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New technological frontiers in the oil and gas industry

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New technological frontiers in the oil and gas industry
By: **Dr. Carole Nahkle**

Contents

List of Abbreviations

AI	Artificial Intelligence
APC	Advanced Process Control
AP-Networks	Asset Performance Networks
CAPP	Canadian Association of Petroleum Producers
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilization and Storage
CO2	Carbon Dioxide
EIA	Energy Information Administration
EOR	Enhanced Oil Recovery
FLNG	Floating Liquefied Natural Gas
HEADS	Hydrocarbon Early and Automatic Detection System
IEA	International Energy Agency
IMO	International Maritime Organization
IoT	Internet of Things
IOR	Improved Oil Recovery
IR	Infrared
IT	Information Technology
LNG	Liquefied Natural Gas
R&D	Research and Development
SAGD	Steam Assisted Gravity Drainage

EXECUTIVE SUMMARY

The oil and gas sector has embraced innovation since its beginnings in the 19th century, and its response to the digital revolution now unfolding continues this tradition. Powerful new technologies, such as artificial intelligence (AI) and cloud applications, have upgraded or overtaken old ones, opening fresh possibilities, efficiencies and opportunities barely imaginable a few decades ago. While some voices call for an end to the era of fossil fuels, the reality is that the entire hydrocarbon industry, like many others, is adapting and innovating at a rapid rate. For the next 20 years, at least, oil and gas will remain key sources of energy, thanks in part to the sector's investments in technology.

In the face of lower prices, severe cost pressures and the need to adhere to the highest environmental standards, the oil and gas industry will continue to deploy new technologies that will ensure it has a strong future. To find out more about the sector's current and future investments, Aspen Technology, Asset Performance Networks (AP-Networks), and Minsait, an Indra company, commissioned Newsweek Vantage to conduct a global survey of 263 energy professionals at senior executive and management level, who are working at enterprises that have strategic interests in the oil and gas industry. The main findings of the study include the following:

• Oil and gas enterprises are investing in a wide range of technologies, and the pattern of those investments is not expected to change radically over the next five years.

• The most popular new energy technology among oil and gas investors is green energy, consisting of alternatives to oil and gas, and technologies that are intended to reduce the environmental cost of oil and gas extraction

• Among a range of transformative technologies, respondents most frequently said they were investing in the Internet of Things (IoT) and mobility/cloud technologies, and these are expected to remain the top-two choices for the next five years.

• When looking at the motivations for investing, state-owned oil and gas enterprises are more focused on policy objectives, while privately owned enterprises are more likely to invest for financial reasons.

- Oil and gas companies, whether private or public, are more likely to invest in green energy, whereas service providers are much more focused on investing in tight/unconventional reservoirs.

- The great majority of respondents fund their investments internally, from such sources as reserves, asset disposals, and re-allocation of existing budgets and funds. More than twice as many people chose internal funding as chose external sourcing of funds.

- Company strategy and the commitment of senior management are seen as two of the most important drivers of technological changes in the industry.

- The chief barriers to investing in technology are the perceived uncertainty over oil and gas prices and over investment returns, which are linked to output prices.

- The areas where transformative technologies are having the biggest impact are production-related, including operations and maintenance, improved/enhanced recovery, fracking/ tight reservoirs and exploitation at greater depths, where large minorities of organizations say they expect significant benefits.

- Survey respondents that are regarded as technology leaders are much more likely to say they are investing in tight/unconventional reservoirs and considerably less likely to invest in green technologies. In the area of transformative technologies, a higher proportion of leaders are choosing to invest in automation, robotics and smart machines.

The rest of the report examines these findings in more detail.

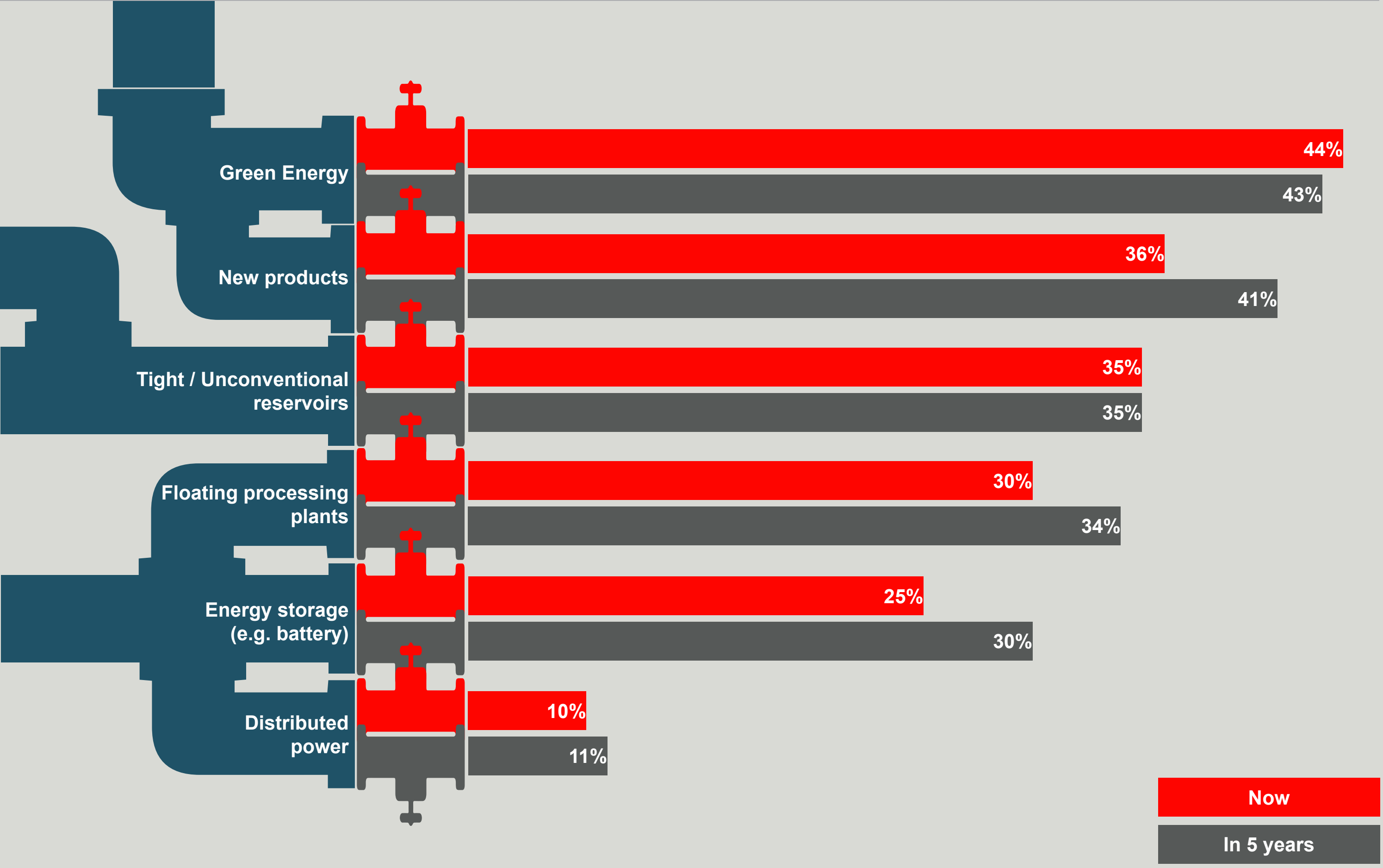
TECHNOLOGY INVESTMENT PATTERNS TO HOLD STEADY

Oil and gas enterprises are investing in a wide range of technologies as they aim to secure their future competitiveness in a fast-changing industrial environment. The survey grouped the technologies into two categories: those that are specific to the oil and gas industry and those that are transforming many industries, including the energy sector.

Six energy technology applications were included in the first group. The survey found that a third of respondents are investing in at least three of those technologies and nearly half are investing in at least two. Green energy tops the list: 44% of respondents say they are investing in it. This may seem surprising, since green energy includes all forms of alternatives to oil and gas. But, in fact, it also includes technologies that aim to reduce the environmental impact of fossil fuels. Energy is the most important input to extract oil and gas. If this input is reduced as a result of more efficient operations, companies can cut both their carbon footprint and their costs. “The paradox the world is facing today is how to stop burning fossil fuels versus the reality of a strongly growing demand across the board. The focus of all our business investment is making our operations safer, more efficient and less impactful”, says David Eyton, BP’s Head of Technology.

Over the next five years, investments in these categories are likely to continue. Green energy remains the most popular, followed by new energy products, tight/unconventional reservoirs and floating processing plants. The proportion of respondents who say they intend to invest in a category they are not currently investing in ranges from 11% for new products to 5% for tight/ unconventional reservoirs.

Which energy technology applications are you investing in and which do you plan to invest in over the next five years? % of respondents



These findings support current trends whereby oil companies are incorporating technological advances in their conventional business while investing in clean energy to reduce their environmental footprint. BP, for instance, is currently one of the top producers of wind energy in the United States. Total has been investing in solar energy and biofuels, with the ambition to derive 20% of its energy portfolio from low-carbon businesses in the next 20 years. ExxonMobil is funding research in algae biofuels as part of its investment in emissions-reducing technologies. These are just a few examples of a widespread push by oil and gas producers to broaden their product portfolio while searching for ways to cut costs.

Selecting energy technologies

Hydrogen is a new energy product that does not emit carbon dioxide (CO_2) when used. Indeed, it can be made from natural gas by decarbonizing the latter. However it is more expensive than natural gas, for example, deterring its use in vehicles. Hydrogen is currently used more frequently in refineries to make oil products cleaner and to reduce the sulfur content of diesel.

Carbon Capture and Storage (or Carbon Capture, Utilization and Storage) is a 20-year-old technology that captures CO_2 and stops it from entering the atmosphere. For example, NRG, in partnership with JX Nippon, has developed the world's largest carbon capture facility at the coal-powered Petra Nova plant near Houston (see box).

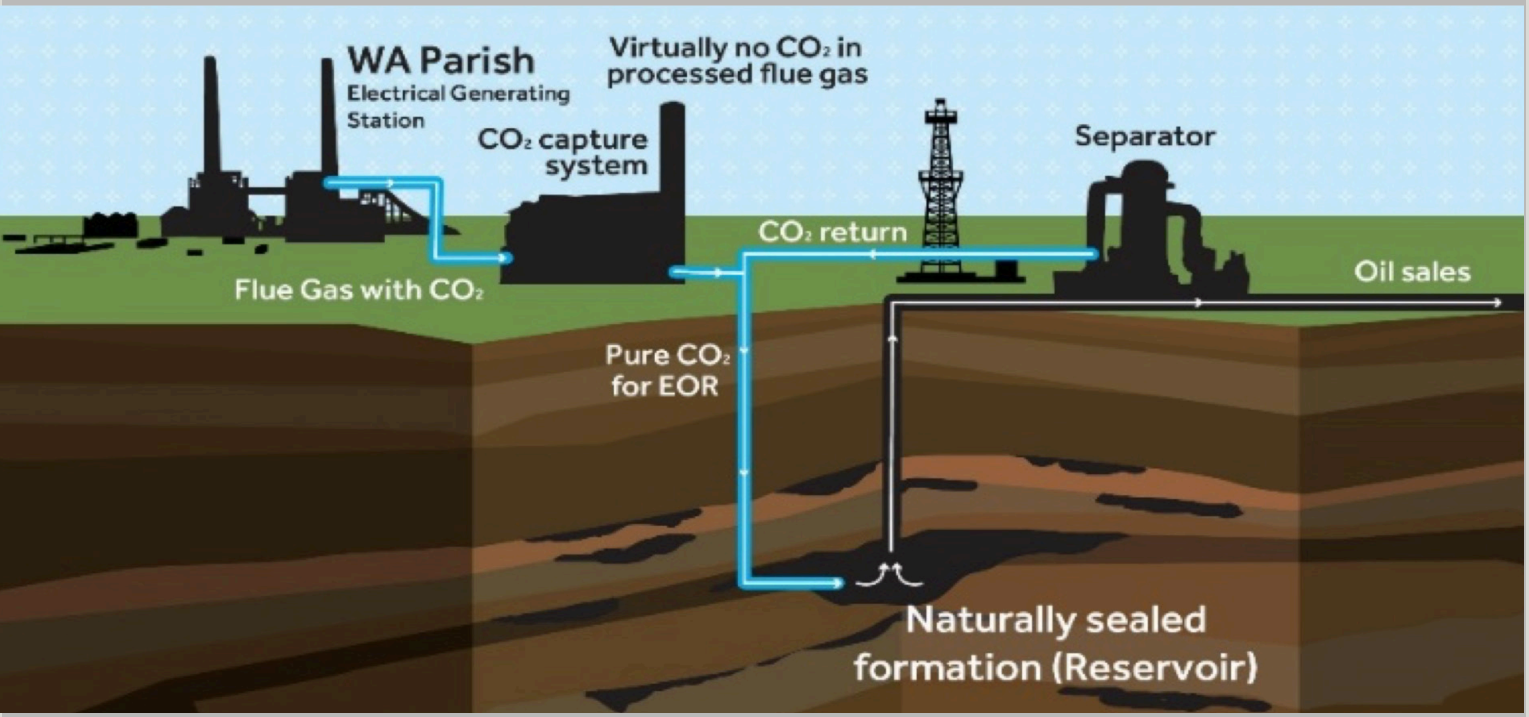
Enhanced Oil Recovery (EOR) enables operators to extract more oil from a reservoir, by using such materials as CO_2, natural gas and steam to lower the viscosity of the oil. The Miraah project in Oman, for example, harnesses solar rays to produce steam that improves oil recovery in the adjacent field (see box).

Tight/unconventional reservoirs require a combination of horizontal drilling and fracturing to extract oil. The technology has existed since 1947 and was given a new lease on life in the past decade when it was applied to extraction from hard rock and shale that previously were thought to be too expensive to develop. Conventional oil extraction takes seven to ten years to bear fruit, whereas tight oil can be brought on stream within a few months of breaking ground.

Floating processing plants enable enterprises to exploit small, offshore gas fields whose output is processed and liquefied on a floating facility. PETRONAS, the Malaysian national oil company, operates a floating natural gas facility more than 100 miles from the coast of Sarawak (see box).

Capturing carbon in Texas

Interview with Noriaki Shimokata, Group Manager of Reservoir Engineering & Production, JX Nippon, a partner in the Petra Nova project.



What is distinctive about this project?

There are many depleted oil fields in the world. CO2 EOR can potentially revive oil production. The West Ranch Oil Field is the one of these. Oil production at the West Ranch field was 300 barrels per day before beginning CO2 EOR operations and it has now increased to 5,000 barrels per day following the application of the technology. It also presents a potential path to make coal more sustainable for future uses.

How can CCS be made more cost-effective?

It would be difficult for private enterprises in the near future to decide to develop a new carbon capture system without either drastic innovation or external financial aid from governments.

What enabled CCS to be used in the case of Petra Nova?

There were a number of factors:

• A grant from the US Department of Energy, and financing from Japan Bank for International Cooperation.

• A robust crude oil market at the time of the investment decision justified the modest return.

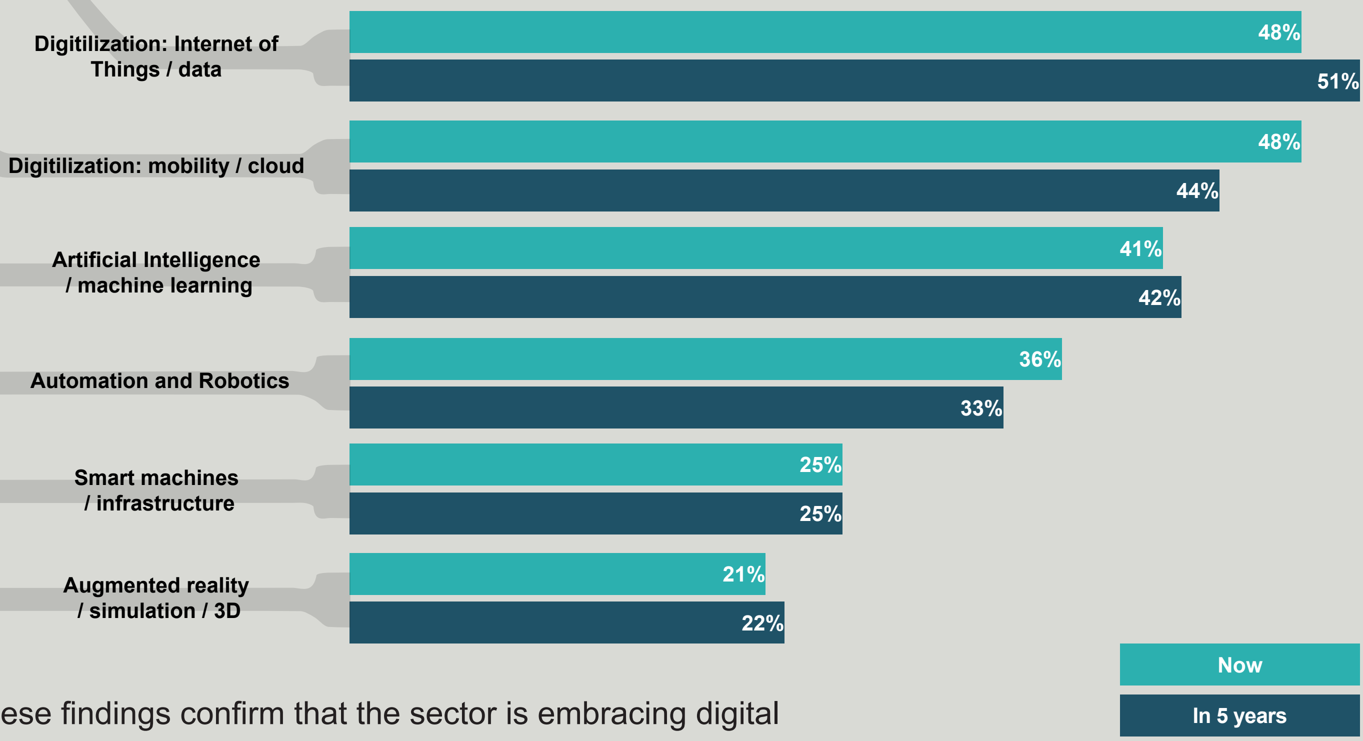
• The desire to contribute to society, as a responsible energy company, and reduce greenhouse gas emissions.

• Opportunities in the CO2 EOR business, including reviving mature oil fields and re-boosting production, and expanding exploration and production activities by using anthropogenic CO2 to expand the geographic footprint of the process beyond the reach of naturally produced CO2.

THE POWER TO TRANSFORM

While the oil and gas industry is making significant bets on a wide range of energy technologies, it is also focusing on digital technologies that promise to transform enterprises as fundamentally as in other sectors. When asked to select which of six different digital technologies they are investing in, respondents most frequently choose IoT and mobility/cloud technologies. AI and machine learning comes next. When the focus of the question shifts to the next five years, respondents' preferences change only slightly, as they do with energy technologies. IoT moves ahead of mobility/cloud, with AI/ machine learning in third place.

Which transformative technologies are you investing in and which do you plan to invest in over the next five years? % of respondents



These findings confirm that the sector is embracing digital change and the opportunities it offers to improve efficiency and decision-making. Luis Abril is Global Head of Energy, Industry, Consumer Products and Enterprise Business Solutions at Minsait, an Indra Company, a global technology and consulting company and a leader in Spain and Latin America. He says that IoT, AI and robotics will leverage the development of intelligent and more automatic infrastructures; thanks to the growing use of remote sensors, enormous amounts of operational data are available to analyze in real time, enabling enterprises to improve their decision-making processes, for example.

Michael Cohen, Director and Head of Energy Market Research at Barclays, believes that AI is likely to generate the highest potential cost savings compared to other digital applications, but that the benefits may be difficult to quantify, given a lack of cost disclosure by companies. Other digital technologies, such as simulations and augmented reality (another technology option in the survey), will help train workers to operate more safely and to certify subcontractors at production sites.

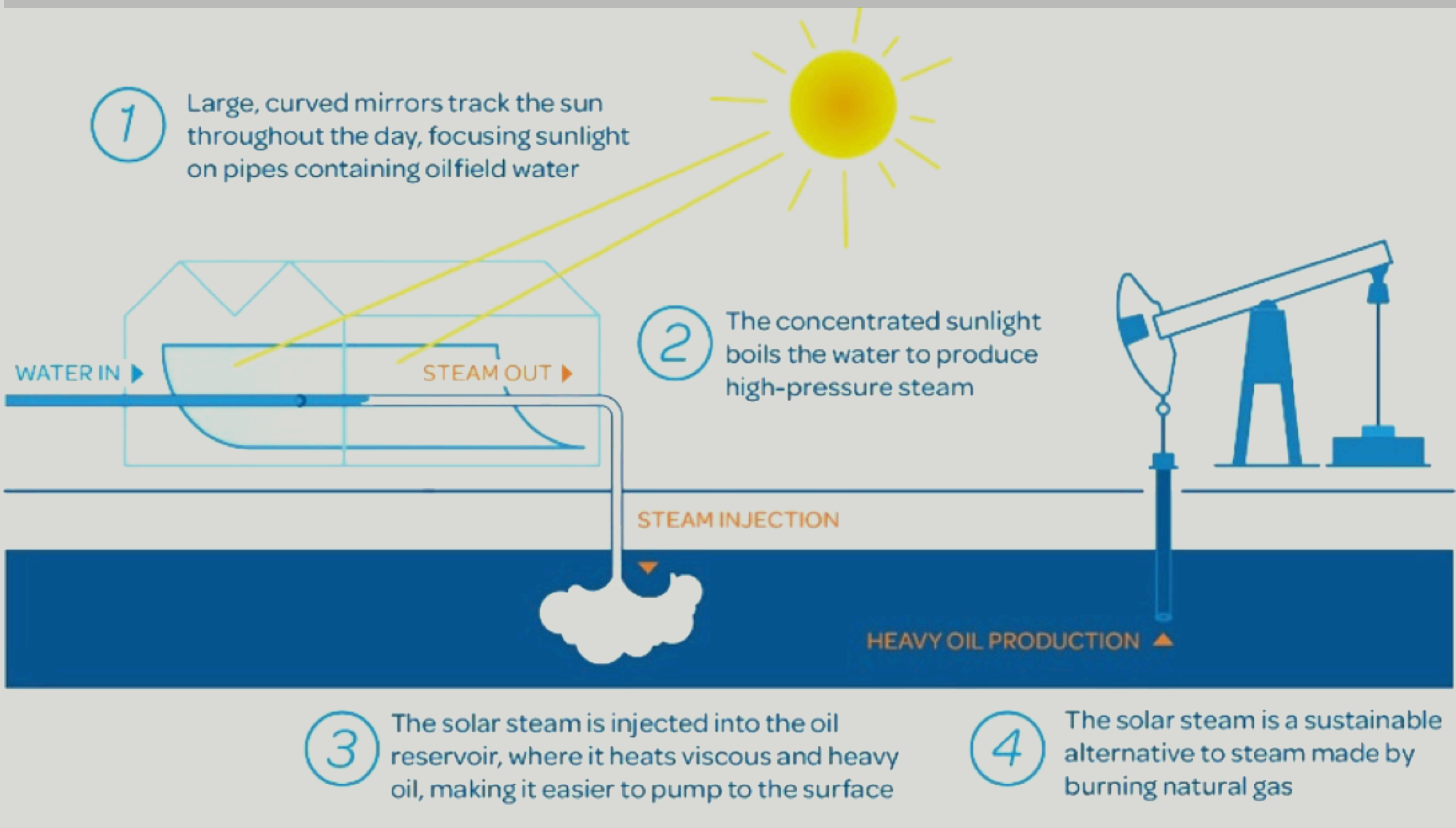
Ron Beck, Industry Marketing Director at Aspen Technology, says that advances in the next five years achieved through machine learning in the oil and gas sector will exceed people's expectations. John Scrimgeour, Executive Director at the University of Aberdeen's Institute of Energy, adds that machine learning will help enormously in many areas, particularly geophysics and well design, where there are massive amounts of data to learn from, though not always in an easily usable form. "A lot if it is written and varies from person to person, company to company and even from one rig to another," he says.

Although autonomous robotics have not yet been fully adopted by the industry, the picture may change drastically in the next few years. Drones are already being deployed in Alaska around oil and gas facilities. The Oil & Gas Technology Centre in the UK announced in May 2018 that it had invested in three robotics projects to transform pressure vessel inspection, which costs the industry hundreds of millions of dollars each year and poses significant safety challenges. In the same year, Total said it would deploy an autonomous ground robot for the first time for offshore inspection purposes on its Alwyn platform in the North Sea. Such examples of autonomous machines will cut labor costs and improve continuous monitoring.

Solar-powered oil recovery

GlassPoint Solar of California harnesses sunshine to produce low-cost, emissions-free steam, replacing the use of natural gas in heavy oilfields and finding a more valuable use of this fuel. The enclosed trough technology uses large, curved mirrors to concentrate sunlight on a steel pipe containing oilfield water. The concentrated sunlight boils the water to produce high-pressured steam, which is injected into the oil reservoir to heat the heavy oil and boost production. The natural gas saved by using this technology can be exported or directed toward higher-value applications, such as power generation or industrial development.

How Solar EOR Works



Source: GlassPoint

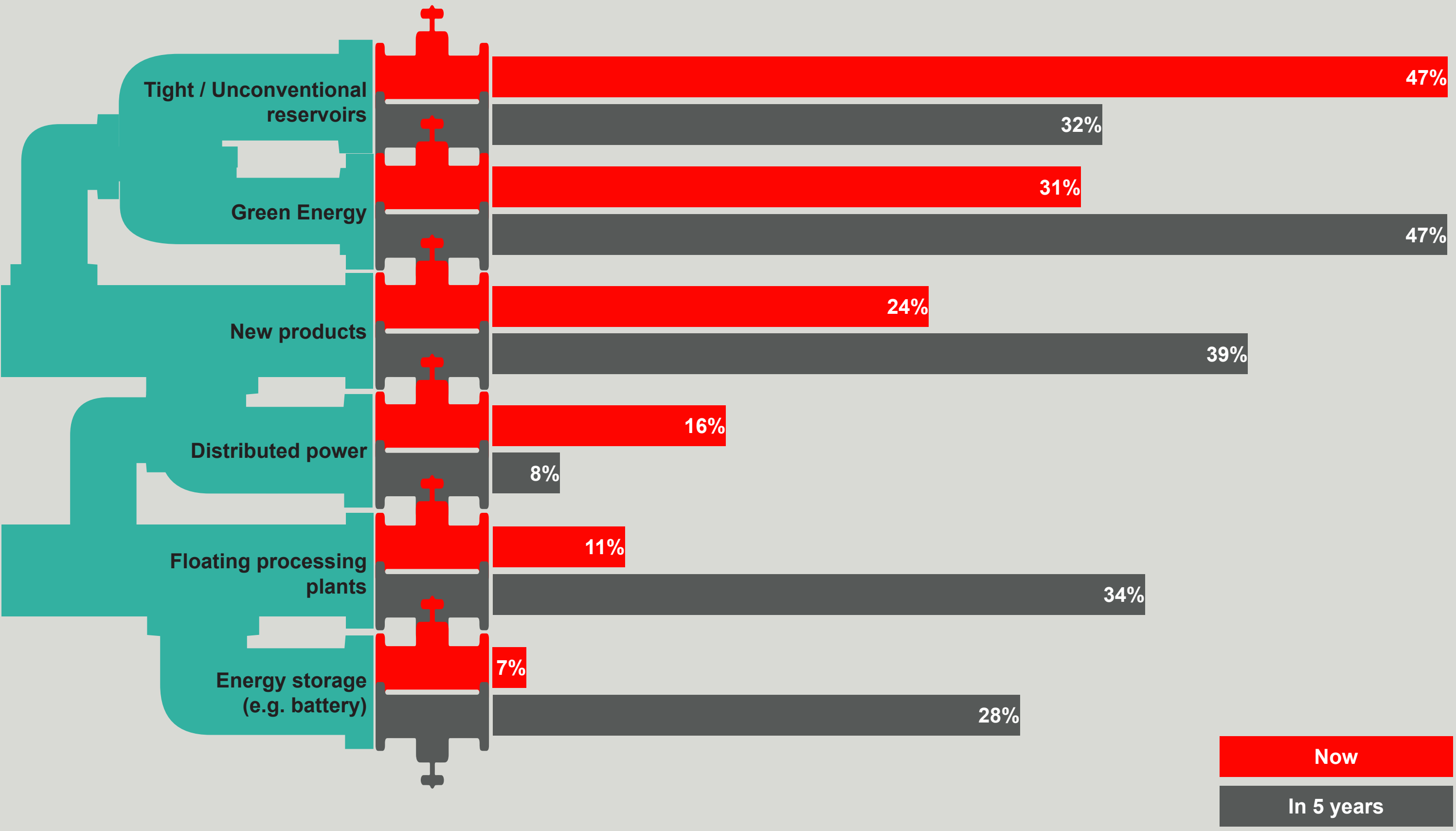
GlassPoint brings the mirrors and other system components indoors, using a greenhouse structure to protect it from wind and sand, which is important in desert oilfields. The greenhouse helps create major cost and performance advantages compared to exposed solar thermal designs. This technology has been deployed the state-owned Petroleum Development Oman which partnered with GlassPoint to build the Miraah solar plant on the Amal oilfield.

CONTRASTING APPROACHES TO TECHNOLOGY

Having divided survey respondents into two groups according to the technologies they are investing in—energy-related and transformative—we now go deeper into contrasting sub-groups of respondents. By analyzing the data further, we found two different patterns of investment in energy technology, one that distinguishes private-sector and state-owned enterprises, and the other that differentiates oil and gas enterprises from service providers.

The survey shows that public-sector companies are more focused on policy objectives, while privately owned enterprises are more likely to invest for financial reasons: 74% of the former are investing in green energy technology that is likely to reduce greenhouse gas emissions, compared with only 34% of private enterprises. The contrast is equally marked when investing in new products and floating processing plants. The one area where private companies are much more likely to be investing in is tight/unconventional reservoirs, by a margin of 41% to 17%.

Which energy technology applications are you investing in and which do you plan to invest in over the next five years? % of respondents



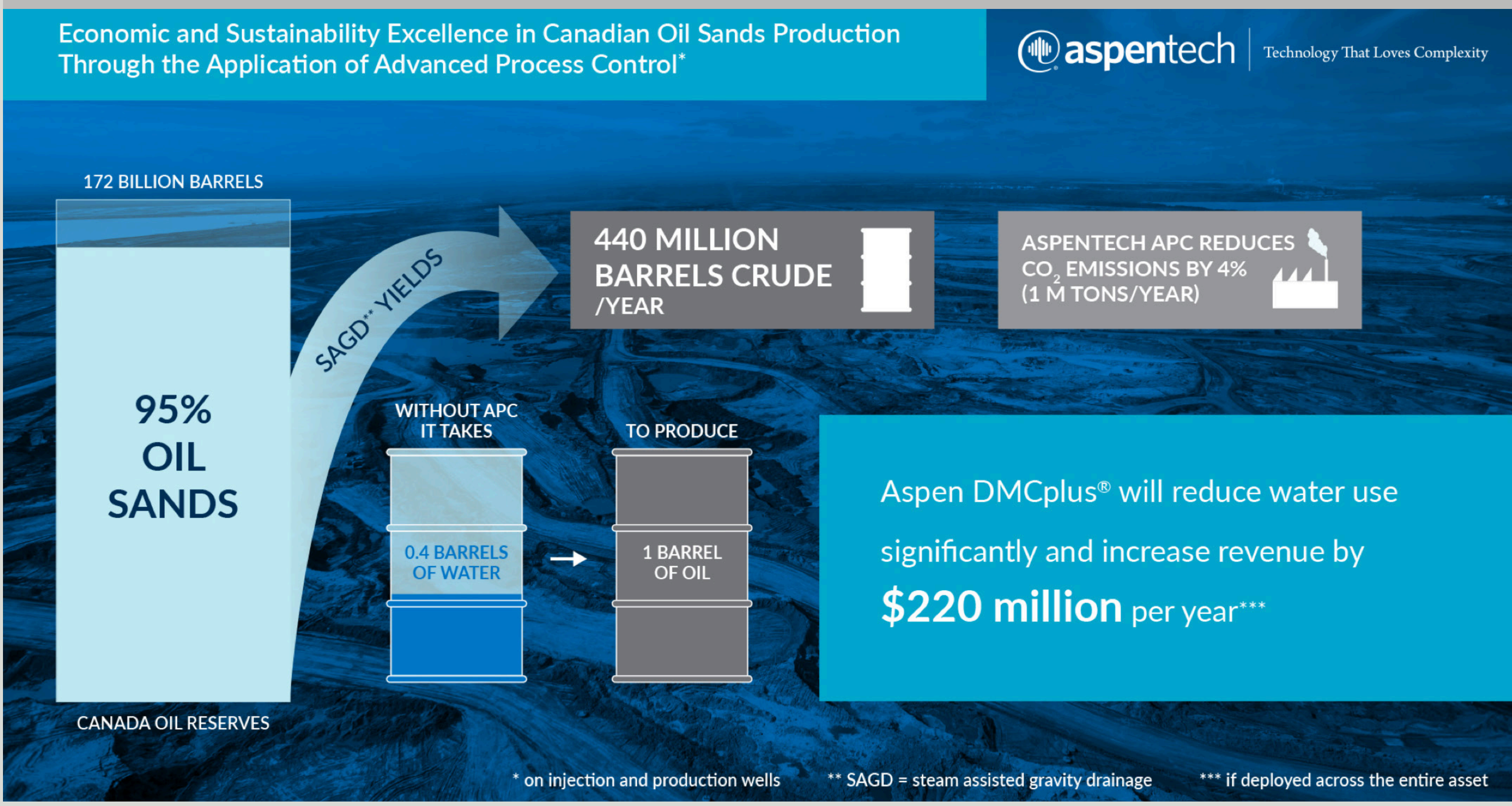
Big differences can also be seen in the approach to investing taken by oil and gas companies, compared with service providers. The former are far more likely to be investing in green energy, new products and floating processing plants, whereas service providers are much more focused on investing in tight/ unconventional reservoirs.

Maximizing oil extraction while minimizing the environmental impact

There are technical constraints in ensuring that the steam used in the Steam Assisted Gravity Drainage (SAGD) extraction method is properly distributed to wells, while also preventing steam breaking through into reservoirs, which can adversely affect production and equipment. Additionally, SAGD sites are under environmental scrutiny to minimize their use of fresh water and reduce their carbon footprint. Operating as close as possible to the reservoir engineer's design produces the best bitumen production for the dollars spent.

One answer to the challenge is a digitalization technology known as advanced process control (APC), developed by AspenTech using DMCplus and DMC3 technologies, which is making its way to the oilfields. In Alberta, the technology has been deployed at many wells and shows what digitalization is able to accomplish. It is an autonomous technology capable of being distributed across an entire SAGD operation, adjusting the steam injection and production parameters in a much faster and more precise way than field or control room operators could normally accomplish. It therefore makes a significant impact on the economics of a project and on the sustainability of the SAGD production, since it optimizes the injection steam distribution as well as the bitumen production. The use of the digitalization strategy across a SAGD operation achieves at least a 2% reduction in steam generation costs and a 2% increase in bitumen production rates for a current asset infrastructure.

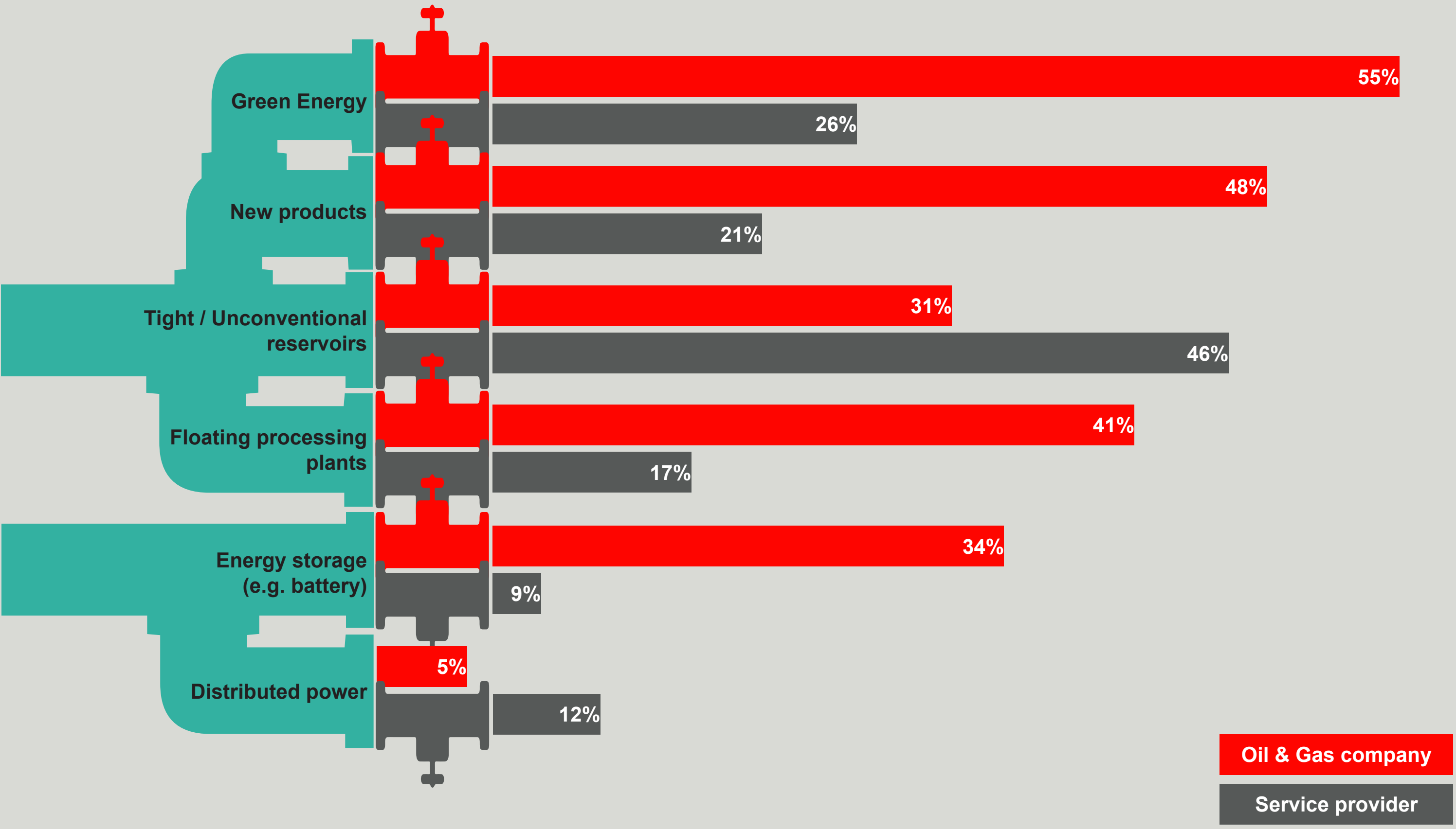
The Application of APC in Oil Sands Production



Source: AspenTech

These contrasts are partly determined by the fact that the frequency of public ownership is low among service providers, whereas public ownership is concentrated in upstream and midstream oil and gas companies. Another reason is that oil and gas companies have tended to outsource more of their technology requirements to service providers, sometimes because the cost of technology has increased.

Which energy technology applications are you investing in and which do you plan to invest in over the next five years? % of respondents



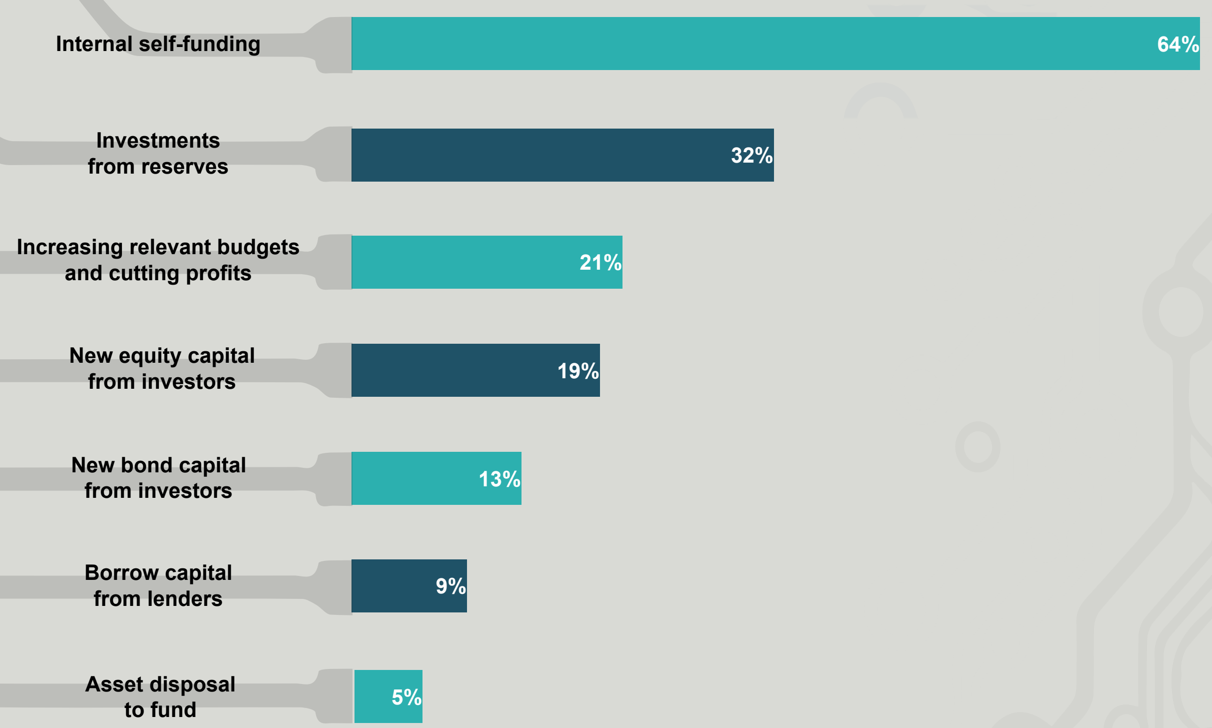
One example of outsourcing is seismic upgrading, where service providers offer new, digital technologies that are enabling companies to re-assess old data from oil and gas fields. In the past, this analysis was time-consuming, but now, AI-powered technologies can do this work in a matter of a few hours and can identify exploitable resources that would otherwise have been missed. This benefits both new exploration and the enhanced exploration of existing assets.

PAYING FOR THE TECHNOLOGY

Seismic upgrading technology does not come cheap, and to pay for it and other technologies, the majority of respondents fund such investments internally, from such sources as reserves, asset disposals, and re-allocation of existing budgets and funds raised by reducing profit margins.

Some form of internal funding is cited by 88% of all respondents, compared with just over 40% who point to raising capital via debt/equity instruments or by other borrowing. The propensity towards internal funding is even stronger among state-owned enterprises (97%), although they also rely on bond issues more frequently than private firms (30% vs 6%), presumably reflecting the number of joint ventures the former have with private companies. Although there are some contrasts in funding sources among respondents, finding the money to pay for investments is not seen as a significant barrier, but the cost of innovation is, by a factor of 17% to 42%.

How do you fund technological innovation? % of respondents

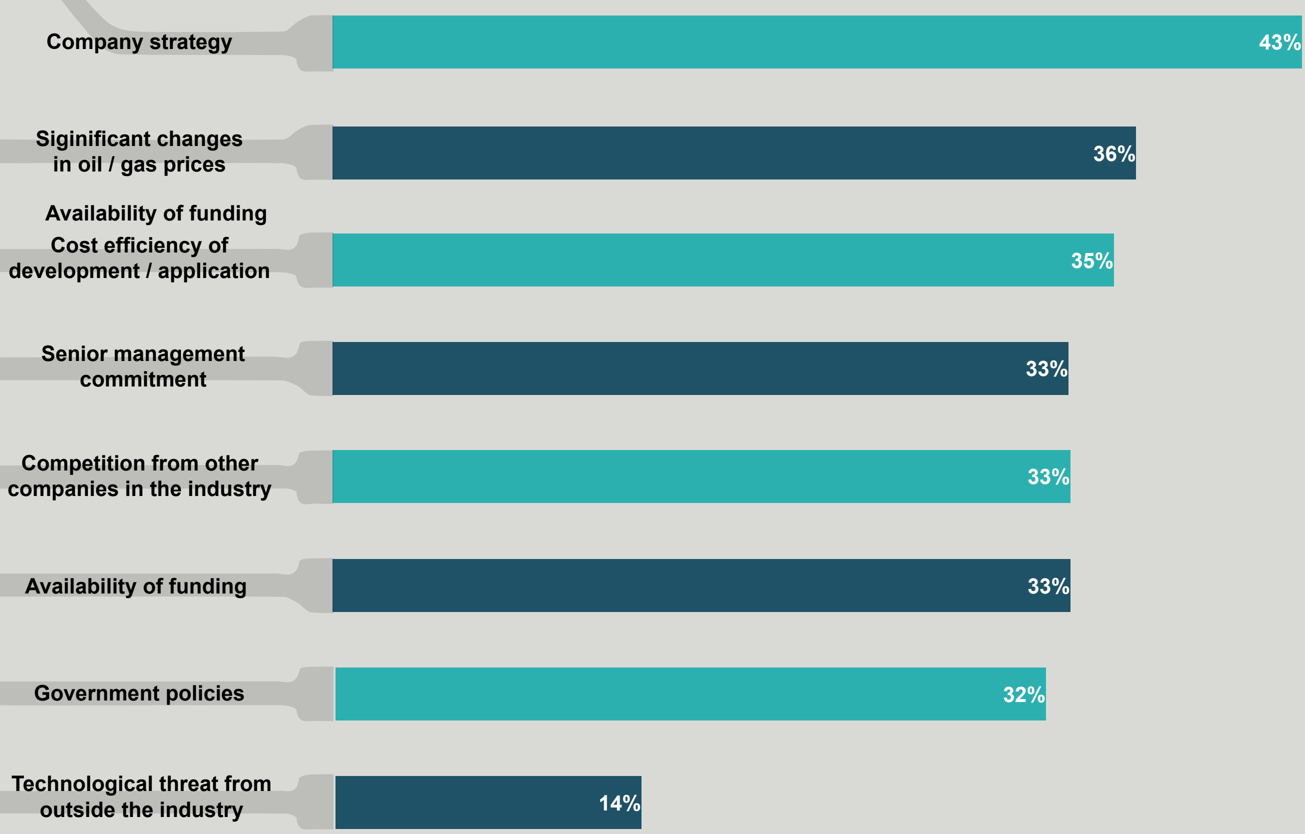


DRIVING FORCES

Finding the money for technology investments is one thing, but what are the factors causing oil and gas enterprises to innovate in the first place? When survey respondents were asked to choose the most important drivers of technological change in the oil and gas industry, the most frequently chosen option was company strategy, at more than 40%. Another six options received a 32%-36% response rate, including the commitment of senior management to bring about technological changes. Clearly, if a company approaches technological investments cautiously, then the rate of change will be slow. The International Energy Agency (IEA) has noted that a risk-averse management perspective is one of the leading causes of slow adoption of new technologies. By contrast, boldness seems to pay off. As we note later in the report, technology leaders are more likely than other respondents to say that they have seen gains from transformative technologies.

What is the most important driver behind technological changes in the industry?

% of respondents



Government policies were chosen by almost a third of respondents as an important technology driver. Peter Tertzakian, Executive Director at ARC Energy Research Institute in Calgary, says that fiscal policy is the most influential driver in a government's arsenal, and that environmental policy is another key factor, especially if such things as drilling permits are restricted. The Canadian Association of Petroleum Producers has expressed concerns about the cumulative effect of costly, inefficient and duplicative policies and regulations that are damaging the industry's global competitiveness and eroding investors' confidence. "Reduced investment in turn delays or halts the commercialization of promising innovative technologies that could significantly reduce emissions," it says.[2]

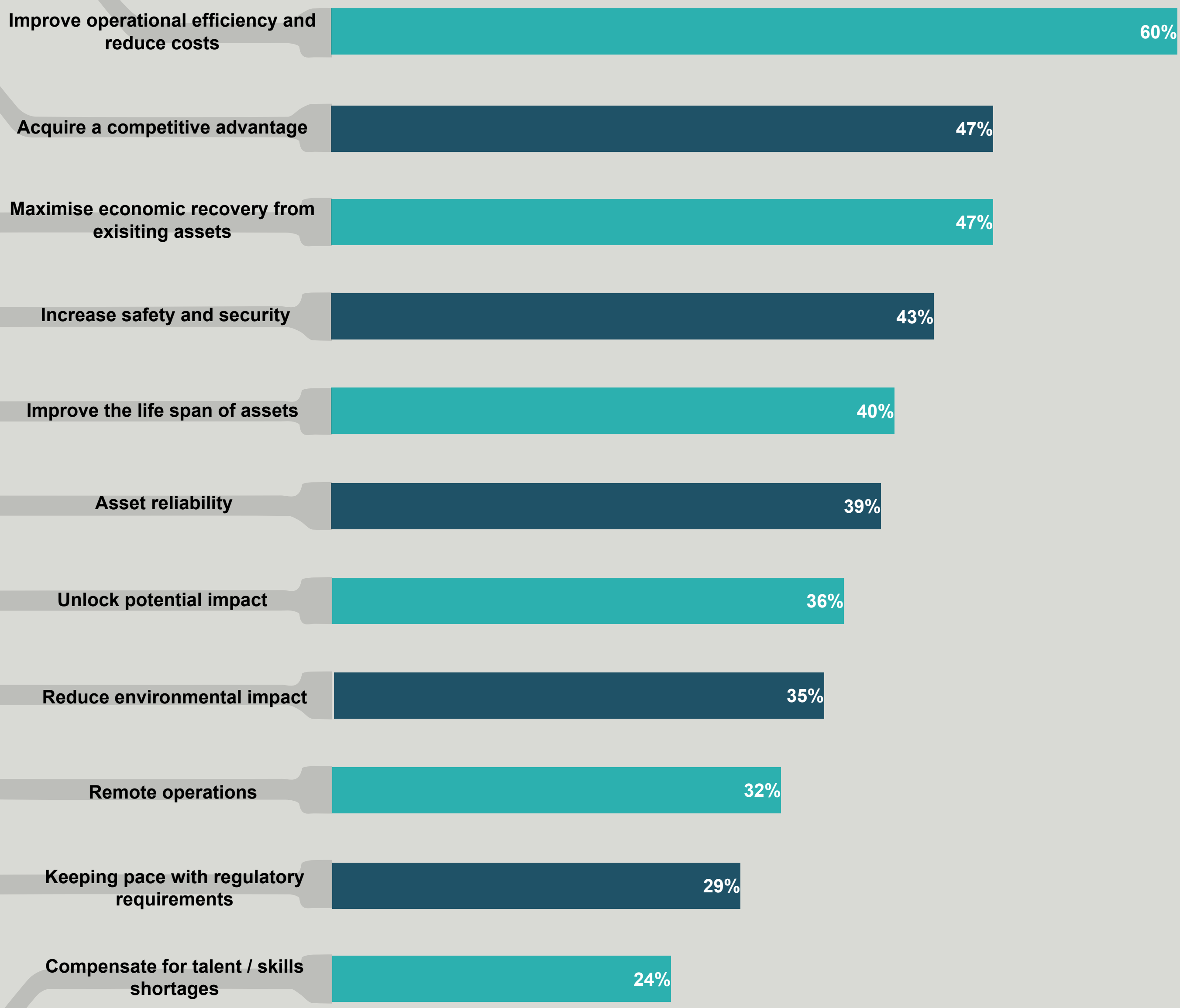
Governments are also enablers of technology investments. Mike Tholen, Upstream Policy Director at industry association Oil & Gas UK, points to Norway's tax rebates for technology-led initiatives, while the UK government has been working with the industry since 2016 to search for new R&D solutions, through the Oil & Gas Technology Centre in Scotland[3].

These drivers reflect the motives that executives cite for their investments in technology and innovation. The motives most frequently rated as "most important" are to improve operational efficiency and reduce costs, to acquire a competitive advantage and to maximize economic recovery from existing assets. Public sector firms cite these motivations less frequently than their private counterparts, except when it comes to unlocking potential reserves (43% compared with 34% for private firms). Service providers tend to be more focused on efficiency, costs and competitive advantage than producers.

[2]*CAPP (2018, p. 3),* [3] Oil & Gas Authority Technology Strategy (2016)

What is your primary motivation for investing in technology and innovation?

% reporting “most important” motivation



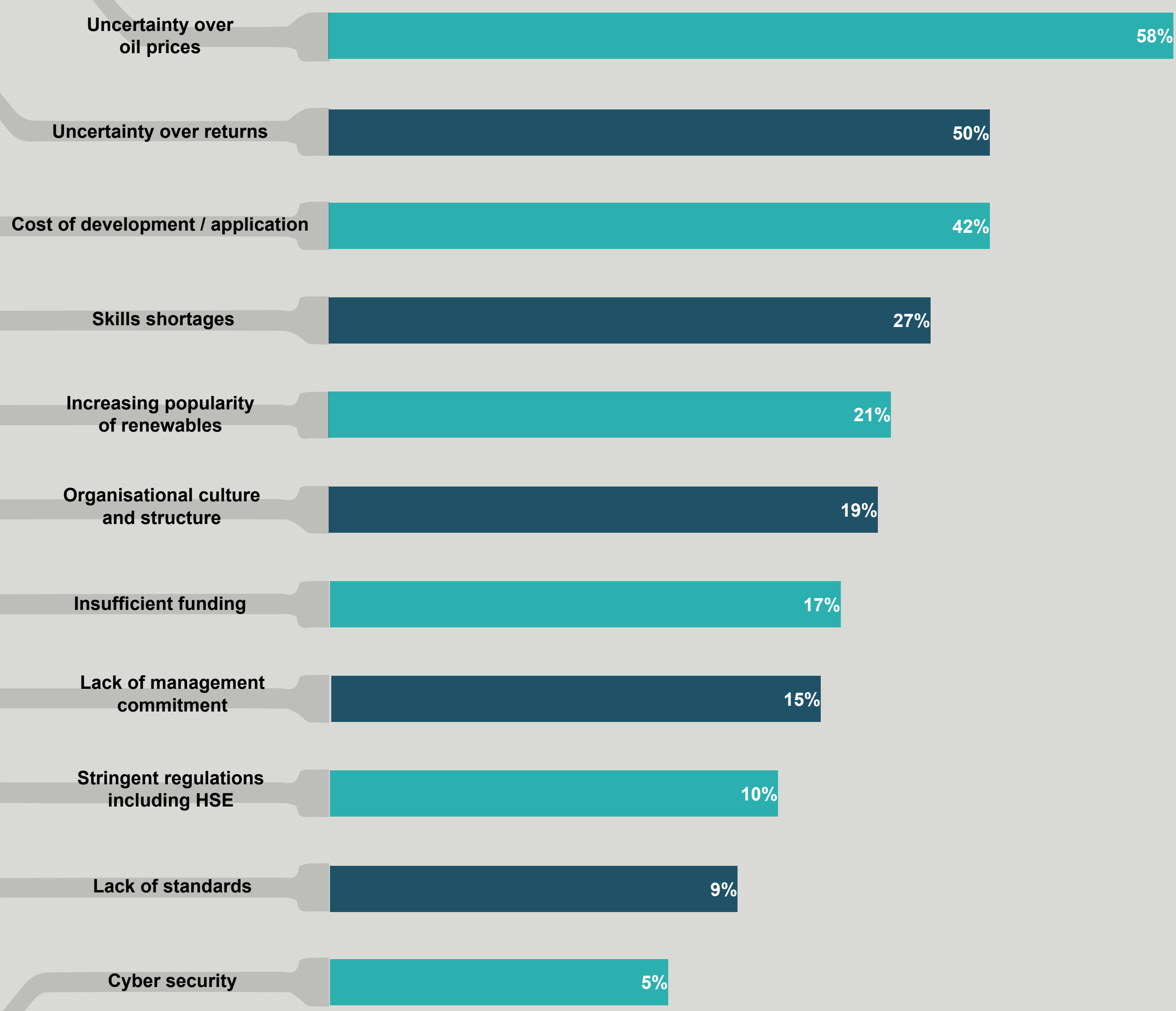
VOLATILITY AND UNCERTAINTY

Stringent regulations are rarely regarded by respondents to the survey as a barrier to investing in technology. Much more frequently cited obstacles are uncertainty over oil and gas prices and investment returns, which are linked to output prices. Certainly, price volatility creates uncertainty; the IEA estimates that global capital expenditure in the oil and gas industry dropped by 44% between 2014 and 2016, when output prices fell by half.

The high cost of technological development or applications is the only other barrier cited by more than one-third of executives. Organizational culture, for example, is cited by less than a fifth of respondents.

What are the main barriers for investing in technology in oil & gas industry?

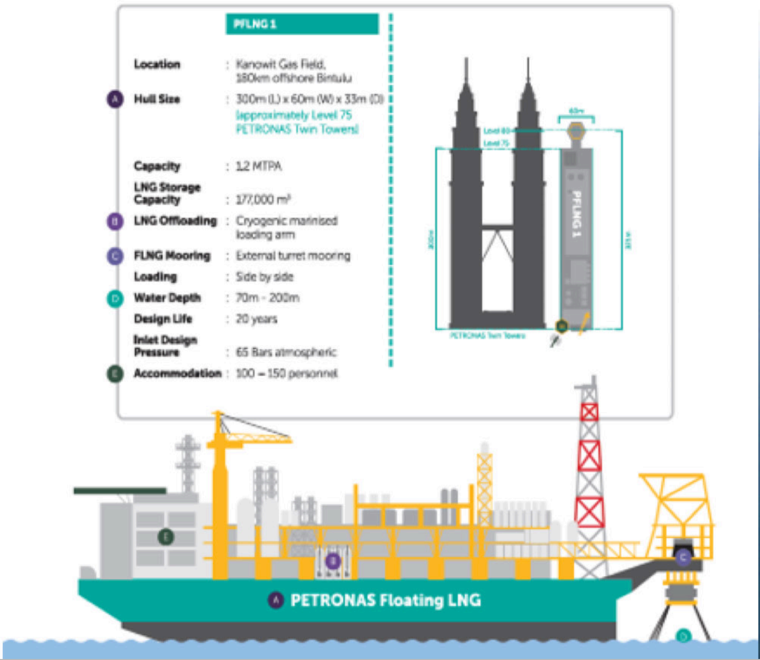
% of respondents



It is worth noting that public and private sector enterprises are largely aligned concerning the main barriers. This suggests that while the two sectors operate differently, they are still constrained by the same factors, notably uncertainty over returns and the cost of technological development. But, by contrast, public enterprises are much more concerned about skills shortages and the increasing popularity of renewables (by a factor of 38% to 15%, respectively). Public-sector enterprises are much less likely to recognize organizational culture and structure as a barrier to investment.

For Mazuin Ismail, Senior Vice President, Project Delivery & Technology at Malaysia's state-owned PETRONAS, investment in technology unlocks new revenue streams and creates innovative approaches to operational excellence that will drive costs down. "It reinforces our efforts to deliver the cleanest and cheapest sources of energy to our customers," he says. Mr. Ismail adds that PETRONAS maintains a long-term approach to technology, even in a downswing: when crude prices fell, the company made the decision that it would be the best time to intensify its R&D efforts by increasing expenditure on research.

PETRONAS develops floating LNG technology



Source: PETRONAS

Interview with Mazuin Ismail, Senior Vice President, Project Delivery & Technology, PETRONAS

What challenges has PETRONAS faced in developing and implementing floating liquefied natural gas (FLNG) technology?

While our onshore LNG facility allows for trains and modules to be spread out, FLNG has to be more compact and stacked-up, compressing 20 acres into a 365-metre-long facility. We had to manage the interface between traditional LNG and marine disciplines, for example, and the impact of wave and ship motion on gas processing, equipment and LNG storage. Offloading LNG from FLNG to a carrier in an open-sea environment was a relatively new concept.

What is innovative about your FLNG project?
The PETRONAS FLNG facility has been built to withstand a harsh marine environment in order to monetize stranded gas reserves that would otherwise be unfeasible to develop conventionally. This technology offers the flexibility in operations to be redeployed in multiple fields. This would enable better access for processing a wider range of gas reserves far out to sea. The facility also allows us to produce gas with a minimized environmental footprint, setting a new benchmark for the industry.

Do you envisage more widespread use of FLNG in the coming five years?
The value of FLNG as a proven technology is in having it as an option for monetization. It is a tried and tested technology that can be replicated not just in Malaysia, but elsewhere, and is something which PETRONAS can offer to others looking to monetize their gas fields without incurring the capital expenditure for conventional infrastructures.

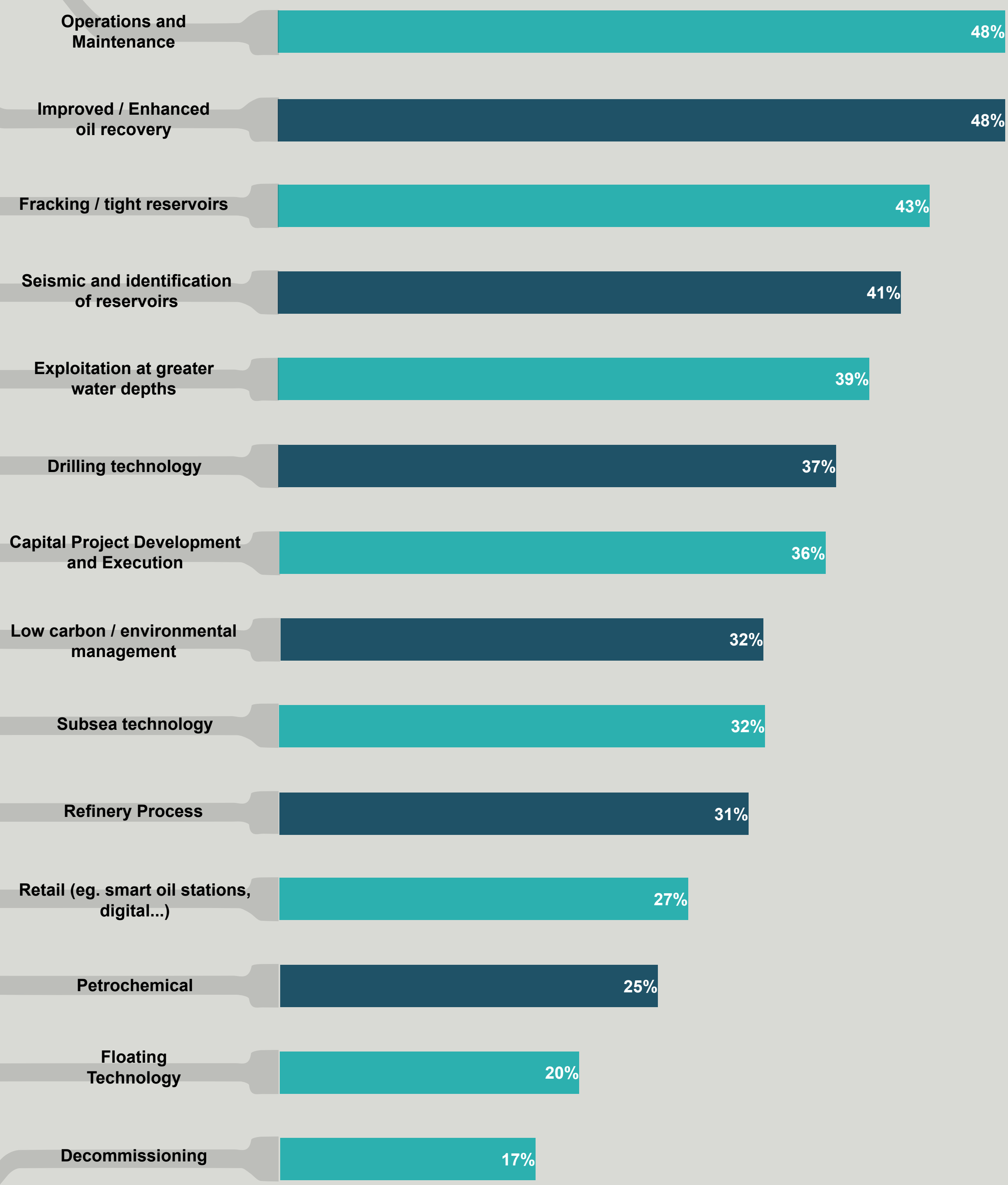
THE BENEFITS OF TECHNOLOGY INVESTMENTS

The money to pay for new investments is forthcoming if the return is high enough, after adjusting for unpredictable changes in oil and gas prices. And so far, the benefits of transformative technologies are proving to be considerable. The digitalization of the oil and gas industry is having as far-reaching an effect as the shift that occurred a century ago when companies switched from wooden rigs to rotary drilling and steel casing, which caused a tenfold improvement in productivity. Peter Tertzakian says that the sector has made similar progress in the current decade. In the view of BP's David Eyton, the underlying physics of the oil and gas industry will not change, but the way companies do things will, thanks to digitalization.

The survey shows that the areas where transformative technologies are having the biggest impact are production-related, including operations and maintenance, improved/enhanced recovery, fracking/tight reservoirs and exploitation at greater depths, where large minorities of respondents say they expect significant benefits. Exploration, development and drilling technologies are regarded as the next biggest beneficiaries. Indeed, the IEA reckons that digital technologies could help increase technically recoverable oil and gas resources by 5% globally[4].

Which areas will benefit most from transformative technology?

% reporting "significant" benefits



[4] *https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf p17*

Notably, the gains from these transformative technologies are seen by survey respondents to be industry-wide, and this view does not vary substantially between producers and service providers. Similarly, while private firms tend to report higher benefits than state-owned companies across the range of technologies, the differences are not substantial. But there are two exceptions: state firms are more likely to report significant benefits from the exploitation of oil wells at greater water depths (52% compared with 35% for privately owned companies), and in refinery processing (39% compared with 28%).

Brett Schroeder, Managing Director of AP-Networks, sees a range of technologies that are helping oil and gas enterprises find ways to reduce the cost of operations and maintenance. Advanced data analytics is being used to measure and select the optimal scope of work for facility turnarounds, helping executives decide whether to replace or repair equipment. This leads to better cost performance and improved reliability. Data analytics can also help with the planning of new facilities, leading to faster ramp-up times. The availability of real-time location data cuts logistics costs. And predictive analytics helps companies to optimize their project portfolios and turnarounds.

Luis Abril of Minsait says that digital technology enables companies to extract more value from data, using new platforms to share data with the entire organization, as well as with suppliers, contractors and partners. The real-time visualization of the data helps optimize decision-making. It can also automate and simplify the value chain to obtain higher levels of efficiency and to optimize production and logistics, while achieving greater autonomy, efficiency and flexibility through intelligent infrastructures, as well as improving safety and security levels during operation.

Estimates of the financial gains accruing to the oil and gas industry from transformative technologies vary widely. The IEA believes that digital technologies, including advanced processing of seismic data, use of sensors, and enhanced reservoir modelling, could reduce production costs by 10%-20% . Ahmed Hashmi, Head of Upstream Technology at BP, expects digitalization in the oil and gas industry will lead to a reduction in costs of more than 30% in the next 25-30 years. A simple example is the use of more sensors at the wellhead to monitor operational efficiency; this would lead to a reduction in the number of trips to the fields, thereby cutting fuel usage and saving man hours.

Automation will also help companies to manage their operational risks. According to Ron Beck of Aspen Technology, one of the main benefits of digital technology is the ability to predict potential failures and issue advance warnings in case of anomalies, giving operators enough time to address the problem. As predictive analytics continues to teach itself, the software can recognize anomalies increasingly quickly, and be able to tell operators what might cause a failure.

Achieving bottom-line savings through turnaround improvement

Turnarounds are planned shutdowns of a facility to perform maintenance and install new capital projects. Typically, these events occur every few years, and must be executed with a proven strategy and dedicated, effective preparation to achieve the planned schedule and estimated budget. A high-complexity event for a refinery or petrochemical plant can cost $100-200 million on average and take 60 days. During the shutdown, sites may bring in up to 2,000 workers. The upfront planning and coordination of these workers must be flawless, if cost and schedule targets are to be met. The same is true for offshore upstream facilities, which execute high-complexity events that can take more than 30 days and involve more than 450 people on board.

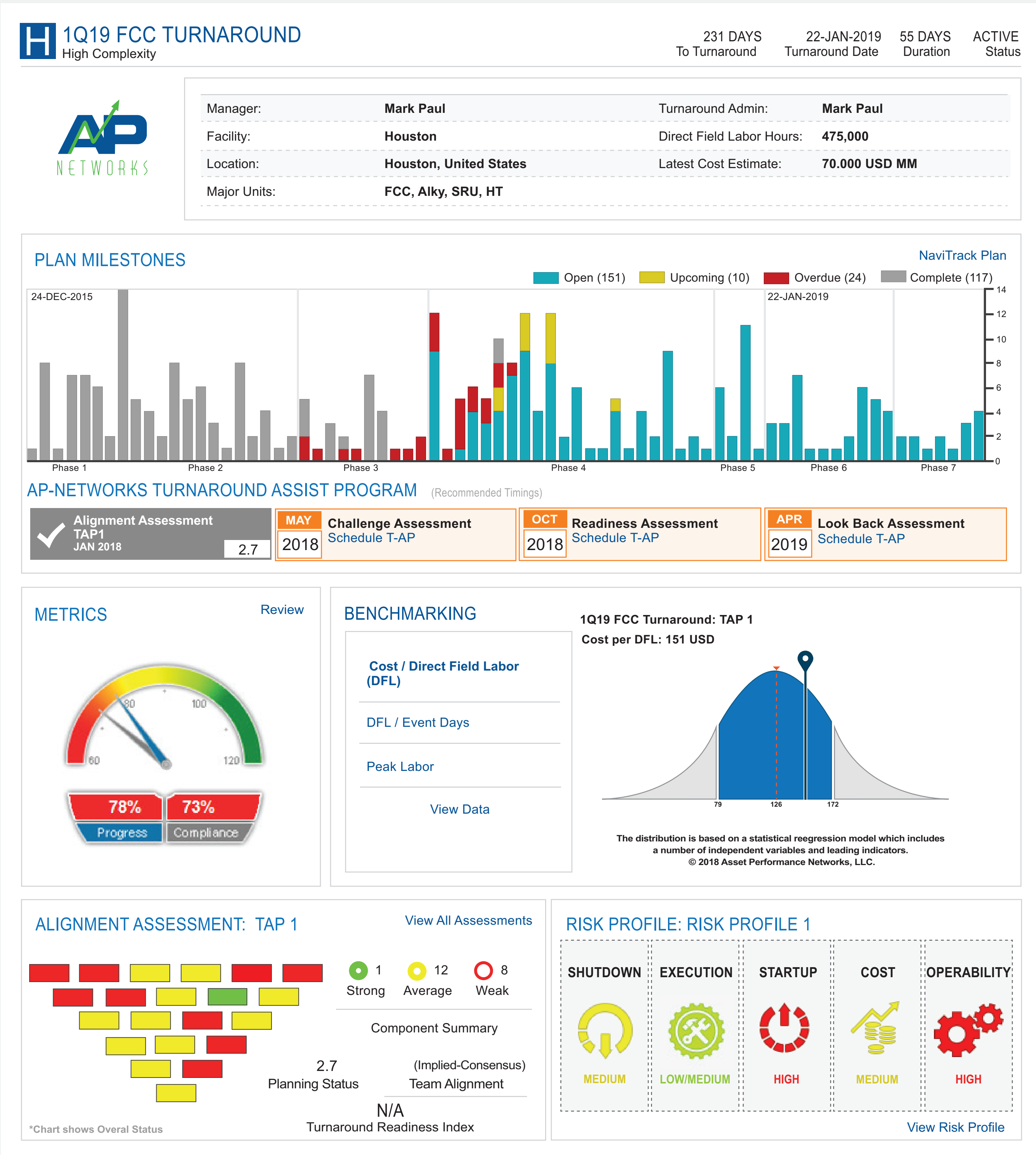
Historically, the oil and gas industry has struggled to effectively manage turnarounds. According to AP-Networks, the average cost and schedule overrun for a highly complex turnaround is more than 20%. Traditionally, sites have used paper-based manuals or spreadsheets to manage the planning process. NaviTrack, the web-based work process deployment tool from AP-Networks, has replaced these systems with a web-based system. The tool provides a dashboard view for management to understand the planning status, monitor key performance indicators and identify bottlenecks in the turnaround planning effort. The timing and responsibility for every task leading up to the shutdown is identified more than two years in advance. The improved preparation and overall readiness for turnarounds has resulted in higher performance, while providing better and earlier visibility when planning and preparation go off the rails.

NaviTrack enables companies to see the progress of every event for every site in the organization. The lessons learned and best practices can then be shared across the entire company. According

[5] *https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf p17*

to Sonny Best, Global Turnaround Assurance Advisor at BP, the use of NaviTrack at the Whiting Refinery in the US state of Indiana “has brought more transparency to leadership and stakeholders, allowing us to better ensure process compliance for proper turnaround delivery.” The Whiting Refinery is BP’s largest and one of the biggest in the US, processing up to 430,000 barrels of oil per day.

The Turnaround Network dashboard, featuring NaviTrack plan milestones

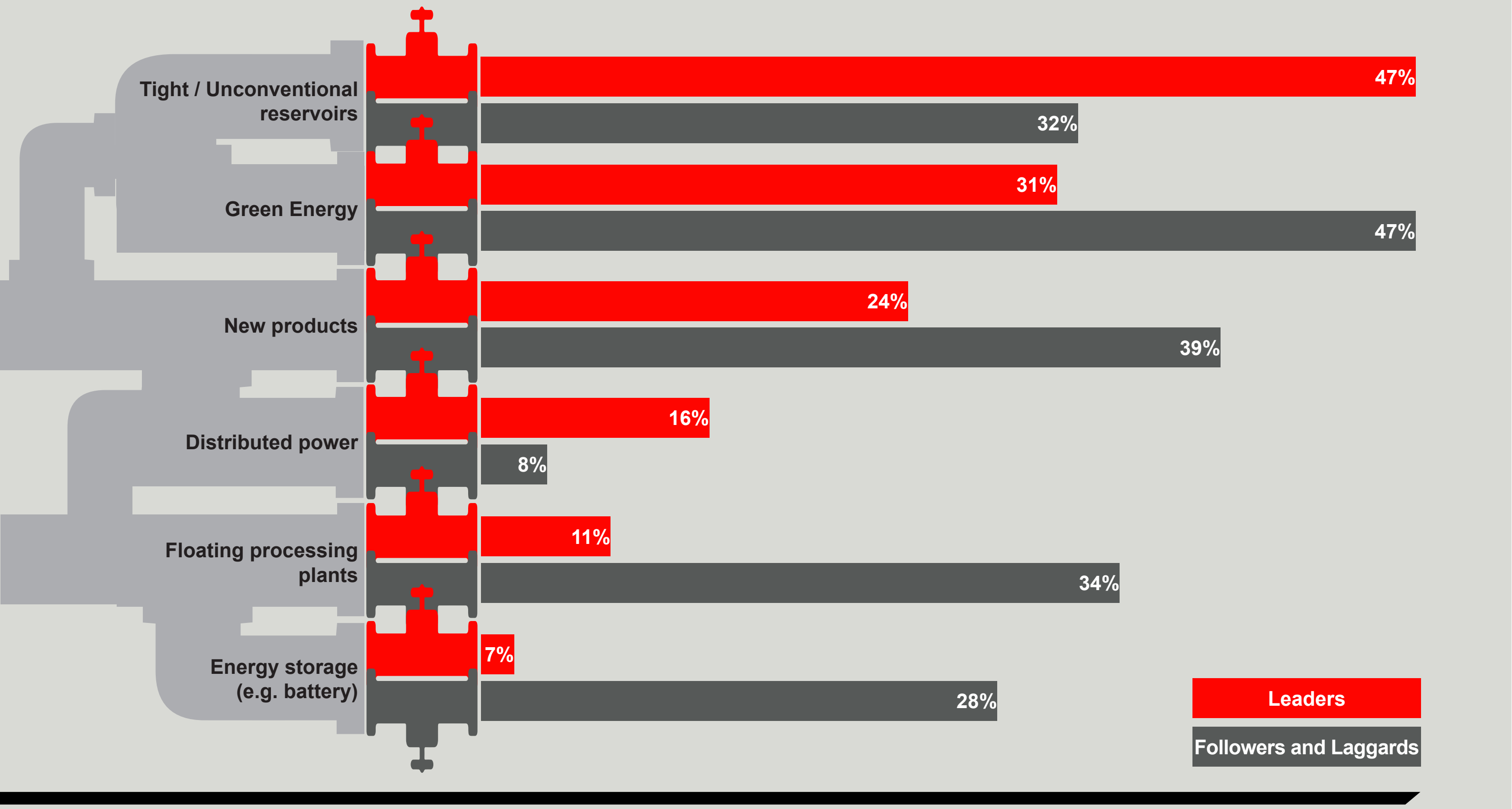


WHERE TECHNOLOGY LEADERS ARE HEADED

By delving a little deeper into the survey results, it is possible to see how the strategies and approaches of technology leaders compare with the rest of the respondents. We define the former as companies that have been identified as technology leaders by the respondents who work in those organisations, and whose vision of technology implementation has been described by the latter as 'clearly articulated.' This group comprises 17% of respondents, the remainder being defined as followers and laggards. Service providers are more likely to be leaders (28%) than oil and gas producers (9%), probably because their smaller size enables them to be more agile. All but one of the leaders are privately owned enterprises, a notable disparity between the public and private sectors.

The difference between the two groups is quite stark when it comes to technology investment patterns. Leaders are much more likely to say they are investing in tight/unconventional reservoirs (47%) than others (32%) and considerably less likely to invest in technologies designed to reduce greenhouse gas emissions, including green energy and new products.

Which energy technology applications are you investing in? % of respondents

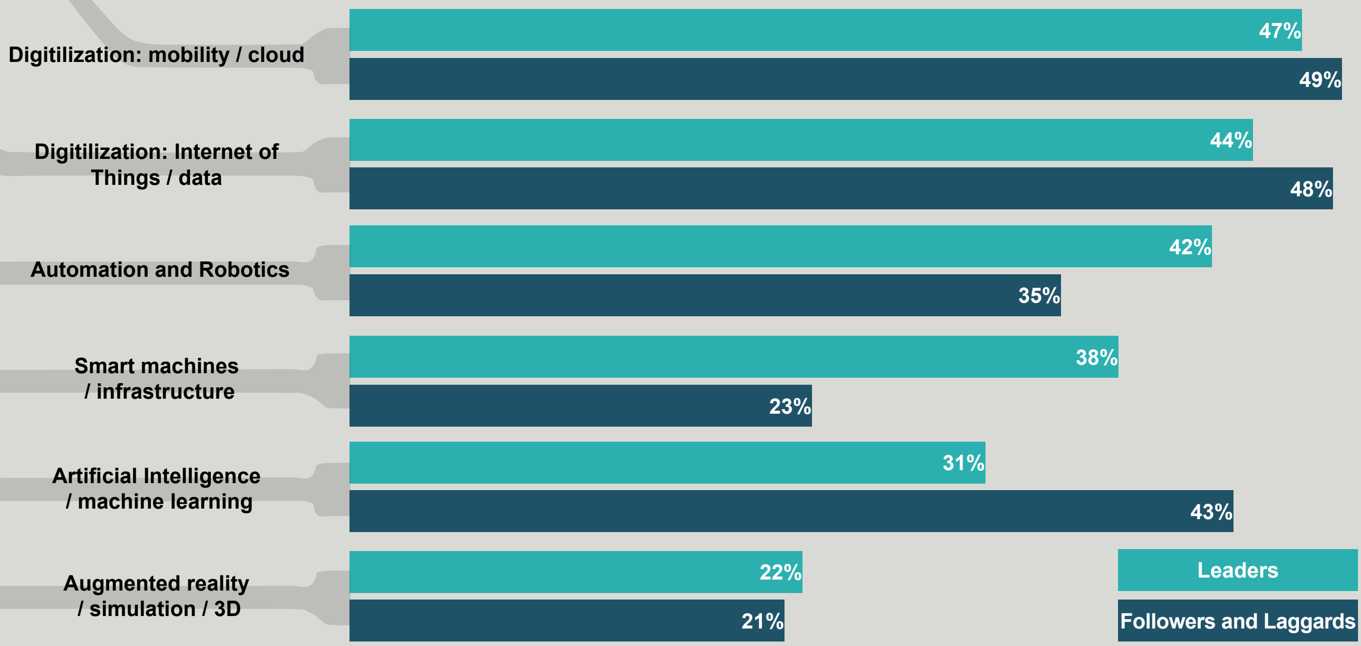


In the area of transformative technologies, the differences are quite telling. A higher proportion of leaders choose automation and robotics (42% compared to 35% of other respondents), and smart machines (38% to 22%).

Leaders are also more likely than other respondents to say that they have seen gains from transformative technologies. More than two thirds of them say they receive significant benefits in operations and maintenance compared with only 44% of other firms, and they also claim greater benefits in drilling technology (51% against 33%) and in seismic analysis & identification of reservoirs (49% to 39%).

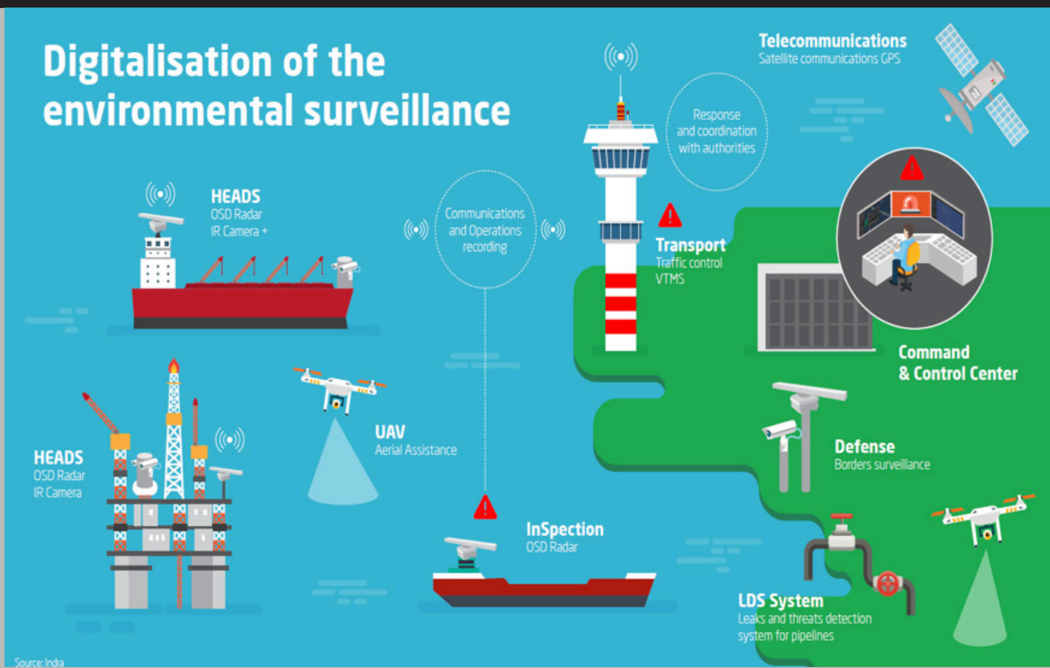
These benefits stem in part from leaders' motivations for technology and innovation investment, which are focused more on economic and commercial goals. More than four in five leaders say that improving operational efficiency or reducing costs is a 'most important' benefit, compared with just over half of other firms. The gaps are also large for acquiring competitive advantage (78% compared with 41%) and maximizing economic recovery from existing assets (60% to 45%).

Which transformative technologies are you investing in? % of respondents



Given the different investment patterns, it is not surprising that the leaders are responding to a different set of drivers compared with other respondents to the survey. The most important pressure points are cost efficiency and significant changes in oil and gas prices. Leaders are much less affected than followers & laggards by the availability of funding and government policies. Interestingly, none of the groups regards the technological threat from such advances as electric vehicles as being a significant spur to investment. Instead, they are twice as likely to say that competition from inside the industry is an important driver of technology changes. Energy-efficient transport technologies do not fundamentally alter the competitive picture, because oil and gas companies will continue to strive for lower costs and better processes.

Digital transformation of environmental surveillance



Minsait, an Indra company, a Spanish consulting and technology company, has patented the use of automated infrared video processing in combination with other sensors for oil spills automatic detection. The Hydrocarbon Early and Automatic Detection System (HEADS) is a system that automatically detects hydrocarbon leaks in the marine environment, with high precision and reliability and the shortest detection time. Even very small leaks of a few liters can be detected within five minutes of them occurring, thereby improving the safety of the operations.

This pioneering technology is based on highly advanced infrared sensors, radars, superfast algorithms and advanced analytics capable of activating alarms without human intervention. The combined use of infrared images and radar signals can maximize reliability in any weather condition while automated processing allows for constant monitoring without the intervention of a human operator, minimizing the risk of error and allowing a response time of just a few minutes. It also includes specific capabilities for automated (unmanned) detection, integration with satellite services and response ships, 24/7 recording, remote surveillance, alarm logging or automatic vessel identification. The system is a valuable tool for operational real-time decision-making, providing a record and tracking of all existing data to make it available in case of conflict resolution or safety improvement analysis. It is also ideal for unmanned platforms.

Source: Minsait, an Indra company

LESSONS AND IMPLICATIONS

Since its inception, the oil and gas industry has survived and prospered with the help of technological innovation. Its future is likely to be as dependent on new technologies as its past. To gain a sense of where the industry is heading, our survey of oil and gas executives offers the following implications:

- Oil and gas companies will continue to invest in technologies that help them improve efficiency while reducing their environmental impact. At the same time, they will continue to develop new products to adapt better to the global energy transition toward a greener, cleaner future. The industry will be at the forefront of this shift.

- Because the funding of new technologies will come primarily from internal resources, investing in technologies that improve efficiency and have an immediate impact on revenues is likely to capture greater interest than riskier investments in new products. If oil and gas companies are to invest more in potentially planet-saving areas such as carbon capture and storage, then government policies will need to be changed to make such investments more attractive.

- Transformative technologies, particularly IoT, mobility and cloud applications are going to have a profound effect on the future of the oil and gas sector. Every enterprise in the sector needs to develop a digital transformation strategy to maximize the potential of these, and other, digital technologies.

- Executives at oil and gas enterprises need to pay attention to the industry's technology leaders if they are going to adapt and survive. These leaders are choosing to invest in automation and robotics, and smart machines.

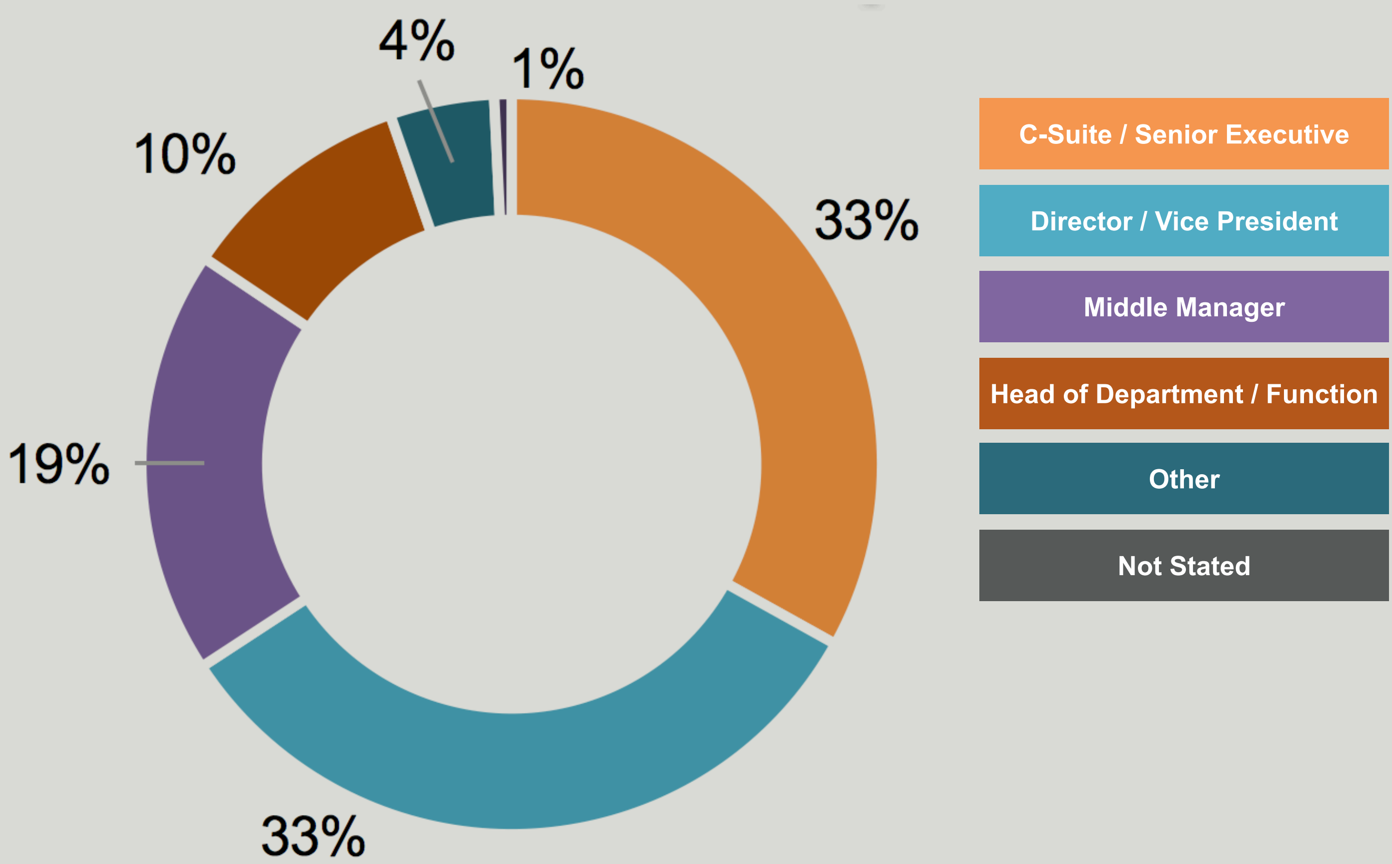
- How do organizations become leaders? The survey offers one answer: company strategy and the commitment of senior management are seen as two of the most important drivers of technological changes in the industry. Every oil and gas enterprise has the ability to become a leader, but it requires a clear vision and the dedication of senior management to achieve it.

ABOUT THE SURVEY

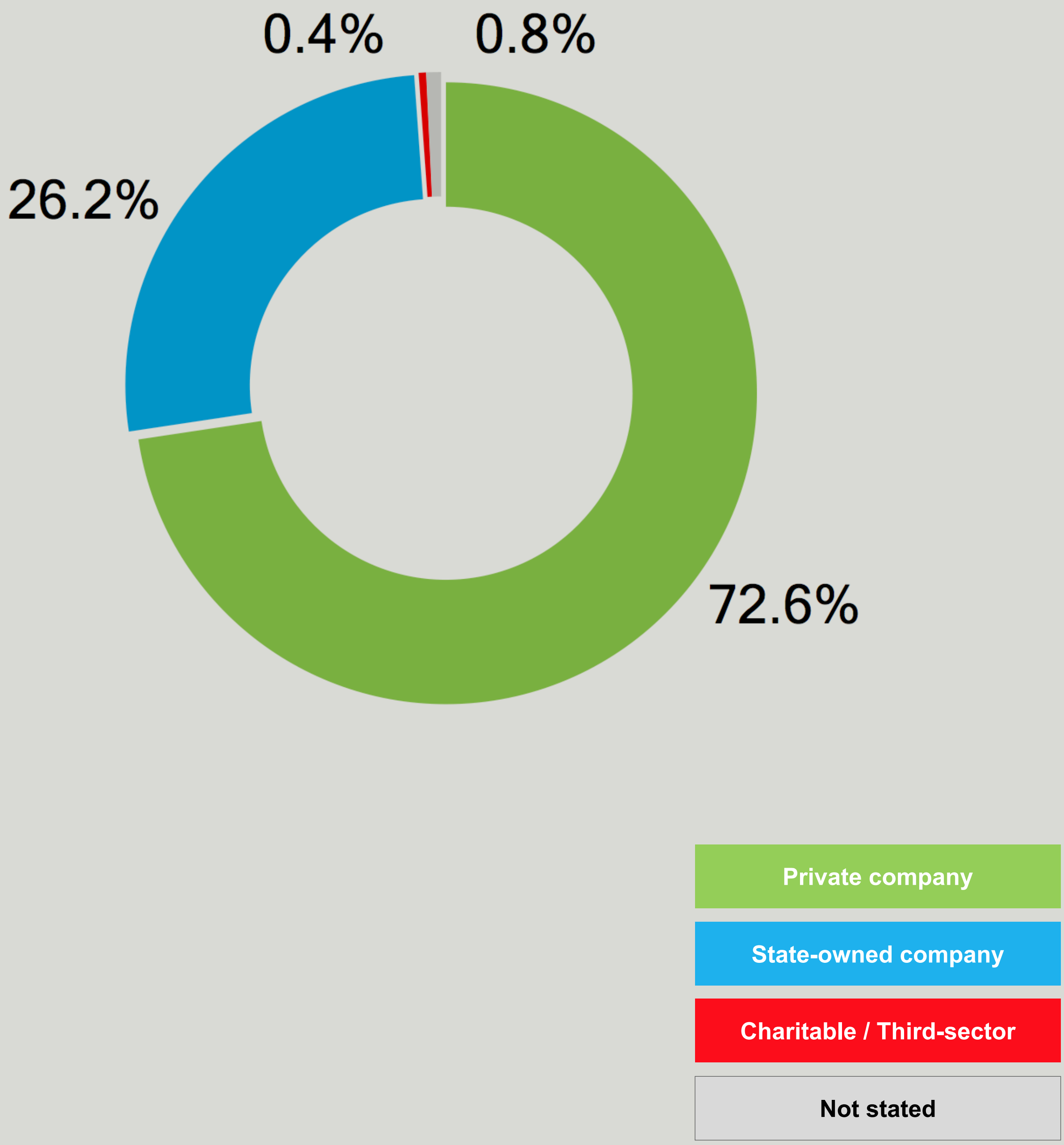
The analysis in this report is based on a global online survey that was fielded in the first half of 2018 by Newsweek Vantage, on behalf of Aspen Technology, AP-Networks and Minsait, an Indra company. The survey targeted energy professionals at senior executive and management level who are working at enterprises that have strategic interests in the oil and gas industry.

A total of 263 respondents were selected, with roles spanning a range of activities and disciplines. Nearly three quarters come from the private sector and almost all of the remainder are from the public sector. Sixty percent work in oil and gas companies (including upstream, midstream, downstream and fully integrated companies), and the remaining 40% at service providers (oilfield services, professional services and technology providers, among others). The oil and gas interests of respondents' organizations are located throughout the world, with 53% in North America, 15% in the Middle East and North Africa, 14% in Asia-Pacific and 10% in Europe.

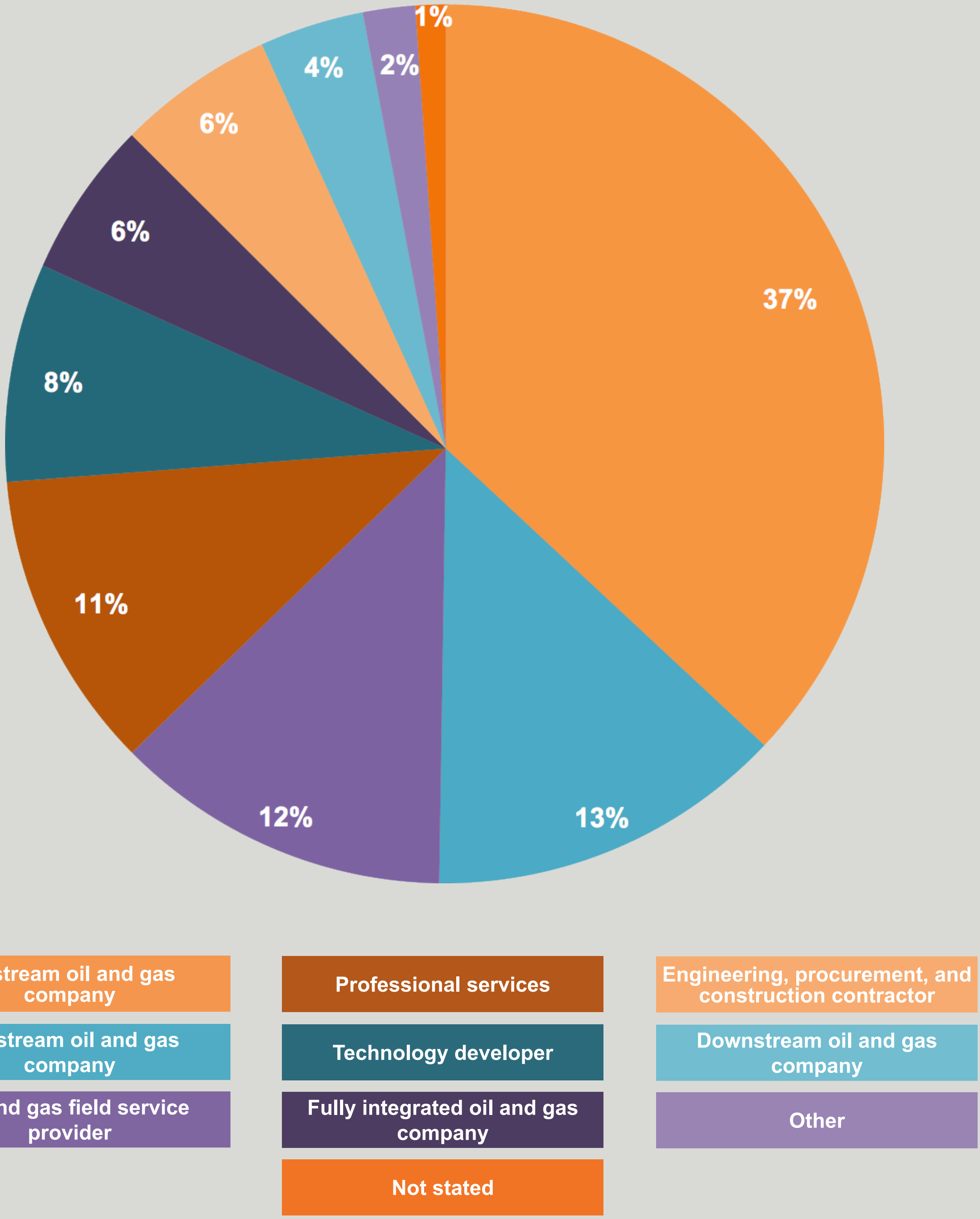
Which title best describes your current position?



Which best describes your organization?



Which best describes your organization's activities?



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