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King Abdullah Petroleum Studies and Research Center

Baker Hughes

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Digital Energy Technical Section

Digital Transformation in the Context of the Energy Transition

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About KAPSARC

KAPSARC is an advisory think tank within global energy economics and sustainability providing advisory services to entities and authorities in the Saudi energy sector to advance Saudi Arabia's energy sector and inform global policies through evidence-based advice and applied research.

This publication is also available in Arabic.

Legal Notice

Key Points

For decades, the oil and gas industry has delivered the world with the best value proposition in the forms of reliable, affordable, safe energy supplies. As global population projections soar, demand for all forms of energy is also set to rise, with hydrocarbons expected to play a dominant role in the energy mix for the foreseeable future. However, current global greenhouse gas (GHG) targets and today's definition of clean energy highlight the opportunity for emissions management and create an economic incentive for producers and consumers to decarbonize, with both groups playing a critical role in the energy transition.

Digital transformation has gained greater momentum during the COVID-19 pandemic. It accelerated the adoption of digital technologies and is perceived by leading oil and gas enterprises as a pivotal vehicle to improve efficiency and accelerate the decarbonization of the oil and gas value chain. Historically, many large-scale digital transformation endeavors have experienced setbacks and challenges and have under delivered on what they had set out to accomplish. In the era of the energy transition, major oil and gas producers are emphasizing the role digitalization will play in reshaping the future of the oil and gas industry.

Digital transformation poses challenges and risks if not carefully accounted for or if redundant systems are not in place to ensure operational continuity. It also requires derisking strategies and mitigation plans to be put in place to minimize adverse unintended consequences, as major players in the oil and gas industry gradually embrace digitalization as the way forward.

Key takeaways and points addressed in the webinar were as follows:

- Digital transformation has brought transformative efficiency improvements and enabled effective decisions by changing technology-data-process capabilities.
- Several factors deterred the widespread use and commercialization of digitalization, including high oil prices, high capital expenditures, organizations lacking agility, and people's resistance to change.
- Recent GHG targets announced by many countries and companies created economic incentives for investments in decarbonization and decarbonization solutions for oil and gas operators, and for technology companies servicing the energy sector.
- Standardization and regulations, access to capital, and dynamic digital innovations will help oil and gas developers to decarbonize their value chains and achieve carbon neutrality.

Background to the Workshop

On December 2, 2021, the King Abdullah Petroleum Studies and Research Center (KAPSARC) welcomed regulators, policymakers, and petroleum professionals from a wide range of global institutions, including those in the financial sector, the oil and gas industry, and energy consulting, to shed light on digitalization in the oil and gas industry.

The webinar titled "Digital Transformation in the Context of Energy Transition" was hosted by KAPSARC in collaboration with Baker Hughes and the Society of Petroleum Engineers (SPE) – the Digital Energy Technical Section (DETS). The first panel highlighted the status of digitalization in the oil and gas industry and the setbacks and roadblocks experienced in past applications. Participants discussed the intrinsic value digital transformation brings to the oil and gas industry and the imperatives for successful, scalable digital projects.

The second panel presented the oil and gas industry's perception of the energy transition. It stressed the importance of setting standards and regulations to measure, monitor, verify, and mitigate GHG emissions across the oil and gas value chain in addressing climate change. It also underscored the role of digital technological diffusion and innovation in accelerating the energy transition.

In the final panel, presenters discussed the role of digitalization in advanced emissions quantification, and in fugitive gas monitoring and management across the oil and gas value chain. The panel also underscored the importance of tailoring fit-for-purpose de-risking strategies and executing mitigation plans to counter cyber threats and minimize and prevent operational disruptions.

Digital Transformation in the Oil and Gas Industry

Digitalization is often mistaken for digitization. The latter is merely focused on capturing and managing the data, whereas digitalization is broader and encompasses workflows and processes and how they can be optimized and enhanced.

Digital transformation is not only about technology. It is an umbrella term that covers many different technology approaches which can synergically generate efficiency gains for firms. For the oil and gas industry, digital transformation has the potential to transform organizations from being reactive to predictive, streamline communication, overcome geographic barriers, and optimize processes across the value chain. In offshore remote-control operations, for instance, digitalization helped many operators to reduce their capital expenditures by 10% and their operational expenditures by 50%.

Digitalization is not new to the industry. The earliest digital applications began in the late 1980s, most of which were in the fields of geosciences and reservoir simulation, which witnessed major breakthroughs driven by advanced computing and big data. Since then, numerous digital applications and projects have increased steadily to enable accurate decision making and ensure that health, safety, and environmental precautions are always met. The industry is risk averse because mistakes may result in operational disruptions due to cyberthreats, thus impeding the widespread adoption of digital transformation.

Most of the successes in the digital transformation space occurred with pilot tests or in small-to-medium size fields, and especially in remote operations (e.g., offshore platforms and installations) because of the incremental efficiency gains they yielded. The success of these applications induced major oil companies to scale them up. Most of these large scale digital projects, however, have experienced setbacks and challenges and have under delivered for various reasons, including volatile oil prices, high initial investment, and organizations lacking agility and adequate competencies in the digital space.

The boom-and-bust oil price cycles have had adverse implications for investments in digital transformation projects. When oil prices were high, major oil and gas companies formed long term plans to develop and deploy digital transformation strategies and relevant business models. Once oil prices fell, most digital transformation projects were either postponed or completely scraped. As prices are recovering from the aftermath of COVID-19, many operators are focusing on remote operations and virtual offices, which has inadvertently accelerated the pace of digital adoption.

Due to the high cost associated with the digitalization of operations and because the industry tends to resist change, many operators opted to not digitalize their operations. With rapid technological breakthroughs in the last few years, however, the cost of digitalization has dropped significantly due to the stiff competition among tech developers, along with increased data storage capacity and faster processing times. Slowly and increasingly operators are appreciating the value digital technologies bring, especially in the domains of remote operations, data analytics and modelling, and human and external interfaces.

Digital technologies promise safety and efficiency gains, reduce the industry's environmental impact and enable effective decisions via enhanced technology-data-process capabilities for the industry. However, employees' unwillingness to change and inadequate organizational practices

were identified as major factors hindering the pace of digital transformation. Previous processes placed more emphasis on data mining and designing workflows over implementation. This discouraged many operators from realizing the benefits of digital adoption and kept them sticking to old practices. This behavioral pattern was further exacerbated for major oil and gas developers whose operations span the globe and who struggled in executing digitally enabled technologies. They were compelled to customize processes, taking into account geographic and cultural differences, and host countries' standards and regulations.

Talent acquisition in the oil and gas industry is another major challenge. The industry is losing the competition for recruitment to industries that are more appealing to millennials, and it will face a talent crunch soon. In a survey conducted by Accenture, 77% of respondents between the ages 15 and 39 in the Asia Pacific region stated that they aspire to work in the green economy within the next 10 years (Casati, Savic, de Miguel, Gruzin, & Tachibana 2021). This growing workforce deficit will, in fact, be a greater barrier to oil and gas companies' success in embracing digital transformation.

The Oil and Gas Industry and the Energy Transition

Oil and gas have helped over 270 million people to move out of poverty in the past decade. Yet, over 2 billion people are still underserved. The demand for energy in all forms is rising to meet population growth, and hydrocarbons are envisioned to play a dominant role in the energy mix in the foreseeable future. The current national and corporate GHG targets highlighted the challenges and opportunities in creating economic incentives for investments in decarbonization, including decarbonization solutions for oil and gas operators and technology companies servicing the energy sector.

In response, oil and gas producers have been leveraging their comparative advantages in project management and operational excellence as they pivot into the energy transition and decarbonization space. Thus, three strategic archetypes have emerged in recent years to address the energy transition.

First Archetype: Energy Supermajors

The first business model is pioneered by European supermajors such as Shell and BP who aim to become integrated energy companies by capturing a larger portion of the energy value chain and driving value from electrons instead of hydrocarbon molecules.

Second Archetype: Decarbonization Specialists

This archetype is led by major oil and gas developers such as Petronas and Occidental. These enterprises remain focused on oil and gas operations while reducing their scope 1 and 2 emissions by tapping into natural carbon sinks including the preservation and restoration of marine environment and deploying carbon capture, utilization, and storage (CCUS) projects, or expanding into the geothermal energy space.

Third Archetype: Low-Carbon Solution Leaders

This archetype describes a handful of operators such as Ørsted that pivoted to focus on renewables in the short-to-medium-term and shifted away from fossil fuels. They build large renewable capacities by being efficient and commercially optimized in the countries they operate in. They also rely on government offsets and carbon credits to achieve carbon neutrality.

Digitally enabled technologies are at the epicenter of the process for all the above archetypes. Most of these technologies are developed and commercialized by information technology, consulting and service companies. These companies, especially international service providers, respond to market dynamics and are poised to lead the energy transition. This is because of the know-how they acquired from projects they worked on with oil and gas developers, and the technology solutions they customized to meet the needs of their customers. In the digital transformation space, international service providers can transform data, data mining, big data, and artificial intelligence to workflows that can help to optimize workforce requirements, digitize supply networks, assess asset responsiveness to hazards, and increase data transparency.artificial intelligence to workflows that can help to optimize workforce requirements, digitize supply networks, assess asset responsiveness to hazards, and increase data transparency.

The Oil and Gas Emissions

About 65% of the oil and gas industry's GHG emissions comes from the combustion of hydrocarbons, 33% comes from flaring and venting, and 2% are fugitive gases (International Association of Oil & Gas Producers 2019). Digital transformation initiatives can help emissions quantification, monitoring and management across the oil and gas value chain, particularly with respect to methane. Over 100 countries have not published their emissions data. This is because quantification methods are still evolving, and data management system implementations have only recently been prioritized.

Data solutions are incorporating machine learning algorithms that can detect flare on/off statuses using satellite images. This novel solution brings transparency and insights around the location, timescale and quantity of emissions drawn on a map. The European Space Agency launched its TROPOspheric monitoring instruments that can measure methane in 12-square mile blocks of the atmosphere (Charles 2022). These digital methods will further emissions quantification and enhance data transparency. This solution, coupled with decentralized blockchain verification and the immutable transaction storage of data, will solve any reporting inconsistencies.

For both emitters and regulators, a baseline of GHG emissions quantification, verification, certification, and monitoring with full transparency is the first step to tackling and monetizing emissions. Participants believe that a digital solution is at the heart of this framework, using technologies such as spatial systems, deep neural networks, and generative artificial intelligence (AI) utilizing advanced analytics. Utilizing emissions data enables quick win abatement opportunities through optimization, equipment selection, flare initiatives and equipment repair. In addition, when this data is combined with economic and regulatory incentives, it can influence power generation choices as well as process electrification decisions and investments. Thus, the adoption of CCUS and hydrogen can be accelerated.

Building robust carbon management and quantification systems will help operators to address climate change and unlock opportunities by monetizing gas and pricing carbon. The application of digital technology makes carbon management systems scalable across assets with the possibility of automation, while at the same time maintaining the ability to localize problem areas. Unarmed sensors and vehicles can help in surveying a wide range of assets such as pipelines and storage tanks, and it can help operators to monitor, quantify, and mitigate GHG emissions.

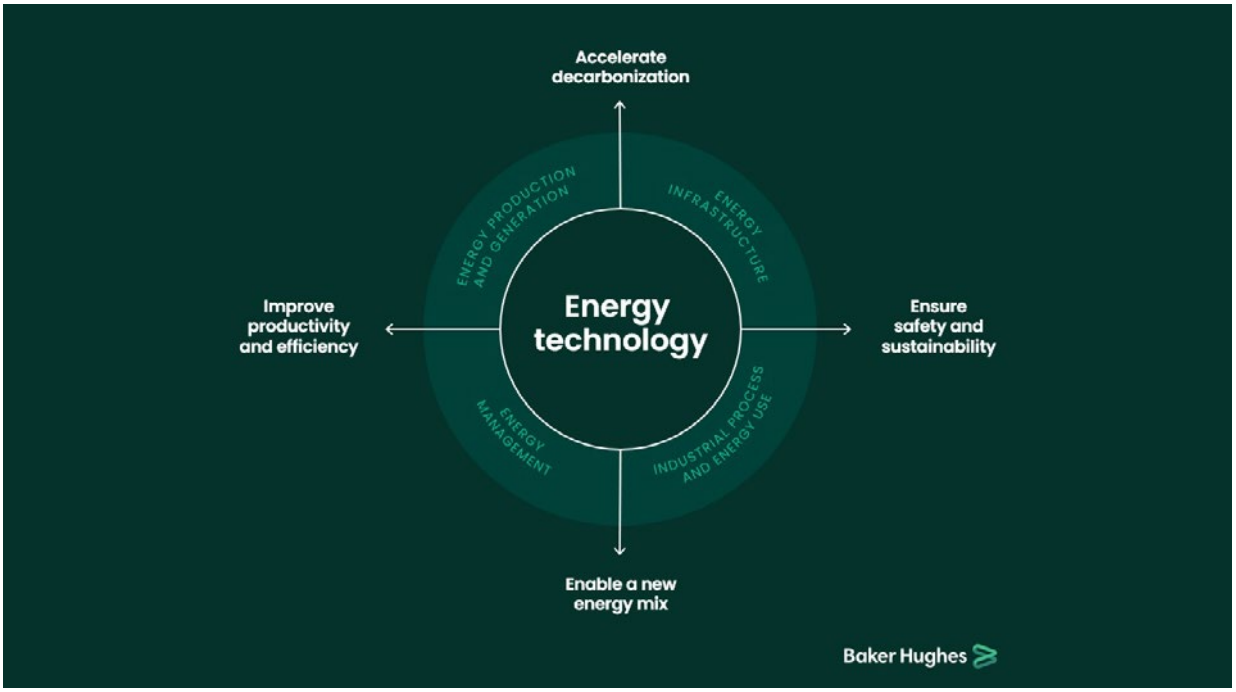
The Role of Regulations and Standards in Accelerating the Energy Transition

Hydrocarbons will continue to play a role as an energy source in the decades to come, but they need to be made cleaner without impacting human and economic progress. Webinar participants discussed two frameworks that will enable the energy transition.

The first framework is centered around technology, as depicted in Figure 1. This framework would tackle multiple themes around improved productivity and efficiency, decarbonization, and a diversified energy mix while maintaining energy security and sustainability.

The second framework addresses the energy transition with a combination of financial instruments, regulations and policies intendedto accelerate the energy transition by creating incentives that bring everyone to the table. These incentives are meant to highlight opportunities for emitters to monetize their efforts to decarbonize. One example is the application of cap-and-trade regulations where an emitting entity trades its quota surplus for a monetary benefit higher than the sum spent on producing the surplus. Other initiatives, such as the creation of storage markets via circular carbon economy practices, play a similar role and provide investment opportunities in the green economy. Subsequently, this framework helps accelerate the commercialization of immature and novel technologies to reach society's decarbonization targets.

Figure 1. Technology framework in the oil and gas industry



Source: Baker Hughes.

Cybersecurity and the Energy

Even though major oil and gas enterprises consider digital and AI to be game changers, they are concerned over the potential for increased cybersecurity threats. The energy sector has experienced a major increase in cyberthreats and ransomware attacks. On May 7, 2021, the Colonial Pipeline system was shut down for six days in response to a cyberattack. The shutdown pipeline, which provides nearly half of the U.S. East Coast's fuel supply, led to a 4 cents per gallon increase in average gasoline prices in affected areas (Tsvetanov & Slaria 2021).

Cyber risk is inherited in any system that is digitally connected. Recent cyberattacks in the oil and gas industry have been driven by three trends:

1. **Business transformation:** Mergers and acquisitions continue to drive massive reorganizations across the industry, creating some confusion in the roles and responsibilities within organizations.

2. **Digital connectivity:** Outdated and unpatched equipment increases both the attack vector and the attack surface.

3. **COVID-19 effect:** Commodity pressures are forcing the sector to decide between prioritizing budgets in operations or security. At the same time, IT safeguards create increased exposure to attacks.

As digitalization advances, tackling cybersecurity requires resiliency and the implementation of security measures and safeguards. Several measures are being taken by regulators and the energy industry to ensure resiliency, improve information management and mitigate cybercrimes.

Saudi Arabia has national regulations, such as:

1. National Data Governance Regulations from the Saudi Data and AI Authority (SDAIA)

2. Controls and Guidelines from the National Cybersecurity Authority (NCA)

3. Cybersecurity Regulatory Framework from the Communications and IT Commission (CITC)

These regulations provide comprehensive policies, governance mechanisms, standards, frameworks, controls, and compliance guidelines to reduce cybersecurity risks. The SDAIA Data governance regulations detail key data governance concepts, data classification levels, data controls, open data rules and obligations. The NCA controls items such as social media accounts, cloud accounts, telework controls, and critical system controls. The CITC framework for service providers comprehensively details the minimum-security requirements, including controls that cover cybersecurity governance, asset management, risk management and physical security.

The NCA is in charge of cybersecurity in the country. It has regulatory and operational functions related to cybersecurity, and it works closely with public and private entities to improve the cybersecurity of the Kingdom of Saudi Arabia to safeguard its vital interests, national security, critical infrastructure, high-priority sectors, and government services and activities.

Besides national level frameworks, a consortium between oil and gas enterprises can help to fulfil the above objectives. For instance, Saudi Aramco and the Sadara Chemical Company led the

Intelligence Sharing Consortium for the energy industry. The consortium comprises 14 partners collaborating on intelligence to combat cybersecurity risks. The Sadara Chemical Company is a joint venture developed by the Saudi Aramco and The Dow Chemical Company.

Digital experience for customers is key for business growth, and cloud and internet applications are prone to targeted attacks such as distributed denial of service; advanced persistent threats bring digital services down. There is a need for mechanisms that establish trust to allow for such a collective defense. Collective consortia members share possible and known threats, share knowledge on the quality of detection and the quality of mitigation. An awareness of cybersecurity metrics such as detection time, mitigation time and attack recurrence rate will help to combat cyber threats.

Oil and gas producers can partner with leading institutions to develop cybersecurity frameworks. For example, Saudi Aramco is a founding member of the World Economic Forum's Centre for Cybersecurity, an independent and impartial global platform committed to fostering international dialogues and collaboration between the global cybersecurity community in the public and private sectors. Its priorities are aligned with reducing risk by:

- Enhancing cyber resilience by developing and scaling forward-looking solutions and promoting effective practices across digital ecosystems.
- Increasing global cooperation between public and private stakeholders by fostering a collective response to cybercrime and jointly addressing key security challenges.
- Identifying future cybersecurity challenges and opportunities related to Fourth Industrial Revolution technologies and envisioning solutions to ensure business continuity and minimize operational disruptions.

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About the Workshop

KAPSARC held a virtual workshop on December 2, 2021, in partnership with Baker Hughes and the Society of Petroleum Engineers – Digital Energy Technical Section. The workshop participants discussed the following topics to shed light on digital adoption in the oil and gas industry:

- Balancing the realities and expectations of digital transformation
- Bridging digital transformation and the energy transition
- Application opportunities, potential solutions, and associated risks

The workshop gathered over 70 attendees from various fields, including regulatory, policy, research, investment, and the oil and gas industry.

List of participants

Abderrehman Beloucif – Vice President of Saudi Arabia and Bahrain at Baker Hughes

Anak Bt. Karim – Digital Strategy and Planning Upstream Head at Petronas

Amar Amaranth – Energy Information Management Director at KAPSARC

Anthony Kakpovbia – Emissions Management Leader at Baker Hughes

James Wimbury – Managing Director at Accenture Middle East

Fahad Almalki – Workshop Coordinator, KAPSARC

Fahad Alturki – VP and Head of Knowledge and Analysis, KAPSARC

Majed Alsuwailem – Research Fellow I, KAPSARC

Medhat Kamal – 2023 SPE President

Mike Roschin – Chief Technology Officer at C3.ai

Mohammed Al-Habib – Energy Transition Executive at Baker Hughes

Osamah Al-Momen – Regional Marketing and Strategy Manager at Baker Hughes

Saeed Al-Mubarak – Chairman of SPE Digital Energy Technical Section

Thamir Al Shehri – Research Associate at KAPSARC

Tony Edwards – CEO of Stepchange

Yousef Al-Ghamdi – Chief Development Officer at SDAIA

About the team

Dr. Fahad Alturki

Dr. Fahad Alturki is Vice President of Research at King Abdullah Petroleum Studies and Research Center (KAPSARC). In this role, he oversees KAPSARC's research programs and priorities, ensuring that these are strategically focused on impacts within the Kingdom of Saudi Arabia, both regionally and globally. Dr. Fahad interacts with key stakeholder groups within the Kingdom and internationally, in the private, academic, and government sectors. Moreover, he is responsible for setting the overall directions and parameters for collaboration with KAPSARC's partners and affiliates. Externally, Dr. Fahad is an independent board member of the General Authority of Statistics Board of Directors and the Islamic Corporation for the Development of the Private Sector (ICD). He frequently presents papers at a number of high profile local, regional, and international conferences, participates in roundtable discussions and is a well-known media figure in Saudi Arabia and overseas. Prior to joining KAPSARC, Dr. Fahad was the chief economist and head of research at the Jadwa Investment Company in Riyadh, where he managed the economic research department and published regular reports on issues related to the Saudi and global economies and the world oil market. He was also the chairperson of the Public Funds Board, a board member of the Jadwa REIT Al Haramain Fund and Jadwa REIT Saudi Fund, and a member of Jadwa's executive management committee. Dr. Fahad has a proven track record in economics, with more than 20 years of experience in the field. Before joining Jadwa, Dr. Fahad was the chief economist at Barclays, Saudi Arabia. Prior to his time at Barclays, he was an economics specialist at the Saudi Arabian Monetary Authority, where he worked for 11 years in the Economic Research and Statistics Department. Dr. Fahad has also worked as an economist at the Middle East and Central Asia Department of the International Monetary Fund. Dr. Fahad holds a B.A. in Business Administration from King Saud University in Saudi Arabia and master's and Ph.D. degrees in economics from the University of Oregon (Eugene, United States).

Abderrehman Beloucif

Abderrehmane Beloucif is the Vice President of Saudi Arabia and Bahrain at Baker Hughes based in Dhahran, Saudi Arabia. In this role, he oversees Baker Hughes' strategic and commercial priorities in the region. Abderrehmane has over 20 years of experience in the oil and gas industry in both regional and global role. Prior to his current role, he was leading the global Oilfield Services (OFS) Reservoir Technical Services with Baker Hughes. Abderrehmane holds a B.Sc. degree in Petroleum Geophysics Engineering from the Algerian Petroleum institute, and a master's degree in Nuclear Physics from the University of Science and Technology (USTHB) in Algeria.

Saeed Al-Mubarak

Saeed is a worldwide recognized digital transformation expert. He has about 30 years of experience in the petroleum industry and has served the industry in various capacities that span across local and international levels, technical and administrative, and from simple to leadership roles. He began his career in 1992 with Saudi Aramco, where he worked as a reservoir, production, drilling and completion, facilities, knowledge management, and intelligent fields engineer and specialist. He has led several important teams, including the strategic team managing the world's largest intelligent fields. He is currently an intelligent fields and petroleum engineering consultant at Saudi Aramco, based in Dhahran, Saudi Arabia. He has also served as the Chairman of SPE Digital Energy International Technical Section (DETS), a member of the Advisory Committee of SPE Data Science and Engineering Analytics (DSEA), an industry advisor for Texas A&M University SPE student chapter, a member of numerous international technical steering committees, advisory boards, program committees, and in the SPE International awards advisory committee. His contributions to industry were recognized by renowned technical, governmental and social authorities. He is the recipient of several recognitions, including the 2009 SPE Regional Management and Information Award, the 2012 WorldOil Innovative Thinker Award, the 2013 Saudi King's award for innovation and the 2014 SPE International Award for Management and Information. He also earned the 2011/2012 SPE Saudi Section Community Service Award for his contribution to social programs. He was a finalist in the 2016 WorldOil Lifetime Achievement award, and the recipient of the international 2019 SPE Distinguished Service Award, and the 2019 SPE Distinguished Member Award. He is also a recognized as a thought-provoking author and a speaker who has developed and conducted several technical courses and workshops, mostly about digital energy and challenging paradigms. He is a prolific technical writer who has published tens of articles to promote innovation and challenge conventional wisdom within and beyond the digital energy and intelligent field. His work includes including the book Any Version of History is just a Story. He has been an SPE international distinguished lecturer, a panelist, keynote and invited speaker, and a discussion leader at numerous events held in 20 countries, including conferences, workshops, forums, symposia and social events. Saeed is also a co-founder and a CEO of Monuments, a 3D printing company in Saudi Arabia. He holds a bachelor's degree in chemical engineering and a master's degree in petroleum engineering, both from KFUPM. He graduated from the Saudi Aramco Technologist Development Program as real-time reservoir management and intelligent fields specialist.

Majed Al-Suwailem

Majed is a Research Fellow at KAPSARC with a focus on energy security, oil trade, and market structure. He has more than 15 years of experience in the oil and gas industry in the fields of simulation and modeling, asset management, oil field development, disruptive technologies, and business planning, gained at Chevron and Saudi Aramco.

Osamah Al-Momen

Osamah currently serves as Baker Hughes' Strategy and Marketing Manager for the Middle East, North Africa, Turkey and India region. He focuses on studying and evaluating macro- and microeconomic drivers in the region that affect the energy and industrial sectors. This drives his role in new business strategy development. Osamah has more than 20 years of experience in the oil and gas sector and has served multiple major service companies across multiple disciplines and multiple roles in the upstream business. Osamah holds a B.S. degree in electrical engineering from KFUPM in Dhahran, Saudi Arabia

Amar Amarenth

As head of the Energy Information Management program at KAPSARC, Amar is responsible for running all facets of the energy data portal design, development and research insight web apps. He has over 20 years of experience building data management platforms for the research and technology industries. Prior to joining KAPSARC, Amar was Chief Information Officer for Swiftpage, where he was responsible for all technology and customer care delivery. At Swiftpage, he led the company's technology transformation from startup to enterprise-ready platforms. Before that, he was Information Technology Vice President at IHS Markit, where he led the design and implementation of global data operations, technology platforms and strategies. He also served as Senior Director of i2 Technologies' data consulting services division for a decade, holding several international positions.

About the Project

Saudi Arabia has introduced the circular carbon economy (CCE) concept as a holistic approach to managing the carbon cycle and addressing climate change. The digital carbon accounting project explores how digital tools can support the measurement reporting and verification of carbon cycles. It focuses on improving the transparency of carbon accounting practices and standards across commodity supply chains to promote and enable efforts to value carbon management within a global CCE framework.

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