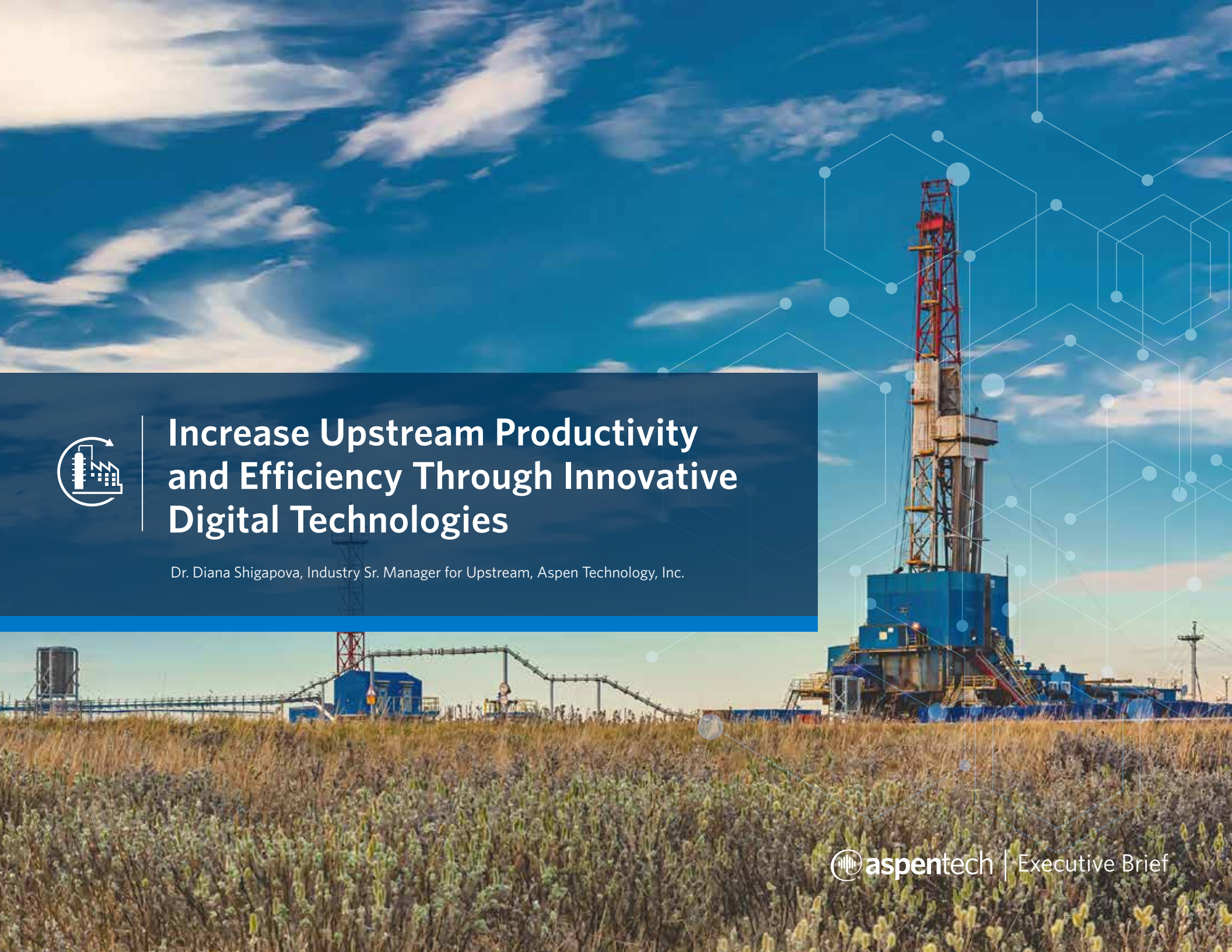

Increase Upstream Productivity and Efficiency Through Innovative Digital Technologies

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aspentech | Executive Brief

Executive Summary—Digitalization as a Strategic Tool

The upstream industry is facing the daunting challenge of producing secure, sustainable and affordable energy for the world's current and future needs. Oil and gas exploration and production companies need to optimize operational performance to remain profitable, while at the same time, lower geological risks and minimize the impact of their operations on the environment. Optimization across the upstream value chain and further automation are required to reduce dependencies on scarce skilled resources.

Oil and gas are among the largest sources of primary energy, making up 32% and 24% of the total energy supply, respectively (as of 2022). Oil and gas will continue to play a critical role in the energy mix even under a low carbon economic model.[1]

Innovative digital geoscience, petroleum engineering, process simulation and advanced process control solutions can help optimize operations, increase confidence in reserves estimation, minimize risk and reduce emissions. As planning tools, digital solutions help reduce project costs and timetables, accelerate time to revenue, leverage existing assets and infrastructure, and lower the carbon intensity of products.

Geoscience digitalization is equally valuable in traditional exploration and production activities, and in new energy markets. Digitalization leads to:

More informed decision-making: Leveraging digital technologies helps companies make informed decisions based on real-time data insights. It enables them to anticipate crises, prevent failures and shutdowns, and identify patterns and trends that were previously difficult to detect. These lead to better decisions about resource allocation, equipment maintenance and production planning, helping them to stay competitive and succeed in a rapidly changing market.

An annual upstream investment of $640B USD will be needed by 2030 to ensure adequate supplies (according to S&P Global Commodity Insights).[2]

Improved financial stability: Digital transformation offers real-time analytics to better understand market trends. An automated system improves financial performance by optimizing operations and reducing costs, including for maintenance and repair, and ensures business continuity and viability of operations. It also streamlines processes and enhances communication between different departments and stakeholders.

Safer operation: Digitalization improves safety through real-time monitoring and analysis of data. By facilitating remote operation, it reduces exposure to dangerous environments. Digital tools also help companies manage regulatory and environmental compliance.

Reduced carbon intensity: The use of digital technologies facilitates the adoption of renewable energy sources, reducing energy consumption and optimizing operations to minimize waste and emissions.

Top Three Business Challenges

Challenges to the upstream market can be divided into three strategic areas: ensure energy security, enable energy transition and optimize operational efficiencies and costs.

1. Ensure Energy Security

Today's energy industry is facing the unprecedented challenge of balancing energy security, affordability and environmental sustainability. The International Energy Agency (IEA) defines energy security as uninterrupted, reliable and affordable "access to all fuel and energy sources." This means both a reliable supply of fuel and dependable infrastructure to carry energy to the end user. The IAE notes that energy security includes both long-term—investments needed to supply energy in line with economic developments and environmental needs; and short-term—the system's ability to react promptly to sudden changes in the supply-demand balance.

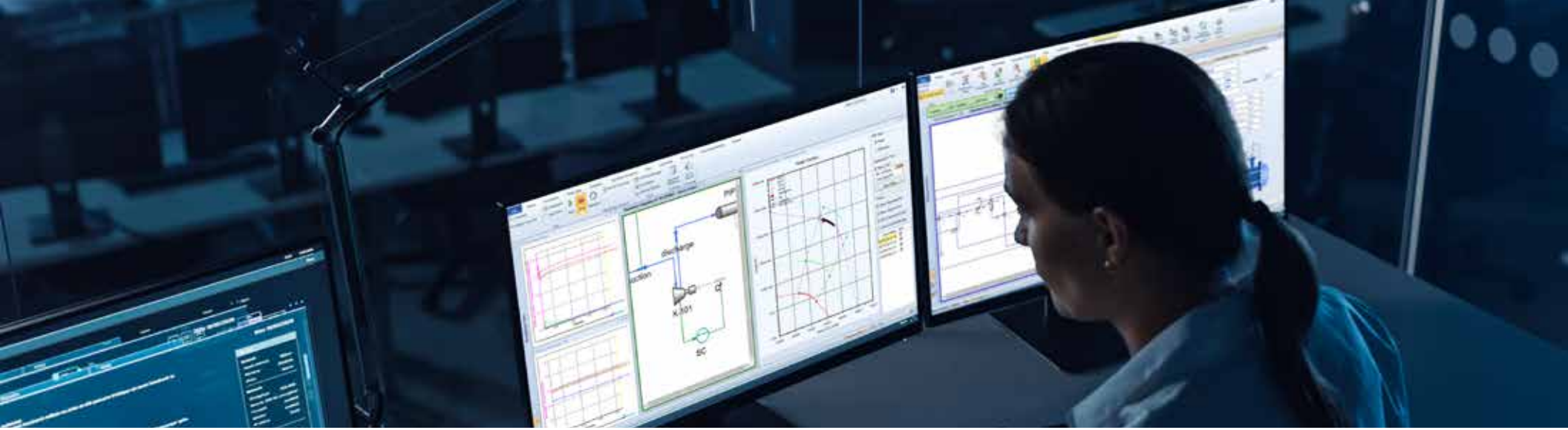
- **Availability and reliability:** To ensure that energy sources are available in sufficient amounts, companies will likely be making fundamental changes in their investment strategy, portfolio composition and fuel priorities, moving to a focus on low-carbon energy.[3] At the same time, as oil and gas will continue to be the chief sources of energy in the foreseeable future, investment in exploration and development will continue, with more emphasis on areas where there is already activity and existing infrastructure, to ensure a higher return on investment.
- **Affordability and accessibility:** Ensuring that reliable production infrastructure is in place to deliver energy supplies to the end user in an affordable manner has been an important driver in the massive investment in Liquified Natural Gas (LNG) and offshore E&P rather than land-based facilities. Thus, investment in offshore E&P is forecasted to reach $233B USD by the end of 2027[4], with Floating Production Storage and Offloading (FPSO) market size expected to reach $16.69B USD by 2028.

BP's current trajectories scenario projects that the world's oil demand will still be about 90% of today's demand in 2050, necessitating continued investment in production optimization.[5]

2. Enable Energy Transition

Governments, intergovernmental commissions and financial institutions around the world have set a global target of achieving net zero carbon emissions by 2050. This is putting pressure on energy producers to move faster and be more transparent regarding their efforts to reduce the carbon footprint. The core components of this transition are increasing low-carbon energy businesses, natural gas, and carbon capture and sequestration (CCS), as well as reducing emissions from traditional hydrocarbon production and electrifying oil field equipment.

To make fugitive emission reduction a component of the business, oil and gas companies have to truly understand their operational data so they can make effective decisions around carbon mitigation, with a particular focus on monitoring and identifying leaks and remediation. For example, companies can make decisions based on trade-offs between emissions, water and energy use, yields and marginal cost per BOE (barrel of oil equivalent). The key to success is technology that enables operators to optimize across multiple disciplines (engineering, operations and maintenance) and show where problems are occurring in real time so they can take immediate action to resolve them, or even change operational plans to avoid them in the first place.



3. Optimize Operational Efficiencies and Costs

While global demand for energy continues to climb, exploration and production companies are finding effective ways to reduce costs, with a positive spillover effect on safety, carbon emissions and production outcomes. Some companies have reduced new exploration in traditional industries in favor of alternative energy strategies, putting a premium on maximizing the value of current production. They typically drive higher efficiency from inputs and can deliver savings of 10-15% of OPEX.[6] In order to achieve this goal, upstream companies need to improve operational excellence through:

- **Optimizing production at existing assets:** Advanced, digitally-enabled operational processes help capture data and report on asset performance, giving the insight needed to help companies improve efficiency, cut costs and reduce resource consumption. Companies focus on leveraging already depreciated costs in infrastructure while simultaneously extending the life of a declining field and/or increasing production through access to new or previously bypassed reservoirs and unlocking extra capacity in existing infrastructure.
- **Proactively evaluating operations:** With capital budgets stretched thin, maintaining equipment integrity and functionality is critical. Digital solutions—including digital twins to monitor well and production infrastructure, digitally-enabled process optimization and APC, and predictive analytics to detect equipment or well degradation—can help improve system efficiency and uptime, leading to lower operational costs and improved margins.
- **Enhancing collaboration:** Oil and gas companies generate vast amounts of data from different sources. Efficient data management and workflow integration are needed to break down data silos, to enhance collaboration and reduce the time needed to make critical decisions.

In offshore Australia, a patented, full-azimuth, specular and diffraction seismic imaging technology allowed an operator to greatly enhance the seismic image in a complex basin, resulting in increased confidence in the overall structure of the reservoir and the successful drilling of new wells. The outcome of this project demonstrated the advantages that modern seismic imaging technologies can offer in providing additional insights into legacy seismic data, even data acquired years earlier using older techniques, without the need for significant additional CAPEX investments.

Digital Solution Initiatives

Digitalization and operational optimization enhance energy security, boost efficiency and reduce emissions across exploration, production and primary treatment. These solutions can help mitigate geologic risks and accelerate field development strategy. They can help increase NG production and reduce carbon intensity with CCS, increase mature field production, improve energy efficiency and reduce emissions with technologies based on first principles, hybrid models and Industrial AI. AspenTech focuses on Industrial AI—the combination of AI with domain expertise in petroleum, geological and process engineering, and asset and industry knowledge—to drive improved agility, guidance and automation capabilities across its products and solutions.

1. Ensure Energy Security

- **Reduce geological risks in exploration, drilling and field development**

  Understanding, characterizing and evaluating the reservoir, the available resources and technically feasible production are key to reducing geological risks. Geophysics, geology and engineering modeling solutions, together with analytics, automation, and data and workflow integration, help increase operational efficiency, productivity, reliability and predictability. The skillful combination of these technologies is moving the industry toward optimizing asset performance across the full lifecycle of a reservoir with minimal human intervention.

  Fully automated cross-domain reservoir workflows facilitate easy model updates, enabling domain specialists to focus on analyzing results and not (re)making manual fixes. Aligning disciplines through a common platform increases efficiency, enables better collaboration across typically siloed disciplines, and supports optimal decision making.

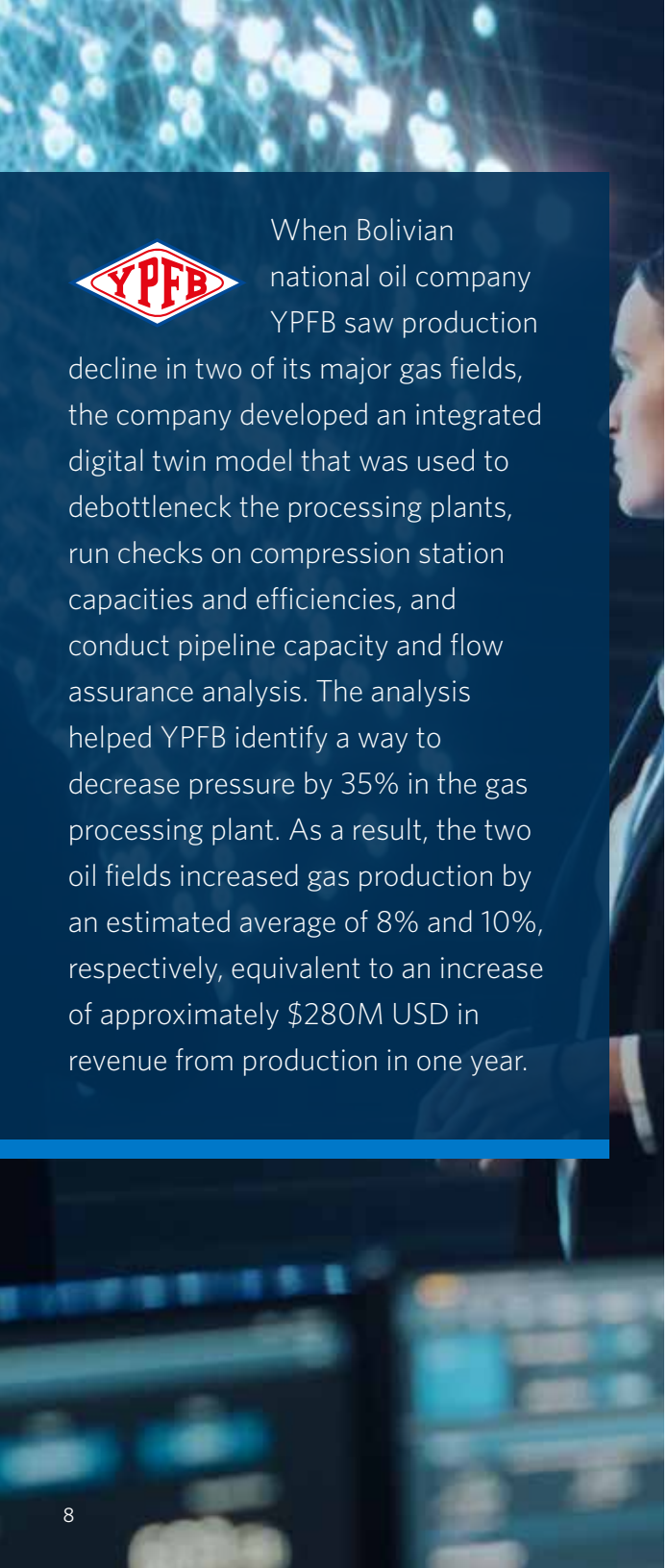
  Machine learning can streamline subsurface modeling workflows to enable faster and more accurate prediction of rock types, reservoir properties and fluid variations. It can also help offset a projected lack of skilled professionals with adequate expertise, providing next-generation workers with guidance in handling the complex data being acquired today.

Comprehensive ensemble modeling based on machine learning, is performed in multiple simulation runs. Each is calibrated using all available geophysical, geological and production data, thereby representing a plausible realization of the reservoir's properties and behavior. Analysis of the results provides a deeper understanding of the reservoir and its uncertainties, as well as the range of possible reservoir performance and associated risks throughout the field lifecycle.

- **Ensure effective resource management**

  A strategic focus for governments and companies is to ensure that sufficient high-quality, producible resources will continue to be available to a growing population over the years. Petroleum resource management offers a consistent approach to estimating petroleum quantities and evaluating development projects under various uncertainties, taking into consideration the requirement for long-term, integrated and effective solutions at all stages, from field development to decommissioning. Petroleum resource assessments estimate the total amount of hydrocarbons in known and yet-to-be discovered accumulations. Resource evaluations focus on those quantities that can potentially be recovered and marketed by commercial projects, e.g., smaller new deposits can only be profitably developed and produced by using existing infrastructure.

An automated, reproducible and auditable subsurface workflow that helps propagate uncertainties and capture dependencies while calibrating reservoir models was applied to an offshore field in Norway. This workflow enhanced the model's reliability by providing geologically consistent models. The crucial information generated helped reduce risk and optimized production, resulting in more reliable decision-making by a major operator, and protecting the company's ROI.



When Bolivian national oil company YPFB saw production decline in two of its major gas fields, the company developed an integrated digital twin model that was used to debottleneck the processing plants, run checks on compression station capacities and efficiencies, and conduct pipeline capacity and flow assurance analysis. The analysis helped YPFB identify a way to decrease pressure by 35% in the gas processing plant. As a result, the two oil fields increased gas production by an estimated average of 8% and 10%, respectively, equivalent to an increase of approximately $280M USD in revenue from production in one year.

- **Accelerate first oil/gas**

  Every company seeks to fast-track time to first oil/gas in order to reduce capital costs and improve return on investment (ROI) without compromising safety, environmental considerations or project quality. This is where the efficiency of automation and digitalization can be key to reducing timelines. Digital twins can be used to create comprehensive project plans to help identify and address potential bottlenecks early on, minimizing delays and costs. An integrated front-end digital twin of the conceptual plant layout, estimation and simulation helps reduce time to front-end business decisions.

A super-major reduced time to first oil by an entire year using a consistent costing model from conceptual to detailed engineering. The company faced challenges when building in remote, cold and snowy locations, and executing projects with assurance and predictable results to mitigate key risks. Using this modularized approach helped eliminate as much stick-built construction as possible and demonstrate commissioning and construction planning in the early stages of design. This reduced cost and concept selection time by 50%.

2. Enable Energy Transition

- **Increase natural gas production**

  As a lower-emissions fuel source, natural gas will play a vital role in meeting the world's energy needs for the foreseeable future; thus, an increase in gas production is essential. However, natural gas production is often subject to various surface constraints and challenges due to the connection between reservoir production and processing capabilities.

  A subsurface-to-surface integrated model and end-to-end digital twin model spanning the reservoir to the wells and the processing infrastructure, provides a holistic overview of the system and enables operators to optimize production and reduce emissions across the entire value chain.

- **Reduce companies' carbon intensity with carbon capture and sequestration**

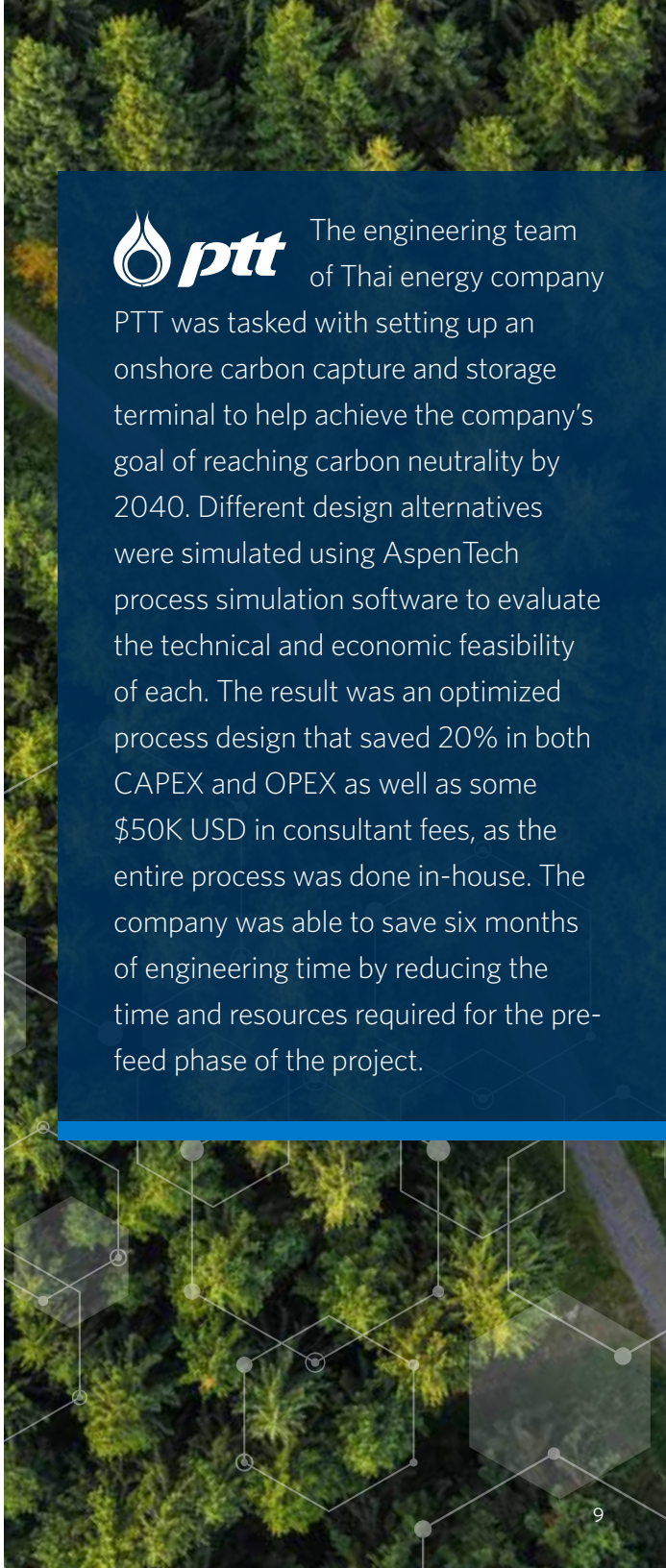
  In the IEA's sustainable development scenario, carbon capture, utilization and storage account for nearly 15% of the cumulative reduction in emissions. Companies are deploying CCS to lower the carbon intensity of production in their existing assets, and when looking to grow CCUS business and explore new business opportunities through various co-operations. Digitalization can help optimize the entire value chain, from capture to sequestration, presenting organizations with a unique opportunity to rapidly screen CCS projects, look at multiple options and design effective, economic solutions to address carbon mitigation requirements.

  Process engineering and production optimization solutions offer strong capabilities for the design, operation, control and optimization of carbon capture plants, while interpretation, reservoir characterization, modeling and engineering technologies are strategic in selecting, characterizing and monitoring carbon sequestration in geologic formations. Together, they ensure the correct representation of often complex geological structures and lead to a realistic assessment of the sealing capacity of the reservoir or production yield in Enhanced Oil Recovery (EOR).

- **Improve energy efficiency and reduce emissions**

  Technology has played a central role in accelerating the energy transition, as it improves the efficiency of operations and reduces the carbon footprint of conventional fuels while supporting the deployment of green energy. According to the UN, readily available technological solutions already exist for more than 70% of today's emissions. Digital technologies—edge computing, mobility, cloud technologies and artificial intelligence (AI)—are transforming the way the world produces and consumes energy. For example, advanced process control (APC) solutions can optimize production asset operation, increasing throughput by 2-4% and reducing energy consumption and CO_2 emissions by as much as 10%.

  The infrastructure used for oil and gas field exploration and production can be repurposed later for carbon reduction and removal activities such as subsurface carbon storage, and green energy in the form of geothermal power generation and hydrogen storage.



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The engineering team of Thai energy company PTT was tasked with setting up an onshore carbon capture and storage terminal to help achieve the company's goal of reaching carbon neutrality by 2040. Different design alternatives were simulated using AspenTech process simulation software to evaluate the technical and economic feasibility of each. The result was an optimized process design that saved 20% in both CAPEX and OPEX as well as some $50K USD in consultant fees, as the entire process was done in-house. The company was able to save six months of engineering time by reducing the time and resources required for the pre-feed phase of the project.

An engineering company in Canada needed an integrated model for reservoir and facilities to plan steam injection operations in order to maximize production and reduce emissions. The company built an integrated model by deploying a hybrid reservoir model, trained on data from discretized models of the reservoir, in a single flowsheet with the first principles model of processing facilities. Due to its faster calculation speed and accuracy, the team was able to optimize production by leveraging uncertainty analysis to improve steam allocation, technology selection and de-bottlenecking. Altogether, this led to an 8% increase in NPV.

3. Optimize Operational Efficiencies and Costs

Companies recognize the need to acquire sufficient knowledge to efficiently access, manage and analyze the huge amounts of data now available to them. Industrial AI, combining AI with domain expertise, plays a key role in meeting this challenge. From advanced process control to front-end engineering, geophysical interpretation and modeling, engineering hybrid models, and tools to optimize dynamic transmission and distribution grids, AspenTech is rapidly introducing Industrial AI into the marketplace to drive operational excellence.

- **Enhance production and near-field expansion using existing infrastructure**

  Mature fields are valuable global resources, and near-field expansion enables upstream companies to leverage already depreciated costs in operating infrastructure while simultaneously extending the life of a declining field and/or improving production performance through access to new or previously bypassed reservoirs. Emerging high-end technologies can help geoscientists and engineers extract maximum information from both modern and legacy data. By improving reservoir understanding and reducing production forecast uncertainties, they support reliable decisions about production optimization.

  A subsurface-to-surface connection is essential, as it can help operators find solutions to production bottlenecks and identify future problems, as well as understand and predict the impact of changes in reservoir behavior on production facilities and vice versa. Subsurface and surface modeling and engineering solutions can be leveraged to qualify opportunities for production enhancement, increase confidence in reserves estimation and producibility, and minimize risk associated with further operations.

- **Ensure production stability and agility**

  Most upstream assets have large untapped benefits that advanced process control (APC) can unlock by mitigating slugging effects, increasing throughput, reducing flaring, optimizing well production and improving energy efficiency. APC solutions can maximize profitability by reducing process variability, thereby allowing operations to run closer to gathering system constraints. Using embedded AI, APC can handle process non-linearities and build seed models from historical data. Actionable process control guidance is provided to users through an AI virtual advisor, which enables upstream operations teams to interpret and adjust the APC settings with minimum technical assistance.

- **Decrease energy and water use**

  Upstream oil and gas producers generate tens of millions of barrels of produced water that need to be managed on a daily basis. Digital solutions that enable companies to sustainably and cost-effectively manage their entire water lifecycle can significantly reduce their water footprint and thereby improve environmental, social and corporate governance (ESG) performance.

  Operational digital twins can help monitor environmental metrics and recommend actions to achieve sustainability goals. Online utility models of the asset show the minute-to-minute and long-term energy and water use metrics of the enterprise and individual assets. Combined with a hydrocarbon reconciliation model, they incorporate water use, utility choices, energy use and cost and emissions, providing a near real-time picture of sustainability performance.

The Middle Eastern oil and gas company ADNOC reduced its hydrocarbon loss and energy use as well as its water loss in one of its largest gas fields in Abu Dhabi. Looking to improve overall performance, the company deployed 80+ sustainability dashboards using digital twins. These solutions provided them with role-based insights and streamlined the company's decision-making.

A super-major is using advanced process control to maximize Permian basin oil production while minimizing flaring intensity and GHG emissions. The complexity of rapidly changing fields with system-wide constraints makes it challenging for operators to optimally control the field. Using sophisticated adapted controls combined with the customer's APC capability helped reduce flaring while increasing oil production. In addition, it minimized emergency shut-down (ESD) events and field operators' "windshield time" through improved control of system pressures.

A major operator in Asia implemented a prescriptive maintenance and asset monitoring solution for two geographically distributed FPSOs. For both facilities, asset health monitoring happened at the central office onshore. The main focus was on water handling and high-maintenance items such as sea water and injection pumps, as well as water filters. The result was lower maintenance costs, a reduced need for staff on the FPSO and increased production uptime.

- **Improve equipment reliability and availability, reduce unnecessary and emergency maintenance activities**

  Gathering system fluid flow, equipment failures and process disruptions are the main drivers of unplanned downtime, resulting in billions of dollars in lost revenue and profit every year. Early asset degradation and failure prediction based on prescriptive maintenance, powered by AI, is the key to preventing these issues. The ability to digitalize and monitor assets via sensors and aggregate and contextualize data has steadily evolved to where today's asset performance management technology can create a maintenance strategy that can accurately predict failures.

  Asset reliability also improves safety—the rate of accidents increases significantly during transitory operations like shutdowns and startups. By avoiding unexpected failures, safety is improved, especially for maintenance workers, and early warnings enable companies to move from emergency to planned maintenance.

Conclusion

The world is facing an energy trilemma—energy security, sustainability and affordability—and the upstream industry plays a key role in meeting these challenges to support global needs, both current and future.

Governments, intergovernmental commissions and financial institutions around the world have set a global target of achieving net zero carbon emissions by 2050. This is putting pressure on energy producers to move faster and be more transparent regarding their efforts to reduce the carbon footprint, and many have set net zero targets. Oil and gas exploration and production companies need to optimize operational performance in order to remain profitable, while at the same time improving field development efficiency and minimizing the impact of their operations on the environment. Optimization across the upstream value chain and further automation are required to reduce dependencies on scarce skilled resources.

To meet these challenges, innovative digital geoscience, petroleum engineering, process simulation and advanced process control solutions can help optimize operational excellence, minimize risk and reduce emissions associated with the traditional oil & gas industry, while developing new, low-carbon businesses to support the energy transition.

Citations

[1] Energy Demand (bp)

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[3] 2024 Oil and Gas Industry Outlook (Deloitte)

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[6] Can Upstream Energy Companies Sustain Reduced Costs? | BCG

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About Aspen Technology

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in asset-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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