

**House Science, Space, and Technology Subcommittee on Energy Hearing; "Oil and Gas Technology Innovation."; Testimony by Edward Johnston, Senior Vice President for Research and Development, Gas Technology Institute**

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Chairman Weber, Ranking Member Veasey, and Members of the Subcommittee, on behalf of GTI, I would like to thank you for this opportunity to testify before you today regarding the value of innovation, research, and Public-Private partnerships.

My name is Eddie Johnston, Senior Vice President of Research and Technology Development. I oversee GTI's entire research staff, leading efforts across unconventional supply, energy conversion, natural gas delivery, and end use market sectors. Prior to joining GTI in 2007, I worked for Atmos Energy Corporation for 15 years, and also worked hands-on in the off-shore oil and gas drilling industry with Rowan Companies.

GTI is a leading non-profit research, development, and training organization, and our vision is to turn raw technology into practical energy solutions that have meaningful impact for the economy and the environment. We have spent the last seven+ decades creating innovative solutions to critical challenges along the entire gas value chain, improving the ways of producing, transporting, converting, and using energy to benefit the general public.

We cover a robust spectrum of initiatives. In addition to reducing the environmental footprint of shale gas production, which you'll hear more about, GTI's focus includes:

- . Expanding the supply of natural gas and renewable energy
- . Developing clean and renewable alternatives to petroleum-based transportation fuels and chemicals
- . Enhancing the integrity of our nation's vast pipeline infrastructure
- . Reducing methane emissions across the value chain
- . Promoting energy efficiency by developing and demonstrating high-efficiency technologies
- . Advancing clean, low-cost power production from all of our energy resources

With more than 360 employees across the nation, GTI expert engineers and scientists are developing innovative new tools, technologies, and methodologies, and delivering science-based factual data that helps to guide informed decision-making and enlightened policy development.

GTI has a storied history rich in meaningful Public-Private partnerships on various energy related topics, especially in the development of our country's unconventional oil and gas resource.

Shale: Revolution or Evolution?

While shale development seems like an overnight occurrence to most, decades of research underpin the technical understanding and complexities of producing this seemingly impermeable resource. GRI, DOE, and the Research Partnership to Secure Energy for America (RPSEA) conducted focused research programs for the development of unconventional resources (coal bed methane, tight sands, and shale) spanning more than three

decades and nearly \$1 billion; specifically addressing fracturing in shale formations by investing more than \$100 million (unadjusted figures).

Much of what now is considered seminal research was conducted in a series of field experiments that took place in eastern U.S. shales in the 1980s. Researchers from industry, national labs, and universities have studied the data sets from these empirical field tests and have successfully built important fracture models and other technology that have tremendously improved shale production over time.

It is of interest to note that this research was severely criticized by much of industry at the time, with some larger exploration and production (E&P) companies describing the research as a "waste of money". Two men, former GRI President Henry Linden and George Mitchell, CEO of Mitchell Energy who was serving on the GRI Board of Directors at that time, fortunately did not share this sentiment. Mitchell expressed his support for shale research, but also recommended a new approach. At the time, all of the research was focused on shallow, eastern U.S. Devonian shales and had been for many years. Shale production was at a miniscule 50 bcf/year and was not changing significantly.

Mitchell made a recommendation to move the research program to a new area and new geologic basins. Heeding his advice and working with Mitchell Energy, efforts were moved eventually to the Barnett shale in Texas. In 1988, GRI and Mitchell Energy initiated the first of many cooperative wells that proved through new core techniques that there was actually four times more gas in place than previously believed. This discovery at the T.P. Sims well provided the target that innovations in horizontal drilling and hydraulic fracturing effectively exploited. In 1991, GRI worked with Mitchell Energy to drill the Stella Young well in the Barnett Shale--a horizontal well stimulated with new technology that produced three times more gas than any other well up to that time. This was a pivotal point in the U.S. shale gas evolution that transformed the energy industry. n1

#### Shale by the Numbers

Fast forward, oil and gas production from U.S. shale formations has become what most consider the world's "swing supply", a truly amazing success and likely the biggest energy breakthrough of the last 50 years. While the oil and gas sector is responsible for an estimated \$1.2 trillion in GDP and 9.3 million U.S. jobs, n2 one of the most meaningful and visible impacts of shale gas is lower utility bills for consumers, putting \$1,372 per year back into the pockets of the average American family. n3 Since shale gas is used to heat homes and produce electricity, consumers are spending less money on both natural gas and electricity bills. The increased use of natural gas in electricity generation has also produced significant reductions in CO2 from the power sector - down 21% from 2005 levels according to EIA. n4

The U.S. has also seen important decreases in energy imports as a result of shale development, and if development continues as projected, then we could be a net energy exporter by as early as 2030, which would be a significant improvement in balance of trade. Therefore, domestic energy security and independence is actually in sight. However, one metric must be improved to optimize the value of this resource - the recovery rate from oil and gas shale formations.

#### Unconventional Resources Defy Conventional Wisdom

Even during times of declining prices, domestic production has increased; primarily because of tremendous mechanical advances in drilling and completion techniques that keeps some shale production economically viable in this lower-price environment. Some may infer that all is understood and that shale development has matured; however, one look at the current resource recovery rates, and one can quickly deduce that much is left to be done.

The primary opportunity to have meaningful impact for broader success in shale is to optimize the network of natural and induced fractures to greatly increase recovery. Shale rock can exhibit permeability properties that are a factor of nine less than conventional resources (nanodarcies versus darcies), so reservoir stimulation of shale can be quite challenging and requires significant energy. The volume of available U.S. shale gas and shale oil recovered is typically below 20% and 10%, respectively, and sometimes much lower. This is the grand challenge. These low recovery rates (a fraction of what conventional reservoirs offer) and rapid decline rates of wells lead to intensive drilling operations. Field experiments indicate that as many as 80% of fracture stages in a single horizontal well do not significantly contribute to the overall production of the well. So although the process may prove effective, it is certainly not efficient.

This inefficiency has direct implications on the environmental footprint of shale production. By optimizing fracture efficiencies fewer wells will need to be drilled, fewer trucks will be required, less water will be used, emissions will be reduced, and community impact will be minimized, all while producing more oil and natural gas.

## Why the Permian?

The combination of the Midland and Delaware basins in the Permian of West Texas is now considered by many to be the largest hydrocarbon resource in the world, and estimates continue to rise with every evaluation. Rig activity grows daily, and now more than 40% of the domestic fleet is dispatched in West Texas. Current oil production is approximately 2.4 million barrels per day, and projections suggest that this could more than double over the next seven to ten years. Similar increases in natural gas and liquids production are likely as well. This increase in Permian production alone could set the U.S. on a very plausible path to energy security.

## The Permian Project: GTI's Hydraulic Fracturing Test Site (HFTS)

Our goal is simple - substantially advance the hydraulic fracturing process to optimize well spacing so that fewer wells are needed to increase resource recovery and simultaneously reduce the environmental footprint of production.

The problem is multifaceted - subsurface completion science has the greatest uncertainty and variability of the shale development process. Yet, even as hydraulic fracturing is in wide use, it continues to be a complex and controversial process with many variables that affect the locations where the fractures propagate, their dimensions, and their ability to enhance production of hydrocarbons. The extent, complexity, and volumes of the fractures created along the horizontal holes that are drilled during each stage are not well understood. While we know that the fractures form a complex three-dimensional pattern, direct and reliable data is still needed about the size, shape, and distance of hydraulic fracturing propagation.

Understanding and optimizing this resource recovery technique requires input from scientific, engineering, and operating subject matter experts from industry (operators and service providers), universities, national laboratories, and other research institutes, and the only realistic way to do this is via a Public-Private partnership. So with the assistance of a cooperative agreement in the amount of \$7.4MM from U.S. DOE Fossil Energy, GTI was able to attract:

- . A host site partner in Laredo Petroleum that provided a test site in the Permian, pertinent micro-seismic and other background data with an approximate value of \$100MM, and approximately 25 engineers and operations staff for the experiment.

- . A Joint Industry Partnership (JIP) of service companies, independent producers, and integrated majors that sponsored the additional \$16MM of research work and also provided subject matter experts to technically contribute to the program. (JIP participants are Chevron, ConocoPhillips, Core Laboratories, Devon, Discovery Natural Resources, Encana, Energen, Halliburton, Shell, and TOTAL).

- . A team of leading researchers at the University of Texas (UT) Petroleum Engineering Department, at the UT Bureau of Economic Geology, and at the National Energy Technology Laboratory.

In September 2015, the HFTS research team drilled and stimulated eleven 10,000-foot-long horizontal wells. More than 400 fracture stages were completed in those wells. Using microseismic and tiltmeter technologies, the team monitored the fracturing process.

A comprehensive set of state-of-the-art technologies were used to observe and monitor activities and production throughout the project, but the key differentiator of this field experiment is the 600 feet of unique core that was obtained by drilling a one-of-a-kind core well through created hydraulic fractures at the test site. Extracting core of this magnitude is an expensive and risky undertaking, but all participants agreed in advance that this ground truth evidence is paramount to understanding fractures, validating and developing models, and providing for an assessment of how predictive analytics can improve the process.

The analysis of the influence of reservoir rock conditions on fracture properties will help researchers develop a cause-and-effect relationship between fracturing parameters and reservoir geology to measure the consequences of fracturing--results that can be applied to other locations and plays. Important data about subsurface fracture propagation and proppant transport dynamics will lead to the design of optimal fracture treatments and, ultimately, ideal well spacing. Many of the findings will likely be transferrable to other basins, but shale is a heterogeneous resource so much more work needs to be done.

## Future Work in the Permian

GTI and BHP Billiton Petroleum (BHP) signed a letter of intent for another Hydraulic Fracture Test Site in the Reeves County area of the Delaware basin, a subset of the West Texas Permian basin that is deeper, at higher

pressures, and different permeability than the Laredo site in the Midland portion of the Permian. An important feature of this experiment will be a dedicated well drilled to extract a core to better understand the stimulated reservoir volume (SRV). The diagnostic information will provide insight to the fracturing network and connectivity between fractures across horizontal wellbores. At the same time, air and water samples will be taken in the test site area to evaluate air and water quality. The information will deliver an understanding of appropriate well and fracture spacing to optimize production with reduced environmental impacts.

Some of the participants of HFTS #1 will likely participate in this second field experiment based on owning acreage in the Delaware basin, and we will pick up new participants, expanding the learnings from this critical field work. As with the first experiment in the Permian, interested industry partners are looking for a commitment from DOE that signals continued support for this important research. This investment will be the catalyst for the next phase of learning.

## Conclusion

In addition to the research and technology underpinning that occurred over decades, the U.S. has a very unique alignment of factors that no other country in the world enjoys that has made shale development such an amazing success:

- . Incredible and vast resource of brittle shale
- . Tremendous pipeline infrastructure
- . Mineral right ownership by landowners
- . Robust service sector
- . Entrepreneurial spirit of the independent producer
- . Great access to capital
- . Public policy that incentivizes development

This confluence of elements has re-calibrated world energy markets, resurrected our economy in the midst of the Great Recession, and provided consumers clean energy at the lowest prices in the world. But the work is far from finished. As you can see, the subsurface science related to resource development in U.S. shale is both complex and under-appreciated. The fact is that even with the breakthrough science performed in our Field Test Program, there is much more to learn in order to gain a sufficient understanding to maximize our national energy resources in the different shale plays we are so fortunate to have.

Continued research and field tests will be required to achieve desired recovery rates for responsible development, supported by a robust DOE research portfolio. The opportunity and funding DOE provides in this area initiates and galvanizes interest to perform research that most operators are not willing to conduct independently, and since public funding is involved, the results are ultimately disseminated across the industry and research community, rather than being held tightly by a select few.

Make no mistake, these prior public and private investments in research and field tests in unconventional development have been the catalyst that dramatically altered the energy landscape in the U.S., with these rewards being shared by consumers, taxpayers, manufacturers, and industry. With continued public support for these research efforts, the U.S. will continue to lead the world into the next evolution of shale.

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