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Digital Transformation in Oil and Gas Industry
Opportunities and Challenges

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Abstract

Digital technology can benefit the oil and gas sector by increasing hydrocarbon recovery, ensuring safety throughout the corporate ecosystem, and improving operational reliability. This study addresses the oil and gas supply chain digital transformation tendencies as well as the Norwegian petroleum refining company Equinor's initiatives. The main objective is to explore the opportunities for digitalisation in the oil and gas industry as well as the state of the industry's digital strategy more generally. The findings support the industry's major players continuing to invest in their collaborative ecosystem by partnering with their suppliers and start-ups and sharing with them a platform where data that can help them improve their economic position can easily be shared. It is recommended that they should develop a digital strategy roadmap, as in the case of Equinor, as a matter of priority. Supporting innovation and technology adoption through continued investment and the hiring of qualified experts is also of critical importance. It is also important to improve the digital skills of employees and spread a digital culture throughout the company so that they can protect themselves against future cyberattacks or other potential risks. On a global level, the successful implementation of a digital solution will reshape market dynamics (in terms of supply, demand, and investment) as well as the way energy networks are managed.

Keywords

digital transformation, digital solution, oil industry, gas industry, supply chain

1 Introduction

Today, the oil and gas industry face three major challenges:

1. The increasing transition to clean, green energy.
2. The international pandemic that has caused a huge shock to oil and gas prices worldwide due to the spread of Covid-19, and its impact, both directly and indirectly, has caused massive disruptions in global trade and supply chains. While some supply chains have recovered or adapted, others are still struggling to cope with the pandemic.
3. Technological innovation is disrupting nearly all industries, such as energy companies, as well as governments. It affects how companies can compete, run, and develop their businesses.

To manage this change and remain competitive, it is advisable to invest in digitalisation, because fostering the transformation from hierarchically managed organisations to digitalised businesses creates value for all stakeholders and has enormous potential to benefit society. It also lowers operating costs and eliminates waste by automating processes, improves safety, and increases sustainability. Successful digitalisation requires collaboration among key stakeholders in leading industries, communities, and policymakers. Creating global data standards will also require new regulations for data sharing and security, as well as promoting operational transparency. As a result, policymakers should take action to assess, channel, and harness the benefits of digitalisation, as well as mitigate its threats. On a global scale, the successful implementation of digital solutions will change the dynamics of the energy market (in terms of supply, demand, oil prices, and investment) as well as the way energy networks are managed.

1.1 Research questions

In this context, the research question is as follows. How is digitalisation transforming the oil and gas industry, is it changing from a disruption into an opportunity? And how can major industry players reform their strategy to meet

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this challenge? If oil companies succeed in implementing a digital solution in their value chain, how will the market dynamics change, and what could be the future scenarios and trends of digitalisation in the oil and gas industry?

The research was conducted using a qualitative, exploratory approach. Extensive secondary literature was collected and data was analysed from industry observations, a review of research articles, books, journals, company reports, and electronic sources dealing with digitalisation in the oil and gas industry and its technological innovations (trends, issues, and opportunities), followed by an in-depth case study assessment focusing primarily on the strategies of oil and gas companies: Equinor as an early adopter company in terms of the digitalisation of the oil and gas industry.

The rest of this paper is organised as follows. In the Section 2, we examine the characteristics of the oil and gas industry and how they can implement digital innovation in their value chain. Then, we draw attention to the digital capabilities of the oil and gas industry. In Section 4, we outline a research approach to study the strategy and policy of digital innovation, the future scenario where digitalisation has been implemented successfully, and its impact on market dynamics. The paper concludes with a case study analysis providing insights into oil and gas companies' strategies: Equinor is an early adopter company in terms of the digitalisation of the oil and gas industry.

2 Digitalisation in the oil and gas industries

Traditional manufacturing industries worldwide are in the early stages of a digital transformation driven by exponentially increasing innovation and technology. The pace of change is in line with 'Moore's Law' concerning the speed at which change occurs through information technology. A new process that connects digital and physical realms and improves human decision-making with data-driven ideas is essentially changing the way businesses do things (MEED Mashrek, 2019). Enterprises and the energy industry are now forced to change their strategies and, more importantly, the way they do business, adopt new technologies and digitise their industries to adapt to this rapid change, else they will lose their competitive advantages and be left behind by their rivals. The widespread adoption of communication and information technologies by manufacturing industries around the globe is now paving the way for disruptive development methods that imply a drastic change by improving the productivity of new business models, as well as the safety, efficiency, and reliability of their operations; this will then have a remarkable impact on the economy in the context of other industrial revolutions (Bauer et al., 2014). Today we are witnessing a fourth industrial revolution that is taking the world by storm (Deloitte, 2015). Industry 4.0 is one of the most innovative recent research areas (Drath and Horch, 2014). It is taking place not only in the technology sector itself but everywhere, including the value chain of the oil and gas industry, which has played a significant role in the implementation of these advanced technological solutions (Al-Nahhas, 2018). In addition, we can see that the discourse about it is clouded by new technical jargon and concepts such as artificial intelligence, Big Data, and machine learning, which promote autonomous decision-making, interoperability, effectiveness, and cost reduction, among others (Perales et al., 2018).

Since the Industrial Revolution, the oil and gas industry has played a crucial role in the economic transformation of the world by meeting the needs of the world's population for heat, light, and mobility. Currently, the oil and gas industry has an opportunity to redefine its boundaries through digitalisation. After a period of falling crude oil prices and regular budget and schedule overruns, as well as higher transparency requirements related to climate change and the challenge of attracting talent, it can now offer practical solutions. Digitalisation can act as an enabler in overcoming these issues and can provide value to all investors (World Economic Forum, 2017). According to the IEA, the extensive use of current digital technologies could reduce production costs by 10 to 20%. Technically recoverable oil and gas reserves could be increased by about 5 billion barrels globally through the adoption of current and new digital technologies (IEA, 2017).

2.1 What is digitalisation?

Digitalisation represents the increasing use of information and communications technology (ICT) across the economy, particularly in energy systems.

The approach, practice, or procedures of converting (usually analogue) information into a computer-readable digital form is commonly referred to as digitisation. Digitising information allows it to be archived, stored, and shared more quickly, which is more practical and beneficial. This general term corresponds to the real-world conversion of analogue data into digital bits of the 1 s and 0 s series, the binary language. This is the binary data that can be processed by computers and many devices with computing capacity (Freeman, 2018).

The increasing communication, convergence, and integration between the physical and digital worlds can be considered digitalisation. Moreover, the digital world consists of three basic elements:

1. Data: digital information.
2. Analytics: the use of data to gain valuable information and insights.
3. Connectivity: data exchange between people, machines (including machine-to-machine), and devices via digital communication networks.

We find that the trend toward greater digitalisation is driven by advances in all three areas: increasing volumes of data due to falling costs of sensors and data storage, the rapid development of advanced analytics and computational technologies, and improved connectivity with the faster and cheaper transmission of information.

2.2 History of digital impacts on exploration and production (E&P)

Energy companies have relied on digital technologies for years to help increase fossil fuel production, optimise production methods, reduce costs and improve safety. The oil and gas industry has a particularly long history of implementing digital technologies and is no newcomer to Big Data, technology, and innovation, especially in the upstream sector, which was among the earliest adopters of computer technology to process inventory data in mature fields. This is the most lucrative part of the oil and gas sector, and it is here that digital technologies have had the greatest impact. In addition, technologies that can produce more oil or natural gas and increase the efficiency of production processes are prime candidates for research, development, and deployment. For example, to define the makeup and structure of reservoirs to optimise production, the upstream industry has taken on the complex task of processing enormously large data sets generated by seismic surveys of land and oceans. Processing this information requires some of the most powerful computers in the world (IEA, 2017).

As early as the 1980s, oil and gas companies began using digital technologies to better understand reservoir resources and their production capacity, improve health and safety, and increase marginal operational efficiencies in oil fields around the world (World Economic Forum, 2017).

As oil and gas companies expand their operations to more remote parts of the world, satellite imagery and the data derived from it are increasingly being used to manage exploration and production activities. Satellite imaging has evolved significantly since the launch of the first satellite to image the Earth's surface, Explorer VII, in orbit (Kio and Agboola, 2010). Furthermore, with the release of the first commercial GIS product, ARC/INFO, in 1981, ESRI began to evolve into a manufacturer of GIS software (Kumar et al, 2019).

Workflows in the oil and gas industry have rapidly developed and improved with the introduction of Geographic Information System (GIS) technology, especially in terms of exploration, production, and distribution of goods from the field to end users (Epuh et al., 2017).

Moreover, when satellite imagery and other digital information is combined with GIS, it can provide project managers with a bird's-eye view of oil and gas exploration and development operations and help monitor production fields without being on site, as well as assist in asset assessment, pipeline corridor planning, contingencies, and hazards, which can highlight potential risks to sensitive areas (Durham and Marr, 1999).

As PCs evolved, operators began to use them for non-seismic processing and modelling purposes. For example, the first computerised improvement in drilling hydraulics in 1986 led the industry to increase drilling success rates by 50% by the late 1990s. Since then, the 1990s and early part of this century have seen a flood of digital oilfield projects in many industries.

Yet until now the oil industry has failed to capitalise on the opportunities presented by the effective use of data and technology. For example, a single rig in an oilfield can produce terabytes of data every day, but only a small portion of it has been used to make decisions. The revolutionary impact of digitalisation is becoming increasingly clear to the oil and gas industry, prompting them to consider investing in digital solutions (Ernst & Young, 2016).

2.3 The current state of the industry

The oil and gas industry remains the world's most important source of primary energy and has a significant impact on the development of the global economy.

On the one hand, the global demand for fossil fuels continues to increase, while on the other hand, companies face complicated investment challenges due to the difficult environment for exploration and production work (Mojarad et al., 2018).

Many studies that have been developed based on long-term energy scenarios and published by major energy companies such as Shell, BP, and Exxon Mobil are consistent with the U.S. Energy Information Agency's (EIA) International Energy Outlook for 2017. They show continued global demand for hydrocarbons, but at a slow growth rate, suggesting that crude oil prices may remain near current prices (Aspen Technology, 2017).

According to BP, the oil and gas industry currently already accounts for more than 50% of global fuel consumption, and hydrocarbons are projected to remain the main source of energy in 2035 (BP, 2017).

The U.S. Energy Information Administration's International Energy Outlook 2017 projects that global energy consumption will increase by 28% between 2015 and 2040 (see Fig. 1).

Most of this increase is expected to come from countries outside the Organisation for Economic Co-operation and Development (OECD), and mainly from countries where demand is fuelled by strong economic growth, especially in Asia. Non-OECD Asia (including China and India) accounts for over 60% of the growth in global energy consumption from 2015 to 2040 (EIA, 2017a).

By 2040, the IEO2017 forecasts an increase in global consumption of marketed energy from all fuel sources except coal demand, which is projected to remain constant (EIA, 2017b).

To meet this long-term demand, new production from existing and added resources must come on the line. This means that future upstream investments must be sustainably lower than today's breakeven costs (Aspen Technology, 2017).

2.4 A new trend in oil and gas operations

The oil and gas industry and the broader energy value chain were influenced by several strong supply and demand forces, as previously discussed Section 2.3 outlining the current industry situation. This involves advances in technology such as horizontal drilling and hydraulic fracturing, which unleash shale reserves and play a major role in developing the oversupply accounting for persistently low crude prices.

Several trends influencing demand should be taken into consideration, such as the growing interest in electric vehicles. The effect of these movements can be felt in Oil and Gas and related markets, along with the possible disruption of digitalisation.

Remarkably, there is growing consensus that the oil and gas industry is on the verge of a new era, as a surge of business and digital technology is expected to reshape the market, powered by a variety of macroeconomic, industrial, and technological trends.

2.5 Disruption of supply, demand, and commodity prices

The sector is experiencing one of its worst downturns, driven by a slowdown in the supply side. Compared to the rates of June 2014, we can see that the commodity prices had dropped by more than 70% at one point and, just as some nascent signs of recovery appear, another crisis could be on the horizon, induced, on this occasion, by high oil demand. We would say that this disruption would create pressure on oil and gas prices and will enable oil companies to concentrate more on restructuring their portfolio and taking a significant presence in the energy transition. But, the disruption of supply, demand, and commodity prices, together with excessive market volatility, has left shareholders suspicious and less confident of the sector, which has a lower total shareholder return (TRS) than other sectors (see Fig. 2) (World Economic Forum, 2017). We can assume that this will have serious drawbacks for the industry, as if there is no trust, the shareholders could abstain from investing any more in the oil and gas industry and will choose another profitable business instead.

2.6 Rapid technological advances

Increased complexity of the platform as well as flexibility, connectivity monitoring, and storage technologies combined with the ability to process and analyse data instantly, we believe it will improve efficiency and facilitate real-time decision-making and execution.

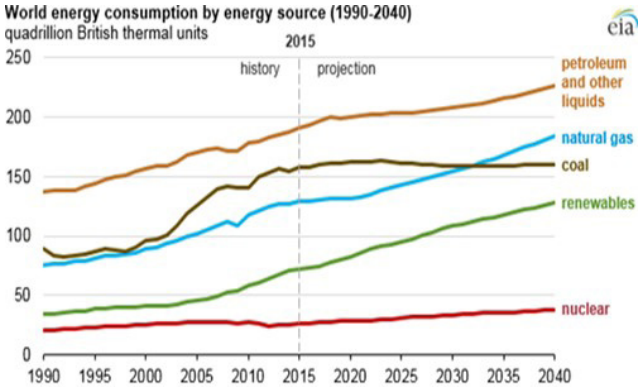

Fig. 1 World energy consumption by energy source (1990–2040) (EIA, 2017a)

10-Yr TRS CAGR (09/2006 – 09/2016)		5-Yr TRS CAGR (09/2011 – 09/2016)		3-Yr TRS CAGR (09/2013 – 09/2016)		1-Yr TRS CAGR (09/2015 – 09/2016)		MARKET CAP (09/2016; USD Bn)	
Technology	9.0%	Healthcare	17.1%	Technology	13.6%	Mining	32.0%	Banking	5,351
Healthcare	8.8%	Technology	14.4%	Healthcare	11.1%	Technology	19.8%	Healthcare	4,506
Retail	8.2%	Machinery	11.6%	Machinery	6.9%	Chemicals	15.5%	Technology	4,241
Machinery	7.1%	Retail	11.5%	Utilities	4.8%	Oil and Gas	14.9%	Oil and Gas	2,567
Chemicals	6.8%	Banking	9.2%	Retail	4.3%	Machinery	11.6%	Telecom	2,523
Telecom	6.8%	Automotive	8.5%	Telecom	3.6%	Telecom	11.0%	Retail	2,421
Mining	4.3%	Chemicals	8.0%	Chemicals	2.9%	Utilities	7.4%	Utilities	1,831
Automotive	2.7%	Telecom	7.5%	Banking	0.6%	Healthcare	5.9%	Chemicals	1,608
Utilities	2.3%	Utilities	5.2%	Automotive	-1.7%	Automotive	4.3%	Automotive	910
Oil and Gas	0.0%	Oil and Gas	0.2%	Oil and Gas	-5.3%	Retail	0.6%	Mining	823
Banking	-0.3%	Mining	-7.8%	Mining	-6.3%	Banking	0.4%	Machinery	557

Source: Accenture analysis based on Bloomberg data

Fig. 2 Total return to shareholders across industries (World Economic Forum, 2017)

2.7 Changing needs and expectations of consumers

Consumers expect enhanced engagement, customisation, and accuracy across industries. They also pay more attention to environmental issues that affect their energy choices; seek transparency from businesses in a variety of areas (e.g. greenhouse gas emissions and hydrocarbon sources) and improve their technical competence by linking them to a wide range of technology or digital platforms. Regarding these important shifts, many of Oil and Gas's digital initiatives to date have been seen as conservative and have limited effect on an existing business or operating models. Almost all the effort has yielded progress so far. Companies are making gradual improvements in performance while strategically leveraging market and emerging technology. These include basic effective maintenance practices, look-backs on finished activities, and the use of limited data sets for all aspects of the value chain of oil and gas. Digital innovation will generate tremendous value for the business as well as the community (World Economic Forum, 2017). However, we would like to point out that such a transition will necessarily involve companies adopting a structured digital strategy sponsored by CEOs and executive teams, as well as a culture of innovation and adoption of technological advances. It will also require dedication and determination to evaluate and revamp the current procedures, infrastructure, operation, systems, and facilities also the ability to cooperate across the ecosystem.

3 Emerging digital technologies and their opportunities for the industry

3.1 4D seismic imaging

Nowadays, a seismic "4D" image can be achieved by performing 3D tests over time. This provides a moving image to understand how properties have changed in existing oil fields. In addition, many organisations have developed algorithms to produce more accurate images, such as reverse time migration, wave-equation migration, Kirchhoff migration, and full wavefield migration. Recently, a research team at the College of Calgary has experimented with the use of advanced visualisation techniques and virtual reality to help Canadian producers better manage and understand steam-assisted gravity drainage (SAGD) technology (Giovanni, 2018).

In addition, introducing the time-lapse dimension to the legacy 3D imaging technique allows operators to measure and estimate changes in the reservoir. It has proven to increase upstream revenues by 5% and recovery rates by 40%.

3.2 Big data and analytics

Cheap detectors, expanded connectivity, and ever-increasing computing power are driving the growth of data collected by oil and gas companies.

In a single day, the oil and gas industry generate a large amount of data. The new offshore drilling fields, with a total of 80,000 sensors, can generate 15 petabytes and 15 million gigabytes of data during their lifetime.

Digitisation is helping to manage and analyse Big Data. Some studies have shown that while nearly 36% of the oil and gas industry has invested in these tools, only 13% are using their data strategically (IQPC Middle East, 2018). This discrepancy highlights that these companies have not always fully integrated Big Data and analytics into their processes but are merely applying Big Data technology. Full implementation could have far-reaching implications for operations and productivity (World Economic Forum, 2017).

The oil and gas industry's experience with this tool is currently limited to pilot projects, and efforts are underway to test this technology in practice and analyse its potential benefits.

Shell has conducted a trial project using Hadoop for seismic sensor data; sensors with fibre optic cables are installed in the wellbore to collect data. The data collected is analysed to determine how the wells are performing and how much oil/gas is left. Large amounts of sensor data will be stored in the Amazon Virtual Private Cloud (Amazon VPC). Shell intends to install fibre optic cables in 10,000 oil wells (Aliguliyev and Imamverdiyev, 2017).

3.3 Mobile technology

Like every other industry in the world, oil and gas companies are investing heavily to incorporate mobile devices into their daily activities and operations. The benefits of this inclusion range from better workflows to improved communication, higher productivity, and greater reliability of field data collected (IQPC Middle East, 2018). By using advanced smartphones, tablets, and even wearable devices, oil and gas industry workers can track data in real-time and perform proactive maintenance, enhancing their safety by eliminating hazardous conditions. When used in conjunction with radio frequency identification tags, mobile applications make assets intelligent and their movements identifiable (World Economic Forum, 2017).

3.3.1 Autonomous operations and robotics

In addition to improving the efficiency and safety standards of oil and gas assets, automating appropriate pro-

cedures will also help inform future planning decisions such as portfolio management, well-site identification, and improved maintenance.

For example, an Enterprise Resource Planning (ERP) system is a business management system that controls key business processes. These comprise: controlling resources, automating processes, and bringing together various organisational functional areas. ERP enables the integration and optimisation of several business processes, improves the quality of planning and decision-making, enables smoother coordination between business units, increases efficiency, and speeds up responses to customer inquiries and requests (Mishra and Mishra, 2009).

With capital spending on exploration down about 25% since 2014, optimising the quality of existing assets is more important than ever. Drones are perhaps the most widespread and prominent type of robotics currently being deployed to achieve the dual goals of increasing operational efficiency and safety.

ExxonMobil is the first company to use automated drilling in Deepwater. The company has developed its drilling advisory system, now deployed in Guyana, which uses artificial intelligence to select the best drilling parameters. Closed-loop automation, which regulates the drilling process without human intervention, is also possible.

First, this technology increases drilling security and efficiency through consistent, repeatable processes. Second, it relieves rig personnel of repetitive tasks, allowing them to focus on other tasks (ExxonMobil, 2022).

3.4 Digital marketing and digital sales

Many companies have already used digital marketing to increase their sales. Modern retailers have used digital technologies very effectively to gain a more comprehensive view of their customers (IQPC Middle East, 2018). The oil and gas industry has also used the same strategies and tactics to promote its business. They use digital marketing to identify and study customer behaviours, habits, and preferences. It is also used to better manage supply chains. According to some studies, this strategy can increase sales by 3% and reduce operating costs by 10% (Blue Mail Media, 2019).

From lubricant analytics to mobile apps for paying at the pump to digital products for car care, new digital solutions are redefining the experience ExxonMobil offers its customers.

ExxonMobil is partnering with IBM, Amazon, and other digital giants to offer consumers additional payment alternatives at Exxon and Mobil gas stations across the United States, including 'Alexa, pay for gas'. This digital technology, which uses your vehicle's Alexa-enabled device or the Alexa app, enables a new contactless form of payment for our retail customers and has the potential to reach more than 60 million U.S. households using Alexa at home and on the go (ExxonMobil, 2022).

3.4.1 Blockchain

Emerging digital technologies such as blockchain can also help accelerate the industry's very sluggish payments process and free up resources for exploration growth and further digitalisation initiatives. Years of limited innovation in compensation technologies have resulted in upstream companies having production-to-payment cycles of up to four months, posing a potential terminal dilemma for many companies (IQPC Middle East, 2018).

All major industries have begun to incorporate blockchain technology into their business operations. Now is the time for oil and gas companies to embrace this innovation, as it is known to create more opportunities in this industry. Some of the key opportunities for blockchain include supply chain, land management, finance, marketing, and warehousing. For example, some oil and gas companies began utilising Blockchain-powered smart contracts that are self-checking as well as self-executing contracts that operate autonomously while communicating with their vendors and companies in engineering procurement and construction (EPC) (Blue Mail Media, 2019).

Shell has completed a pilot project to create a decentralised digital passport for verifying equipment, components, and products. Blockchain technology allows data to be disclosed between specific parties in a supply chain, creating a digital passport for a piece of equipment. Shell is collaborating with other companies, such as manufacturers, inspectors, and contractors, to rethink how they work with suppliers. These improvements are expected to save costs, increase production, and contribute to safer operations for all stakeholders in the ecosystem (Shell, 2022).

3.5 The Industrial Internet of Things (IoT)

The IoT (an IoT application) is a "system of interconnected computing devices, mechanical or digital machines" as well as people with unique identifiers and the ability to transmit information over a network without human-to-human or human-to-computer interaction. The IoT has broken down the walls between operational (OT) and information technology (IT). The IoT can help optimise the upstream sector by revealing new technical perspectives through the analysis of various operational data (e.g., drilling parameters).

Midstream companies – e.g., in transportation, including pipelines and storage, to increase network reliability and create new business opportunities – will gain opportunities by building data-driven infrastructure. Then, downstream operators (e.g., oil refiners and retailers) could see the potential for new sales opportunities by expanding the visibility of the hydrocarbon supply chain and reaching out to digital customers with new forms of connected advertising (World Economic Forum, 2017).

We can summarise the main potential benefits in Table 1 (IBM Chemicals and Petroleum, 2017; IQPC Middle East, 2018).

3.6 Benefits for stakeholders

Digital technologies may play a pivotal role in reducing costs, risks and increasing production and operations performance. McKinsey & Company concluded that digital technologies could minimise capital spending by about 20%, upstream operating costs by 3–5%, and downstream costs by around 50% (Ward, 2016).

We already mentioned that digital technologies have an enormous ability to push oil and gas companies beyond sluggish growth and offer exceptional benefits to investors, customers, and the environment however, capturing this value does not have to take place outside or instead of corporate goals where they can potentially play an important role in creating a coherent approach to shifts in the industry. In the following White Paper framework (World Economic Forum, 2017), we want to show you how value creation in the industry is a function of financial performance and customer, environmental and societal value. Where the value-at-stake analysis aims to evaluate the ability of these digital transition projects to obtain value over the next decade (2016–2025) for the oil and gas industry, its clients, wider society, and the environment.

The primary results are as follows:

- In the oil and gas industry, digital transformation can create approximately $1.6 trillion in value for the industry, wider society, and its customers.
- This total predicted value from digitalisation may further rise to $2.5 trillion if existing organisational/operational limitations are laid back and consideration is given to the effect of "innovative" technologies, such as cognitive computing (for which there is a lack of evidence at this time to make a significant value assessment).
- Digitisation has the potential to create a profit of about $1 trillion for oil and gas companies. Of Fig. 3, upstream companies are expected to receive $580–$600 billion, midstream companies approximately $100 billion, and downstream companies $260–$275 billion.
- The industry's digital transformation could bring benefits worth around $640 billion to the wider society. In addition, digitalisation could also improve productivity by about $10 billion, reduce water use and emissions by $30 billion and $430 billion, respectively, and save customers $170 billion.

Table 1 The potential benefit of the implementation of digital technologies in the oil and gas industries

Digitalisation in the petroleum industry		
Digital technology	Sector/areas of application	Benefit
4D seismic imaging, autonomous operations and robotics	Exploration	Operators can determine and forecast fluid changes in reservoirs, increasing recovery rate. Thus, boosting the profitability (IQPC Middle East, 2018).
Big data and analytics, mobile technology, blockchain	Drilling process	Allows using a large portion of the generated data while drilling to choose the right strategic decisions. Mobile technology could also provide data monitoring in real time, thereby improving security and safety.
Big data and analytics	Reservoir modelling	Gives a good and dynamic reservoir model for (initial oil in place, recovery among other necessary information which may be needed) as well as for good decision-making.
Autonomous operations and robotics	Production	Makes it possible to ramp production.
Blockchain	Finance	Decreased cash cycle times. Enhanced efficiency with lower capital costs and lower intermediaries. Enhanced visibility of transactions to limit the spread of tampering, fraud and cybercrime. Creating transparent transactions through the use of shared processes and record keeping (IBM Chemicals and Petroleum, 2017).
Big data and analytics, mobile technology, blockchain, cybersecurity	Data management	The industry could make better use of data trending to support decision making, with the intention of identifying problems that industry could address.

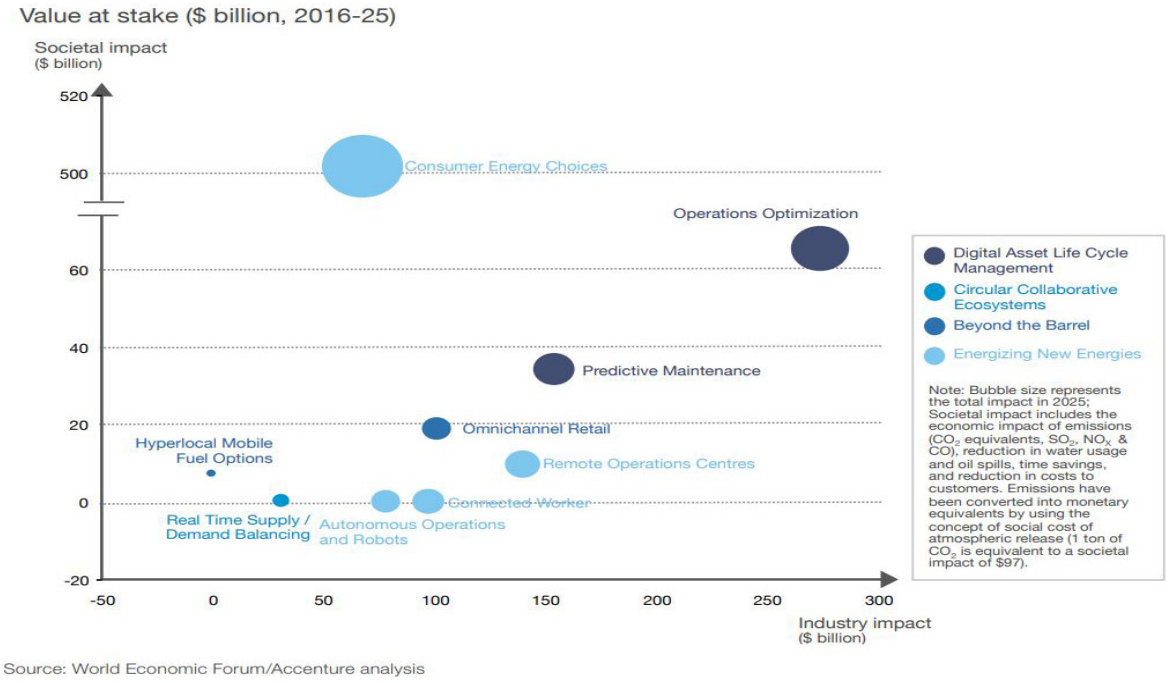

Fig. 3 Potential value of digital initiatives and technologies in oil and gas for the industry and the society (World Economic Forum, 2017)

- Environmental gains include lowering CO_2 pollution by about 1.300 million tons, saving about 800 million gallons of water, and preventing oil spills of about 230,000 barrels of oil (World Economic Forum, 2017).

4 Digital transition strategy advances in oil and gas industries

Due to the increasing complexity of today's business environment, organisations are starting to rethink their strategies and adopt new technologies. These changes are likely to affect how they compete in the market. Some of the key factors that have changed include the limitations of traditional business strategy and the increasing familiarity of IT.

Table 2 summarises the various changes that have occurred due to the emergence of digitalisation (Mustafa, 2021).

To remain competitive in this market, a company must thoughtfully plan and develop a strategy that will determine the fate of the company.

A well-defined strategy summarises a company's key plans, objectives, actions, activities, and commitments. Today's business environment is changing rapidly, and most leaders are trying to implement flexible procedural techniques to ensure that the company can respond to change (Mjaku, 2020).

Developing a digital strategy is a must for successfully transforming a business into one that operates in the digital

Table 2 Comparison between traditional business strategy vs. digital business strategy

Traditional business strategy	Drivers of the digital transformation	Digital business strategy
Market research and surveys are examples of traditional data collection approaches. Limited data points that require time to analyse. Producers have limited incentives to improve the efficiency of their products. Direct client interaction is limited. The client database was kept up to date by maintaining the manual registers and record books (Mustafa, 2021).	Enterprise resource planning (ERP) system Cloud computing Connectivity and Internet of Things Machine learning Autonomous operations and robotics Big data Block chain etc.	Digitalisation allows organizations to improve their processes modelling by providing them with more accurate and timely data. For example, through advanced sensor networks, the oil and gas companies can also automate the monitoring and analysis of their geological and geophysical data. With real-time data, producers can improve their production performance. This can help them make informed decisions and improve their safety. For instance, by analysing data related to accidents and maintenance, E&P can provide better insight into their operations. Strong incentives for service providers to invest in maintenance and efficiency as their strategy in order to instantly increase profits Automated management of systems and processes (such as fully automated offshore platform). Interaction with customers via platforms and apps that is timely and regular. The digital customer database facilitates the recording and updating of customer records (Mustafa, 2021).

age. The pace of development and innovation in digital organisations is not slowing down, and almost no company today can ignore its digital component. However, digital transformation is a strategy rather than just the adoption of technology. Therefore, the ability to digitally reshape the enterprise depends on a clear digital strategy and leaders who can put that strategy into action (Turuk, 2020).

Strategic management is an ongoing process that involves identifying an organisation's strategic goals, vision, mission, and objectives; analysing the current situation; developing appropriate strategies; implementing those strategies; and evaluating, modifying, or changing those strategies (Dess et al., 2008).

The most important task of leadership is to align its vision with the company's goals so that the company can compete effectively in a dynamic environment, and train and motivate employees to achieve the vision. The vision should be simple enough to be understood by all. A person's mission should be clearly defined and different from that of another company (Mjaku, 2020).

According to management professor Peter Drucker, the founder of many contemporary ideas on the corporate mission, the question "What is our business?" Is akin to asking: "What is our mission?" A company's mission defines it. Only a clear definition of the corporate mission enables clear and realistic corporate goals because the mission defines the purpose of the company in terms of its sustainability. The mission sets the long-term vision of the organisation in terms of what it wants to be and whom it wants to serve (Drucker, 1974:p.96).

The Oil and Gas companies need to act decisively by proactively preparing plans and pledging resources to identify digital technology as a catalyst for success and profitability. Most oil companies and players in oilfield services conduct restructuring projects to improve their core business performance. Those who integrate digital and innovation as a strategy beyond efficiency, are already capturing multiples values and gains such as they found out that those technologies can create wide synergies across the business, decrease investment duplications and gain new opportunities for their investment. Added to that, they can hold off from building the new with traditional thinking and technology. Moreover, the best digital strategy may require changes in management or different leadership skills; new resources and expertise are most likely needed.

Additionally, companies have found that the digital technologies that provide the greatest investment value are the ones that have gaps in ability and qualifications. Recent Accenture research into the value of digital technology to Asset Intensive Companies shows that digital technologies persist underexploited by most Asset Intensive Businesses, the omission being those that have adopted fully incorporated digital strategies (Accenture, 2017).

However, we think that developing and implementing a strategy that is effectively enabled by digital is a difficult task. Concentrating on agility, flexibility, innovation, and better management of technology, involves moving away from thinking less about markets, rivalry, and value in the core business alone.

4.1 Keys to successful technology adoption

The Deloitte Insights team has developed three key questions that they assume to be important to the development of any digitalisation project in an oil and gas company (Mittal et al., 2017). Table 3 represents how oil companies can adopt digital technology strategically by answering those questions (Sylthe and Brewer, 2018).

Table 3 Main questions to address to successfully adopt the digital technology in the company's strategy (Sylthe and Brewer, 2018)

Basic questions	Steps for adoption
How digital are you today?	This self-assessment would allow Chief Technology Officers (CTOs) and other Chief Digital Officers to create a matrix for current digitalisation within their organization, that will be the framework for the next move towards forward-thinking integration objectives.
How digital should you become?	Typically begins in relation to the framework that you developed according to the previous question. Based on the start-up level of digitalisation of the company, especially their ability to incorporate digital technology in their activities also their actual capital reserves, will help you to create a road map for step-by-step digital incorporation. This roadmap will address the key questions of "why" and "why now", as well as give CTOs an overview of their business's place in the sector of industry and the specific role they perform in optimising their unique skills to create competitive advantages, improve collaborative effectiveness, and differentiate themselves.
How do you become more digital?	In order to successfully transforming the digital capacity of an oil and gas company the best place to start is with the use of "Big Data", "Internet of Things", and "Smart Devices", all of these technologies are basically only valuable when their data can be resolved and processed into productive things. This occurs within oil and gas companies 'processing systems or, as technology continues to improve and develop, programs based on cloud platforms and databases.

5 Case study: Statoil's digital transition and renaissance as Equinor

5.1 About Equinor

Equinor is an international energy company operating in more than 30 countries around the world, including one of the most important oil and gas provinces in the world. It was founded in 1972 as Statoil (Norwegian State Oil Company) under the name Den Norske Stats Oljeselskap and was renamed Equinor in 2018 to support the company's strategy and growth as a broad-based energy company. The company is headquartered in Stavanger, Norway, employs more than 20,000 people, and is 67% owned by the Norwegian government.

The company's total revenues in 2018 were $79,593 million and total assets were approximately $ 112,508 million. Oil and gas production per day is 2.11 million boe and renewable power generation is 1.25 TWh.

Equinor is the leading operator of the Norwegian continental shelf and has significant international operations. The company is active in oil and gas exploration, development, and production, as well as wind and solar energy. Equinor is a major European supplier of natural gas and sells crude oil, with operations in processing, refining, and trading. The company has eight business units, personnel, and assistance groups operating in Africa, Asia, North and South America, Europe, Norway, and Oceania.

It is a good example of digital transformation in the oil and gas industry. Currently, Equinor is rolling out new initiatives to develop the Norwegian Continental Shelf (NCS) to address the future issues of declining production, ageing infrastructure, and the need for lower carbon emissions. The organisation aims to maintain competitive oil production from the NCS at current levels through to 2030 as well as to improve drilling, but the NCS will reach a more mature stage thereafter.

They have leveraged elements of digitalisation, which we describe as the strategic business value of data-based technology that includes the Internet of Things (IoT), cloud computing, and artificial intelligence. Examples of these elements include 3D geological engineering, automated oil and gas installations, and advanced reservoir modelling in the North Sea areas. Equinor's activities generate huge amounts of data, operational data, drilling data, subsurface data, and supplier data, with a total of more than 26 petabytes stored in Equinor's data centres, equivalent to 50 times the US Genetic database. It is not in doubt that they will reach 2500 petabytes by 2030. Now Equinor has embarked on a centralised and integrated technology transformation programme (Equinor, 2019). The company is establishing a digital centre of excellence with a holistic roadmap for the digitalisation that extends to 2020. The company has committed spending of 1 billion to 2 billion Norwegian kroner ($128 million to $257 million) to be delivered through the centre of excellence for new and emerging technologies. Equinor's main goal is to significantly increase the use of data analytics and robotics to improve safety, reduce its carbon footprint, and increase profitability (Strategy and part of the PWC network, 2018).

5.2 Digital innovation strategy

According to Åshild Hanne Larsen, CIO and Senior Vice President Corporate IT, and her co-authors, Equinor is one of the companies that have asked themselves almost the same questions that many large companies are asking themselves now. There are four main questions to answer: How do we balance future investment with today's opportunities? How will we win the new war for digital talent? How do we fund digital initiatives as effectively as possible? How do we continue to increase the scale of digital initiatives? (Larsen et al., 2018; Fig. 4).

5.3 Four main building blocks

We have tried to answer these questions based on the information and data available to us to show how Equinor has changed its strategy by following the four main building blocks that contain the same basic keys to successful technology adoption that we analysed in Section 5.2 with the measures for new business models. This gives us a clear overview of how the company can grow and develop its operations and processes to achieve its goals.

5.3.1 Adoption of innovation (digital strategy): Where do you want your company to go?

First, we can state that digitalisation is already part of Equinor's DNA. They invest in digitalisation not because digitalisation and innovation are goals in themselves, but

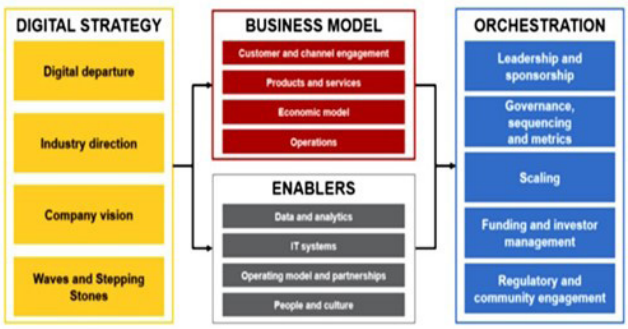

Fig. 4 Building blocks and subtopics for a digital transformation (Larsen et al., 2018)

because digitalisation is an important part of their business strategy. They want to produce more effective oil and gas with lower greenhouse gas emissions, pioneer carbon capture and storage, and invest heavily in renewable energy (Fig. 5).

Equinor's main new technology strategy is to expand the company's research on CO_2 reduction and digital solutions. The strategy focuses on five technology directions:

1. Low-carbon digital solutions for oil and gas and minimise greenhouse gas emissions.
2. Discover and develop frontiers and Deepwater areas.
3. Unlock low recovery reservoirs. Develop opportunities for renewable energy.
4. Improve production from existing and near-field resources.

Their digital roadmap is the priority of their top management teams. They have developed a detailed digital roadmap for Equinor and are now working to accelerate innovative solutions, pilots, and trials, and scale them across the business. They have already carried out some major projects that create value today for the industry, stakeholders, and society (Equinor, 2019).

Their digital roadmap focuses on six company-wide digital programmes and three key enablers: developing digital functionality, capabilities, and leadership, using the external ecosystem, and establishing a unified data platform.

For example, they also established a digital Centre of Excellence, which will focus on improving business performance using advanced digital solutions and new business models. It will drive digital opportunities via three technology enablers: digitalisation processes, data science, robotics, and remote control.

By 2020, Equinor is planning to invest approximately $4 billion in digital technology to develop more benefits and improve processes.

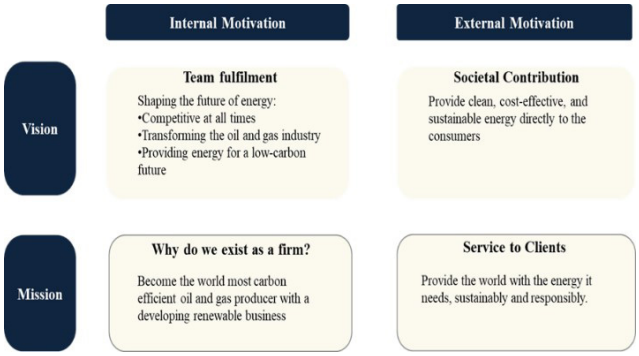

Fig. 5 Internal and external mission and vision of Equinor (Author's owned)

5.3.2 Transforming operations and activities (business model): How does that fit what your business does?

Equinor recently commissioned an Integrated Operations Centre (IOC) to improve safety, increase productivity, and reduce emissions from their facilities on the Norwegian Continental Shelf. Over time, the centre will be connected to all its 30 operating offshore facilities on the Norwegian continental shelf. In the U.S., the Onshore Integrated Remote Operations Centre is already using this cloud-based data platform called "Omnia" to develop machine learning and data analytics that will significantly improve operations and make better data-driven decisions.

Omnia is a cloud-based data platform that, along with data science and virtual reality, are the three innovations that most support the company's core strategy to achieve its goals and gain a competitive advantage in the market. Omnia is designed to give the company's employees access to integrated information across networks and organisational boundaries, and to connect the broader ecosystem with the same platform. They are already developing the capabilities of internal data science and using AR/VR on the digital twins to improve the efficiency of their employees, which is also a major concern for them. They are now looking at other emerging technologies, including blockchain and 3D printing (Capgemini, 2019).

5.3.3 Encouraging collaboration (Enablers): What do you need to get there?

Leveraging and developing the existing ecosystem is critical for the company, working with start-ups and exploring new avenues with its current partners – such as major oil and gas service providers – by more seamlessly integrating data between companies. They have partnered with Techstars, a start-up acceleration programme that has selected ten international start-ups to work with for three months. To work on and develop new solutions, these start-ups have access to their experts and data. One of the start-ups, Deep Stream in the UK, is a technology-enabled bidding and supplier prequalification platform for oil and natural gas companies.

Equinor also uses Aspen ONE Process Explorer visualisation with IP.21 process historian to drive the digitalisation of its offshore operations, enable remote and onshore data access, save significant OPEX, and increase production (Aspen Technology, 2017).

5.3.4 Change management practices (orchestration): How will you manage change to achieve your goal?

You have chosen both a bottom-up and a top-down approach. Equinor has three main challenging tasks: shape the future, empower people, and deliver results. These tasks fit very well with their digital vision. The company is evolving its operations and improving its business model to enable its leaders to achieve these goals.

A few years ago, they launched a programme called "Taking Equinor beyond 2025 Digital", which involved 11 senior vice presidents. Today, the CEO and the board spend a lot of time understanding and working on the digital roadmap. They also invest in improving the digital skills of all employees. The company has set up its own Digital Academy to develop the skills of its employees and prepare them for the digital future. There they can learn everything about digitalisation, from machine learning to programming to cybersecurity, and they are inspired and motivated to understand the impact of digitalisation on the industry in the future. The academy has already conducted more than 20000 training sessions.

In answering these questions, we have found that Equinor is on the right path to fully digitalised operational systems by developing its digital solutions, improving the digital skills of its employees, partnering with start-ups, and expanding its ecosystem. These actions will help them take advantage of digital opportunities, but the question that remains is: Are they able to address the cyber threat and regulatory challenges?

We think that we will be able to answer this question soon, because they have already launched another project that is characterised by digitalisation, an unmanned platform on the Norwegian continental shelf: Oseberg Vestflanken 2. An analysis of this project now follows.

5.4 The Equinor project in the sign of digitisation: Oseberg Vestflanken 2

On October 14 of 2018, the Oseberg Vestflanken 2 was put into operation in the North Sea area. The new Oseberg platform is the first unmanned platform on the Norwegian continental shelf to be remotely controlled from the Oseberg field headquarters, requiring only two maintenance visits per year. Recoverable resources are approximately 110 million barrels. The project was well under budget and more than 20% below the development and operations plan (PDO) cost estimate. The breakeven price was reduced from $34 to below $20 per barrel, further strengthening the already highly profitable development. Equinor operates the Oseberg Vestflanken 2 project with a 49.3% interest, while other partners are Total (14.7%), ConocoPhillips (2.4%), and Petoro (33.6%). Equinor's digital team has developed the Dashboard Operational Planning Tool (OPT) to make it possible easily and quickly to locate all information and data sets about the situation of the plant in real-time (Equinor, 2018).

The AI tool draws on multiple OPT-integrated data sources, including incident reports. A case is generated whenever an incident occurs at one of their facilities, whether large or small. It details what, where, and why the incident occurred. The main purpose of these case reports is to prevent such incidents from happening again. They can now use them to provide a wealth of new insights to their operational team.

Automation technology can drive efficiencies that improve safety by removing human workers from the danger zone, as well as delivering environmental and financial benefits. It has the potential to increase revenue, decrease costs and carbon emissions, added to that reduce CAPEX by 30%, and OPEX by 50% compared to a traditional concept. These advantages seem clear; however, an entirely unmanned platform raises some concerns. The idea of fully automated systems puts numerous safety aspects into doubt. Cybersecurity is essential to its success, as with any industry embracing the fourth industrial revolution. Norwegian intelligence authorities have already warned about potential risks to the oil and gas industry. Equinor must protect their digital infrastructure properly to keep their employees safe and secure installation. They have chosen to adopt an integrative approach to managing security risks where physical security, security of personnel, and cyber security follow the same process of security risk management.

Equinor manages the threats to cyber security and data, by concentrating on three key areas. Governance and policies, based on international standards of cyber and information security, determine the company's requirements and expected level of security. Technologies are introduced to meet the criteria and staff are equipped with cyber security and information security education to ensure consciousness in the organisation (Molly, 2019).

Equinor's rebranding for the transition to a global energy company appears to have been launched at a particularly good time, both in terms of the maturity of the petroleum industry and in terms of developing the view of society on climate. Their constructive and sharp strategy, which emphasises innovation and technology as one of the four key enablers to deliver, has not only improved their potential resilience but has also helped them to move smoothly into a new industry.

5.5 SWOT analysis model for Equinor

Using the SWOT analysis model will help us to point out what could be the most influential factors that are favourable and unfavourable for accomplishing their objectives by looking at the positive and negative aspects of the internal and external environment of the company.

We see in Table 4, that Equinor's key competitive advantage is its strong technology base and ability to apply new technologies, which puts the company on the right track to achieving its mission and vision.

Equinor is on the right track to fully leverage digital technology in its core business, but to make the transformation at scale requires high investments, and this takes time because digital transformation is a continuous process. On the one hand, the digitalisation strategy has been a great success for the company, as it has been an important factor in improving production, improving drilling operations, and reducing the carbon footprint. Working closely with internal and external stakeholders throughout the digital journey and improving the digital capabilities of employees across the company, as well as the continuous development of autonomous assets and digital solutions based on artificial intelligence, will be critical to strengthening the company's competitiveness in the oil and gas sector for the near future. On the other hand, it is necessary to consider the data protection and security measures that Equinor has adopted as part of an integrative approach to security risk management, where physical security, personnel security, and cybersecurity all follow the same security risk management process. Still, the potential for attacks is likely as clever adversaries are still working to develop their skills and capabilities to disrupt the organisation's operations. Working on vulnerabilities and focusing on the most valuable points of attack is one of the biggest challenges they must address.

In general, oil and gas companies are taking different approaches to digitalisation depending on their development priorities. For example, ExxonMobil partnered with Microsoft to drive capital efficiency and unlock the largest O&G acreage in the Permian Basin with cloud technologies. ExxonMobil has teamed up with Fuel Cell Energy, Inc. to "enhance carbonate fuel cell technology to absorb carbon dioxide from industrial facilities" to help reduce greenhouse gas emissions (ExxonMobil, 2018).

Shell is focused on introducing digital solutions to its existing business, such as standardising operations across its global footprint or streamlining supply chain processes. In addition, the company is concentrating on developing new business models by investing in digital businesses and bringing them together with the expertise of its industry leaders. Shell is also working with Microsoft to deploy AI applications in Shell's business operations (Shell, 2018).

In summary, the oil and gas industry must overcome several historical and structural obstacles to realise the full potential of digital transformation. There are major

Table 4 SWOT analysis of Equinor (Author's owned)

Strength	Weakness
Pioneer in the advancement and innovation of technology: The most effective, reliable, and accessible technologies (various business applications in the value chain of oil and gas). Digital technology experience and competence: Highly skilled specialists and experts. Entering new markets: Their innovative teams have permitted them to develop new products and enter new markets. Diversification Early mover advantage Strong financial position with consecutive profits Strategic partnerships with suppliers, retailers, and other interested parties. This allows them to be able to leverage in the future.	Lack of established supply chain and logistics network. Lack of expertise in solar energy technologies. Heavily reliant on the petroleum industry. Constraints (financial, security) linked to the deployment of technology. Inherent drawbacks and challenges of big data (maintain data quality and integrity).
Opportunities	**Threats**
Globally Renewable Energy Project (wind and solar). Growing energy demand. Market growth is estimated at 10% per annum in renewable energy. Automation of burdensome, dangerous, or risky tasks. Improved company and equipment oversight. Maintenance anticipation and automation. Decrease the risk of shutdowns or crises in production. Capacity to manage production levels based on expected demand, and even operating platform failure situations. Increases in energy efficiency. Creating new technologies that provide new outlets and new revenue streams.	With their reliance on it, the oil price is a huge threat. Geopolitical instability and innovations. Rapid rival technological growth. Internet of Things (lot) information security. Data security regulation. Cyber-attacks risks Security at facilities that may result in shutdowns in production and threats to supply line safety and environmental disaster.

obstacles facing oil and gas companies that make it difficult for them to take full advantage of the digital initiatives described in the analysis from SWOT. The major key barriers are a starting point for attempts to address the difficulties in unlocking the value of digitalisation for business and society. The oil and gas industry needs to develop an effective strategy based on advanced processing systems, programmes, and procedures to defend against cyberattacks, a digital culture developed within the companies, and the skills of its employees, without forgetting that it still has highly professional management teams and information technology executives.

6 Conclusion

In this study, we attempted to answer two main questions:

1. How is digitalisation changing the oil and gas industry, is it changing from a disruption to an opportunity?
2. How can these companies change their strategy to meet this challenge?

To properly answer these questions, it was first important to examine the current state of digitalisation in the energy sector and analyse the main characteristics of the oil and gas industry. In doing so, we find that the trend toward greater digitalisation is due to advances in all three areas: increasing volumes of data due to falling costs of sensors and data storage, the rapid development of computing capacity and advanced analytics, and increasing connectivity with the faster and cheaper transmission of information.

On the first question, we noted that the oil and gas industry has already begun to radically reinvent its business models to address this disruption and take advantage of the potential benefits it can offer; improving its business operations, efficiency, and productivity are its main goals. Even if capital expenditures or acquisitions are a headache for executives, investing in digital solutions is a move that should not be regretted, as it can improve the production of current operations. However, there are several prerequisites for such a transformation. We think that the best starting point is the use of "Big Data", "Internet of Things" and "Smart Devices". All these technologies are only valuable if their data can be resolved and processed into productive things. This is happening in the processing systems of oil and gas companies or, as technology continues to evolve, in programs based on cloud platforms, programs, and databases. In addition, many challenges and barriers prevent the oil and gas industry from implementing digital solutions into their operations and activities. For example, cyberattacks can damage company operations, which is a major concern for upstream, midstream, and downstream asset owners and operators. These destructive cyberattacks pose a risk to the oil industry because their operations and activities are highly volatile and have economic and political implications. Therefore, companies need to establish a good security system, take control of data, and create a culture of security for their employees. In addition, private companies, parastatal organisations, regulators, and policymakers must work together to improve the security of these industrial processes and facilities and mitigate the damage of such attacks that will inevitably occur at some point in the future. In the next part, we will highlight the key requirements for successful technology adoption by analysing how companies can go down the path of digitalisation, how they can conduct their environmental audit, and set a good strategy that will lead them to success. In our opinion, the oil and gas industry needs to overcome some historical and structural barriers to unleash the full potential of digital transformation. There are major obstacles that make it difficult for oil and gas companies to achieve the full value of digital initiatives. The key obstacles are the starting point for attempts to address the difficulties in unlocking the value of digitalisation for business and society. The oil and gas industry needs to develop an effective strategy based on advanced processing systems, programmes, and procedures to defend against cyberattacks, a digital culture developed within companies, and the skills of their employees, without forgetting that they have highly professional management teams and information technology executives. These key factors have been well integrated into the case of Equinor's digital strategy. We can see the benefits of Equinor becoming one of the pioneers in the development and deployment of digital solutions in the energy market. Moreover, this potential opportunity will create tremendous value for both the industry and society. However, a fully digitalised oilfield also raises some concerns. The notion of fully automated systems calls into question numerous safety issues. As in any industry facing the fourth industrial revolution, cybersecurity is a key factor for success. It is important that Equinor, and oil companies in general, adequately protect their digital infrastructure to keep their employees safe and the rig secure. In conclusion, we believe that companies should always ask themselves how they can counter the threats that are likely to change shortly based on the capabilities of their adversaries, and how they can stay informed and prepared for likely attacks?

Oil and gas companies must continue to invest in the collaborative ecosystem by partnering with their suppliers and start-ups and sharing with them a platform where they can easily share data that will help them improve their economic position. They should develop a digital strategy, as in the case of Equinor, which must be a priority for their executives. It is also crucial to support innovation and technology adoption by continuing to invest and hire qualified experts. It is also important to improve the digital skills of employees and spread a digital culture throughout the company so that they can protect themselves against cyberattacks or other potential risks in the future.

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