

America’s Energy Future Reshaped By Oil, Gas Supplies From Tight Rock Formations

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and Bob Fryklund

HOUSTON—Ten years ago, the United States was producing 63 billion cubic feet of natural gas and 5 million barrels of oil a day, with only a slight percentage of total supplies flowing from “tight rocks.” Jump forward to 2018 and America has been recast as a global energy superpower, on track to produce more than 80 Bcf of gas and 10 MMbbl/d of oil—both all-time highs, and both enabled almost entirely by soaring output from resource plays.

What the U.S. energy industry—led by independent oil and gas companies with corporate logos few of the consumers benefitting from their efforts would recognize—has accomplished is nothing short of astonishing.

The laws of nature and physics, not to mention petroleum engineering, dictate that a finite resource will deplete over time. Instead, after more than a century of producing oil and gas, U.S. reserve estimates and production volumes for both oil and gas abruptly and dramatically reversed course with the development of shale gas and tight oil. Given the magnitude of the swing from world’s largest energy importer to potentially one of the world’s largest exporters, it is hard to think of a single historic corollary.

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Certainly, there never has been anything like it among countries in the Organization for Economic Cooperation and Development. In fact, the amount of oil production growth that the United States experienced between 2012 and 2014 was the largest continual year-over-year increase in history, exceeding even the best years of production growth in Saudi Arabia.

The same meteoric rise also occurred in natural gas, with the United States adding nearly 1 trillion cubic feet of new production each year between 2009 and 2013 to become the world's largest producer seemingly overnight.

As a result, the nation has been able to completely reshape its energy fortunes. Gone are worries about economy-crippling shortages and price shocks, concerns about dependencies on foreign supplies, and fears of inadequate feedstocks for high-value domestic industries such as petrochemical manufacturing and steel-making. America has gone from being a major demand center dependent on high-cost imports to being a major new supply epicenter with low-cost resources abundant enough to share with the world.

Resource plays have not only hit the reset button on U.S. oil and natural gas supplies at the same time, but also have transformed the global market. The United States has a new function: crude oil, refined oil products, natural gas and natural gas liquids supplier to the world. The benefits are nearly as extraordinary as the story of the U.S. unconventional revolution itself. Consider the difference in world economies today if, as forecast 10 years ago, oil was trading at \$125/bbl and natural gas was selling for \$12/MMBtu. The U.S. economy would be limping along, as would the economies of many other countries.

Historic Achievement

When scientists look back in 60 years at what technologies or innovations changed the way people lived, the shale revolution will rank among the greatest advancements of this century. U.S. resource plays have altered the energy markets forever, similar to how the smart phone and Internet have changed how we communicate with and relate to our world. The number one factor that makes societies economically competitive and ensures a high quality of life is access to

sustainable and affordable energy. That is why horizontal resource plays have massively changed the game.

The United States can be confident that it not only possesses plentiful energy supplies to power the domestic economy, but also can export a portion of those supplies to allies overseas. Already the globe's top exporter of liquefied propane gas and among the top five exporters of refined crude products, now America consistently is exporting 1 MMbbl/d of crude oil and soon will be one of the largest liquefied natural gas exporters. That provides security advantages almost beyond measure, and enables much greater flexibility in international affairs and policy making.

Then, of course, are all the economic benefits (such as more than 1.6 million newly created jobs). The results are evident everywhere, whether in Oklahoma and North Dakota, where tight oil has led to economic rebirths, or Pennsylvania and West Virginia, which are benefitting from growing shale gas production even as their coal industries decline. Texas is now the number one state for oil, gas and wind energy production. Major new transportation, storage, refining and petrochemical infrastructure is being built in regions across the country, creating jobs and boosting tax revenues.

In only two short decades since U.S. operators opened a new class of hydrocarbon reservoirs, oil and gas production volumes have climbed to historic peaks and America is positioned to become a top energy exporter. Where does the shale gas and tight oil revolution go from here, and what will U.S. independents—the pioneering companies that set this profound cycle of disruptive change in motion—do for an encore?

The industry has come a long way in a short time, but there is still much more to learn. We have discovered so much about the rocks themselves. It is clear that the wrong development approach can render a good rock bad, and that no approach can make a bad rock good, but operators are challenging that dictum to some degree by moving outside the fairways to investigate what it takes to make shale basins' second- and third-tier areas profitable.

It also is fair to say that the shale revolution is reinventing geology itself.

We are witnessing a new way of thinking about rocks and the volumes of potential hydrocarbons trapped in their three-dimensional spaces. We know there are a lot more alternatives to accessing those hydrocarbons, whether conventional stratigraphic and structural traps or source rocks and basin centers. This is a paradigm shift away from what geologists were learning in college classrooms 15 years ago.

Downturn Upside

The first decade of the shale revolution was characterized by proving up the economics, securing leaseholds and drilling. That came to a screeching halt in late 2014, when one of the most severe downturns in the industry's history interrupted the party. Taking the long view, however, for all the pain the down cycle caused, the U.S. industry accomplished a remarkable feat. Out of sheer necessity, operators and service and supply companies swiftly turned erstwhile high-cost shale gas and tight oil into some of the world's lowest-cost energy supplies.

It could be argued, in fact, that the past three years' efficiency gains, productivity enhancements and structural cost improvements constituted the most rapid transformation in industry history. Without the extreme pressure to prevail in the low-commodity price environment, these stunning improvements may not have materialized for a decade or two. It was made possible by innovative thinking about how to apply technology to better understand tight rock formations and optimize well construction operations.

The break-even cost in the best tight oil projects has dropped from \$60-\$65 to \$25-\$30 a barrel. While productivity and cost probably will not improve as rapidly during the next three years, experience suggests additional breakthroughs await to nudge costs downward and recovery factors upward, while opening additional resources for economic recovery.

The industry also has learned how to take greater advantage of the data it already has. During the downturn, oil and gas professionals had more time to dig deeper into data. Companies began using sophisticated algorithms and analytical tools to mine datasets and gain new insights into geology, operational workflows and engineering designs. That

has led to much better wells at much lower costs.

Data analysis also directly factors into one of the key contributors to resource plays' economic success: speeding decision making and field activities. Drilling Bakken and Eagle Ford wells once took 45-60 days. Now, these wells are reaching total depth in only six or seven days, even with significantly longer laterals. Every well drilled on a pad is a new information center, and operators are feeding that information back into the decision making process for the next well. It is "real-time thinking" based on new ways to quickly and accurately analyze data.

Tomorrow's Challenges

Most tight rock plays have a steep growth curve for the first four-five years, after which productivities tend to decelerate. That is because operators achieve the most they can by increasing lateral lengths, frac densities, proppant and fluid volumes, etc., in the best available rock. After the steep initial four- to five-year ramp up, efforts to further enhance productivity begin to yield diminishing returns. With drilling and completion activity now expanding outside core areas in tight oil and shale gas plays, it raises major questions about what that could ultimately mean to productivities, decline curves, estimated ultimate recoveries and general well economics. It is similar to dollar cost averaging, with overall performance reduced to some degree by second- and third-tier areas as operators try to figure out the right recipes for imperfect rocks.

It stands to reason that acreage in second- and third-tier areas will not perform as well as first-tier acreage. Therefore, it is hard to see how moving into areas with lesser-quality rock will not contribute to a plateauing of overall efficiencies and productivities. In fact, the data indicate that many plays already have arrived at that stage. The Permian is an exception because it is still in the initial four-year ramp up phase.

Moving to the next acceleration point will require even more technology and innovation, especially outside the fairways. Instead of drilling 10,000-foot laterals and pumping 30 stages, perhaps wells in the second and third tiers would be better with 4,500-foot laterals and 18 stages. Operators will have to undertake a new

era of experimentation to figure out the optimal drilling and completion designs, and getting it right may prove a struggle in some areas.

The single biggest challenge going forward is increasing EURs. This is an extremely important driver on which almost every company is working. There is a lot of room to run. The very best recovery factors in the very best tight oil wells are in the 10-15 percent range. That is better than five years ago, but still not good enough. During the next decade, it is feasible that tight oil EURs can increase to 20 percent, and in some fields, even approach conventional fields' 34 percent estimated global EUR average.

This will require returning the focus to the stimulated rock volume to figure out how to open more reservoir to allow more hydrocarbons to escape tight rocks. It will not be easy, particularly in second- and third-tier areas, but the productivity learning curve that operators recently navigated when they were under pressure to perform at low prices indicates the type of EUR enhancement that is possible.

Other variables that may impact the industry's collective ability to tap resource plays' fullest potential are aboveground issues such as opposition to constructing new pipelines and plants, changing public attitudes about energy, and governmental policies. The industry simply must operate in environmentally responsible ways. Good environmental stewardship is as critical to long-term sustainability as efficiency and EUR improvements.

Tight Rock Opportunities

By 2020, IHS Markit forecasts that U.S. oil production will stand between 11 MMbbl/d and 12 MMbbl/d, while natural gas production will be north of 85 Bcf/d. Oil supply will revolve around the Permian Basin while natural gas focuses on the Marcellus/Utica plus associated gas in the Permian. In fact, in 10 years, we see 70 percent of oil production growth coming from the Permian. That does not mean production in the Eagle Ford, Bakken, SCOOP, STACK, Niobrara and offshore Gulf of Mexico will not be growing, but that growth in the Permian will be significant enough to overshadow other basins.

Moreover, with so much associated gas in tight oil plays, oil activity will start to function as a governor of gas supply, especially in the Permian. Some companies may find themselves "caught in the middle" to some extent between the Permian and Appalachian superbasins, but again, that is not to suggest that players in the Eagle Ford, Bakken, SCOOP, STACK, Niobrara and other basins outside the Permian and Appalachian will not thrive.

The big question is whether any plays that are not yet on the map will emerge during the next couple years. At IHS Markit, we no longer talk about unconventional plays, but tight rock plays, many of which are actually conventional formations. Many of these conventional plays have remained off the radar—hence, we call them "sleeper plays." We are starting to see sleeper plays pick up steam. By and large, these are low-permeability/low-porosity formations that were tested with vertical wells in the past and found uneconomic. This includes a number of intervals in basins such as the Anadarko, Powder River, Uinta, Greater Green River and East Texas/Upper Gulf Coast.

Independents have been scouring older basins in search of tight rocks. Soon, some of these plays will begin to pop up, especially in the Powder River and Green River basins. But even a mature province such as the Gulf Coast will see new tight rock plays, including perhaps some Eagle Ford-equivalent tight formations in northern Louisiana. This is a new concept whereby operators are thinking differently about geology and figuring out new ways to apply horizontal drilling and hydraulic fracturing technologies.

With activity focusing on two U.S. superbasins—one for oil, and one for gas—smaller independents will find a wealth of opportunities to use horizontal drilling and hydraulic fracturing in secondary plays throughout most of the country's historic oil and gas-producing areas. We have identified many tight conventional reservoirs that historically have underperformed with vertical drilling, but hold the potential to deliver economic production using shale play-like drilling and completion methods. The production volumes will not necessarily overwhelm, but these sleeper plays will provide ex-

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cellent opportunities to keep smaller independents active for years.

Meantime, larger independents will remain the dominant players in the established shale plays. We are seeing the rise of the pure-play specialist in the Permian and Appalachian basins. There is some question as to whether these pure-play basin masters will become the commercial masters, which may drive further consolidation post-2020, but it should be, more or less, business as usual for the big plays in the big plays.

The Permian provides a good microcosm of the overall trends. There are some 600 operators active in the basin. That is related to the fact that when the majors exited 20-30 years ago, the independents moved in and acquired parts and parcels of their holdings. The larger independents are leading the way in the Wolfcamp, Bone Spring and other plays, but the majors and super independents are coming back with Chevron, Exxon-Mobil and Occidental each announcing multibillion-dollar investments.

However, while it does not make the news, a significant percentage of all horizontal wells drilled in the Permian have been outside the shales in tight conventional formations such as the San Andres, Clear Fork, and Abo. These off-the-radar plays are yielding additional hydrocarbons and boosting EURs in and around the main shale fairways.

In the final analysis, the rise of resource plays and the improved economics of developing these reserves has reset the oil and gas business in very positive ways. North America has more than 1,100 trillion cubic feet of estimated economically recoverable gas reserves at a commodity price of less than \$4 an Mcf. The same thing is happening in oil reserves. This is critical to the long-term sustainability of oil and gas. Affordable prices and reliable supplies will keep oil and gas competitive with other energy sources far into the future, and that is one of the legacies of lower-48 resource plays that transcend short- and intermediate-term market conditions.

For instance, in the race between natural gas and alternative fuels in power generation, and between oil and electricity for transportation, efficiency and cost-effectiveness will be of paramount importance. The U.S. companies that figured out how to economically produce from shales and tight rocks, and then pushed into new productivity and efficiency frontiers during the downturn, have made the oil and gas business viable for decades. □

Editor's Note: As Pete Stark prepares to retire from a long and productive career, *AOGR's* staff extends its sincere gratitude to Pete for his invaluable contributions to the magazine over the years. Few industry thought leaders have provided more insights to help *AOGR's* readers understand market and technical trends. *AOGR* Publisher Charlie Cookson adds his personal thanks for helping him make it through the rigors of Colorado State University 40 years ago. Happy trails, old friend!



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