Written Testimony of E. Russell Braziel

President and Chief Executive Officer, RBN Energy, LLC

Before the U.S. Senate Committee on Energy and Natural Resources

July 24, 2018

Introduction

Chairman Murkowski, Ranking Member Cantwell, and distinguished Members of the Committee, thank you for the opportunity to discuss U.S. oil production and the impact it is having on global markets. My name is Rusty Braziel. I am president of RBN Energy, an energy market consultancy and analytics company based in Houston. Most of our work involves the analysis of energy markets, especially the development of infrastructure for the production, transportation and processing of North America's crude oil, natural gas and natural gas liquids. I am a member of the North American Energy Standards Board and was recently appointed by Secretary Perry to the National Petroleum Council.

Today I will focus on the dynamics of U.S. crude oil production growth, what that growth has meant for oil trading patterns here in North America, and why market forces unleashed by that production growth have dominated global energy markets over the past five years. I'll then turn to what these developments mean for the future of oil markets, both here in the U.S. and globally.

Of course, the driver behind all of this is what has become known as the *Shale Revolution*, an umbrella term that I will use for that combination of technological advances, petroleum engineering breakthroughs and productivity improvements that have transformed U.S. energy markets from an era characterized by shortage into one of abundance. The intricacies of how these developments launched the Shale Revolution are beyond our scope in this discussion, but a short recap of what happened to energy markets as a consequence of shale development will help us understand what is likely to happen next in these markets.

How the Shale Revolution Happened

Less than ten years ago, the accepted wisdom of most energy industry participants, and regulators of the industry here in Washington, was that the U.S. was rapidly depleting its oil and gas resources and would someday run out. Pundits pointed toward the decline of U.S. production from the mid-1980s through the 1990s as conclusive evidence that this must be true. As the world entered the new millennium, the U.S. energy industry was in full swing with investments to accommodate a world of energy shortage. Multi-billion-dollar investments in liquefied natural gas (LNG) import terminals were underway. Refineries were gearing up to run far greater quantities of imported crude oil because U.S. oil was running out. Power generation companies were scrambling to bring on coal, wind, solar, and even nuclear generation to avoid being caught by declining supplies of natural gas.

But then, seemingly overnight, evidence started to emerge that something had changed. Ten years ago this month (July 2008), natural gas prices started a steep decline and stayed low. Defying conventional wisdom, gas production started to ramp up toward all-time historical highs. That caught much of the industry by surprise. Historically, lower prices had resulted in fewer working drill rigs, which reduced drilling activity, and less drilling resulted in lower production volumes due to the natural volumetric decline of all oil and gas wells. This time, in the natural gas markets of the late 2000s, that relationship did not hold true.

Over time it became apparent that a technological transformation – the Shale Revolution – had fundamentally changed the historical cause-and-effect relationships among price, active rigs, drilling activity and production. Initially that transformation was confined to natural gas. But by 2012, it was apparent that the same phenomenon had come to the markets for natural gas liquids (NGLs) – including ethane, propane, and butanes. With gas prices low, to augment their revenue more producers were drilling for natural gas containing greater quantities of NGLs and production was increasing. Just like gas a few years before, eventually NGL prices succumbed to oversupply and consequently many producers shifted their targeted drilling activity to crude oil. Oil production increased, the U.S. market struggled with regional supply surpluses, and by 2014 the full brunt of this oversupply hit global crude oil markets. Global crude prices crashed.

It was simple economics that brought about this transformation. Due to the advances in drilling and well-completion technologies that have been applied over the past few years to shale and other "tight" formations, today a single rig can drill more wells within a given timeframe, produce far more hydrocarbons during the well's initial highly productive period and do so at a much lower per-unit cost than was possible in the pre-shale era.

Consider the following productivity improvements monitored by the Department of Energy's Energy Information Administration (EIA) in its monthly Drilling Productivity Report (DPR). In 2011, one rig operating in the Bakken (the shale play located in the Williston Basin, being developed primarily in North Dakota) could bring on incremental daily production of about 225 barrels each month. Today that rig can bring on daily production of approximately 1,450 barrels every month, a productivity improvement factor of 6.5 times over a period of seven years. A few hundred miles to the south in the Niobrara (mostly in Colorado and Wyoming), the monthly productivity improvement has been nearly *eleven* times, from 110 barrels per day in 2011 to about 1,200 barrels per day today.

There are a number of factors that have contributed to these remarkable advances, but two factors stand out: (1) each well drilled produces far more hydrocarbons than in the pre-shale era, and (2) producers have learned to drill shale wells much faster than in the early days of the Shale Revolution. Also, while each well is more costly to drill than most wells in the pre-shale era, the output of these new wells is so much greater that the <u>per-unit</u> cost of production has been reduced dramatically. It is this improvement in productivity on a per-barrel basis that has changed the landscape of energy markets.

Economics 101 tells us that commodity prices tend to reach equilibrium at a level equal to the marginal cost of production – that is, the cost of producing the next incremental unit. As U.S. crude oil production from shale increased, the per-unit cost of that production was declining, and U.S. production became the marginal barrel (subject to economic decision processes). As advances in U.S. productivity continued, the result was a collapse in global crude prices from the $100+ per barrel level down to a low of under $30 per barrel in early 2016. Even today, the price for crude oil is at only about two-thirds of its pre-crash level – $69 per barrel at the time of this writing – a price that would have been viewed as quite cheap four years ago on July 24, 2014, when the price of West Texas Intermediate oil at the Cushing, Oklahoma hub was $102 per barrel.

U.S. Crude Oil Production Growth

The doubling in U.S. crude oil production from 5.5 million barrels per day in 2010 to 11.0 million barrels per day, as reported by EIA for the week ended July 13, 2018 – a 9% compound annual growth rate – is well documented, so there is no need to belabor the issue here. But there are a few aspects of this surge in production that are worth noting.

First, U.S shale production of crude oil has been highly responsive to price. For example, when prices crashed in 2014-15, drilling activity waned and production fell by about 550,000 barrels per day in 2016. When prices partially rebounded, so did drilling activity and production.

Second, the decline in production following the 2014-15 price crash was far less than expected by many market participants. Back then it was a widely held belief that crude prices in the $50 per barrel range would devastate the economics of shale well drilling, and for a brief time it appeared that might be true. But U.S. producers responded to the market adversity by radically cutting their costs; by concentrating their drilling activities in their core, most productive acreage (called their "sweet spots," discussed below); and by exercising rigorous financial discipline. Many were able not only to survive, but to thrive through the downturn, which positioned them for aggressive drilling programs as oil prices increased in 2017 and 2018.

Third, the oil production growth enjoyed by the U.S. as a whole has not been evenly distributed on a geographic basis. For example, the decline in total U.S. crude production following the 2014-15 price crash bottomed out in September 2016 at just under 8.6 million barrels per day. Production has since grown to the 11.0 million barrels per day mentioned above, an increase of more than 2.4 million barrels per day. Of that total, 2.1 million barrels per day – or 85% of the growth – has come from only five basins: the Bakken, the Anadarko, the Eagle Ford, the Niobrara, and the Permian. An incredible 55% or 1.4 million barrels per day of the total growth has come from only one basin: the Permian. In fact, most of the growth in U.S. production over the past 22 months has come from only a relatively small geographic footprint within each of these basins: twenty-eight counties with a total land area of only fifty thousand square miles, or about 1.7% of the U.S. lower-48 surface area.

It is important to note that the land area in which crude oil production is economically viable expands and contracts with oil prices. That is because higher prices provide higher revenue per well, which means that as prices increase, new wells that would yield lower quantities of crude oil production can become economically viable. When crude prices declined in 2014-15, producers focused on their "sweet spots" – the specific counties and parts of counties within key shale plays where new wells could be expected to produce economically viable quantities of crude at then-current crude prices. And, more recently, as crude prices surpassed $55, $60 and then $65 per barrel, the geographic areas within which new wells would be economically viable increased too. This dynamic is key to understanding the responsiveness of U.S. crude oil production. *Higher crude prices improve the economics of crude production over a broader geographic area.* Thus, crude oil production will increase in response to higher prices. Of course, the reverse is true as well. Lower prices shrink the "sweet spots," producers drill fewer wells, and production levels off and ultimately declines. This price responsiveness has been the most important contributor to the still-growing influence that U.S. crude production now has over global energy markets.

Implications for Oil Trading Patterns in North America

As the Shale Revolution has advanced over the past few years, it has resulted in dramatic shifts in U.S. oil flow patterns, and consequently the need for additional infrastructure to support the transportation and processing of those barrels. In the pre-shale era, imported barrels dominated crude flows – moving to the U.S. coasts on ships, and continuing from the Gulf Coast into the U.S. heartland on pipelines. Significant volumes of imported crude also moved south from Canada on pipelines. But the huge Gulf Coast demand tended to dominate flow patterns, both from the large number of refineries in the region, and because of access to pipelines that moved still more imported barrels to refineries in the Midwest and Midcontinent (Midcon) regions.

Then shale happened. As crude production increased in those basins named above – Bakken, Anadarko, Eagle Ford, Niobrara, and Permian – the Midwest and Midcon became oversupplied. There were not enough pipelines to get this new production now coming from the heartland to the country's refineries – mostly those same Gulf Coast refineries that had been so dependent on imports. As regional crude surpluses grew, crude prices in the Midcon traded at significant discounts to crude at the coasts, providing the economic incentive for new infrastructure development. U.S. midstream companies responded, reversing existing pipelines and building new systems to move U.S. crudes to U.S. refineries, both in the coastal regions and elsewhere. Consequently, oil flow shifted from its historic south-to-north pattern, flipping around to move largely north-to-south.

Then on December 18, 2015, Congress voted to remove the ban on exporting U.S. crude oil to countries other than Canada and President Obama signed the bill into law. It took some time for the market to respond to this new potential outlet for U.S. crude oil, but respond it did. During 2016 new infrastructure and commercial deals were put in place, and that year an average of about 600,000 barrels per day were exported, nearly all of it from the Gulf Coast. In 2017 that export volume rose to 1.1 million barrels per day, and so far this year crude exports have averaged just under 2.0 million barrels per day. According to recent statistics from EIA, crude exports hit *3.0 million* barrels per day for the week ended June 22, 2018.

The export market has enabled U.S. crude oil to become even more responsive to – and influential in – global crude oil markets. Now, if global crude oil prices increase, incremental U.S. production moves directly into that market – potentially dampening further price increases. That is exactly what has happened over the past year.

However, the combination of geographically concentrated production growth – and geographically concentrated demand from Gulf Coast refineries and exports – has not been without consequences, or without implications for infrastructure. As the Permian Basin has increasingly dominated growth in U.S. crude oil production, output there has outstripped pipeline takeaway capacity from the region to the Gulf Coast and other markets. The result has been a surplus of crude oil in the Permian without adequate pipeline access to market, forcing incremental barrels into very expensive truck and rail transportation alternatives, or in some cases forcing producers to curtail drilling programs for lack of "takeaway" infrastructure to move their product to market.

Crude pricing in the region tells the story. As of this writing, the price of crude on the Gulf Coast (a hub known as Magellan East Houston) was about $70 per barrel while the West Texas price at the Midland, Texas hub in the Permian Basin was only $55 per barrel, a differential of $15 per barrel. This price discrepancy exists solely because of the lack of pipeline capacity between the Permian and the Gulf Coast. There are at least ten new pipeline projects in the works designed to bring a total of about 5 million barrels a day of additional takeaway capacity online over the next three years, with almost all of them planning to bring the incremental volumes to the Gulf Coast. That should be more than enough capacity to meet the demands of the market. Unfortunately for Permian producers that did not secure pipeline capacity contracts to move their barrels out of the constrained region, it will be sometime late next year before the first of these projects is online. In the meantime, Permian prices will remain low and production growth stalled. This is a clear example of how lack of adequate infrastructure can result in shackled production and thus lower supply available to the market. The good news for Permian producers is that the problem will be resolved sometime next year, and prices at the Midland hub will rebound to levels near those on the Gulf Coast.

Consequences for Global Oil Markets

As U.S. crude oil production has increased from 5.5 million barrels per day in 2010 to 11.0 million barrels per day today, as noted above, most of that production growth has found its way into the global market, either directly or indirectly. According to EIA data, between 2011 and 2018, imports of crude oil into the U.S. fell by about 1.2 million barrels per day, effectively displacing that volume back into the global market. Said another way, if the volume does not come to the U.S., it must go somewhere else, which increases global supply. And, as described above, since 2016 the U.S. has been exporting significant volumes of crude directly into the global market, up from less than 50,000 barrels per day in 2010 (mostly to Canada) to an average of 1.8 million barrels per day thus far in 2018.

There is more. A significant portion of the growth in U.S. crude supplies moves to U.S. refineries, which are enjoying very high run rates. (According to EIA, refinery crude-input volume hit an all-time record of 17.8 million barrels per day the week ended June 22, 2018.) Consequently, refineries are churning out more gasoline, diesel and other products than the U.S. can consume. Net exports of finished and unfinished barrels of gasoline, diesel and jet fuel have increased from about zero in 2010 to average 1.5 million barrels per day in 2018. These volumes have essentially the same impact as crude exports on the global market – increasing supply. Adding together the 1.2 million barrels per day of lower crude imports plus 1.8 million barrels per day of crude exports plus the 1.5 million barrels per day increase in net gasoline, diesel and jet imports, the sum is 4.5 million barrels per day. That was more than enough volume to have a significant impact on global markets, and potentially drive other producing countries to cut production to make room for U.S. barrels.

And of course, they did. Oversupply crushed prices in 2014-15 and into early 2016, and in response, in November 2016 OPEC and NOPEC (non-OPEC producers, with Russia the principal player) implemented a production curtailment of 1.8 million barrels per day. Of that, 1.2 million barrels per day came from OPEC, almost half of it from Saudi Arabia. From the U.S. perspective, the production cut had two important outcomes. First, its goal of supporting higher prices worked. As a result of the agreement (aided by a few market disruptions), substantial production volumes were taken off the market, the supply/demand balance moved to correct itself, and prices increased. Second, OPEC/NOPEC effectively ceded market share to U.S. producers. That provided a hefty boost to profits of U.S. producers, providing funds for still more drilling. In the nearly two years since the OPEC/NOPEC agreement was reached, the number of rigs drilling for crude oil in the U.S. has increased from 440 to 845, according to Baker Hughes, a gain of more than 90%.

The fact that OPEC/NOPEC found it necessary to cut production in order to support prices is strong evidence that U.S. production has become a dominant factor in the global oil market. But the success of their production cut reminds us that the newfound U.S. status is not impervious to global markets, nor those that hold sway in those markets.

U.S. Production and Global Oil Markets: Current Developments and Outlook

In recent weeks, OPEC/NOPEC reached a new deal to *increase* production, ostensibly to dampen crude prices but also to allow certain players – Saudi Arabia and Russia in particular – to sell additional barrels at today's higher prices for the cash flow those sales will generate. Although prices did drop slightly in response to this agreement, they have remained relatively resilient – mostly due to a series of market disruptions, including conflict in Libya, an outage at a huge Canadian syncrude upgrader, the looming impact of Iranian sanctions and continuing turmoil in Venezuela. No doubt these factors have muted the price impact of OPEC/NOPEC's agreement to allow some production increases.

All that said, today's price levels do suggest that the market is tighter than it has been in the recent past – meaning that a combination of increasing global demand, lower production from several countries, and pipeline capacity constraints on U.S. production growth could combine to make global markets more susceptible to short-term supply disruptions, resulting in another round of price increases. However, if such a shortfall does develop, it is quite likely that price increases will be, at least in part, mitigated by growing production in the U.S. The global crude oil market will always be susceptible to disruption due to regional conflicts, equipment malfunction, cartel supply curtailments and economic maladies. But generally speaking, it is important to recognize that the U.S. now provides a market-based balancing mechanism that the global market has not enjoyed in decades, if ever. It is not perfect, it is a delayed response and its reach is limited. But there is no doubt that if global prices increase, then U.S. production will respond positively, counteracting the prospects for long-term periods of very high prices such as were experienced in the 1970s.

It is highly likely that the responsive capacity of U.S. crude oil production will continue for many years into the future. Our firm prepares production forecasts for U.S. crude oil several times a year, and we have just completed a new update. These forecasts are based on historical production trends in each basin, recent drilling results (the initial production from new wells and the rate of production decline experienced by existing wells), and the relationship between the economics of drilling a new well to the activity level historically experience in each basin (e.g., the rig count). Based on this data we can compute the likely level of production under several alternative price scenarios for West Texas Intermediate (WTI) crude oil at the Cushing, Oklahoma hub – the benchmark for most crude pricing in North America, and based on that price by extension for crude production across the U.S.

Three scenarios that we assessed in our most recent update were (a) $70 per barrel flat for the next five years, (b) $55 per barrel flat for the next five years, and (c) a scenario similar to the current futures market forward curve (Chicago Mercantile Exchange as of July 19, 2018), which declines from about $70 per barrel in August 2018 to average about $55 per barrel in 2023, an implied price decline of $15 per barrel over the next five years. Using these price trajectories, we see U.S. production increasing by about 5.0 million barrels per day by 2023 in the $70 per barrel scenario, increasing 2.0 million barrels per day in the $55 per barrel scenario, and increasing 3.5 million barrels per day in the forward curve scenario. We consider these to be relatively conservative projections, since we do not assume productivity improvements in our calculations for future well results – even though such productivity gains have been a consistent fixture of the Shale Revolution since its inception.

There are three important conclusions that can be reached based on this analysis. First, U.S. oil production growth is quite sensitive to price. The $15 per barrel difference between the $55 per barrel and the $70-per-barrel scenarios results in a 3.0 million barrels per day difference in 2023 production levels. Recall that prior to the Shale Revolution, total U.S. production was only 5.0 million barrels per day. So a relatively small shift in oil prices results in a big change in our outlook for U.S. production. Second, U.S. production grows even in our low case of $55 per barrel flat price over the five years. It would take a price well below $55 per barrel to shut down growth in U.S. production. And finally, with the higher level of production that comes from the higher price scenarios, so goes the need for more infrastructure to move those barrels to market. Since that infrastructure is being actively developed, this implies that midstream companies and their committed shippers are betting that prices will be high enough to drive production to the level needed to justify the infrastructure investments. This commercial risk has always been a part of the energy industry in the U.S., and while the Shale Revolution has created many opportunities for infrastructure development, it has not eliminated this fundamental energy market dynamic.

Conclusion

The U.S. Shale Revolution has upended much more than prices and global petropolitics. As the analysis above illustrates, U.S. production is now fully capable of responding in a meaningful way to both increases and decreases in price – enough to have a substantial impact on the global crude oil market. If prices increase, drilling economics improve, producers drill more wells, and production increases. If prices fall, drilling economics become less favorable, producers drill fewer wells, and production volume drops. But the oil in the ground does not go away! The production of those barrels is simply put "on hold," waiting for the price signal needed to bring those barrels to market. It is almost as if the barrels were in a storage tank, just waiting for the sign to be withdrawn from storage and moved to refineries – both in the U.S. and throughout the world. And moreover, the triggering mechanism for that withdrawal is the market price, not a government mandate or political maneuver.

Of course, that is not to say that oil markets are free from the intervention of governments, both friendly and less than friendly. Far from it. These markets are critically important to the global economy, which makes them frequent targets of government intrusion. A number of key players in the global market retain significant market power, regardless of U.S. shale. But that power has been restrained by U.S. shale development, and most likely it will be further checked in coming years as shale production continues to grow. That is a good thing for the United States of America.

Thank you for the opportunity to discuss my firm's views on U.S. oil production and the impact it is having on global markets. I look forward to your questions.