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INTERNATIONAL

Lending a hand to save a rare bird

A joint effort between the Saudi Wildlife Authority, the Smithsonian Institution, and Saudi Aramco



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INTERNATIONAL

Spring 2019

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About the cover:

At 46 centimeters and approximately 240 grams, the Asir magpie is a mystery. Found only in Saudi Arabia, the magpie lives exclusively in the comfortable Asir ecosystem.

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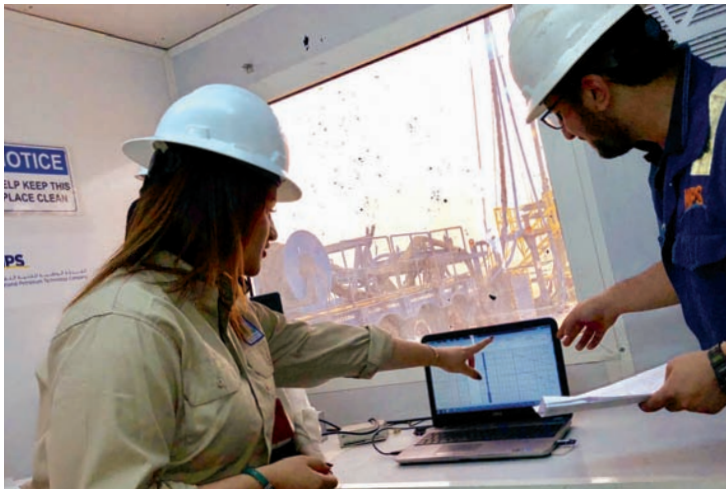
2 Protecting the Asir magpie

In the Kingdom's southwest Asir region, a rescue mission is underway to save one of its residents — the highly endangered Asir magpie — whose estimated numbers have dwindled to merely 130 breeding pairs.



8 Crude to Chemicals — What's that all about?

A flagship technology that will help Saudi Aramco's goal to become the global preeminent energy and chemicals company continues with the company's Crude to Chemicals (C2C) program — the direct and optimized conversion of crude oil to chemicals.



16 Diversity makes further inroads into the Southern Area

In 2018, Saudi Aramco's Southern Area Production Engineering Department (SAPED) made a paradigm shift. Once a bastion of male engineers, SAPED now has female petroleum engineers who have joined the department, increasing gender diversity in the workforce.



22 New amphibious vehicle: By land and by sea, safe and reliable

Saudi Aramco puts safety first, and recently introduced the new ARKTOS amphibious vehicle at the Berri Causeway, which can evacuate up to 52 personnel in the unlikely event of a hydrogen sulfide gas release.

departments

abbrev. 28 **worldview** Back Cover





Protecting the

Asir magpie

Saudi Aramco
lends a hand to
save a rare bird

BY JANET E. PINHEIRO

PHOTOS BY AHMAD EL ITANI

Joining forces with the Saudi Wildlife Authority, and the Smithsonian Institution in the U.S., Saudi Aramco is working to preserve one of the Kingdom's rarest treasures — the Asir magpie.

With its estimated numbers reduced to merely 130 breeding pairs, the rare species of bird is elusive. Renowned for its high intelligence, it lives exclusively in the comfortable Asir ecosystem of the Kingdom's Southwest. And while it suffers from no shortage of food or

nesting areas, and it has seen no new up-tick in predators or competitors for land, it continues to struggle to survive.

That's why Saudi Aramco's Environmental Protection Department (EPD) identified it as a high conservation priority from the 500 species of birds recorded in Saudi Arabia.

As part of its commitment to preserve and protect the natural environment, Saudi Aramco is partnering with the Saudi Wildlife Authority and the Smithsonian Institution to conduct research into the magpie's perilous status.



In the early summer of 2018, two Smithsonian scientists from the U.S. visited Asir to observe and prepare for an initial 12-month research study. During their time, they successfully captured 12 Asir magpies, tagging the birds, obtaining measurements, and then releasing them unharmed. The study's scientific recordings are the first known basic measurements of the bird, which has seen declining numbers over recent years and is facing a significant threat.

The highest, coldest, and wettest part of Saudi Arabia is an exquisite land where misty clouds silently wrap themselves around steep peaks, veiling biodiversity preserves concealed in remote corners.

In the Kingdom's southwest Asir region, spectacular mountain ranges span across 100,000 square kilometers, pushing imposing peaks up to 3,000 meters above sea level and randomly scattering giant granite boulders across the landscape.

Within the region's rich sprinkling of juniper forest, a rescue mission is underway to save one of its residents — the highly endangered Asir magpie, whose estimated numbers have dwindled to merely 130 breeding pairs.

Research is needed as the explanation for the decline is as elusive as information about the bird. Therefore, EPD is working with Smithsonian officials to capture, record, tag, and release the birds so their dilemma can be better understood and addressed.

Found only in Saudi Arabia, the sleek black-and-white Asir magpie, renowned for its high intelligence, lives exclusively in the comfortable Asir ecosystem, where more rain falls than anywhere else in the country.

In the early summer of 2018, scientists from the Smithsonian Institution commenced a joint project with EPD to research the mystery of the magpie's declining population.

According to EPD terrestrial ecologist Christopher R. Boland, the causes of the decline are not clear, but could be habitat fragmentation and lack of genetic diversity.

"It's perplexing. There is no shortage of food or nesting sites. There doesn't appear to be any new predators or competitors in the landscape driving the magpies toward extinction," Boland said.

"If the birds are unable to disperse from one patch of juniper to another, then they may be suffering from genetic problems, such as inbreeding. Scientific research is required to form effective conservation actions to protect this precious bird."

Saudi Arabia's only endemic bird

At 46 centimeters and weighing an average of 240 grams, the Asir magpie is a striking mid-sized bird, found only in Saudi Arabia.

It is known locally as the "Ack-Ack," a name that is reflective of the bird's series of charismatic calls, and its nest is a massive dome, usually built 4 to 7 meters high in a juniper or acacia tree.

Beyond this, very little is known about what the Asir magpie eats, its breeding patterns, how far it moves, the composition of its family group — and all this key information is needed for its conservation.

"It's just one part of our larger effort to preserve biodiversity and their habitats — in the Kingdom and abroad." — OMAR S. ABDULHAMID

Tracking movement and numbers

The first joint in-Kingdom initiative between the Smithsonian and EPD, the Asir magpie project involves collecting DNA samples from the birds and tracking their movements to better understand and mitigate the factors impacting their population.

The Saudi Wildlife Authority is working closely with the research team, as well as local community volunteers.

Local communities play a significant role in the preservation of an ecosystem.

During May and June, two Smithsonian scientists from the U.S. visited the Asir region to observe the rare birds and prepare for an initial 12-month research study.

Before the research team arrived in the region, volunteer birdwatchers from the surrounding mountains spent two weeks identifying the best magpie sites.

Retired school teacher Ahmed Al-Omari saved the project

significant time by revealing the birds' homes around the Tanomah area.

Twelve Asir magpies were successfully caught, their vital measurements recorded, tagged with a state-of-the-art tracking system, and then immediately released unharmed.

The study's scientific recordings are the first known basic measurements of the bird.

Top: Project ornithologists keep a close eye on the Asir magpie and its genetic markers, which are important to identify conservation issues such as inbreeding. The markers are measured by taking a tiny blood sample. *Bottom:* Evan Buechley works on a cage designed to capture an Asir magpie for measuring, recording, and tagging.



GPS tracker

Using a leg-loop harness, each research bird is tagged with a GPS tracker, the combined weight of which is no more than 4% of the magpie's body mass.

The birds receive one of two types of miniature trackers — one uploading lots of data from multiple pinpoint locations visited by the bird, and the other type uploading fewer locations, but with data that is immediately transmitted via satellite back to the Smithsonian's research facilities in Washington, D.C.

Smithsonian ornithologist Evan Buechley described the trackers as “pretty amazing” cutting-edge technology. “By deploying these trackers, we'll be able to track the precise movements of magpies throughout the year,” Buechley noted.

Location fixes from the trackers are the first step toward understanding where the Asir magpie lives and where it goes.

Buechley explains the trackers will deliver three sets of key information. “First, the trackers will let us know whether the Asir magpie migrates seasonally from lower to higher ground. Second, how and when their offspring disperses from the family home. Third, we can find out what habitats they like to use,” he said.

When captured for tracking, each bird is also given its own identity with a uniquely numbered aluminum band on its right leg.

Genetic markers

A tiny 0.5 milliliter blood sample taken from each of the 12 captured birds will be housed by the Saudi Wildlife Authority.

DNA extracted from the blood and analyzed in the lab will be used to identify the sex of each bird and assess population genetics.

Smithsonian ornithologist Alex Jahn said genetic markers are important to identify conservation issues such as inbreeding.

“There can be negative consequences for a population if it is too small and close relatives are inbreeding,” Jahn said. “We like to see bird populations with high genetic variability.”

“Genetic markers help us understand if there are issues in the genetic make-up of the parent population, and potential issues with offspring.”

Significant discovery

Already, the scientists have made a significant observational discovery from the preliminary research into the Asir magpie; it appears they live in family groups of two to four adults.

Some birds, particularly those living in arid ecosystems such as Saudi Arabia, require a family group to share the hard work of raising offspring. Several adults may be required to find enough food to raise a single brood of chicks.

Boland said the previously unknown family living arrangement was an important finding toward tailoring conservation efforts for the Asir magpie.

Based on what the 12-month initial study finds, the research team aspires to tailor a conservation plan to ensure a long-term viable population.



An early morning call

Ornithologists drink in the character of the Kingdom

A characteristically cool summer sunrise in Saudi Arabia's mountain region of Asir is welcomed by the distinctive call of the Asir magpie, the only bird found exclusively in the Kingdom.

Waiting among the Asir's juniper trees are two American ornithologists, making the most of the early morning hours when the birds are most active. They're watching for Asir magpies.

Ornithologist Evan Buechley has just trapped a mature male magpie, and breathes in deeply before he carefully starts the process of recording and tagging one of these rare birds.

Stunning turquoise-tinted feathers adorn the black-and-white plumage of the magpie, which is cautiously removed from the specially designed trap to ensure no harm, and placed in a soft cotton bag for weighing.

The other ornithologist, Alex Jahn, records the weight and helps Buechley keep the bird calm by placing a hood over its head.

After recording its sex, estimated age, fat content, condition of its feathers, and measurements of its wings, tail and beak, the magpie is tagged with a petite-sized GPS tracker.

The final interruption to the magpie's morning is a blood sample, before the bird is released back toward the climbing sun.

These ornithologists are from the Smithsonian Institute, which is collaborating with Saudi Aramco's Environmental Protection Department (EPD) to research the mystery of why the highly endangered Asir magpie's numbers have been reduced to approximately 130 breeding pairs.

The research is starting with a 12-month project to estimate magpie population size, density, habitat use, and distribution, and Buechley says it is an exciting privilege to come to Saudi Arabia to study a little-known species and its ecosystem.

"Saudi Arabia is a key country on one of the world's largest migratory flight paths, where birds from Europe, Asia, and Africa congregate in large numbers. Further, the world recognizes the Asir Mountains as a unique and globally important area for biodiversity conservation," he notes.

"The people of Saudi Arabia understand a harsh and fragile environment like no one else, and our research into the Asir magpies will assist the Kingdom's conservation work," Buechley adds.

With an extensive history of promoting environmental awareness and protecting ecologically sensitive areas, EPD identified the Asir magpie as a major conservation priority.

The company engenders an environmentally responsible culture by helping to preserve the balance and integrity of the Kingdom's natural ecosystem through judicious use of natural resources.

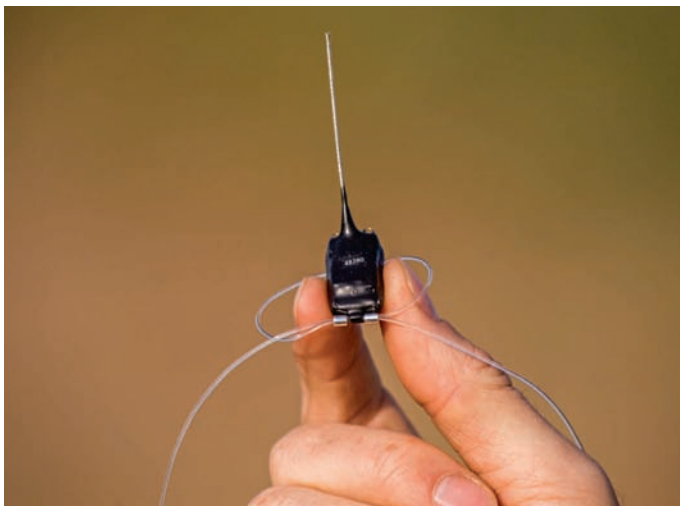
"Saudi Arabia has been the only place I have visited that when I get up to see birds at 4 a.m., I also hear the call to prayer," reflects Jahn.



Top: The highly endangered Asir magpie is the only bird species to occur entirely within Saudi Arabia. Numbers have dropped to around 130 breeding pairs and the United States' Smithsonian Institution and Saudi Aramco's Environmental Protection Department have commenced a preliminary research study aimed at saving the bird. *Photo by Nader Al-Basri.* *Middle:* Evan Buechley (right) and Alex Jahn work to tag a captured Asir magpie with a petite-sized GPS tracker. The two Smithsonian ornithologists got up at 4 a.m. daily to monitor, capture, and release Asir magpies as part of a joint effort between the company, the Saudi Wildlife Authority, and the Smithsonian Institution. *Bottom:* Alex Jahn sets a trap with food to catch the Asir magpie.



*Above: An Asir magpie as it is just released by Alex Jahn.
Below: A close-up image of the state-of-the-art tracking system used on the Asir magpies.*



“As a company of scientists and engineers, we appreciate the importance of each individual component of a healthy, functioning ecosystem. By working with the Smithsonian Institution and the Saudi Wildlife Authority to reverse the decline of the Asir magpie, we’re helping preserve the balance and integrity of the Kingdom’s natural ecosystem,” he stated.

“Birds are important to the cultural heritage of Saudi Arabia, and the health of their populations is an indicator as to the health of our environment. We will use data collected in the field to create models that help us understand how a changing environment may contribute to their endangered status,” Abdulhamid added.

Saudi Aramco’s role

Protecting endangered species and preserving habitats for biodiversity is a priority for Saudi Aramco.

Omar S. Abdulhamid, EPD manager, said partnering with the Smithsonian Institution to protect the endangered Asir magpie was about more than keeping a single bird species from slipping into extinction.

“It’s just one part of our larger effort to preserve biodiversity and their habitats — in the Kingdom and abroad,” Abdulhamid said.

The Smithsonian

Established in 1846, the Smithsonian Institution is one of the world’s great knowledge institutions. Based in the United States, the Smithsonian has 19 global research centers.

Smithsonian scientists are also putting collars on endangered wildlife at Saudi Aramco’s Shaybah Wildlife Sanctuary, located at the company’s oil and gas site in the Kingdom’s iconic southeast Rub’ al-Khali. 🌐

CRUDE — TO — CHEMICALS

WHAT'S THAT ALL ABOUT?

BY JAMSHEED M. DIN

PHOTOS BY BRIGIDO D. ALCAYDE





Above: Collaboration is key to success in the Crude to Chemicals program. In a research lab at the R&DC, scientists Gopal Juttu (left) and Musaed S. Al Ghrami discuss key elements of the program, while lab technicians are busy at work. Left: At the Research and Development Center in Dhahran, company scientists are pursuing multiple research streams in crude to chemicals technology, helping to position the company as a global leader in the field.

Saudi Aramco's relentless march to becoming the global preeminent energy and chemicals enterprise continues unabated.

A flagship technology initiative propelling this momentum is the company's Crude to Chemicals (C2C) program.

For those who dwell outside the chemicals world, the program's objective sounds relatively simple — the direct and optimized conversion of crude oil to chemicals.

But chemical engineers and chemists know the true reality that masks this seemingly straightforward proposition. And

at Saudi Aramco's Research and Development Center (R&DC) in Dhahran, scientists are determined to break new ground and position the company as a global leader in the field.

By leveraging the Kingdom's vast hydrocarbon resources, company scientists are working to develop optimized conversion processes to bring about a drastic reduction in the cost of producing a wide variety of petrochemical products.

Petrochemicals are the raw ingredients that constitute practically every essential item in modern life. With the diversification of the Kingdom's economy being a key pillar of Saudi Vision 2030, the potential benefits of the program for the nation's development and prosperity are evident.

"Today, chemicals represent the fastest growing crude oil demand sector," says Ahmad O. Al-Khowaiter, Saudi Aramco's chief technology officer. "Crude to chemicals technologies allow us to increase the quantity of high-value chemicals we produce, and at the same time, reduce the carbon footprint associated with the use of our oil.



Abdenour Bourane has been involved in the C2C project for seven years.

Saudi Aramco is setting its sights on becoming the world's leading fully integrated energy and chemicals enterprise. To help reach this summit a host of collaborations, acquisitions, and joint ventures have already taken place. In parallel, an ambitious technology strategy is in full swing at the R&DC to help achieve this vision.

The research facility is breaking new ground. By unraveling the chemistry behind crude oil composition and conversion into chemicals, the R&DC is braving uncharted territory.

"This is truly pioneering research where we are taking crude oil and looking at the shortest and most optimal pathways to derive chemicals directly through breakthroughs in catalyst and separation devices," says Ammar A. Al Nahwi, R&DC manager.

"We are targeting 70% to 80% of each barrel of crude oil being converted to chemicals in a competitive manner. We are demonstrating clear technology leadership in this field."

As an engineer himself with a Ph.D. from the Massachusetts Institute of Technology, Al Nahwi understands the mechanics that govern the research world and the complexities of the task at hand.

Furthermore, growing our chemicals business enables expansion of the downstream industry and greater job creation in the Kingdom."

RESEARCH HUB

The curved blue stained glass windows of R&DC glisten in the sunlight as they absorb the rays of the midmorning sun. Inside the expansive research facility, there's an air of coolness that permeates through its labyrinth of corridors and laboratories.

Scientists are busy at work. Some are engrossed in fuel technology research, while others are immersed in optimizing the combustion engines of the future. Whiteboards are covered in complex formulas and schemata — the inner thoughts of some of the company's brightest minds laid bare. With a diverse research agenda spanning sustainability, midstream and downstream, there is simply no time to waste at this corporate technology hub — technology moves fast.

One group of researchers knows this all too well.

THE CURRENT PROCESS

Typically processed in an oil refinery, crude oil is transformed into a variety of fractions such as naphtha, diesel, kerosene, gas oil, and high boiling residue.

Some of these fractionated products are then used as feedstocks for conventional petrochemical production.

But it's costly. The process requires substantial, expensive, and energy-intensive refining steps.

One approach to improve the process is by optimally integrating current refining processes to yield more chemical products per barrel of oil. This involves tweaking existing proven technologies and processes

in an integrated refining complex to raise the chemical production level per barrel of oil from the regular 8% to 12%, up to 50%.

The recent Saudi Aramco and SABIC crude oil to chemicals partnership is a good example of this approach.

The team developed an innovative configuration utilizing proven refinery and petrochemical technologies for chemicals production directly from crude oil.

But what if the yield could be increased even more with fewer processes? This is the primary motivation for the C2C technology program: Developing novel competitive routes

"TODAY, CHEMICALS REPRESENT THE FASTEST GROWING CRUDE OIL DEMAND SECTOR."

— AHMAD O. AL-KHOWAITER

to obtain higher yields of chemicals per barrel, while at the same time, streamlining the whole process — reducing energy and capital intensity, and increasing profitability.

To crack the code, company engineers and scientists are pursuing multiple research strategies and technologies. Their research focuses on thermal and catalytic routes to convert crude oil to chemicals.

Each research track has its own special qualities and intricacies, and is at a different stage in the development process. All, however, share a unifying theme — developing a process for the direct conversion of crude oil to chemicals.

“Each research track will give us a different technology option,” notes Ibrahim A. Abba, principal scientist and chief technologist for the Chemicals Research and Development Division.

“We are not putting all our eggs in one basket. By



“WE ARE FORTUNATE TODAY TO HAVE BUILT A TRULY CAPABLE GLOBAL NETWORK OF TALENT, WHICH IS VITAL FOR OUR SUCCESS IN SUCH AN AMBITIOUS UNDERTAKING.”

— IBRAHIM A. ABBA

pursuing multiple research tracks, we are diversifying our options and offering the company — and the Kingdom — the most opportunities possible in the future as these technology options cover different crude types, product slates, timelines, and varying capital intensities.”

Abba leads a team of 80 scientists and engineers, including those working on the flagship program at the R&DC. As chief technologist for the program, his

role involves providing technical direction and coordinating the activities of the different research tracks, as well as establishing international partnerships, including those with the company’s global research centers around the world.

“We are working closely with our colleagues at the Boston Research Center, which specializes in catalysis and advanced materials, to explore

additional novel catalyst options that complement our efforts in Dhahran,” says Abba. “We are fortunate today to have built a truly capable global network of talent, which is vital for our success in such an ambitious undertaking.”

ALL AROUND US

Abdennour Bourane looks around his office. His desk, his stationary, the chair he sits on, the shirt on his back — in each can be found the impact of petrochemicals.

“Apart from the plant pot, everything is made of plastic,” says Bourane. “Isn’t that incredible?”

For seven years, he has been at the heart of the project and now serves as program leader. He’s seen the progress and the milestones, but also knows the challenges that lie ahead.

“We are certainly progressing, and the different research teams are all heading in the right direction. They are at different phases of the development stage, but they are all moving forward.”

Early work on the program began back in 2006, beginning with research on cracking Khuff gas condensate. It was a year later that scientist Musaed S. Al Ghrami joined the R&DC.

“These were the concept stages,” he notes. “In the subsequent years, we developed and moved on to other feeds like Arab Light and Extra Light crude oil and other forms of crude oil to expand the options.”

For Ibrahim A. Abba, collaboration is a key factor in ensuring success of the C2C program.

Al Ghrami oversees the catalytic crude oil to chemicals research streams, and understands the impact of his responsibility.

“The research we are engaged in is a real game changer and is of huge significance for the future of the Kingdom. It’s a great source of pride to be involved in such cutting-edge research that will help shape the destiny of my country — and will have a global impact.”

PARTNERING FOR SUCCESS

Of the research tracks, the most advanced is the Thermal Crude to Chemicals (TC2C™) program. Saudi Aramco has already entered into a Joint Development Agreement with U.S.-based leading technology provider CB&I (now McDermott) and Chevron Lummus Global (CLG) to further accelerate the development and demonstration of the technology.

“This collaboration will substantially accelerate this technology toward commercialization,” says TC2C™ team leader Kareemuddin M. Shaik. “Our team is diligently working to demonstrate the technology on a larger scale at CLG’s

Richmond Technology Center. This is part of taking the necessary technology de-risking steps in preparation for commercialization.”

It’s a major milestone, but Al Nahwi and the team have their feet firmly placed on the ground. Patience and perseverance is the key — getting the technology completely right is more important than unrealistic timelines.

“A complex and diverse research portfolio will naturally have very different timelines for different types of technologies. A new process-based technology — such as TC2C™ — will typically require a much longer development cycle compared to a device- or a software-based technology,” says Al Nahwi.

He alludes to an analogy of comparing the relatively fast development cycle of a smart phone, which sees a new model with new technologies introduced almost every year, to the development of a new aircraft engine, which typically can take a decade.

“New process technologies start from a concept, but they must then be scaled up at multiple levels before they are deployed at an industrial scale through huge capital investments,” notes Al Nahwi. “This requires elaborate research, experimentation, the building of new test facilities, then larger demonstration and semi-commercial facilities, and so on. It requires patience and a careful balance of technical risks at different scales.”

The development of the technologies being undertaken by Saudi Aramco in the C2C program would normally take around a decade to develop. To the C2C team, two key factors are critical in ensuring the success of the program.

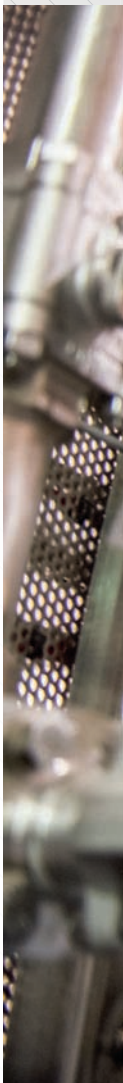
“This requires elaborate research, experimentation, the building of new test facilities, then larger demonstration and semi-commercial facilities, and so on. It requires patience and a careful balance of technical risks at different scales.”

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— MUSAED S. AL GHRAMI



At one of the C2C laboratories, lab technician Duhaiman U. Yami monitors the wet test gas meter on a pilot plant for the crude conditioning step of the Thermal Crude to Chemicals research stream.





Scientist Kareemuddin M. Shaikh checks the pressure control valve for the pilot plant used for one of the crude to chemicals technologies.

“We have received exceptional support from our leadership at all levels,” says Al Nahwi. “The Technology Council headed by the CEO and the Downstream Technology Steering Committee headed by the senior vice president of Downstream have been providing us with unlimited support and trust. This is critical and extremely motivating for the whole team.”

Abba notes that of equal importance are the ongoing internal collaborations.

“We also have great partnerships from within the company, particularly with the Chemicals business. Our alignment with them in terms of technology, engineering, and economics throughout this journey has been crucial. They are the proponent and we are working side by side with them to deliver the products and solutions,” says Abba.

“In addition, we need to partner globally. We have a piece of the puzzle and others have other pieces. By leveraging other facilities and knowledge, we can compress our timelines and optimize our work, while at the same

time, build those lasting relationships that will enhance our business. We also embed some of our young scientists within such partnerships, capturing a unique growth and knowledge transfer opportunity.”

One of the co-founders of the C2C program is Essam A. Al-Sayed. After leading the C2C program until 2016, Al-Sayed is now the co-project leader of the TC2C™ collaboration project with McDermott, and is based in the U.S.

Al-Sayed joined R&DC in 2001 as a lab scientist, where later he received his Ph.D. in chemical engineering from Imperial College in the U.K. He is currently part of ASC’s Technical Services Department team working on different C2C projects.

“As researchers, our general challenge is competing with existing processes, by introducing new breakthrough technologies that should also be economically viable,” observes Al-Sayed. “In our program, I will also add time as a major challenge. As a team, we need to be alert about other efforts in this field and update our analyses of the future chemicals market.”



Ola Ali is working with the KAUST research team on developing a catalyst that can convert crude oil to chemicals in one step.

CLG is a perfect example of Saudi Aramco's approach to open innovation and research partnerships. It was in the research laboratories at R&DC that the concept was developed and initially proven through successful and comprehensive pilot scale testing. When the team needed to scale up the process, partnering with an existing technology provider with well-established, large-scale piloting capabilities ticked all of the remaining boxes.

"Building all the required capabilities internally only is not as efficient," comments Abba. "In technology, the world realizes that you cannot go alone. We recognize this too."

AT THE HEART IS THE CATALYST

The common theme that binds the different research tracks in C2C together is the pursuit of the catalyst. This is the elixir — the potion that makes it all happen. The purpose of the catalyst is to mix in with the hydrocarbons and initiate the reactions that lead to the production of chemicals.

It's at the core of the research being carried out at R&DC.

"In the labs, we tailor our catalysts so we can maximize ethylene and propylene," says scientist Gopal Juttu, referring to his work on the catalytic C2C stream.

He spends his day with his research colleagues as they experiment with various compositions of the catalyst. "In addition to chemical reactivity, we also have to get the correct shape and strength of the catalyst before we evaluate its performance," he adds.

"Imagine you are making food and the recipe has many ingredients," explains Juttu. "You start with the main

Al-Sayed is a 17-year veteran of the company and can see the transformational potential of the program.

"It is an honor for me to be part of such a program, which gives me the opportunity to contribute in many of the company's transformation program initiatives, as well as the Kingdom's Vision 2030, such as promoting new technologies, increasing the downstream and chemicals business, and creating new job opportunities."

In a globalized world there is a need for complementary synergy, and the collaboration with McDermott and

ingredient, in our case zeolite, then add extra ingredients to get the desired flavor and texture.”

This has led to the team collaborating with a number of leading universities to create test labs to optimize and monitor performance of the catalyst — another example of successful collaboration.

“We are preparing Saudi Aramco for the future,” Juttu says proudly. “The company will have a footprint as the preferred provider of chemicals. As a scientist, it means a lot to me that I am making a positive contribution not only to the company, but also the Kingdom.”

Of all the research tracks in the C2C program, the most ambitious is being conducted in conjunction with the King Abdullah University of Science and Technology (KAUST). While the other tracks target optimizing the conversion of select crude types to chemicals, Saudi Aramco scientist Ola Ali, who is located at the company’s research center at KAUST, is pursuing the Holy Grail in C2C research — creating a

catalytic process that can upgrade and directly convert any crude type into chemicals in a single step.

“We are targeting to make the reaction in one step,” she says confidently. “At the heart is a multifunctional catalyst that is able to crack, dehydrogenate, dearomatize, and remove sulfur, etc.”

The research is in its early stages, and Ali is under no illusions at the magnitude of the task.

“The project is very challenging, upgrading and cracking crude in one step seems like science fiction. In 2017, we finished three years of collaboration with the KAUST Catalysis Center, during which we have

developed a first-generation catalyst showing superior performance. We have a long way to go, but we have very talented people on the team.”

“OUR SCIENTISTS ARE CLEARLY LEADING THE FIELD, AND THERE ARE MORE TO COME. THERE IS NO BETTER TIME TO BE A CHEMICALS RESEARCHER IN SAUDI ARAMCO.”

— AMMAR A. AL-NAHWI

POWERING FORWARD

If progress in the projects needed a gauge of measurement, nothing would fit the bill more than the growing number of Saudi Aramco patents in the field of C2C. The body of patents to date is close to 50.

“This is a primary indicator of leadership,” said Al Nahwi. “Our scientists are clearly leading the field, and there are more to come. There is no better time to be a chemicals researcher in Saudi Aramco.”

As team members continue with their cutting-edge research and collaboration with partners, they remain fully engaged with company leadership to ensure alignment and a common vision for the future.

Down the road, they look to 2025 and see the construction of a world-scale TC2C™ complex underway. They believe the other research tracks are also close to fruition, and envision that major discoveries and breakthroughs will occur in the one-step direct conversion route. This is in addition to the projected doubling of patents by 2025.

“It’s ambitious, but as a scientist, you have to be,” said Al Nahwi. “At the beginning of any R&D journey things don’t always look good. But if you have a great team, a solid plan, disciplined execution and passion, then you have a much better chance of hitting the jackpot.

“We are on this journey for the benefit of the company and the Kingdom. It’s a delicate balance — to make the magic of R&D happen — but through patience, collaboration, and determination, we’ll get there.” 🌐

Essam A. Al-Sayed is currently part of ASC’s Technical Services Department team working on different C2C projects.



DIVERSITY

MAKES FURTHER
INROADS INTO THE
SOUTHERN AREA

BY SANJIV KUMAR



Once a bastion of male engineers, the Southern Area Production Engineering Department (SAPED) made a paradigm shift in 2018 as female petroleum engineers joined the department on assignment from the Reservoir Engineering Department.

Thanks to their hard work, dedication, and perseverance, coupled with SAPED's uniquely designed Individual Development Plan (IDP) — especially tailor-made for female engineers — a historic transformation has taken place. Female engineers have not only proven their capabilities in the operational environment, but have emerged as front runners in both the office and field environments.

“This is a major step the company is taking toward encouraging diversity in workplaces and unleashing the young talents in various environments,” said SAPED manager Hamad M. Al-Marri. “Now that more females are in the business, let’s just fathom the thought of how much great input we will have as a company, achieving growth, innovation — and most importantly — a great evolution.”

Gender diversity in the workforce is not only a top priority for Saudi Aramco, but also for the Kingdom through

Saudi Vision 2030. It also brings tangible benefits to the company by tapping into the rich talents and hard work ethic of the large and growing female portion of the company’s workforce.

“The objective of introducing female engineers is to expand job opportunities and capitalize on women’s talent growth in the Kingdom for sustainable development,” said Saad M. Al-Mutairi, general supervisor for the South Ghawar Production Engineering Division.



Opposite: Walaa Al-Mukhtar, a petroleum engineer on a one-year assignment with the Southern Area Production Engineering Department, reviews data with a rigless contractor at a Saudi Aramco rigless site. *Above:* Saad M. Al-Mutairi, general supervisor with the Southern Ghawar Production Engineering Division.



Left: Fahad Meshal, general supervisor with the North Ghawar Production Engineering Division. Below: Walaa Al-Mukhtar performs a production logging tool inspection before running it in the hole.

Fearless spirit

From day one, it was apparent that SAPED's pioneer female engineers were united in having a fearless spirit and a strong will to come out of their comfort zone and take on new challenges.

"I always wanted to challenge myself and go beyond," said Fatimah Alkayadi, one of the female engineers with SAPED, adding that her time with the organization has helped to expand her knowledge of field operations.

Walaa Al-Mukhtar, another of the female engineers taking advantage of this opportunity, said breaking barriers was one key reason she jumped at the chance to work with SAPED, along with the determination to prove that female engineers can add to the industry as much as males do.

Hosting female engineers was equally challenging for SAPED, as the experience was new for this engineering department. SAPED welcomed this challenge and took a dramatic stride to draw the company's greatest untapped resource — female employees.

Specific IDPs were developed and individual mentors were assigned to each engineer for close monitoring and guidance to reinforce holistic talent management, competencies, and leadership development. The female engineers were placed in strategic units to ensure an easy and smooth transformation to their new job.

Surajit Halder, a petroleum engineer specialist with SAPED, was responsible for finalizing the development plans.

"Technically, all existing Professional Development Program development plans were applied to them," Halder explained. "However, special plans were formulated to accelerate their mobility to gas-oil separation plant (GOSP) visits and field jobs.

Adjusting SAPED's training to accommodate female engineers proved to be a win-win scenario, and produced a team of field engineers with unique skills and excellent results.

Mastering production engineering

To ensure a successful transition, the female engineers were assigned to work





Fatimah Alkayadi, a petroleum engineer on assignment with the Southern Area Production Engineering Department, records wellhead parameters at one of the rigless well intervention sites.

as support engineers with an experienced professional. Within a short period of three months, they independently started handling all production engineering jobs for a GOSP connected with more than 120 wells in mature fields, and the multiple challenges that followed.

The challenges worked as an asset for learning as they encountered situations that many production engineers

“BY WORKING CLOSER TO WELLS AND VISITING WELL SITES, THINGS STARTED MAKING MORE SENSE.”

— FATIMAH ALKAYADI

do not get exposed to for a long time. Female engineers are now successfully discharging all normal production engineering activities such as validating well survey results, and designing well intervention programs, including complex coiled tubing intervention jobs, reviewing well integrity and performance, and providing engineering solutions to field challenges.

“They were found to be very capable of handling all production engineering duties in the office and field,” said Mohammed Al-Malki, supervisor of the Mubarraz Production Engineering Unit.

“They have high potential and a level of dedication, which is reflected in their performance.”

“As per the research, gender diversity improves the productivity,” said Fahad Meshal, general supervisor with the North Ghawar Production Engineering Division. “Having females in the oil and gas business is

“WE ARE VERY SATISFIED WITH THE PERFORMANCE OF THE YOUNG FEMALE PROFESSIONALS AND ARE PLANNING TO HIRE MORE IN THE FUTURE. IT IS A SMALL BUT GREAT STEP AND WILL GO A LONG WAY IN TRANSFORMING THE COMPANY AND SAUDI ARABIA.”

— SANJIV KUMAR

studies — some involving multi-departmental teams — that produced some sound innovative and long-lasting solutions to the current problems. Capitalizing on the company’s Four Critical Behaviors and corporate values, engineers developed needed competencies in a very short period of time.

in alignment with the company, and the Kingdom’s Vision 2030.”

The challenges in their area of operation provided an opportunity to further sharpen their understanding and skills by doing technical

Female engineers discuss a plan during a complex well intervention job with senior engineers and site personnel.



Field job proficiency

The production engineer's job is a combination of office and field operations. The engineers need to drive to the wells to witness jobs and provide necessary consultancy. The Kingdom's policy to allow women to drive provided the female engineers with an opportunity to develop themselves as production engineers, and to visit the wells independently. To be able to visit and witness jobs at the well site, gives an added advantage and makes the job of a production engineer easier and more resourceful.

As of today, the female engineers are doing all field activities, including witnessing complicated operations in the field, acquiring well information, meeting their counterparts in plants and providing sound engineering solutions at the site.

"By working closer to wells and visiting well sites and plants, things started making more sense," Alkayadi said. "Hearing about operations is different from actually witnessing them."

Witnessing the operations that they have engineered on paper gives a sense of fulfillment and making decisions related to them feels empowering, she added.

Beyond production engineering

SAPED is not only committed to the technical growth of its engineers, but it also strives to develop and produce future leaders. The female engineers were encouraged to participate in many leadership courses as well as in-Kingdom and out-of-Kingdom conferences on leadership development.

They attended the Leadership Excellence for Women Awards and Symposium in Bahrain. Alkayadi and Al-Mukhtar represented SAPED and shared the Saudi Aramco empowerment to them with many dignitaries.

"My experience has been amazing," said



Fatimah Alkayadi in discussion with the site foreman about the logging procedure making sure the objective of the operation is accomplished.

Al-Mukhtar. "After spending almost one year here, I feel like a different person now — stronger, more independent, empowered, more experienced, and knowledgeable."

Alkayadi agreed.

"Having one person believing in you is so empowering," she said. "Now imagine, in my case, having all the empowerment I needed from the top of the organization on down. I can't be thankful enough."

Leveraging this positive first experience, SAPED plans to bring more female engineers into the department. 🌐

BY SCOTT BALDAUF

PHOTOS BY HASAN ALMUBARAK



NEW AMPHIBIOUS VEHICLE

BY LAND
AND BY SEA,
SAFE AND
RELIABLE



The ARKTOS is actually a pair of vehicles that are capable of moving both on land and shallow water areas, as well as on the open sea as a boat. The paired vehicles provide oxygen for up to 52 personnel, as well as feeding oxygen to the vehicles' combustion engines.

ON THE GIANT SQUARE ISLAND OF SAND KNOWN AS DRILL SITE P-4, RIG FOREMAN WILLIAM E. GUZMAN CLIMBS ABOARD AN ORANGE VEHICLE THAT LOOKS LIKE A TANK BUT FLOATS LIKE A BOAT. WITH THE FLICK OF A SWITCH, THE AMPHIBIOUS VEHICLE ROARS TO LIFE AND THE ARKTOS IS PUT THROUGH ITS PACES.

Now stationed at Berri Causeway to provide evacuation services for drilling crews that work night and day next to a sour crude oil trunk line capable of delivering up to 50,000 barrels per day from the Berri field off the coast of Jubail, the ARKTOS vehicle is considered to have the highest amphibious mobility in the world.

With tank-like tracks (called grousers) to move around on land, and jets to move on the sea, the vehicle also provides breathable air to 52

crew and passengers, as well as a positive oxygen source for the ARKTOS engine — to keep it running in the unlikely event of a catastrophic release of toxic hydrogen sulfide (H₂S) gas.

SAFETY AS PRIORITY NO. 1

Najeeb I. Al-Abdulrahman, manager of the Exploration and Oil Drilling Engineering Department, explained that the company's commitment to safety and protection of personnel is the No. 1 priority. It is also a critical aspect of Drilling and Workover's (D&WO) mission.



Top, drilling rig foreman William E. Guzman prepares to enter the ARKTOS vehicle, alongside pilot Hishamuddin Umdre.

“Safety of our working personnel cannot be compromised at any point in time, and the addition of the amphibious vehicle to Saudi Aramco’s fleet of emergency transport vehicles shows that the company’s safety culture is alive and well,” said Al-Abdulrahman.

For that reason, the Berri drilling engineering team had to look for unconventional and creative ways to ensure safe operations on the Berri Causeway, including the introduction of the ARKTOS amphibious vehicle for the first time in the Middle East.

“We explored a number of different options, but none of them met the company’s dual needs to optimize operations while also protecting the natural environment,” said Mohammad A. Al-Umair, manager of the Northern Area Oil Drilling Department.

“I am really proud of this newly introduced system. We looked at other options that would allow us to maintain operations, such as dredging the bay to allow the boats to evacuate, but this would jeopardize the environment. We considered shutting down production during drilling, but this would interrupt our production and impact the company’s need to meet energy demand. Implementing this innovative solution allows us to evacuate our people in the event of an emergency without damaging the environment.”

A SAFE EYE TOWARD THE CAUSEWAY

The Berri Causeway — the first ever to be built by Saudi Aramco — was initially constructed in the early 1970s

UNDER THE HOOD

The vehicle has the following features:

- It has a land speed of up to 16 kilometers per hour, and a water speed of up to 5.5 knots.
- It utilizes tank-like tracks (grousers) on land and then switches to jets in water. It can shift from jets to the grousers based on the depth of the water. The arm between the two vehicles provides flexibility.
- It can maneuver and move uphill and downhill. It's a remarkable testament of how far the company is prepared to go to protect our employees and the environment.
- It has a cascading system for the passengers to plug in their own personal SABA breathing apparatus into a central air supply, which supplies the crew with oxygen while on board.

and has been extended through the years.

With a newly commissioned giant trunk line carrying produced oil along the length of the causeway to Abu Ali Island, and drilling crews actively drilling new wells, engineers had to prepare in case there was ever an H₂S release, not only at a drilling site but also along the length of the trunk line. That meant engineers needed an evacuation solution that didn't require driving the causeway route along the length of that trunk line in case of an emergency.

Driving along the causeway to Drill Site P-4, Fahad M. Al-Yami, then general supervisor of the Northern Area Oil Drilling Engineering Division in the Exploration and Oil Drilling Engineering Department, noted the special challenges of aligning the needs for safety and the environment.

"Our challenge was to not only provide an evacuation vehicle that provides safety to our employees, but to do so without damaging the environment," Al-Yami said, pointing at a flock of pink flamingos standing ankle-deep in the surrounding bay waters. "If you dredge the waters, you destroy all of this.

"So we aligned our policies with the Environmental Protection Department, and we considered the option of the ARKTOS," he said. "From a cost perspective, it is expensive, but it aligns with our value of safety and takes into account environmental protection, and that is why this solution was selected."

A RECORD BUOYED BY MITIGATING RISK

The perfect safety record at the Berri Causeway since it began operating the trunk line is evidence that the company doesn't cut corners when it comes to safety.

Initially developed to be dedicated for water injection to maintain pressure to support oil production in the field, the causeway is now hosting a sour

Flamingos wade through the shallow waters of Tarut Bay, next to the Berri Causeway. To protect the fragile marine environment, Saudi Aramco opted not to dredge channels for more normal and shallow-draft evacuation boats, which are more readily available. ARKTOS allows Saudi Aramco to minimize the impact of our operations on the local environment.



crude oil trunk line.

The strategic location of the causeway has played a major role in how it evolved through the years. This development has increased the risk of working in an H₂S environment for drilling personnel.

To mitigate that risk, D&WO engineers swung into ac-

tion. They maintained rigorous inspections of the trunk line and flow lines to monitor any signs of corrosion, and placed gas monitoring stations in strategic locations along the length of the trunk line.

They upgraded the controls of vehicle traffic along the causeway and provided a safety vehicle to escort outside

contractor trucks to the drilling sites. The traffic control and escort vehicles also serve as emergency evacuation vehicles for truck crews in the event of an H₂S emergency. They are equipped with air breathing and gas monitoring systems.

In addition to that, a safety induction center was established at the gate of the causeway. At this point, all personnel entering the causeway receive a safety orientation where the criticality of causeway operations and evacuation plans are explained. Then, crew members are supplied with self-contained breathing apparatuses and H₂S personal monitors. The policy requires all personnel to carry them while operating on the causeway, due to the existing risk of toxic gas release around the clock. All of these additional mitigation measures have been tailored to address the specific risks and challenges of the Berri Causeway.

Most importantly, D&WO engineers swiftly identified alternative sea evacuation routes and explored new boats and amphibious vehicles that could take drilling crews to safety. Initially designed to serve as an immediate short-term



Above: The cockpit provides room for one pilot for each of the two paired ARKTOS vehicles.

Left: Drilling rig foreman William E. Guzman and ARKTOS team engineers Fahad M. Al-Yami and Muataz S. Al-Ghamdi prepare to board the ARKTOS for a test ride at the Berri Causeway.



Trunk lines along the Berri Causeway are a reminder that the causeway provides for simultaneous operations for oil producing from existing wells, and drilling operations for future wells.

solution, shallow-draft boats were commissioned and modified to provide oxygen for both passengers, and for the boat engines.

The Northern Area Oil Drilling Engineering team worked with several contractors to modify the boats to make them fit-for-purpose. All of this was done in-Kingdom and with local contractors. Located at a pier in the deeper waters at the southernmost drill site of the causeway, those boats were unable to reach the shallower waters of the remaining sites along the causeway. It is a drill site along the northern leg of the causeway where Drill Site P-4 — the current beehive of drilling activity — is located.

A SAFE SOLUTION

Then in August 2017, Saudi Aramco signed a contract for the ARKTOS vehicle and received it in September 2018. This amphibious vehicle serves as the long-term solution for Berri Causeway operations.

“A lot of engineering went into the design of this vehicle,” said Guzman, who as rig foreman at Drill Site P-4, would be the incident commander in the event of an emergency.

The ARKTOS is technically two vehicles held together by an iron arm that pivots as needed for descending down ramps into the water or ascending back onto land. Twenty-four passengers fit into the first of the two vehicles, and 28 fit into the rear vehicle, which provides stability and support for the paired amphibious crafts as they navigate into the surrounding bay water, which is too shallow for emergency boats.

“The ARKTOS amphibious vehicle is an impressive bit of engineering,” said Muataz S. Al-Ghamdi, who works as a drilling engineer in Berri field.

And by using that piece of impressive engineering, Saudi Aramco again is able to live up to its values of safety and accountability by delivering energy reliably from challenging environments in a safe and efficient manner. 🌐

abbrev.

Saudi Aramco news in brief



Ali Dogru works on a TeraPOWERS simulation with his team in Dhahran.

Ali Dogru receives new recognition from MIT

DHAHRAN, SAUDI ARABIA — Saudi Aramco Fellow Ali Dogru has been recognized by the Massachusetts Institute of Technology's (MIT) Earth Resources Laboratory (ERL) and the Department of Earth, Atmospheric and Planetary Sciences (EAPS) with a new Fellowship honoring leading researchers in geophysics, and related areas.

Dogru is among the first class of ERL Fellows, which also includes Dirk Smit, the vice president of Exploration Technology and chief scientist of geophysics at Shell, and Arthur Cheng, a professor

of petroleum geosciences at the National University of Singapore.

The selection of the first class of ERL Fellows was done by a prestigious committee, including oil industry executives and EAPS professor emeritus and ERL founding director M. Nafi Toksöz.

Dogru has published extensively throughout his career and holds many U.S. patents. He has received SPE's John Franklin Carll, Reservoir Description and Dynamics, Honorary and Distinguished Membership Awards, along with World Oil's Innovative Thinker Award and ADIPEC's Best Technology Award. He is also a member of the U.S. National Academy of Engineering.

A visiting scientist at MIT since 2011 and a Saudi Aramco Fellow since

2013, Dogru is the director of Saudi Aramco's Computational Modeling Technology team, which is creating the world leading TeraPOWERS program for modeling Saudi Arabia's reservoirs with granular accuracy.

ASC honored for recovery efforts in Galveston Bay

HOUSTON, TEXAS, USA — The Galveston Bay Association recently honored the volunteer efforts of Aramco Services Company (ASC) with its "Guardian of the Bay" award. This award recognizes ASC's "leadership, work, and commitment for the betterment of Galveston Bay."

Accepting the award on behalf of ASC were director of Public Affairs Abdulrahman A. Bayounis, and Strategic Communications supervisor Alma S. Kombargi.

"ASC is proud to partner with the Galveston Bay Foundation to revitalize such a precious resource," said Bayounis. "I would like to recognize the efforts of our ASC volunteers who come out year-after-year to give their time and effort to such a worthy cause."

For many years, ASC volunteers have

The Galveston Bay Foundation's "Guardian of the Bay" award recognizes ASC community efforts to help the environment.





Amer A. Amer (seated, left), chief technologist of Saudi Aramco's Fuel Technology R&D Division, joins officials from Tsinghua University, FAW Jiefang Automotive Wuxi Diesel Engine Works, and Shandong Chambroad Petrochemicals Company in signing an agreement to work together on advanced fuel and engine technology research. He is joined by officials from all of the entities, including Anwar A. Al Hejazi (behind Amer), president of Aramco Far East Business Services Co.

Ground-breaking held at Moscow R&D center site

MOSCOW, RUSSIA — Strategic collaboration between Saudi Arabia and Russia continues to progress with Saudi

Aramco president and CEO Amin Nasser attending the groundbreaking ceremony of a new Saudi Aramco Research Center at the Lomonosov Moscow State University (MSU) Science Park.

The center is Saudi Aramco's ninth R&D facility outside the Kingdom and will focus on upstream technologies in simulation and modeling, advanced materials, data analytics, and artificial intelligence. It promotes collaborative research activities primarily with MSU and other entities in Russia.

At the event, a research agreement between Saudi Aramco and MSU was signed to enable collaborative research projects between the two entities. 🌐

helped restore sensitive oyster reefs in the bay. The delicate reefs are vital in maintaining the bay's ecosystem. Hurricanes Harvey and Ike caused serious damage to the reefs.

Since ASC's volunteer efforts began, more than five tons of oyster shells have been recycled to build the new reefs.

Most of Galveston Bay's oyster reefs have been closed to commercial operations for more than a year after Hurricane Harvey, but are now showing signs of recovery.

Saudi Aramco and Chinese partners pursue research program to optimize fuel and engine technologies

WUXI, CHINA — Saudi Aramco and Chinese entities Tsinghua University, FAW Jiefang Automotive Wuxi Diesel Engine Works (FAWDE), and Shandong Chambroad Petrochemicals Company, announced the start of a research program dedicated to fuel and engine optimization, and exhaust after-treatment technologies.

For the first time, a major energy company, engine manufacturer, petrochemicals company, and a renowned university, come together to develop advanced fuel and engine

technologies to reduce emissions.

Under the research program, Saudi Aramco will propose new fuel formulations, support its flagship technology, gasoline compression ignition, and further develop mobile carbon capture technologies as a viable route to achieve lower greenhouse gas emissions.

Chambroad Petrochemical will conduct refinery modeling, techno-economic analysis, and produce new fuels for testing.

FAWDE will provide prototype engines and after-treatment systems, as well as conduct system integration and vehicle demonstration.

Amin Nasser, Saudi Aramco president and CEO (center), is joined by Nasir K. Al-Naimi, vice president of Petroleum Engineering and Development (to his right), during a ground-breaking ceremony in Moscow, Russia, for a new Aramco Research Center.



worldview



A View along the River Seine

This row of buildings shows the French Renaissance architectural style, one that makes Parisian buildings unique in their design, beauty, and architectural significance.

Batool A. Khalaf took this photo while strolling along the River Seine in Ile de la Cite, France, or what is called the “old Paris.” She captured the image during the summer of 2015. Khalaf states that it is one of her favorite walks in Paris as

this area in particular is filled with amazing bakeries, unique restaurants, and lots of other hidden gems. She used an Olympus OMD-1 camera to take the photo.

Khalaf works in the Energy Sector Training Support Unit at the Local Workforce Development Department under the Training and Development Admin Area. She has been with Saudi Aramco for eight years, and resides in al-Khobar with her family.

