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**Shale Energy in Pennsylvania and Globally**

**Comments for Pennsylvania Senate Environmental Resources and Energy Committee**

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Since the advent of shale energy exploration and production in Pennsylvania starting in 2004 with the Marcellus resource, the State has seen a surge of production in a relatively short number of years. What was once estimated by some domestic government agencies to have a final collective yield of nearly 5 trillion cubic feet over the lifetime of the development, has now seen the annual yields in each of the past three years surpassing that amount. 2018 is also on track to have a similar outcome, with cumulative production continuing to rise each year, due the deployment of rapidly evolving extraction techniques and innovative technologies. Capital continues to backstop this development at an elevated rate in PA, with increasing amounts of funding currently being directed to new midstream investments of interstate pipelines to meet growing demands for shale gas. This has facilitated increased capacity to generate a larger share of electrical power in the Commonwealth, heat more homes, and add lower cost feedstock for new industrial uses. Royal Dutch Shell's multi-billion dollar investment in western Pennsylvania is an example of moving the state towards being a new leader in both petrochemical production and advanced plastics manufacturing, including the use of cutting edge 3-D printing technologies.

Pennsylvania now leads the nation as the top U.S. producer of shale gas. The Marcellus and Utica shale gas resources alone are providing over 35% of the U.S. total dry natural gas production, with the Appalachian basin producing over 24 billion cubic feet/day (bcf/d). That trend is increasing year on year in part driven by longer horizontal wellbores now reaching in some cases 20,000 feet in length, and new innovative engineering, which is maximizing output and reducing the environmental impact of this form of energy development.

In PA, this has also led to new opportunities in many rural communities, as well as, urban centers, for enhanced economic development and new workforce possibilities. As an example, the ShaleNET program in PA has now trained over 14,000 people, offering the valuable skills critical to the shale energy industry in the State. And there are numerous examples of new industrial parks, airport expansions, downtown renovations, healthcare buildout, and private/public partnerships formed with an underpinning from this new energy development occurring in the state. These changes have a wider direct and indirect benefit to the communities where they are occurring in that even residents not directly involved in the O&G industry are able to utilize these new services and opportunities occurring around them.



In short, shale energy production has represented a paradigm shift in the Commonwealth, both in how the State sources energy, and now more importantly, how it utilizes natural gas as a transition fuel, while on the path to an evolving energy future with increasing emphasis on lower carbon fuels including renewables, nuclear, fuel cells, and other emerging technologies.

Along with the significant shale energy implications in Pennsylvania and across the U.S. and Canada, there are equally large impacts observed in other regions around the globe. One estimate has illustrated that 80% of potential shale gas development, is or could occur, in countries which in the past have constituted only 30% of conventional O&G resource production. This is a potential seismic shift geopolitically as more countries that have annually spent considerable financial resources to import energy, now have the potential to produce for their own needs, and possibly export into the larger global market. Already this has had a disruptive influence on global energy markets leading in many cases to a new equation of suppliers and consumers. The U.S. was only recently the world's largest importer of oil and natural gas. Now it is the world's largest producer of natural gas and is poised to emerge before the end of 2018 as the largest oil producer globally, due to the technical innovation that has made shale energy commercially viable. And both are now being exported from the U.S. in increasing amounts. LNG shipments are now leaving two large U.S. export facilities, including the Cove Point location on the Eastern Shore, with a number of other export locations in the queue for completion in the next two years. Much of that gas headed to our European, Asian, and Latin American trading partners, offering a different source of energy at newly competitive pricing. And with the expansion of the Panama Canal, new markets for U.S. shale gas are opening in the Pacific basin as well. Along with LNG shipments, increasing amounts of shale gas is finding its way to Canada and Mexico by pipeline, with approximately 4 bcf/d to each respective location. Marcellus/Utica sourced gas for example, is expected to supply Ontario with nearly 70% of their needs with the next five years.

Our Penn State Marcellus Center for Outreach and Research has had the opportunity to work with over 50 countries worldwide with an interest in shale gas as either a resource to be developed in their respective jurisdiction or a resource to import from a new list of global suppliers. In eastern Europe where we have considerable experience for instance, many of the countries have in the past been solely dependent on Russia for these energy resources, due to historical political connections and the pipeline infrastructure in place. As these countries transitioned to the EU, they have been attempting to diversify their energy supply, investing in new options to provide the energy which is a foundation of their increasingly modern economies. This has challenged Russia for instance, which has over 40% of its national budget dependent on the sales of O&G. Friction from this changing dynamic was on display twice in recent years, when transshipments of natural gas were blocked to Ukraine, which has traditionally been the pathway of most of this gas to Europe. A separate example is in motion now with the likely construction of the Nord Stream pipeline through the Baltic Sea scheduled to deliver supplies of Russian gas directly to Germany, bypassing Ukraine, and attempting to supply an ongoing market for a significant share of their premium priced gas exports. The current Trump administration, like the Obama administration before it, has attempted to block this pipeline, based on the premise it would give a geopolitical advantage to Russia and lock out new supplies of increasingly available shale gas from numerous world suppliers, including



that from U.S. LNG. Shipments of LNG and natural gas liquids such as ethane, are now finding their way from not just the U.S., but specifically from Pennsylvania, to some of these European countries, with additional supplies still being requested. Delivery to Norway, Scotland, Poland, and Lithuania are prime examples. On a competitive basis, any new U.S. supply offsets quantities previously delivered by Russia. And U.S. natural gas exported is now mostly sold priced on Henry Hub versus the previous model of 20-year contracts linked to a higher priced oil market formula. It is interesting to note that Russia, as an emerging LNG exporter itself, used a similar approach to ship two cargos of LNG into the Boston market this past winter due to high domestic winter heating and power generation demand in that region, and limited supply due to pipeline constraints from states south of it, including the Marcellus of Pennsylvania.

Beyond the example of Europe, many other countries are moving forward with shale gas in some manner. For instance in Latin America, Brazil, Columbia, Chile, and Argentina all have the potential for shale gas development. We have recently hosted governmental delegations here in PA for them to study successful environmental regulatory protocols, establish a firm understanding of the technologies involved in exploration and production, and learn how to build a domestic workforce related to safe and sustainable production. Most of these countries are also now significant importers of U.S. LNG and will continue to be as they attempt to diversify energy supplies, lower their national energy costs, along with diminishing their carbon footprint. Most of them are also commercially purchasing U.S. technologies and utilizing PA companies, as they continue to move forward in their shale energy pursuits. And the illustration of what is occurring in Latin America is not so different than similar efforts in South Africa, Algeria, Australia, Indonesia, and certainly China, among other countries globally.

The Marcellus Center at Penn State has been embedded in this national and global dialogue for 10+ years. During that time, while shale energy production has expanded in PA and across the world, there has been a parallel expansion of the use of social media. This relatively new means of mass communication has allowed anyone and everyone to participate in the discussion and potentially influence the outcome. Broadly educating the diverse array of stakeholders interested in shale energy production and utilization, continues to be valuable, and is changing families and political jurisdictions worldwide. Social media has offered stakeholders access to information they may not have encountered otherwise. The challenge for some receiving this information in non-legacy regions, is lack the of local experience with exploration and production, which prevents a balanced assessment of the data, allowing for possible undue influence from those with an agenda that is not matched to the local situation as it may occur. Our Center has strived to provide a “translational outreach” based on delivering research outcomes, which explore all sides of the many issues involved, combined with global experiences, to offer stakeholders informed perspectives to make the best decisions possible.

Thank you for the time to discuss these topics of ongoing importance for many of your constituents in the Commonwealth and those beyond. I would be glad to address any related questions.