WHITE PAPER

FROM SURVIVAL TO REVIVAL
DIGITAL TRANSFORMATION FOR OIL AND GAS

Introduction

The Paleozoic era, which ended around 250 million years ago, was a period marked by intense climatic, geological and evolutionary change. This period witnessed a rapid and widespread diversification of life brought on by the most severe mass extinction ever witnessed on this planet. Organic life like plants and marine animals died during this era and their remains got buried thousands of feet below the surface of the earth.

It is hard to believe that these buried remains sparked one of the most important revolutions for mankind – the Industrial Revolution. Transformed over the years by high temperature and pressure, these remains spread over vast areas became large fields of crude oil that has been powering our industries, machines and transport for over a century now. Today, the entire oil and gas industry, the global economy and perhaps even the world order revolves around these remnants of the Paleozoic era.

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Challenges for the oil and gas industry

Since the 4th century AD when the first oil well was drilled in China using bamboo poles, the oil and gas industry has witnessed many ups and downs. While majority of the world's energy needs are still being met through coal, oil and gas, in the last few years, the value of energy companies has halved.

Today, this US $5 trillion industry is under tremendous pressure to change its business model. Some of the main challenges faced by the oil and gas industry are:

1. **Dwindling reserves** – The current global demand for oil is about 100 million barrels per day. However, over-drilling to meet consistent demand has led to dwindling reserves that are unable to sustain the average output. Another challenge is the economic viability of extracting oil, which depends on the market price and technical capabilities. As most of the large oil fields have already reached peak production, new reserves are becoming difficult to find.

2. **Cost management** – The cyclic oil and gas industry is vulnerable to volatile market conditions and geopolitics. With depleting reserves, the costs of production increase. While cost cutting is traditionally the response to adverse market conditions, in this sector it is not a sustainable strategy to manage price volatility. The focus should shift towards cost management by enabling economically viable production based on expected revenue and associated costs. This calls for systematic analysis of cost and production curves and a better understanding of cost and its associated drivers.
   Levers like automation, process optimization, contract renegotiation, waste reduction, and use of efficient technology can help reduce cost and enable high return on investment. For long-term success, the industry should move from price-based relationships between operators and suppliers to one that is more collaborative and mutually-beneficial whereby risks and rewards are shared. This will help players generate value, eliminate waste and promote accountability. Finally, improved demand planning and data-driven decision making should be adopted to reduce organizational inefficiencies.

3. **Geopolitical situation and market volatility** – Market volatility is often directly related to the world's geopolitical situation at any given moment in time. Geopolitics is driven by people, businesses and institutions within the limitations of three key factors:

   - Geography – This comprises sovereign borders, sovereign regulations, climate, and topography.
   - Economy – Economic limitations are driven by market forces, commodity prices, trade barriers, interest rate, and inflation
   - Technology – For the oil and gas sector, this involves availability of advance drilling and recovery techniques, automation, security, network, mobility, electricity, and global positioning systems (GPS)

   There are many examples of how geopolitical factors affect oil prices and production. For instance, crude oil prices doubled in 1990 as the Gulf war began and dropped by almost 30% by the end of war. With the US invasion of Iraq in 2003, oil prices increased by roughly 8% and subsequently declined by 12% by the end of war. While tension in the Middle East in 2013 started impacting oil prices, the US increased its crude oil production to stabilize the prices.

Another example of market volatility is how Turkmenistan, a land-locked country could not utilize and sell its gas reserves as all the pipelines connecting the region to world market were owned by Russia. As Turkmenistan challenged Russia's monopoly in gas production, there was a drop in the amount of gas being produced globally. In 2014, Saudi Arabia began to flood the energy market, possibly to compete with US shale production. This resulted in plummeting oil prices in 2016 with a gradual recovery only after the OPEC intervention. In Nigeria, political instability led to theft of crude oil (costing approximately US $1 billion per month). Today, more than 90% of the oil exported from the Persian Gulf passes through the Strait of Hormuz, which is 30 miles wide at its narrowest point. A single tanker accident, terrorist attack or any military intervention in this strategic area can threaten the global economy. Thus, managing the risks and dynamics of the global geopolitical situation is a tough challenge for the oil and gas industry.

4. **Aging workforce and knowledge retention** – Faced with an ageing workforce, the oil and gas industry is struggling to retain experienced staff and hire new talent. Despite attractive remuneration, working in this industry involves months away from one's home, harsh terrain and dangerous environments, which seem unappealing to the next generation. A study predicts that there will be a critical shortage of talent in the energy industry by 2030. It is expected that within 10 years the industry will be short of human resources by around millions. Added to this, the lack of knowledge retention strategies such as creating knowledge databases and portals and gathering community practices owing to cost pressures results in the drain of experienced talent. Addressing this is extremely crucial as most of the ageing workforce have vital experience in dealing with difficult on-shore and off-shore situations.
5. **Strict environmental regulations** – The oil and gas value chain releases several harmful chemicals like carbon dioxide, nitrous oxides, aerosols, carbon monoxide, and methane into the earth's atmosphere. The effect of this is dangerous for humankind as seen in instances of acid rain in the US and Europe, rising surface temperatures, unpredictable weather cycles, floods in deserts, draught in rainy areas, retreating glaciers, and fluctuating water levels. Studies also report occurrences of pre-mature births, altered sex ratios and birth weight issues in children living close to refineries. Moreover, despite precautions, oil spillages continue to occur, affecting marine life, birds and mammals. Therefore, global authorities are tightening environmental regulations in the oil and gas industry, which poses a challenge amid the existing cost pressures. Nevertheless, it is important to establish the right balance between economic development and social and environmental factors to ensure sustainability and profitability.
6. **High costs of safety** – With dangers such as fires, explosions, falls, toxic exposure, vehicle crashes, electrocution, extreme weather, material spillage, fatigue, and physical injuries, the oil and gas sector is among the most hazardous industries. Thus, Health and Safety (HSE) is a big concern, particularly for offshore operators. Oil spill disasters such as the Deepwater Horizon spill have placed HSE at the heart of operational planning. However, the challenge is creating a balance between safety and cost as ensuring safety can be an expensive affair. Moreover, safety management should focus on minimizing liabilities rather than return on investment.
7. **Demand for renewable energy** – The movement to stop climate change and global pollution caused by oil and gas based products is forcing players to diversify their energy portfolio. While crude and coal are still the cheapest sources of energy, there is a growing thrust on bringing renewable energy into the mix to reduce greenhouse gases and promote cleaner sources of energy. Companies are now looking for ways to make renewable energy production sustainable and scalable, particularly as its economic viability increases. For instance, biofuels, solar and wind have always been a major source of green and clean energy. Waste and non-productive land sites are being used to set up solar and wind plants. Nowadays, ethanol from sugarcane residue is being added to petroleum products. As the demand for renewable energy increases, the cost of producing green energy will continue to decline even as the cost of producing oil increases.

What is digital transformation?

Digital transformation is a strategic and disruptive shift in how companies do business. It involves the sensible utilization of digital technologies to improve processes, optimize business models and enhance operational efficiencies.

The onset of digitalization is transforming every aspect of businesses and human life by enabling rapid innovation to meet the demand for better quality. Let us examine what has led to this era of digital transformation and what its drivers are:

1. **Exponential computing power based on Moore's Law** – The number of transistors in an integrated circuit doubles nearly every two years. Today, the power of a smartphone is far greater than the power of first IBM mainframe computer that was so large it had to be housed in an entire building. As computers and microprocessors become smaller, cheaper and faster, they can be easily equipped with embedded sensors and software. Moore's Law has transformed the ability to use sensors and microprocessors in all devices.
2. **Pervasive connectivity based on Metcalfe's Law** – This law describes effect of a telecommunications network on the number of connected users of the system, providing insights into how networking affects value. According to this law, the value does not lie in individual devices but in the connectedness of things. Thus, value increases according to the square of the number of users. While the impact of this law began with the first telephone, today, the pervasiveness of mobiles and smartphones has turned every person and every 'thing' into a live connection.
3. **Deep data availability based on Bandwidth Law** – This law observes that the connection speed of a high-end user grows by 50% per year. In fact, this drives our daily digital experience by enabling us to move from the limited capacity of dial-up internet to high-speed features of live streaming/video calls and augmented and virtual reality (AR/VR).

The combined strength of high computing power, connectivity and bandwidth availability have ushered in the age of digital transformation for businesses, individuals and the society at large.

Benefits of digital transformation

While digital transformation is not a panacea for all the challenges being faced by the oil and gas industry, it certainly can drive significant growth within the sector. Some of the main benefits of digital transformation in the oil and gas industry are:

1. **Unlocking new business opportunities** – Digital technologies help businesses look beyond the geographical, product/service-based and operational confines of their business models to new opportunities and offerings driven by data and collaboration. Energy companies embarking on digital transformation journeys are already moving beyond their existing portfolio offerings to include a strategic mix of green and non-renewable energy.
2. **Increasing capital profitability** – Construction inefficiency in the oil and gas sector impacts the world economy by approximately US $1 trillion per year. Digital technologies such as advanced

computing techniques for reservoir modeling and 3D seismic imaging as well as drilling advancements have helped producers extract oil from deep wells, a feat that was impossible a few years ago. Thus, the increased standardization of design, process and equipment with digital technologies is improving production and eliminating inefficiencies across the value chain.

3. **Improving operational efficiency** – Energy companies can improve margins and reduce cost through smart use of technology, particularly for predictive asset management, smart maintenance, workflow automation, and talent utilization. Real-time monitoring enables timely decision-making on plant operations. Predictive asset management technology allows preemptive equipment maintenance, thereby reducing machine downtime. Connected platforms and constant data availability provides operational insights and root cause analysis. All of this has a direct impact in boosting operational efficiency.

4. **Managing an ageing workforce** – A majority of the active workforce in this industry is on the verge of retirement. Digital technology enables knowledge discovery and robust knowledge management, whereby all employee knowledge is stored in centralized repositories. The digitalization of knowledge, processes and even system experiences reduces dependency on human memory. Moreover, technologies like artificial intelligence (AI) and the Internet of Things (IoT) can store the operational data of oil plants for future reference and timely guidance. In this way, the next generation of employees will have a ready source of information and experience-led knowledge to guide future operations.

5. **Reducing the cost of safety** – Plant accidents that endanger human life can cause severe reputational damage for organizations. Digital technologies allow companies to use robots and drones instead of human workers for inspections and problem detection in remote, hazardous and inaccessible terrain, particularly when there is a possibility of toxic chemicals or gases. Moreover, repetitive tasks such as constant monitoring can be performed solely by robots or with human supervision. The use of IoT sensors can provide timely warnings to ensure safety while IoT devices help companies monitor employee health, track their location, and more, thereby improving the safety net.

6. **Enabling agility to respond to market volatility** – Agility is one of the core concepts of digital transformation. Digital tools should not only improve incident response time but allow the business to respond effectively to market changes. In the current volatile economic climate, energy companies need to be agile with their planning and response. Agility helps upstream companies quickly scale production in keeping with market demands.

Digital technologies across the oil and gas value chain

Unlike other industries that can easily plug and play digital initiatives, capital intensive businesses like the oil and gas sector must carefully evaluate the power of digital to avoid costly failures. Some digital technologies have the potential to revamp the entire value chain across upstream, midstream and downstream operations.

The focus should not be on adopting a single technology in isolation. Digital transformation delivers maximum value when multiple technologies are implemented intelligently within integrated frameworks to boost productivity and efficiency.

Here are some of the key technologies that, when deployed judiciously, can transform the business model of the oil and gas industry:

1. **4D seismic imaging** – Traditionally, 3D imaging was used to understand the geology of the earth's surface and locate reserves. Now, 4D seismic imaging adds a time-lapse dimension to measure and predict fluid changes in the reservoir. This increases the recovery rate in the deposits and improves upstream revenue.

2. **IoT** – There has always been a gap between OT and IT, and integration is a constant challenge. IoT has the capability to bridge this gap by enabling collection and analysis of raw and unstructured data to get actionable insights. IoT combines sensors, communication and analytics to provide real-time information about temperature, pressure, density, flow rates, and location co-ordinates. Moreover, system and equipment performance can be easily tracked through proactive performance monitoring, thereby shifting assets from a time-based maintenance model to predictive maintenance.

3. **Big data and analytics** – Modern offshore drilling platforms have over 90,000 sensors generating gigabytes of data on a daily basis that can be used to gain actionable intelligence. Big data and analytics can generate insights, trends and patterns out of large raw unstructured datasets. Such real-time intelligence on geology and operations can improve drilling and well operations. Big data has also helped in the development of enhanced oil recovery (EOR), a technique that improves the productivity of mature wells that have already reached peak production. Data can also be utilized to improve asset performance through predictive maintenance algorithms that identify operational inefficiencies.

4. **AI** – When data from sensors is coupled with data about business processes, it unlocks new business value by enabling predictions, new efficiencies and revenue streams. This is possible with AI and machine learning (ML) solutions that integrate seismic and business data to accurately detect energy reserves, predict the economic viability of drilling, better assess risk, and proactively determine cost. AI solutions can also perform analysis on profit and loss calculations and predict market scenarios based on the existing conditions. Further, AI solutions can drive operational efficiency with the use of virtual assistants and intelligent robots.

5. **Blockchain** – The oil and gas supply chain involves multiple stakeholders, and trust and timely payments are often key issues. A distributed ledger system like Blockchain can address these challenges through its auditable and immutable processes. Blockchain hosts compliance and audit documents, thereby providing transparency for stakeholders as well as regulatory authorities across the entire value chain. Additionally, it simplifies the complexity of energy transactions that often include various details right from production information to payment documents. Having such readily-available information reduces cost and time for all stakeholders. In fact, Blockchain has several use cases in the oil and gas sector ranging from hydrocarbon and fleet tracking to trade finance, B2B/B2C payments, joint venture accounting, and intragroup payment settlements.

6. **Robots and drones** – Oil and gas operations are often hazardous due to exposure to dangerous chemicals, gases, weather, and terrain as well as tough living conditions. Robots can be used to automate many manual processes, thereby improving operational efficiency, ensuring human safety and preventing asset damage. For instance, inspection of pipelines is a costly, tedious and dangerous process, one that can be performed by drones even in the most challenging of terrains and conditions. Moreover, data from robots and drones can be leveraged by AI and analytics to predict risks like corrosion, leakage or any other mechanical damage.

7. **AR/VR** – Simulated reality using AR and VR technologies can improve risk assessment and maintenance with real-time feeds about rig machinery and its maintenance needs. Immersive views of the machinery can improve planning and enable timely resolution of maintenance issues. AR and VR can also be leveraged to provide virtual and simulated training sessions on machines or rigs in difficult terrain.

8. **Mobile technology** – The convergence of mobile technology with big data and cloud is making a deep impact on all industries. Mobility solutions can integrate devices with daily operations and streamline workflows for better communication and productivity. Wearable devices, smart phones and tablets can support real-time monitoring of personnel and assets, thereby improving overall safety across the value chain.

Conclusion

The oil and gas industry is grappling with myriad challenges such as cost compulsions, environmental issues, dwindling resources, workforce challenges, and safety concerns. Digitalization has the potential to address these challenges and improve efficiency. To remain profitable, companies in this sector should understand how various digital technologies like IoT, Blockchain, AI, ML, AR/VR, etc., can be applied across the value chain of upstream, midstream and downstream activities. Digital transformation can help these companies enhance safety, boost productivity, enable agility, and unlock new revenue streams. Planning such transformation journeys requires clear vision, strategy and commitment from senior management. This will help players in the oil and gas sector revive their businesses to adapt to the digital age where environmental, safety and economic concerns are paramount.

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