

# dimensions

INTERNATIONAL

**PURSUING THE  
CUTTING EDGE**



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## Capturing Carbon

At its 'Uthmaniyah and Hawiyah NGL facilities, Saudi Aramco has launched the Kingdom's first carbon capture and sequestration project and carbon dioxide enhanced oil recovery (CO<sub>2</sub> EOR) project. Carbon sequestration is a win-win technological solution, and CO<sub>2</sub> EOR enables the company to reduce CO<sub>2</sub> emissions in the atmosphere, while also helping to meet the global energy demand.



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## Turbocharged for success

A new technology being used in Hawiyah is the first of its kind in the world. The hydraulic turbine electric generator, or turbocharger, extracts hydraulic energy that is traditionally wasted at the plant and turns it into electrical power.

## departments

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worldview Back Cover



The Saudi Arabian Oil Company, also known as Saudi Aramco, was established by Royal Decree in November 1988 to succeed the original U.S. concessionary company, Aramco. The Aramco concession dates back to 1933.

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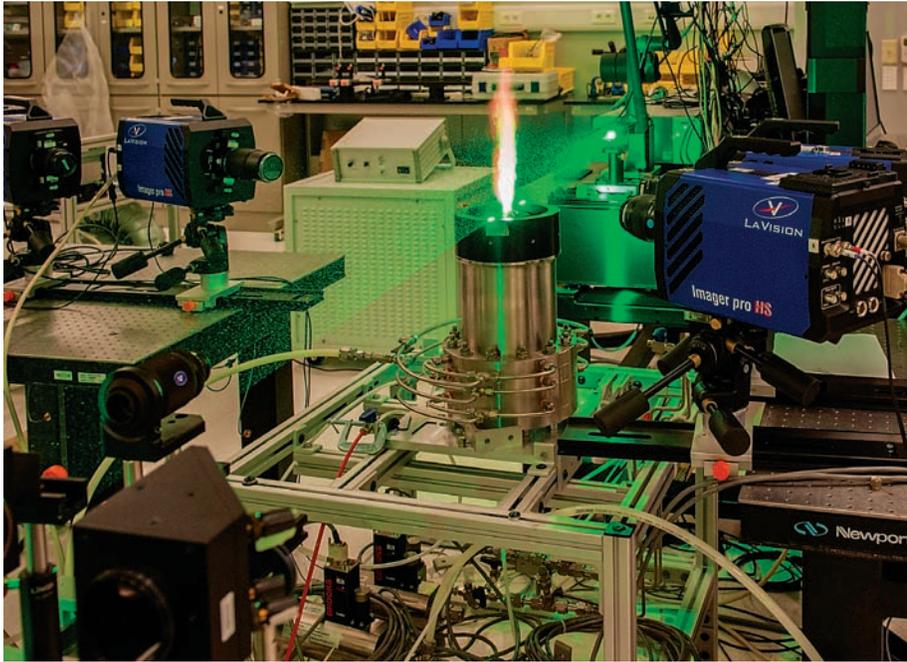
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## Pursuing the cutting edge

Learn more about Saudi Aramco's FUELCOM program, a 10-year collaborative research undertaking that is addressing fundamental aspects of hydrocarbon fuel combustion in engines, and enabling R&DC scientists to formulate oil derived fuels that are suitable for the next generation of high efficiency and low emission combustion engines.



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## Going strong at 70

More than seven decades ago, the first company self-directed group came into existence. Living up to its tagline of "Family, Friends, Fun," the Saudi Aramco Employees Association (SAEA) has offered its members cultural activities, family festivities, world-class entertainment, and organized tours showcasing the geography and history of Saudi Arabia.

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**About the cover:**

Assistant professor Aamir Farooq analyzes a breath sample using a laser-based ammonia sensor, one of the many technologies available as part of the FUELCOM program at KAUST.





Ahmed Yousif, an operations supervisor at 'Uthmaniyah GOSP-7, checks the controls for the CO<sub>2</sub> inlet at the CO<sub>2</sub> injection unit. The 'Uthmaniyah field plays a critical role in this pilot project to test the effectiveness of CO<sub>2</sub> injection for enhancing the recovery of oil from the Kingdom's reservoirs.



# *Capturing* **CARBON** LEADING *by* EXAMPLE

## COMPANY LAUNCHES KINGDOM'S FIRST CARBON CAPTURE PROJECT

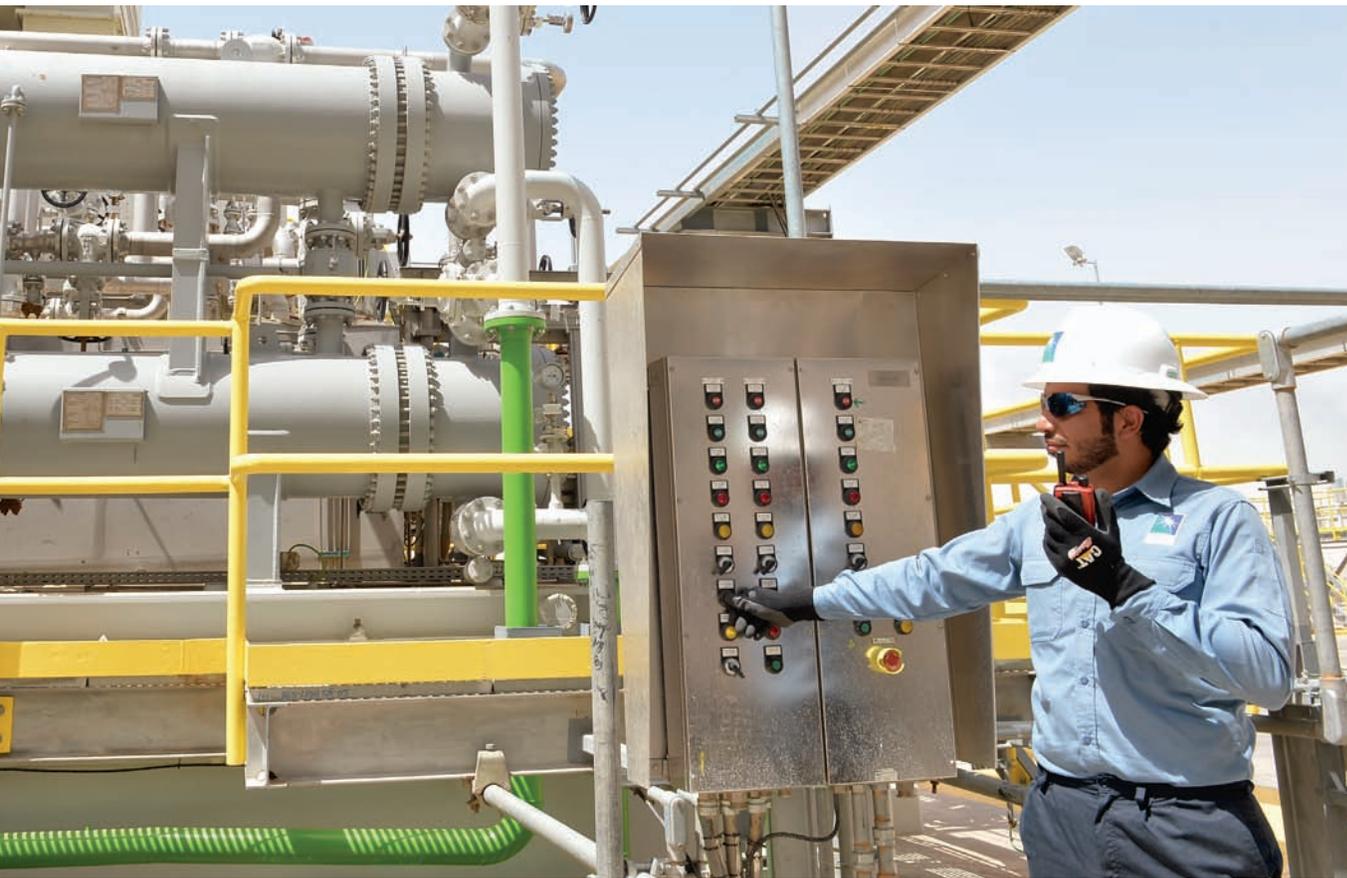
*By* **SCOTT BALDAUF**

*Photos by* **ABDULAZIZ AL MOAIWEED**

**SAUDI ARAMCO HAS LAUNCHED THE KINGDOM'S FIRST CARBON CAPTURE AND SEQUESTRATION PROJECT AND CARBON DIOXIDE (CO<sub>2</sub>) ENHANCED OIL RECOVERY (EOR) PROJECT AT ITS 'UTHMANIYAH AND HAWIYAH NGL FACILITIES. THE CO<sub>2</sub> EOR PROJECT IS THE LARGEST SEQUESTRATION PROJECT IN THE MIDDLE EAST.**

**T**he pilot project, comprised of a CO<sub>2</sub> capture plant in Hawiyah, Saudi Arabia, and an EOR project in the 'Uthmaniyah oil field, demonstrates the company's commitment to lead by example through environmental stewardship and citizenship.

The CO<sub>2</sub> capture project injects compressed CO<sub>2</sub> into flooded oil reservoirs as a mechanism for CO<sub>2</sub> storage; and the injection of CO<sub>2</sub> under high pressure simultaneously enhances oil recovery. For these reasons, carbon capture and storage is considered a win-win technological solution.



**ABOVE: Abdulmohsen Al Shehri works the CO<sub>2</sub> compressor panel in Hawiyah. After the CO<sub>2</sub> is compressed, the gas is transported via a pipeline to the North 'Uthmaniyah area of the Ghawar field for injection. LEFT: From left, control operators Amer Haddad and Hussain Saleh monitor the compression process in Hawiyah.**

technologies to reduce CO<sub>2</sub> emissions.

“This breakthrough initiative demonstrates that we, as an industry leader, are part of the solution to proactively address global environmental challenges,” said Amin Nasser, president and CEO of Saudi Aramco. “Saudi Aramco is carrying out extensive research as part of our Corporate Carbon Management Technology Road Map, enabling us to lower our carbon footprint while continuing to supply the energy the world needs.”

Carbon management is now an integral part of our business. Since the company established its Master Gas System in the 1970s, CO<sub>2</sub> emissions have been reduced significantly.

Led by the Exploration and Petroleum Engineering Center (EXPEC) Advanced Research Center (EXPEC ARC), our carbon management technology road map includes many focus areas with a main goal of developing the required

Environmental stewardship has long been a hallmark of Saudi Aramco’s business, with the company’s environmental protection policy formally established in 1963. Effective carbon management is one of the many strategies that Saudi Aramco employs to meet the goals of reliably supplying energy safely and responsibly. Reducing gas flaring, introducing zero discharge technologies at



***“This breakthrough initiative demonstrates that we, as an industry leader, are part of the solution to proactively address global environmental challenges.”***

**– AMIN NASSER**

**ABOVE: Khalid Mulhim, shown here working near the CO<sub>2</sub> compressor instrument panel in Hawiyah, is one of several employees who worked diligently to bring the CO<sub>2</sub> EOR Demonstration Project to life. It is the largest project of its kind in the Middle East.**

well sites, and implementing a comprehensive water conservation policy at all plants and communities are also among the company’s environmental protection efforts.

“It is indeed a very proud moment for EXPEC ARC and the team that has been spearheading the effort over the past several years to conceptualize, generate research data, design and implement the pilot project in ‘Uthmaniyah,” said Waleed Al-Mulhim, EXPEC ARC manager. “The project has been supported by several Upstream and Downstream departments. It has been a concerted team effort to bring it to fruition.”

Ali Al-Meshari, chief technologist for Reservoir Engineering at EXPEC ARC and coordinator for the Carbon Management Team, said the culmination of the pilot project is a significant achievement.

“It will have a measurable impact on reducing overall CO<sub>2</sub> emissions. It will inject 800,000 tons of CO<sub>2</sub> every year, and establish a monitoring system to measure how much of that CO<sub>2</sub> remains sequestered underground,” said Al-Meshari.

## CONSTANT MONITORING

Sunil Kokal, who led the CO<sub>2</sub> EOR project team and is the Focus Area Champion of CO<sub>2</sub> EOR research at EXPEC ARC, said the project includes a row of four injector

wells and four producer wells, and another two observation wells for monitoring and surveillance. It is estimated that

as much as 40% of the injected CO<sub>2</sub> will be sequestered permanently in the reservoir.

The project also strives to enhance oil recovery beyond the more common method of waterflooding. The main objectives of the pilot are a determination of how much CO<sub>2</sub> remains sequestered or stored in the reservoir, estimation of incremental oil recovery (beyond waterflooding), addressing the risks and uncertainties involved, including migration of CO<sub>2</sub> within the reservoir, and identifying operational concerns.

The project will use 40 million standard cubic feet per day of CO<sub>2</sub> that will be captured and processed at the Hawiyah NGL Recovery Plant and piped 85 kilometers to the ‘Uthmaniyah field for injection.

“The CO<sub>2</sub> will be injected into four injector wells in a water-alternating-gas mode,” said Kokal, noting that the CO<sub>2</sub> and water will be injected at around 2,800 pounds per square inch (psi) into alternate injectors and switched every month.

## FIRST IN THE REGION

An elaborate monitoring and surveillance program has been developed for the pilot project to obtain data and evaluate its performance. The main objectives of the

**The pilot project demonstrates the company's commitment to lead by example through environmental stewardship and citizenship.**



monitoring program include the migration of CO<sub>2</sub> within the reservoir, assessing key risks and uncertainties, understanding recovery mechanisms, identifying operational issues, and building public confidence in the first CO<sub>2</sub> sequestration project not just in the Kingdom but throughout the GCC region. Monitoring will take place with a range of methods, including seismic monitoring, electromagnetic surveys, borehole and surface gravity, and inter-well tracer tests.

“Many new technologies are being implemented, some for the first time in the Kingdom, some for the first time in the region, and many for the first time in the world,” said Al-Mulhim.

At the end of the compression process, the CO<sub>2</sub> is compressed to 3,500 psi, and is in a supercritical phase, like a dense fluid. It is in this state that the gas is transported via pipeline to the North 'Uthmaniyah area of the Ghawar field for injection at 2,800 psi. Processing of the EOR fluids is done at 'Uthmaniyah's gas-oil separation plant (GOSP)-7.

“The compression process takes place in a seven-stage internally geared compressor — the largest such compressor to be used in the company,” said Abdullatef Al-Mufti, chief commissioning engineer at HNGI. After the fifth stage of compression, the CO<sub>2</sub> is still considered “wet,” and so it is routed to a Gas Dehydration Unit for processing, before being reintroduced into the compressor for stages six and seven.

Getting the project up and running was complicated by

**ABOVE: The HPPT gas compressor located at the 'Uthmaniyah gas-oil separator plant (UGOSP-7) is utilized to process the recovered associated gas rich of CO<sub>2</sub>. The compressed gas then is sent to the 'Uthmaniyah and Shedgum NGL plant for further processing and fractionation. This compressor is unique in design and material to withstand the wet CO<sub>2</sub> corrosiveness. Also, it is equipped with a variable speed drive to handle the wide range of gas expected during the project evaluation. Moreover, it is hermetically sealed and equipped with magnetic bearings, which reduce emissions and enhanced its efficiency. It is worth noting that this kind of compressor is the first of its kind installation at Saudi Aramco and the second installation worldwide.**

the fact that new contractors and new technologies were being deployed. Mohammed A. Suwaiyel, lead project engineer with the Southern Area Projects Department, said the key to success was the collaboration of all departments in completing the project — all conducted during normal operations at Hawiyah and 'Uthmaniyah.

“The project has completed 11 million construction man-hours with zero incidents,” said Suwaiyel.

After commissioning of the CO<sub>2</sub> Capture Unit at Hawiyah NGL, liquefied CO<sub>2</sub> is now being sent to the 'Uthmaniyah field for injection. Nearby, at 'Uthmaniyah



GOSP-7, a new standalone high-pressure production trap, a new compressor and associated facilities for handling the high concentrated CO<sub>2</sub> production streams have been built. This is where the monitoring of produced fluids will take place, and where Saudi Aramco takes extra steps to ensure as much CO<sub>2</sub> as possible remains sequestered underground.

As the site for injection, Southern Area's 'Uthmaniyah field was key to the project. The Southern Area Oil Operations Technical Services Department coordinated and interfaced the construction of the facilities at both ends, ensuring that the CO<sub>2</sub> can be injected safely. Several departments are contributing to the ongoing production-related activities that include logging, testing, and evaluation.

At 'Uthmaniyah GOSP-7, engineers will be monitoring the project to ensure that the CO<sub>2</sub> remains sequestered underground. For this reason, GOSP-7 has been retrofitted to include new facilities, such as a three-phase separator,

CO<sub>2</sub> compressor train, and a flare system, to handle recovered fluids for further processing.

Out in the field, 10 wells specifically drilled for the EOR project have been equipped with downhole monitoring sensors to provide full surveillance of reservoir parameters during the project period. All 10 wells are connected and equipped with real-time flow measurement devices, automated and remotely controlled choke valves to ensure full accessibility and control over the project area.

Over the next three to five years, the pilot project will be studied by engineers in the field and at EXPEC ARC. Lessons learned from this project will be utilized at other facilities and oil fields around the Kingdom, helping to maintain Saudi Aramco's position as the world's most productive and reliable provider of energy. 🌐

**BELOW: The High-Pressure Production Trap (HPPT) vessel located at UGOSP-7 is a three-phase separator utilized to process the crude oil recovered from the reservoir as a result of the CO<sub>2</sub> injection. The vessel is internally clad with high resistance corrosion alloy to handle the corrosiveness of the wet CO<sub>2</sub> in association with chlorine residuals. Moreover, the vessel is carefully sized to handle the total forecasted fluid (oil in association of gas and formation water) during the project evaluation — over the period of five years.**



# TURBO CHARGED

FOR SUCCESS

A new technology being used in Hawiyah  
is the first of its kind in the world

*BY* Jamsheed M. Din

Innovation, collaboration and determination: these three words sum up a new game-changing technology now being deployed at the Hawiyah Gas Plant (HGP).

The hydraulic turbine electric generator, or turbo-charger, extracts hydraulic energy that is traditionally wasted at the plant and turns it into electrical power.

The result is an enormous cost savings to the company each year and a reduction in the plant's carbon footprint. As the world's first deployment of such a technology, the turbocharger has put HGP on the global map of power and environmental efficiency.

Machinists Ali H. Taweel, left, and Haider H. Alshoraiyet discuss their newly gained knowledge of the turbocharger at HGP. Young employees played a key role in developing the game-changing technology. *Photo Ahmad Al Thani/MPD*





The turbocharger is now being piloted under the watchful eye of plant employees, and if it continues to operate smoothly, it could soon find itself deployed across various company facilities.

“This technology deployment is in line with Saudi Aramco’s commitment to energy efficient operations and is a proud moment for the Hawiyah Gas Plant,” said Ahmed Al-Ghamdi, manager of HGP.

Most impressive about the project is that the idea was developed by employees at the plant, along with the Process and Control Systems Department (P&CSD). The project checked all the boxes that make Saudi Aramco and its people stand head and shoulders above the rest. Not the least was collaboration — a key element in making it all come together. It was back in 2012 that an opportunity was spotted to turn wasted energy into power — an opportunity HGP and P&CSD had no intention of letting go.

## OPPORTUNITY KNOCKS

The Hawiyah plant is a typical Saudi Aramco facility. Thousands of tons of steel structure weave their way around the vast complex — a true feat of engineering.

Deep within the plant, nesting beneath its steel pipes, are amine gas treating units. At the plant, there are five units, and in these units, hydrogen sulfide and carbon dioxide from raw natural gas are removed by using solutions of amine, known as acid gas removal and gas sweetening. The amine solutions are pumped into a high-pressure contactor where they come into contact with raw natural gas and absorb any acidic gases contained in the stream.

The amine solution with the dissolved acid gases exits the bottom of the contactor, is depressurized through a control valve and is sent to a low-pressure regenerator, where the acid gases are removed. The regenerated amine solution is then injected back into the high-pressure contactor with a large pump.



Depressurizing wastes energy. Also, the same amount of energy is consumed again to pressurize the lean amine up to the contactor pressure. This is the moment where lost or wasted energy is most apparent.

## ENTER OPPORTUNITY

“We knew we were having an energy loss,” said Hussain S. Al-Nassir, senior operations engineer at the plant. “The question was how to utilize it.”

The turbocharger replaces one of the redundant amine level control valves at a gas treating unit within HGP. The custom-made device, through cutting-edge technology, then extracts the hydraulic energy that is normally wasted by the amine level control valve. With maximum efficiency, a generator extracts energy from the turbine shaft while maintaining the optimum shaft speed for the given conditions. Advanced control electronics operate the generator and convert the output to a standard power format that is absorbed into the plant substation.

*Photo Ahmed Al Thani/MPD*

The search began to find a partner that could help the plant develop a bespoke device that could capture wasted energy and transform it into electrical power.

HGP and P&CSD collaborated internally to define potential solution requirements, followed by an in-depth search for a technology provider, with a suitable vendor soon identified.

## COLLABORATION THE KEY

With P&CSD involved, HGP now had a partner to help bring the project to fruition.

“We identify technologies and recommend their deployment,” said Mohammad Haji from P&CSD.

Through P&CSD, the financing of the turbocharger was approved via the corporate technology fund, in alignment with the corporate direction to generate value from technology deployment.

## YOUNG EMPLOYEES SHINE AT HAWIYAH GAS PLANT

At the heart of the success of the turbocharger project at the HGP were young employees. “We engaged our young operators, technicians and engineers to learn and supervise the construction,” said HGP manager Ahmed Al-Ghamdi. “They were also involved in the design, construction, pre-commissioning and commissioning. We are proud to have this young team taking the lead, and they will take the lead in future installations.”

Ali H. Al Taweel was one such employee. The 29-year-old machinist technician played a

critical role in the installation of the commissioning unit. He says he found the project challenging.

“I was involved in installing the skid foundation; I learned a lot from the experience. It was true collaboration, and our more experienced colleagues helped us along,” he said.

“I think what I gained most was a practical understanding of how to maintain and align this new technology within our existing facilities. This was probably the biggest challenge of the project, but we succeeded,” Al Taweel said.

Operator Mahmoud Mohsin, 27, was another key figure in the successful startup. “I was the operations representative in the loop check and reviewed the startup procedure,” he said. “I was then involved in putting the system into service.

“I learned how to review all activities carried out by the vendor to ensure they complied with what we required from an engineering perspective — and of course, starting the machine safely was a big learning curve.”



In the control room at Hawiyah Gas Plant, engineers like Abdallah A. Wabari are able to keep track of the performance of the turbocharger.

“It was a difficult journey,” Haji added. “Fortunately, with the will of the plant, we overcame several challenges that required a lot of coordination with Power Systems, Consulting Services, Aramco Services Company and the Hawiyah Gas Plant. It was a lot of effort from many disciplines.”

Subsequent meetings with the vendor led to a concept design, and a plan to create a device to capture the wasted energy was put in motion.

It was now all hands on deck. In the HGP Engineering Division, led by Faisal Al-Odah, the new technology was examined. Could it work? How would it fit into the current system?

“This was the biggest challenge,” noted Al-Odah. “So we had to take a good look at how it could work, and more importantly, how we could put in this new system without interruption to plant operations.”

Work then began in earnest, with detailed blueprints discussed and design issues ironed out. “You have to study all the different disciplines, because you are going to integrate something that can disrupt our systems,” said Yousef Al Mubarak, supervisor of Operations Engineering at HGP. “So we made detailed studies to make sure the systems could

integrate safely and reliably. We really pulled together as a team; it was a great effort.”

With the turbocharger now being designed to HGP’s specifications, employees at the plant teamed up with colleagues in P&CSD and the Power Operations Department to execute the installation of the piping and electrical wiring for the turbocharger, all of which was done in-house.

Another challenge was integrating its power into the existing substation in Gas Treating Unit 3, where the power would be used.

“It was all done without shutting down any of our operations — quite an achievement,” commented Al-Odah.

“This is a credit to all the engineers and the operation and maintenance staff. They had a focus and a job to do, and they pulled it off.”

The turbocharger was commissioned in early 2015, and so far — under the close maintenance and watchful eye of HGP — it has performed to expectations with an average output of 300 kilowatts.

“It’s an outstanding opportunity for us to have this technology,” said Faisal Yaeesh, superintendent of the Operations

“IT WAS ALL DONE WITHOUT  
SHUTTING DOWN ANY OF  
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ACHIEVEMENT.”  
FAISAL AL-ODAH



Ahmed Al-Ghamdi



Faisal Al-Odah

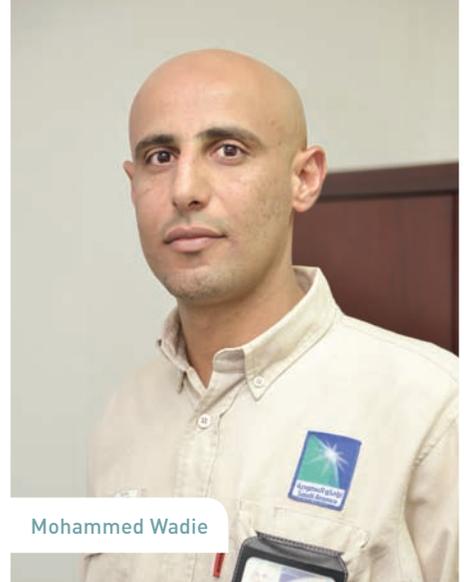
“I’M PROUD OF OUR DEVELOPMENT OF YOUNG ENGINEERS AND TECHNICIANS. THEY PLAYED AN IMPORTANT ROLE AND WORKED ALONGSIDE THEIR MORE EXPERIENCED COLLEAGUES FROM THE BEGINNING TO THE END OF THE PROJECT.”  
**FAISAL YAEESH**



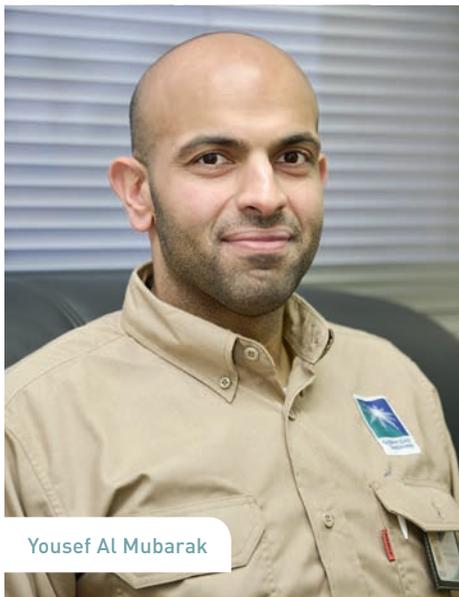
Mohammad Haji



Hussain S. Al-Nassir



Mohammed Wadie



Yousef Al Mubarak



Faisal Yaeesh



Mahmoud Mohsin

Division in HGP. “We are leading the industry. This could be a paradigm shift, albeit a small one.”

Yaesh also pointed out that one of the major hallmarks of the project was the involvement of young employees.

“I’m proud of our development of young engineers and technicians. They played an important role and worked alongside their more experienced colleagues from the beginning to the end of the project. This marks a huge achievement.”

## THE WORK DOESN'T END HERE

“After the commissioning, we are responsible for the maintenance,” said Mohammed Wadie, superintendent of HGP maintenance. “We now have extremely competent people who can deliver. Our taskforce is mostly young, and this was an excellent learning experience for them. Most of them had less than 10 years of experience, which is something remarkable.”

For Al-Ghamdi, the project is a reflection of the plant’s commitment to energy conservation.

“We have a dedicated energy team and coordinator who is internationally certified,” he said. “Our program helps us capture these kinds of opportunities. It was a true collaboration with P&CSD and the Technology Management group; they played a major role.

“The project was executed safely and without disruptions,” Al-Ghamdi said. “And we have seen no deficiencies or concerns so far. This project succeeded due to great team spirit. Everyone was energized and inspired to see it producing power.”

Al-Nassir agrees that the working environment at HGP played a crucial role in the successful startup.

“With a facility like this, there is always a chance for new ideas,” he noted.

As the turbocharger powered through its trial phase, its successful deployment is another feather in the cap of Saudi Aramco’s proven commitment to environmental efficiency, as well as technological innovation. 🌐

Hussain S. Al-Nassir is joined by other members of the team as they observe the key features of the “turbocharger.”







# PURSuing THE CUTTING EDGE

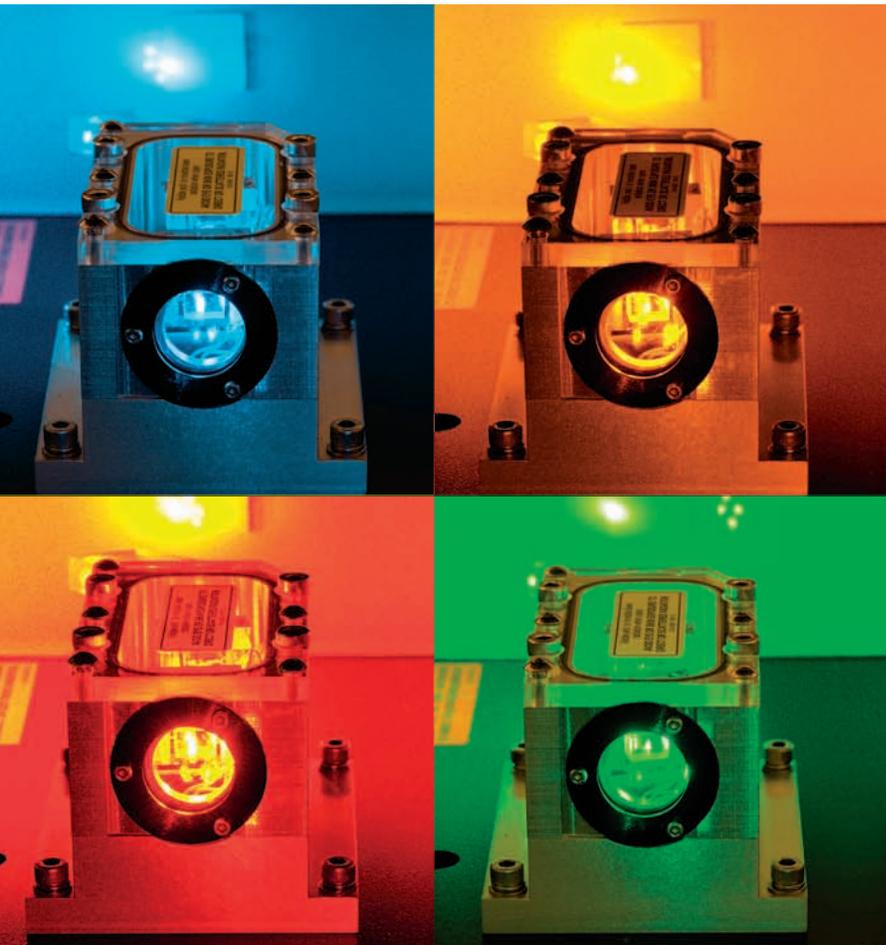
Partnership fuels development  
of game-changing technologies

BY SCOTT BALDAUF  
PHOTOS PROVIDED BY KAUST



As the world debates the future of transportation fuels and how best to reduce the effects of climate change, Saudi Aramco's Research and Development Center (R&DC) has been making headway with several game-changing technologies that not only could dramatically alter the landscape of personal mobility but do so in sustainable and efficient ways.

KAUST Ph.D. student Yuan Xiong sets up the laminar diffusion flame experiment at the Saudi Aramco Research & Development Center at KAUST in Thuwal. Saudi Aramco's FUELCOM program collaborates with a number of partner research centers around the globe, including IFPEN in Paris, KAUST, and engine research at the R&D Center in Detroit.



**LEFT:** A Beta Barium Borate doubling crystal that is used for the purpose of selectively detecting the presence of important chemical species during combustion. The presence or absence of certain chemical species provides researchers with important insights into the efficiency and emissions of the combustion system. **ABOVE:** Ph.D. students Tamour Javed, Fathi Khaled and Bilal Sajid join postdoctoral students Ahmed Elwardany and Markous Abdu as they prepare for homogeneous ignition delay time experiments in the KAUST-CCRC shock tube laboratory using both the low-pressure and high-pressure shock tube facilities. The collaboration between Saudi Aramco and KAUST is key in pushing the boundaries of what is known about the combustion of oil-based fuels, and by extension, demonstrate the reliability of oil-based fuel for years to come.

The key to making these breakthroughs is collaboration. In recent years, scientists and researchers at the R&DC's Fuel Technology Division in Dhahran, Saudi Arabia, have been working closely with satellite research centers in Paris and Detroit, as well as with the Clean Combustion Research Center at the King Abdullah University for Science and Technology (KAUST-CCRC) in Thuwal, Saudi Arabia.

This work will not only put Saudi Aramco at the forefront of the search for efficient engine fuel systems but also set a new course for the auto industry and influence the design of cars that we'll all drive in the future.

### A BRIEF HISTORY OF FUELCOM

Launched in February 2013, the FUELCOM program is a 10-year collaborative research undertaking between the Saudi Aramco R&DC's Fuel Technology Division and the KAUST-CCRC.

This research program is intended to address fundamental aspects of hydrocarbon fuel combustion in engines, and

will enable R&DC scientists to formulate oil derived fuels that are suitable for the next generation of high efficiency and low emission combustion engines.

Although FUELCOM is only in its fifth year, the program has already made a substantial contribution toward key

research activities within the R&DC. One of the key technologies is a promising engine fuel concept that could enable diesel-like levels of efficiency, but with far lower pollutant emissions. This translates into fewer carbon emissions, and more miles per gallon.

These collaborations, therefore, position the R&DC at the forefront of the search for pioneering technologies that

will maintain the economic and environmental competitiveness of oil derived transport fuels well into the future.

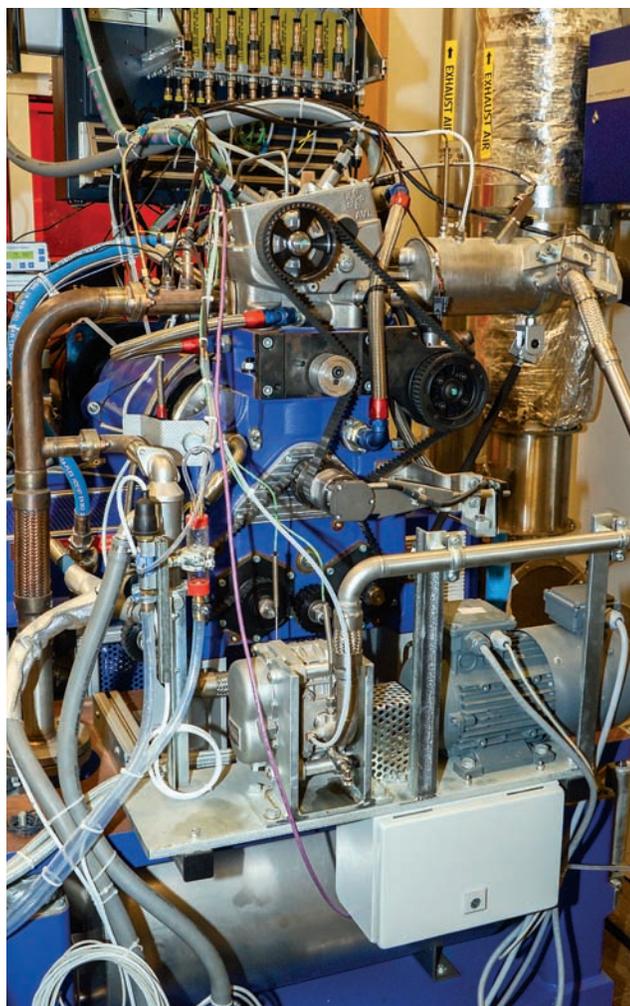
**“WHEN I RETURN TO SAUDI ARAMCO, I’M CONFIDENT THAT I CAN CONTRIBUTE A LOT OF VALUE TO MY TEAM AS A RESULT OF THESE ASSIGNMENTS WITH THE KAUST-CCRC.” NEHAL BOKHUMSEEN**

### COLLABORATION AND COMBUSTION

“This research is important because it is pushing the boundaries of what we know about the combustion of oil-based fuels,” said Amer A. Amer, chief technologist of the Fuel Technology Division at Saudi Aramco’s R&DC. “Saudi



Aramco wants to be at the forefront of creating perfect fuels and perfect engines, in synergy. Why are we doing this? Because oil has become the power source of engines for decades, and we feel that we can do something that demonstrates the importance and the sustainability of oil-based fuels for many decades to come.”



An AVL single cylinder engine used for testing.

## FUELCOM SUCCESS STORIES

In the past five years, Saudi Aramco’s FUELCOM initiative has produced a number of accomplishments that are cementing Saudi Arabia’s position as a technology leader in combustion science.

The Saudi Aramco R&DC and KAUST-CCRC jointly established the Saudi Arabian Section of the Combustion Institute (SAS-CI). The section brings together combustion scientists from global research institutions to develop and share innovative solutions that contribute toward sustainable energy systems.

Earlier this year, the fifth annual SAS-CI meeting was held at the King Abdulaziz City for Science and Technology in Riyadh, Saudi Arabia, with 80 combustion scientists from Saudi Arabia, Egypt, Turkey, the United Arab Emirates, and the United States in attendance.

## ARAMCOMECH

AramcoMech is a new industry standard in base fuel chemistry modeling. In 2010, Saudi Aramco’s R&DC commenced a long-term collaboration with several research partners that resulted in the development of a state-of-the-art chemical kinetic model capable of describing hydrocarbon fuel oxidation in a variety of combustion systems.

This program brought together researchers from the KAUST-CCRC, Sandia National Laboratory in the U.S., CNRS-Nancy in France, and National University of Ireland-Galway.

The model was first published in 2013 under the name “AramcoMech” and has since been cited in 105 publications by top international research institutions. The existing version of AramcoMech is capable of accurately predicting the ignition characteristics of a range of hydrocarbon fuels.

This capability is currently being extended by KAUST-CCRC researchers to include accurate descriptions of the combustion emissions, including the formation of soot.

To date, AramcoMech has been used by organizations such as Rolls Royce and Alstom for both product development and research purposes.

## FUEL DESIGN TOOL

Researchers from Saudi Aramco’s R&DC and KAUST-CCRC have jointly developed the Aramco KAUST Fuel Design Tool. This tool complements AramcoMech in that it can be used to develop surrogate fuels that match the physical and chemical properties of real fuels.

This is an achievement of great significance as real fuels are generally unable to be studied numerically due to their complexity. The tool will soon be made openly available to benefit the broader combustion research community.

William Roberts, director of the KAUST-CCRC, agrees, saying that the collaboration between KAUST and Saudi Aramco allows for a cross-fertilization that mutually benefits both partners.

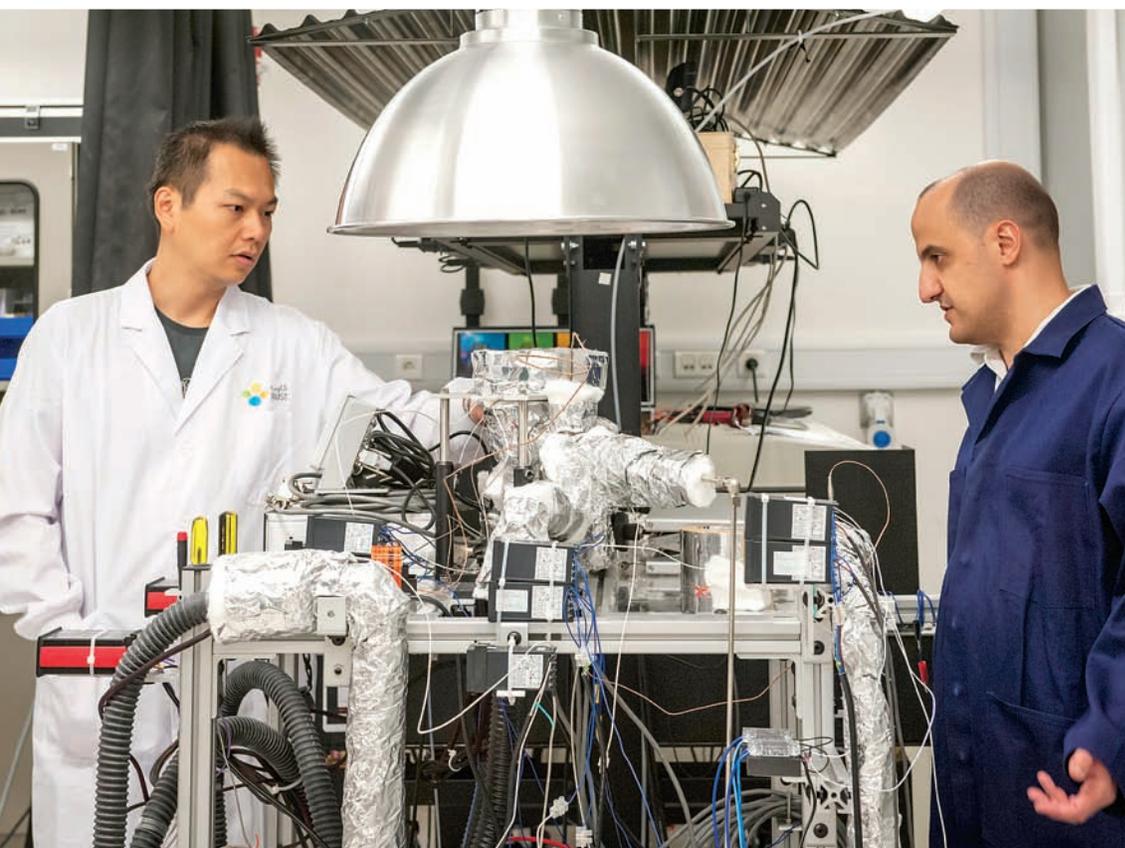
“Globally, this can have a big impact,” Roberts said. “What makes this FUELCOM program so successful is collaboration. Foremost, KAUST is an educational institution. We graduate students and provide them with good academic and research skills. But through our collaboration with Saudi Aramco, our students also get the opportunity to focus on real-world problems and to work on research that the industry feels is crucial to their business.”

At KAUST-CCRC, professor Mani Sarathy indicates that KAUST researchers realize that these collaborative research activities are essential for the future of transportation and could have very powerful ripple effects.

“For decades, automotive engine design has been conducted in a vacuum, simply striving for improvements to the combustion engine itself, without altering the fuel that goes inside,” Sarathy said. “Here at KAUST, by understanding how fuels behave in engines, we have the chance to further improve the engine design. So by collaborating with Saudi Aramco, we bring two different research streams together. You can now begin to think about altering fuels such that they are better optimized for a particular engine or combustion system.”

### GOING BEYOND INNOVATIVE RESEARCH

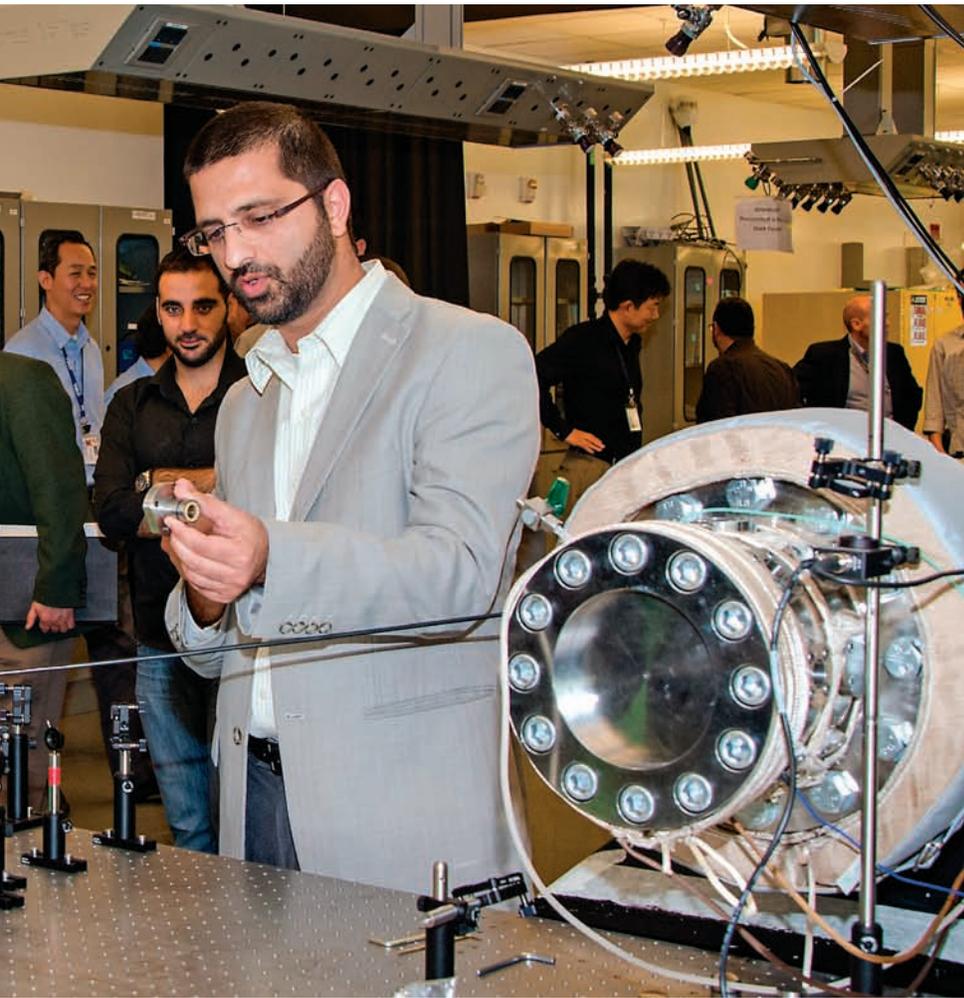
But importantly, the cross fertilization between Saudi Aramco’s R&DC and KAUST-CCRC extends far beyond



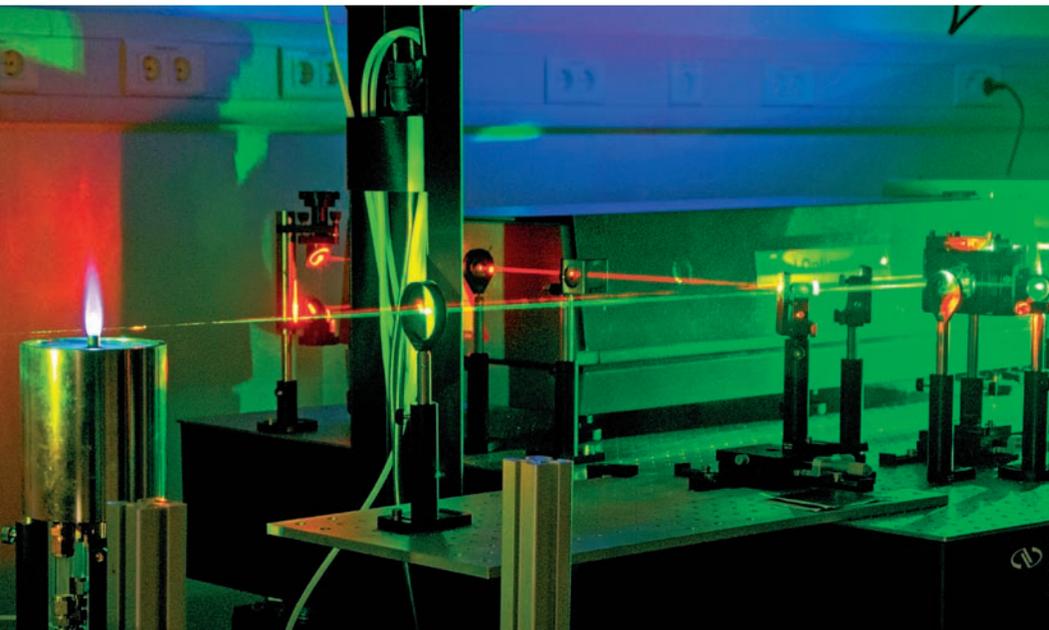
innovative research. Indeed, this research program also provides opportunities for KAUST-CCRC students to undertake various assignments at Saudi Aramco’s R&DC in Dhahran.

Muneeb Khurshid is one student who has benefited from his time in Dhahran. As a KAUST graduate student, Khurshid spent two years shuttling between KAUST and the R&DC in Dhahran, studying an array of fuels as part of his KAUST-CCRC project.

Postdoctoral students Ying-Hao Liao and Gianfranco Scribano screen the experimental setup for product gas sampling from laminar premixed flame.



**LEFT:** Amer A. Amer, left, chief technologist at Saudi Aramco's Research and Development Center, and Gautam Kalghatgi, the principal professional in the company's Fuel Technology Division, listen to a presentation by Aamir Farooq, right, a professor at King Abdullah University of Science and Technology, about the high-pressure shock tube, one of many technologies being developed under a collaborative program called FUELCOM. The goal of the program is to position R&DC at the forefront of research that will help maintain the role of oil derived transport fuels in an ever-changing energy market. **BELOW:** A laser shoots through a blue flame in a laminar diffusion flame experiment, one of many conducted through the collaboration of Saudi Aramco and KAUST.



“As a research student, I have the opportunity to explore everything at KAUST and get the academic skills I need for my career,” Khurshid said. “But the collaboration with Saudi Aramco allows me to combine my academic studies with real-world problems that will have an impact.”

Nehal Bokhumseen, a junior scientist in Saudi Aramco's R&DC, conveys a similar experience. Currently on her second six-month assignment with the KAUST-CCRC, Bokhumseen is using a range of experimental techniques to validate chemical kinetic models describing hydrocarbon fuel oxidation. “When I return to Saudi Aramco, I'm confident that I can contribute a lot of value to my team as a result of these assignments with the KAUST-CCRC,” Bokhumseen said.

Mohannad Khodaier is another Saudi Aramco R&DC team member who is undertaking work within the KAUST-CCRC while concurrently pursuing a doctorate in fuel chemistry. Above all else, he enjoys working on projects that he knows are important for Saudi Aramco.

Collaboration is the key to success in this project, Khodaier said, particularly when researchers are working on the problem from two different directions.

“In our case, this involves trying to gain a better understanding of fuel chemistry on one hand, and rethinking how we should design engines on the other,” he said. “This is why this collaborative research program between Saudi Aramco's R&DC and KAUST-CCRC is so important.”

Bringing academic researchers to Dhahran to work on such projects helps Khurshid to understand how the theoretical combustion knowledge gained at KAUST can be applied in a faster-paced industrial setting.

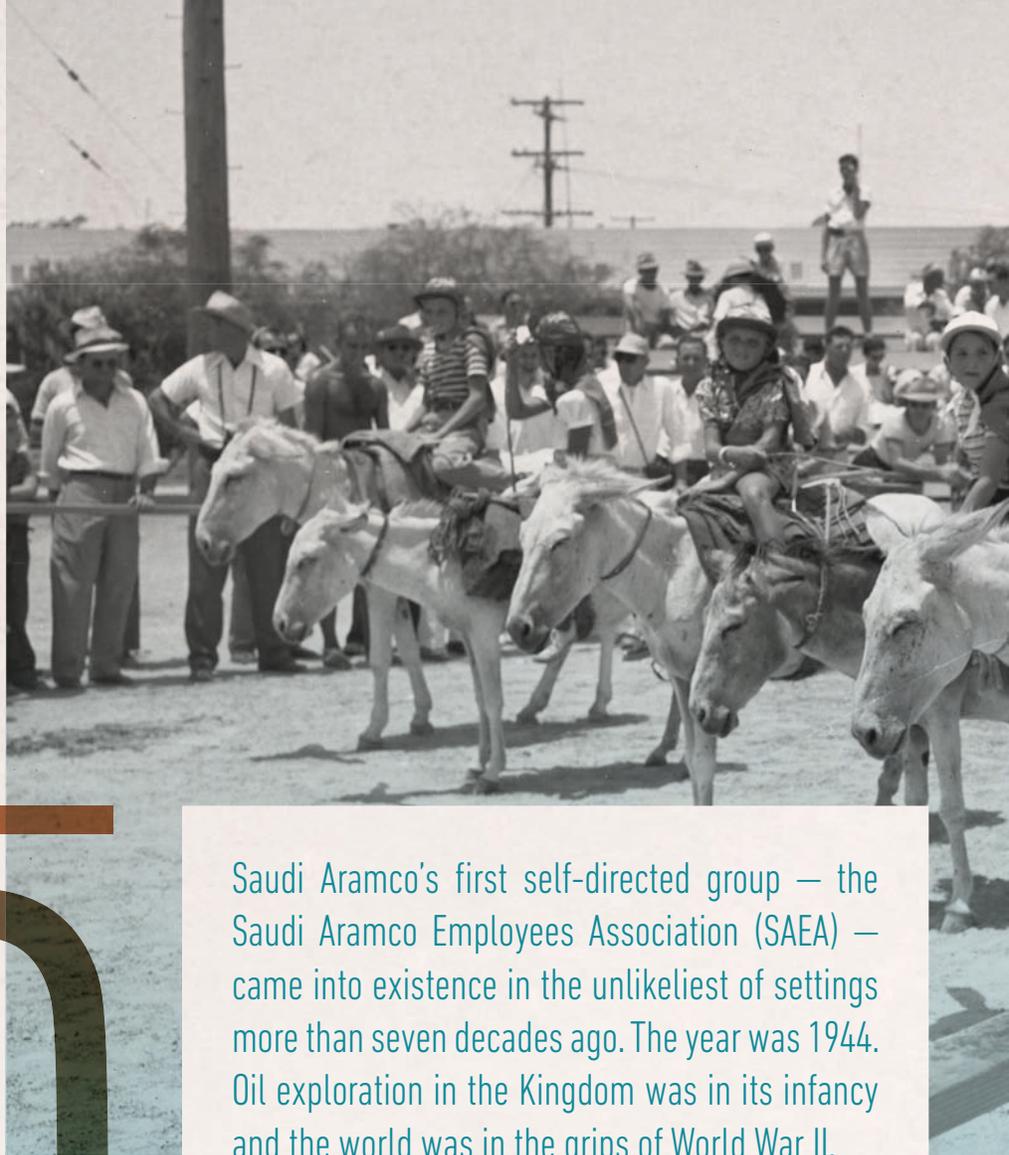
standing of fuel chemistry on one hand, and rethinking how we should design engines on the other,” he said. “This is why this collaborative research program between Saudi Aramco's R&DC and KAUST-CCRC is so important.”

# GOING STRONG AT

# 70

## The Saudi Aramco Employees Association

By Delshad Karanjia



Saudi Aramco's first self-directed group — the Saudi Aramco Employees Association (SAEA) — came into existence in the unlikelyst of settings more than seven decades ago. The year was 1944. Oil exploration in the Kingdom was in its infancy and the world was in the grips of World War II.

The pioneering generations of Aramco's expatriate employees did not have many of the privileges and recreational facilities that today's employees take for granted, but were determined to make Dhahran and the Eastern Province their home away from home. In those days, the most popular meeting point for employees and their families was a modest field canteen that had opened in Dhahran in 1940.

One can picture these adventurous employees meeting in the canteen and making plans for the weekend. The outings and events arranged on a casual basis gradually took on a more formal structure and began to be organized under the label of the Aramco Employees Association (later called SAEA). Eventually, the little canteen became the office and headquarters of the association, whose remit was to sponsor recreational and social events for the company's growing population of expat workers and their families. From its inception, the association was a partnership between the company and its employ-



**UNDER STARTER'S ORDERS:** Eager participants line up for a donkey race, a popular event at SAEA festivals in Saudi Aramco's early days.

ees and residents — association members organized community building social and recreational events, and the company provided logistical support and recreational facilities for leisure activities.

The popularity and success of the Dhahran chapter of SAEA inspired Ras Tanura, Abqaiq, 'Udhailiyah, and Yanbu' to set up their own chapters, all of which were manned and run by volunteers. Given the huge demand for recreational and social events, a group of dependent wives approached the Dhahran chapter to set up an auxiliary group under their banner. After much discussion between association officials and the ladies, it was decided that while female employees were welcome as members, dependent wives should set up their own independent group, which is how the Dhahran Women's Group came into being. In the spirit of harmony and camaraderie that is the hallmark of Saudi Aramco communities, SAEA and the Women's Groups in all company locations have successfully collaborated on many major community events over the years.

For the past seven decades, SAEA has grown and flourished thanks to hundreds of volunteers who make up the board of directors. Today, SAEA's Dhahran chapter

has 46 board members from company business lines as well as representatives from the community. The board meets once a month to discuss and approve event proposals put forward by directors, to keep track of the association's finances, and to discuss membership issues and concerns.

Every SAEA event has a volunteer chairperson and a co-chair, who work with the SAEA office staff to plan and implement the varied programs and activities. SAEA now has chapters in Ras Tanura and 'Udhailiyah, which organize a variety of events catering to their members' diverse tastes and interests. For a nominal fee of SR 4 a month (about \$1.07), membership of

SAEA is an exceptional value for the money.

The company matches each employee contribution, enabling SAEA to offer subsidized rates for most of its events. On average, SAEA's Dhahran chapter alone offers



The annual SAEA festival, with numerous outdoor activities and entertainment for all ages, continues to be a special time for members and their families to enjoy a fun time together.



**LEFT: PAST TIMES:** SAEA members get a glimpse of ancient petroglyphs on visits to historical sites, such as this site in Hail.

its members a choice of more than four events each month.

In the early days, many SAEA events centered on western holidays, such as the Fourth of July, Halloween, and New Year celebrations. At a time when many expatriate employees traveled home only once every two years, the seasonal events and musical programs organized by the association made employees and their families feel at home.

**LEFT: HAVING FUN IN THE SUN:**  
Children enjoy a camel ride on a day out in the desert.

picnics and outdoor events. Huge crowds cheered as riders and donkeys took part in the Commissary Handicap, the al-Khobar Sprint, and the Ras Tanura Derby. One assumes that the donkeys must have been extremely docile and submissive, because SAEA also organized donkey polo and donkey softball matches.

With the support of other self-directed groups, SAEA began to organize more ambitious community entertainment. County fairs and parades became an annual fixture on the SAEA calendar, attracting thousands of visitors. The fairs showcased the growing number of self-directed groups, provided food and entertainment for all ages, and

For reasons that are not immediately obvious, donkey racing became a highlight at many SAEA community

offered a platform for outside companies, such as airlines and travel agencies, to promote their services.

In the 1970s, when the company expanded dramatically, Aramco added more than 32,000 new employees. As the workforce diversified, SAEA activities expanded to showcase and celebrate this diversity.

The county fair theme evolved into international festivals and events focused on customs, cuisine, and culture from around the globe, including the Middle East, Latin America, Asia, and Africa. SAEA's annual festival continues to be a big draw to this day.

Living up to its tagline of "Family, Friends, Fun," SAEA has offered its members cultural activities, family festivities, world-class entertainment, and organized tours showcasing the geography and history of Saudi Arabia.

**DISCOVERING ARABIA:** This beautiful stone building is one of the architectural highlights that can be seen in Asir.



Themed cultural events such as Indian, Persian, Asian, and Lebanese Nights, Latino Festivals, and Mardi Gras celebrations provide the perfect showcase for multicultural Saudi Aramco communities.

These events feature authentic cuisine and entertainment from the region being showcased. Food competitions are a popular SAEA offering, with chili and curry cook-offs and gumbo contests being served up regularly.

Members can buy subsidized tickets for events as diverse as the Grand Prix in Bahrain, or the Chuckle Club. Variety acts, such as the Houdini Show, Stars on Ice, Fawly Towers, and puppet shows for children sold out at all community venues. The association has regularly partnered with the Dhahran Theater Group to present live events.

SAEA also offers members and their families an opportunity to tour parts of the Kingdom that are not easily accessible to others. Popular excursions include visits to Hofuf, Qatif, al-Hasa, and Nariya.

In recent years, SAEA trips have ventured further afield to Riyadh, Jiddah, Hawar Island, Abha, Asir, and Madein Saleh. Trips to the Saudi Aramco Shaybah facility in the vast Rub' al-Khali or "Empty Quarter" have proved so popular that SAEA uses a lottery system to draw tickets for the trip.

In 2014, SAEA led a trip to the Janadriyah National Festival for Heritage and Culture in Riyadh. As the tourism industry begins to grow within the Kingdom, SAEA

now works with licensed tour guides to offer trips to hitherto unexplored locations, such as the Farasan Islands and Hail.

As the company prospers and expands, SAEA will continue to offer programs and events to

**"SAUDI ARAMCO'S CORPORATE MANAGEMENT IS PROUD OF SAEA'S SEVEN DECADES OF ACCOMPLISHMENTS, AND GRATEFUL TO ITS VOLUNTEERS FOR THE OUTSTANDING EFFORT THEY HAVE CONTRIBUTED OVER THESE YEARS."  
MUHAMMAD M. AL-SAGGAF**



**ABOVE: THAT'S ENTERTAINMENT:** Musical performances by local troupes give members a taste of local culture and are a mainstay at many SAEA events.  
**RIGHT: Shaybah, with its giant red sand dunes, is just one of the many trips that are part of SAEA's Discover Arabia tours, which it organizes for its members.**





**ABOVE: TASTE TEST:** Judges sample a variety of delicacies at a cooking contest organized by SAEA in 1984. **RIGHT: ENTER THE DRAGON:** Community members proudly display their rich cultural heritage during the traditional parade at the 2010 SAEA festival in Dhahran.



members and their families. Instead of resting on its laurels, the association is constantly on the lookout to provide new and exciting opportunities, programs, and events to members.

In his congratulatory message on the occasion of SAEA's 70<sup>th</sup> anniversary, Muhammad M. Al-Saggaf, acting service line head of Operations & Business Services, summed up the association's role in community life: "SAEA makes a powerful difference in the lives of Saudi Aramco employees and families. For seven decades, SAEA has enabled tens of thousands of employees and their families to build cross-cultural ties in the community and promote understanding of local and international cultures.

"SAEA's achievements involve a huge amount of work. None of it would be possible without a host of unsung heroes — SAEA's volunteers. Saudi Aramco's corporate management is proud of SAEA's seven decades of

accomplishments, and grateful to its volunteers for the outstanding effort they have contributed over these years."

From humble beginnings in a canteen in 1944, SAEA has grown into the company's largest self-directed group with a membership of more than 7,500 employees in the Dhahran chapter alone. Being a volunteer organization, SAEA's very existence depends on the active participation and support of its members. SAEA is where it is today thanks to generations of selfless volunteers and part-time staff who kept the ball rolling for 70 years. With community spirit being one of Saudi Aramco's biggest strengths, SAEA's future looks bright as it continues to be of the community, by the community, and for the community. ☺

# abbrev.

Saudi Aramco news in brief



Adnan A. Al-Kanaan, second from left, with the Society of Petroleum Engineers Service Award. Pictured from left are Khaled F. Al-Faleh, Al-Kanaan, Zillur Rahim and Ahmed M. Al-Omaid.

## SPE honors GRMD manager Al-Kanaan

**ABU DHABI, UAE** — The manager of Saudi Aramco's Gas Reservoir Management Department (GRMD), Adnan A. Al-Kanaan, received the Service Award from the international Society of Petroleum Engineers (SPE) at a recent convention in Abu Dhabi, UAE. The award was given in recognition of his knowledge-sharing efforts across the fields of research, new technologies, field applications, communication skills in dealing with a wide variety of industry professionals, and unwavering support for SPE events, conferences, and technical workshops.

GRMD, which is responsible for all of the Kingdom's nonassociated gas reserves and production, has 120 employees and currently manages

more than 750 producing wells from onshore and offshore fields that deliver 10 billion standard cubic feet (Bscfd) of gas production — a volume that is set to rise to 15 Bscfd within the next three years.

GRMD is accountable for the overall initiative to expand the Kingdom's gas program with strategic planning and development efforts so that future increases in energy demands are met in an optimal and safe manner with a focus on environmentally friendly practices.

## Kingdom open for business

**SHANGHAI, CHINA** — Saudi Aramco recently hosted a two-day forum in the Chinese financial hub of Shanghai to boost investment

in the Kingdom, including promotion of the three newly developed industrial platforms of Jazan Economic City, Al-Hasa Energy Industrial City and Ras Al-Khair Industrial City.

Under the theme of "Building the belt and road together, connect with opportunities in Saudi Arabia," the forum was intended to inform Chinese manufacturers and investors of the sustained investment opportunities in Saudi Arabia and explore closer partnerships in the energy sector, i.e., upstream, oil and gas, refining and petrochemical, water and power.

The forum brought together more than 150 participants, including officials and professionals from Saudi Aramco and Aramco Asia, policymakers from China, as well as representatives from 60 local companies.

"Chinese investment is welcome in Saudi Arabia, and there are plenty of opportunities for Chinese companies in the country, in both energy and non-energy sectors," Nabil A. Al-Nuaim, president of Aramco Asia, said in his keynote speech at the opening ceremony.



Nabil A. Al-Nuaim, president of Aramco Asia, delivers opening remarks during the forum that aimed to boost Chinese investment in the Kingdom.



Senior management from Saudi Aramco and LANXESS pose for a photo after the signing ceremony for the new 50-50 joint venture.

## AOC and LANXESS sign joint venture agreement

**COLOGNE, GERMANY** — Saudi Aramco’s subsidiary, Aramco Overseas Company, and German specialty chemicals company LANXESS have signed a binding agreement to create a new 50-50 joint venture company for the development, production, marketing, sale and distribution of performance polymers (including synthetic rubber and high-performance elastomers) used in the global tire industry, auto parts manufacturing and a wide range of other applications.

LANXESS will contribute to the joint venture its existing global synthetic rubber and elastomers business units, which include 3,700 highly skilled employees, an established footprint of 20 production sites and four research centers in nine countries across Europe, Asia and the Americas.

“This is yet another major step forward in Saudi Aramco’s globally integrated downstream expansion strategy. It will further enhance our competitive

position in integrating our diverse portfolio,” said Amin Nasser, president and CEO of Saudi Aramco. “Partnering with a world-class company like LANXESS will help scale up our global presence, and in turn create more opportunities for sustainable growth in Saudi Arabia and in markets around the world.”

## Innovation sees Riyadh Refinery deploy in-house patented technology

**RIYADH, SAUDI ARABIA** — In a major boost to Saudi Aramco’s drive toward becoming a global leader in industry technology, the Riyadh Refinery has deployed an in-house innovation that will have considerable cost saving benefits.



The Sound Velocity Dewatering System, the brainchild of two Saudi Aramco engineers, Fawaz Al-Sahan and Omar Al-Zayed, enables the safe control of a water stream exiting a dewatering tank system. The innovation works by calculating the velocity of sound energy as the sound travels through the water stream flowing through the drain line connected to a dewatering tank.

By monitoring the velocity of the sound energy for a period of time, the reading is used to automatically operate a control valve to a precise position, enabling the draining of the water.

## PMT and EPD join to relocate lizards



These reptiles have been relocated to new homes in a protected area in Manifa.

**DHAHRAN, SAUDI ARABIA** — While conducting an Environmental Impact Assessment to ensure Saudi Aramco’s new Fadhili Gas Plant complies with company and international regulatory norms, the Project Management Team discovered that several Dhub (spiny-tailed lizards) were using the project area that has been earmarked for development as their home.

Based on population declines in recent decades due to habitat loss and overhunting, the International Union for Conservation of Nature has classified the species at regional and international

The Sound Velocity Dewatering System costs only 30% of a conventional dewatering system. By monitoring the velocity of the sound energy for a period of time, the reading is used to automatically operate a control valve to a precise position, enabling the draining of the water.



Young employees gather around subject matter expert Umesh Gadani as he explains ball-type valve functionality and internal parts during a recent course at TADRIB, the new training facility in Manifa that features an accelerated knowledge-transfer program in a variety of areas for Manifa technicians specialized in mechanical, electrical, air conditioning, metal fabrication, and instrumentation.

levels as “Vulnerable,” defined as facing a high risk of extinction in the wild.

In line with EPD’s mission to continually protect the environment, EPD took the lead during the planning phase to provide guidance, coordination and field support during the capture and relocation of these reptiles, which began in March 2015.

They have now been relocated to their new home in a protected area within Manifa and are doing well today. Further monitoring of the ecological success of the relocation will continue for many months. The reptiles will start breeding in the spring season and bring to life a new Dhub colony at Manifa.

## Manifa rolls out new training facility

**MANIFA, SAUDI ARABIA** — In the pursuit of excellence, the Manifa Producing Department recently unveiled a newly established training facility in Manifa called TADRIB.

As the name suggests (“tadrib” means training in Arabic), the center is designed

to provide the tools needed to acquire the Technical Aptitude Development and Reinforcement of Industrial Best practices.

Established in Manifa in late 2014 to reduce the gap between experienced and young technicians, TADRIB offers an accelerated knowledge-transfer program in a variety of areas for Manifa technicians

ASC president Basil Abul-Hamayel interacts with officials from various top universities in the United States.



specialized in mechanical, electrical, air conditioning, metal fabrication and instrumentation.

Since its inception, 51 training sessions have been conducted in the center with 173 Manifa technicians attending.

The Manifa TADRIB center comprises a training workshop to provide hands-on training, a classroom facility, an instrument testing bench, a simulator training room equipped with an emergency shutdown system, a distributed control system, a vibration monitoring system, and a remote terminal unit to provide specialized instrumentation training sessions.

## Road to Success — ASC helps get Saudi students off on right foot

**HOUSTON, TX, USA** — For this year’s group of nearly 180 company-sponsored freshmen who attended our “Road to Success” orientation in Houston, the message they received was an important one: We are here to support you during every step of your college experience.

This message was recently conveyed at the annual orientation program led by the Industrial Relations — Career Development Division in the United States.



Crews prepare to transplant Acacia trees that were in a proposed expansion zone for the Master Gas System Project. In alignment with the company's commitment to environmental preservation, the trees were safely transplanted to a new area where they can thrive. So far, most of the replanted trees have taken root.

compression station, with an approximate area of 420,000 square meters, was found to be an important habitat for the old Acacia trees and many other native plants and wildlife.

Acacia trees help soil stabilization and they are a food source for wildlife, in addition to their use in traditional medicine recipes.

The replanting was completed and a recent visit showed that the majority of the replanted trees are flourishing in the new location.

The project has been well received by communities near the pump station, as well as national environmental authorities. Also, the effort has been shared with international authorities as an example of our commitment toward controlling desertification. 🌍

Each year, Road to Success reflects the commitment toward cultivating future leaders, a dedicated effort that is carried through by the staff leading the program.

The Road to Success orientation featured activities and workshops covering subjects such as cultural awareness, campus resources, health and well-being, the legal system and finances.

The orientation also gave students the opportunity to hear from speakers such as ASC president Basil Abul-Hamayel, ASC Industrial Relations manager Ghassan AISuwayied, and Vice Consul of the Royal General consulate of Saudi Arabia in Houston, Fawaz Al Dawish.

## Preserving the green — progress and preservation with Pipelines' Acacia efforts

**DHAHRAN, SAUDI ARABIA** — In an effort to preserve the biodiversity along the East-West Pipelines Department's (EWPD) corridor and facilities, EWPD

has successfully replanted 192 mature Acacia trees and saved the local habitat near one of its operating areas. This is in compliance with the Saudi Aramco Environmental Protection Policy calling for environmental protection and minimizing operational impacts on the environment from company operations.

As EWPD is going through a massive expansion as part of the Master Gas System Project, a new grass root gas compression station will be constructed east of Riyadh. The proposed location of the new

# YOUR FEEDBACK Matters

Help us develop the new Saudi Aramco *Dimensions International*. Please take a moment to answer these brief questions.



[www.saudiaramco.com/dimensionsurvey](http://www.saudiaramco.com/dimensionsurvey)

## worldview



### *In the shadow of Half Dome*

Eric M. Cordoves captured this image of Half Dome in Yosemite National Park, California in the U.S. last August while on vacation. Located in the eastern end of Yosemite Valley, Half Dome stands 4,737 feet (1,444 m) above the valley floor. Each year, thousands of people hike the 14- to 16-mile long trail to reach the top — another option is to scale the face of the mountain.

While standing atop Glacier Point, he used his D-7000 Nikon to take the photograph. Cordoves lives in Najmah, Saudi Arabia, and works in Ras Tanura as a maintenance engineer in the North Refinery Maintenance Division. He has been with the company for 7 years.