

# dimensions



## INTERNATIONAL

# KHURRAIS

COMPLETES OIL  
INCREMENT PROGRAM



# dimensions



## INTERNATIONAL

Summer 2019

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**About the cover:**

An illuminated view of the Khurais Complex expansion, which significantly raised the plant's production capacity by 300,000 bpd of Arabian Light crude oil.

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Momentous milestone reached with the successful commissioning of Khurais Oil Train-5 and the Mazalij/Abu Jifan satellite GOSP that boosts the plant's capacity by 300,000 bpd of Arabian Light crude oil.



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Commitment to making the internal combustion engine — and the fuels that power it — more efficient on display for the world to see as Saudi Aramco showcases technologies designed to reduce the carbon footprint of transport energy.



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Adoption and use of emerging technologies that create efficiencies and enhance safety results in the 'Uthmaniyah Gas Plant becoming the first energy producing facility to earn a prestigious award on the global stage.



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# HISTORIC



In Khurais, the recent commissioning of an Arabian Light Crude increment program has added 300,000 barrels per day to the company's overall production capacity. (Photo by Hasan AlMubarak)

# MOMENT

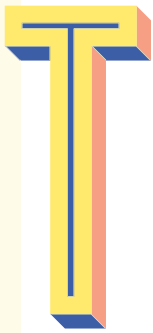


## AS KHURAIS COMPLETES FIRST OIL INCREMENT PROGRAM

*By* **JANET E. PINHIERO**

*Photos by* **MOAYED AL-QATTAN**

Khurais celebrated a major milestone late last year with the completion of the first oil for its increment program, significantly raising the plant's production capacity by 300,000 barrels per day (bpd) of Arabian Light (AL) crude oil, making it one of the largest oil producing facilities in the world.



To mark the momentous achievements of the people behind the “Khurais Arabian Light Crude Increment” program, the senior vice president of Upstream, Mohammed Y. Al Qahtani, Southern Area Oil Operations (SAOO) vice president Khaled A. Al-Buraik, Project Management vice president Fahad E. Al-Helal, and members of the Khurais Producing team, project management team, as well as supporting departments, gathered to mark the accomplishment.

Al Qahtani expressed the company’s appreciation to the project team and all field personnel for the safe and successful commissioning and startup of Khurais Oil Train-5 and Mazalij/Abu Jifan satellite gas-oil separation plant (GOSP), commending the quality of the commissioning activities and quick turnaround where these activities were completed three weeks ahead of the planned schedules.

Al-Buraik praised the remarkable efforts of the teams and individuals working around the clock to achieve the startup safely to mark a major milestone in the company’s as well as the Kingdom’s history and supplementing Saudi Aramco’s crude production capacity.

### Complex scope of works

Scattered across several geographical locations, the Khurais Complex program scope included the integration of many new facilities, as well as the expansion and upgrade of existing facilities.

Adding to the Khurais Complex execution was the significant magnitude of its scope, an aggressive schedule, and a significant number of interfaces with the existing operating Khurais Central Processing Facility (CPF). The first oil scope included around 6,000 tons of steel to build all structures supporting plant piping with a total length of 123 kilometers (km).

The first oil scope of work for the Khurais Arabian Light Crude Increment program was delivered through eight major contractors.

Peak manpower reached 10,826 people, who collectively clocked an accumulated total of 55,269,907 construction work hours.

### Oil Train-5

A vital part of the program was the construction and startup of the new Oil Train-5 outside the Khurais CPF plant areas, adjacent to the existing Khurais CPF plant fence.

A pipe rack was used to connect the new train to the existing plants, and a specially designed modular bridge was lifted into position in one piece using a 600-ton crane — similar to offshore installations. This extended the Khurais CPF pipe rack to 1.8 km in length, one of the longest pipe racks in the company.

With pre-installed piping, instrument, and electrical cable trays, the modular bridge installation approach is a smart alternative to the conventional stick built construction technique.

Rami Al-Otaibi shares with management the process used to analyze key construction activities and fix small problems to help expedite the team’s progress on key construction activities.





A Khurais operator prepares the system for commissioning.

### Mazalij/Abu Jifan GOSP

Another key part of the program is the new Mazalij/Abu Jifan satellite GOSP, its associated 63 km of upstream trunk lines, and two 90-km downstream export lines. With a crude oil capacity of 200,000 bpd, the GOSP was constructed in the proximity of the Abu Jifan and Mazalij fields, southwest of Khurais.

Two trunk lines support the upstream transportation of the gas and oil from the Abu Jifan and Mazalij well-heads to the satellite GOSP, which was set in an optimum location from operation and cost viewpoints. The satellite GOSP products are carried by two pipelines to the Khurais CPF for further processing.

Another completed scope item is the expansion of the 'Ain Dar Seawater Injection Plant and the seawater pipeline that will support the forecasted incremental water

injection rate into the reservoir, along with the expansion of the residential complex in Khurais, accommodating the additional employees to support operating the new facilities.

### Team effort

Yousef A. Al-Furaidan, then general manager of Southern Area Producing, said it was rewarding to celebrate the startup, and highlighted the joint collaboration and commitment of the team to achieve the challenging task of adding 300,000 bpd of crude oil capacity before the end of 2018.

Describing the commissioning of the Khurais program scope ahead of schedule as a great moment in the Khurais field development, Khurais Producing Department manager Mohammed I. Al-Sowayigh said the team's joint

Mohammed Y. Al Qahtani, Khaled A. Al-Buraik, and Fahad E. Al-Helal attended the celebration of the first oil completion at Khurais, expressing their appreciation to employees of the Khurais Producing Department and the Oil Facilities Project Department who were part of the recent Khurais Increment Program First Oil success.



# KHURAIS

## Arabian Light Crude Increment program:

- New Khurais Oil Train-5 processing an increment of 300,000 barrels per day (bpd) of AL crude oil.
- 257 million standard cubic feet per day third gas train.
- Crude oil storage tank with 900,000 barrels capacity.
- Crude oil shipping pump with a capacity of 717,000 bpd.
- Two gas turbine water injection pumps with a total capacity of 1,070,000 bpd.
- Sulfate Removal Facility coupled with water injection pumps that can operate at a total capacity of 250,000 bpd to support production from the Khurais Lower Fadhili Reservoir.
- Seawater Reverse Osmosis Plant to treat seawater for plant usage to replace the entire consumption of non-potable groundwater.
- 160 megawatt combined cycle cogeneration plant to provide a more efficient and diversified source of power, electrical and nonelectrical utilities.
- 243 kilometers (km) of oil and gas pipelines with a state-of-the-art pipeline external leak detection system.
- New gas turbine driven booster pump at Ain Dar Water Injection Plant, with a capacity of 1,600,000 bpd, to increase the seawater supply to the Khurais Central Processing Facility (KhCPF).
- Nonmetallic reinforced thermoplastic pipe flow lines connecting the oil wells with a total length of 390 km.
- 72 km of 48-inch seawater injection pipeline with loop and the associated tie-ins inside the KhCPF.

efforts led to the successful startup of the new oil train and GOSP with more than 55 million incident-free construction hours.

### Leading technology

Oil Train-5 included implementation of leading technologies, making the expanded oil and gas facility highly efficient and reliable, and providing environmental benefits.

Included in the innovation is a flare gas recovery system using gas ejector technology with no rotating equipment to minimize the facility's emissions by reprocessing the purge gas. Recovering the flare gas helps in reducing greenhouse gas emissions, which positively contributes to one of the corporate business focus areas and brings the Khurais CPF to a higher level of environmental stewardship.

A new electrostatic desalting field technology, known as a dual frequency desalter, combines two modes of voltage modulation to lower both power consumption and reduce chemical dosage.

Other innovations include a high-pressure gas compressor swing line connecting the five oil trains, a low-pressure production three-phase separator, an optimized stabilizer steam condensate control, and gas compressor dry gas seal with an incorporated electrical heater to prevent mechanical seals failure.

### Nonmetallic flow lines wide-scale deployment

The Khurais increment program included the construction and tie-in of a significant off-plot oil flow line network as part of the Maintain Potential project. For the first time in the development of a new increment,





**Right:** A technique of using pre-assembled modular pipe racks was applied to optimize construction time as part of the Khurais Arabian Light Crude Increment program. **Below:** Along with the expansion and upgrade of existing facilities, the residential complex in Khurais was expanded to accommodate the additional employees to support operating the new facilities.

all oil well flow lines were constructed with nonmetallic piping using reinforced thermoplastic piping materials. The key advantages of nonmetallic piping utilization is not only for mitigating corrosion, but also due to its strategic value to Saudi Aramco, as it is a hydrocarbon-based material.

### Young Saudi workforce

Thanks to a career day to recruit young Saudi talent to work for the construction contractors, at the project's peak more than 2,105 young Saudis worked on the project doing project management, engineering, and skilled and unskilled labor.

The Saudization percentage reached about 20%.

During the highly valuable commissioning period, approximately 36% of the team were young Saudi Aramco engineers, operators, and multi-craft technicians who strengthened their technical knowledge and experience through mentoring from more experienced team members. 🌐



IGNITING AN ALTERNATIVE PERSPECTIVE AT THE  
GENEVA INTERNATIONAL

# MOTOR SHOW

SAUDI ARAMCO  
DRIVING  
REAL WORLD  
TRANSPORTATION  
ANSWERS

BY JANET E. PINHEIRO

**T**urning heads at the opening of one of the world's premier motoring events in Switzerland this spring was Saudi Aramco's crisp thinking about how to reduce carbon emissions from the light-duty transportation sector.

In a world needing to decrease greenhouse gases, the company invited the 10,000 journalists and 700,000 visitors attending the two-week "Geneva International Motor Show" to learn about the critical importance of making the internal combustion engine — and the fuels that power it — more efficient.

Saudi Aramco, the world's largest producer of energy, doesn't manufacture cars but 53% of crude oil's final consumer destination is transport fuels, and research shows the easiest and quickest way to bring down emissions in the transportation sector is through a focus on the workings of the internal combustion engine.

"We definitely see that carbon constraints are with us, and society needs to reduce its carbon footprint," said Saudi Aramco chief technology officer Ahmad O. Al-Khowaiter. "We feel that we have a role to play in working with the auto industry in improving the efficiency of the internal combustion engine, and therefore, reducing emissions across our value chain."

Through its membership of the CEO-led Oil and Gas Climate Initiative, Saudi Aramco believes collaboration is key to develop and accelerate the commercial deployment of innovative low-emission technologies designed to address climate change.

## TODAY'S ENGINE REIMAGINED

### Both electric and combustion power needed

Electric cars are part of the solution for the transportation sector, but even conservative predictions show the



**Above:** Ahmad O. Al-Khowaiter conducted exclusive interviews with international media outlets, reiterating the company's message that policymakers setting the rules for the world's emission reduction targets need to include innovating the internal combustion engine, as its use will continue at least until the 2040s. **Right:** For the first time, Saudi Aramco participated in the "Geneva International Motor Show" to showcase significant transport technology with the potential to significantly enhance efficiency and reduce carbon dioxide emissions. Aramcon Fahad S. Al-Gosaibi inspects a reimagined internal combustion engine.

internal combustion engine will still be powering 85% of our vehicles by the 2040s.

"People try to pit the internal combustion engine against electrification but we don't really see it as a zero-sum game," said Al-Khowaiter. "We see both of those technologies as complementary for transport, and we believe that hybrid cars are a great example of this.

"We see a lot of value in improving the efficiency of the internal combustion engine, which is a primary source of energy. Even electric vehicles get their source of energy from a power plant," he said.

Explaining that the bulk of the transport market was more than just light-duty vehicles where battery electric vehicles could have an impact, Al-Khowaiter said the internal combustion engines will be with us for decades to come.

"The world needs to reduce its carbon footprint, and electrification can play a role in addressing emissions, but



the consensus is that the internal combustion engine will be prevalent for decades to come, and in the short- to medium-term, improving it will yield the greatest environmental benefits," he said.

Al-Khowaiter warned against proposals by some governments to ban the sale, production, and use of vehicles running on internal combustion engines. The best outcome for the planet, he said, is for policymakers to implement policies that are technology neutral.



Visitors keenly scrutinized the turbulent jet ignition, which leads to higher efficiency and lower emissions.

“Policies that account for life cycle emissions of both electric vehicles and internal combustion engines — not just tailpipe emissions — will ensure regulation is reducing actual emissions and not just favoring one technology over another,” he said.

### Sustainable mobility future

Saudi Aramco is committed to developing efficient low-emitting technologies to address global energy demands, and innovating the internal combustion engine will play a bigger short-term role in cutting emissions than electric vehicles.

The global demand for transport energy is expected to grow significantly in the coming decades, driven primarily by heavy-duty applications like trucks and marine — both of which use internal combustion engines.

### Getting better engines on the road, faster

Saudi Aramco Research and Development Center (R&DC) transport chief technologist Amer A. Amer said through close collaboration with global automakers, the company is pursuing research programs to develop and prove novel fuel and engine solutions capable of delivering sizable reductions in carbon dioxide (CO<sub>2</sub>).

“Our Geneva attendance is to prompt a critical mindset change regarding the way auto-makers design future car engines, and the fuels they use,” said Amer.

“In a carbon constrained world, it is prudent to consider the full life cycle emissions of all types of mobility solutions,” he said. “Picking winners and losers will only lead to unintended consequences in the long-term and could, in fact, increase CO<sub>2</sub> emissions.”

Set against a background of the

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## FOCUS ON THE INTERNAL COMBUSTION ENGINE: EASIEST AND QUICKEST WAY TO REDUCE EMISSIONS

**Top:** Visitors examine the gasoline compression ignition engine, which combines the best of gasoline and diesel engines. **Bottom:** The company showcased its onboard mobile carbon capture technology.

magnificent snow covered spring alps, Switzerland's second largest city, Geneva, sits gracefully on the shores of one of the largest lakes in Europe.

Home to numerous global organizations, the world's languages are the sounds of Geneva's streets, and since 1905, her cosmopolitan residents have hosted one of the most well-known and popular motor shows.

Saudi Aramco was one of only two oil and gas companies among the 180 exhibitors at the show.

André Hefti, Geneva International Motor Show managing director, said the world of individual transportation was evolving and Saudi Aramco exhibiting at the 2019 show was reflective of this change.

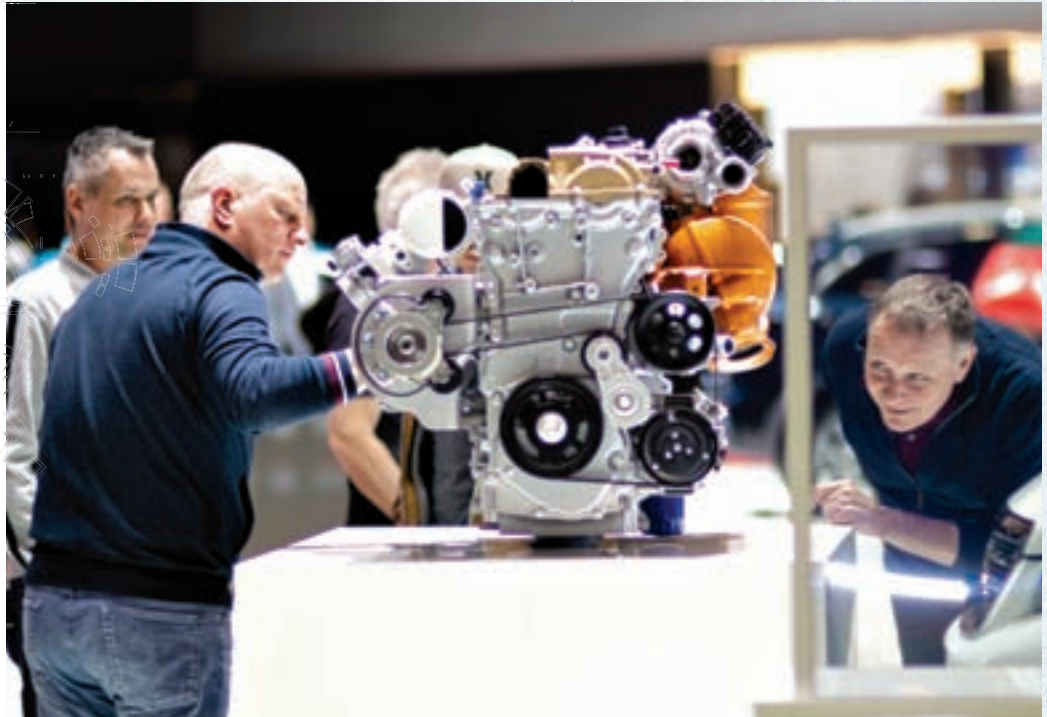
"The show is open to all facets of individual transportation," said Hefti.

### Today, tomorrow, and the future

Poised with quiet elegance alongside an international display of motoring's latest and best vehicles, Saudi Aramco's exhibition stand was a sophisticated display of mobility technology answers for today, tomorrow, and for the future.

Media Relations representative Nejoud Almatrodi said the spacious stand with its sleek clean lines told a sequential story of the company's work from innovating ways in transportation to produce less carbon, as well as capturing carbon that is produced, and using the captured carbon.

"There are many things you can do to a vehicle to make it more efficient and produce fewer emissions,"



said Almatrodi. "Everything from alternate engine architectures, different combustion modes, and fuel optimization — the technologies we're showing here cover that spectrum.

"The stand's theme, 'Today, Tomorrow, and the Future,' is the timeline for which these technologies could be prepared for mass production, when they could be commercialized," she said.

The story ends with a display of Saudi Aramco's proprietary catalyst, Converge, which takes greenhouse

gas CO<sub>2</sub> and creates new everyday products such as skateboard wheels, shoes, and food packaging.

### Under the innovation hood

With a Ph.D. in combustion science, research scientist Kai Morganti is living his career dream with the company's R&DC facility in Dhahran, and explains that Saudi Aramco is investing in technologies that will allow the internal combustion engine to burn gasoline more efficiently, significantly lowering its greenhouse gas emissions.

Four areas of the internal combustion engine are the focus of the leading research — combustion modes, engine architecture, optimized fuels, and after-treatment systems.

“The internal combustion engine was invented more than 150 years ago, and its basic concept has not changed much since then,” said Morganti.

Explaining that, for instance, lifting a commercial aircraft with battery power is near impossible due to its low power intensity, the engineer said: “Until the intensity of energy storage is improved, the internal combustion

engine is going to be enabling modern lifestyles for many decades to come.

“Electric vehicles are an important part of the world's energy transition, but the most effective way of driving down emissions in the near- to mid-term is to make conventionally powered cars and trucks more efficient,” he said.

By taking a modern look at what's possible with this 150-year-old engine, technology has emerged that lowers its emissions, and increases its efficiency.

### Combustion modes

Pioneering internal combustion technology was a standout at the Saudi Aramco booth.

Working with automakers, Saudi Aramco took a fresh look at the internal combustion engine and the fuels that power them.

Together, they have invented a futuristic mix of “gasoline compression ignition” technology, which produces 30% less CO<sub>2</sub> than a conventional spark-ignition engine.

Research scientist Kai Morganti was on hand to explain emissions reducing technologies for the transportation industry, such as an internal combustion engine mixing the best of diesel and gasoline engines.





**Above:** Paris Aramco Fuel Research Center chief representative Pierre Olivier Calendini (right) explains a two-stroke opposed piston engine concept with the pistons arranged around a central shaft.

**Right:** Answering questions at the show, Research and Development Center engineer, and recent U.S. Boston University mechanical engineering graduate, Alma Alhussaini said Saudi Aramco was one of the very few exhibitors displaying car engines and that people wanted to hear about the benefit of the technologies on show. "It is exciting to let people know about the opportunities these technologies represent in reducing the carbon footprint in transportation," she said.

Gasoline engines produce lower emissions, while diesel engines deliver higher efficiency. Gasoline compression ignition technology combines the best of both.

Morganti said gasoline compression ignition delivers diesel-like efficiency with considerably lower emissions.

"The technology exploits gasoline-like fuels that ignite less readily, thereby enabling improved mixture formations prior to combustion," he said.

The technology can go in passenger and commercial vehicles, and Mazda is pioneering this approach with its Skyactiv-X engine, which it plans to launch later this year.

### Turbulent jet ignition

Gasoline engines use heat. Fuel is combusted inside a confined space called a combustion chamber, firing up



pistons, which turns a crank shank to set the car's wheels in motion.

Our scientists are developing a better way to start combustion under ultra-lean conditions, and its increasing efficiency, plus lowering CO<sub>2</sub> emissions.

Instead of a spark plug using a limited number of ignition sources, the innovative "turbulent jet ignition" technology premixes a small quantity of air and fuel in a pre-combustion chamber. A jet of hot radicals is then



Driving turns economies, unlocks opportunities, and ignites imaginations, and during the Geneva International Motor Show in Switzerland, the world was invited to think differently about the internal combustion engine and efficient fuels when Saudi Aramco shared its foremost emissions reducing research.

blasted into the main combustion chamber, providing a wider distribution of ignition sources than a traditional sparkplug.

### Engine architecture

Agile thinking about the physical layout of the internal combustion engine has come up with one of the most promising designs driving maximum engine efficiency. It has also doubled the power density of the engine.

The opposed piston engine is a fresh design that Saudi Aramco is working on with two technology developers — U.S. based Achates Power and European-based INNengine.

Morganti explained that instead of a single piston per cylinder, it utilizes two pistons per cylinder, allowing for a higher expansion ratio, and significantly lower heat losses, in turn, leading to superior efficiency.

“The design utilizes dual pistons in each combustion





chamber, which move toward each other in the compression stroke, meet at top dead center, and then are forced away from each other when combustion occurs in a two-stroke cycle,” he said.

“The design eliminates the cylinder head and valve train, which are major sources of friction and heat losses, respectively.”

### Optimized fuels

Saudi Aramco researchers have improved the performance and emissions of fuel by using a two-fuel system.

A second high-octane fuel augments the performance of



The turbulent jet ignition produces a jet of hot radicals for wider ignition sources.

a standard gasoline fuel system — a high-octane fuel for conditions that require it, and low-octane for normal driving conditions.

Octane is only used when needed to match the specific requirements of the engine in real time, and efficiency gains are between 6% and 8%.

The company recently fitted its octane on demand technology to the Ford Raptor, and has previously demonstrated the concept on a Peugeot 308 passenger vehicle.

### After-treatment systems

Capturing carbon from exhaust gases is one way to tackle the world’s climate challenge, and Saudi Aramco’s redesigned exhaust system captures CO<sub>2</sub> onboard a vehicle.

“Our first prototype installed in a Ford F-250 pickup truck was able to capture 15% of the carbon, and we improved that to 25% in the second-generation system installed on a Toyota Camry,” said Detroit Research Center senior scientist Michael Traver. “Our latest version is currently being integrated into a Class 8 heavy-duty truck, and we’re expecting to capture over 40% of the carbon in the exhaust gas.”

CO<sub>2</sub> stored onboard the vehicle can be offloaded during refueling, and captured CO<sub>2</sub> can be converted to useful materials and products.

Paris Research Center senior scientist Christophe Chaillou said the technology was timely, since new European Union regulations will oblige heavy-duty “original equipment manufacturers” to reduce CO<sub>2</sub> emissions by 30% by 2030. 🌐

# A WORLD LEADER IN TECHNOLOGY: WEF RECOGNIZES SAUDI ARAMCO FACILITY AS A ‘LIGHTHOUSE’ SITE FOR IR 4.0

By Scott Baldauf

*Saudi Aramco’s ‘Uthmaniyah Gas Plant (UGP)’ was recently recognized for its leadership in Fourth Industrial Revolution (IR 4.0) technologies by the World Economic Forum’s (WEF) ‘Manufacturing Lighthouse Program.’*

**N**ow in its second year, the program was designed to help industries adopt technologies of the future. ‘Uthmaniyah and six other facilities, including four factories in Europe, and two in China, were selected from an initial list of 1,000 manufacturers based on their successful implementation of IR 4.0 technologies in ways that have driven financial and operational benefits.

A total of 16 facilities have been recognized as IR 4.0 Lighthouses to date. UGP is the first plant in the oil and gas industry worldwide to be recognized by WEF.

WEF commended ‘Uthmaniyah for being a site that is leveraging digital technologies to enable a more efficient, greener, and safer way of working.

## **A STRONG INVESTMENT IN THE FUTURE NOW**

“We are so honored and proud to be recognized by WEF as a ‘Manufacturing Lighthouse’ facility representing

Saudi Aramco,” said Hesham A. Al-Adel, UGP manager. “The UGP team recognized the potential impact that IR 4.0 technologies could have in monitoring day-to-day operations, and in responding to the plant’s needs promptly and effectively.

“We believe that the deployment of these technologies will help to transform the oil and gas industry, and we are grateful for the opportunity to share and demonstrate these cutting-edge technologies with our peers, which wouldn’t be possible without the successful partnership with our colleagues in Engineering Services, led by the Process and Control Systems Department (P&CSD),” Al-Adel added.

“Saudi Aramco has invested heavily in the deployment of cutting-edge technologies of IR 4.0 to enhance the reliability, efficiency, and safety of its operations, and UGP will continue in the company’s footsteps by deploying groundbreaking technologies to help achieve the



Kingdom's Vision 2030," he said

Ahmed A. Al Ghamdi, acting manager of Wasit Gas Plant and Saudi Aramco's chief representative at WEF for the "Shaping the Future of Manufacturing and Production System Initiative," said the Lighthouse designation is a recognition of efforts toward a digital transformation vision to become the world's leading digitized energy company by 2022.

Being recognized with the award is an honor, said Al Ghamdi, because "Lighthouse demonstrates how forward-thinking engagement of technology can create a better, cleaner world through new levels of efficiency in manufacturing and production. Likewise, they illustrate how IR 4.0 technology at scale can transform the nature of work itself by engaging and improving the skills of human workers with minimal displacement."

"The recognition of UGP as an IR 4.0 Lighthouse by WEF is a testament to the results achieved by Saudi Aramco's Digital Transformation Program," said Khalid Y. Al-Qahtani, P&CSD manager.

"This would not have been possible without the

leadership displayed by UGP, and Gas Operations, in being early adopters of these cutting-edge technologies. "The 4IR Center played a pivotal role in successfully piloting these technologies while minimizing the risk to our operations and paving the way for deployment in the field."

## DIGITAL TRANSFORMATION

Saudi Aramco's digital transformation vision is to become the world's leading digitalized energy corporation by 2022, maximizing shareholder value and spearheading digital innovation in energy globally. To achieve this, the Digital Transformation Program has the following five main pillars designed to:

- Optimize operations and provide end-to-end value chain visibility to improve our margin
- Lead the industry in technology innovation, and build partnerships with global digital hubs
- Commercialize innovative solutions to diversify revenue

Hamad S. Al-Balhareth, a Process and Control Systems engineer, demonstrates the capabilities of a smart helmet, one of a bevy of technological innovations and applications currently used at the 'Uthmaniyah Gas Plant.



Fourth Industrial Revolution technology allows the monitoring of performance data from major assets in the UGP area. The use of high-tech tools helped the Saudi Aramco facility to be recognized by the World Economic Forum as a "Manufacturing Lighthouse." Now in its second year, the Lighthouse Program is designed to help industries adopt technologies of the future. UGP is one of 16 facilities worldwide to be recognized through the program.

- Upgrade the skills our workforce in the digital domain
- Maximize local content required to support our digital program.

Disruptive technologies such as artificial intelligence, augmented and virtual reality, unmanned aerial vehicles (UAVs), robotics, digital twin, mobility, 3-D printing, cloud computing, and blockchain are key enabling technologies for the program and IR 4.0 in general. More than 100 transformative use cases that cover industrial and nonindustrial business domains have been identified. Through these use cases, the plan is to translate the program's vision and strategy into tangible real-life applications and benefits.

### FIVE KEY APPLICATIONS

UGP's use of IR 4.0 technologies covers a broad range, from robotics and wearable technologies to data analytics and machine learning. Tying all of these elements together is a support network of engineers and experts through the 4IR Center, which provides necessary technical support on demand.

A range of robots, including drones, underwater robots, and ground crawlers comprise the UAV and robotics fleet at Saudi Aramco. All three of these robot types help to extend the reach of operators and give the opportunity to:

- Inspect assets from great heights, in the case of drones
- Get a view inside underwater pipes and subsea structures, in the case of underwater robots, or inside and outside pipes and tanks to inspect for corrosion, residue formation, and structural deterioration.



Through the use of UAVs, UGP has reduced inspection costs by 10%, and sped up safety and emergency response by 5%.

In the field, operators and inspection engineers at UGP also have access to wearable technologies, such as a smart helmet fitted with a camera, a tiny smart screen, and noise-reducing headphones that allow field personnel to establish safe audio/video communication with subject matter experts for on-the-spot technical support. The camera not only grabs video images, but also scans smart tags on rotating equipment, and through augmented reality, an operator can instantly see the health of the asset and its maintenance record.

If there are issues, the operator can call for technical support from a consulting services engineer. This allows for the avoidance of unnecessary costs while ensuring documentation of the inspection process through an augmented reality application for future references.

The solution, using smart glasses, empowers field engineers with accurate and up-to-date information on the device, reducing the number of resources required to maintain the asset, and ensuring that consistent and safe procedures are followed.

While wearable technologies



◀ Hesham A. Al-Adel

are the hardware that operators use to get instant support, asset predictive analytics (APA) are the advanced analytics and machine learning solutions that make these tools so powerful in catching asset anomalies quickly and proactively. APA applies advanced analytics modeling algorithms on asset data, combining rule-based and data-driven modeling techniques to detect any degradation of performance in an asset.

“We are utilizing the notifications from the solution to set our priorities when we plan asset health checks,” said UGP maintenance engineer Abdulrahman Alzahrani. “Moreover, we integrate the highlighted asset cases into our asset monitoring solution to ensure these cases are monitored, actioned, and resolved.”

So far, the solution has helped the plant realize maintenance cost avoidance of more than \$1 million, and a significant amount of savings in energy consumption.

For longer term analytics, UGP also utilizes an asset performance management (APM) solution — a large spectrum of applications and digitalized business process



◀ Khalid Y. Al-Qahtani

areas that span multiple disciplines. APM hosts all of the data about assets, including maintenance records and preventive maintenance schedules, as well as live data from a range of IR 4.0 technologies and sensors. Through all of this data, engineers and operators can get an automated view of the health, reliability, safety, and performance of an asset.

“APM provides ‘Uthmaniyah with a holistic solution that capitalizes on full process integration with existing company technologies, which helps to

standardize and automate work processes, predict performance degradation, and propose the best asset strategy to effectively achieve operational goals,” said UGP reliability engineer Abdullatif Al Johar.

The implementation of APM at ‘Uthmaniyah is expected to reduce maintenance costs at UGP by 2% to 5%.

The 4IR Center itself has been recognized as a key enabler for the deployment of these technologies at UGP. By bringing together the data, the technologies, and the

domain experts, it has allowed for rapid evaluation and deployment of these emerging technologies while ensuring life cycle support.

“Saudi Aramco has been reinventing its operations through digital technologies, introducing smarter and more efficient ways of working, and unlocking new business and operating models. WEF’s recent recognition is a tribute to Saudi Aramco’s excellence in digital transformation, and a testament of our leadership in the oil and gas industry,” said Majid Al-Gwaiz, an engineering consultant with the P&CSD and Saudi Aramco’s representative in the “Technology and Innovation for the Future of Production” project with WEF. 🌐

Ahmed A. Al Ghamdi discusses some of the key elements of the Fourth Industrial Revolution, a key ingredient to current and future success of ‘Uthmaniyah Gas Plant and the company at large. The facility was recently named a “Manufacturing Lighthouse” by the World Economic Forum, a global first for the oil and gas industry.



SPEARHEADING INNOVATION:  
SAUDI ARAMCO UNVEILS NEW

# Fourth Industrial Revolution Center

BY EAMONN J. HOUSTON

PHOTOS BY MUSLEH AL-KHATHAMI

**As global industry negotiates the hi-tech Fourth Industrial Revolution where artificial intelligence, machine learning, and big data are offering an unprecedented competitive advantage, Saudi Aramco remains a leader, wisely investing in staying ahead of the curve.**



n a global economy that is increasingly leveraging the opportunities afforded by what is known as the Fourth Industrial Revolution (IR 4.0), it is essential for industry to tap into the many opportunities and possibilities contained within it.

Lagging behind is simply not an option, and Saudi Aramco is effectively blazing a trail in the energy industry with its targeted strategic focus on cutting-edge digital technology.

Evidence of this can be found on the 13<sup>th</sup> Floor of Dhahran's iconic Al-Midra Tower where an entire wing has been transformed

**Counterclockwise from top:** Khalid Abusalem, chairman of UAV and Robotics, operates a drone pilot simulator in the Immersive Zones Hub at the 4IR Center, while Osama Bahwal instructs. The zone showcases Saudi Aramco's readiness and capabilities related to immersive technologies and digital transformation; HE Khalid A. Al Falih, members of the Saudi Aramco Board of Directors and corporate management, including president and CEO Amin Nasser, listen to a presentation by Rakan S. Bilau during a tour of the company's new 4IR Center at Al-Midra Tower in Dhahran. (Photo: Mohammad AlShaikh); Information Technology systems analyst Ali Al Saleh and Engineering Solutions Center supervisor Hamza Hamada at work in the state-of-the-art Artificial Intelligence (AI) Zone. The zone develops and monitors AI solutions related to engineering, predictive maintenance, environment, enterprise, and other critical areas of Saudi Aramco's business.







Senior project engineer Ghassan Al Ghamdi, Information Security analyst Mishaal Alageel, and engineer Abdullah Albannay survey one of the high-tech solutions on the massive digital screen of the AI Zone. The screen is one of the biggest of its type in the world.

into a 4IR Center, where technological and digital innovation is, in turn, transforming the way in which Saudi Aramco runs its operations.

The center, impressively remodeled and vastly expanded, recently opened its doors for the first time and boasts some jaw dropping technology and solutions.

#### BOARD OF DIRECTORS VISIT

A visit by Saudi Aramco's Board of Directors, led by the Minister of Energy, Industry and Mineral Resources and Board chairman HE Khalid A. Al-Falih, members of Saudi Aramco's corporate management coincided with the opening of the center, which was designed to inspire

a tech savvy and young employee population who will take the company into the future.

Members of corporate management in attendance included Amin Nasser, president and CEO; Ahmad A. Al-Sa'adi, senior vice president of Technical Services; and Mohammed Y. Al-Qahtani, senior vice president of Upstream.

Members of the VIP touring group were visibly impressed with the center's content and were shown the practical applications for Saudi Aramco operations.

The center creates value through the deployment of the latest technologies, ensuring a smarter, faster, greener, and safer way of doing business.



## DIGITAL VISION

Over the past years, Saudi Aramco has been transforming into a highly digitalized energy company with a vision to become the leading digitalized energy company in both value creation and innovation by 2022. Under the Digital Transformation Program, Saudi Aramco is undertaking hundreds of use cases that will unlock new business opportunities and operating models.

The center will play a pivotal role in uplifting the technical skills of our workforce and bringing advanced technology capabilities to realize the company's digital transformation vision.

According to Al-Sa'adi, there is much to look forward to. "The 4IR Center will help the company's operational performance to enable greater efficiencies and significant cost savings, and help further strengthen our global leadership in the oil and gas industry.

"We are excited about the potential of this new 4IR Center. The center will play a key role in accelerating the digital transformation across Saudi Aramco. It will be pivotal in enabling a paradigm shift for our operations through more digital technologies, while unlocking new business and operating models," added Al Sa'adi.

As a major milestone in Saudi Aramco's digital

transformation journey, the center is leveraging various technology areas and tapping into the company's ever growing pool of young talent. Indeed, the center is not just a commitment to the company's future, it's a commitment to the future of the Kingdom as envisioned by its ambitious Vision 2030.

## TECHNOLOGY ZONES

With advanced capabilities, extensive access to information, and people-centric environment, the center is a digital transformation ecosystem for digital solutions throughout the hydrocarbon value chain. The center is designed to support the end-to-end use case development throughout its ideation, prototyping, piloting, and full-scale deployment.

Some 2,500 square meters of office space in Al-Midra was remodeled in the construction process. The center features 279 square meters of video walls, with a total of more than 109 million pixels pitch that split into multiple clusters and zones.

Visitors are welcomed by a "V-receptionist" hologram that provides safety instructions and gives an overview of the center. At the heart of the center is the futuristic circular bright space of the Artificial Intelligence (AI)

Hub, which is ringed by a massive concave video screen on which over 20 operational solutions are displayed. It is one of the biggest screens of its kind in the world.

The AI Hub is focused on developing advanced analytics and machine learning solutions in hydrocarbon related applications. The big data and advanced analytics make use of the innovative solutions in this domain to visualize



**"This is one of the main enablers for accelerating the development and deployment of different IR 4.0 technologies, and setting the stage for a new level in Operational Excellence."**

— KHALID Y. AL-QAHTANI



**“The Fourth Industrial Revolution Center is an integral part of Saudi Aramco’s digital transformation, and the center offers a good space for our people to develop, deploy, and innovate with IR 4.0 technologies.”**

— KHALID S. AL-GHAMDI

and predict the performance of critical Saudi Aramco assets. This hub combines in-house development and external tools to enable our subject matter experts to make timely decisions to improve asset availability, utilization, and efficiency. The value and cost savings realized from these solutions underline the significant impact on our operations and business.

Next to the AI Hub is the “VR Zone,” which is used to develop, prototype, and train for augmented and virtual reality, among other capabilities. This hub can be used to visualize plant assets and to get a live sense of the plant experience from a simulation booth.

The center also has the capability to demonstrate operational use cases of air, ground, and underwater robots through the “UAV Space.” This section combines cutting-edge technologies that supports a variety of different applications — including methane detection, emergency response, inspection services, project monitoring, inventory management and many others — to reduce cost, enhance efficiency, and improve health, safety, and environment.

Prototyping is made possible at the center through 3-D scanning and printing in the “3-D Zone.” In addition, the ideation corner (i-Corner) brings together expertise from across the company to address our corporate challenges through materializing ideas and leveraging the latest technologies. After ideation, the development

corner (d-Corner) has the ability to test the ideas and digital technologies that support our operations and IR 4.0 transformation.

As knowledge sharing is ingrained in the center’s DNA, the center provides a platform for inspirational talks and interactive knowledge transfer sessions through a “G-Talk” section. With all of these technology clusters, the center is very much at the heartbeat of innovation.

Process and Control Systems Department manager and project sponsor Khalid Y. Al-Qahtani explained that the center represents a “quantum leap” in technological advancement in terms of computational capability, development, and testing capacity for advanced analytics and AI solutions, in addition to other IR 4.0 technologies.

“This is one of the main enablers for accelerating the development and deployment of different IR 4.0 technologies, and setting the stage for a new level in Operational Excellence,” Al-Qahtani said.

## SHAPING THE FUTURE

On arrival at the center, the Board of Directors and corporate management were greeted by the V-Receptionist, where it was explained, “Here, we develop and showcase technology and solutions that will shape our future.”

And that future looks bright with a robust and vibrant digital strategy. According to Khalid S. Al-Ghamdi, project manager, the new center was made possible by the efforts of a young team of Aramcons.

“Actually, the Fourth Industrial Revolution Center is an integral part of Saudi Aramco’s digital transformation and the center offers a good space for our people to

develop, deploy, and innovate with IR 4.0 technologies,” Al-Ghamdi said.

“I am very proud — as a project manager — of a

Fourth Industrial Revolution Center in which many of the integrated project team were young Saudis, male and female,” he added. “They made it happen. It was a very aggressive schedule, and we had very high expectations from our corporate management. I saw the commitment in their eyes, and such an integrated and collaborative approach was vital to success.”

Over the Digital Transformation Program’s duration,

the center will play a major role in executing the digital transformation strategy through value creation, driving innovation, commercializing solutions, and developing

and attracting a talented workforce.

IR 4.0 promises limitless opportunities through the diffusion of technologies and information. The center brings both components with the focus on business needs in a highly collaborative environment.

Saudi Aramco has so far achieved outstanding outcomes

in the Digital Transformation Program, and time will reveal the extent of the center’s contribution to the company’s digital transformation journey. 🌐

**THE CENTER CREATES  
VALUE THROUGH THE  
DEPLOYMENT OF THE LATEST  
TECHNOLOGIES, ENSURING  
A SMARTER, FASTER,  
GREENER, AND SAFER  
WAY OF DOING BUSINESS.**

The Virtual Reality (VR) hub allows employees to navigate and explore some of Saudi Aramco’s major areas of operations and detailed equipment inspection. Engineering specialist Yuk San Man, wearing the VR headset, explores the Ras Tanura Refinery while Ahmed M. Altunisi and Abdullah A. Al Bannai give directions.



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Saudi Aramco news in brief



Mohammed I. Al Assaf, Saudi Aramco vice president of New Business Development, and Dustin Whitely, general manager of McDermott International Inc. in Saudi Arabia, exchange documents during the signing of an agreement for the engineering, procurement, construction, and installation of a fabrication facility within the King Salman International Complex for Maritime Industries in Ras al-Khair. They were joined by management from both Saudi Aramco and McDermott, including Saudi Aramco senior vice president of Technical Services Ahmad A. Al Sa'adi and David Dickson, president and CEO of McDermott.

## McDermott agreement looks to establish fabrication facility in Ras al-Khair

**DHAHRAN, SAUDI ARABIA** — Saudi Aramco recently signed a land lease agreement with McDermott Arabia Company Ltd., a wholly owned subsidiary of McDermott International Inc., to grant McDermott a lease to establish a fabrication facility within the King Salman International Complex for Maritime Industries in Ras al-Khair. This is pursuant to a Memorandum of Understanding signed between Saudi Aramco and McDermott.

The new facility will be used for the large-scale fabrication of offshore platforms and onshore/offshore modules. To further enhance project execution capabilities in Saudi Arabia, McDermott will also expand its in-country engineering and procurement offices, as well as establish a new marine base in the Eastern Province to support the installation of offshore platforms, subsea pipelines and cables, skids, and associated structures and assemblies.

The new facility in Ras al-Khair will be located near Jubail Industrial City on the Kingdom's East Coast.

It will cover an area of approximately 1,150,000 m<sup>2</sup> and will utilize cutting-edge technologies to ensure world-class standards in safety, quality, and efficiency.

## CEO in China: Technology and partnerships critical for an efficient energy transition

**BEIJING, CHINA** — Addressing the International Petroleum Technology Conference in Beijing, Saudi Aramco president and CEO Amin Nasser said that despite the energy industry facing a “crisis of perception,” it is undergoing a major transformation thanks to technological breakthroughs that help energy companies meet the growing energy demand more efficiently.

Nasser said these misperceptions — which relate mainly to the impact of electric vehicles and carbon emissions — challenge the oil and gas industry's ability to transition to a secure and sustainable energy future.

“We need to help people realize that oil and gas will remain vital to world energy for decades to come,” said Nasser. “We need to reassure them with our own long-term investments that the safety belt we have always provided is

Addressing what he calls a crisis of perception, Saudi Aramco president and CEO Amin Nasser told attendees at the International Petroleum Technology Conference in Beijing that the company needs to help people realize that oil and gas will remain vital for years to come.





**Ahmad O. Al-Khowaiter, Saudi Aramco's chief technology officer, addresses the crowd at a panel discussion during CERAWeek 2019 in Houston. Al-Khowaiter spoke on two panels — "Digital Transformation: Creating Value," and "The Quiet ICE (Internal Combustion Engine) Revolution. New Tech Driving New Directions."**

one they can continue to rely on."

While in Beijing, Nasser also attended the China Development Forum — an annual business gathering for China's senior leadership and representatives from global leading businesses, international organizations, and scholars from China and around the world.

## Saudi Aramco shows innovation and technology leadership at Houston energy summit

**HOUSTON, TEXAS** — Saudi Aramco's leading role in energy innovation was on full display at CERAWeek 2019 in Houston as the company's technology strategists and researchers discussed their latest solutions and spoke about the path forward for new technologies to drive sustainability in the industry.

Saudi Aramco chief technology officer Ahmad O. Al-Khowaiter spoke on a panel called "Digital Transformation: Creating Value," and another titled "The Quiet ICE (Internal Combustion Engine) Revolution. New Tech Driving New Directions."

Al-Khowaiter spoke about the need for governments to ensure a sound policy environment that adequately addresses climate challenges. Looking at carbon

emissions through a more holistic "wells-to-wheels" lens can help create better policy outcomes — especially when it comes to evaluating various transport technologies, he said.

Given the consensus among all major forecasts that ICEs will make up the overwhelming majority of the world's light-duty vehicle fleet for decades to come, the development of cleaner burning engines would reduce emissions faster and more economically than trying to switch fleets around the world to electric vehicles, he said.

Saudi Aramco's research centers are

developing new engines that boost fuel economy 30% or more, and reduce particulate emissions to nearly zero.

## A Kingdom first: Halliburton breaks ground on chemicals manufacturing reaction plant

**JUBAIL, SAUDI ARABIA** —

Representatives from Saudi Aramco, Halliburton, Sadara, Fluor, and the Royal Commission of Jubail recently gathered to celebrate the groundbreaking of a manufacturing plant to be built by Halliburton at the ethylene oxide/propylene oxide (EO/PO) cluster of the PlasChem Value Park at Jubail Industrial City II.

The new facility — expected to be operational by the end of 2020 — will be the first specialty oil field chemicals manufacturing reaction plant in Saudi Arabia, and will initially create approximately 100 jobs — three-quarters of which will go to Saudis.

Halliburton will manufacture process treatment chemicals at the facility, which in turn will be sold primarily to Saudi Aramco for use in upstream and downstream drilling and extraction activities.

**Mohammed Y. Al Qahtani, Saudi Aramco senior vice president of Upstream, joined by (to his left) Jeff Miller, Halliburton president and CEO; Nasir K. Al-Naimi, Saudi Aramco vice president of Petroleum Engineering and Development; and Faisal Al Fageer, Sadara CEO; review a model of the manufacturing plant to be built by Halliburton at the ethylene oxide/propylene oxide cluster of the PlasChem Value Park at Jubail Industrial City II.**



Production will be fueled by a steady supply of EO and PO from Sadara via an extensive pipeline network currently under construction.

## Saudi Aramco signs agreements to acquire stake in Zhejiang integrated refining and petrochemical complex

**ZHEJIANG, CHINA** — Saudi Aramco recently signed three Memorandums of Understanding designed to expand its downstream presence in the Zhejiang Province, one of the most developed regions in China. The company is looking to acquire a 9% stake in Zhejiang Petrochemical's 800,000 barrels per day integrated refinery and petrochemical complex, located in the city of Zhoushan.

The first agreement was signed with the Zhoushan government to acquire its 9% stake in the project. The second agreement was signed with Rongsheng Petrochemical, Juhua Group, and Tongkun Group, who are the other shareholders of Zhejiang Petrochemicals. Saudi Aramco's involvement in the



Saudi Aramco president and CEO Amin Nasser meets with Jiao Kaihe (left), chairman of the NORINCO Group, and Tang Yijun, Governor of the Liaoning Province, during a ceremony to mark the signing of an agreement for forming a joint venture to develop a fully integrated refining and petrochemical complex in the city of Panjin.

project will come with a long-term crude supply agreement and the ability to utilize Zhejiang Petrochemical's large crude oil storage facility to serve its customers in the Asian region.

An integral part of the project includes a third agreement with Zhejiang Energy to invest in a retail fuel network. The companies plan to build a large-scale retail network over the course of the next five years in the Zhejiang Province. The retail business will be integrated with the Zhejiang Petrochemical complex as an outlet for the refined products produced.

## Saudi Aramco signs JV agreement with NORINCO Group, Panjin Sincen to build petrochemical complex in China

**PANJIN, CHINA** — Saudi Aramco has signed an agreement to form a joint venture (JV) with NORINCO Group and Panjin Sincen to develop a fully integrated refining and petrochemical complex in the city of Panjin in the Liaoning Province of China.

The partners will create a new company, Huajin Aramco Petrochemical Co. Ltd., as part of a project that will include a 300,000 barrels per day refinery with a 1.5 million metric tons per annum (mmtpa) ethylene cracker and a 1.3 mmtpa PX unit.

The JV will be held by Saudi Aramco (35%), the NORINCO Group (36%), and Panjin Sincen (29%).

Saudi Aramco will supply up to 70% of the crude feedstock for the complex, which is expected to start operations in 2024.

Saudi Aramco president and CEO Amin Nasser said: "Our agreement today with NORINCO and the Liaoning Province is a clear demonstration of Saudi



Saudi Aramco president and CEO Amin Nasser poses for a photo with Juhua chairman Hu Zhongming (far left), Rongsheng chairman Li Shuirong (second from left), and TongKun chairman Chen Shiliang following the signing of three Memorandums of Understanding designed to expand its downstream presence in the Zhejiang Province.

Aramco's strategy to move from beyond a buyer-seller relationship, to one where we can make significant investments to contribute to China's economic growth and development."

## Saudi Aramco participates in Saudi-India Forum in New Delhi

**NEW DELHI, INDIA** — Saudi Aramco recently participated in the first Saudi-India Forum held in New Delhi to promote bilateral business and cooperation between the two countries. The forum was scheduled to coincide with the official visit to India by HRH Prince Mohammed bin Salman ibn 'Abd Al-'Aziz Al Sa'ud, who after meeting the Prime Minister of India, HE Narendra Modi, announced that Saudi Arabia would invest \$100 billion in India across several sectors.

The forum saw participation from ministers, senior government officials and leaders of major corporations, as well as economic and investment institutions from both countries.

The high-level forum was co-organized by the Saudi Arabian General Investment Authority (SAGIA), in partnership with the Saudi Center for International Strategic Partnerships and



Drilling engineers Jawaher Al Saleh (center) and Zainab Al Saihati (far left) demonstrate to Dhahran Ahliyya School students the Well Control Simulator. The exercise is part of Drilling & Workover Training Division's outreach event for 50 female students from the Dhahran Ahliyya School and King Fahd University of Petroleum and Minerals as part of its outreach initiatives.

the Confederation of Indian Industry. The forum brought together high ranking government officials and business leaders from both countries to foster deeper collaborations, building on the long-standing bilateral trade and economic ties between Saudi Arabia and India.

During the forum, SAGIA signed four investment agreements worth more than \$28 million, along with 11 Memorandums of Understanding aimed at boosting collaboration among government entities and private Indian firms.

## Outreach initiative: Drilling and Workover encouraging young females to become future engineers

**DHAHRAN, SAUDI ARABIA** — Saudi Aramco's Drilling and Workover (D&WO) Training Division recently conducted an outreach event for 50 female students from the Dhahran Ahliyya School and King Fahd University of Petroleum and Minerals.

The event took place at the D&WO Well Control School — a recently inaugurated state-of-the-art training facility school equipped with high-end well control simulators and classrooms.

The visit is in line with Training & Development's strategy to attract young talent at an early stage — headed by the Academic Programs & Partnership Department (AP&PD).

The early attraction of young talent strategy is founded on four main pillars — communication, partnerships, promotion, and programs. Part of AP&PD's promotional activities is to invite students from top schools to field visits in Saudi Aramco facilities, such as this recent D&WO outreach event, to raise awareness of employment opportunities with the company.

The event focused on promoting the D&WO industrial work environment, enriching students' knowledge, and building interest in the energy industry — specifically D&WO operations. 🌐

Amin Nasser, president and CEO of Saudi Aramco, speaking on "Future Forward Sectors" during the Saudi-India Forum.



## worldview



### *Iseltwald Village on Lake Brienz, Switzerland*

Alaa A. Othman took this picture during one of his visits to Switzerland. Iseltwald is a village and municipality on the southern shore of Lake Brienz in the Bernese Oberland region of Switzerland. It is 15 minutes from Interlaken and considered one of the most beautiful travel destinations in Switzerland.

Othman used his Mavic pro drone to capture this image. He lives with his family in Dammam, Saudi Arabia, and works in Dhahran. Othman works in the Eastern Region Joint Venture Management division of the Domestic Joint Venture Management Department. He has been with the company for 25 years.

