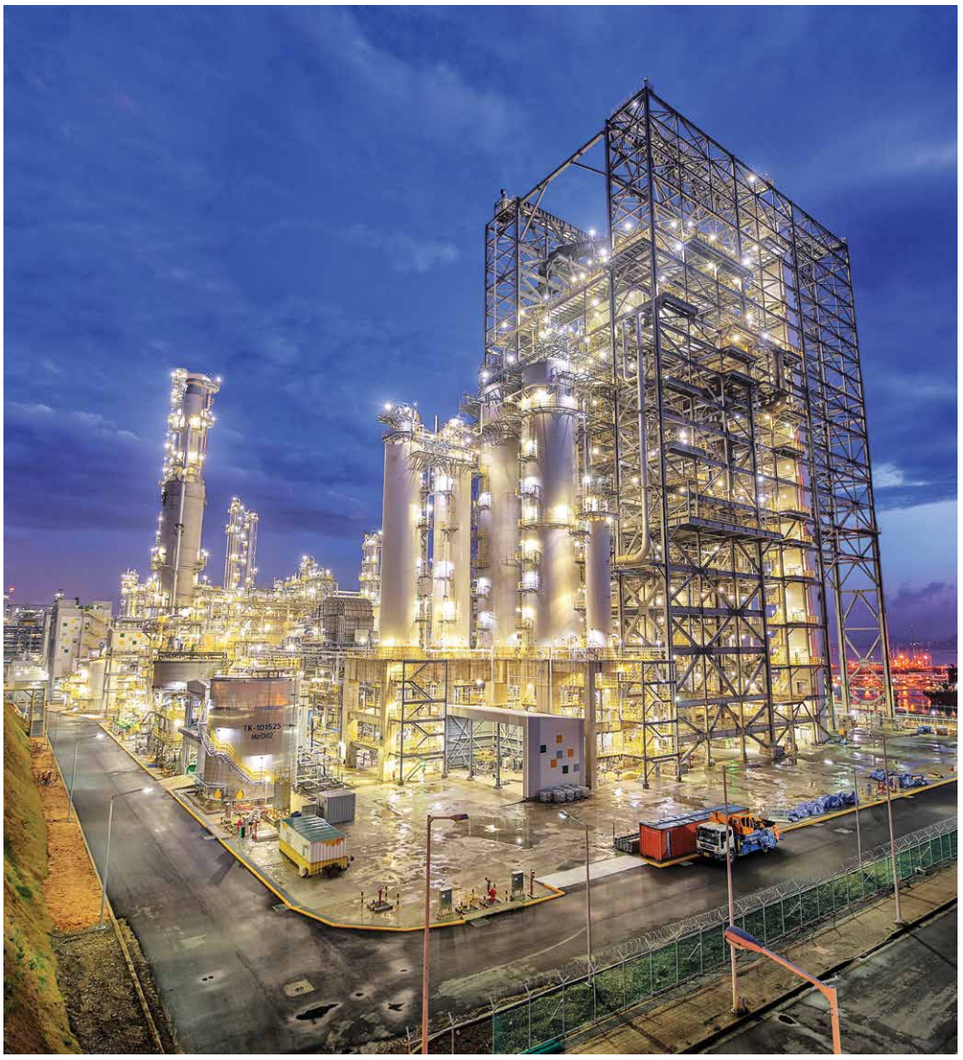
Mike Erspamer, the Ras Tanura Terminal manager who served as oil cleanup coordinator reporting directly to Al-Utaibi during the Gulf War crisis, praised the Aramco crews on the job for their bravery and ingenuity. He and a crew of about 30 Aramcons were laying booms to direct the oil spill away from water intakes near the Safaniyah facilities in late January 1991. The Saudi National Guard and coalition forces were in the process of forcing Iraqi troops out of the northernmost portion of Saudi Arabia's Gulf Coast and back into Kuwait. The Iraqis fired several "frog" missiles as they retreated. The inaccurate but deadly projectiles roared over the Aramco crew at a height of less than 100 meters and landed roughly 1,000 meters out in the Gulf. While clearly shaken, the company crew worked continuously through the day, and for weeks afterward, to safeguard facilities from the massive oil spill.

Much of the equipment the cleanup crews used was designed in the wake of the 1989 *Exxon Valdez* spill off the coast of Alaska, and some of it was overwhelmed by the sheer size of the Gulf spill and the condition of the oil, which Erspamer likened to "chocolate mousse." Some of the pumps designated for cleanup duty couldn't handle the thick mass of oil, so the engineers and others assigned to the project came up with an alternative. Henry Clark, manager of Offshore Drilling, suggested they use the minivan-sized pumps that forced drilling "mud" down drill holes to instead supply the force necessary to suck up the spill. Oil recovered using the pumps was mixed with demulsifiers and sent to company desalting facilities for further treatment.

Aramco eventually recovered more than 1 million barrels of oil from the spill — perhaps the largest amount of oil recovered from a spill and roughly four times the amount lost in the *Exxon Valdez* disaster. The recovered oil was transferred to containment basins on land, where it was treated to remove seawater and later used for commercial purposes. The Aramco team may have recovered only 18% to 24% of the oil spilled, but this was impressive compared to the global average recovery rate of 10% to 15% of most spills. Indeed, *The Los Angeles Times* noted that Aramco's ability to recover so much oil was pivotal to the cleanup effort: "Key to the increased cleanup pace was the ability of Aramco, the Saudi-owned petroleum conglomerate, to more than double the amount of oil it is retrieving."

The company's response did not end there. Environmental teams, which included employees and volunteers from within and outside the company, worked for weeks, in cooperation with related government organizations such as the National Commission for Wildlife Protection and Development and the Presidency of Meteorology and Environmental Protection, to rescue Gulf wildlife threatened by the spill. Aramco also conducted numerous environmental impact studies to evaluate the spill's toll on the coastline of the Eastern Province and adjoining areas, including monitoring the air quality.

Patti Echezuria passes a sea turtle to another volunteer as part of wildlife rescue operations in February 1991. Hundreds of Aramco employees joined the volunteer effort to rescue and clean turtles, seabirds, and other animals.



Aramco expanded its international presence in August 1991, when a company affiliate purchased a 35% interest in the SsangYong Oil Refining Company (now S-Oil) in the Republic of Korea.

EXPANDING GLOBAL REACH

Even in the midst of a serious regional crisis, Aramco continued to expand its strategic international reach in downstream operations. In 1990, the company agreed to an equity venture with the Republic of Korea refiner SsangYong Oil Refining Company, today's S-Oil Corporation. The companies agreed to jointly own and operate SsangYong's recently completed refining facilities at Onsan.

In August 1991, Aramco announced that one of its affiliates had purchased a 35% interest in SsangYong Oil Refining itself. In 2007, Khalid G. Al-Buainain, then senior vice president of Refining, Marketing & International who retired as senior vice president of Technical Services in 2015, commented that SsangYong ended up being one of the best refining investments Aramco ever made, at that time calling the refinery "the most profitable refinery we have in our system."

Following its Korean venture, Aramco in early 1994 acquired a 40% equity interest in Petron Corporation, the largest crude oil refiner and marketer in the Philippines.

Two years later, Aramco announced its first joint venture in Europe — the purchase of a 50% stake in privately held Greek refiner Motor Oil (Hellas) Corinth Refineries, S.A., and its marketing affiliate, Avinoil Industrial Commercial and Maritime Oil Company, S.A. After a decade of partnership, Aramco sold its interest back to the Vardinoyannis family. In 2007, the company reviewed Petron's strategic fit and the company's commercial return on its investment in Petron, and decided to divest its total equity interest. An acceptable price was offered by an investor for the shareholding interest in Petron, and a sale was completed in 2008.

In May 1994, Hisham Nazer, Minister of Petroleum and Mineral Resources, second from left, and Ali I. Al-Naimi, president and CEO of Aramco, third from left, visited Asia to explore additional international opportunities.

With the 1995 merger of Saudi Arabian Marketing and Refining Company (Samarec) into Aramco, Aramco became the world's largest integrated oil company. One of the assets Aramco gained was the Yanbu' Refinery, below, which produces 230,000 bpd.

DOMESTIC INTEGRATION

The company's international ventures in the 1990s were accompanied by a domestic transformation. A few years previously, in 1988, the government had created, as part of Petromin, the Saudi Arabian Marketing and Refining Company, or Samarec, tasked with refining, marketing, and distributing refined products. On July 1, 1993, King Fahd issued a Royal Decree sanctioning a June 14 decision by the Council of Ministers, dissolving Samarec and transferring its assets to Aramco.

Among the assets transferred were three domestic refineries: a 230,000-bpd refinery at Yanbu', a 140,000-bpd refinery at Riyadh, and Petromin's 75% stake in Jiddah's 90,000-bpd refinery — the remaining 25% of which was held by local private investors. Aramco also assumed Petromin's 50% stake in its three joint-venture export refineries: a 320,000-bpd refinery with Mobil in Yanbu', a 300,000-bpd refinery with Shell Oil in Jubail, and a 325,000-bpd refinery with Greece's Petrola in Rabigh.

Going green

As an increasing amount of wastewater went through tertiary treatment processes, Aramco started using it to improve the landscaping of its residential communities and facilities. By the mid-1990s, the company was irrigating common areas and beautifying company grounds. In 2001, a project got under way to replace the sand golf course of the Rolling Hills Country Club in Dhahran with a grass course irrigated with treated wastewater. This created an oasis of lush fairways and greens, along with trees and ponds that earlier generations of Aramcon duffers could have only dreamed of. The trees and water features of the verdant course quickly became a haven for resident and migratory birds.

Golfers enjoy a round on Dhahran's Rolling Hills course. The transformation from a sand course to a grass course was made possible by the company's growing use of treated wastewater for landscaping.

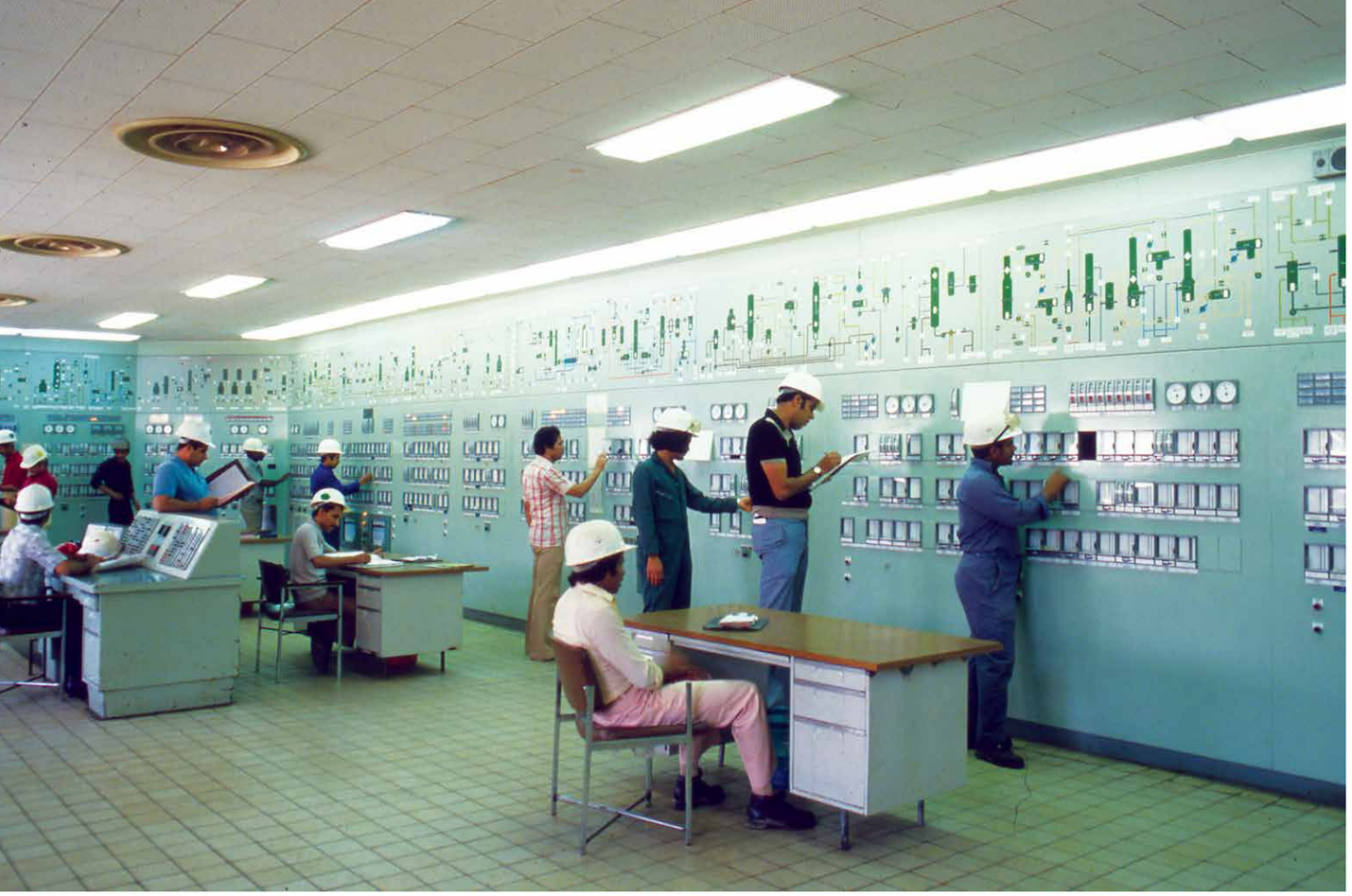
In 2020, 65% of the company's sanitary wastewater was being recycled for beneficial reuse via tertiary sanitary wastewater treatment facilities in the company's main communities. In addition to landscape irrigation, reuse applications included sod farming, cooling tower water, and boiler feed-water. Innovations such as ceramic membrane filtration technology that have been demonstrated to recover from water systems up to 90% of the backwash — the water that flows back through filters and is usually disposed of because of contamination — have been utilized.

Aramco also assumed responsibility for operating eight terminals on the Red Sea for shipping and receiving crude oil, NGL, and other refined products. The company also took over operation of the Kingdom's petroleum product distribution network, which included 18 bulk storage plants and 14 air-fueling units at airports.

Now the responsibility for operating the Kingdom's domestic oil refineries and distribution facilities and its joint venture export refineries belonged solely to Aramco. With a stroke of his pen, King Fahd had transformed Aramco into the world's third-largest refiner after Exxon and Royal Dutch-Shell.

"A SEAMLESS ORGANIZATION"

Like most Aramco employees, Khalid A. Al-Falih, at the time a general supervisor in the Consulting Services Department, learned about King Fahd's Royal Decree when he picked up the newspaper one morning in mid-June 1993. As was the case with 10 other senior Aramco employees, Al-Falih also quickly learned that he had been drafted by senior management to help execute the integration of Samarec's in-Kingdom facilities and its employees into Aramco.



Plant operators monitor refinery operations in a Saudi Arabian Marketing and Refining Company (Samarec) control room in 1988. Five years later, Samarec was dissolved and its assets transferred to Aramco.

The integration team moved to Jiddah, where Samarec was based, and immediately began working with Samarec management to merge its workforce into Aramco's as quickly and smoothly as possible. The team eventually swelled to 200 members to better deal with complex infrastructure, hydrocarbon system, financial, and human resources issues.

The immediate challenge was to restructure the company's operations to more effectively fulfill its new role. The integration team determined that Aramco's organizational structure, processes and systems should be the model for managing the new responsibilities. "The government felt that rather than reinventing the wheel, and creating all of these systems and practices, it would be best to adopt some system that we know already works, which is the Saudi Aramco system," Al-Falih said.

On Aug. 8, 1993, 11 days after the integration task force completed its work, Aramco announced a revamped organizational structure. Having eliminated redundant roles and responsibilities, a newly enlarged Aramco was poised to exploit the advantages of a centralized organization.

The assimilation of more than 10,250 Samarec employees and approximately 1,600 expatriate contractors into Aramco's workforce was complete within six months and increased the number of employees by approximately 25%, though fully integrating them understandably took several more months to accomplish.

"Today," noted Al-Falih in a 2006 interview, "it's a seamless organization. We look across the assets and across the employees, and it's very difficult to distinguish an employee as having been ex-Samarec or ex-Aramco. Everybody's a Aramco employee, and the assets have all been upgraded and standardized in the same manner."

NEW LEADERSHIP

In 1995, after finishing a round of international meetings with Aramco's refining equity venture partners in the Philippines, president and CEO Al-Naimi flew to Alaska for a vacation. He had already donned his waders in anticipation of a day of fishing on a remote stretch of river when he received a phone message. Someone back in Jiddah was trying very hard to get in touch with him. He did not recognize the phone number, but he thought he ought to return the call in case it was critical. The message was from a senior adviser to King Fahd telling him to return to Saudi Arabia immediately. He had been appointed Minister of Petroleum and Mineral Resources and needed to be back in time for the official ceremonies. "It was a complete surprise," Al-Naimi recalled.

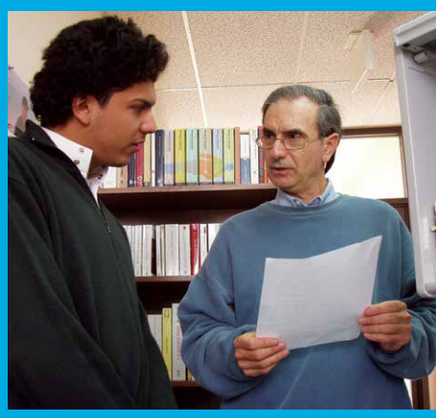
Al-Naimi's appointment opened up the president and CEO positions at Aramco. Since the retirement of executive vice president Ajmi at the end of 1992, four executive vice presidents had served directly below Al-Naimi. Nabil I. Al-Bassam was responsible for Finance and Government Affairs; Abdulaziz Al-Hokail was in charge of Human Resources and Training; Sadad Al-Husseini headed Engineering, Exploration, Production, and Industrial Services; and Abdallah S. Jum'ah led International Operations and Joint Ventures. Eventually, Jum'ah, who was known for his strong people skills as well as international experience, was chosen to succeed Al-Naimi as president and CEO of Aramco. His skill set was widely viewed within the company as complementary to that of Al-Naimi, who had spent much of his career at the oil company in operational roles.

Al-Naimi and Jum'ah developed a close working relationship during the early 1990s as they negotiated several international deals. Jum'ah — the first company president not trained as an engineer or geologist — earned his undergraduate degree in political science, and his management approach and skills were fine-tuned through diverse business assignments and his participation in Harvard University's executive management program. Al-Naimi recognized Jum'ah's potential and helped him broaden his understanding of the oil business. As Jum'ah recalled, "At that time I was traveling a lot together with him. That was close, you know, walking at night or jogging at night in Holland or in London. He was throwing things to me to get me interested in the technical side of the business. …"

Developing potential

To help develop the brainpower needed to guide the company in the future, Aramco started its College Degree Program for Non-Employees (CDPNE) in 1987, providing educational assistance to promising Saudi students as they finish high school. The program is a highly selective scholarship opportunity for male and female Saudi high school science graduates. The company provides free lodging and pays students a monthly stipend while they attend a one-year college preparatory program. Those who successfully complete the program are enrolled in a university of Aramco's choice and follow a mandated program of study. Students must maintain a required academic standard throughout their years of study. If a graduate of this program is offered employment by Aramco and passes the mandatory 90-day probationary period, the years of study are included in the employee's term of service with the company.

"We see ourselves as seeds planted by Aramco," said Ayed Al-Qahtani, who since 1993 has earned bachelor's and master's degrees, and in 2008 received a doctorate degree in energy economics from the Colorado School of Mines in the United States. "This whole effort has been an orchestrated, long-term investment by the company, with harvests along the way." In the 34 years since the inception of CDPNE, almost 9,400 employees have earned college degrees through the program.



Scholarship student Munif Al-Munif consults with George J. Mollo Jr., in June 2007. Aramco has been providing its scholarship students with both financial support and counsel from experienced advisers for decades.

Aramco geologists at EXPEC began utilizing computer-enhanced satellite images, such as this one, recorded by Landsat satellite, 700 kilometers above the Earth. Studying these images allow geologists to identify strucutral anomalies on the surface that might point to the hydrocarbon traps under the ground.

TRANSCENDING THE TECHNICAL

Over his years with the company, Jum'ah developed a valuable insight that served the company well: Despite the focus on materials and technology inherent in the oil business, the true core of Aramco was its people. Adopting a merely technocratic approach to the business was naturally not Jum'ah's style, and he believed that human resources issues often lie at the heart of what might initially appear to be distinctly operational problems, especially in a company with such a strong engineering and technical heritage.

Attention to the human side of the business prompted almost immediate steps to change the face of the company. In 1996 and early 1997, a number of industrial leaks, accidents, and other problems at Aramco suggested that a review of operations was in order. None of the events was catastrophic, but collectively they were more than management was willing to tolerate. Jum'ah felt management needed to dig beyond technical problems to find long-term solutions.

Jum'ah asked Al-Utaibi, who by this time was senior vice president of Engineering and Operation Services, to head a committee to investigate the issue and develop recommendations. Al-Utaibi was the right man for the job, recalled Bryan Bartlett, a committee member: "He wasn't afraid of anything. He wasn't afraid of anybody. He was also loyal to the company, and he worked us to death for two or three months." The committee went throughout the entire company, interviewing people and engaging company psychologists and other experts to create and analyze surveys.

The group developed a "health of the company" report, which Al-Utaibi presented to management. Subsequently reviewed by Jum'ah and the company's senior vice presidents, the report was bitter medicine for some Aramco executives who did not appreciate hearing long-standing company practices criticized. But sound leadership depends upon honest feedback, and many of the recommendations included in the report were implemented. Compensation policies and shift schedules were improved for employees living and working offshore. Recognition programs for awards and merit were altered as well.

TECHNOLOGY UPDATES

In the 1980s, Aramco lagged technologically behind some international oil companies. The relative accessibility of its largest fields, overall low production costs, and the significant costs of new technology kept it from being a top priority for the company.

Two-dimensional seismic imaging had been used in a relatively simple form as early as the 1920s in the United States and Europe to help identify possible hydrocarbon reservoirs in sedimentary rock formations. More advanced forms had long been used by the company. For several decades after seismic technology came into use, dynamite was used to create shock waves that were recorded as they bounced back from underground formations, much the way earthquakes are recorded on seismographs. Today, huge trucks press large vibrating metal plates against the ground, causing strong pulsations to penetrate the earth. Sophisticated geophones capture the resulting echoes returning from formations and faults in the rock below.

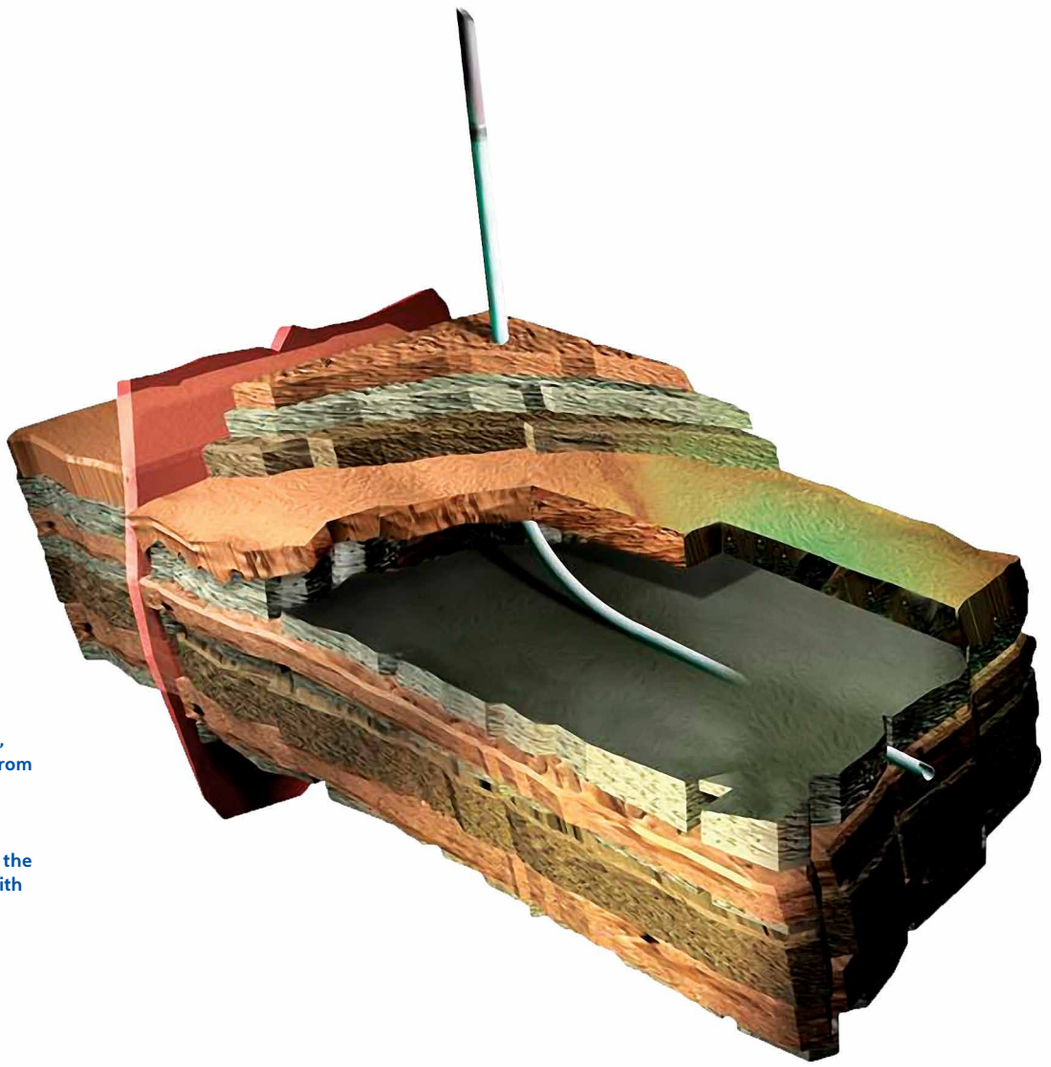
Three-dimensional seismic technology, as the name suggests, adds depth to the length and breadth recorded by 2D technology. The 3D seismic imaging produces a much more detailed image of underground reservoirs. This allows geoscientists and petroleum engineers to make better decisions about where to place wells to maximize the amount of oil and gas that can be drawn from subterranean structures.

The company used 3D seismic imaging as early as 1979 on parts of the offshore Marjan field. But cost cutting associated with the oil industry slowdown and low oil prices of the mid-1980s left company officials leery of spending on such advanced technology beyond small amounts at experimental levels. It was not until 1991 that Aramco initiated its first onshore 3D program, at Abu Jifan. The following year, three more 3D surveys were completed, at Hawtah, Ghinah, and Hazmiyah, as part of the initial development of these central Saudi Arabian oil fields. From that point forward, 3D became an integral part of the exploration process at Aramco.

GOING HORIZONTAL

At roughly the same time that Aramco was embracing 3D technology in exploration, it was warming up to another new technology as well — horizontal drilling. For years, due to the cost and difficulty of locating multiple drilling platforms offshore, the company had been drilling offshore wells at varying angles, as opposed to traditional vertical wells. Horizontal drilling takes the concept one step further: Wells begin as vertical wells, then at a certain depth the drill bit is turned to drill horizontally at a specific angle to reach a particular target within the hydrocarbon reservoir. Not only does the horizontal technique allow for targeting hard-to-reach reservoirs, but it also enables the reservoir engineers to better manage production and reservoir depletion issues by drilling the wellbore across the widest dimension of oil-bearing strata in a reservoir, rather than down through it.

A convoy of thumper, or vibroseis, trucks crosses the desert near Abqaiq, part of an exploration survey. Large vibrating plates mounted on the undercarriage of the trucks are lowered to the ground to create sound waves that are recorded by sensors. This data is crunched by computer programs to produce 3D images of the subterranean structure for analysis by geoscientists.



Horizontal drilling, first employed by Aramco in 1991, proved key to extracting oil from difficult-to-reach reservoirs. An additional benefit over vertical drilling was that it greatly increased the contact the producing well could have with the reservoir.

Aramco completed drilling its first successful horizontal wells in the offshore Berri field in January and April 1991. The first Berri well was drilled vertically to about 1,980 meters and then at a horizontal angle for another 2,700 meters to its predetermined target "window," which was only about 6 meters in diameter. Once in the oil-bearing rock, the horizontal well remained in contact with the oil-bearing strata for 760 meters. If a traditional vertical well had entered the same strata, it would have been in contact with the oil-bearing rock for only about 40 meters.

As Al-Husseini, who retired in 2004 as executive vice president of Exploration and Producing, later recalled, "When we did it at Berri, suddenly the wells that were producing 2,000 barrels and 1,500 barrels [per day] were coming in at 5,000 to 6,000 barrels, because of the horizontal drilling. So that made people sort of say, 'Well, this isn't just for fun; there is some advantage here.'"

ULTIMATE RECOVERY

In the early 1990s, Aramco officials visited several international oil companies to gauge the latest in exploration and production technologies. The team realized that 3D seismic and horizontal drilling were especially well suited to the company's increasing emphasis on long-term reservoir management, and its role as steward of the Kingdom's oil and gas resources. Aramco immediately also saw the value of the latest technology called multilateral drilling. Using this technique, drillers extend wells off of a common horizontal well, much like fingers on a hand, allowing them to target specific pockets of hydrocarbons. As Al-Husseini later recalled:

The international oil companies were using the technology for exploration. We took the technology and applied it to reservoir management. They would use 3D seismic to discover an oil field which was small, so they needed the seismic, and then they would drill it with a horizontal completion, or a few horizontal completions, to get the most out of it, and then they would walk away. To them, that was the end of the game.

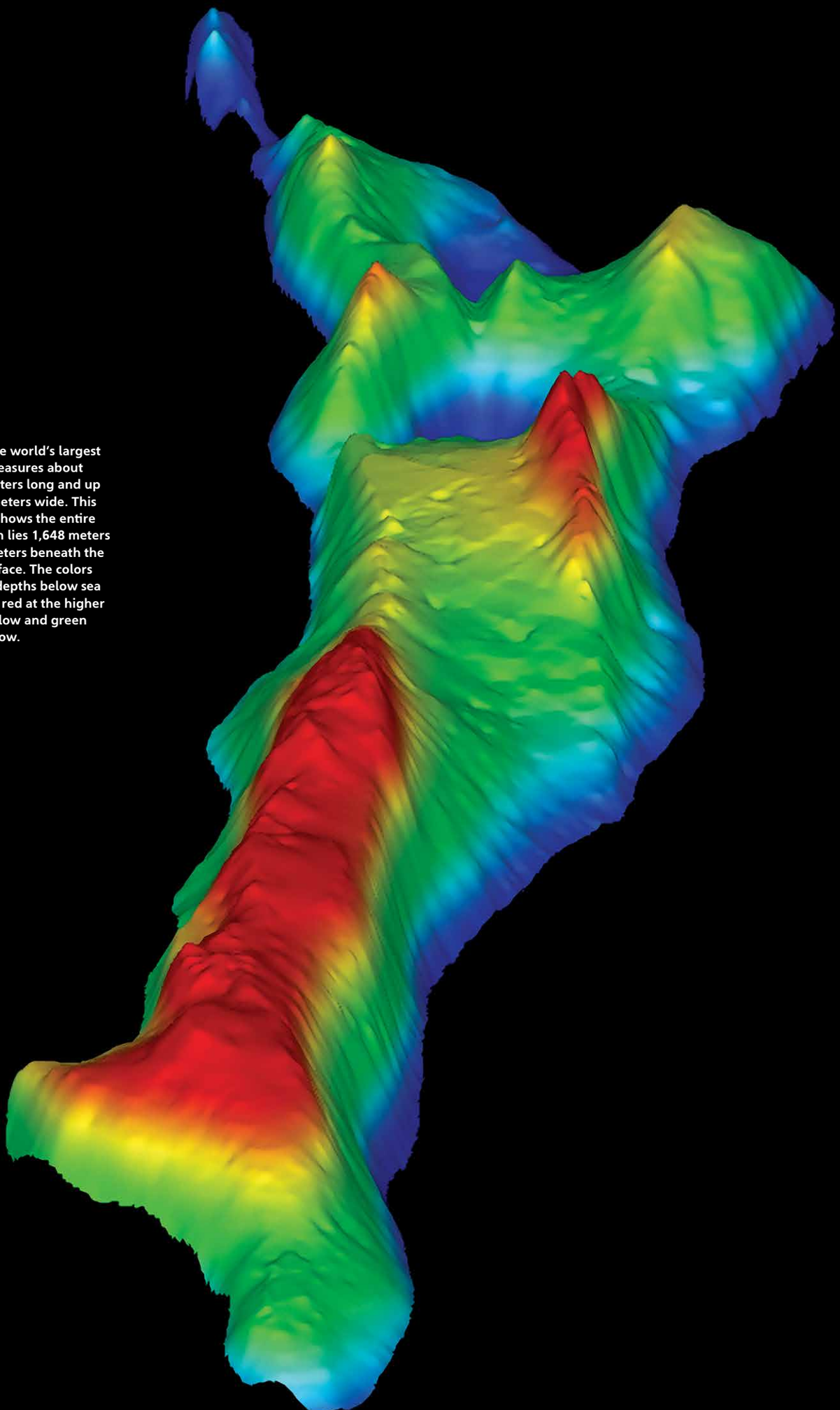
To us, that was the beginning. We would go to an oil field, [and] we would shoot the 3D seismic to say, OK, now what can we say about this field? How can we link rock properties to seismic properties to fill in the gap between one well and the next, to create a database that really reflects what the field looks like? And then how can we use the horizontal drilling — eventually multilateral horizontal drilling — to optimize the recoveries from the zones that we have no control over in between the wells and so on at the surface? So, they had the technologies, but they weren't looking at the problem that we were looking at. They couldn't care in terms of ultimate recovery.

Overseeing the development and production of all the crude oil and gas reserves of Aramco is the responsibility of the company's three reservoir management departments. The work here is among the most technologically advanced of its kind in the world. The company's immense computing power makes it among the top commercial computing centers in the world.

This massive computing power is used to run simulation models. Reservoir simulation is a 3D mathematical representation of the total petroleum system, including the reservoir and its associated aquifer, wellbore, and surface facilities. These models are the primary tool used to locate, develop, and manage oil and gas reservoirs.

Forty years ago, reservoir simulation consisted of creating 3D models using a few thousand "cells." Each cell represented a cube-shaped portion of the reservoir, measuring about two kilometers on each side and with a depth of from 15 to 30 meters. This technology was a big improvement over the 2D seismic images used for decades in the industry, but it did not provide much specificity in terms of placing wells or understanding reservoir characteristics. The models also took weeks for mainframe computers to produce.

Petroleum engineers Amal A. Al-Awami, right, and Mubarak N. Al-Dossary model a hydrocarbon reservoir in one of the 3D visualization rooms housed in the Exploration and Petroleum Engineering Center in Dhahran.



Ghawar, the world's largest oil field, measures about 280 kilometers long and up to 26 kilometers wide. This 3D model shows the entire field, which lies 1,648 meters to 2,472 meters beneath the Earth's surface. The colors represent depths below sea level, from red at the higher level to yellow and green deeper below.

The core store

After almost 90 years of drilling, Aramco has amassed a wealth of rock-based information from literally hundreds of kilometers of rock core samples — the physical samples that allow company scientists to understand the geology of the Kingdom's hydrocarbon-bearing reservoirs and prospective fields. These unique samples, housed for 40 years in the building popularly known as the "Core Store" (more formally known as the Exploration Core Laboratory and its storage annexes), were relocated in 2021 to the new Aramco Core Laboratories Center. The move ensured the core samples are available near Aramco's geoscience and engineering experts. The new facility's 14,700 m^2 area not only includes a cavernous storage structure with multi-tier racking systems dedicated for core samples, plugs, sidewall cores, and double-slabbed core boxes but also specialist rock processing laboratories and sample examination rooms through which the information held in the rocks is revealed.

"This is going to be one of the world's largest rock storage facilities and one of the largest specialist labs for the analysis of subsurface material," said Sa'id Al Hajri, manager of the Geological Operations Department at the time of the move. "The new center will enable smarter, quicker, more integrated ways of processing and analyzing rock samples — the underlying ground truths for geological studies, reservoir modeling, and prospect generation."

Every core sample yields a wealth of knowledge about the hydrocarbon reservoir from which it came. Core samples — and drill cuttings — are the only direct, hands-on contact anyone has with a hydrocarbon reservoir, thereby allowing geologists to see the reservoir and its component rocks and fluids. "Cores are the ground truth for everything else we do," Dave Cantrell, then chief technologist of EXPEC's Advanced Research Center, said in a 2006 interview. "All the other data we collect is indirect. We need the kind of data supplied by cores to keep our models honest."

Aus Al-Tawil, left, discusses a core sample with fellow geologist Nasser Al-Ghamdi. The rock cylinders provide direct contact with the component rocks and fluids of a hydrocarbon reservoir, and thus hold a wealth of clues as to whether economically producible oil and gas, and how much of it, may lie in a reservoir.

Core samples are taken from a zone of interest in a well, not from the entire depth, and not every well is cored because it is a time-consuming and costly procedure. Core samples are handled carefully at well sites, where they are cut, labeled, and packed into protective crates and trucked to the lab in Dhahran. There, the cores go through a four-step process that includes prep work, sampling, analysis, and archiving. "The more rock you look at from more wells, the better you understand how it's all put together," explained Aus A. Al-Tawil, director of Exploration and Geosciences Excellence. "You start to unlock the story of the reservoir, and with more data from other disciplines, the story becomes more complete."

The specialist rock laboratories at the new center provide geoscientists with the high-tech analytical tools needed to process and analyze rock samples, with robotic systems being incorporated to handle routine sample processing and radio frequency identification that allow sample tracking. Cutting-edge X-ray fluorescence, inductively coupled plasma spectrometry, and X-ray diffraction help geochemists better understand the elemental and mineralogical composition of rocks. Enhanced core examination rooms ensure that critical "fingertip" access is retained, while digital imaging — through scanning electron microscopy, geological slide imaging, and 3D X-ray microscopy — give geoscientists the ability to study rock samples at the granular level, even at their desktops. Supported by a wealth of data unleashed through implementation of Fourth Industrial Revolution (IR 4.0) technologies, the new facility provides geoscientists and engineers with an unprecedented toolbox to unlock the secrets of the Kingdom's rocks.

The great technological leaps taken by Aramco in the 1990s would accelerate at an even faster clip beginning in the early 2000s. Taking advantage of accelerating advances in computing technology, Aramco would vault to the vanguard of the global energy industry in terms of simulating the flow of oil and gas in its reservoirs with a precision unimaginable to the previous generation of reservoir engineers.

Advancements in reservoir management and production technologies grew apace in the light of supply dislocations caused by the Gulf War, which underscored the need for additional production capacity to meet the challenges of the rapidly evolving world energy markets. In 1994, the company completed a five-year program to raise its maximum sustainable crude oil production capacity to 10 million bpd, giving the Kingdom the largest spare production capacity of any country in the world at a time when almost all oil-producing countries were producing at or near capacity.

In late 1997, for the first time in four years, OPEC decided to increase its production ceiling. The 10% increase to 27.5 million bpd took effect in January 1998. Unfortunately, it occurred almost simultaneously with a financial crisis that swept much of Asia, sharply reducing the region's demand for crude oil. Consecutive warm winters in North America and Europe in 1996 and 1997, combined with the dearth of Asian demand, led to an increase in world oil inventories and drove prices sharply lower. After hitting $22 a barrel in late 1996, the price of oil slid through much of 1997 and plunged to below $10 a barrel in late 1998.

Managing for the future

Geoscientists analyze seismic data in November 1992, the year when the company first began using 3D seismic surveying in reservoir development operations to more accurately delineate known reservoirs.

Aramco's reservoir management departments are responsible for managing the Kingdom's hydrocarbon resources to maximize recovery over the life of the reservoirs. That is a weighty responsibility, considering that the Kingdom's proven hydrocarbon reserves, at roughly 255 billion barrels, are among the largest conventional reserves in the world.

The key to sound reservoir management lies in controlling the pace at which oil is extracted. International oil companies tend to focus on extracting oil as quickly as feasible to recoup upfront exploration and development costs and to reward shareholders. Aramco, on the other hand, has longer term goals, striving to maximize hydrocarbon recovery from its fields. Rapid production of oil from reservoirs risks damaging the oil-bearing strata by promoting the rapid infiltration of water into rock layers from which oil is being drawn, among other things.

The company's policy for decades has been to produce oil gradually from its fields — not maximizing short-term profits, but managing the flow of oil in the reservoir for optimal recovery. Therefore, the benefits to the Kingdom from its hydrocarbon resources are extended for the longest time possible, and the reliability of crude oil supplies to world markets is sustained.

TAMING SHAYBAH

Development of the Shaybah oil field deep in the beautiful but unforgiving Rub' al-Khali — on time and within budget — was in many ways the pinnacle of Aramco's achievements in the 1990s. The vast desert's deserved reputation as one of Earth's most inhospitable places made early expeditions, beginning in the late 1930s, few and far between and delayed the development of the region for decades. Geologists surveyed the barren region's northwestern stretches in 1938, and again in 1948, but exploratory drilling did not occur until the late 1950s. In 1968, a drilling team struck oil at Shaybah Well No. 1.

At the time, traveling the 800 kilometers from Dhahran to Shaybah by land could take longer than a week. Small airplanes reduced the trip to a few hours, which provided a solution for transporting people, but the vast quantities of supplies needed to sustain a drilling camp and build oil and gas facilities required trucks. In the late 1960s, technical and economic reasons made Aramco hesitant to establish a permanent operation at Shaybah, where summer temperatures often hit 50 degrees Celsius and sand dunes tower up to 300 meters high. Company officials feared the shifting sands might bury buildings even if they were erected on the *sabkhah*s, the narrow salt flats between the dunes.

By the 1990s, improvements in technology and decades of measurements suggesting that the *sabkhah*s remained consistently free of drifting sand alleviated concern. Continuing advances in computing power, 3D seismic imaging technology, and horizontal drilling gave the company's geologists and engineers a much more detailed look at the Shaybah reservoir than had been available for any previous drilling target of this magnitude. What they found was astounding: To put Shaybah in perspective, the field holds more oil — more than 14 billion barrels of oil equivalent — than the entire country of Brazil, even after more than two decades of production. It contains 25 trillion cubic feet of natural gas as well.

Abdallah Jum'ah, president and CEO of Aramco, center, leads a management team on a March 1997 visit to the Shaybah project. On Jum'ah's left is Sadad Al-Husseini, executive vice president of Exploration & Producing (E&P), and on his right, in the white shirt, is Abd Allah Al-Saif, senior vice president of E&P.

The logistics of developing Shaybah were mind-boggling. Until a road was graded through the sand dunes, materials had to be brought two-thirds of the way by contracted trucks and then transferred to Aramco's specially designed deep-desert vehicles, which carried the supplies the rest of the way. In 1996 alone, the company used 300 trucks to transport more than 3,800 loads weighing a total of 90,000 metric tons to the construction site. A paved access road was needed, so contractors built a 386-kilometer road across previously trackless desert. The construction took 12 months and was completed three months early, due in part to the 1,300 workers dedicated to the project and the 533 pieces of heavy equipment used to move nearly 15 million cubic meters of dirt and sand. To build the road more quickly, Aramco arranged for the access road to be built by three different contractors working on different sections simultaneously.

The road was constructed by collecting earth from marl pits composed of clay-like soil with good bonding properties, and depositing it along the road's path. Once laid, the marl was watered and then compacted by heavy equipment. This process was repeated several times to form layers, or "lifts," of watered and compacted material to ensure the road's reliability. After the road was completed, the trip from Dhahran to Shaybah could be made in less than 12 hours. A concrete runway large enough for a Boeing 737 followed 10 months later. With the regular delivery of supplies ensured, construction on facilities there continued at a rapid pace.

Deep in the Rub' al-Khali, construction crews lay pipe parallel to the Shaybah access road in August 1997. The pipeline carries oil 645 kilometers to Abqaiq, where it is processed for export from Ras Tanura and Ju'aymah.

In the footsteps of Khamis

Legendary Bedouin guide Khamis bin Rimthan's desert reading skills lived on in Quriyan M. Al-Hajri, a desert road building supervisor in the Drilling and Workover Department. Al-Hajri, the great-grandson of Bedouin herdsmen, and his crews criss-crossed large parts of Saudi Arabia in the 1980s, 1990s, and 2000s as they prepared access roads and drilling sites.

Following desert landmarks during the day and the stars at night, Al-Hajri relied on orienteering skills honed during his boyhood in the early 1960s when he helped his family herd their camels in search of fresh grass and water. He joined Aramco in 1979 after working for several years with a company contractor. While he and all employees in the department were trained in using Global Positioning System (GPS) navigational devices, Al-Hajri preferred to rely on his innate skill. "I'm afraid that if I don't use it, I will lose the knowledge," he said.

Quriyan M. Al-Hajri and Richard G. Moffitt check map coordinates near the Haruri airstrip about 200 kilometers northwest of Abqaiq in the spring of 2004. The two men were scouting the proposed location of an exploration well site.

"Our people may have to stay one or two nights out in the wilderness, dealing with whatever comes up," said Neil Brown, now retired Wellsites Division superintendent and longtime friend of Al-Hajri.

Al-Hajri once spent six months living in a tent high atop one of the red dunes in the Rub' al-Khali, helping direct road construction through the desert to Shaybah. Every night, Al-Hajri would light a fire and serve Arabian coffee for the weary workers. His tent became a focal point for relaxation and socializing for the people on the project, 800 kilometers south of Dhahran.

An appreciative guest of Al-Hajri's hospitality nominated him for Employee of the Year in 1996, noting in the nomination letter that Al-Hajri's tent was a place "where people of all nationalities could relax from the rigors of the day [and] has become a well-known feature of Shaybah and has helped tremendously to maintain morale and bring a certain kind of normality to an abnormally difficult area to work and live." Al-Hajri retired from Aramco in 2016.

Discovered in 1968, the Shaybah oil field, located 800 kilometers south of Dhahran in the Rub' al-Khali, was held in reserve until technological challenges and other factors could be resolved.

Expanding in the United States

In 1998, Aramco joined the top ranks of the U.S. gasoline marketing and refining industries. Saudi Refining Inc., a subsidiary of Houston-based Aramco Services Company (now known as Aramco Americas), and Texaco merged their Star Enterprise joint venture with Shell Oil assets in the southern and eastern portions of the United States to form Motiva Enterprises LLC. The transaction included a 20-year oil supply contract, obligating Motiva to purchase a minimum of 450,000 bpd of Saudi crude oil.

The Port Arthur facility, at 600,000 bpd, is the largest refinery in North America and one of the largest in the world, and is a key element in Aramco's strategy to build an integrated, global downstream system.

The ownership changed in 2002 when Saudi Refining Inc. and Shell purchased Texaco's interest and became 50-50 partners in Motiva as a result of the merger of Texaco and Chevron. In 2017, Shell and Aramco split Motiva's assets, with Aramco retaining the Motiva name, Motiva's Port Arthur, Texas, refinery, and 24 distribution terminals. Shell kept the approximately 5,300 Shell-branded service stations in the southeastern U.S.

The Port Arthur facility, at 600,000 bpd, is the largest refinery in North America and one of the largest in the world, and is considered the "crown jewel" of the U.S. refinery system.

"We view this transaction as a positive outcome of the strong and historic business of Saudi Aramco in the U.S.," said Amin H. Nasser, Saudi Aramco's president and CEO, "and see next steps to support Motiva in its ongoing role as a major refiner and a top provider of refined products and derivatives in the U.S."

Enabling easy air and ground transportation to Shaybah was only part of the challenge. The project also included construction of three GOSPs and scores of horizontal wells, scattered across the oil field.

A 645-kilometer pipeline was constructed to transport the oil from Shaybah for processing at Abqaiq. To avoid the time and expense of building and maintaining a pump station in the deep desert, the oil was kept at high pressure, roughly 45 kilograms per cm^2, after leaving the wells. Housing and recreation facilities to accommodate 1,000 men were also built.

The marquee 500,000-bpd project had the undivided attention of new president and CEO Jum'ah and his management team. Dozens of Saudi-owned companies and top international engineering and contracting firms were enlisted for the project. Many of the Saudi partners were involved from an early stage as the company pursued an accelerated contracting process to streamline planning, bidding, and construction.

In July 1998, three years after the development effort began and 30 years after the discovery of oil there, Shaybah opened for production. In March 1999, King Abdullah, then Crown Prince, inaugurated the $1.7 billion project, which represented not only an extraordinary technical and logistical achievement, but a cultural milestone as well. In a significant development for the company and the Kingdom, 90% of the team in charge of the Shaybah project was Saudi.

Oil prices rebounded from their 1998 lows as demand from Asia picked up and OPEC reduced production quotas, but the price collapse nonetheless reverberated throughout the industry. The mergers of Exxon and Mobil, British Petroleum and Amoco, and Total Fina and Elf Aquitane during this period were all driven at least in part by a desire to reduce operating costs in the face of lost revenue. Investments in capital programs worldwide all but dried up for several years for the same reason, setting the stage for oil production and refining capacity constraints in the following decade.

LESSONS LEARNED

Jum'ah later conceded that the intense focus on Shaybah caused the company to briefly let its attention slip from another contemporaneous project: the $1.3 billion upgrade of the Ras Tanura Refinery. The complex refinery project had started four years before Shaybah, but was completed two years behind schedule, the same year as the development of the oil field.

King Abdullah, then Crown Prince, center, with President and CEO Abdallah Jum'ah, on his right, and Ali Al-Naimi, Minister of Petroleum and Mineral Resources, on his left, are accompanied by members of the royal family and company management — and one young guest — on a visit to Dhahran in April 1999 for inaugurations of the Ras Tanura Refinery upgrade and a pipeline linking bulk plants at Dhahran, Qasim, Riyadh, and al-Hasa.

"We made the horrendous mistake of … not doing the inspection ourselves because at that time we were trying to economize. [Oil] prices were low and we were trying to cut costs as well as we can, so we sort of turned [over] a lot of the activities that we should be doing to contractors without proper attention," Jum'ah said. He recalled that while he and the management team were going to Shaybah nearly every month during the construction process, he could only remember visiting the Ras Tanura Refinery once or twice during the upgrade.

"We certainly failed in Ras Tanura, but that failure was an eye-opener," Jum'ah said. "To me, Ras Tanura was a hard lesson from which we emerged subsequently to be masters of mega-projects."

As a result of the setback at Ras Tanura, project management, construction, and engineering teams reexamined their practices and began consistently benchmarking their efforts against international standards. In 1995, the company had joined the U.S. Construction Industry Institute, to take advantage of its best practices experience, and sponsored a chapter of the Project Management Institute in the Gulf region. Aramco began the process of taking personnel off one successfully completed project and moving them right on to the next

project in a position of higher authority, so they could apply what they had just learned. The company also put operating and project management personnel on integrated teams so they worked more closely together. In addition, Total Quality Management programs, a series of subprograms and guidelines to improve project management, were introduced in 1994 and were reinforced from 1998 to 2002 in the wake of the delays at Ras Tanura to keep Aramco on the path of continuous improvement.

Concurrent with the Shaybah development and Ras Tanura Refinery upgrade, Aramco was also bolstering its domestic product network, building a series of pipelines to transport refined products such as diesel, gasoline, and kerosene to and from its bulk plants at Dhahran, Qasim, Riyadh, and al-Hasa. Included in the project were new bottom-loading facilities for tanker trucks at the North Riyadh Bulk Plant, which eliminated operator exposure to product vapors. The network provided many benefits, including increasing operating efficiency and the reliability of product supplies in the Central Province, eliminating approximately 1,650 tanker trucks daily from the highways, reducing trucking costs and road degradation, improving traffic safety, and easing traffic congestion around the company's bulk plants.

Despite delays in construction, the Ras Tanura Refinery upgrade, completed in 1998, four years after this photo was taken, was a valuable addition to company facilities. The improvements increased the percentage of high-value products, such as gasoline and diesel fuel, that the refinery can produce from each barrel of crude oil.

Hawiyah Gas Plant, shown here under construction in 2001, was designed to process 1.4 billion standard cubic feet of nonassociated gas per day for the Master Gas System. Aramco entered the new century with an increased emphasis on production of natural gas to fuel the Kingdom's economic diversification plans.

VALUE ENGINEERING

Aramco in the 1990s explored numerous ways to increase its competitive edge. One example was the company's adoption of value engineering, a process aimed at reducing costs while improving quality. A value engineering team was assigned in 1992, under the leadership of Abdulaziz O. Al-Ajaji, then acting general manager of Southern Area Projects and later executive director of Industrial Services, to evaluate all projects and eliminate what is often referred to as "gold plating": the addition of features that come in the "nice to have" category but are ultimately not essential to the success of the project.

Value engineering naturally creates internal friction between operating organizations that want the best facilities possible and project management teams responsible for bringing in projects on time and within budget. In the face of this natural tension, the value engineering team learned to listen to both sides, always with a keen eye on its ultimate mission: reducing costs while maintaining — or even improving — the quality and integrity of projects.

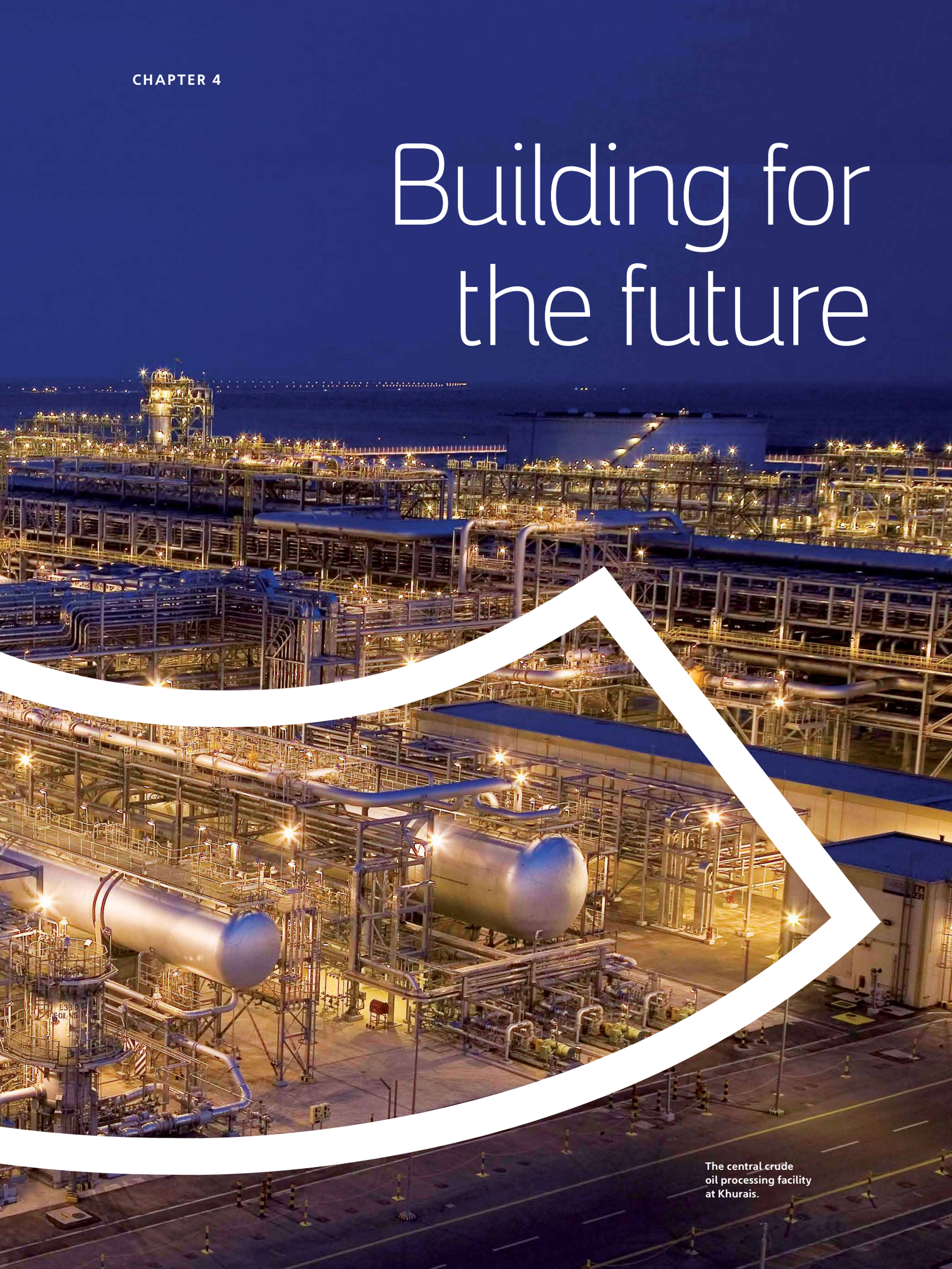
The timing of the team's creation could not have been better. The first project it reviewed was the giant Hawiyah Gas Plant. The plant was part of a push to develop additional nonassociated gas reserves to supply local industry with fuel and feedstocks. The team scrutinized every expenditure and trimmed $100 million off the $1.45 billion cost of the project. The plant opened in 2001, four months ahead of schedule.

The company's self-evaluation of its project planning and execution process that began in the late 1990s served Aramco well as the start of the 21st century brought multiple projects that placed even greater demands on company management. Aramco's ability to execute such precedent-setting projects and meet other challenges would depend largely upon tapping the full potential of its Saudi and expatriate workforce.

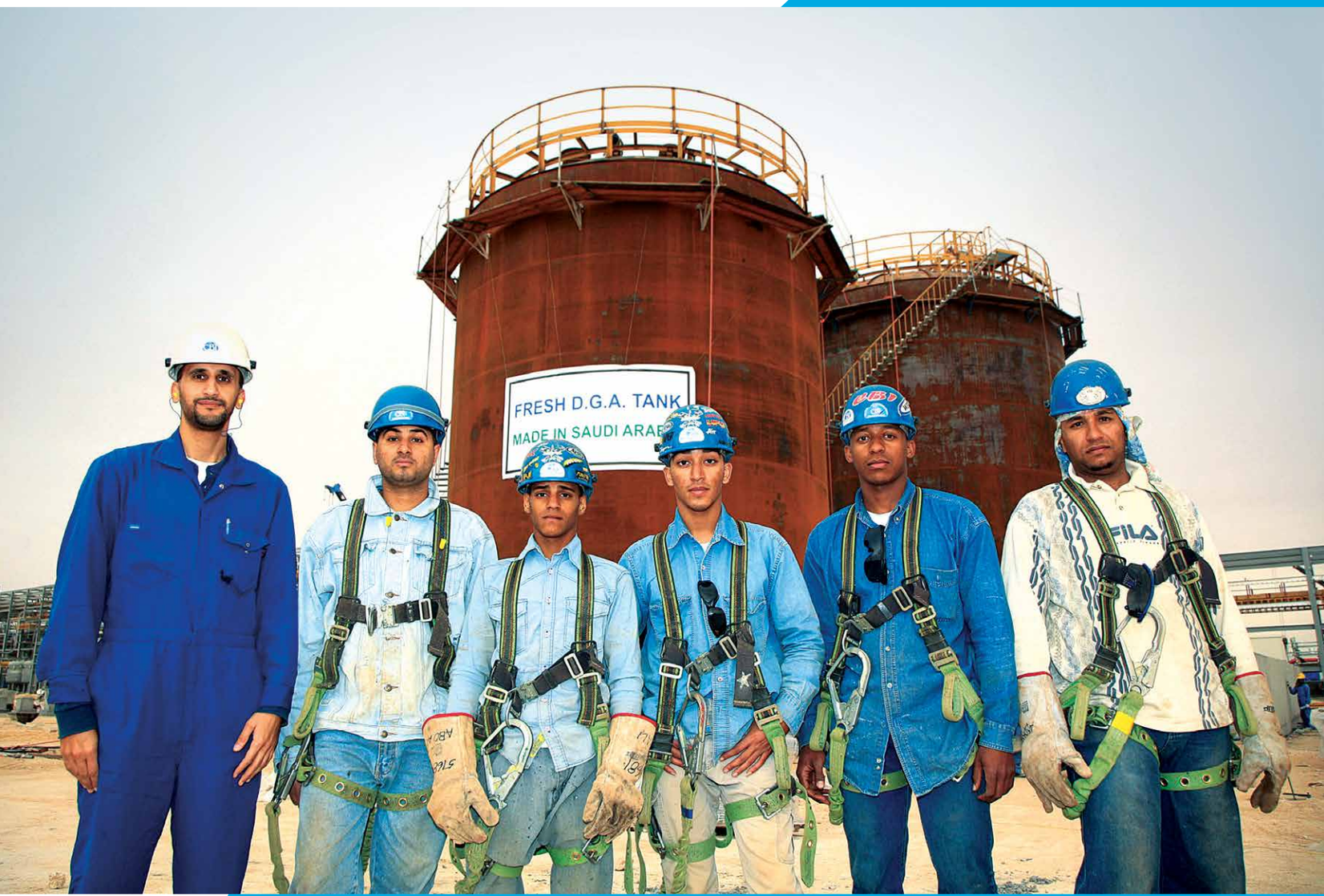
The Shaybah project was a proving ground for Aramco's workforce in the late 1990s, as many of the project managers and other key personnel moved on to even larger and more complex oil and gas projects in the new millennium.

CHAPTER 4

Building for the future



The central crude oil processing facility at Khurais.



Engineer Jamal Al-Marhoun, far left, and Saudi welders, left to right, Abbas Al-Darwish, Mohammad Al-Noor, Mohammad Al-Khabbaz, Hasan Al-Hasawi, and Ali Al-Abbad pose in front of two storage tanks they helped construct at the Hawiyah NGL Recovery Plant in 2007.

The first decade of the new millennium gave few hints of the boom that was to come. Relatively weak oil prices and slack global demand for much of the 1990s led the oil company to look inward and tighten its belt and focus on operating efficiencies.

But as the new century got underway and oil prices recovered, the company pivoted to planning the biggest expansion program in a generation to meet soaring global demand for oil — and surging domestic demand for gas to power the growth of the Saudi economy.

The unprecedented building boom encompassed massive processing facilities rising from Saudi Arabia's vast deserts and shallow seas. They were custom-designed to tap Saudi Aramco's onshore and offshore oil and gas fields, and develop mammoth stand-alone, nonassociated gas finds.

Paralleling the tremendous increase in capital expenditures was a dramatic increase in investment in Saudi Aramco's human capital. Leadership realized that it would have to transform the company workforce to remain at the forefront of the energy industry in the 2000s. That meant breaking down barriers that were keeping employees, especially the majority of workers in their 20s and 30s, from tapping their creative, problem-solving skills. And it meant bringing more women into the Saudi Aramco workforce and giving them more responsibilities and opportunities.

"Building for the future isn't simply a matter of laying pipeline, erecting distillation columns or building gas plants," said president and CEO Abdallah S. Jum'ah. "It also means developing minds — and mindsets — ready to meet the scientific, technical, and intellectual challenges for an ever more complex world."

PEOPLE POWER

Jum'ah declared 2001 "The Year of Self-Development," and with the advent of the internet and the fast-growing world of online training resources, Aramco embraced these powerful new tools. The company instituted new programs, increased its support for employee participation in professional societies, hosted exhibitions, and launched a special website to help employees take control of their own intellectual growth and career paths. The initiative emphasized the potential for employees to use personal computer technology to take online courses tailored to their specific fields.

Employee Abdulrahman M. Abdulqadir said the system demonstrated that Saudi Aramco was "looking for ways to lead, not just survive." Abdullatif A. Al-Othman, senior vice president for Finance, who left the company in 2012 to become Governor of the Saudi Arabian General Investment Authority, noted, "We understand that sustained business success comes through providing our employees with opportunities to hone their skills and apply their talents, and helping them realize their potential as professionals, and as people."

Keeping the focus on the potential of each employee to use insights and experience to benefit the company, Jum'ah declared 2002 the "Year of Innovation." Employees were encouraged to submit ideas for improving company performance via the company's proprietary web-based Idea Management System. By the end of the year, thousands of suggestions had been received. Proposals ranged from ways to improve basic work processes to patentable ideas. Added together, those suggestions saved the company a significant amount of money within a few years. Sami A. Abdel Mohsin and his team from the Central Ghawar Well Services Division, for example, found that some pumping units could be built from recycled parts at a fraction of the cost of a new unit.

RETHINKING PERFORMANCE STANDARDS

To ensure the success of future projects, senior management understood that it had to analyze its own performance as well as long-embedded company practices. They decided Saudi Aramco needed to be measured against its global best-in-class competitors if it was truly going to be transformed into a high performance organization.

The results were sobering. In 2000, Independent Project Analysis (IPA), a private U.S. consulting firm, conducted a benchmark study of 30 industry projects. It found that Saudi Aramco's projects were taking 60% longer than the average global industry project and costing almost 30% more.

Rather than searching for excuses, the company redoubled its efforts to improve

Like its sister plant at Hawiyah, the Haradh Gas Plant's project team was nearly all Saudi. The Haradh facility, with a processing capacity of 1.8 billion standard cubic feet per day of nonassociated gas, started up in June 2003. Both gas plants were named Project of the Year by the Project Management Institute.

performance. The Hawiyah Gas Plant, completed in 2001, was the first $1 billion-plus project completed after the IPA benchmarking. It provided the first solid evidence that Saudi Aramco was applying the lessons of Shaybah and Ras Tanura, as well as value engineering (providing necessary functions in a project at the lowest cost) and related concepts. By mid-decade, major projects were being completed on schedule and under budget 80% to 90% of the time.

NATURAL GAS MOVES TO CENTER STAGE

The stakes could hardly have been higher. Representing the first expansion of the MGS since the 1970s, the Hawiyah Gas Plant was a critical component of the Kingdom's industrial infrastructure, which was operating under the strain of greater than expected local demand for natural gas fuel and feedstock. Hawiyah, the first plant built exclusively to process nonassociated gas, provided facilities to process 1.6 billion scfd of gas from the deep, high-pressure Khuff and Jawf gas reservoirs — the latter a sandstone formation found in 1994 lying even deeper than the limestone Khuff formation — at the southern end of the Ghawar field. The gas produced by the plant freed additional crude oil for export that had been used to fuel domestic industry.

The Hawiyah Gas Plant was the model of a modern construction project. The Project Management Institute (PMI) awarded the plant its prestigious Project of the Year Award in 2002. Also sited at the southern end of the Ghawar field and completed two years later, the equally large, but even more energy efficient and environmentally friendly Haradh Gas Plant reduced the amount of energy lost in the plant's steam cycle from 65% to 20% and won PMI's Project of the Year Award in 2003.

The construction of the Hawiyah and Haradh gas plants, and later upgrades, increased the total capacity of the MGS to 9.4 billion scfd, compared with 2 billion scfd capacity in 1983, when the MGS was established. The giant projects underscored the increasing importance the Kingdom and the company placed on developing the country's gas resources, especially nonassociated gas. Indeed, in June 2000, while the Hawiyah plant was still under construction, Saudi Aramco formed its first Gas Operations business line to consolidate all gas-related activities.

In June 2000, M. Yusof Rafie, who joined the company in 1970 after graduating from the University of Cairo with a bachelor's degree in petroleum engineering, was appointed the first senior vice president of Gas Operations. Rafie, who retired in December 2008, became responsible for all gas plants. He also led the planning, engineering, maintenance, and future development of gas facilities.

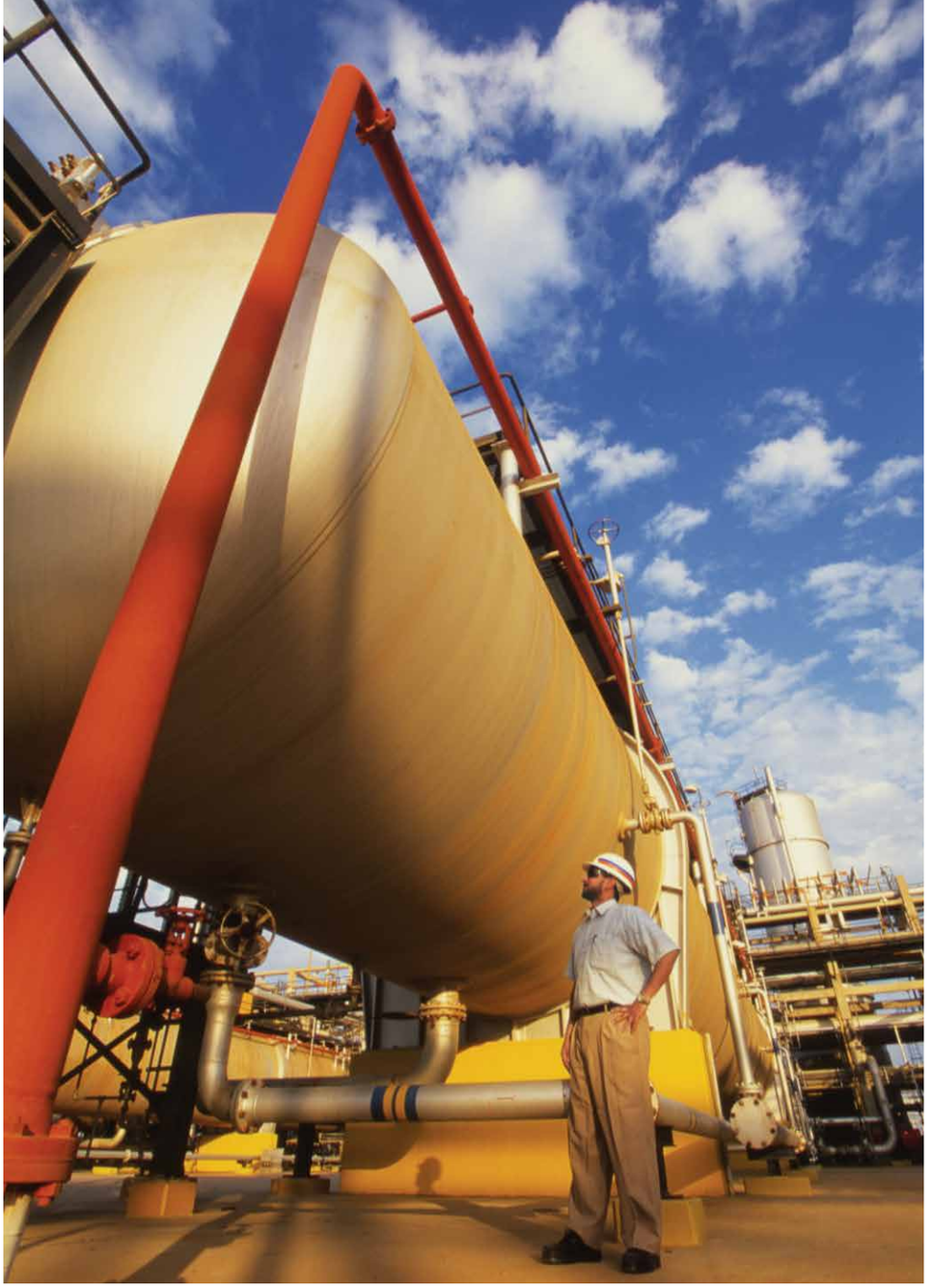
The appointment of the widely respected Rafie to helm Gas Operations no doubt underscored for many employees the urgency and significance of the expansion of the MGS. And there was no doubt Rafie respected the Saudi Aramco workforce in return. "I believe in the people," Rafie said upon his retirement. His advice to those who followed in expanding the MGS, and for all employees committed to the success of Aramco? "Make your mark by working hard, leading by example."

NATURAL GAS INITIATIVE

The Natural Gas Initiative (NGI) was started in 2001, in response to a government directive, to attract international oil companies to prospect for and develop gas reserves in regions that were not being actively explored by Saudi Aramco. The initiative focused on areas that earlier company research indicated contained subterranean structures that were likely to be more difficult to develop commercially.

Khalid A. Al-Falih, who had not long been serving as president and CEO of Petron, the company's refining and marketing equity venture in the Philippines, was assigned to lead the NGI negotiating team in 2001. In the 1990s, Al-Falih had helped draft the Kingdom's first gas strategy and development options to grow supplies to meet rising demand. The gas joint ventures were put under the aegis of the New Business Development organization in 2003, and Al-Falih was named the vice president of that organization.

The first international gas exploration joint venture was formed in October 2003 when Royal Dutch Shell and France's Total signed agreements with Saudi Aramco to explore for, develop, and produce nonassociated gas in nearly 210,000 square kilometers in the southern part of the Rub' al-Khali. In early February 2008, Total exercised its right to withdraw under the terms of the agreement, transferring its stake to project partners Royal Dutch Shell and Saudi Aramco.



The first big crude oil increment of the new millennium was the Qatif and Abu Sa'fah project, which added 800,000 bpd of production capacity in the summer of 2004. The project also included expansion of Berri Gas Plant to handle the additional volumes of associated gas produced with the crude oil.

Three more international joint ventures were created in 2004, with Saudi Aramco holding a 20% equity stake in each. Lukoil Saudi Arabia, a joint venture with Russia's Lukoil, was created to explore a 30,000 square kilometers area; a joint venture with China's Sinopec, Sino Saudi Arabia, was granted a 39,000 square kilometers exploration area; and EniRepSa, a joint venture with Italy's ENI and Spain's Repsol YPF, was assigned an area covering 52,000 square kilometers.

The harsh environment of the desolate desert expanses in which the international companies prospected proved challenging for the gas joint ventures. Saudi Aramco geologists earlier had predicted that the odds were long that commercial quantities of gas would be found in these regions, and they were proved correct — at least at that time. After a trying decade, three of the four joint ventures had shelved or wound down their exploratory efforts. The joint venture between Saudi Aramco and Lukoil was the last to cease operations, in 2016. With new technology, Aramco would later find substantial quantities of gas in several of these same fields.

QATIF: BLENDING SUCCESS

Saad Turaiki, vice president of Southern Area Oil Operations, now retired, embodied the characteristics of innovation and self-motivation that the company promoted among employees. Long before innovation became an official part of the Saudi Aramco management vocabulary, Turaiki championed ideas that at first left many co-workers scratching their heads. In short order, however, they were applauding his concepts.

Turaiki joined Aramco in 1975 after graduating from what was then the University of Petroleum and Minerals and worked on the development of Qatif and

Strategic imperatives

To help set long-term goals for the company, president and CEO Abdallah S. Jum'ah in 2002 convened a retreat for senior management at Shaybah. Despite the fact that the company's growing slate of projects was consuming huge amounts of management attention, Jum'ah wanted to allow the executive team to step back and identify future challenges and develop strategies required to meet them. Six strategic imperatives grew out of that meeting:

- Maximize revenues by capturing oil growth opportunities.
- Protect the future market for oil.
- Leverage oil and gas resources to expand the Kingdom's economy.
- Optimize the corporate portfolio.
- Transform corporate performance.
- Prepare Aramco's workforce for the future.

Abu Sa'fah fields in the mid-1990s. At the time, production was declining as OPEC tightened supply in an effort to curb falling prices, and managers were trying to cut operating costs any way they could.

One day, Turaiki was thinking about processing costs and how the company needed different facilities to process each grade of oil it produces. "I said, 'Why do we have three increments at Qatif? It's in one area. Can't you blend the crude and produce it as one increment?'" He wrote a letter to his superiors asking that the company investigate blending the crude oil grades, a concept that did not receive much initial support from his peers.

"Everybody was sort of saying, you know, 'What is this crazy idea?'" he said. Company engineers nonetheless took the idea to research and development. "To their surprise, they came to me and said, 'You know, Saad, it's great. It's great Arabian Light crude,'" Turaiki recalled.

Given the associated costs, senior operations management had not been interested in producing individual grades of Qatif crude oil if they could be delivered in increments of only 150,000 to 200,000 bpd for each grade. Bringing the field online as a single, 500,000-bpd increment of blended crude oil, processed in a single facility, was a far more attractive proposition.

With prices clearly recovering by 2000 (when Arabian Light hit a year high of $31.93 a barrel on September 22), the project, which included doubling oil production capacity from the offshore Abu Sa'fah field to 300,000 bpd, got the green light. Development of the increment began in 2001 and was completed in July 2004, three months ahead of schedule.

CAPACITY CONCERNS

Saudi Aramco significantly increased production in 2003 to help compensate for the Iraqi production taken off the market following the U.S. invasion of Iraq in the spring of that year. The company's average production for that year was 8.1 million bpd, up 1.3 million bpd from 2002. When production from the Qatif plant came online in 2004, average daily production increased to 8.6 million bpd, helping to meet rapidly increasing demand from China in particular.

The production hike narrowed Saudi Aramco's spare production capacity to less than its comfort level of 1.5 million to 2 million bpd (out of a total of about 10 million bpd) — and all signs indicated that world demand was likely to continue increasing at a brisk pace. At the same time, the level of hostilities in Iraq, including the sabotaging of oil facilities and pipelines, made it increasingly clear that world markets could not expect significant amounts of crude from that country anytime soon. Saudi Aramco and government officials realized by the latter part of 2004 that the Qatif complex, while setting important milestones in terms of size and complexity, was a harbinger of even bigger, costlier, and more complex projects to come.

The massive Khursaniyah oil- and gas-processing complex, shown here during construction, was built to process 500,000 bpd of Arabian Light crude oil and 1 billion scfd of associated gas.

Fawaz Hassan, left, a safety officer with a contractor company on the Khursaniyah Gas Plant project, discusses proper safety harness rigging with a fellow employee early in 2007. Hassan was one of thousands of young Saudis trained to take on important construction jobs essential for the success of the long list of Aramco projects under way in the mid- to late 2000s.

MEGA-PROJECTS TO BOOST MSC

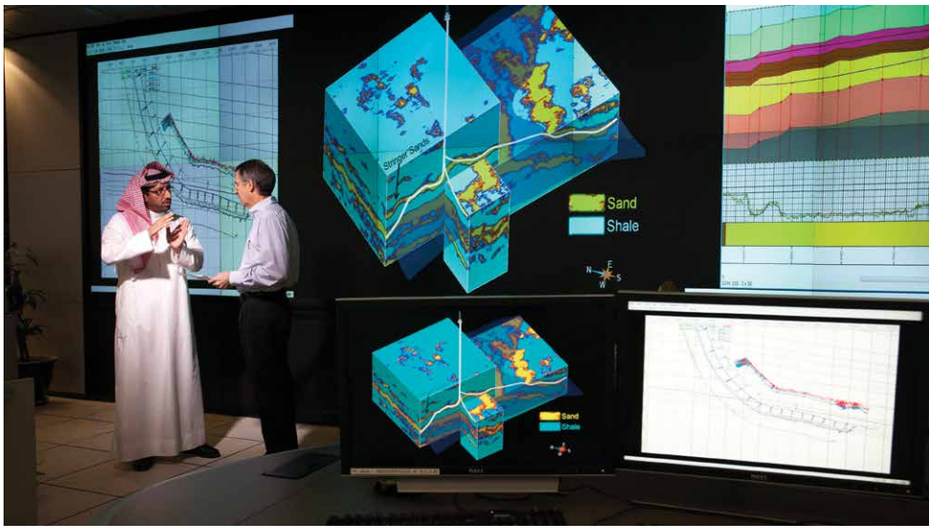
In early 2005, then Crown Prince Abdullah, Minister Al-Naimi, and other Saudi senior government officials began discretely contacting the Kingdom's major trading partners and allies to alert them about an important development. After reassessing the Kingdom's oil and gas strategies, the Saudis had news that was likely to make headlines and move oil markets when it was announced in May: Saudi Aramco was budgeting tens of billions of dollars over five years on one of the largest oil industry capital spending programs anywhere in the world.

More than half the total was slated for the construction of a half-dozen mammoth oil production facilities — any one of which deserved a place in oil industry record books. Collectively, the new facilities were designed to boost the company's maximum sustainable capacity (MSC) of crude oil production by 2 million bpd to about 12 million bpd. That increase, roughly equivalent to the total daily production of Venezuela, would maintain Saudi Aramco's spare capacity of at least 1.5 million to 2 million bpd to help meet unexpected global demand.

Concerns about meeting demand were underscored within a few months of the announcement when hurricanes Katrina and Rita slammed into the U.S. Gulf Coast, disrupting refining in several locations and sending crude oil and gasoline prices soaring. The twin disasters sent a clear message to world energy markets: The sooner additional production could be brought online and refined, the better.

POINT OF TRANSFORMATION

A host of new technical advances the company had recently rolled out or was in the process of employing in the field gave Saudi Aramco officials confidence that the company was more than ready for the massive projects in the works. At the southern tip of the Ghawar field, 280 kilometers from Dhahran, the Haradh-3 crude oil increment was completed in January 2006, five months ahead of an already tight 26-month design and construction schedule. Equally remarkable, the project came in under budget. The Haradh-3 GOSP and associated facilities added 300,000 bpd in Arabian Light crude oil production and also produced 140 million scfd of associated gas.



Aramco geologists direct well drilling from the company's Geosteering Center in Dhahran as real-time information is transmitted from sensors near the drill bits. The center operates 24 hours a day, seven days a week.

Surrounded by a barren, tabletop terrain of gravel and sand, the Haradh project became recognized around the world as a showplace for cutting-edge technologies. Here, the unprecedented integration of drilling and producing technologies — maximum reservoir contact (MRC) wells, "geosteering" for optimal placement of wells, "smart" well completion technology, and the revolutionary intelligent field concept (in which surface and subsurface sensors transfer real-time data on temperature, pressure, flow rates, and other factors to Dhahran) — represented "a point of transformation" for Saudi Aramco, said Amin H. Nasser, then executive director of Petroleum Engineering and Development. Nasser, who became senior vice president for the company's upstream operations in 2008 and president and CEO in 2015, said bundling these technologies created "a model to be followed by the rest of the industry."

Many of these practices had been used separately or in pairs by the company on individual wells — the first MRC well in Saudi Arabia was drilled in Shaybah in 2002, and the first "smart" well was drilled in Shaybah in 2004. But Haradh-3 was the first major addition to production capacity — at Saudi Aramco or anywhere in the world — that bundled the technologies and applied them to a drilling program developing a particular field.

By using geosteered MRCs — as opposed to traditional vertical drilling — reduced the number of wells needed to produce 300,000 bpd in the Ghawar field by nearly 90%. Haradh-3 required only 32 MRC wells versus the 280 that would have been required using vertical wells.

Working at scale

The scale at which Saudi Aramco processes crude oil and gas is mind-boggling. Take just one portion of the kilometers-long remote Khursaniyah oil- and gas-processing complex, 154 kilometers north of Dhahran, part of the mid-decade expansion plan. Lined up side by side are an array of six massive steel storage vessels designed to hold natural gas liquids (NGL). Each vessel is 67.7 meters long and 6.6 meters wide and tips the scales at 1,050 metric tons.

A worker is dwarfed by an NGL storage vessel under construction on the Khursaniyah project site north of Dhahran in 2006. A Saudi firm was contracted to build six of the mammoth NGL tanks and 33 other vessels, and did so onsite.

Even though the intense desert sun makes the steel far too hot to touch, the metal still required heat treating to 690 degrees Celsius for seven days. As hard as it is to imagine that kind of intense heat for so long, it is just as difficult to realize that, to speed delivery schedules, the vessels were baked on-site in gigantic gas-fired ovens as if they were so many loaves of bread.

Impossibly big, impossibly heavy, and impossibly hot. And as impossible as it seems, relatively insignificant in terms of the sheer scope of the total Khursaniyah complex itself, not to mention the half-dozen other multi-billion dollar projects that were being built at the same time across the Kingdom.

EXPEC ARC

Saudi Aramco's upstream technological progress supporting the megaproject development was spearheaded by scientists at the Exploration and Petroleum Engineering Center's Advanced Research Center (EXPEC ARC) in Dhahran. Teams of researchers there — then and now — explore new avenues in the fields of geophysics, geology, reservoir engineering (including enhanced oil recovery technologies), drilling, and computational modeling of reservoirs.

Muhammad M. Saggaf, then-chief petroleum engineer, was eminently qualified to lead company scientists on their quests during the mega-project era. Saggaf joined the company in 1989 after completing a degree in mathematics at King Fahd University of Petroleum and Minerals (KFUPM). That same year, he earned his master's degree in geophysics from Massachusetts Institute of Technology (MIT). After stints in Geophysical Research & Development and Reservoir Characterization at Saudi Aramco, he returned to MIT in 1998 and completed his doctorate in geophysics in less than two years. Saggaf is also a recipient of the prestigious J. Clarence Karcher Award from the Society of Exploration Geophysicists.

After serving as president of the King Abdullah Petroleum Studies and Research Center (KAPSARC) from 2012 to 2014 and then returning to the company as acting service line head, and later senior vice president of Operations and Business Services, Saggaf in January 2020 was named acting president of KFUPM.

Saggaf's resume, and many others like it, was a testament to the caliber of scientists attracted to Saudi Aramco: Nearly half of the roughly 250 people who worked at EXPEC ARC during the building phase for the mega-projects had doctoral degrees.

"We have people working here from all over the world, of many different nationalities," Saggaf said. "We believe in the value of working with a diversity of cultures to include the breadth of experience and knowledge that people from different countries can bring to Saudi Aramco. We also appreciate the value of the synergies that can be developed from this interaction between people." In the following decade, Saudi Aramco continued to not only attract top global researchers, it expanded its global reach with an unparalleled network of research centers in Europe, Asia, and the United States.

A team from the Exploration and Petroleum Engineering Center's Advanced Research Center (EXPEC ARC) discusses extreme reservoir contact well technology in 2007. Team members, left to right, are Hiba A. Dialdin; Nabeel S. Habib; Mohammad N. Asker; Muhammad M. Saggaf, then manager of the center; Jin Jiang Xiao; and Abdullah M. Al-Qahtani.

Aramco personnel walk through the completed Khurais facilities, which were among the most complex and challenging Aramco had ever built. When completed, it represented the world's largest crude oil increment ever at 1.2 million bpd.

KHURAIS: "AGAINST ALL ODDS"

The biggest mega-project of the decade in terms of added crude oil production, as well as its $10 billion price tag, was a dust-covered sleeping beauty of the deep desert. Discovered in 1957, the Khurais field is 250 kilometers southwest of Dhahran, and wandering camels made nighttime transit in the area extremely hazardous. For years, the low-pressure field produced a modest 190,000 bpd. An upgrade in 1982 boosted daily production to 300,000 bpd. The production facilities were shut down in 1993 during a period of slack global demand for oil and would remain in a state of slumber for the next dozen years.

By 2005, two trends converged that would prompt Saudi Aramco to bring Khurais back to life. Between 2003 and 2005, the price of oil on world markets doubled to $60 a barrel as booming global economies drove demand. That demand from its international customer base, as noted previously, led Saudi officials to commit to the era of mega-projects. Demand continued to drive prices higher, with oil regularly trading above $100 a barrel in 2008, until the financial crisis of 2008 and 2009 cratered global growth and oil prices collapsed. The second trend was the track record of successful execution of increasingly complex projects and the upstream technological acumen coming out of EXPEC ARC.

The company's scientists were confident that the sprawling Khurais field — comprising 1,200 square kilometers, and two smaller adjacent fields, Abu Jifan and Mazalij, each 250 square kilometers — could produce several multiples of the 300,000 bpd Khurais was producing before being shut down. They determined that the Khurais area fields combined would rate as a supergiant, which is the title bestowed on the fewer than a dozen global oil fields capable of producing more than 1 million bpd of oil. Their target for this project: four times the production of its earlier life, or 1.2 million bpd.

The oil was there. The trick was getting it out, processing it, and pumping it back to the company's existing facilities for export. A two-year study considered six options and ended up recommending scrapping much of the existing infrastructure, including six separate oil- and gas-processing facilities. Instead, a single processing facility would process the oil produced by the more than 300 wells tapping Khurais and the two smaller fields. Electric submersible pumps were to be installed in each well to help compensate for the relatively low pressure of the fields. Also attacking the pressure issue would be more than 2 million bpd of desalinated water pumped under pressure into the oil-bearing substrate.

Adding to the complexity of the Khurais and other mega-projects underway was the fact that while Saudi Aramco was working in barren deserts, it wasn't operating in a vacuum. A global boom in industrial construction fueled by round-the-world growth created intense competition for construction expertise and materials. The cost of structural steel on world markets nearly doubled between 2005 and 2008, and other key materials such as concrete, pipe, and electrical cables were close behind, or in some cases, actually rising at a faster rate. That would leave little room for error or delay without sending costs skyward.

Bringing the supergiant Khurais area fields online necessitated a chain reaction of upgrades to existing infrastructure as well as building an array of new supporting infrastructure, such as power stations and roads. The top priority was the Qurayyah Seawater Treatment Plant on the Arabian Gulf. Already the world's largest seawater treatment plant, the capacity needed to be increased by about 2.5 million bpd just to meet the seawater injection needs of the Khurais field. Another 2 million bpd of added capacity was piped on past Khurais to water injection plants serving the nearby supergiant Ghawar Field, bringing the total capacity of Qurayyah to nearly 13.5 million bpd. That added capacity, in turn, required a new, 60-inch diameter pipeline, resin-coated inside and out, dedicated to transporting seawater 200 kilometers from the coast to Khurais. Likewise, the transnational East/West Pipeline carrying crude oil directly over the center of the field would be upgraded to handle the added capacity.

When the project planners were through with their first phase of work, they had created more than 25 major contract packages to develop Khurais that were bid out to a global network of contractors. In addition to the seawater capacity expansion and upstream and downstream oil pipelines, the contracts covered everything from oil- and natural gas-processing facilities, process control systems, and drilling oil and water injection wells, to electrical and other utilities. Also constructed was a community to house the Khurais construction workforce, 30,000 of whom labored on the multi-year project, and 1,200 permanent employees.

Saudi Aramco's commitment to safety and resiliency and its ability to bring best-in-class technology to bear played key roles in bringing the Khurais facility online in 2009, on schedule and within budget. Nasser, then senior vice president for Exploration and Producing, cited the dedicated workforce as the most important ingredient to Khurais' success. In *Against All Odds*, a book produced by Saudi Aramco to celebrate the achievement at Khurais, Nasser said, "This team possessed the right skills, attitudes, and values. The investment in our workforce and their empowerment bore fruit as even the most difficult challenges were overcome."

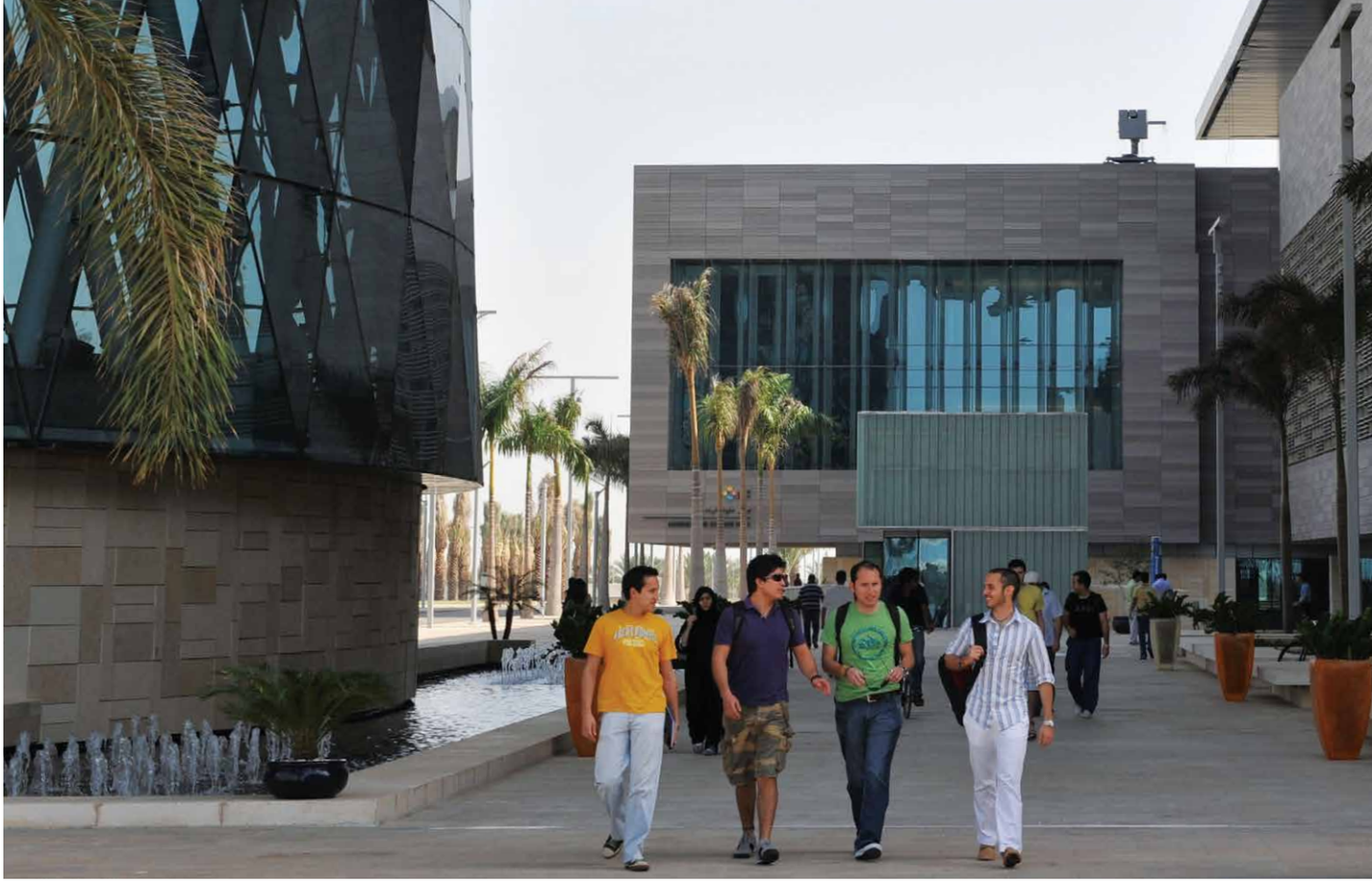
Assisted by tugboats, a supertanker — all 333 meters and 300,000 tons of her — eases into a crude oil loading berth at Ras Tanura Sea Island while a departing ship crosses her bow in early 2005. The delicate procedure of berthing and unberthing these enormous ships was performed by company harbor pilots — all Saudis — thousands of times during the year in which more than 2.6 billion barrels of oil were exported to markets around the world.

Celebrating 75 years

In May 2008, King Abdullah traveled to Dhahran to mark the 75th anniversary of the founding of the oil company in 1933. He was following in the footsteps of his father, King Abdulaziz Al-Saud, who in 1939 and again in 1947 visited company facilities in the Eastern Province. In fact, the visit was a royal reunion of sorts. Twenty-five of the 29 children of expatriate oil company workers who had met his father in 1947 were brought back to Dhahran by the company, some accompanied by their spouses and children, to meet King Abdullah.

As well as honoring the past, King Abdullah's visit for the Diamond Jubilee focused on the future, with the King laying the symbolic cornerstone for the King Abdulaziz Center for World Culture, Aramco's flagship community outreach and cultural gift to the Kingdom and its people. Located near the site of Well No. 7, the Prosperity Well, the center was destined to become an iconic architectural landmark and a model for social progress through education, the arts, and cross-cultural exchange.

King Abdullah, center, joined by leaders of other Gulf states, members of the royal family, Aramco management and a group of Saudi children, celebrates Aramco's 75th anniversary in Dhahran in May 2008.



Students head to class on the campus of the King Abdullah University of Science and Technology. The graduate research university, built by Aramco, opened its doors in the fall of 2009.

BUILDING A KNOWLEDGE-BASED SOCIETY

Even as Saudi Aramco teams were going all out to build the array of hydrocarbon mega-projects, they were tasked with another, unique project. In July 2006, King Abdullah, who became King in 2005 after King Fahd passed away, asked the company to take the lead in building and developing King Abdullah University of Science and Technology (KAUST) to become one of the world's great research institutions and a centerpiece of the plan to broaden the Kingdom's educational offerings. The company was charged with constructing the multi-billion dollar, coed graduate research university from scratch on a 36-million square meter site located near the fishing village of Thuwal, about 80 kilometers north of Jiddah on the Red Sea.

Saudi Aramco assembled a project team and enlisted the help of an international advisory council to craft the university based upon the best practices of the world's top academic and research institutions. In an innovative approach, the university was organized around interdisciplinary research institutes and featured an adjacent research park to link activities with private-sector research and economic development.

Officials of the nascent university began creating programs and signing international development agreements even while facilities were under construction. KAUST initiated partnerships with some of the world's foremost research institutions, with each partnership drawing upon the strengths of the respective institution. For example, KAUST and the Woods Hole Oceanographic Institution in Massachusetts agreed to engage in research focused on coral reefs, coastal hydrography, and fisheries and aquaculture. A partnership with the Institut Français du Pétrole focused on carbon capture, clean fuels, catalysis, polymers, and chemical engineering modeling.

In January 2008, the university awarded its first KAUST Discovery Scholarships to 178 outstanding male and female engineering and technology undergraduate students from around the world, including more than 80 students of both genders from Saudi universities. They were among the first group of graduate students to attend classes when the campus opened in September 2009.

Underscoring its commitment to supporting hydrocarbon research in the Kingdom, Saudi Aramco collaborated with KAUST in 2016 to create the Ali Al-Naimi Petroleum Engineering Research Center, named in honor of the then-Minister of Petroleum and Mineral Resources. Several of KAUST's young researchers have conducted innovative applied research that Saudi Aramco has deployed. In 2019, KAUST was named among the top 10 leading "young" global research universities less than 50 years old, based on the quality of its research output.

Vela-Bahri merger

Saudi Aramco established its shipping subsidiary, Vela International Marine Limited, in 1984, when rights to Vela's name and four existing tankers were acquired. By the early 1990s, the company was determined to increase its presence in the shipping industry. To steer the effort, company leadership tapped a rising star, even if he was a bit of a landlubber.

One day in 1992, vice president of Supply and Transportation Dhaifallah Al-Utaibi was summoned to meet with president and CEO Al-Naimi and executive vice president Ajmi in Al-Naimi's office. The two executives told Al-Utaibi he had been selected to be president of Vela. Surprised by the selection considering his relative lack of experience, Al-Utaibi replied, only half in jest, "I don't have a clue about the shipping business."

Al-Utaibi proved more than capable. When he was named president of Vela in December 1992, the affiliate consisted of eight supertankers: four very large crude carriers (VLCCs), which can carry up to 2 million barrels, and four ultra-large crude carriers (ULCCs), which can carry more than 2 million barrels. Four smaller product tankers rounded out the fleet. An additional 15 new VLCCs were on order from shipyards in Japan, Denmark, and the Republic of Korea. The fleet's headquarters was located in a small suite of offices in the Aramco Tower Building in Dhahran.

Khalid G. Al Buainain, seated right, then senior vice president of Downstream, shakes the hand of Abdullah S. Al-Rubaian, Bahri chairman, after the 2012 announcement of the signing of a Memorandum of Understanding to pursue the merger of Vela International Marine Limited and Bahri.

Al-Utaibi spent nearly four years reconfiguring Vela's operations into a world-class shipping company. He brought the management of all aspects of Vela's business in-house, training Saudis to assume jobs that had been previously performed by a number of different European management companies. Vela's ship management operations moved to Dubai in 1995 to take advantage of its strategic location for Gulf shipping. That same year, after the last of the 15 VLCCs ordered in 1992 had been delivered, Vela's fleet included 27 tankers, ranking it among the largest such fleets in the world. During Al-Utaibi's time at the helm, Vela began a track record as a leader in the maritime transportation industry in safety and operational efficiency.

To achieve greater economies of scale in shipping and focus on its core oil and gas operations, Saudi Aramco in 2012 agreed to merge Vela with Bahri, the National Shipping Co. of Saudi Arabia. Vela transferred ownership of its entire fleet, consisting of 14 VLCCs, a floating storage VLCC, one Aframax tanker, and four product tankers, to Bahri. The merger created a fleet of 77 vessels, making Bahri the fourth largest owner of VLCCs at the time.

Khalid Al-Falih poses with project teams on the Jazan project in 2015. Al-Falih succeeded Abdallah Jum'ah as president and CEO in January 2009.

A BURNING OPPORTUNITY

In January 2009, Khalid A. Al-Falih, who had been serving as Saudi Aramco's executive vice president of operations since 2007, succeeded Abdallah S. Jum'ah as president and CEO. Educated in-Kingdom and at Texas A&M University, he rose through the leadership ranks and participated in many of the key initiatives of the previous decade, working closely with Jum'ah as well as his predecessor Al-Naimi.

There would be no honeymoon period. He assumed office in the middle of the global financial crisis, and his highest priority was steering Saudi Aramco to calmer waters. Resurgent demand from China buoyed global oil prices faster than many had suspected, and Saudi Aramco weathered the global storm relatively unscathed. With the worst of the downturn behind him by early 2010, Al-Falih and his leadership team were free to focus on the long-term challenges facing Saudi Aramco.

In many ways Saudi Aramco was at the top of its game coming out of the financial crisis. The mega-projects were completed or near completion. The added capacity would ensure Saudi Aramco could fulfill its role as the world's most reliable supplier of energy for years to come. But Al-Falih and his leadership team knew they couldn't afford to take a breather if they were to continue to prevail going forward. "Ultimately, we came to realize that, while we didn't have a burning platform, we did have a burning opportunity," Al-Falih said.

After announcing the Accelerated Transformation Program in 2011, former president and CEO Khalid A. Al-Falih and other company executives went to Aramco facilities around the Kingdom and internationally to explain the initiative. Here Al-Falih addresses employees at Aramco Services Company, now Aramco Americas, in Houston.

"I started reflecting on what should this great performing machine do differently in the decades to come," Al-Falih added. "What are the mega-trends happening globally? What are the big trends happening at the national level, and what are the trends happening within the company, its workforce, its scope and mandate, which has creeped up over the years? And should the machine just simply continuously be worked over, re-oiled, and continue doing what it's doing, or does it need a major overhaul?"

In the spring of 2010, the leadership team embarked on a process of corporate reinvention. It launched a sweeping reassessment of its corporate strategy. At the same time, it gave its organizational health a complete physical examination.

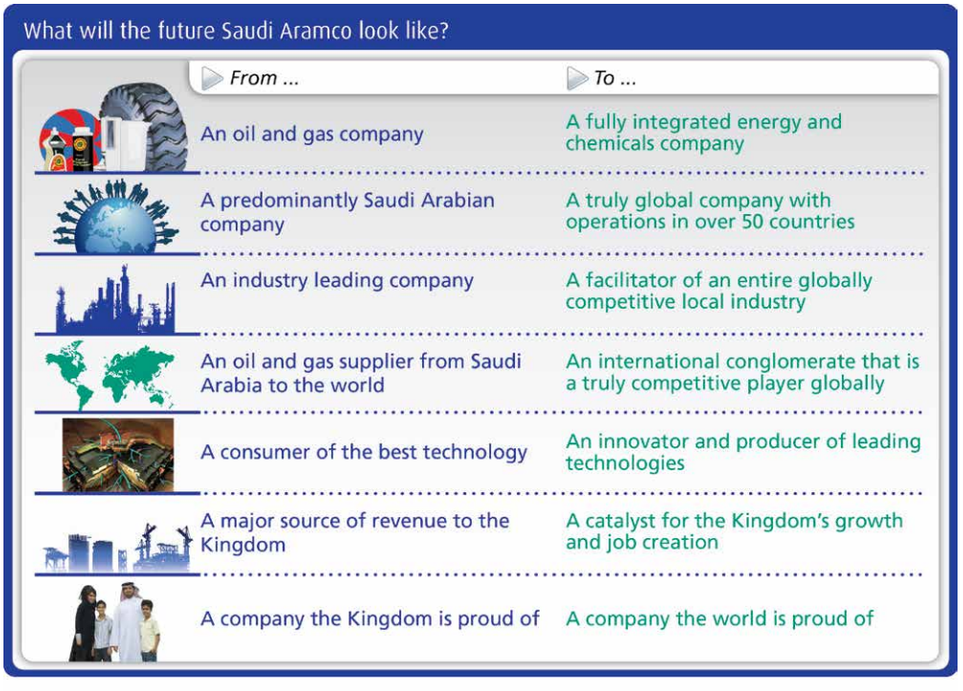
Focus groups and planning and listening sessions were conducted with employees in multiple company business lines, as were meetings with a stream of consultants. Surveys were sent to more than 3,000 employees. This work would spark the initiative unveiled in May 2011 — the Accelerated Transformation Program (ATP) — that would take Saudi Aramco's operations to the next level of technological sophistication and start it down the path of becoming a truly integrated global energy and petrochemicals leader.

Explaining ATP to employees in May 2011, Al-Falih said: "Saudi Aramco is indeed doing well whether in terms of financial standing, growth, performance reliability, safety trends, or other aspects of its business. Many companies transform because they are faced with adversity, but the best transform while they are doing well to capitalize on opportunities and realize their full potential. This is what we intend to do: transform to unlock the full potential of an already successful company."

"LET'S TRANSFORM THE ENTIRE COMPANY"

Yasser M. Mufti, executive vice president of Products and Customer, was involved from the formative stages of the project. He said the group understood that the company was at an important turning point and poised to go from strength to strength. He said, "ATP was driven by, 'We've got an opportunity to do something wonderful here, so let's transform the entire company.'"

Mufti recalled that Al-Falih wasn't afraid to push his team and ask hard questions that needed asking. "He felt that the company needed to go beyond oil and gas. He was asking, 'Why can't we replicate the success that America had exploiting tight shale, or tight gas, shale gas?' He wanted to know, 'Is our portfolio right?' Then he asked uncomfortable questions like, 'Are we efficient? Do we have too much bureaucracy? Is our workplace that great? Are we a company that attracts talent from around the world? Are we giving the youth a fair shot at getting their voices heard?'"



At a 2012 Accelerated Transformation Program workshop, employees share their views on the wide-ranging initiative.

Print materials, such as this graphic published in the company's employee newspaper *The Arabian Sun*, were developed to explain the aspirations of the ATP initiative.

Al-Falih made it clear that ATP was intended to have global impact: "ATP establishes the groundwork for us to become the preeminent force in global refining, chemicals, and technology — at par with our leadership position in the upstream." In essence, said Al-Falih, "We want to unlock the potential of our people and our enterprise to transform from a company of which the *Kingdom* is proud into a company of which the *world* is proud."

At the heart of ATP was the statement of 2020 Strategic Intent: "In 2020, Saudi Aramco will be the world's leading integrated energy and chemicals company, focusing on maximizing its income, facilitating the sustainable and diversified expansion of the Kingdom's economy, and enabling a globally competitive and vibrant Saudi energy sector."

As Al-Falih said at the time, "Those 39 words are basically the mandate I give to my management in every interaction I have with them." Everyone in the leadership team was acutely aware that lofty words do not a corporate transformation make. They had risen through the ranks like Al-Falih, and many also were second-generation employees. They had seen the neat rows of binders on their managers' office shelves. Too often, the binders were the fossilized remains of corporate initiatives past, providing a layer by layer look at the company's history as surely as the rock strata buried beneath the Saudi deserts memorialized the formation of oil and gas reservoirs over the eons.

If this time was going to be different, the leadership team had to change the organization's thinking and attitudes, not just create new organizational charts. As Al-Falih said, "70% of corporate transformations fail because they did not achieve the desired shift in mindsets and behaviors."

CHARTING FUTURE DEMAND

While the statement of 2020 Strategic Intent was the stake ATP put in the ground in terms of program goals, the transformation also looked much further into the future. Mohammed Y. Al Qahtani, president of Downstream, who at the time of the ATP rollout was vice president of Petroleum Engineering & Development, said they projected out to the end of the century, not just the decade, in terms of global demand and reservoir management.

His team asked, "How will this huge resource of ours sustain us for the long term? And how can we best produce it, at what level, and for how long, and for how much cost?" It was the first time Saudi Aramco had asked for such detailed analysis of a 100-year production profile, and explored the implications not just for the company, but for Saudi society as well. Even out to 2200, the team was projecting that Saudi Aramco would have a "still very respectable production rate," Al Qahtani said.

"That was a humbling experience, when you take four generations into the light, and see how this wealth will be distributed. And you can put all kinds of speculation on prices and changes in climate change policies. At that time, they [climate policies] were not as clear or prominent as now. But it was all a factor then, and we saw something very, very interesting," Al Qahtani said in a 2020 interview. "It gave us in-depth analysis of the various assets that we were working on here and reserves, and how we can sustain also an active exploration program that will help us to reduce the cost as well."

ASSET OWNERS TO BUSINESS OWNERS

One of the biggest changes in mindset driven by ATP upended, or at least augmented, the way in which generations of Saudi Aramco leaders had viewed the company, dating back to its formative days in the 1930s and 1940s. Ahmed Al-Subaey, now retired vice president of Marketing, Sales & Supply Planning who was leading the day-to-day ATP effort, described it as going from viewing themselves as asset owners to business owners.

"As an asset owner, you're worried about the integrity of the asset," Al-Subaey said. "Safety first, operational excellence, cost cutting — all these things we've become brilliant at for the first 80 or so years. And then after that, from 2010 onward, we began to be business owners, and business owners are [also] concerned with other things. They're concerned with how you grow the business, the bottom line of the business. Does it generate the income that you're looking for, the ROI that you're looking for, the returns that you're looking for?"

Aramco Asia executives and representatives of SinoTrans, a Chinese shipping company, celebrate the first shipment of polymers to a Chinese customer, in 2013.

PETROCHEMICALS PUSH

One of the business lines to receive a renewed focus under ATP was petrochemicals. While petrochemicals — key ingredients in an array of plastics — were predicted to account for an increasing portion of demand for hydrocarbons in decades to come, especially from rapidly growing Asian countries, they hadn't previously been given the emphasis they received with the rollout of ATP. Soon after, they received company attention by starting Petro Rabigh, and the Sadara joint venture with Dow. It's worth noting that at the 2002 leadership retreat to focus on strategic imperatives (See Strategic Imperatives, page 111), growing the petrochemicals business was not explicitly included on the list of key imperatives. The ATP's 2020 Strategic Intent, on the other hand, described Saudi Aramco as an "integrated energy and chemicals company," and saw the chemicals business as a prime driver for growth.

With the ATP, petrochemicals would be integrated into the strategic business plan. "ATP got us into the field of petrochemicals and integrated petrochemical facilities," said Al Qahtani. Many of the next cadre of world-class production facilities to come online over the next five years would integrate petrochemicals into their operations from the earliest planning stages.

Now retired, Abdulaziz M. Al-Gudaimi, who in 2020 was named senior vice president of Corporate Development, led the development of the company's chemical strategy as head of the Chemicals organization. In that effort, leaders of the petrochemicals industry were identified and their operating models were analyzed. Eventually benchmarks were established in order to successfully compete.

There was much to learn. While Saudi Aramco typically sells crude oil in a few large volume orders, the chemicals business is different. "You sell chemicals in many, many small orders — in bags and containers," said Al-Gudaimi. An additional complexity is that chemicals are not only sold in relatively small shipments compared with crude oil, the products are also formulated to meet specific customer needs.

On Jan. 5, 2013, less than two years after ATP was unveiled, Saudi Aramco made its first direct sale of polymers, to a customer in Xiamen, China. The linear low-density polyethylene was delivered to the Chinese customer, who converted

it into stretch film that its customers, in turn, use for packaging. "It is exciting to see the conversion of our polymer to this film knowing that it continues to create value for many others on its way to the final customer," said Fayez M. Al-Sharef, manager of the Chemicals Coordination and Support Department.

Petrochemicals were identified as a primary driver to bolster Saudi Aramco's downstream business and help diversify its business portfolio. "We need to have refined products — chemicals — to create a more diverse portfolio and therefore a more resilient company," said Ahmad O. Al-Khowaiter, executive vice president of Technology and Innovation. "So downstream is critical long term for the company's resilience and its growth."

Using petrochemicals to grow Saudi Aramco's downstream business forced the company leadership team to up its game. In upstream oil production, Saudi Aramco had the advantage of the lowest production costs among global oil producers. Wading into the downstream arena, that home-field advantage disappeared. "The challenge, of course, in downstream is that it's a level playing field globally," said Al-Khowaiter. "There's no resource advantage; you need to create a technology advantage."

TECHNOLOGY AND INNOVATION DRIVE CHANGE

Whether the ATP teams were charged with plotting how to maximize the value of Saudi Aramco's assets or managing the company's far-flung operations as businesses, there was an intertwined common thread to virtually all ATP efforts: technology paired with innovation. The teams at EXPEC ARC in Dhahran were producing industry-leading work, no question. But that wasn't going to be enough to propel Saudi Aramco to the global vanguard of energy industry innovation. Saudi Aramco had to do a better job aligning technological advances with the needs of its global customers. And the best way to do that was to go where the customers were.

The company also realized that rather than relying on talent being willing to move to Dhahran and join EXPEC ARC, it had to be willing to go where the intellectual talent was if its innovation efforts were to remain cutting-edge. "Diversity creates innovation. … So, in order for us to truly bring the best solutions, you have to have this diversity," said Al-Subaey.

Al-Khowaiter served as the company's chief engineer during the early stages of the ATP and was among the leaders pushing for a broader approach to technology. When the ATP established the position of CTO for the first time, it was Al-Khowaiter who would take on the role. "We looked at, what does it take to compete globally?" he said. "We realized that we had to tap into the hubs of talent around the world in particular areas."

Company leadership realized that, to get the most out of its investment in research, it needed to go where the world's top research centers are located. For understanding the fuel needs of automobiles, that meant establishing the Detroit Research Center, shown here, where tests on fuel formulations are conducted.

Aramco Research Center-Boston is adjacent to the Massachusetts Institute of Technology where researchers such as these study problems in computational modeling, advanced materials and nanotechnology that have applications to the oil and gas industry.

Aramco's global research network aligns with the work conducted at the Exploration and Petroleum Engineering Center's Advanced Research Center (EXPEC ARC) and the Research and Development Center, both based in Dhahran.

GLOBAL R&D NETWORK

The company decided to create a global network of research and development centers to work with and complement the research group in-Kingdom, which over time would expand to centers around the world. Houston, the heart of America's energy industry and where Saudi Aramco had been operating for a half-century, was an obvious choice.

Houston was especially attractive due to its concentration of research talent in the shale oil and gas fields. "That was one of the reasons we were able to advance our subsurface type shale plays, because we were tapping into all the best knowledge in that field," Al-Khowaiter said. "Subsurface talent was in Houston."

When it came to understanding the future fuel needs of the auto industry, Saudi Aramco turned to Detroit. Every auto company in the world had a research center in the Detroit area. Saudi Aramco attracted some of the best engine designers in the world to its Detroit center to help optimize fuels.

Another key R&D presence in the U.S. for Saudi Aramco is the Boston area, or more specifically the complex of research institutions surrounding MIT in Cambridge. "We have a number of people in Boston looking at both downstream and upstream material sciences," Al-Khowaiter said. "We also have a need for supercomputing and computational knowledge.

"All the computational team in Boston is hired directly out of MIT," he said. "Ph.D. graduates fresh out of MIT, many of them aerospace, civil engineering, little to do with petroleum, but it's the computational capability; to them petroleum engineering problems [are] just another computational problem," he said.

Bringing such a diverse group of technical experts together sparked new technological solutions. "The way you address these challenges is to address them through an interdisciplinary approach," Al-Khowaiter said. "That's where a lot of the innovation happens. It happens at the boundaries of the different disciplines. When you move out of your discipline, out of your box, you're trying to apply somebody else's approaches to your problem. That normally gives you new solutions. So, this is why these kinds of diverse research talents are so critical."

In Europe, the company's R&D Center in Paris dovetails with the Detroit center's work on fuel technology from a European auto industry perspective.

Another center at Delft University of Technology in the Netherlands concentrates on seismic processing and subsurface imaging. In Aberdeen, Scotland, Saudi Aramco's efforts focus on offshore oil and gas production technology and energy industry innovations. Beijing was chosen as a key Asian R&D center by virtue of China being Saudi Aramco's largest customer, as well as the Chinese oil industry's expertise in oil field chemicals.

Leveraging the talent pools of supply chains, universities, and industries has played an important role in Saudi Aramco's ability to take its research effort to the next level. "You need partnerships, you need services from others who really have done it before in their own areas. That allows you to really accelerate your technology and move quickly," Al-Khowaiter said.

Rounding out its Asian research presence, Saudi Aramco and the Korea Advanced Institute of Science and Technology (KAIST) established an R&D center in South Korea to tap the country's expertise in turning ideas into products or services. Al-Subaey noted, "We were impressed with their execution. Bringing ideas and plans to actual commercialization, Korea was the fastest. So, we needed to learn from that."

VENTURE CAPITAL

In addition to building out its global research network, Saudi Aramco decided as part of its ATP rollout to invest directly in technology companies as a means of gaining access to early-stage innovations. "We were looking for technologies which were strategically aligned with our business that would help us accelerate the adoption of technologies from outside of the company into the company, by looking for startups and technology startups in upstream and downstream," Al-Khowaiter said.

Saudi Aramco usually works with major technology companies as service providers. When they bring new technologies to market, however, Saudi Aramco typically doesn't get its hands on the product or service for some time. Being a venture investor would enable early-stage access.

As a startup itself in its early decades, Saudi Aramco didn't make venture capital investments. But it did have early access to startup technology, Al-Khowaiter pointed out. "The Schlumberger brothers were a startup. We were one of [their] first users. That's the way we were in the 1930s and '40s. We were using startup technology because we had challenges that nobody else had. ... We had some of the deepest wells in Saudi Arabia at the time compared to what was happening in Texas or elsewhere."

Al-Khowaiter added, "We're going back to saying, 'OK, let's take these technology companies that are really early-stage that nobody has yet proven. Let's work with them to prove their technologies and accelerate that because they offer something that we need.'"

PATENTING SUCCESS

For much of its history, especially in the early decades when it was owned by a group of American oil companies, Saudi Aramco was not in the vanguard of innovation. It was a workhorse producer with a very strong record of safety and reliability. Innovations tended to be the province of the parent companies, and were then applied to Saudi Aramco, or by leading industry contractors such as Schlumberger.

The ATP proved to be a point of acceleration for the company, and it coincided with a milestone for Saudi Aramco's success in patents. The company celebrated the granting of its 100th patent in November 2010. The leadership team realized that marker of innovation had to accelerate if the ATP was going to be measured as a success.

Accelerate it did. From 100 patents in nearly eight decades, Saudi Aramco was granted 524 patents in one year in 2019. That performance vaulted the company past perennial industry patent leaders ExxonMobil and Chevron. In 2021, the company was granted 866 patents, ranking it among the top 50 companies in the world granted patents by the U.S. Patent and Trademark Office, and in 2022, the number of patents reached close to 1,000.

"Nobody would have believed it back then," said Al-Subaey in a 2020 interview, "but we are now the No. 1 technology company (by patents) in our industry." Added Al-Khowaiter, "That's a big change. That tells you that the productivity, the innovation has changed in the company. We're much more focused on creating a competitive advantage through innovation than we were six, seven, 10 years ago."

Students from Aramco's College Preparatory Program visit the Saudi Petroleum Services Polytechnic, a Dammam-based vocational training center. Part of the company's effort to boost the future Saudi workforce, the CPP program prepares high-performing Saudi high school students for out-of-Kingdom university education in their assigned field of study.

YOUNG LEADERS

The more emphasis the company has put on technology in recent years, the more emphasis it has put on attracting and retaining the tech-friendly generation of younger workers. Greater involvement of younger workers in leadership was a key goal of ATP from the start. As Al-Falih said in announcing the program in May 2011, "We will also emphasize the role of the young generation, to whom we will pass the leadership responsibility to carry forward in the future. We'll do this by focusing not only on preparing them for the company, but also by preparing the company for them. This is why they represent a critical cornerstone of this transformation."

At the time of the ATP, the leadership team had risen through the ranks of a very hierarchical organization with a strong engineering and field operations heritage. Change, and promotions, happened methodically, and most often, slowly. Decades of service typically preceded any move into a senior position. Plus, there were few other comparable opportunities in the Saudi private sector. All of which produced little impetus to challenge the status quo. Al-Subaey said, "We were getting stale, and we were getting very traditional in our approach to things, and that was not appealing to the next generation of leaders."

The Young Leaders Advisory Board program provides young professionals at Aramco opportunities to speak with and ask questions directly to corporate management.

To help prepare a new generation of leaders for the company, Aramco started the Youth Leaders Advisory Board (YLAB) as a channel for youth engagment with senior management. Here, Nada F. Qari practices her team's presentation on a major corporate challenge during the YLAB 5.0 Academy in Dhahran.

By the time ATP was launched, the leadership was faced with a much younger and more ambitious workforce that reflected the demographics of the Saudi population as a whole with nearly half of the employees under the age of 35. And they had come of age in the era of social media and the mobile internet, where different models of leadership and success are omnipresent. Also, the Saudi private sector and government were offering many more options for ambitious future leaders than was the case a generation ago.

The Young Leaders Advisory Board (YLAB) was created as a link between the younger generation of aspiring leaders, some with four to five years of experience, and the executive leadership of Saudi Aramco. Much as if they were applying to graduate business school, employees interested in joining YLAB fill out application forms, and a subset of the most promising go through a vigorous interview and problem-solving process. The initial YLAB groups consisted of 14 members, with two working full time on the project and the rest retaining their full-time jobs while meeting on YLAB projects after-hours. From the start, each group included a significant proportion of women.

Plunging right in, the YLAB team is given issues to address, such as flex-time for office workers, and then gets direct access to the most senior leaders of the company for a frank exchange of views. "To be standing and dialoguing with Khalid A. Al-Falih or Amin H. Nasser, who was then senior vice president of Upstream, or some of the vice presidents, having one-on-one sessions with them for two hours, explaining their very strong views on how the company should change, I think for many of them it was a breath of fresh air and of hope," said Mahdi Aladel, a former member of Saudi Aramco's Strategic Transformation Office (STO) in charge of YLAB and now chief executive officer of Aramco Ventures.

In 2022, YLAB celebrated its 10th anniversary. Amin Nasser asked the current cohort to reinvent itself for the next 10 years and to bring in further alignment with the Kingdom's ambitious Vision 2030 plan. Nearly 100 YLABers have graduated through eight cohorts, each serving one and a half years. They represent the crème de la crème of Aramco youth, and nearly 150 have risen to serve in key roles in the public and private sectors.

Most of the YLAB participants benefit from the experience and continue to advance through the leadership ranks at Saudi Aramco. Reflecting the greater mobility of today's Saudi workforce, some have taken other leadership positions in-Kingdom, including relatively senior government posts. One of them is the Minister of Economy and Planning, Faisal F. Alibrahim. In that sense, it was "a win for the company and a win for the country" in that Saudi Aramco has contributed to nuturing the abilities of the next generation of Saudi leadership across employment sectors, Aladel said.

PREPARING FOR A DISRUPTIVE FUTURE

Not all 14 initial ATP initiatives were continued beyond the launch phase. Yet the process succeeded in transforming Saudi Aramco. "It shook the entire company," Mufti said, "It made us think. ... And we came out of it with a newfound respect for our capabilities."

The incrementalism of past decades was out. The decade ahead would be marked by disruptive changes and plenty of calculated risk taking. "We did not have a specific road map to get us there," said Al-Subaey, but the vision and the strategy for 2020 positioned the company for success.

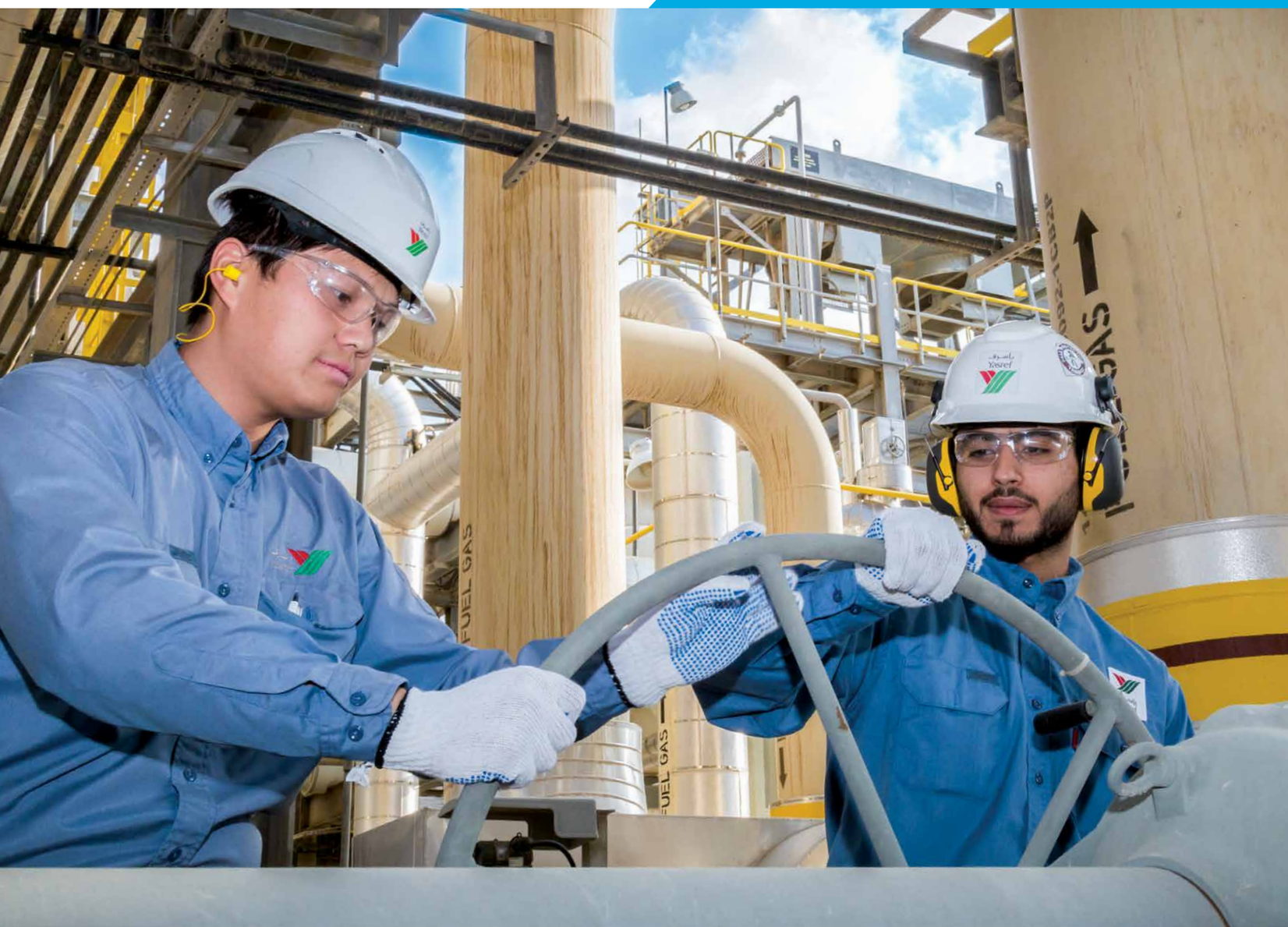
The implementation of the ATP and the strategy for 2020 together rank as significant turning points in Saudi Aramco's history. They helped future proof Saudi Aramco and ensure its role going forward in the global energy and chemical industry vanguard. And they prepared a new generation of leadership with the skills and confidence to address an unprecedented array of challenges in the years ahead.

At the Upstream Professional Development Center in Dhahran, young engineers are able to work through various simulations under the guidance of their more experienced colleagues.

CHAPTER 5

Global impact

Manifa's drilling islands minimized environmental impact.



Aramco and Sinopec teamed up to build, own, and operate YASREF, a full-conversion refinery that produces transportation fuels and other high-value refined products. The plant was commissioned in 2014.

The array of mega-projects rising across the Kingdom — and the unleashing of Saudi Aramco's human potential — positioned the company as of 2012 for a dramatic new phase of accelerated global growth. And not a moment too soon.

The company's oil and gas production in 2012 reached its highest levels in 30 years in response to robust customer demand. Global demand for oil was projected to grow more than 15% by 2040, with much of the demand coming from rapidly expanding Asian economies. The world's appetite for natural gas was expected to soar at more than three times that amount. And the rapidly growing global petrochemicals industry was projected to account for a significant portion of future demand for hydrocarbons. (Aramco briefly exceeded this production level in early 2020, meeting its March 11, 2020, obligation to the Ministry of Energy to raise oil production to 12 million bpd.)

The company not only grew faster as the decade progressed, it grew smarter. Increased emphasis on technology, especially Fourth Industrial Revolution (IR 4.0) digitalization, data mining, and machine learning — as well as sustainability goals — added to the tools Saudi Aramco used to enhance its competitive advantage and better serve its customers. And even as the company extended the reach of its traditional hydrocarbon business, especially in Asia, it rapidly developed its petrochemicals operations with a series of joint ventures with leading global petrochemical producers such as Japan's Sumitomo and China's Sinopec.

Former president and CEO Khalid A. Al-Falih realized at the time that, despite Saudi Aramco's global presence, even some of the best minds in the industry didn't fully appreciate how good Saudi Aramco already was, or appreciate its full potential. "There was this side of me that said if you were to present Aramco to the rest of the world, they would see a machine that is functioning not only financially, not only operationally, not only from the point of view of safety, human resources, and the environment, but also in terms of its values and its creation, like no other."

ARAMCO ASIA

To address the burgeoning demand from China as well as growing markets across Asia, Saudi Aramco in 2012 formed a new subsidiary, Aramco Asia, with its headquarters in Beijing. The company had maintained a representative office in Beijing since 1998 in response to the rising importance of trade with China. But the increase in business with China demanded more of a physical commitment. As of 2011, China ranked as Saudi Arabia's largest trading partner, with bilateral trade totaling $64.4 billion per year, and by 2012, the company was selling more than 1 million bpd of oil to China. The following year, as noted previously, Aramco made its first petrochemical sale to China.

"We are aware of our role in providing the vital energy China needs, and we are also aware of China's developmental needs now and in the future," said Sulaiman M. Ababtain, Aramco Asia's first president.

S-OIL has been recognized among Aramco's downstream affiliates for its operational excellence, including at the Olefin Downstream Complex shown here.

Aramco Asia assumed oversight of the company's offices that were strung across the region like a jade necklace, from Beijing, Shanghai, and Xiamen in China, to the Republic of Korea, Japan, Singapore, Malaysia, and India. Since then, additional offices and subsidiary offices have been added in Thailand, Vietnam, Malaysia, Australia, Indonesia, and Pakistan.

"Frankly, given its geographic proximity to Saudi Arabia and the escalating demand for energy in Asia and the Pacific, this is our natural market, and we value it accordingly," said Ahmed Al-Subaey, who had served at the Tokyo branch of Saudi Petroleum Ltd., and later was president of S-OIL, the company's affiliate in the Republic of Korea.

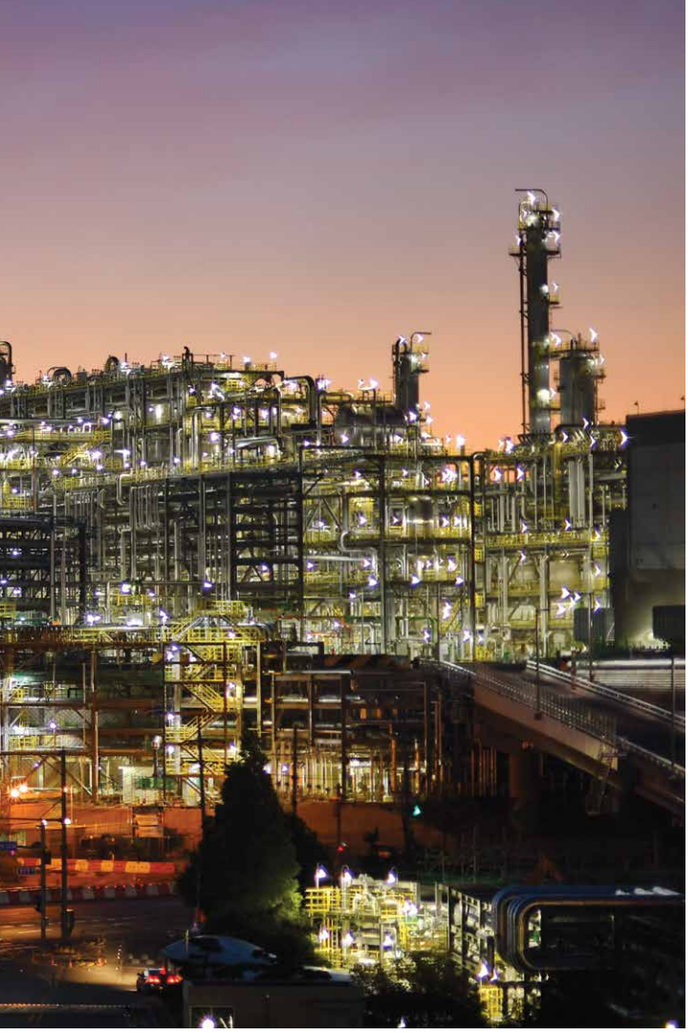
SINO-SAUDI PARTNERSHIPS

China also developed as a vital business partner in the early 2000s. Aramco Asia managed the company's interests in two closely aligned joint ventures: Fujian Refining and Petrochemicals Co. (FREP), and Sinopec SenMei Petroleum Co. Ltd. (SSPC). Saudi Aramco and ExxonMobil each have a 25% stake in FREP, with Fujian Petrochemical Co. Ltd. owning the remaining 50%. FREP began operations in 2009 by taking over an existing refinery in Quanzhou, Fujian Province, and tripling production to 240,000 bpd.

Saudi Aramco again partnered with ExxonMobil to invest in SSPC, with each holding a 22.5% stake. China's state-owned Sinopec has the remaining 55%. SSPC takes products produced by FREP, including gasoline, diesel, and kerosene, and markets them through its network of more than 1,000 service stations and 17 distribution terminals located throughout the Fujian Province. Started in 2007, SSPC was the first provincial transportation fuel marketing joint venture in China.

Saudi Aramco's commitment to China extended beyond the sale of oil, gas, and petrochemicals. To further its understanding of China's energy needs and its culture, Saudi Aramco sent 10 students to China in 1998 to learn the language and then earn bachelor's degrees in engineering, finance, or marketing. Following the creation of Aramco Asia, more than 90 company-sponsored students have graduated in China, and in 2023, 11 were studying there. The company has also been supporting cultural and exchange programs and making charitable contributions to a number of Chinese organizations for many years.

Saudi Aramco and Sinopec invested together in-Kingdom as well. They formed Yanbu' Aramco Sinopec Refining Co. (YASREF) Ltd. The joint venture built, and continues to own and operate,



a full-conversion refinery in Yanbu' Industrial City on the Red Sea. The refinery, which uses 400,000 bpd of Saudi Aramco's Arabian heavy crude oil to produce transportation fuels and other high-value refined products, was commissioned in 2014 and reached full operating capacity in 2015.

KOREAN TIES

Saudi Aramco's interest in bolstering its investments in Asia has always included the Republic of Korea. The company had held a minority interest of 35% in the Republic of Korea's SsangYong refinery since 1991. Founded in 1976, SsangYong operates a 669,000 bpd refinery in the country's southeastern province of Ulsan as well as adjacent petrochemical facilities.

Saudi Aramco formed its Korean affiliate, Aramco Korea, in 2012, to better serve its growing business in the Republic of Korea and its partnerships with various South Korean companies. In 2015, Saudi Aramco increased its holding in S-OIL, as SsangYong was renamed, to a controlling 63.4% interest. The company purchased its additional ownership stake in S-OIL from Hanjin Group. Underscoring the ties between Saudi Arabia and the Republic of Korea, S-OIL named a road at its Onsan Refinery "A.I. Naimi Road" in honor of the former Saudi oil minister.

With Aramco's investments, S-OIL has grown from a relatively small refinery and is on a path to become one of the largest and best performing refineries in Asia. The $7 billion Shaheen project in S-OIL's Ulsan complex, for example, aims to convert crude oil into petrochemical feedstock, following an earlier investment of $4 billion into petrochemical expansion in 2018. In 2021, S-OIL won the Best Performance Award, the top prize in the operational excellence category at Saudi Aramco's 2021 President's Affiliates Excellence Awards. Saudi Aramco assesses the business results of its downstream affiliates every year and presents awards in four categories — health, safety and environment, asset availability, energy intensity, and operational excellence. S-OIL has earned prizes in the five years after the awards were established in 2017.

In addition, Saudi Aramco announced an agreement with Hyundai Heavy Industries Holdings to purchase a 17% stake in South Korea's Hyundai Oilbank in 2019, in order to support Aramco's crude oil placement strategy by providing a dedicated outlet for Arabian crude to South Korea.

ARAMCO ASIA JAPAN

Saudi Aramco has been operating in Japan for more than three decades, following the opening of a modest representative office in 1990. The company's mounting commitment to Japan is reflected in the fact that Saudi Aramco is the largest exporter of crude oil to Japan.

In 2004, Saudi Aramco increased its stake in Japan by purchasing 9.96% of Showa Shell, and subsequently acquired an additional 4.99%. When Idemitsu Kosan absorbed Showa Shell in a 2019, Saudi Aramco remained the second largest equity holder in Showa Shell, with 7.65%. Closer to home, Saudi Aramco also partnered with Japan's Sumitomo Chemical Company Ltd., breaking ground in 2006 on the massive Petro Rabigh petrochemicals complex on the Red Sea. As it does in China and Korea, the company sponsors employees to study in Japan, and contributes to charitable and environmental organizations. Since Aramco started its program to support students in Asia in 1998, the number of sponsored students has reached more than 1,000.

General Mansour al-Turki, left, spokesman for Saudi Ministry of the Interior, and Aramco executive Abdallah I. Al Saadan answer questions at a press conference following the August 2012 cyberattack.

CYBERATTACKS

At the same time as it was focusing on its global growth with the creation of Aramco Asia, the company faced a dramatic new threat to its operations in its own backyard. Hiba Dialdin, head of Petroleum Engineering & Development Training at the time, and her work colleagues didn't understand what was happening one morning in mid-August 2012. Suddenly, they couldn't email each other from their offices or homes. They couldn't access the internet, either. Waleed Al-Saif, working in the company's Treasury Department at the time, faced the same problem. When he couldn't get online, he resorted to dusting off an old fax machine and plugging it in to send documents.

Dialdin said: "I remember that we were all calling each other and asking one another, 'How about you, what about you, you too?' And we realized that we were under attack, and we were all skeptical and wary. 'Really? Cyberattacks on this scale actually happen? It's not just an urban myth?'"

It was more like a nightmare come true. Saudi Aramco was the target of what apparently was the largest cyberattack in history, starting the morning of Aug. 15, 2012. Someone or some group had planted a computer virus in Saudi Aramco's vast internal communications network on the day before a religious holiday. The company immediately shut down the internal system to halt the spread of the virus. But the damage was done. The Shamoon virus, as it was called, had already erased data on three-quarters of the company's desktop and laptop computers that were linked into the system. It would take days for employees to regain access to their corporate email, and for months afterward, they could not remotely access their corporate accounts.

The good news was that the company's decades-long commitment to safety and resiliency had once again paid off. Saudi Aramco had always taken deliberate steps to keep the computer systems operating at its production facilities and those running EXPEC and other research facilities completely separate from the communications network. As a result, the Shamoon virus didn't have any impact on the company's core operations or research and exploration computer systems.

The bad news was that the company, which prided itself on its rate of digitization at the time, was running its enterprisewide SAP software, as well as Microsoft Office and systems operating finance, payroll, human relations, and procurement, among others, on the system that was disabled. "We had to switch everything to manual without interrupting operations," said Al-Falih.

While he was proud of the way employees scrambled to execute so many core operations on a manual basis, "It was a psychological blow because we were confident and somewhat cocky as an organization," Al-Falih said. "I'm proud that we did not hide it; we spoke about it." He was also proud of the fact that company leadership thanked its IT organization for its effective improvisation during the crisis and supported every effort to ensure additional steps were taken going forward.

His message to his global CEO peer group, including attendees at the World Economic Forum in Davos, Switzerland, was blunt. "Our (office) operations have been disabled. Here's the lesson learned: The bad guys are out there. This is a movie that is coming to your neighborhood soon, so get ready."

The company realized it might be worse the next time. "We learned big time from what happened in 2012," said Amin Nasser, who was senior vice president of Upstream at the time. Cyber teams constantly monitor the Saudi Aramco systems linked to the outside world for evidence of attempted cyber break-ins. They examine the specific coding of the

The Karan nonassociated gas field was discovered in 2006 in the Arabian Gulf north of Dhahran and developed to produce 1.8 billion scfd, which is delivered from offshore platforms, such as the one shown here, to the onshore Khursaniyah processing facility via a subsea pipeline.

viruses, the DNA of each attack, and track and manage the situation.

The company continues to increase its cyber defense spending. "It will become a major ongoing risk as companies digitalize more," said Nasser. "Think about what's going to happen in five to 10 years from now, as the bad actors become more sophisticated. We can never take cybersecurity for granted, and any breach can hurt and harm people, communities, and economies."

UPSTREAM EXPANSION

While demand for crude oil was driving much of its growth in Asian markets, Saudi Aramco faced continually rising domestic demand for natural gas in the 2010s. Not only did the company need to feed the MGS to supply energy to the rapidly growing population of the Kingdom, which was increasing domestic demand for natural gas by 5% to 6% a year, it also needed to free up crude oil that was being burned in-Kingdom for electricity so the oil was available for export.

Since its early decades, the company had been producing natural gas as an "associated" component of crude oil production. The gas was formed millions of years ago in the same reservoirs as the crude oil and brought to the surface with the oil, where the two were separated and processed. To meet demand going forward, Saudi Aramco prepared to tap stand-alone, or nonassociated, gas fields.

Ali Al-Hauwaj, manager of the Exploration Department from 2004 to 2011, noted that since the mid-1990s, the emphasis in exploration had shifted from finding additional oil and gas fields in central Arabia to a concentrated focus on finding nonassociated gas in the Eastern Province. Based on seismic interpretation and years of working with existing fields, Saudi Aramco decided to look for gas near existing oil fields but not actually associated with the oil fields.

KARAN: LARGEST OFFSHORE GAS FIELD

To find their target, these geologists-turned-time-travelers looked much deeper and further back in time than earlier generations of Saudi Aramco geologists. After a decade of hard work, that strategy paid off in 2006 with the discovery of the mammoth reservoir of nonassociated gas in the offshore Karan field — Saudi Aramco's largest.

The Karan nonassociated gas field was discovered by a team drilling in 40 to 60 meters of water in the Arabian Gulf north of Dhahran. The gas is in deep Khuff carbonate reservoirs, which formed almost 300 million years ago in the Permian and Triassic periods. The formation is more than 10,500 feet underground and substantially deeper and older than the four Arab strata formed in the Jurassic period 140-150 million years ago that contain much of the Kingdom's crude oil reserves.

More than 40% of Aramco's nonassociated gas comes from offshore fields such as Hasbah, which feeds the Wasit Gas Plant. Construction on the Wasit facility began in 2016.

The $8 billion development project originally called for a production rate of 1 billion scfd in its initial phases. As work progressed, the target was raised 80%, to 1.8 billion scfd, reflecting increased demand. The gas produced from 20 planned wells spread over four offshore platforms is delivered to the onshore Khursaniyah processing facility 110 kilometers away via a subsea pipeline. Despite the increase in capacity, the Karan project was completed ahead of schedule and under budget, thanks in part to a renegotiating of several contractor bids following the 2008-2009 financial crisis and the subsequent collapse in oil prices.

EXPANDING MGS

The development of the Karan field ushered in a sustained focus on adding to the capacity of the MGS. The company applied what it learned from developing Karan, and added more technological advances when it built its massive Wasit integrated facility, near the coast north of Ras Tanura. This facility was also built to process nonassociated gas held in the Khuff formation, in the Arabiyah and Hasbah offshore fields. It was located not far from Jubail and the Khursaniyah processing complex to take advantage of existing infrastructure, including electricity and water systems. Another plant at Fadhili was built to process gas from onshore and offshore fields.

The Wasit plant came online in 2015 and was capable of processing 2.66 billion scfd, or nearly 50%more than the Karan facility. As impressive as that figure was, the Wasit plant was designed with the ability to produce a potential 3.05 billion scfd of raw gas during emergencies or demand peaks. Wasit also included a fractionation module for producing ethane, propane, butane, and natural gas.

One of the technological innovations applied to the Wasit project was the use of "big bore" well completions. This process creates high capacity wells that can produce gas at very high rates, cutting production costs and enhancing flexibility to meet changes in demand. And in the cogeneration power plant built as part of the facility, Saudi Aramco for the first time deployed Sulfinol-M gas treating technology. This latest advance enabled the company to improve its already impressive ability to capture 95% of the sulfur produced in the production process to 99.1%.

The Fadhili mega-project followed Wasit and was designed to process nonassociated gas from offshore as well as onshore fields. Construction began on Fadhili in 2016. By year-end 2019, the plant was producing 1.5 billion scfd from the Haradh and Khursaniyah onshore fields. The following year it reached its designed capacity of 2.5 billion scfd.

Operators at the Wasit plant pause for a photo in 2015, the year the plant came online. The plant was developed to process 2.66 billion scfd but also designed to produce a potential 3.05 billion scfd during emergencies or demand peaks.

MANIFA'S ENVIRONMENTAL MILESTONES

Appearing from the air as if it were a stunning homage to the region's traditional pearl-diving way of life, the Manifa offshore mega-project's array of manmade islands and causeways resembles a gleaming string of pearls set amid the azure waters of Manifa Bay. Zoom in and each of the 27 "pearls" in the project is revealed to be a manmade island the size of 10 soccer fields. From any angle or distance, the Manifa mega-project on the shores of the Arabian Gulf is an example of Saudi Aramco's commitment to environmentally sensitive engineering and construction.

And that point of view is shared far beyond the oil and gas industry. The unprecedented mega-project, which came online in 2013, earned Saudi Aramco a UNESCO environmental responsibility award nomination.

Located roughly 200 kilometers northwest of Dhahran, the Manifa mega-project testifies to the company's commitment to meeting the world's energy needs while at the same time sustaining — and in many cases improving — the quality of life not just for residents near its facilities but for the area's flora and fauna as well.

The company discovered oil far beneath the shallow waters of Manifa Bay in 1957 (the same year the Khurais onshore field was discovered), making Manifa the second offshore oil field identified in the Kingdom's coastal waters. While the Manifa oil field with its six reservoirs ranks as the third largest offshore field worldwide, the initial facility produced a relatively modest 125,000 bpd of Arabian Heavy crude. Production at Manifa was halted in the mid-1980s in response to slumping global demand and prices that tumbled into the single digits per barrel.

Plans were drawn up in 2006 for producing crude oil from the Manifa field to supply burgeoning global demand. Much had changed since the field had first been developed in the mid-1960s. The company's evolving commitment to sustainability and promoting the health of local ecosystems made for a much more complex and demanding path to developing the Manifa field compared to the initial development.

Manifa was designed to minimize the environmental impact on the Arabian Gulf, where the company has installed modular artificial habitats to help restore coral reefs.

ONSHORE-OFFSHORE

To develop the field in traditional offshore fashion would have involved placing scores of offshore drilling rigs in the shallow waters. The continuous dredging required to enable boats and barges to service the rigs would have in turn caused tremendous damage to the fragile marine environment. That was not an option. Manifa Bay is an integral part of the Saudi fishing industry in the Arabian Gulf. It is home to more than 85 different fish species in addition to roughly 50 species of coral. Dense kelp beds and various algae habitats add to the region's biodiversity. There had to be a Plan B.

The solution that teams of Saudi engineers and planners came up with was as ingenious as it was environmentally sensitive and cost-effective. If they couldn't develop Manifa as a typical offshore field, they would create a minimal footprint of reclaimed land and develop it as a mostly onshore field. Their modeling determined that an archipelago of 27 drilling islands connected by 41 kilometers of narrow causeways would enable Saudi Aramco to develop 70% of the field as an onshore field.

The project, originally budgeted at $10 billion, minimized the environmental impact of the construction by building bridges in key locations of the causeways to allow for, and in places enhance, the flow of seawater across the shallow bay. The main causeway was opened to tidal flow and water circulation via a 2,400-meter bridge. An additional five 150-meter bridges and eight 50-meter bridges were strategically located throughout the causeway network to maximize water circulation and the preservation of marine life.

The strategic location of islands and bridges in the causeways reduced the time oxygen- and nutrient-rich water took to recirculate through the bay. That resulted in higher dissolved oxygen rates in the water, creating a healthier environment for fish and shrimp larvae. The causeways connecting the artificial islands stimulate algae formation and the growth of other marine life, including coral reefs. Seagrass meadows also blossomed in these nutrient-rich waters.

Drilling teams work on the Manifa project, which included building and operating 30 drilling rigs, including one horizontal well that extended 35,000 feet — more than 11 kilometers — the longest horizontal well ever drilled by the company.

Manifa milestones also were achieved far below the surface of the bay. "This mega-project marks a departure for Saudi Aramco as new technologies were developed and solutions were custom-designed," said then-chief engineer Nabilah Al-Tunisi, who served as the company's first female chief engineer until moving into a position with the Kingdom's NEOM project. To steer drilling wells through the complex reservoir, Saudi Aramco developed a nuclear magnetic resonance tool to guide drilling teams. Saudi Aramco set a company record at Manifa for the deepest intelligent completion well at 18,570 feet. In another project first, teams drilled a "mega-reach" well beyond 37,000 feet, or more than 11 kilometers, long.

Onshore, the complex includes a co-generation power plant that makes the mega-project energy self-sufficient and even produces a power surplus that is fed back into the national power grid. It is one of the most efficient cogeneration plants built in-Kingdom to date. The complex also recycles 3 million scfd of flare gas.

Like all mega-projects under construction at the time, Manifa felt the impact of the 2008-2009 global financial crisis and the temporary collapse in oil demand and prices. The company took advantage of the disruption to renegotiate key aspects of its construction contracts. The resulting savings, which were shared with contractors, enabled the company to bring the project online in 2013 three months ahead of schedule and $1 billion under budget.

The Manifa facility was producing 500,000 barrels of crude oil from about 350 wells when it was brought online in April 2013. It reached its maximum production capacity of 900,000 barrels a day by the end of 2015. Saluting the unprecedented accomplishment upon completion, Al-Falih described the Manifa mega-project as "the jewel in the crown" of company operations.

RISING PETROCHEMICALS PROFILE

The ambitious upstream developments during much of the 2010s were paralleled by equally rapid growth in expanding and enhancing Saudi Aramco's downstream operations. That was especially true in the petrochemical and refining businesses. Long-term strategic shifts, including capturing growth in petrochemical demand worldwide, gathered momentum with an array of international downstream partnerships in petrochemicals and refining.

Now retired, Abdulaziz Al-Gudaimi, served as senior vice president of Downstream from 2017 through September 2020, when he was named senior vice president of Corporate Development. Al-Gudaimi worked in a wide range of Saudi Aramco operations over the course of nearly four decades before his retirement in January 2023. From giant oil and gas fields to mammoth petrochemical complexes, he developed a keen understanding of what makes the company's operations — and its people — tick.

While head of Downstream, Al-Gudaimi teased his Upstream colleagues that they, in effect, had it easy. Recognizing that a great deal of work goes into maintaining the cutting-edge aspects of nearly every facet of the company's oil and gas production, he noted that Saudi Aramco is blessed with its prolific reservoirs and their low cost structure. And then it sells its crude oil by the shipload, sometimes 2 million barrels at a time. Large volumes and low costs yield sizeable profits.

On the other hand, the Downstream refining and petrochemicals businesses have multiple challenges. There are many competitors and many products. Products must be tailored to meet customer needs, requiring investments in technical services. Shipments are smaller, and customers expect shorter lead times. Addressing these challenges requires extensive sales and marketing efforts. These factors combine to squeeze profit margins to single digits.

Al-Gudaimi told his Downstream team they needed to surround themselves with "really smart people" to thrive in these businesses. "The upstream is made by God, which is perfect. And the downstream is made by man, which is imperfect," says Al-Gudaimi, now retired. So the company needs to put the best people and technology to work on making its downstream operations as close to perfect as is humanly possible.

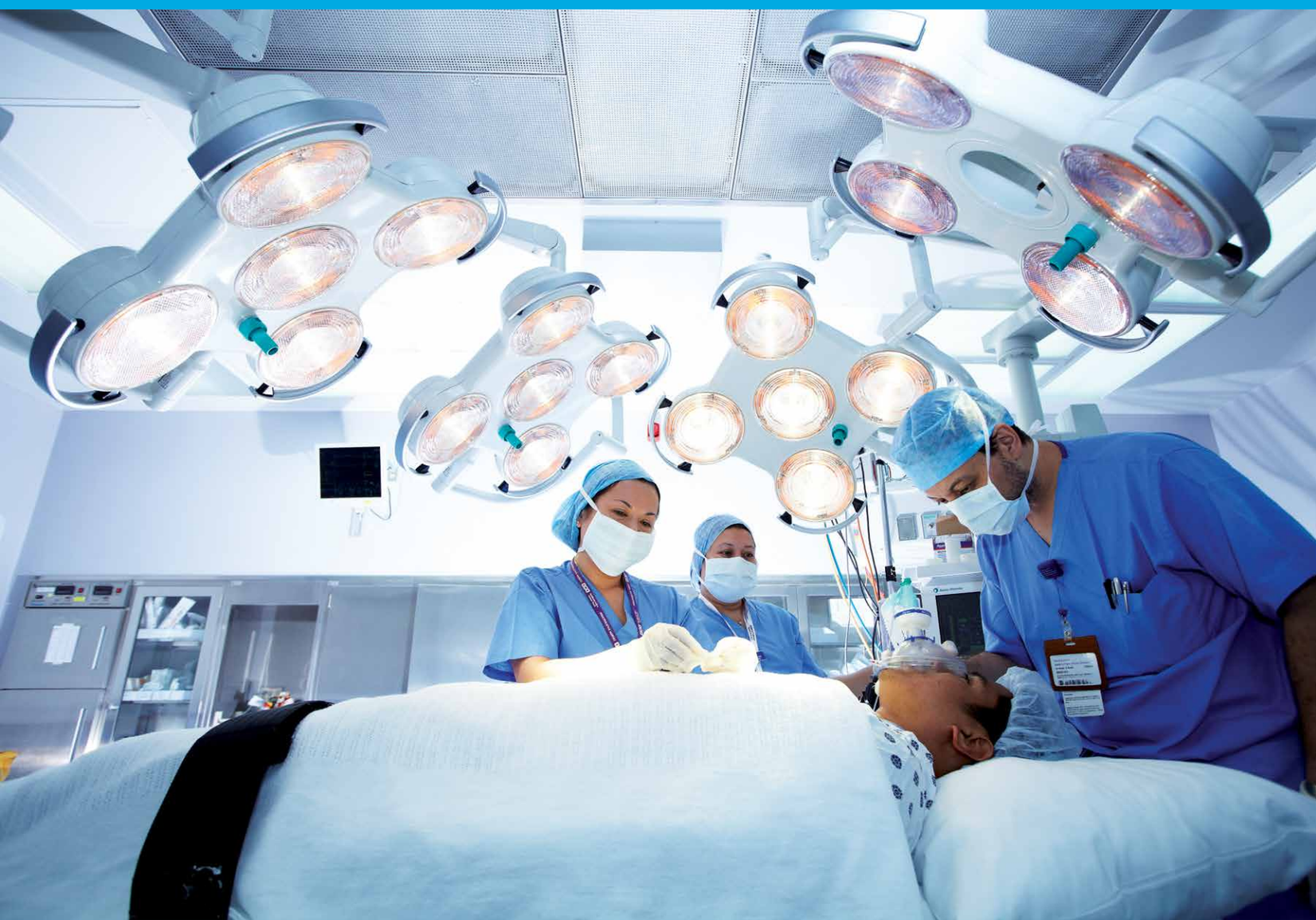
Johns Hopkins Aramco Healthcare

In 2014, Saudi Aramco formed a first-of-its-kind health care joint venture — Johns Hopkins Aramco Healthcare (JHAH) — with one of the world's leading health care research institutions and providers, Johns Hopkins Medicine.

JHAH proved to be the model for best-in-Kingdom health care that set the standard for other companies. This model health care partnership built upon decades of health care outreach and education performed by the company as it helped improve the lives of its workers and their families.

The JHAH joint venture — with its internationally recognized staff of doctors, researchers, and infectious disease experts — would uniquely position Saudi Aramco to respond rapidly and effectively to the COVID-19 pandemic in 2020-2022.

An Aramco and Johns Hopkins joint venture, Johns Hopkins Aramco Healthcare (JHAH), provides world-class health care services to Aramco employees, their families, and Aramco retirees.



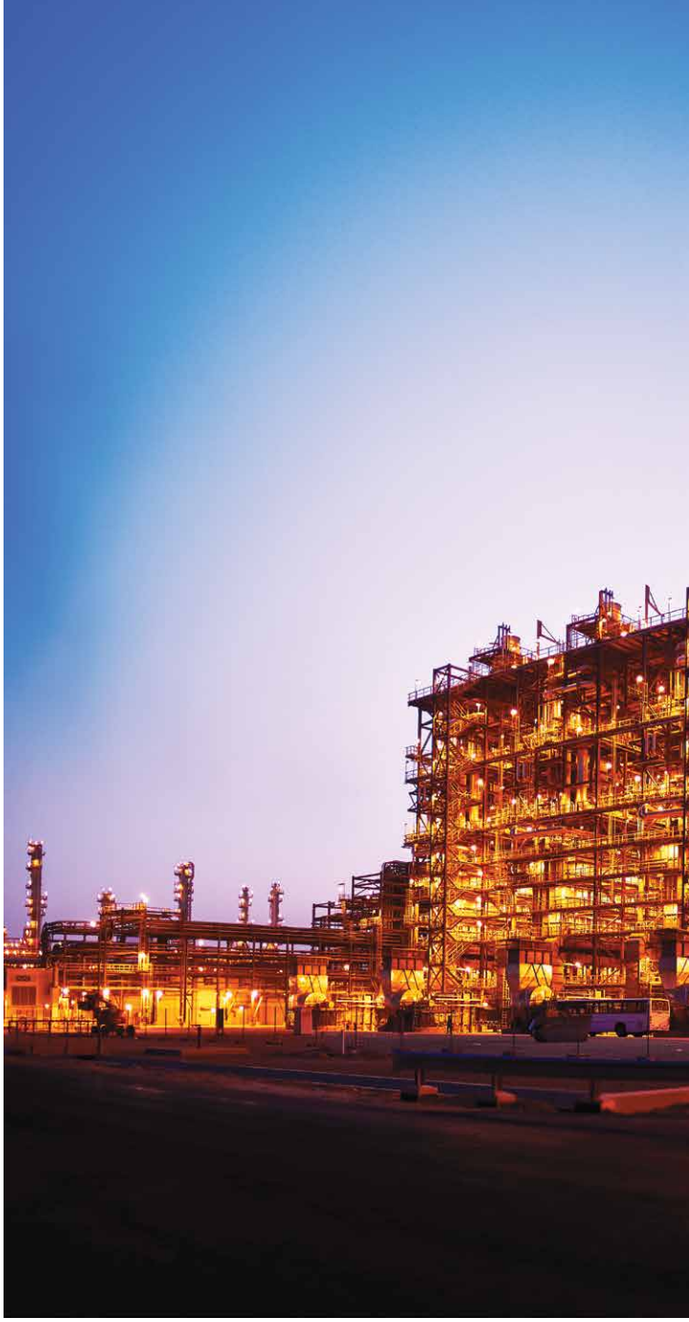
Motiva, a Houston-based refining and marketing joint venture with Shell when this photo was taken in 2014, became much more profitable after the two companies dissolved the joint venture and divided up the assets in 2017. Aramco's share included Motiva's Port Arthur facility, North America's largest oil refinery.

JOINING FORCES WITH SUMITOMO

Two large petrochemical projects formed the backbone of Saudi industrialization in the 2010s. The first was Petro Rabigh, a roughly $10 billion joint venture with Japan's Sumitomo Chemical Co. Ltd., which developed Saudi Aramco's existing Rabigh Refinery on the Red Sea into an integrated refining and petrochemical processing plant.

Saudi Aramco and Sumitomo broke ground on the Petro Rabigh project in March 2006. In addition to originating about 30% of the financing within Saudi Arabia, 25% of the equity in the project was sold in an initial public offering to Saudi citizens and institutions in January 2008. The stock offering raised $1.23 billion. It was the largest stock sale in Saudi history at the time and marked the first time Saudi Aramco had offered shares in one of its affiliates to the public.

Production began in 2017 with 5 million tons a year of petrochemical solids and liquids, mainly ethylene and propylene. The petrochemicals are used to make everything from plastic fibers and films to foam for furniture and automobiles, sealants, resins, and antifreeze. Large volumes of gasoline and other refined products are also produced.



An 800-ton regenerator is offloaded at the Petro Rabigh project site in 2007. The regenerator and several other larger vessels were later lifted into position by an MSG 80 heavy-lift crane, one of the two largest cranes in the world at the time.

Sadara's 26 integrated manufacturing plants produce more than 3 million tons of plastics and high-value chemicals a year.

GOING GIANT WITH DOW

Petro Rabigh was just the start. Saudi Aramco upped the ante to become a global leader in petrochemicals when it broke ground in 2011 on a mammoth processing complex, Sadara Chemical Co., a $20 billion joint venture with Dow Chemical. Located across the country from Petro Rabigh, Sadara is strategically positioned on the Arabian Gulf near Jubail and the Ras Tanura refinery, the source of much of its feedstock. From there, Saudi Aramco efficiently ships petrochemicals directly to customers in the Gulf and Asia.

The company initially had discussed partnering with Dow, a global chemicals industry powerhouse, to develop Petro Rabigh. That deal was eventually signed with Sumitomo Chemical, but Saudi Aramco remained interested in teaming up with Dow. When plans for Sadara began to take shape, Dow, with its technical expertise in producing high volumes of specialty chemicals, was the "preferred partner," Al-Gudaimi said.

Sadara represents the largest foreign direct investment in the Saudi petrochemicals industry. Dow initially owned 35% of the company and Saudi Aramco 65%. In 2017, the companies agreed to restructure the ownership structure so that each company owned 50%.

The enormous, six square kilometer complex is one of the largest plastics and chemicals production facilities in the world. The amount of steel used to construct Sadara was the equivalent of two San Francisco Golden Gate bridges. The concrete used for Sadara could have built three additional King Fahd causeways from Saudi Arabia to Bahrain. Sadara remains the largest petrochemical plant ever completed in a single phase, and is likely to remain so for years, if not decades, to come. "Sadara stands out in terms of scale, complexity, and impact," said Al-Falih. "I think it will be decades before we see the potential of Sadara unfolding in the downstream and in other industries."

Sadara's 26 integrated manufacturing plants — the first went online in December 2015 — produce more than 3 million tons of plastics and high value chemicals a year. Fourteen of the plants produce specialty chemicals never before produced in the Kingdom, and in some cases, the region. In 2016, for instance, the facility became the first in a Gulf Cooperation Council country to crack naphtha feedstock and produce new plastics and chemicals. The cracker creates products such as ethylene and propylene, which in turn are used in a variety of packaging, construction, electronics, and other products. Sadara also became the first in the region to produce toluene diisocyanate used in flexible foam for furniture, cushioning, and car seats.

"Sadara is a flagship chemicals project that significantly advances our ability to derive the maximum value from every hydrocarbon molecule, and to participate more broadly across the petroleum value chain," said Nasser, who became president and CEO in 2015.

Sadara: "In the lead"

Employees at Sadara's packaging center work to ensure the quality of a shipment.

As the partners in Sadara began to work out the details of the project, they needed to settle on a name. With its tradition steeped in engineering, Saudi Aramco typically forged an acronym for such projects beginning with SA for Saudi Aramco, followed by initials representing its project partner and the nature of the project. For example, a successful joint venture by Saudi Aramco (SA) with Total Oil Co. (TO) of France in refining (R) and petrochemicals (P), is called Saudi Aramco Total Refining and Petrochemical Co. (SATORP). SATORP provides feedstocks to Sadara as well as to Aramco customers.

Dow CEO Andrew Liveris, on the other hand, didn't want this transformational project to sound like just another example of an engineer's shorthand. Liveris wanted a name in Arabic that would be appropriate for the game-changing enterprise. Saudi Aramco's then-president and CEO Al-Falih and his team would have been happy to follow company practice.

It fell on Al-Gudaimi as project leader to craft a solution amenable to both executives. After considerable thought and deliberation, the two CEOs voted thumbs down on a short list of names. Al-Gudaimi didn't think they were any closer to a solution.

Then one of his team proposed they look for words in Arabic that start with the letters S and A. They poured through an Arabic dictionary and came across "sadara." It translates into English roughly as "in the lead." The Dow CEO thought the word captured his vision of Sadara being in the global petrochemical industry vanguard. Al-Falih and Saudi Aramco leadership embraced the new name as well, aligned as it was with their engineer's sense of nomenclature.

The multiplier effect of Sadara is still being realized. Sadara employs more than 4,000 workers. It is expected to create hundreds if not thousands more jobs in the Jubail area as manufacturing and service companies spring up to use Sadara's petrochemicals in products of their own. The government created the PlasChem conversion park next to the Sadara complex to promote the growth of enterprises that produce high value finished products.

Both Al-Falih and Nasser rose to the top of Saudi Aramco from the operations side, and their pride in Saudi Aramco's people and the company's ability to conceive of, design, and execute its array of mega-projects in-Kingdom is self-evident. "On the emotional side, these projects were great journeys," Al-Falih said.

When he was president and CEO, Al-Falih said: "What stands out the most is my pride at having been a cheerleader. I was one of the ones being cheered back in the '80s and '90s, because I spent some time in project management. So, I know how difficult it is to execute a project and balance all of the things that need to be balanced." He is confident that a survey of major global corporations and the number of projects they attempted and their success rate measured across multiple factors would find that "Aramco would be in a league of its own in project execution."

OPPORTUNITY IN JAZAN

While many Saudi Aramco projects such as Sadara were constructed near the Kingdom's core oil and gas reserves in the Eastern Province, other company complexes have driven development in more remote regions of the country.

In 2006, King Abdullah announced that the Kingdom planned to set up a new economic city in the impoverished region of Jazan, in southwest Saudi Arabia on the Red Sea, with an investment of up to 100 billion riyals ($26.7 billion). Jazan had long been overlooked as a destination for foreign direct investment.

In response, Saudi Aramco planned and carried out the Jazan mega-project. Construction began in 2014, and by 2022, Saudi Aramco had built a world-class refinery for refined petroleum products; an integrated gasification combined-cycle (IGCC) complex producing power to cater to growing industrial requirements; a marine terminal from which petroleum products are shipped to market; a commercial port to serve as a gateway to three continents; and training institutes to supply the region with highly skilled technicians.

The refinery was designed with the capacity to process 400,000 bpd of oil. From that, it produces 80,000 bpd of gasoline, 250,000 bpd of ultra-low sulfur diesel, and more than 1 million tons a year of benzene and paraxylene compounds.

Khalid Al-Faifi, who grew up in the mountains near Jazan, went to work as a mechanical engineer on construction of the Jazan Refinery as the Aramco project helped spur development of that region of the Kingdom.

As important as the refinery's production is the boost the complex gives to a regional economy that has lagged behind much of the rest of the Kingdom in economic growth in recent decades. Even before construction began, in October 2013, the company started training 550 Saudis from the area for jobs in the construction phase of the project. Thousands would pass through the training program over the next four years.

Saudi Aramco was doing its part to stimulate regional development in line with the Kingdom's goals, but no one expected a pandemic. The Jazan mega-project faced a number of delays, particularly in 2020 and 2021, related to the fact that the COVID-19 outbreak presented a major challenge for Aramco.

The pandemic resulted in curfews throughout the Kingdom and in Jazan, which made it necessary to pause business operations from time to time. Aramco's work practices also had to be revised to ensure the health and safety of staff and to comply with the Ministry of Health's regulations. In addition, the pandemic had a disruptive effect on global value chains, leading to delays to projects around the world, including the Jazan megaproject. Originally scheduled to be ready for full operations in mid-2020, commercial operations began in 2021, reaching 50% capacity in 2022.

EXPANSION IN MALAYSIA

Saudi Aramco moved to further expand its global refining and petrochemicals capacity via a joint venture known as PrefChem with Malaysia's state-run oil company Petronas. Agreed to in 2017, the joint venture is located in Malaysia's Pengerang Integrated Complex near Singapore and its market opportunities.

The PrefChem project, which was already underway when Aramco joined as a partner, faced setbacks in the execution phase. A small fire at the refinery in 2019 delayed commissioning of the facility.

The facility includes a 300,000 bpd refinery, a steam cracker capable of producing 1.3 million metric tons of ethylene, and associated facilities for the production of propylene, butadiene, benzene, polyolefins, and ethylene glycol.

MOTIVATING MOTIVA

As Saudi Aramco reviewed its overseas downstream investments and opportunities in the mid-2010s, its largest and in some ways most challenging was its Motiva partnership with Shell. Formed in 1998 as a joint venture with Texaco called Star Enterprisees, and modified over the years, the partnership included North America's largest oil refinery, capable of processing 600,000 bpd of crude oil, at Port Arthur, Texas, on the Gulf Coast. Two smaller refineries were also included in the joint venture.

Renamed Motiva, after Shell purchased Texaco's stakes, the partnership was struggling to turn a profit. A $10 billion upgrade to double the size of the Port Arthur refinery in 2012 was followed by a string of costly missteps. A series of small leaks and fires forced expensive repairs and kept plant operations sidelined for weeks at a time. Neither partner was seeing the financial returns on the upgrade they had expected.

Shell didn't appear to be as motivated as Saudi Aramco to restructure or grow Motiva, said Mahdi Aladel, CEO of Aramco Ventures. He was seconded to Motiva from Saudi Aramco to participate in turning around the business. Shell was providing a range of services to Motiva, Aladel noted. That meant the company was generating service income from Motiva even if it wasn't making money in refining, he said.

Saudi Aramco realized it would have to initiate an extreme turnaround in Motiva after having waited for years to see better performance results. "We had to be honest back then, kind of put our foot down and say, no, we can't. We just have to relook at this company. We've tried … we've waited," said Aladel. "Enough was enough."

The two parties divided Motiva's assets in the breakup, which took effect in 2017. The large Port Arthur refinery, roughly half of the terminal assets, and the Motiva name and headquarters went to Saudi Aramco. The two smaller refineries went to Shell.

"When we did that, we were able to focus on the growth of Motiva and then serving the Saudi Aramco strategy as opposed to a joint venture that was closer to Shell and responded to what Shell wanted to do," Aladel said.

Taking sole ownership of Motiva not only helped get the refinery business in the U.S. back on track and aligned with Saudi Aramco's global strategy, it also was a milestone marking Saudi Aramco's first wholly owned, core operational business based outside of the Kingdom. There were doubts among some senior leaders in Dhahran whether the Saudi Aramco team could make Motiva a success without a partner, said Aladel. But he and the rest of the Motiva team proved they could make it happen.

"Aramco, with the agreement of Shell, brought fresh new leadership from the market to turn around this company. And in a year and a half, this company went from almost a $400 million loss annually to a profit of about $1.2 billion. And that was one of the most successful transformations that rating agencies like Moody's talk about in the oil and gas industry," Aladel said.

Base oils

For years, Saudi Aramco has ranked among the largest producers of base oils, which are used to produce finished lubricants, or lube oils. Produced under the AramcoDURA, AramcoPRIMA, and AramcoULTRA brand names, the base oils have more recently been taken a step further downstream as the company begins to produce lube oils sold commercially under the Orizon brand. The base oils are produced in the Republic of Korea at S-Oil, in-Kingdom at Luberef, and in the U.S. at Motiva to meet the same specifications, so there are multiple sources for these products to minimize the potential for supply chain disruption.

Aramco has produced base oils for years but in recent years has launched commercially branded product lines such as AramcoDURA, AramcoPRIMA, and AramcoULTRA.

Amin Nasser, who succeeded Khalid Al-Falih as president and CEO in 2015, speaks with employees on the floor at Aramco Trading Co. To Nasser's left is Yasser Mufti, now executive vice president of Products and Customers.

THE TRADING GAME

In late 2010, to facilitate its downstream integration, the company formed Aramco Trading Co. (ATC) to trade refined hydrocarbons, and liquid chemical and polymer products. By 2012, ATC was handling an average of 680,000 bpd of global sales and purchases. ATC added gasoline blending in 2013 and was soon recognized as one of the largest blenders in the Gulf, handling 300,000 bpd.

The following year, ATC expanded into handling chemical products. Working with Petro Rabigh, ATC staff began loading polypropylene, high-density and low-linear polyethylene, and monoethylene glycol. To better serve demand for petrochemical products trading, Saudi Aramco formed the Aramco Chemicals Co. in 2018 as a separate affiliate. Reflecting its increased global presence, ATC opened an office in Singapore in 2018, and subsequently added offices in the United Arab Emirates and the United Kingdom.

VENTURING TO EUROPE

Saudi Aramco saw another opportunity to expand its downstream presence outside of the Kingdom in 2016 — in synthetic rubbers and elastomers — and reached out to leading synthetic rubber manufacturer LANXESS AG of Germany about forming a joint venture.

The two parties agreed to form ARLANXEO, based in the Netherlands. Al-Gudaimi, who negotiated the agreement, noted that the name marked a reversion to the engineering acronym process of pre-Sadara days, with "Ar" for Aramco and "lanxess" for the German partner. In agreeing to the joint venture, LANXESS insisted on having the option of selling its 50% stake in the joint venture back to Saudi Aramco under certain conditions.

In 2018, LANXESS CEO Matthias Zachert decided to exercise that option and sell his half-interest in ARLANXEO back to Saudi Aramco. The deal was getting bogged down in details, so Al-Gudaimi, chairman of ARLANXEO, traveled to meet Zachert at his home to get the negotiations back on track. The two spoke for hours and agreed that they, and the two companies, should part ways as friends, so an agreement was reached.

The deal giving Saudi Aramco 100% ownership of ARLANXEO, its second wholly owned foreign operating company, closed in December 2018. Saudi Aramco valued the LANXESS stake at 1.5 billion euros on an enterprise value basis. Today, Saudi Aramco's ARLANXEO business is a global leader in synthetic rubbers, with ExxonMobil and China's Sinopec as its main competitors. In elastomers, its Sadara partner Dow Chemical is among Saudi Aramco's top competitors, as is ExxonMobil.

Aramco formed its joint venture ARLANXEO with LANXESS, a leading manufacturer of synthetic rubber, in 2016. LANXESS exercised its option to sell its half-interest in ARLANXEO to Aramco in 2018.

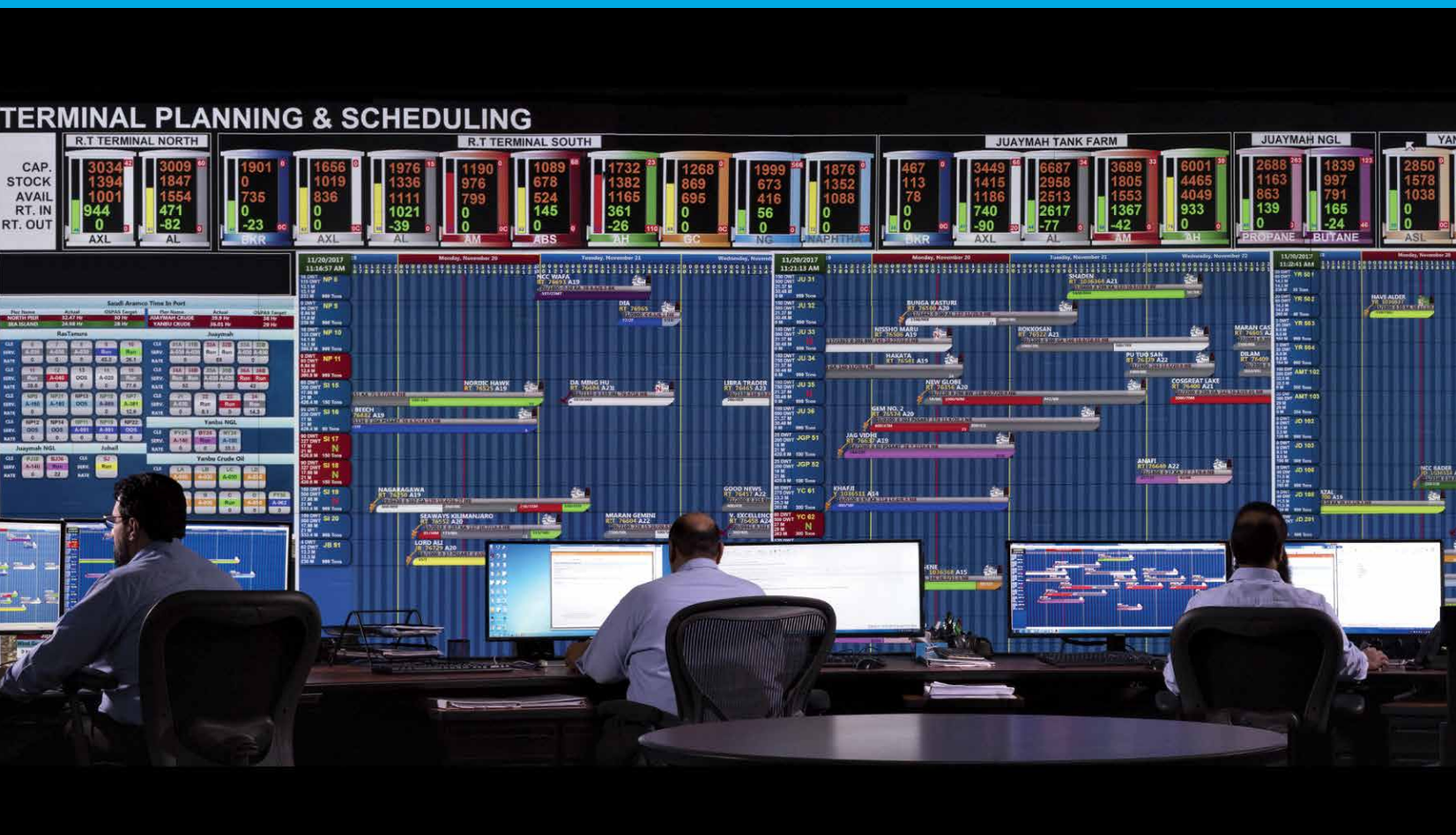
The nerve center

Saudi Aramco's Operations Coordination Center (OCC), which is managed by the Oil Supply Planning and Scheduling Department (OSPAS), is the central control room for the company's far-flung oil and gas operations. Entrance to the cavernous space in Dhahran's core office complex is tightly controlled, and with good reason. Here, the biggest video display wall in the hydrocarbon industry — with 150 video screens totaling 196 million pixels and forming an arc 67 meters long by three meters high — provides real-time monitoring of virtually all of the company's operations: terminal scheduling, electric power generation and distribution, and the production and distribution of oil, gas, NGL, and refined products.

Most of the data used to generate the displays is refreshed every 15 seconds and is provided by more than 60,000 remote terminal units embedded throughout Saudi Aramco's extensive operations network. This enables OSPAS personnel to track the flow of virtually every drop of hydrocarbons produced and shipped by the company, from wellhead to processing facilities, through more than 21,000 kilometers of pipeline, and finally to loading terminals on both the Gulf and the Red Sea. Workers track performance of key system components around the clock and have the ability from their desks in the OCC to shut off a remote pipeline valve if, for instance, sensors embedded in the distribution system detect a malfunction.

The company uses the system to respond to international events as well. For example, in the wake of hurricanes Katrina and Rita in 2005, OSPAS operators redirected tankers headed for damaged U.S. Gulf Coast refineries, built up inventory of other products, and juggled delivery schedules to major international clients. The result was that the company met clients' needs on a global basis and did not have to cut back production, despite the damage to U.S. oil facilities.

Personnel in the Operations Coordination Center use the largest video display wall in the industry to track the flow of hydrocarbons from wellhead all the way to loading terminals.



OIL PRICES PLUNGE

The sustained global economic boom that followed the 2008-2009 financial crisis pushed oil prices to near or above $100 a barrel from late 2010 through much of 2014. Higher prices, while also driving up the cost of steel pipe, concrete, and other construction materials used in Saudi Aramco mega-projects, dramatically boosted the revenue of Saudi Aramco and other oil-producing companies. At the same time, sustained higher prices made it profitable for producers of higher cost, so-called tight oil, including shale oil and gas in the U.S., to drill almost nonstop.

The surge in oil production from the U.S., which topped Saudi production in 2013, and signs of economic slowdowns in China sent oil prices somewhat lower by the second half of 2014. Given its ability to take a leading role in stabilizing oil markets, Saudi Arabia was expected by many market observers to cut its production, surrendering market share to maintain stable or higher prices. Not this time.

Saudi Arabia and other OPEC members agreed they were not willing to give up market share to the shale industry, many of whose members were highly leveraged and unlikely to survive a sustained plunge in oil prices. OPEC refused to cut its output. OPEC members tightened their belts and prepared for turbulent times ahead. While there were no guarantees that the price of oil would settle within recent historical price ranges, it was certain to trend lower before rebounding.

World oil prices plunged from $112 a barrel in June 2014 to $32 a barrel in February 2016. Several shale oil producers dramatically cut their production. The shale oil industry was wounded, but still in business. Investors did, however, increasingly demand that shale oil companies focus more on producing a return on capital rather than simply focusing on producing the next well. Saudi Aramco, as it had in so many market downturns before, cut back on spending where it could to ride out the dramatic collapse in oil prices.

Custodian of The Two Holy Mosques King Salman and former Aramco board chairman Khalid Al-Falih look at a photograph with Jacqueline Haug Larsen and Joyceline Haug Kriesmer, twins who met the King's father, King Abdulaziz, when the Kingdom's founder visited Dhahran in 1947. After ascending to the throne in 2015, King Salman visited the U.S., where he met with a number of Aramco retirees.

ROYAL SUCCESSION

Indeed, the accelerating collapse continued to dominate the headlines in Saudi Arabia as 2015 began. Within a few weeks, however, Saudi media and citizens were transfixed by another event. There was a new king on the Saudi throne.

Custodian of The Two Holy Mosques King Salman bin Abdulaziz Al Saud ascended to the throne in January 2015 following the passing of his half-brother King Abdullah, who was 90. Well-known and respected within the Kingdom, King Salman had served as governor of Riyadh for nearly 50 years and was named Defense Minister in 2011. He pledged continuity with his predecessor's agenda, facing not only falling oil prices, but rising Islamist radicalism in the region and a civil war in neighboring Yemen. One of King Salman's sons, Prince Mohammad bin Salman, would soon rise to prominence as the royal family's next-generation visionary.

Adding momentum to the rate of change in the Kingdom and the global oil industry was turnover at the top ranks of Saudi Aramco and the energy and industrial sectors. Amin H. Nasser replaced Al-Falih as president and CEO of Saudi Aramco in 2015 when Al-Falih was appointed Minister of Health and chairman of the Saudi Aramco Board of Directors. In May 2016, long-serving oil minister and former Saudi Aramco president and CEO Ali I. Al-Naimi was succeeded by Al-Falih. Coinciding with this generational changing of the guard, the Ministry of Petroleum and Mineral Resources was restructured as the Ministry of Energy, Industry and Mineral Resources, and that was part of a new vision for growth and transformation in Saudi Arabia.

TRILLION-CELL SIMULATIONS

Generational change of another sort further enhanced Saudi Aramco's cutting-edge ability to produce oil and gas. Building on more than two decades of industry-leading research in mapping oil and gas reservoirs, Saudi Aramco in late 2016 took its technological prowess to a new order of magnitude with the introduction of TeraPOWERS. This reservoir simulation technology employed an unprecedented 1 trillion cells to simulate the flow of oil and gas through source rock to reservoirs.

TeraPOWERS was the third generation of POWERS (Parallel Oil Water and Gas Enhanced Reservoir Simulator), which Saudi Aramco researchers, finding nothing available to meet the unique needs of managing some of the largest oil and gas reservoirs on Earth, began developing in 1994. In 2000, they debuted a package processing 1 million cells to visualize reservoirs. A decade later, they deployed the next generation, GigaPOWERS, capable of using 1 billion cells to get a much more detailed view of oil and gas flow in reservoirs. While much of the rest of the oil and gas industry could only aspire to 1 billion cell resolution at the time, Saudi Aramco researchers pushed ahead for still more detailed depictions of the Kingdom's resources.

Saudi Aramco Fellow Ali H. Dogru led a team of scientists and engineers at EXPEC ARC in Dhahran in developing POWERS, and in achieving the trillion-cell threshold. His team tapped another one of the Kingdom's world-class technologies, the Shaheen II supercomputer at KAUST, to run its simulation. The simulated migration of oil from source rock to reservoir that in nature takes hundreds of millions of years was no problem for Shaheen II, ranked among the world's top 10 supercomputers and the fastest supercomputer in the Middle East at the time, to quickly compute.

"TeraPOWERS is a significant step forward for Aramco as it provides increasingly more accurate details about our reservoirs for our engineers and scientists, who continuously strive to optimize our assets," said Nasir Al-Naimi, president of Upstream.

In 2021, the company's TeraPOWERS simulator capability was significantly expanded with the EXPEC Computer Center's new Ghawar One supercomputer, which can do 23 petabyte (1,000 trillion) calculations per second. The center's 2021 computing capacity provided 1 million times more computing power than the company had in 1990.

Such trends in computing and the dedicated scientists' innovative mathematical and technological breakthroughs made it possible to take Aramco's powerful simulation capabilities to yet another level: modeling the entire basin. Work progresses in revealing the deep secrets of the reservoirs, unlocking critical knowledge for the company's engineers to be effective stewards of current fields and tackle those waiting to be developed.

Ali H. Dogru (left), Aramco Fellow and the chief technologist at EXPEC ARC, led a team of scientists and engineers in development of TeraPOWERS. With Dogru is Guido Port, a geological specialist in the Strategic Modeling Technology Department.

TeraPOWERS has been instrumental in Saudi Aramco's ability to simulate the production of unconventional hydrocarbons buried deep in shale or other tight rock formations. In a 2020 interview, Upstream Digital Center vice president Ashraf M. Al-Tahini, who was manager of EXPEC ARC at that time, noted that TeraPOWERS played a vital role in simulating the development of the Jafurah unconventional gas field, the largest in Saudi Arabia and believed to be the largest such field outside of the U.S.

With TeraPOWERS, "We go into the basin, the kitchen, where basically you have hydrocarbons being cooked and being migrated to the reservoir," said Al-Tahini. Being able to simulate gas formation at such early stages greatly enhances the company's ability to cost-effectively produce such massive but previously hard to reach or understand gas reserves. The Jafurah field is expected to produce 2.2 billion scfd by the time it is fully operational in the 2030s.

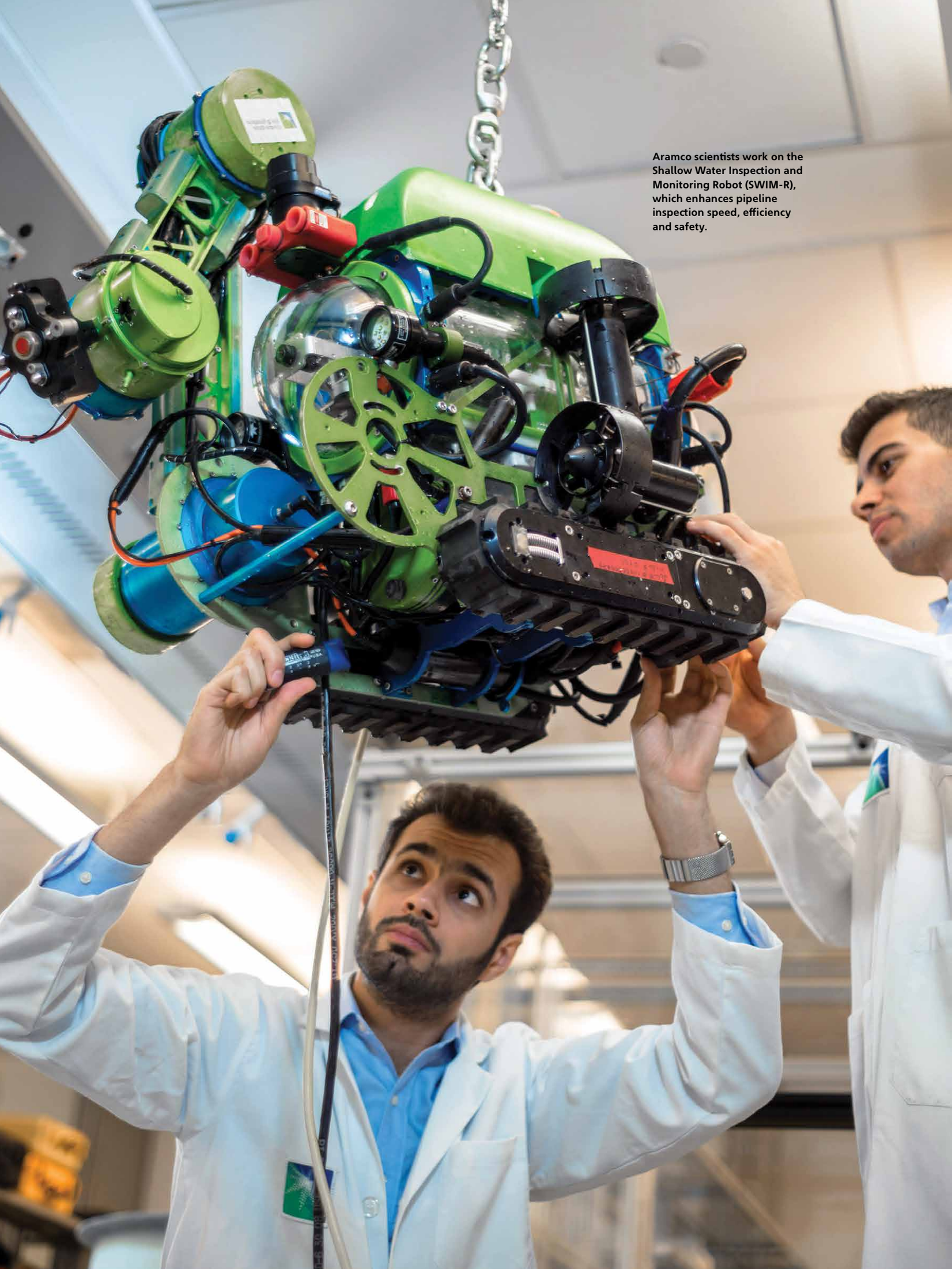
FOURTH INDUSTRIAL REVOLUTION (IR 4.0) RESEARCH

Saudi Aramco's technological research assets grew even greater in October 2018 when the company launched its ninth research center located outside of the Kingdom, in Moscow State University's Science Park.

At a launch event for the center, President and CEO Nasser said that Saudi Aramco's network of research centers can apply IR 4.0 solutions such as machine learning and artificial intelligence to a range of issues the company faces now and in the future. "It is central to identifying and developing new ways to increase discovery and recovery, to protecting the environment, and at the same time, also unlocking new value-adding noncombustible uses for oil," Nasser said.

The dozen research centers — nine overseas, two in Dhahran and one at KAUST — communicate and coordinate their activities so that creative solutions applied in one center generate solutions, quite possibly in a distinct field of research, in another. The global research

Aramco geoscientists use technology and traditional techniques to carefully examine core samples and drill cuttings to yield knowledge about hydrocarbon reservoirs. Since the 1930s, the company has collected cores and cuttings, and Aramco's Core Laboratories Center in Dhahran houses more than 26,000 kilometers of samples.



Aramco scientists work on the Shallow Water Inspection and Monitoring Robot (SWIM-R), which enhances pipeline inspection speed, efficiency and safety.

group recently rolled out a system called Aramco Innovation Management System (AIMS) that promotes collaboration, where researchers in different centers can seek advice and solutions from subject matter experts in their network.

RISK TAKING AND ROBOTICS

While being able to tap global talent through its network of research centers, Saudi Aramco also realized that recently completed KAUST was a magnet for just the kind of risk-taking researchers and entrepreneurial thinkers the company needed to drive disruptive change. Initially, the company thought it was doing its civic duty to support education in the Kingdom by hiring 10-12 graduate students from KAUST. "We thought it was a good thing to do for the university. But we didn't realize it was a great thing to do for the company," said Ahmad O. Al-Khowaiter, executive vice president for Technology and Innovation.

"What happened was KAUST had attracted some of the most innovative, I would say, risk-taking type individuals that were willing to come to Saudi Arabia, to a new university, and also very, very smart people," Al-Khowaiter said. The graduate students who Saudi Aramco hired hailed from nearly a dozen countries. "So, we were able to capture a really unique set of people in KAUST. And by hiring those young, talented engineers and scientists, we were able to capture a new type of talent for the company that we didn't have before."

Inspections are a crucial, but hardly glamorous, part of maintaining processing facilities. Making the most of their assignment, a group of the KAUST students observed in the field the laborious work of building scaffolding and then scaling facilities to make crucial measurements. They reasoned that a robot could accomplish the goals that required teams of workers.

Tapping the inventory of the Saudi Aramco research center at KAUST, they built a prototype robot as new hires for the company's Research and Development Center. They demonstrated that a robot with a magnetic wheel could drive up steel pipes and take the measurements required for inspections and communicate them wirelessly.

They christened the robot SAIR, which means "walker" in Arabic. It also complies with the engineering naming culture, as an acronym for Saudi Aramco Inspection Robot. The company embraced the new robot as a means of cutting the time and costs associated with certain inspections, and improving safety. That robot led to the creation of a robotics group within the company and the creation of additional robots, including a robot capable of underwater inspections, dubbed the Shallow Water Inspection and Monitoring Robot (SWIMR), and a robotic solution to removing the ever-present Saudi desert dust from solar panel arrays.

"We were very proud of our accomplishments," said Fadl Abdellatif, a founding member of the robotics team. "This was the first robotics project Aramco came out with, and it was conceived in-house. Few people believed something like this could be done in Saudi Arabia, but we proved we could build an internationally recognized robot here."

"It's a really exciting part of our research," Al-Khowaiter noted, "because it's something that people can see, can connect with, can understand immediately the value of. So, this is that ability to think out of the box, rethink what we've been doing for the last 80 years and reinvent it, which is so exciting about the new generation."

HRH Crown Prince Mohammad bin Salman announces Vision 2030 in April 2016, establishing a blueprint for diversifying the Saudi economy.

SELLING SHARES IN SAUDI ARAMCO

Just as the new generation of researchers and technologists was making itself felt within the company, the standard bearer for generational change countrywide was HRH Crown Prince Mohammad bin Salman.

In April 2016, he unveiled Vision 2030, an ambitious blueprint for diversifying the Saudi economy and society. Crucial to Saudi Aramco, Vision 2030 was supported by the primary goals of the company's strategy for 2020 and beyond. The emphasis on developing petrochemicals as a major downstream focus and using that business to encourage the development of ancillary businesses — and jobs — in the Kingdom to further diversify the economy aligned seamlessly with Vision 2030.

The Crown Prince, named heir to the throne in 2017, also led the push to loosen previous cultural restrictions in-Kingdom as part of his diversification and modernization program. Allowing women to drive boosted economic activity, with many more women able to work in sectors previously not open to them. A broad range of cultural events and activities such as movies and concerts were permitted.

One key aspect of Vision 2030 came as a surprise to most within Saudi Aramco. Since 1980, the oil company had been wholly owned by the Saudi government. Saudi Aramco had its own board of directors and governance structures. The shareholder to whom the company ultimately reported and paid dividends was the Saudi government. The government required periodic reports on the performance of the company, but generally kept an arm's length when it came to company operations.

The Crown Prince proposed selling a small stake in the company to public shareholders. The goal was to use funds generated by the sale of Saudi Aramco stock to help fund the diversification of the Saudi economy. The Saudi government would continue as the largest shareholder after the proposed Initial Public Offering (IPO).

An IPO, even the sale of a relatively modest stake, would have a tremendous impact on Saudi Aramco in many ways. Financial reporting and regulatory practices would need to comply with the requirements of any exchange where the company's stock would be listed for trading. And the company would be making public key aspects of its operations, some of which had been closely guarded secrets for decades.

Additionally, an IPO would finally let the world in on what Minister Al-Falih and president and CEO Nasser firmly believed was Saudi Aramco's best-kept secret. It really was the best-run, top-performing oil and petrochemicals company in the world, bar none.

At the Upstream Professional Development Center in Dhahran, young professionals are able to use cutting-edge training technology to develop their understanding of hydrocarbon reservoirs.

CHAPTER 6

Achieving our vision

The King Abdulaziz Center for World Culture.

Aramco president and CEO Amin Nasser rings the bell marking the launch of public trading of Aramco stock on the Tadawul, the Saudi stock exchange.

Decades of investment by Aramco in its careful and proactive stewardship of the Kingdom's hydrocarbon resources have borne ample fruit in recent years. The impact of increased growth and diversification of the Saudi economy will continue to be felt for decades to come.

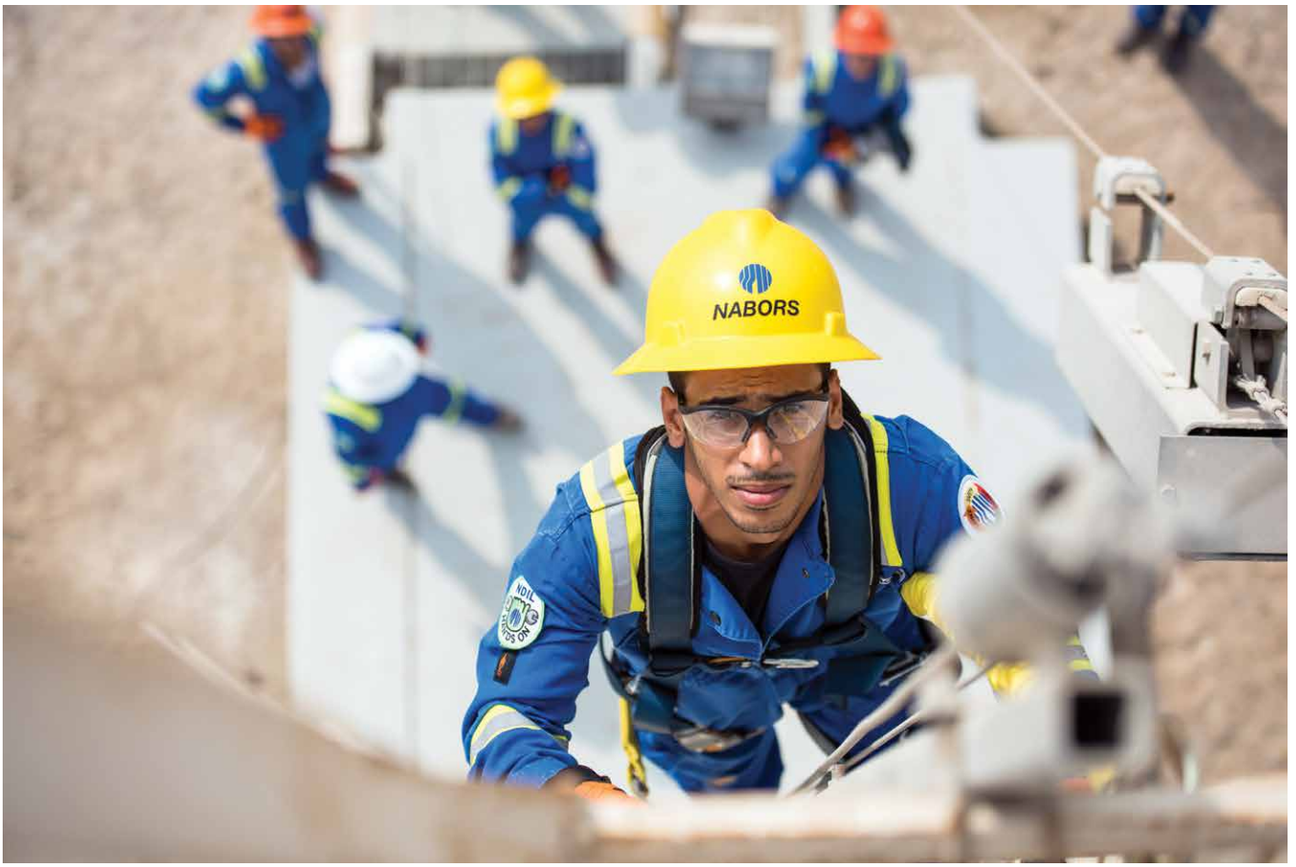
Aramco, and its key role supporting the government's Vision 2030, has had a transformational impact at home and abroad. Saudi society has benefited from the company's support of cultural and educational achievement, as have the communities around the world in which Aramco operates.

Globally, the company is among the largest and most efficient integrated energy and petrochemicals companies. The total hydrocarbon reserves of 258.8 billion barrels of oil equivalent (boe), for which Aramco is the Kingdom's steward, as of 2022 were more than five times that of the five major independent oil companies (IOCs) plus Norway's state-owned Equinor combined. And its total daily hydrocarbon production of 13.6 million boe in 2022 was greater than the total production of the group as well. Aramco's scale of operations is underpinned by an exemplary reputation for reliable customer delivery. In the first quarter of 2021, even while coping with the challenges of a lingering pandemic, the company maintained its reliability on deliveries to its global customers.

Aramco's low-cost of upstream oil production — less than a third of its nearest IOC rival — and its commitment to sustainability initiatives, including an ambition to achieve net zero Scope 1 and Scope 2 greenhouse gas emissions across its wholly owned and operated assets by 2050 — supported by industry-leading positions in upstream carbon and methane intensities, minimal gas flaring, and its investments in innovation — also place Aramco in the international oil industry vanguard.

While rivals trim plans for producing and refining hydrocarbons, Aramco sees no contradiction between its role of meeting the world's long-term energy needs and its focus on sustainability; they are inexorably linked. It also continues to invest in best-in-class technology and develop its next generation of global leaders. All of these factors combine to maintain Aramco's unrivalled operational and financial performance as an undisputed leader in the global energy and chemicals industries.

Daniel Yergin, Pulitzer Prize-winning author and energy industry analyst, notes that Aramco is in a class by itself, a category of one. "Saudi Aramco has a couple of things that no other company has. It has scale like no other company has. And it has flexibility like no other company has. And then the third thing it has is the capabilities and the human talent to manage that system efficiently."



The Saudi Arabian Drilling Academy is helping to develop the next generation of drilling professionals.

SUPPORTING SOCIAL CHANGE

Aramco's effort since the 1950s to support and develop local businesses and industries has continued to accelerate. This effort began in the Eastern Province where most of the company's operations are located, and has spread across the Kingdom in recent years in step with Aramco's oil, gas, and petrochemical facilities and related development projects. The company plays a unique role as a catalyst at the heart of the Saudi economy.

Working to encourage local business and industry has obvious benefits for the company. It works to develop suppliers and supply chains close to home that produce parts and equipment vital to hydrocarbon discovery and production. It also is in accordance with a key provision of the company's original concession agreement signed in 1933 that directed the company to employ Saudis whenever possible. That provision, reflecting the intergenerational vision of Saudi Arabia's founder, King Abdulaziz, finds its counterpart for today's generation and that of tomorrow in key aspects of the government's transformational Vision 2030's efforts to diversify the Saudi economy.

LOCALIZATION

Wanting to accelerate and expand Aramco's traditional support of local manufacturing and business, in December 2015, president and CEO Amin H. Nasser and his senior management team launched a new program known by the acronym iktva, for In-Kingdom Total Value Add — the company's signature supply chain efficiency and localization initiative.

After decades of working with local manufacturers, the local contingent still accounted for only about 30% of the value of Aramco's direct material procurement. The initial ambitious goal of the new iktva initiative was to more than double the local content within a decade, and to drive Saudi employment higher in the bargain.

Nasser and his leadership team identified that the existing approach to attracting business partners to participate in the projects was overly top-down. For that reason, it was taking too long to gain sufficient momentum to generate growth and attract enough suppliers. The team needed to jump-start the effort, and Nasser made it one of his highest priorities on becoming president and CEO.

Nasser saw it as a huge opportunity for increasing the reliability of the supply chain while also creating thousands of jobs in Saudi Arabia. He personally reached out to several major suppliers to understand their needs and concerns about investing in the Kingdom. Yasser M. Mufti, executive vice president of Products and Customers, said, "He spent one-on-one time with the CEOs and leaders of Aramco's supply chain companies, and asked, 'What do you want? How can I get you to localize more?'"

The responses tended to focus on three major points. The foreign manufacturers and service companies wanted a longer term view of potential demand for their products and services. They didn't expect guarantees, but they wanted visibility in terms of Aramco's multi-year demand outlook. They also wanted the company or government to provide training. Skilled technicians were available, but the companies needed training provided for the tens of thousands of high school graduates and others who would fill most of the jobs to be created to meet the iktva goals. Last, they wanted specialized equipment and services to support their industries, akin to those provided in industrial centers in the United Arab Emirates and Egypt.

A daunting list of demands, but the Aramco team was determined to do what it took to rapidly spur manufacturing growth and jobs in-Kingdom and to create an energy and industrial ecosystem that enables this momentum to be maintained on a sustainable, long-term basis. Nasser said: "When we launched the iktva program, the thinking was we need to make it a win-win for us and our partners. It wouldn't succeed if it wasn't a win-win for both. So, we had to make sure that the right strategy and objectives were in place, and at the same time, we made sure iktva considered all our partners' objectives and could enable successful outcomes for all of us involved."

A WORLD-CLASS ECOSYSTEM

The Aramco team understood that Aramco couldn't be a truly world-class company if it didn't bring its business ecosystem along with it, executive vice president of Technology and Innovation Ahmad O. Al-Khowaiter said. "Now iktva is allowing us to create a new ecosystem around Aramco that will meet our global ambitions."

He added, "It's really the whole ecosystem that makes a difference — the way we've established ourselves here, the contractors' capabilities, the way of energizing them and getting them to work in partnership with Aramco. It is like a family, I have to say. We really work together in this part of the world."

The potential for increased business in-Kingdom quickly attracted a global who's who of manufacturing to participate in iktva. Within months, German industrial giant Siemens created the Siemens Dammam Energy Hub, Saudi Arabia's first gas turbine manufacturing site and the largest in the Middle East. In 2016, Siemens delivered the first of five planned gas turbines built in-Kingdom.

The iktva initiative creates employment opportunities for Saudis and develops a private sector ecosystem that supports Aramco's core business objectives.

Companies participating in iktva enabled Aramco to double its direct material procurement from local manufacturers to almost 60% by the end of 2021.

Since its inception, the iktva program has added to the economic diversification of the Kingdom by attracting more than 540 investments from 35-plus countries.

Scores of global corporations of all sizes, as well as companies based in the Gulf region, stepped up to participate in iktva. By the end of 2016, the local component of direct material procurement had more than tripled and represented 43.5% of the total procurement. By 2018, local manufacturers were providing 51% of total direct procurement, and by the end of 2022, that figure was 63%. Since its inception, suppliers in the iktva program had increased their contribution to the company's procurement to $14 billion and had added to the Kingdom's economic diversification by attracting more than 540 investments from 35-plus countries.

There is much more driving iktva than the hiring of Saudis, known as Saudization, as laudable as that goal is. The iktva program drives a reliable, efficient supply chain that sets a foundation for a strong industrial ecosystem. "Indeed, iktva continues to prove to be an invaluable asset in expanding our suppliers' capabilities and the local supply chain's efficiency," said Mohammad A. Al Shammary, senior vice president of Procurement & Supply Chain Management.

"Why would a company like Saudi Aramco localize? It's not just a corporate responsibility; it actually boils down to the strength of the company," Al Shammary said. "iktva has created best-in-class infrastructure and pioneered industry initiatives that ensure operational resiliency and efficiency while enabling new opportunities."

COMPLEX FOR MARITIME INDUSTRIES

The iktva initiative aligns with localization plans drawn up under the Accelerated Transformation Program (ATP) for developing major new industrial hubs in the Kingdom. The first was a maritime hub, the King Salman International Complex for Maritime Industries, to service the needs of Aramco and others in the offshore drilling and shipping industries. Inaugurated in November 2016, the nearly 5 million square meter facility on the Arabian Gulf north of Jubail will be the largest in the region when it is fully operational by the last quarter of 2024.

Aramco joined forces with three maritime industry leaders, Hyundai Heavy Industries (HHI), Lamprell Energy Limited (LEL), and The Saudi National Shipping Company (Bahri) to form International Maritime Industries (IMI) JV, which is the anchor project within the King Salman maritime complex.

The complex will also include a Marine Engines Manufacturing and EPC offshore platform facility. This development is expected to have a positive macro-effect on the Kingdom's economy and estimated to create 80,000 jobs; $12 billion of import substitution; and $17 billion of value add to the GDP as well as localizing the supply chain for this industry and enabling self-sufficiency with offshore products and services.

IMI will operate this world-class maritime facility at Ras Al-Khair for the construction of commercial ships, offshore support vessels, and offshore drilling rigs, and will provide the associated maintenance, repair, and overhaul services for these products. When fully operational, the yard will have an annual capacity to manufacture four offshore rigs, over 40 vessels including three very large crude carriers, and service over 260 maritime products. The annual capacity for the yard will be 15 rigs, 137 vessels, and 116 offshore support vessels.

Aramco executives participate in a ground-breaking ceremony at King Salman Energy Park (SPARK) for a new 227,000 square meter drilling and workover facility.

To meet its business partners' needs for trained workers, Aramco and its partners created a network of training academies located across the country with the intention of training and developing the future workforce that will operate the new facilities. The first was created to train workers for the maritime hub. Aramco's leading business partners in operating the hub, Bahri and Hyundai, oversaw the creation of the academy.

The maritime academy became a model for the training network, which is comprised so far of 16 academies. "Each one of these academies is intended to train and groom the people who will be operating facilities in the new subsectors added to the energy services sector," said Fahad K. Al-Dhubaib, senior vice president of Strategy and Market Analysis. "It is expected that hundreds of thousands of Saudi students will have passed through these academies and joined the local workforce by 2030," he said.

The academies weren't confined to industrial skills. In early 2021, Aramco joined with several international financial and investment firms to launch Altamayyuz Academy, offering a transformative approach to finance and accounting skills development through state-of-the-art curriculum and teaching methodologies provided by the globally renowned IE Business School.

Aramco board member Khalid H. Al-Dabbagh served as senior vice president of Finance and Strategy Development from 2018 to 2021, when he became chairman of SABIC and also joined the Aramco board of directors. During the academy's inauguration he said, "Our goal from the genesis of Altamayyuz Academy was investing in the promising young men and women of the future. The success of many Vision 2030 programs, as we know, will depend on highly skilled professionals in the finance and accounting sectors. We hope Altamayyuz will help us and our nation achieve this goal."

SPARK

The King Salman Energy Park, known as SPARK, grew out of Aramco's desire to localize key aspects of its crucial energy supply chain for the benefit of the company and the Kingdom. Initially, planners considered locating such suppliers in existing industrial cities in different locations across the Kingdom to literally spread the wealth in the form of supplier payments and job creation. But they concluded that grouping the suppliers would produce synergies and economies of scale that would outweigh the cost of creating another industrial hub.

Promoting biodiversity

A joint initiative between the Saudi Wildlife Authority, the Smithsonian Institution, and Aramco has worked to prevent the 'Asir magpie from becoming extinct.

Aramco participates in numerous efforts to protect the environment, support natural ecosystems, nurture biodiversity, and combat the effects of climate change. Starting with just 100 mangrove tree seedlings nearly 30 years ago, the company has planted millions of mangrove seedlings along the Kingdom's coastlines. Not only do the trees, native to the Gulf region, thrive in salt water and help revive and support marine ecosystems, they are among nature's most efficient carbon capturers. Aramco environmental engineer Mousa O. Alharthi said, "Studies show that mangroves sequester carbon many times faster and more permanently than land-based forests, and compared to most tropical forests, store up to five times more carbon."

At Aramco's Shaybah Wildlife Sanctuary, native species such as the Arabian oryx are protected.

The Mangrove Eco-Park near Ras Tanura raises awareness of the importance of mangrove forests.

Aramco's operating areas "contain most of the remaining healthy old growth mangrove forests along the Kingdom's Arabian Gulf Coast," said senior environmental consultant Ronald A. Loughland. To raise regional awareness of the importance of mangroves, the company has developed a 63 square kilometer Mangrove Eco-Park near Ras Tanura with an educational visitor center and boardwalk leading visitors through mangrove and intertidal habitats.

Far from the Arabian coasts, Aramco is also promoting biodiversity in the Rub' al-Khali desert wilderness. World renowned for its majestic, barren sand dunes, the region hosts hundreds of species, including an estimated 180 types of birds, as well as numerous reptiles and mammals. The company created the Shaybah Wildlife Sanctuary near its production facilities of the same name to help preserve the desert ecosystem.

The company has also worked with government wildlife officials to reintroduce three iconic desert species that have vanished from the region over the past century: the Arabian oryx, the Arabian sand gazelle, and the ostrich.

Crown Prince Mohammed bin Salman broke ground for the project located between Dammam and al-Hasa in December 2018. President and CEO Nasser said, "SPARK will serve as a central gateway to the region's economies, with Saudi Aramco continuing to be at the heart of the global oil and gas industry." When fully operational, SPARK is expected to create up to 100,000 jobs and contribute up to $6 billion annually to the Kingdom's GDP.

The project is being developed in three phases, with second and third phases planned as geographic rings around the initial phase. The suppliers will locate in industrial clusters, with the clusters expanding in each subsequent phase of development.

VALIDATING RESERVES

Ithra, iktva, SPARK — the flurry of initials, shorthand, and acronyms capture a culture leaning into a future of accelerating change and opportunity. Marching in step during this period was another acronym heralding change: IPO (initial public offering). Crown Prince Mohammad bin Salman's announcement in 2016 that the Kingdom was considering such an offering set in motion a cascade of meetings, studies, reorganizations, and refinements as the company reconstituted many aspects of its structure to meet the requirements of public ownership. Even though the Saudi government was planning to sell only a small percentage of its ownership in Aramco, there were still multiple steps required to prepare for the transition.

To prepare for the IPO, Aramco sought an independent certification and estimate of the size of Saudi oil and gas reserves by DeGolyer and MacNaughton, a company with highly regarded international expertise in the field. At Aramco's request, the firm began its study in 2016 and sent teams of more than 60 experts to Saudi oil and gas fields and Aramco facilities across the Kingdom. Their study took 30 months and was based on reserves as of December 2018. With the impending IPO process, company and government officials wanted to have the study undertaken to dispel any concerns about the extent of the Kingdom's reserves.

As a petroleum consulting firm, DeGolyer and MacNaughton has a storied history in the region. Co-founder Everette DeGolyer was called on in 1943 by the Allies in World War II to survey the Middle East and Arabian Gulf to provide a greater understanding of the oil reserves in the area. Axis forces were known to have eyed the region as a potential target for precisely that reason. Aramco, aware of the enemy interest, had reduced its manpower to the minimum as war raged on in Europe, Asia, and northern Africa, and was prepared to blow up wellheads if German forces advanced on the oil fields. DeGolyer, who visited Aramco and met its chief geologist, Max Steineke, was quoted during the war as saying, "The oil in this region is the greatest single prize in all history."

For decades, some oil industry skeptics had doubted the veracity of Aramco's estimates of the Kingdom's oil and gas reserves. How could they claim their reserves were increasing if they were pumping millions of barrels of oil a day? At various times theories would take hold that the Kingdom was overstating its reserves. If true, that meant the world might be facing an oil shortage at some point in the future. These "peak oil" theories, without any foundation in fact, received sensational treatment in 2005 with the publication of *Twilight in the Desert* by Matthew Simmons, an investment banker who died in 2010. Simmons' assertions, which received much attention prior to the publishing of his book, prompted a rare occurrence: In 2004, Aramco sent Mahmoud Abdul-Baqi, vice president of Exploration, and Nansen G. Saleri, manager of Reservoir Management, to the U.S. to speak publicly about the company's long-term prospects.

Realizing the company had no mandate to publicize its data to refute such speculation made the issue easy to dismiss for some within Aramco. For others, it was a source of continued frustration. They knew how good their reservoir management and exploration teams were, and how they were employing the best technology in the global petroleum industry.

Since its opening in 2018, the King Abdulaziz Center for World Culture has provided visitors with a doorway to cultural experiences.

Ithra — King Abdulaziz Center for World Culture

When King Abdullah laid the symbolic cornerstone for the King Abdulaziz Center for World Culture as part of the 2008 celebration of Aramco's 75th anniversary, few could have imagined the profound impact the institution would have on Saudi culture. Referred to most often by its informal name "Ithra" — Arabic for enrichment — the iconic center opened to the public in 2018 and continues to transform the way Saudis, and the rest of the world, view Saudi culture. Not since spice and silk caravans criss-crossed Arabia centuries ago has Saudi culture interacted so creatively and with such impact with cultures from around the globe.

The brainchild of then-Saudi Aramco president and CEO Abdallah S. Jum'ah, Ithra was conceived in 2006 initially as a "world-class" library and cultural center to be built by Saudi Aramco for the Saudi people. For years Jum'ah had felt an obligation to help bring Saudi society along with the company as it integrated with the international community, and especially with the increased presence of Aramco globally. That impulse aligned with the company's obligation to benefit the Saudi people that dated back to the signing of the 1933 concession agreement:

Ithra's theater has provided a venue for musical performances. Here, Naseer Shamma and the Oud House Orchestra perform on the center's stage.

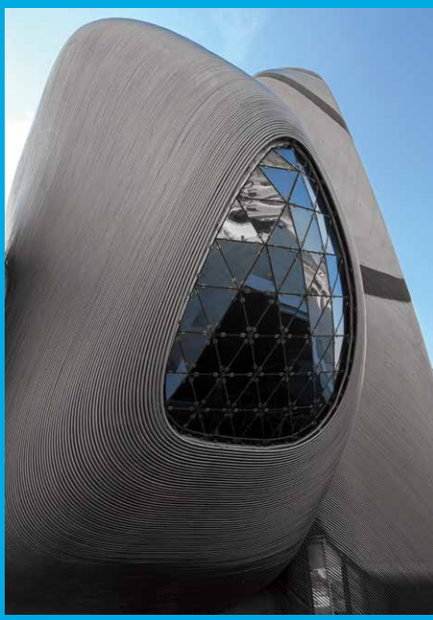
"We were opening up to the world, moving to transform Aramco from a local company to an internationally integrated energy enterprise. I said we can only do that if we take the lead to transform the minds and hearts of the next generation," Jum'ah said. He conceded that, at that time, the company was out in front of more conservative elements in the Kingdom.

With the library as the project anchor, Jum'ah and his team's planning evolved the original idea to encompass a multifaceted cultural center with performance and exhibition spaces, including a 900-seat theater and a 300-seat cinema, as well as lifelong learning and innovation spaces. A Dec. 6, 2006, internal document signed by Jum'ah described building "a world-class cultural center with a major public library to be integrated with the existing [oil company petroleum exhibit]" as "a key contribution from Saudi Aramco to the local community."

As great an impact as Ithra's cultural programming continues to have within the Kingdom and around the world, the institution's initial impact on visitors is delivered by the stunning multi-structure complex that arises from the desert. Not far from the

The center hosted a festival of Vietnamese culture in 2020 including a dazzling show of stunts by performers from the Asian country.

site of Dammam No. 7, the Prosperity Well — the first commercially viable oil well in Saudi Arabia — Ithra appears as a grouping of five futuristic, rock-like buildings. They are assembled as if they were an otherworldly marker denoting the wellspring of cultural offerings in the region. The international design magazine *Wallpaper* heralded Ithra as " Saudi Arabia's most progressive piece of contemporary architecture."



The center's iconic architecture was the result of a competition won by the Norwegian firm Snøhetta.

The unique complex is the result of years of arduous work and overcoming seeming intractable design and construction hurdles. To give the nascent cultural center a truly global feel and impact, an Aramco team organized a design competition that attracted some of the world's leading architectural firms. In 2008, the team awarded the design to the Norwegian firm of Snøhetta, which had gained notice in the Middle East and globally for the design of Egypt's new Library of Alexandria. Even though their initial design underwent several iterations, the Snøhetta partners had a keen insight into the aesthetics of clients in the region, as described in *Architectural Digest*: "While Europe is using its history [to define modernity] … Middle Eastern societies prefer to look to a possible future to define their present … to avoid superficial Westernization of aesthetics. Solutions may rather be found in the emotional translations of a rich iconographic and decorative tradition."

Saudi citizens flock to Ithra to partake in the various cultural offerings, and online access to cultural offerings flourished during the COVID-19 lockdown in 2020. "Ithra is not only a prominent landmark in an architectural sense," said Fahad K. Al-Dhubaib, senior vice president of Strategy and Market Analysis. "It is also known for its multifaceted cultural offerings. This beacon of change was pivotal in providing mental stimulation and well-being for all ages through its online offerings during the lockdown," said Al-Dhubaib.

Al-Dhubaib noted that culture isn't the only thing Ithra has to offer. "It's focused on accelerating human potential by encouraging creativity, inspiring minds, and empowering talent," he said, citing as an example the Bridges program that sponsored Saudi artists in 2016 and 2017 to perform to approximately a half million Americans across the United States.

"Ithra is such a unique center, having many different components with a key goal to institutionalize creativity," he said. "Components, such as cinema, theater, the children's museum, the library, and other creative disciplines all come together in a unique mix that has a distinct Saudi voice and forms part of a global conversation," he said.

President and CEO Amin H. Nasser, said: "Ithra is a key platform for youth engagement and development, and has become one of the most important ways that Aramco can both give something back to the Saudi people and also invest in them. It represents our commitment to growing human potential."

The center's library collection numbers more than 326,000 print and digital materials.

Cranes work in the Jafurah field — site of the largest unconventional gas field in the Kingdom.

The DeGolyer and MacNaughton results were released in early 2019. The numbers demonstrated that, if anything, the Saudis were conservative when it came to estimating their reserves. The consultants found 268.5 billion barrels of oil within the Aramco concession area, as well as the Saudi share of oil in the so-called Neutral Zone shared with Kuwait, compared to the estimate of 266.3 billion barrels published by the Saudi government. The two figures "do not differ materially," DeGolyer and MacNaughton concluded.

UNCONVENTIONAL APPROACHES

Saudi Arabia's massive natural gas reserves, not currently being earmarked for export, didn't receive as much attention as the crude oil holdings during the validation process. They do generate some eye-popping figures in their own right, however. And developing some of these fields, especially those labeled unconventional, where the gas is trapped deep below the surface in tight rock formations, involves some of the most advanced drilling technology employed in the industry worldwide.

Researchers at Aramco's Houston research center formulated fluids to inject into rock formations to create cracks and fissures through which oil or gas can escape the rocks to which they are tightly bound.

In February 2020, Aramco announced it had received government approval to develop the Jafurah gas field, the largest unconventional gas field in the Kingdom. It is similar in formation to the shale oil and gas fields found in the U.S. that form the basis for the renaissance in hydrocarbon production in that country in recent years. The 170 kilometer by 100 kilometer field holds an estimated 200 trillion cubic feet of gas in tight rock formations, which would equal more than one-third of the total natural gas reserves in all of North America.

The governmental green light came at roughly the same time that Aramco's global research network, led by researchers in Houston and Dhahran, developed a novel approach to working with tight rock formations. They formulated fluids to inject into rock formations in the hydraulic fracturing process to create cracks and fissures through which oil or gas can escape the rocks to which they are tightly bound.

"We looked at the microscale interaction of these fluids with the formation, and we started to engineer fluids," said Ashraf M. Al-Tahini, then manager of EXPEC ARC and now vice president of the EXPEC Computer Center. Al-Tahini said his team is confident the modified fluid technology and other industry-leading innovations will significantly boost the company's ability to produce gas efficiently from Jafurah and other unconventional fields.

The field east of the South Ghawar region is expected to begin producing in 2024. Much of the natural gas is expected to be used for power generation in-Kingdom, freeing additional crude oil for export, as well as for feedstock for Saudi Arabia's growing petrochemicals industry. By the 2030s, production from the field could make Saudi Arabia the world's third largest gas producer behind the U.S. and Russia. The development would entail the largest use of hydraulic fracturing technology outside of the U.S.

INVESTING IN SABIC

Aramco's industry-leading advances in upstream oil and gas production occurred in parallel with dramatic changes in its downstream petrochemical business — the source of much of the expected increase in oil demand for decades to come. The company weighed purchasing or merging with other leading petrochemical manufacturers to propel the company into the top ranks of global petrochemical players. But the Aramco leadership team realized that the brand images of leading contenders were so closely associated with host nations that any proposed combination would most likely meet fierce political resistance. There undoubtedly would be potentially costly antitrust scrutiny from U.S. regulators as well if a U.S. company were pursued. As a result, leading global petrochemical rivals were taken out of consideration.

That left Saudi Basic Industries Corporation, commonly known as SABIC, Saudi Arabia's home-grown petrochemicals giant. Initially, following the rollout of the ATP, Aramco executives didn't pursue a business tie-up with SABIC. The sense was that uniting two of the Kingdom's industrial giants wouldn't provide tremendous benefits over operating them separately. To that end, Aramco focused its petrochemicals business on compounds and markets that weren't already being served by SABIC.

SABIC's headquarters are a dominant feature of the Riyadh skyline.

The Kingdom's business landscape changed in many ways as Crown Prince Mohammad bin Salman promoted continued investments in businesses that would help diversify the Saudi economy of the future. In 2019, the Ministry of Energy, Industry, and Mineral Resources was divided into the Ministry of Energy, which serves as the company's regulator, and the Ministry of Industry and Mineral Resources. Prince Abdulaziz bin Salman was named the new Minister of Energy.

The role of chairman of Aramco and Minister of Energy had been held previously by H.E. Khalid A. Al-Falih. Al-Falih's decades of expertise forging some of Aramco's largest global business alliances was recognized, and he was appointed in February 2020 to the newly created position of Minister of Investments.

Lynn Laverty Elsenhans

Aramco adds first woman director

In the run-up to its historic public stock offering, Aramco made history of another sort when it named, for the first time, a woman to its board of directors, and also strengthened the overall board. Petroleum industry veteran Lynn Laverty Elsenhans joined the Aramco Board in April 2018. Elsenhans had served as chairwoman, president, and CEO of U.S. oil refiner Sunoco and on Baker Hughes' board of directors, and sits on the board of GlaxoSmithKline. Prior to her role at Sunoco, Elsenhans was the executive vice president of global manufacturing for Royal Dutch Shell, where she worked for more than 28 years.

To further strengthen the board, in the fall of 2019 Saudi Aramco named a new chairman — H.E. Yasir O. Al-Rumayyan, governor of the Kingdom's Public Investment Fund.

Leading up to the 2019 IPO, Aramco met with investment analysts to provide opportunities to learn more about the company.

The Kingdom's Public Investment Fund (PIF), a long-time supporter of expanding SABIC's global reach, reviewed its portfolio in part to determine how the capital under its control could be redeployed to meet future needs. That review led to conversations between PIF and Aramco about Aramco taking a controlling stake in SABIC.

The transaction was proposed as a win-win for both parties. PIF would end up with funds to redeploy in industries and projects that weren't associated with the Kingdom's energy holdings. Aramco would be catapulted into the front ranks of global petrochemical companies.

The Aramco leadership team brought the SABIC proposal to the company's board of directors for consideration. Some on the board questioned why SABIC was attractive if Aramco had not pursued a corporate combination with its domestic counterpart earlier as part of its petrochemical strategy. The answer was that with a transaction involving a foreign company likely to face tremendous political, cultural, and regulatory backlash almost wherever the other company was located, SABIC made much more sense as a business partner.

In the end, after searching around the world, Aramco discovered that its ideal petrochemicals partner was the company next door. Literally, in many cases. "The synergies are immense. We have plants that are separated by a fence," said Aramco board member Al-Dabbagh. In such cases, Aramco is often the primary provider of hydrocarbon feedstocks to SABIC.

"So, there are a lot of cost savings. We have the same DNA, the same culture; we and SABIC are from the same country. Our employees are cousins, friends, brothers, and sisters. The synergistic journey is going to be much easier, with greater value added across the value chain for both entities, than had we bought a large petrochemical company in the Netherlands, in the U.S., or a company in Singapore or wherever," Al-Dabbagh said.

In March 2019, after months of negotiations, the two parties announced that Aramco would buy 70% of SABIC's shares from PIF for $69.1 billion. Aramco agreed it would not purchase the balance of the company's outstanding shares, which are publicly traded. The 70% stake gave Aramco the controlling interest in a major international chemical company, something it had been seeking for years as it considered merger options in the field. The transaction closed in June 2020. With its group of joint ventures and affiliates, the Saudi Aramco group of companies ranks among the top two or three global petrochemical producers, running nearly neck and neck for global leadership in the production of widely used ethylene, for instance.

PREPARING FOR OUTSIDE INVESTORS

As the preparations for public ownership gathered momentum, Aramco converted to a joint stock company in 2018 and began issuing periodic financial results to comply with capital market requirements. The results were prepared as if the company were already publicly held. And while the government as majority shareholder eventually decided to have the initial stock listing solely in Saudi Arabia, Aramco prepared for the possibility of listing its stock on major global exchanges, including in New York, London, and elsewhere.

Beginning with the first public announcement of a looming Initial Public Offering of stock, Aramco became a center of attention for much of the financial world. Analysts tried to anticipate the impact on global energy markets, while top financial institutions visited Dhahran to try to get an inside look at how Aramco operated.

Fergus I. MacLeod, former head of investor relations and later strategy and planning for BP, was hired in May 2017

Promoting micro-industries

While known for its massive, gleaming mega-projects, Aramco in recent years has also helped build micro-industries in its continuing effort to help diversify the Saudi economy and provide jobs outside of the hydrocarbon industry.

The al-Baha region in southwestern Saudi Arabia has a long tradition of beekeeping and honey production in its valleys. It's not alone. A recent study determined that "beekeeping is one of the most important economic activities for rural communities in Saudi Arabia, where approximately 5,000 beekeepers maintain more than 1 million honeybee colonies and produce approximately 9,000 tons of honey annually." Aramco is working with beekeeping cooperatives in al-Baha to modernize production methods and increase yields.

Aramco is working with 550 growers in the Jazan region to expand the domestic coffee industry.

In the rugged Jazan region, also in the country's southwest, coffee has been grown for centuries. Aramco is working with more than 550 coffee growers in the Jazan mountains to provide tools, education in cultivation techniques, and coffee seedlings for planting. The company's efforts also align with Saudi government support for expanding the domestic coffee industry, and the recent creation of the Saudi Coffee Company, owned by the Kingdom's Public Investment Fund, to provide marketing and other approaches to distributing coffee grown in the region.

Near Yanbu' and Baysh on the Red Sea, the company is working with government ministries to support fishermen with advanced methodologies and equipment. In the al-Jouf area of northern Saudi Arabia, Aramco is working with a charity to improve the regional olive oil industry by planting more than 2 million olive tree seedlings and providing other horticultural support. And in Dammam, over 45 hearing-impaired women are being trained in sewing to enable them to provide additional family income by manufacturing medical supplies and uniforms.

Beekeepers in al-Baha benefit from Aramco's scientific, technical and business support to increase yields.

Fishermen along the Red Sea receive support from an initiative backed by Aramco and the Saudi government.

as vice president of Investor Relations for Aramco to help the company prepare for public ownership. He noted that even though the company had never been publicly owned, it had a long history of issuing quarterly results to the consortium of American oil companies, the shareholders that controlled Aramco for decades prior to its conversion to 100% Saudi ownership in the 1980s. As the company subsequently reported to the government as its shareholder, it did so in a transparent fashion that was not materially different from the way it would have reported results to public shareholders. That made the transition to public ownership somewhat easier, at least in terms of sharing financial information publicly.

Nasser said: "We have been operating and functioning like we were a listed company prior to the IPO. Yes, we had one shareholder, but our reporting on financials and the business were similar to a publicly listed entity."

A hurdle in terms of transparency and public reporting for the Aramco team was making comparisons with the competition. The typical response in any industry is to compare one company with another industry leader. But to compare Aramco to any other leading international oil company is, in some ways, comparing a giant to a dwarf.

Aramco came up with a meaningful comparison in preparation for the IPO. It didn't compare itself to any one major international oil company. It compared itself to a combination of the five leading major international oil companies plus Norway's state-owned Equinor. As a group, their oil production is nearly equal to Aramco. Their combined reserves? Less than a fifth of those under Aramco's control.

In 2018 Aramco made $111.1 billion in profits. In the lead-up to the IPO, Moody's Investors Service compared Aramco on a stand-alone basis to an AAA-rated corporation. The professional investment world was impressed. "There's no debating how strong of an entity this is when looking at its assets and cash flow generation," said Bob Summers, an investment grade portfolio manager at Neuberger Berman in Chicago.

The figures released to the public in the run-up to the IPO put a certain swagger in the step of more than a few Aramco employees, even those more accustomed to reading 3D reservoir maps than balance sheets. Al-Tahini said: "Now when you say, 'I'm from Saudi Arabia; I'm working for Saudi Aramco,' people say, 'Wow.' Because they have seen, and they have witnessed the strength of the company in all the numbers."

In 2022, Aramco reported a record net income of $161.1 billion.

RAPID RECOVERY

Amin H. Nasser knows it is a bad habit, but after spending a career rising through Aramco operations, the president and CEO still sleeps with his cell phone next to his bed. When the phone rings and it's dark outside, he knows the news isn't going to be good. That was certainly the

Within seven hours of the attack on the Abqaiq processing plant, the resulting fires had been extinguished.

case in the early morning hours of Sept. 14, 2019.

The curt message from a senior team member just after 4 a.m. said there had been an attack on the company's massive Eastern Province processing and production facilities at Abqaiq and Khurais. Nasser put on trousers, shoes, and a shirt, and hurried out the door into the darkness. Within seven minutes he was in Aramco's Operations Coordination Center in the Tower Building of the company's Dhahran global headquarters. Wall-to-wall monitors carried images of fires raging at the facilities. It was clear from the near simultaneous explosions and fires in specific facilities that this was an attack, not a process fire resulting from human error or equipment failure during the processing of oil or natural gas.

The first question in any such crisis is, are all employees accounted for? Amazingly, given the scope of the damage and the surprise nature of the attacks, no injuries or fatalities were reported at either facility. It helped that a smaller number of staff was on-site at such an early hour.

Though few in number, the crews on duty that morning performed heroically, tapping into years of safety and crisis management training to avert an even worse disaster from occurring. They did so by taking the initiative, thinking on their feet, and not waiting for direction from the leadership team assembling with Nasser in the Operations Coordination Center. In the minutes it took Nasser to reach the control room, the team leaders on-site had already isolated the facilities from the rest of the network of production and processing facilities to ensure the damage wouldn't

Oil Train-4 at Khurais was the most severely damaged. From 3:31 until 3:48 a.m., the Kingdom's second biggest oil field, Khurais, had projectiles aimed at its producing facility, igniting quickly contained fires and scattering shrapnel across piping infrastructure where roughly 200 workers were inside — most carrying out routine maintenance work.-

spread, and that the fires weren't being fed with oil or gas being piped into the plants.

Nasser's message to the teams on the ground: "The attackers want to test us. They want to break us, and disrupt everything we do. And they will keep trying, they will never stop. But our resilience — our team spirit — is something no attack or anyone can hurt or destroy. If we are together, we can face any challenge coming at us."

SUPER DUMP

One of the most important steps taken to mitigate the severity of the terrorist attack on the huge Abqaiq facility, which processes roughly 5% of the world's crude oil production, actually occurred a few weeks before the attacks. That's when the local manager and his team decided to allocate funds to rehabilitate and maintain a safety system that had never been activated in the more than a half century since it had been constructed. It may have been the most consequential decision any of them will ever make.

Known as the super dump, the safety system is a gigantic catchment facility built and lined to hold massive amounts of crude oil released from the storage tank farm on-site in case of just such a catastrophic event. It is unique to Abqaiq — newer, smaller processing facilities have different safety systems in place, and other systems have been added over the years at Abqaiq as well. Did the team really need to allocate funds to maintain it, they asked themselves?

They decided to spend the money, and they did so without asking their superiors back in Dhahran. Nasser applauded the long-time safety culture in place at Aramco for empowering the local team and informing their decision making.

The manager had made the decision to keep the super dump, and the team on-site that morning made the decision to activate it for the first time ever. By so doing, they drained massive amounts of fuel away from the fires, enabling the fire brigades — which were on the scene within minutes after the attacks — to extinguish the flames within seven hours. Had they not done so, it is possible that some, if not much, of the oil stored in the tank farm could have ignited and fed the fires for days, if not longer.

IKTVA SPEEDS RECOVERY

While the damage could have been worse, the attacks did take a tremendous toll, at least temporarily, on Aramco's ability to serve as the leading supplier of energy to the world. "The synchronized attacks were timed to create maximum damage," Nasser said. Extensive damage caused by the missile volleys temporarily slashed the company's crude oil output by 5.7 million bpd, or roughly 54%. For any other oil company in any other location, repairing such damage and restoring production would take months, if not years. Aramco is not any other oil company.

Downstream president Mohammed Y. Al Qahtani was senior vice president of Upstream at the time of the attack and was on-site in Abqaiq before noon. He didn't have to frantically call steel fabricators in South Korea or elsewhere in Asia or Europe to start the process of making plans and ordering materials to repair the facilities. He was already meeting face to face with suppliers and contractors who had built their businesses in the Kingdom thanks to the iktva program.

"Because of iktva, within 24 hours, 2,000 contractors were on-site delivering products, and plants were delivering spare materials. We activated all our network here in the Kingdom to start manufacturing, and within 48 hours, Abqaiq and Khurais facilities started production, and within 11 days reached their pre-attack levels," Al Qahtani said.

Khaled A. Al-Buraik, vice president of Southern Area Oil Operations, said steel for stabilization columns hit in Abqaiq was fabricated in al-Khobar near the Dhahran headquarters, and reboilers that reheat crude oil to remove the associated gas, which were damaged at Khurais, were repaired in Dammam, adjacent to al-Khobar. All of the steel patches for the damaged spheroids were profiled and curved in Jubail, 150 kilometers north of Abqaiq. Al-Buraik noted that the attitude of contractors was: Let's do what it takes; we'll work out the contract terms later.

The terrorist attacks demonstrated that the iktva ecosystem works and that it delivers tremendous value for Aramco and for Saudi Arabia in developing ever closer ties between the company and its network of local suppliers, according to Al-Buraik. "One of the contractors came to provide hands-on support. Despite the fact he is a successful business owner, he came and stayed for 10 days, working in his own safety shoes and hard hat here, finding accommodations in Abqaiq and even sleeping here," Al-Buraik said. "Although there was no time to put a contract in place due to the immediate nature of the emergency, he brought in a crew of about 4,000 workers to begin work immediately, even installing an air-conditioned tent to provide meals for his team on the site."

Thanks to the all-hands-on-deck response from the suppliers participating in the iktva program, the company was able to return production back to the pre-attack levels faster than even Nasser had expected. After speaking with his leadership team, Nasser went on television the day after the attacks and predicted they could bring back the lost production in three weeks. That may have sounded ambitious to many global viewers who had seen televised images of the flames pouring from oil facilities that appeared to be in the middle of nowhere. It turned out to be a conservative estimate. Oil production resumed at a capacity of 2 million bpd within 48 hours and to 6 million bpd within 10 days.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With advanced capabilities, extensive access to information and a people-centric environment, Aramco's 4IR Center is a digital transformation ecosystem for solutions throughout the hydrocarbon value chain.

The attacks on Abqaiq and Khurais would have garnered worldwide attention at any time given Aramco's position as one of the world's largest oil producers. They attracted particular, sustained attention in mid-September 2019 in light of the fact that they occurred in the midst of Aramco's final months of preparations for its IPO. The momentous offering, the largest in history at the time, may have had scant impact on the day-to-day operations of Aramco, but it did have the effect of putting nearly every aspect of the company under sustained scrutiny and very much in the public eye.

FIRST BOND OFFERING

Even as it was preparing for the stock offering, Aramco decided to take advantage of indications of investor interest and favorable conditions in the bond market in the spring of 2019 to raise funds through its first ever offering of fixed income securities. Previously, the government had sold bonds to raise funds as needed to finance oil industry or other projects. Much of the information that had been compiled for the stock IPO was quickly repackaged for potential bond investors. From that point of view, company insiders viewed the bond offering as an indicator of investor interest in the proposed stock offering, the timing of which was still uncertain.

If demand for the bond offering was any indication, they would not have trouble selling stock in Aramco. Investors swamped the underwriters of the bonds with offers to buy more than $100 billion worth of Aramco debt. Only $12 billion was offered.

Aramco board member Al-Dabbagh noted, "We sold bonds up to 30 years. And it was probably the most oversubscribed tranche. Thirty years from now — what does that mean? It means the investors trust us enough to have their money with us for 30 years, which is a very strong confidence message."

The overwhelming demand enabled the company to sell bonds at a lower interest rate than expected, saving Aramco millions in future interest payments. Buoyed by the success of the April 2019 bond offering and to indicate that it was prepared for the IPO, Aramco delivered a live presentation to securities analysts and potential global investors to discuss its results for the first six months of 2019.

GOING PUBLIC

With oil production restored less than two weeks after the September 2019 attacks on Abqaiq and Khurais, Aramco officials had a chance to catch their breath and catch up on what was going on in the rest of the world. Many fully expected that investor demand for Aramco shares, red-hot on the heels of the oversubscribed bond offering that spring, would cool for the rest of that fall and winter, if not longer. They were happy to discover how wrong they were.

Initial skepticism in some financial capitals that the reporting about oil production being restored was accurate quickly gave way to admiration for the company's ability to pull off such a rapid recovery. And on the geopolitical front, the apparent attempt to damage the reputation of Aramco and the Kingdom had backfired. Worries potential investors may have had about investing in a company headquartered in such a volatile region were largely quelled by the bravura performance of the Aramco workforce and the network of local and regional contractors.

Employees at Riyadh Refinery, shown here, as well as at Aramco facilities in-Kingdom and internationally, celebrated the IPO.

"The attacks were intended to cripple and hurt our production and to destroy our reputation for reliability," Nasser said. "But the opposite happened. No shipment to any of our customers was impacted after the attacks took place."

The timing of the IPO was in the hands of the Saudi government. In November 2019, the Saudi government decided the time was right and went forward with the offering the following month on Tadāwul, the Saudi Stock Exchange. The December 2019 IPO ranked as the largest ever offering of public stock in dollar terms, bringing in $29.4 billion for shares representing 1.5% of the company. The value of the company in subsequent trading exceeded the $2 trillion target originally set by the Crown Prince, and for several months in 2020, Aramco was the world's most valuable company in terms of market capitalization.

In many ways, the IPO was a watershed event in the history of the company and country, akin to the signing of the original concession agreement in 1933 and Saudi Arabia's assumption of full ownership of the oil company in 1980.

The company's excellent standing with international investment markets was reinforced again in early 2021 when it received record demand on the London Stock Exchange for its offering of *sukuk* bonds, which are compliant with Islamic principles. The demand surpassed a whopping $60 billion. Al-Dabbagh, who was still senior vice president of Finance, Strategy and Development at the time, said: "Aramco has become the darling of the financial markets, achieving yet another record demand for its debt and equity issuances. The overwhelming record demand for our 50-year bonds is another testament to the trust and confidence that the world's most sophisticated and demanding investors have in the company and the country at large."

Executive vice president of Technology and Innovation Ahmad O. Al-Khowaiter discusses the company's efforts to create and sustain a circular carbon economy.

CLIMATE CHANGE AND ENERGY TRANSITION

When Amin H. Nasser took over as president and CEO, he elevated and centered Aramco's focus on the environment. He and his team led the company to shift its way of thinking about environmental impact away from one largely of compliance with, for example, rules limiting emissions.

"Climate change is the single most important priority that needs to be addressed to ensure that we are going to be sustainable as an industry over the long term," Nasser said.

Yasser M. Mufti said the company's technology organization is "at the forefront of our climate strategy, which is really interesting if you think about it. It gives sense and purpose for what we're doing."

For Nasser, the climate challenge required a comprehensive plan for an energy transition, and putting the energy industry at the center of finding sustainable solutions. "All energy resources will be needed to support a successful transition, " Nasser said at CERAWeek 2022, the world premier energy conference.

Nasser added, "We need to provide the energy — affordable, reliable, and sustainable energy that the world needs .... The focus on technology, the right investments, be it to reduce CO_2 or methane, or making products such as nonmetallic materials, are critical. And our efforts require that it's not only that the strategy is centered on climate but that each person in the company recognizes that and works toward this critical mission."

The process of preparing for the IPO also brought Aramco's ongoing efforts to support sustainability and respond to climate change into sharper focus on the international stage. Just as it had audited its hydrocarbon reserves, Aramco brought in independent outside experts to gauge its impact on the environment in several key measures, particularly its carbon dioxide and methane emissions.

The third-party results matched the previous, unpublished work of Aramco's own researchers. Nasser wasn't surprised, but he was proud of the results. "That's a testament to the quality of the people who are working in these areas to raise our environmental performance .... To be sure, in addition to our own measurements, metrics, and audits, we bring in different independent experts and auditors, and if their assessment matches ours, that is a testament that our people are doing the right thing and also applying the appropriate methodologies."

One of the key findings of the sustainability audit and related research published in 2018 was that Saudi Arabia ranks second lowest among the top 50 oil-producing countries analyzed in the amount of carbon dioxide produced per barrel of oil equivalent produced. That highly favorable finding wasn't simply a result of the Kingdom's good fortune in having some of the best producing oil reservoirs on the planet, said Aqil Jamal, director of Carbon Management. "It is a very deliberate, thoughtful use of resources and technology," he said.

To control emissions aboveground, "You need to first start with the subsurface, or below the ground," Nasser explained. The more water brought to the surface with every barrel of oil, the more energy you need to push that fluid to the surface. And once it's on the surface and has to be reinjected in the reservoir, which is standard practice at Aramco, still more energy is required. For decades, the company has been investing in an array of technologies and modeling software — from geosteering of drill bits to models that accurately predict 10 to

20 years out the inflow of water in a well based on its exact location — to reduce its cost and carbon production. "It's an expensive proposition up front, but it more than pays for itself in reduced long-term costs over decades and has a lower environmental impact," Nasser added.

CIRCULAR CARBON ECONOMY

An emerging area of interest for Aramco is to create and sustain a circular carbon economy through carbon capture, utilization, and storage (CCUS) technologies. Launched by the Saudi Ministry of Energy at the 2019 Future Investment Initiative in Riyadh, the circular carbon economy takes a page from environmental playbooks used around the world for decades: Reduce, Reuse, Recycle, and Remove. Aramco updates that playbook with the latest IR 4.0 technologies such as machine learning and massive applications of computing power to speed and expand its sustainability impact.

The circular carbon economy approach to reducing emissions adopted by Aramco was also endorsed by the G20 Energy Ministers at their September 2020 meeting, which was hosted by the Saudi government in Riyadh.

Aramco also is a founding member of the Oil and Gas Climate Initiative (OGCI), a global energy industry group created in 2014 to research and implement efforts to offset the industry's impact on climate change. Since its founding, the group has set increasingly aggressive targets to reduce climate warming emissions. In March 2022, OGCI announced "near zero" methane emission targets by 2030, and remained committed to its plans to cut upstream methane emissions intensity to well below 0.20% by 2025, a reduction of roughly 25% since 2017. It also said its goal is to reduce carbon intensity from upstream operations to 20 kg of CO_2e (carbon dioxide equivalent) per barrel of oil equivalent by 2025 and to end routine flaring by 2030. Aramco reported its 2022 upstream carbon intensity at 10.3 kg CO_2 per boe, already well under OGCI's target.

Carbon dioxide is captured at Aramco's Hawiyah NGL Plant, shown here, compressed, and piped to the 'Uthmaniyah oil field where it is injected into the oil reservoir, sequestering the gas while also helping maintain pressure in the reservoir to recover more oil.

Aramco's 2050 ambition

The myriad ways in which Aramco is working to reduce carbon emissions across its businesses align in support of the company's climate ambition announced by president and CEO Amin H. Nasser in the fall of 2021. The company will strive to achieve net-zero Scope 1 and Scope 2 greenhouse gas emissions from its wholly owned and operated assets by 2050.

Aramco's inaugural Sustainability Report, issued in 2022, outlined the company's roadmap to achieving its net zero emissions goal by capturing, utilizing, or storing CO_2; investing in renewables; reducing or mitigating CO_2 equivalent; further reducing upstream carbon intensity; and producing blue ammonia as a carrier for hydrogen.

The King Abdullah Petroleum Studies and Research Center (KAPSARC) in Riyadh was built by Aramco and opened in 2017.

Speaking at the Green Initiatives conference hosted by Saudi Arabia in advance of the United Nations COP26 Climate Conference in Glasgow, Nasser said the company would work toward this ambition while also continuing with plans to boost maximum sustained production to 13 million bpd from 12 million. The Kingdom, building upon initiatives underway in support of Vision 2030, announced that it would drive its carbon emissions to net zero by 2060.

Working to help support these environmental goals is KAPSARC, the King Abdullah Petroleum Studies and Research Center, which was built by Aramco and opened to the public in 2017 in a gleaming futuristic building designed by architect Zaha Hadid. In collaboration with researchers around the world, the independent nonprofit center in Riyadh develops policies for the efficient and environmentally sensitive use of energy.

To track future incremental advances made in support of sustainability goals, KAPSARC unveiled a Circular Carbon Economy Index at the Glasgow conference. The index uses common metrics to rank countries' carbon management performance.

In 2015, Aramco began injecting some of the CO_2 from its operations into a number of reservoirs, to sequester that CO_2 and keep it out of the atmosphere. The pilot program at the Hawiyah Gas Plant captures 40 million scfd of CO_2. The CO_2 is piped 85 kilometers to the 'Uthmaniyah field and injected into the oil reservoir. The company then sequesters the CO_2 underground, and in the process, helps maintain reservoir pressures and drive enhanced oil recovery (EOR). The award-winning pilot program sequestered almost 63% of the injected CO_2 in the ground, said Al-Tahini.

"The world faces a dual challenge: meeting growing energy demand and reducing greenhouse gas emissions," Nasser said. "We are leveraging IR 4.0 technology solutions to work on the 'four R's of reduce, reuse, recycle, and remove' as part of our climate and sustainability efforts. High-impact technological solutions, such as CCUS, can address this dual challenge while contributing to economic development and energy security."

While the company has been capturing associated natural gas during oil production and pumping it into the nation's MGS since the 1970s, it has also been an industry leader in reducing the flaring of methane, a potent greenhouse gas and the largest component of natural gas, into the atmosphere. Flaring of some associated natural gas for safety reasons has been a feature of oil production since the industry's infancy. Aramco, while flaring less gas than many competitors, adopted a flaring minimization program in 2008 to further reduce its methane emissions.

As of mid-2020, the company was flaring less than 1% of its raw gas production and was headed toward fulfilling the commitment it made in August 2019 when it signed on to the World Bank's Zero Routine Flaring by 2030 initiative. Part of the program involves sharing best practices among industry participants with the goal of driving global natural gas flaring to zero.

Aramco's research into using hydrogen as a transportation fuel has led to the opening of the Kingdom's first hydrogen filling station.

HYDROGEN POWER

Hydrocarbon research involving separating hydrogen from CO_2, capturing the CO_2, and using the hydrogen as fuel is opening up research on several long-term sustainable energy solutions. "One of the highlights of my career with Saudi Aramco was the establishment of the Kingdom's first hydrogen filling station in 2019 at the Dhahran Techno Valley (DTV) in partnership with Air Products," said Aqil Jamal.

"Currently, we are procuring hydrogen from Jubail from a production facility run by Air Products and bringing the hydrogen by tube trailers, which is then compressed for dispensing at the DTV station," Jamal said. "But in the future, we are working with our partners to convert hydrocarbons on-site to hydrogen and capture the associated CO_2 for sequestration or reuse. The objective is to give the customer an experience similar to a conventional gasoline station," he added.

Scientists at Aramco's Detroit Research Center are working to advance sustainable transport by developing ultra-clean fuel engine systems.

The first shipment of blue ammonia, used to generate power using hydrogen, embarks for Japan.

Aramco made hydrogen harnessing history in September 2020 with the first-ever shipment of blue ammonia to Japan. The high-grade ammonia was used to generate power using hydrogen. Forty tons of ammonia, which consists of three parts hydrogen and one part nitrogen, were shipped to Japan. Thirty tons of CO_2 that was a byproduct of the ammonia production were captured and earmarked for methanol production at a SABIC facility in Jubail. An additional 20 tons of CO_2 were injected into the 'Uthmaniyah field to stimulate EOR. In addition, Aramco and the SABIC Agri-Nutrients Company (SABIC AN) received the world's first independent certifications recognizing "blue" hydrogen and ammonia production. The certifications were granted by TÜV Rheinland, a leading independent testing, inspection, and certification agency based in Germany.

Technology and Innovation executive vice president Ahmad O. Al-Khowaiter said, "This world's first demonstration represents an exciting opportunity for Aramco to showcase the potential of hydrocarbons as a reliable and affordable source of hydrogen and ammonia production."

LOW CARBON COMPETITION

Aramco researchers take a holistic approach to the circular carbon economy. Don't run away from carbon, Jamal says; leverage the company's hydrocarbon know-how and its network of top research talent to prosper in a very different future. "We are saying that, as a major oil and gas company, we could leverage our existing infrastructure and capabilities to create tomorrow's low carbon economy and achieve our net-zero targets."

Continuing their research halfway around the world, Aramco scientists in Dhahran teamed up with scientists in the company's South Korean research center to push another form of emerging CO_2 technology, known as dry reforming. Here, waste CO_2 gas reacts with methane and creates a syngas, or synthetic gas, which could eventually be converted into olefins. Earlier efforts in this vein by

other research teams had produced coke, which damaged the catalyst used. The Aramco team developed a catalyst that is coke resistant. The work was considered so significant that it was published in the Feb. 14, 2020, issue of *Science* magazine.

Closer to home, scientists on Jamal's team worked with professor Mohamed Eddaoudi at KAUST, home to another company research center. They developed metal-organic frameworks that selectively capture CO_2 right out of the air. Working with a Canadian company, Svante, they hope to one day scale this direct air capture technology from the lab to real-world applications and to demonstrate their ability to capture one ton of CO_2 a day at a cost competitive to other existing technologies.

CONCRETE RESULTS

In another early-stage collaborative project with researchers at the KAUST center as well as initially in South Korea, the Dhahran team is demonstrating they can store CO_2 in precast concrete at a rate of up to 20% of the weight of the precast slab. Not only that, the addition of the CO_2 reduces curing time substantially and enhances the structural strength of the concrete. Aramco is working with a precast manufacturer in the Dammam area to produce the concrete, which Jamal believes could meet Aramco's engineering standards and therefore, be used across the company in construction projects.

Not all CCUS technologies originate in-house at Aramco, even though the company's research network spans the globe. Launched in 2012, Saudi Aramco Energy Ventures (SAEV) is a corporate venture capital program that invests in technologies with strategic value to Aramco with an emphasis on sustainable solutions. Technologies invested in by SAEV have ranged from the manufacturing of hydrogen fuel cells faster and more economically using 3D printing to optimizing shipping performance using artificial intelligence.

Acquisitions are integral to the company's sustainability strategy, said Abdulaziz M. Al-Gudaimi, who retired in 2023 as executive vice president of Corporate Development. "One of the cornerstones of the strategy itself, instead of building technology from scratch — which is time-consuming — is to go after acquisitions, and enhance our strategy on lowering carbon intensity and carbon emission management."

Jamal worked in the private sector as well as at the U.S. Department of Energy prior to joining the company and has never been happier than working at Aramco. He knows there are significant technological challenges ahead, but he is an optimist when it comes to Aramco and the Kingdom prevailing in a low carbon future.

"I see a very bright future for the Kingdom. When I will be sitting and talking to my grandchildren or great-grandchildren, I see them talking about Saudi Aramco as still a major energy supplier — one of the examples to the world, in terms of how it used its resources effectively and how remarkably well it paved the way to meeting the world's energy demand in the most environmentally sustainable way."

In October 2021, at the Saudi Green Initiative forum in Riyadh, Saudi Aramco made another major step in its commitment to operating more sustainably, announcing the ambition to be a net zero Scope 1 and Scope 2 greenhouse gas emitter across its wholly owned and operated assets by 2050. This means that Aramco will not only reduce emissions that come from its own production and refining facilities (Scope 1), but also work to reduce indirect emissions from customers and partners who purchase hydrocarbons to produce electrical power and steam (Scope 2).

Introducing the ambition, Nasser said: "As the largest provider of energy to the world, Aramco's ambition to reach net zero greenhouse gas emissions across our operations in less than three decades is a historic step forward that will help tackle the most pressing challenge facing humanity. Our past success has not been measured by quarters or business cycles, but across generations. The same will apply to the positive results from our net zero ambition, as the actions we take in the coming years will help safeguard our planet for future generations.

"The road ahead will be complex, as the world's transition to a more sustainable energy future will require collective action and major technological breakthroughs. But we remain focused on delivering reliable and affordable energy, investing for the long term as our efforts to further reduce emissions gain momentum."

A Burst of brand energy

Until 1946, the predecessors of Saudi Aramco, first known as Casoc, operated under the concessionaire's corporate identity and therefore lacked a distinctive, individual logo. All that changed with the announcement in the June 2, 1946, issue of the company newspaper the *Arabian Sun and Flare* of a contest to design the first Aramco logo. By the end of the month, at least 110 responses had been received. Harry Flackmeier's double-A design, left, highlighted the company's name, Arabian American Oil Company, and served as the company's official trademark for the next 40 years.

In November 1988, with the creation of Saudi Aramco, a new logo was needed. Once again, the call went out within the company, and in June 1989, the board of directors endorsed the design created by company graphic artist Abdulaziz Al-Ridhwan. The logo and Saudi Aramco's branding was updated in 2001, with the transition to a more dynamic and colorful "energy burst" graphic.

As the company followed through on its bold ATP ambition to become the world's leading global energy and petrochemicals company, Saudi Aramco launched a complete overhaul of its brand strategy in 2013. Over the next few years the company developed what it coined the two "faces" of the corporate brand: Saudi Aramco, the institutional face, and Aramco, the market, or global, face used to interact with customers.

أرامكو السعودية
saudi aramco

Aramco's sponsorship of Formula 1 racing is seen as a platform for telling its story about how it is attempting to change transportation fuels.

aramco

The evolution of the global Aramco brand took a major step beginning in 2019 and 2020, respectively, with the sponsorship of Formula 1 racing and international women's professional golf events, the Aramco Team Series.

"Securing a Formula 1 sponsorship has just been transformational for the company's brand," said Kirk Collingwood, director of Communication Strategy. "Millions of people around the globe are being introduced to our business for the first time, but it's more than just visibility. It's a platform for meaningful stories that we're telling about sustainable fuel use, about lightweight materials, and all the technology solutions we enable to shape the future of transport."

The Aramco brand also debuted in-Kingdom with the opening of the company's first branded gas stations in 2021. The stations include the Aramco brand name and the letter "a" in the shape of a drop of oil that is a key aspect of the graphic representation of the brand at the retail level.

Aramco opened its first branded gas station in the Kingdom in 2021.

Speaking at the Green Initiatives conference hosted by Saudi Arabia in 2021, Aramco president and CEO Amin Nasser announced the company's ambition to achieve net-zero Scope 1 and Scope 2 greenhouse gas emissions from its wholly owned and operated assets by 2050.

CLIMATE + BUSINESS SUSTAINABILITY

The goal of boosting sustainability and addressing climate change aligns with a key aspect of Aramco's long-term strategy. Company research has indicated for years that global rate of growth for petrochemicals was going to outstrip the rate of growth for crude oil as well as the rate of growth in GDP for most developed countries. "As we look at the incremental demand for crude oil over the next two decades, 50% of that demand is expected to come from the petrochemicals sector," said Nasser. "We want to realize some value from that."

The company's goals of promoting sustainability and meeting future demand for petrochemicals have driven continued investment in what's known as liquids to chemicals (LTC) technology. Although not yet commercially viable, this process technology enables the bypass of conventional refining to convert crude oil directly into petrochemicals, producing far fewer greenhouse gases in the process. Current technologies enable the conversion of roughly 40% of a barrel of crude oil directly into chemicals. Aramco's goal is to further improve thermal and catalytic cracking of crude oil molecules to reach a conversion rate of 70% to 80% of a barrel of oil directly into petrochemicals.

When it comes to climate sustainability and economic sustainability, "We don't draw a distinction," said Al-Khowaiter. "I think sustainability is more than just environment. It's really economic sustainability. We need to look at global economic systems as well as corporate sustainability. We tie the two," he said. "Crude to chemicals can become a significant part of that effort, as well as the many forms of carbon capture the company is pursuing. We believe a good environment is good business."

The company's initial steps in developing its petrochemical business organically by building a series of complexes across the country — including Petro Rabigh, SATORP, YASREF, and Sadara — advanced the company's capabilities and its petrochemical and refining capacity. Adding to that capacity, in 2018, Aramco and Total signed an agreement to build a jointly owned $5 billion world-class petrochemicals complex and integrate it with the existing SATORP refinery in Jubail, with operations expected to begin in 2024. And in 2019, Aramco consolidated its ownership of the SASREF joint venture in Jubail by purchasing the 50% stake in the venture that had been held by a subsidiary of Royal Dutch Shell.

Early on in the COVID-19 pandemic, the company developed protocols for keeping its workforce safe.

PANDEMIC RESPONSE

The COVID-19 pandemic that spread around the world in the early weeks of 2020 caught Aramco by surprise in certain ways, but far from unprepared. Few companies had more at stake than Aramco. If the pandemic were to seriously disrupt the operations of the world's largest oil company, global economies large and small would feel the effect almost immediately. Starved of energy, nations' health and welfare could be put at risk, not to mention that of Saudi Arabia itself and Aramco employees and their families.

The company's ability to successfully navigate through the unprecedented COVID-19 crisis — offering state-of-the-art health care while maintaining production to meet global needs — underscores the value Aramco's people bring to their work and the company's success every day.

Warning lights were already flashing in-Kingdom. Aramco's health care joint venture, Johns Hopkins Aramco Healthcare (JHAH), had been preparing, in some ways for years, for the possibility of just such a pandemic arriving in the Kingdom. As of late 2019, JHAH doctors and researchers feared it was simply a matter of time before another virus akin to SARS or MERS hit the Kingdom. Determined not to be caught flat-footed, in November 2019, JHAH and Aramco conducted a drill for a simulated flu-like pandemic. A January 2020 symposium on patient health at JHAH raised awareness further among the medical community, as the virus was starting to spread.

The first COVID-19 case in Saudi Arabia, brought back by a traveler, was reported on March 2, and the second, a traveler on the same trip, on March 4. On March 7, Saudi Arabia closed its land and sea borders and halted all domestic air travel in response to the pandemic.

COVID-19 TASK FORCE

Even before that, Aramco had shifted into rapid response mode. On March 5, Nasser formed the COVID-19 Task Force. He named executive vice president of Human Resources and Corporate Services Nabeel A. Al-Jama' to head the task force, reporting directly to the president and CEO. Nasser understood that keeping the pandemic at bay was key to Aramco's ability to maintain its unparalleled record of delivering on its obligations to its customers. "Business continuity is critical, and our operations had to keep going to best serve our customers. We couldn't afford any shutdowns when the supply chain was under pressure."

To centralize its response to the pandemic, Aramco opened its COVID-19 Support Center in Dhahran in March. Thermal testing at all sites was initiated. High-use areas were regularly

Physicians and staff at Johns Hopkins Aramco Healthcare courageously tackled the threat of COVID-head on with innovation and perseverance.

cleaned and disinfected. Face masks and social distancing procedures were implemented. The steps initially taken in Dhahran to combat the spread of the virus were quickly implemented at Aramco sites across the country and around the world.

Well before the Saudi government declared a curfew on March 23 to slow the spread of COVID-19, Aramco drew up plans for as many of its office workers as possible to work from home. Comprising roughly one-third of the company's workforce, the office staff adapted quickly to the new routine.

Initial anxiety about the change felt by some employees dissipated over time. Business system analyst Bashaer O. Bazuhair said that, at first, "I was thinking, 'How is this going to work out? It is going to be strange.'" She adapted to the change, however, appreciating that while she might have felt a bit isolated at times, she managed to avoid being exposed to the virus as cases increased across the Kingdom.

Among front-line workers, a culture of safety and resiliency ingrained in production, processing, and distribution employees served the workforce well as it pivoted to full pandemic preparedness. Social distancing procedures were an added challenge for workers on offshore oil rigs working in close quarters and no longer allowed to socialize in communal spaces before or after their shifts.

The company made sure the onsite operations followed health protocols that were second to none. One mistake resulting in a viral infection could shut down an entire oil production platform. Aramco's workforce understood what was at stake. Many voluntarily turned down breaks that under normal circumstances would have allowed them to return to their homes and spend time with their families. "We didn't ask them to do that; they volunteered," Nasser said, beaming with a deep sense of gratitude.

Citizenship programs

In the wake of Hurricane Harvey in 2017, employees at Aramco Americas volunteered to help the Houston area's oyster industry recover.

Aramco employees raised money and provided manpower to distribute packages of food and other goods to less fortunate Saudis impacted by the pandemic.

Aramco has a long tradition of offering a helping hand in times of need to the communities in which it operates. As the company expanded in the Kingdom in the post-World War II era, that included constructing hospitals and schools and supporting anti-malarial and other efforts to improve local health.

More recently, such efforts in-Kingdom have included strong support for STEM — science, technology, engineering, and math — educational enrichment programs. Likewise, the plethora of offerings from the King Abdulaziz Center for World Culture are designed to meet the educational and related needs of the Saudi population, and with the COVID-19 pandemic, a premium was put on virtual programming.

The company has taken that same approach around the world as it expanded. In the Houston, Texas, area and along the nearby Gulf Coast, where the company has had a presence for nearly 50 years, Aramco has actively joined local relief efforts in the wake of numerous hurricanes.

The global COVID-19 pandemic highlighted Aramco's commitment to serving its communities. From staff members in-Kingdom using their off hours to fill packages with food and other goods for the less fortunate burdened by the pandemic, to offices and employees from China to southeast Asia, India, Europe, and the U.S. donating money and time to health-related and other community support efforts, Aramco demonstrated its commitment to global good citizenship.

The company sponsors STEM enrichment programs for children in the communities in which it operates.

PRODUCTION RECORD

Even as the front-line workforce was still adjusting to the COVID-19 protocols, the company learned on March 9, 2020, that it was to boost production from 9.7 million bpd to 12 million bpd in line with the Kingdom's policy objectives. And it had only three weeks to reach that goal, as opposed to the three months company executives had always assumed they would have for such a dramatic expansion of production.

The all-out effort that followed met the goal of achieving maximum sustainable capacity (MSC) in three weeks, in the process setting a record production level for Aramco. And the company actually exceeded the 12 million bpd request by pulling an additional 300,000 barrels out of inventory. No other oil producer could have come close to matching such a Herculean lift. In three weeks, just the increase in Aramco's daily production exceeded the total daily production of Brazil. In anticipation of possibly even greater demand for Saudi oil in the future, and at the government's direction, Aramco began work on increasing its MSC to 13 million bpd.

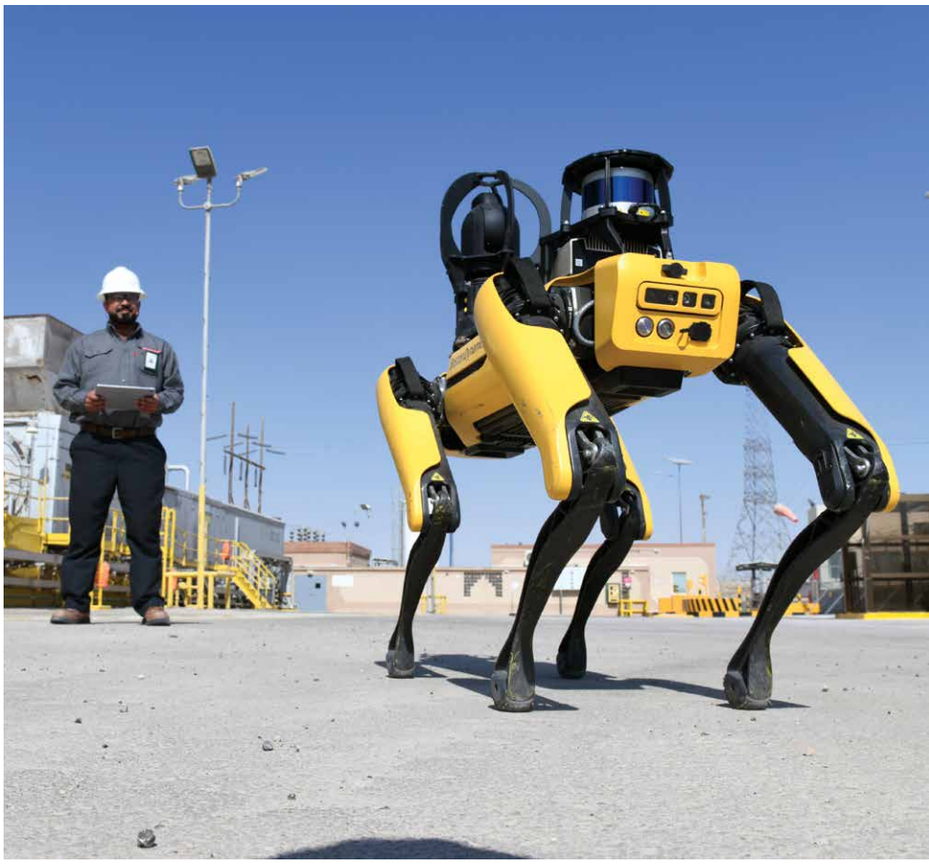
CHARTING THE FUTURE

The worst of the unprecedented crisis passed by the winter of 2020-2021. Pandemic restrictions gradually were eased, and staff began returning to their offices. Workplace distancing, mask wearing, and other strategies remained in place to ensure worker safety.

By the early weeks of 2021, Aramco employees could begin to imagine a "new normal," post-pandemic world. In February 2021, the company opened its initial locations for offering COVID-19 vaccinations in Dhahran, al-Hasa, 'Udhailiyah, Tanajib, Abqaiq, and Ras Tanura. By early 2022, 100% of eligible employees companywide had been vaccinated, excluding those with medical exemptions.

Aramco's culture of innovation and resiliency helped the company navigate through the crisis.

Unwilling to rest on its laurels, the company reviewed its pandemic performance to capture learnings and innovations that it can apply to its operations going forward. Even during the pandemic, the company's financial performance remained solid.



The company's deployment of robotics increased during the COVID-19 pandemic, setting the stage for increased use in the future. In this 2022 photo, FARIS, the inspection robot, watches over equipment at 'Uthmaniyah Water Injection Plant No. 1

The company embraced the accelerated digitization of many functions prompted by the pandemic. Applied technology, including machine learning, was found to increase speed and efficiency across an array of tasks.

In 2023, its 90th year, Aramco is well on its transformative path to becoming a very different company than the one founded after the concession agreement with King Abdulaziz Al Saud, in 1933. Once primarily a traditional oil and gas company, it has made strategic investments to become one of the world's leading energy and chemical companies. Aramco, like many oil companies, once was a major consumer of technologies, but now through its global network of research centers it has become a recognized implementer of cutting-edge IR 4.0 technologies in its operations. At a time of energy transition, Aramco has committed both to continue to produce energy that enables global economic development, as well as to tangible actions in reducing its carbon footprint and finding meaningful climate solutions.

Leadership in sports

In June 2023, Aramco announced that it would purchase the al-Khobar-based Al Qadsiah Sports Club. Aramco viewed the acquisition — which was part of a government plan to encourage private sector investment in sports — as a means of supporting the social impact of sports, including female participation in an expected female soccer league.

Aramco's purchase of Al Qadsiah, the first such acquisition of its kind for the company in Saudi Arabia, came as the company had entered into sponsorship agreements with Formula 1, the Indian Premier League of cricket, and the Aramco Team Series of golf. Investment in sports aligned with a key plank in the Saudi Vision 2030 plan to diversify the Saudi economy and to improve the quality of life and health of the Saudi society through the arts, sports, tourism, and culture.

Aramco's investments in sports are aligned with the Kingdom's Vision 2030 for improving the quality of life, entertainment options, and health for Saudi society. In 2023, Aramco purchased the al-Khobar-based team Al Qadsiah (right). Below, Al Qadsiah fans enjoy a recent match.

Commenting on the Al Qadsiah purchase, Nabeel A. Al Jama', executive vice president of Human Resources and Corporate Affairs, said Aramco's purchase of Al Qadsiah demonstrated the company's commitment to corporate citizenship.

"While preserving the club's legacy, we will seek to develop it and invest in its future success," Al Jama' said. "We are confident that this will contribute to enhancing the sports presence and pushing the club to achieve greater success, enhancing its competitiveness inside and outside the Kingdom."

Al Jama' also mentioned that Aramco has a special relationship with Al Qadsiah. In addition to being Aramco's home team, Al Qadsiah also was the team where Abdallah S. Jum'ah, the president and CEO of Saudi Aramco from 1995 to 2008, was a goalkeeper in 1968.

President and CEO Amin Nasser answers a question from one of the scores of young people who attended a YLAB Town Hall event as moderators Razan Jandali, left, and Ali AlKhatib listen. Nasser shared some of his insights on the company, its future, the company's young employees, and their role in the continuing success of the company and meeting the call of Saudi Vision 2030.

And, as much as digitalization and technology can enhance the company's performance, Aramco continues to focus on its people as its most enduring source of value.

In early 2023, Aramco began a massive restructuring of the company's leadership to align the job titles and roles with the best practices of its industry peers. The goal was to more closely match the job title with the responsibilities of those performing those jobs, with senior vice presidents becoming executive vice presidents, and division heads becoming managers. The increased number of leadership roles was a boon for young high-potential Aramco employees, many of them bringing the skills and energy of a generation raised in a digital age.

Speaking to young employees at a Town Hall meeting arranged by YLAB, Amin Nasser described a bright future built on 90 years of dedication, hard work, and innovation. Nasser said that recent actions – creating a new Technology and Innovation business line, enhancing the Strategy and Corporate Development functions, establishing the new positions of Upstream President and Downstream President, and reorganizing management positions to reflect appropriate job scopes – are all signs of the company's continued transformation to become the world's leading integrated energy and chemicals company.

"The Kingdom is rapidly changing in the context of Vision 2030, and Aramco is a key catalyst for change," Nasser said. "We have an ambitious growth agenda, aimed at meeting the demands of today and laying the foundation for a more sustainable tomorrow. While what has been achieved by Aramco in the last 90 years is very impressive, the plans and visions to grow Aramco in the next 10-20 years are unprecedented."

Working at Aramco is a unique privilege, Nasser added. "There are few companies whose work has the potential to impact nearly everyone on the planet. We are fortunate to have that opportunity."

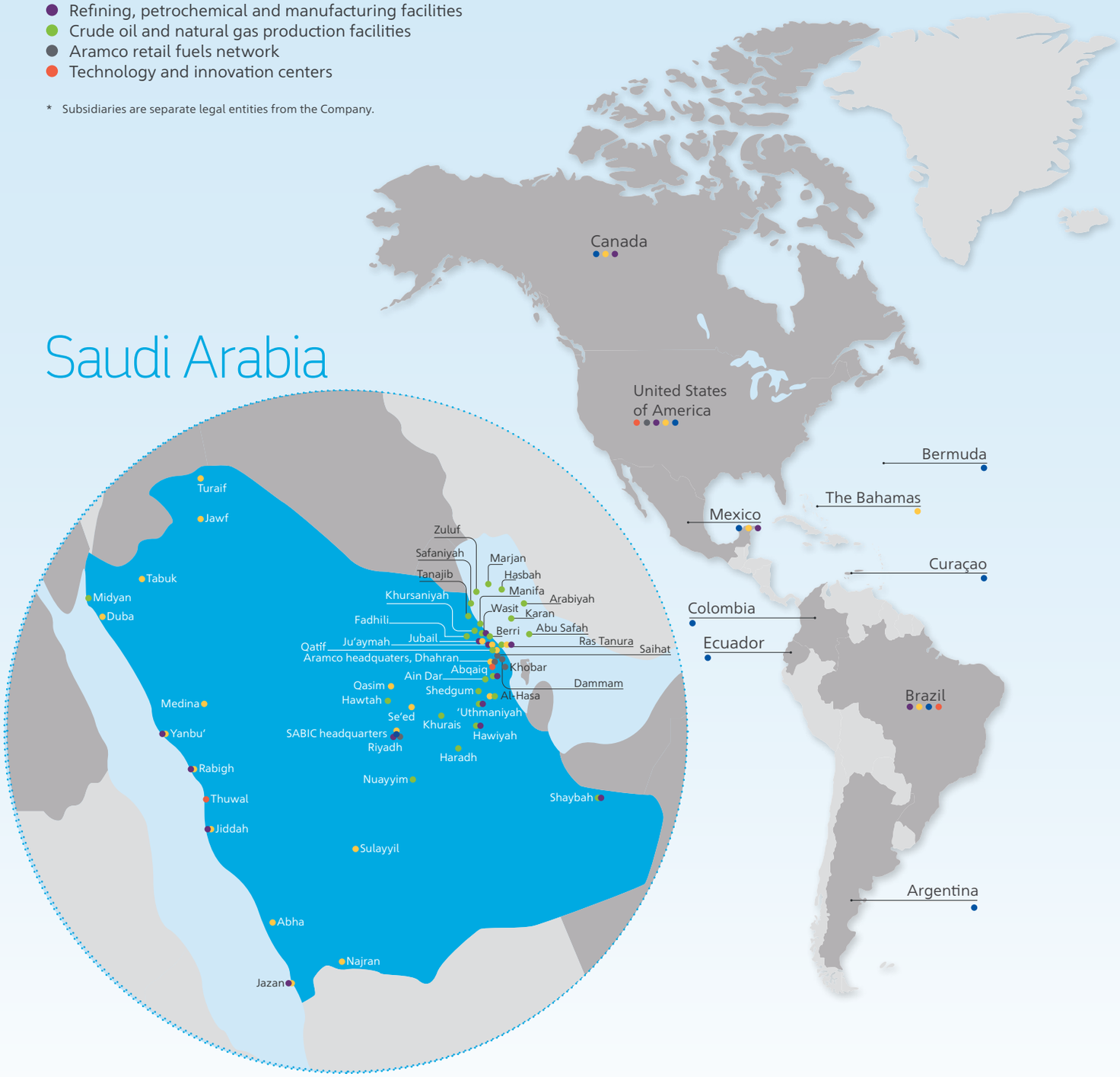
The vision of King Abdulaziz remains central to Saudi Aramco's comprehensive strategy, which plans to ensure success both today and for generations to come. The King's vision, embodied in the original terms of the concession agreement with Socal, has been realized many times over. The growth of Saudi Aramco throughout the Kingdom and its expansion around the world; the improvements in processes and technology that contributed to it; and the global impact of Saudi resources, led by a talented multinational team of Saudis and expatriates, were clearly in alignment with his vision.

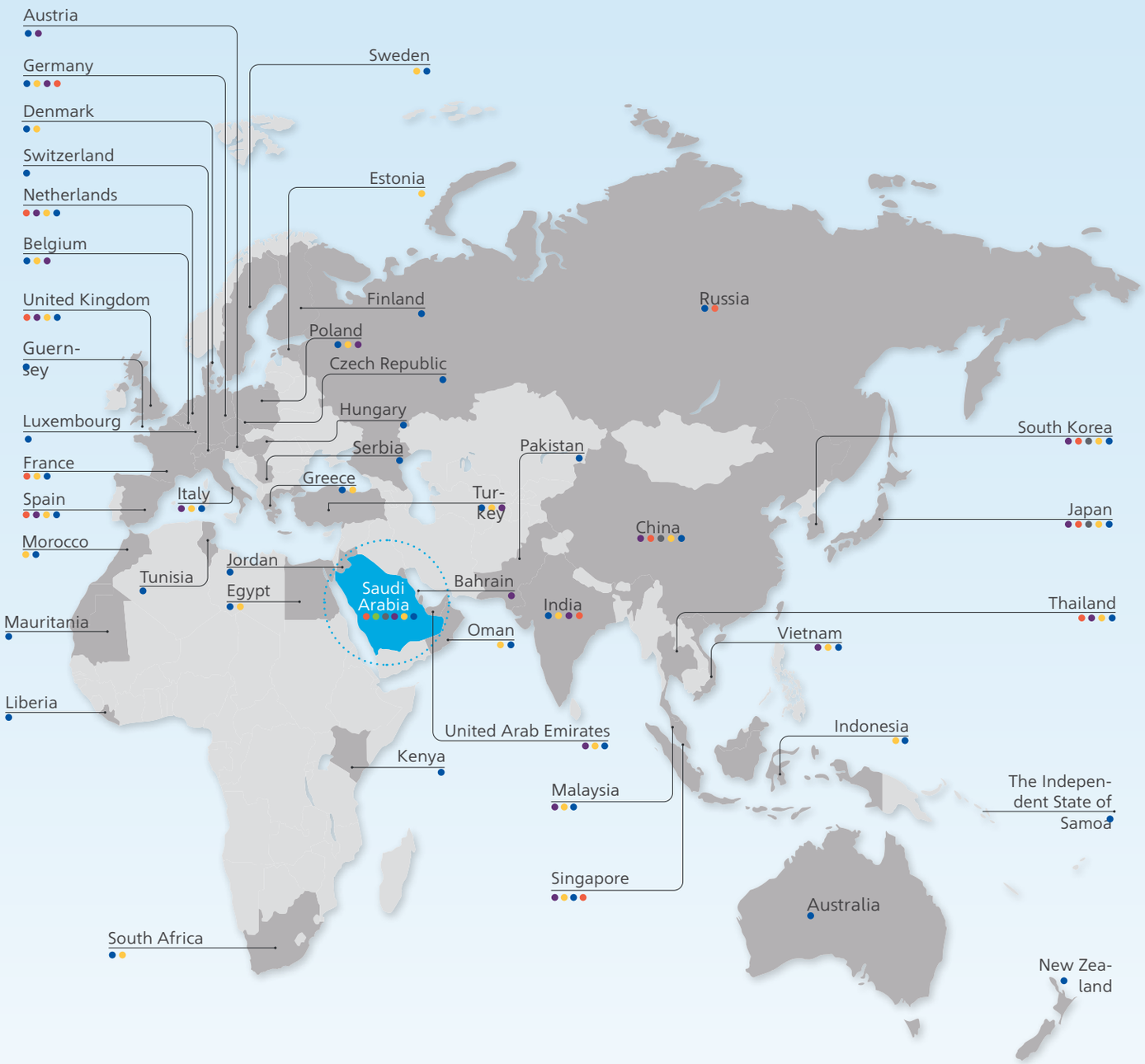
The Dhahran landscape today has a far different look than it did when oil exploration first started in 1933.

Operations map

- Countries of operations – as at December 31, 2023
- Subsidiary offices*
- Terminals and distribution hubs
- Refining, petrochemical and manufacturing facilities
- Crude oil and natural gas production facilities
- Aramco retail fuels network
- Technology and innovation centers

* Subsidiaries are separate legal entities from the Company.

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Tunisia
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Singapore
South Korea
Japan
Thailand
Vietnam
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Australia
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land

Company leadership

COMPANY CEOS

Harry D. Collier
1940-1941, 1944-1951

R. C. Stoner
1941-1944

William S. S. Rodgers
1951-1952

Fred A. Davies
1952-1959

Norman Hardy
1959-1961

Thomas C. Barger
1961-1969

Robert I. Brougham
1969-1970

Liston F. Hills
1971-1973

Frank Jungers
1973-1977

John J. Kelberer
1978-1988

Ali I. Al-Naimi
1988-1995

Abdallah S. Jum'ah
1995-2008

Khalid A. Al-Falih
2009-2015

Amin H. Nasser
2015-

COMPANY PRESIDENTS

Fred A. Davies
1940-1947

W. F. Moore
1947-1952

Robert L. Keyes
1952–1957

Norman Hardy
1958-1959

Thomas C. Barger
1959-1968

Robert I. Brougham
1968-1969

Liston F. Hills
1969-1971

Frank Jungers
1971-1973

R. W. "Brock" Powers
1973-1978

Hugh H. Goerner
1978-1983

Ali I. Al-Naimi
1984-1995

Abdallah S. Jum'ah
1995-2008

Khalid A. Al-Falih
2009-2015

Amin H. Nasser
2015-

CHAIRMEN OF THE BOARD OF DIRECTORS

R. C. Stoner
1943-1944

Harry D. Collier
1944-1951

William S. S. Rodgers
1951-1952

Fred A. Davies
1952-1959

Norman Hardy
1959-1968

Thomas C. Barger
1968-1969

Robert I. Brougham
1969-1970

Liston F. Hills
1970-1973

Frank Jungers
1973-1978

John J. Kelberer
1978-1988

Hisham M. Nazer
1988-1995

Ali I. Al-Naimi
1995-2015

Khalid A. Al-Falih
2015-2019

Yasir O. Al-Rumayyan
2019-

On May 29, 1933, the oil concession agreement was signed between Saudi Arabia and Standard Oil Company of California (Socal).

On November 8, 1933, a subsidiary, California Arabian Standard Oil Company (Casoc), was created to manage the concession.

Casoc operated until January 1944, when the company's name changed to the Arabian American Oil Company (Aramco).

On November 8, 1988, the Saudi Arabian Oil Company (Saudi Aramco) was established.

In an Initial Public Offering on December 11, 2019, the Saudi Arabian Oil Company (Saudi Aramco) was first listed as a public company, on the Tadāwul, the Saudi Stock Exchange.

Acknowledgments

ORAL HISTORY INTERVIEWS CONDUCTED BY HISTORY FACTORY

Former and Current Employees (Second edition)

Abdulaziz M. Al-Gudaimi
Ahmad O. Al Khowaiter
Ahmed A. Al-Subaey
Ahmed A. Alzahid
Amer A. Amer
Amin H. Nasser
Aqil Jamal
Ashraf A. Al Ghazzawi
Ashraf M. Al Tahini
Bashir M. Al Dabbousi
Fahad K. Al-Dhubaib
Fatimah Al Rashid
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Hiba Dialdin
Huda M. Al-Ghoson
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Khaled A. Al Buraik
Khalid A. Al-Falih
Khalid H. Al-Dabbagh
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Mohammad Al Shammary
Mohammed Al Assaf
Mohammed Y. Al Qahtani
Nabeel A. Al-Jama'
Rusha Rawaf
Waleed Al-Mulhim
Yasser M. Mufti
Ziad T. Al Murshed

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Abd Allah S. Al-Saif
Abdallah S. Jum'ah
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Abdulaziz F. Al-Khayyal
Abdulaziz M. Al-Hokail
Abdulaziz Omer Al-Ajaji
Abdulkader M. Afifi
Abdulla Fouad
Abdullatif A. Al-Othman
Ahmad S. Al-Nassar
Ahmed Saleh Al-Humaid
Ali A. Al-Muhareb
Ali I. Al-Naimi
Ali M. Al-Baluchi
Ali Seflan
Ali Y. Al-Hauwaj
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Bidah Al-Qahtani
Bidah Mejdal Al-Gahtani
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Fahmi Basrawi
Fatema H. Al-Awami
Faysal M. Al-Bassam
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Khalid Ali Alturki
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Othman Alkhowaiter
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King Fahd National Library, *Riyadh*, Mohammed A. Al-Rashid, *Vice General Director*
Ministry of Petroleum and Mineral Resources, *Riyadh*
Saudi Aramco Community Heritage Gallery, *Dhahran*
United States Consulate, *Dhahran*

International

American Petroleum Institute, *Washington, D.C., United States*
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Bechtel Corporation, *San Francisco, California, United States*
Bapco, *Bahrain*
BP p.l.c., *London, United Kingdom*
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University of Utah, *Salt Lake City, Utah, United States*
University of Wyoming, *Laramie, Wyoming, United States*

PEOPLE WHO ASSISTED WITH THIS BOOK (SECOND EDITION)

Timothy Achee Jr., Stuart Burt, Stephen Carleton, Arthur Clark, Richard Doughty, Awadh H. Al-Faraj, Osama A. Ramiah, Philip Embleton, Saeed A. Al-Ghamdi, Saad Noor, Glenn Tucker, Hanoof Y. Alseleem, Noora Y. Alamoudi, Haifa K. Al Dossary, Shirley Gast, Sarah Miller, Muhammad Tahlawi, Rod Vera, Janet Pinheiro, William Walsh, Todd Williams, and Daniel Yergin.

PEOPLE WHO ASSISTED WITH THIS BOOK (FIRST EDITION)

Marwan A. Abdrabuh, Abdulrahman M. Al-Abdulqader, Abdulaziz S. Abubshait, Khalid A. Afandi, Graeme Agland, Eyad M. Ajaj, Khalid A. Albahkali, Yousef A. Al-Ali, Shawki M. Alsukairi, Harry Alter, Hassan H. Al-Amri, Ibrahim Al-Anayshah, Wael Faisal Al-Angari, Ross and Patty Atkinson, Tariq A. Al-Awaisi, Ensan M. El-Ayoubi, Fahad S. Al-Aziz, Saad Said Azzahri, Nabil A. Ba'ashan, Mohamed A. Bagais, Raed M. Bahomaid, Robin J. Bally, Tim Barger, Ralph D. Bears, Catarina P. Beresky, Bader Eid Biltagi, Idrees M. Bodah, David D. Bosch, Neil Brown, Salah S. Al-Buraiki, Tina Pakka Cape, Edna K. Catchings, Arthur P. Clark, Basima K. Al-Saleh Darwaza, James C. Davidson, Peter Davidson, Abdullah A. Al-Deraibi, Mohammad G. Al-Domaini, Saad F. Al-Dosari, Adel H. Al-Dossary, Dick Doughty, Nasser Mohammed Al-Dowayan, Gregory J. H. Dowling, Khaled M. Al-Dukeer, David Duncan, Ralph Echezuria, Galal T. Elkhatib, Deya A. Elyas, Dwight Fullingim, Steve Furman, Tony Germani, Michael Gerow, Fouzi M. Al-Ghaithi, Ibrahim A. Al-Ghamdi, Khalid S. Al-Ghamdi, Mohammed S. Al-Ghamdi, Saleh Ghazi Al-Ghamdi, Ahmad H. Al-Ghannam, Nasser H. Ghazzawi, Mohammed A. Al-Ghuwinim, Arthur E. Gregory, Ahmed M. Al-Gusaier, Mohammad A. Al-Haddad, Quraiyan Mohammad Al-Hajri, Saad S. Al-Hajri, Bandar S. Al-Hakami, Ziyad Al-Hamidi, Mohammed O. Hammadi, Mona S. Hassan, Zaid Mohammad Al-Hazmi, Ghalib Moghram Al-Houtan, Charles V. Hudson, Geraint W. Hughes, Haitham K. Al-Jehairan, Mashal M. Jehani, Abdulkarim M. Al-Juhani, S. I. M. Kauser, Thomas H. Keith, Mark W. Kennedy, Abdelkan K. Khalil, Abdelkarim K. Khalil, Dr. Saadeh Khalil, Ibrahim Y. Koheji, Norman H. Kong, Elizabeth C. Lacsamana, Robert W. Lebling, Robert F. Lindsay, Jose A. D. de Luna, Mohammed A. Mahtersh, Richard Maise, James P. Mandaville, Maha A. Al-Mansoury, Saeed N. Al-Marri, Timothy W. Martin, Mark McCarthy, Brian J. McKeage, Jeff D. Meisner, Abdalmatloob Ali Al-Mohammadi, Fadi S. Al-Mubarak, Ibrahim A. Al-Muhaiza, Mohammad A. Mulla, Fayez S. Al-Mutairi, Nazih F. Najjar, Ni'mah I. Nawwab, Gregory C. Noakes, Hussain A. Al-Obaid, Hani A. Al-Omair, Khalid Abdulrahman Al-Omair, Saad M. Al-Omani, Alaa A. Othman, Kathleen M. Owen, Owen Oxley, Alex M. Padippurathu, Honorio S. Pangan, Janis E. Patton, David G. Peck, Thomas A. Pledge, Adel Ali Al-Ramadhan, Saleh M. Al-Rushaid, Abdullah A. Al-Saadoun, Sami A. Sa'ati, Fawzi A. Al-Sadah, Ali Al-Salem, Samer S. Samman, Nestor Sander, Ahmed S. Al-Saqer, Saud Abdulah Al-Saqri, Paul E. Sauser, Moneer A. Sayed, Michelle M. Seaters-Alireza, Douglas C. Seedorf, Hisham A. Shah, Khalid S. Al-Shahab, Omar M. Al-Shahrani, Saad A. Al-Shahrani, Ahmed Abed Shaikh, Khalid G. Al-Shammari, Zaki M. Al-Shobber, Arafat A. Al-Shurei, Ken Slavin, Richard J. Snedeker, Peter C. Speers, Gordon P. Tobert, Yousef S. Al-Ubaid, Khalid D. Al-Usail, Chris P. Vice, Keith G. Wallis, Khalid A. Al-Watban, Marilyn Bunyan Wilkens, Christopher Wszolek, Faisal S. Al-Zahrani, Abdullah S. Zaindin, and James G. Zibbel.

Appreciation is also extended to people who provided assistance but were inadvertently not included in the above lists.

ABOUT THE AUTHOR

Scott McMurray has authored several landmark books for History Factory's clients, including the histories of consulting industry leader Accenture, biotech pioneer Chiron, and one of America's leading health care innovators, Sutter Health System.

A former senior writer with *The Wall Street Journal*, Scott has more than 35 years' experience in business writing, research, and analysis of corporate strategy. A graduate of Grinnell College with a BA in English Literature and American Studies, Scott is a member of the Phi Beta Kappa academic honor society.

List of abbreviations

AAPG	American Association of Petroleum Geologists
AIMS	Aramco Innovation Management System
AMDP	Aramco Mobile Drilling Platform
Aminoil	American Independent Oil Company
AOC	Aramco Overseas Company
APP	Associate Professional Program
Aramco	Arabian American Oil Company
ASC	Aramco Services Company
ATC	Aramco Trading Co.
ATP	Accelerated Transformation Program
Bapco	Bahrain Petroleum Company
BP	British Petroleum Company
boe	barrels of oil equivalent
bpd	barrels per day
Casoc	California Arabian Standard Oil Company
CAT	computer-aided tomography
CCUS	carbon capture, utilization and storage
CDPNE	College Degree Program for Non-Employees
CERA	Cambridge Energy Research Associates
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CTO	chief technology officer
DTV	Dhahran Techno Valley
E&P	exploration and producing
EOR	enhanced oil recovery
EXPEC	Exploration and Petroleum Engineering Center
EXPEC ARC	Exploration and Petroleum Engineering Center's Advanced Research Center
FREP	Fujian Refining and Petroleum Company Ltd.
GDP	gross domestic product
GOSP	gas-oil separation plant
GPS	global positioning system
HPAAS	High-Pressure Air Assist System
IDD	Industrial Development Division
IEA	International Energy Agency
iktva	In-Kingdom Total Value Add
Industry 4.0	Fourth Industrial Revolution
IOC	international oil company
IPA	Independent Project Analysis
IPC	Iraq Petroleum Company
IPO	initial public offering
IT	information technology
ITC	Industrial Training Center
Ithra	King Abdulaziz Center for World Culture
Jersey	Standard Oil Company of New Jersey
JHAH	Johns Hopkins Aramco Healthcare
KAIST	Korea Advanced Institute of Science and Technology
KAPSARC	King Abdullah Petroleum Studies and Research Center
KAUST	King Abdullah University of Science and Technology
KFUPM	King Fahd University of Petroleum and Minerals
kg	kilogram
LLC	limited liability company
LPG	liquefied petroleum gas
Luberef	Saudi Aramco Base Oil Company
MBA	Master of Business Administration degree
MERS	Middle East respiratory syndrome
MGS	Master Gas System
MIT	Massachusetts Institute of Technology
MRC	maximum reservoir contact (well)
MRI	magnetic resonance imaging
MSC	maximum sustainable capacity
NEDC	Near East Development Company
NGI	Natural Gas Initiative
NGL	natural gas liquids
NOC	national (or state-owned) oil company
OAPEC	Organization of Arab Petroleum Exporting Countries
OCC	Operations Coordination Center
OGCI	Oil and Gas Climate Initiative
OPEC	Organization of Petroleum Exporting Countries
OSPAS	Oil Supply Planning and Scheduling Department
PDP	Personal Development Program
PDP	Professional Development Program
PIF	Public Investment Fund
PMI	Project Management Institute
POWERS	Parallel Oil Water and Gas Reservoir Simulator
ppb	parts per billion
PRC	Petroleum Reserves Company
PrefChem	Pengerang Refining Company and Pengerang Petrochemical (collectively)
R&D	research and development

SABIC	Saudi Arabia Basic Industries Corporation
SAEV	Saudi Aramco Energy Ventures
SAG	Saudi Arabian government
SAIR	Saudi Aramco Inspection Robot
Samarec	Saudi Arabian Marketing and Refining Company
SAMCOM	Saudi Arab Manpower Committee
SARS	severe acute respiratory syndrome
SASC	Saudi Aramco Cino Ltd.
SASREF	Saudi Aramco Jubail Refinery Company
SATORP	Saudi Aramco Total Refining and Petrochemical Co.
Saudi Aramco	Saudi Arabian Oil Company
SCECO	Saudi Consolidated Electrical Company
scfd	standard cubic feet per day
Socal	Standard Oil Company of California
Socony	Standard Oil Company of New York
SPARK	King Salman Energy Park
SRAK	South Rub' al-Khali Company Ltd.
SSPC	Sinopec SenMei (Fujian) Petroleum Co. Ltd.
STEM	science, technology, engineering and math
STO	Strategic Transformation Office
SWIM-R	Shallow Water Inspection and Monitoring Robot
Tapline	Trans-Arabian Pipeline or Trans-Arabian Pipe Line Company
TDI	toluene diisocyanate
TOEFL	Test for English as a Foreign Language
TPC	Turkish Petroleum Company
UAE	United Arab Emirates
ULCC	ultra-large crude carrier
UNESCO	United Nations Educational, Scientific and Cultural Organization
VLCC	very large crude carrier
YASREF	Yanbu' Aramco Sinopec Refining Co.
YLAB	Young Leaders Advisory Board
ZHI	al-Zamil Heavy Industries

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ACHIEVING THE VISION

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BOOM TIME

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CHAPTER TWO
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