The Role of Technology in Reducing E&P Costs

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The global demand for oil has considerably reduced the cushion of excess supply of the past. While demand continues to rise, productivity from established fields has continued to fall because of natural decline. The exploration and production (E&P) industry must steadily add production to counter both trends.

E&P companies are increasing activity to meet the demand, and OPEC countries have announced plans to increase production. For example, Saudi Arabia plans to increase its oil production capacity from 11 to 12.5 million b/d by 2009, with the potential for a later increase to 15 million b/d. At the time of the announcement in 2005, the country was producing 9.5 million b/d.

The Saudi petroleum minister cited application of technology as an important aspect of the strategy. Indeed, technology is key to the continuing success of the E&P industry throughout the world. Advances in technology have enabled the energy sector to provide for today's energy needs, but further advancement will be necessary to meet future needs. The challenge is not only to locate new oil resources, but also to produce more from existing resources.

Both challenges require new solutions. The easy oil has been found, and in many cases, already produced. New oil is being sought in extreme locations – ultradeep water, high-pressure, high-temperature formations, and arctic areas – or in small accumulations in more conventional locations. Furthermore, in mature fields, the industry must manage production decline in a manner that maximises net-present value without jeopardising ultimate recovery. This includes dealing with technology deployed many years ago that might limit options today.

In recent years, accessing these more difficult-to-reach resources has led to an increase in the finding and development (F&D) cost of each new barrel of oil. This is a reversal of a trend that began about twenty years ago. Between 1981 and 2003, the price of oil fell and then fluctuated around a low level. Over the same period, inflation-adjusted F&D costs fell by as much as two-thirds.

During this same period, the oilfield service companies assumed a greater role in developing new technologies, while striving to bring down F&D costs. Much of the reduction in these costs can be attributed to newly deployed technologies, particularly three-dimensional (3D) seismic data and extended-reach and horizontal drilling. The E&P industry relies on seismic, drilling, logging, completion, stimulation, testing, modelling, and monitoring methods that were not widely available a decade ago; some were not available at all. To the extent that technology can reduce costs, its application extends the life of a field, makes smaller fields economical and can even enable the redevelopment of fields that have already been abandoned. In addition, new technology is essential for the development of unconventional sources of hydrocarbon – such as oil sands, tight-gas reservoirs, coalbed natural gas, and even gas hydrates – that will play increasingly greater roles in meeting future hydrocarbon demand.

The effect of new technology to reduce overall cost and improve efficiency can best be illustrated by examining a few specific examples. These include 3D seismic acquisition, advanced drilling methods, time-lapse seismic acquisition, behind-casing petrophysical analysis, and intelligent oil fields.

High-Fidelity Seismic Data and Designer Wells to Access New Reserves

Seismic acquisition grew rapidly in the 1990s as 3D seismic data offered a new way to reduce finding and producing costs. Eventually, most offshore activity was 3D rather than two-dimensional (2D). While this was happening, acquisition and processing of seismic data were achieved more quickly; the overall efficiency in seismic activity improved by about tenfold.

As exploration targets, such as satellite fields, became smaller, the quality of seismic data had to improve to resolve small or ambiguous features. WesternGeco recently introduced high-fidelity Q (mark of WesternGeco) single-sensor seismic acquisition and processing methodology. Rather than grouping signals before processing, each receiver signal is captured for processing individually. This tremendous increase in data allows for correction of surface effects and heterogeneities and results in much higher resolution.

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Yet, despite the tremendous increase in the amount of information processed, WesternGeco has delivered data to operators within days of completing survey acquisition. In contrast with the weeks, months or even years that seismic processing consumed in the past, this rapid delivery means that decisions concerning drilling or development can be made soon after acquisition. The resolution is significantly better than conventional seismic sections, helping to resolve thinner features, and visualising exploration-drilling targets that would otherwise be missed.

Accessing these thin features requires new technologies so that a well trajectory can follow almost any path. Novel downhole motor technology has made directional drilling practical. State-of-the-art measurements-while-drilling (MWD) and logging-while-drilling (LWD) tools and their immediate interpretation provide the information necessary to steer a wellbore within specific strata. These tools were improved during recent decades to reach their current level of operations.

In the 1990s, rotary steerable systems (RSS) helped operators set new records in extended-reach drilling. This technology facilitates directional control and steering of the bit while continuously rotating the entire drillstring. Steering is accomplished in a unit behind the bit by activating three pistons, separated on the circumference by 120°, in the proper sequence to force the bit in the correct direction.

With the ability to drill in almost any direction, steering based on real-time data becomes important to optimise the path in the reservoir. MWD and LWD tools provide petrophysical data that locate the bit within specific strata. Placing a measurement collar nearer the bit decreases the time lag between finding out where the bit has just gone and drilling ahead. New, far-seeing LWD technology is now helping drillers understand where the bit is about to go, and to detect lithology or fluid interfaces up to 4.5 m away. This helps access hydrocarbon assets in locations that previously were difficult or costly to produce.

For example, in Oman, Petroleum Development Oman (PDO) wanted to drill into a thin rim of attic oil in a Shuaiba carbonate reservoir. Veering off course upward into the mechanically unstable Nahr Umr shale would likely complicate well construction and completion or even jeopardise the borehole itself.

Previous attempts to place a wellbore just below the Shuaiba-Nahr Umr boundary relied on conventional LWD tools. With their shallow depths of investigation, these older tools provided little advance warning that the wellbore was about to cross the boundary between the high-resistivity reservoir and the low-resistivity shale. This frequently resulted in unintentional exits from the reservoir, requiring a turn to steer the trajectory back down to the Shuaiba. This cost time and money. In addition, the shale loosened by the exits and reentries into the formation created well completion problems, increasing costs even more.

PDO shared information about this difficult drilling task with Schlumberger, who were at the time developing a new tool that it was felt would be vital for PDO's drilling success. This open communication between companies led to the accelerated development of the tool, since it was known that there was a client eagerly waiting to use it.

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PDO was the first company to use the new PeriScope 15 (mark of Schlumberger) directional, deep imaging while drilling service, deploying it in the Shuaiba field. This tool propagates electromagnetic signals and uses a unique array of transmitters and receivers to determine the direction of bed boundaries and water zones up to 4.6 m away from the tool. Real-time measurements from this tool determined that the low-permeability zone lay just 2.5 to 3 m below the top of the Shuaiba reservoir. Guided by PeriScope 15 measurements, PDO drilled the well horizontally for 1,300 m, averaging 1.2 m beneath the Nahr Umr interface. By placing the well so close to the top of the formation, PDO added reserves of attic oil that would otherwise be inaccessible. With 100 percent of its horizontal section placed in the upper zone of the reservoir, this well has produced oil at significantly higher rates than the field average. Results such as these indicate the tremendous value of new technology for accessing reserves previously thought uneconomical.

Advanced Reservoir Monitoring

In the past few years, time-lapse seismic monitoring has become an important technology, particularly in the North Sea. Companies in that area report that they have more than recovered the cost of repeat surveys, also called four-dimensional (4D) seismic acquisition, by locating bypassed oil and improving recovery. The utility of time-lapse seismic surveys rests on the difference in seismic attributes caused by changes in fluid content or porosity. The differences may be caused, for example, by water movement as oil and gas are produced, or by formation compaction.

For example, in the Norne field, offshore Norway, Statoil commissioned a series of high-fidelity Q time-lapse surveys. Because of the rapid turnaround in processing – within a few days of completion of the monitor survey – Statoil had time to adjust horizontal-well drilling plans to avoid a water zone in a planned well, avoiding a costly problem well.

Another source of reserves may be even closer at hand. Existing wells may have hydrocarbon accumulations behind casing that were not accessed by perforating, either because the accumulation was considered uneconomical at the time, because a full suite of logs was not acquired before casing, or because the well is so old that the oil or gas resources were missed by the logging techniques available at the time. Geological compartmentalisation may have isolated resources that the existing completion was expected to drain, but didn't.

Until recently, obtaining detailed petrophysical information in formations behind casing in a well was virtually impossible. After many years of development, Schlumberger introduced a new set of behind-casing logging tools. These tools, introduced starting in 1999, evaluate bypassed pay near existing wells. Measurements are available for formation porosity, density, acoustical properties, lithology, and pressure. Fluid samples and formation dynamics data can also be acquired. Since the wells and infrastructure already exist to access these resources, costs are often minimal, comprising logging and recompletion costs.

In mature fields, additional production or improved economy for production may be available simply by optimising production and designing cost-effective workovers in existing wells. A detailed field study in a mature area can distinguish good candidate wells from bad, and may provide guidance for converting more wells into good or excellent producers or for decreasing water cut, often with minimal investment. Then, a skillfully planned workover programme can boost production without the cost of drilling new wells. Time-lapse seismic monitoring can also be used to optimise scheduling of workovers and maintenance.

The ultimate in field optimisation may be achieved through development of intelligent oil fields. These fields have monitoring devices downhole and at surface, a data-gathering system, software with sufficient intelligence to indicate problems, and control devices to act on the information obtained. Elements of such a system are in place at different locations, but there has been no large-scale implementation of real-time data delivery in an intelligent oil field. Companies are still assessing the trade-off between the cost of permanently installed monitoring systems and increased productivity from wells. Many companies are, however, implementing operation support centres, which is an important step toward development of an intelligent oil field.

The E&P industry is often characterised as conservative, taking longer to adopt new technologies than other industries, such as consumer electronics and pharmaceuticals. This is often justified by the huge investments necessary for developing new fields, the long lead times between discovery and first production, and the low margins on oil and gas that were present until recently. However, our technology adoption rate must improve.

Of all research and development projects undertaken by the oilfield services industry today, only one in ten becomes commercially viable. Of the other nine, one or two don't make it because they were overly ambitious from a technical standpoint. The rest fail for one of two reasons: either the service company misunderstood the problem technically and therefore addressed the wrong market, or the operator was not entirely open about its problem and the resulting solution was poorly adapted. Either way, both sides lose.

Operators and the service industry must communicate and cooperate to speed technology development. The example described earlier of the rapid adoption of Periscope 15 technology by PDO shows the advantage of openness for both sides. Greater service company effort and faster operator adoption will have beneficial effects that can be further enhanced by closer cooperation across the industry. Technology development and deployment will be key in controlling future exploration and production finding and development costs.

The twin demands of declining production and increasing consumption must be met with boldness and determination. While the mandate of the service industry is to provide quality tools and services to meet the challenges of obtaining additional oil and gas, operators must be equally bold in applying these technologies to get those resources out of the reservoir.

Strategies of non-OECD Gas Producers in the Atlantic and the Middle East

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Introduction

The international gas market is undergoing a quiet revolution, by any standard. Gas is the most environmentally friendly fossil fuel and is the most efficient for power generation. This has increased consumption for gas dramatically, as in the image of the Dash for Gas in the UK. At the same time, domestic production has reached its limitations in many consuming markets. The resulting growth in the international trade of the fuel of the twenty-first century comes at a time of high oil prices and at a time of reform and liberalisation of the gas and electricity markets in many consuming markets, notably the EU.

This international natural gas trade, either through pipelines or in tankers in the form of Liquefied Natural Gas (LNG), has traditionally been a rigid one, due to its regulated market structure and its capital-intensive, front-loaded nature; with Long Term Contracts (LTCs), Take-or-Pay (ToP) provisions, destination clauses and prices indexed to oil prices. The international LNG market has also been a geographically divided one, with Atlantic and Pacific markets virtually distinct from one another.

This is changing, slowly but surely. LTCs, which will remain the backbone of the industry, are becoming shorter in duration with ToP provisions diminishing and destination clauses being phased-out in Europe. Furthermore, the emergence of a short-term and spot trade is increasing in prominence with a large order book for the shipyard industry, including super-tankers (up to 250,000m^3) to fulfil the demand for the long distance transportation of LNG.

The changes in the Atlantic market are interesting. Market liberalisation in Europe is creating a stronger corporate identity for previous utility monopolies on the continent. Upstream liberalisation in some producing countries, like Algeria, is also slowly drawing institutional boundaries between the State – the shareholder – and the National Oil Company (NOC). A major development also in the Atlantic market is the