Today, smart devices – elements of the Internet of Things (IoT) embedded in wellheads, on compressors and pump stations, and within refineries – are yielding a new wealth of operational information. But making sense of that data is another matter. That’s why leading oil and gas companies are taking advantage of advanced analytical software and the industrialization of Ethernet to create The Connected Enterprise. By smoothly integrating information technology with operations technology, oil and gas companies can better leverage the full value of their asset information, and accelerate high-performance petroleum production.
The oil and gas industry has entered a transformative era of global competition – what some analysts have labeled the "new oil order."1

This era is rife with fluctuations, as the global oil and gas landscape continues to shift, leaving much uncertainty for economic projections. Case in point: The resurgence of onshore oil and gas production in North America contributed to a seismic shift in oil and gas supplies. The revolution in shale oil and gas technologies – combined with steady flows from conventional onshore and offshore fields – quickly transformed the United States into the world’s No.1 energy producer. In 2014, American crude and natural gas-liquids production rose to an annual average of 11.7 million barrels a day, surpassing Saudi Arabia’s output (11.6 million barrels).2

In 2014 it was predicted this trend would continue, but less than a year later, the market saw rapid constriction as oil prices plunged. Today, energy markets continue to experience instability.

Despite the downward price pressure triggered by the current supply, producers from Brazil to Bahrain have plenty of reason to keep pumping. The world’s appetite for energy is expected to increase 37 percent by 2040, according to the IEA. European dependence on gas imports is expected to continue to fuel LNG markets. More significantly, improving living standards in growing economies like India and China will increase the need for more output. In China alone, demand is expected to increase by 75 percent by 2035.3

The implications of this new oil order extend far beyond the latest fluctuations in the global cost of a barrel. Oil and gas is arguably the world’s most asset-intensive industry, and every additional wellhead, pump and compressor raises a company’s operational risk. The potential cost of an equipment failure or operating error has never been higher. The industry average for a single hour of downtime is $1 million4, while a major event like the Deepwater Horizon oil spill could swipe $40 billion or more from a producer’s balance sheet.

The nature of the new oil order has put new pressures on each major sector of the oil and gas industry. Upstream production is increasingly fragmented because new reserves often lie in far-flung locations. That widening geographic distance, coupled with the unprecedented surge in supply, has put new pressures on the midstream market, increasing the need for more and safer pipelines, and other types of petroleum transport and storage. Finally, refineries are facing unprecedented process changes as they adapt to distilling fuels and other products from more and different feed stocks.

These dynamics – combined with tightening environmental regulations globally and a shrinking pool of skilled, in-house expertise – are forcing oil and gas companies to find new ways to enhance recovery, optimize processes, increase efficiencies and contain costs.

As with manufacturing, telecommunications and other major industries, the search for solutions is leading to a boom in digital technologies. Today, operational technology (OT) led by integrated control and information solutions, including smart devices – elements of the Internet of Things (IoT) embedded in wellheads, on compressors and pump stations, and within refineries – are converging with information technology (IT) to enable enterprise connections that yield a new wealth of data.

Leading oil and gas companies are taking advantage of innovations in industrial Ethernet-based connectivity and advanced analytical software to better leverage the full value of their asset data, and accelerate high-performance petroleum production.
Realizing The Connected Enterprise has become a business imperative. As the benefits from the convergence of automation, communications and information technology multiply, oil and gas companies are creating digital oilfields, pipelines and refineries. Wireless technology, visualization software and other advances now allow oil and gas companies to access and monitor assets in real time, and help merge disparate oilfield data into streams of actionable information – anywhere, anytime.

A few examples:

- Instead of manually checking on remote wellheads, pump stations and storage sites, operators are using remote-monitoring technology designed for oil and gas applications. Combining sensors and cellular or wireless connections, this technology offers producers the ability to supervise their wells and other operations from a single, centralized – and safe – location.

- Operations management solutions help oil and gas producers optimize production in real time by gathering, analyzing, contextualizing and sharing information. By pairing production intelligence with intuitive dashboards and historian functionality, operations-management systems can automatically collect production data, calculate KPIs and present displays that facilitate fast reading of critical operational information.

- Uptime is everything in the refining business. So many petrochemical facilities are investing in industrial Ethernet-enabled control systems that transport diagnostic data from process units to the operations view, notifying staff about critical predictive maintenance needs.

**Global-Size Challenges**

Oil is the world’s most commonly traded commodity, and with good reason. Despite the rise in alternative energy resources, fossil fuels will supply almost 80 percent of world energy use through 2040.\(^5\)

Since the earliest days of drilling, oil and gas has remained among the most capital-intensive industries. The number of assets has quickly multiplied in the last decade with advances in deep-water drilling, and the advent of unconventional oil and gas extraction techniques used to squeeze out resources in areas previously considered impossible to access. Automation has helped increase recovery rates at many wells previously believed to be dry. Meanwhile, energy companies have implemented instrument asset-management systems with the promise of optimizing their production by improving uptime.

However, the energy industry has tended to lag other industries in the area of asset performance. When heavy industry firms are viewed on a global basis, world-class operations achieve an Overall Equipment Effectiveness (OEE) score of 91 percent. Historically, oil and gas producers have been 10 or more percentage points behind this average.\(^6\)

A major reason: The ability of many oil and gas companies to collect, share and decisively act on information has been hobbled by conglomerations of unconnected legacy equipment, siloed proprietary networks and various vendor databases. Cross-disciplinary data transparency often is hampered by application-centric information management.

These information challenges are complicated by other major trends affecting today’s oil and gas sector, from exploration and drilling, to transportation and refining.
• **Growing complexity of operations.** During the last decade, thousands more wells have been drilled globally, both onshore and offshore. Ever-more sophisticated techniques and technologies are required to plumb the depths of the deepest subsea reserves, and to capture diffuse hydrocarbons from tight geological formations. The systems that operate these facilities are extremely complex, often requiring operators to interface with more than 200,000 tags of data and resulting alarms. Meanwhile, the rise of U.S. oil and gas production has spurred a dramatic expansion of the nation’s pipeline infrastructure, increasing the need for innovative diagnostic and monitoring technology. And while a major U.S. refinery hasn’t been built in more than 30 years, refinery owners in America and across the globe are investing in advanced technologies to handle more diverse feed stocks, while seeking to reduce the high costs of energy and other operating expenses.

• **Increasing regulatory pressures.** Expanding global regulations regarding the environment and safety are making compliance increasingly complex for the oil and gas industry. Energy companies continue to face intense scrutiny from government and consumers demanding stricter oversight to prevent environmental damage and protect lives.

• **Growing skills gap.** The pool of highly skilled oil and gas professionals is shrinking as more and more edge toward retirement. Meanwhile, fewer young professionals are in the pipeline for these high-demand jobs. A sign of the times: 22 percent of oil and gas respondents to a recent Ernst & Young survey said a lack of qualified personnel is already impacting their operations.

• **Heightened security risks:** The world’s energy infrastructure is the target of an increasing number of physical and cybersecurity threats, according to a June 2013 study by the Council on Foreign Relations. Several of the world’s major oil and gas producers have already been hit by cybercriminals. Most notably, malware unleashed on Saudi Aramco in August 2012 destroyed and deleted digital data from more than 30,000 computers. Aramco officials believe the attack came from an insider using external devices, such as USB drives, to sabotage the network.

Realizing The Connected Enterprise

How can oil and gas companies effectively tackle these challenges? The answer lies in harnessing the collective power of people, technology and processes using a unified network architecture. Integrated control and information solutions enable oil and gas customers to build a connected infrastructure across the enterprise that meets the requirements of the automation layer and information layer, while providing complete connectivity and integration of data.

Validated reference architectures from Rockwell Automation help expedite the engineering and delivery of oilfield solutions so companies can achieve first time to oil faster. Rockwell Automation also helps oil and gas companies deploy manufacturing execution system (MES) software, which can analyze the current status of production and make decisions on how to optimize operations in real time.

Using these best-practice, proven and repeatable solutions, downstream, midstream and upstream operations can take advantage of advances in technologies like open-standard IoT devices, big data and analytics, virtualization and mobility, and cloud computing that enhance The Connected Enterprise.
Digital remote-monitoring is one of the most significant advances enabled by the IoT. This technology seamlessly integrates sensors, hardware and software, and wireless connections to extract important operational information – such as daily oil production, pump pressure, etc. – from multiple assets across oilfields and along pipelines. Using this information, operators can continuously monitor current and historical operating conditions, troubleshoot any potential issues, and make process adjustments at an earlier stage to help increase uptime – all without leaving their workstation, which can be hundreds or thousands of miles away from the physical site.

One example: Northern Natural Gas Company uses Allen-Bradley® ControlLogix® systems to control all its compressor stations, which move natural gas along the company’s 14,700 miles of pipeline, from Minnesota to Texas. FactoryTalk® software from Rockwell Automation collects the control data from each station and converts the information into easy-to-comprehend visual graphics that operators can access inside company headquarters in Omaha, Nebraska.

Intelligent medium-voltage drives from Rockwell Automation are also an integral part of remote pipeline communications for many oil and gas companies. Embedded with Ethernet connectivity, they send and receive vital information about the condition of pump and compressor motors. If a compressor motor is running too high, for example, the drive will send a signal to central control, where operators can remotely throttle back the power. Preventing potentially dangerous pipeline blowouts carries huge operational and safety benefits.

Remote-monitoring technology is also helping bridge the oil and gas skills gap by allowing companies to fully utilize their best in-house – as well as third-party – expertise. Rather than travel to different sites, an expert can troubleshoot problems from headquarters, or even their home, by reviewing real-time data or viewing a live video stream. They then can direct people on the ground to make the fixes necessary to resume normal operations.

Securely Leveraging the Cloud

The use of cloud technology is growing in oil and gas as a remote-monitoring tool, as well as for storing data, and analyzing and contextualizing information. For example: M.G. Bryan, a leading heavy-equipment and machinery supplier to the oil and gas industry, knew it needed a way to remotely monitor and maintain the performance of its $1 million fracking trucks. The Dallas-headquartered company invested in a cloud-based fleet management system designed and implemented by domain experts at Rockwell Automation.

Using mobile technology and the seamless transfer of business information over the Microsoft® Azure™ cloud platform, M.G. Bryan securely pulls data from the cloud to Web browsers. Then, the software management system produces reports and dashboards showing the condition of individual vehicle’s drivetrains and hydraulic fracturing performance. The system takes the guesswork out of maintenance scheduling, thus preventing unplanned downtime. By using the cloud, M.G. Bryan maintains no infrastructure, and it can scale the solution from one truck to 4,000 trucks.

Oil and gas companies that embrace greater connectivity within and outside the organization must adopt a security strategy that covers production operations and the broader enterprise. Rockwell Automation® solutions take a holistic view of industrial security, addressing people, process and technology risk to maintain operational integrity and protect oil and gas assets.
In most cases, this means following a “defense-in-depth” strategy that addresses internal and external security threats. This is based on the premise that any single point of protection or individual firewall could be penetrated by the persistent attacker over time.

The most effective defensive solution is to erect multiple layers of defense, including physical, electronic and procedural. Under this approach, security is built into the infrastructure and becomes a set of layers within the overall network security. Any single point of penetration can be backstopped by different variables of capabilities provided by the other layers.

**Improving Upstream Performance - Connecting Production**

Advanced connected technology from Rockwell Automation is helping upstream oil and gas operations pull as much oil and gas from reservoirs as possible, while increasing efficiencies and safety. This industry-specific application of The Connected Enterprise is being called Connected Production by Rockwell Automation.

Gas lift is one of the methods used to improve recovery from older fields. These systems are designed to automatically sense and control the wellhead variables of a gas lift production site. The unit adjusts the gas lift injection flow to match an operator-determined flow rate and computes the estimated gas, oil and/or water production in real time. A centrally located computer allows personnel to easily gather communication and results for analysis, such as trending of flow data which can be particularly useful in the early detection of well problems.

To help optimize production, gas lift systems feature ultralow power consumption and lightweight subassemblies. A built-in solar panel can drive an active production well for up to seven cloudy days, making the unit especially attractive in remote areas where electric power is not available and portability is important.

Rockwell Automation is working with one of the world’s largest oil and gas companies in developing autonomous drilling-control systems. These are designed for low-cost land drilling in unconventional plays, where development involves thousands of the same kind of wells. A supervisory control and data acquisition (SCADA) system monitors drilling parameters, determines appropriate controls that need to be communicated back to the rig, and navigates the course of the wellbore.

Using Rockwell Automation controllers and software, the system requires only a small number of highly trained operators in a centralized location. Via a satellite link, operators can view the drilling sites on computer screens, and override the automatic controls to improve drilling efficiency or make other corrections. Besides decreasing the number of days required to complete a well, autonomous drilling reduces worker exposure to on-site hazards.

**Managing Midstream Transfers**

Solutions that advance The Connected Enterprise have helped streamline and better secure midstream operations, including an essential corner of the oil business – hydrocarbon transfers.

Hydrocarbon operations are spread far and wide, often in remote areas. Either on wellheads, storage tanks, pipeline inlets or terminals, buyers and sellers gain unattended access to oil supplies through a LACT unit. Until recently, accounting for these buyer/seller
transfers has been a far less sophisticated process. Most LACT units have little automation and even less network connectivity. In fact, most rely on paper-based tickets that buyers drop into a mailbox that stands next to the unit.

Texas-based Trigg Technologies decided to bring its LACT units into the digital age. Working with Rockwell Automation, the company designed and developed a turnkey asset performance management (APM) solution, leveraging the Microsoft Azure cloud platform. Rockwell Automation software applications combine real-time and historical data into dashboards that provide contextualized information on transfers, overall oil quality, and well productivity over time. These measured variables and diagnostics can be seen from any location via a secure Internet connection.

With information automatically pulled from the LACT control system to populate e-tickets, billing errors are virtually eliminated. Trending capabilities also allow site and operations managers to better understand the type of oil coming out of each well. This allows them to plan for long-term production across a number of wells or they can mix oil from a variety of wells to produce a more consistent product.

**Refining Downstream Operations**

Major refineries are sprawling industrial sites where the main units that process crude oil to generate gasoline, jet fuel and other petroleum products are surrounded by hundreds of auxiliary operations. For example, a major refinery may have seven or eight main processing units. Each of those may be supported by 10 to 20 subunits, including process skids. The configuration of processes depends on various factors, including the location of the facility, the types of raw petroleum it handles, and the products it refines.

Some ancillary units are critical to complying with environmental standards, such as on-site effluent treatment facilities and electrostatic precipitators. Others are essential to the demanding job of keeping the refinery running every hour of every day. Those include motor control centers and cogeneration plants.

The combination of aging legacy equipment, tightening regulations, advancing technology and, more recently, changing feed stocks has required many refinery owners to repeatedly invest in infrastructure upgrades. Today, many of those projects include smart devices and controls that help reduce unplanned downtime, improve preventive maintenance and give efficiencies without adding workers.

As oil refineries and gas processing plants begin to migrate legacy process control equipment, producers should consider a modern approach to migration. This approach delivers all the core capabilities of a traditional DCS to address the process control requirements, but is built on modern technology that easily integrates with other ancillary automation systems and critical business systems. Built using scalable, plantwide control technologies, a modern DCS, integrates process, discrete, power, safety and motor control to improve productivity, reduce unplanned downtime and lower total cost of ownership.

For example, a Southern California refinery that processes more than 200,000 barrels of oil per day tapped Rockwell Automation to design and develop an intelligent electrical SCADA system. The electrical-infrastructure upgrade, which replaced process equipment and systems that dated back to the 1950s, connects the motor control with a centralized maintenance and operations system where workers can view parameters and make sure
the main process units are receiving optimum power. The system also alerts operators about preventive maintenance needs, reducing the possibility of costly unplanned downtime.

Conclusion

Realizing The Connected Enterprise and reaping the exponential benefits from the convergence of automation, communications and information technology across digital oilfields, pipelines and refineries requires a holistic approach. Accessing and monitoring assets from upstream, midstream and downstream operations and merging disparate oilfield data into streams of actionable information – anywhere, anytime – are essential to remaining competitive as the industry landscape continues to fluctuate and evolve.

References