Technology Challenges, Opportunities of Next 25 years

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"It's tough to make predictions, especially about the future." This wisdom from Niels Bohr (or was it Yogi Berra?) is worth pondering as we consider technical challenges and opportunities that will be important in the coming decades. Just a few years ago, who would have foreseen the sudden emergence of North American resource plays or the Macondo disaster in the US Gulf of Mexico (GOM) and its aftermath? We will look at areas where change is certain, such as automation and information technology, and others where game-changing advances might occur, such as the promise of nanotechnology. Which specific technologies will dominate the oil fields of the future remains unknown, but if past advancements are any guide, as Berra put it, "The future ain't what it used to be."

Automation

Henry Ford only saw handmade cars during his lifetime, yet surely he envisioned the automated assembly lines of today as a replacement for those of his time. This is the path the oil industry will travel in the next several decades. The aim will be to automate the different activities that require intensive human labor. The main drivers for widespread automation will be increasing efficiency (i.e., faster operations, with better control and lower cost), improving safety (minimizing exposure of the workforce to hazards), and assisting the pursuit of oil and gas in remote locations and hostile environments.

Oilfield automation comprises the digital and electromechanical solutions that enable remote monitoring and control of field operations and production. These solutions can be applied to drilling, production, and exploration activities. In the last two decades, automation initiatives have gained traction in our industry. Remotely operated vehicles, intelligent completions, and advanced drilling equipment are a few examples. With improved monitoring equipment and information technologies (IT), there are vast opportunities for oilfield automation—from advanced smart fields to remotely operated drilling rigs, unmanned oil and gas processing facilities, and robust deepwater safety systems.

Throughout our careers, we will be exposed to a changing oil field, in which remote control and minimizing on-site human labor will be the norm. However, there is still another automation frontier to conquer. The goal is to develop autonomous systems capable of self-regulating and controlling the process, as intelligently and independently as possible. Such systems might be the solution to the problems stemming from the "big crew change" in the coming decades.

Information Technology

This is probably the most obvious technological breakthrough for all industries, including ours. New IT has dominated our lives over the past 30 years and will continue to do so in the foreseeable future. Faster computing speed, improved interfaces, increased connectivity, and widespread user accessibility will continue to be developed at a hectic pace. Unfortunately, our industry is always playing catchup with the latest IT breakthroughs. In order to overcome the oil and gas production challenges of the future, we will need to close the gap and dynamically adapt newly developed technologies from outside our industry. Ours is a digitally dominated workplace. We can't make it through a workday without our computing devices and software tools. Yet, we frequently hear the stories of our older peers describing a not-so-old oil field without computers, software, digital instrumentation, and automated process controls. The future is, as an industry, to accelerate our uptake of new technologies while fully using the power of existing IT.

The focus of oil and gas IT developments will shift from data gathering, data processing, and business communications to data analysis and simulation, workflow integration and collaboration, knowledge networks, advanced visualization, and data processing automation. Genetic algorithms, neural networks, finite element analysis, and computational fluid dynamics modeling tools are currently reserved for a few researchers in our industry. The complexity of the technical challenges ahead will require that more of us become routine users of these and other computational advances. The integrated nature of the upstream and downstream industry requires more integration of different simulation software and paradigms used in the design process and operations management. So far, the industry has taken great strides toward this objective, but more joint industry collaboration is required to address this issue fully.

Social networking is a term that covers all the digital solutions designed to change the way members of society, and employees, share knowledge and information. The challenge is how to build an organizational network that allows us to manage knowledge, standardize collaboration, integrate processes, and revolutionize our workplace interactions, while maintaining control of sensitive business information and comparative advantage. As the pace of IT change accelerates, it is our responsibility to be prepared and capitalize on these advances.

Nanotechnology

Nanotechnology is the process of controlling matter at a subatomic level. Its potential applications are huge in number, stretching across a vast array of industries, and our oil and gas industry stands to benefit a great deal. In a general sense, nanotechnology is the ability to create and manipulate matter at the molecular level, making it possible to create materials with altered properties—such as being both lightweight and having ultrahigh strength and having greater electrical and thermal conductivity capabilities.

In 2006, the world's first oil and gas nanotechnology project started at the University of Queensland's Australian Institute for Bioengineering and Nanotechnology, which developed a product known as pepfactants. The project's objective was to use nanotechnology to extract additional hydrocarbons. During routine production operations, we leave behind up to two barrels of oil for every barrel produced, meaning that if nanotechnology could increase recovery factors, it potentially would revolutionize the industry. In similar applications for enhanced oil recovery, researchers are developing "designer properties" to enhance hydrophobic or hydrophilic behavior and improve materials for waterflood projects.

The US-based Advanced Energy Consortium is supporting a research project to develop subsurface sensors that can be used to improve the discovery and the recovery of hydrocarbons. It is expected that by injecting these novel nanosensors into reservoirs, it will be possible to more accurately map them in 3D, increase the volume of hydrocarbons extracted, and minimize the environmental impact of production. Ten of the world's leading petroleum companies are funding this research body. In the drilling and completions arena, scientists at Shandong University in China are researching advanced fluid compositions with nano-sized particles and superfine powder that might significantly improve rate of penetration during drilling. Another nanomaterial application is the design of improved elastomers for high-pressure/high-temperature environments. With nanotechnology, the potential applications seem endless, but a great deal of research and ingenuity is still needed for this technology to achieve its potential. The oil field of the future, enabled by nanotechnology, will require big thinking.

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Smart Fields

The days of the pumper appear limited. For decades, pumpers have been the first line of defense against well failures, making their daily rounds through lonely oil fields, recording pressures, adjusting stroke rates, tightening stuffing box packings, and generally making sure that the wells are producing as they should be. But the fields of the future will no longer rely on human intervention to diagnose or fix problems. The well will do both automatically.

Sandface completions—that is, the pipe contacting the formation—will be able to detect common problems, such as sand production or pore throat plugging, and either fix the problem outright or notify the engineer, possibly hundreds of miles away, that a potential problem is developing. At the surface, wellheads and trees will no longer be massive pieces of "dumb iron" designed solely to contain the well's pressure. They will resemble a computer; be capable of flow metering, automatically detecting corrosion and valve and seat wear; and will incorporate auto-chokes that can respond seamlessly to upstream and downstream pressure changes. However, it is not all bad news for pumpers. They will still be needed, but they will likely be diagnosing and troubleshooting problems in the wellhead electronics rather than the reservoir.

Stimulation

Worried about your fracture stimulation screening out? No need to worry in the future oil field. Nanobots injected with hydraulic fracturing fluid will automatically feed critical information to the operator, who will adjust frac fluid properties to ensure optimal stimulation. There will be advances in safety, as well. Any hydraulic fracturing job involves massive amounts of high-pressure surface pipe, used repeatedly. This pipe must be maintained properly to ensure safe wall thickness and pressure integrity. With the increasing use of radio frequency tagging, service companies can more easily keep track of service dates, amount of usage, and maintenance schedules. All of this will reduce the possibility of a mishap.

Multistage hydraulic fracturing has enabled profitable production of liquids and gas from previously uneconomic tight formations. Many of these wells have come on stream in the past few years, as development has expanded from the Barnett Shale to other plays. Designing and implementing the most efficient stimulation (and restimulation) programs for these wells will be a central challenge of petroleum engineering in the future. Because tight formations, and shales in particular, are variable in their petrophysics, a one-size-fits-all solution is not likely to emerge. Knowing the nuances of particular reservoirs will be critical to landing and keeping extended-length laterals in the optimal pay zone. Advanced logging-while-drilling tools will make precise geosteering routine. Managing these assets will require effective use of microseismic fracture monitoring and realistic modeling of reservoir drainage to design the most efficient field development plans.

Water Management

Managing the water cut from production wells has been a fact of life in the oil fields for decades. However, recent major "resource plays" that require high-volume hydraulic fracturing to be economic are completely resetting the issue of water management. The problem must be approached from many angles, but the goals are to minimize water demand (including through effective reuse), minimize transportation costs, and efficiently treat and dispose of wastewater. Because water acquisition and transportation are expensive and can be politically contentious, water treatment and reuse at the wellsite minimize these costs and issues. For dense developments, temporary piping systems can also be effective alternatives to trucking. Innovative use of overlooked water resources, such as mine water in the Appalachian basin, will increasingly be incorporated in fracturing jobs.

In many basins, disposal wells are not available for produced water, and induced seismicity remains a concern in other areas. Therefore, wastewater will have to be treated to very high standards for discharge to surface waters. Dedicated treatment plants will use advanced membranes and vapor-distillation processes to close the loop and enable reuse of the water for the next job. Looking ahead, technological and process improvements will focus on efficient water use (per fracturing stage); treatment; and reuse of water at the wellsite, using modular, transportable treatment units and economical wastewater treatment incorporating membrane and vapor distillation technologies.

Well Control and Containment Systems

The Macondo disaster came as a tragic surprise to the industry. Measures of last resort failed in succession and could not contain the hydrocarbons. This failure has already led to design and regulatory changes, but its influence will be longer lasting. Well control planning will necessarily require more of a systems engineering approach, comparison frequently being made to the nuclear Navy and human spaceflight. There will be additional focus on control systems' independent redundancy, rigorous verification, and testing regimes. Enhanced modeling will be important in complex well planning, as will be improved instruments for monitoring wellbore conditions in real time. New blowout preventer (BOP) shear ram designs are already coming on the market and rigs equipped with a backup BOP unit will likely become more common. Demand and requirements for subsurface and subsea information will drive the development of additional instrumentation on development and production hardware to report pressures, volumes, and equipment status in real time.

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Requirements in the aftermath of Macondo have led to the development of two deepwater well containment systems in the GOM. These systems provide the ultimate assurance to stakeholders. They will be deployable faster than the resources deployed at Macondo, and the new systems can be tailored to a variety of well conditions and situations.

Decommissioning

Even with field life extensions, eventually all good things come to an end. Many oil fields will require decommissioning of older assets in coming decades. This will entail removal and abatement of hazardous materials, recycling, and final disposal of residual materials and structures. Given the age of these facilities and potential degradation, environmental, health, and safety issues will be chief concerns during decommissioning. Particularly in the GOM, offshore installations often provide important wildlife habitat. Establishment of innovative partnerships may allow for platform jackets and structures to remain as artificial habitats after decommissioning and removal of topsides.

Harsh Environments

All the "easy oil" may not be gone, but the future will certainly see further industry expansion into harsh environments such as the circum-Arctic region, especially the offshore areas. Surface ice dynamics in this region will present a new challenge for both fixed and mobile assets. Small unmanned aerial vehicles will be used to monitor ice conditions in real time. Ice breakers will be an essential part of the offshore repertoire. Other "harsh" offshore environments include those far from existing industry infrastructure and support bases, such as Greenland, the Falkland Islands, and East Africa.

Other Challenges

Another challenging area is onshore in parts of Europe, where shale gas exploration faces political opposition. Education, public outreach, and ensuring benefits for local communities will be important factors in the effort to overcome this hurdle. Similar challenges apply in urban and suburban areas elsewhere in the world, where modular rigs, hospital-grade exhaust silencers, careful lighting plans, and visual barriers will be routine tools for well construction. In addition, extended reach wells will enable access to resources underneath areas too populated for drilling sites. **TWA**