The power of integration to produce ingenuity at speed

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The ancient Greek mathematician Archimedes would have loved the modern energy industry. In oil fields dotted with pumpjacks, he would recognise familiar principles of leverage from his ingenious catapult designs. His water-lifting device, the Archimedes' Screw, revolutionised irrigation and in a manner, evolved through the ages to ultimately give rise to an enormous variety of positive displacement pumps and compressors. Today, we depend on compression to do everything from pipeline transport to enhanced oil recovery – and more recently, hydraulic fracturing, a technology having demonstrated the potential to unlock significant new energy supplies.

Past generations of technologists, including Archimedes, have given our industry many gifts and have allowed us to achieve our present state – ingenuity at speed. Of course, they faced problems we can't imagine – nor could they have imagined ours. For example, increasing and diversifying the world's energy supply in support of 9 billion people will no doubt be a monumental challenge. The International Energy Agency forecasts that global demand will increase 40 per cent by 2035. Clearly, we'll need more of every type of energy, especially oil and natural gas.

Ingenuity and integration

Throughout history, the inexhaustible resources of human energy and ingenuity have enabled us to do more, and to do it faster with less effort. The energy industry continues to build on this heritage of technology development and deployment. One of the greatest strengths of an international oil company (IOC) is integration: linking technologies, knowledge and worldwide experience to help create the reliable, safe, efficient and affordable energy supply that fuels human progress.

Today, digital technologies and new, efficient processes are transforming our workflows. They are empowering us to apply our best minds to the toughest challenges everywhere in the world, and to rapidly integrate information and innovate at speed. We connect surface to subsurface, past to present and present to future, predicting and optimising performance in reservoirs, wells and facilities measured and monitored in real time. This 21st century capability will ensure that IOCs and producing countries will continue to open new frontiers, raise performance to new levels and meet the world's energy needs.

From ramps to robots

How do we know ingenuity will prevail in meeting the energy supply challenge?

Consider our evolutionary advance into the offshore: To monitor the first near-shore wells over 100 years ago, we walked on wooden piers, while today, we use robotic, remote, autonomous underwater vehicles to monitor subsea deepwater wells and facilities.

The evolution into the deep continues. Facing the incredible pressures inherent in deep water activities, we have found a way to remove water depth as a pressure-related issue. To improve safety and reliability under extreme deepwater conditions, we have been developing and will soon deploy "dual-gradient drilling." This technology will significantly reduce deepwater drilling costs and improve outcome predictability. A dual gradient system, in effect, makes the deepwater well comparable to a land well.

Some of the tools we rely on today had their beginnings before recorded history. Without the innovations of metallurgists through the centuries, for example, the progression towards sophisticated alloys used in modern tubulars would not exist. Today, these materials make most of the world's deepwater oil industry possible. During the next decade, deepwater production could grow to more than 10 million barrels per day, according to IHS CERA. Corrosion-resistant tubulars and components also make possible all of the world's sour (high H_2S content) gas production, including growing output from Kazakhstan's giant Tengiz Field and new energy from Chuandongbei, a gas project in China being developed by a partnership of Chevron and the Chinese National Petroleum Company.

It is unlikely that the first metallurgists could have envisioned the extension of their technologies to help enable the Gorgon liquefied natural gas (LNG) project in Western Australia. This project will significantly enhance Asia-Pacific LNG supplies while re-injecting much of its corrosive, produced CO_2 into the ground with the largest greenhouse gas storage project of its kind in the world – enabled by both metallurgy and compression.

Measuring time – simulating the future

One does not think of the hourglass, an ancient invention, and the seismic geophone as related, but in fact both record time. By continuously improving our ability to measure the time required for sound to travel through rock, we are finding new supplies and recovering more by optimising reservoir

management. Advances in seismic data processing using Gaussian Beam pre-stack depth migration have allowed us to "see" into the past, deep into the subsurface, often below volcanics and salt layers. Without this technology, Chevron and others might never have discovered many of the deepwater fields now contributing significantly to energy supplies around the world.

With "4D" or time-lapse seismic, we can measure change in reservoirs and predict behaviour and response. Our reservoir simulators and predictive tools allow us to travel "virtually" into the future, testing development scenarios and forecasting decades of potential performance. We can even simulate years of deepwater platform operations and optimise design before we invest – a game-changer in reducing risk and accelerating the time to peak performance.

The awesome power of integration

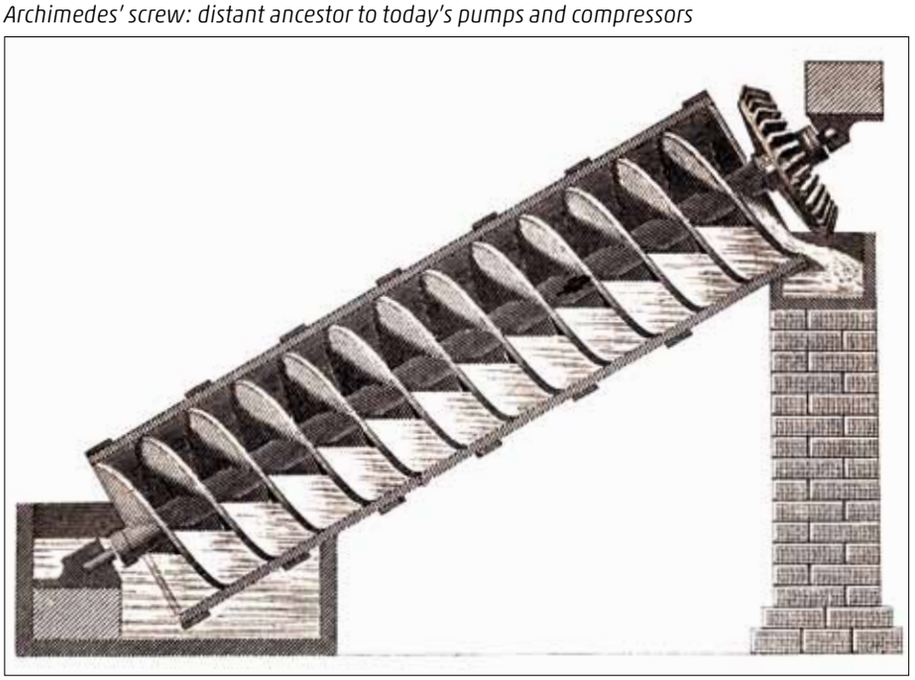
While applying a new technology can improve our work, integrating multiple technologies can create whole new sectors of our business. Evolving separately, horizontal drilling and hydraulic fracturing have enabled us to add new oil and gas reserves once thought unrecoverable. Now integrated, they have set off a phenomenal boom in shale gas development. In less than a decade, new output from shale has grown to 25 per cent of US gas production, according to the US Energy Information Administration (EIA). The industry is still assessing the global potential with exploration programmes, notably in Eastern Europe and China. One recent EIA study looked at 48 basins in 32 countries and found more than 6,000 trillion cubic feet of "technically recoverable" gas in 70 major shale formations. Time will tell how much resource we can reach. But IOCs by sharing the integrated technologies and best practices well proven in the United States can now help countries everywhere to evaluate the potential – and hopefully, grow their national energy supplies.

Steamflooding technology is another integrated solution poised for growth. After decades of improving this method in California and Indonesia, its application for developing heavy oil is now being piloted by Chevron in the giant Wafra Field located in the onshore Partitioned Zone between Saudi Arabia and Kuwait. If successful, the incremental upside potential for this one field could be 6 billion new barrels of recoverable oil. While steamflooding is a proven solution in sandstone reservoirs, the Wafra Field is a carbonate reservoir requiring the extension and integration of existing technologies applied in new ways, and the development of new technologies to meet the challenges not seen in sandstone. Additionally, with water being a scarce commodity in the region, our project is integrating a technology called "seeded slurry vapour compression" evaporation – to make pure water distillate for steam generators from reservoir brine. Successful integration of all of these technologies will help create opportunities for arid countries to unlock their heavy resources.

The renewables conundrum

We need to grow every form of energy, and renewables are forecasted to grow the fastest. But they must be

Archimedes' screw: distant ancestor to today's pumps and compressors



competitive at scale. By 2035 renewables are still expected to contribute only a small share of global energy supply. Solar, wind and biomass have been relied upon for energy since ancient times. But these energy sources lack the energy density of fossil fuels, which nature has pressure-cooked over millions of years to create natural energy cells packed with power.

Capturing and densifying renewable resources at scale represents a challenge that can only be met by extending, researching, developing and ultimately integrating technologies that improve our ability to concentrate and store energy from the resource to final product. To be cost effective without sustained subsidies, it is likely that technologies that can build on existing supply chain infrastructure to produce "drop-in" bio-hydrocarbon liquid fuels, for example, may succeed earlier than those that don't. Elsewhere, the geothermal industry evolved by combining and extending technologies from the petroleum and the power-generation sectors. Chevron, the world's largest producer of geothermal energy, is deploying this model at scale in Indonesia and the Philippines.

IOCs, including Chevron and many other companies, are working to commercialise and advance renewable energy. In California, our solar-to-steam demonstration project will employ more than 7,000 sun-tracking mirrors to make supplemental steam for enhanced oil recovery. And at the Qatar Science and Technology Park, we are helping test solar technologies in desert applications, where many large-scale solar projects are being considered.

Connectivity - integration's new wave

One of the many uplifting stories in our industry's history has been the way in which we have embraced information technology. The skyrocketing evolution of computing technology has made early calculating machines, such as the slide rule and the abacus, long forgotten. Today, high performance computing makes possible the miracle of reservoir modeling and high-speed simulation, integrating data, information technologies and mathematics to show us how best to develop oil and gas fields and extend their lives.

The next chapter in information technology promises to be even more exciting, because it is enabling connectivity and process improvements at an astonishing pace. This is driving integration on a whole new level, allowing us to create linked, global networks of experts in real-time without travel. A case in point are the visualisation rooms where top explorers and specialists gather to support the drilling of complex, deepwater wells while connected digitally to teams in control rooms on working rigs. Everyone sees the same data. We call ours the Well Decision and Execution Collaboration Center – and it ensures not just good decisions as drilling progresses, but the best possible decisions.

Meanwhile in the oil and gas fields, digital connectivity is allowing our industry to track operations much as a hospital monitors patients in surgery. Information from reservoirs, well and facilities feeds decision support centres in real time, guiding the management, well maintenance and fine tuning of every element of operations. With innovations such as continuous downhole sensors and wireless communications becoming common in the field, we are beyond automation and optimisation. We are transforming and integrating workflows with new operating behaviours and technology to enable new levels of performance.

Human energy

The combined potential for connectivity and integration to accelerate business insight seems endless. Our industry has been able to link geologic knowledge, geotechnical experience and human energy by integrating the best geoscientists and their tools. At Chevron, our rigorous process for rating, ranking, selecting and drilling exploration prospects worldwide has enabled us to achieve an exploration success rate approaching 50 per cent. Results like these tell us that with ingenuity at speed, IOCs have never been better equipped to add value, reserves and production. Everywhere partnerships take advantage of the global capability of this integrative mindset and human energy, new energy is sure to follow.

Consider again the compressor. Evolving throughout our industry's history, it has taken many impressive forms and created new opportunities. With worldwide connectivity, we've found another way to capture value from this technology. We've long known that compressor reliability is a key to performance in individual fields and facilities. Now we're going global, with a Chevron centre of expertise in Houston which digitally monitors every major compressor in the company – and serves as an on-line, 24 hours-per-day, seven-days-a-week consultant to field operations worldwide. Archimedes would have appreciated that. ■