

The background of the entire page is a dark, moody image of an industrial facility, likely an oil refinery or gas processing plant, with tall distillation columns and complex piping. Overlaid on this is a large, semi-transparent image of a hand holding a globe. Inside the globe, a bright, colorful industrial scene is visible, suggesting a different perspective or a specific process. A white technical diagram is overlaid on the left side of the image, featuring a central circle with a wrench icon, connected by lines to several smaller circles, some of which contain icons like a briefcase, a gear, and a flame.

The Greatest Story Never Told:

Technology, Innovation, and American Oil & Gas



Texans
FOR NATURAL GAS

Key Findings



The history of hydraulic fracturing innovation stretches back over 80 years.

Although the fracking techniques most commonly used today became widely known in the 1990s, the first attempt to apply fracturing technology was fifty years prior, in the 1940s. In 1947, a company experimentally applied the process – termed “Hydrafrac” – to a well in the Hugoton Field of southwest Kansas.

SEE MORE ON PAGE 3



Technologies like downhole cameras, advanced drill bits and new software made the evolution of horizontal drilling possible.

[Downhole cameras](#) enabled operators to see what was happening underground as they drill, elevating engineers’ insight and understanding of the rock they were navigating. In recent years, the growth in computational power and [software](#) have also allowed geologists to accurately map planned drill paths. Additionally, single well pads become immensely more productive, as one well pad can house several highly productive horizontal wells.

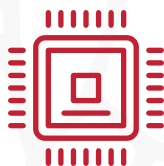
SEE MORE ON PAGE 5



Innovators have developed impressive means to recycle produced water from oil and gas operations.

The latest recycling technologies are even converting highly saline produced water into fresh water. One water recycling company in West Texas, for example, has a zero-discharge facility that can [recover over 99.7 percent](#) of produced water. These recycling technologies help reduce the use of freshwater resources for fracking. In 2018, 90 percent of [water used](#) by Apache Corp. in its Alpine High operations was recycled or non-potable, while EOG Resources [sourced](#) 63 percent of its companywide water needs in 2018 from reuse and non-fresh sources.

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The oil and gas industry is a pioneer in the use of supercomputers.

Dating back to at least the 1980s, the oil and gas sector has turned to supercomputers to crunch vast amounts of data. More recently, major producers have unveiled some of the fastest supercomputers on earth, such as BP’s [Center for High-Performance Computing](#) in Houston, Tex., or Eni’s HPC4 supercomputer in Milan, Italy, which can [process 100,000 reservoir models](#) in just over 15 hours.

SEE MORE ON PAGE 9



Science, not science fiction: cutting edge technology is ubiquitous in the oilfield...

...including artificial intelligence, cloud computing, and robots. From “[smart pigs](#)” and [robotic tank inspectors](#), to [gas cloud imaging](#), [drones](#), [machine learning](#), and real time communication across equipment through the [Internet of Things](#), oil and gas operators are more “silicon valley” than some would think. Using these technologies, operators are able to increase production efficiency, mitigate emissions, better predict equipment malfunction and more accurately determine where resources are located. This saves time, money, and limits health and environmental risks.

SEE MORE ON PAGE 11

Introduction

Overall, technological advances in the oilfield are helping the United States reach new heights in oil and gas production, improving American energy security and driving growth in energy exports.

Over the past century, a stunning series of technological advances have transformed the oil and gas industry. While numerous innovations have influenced American production, a handful of key technologies have had an outsized impact, culminating in the United States becoming the world's largest oil and gas producer. This position has not only strengthened U.S. energy security by decreasing our reliance on foreign energy resources, but has allowed the United States to become an increasingly important energy exporter.

This report examines how innovation across the oil and gas industry has driven the United States to become a global leader in energy. The report begins with two key technologies that served as inflection points in America's rise as an energy powerhouse: hydraulic fracturing and horizontal directional drilling. As the industry continues to evolve, innovation is increasingly focused on minimizing environmental impacts, by mitigating emissions and using water more efficiently. The final section of the report details how energy companies are partnering with Silicon Valley on cutting-edge technologies aimed at improving efficiency, reducing costs, and enhancing safety – all while increasing production.

Overall, technological advances in the oilfield are helping the United States reach new heights in oil and gas production, improving [American energy security](#) and driving growth in energy exports. In fact, thanks to technological advances in production, the Permian Basin in West Texas became the top producing oilfield in the world in May 2019, reaching 4.1 million barrels per day (b/d). Additionally, increased domestic natural gas production, similarly bolstered by advanced technology, allowed the United States to become a net natural gas exporter in 2017, a status it has retained ever since.

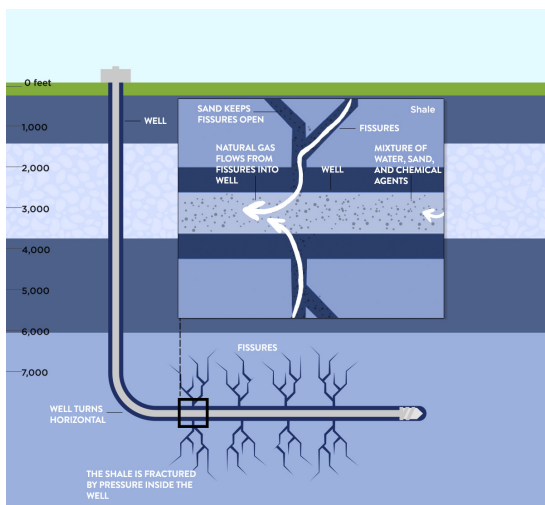
American oil and gas production is a high-tech industry where innovation is constantly delivering the energy we all demand for a lower cost and with a smaller environmental footprint. The significance of this innovation will only grow as the United States reasserts itself in the global energy market not just as a major producer, but also as one of the world's largest exporters of both oil and gas.

Part 1: History of a Technology Driven Energy Revolution

The shale revolution is a story of how innovators used a combination of existing and cutting-edge technologies to unlock what most experts considered inaccessible; namely, enormous quantities of oil and gas locked away in shale and other tight reservoirs. Two key technologies can help us understand how the United States became the global leader in oil and gas production: hydraulic fracturing and horizontal drilling. This section provides a brief history of those two technologies.

“Things like horizontal drilling and fracturing, the Shale Revolution, the oil derricks that dot the landscape all throughout the Permian Basin matters. New drilling technology and greater energy output are transforming American life and lives all around the world in the same way that the changes did when Spindletop first took place back in 1901. It was a game-changer, and what this industry is doing today is game-changing as well.”

MIKE POMPEO, U.S. SECRETARY OF STATE



Hydraulic fracturing, or “fracking”, involves the injection of an average 3-5 million gallons of water plus sand and additives, at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.

HYDRAULIC FRACTURING

Hydraulic fracturing has made the United States a world leader in oil and gas production. Though the term “fracking” is often used to describe all oil and gas production from shale and other tight reservoirs, hydraulic fracturing is a technology that has been around for decades.

Modern fracking is the process of using pressure to pump fluids – a mixture of water, sand and additives – down a well to fracture the rock formation thousands of feet below the surface, releasing the trapped oil or gas.

Today, the fluid mixture used in fracking is typically 99 percent water and sand, with about 1 percent of the mix comprised of chemicals that preserve the integrity of the well by reducing friction and preventing corrosion. Many of the chemicals used can also be found in a typical kitchen or bathroom. For example, one common additive is guar, an emulsifying agent, which can also be found in toothpaste and ice cream. Other additives are similar to common products like dish soap.

Although the fracking techniques most commonly used today became widely known in the 1990s, the first attempt to apply fracturing technology was fifty years prior.

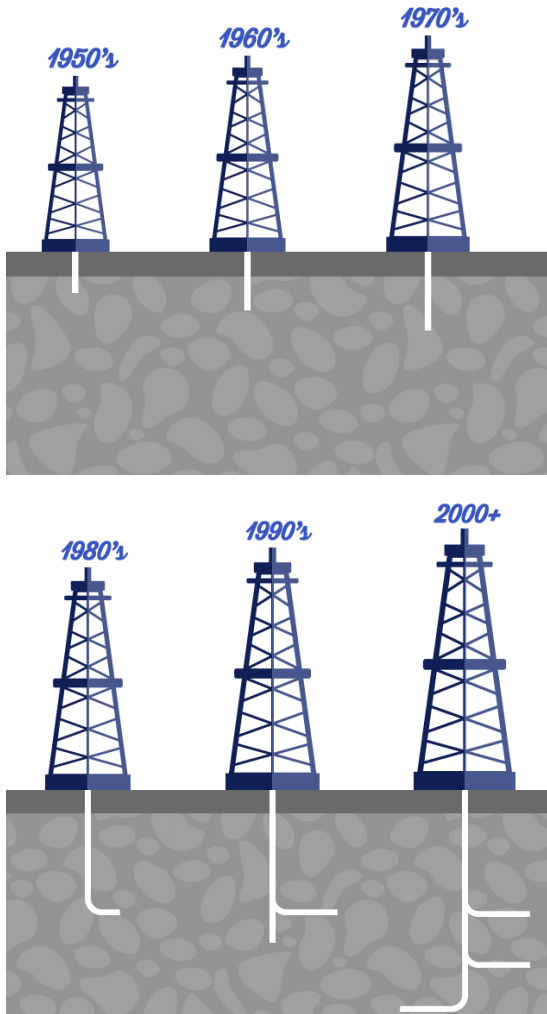
In the 1940s, Floyd Farris of Stanolind Oil and Gas Corporation [hypothesized](#) that applying hydraulic pressure to a rock formation might fracture it, and hence increase well productivity. In 1947, the company experimentally applied the process – termed “Hydrafrac” – to a well in the Hugoton Field of southwest Kansas. The experiment proved a success, and in 1949, a patent was issued for the Hydrafrac process and obtained by Halliburton Oil Well Cementing Company. In the first several hundred wells that used hydraulic fracturing, [production increased](#), on average, by 75 percent.

In the early 1950s, a Canadian oil company demonstrated that hydraulic fracturing could be used to [extract hydrocarbons](#) from oil fields where it otherwise would not have made economic sense. The Pembina Cardium oil field in [central Alberta](#) was drilled by what would become Mobil Oil.

However, the true potential of hydraulic fracturing became clear with its application within the Barnett Shale several decades later. The Barnett Shale formation lies in north-central Texas, spanning [over 5,000 square miles](#), surrounding much of the Dallas-Fort Worth metroplex. Shale is a dense rock with low permeability; conventional drilling methods to capture natural gas from the rock were prohibitively expensive because of their low production yield. Though the Barnett Shale formation was well-known to be one of the largest onshore natural gas fields in the United States, geologists had deemed the natural gas trapped between the densely packed shale formations impossible to economically recover.

Mitchell Energy, led by energy pioneer [George Mitchell](#), thought differently. He had a vision that technology could crack the code of the Barnett Shale. Hydraulic fracturing had never been used to recover free natural gas from a shale formation, but in the late 1990s, Mitchell Energy geologists and engineers continuously experimented with fracking. Ultimately, they were able to [economically capture](#)

The Evolution of Horizontal Drilling over time



Technology had created a renaissance in oil and gas development, in Texas and beyond. Between 2005 and 2018, U.S. natural gas production rose by 70 percent.

the natural gas in the Barnett through “slick-water” fracking. [Slick water fracking](#) differed from its predecessors as it used primarily water-based frack fluid, instead of the gels and high-viscosity fluids that were common at the time.

Technology had created a renaissance in oil and gas development, in Texas and beyond – which quickly became widespread. In 2000, the Barnett Shale was [producing](#) roughly 216 million cubic feet of natural gas per day. By 2012, that production peaked at over 5.7 billion cubic feet per day. All told, the Barnett has produced more than 15 trillion cubic feet of natural gas since 2003, enough to heat 225 million homes for a year.

Between 2005 and 2018, U.S. natural gas production rose by 70 percent – thanks to the widespread adoption of hydraulic fracturing – with Texas currently [the top-producing natural gas state](#). Before 1997, shale gas and tight oil plays – those which otherwise wouldn’t have been drilled without the use of hydraulic fracturing – made up a minority of U.S. dry natural gas production. By 2020, the EIA predicts that shale gas and tight oil plays will make up [almost 60%](#) of U.S. natural gas production.

What happened in the Barnett eventually was replicated in shale regions all over the country, resulting in the shale revolution that we are now familiar with. Resources that were previously unreachable were unlocked, and America’s energy outlook fundamentally changed. The Permian Basin – which in the early 2000s was considered a mature, dying oilfield – was suddenly reborn. In 2018, [a survey](#) of the Permian Basin from the U.S. Geological Survey (USGS) revealed an undiscovered estimated mean of 46.3 billion barrels of oil, 281 trillion cubic feet of natural gas, and 20 billion barrels of natural gas liquids. In September of 2019, oil production in the Permian Basin reached over [4 million barrels](#) per day. If not for the advent of hydraulic fracturing, those resources would likely still be locked away.

Over the past 10 years, innovation with hydraulic fracturing technology has advanced by leaps and bounds. Companies have introduced multi-stage and bigger fracks, which have allowed companies to produce vastly greater quantities of oil and gas with each well drilled. This means more energy with less surface impact, and ultimately cost savings that make American oil and gas more competitive in the world market.

HORIZONTAL DIRECTIONAL DRILLING

In the early days of drilling, oil and gas producers could only drill one way: what they perceived as straight down. It wasn’t until the early 20th century, with the advent of new devices that could measure the angle of a well, that they found their wells were skewing significantly with the tendencies and fluctuations of the rock formations below their feet.

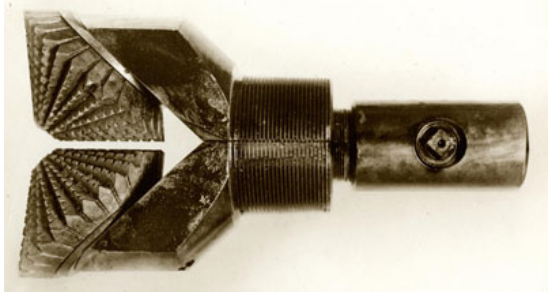
In the 1920s and 1930s, drillers experimented with new technologies, seeking to introduce some precision into the direction in which they bored the well. Ultimately, the industry turned to whipstocks to drill with directional control. The modern whipstock is a curved steel wedge, which is inserted into the borehole of the well to dictate the direction of a new branch. In 1934, directional drilling



MODERN DRILL BIT
[SOURCE: WORLD OIL]

“By using directional drilling and fracking, we have an opportunity to have a softer footprint on the land”

SALLY JEWELL, FORMER SECRETARY
OF THE INTERIOR



TWO-CONE DRILL BIT
[SOURCE: IPFOLIO]

became industry standard when [a blowout](#) in Conroe, Tex., threatened the entire surrounding oil field. The blowout was prevented, thanks to quick work from H. John Eastman, who used a mobile drilling truck and his knowledge of directional drilling to drill a relief well.

Directional drilling eventually progressed to another engineering feat: horizontal drilling. Horizontal drilling is built on the principles of directional drilling, relying on instruments to drill in a controlled, precise manner from a kick-off point. To drill horizontally, operators angle their drill just a few degrees from vertical after their kick-off point (which is where the well bore turns from its existing vertical path), eventually achieving a horizontal well.

Several technologies made the evolution of horizontal drilling possible. For instance, [downhole cameras](#) enabled operators to see what was happening underground as they drill, elevating engineers’ insight and understanding of the rock they were navigating. Today, downhole cameras relay detailed data in real-time, even several thousand feet below the surface.

Specialized drill bits have also added precision to the drilling process. Since 1901, drill bits have evolved quite significantly from the [Two Cone Drill Bit](#), which was the first commercially successful rolling cutter drill bit. Modern drill bits contain many rotating cones, and are made of incredibly durable materials, including diamond. In recent years, the growth in computational power [and software](#) have also allowed geologists to accurately map planned drill paths.

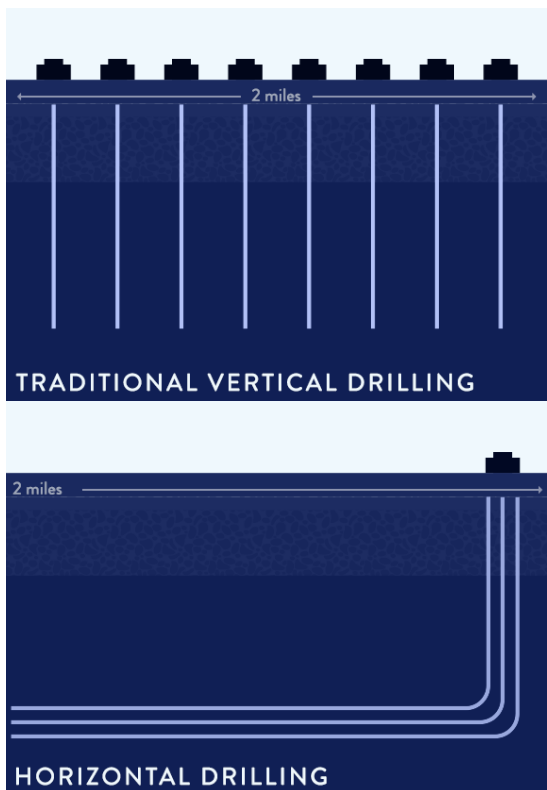
Horizontal drilling offers incredible benefits for the oil and gas industry. Most notably, horizontal drilling enabled efficiency in drilling operations that was never seen before. Single well pads became immensely more productive, as one well pad could house several highly productive horizontal wells. Simply put, horizontal drilling maximizes efficiency while minimizing surface impacts.

In recent years, horizontal drilling has been coupled with hydraulic fracturing to capture enormous quantities of oil and gas. Each of those horizontal wells can access a volume of resources that previously would have required a dozen or more individual wells.

Oil and gas production is widely set in two categories – unconventional and conventional drilling – which boils down to the type of rock formations being targeted. Conventional rock formations are comprised of younger, fractured sandstone. Unconventional drilling is focused on capturing oil and gas reserves from previously inaccessible sources, or otherwise stated, unconventional sources, such as shale formations.

While hydraulic fracturing had proven successful at capturing oil and gas from dense rock formations, horizontal drilling technology enabled unconventional production to reach new heights. Where a vertical frack could reach 100 feet of a tight oil reservoir, a horizontal well could reach almost 5,000 feet.

As horizontal drilling has become increasingly advanced, producers have embraced new innovations, such as multi-stage fracking. Horizontal wells can stretch thousands of feet; multi-stage fracking is the process of fracking the thousands of feet in that well in portions, or stages. Producers isolate the far-end of their wells, and frack each portion separately, plugging the well as they continue along. Each isolated frack counts as a stage, ensuring the well captures



Horizontal drilling is the unsung hero of today's astonishing oil and gas production.

"The same ingenuity and hard work that created the shale revolution is taking Texas' water reuse and recycling to new heights,"

JOHN TINTERA, TEXAS ALLIANCE OF ENERGY PRODUCERS

the most oil or gas possible. With the enormous distance that can now be drilled horizontally, some oil and gas producers may have upwards of 20 stages.

Horizontal drilling is the unsung hero of today's astonishing oil and gas production. Hydraulic fracturing may enable the industry to pursue shale plays, but horizontal drilling made pursuing those shale plays immensely productive, while also reducing the surface disturbance required to access those resources.

Part 2: Advanced Technology to Reduce Environmental Impacts

The technologies that enabled the shale revolution are not the end of the story; they're just the beginning. Building on the oilfield innovation that made the U.S. energy renaissance possible, innovators are now using advanced technologies to use less water, reduce emissions, and enhance safety. This section explores some of the technologies currently being deployed to address environmental concerns.

WATER MANAGEMENT AND RECYCLING

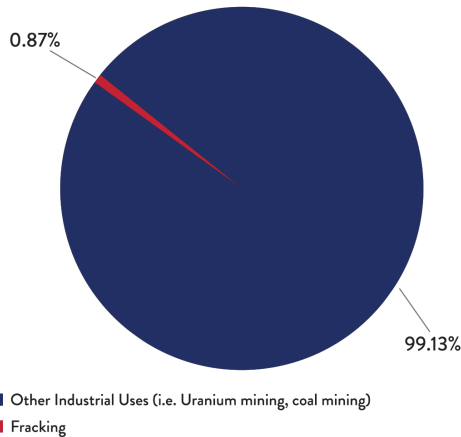
As shale development has become prevalent over the past decade, oil and gas companies have deployed technologies to protect and more efficiently use water resources. This includes implementing best practices for water management and fostering innovation in areas such as water transportation and recycling. Taken together, technological advances in how water is used, transported, treated and re-purposed has made oil and gas development safer and more environmentally responsible – especially in water scarce regions.

While oil and gas development accounts for [less than one percent](#) of fresh water withdrawals nationwide, record energy production has not only meant an increase in the amount of water used for development, but in the amount of water co-produced during development. Referred to as "produced water" this is most often comprised of brackish, non-potable water from ancient seas trapped deep underground.

How much water is produced, as well as the exact composition of the water, depends on the region where production is taking place. While West Texas is a generally water scarce region, oil development in the Permian Basin can see water-to-oil ratios (WOR) that are higher than many other shale plays, [ranging from 2:1 up to 15:1](#). This has created a challenge for the industry. How can these vast quantities of water be put to use? Once again, this is a story of innovation in the oilfield.

Because of both the quantity and quality of the produced water in Texas, the most common way to manage produced water has been to inject it back deep underground in saltwater disposal wells or back into the formation to improve oil

Fracking accounts for less than 1 percent of America's total industrial water use



[SOURCE: "WATER FOOTPRINT OF HYDRAULIC FRACTURING"]

Companies in the Permian Basin are using new technologies, as well as improving existing ones, to make water recycling and reuse more common.

WATER RECYCLED BY ONE OPERATOR IN THE PERMIAN



[SOURCE: EOG RESOURCES]

production. In fact, [nationally, about 45 percent](#) of produced water is reused for enhanced oil recovered by injecting it into a formation.

But while the use of disposal wells is still a common practice, companies in the Permian Basin are using new technologies, as well as improving existing ones, to make water recycling and reuse more common and cost effective. For example, [innovation](#) in water management practices and fracking fluid chemistry has allowed Texas operators to reuse millions of gallons of produced water – even [those with very high salinity](#) (up to >220,000 mg/liter TDS) – for fracking operations. This innovation [translates](#) to a reduction in truck traffic that would otherwise be needed to transport the produced water, mitigating both air emissions and road impacts. Needless to say, it also means less overall use of freshwater.

Thanks to these developments, a [2018 report](#) from the Ground Water Protection Council (GWPC) cites the Permian as the region where water reuse is growing the fastest. At a recent conference, multiple major operators in the region stated they use over 10 percent treated produced water in their fracking operations – with a number of companies stating they use a much higher percentage. One operator, for example, used [more than 20 million barrels](#) of recycled water in its operations between 2013 and 2016.

In the Permian Basin, oil and gas producer EOG Resources [currently sources](#) about 91 percent of its water needs from recycled produced water, and companywide, EOG sourced 63 percent of its water needs in 2018 from reuse and non-fresh water sources. Apache Corp., which has been an industry leader in water recycling efforts, [reported that](#) in 2018, 90 percent of water used for drilling and completions in its Alpine High operations was recycled or non-potable. Another operator in West Texas owns and operates eight water treatment facilities in the Permian's Delaware Basin, with the company estimating that [about 80 percent](#) of the water it used in the region is reused. All told, the company has recycled or reused about 38 million barrels of water in its operations over the last five years.

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The latest recycling technologies are even converting highly saline produced water into fresh water. Gradient, a water recycling and desalination company, installed a zero-discharge treatment facility for oil and gas produced water in Midland, Texas. Earning the [2014 Industrial Water Project of the Year](#) award, the facility's carrier gas extraction (CGE) technology treats 12,000 barrels per day (bbl/d) of produced water, [recovering over 99.7 percent](#).

“The U.S. has led the world in emission reductions and has the cleanest air in the world, and we should expect to see these positive trends to persist with continued adoption of cutting-edge innovation and other industry-led initiatives such as The Environmental Partnership.”

TODD STAPLES, TEXAS OIL & GAS ASSOCIATION

Between 1990 and 2016, methane emissions from U.S. petroleum systems and natural gas systems declined 3 percent.



BPX TECHNICIAN USING MULTI-SOURCE AUGMENTED REALITY SMART GLASSES [SOURCE: BP]

Combined with technological advances in the fracking process that have made Texas companies less dependent on freshwater, innovation in water recycling and reuse can provide a number of benefits. These benefits include leaving more freshwater for agricultural and municipal consumption, limiting truck traffic associated with water transport, and reducing exposure to factors such as drought or increased water use. Not to mention, innovation in recycling technology has allowed for produced water to be used in a number of [other capacities](#) such as in agriculture for irrigation and livestock watering, snow and ice control during winter storms, and cooling water at industrial facilities.

REDUCING METHANE EMISSIONS

The significant growth in U.S. oil and gas development over the past decade has made mitigating emissions an even greater focus for energy producers. Recent data show an encouraging trend in this regard, particularly with methane.

An analysis from Texans for Natural Gas in 2018 found that between 1990 and 2016, methane emissions from U.S. petroleum systems and natural gas systems [declined](#) 3 percent and 16 percent, respectively. Over this same period, U.S. oil production increased 20 percent, while U.S. natural gas production increased 53 percent. Methane emissions from natural gas transmission and distribution pipelines also fell by 56 percent over this period, even as the United States added 353,000 miles of pipeline across the country.

There's no one technology driving these emissions reductions. Rather, it's the result of individual operators applying cutting edge technologies that are tailored to their own operations. The success of those voluntary efforts has, in turn, allowed companies to learn from each other through partnerships and coalitions. One example is the [Environmental Partnership](#), a collaboration of more than 60 upstream and midstream companies, whose goal is to develop and implement best practices and technologies into their operations. In 2018 alone, the partnership [surveyed](#) more than 78,000 sites, inspected over 56 million components and replaced, retrofitted or removed more than 28,000 high-bleed pneumatic controllers from service. Taken together, these efforts resulted in a [0.16% leak rate occurrence](#). One member of the Environmental Partnership, Apache Corp., has seen a [22% decrease](#) in methane emissions intensity since 2013.

To monitor and limit emissions from development activities and infrastructure, operators are increasingly turning to advances in imaging technology, robotics, and automation.

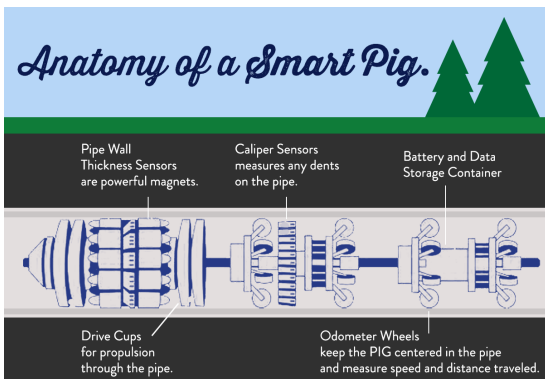
In September 2019, BP [announced](#) a number of technologies it was deploying across its operations. These include drone-mounted leak detection technologies, which allow the company to survey as many as 1,500 well sites per month, as well as Augmented Reality glasses which enable technicians in the field to virtually link to technical support. The company also [introduced tools](#) like gas cloud imaging, which provides continuous emissions measurements at projects, that can make inspections take 30 minutes when they used to take seven days.

But BP isn't the only company looking to drones and autonomous vehicles to reduce emissions. [Avitas Systems](#), a GE Venture, employs high tech sensors



AVITAS SYSTEMS OILFIELD
INSPECTION DRONE
[SOURCE: AVITAS SYSTEMS]

Technology is also helping monitor and reduce emissions outside of production activities.



Smart PIGs, or Pipeline Inspection Gauges, are used to inspect and clean pipelines. Measuring up to 18 feet long, these smart PIGs use a combination of technologies such as computers, GPS and magnetic sensors to detect structural issues within a pipeline.

[RECREATED AS TNG
INFORMATION SOURCED
FROM DUKE ENERGY]

on robotic crawlers and unmanned vehicles in the air and underwater to collect inspection data by using pre-set 3-D models. In doing so, these vehicles can improve safety and inspection efficiency, as well as create a digital record of operations and infrastructure for comparison over time.

As a whole, the digital oilfield is making production safer while lowering emissions – but the drones, autonomous vehicles and sensors need a reliable data network to work effectively. The flat, empty land of West Texas isn't known for its reliable cell service after all. The solution operators are looking into? [Mobile network infrastructure](#). Being able to put a “network on wheels” would ensure that the digital information a production site needs to operate is always accessible. [Wireless mesh networks](#) may be the first step towards mobile network infrastructure. Mesh networks operate with nodes, which work together to blanket an area with WiFi. The flexibility of the system offers – since one can increase and decrease nodes as needed for network strength – makes it ideal for the ever-changing demands of a production site.

Technology is also helping monitor and reduce emissions outside of production activities. Advanced pipeline inspection gauges – also known as “[smart pigs](#)” – travel through pipelines to measure and record any issues, such as corrosion, leaks, dents and other defects. These smart pigs not only provide enhanced efficiency in the pipeline inspection process, they also allow pipeline technicians to more accurately predict and plan maintenance.

Some midstream industry innovators are also turning towards virtual reality (VR) to improve pipeline safety efforts. Companies are [using VR](#) not only to train employees to handle real-world tasks, but to optimize pipeline design. In doing so, pipeline operators are limiting the impact on the environment by identifying design issues before construction even starts. Some researchers, like those at Rowan University, are even combining VR tech with smart pigs, enabling pipeline operators to [visually travel](#) down a pipeline and identify issues.

Further down the supply chain, companies are using technology to monitor and inspect other pieces of infrastructure. Phillips 66, a refiner based in Houston, [teamed up](#) with the robotics company Square Robot to develop a robot that can inspect a diesel storage tank without the tank needing to be drained, opened and cleaned. This development not only saves time and reduces costs, but having a robot inspect the tank means company employees don't need to enter the tank for inspection. This is yet another example of how innovation and cutting-edge technologies are making oil and gas operations safer and more sustainable.

Part 3: Silicon Valley Meets Permian Basin

Many people would be surprised to learn how advanced the technologies currently being used in the oilfield are. As this section highlights, the oil and gas industry is actually on the cutting edge of technological advancement, partnering with “Big Tech” to increase production while also reducing impacts.

“A great wave of innovation and technology is transforming the industry and reshaping the energy future...What happens in tech matters to energy, and what happens to energy matters to tech.”

**DANIEL YERGIN, VICE CHAIRMAN OF
IHS MARKIT**

It is energy companies that are driving some of the most innovative and powerful technology in order to find, develop and transport the resources that make modern life possible.



ENI GREEN DATA CENTER
NEAR MILAN, WHICH HOUSES
THE HPC4 SUPERCOMPUTER
[SOURCE: BLOOMBERG]

The cutting edge of technology used by oil and gas companies could seem more at home in Silicon Valley than the oilfield – supercomputers, artificial intelligence and machine learning, just to name a few. Yet, it is energy companies that are driving some of the most innovative and powerful technology in order to find, develop and transport the resources that make modern life possible.

Dating back to at least the 1980s, the oil and gas sector has turned to supercomputers to crunch vast amounts of data. As a [paper from 1985](#) notes, “applications of supercomputers in the petroleum industry involve two important aspects: enormous computation power and massive data management.” Today, energy companies are relying on some of the fastest supercomputers in the world to track down and analyze new resources, as well as manage enormous quantities of data across the supply chain.

In 2013, BP opened the Center for High-Performance Computing, a massive supercomputer located in Houston, Texas. Since then, the company has [quadrupled its computing power](#), making it one of the fastest computers used for commercial research in the world. Between 2014 and 2017, the CHPC helped BP discover an additional 1 billion barrels of oil at its four hubs offshore in the Gulf of Mexico. This includes an [estimated 200 million barrels](#) of oil in the Atlantis oilfield, from where the company has been producing for years. More impressive still, to make this finding, the data processing would have normally taken a year, but the supercomputer analyzed the data [in just a few weeks](#).

Italian energy company ENI unveiled its [HPC4 supercomputer](#) outside of Milan, Italy, in 2018, which boasts a peak performance of 18.6 Petaflops – more than twice BP’s CHPC. So impressive is the HPC4 supercomputer, it ranks in the top 10 most powerful supercomputers on Earth and is the only non-governmental and non-institutional system on that list. As an example of just [how powerful the HPC4 computer](#) is, the computer was able to process 100,000 reservoir models in about 15.5 hours – a task that previously would have taken 10 days. Further, each individual model simulated 15 years of production in an average of just 28 minutes.

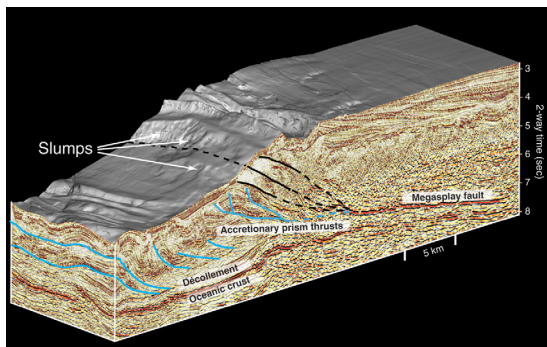
Supercomputers help companies find these reserves by crunching increasingly complex data for seismic imaging. Put simply, seismic imaging is the process of bouncing soundwaves off the rock formations below the earth to create a ‘map’. Geologists use these maps to identify the location of hydrocarbons below the earth’s surface. In fact, 3D seismic imaging can show formations from all angles, while 4D imaging takes it a step further by showing the movement of fluids in rock formations over time.

The Pangea III, the world’s [most powerful commercial](#) supercomputer, was built for Total, which has planned to dedicate 80% of the supercomputer’s power time to seismic imaging. Built by IBM, the Pangea III has the computing power of 31.7 petaflops, or [170,000 laptops](#) combined.

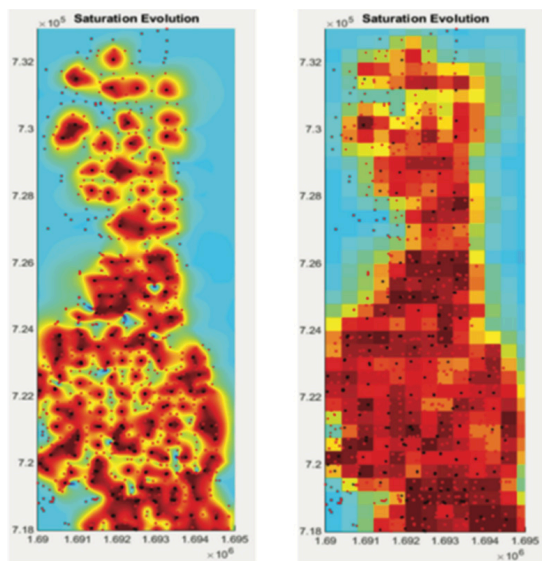
PARTNERING WITH SILICON VALLEY

So integral is computing and data management in the oil and gas industry that a number of Silicon Valley giants have partnered with energy companies

The size of the artificial intelligence market in the oil and gas industry is expected to grow to \$2.85 billion by 2022



3D SEISMIC IMAGE
[SOURCE: WIRED]



COMPARISON OF A MACHINE
LEARNING AUGMENTED RESERVOIR
MODEL [LEFT] AND A CONVENTIONAL
MODEL [RIGHT] [SOURCE: TACHYUS]

Innovation in the oilfield is also turning what many would consider science fiction into reality.

to develop new and innovative computing technologies. Maana – an artificial intelligence start-up whose investors include Shell, Saudi Aramco and Chevron – is [partnering](#) with Microsoft and its cloud computing platform, Azure, in order to integrate data analytics tools into the platform. This strategic partnership allows energy companies using Azure to [link](#) to Maana’s set of software tools that use machine learning and artificial intelligence to analyze and interpret data. Combined, these technologies can help energy companies make decisions like how to improve well efficiency or reduce the risk of corrosion, which once again means safer operations for workers and communities alike.

Cloud computing presents a game-changing opportunity for oil and gas producers. By allowing companies to securely collect real-time data across the oilfield, cloud computing allows producers to make more informed and efficient decisions. Coupled with other technologies such as machine learning and [Internet of Things](#), which creates a network of real-time data communication between sensors on equipment and infrastructure, companies can improve costs, efficiency and limit environmental impacts.

For example, ExxonMobil recently [partnered](#) with Microsoft to rollout a full suite of technologies into its operations in the Permian Basin. The combination of cloud computing, machine learning and Internet of Things technologies will support an estimated 50,000 oil-equivalent bbl/d increase in production growth in the Permian by 2025, while offering the possibility to generate billions of dollars in value over the next decade.

Other technologies, such as artificial intelligence, also provide producers with the ability to improve efficiency while also mitigating impacts. The size of the artificial intelligence market in the oil and gas industry is [expected to grow](#) to \$2.85 billion by 2022 from about \$1.57 billion in 2017, with other estimates increasing that number to just [over \\$4 billion](#) in 2025.

Tachyus, a Houston-based “digital solutions” start-up focused on oil and gas, [combines](#) artificial intelligence with machine learning on its platform to allow companies to “build a predictive model of an oil reservoir,” allowing engineers to improve the accuracy of their predictions and implement a more optimized production plan. Moreover, the technology helps companies to better predict mechanical equipment failure, saving time, money and limiting possible environmental impacts.

Innovation in the oilfield is also turning what many would consider science fiction into reality. Robots and autonomous vehicles are being deployed throughout the oil and gas supply chain. Remote-controlled drill ships, like those being [developed](#) by Houston-based National Oilwell Varco, could support offshore operations while being controlled by workers inland. The use of [robotics](#) on rigs to manage fire suppression and other situations would both limit costs and enhance safety. [Autonomous trucks](#) that could be used for hauling equipment and materials in the oilfield would provide greater efficiency and increase safety for those on the road.

Conclusion

Operators today are focused on meeting the world's growing energy demands while also protecting the planet.

Thanks to oilfield innovation over the past several decades, the United States has become a global energy powerhouse. Directional drilling, which evolved into horizontal drilling, enabled oil and gas producers to minimize surface impacts while maximizing production volumes. This feat of technology was married with hydraulic fracturing to unlock the vast U.S. shale formations and ushered in record-breaking production that has positioned the United States as a driver of the global energy market. This record-breaking development, in turn, has improved our nation's energy security, greatly decreasing America's reliance on foreign oil and gas while also bolstering U.S. exports.

Operators today are focused on meeting the world's growing energy demands while also protecting the planet. A multitude of technologies continue to reduce emissions, even as production grows. This is in addition to the nearly 2.4 billion metric tons of CO₂ emissions that natural gas has prevented in the U.S. since 2005. Further, energy producers are implementing new technologies and best practices to limit freshwater use, turning to recycling and reusing greater percentages of produced water in their operations.

Looking to the future, the industry will maintain its position as a technological leader, making use of powerful computing and artificial intelligence technologies, state-of-the-art sensors and imaging, and cutting-edge robotics and autonomous vehicles. Partnerships with other innovators in Silicon Valley will ensure that the oil and gas industry remains on the cutting edge of new technologies.

The story of America's rise to global energy dominance is a story of innovation. It's a story of using technology to turn the impossible into the possible, and then leveraging those same technologies to address environmental concerns. As the next chapters unfold in America's energy landscape, newer technologies and processes will deliver greater resources with even less impact, all while ensuring America retains its capacity for energy dominance. 🇺🇸



10 Most Innovative Oilfield Technologies



Hydraulic Fracturing



Horizontal Drilling



Supercomputers



Seismic Imaging



Smart PIGS



Drones and Robots



Water Recycling



Cloud Computing



Gas Imaging/VR



Mobile Data/
Internet of Things

Hydraulic fracturing (a.k.a. fracking) has recently made the United States a world leader in oil and gas production, but it is a technology that has been around for decades. Hydraulic fracturing is the process of using pressure to pump fluids – a mixture of water, sand and additives – down a well to fracture the rock formation thousands of feet below the surface, releasing the trapped oil or gas. Hydraulic fracturing was first applied experimentally in 1947, and since then, innovation has enabled hydraulic fracturing technology to advance by leaps and bounds. Companies have introduced multi-stage and bigger fracks, which have allowed operators to produce vastly greater quantities of oil and gas from previously inaccessible shale formations.

Seismic imaging is the process of bouncing soundwaves off rock formations below the earth to create a 'map'. Geologists use these maps to identify the location of hydrocarbons below the earth's surface. The Pangea III, the world's most powerful commercial supercomputer, built for Total, will have 80% of the supercomputer's power time dedicated to seismic imaging. Improvements in seismic technology have resulted in more detailed images of the subsurface, reducing the likelihood of drilling a dry (or economically unviable) well.

Cloud computing presents a game-changing opportunity for oil and gas producers. By collecting real-time data across the oilfield, cloud computing allows producers to make more informed and efficient decisions throughout all aspects of their operations. For example, ExxonMobil recently partnered with Microsoft to rollout a full suite of technologies, including their cloud-computing platform Azure, into its operations in the Permian Basin.

Technologies such as machine learning and the Internet of Things are creating a network of real-time data communication between sensors on equipment and infrastructure, helping companies improve costs, efficiency and limit environmental impacts. For example, the combination of mobile data and Internet of Things technologies will help ExxonMobil support an estimated 50,000 oil-equivalent bbl/d increase in production growth in the Permian by 2025.

Horizontal drilling is built on the principles of directional drilling, relying on instruments to drill in a controlled, precise manner from a "kick-off point". To drill horizontally, operators angle their drill just a few degrees from vertical after their kick-off point, eventually achieving a horizontal well. Like hydraulic fracturing, the practice isn't new. In the 1920s and 1930s, drillers experimented with new technologies, seeking to introduce some precision into the direction in which they bored the well. Advances in this drilling method over the last decade have enabled companies to develop more wells with a significantly reduced environmental footprint.

Advanced pipeline inspection gauges – also known as "smart PIGs" – travel through pipelines to measure and record any issues, such as corrosion, leaks, dents and other defects. These smart PIGs not only provide enhanced efficiency in the pipeline inspection process, they also allow pipeline technicians to more accurately predict and plan maintenance, improving the safety of operations. Some researchers, like those at Rowan University, are even combining VR tech with smart PIGs, enabling pipeline operators to visually travel down a pipeline and identify issues.

Innovators have developed impressive means to recycle produced water from oil and gas operations. The latest recycling technologies are converting highly saline produced water into fresh water. EOG Resources sourced 63 percent of its companywide water needs in 2018 from reuse and non-fresh sources.

Supercomputers help companies find oil and gas reserves by crunching increasingly complex data, with some supercomputers able to model up to 100,000 wells in 15 hours. Today, energy companies are relying on some of the fastest supercomputers in the world to track down and analyze new resources and manage enormous quantities of data across the supply chain. In 2013, BP opened the Center for High-Performance Computing, a massive supercomputer located in Houston, Texas. Since then, the company has quadrupled its computing power, making it one of the fastest computers used for commercial research in the world.

Robots, drones and autonomous vehicles are being deployed throughout the oil and gas supply chain. In September 2019, BP announced a number of technologies, including drone-mounted leak detection technologies, which allow the company to survey as many as 1,500 well sites per month.

Some midstream industry innovators are also turning towards virtual reality (VR) to improve pipeline safety efforts. Companies are using VR not only to train employees to handle real-world tasks, but to optimize pipeline design and reduce emissions. Thanks to these tools, among many others, Apache Corp. has seen a 22% decrease in methane emissions intensity since 2013.