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U.S Public Finance | Municipal Bonds—Special Comment Report

Potential Impact of Natural Gas Fracking on Municipal Bond Issuers

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Table of Contents

This report highlights some of the credit metrics investors can use to identify which municipal securities may be impacted by the rapid development of shale gas production in the United States via recent technological advances in hydraulic fracturing and horizontal drilling. ***This report is neither an endorsement nor condemnation of the expansion of shale gas technology in the United States.***

Executive Summary

The goal of this preliminary report is to alert investors to a new dynamic in the market, the potential development of trillions of dollars[1] of unanticipated, domestic shale gas reserves over the next few decades. While there are significant environmental challenges, particularly contamination of groundwater and aquifers as well as water usage issues, the focus of this report is the potential impact on municipal credit quality if these shale gas reserves are developed on a large-scale.

It has been known since the 1950s that North America has tremendous quantities of gas and oil trapped in shale formations, but until recently, almost all of this was deemed non-recoverable. Recent advances in combining hydraulic fracturing and horizontal drilling have materially reduced the cost of recovering shale gas and dramatically increased projected reserves.

This report provides estimates of these new reserves by state and metrics to help investors determine how their development could affect credit quality of "taxed-backed" municipal issuers. It also explains how the further expansion of shale gas development in the United States could benefit many public power utilities by:

- Reducing financing, operating, and construction risks associated with multi-billion dollar projects;
- Providing a low cost, relatively clean fuel with ample supply and expected price stability;
- Significantly reducing future capital costs and forecasted bond issuance; and
- Allowing an inexpensive way to reduce plant emissions of CO_2, mercury and SOXs (sulfur oxides).

Although estimates surrounding many key factors are in flux, and concerns over health and environmental issues have still not been adequately addressed, we believe investors need to be cognizant of the potential credit impact shale gas development could have on securities issued on behalf of states, localities, and utilities.

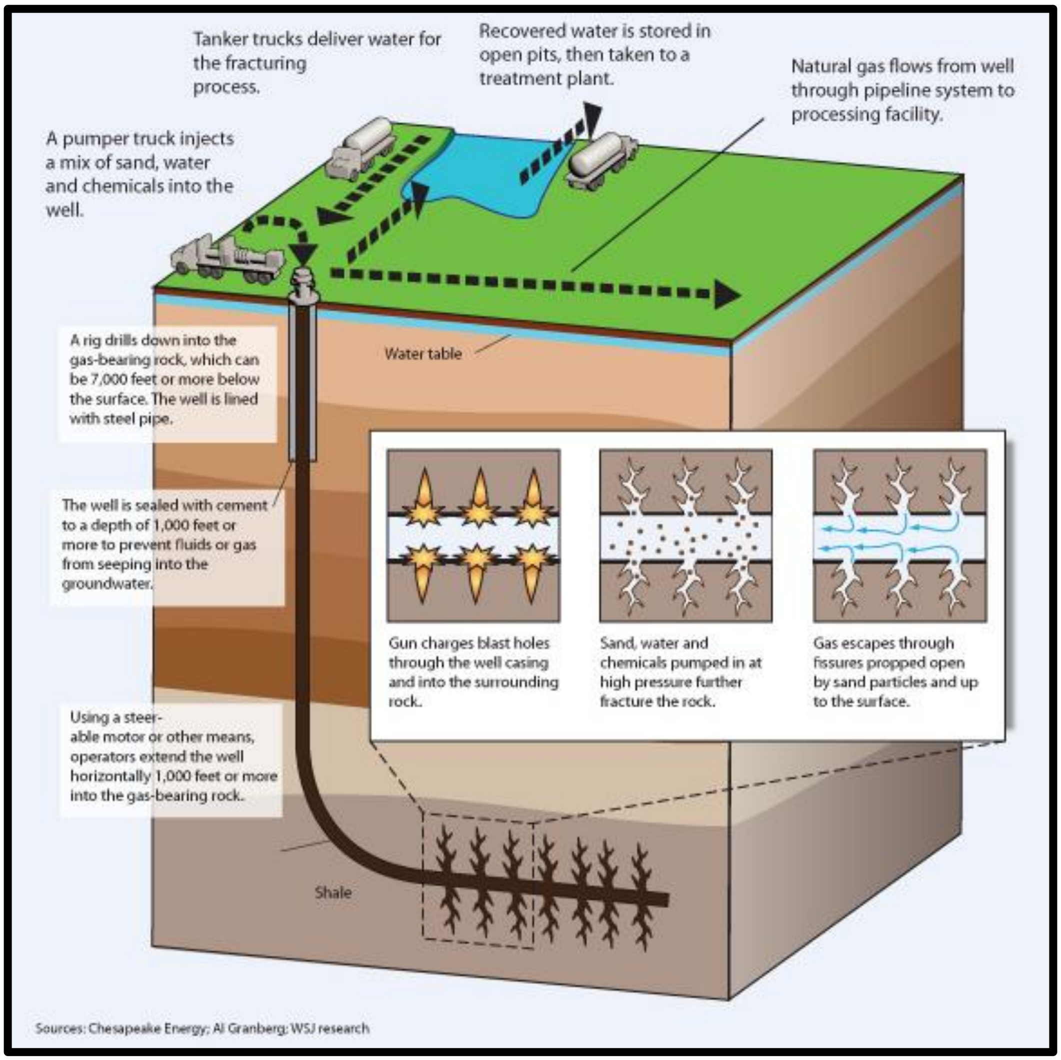
On a macro level, the development of this resource has the potential to materially increase the nation's GDP, lower energy costs, create a large number of new jobs, and enhance national security. However, significant environmental challenges must be overcome. These are discussed in detail in Appendix 1, Impact on America's Energy Position, and Appendix 2, Economic and Environmental Impacts of Fracking.

Kroll Bond Rating Agency (KBRA) plans to publish additional reports on this issue to refine our metrics and estimates for gross potential value of production as well as providing updates on regulatory issues (which vary significantly by state) and environmental concerns.

[1] New estimates for economically recoverable, unconventional gas range from a low of approximately 300 Tcf (trillion cubic feet) to over 2,000 Tcf. At an average price of $4/Mcf (thousand cubic feet) over the next few decades, recoverable shale gas could be worth from $1.2 trillion to over $8 trillion.

What is “Fracking”?

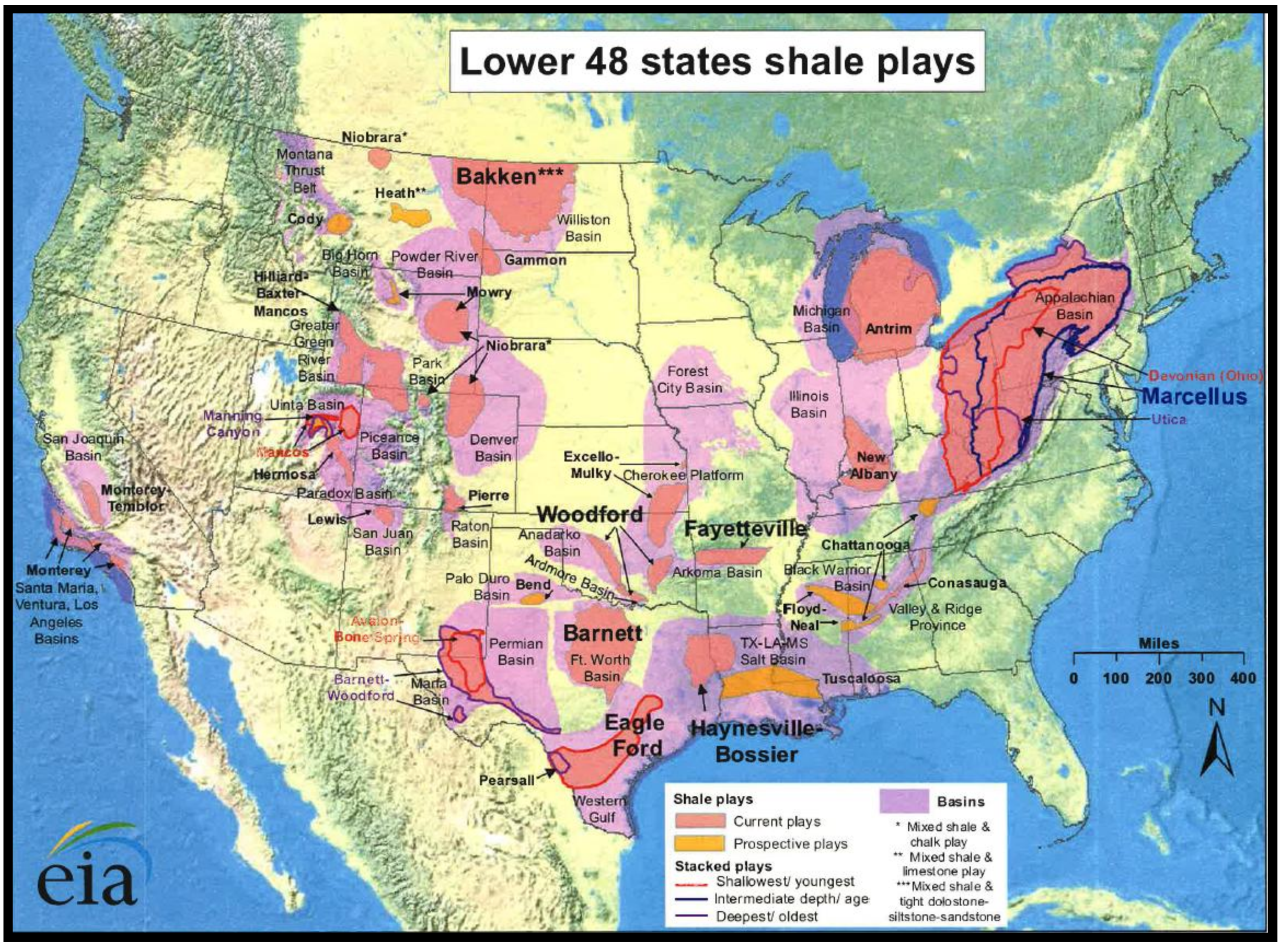
Large quantities of gas and oil are contained within shale reserve formations in the United States. Shale and other geological formations containing fossil fuels are usually found in “seams” or layers, several thousand feet below the earth’s surface. The seams are relatively short in vertical height (typically 40 to 400 feet) but often extend horizontally for miles. Consequently, traditional vertical drilling of shale deposits yielded small amounts of gas and/or oil because only the relatively short length where the well vertically penetrated the seam could be accessed. However, the use of hydraulic fracturing combined with horizontal drilling has been successful in releasing significant amounts of previously classified “non-recoverable” shale gas.



Hydraulic fracturing, specifically hydro fracking, is used to expand tiny pre-existing fractures in the shale rock formation. This can be done by pumping large amounts of pressurized water, combined with chemicals and sand, into a drilled gas well to fracture the rock. When the pressure is released and the “flowback” water removed, the sand remains behind, propping open the enlarged fractures as well as some newly created fractures, allowing the gas and/or oil to flow more freely into the well. Horizontal drilling, the ability to turn a downward-plodding drill bit by 90 degrees or more, is used to drill into the seam for thousands of additional feet, thus significantly increasing the potential recovery of gas (and oil).

Potential Impact on “Tax-Backed” Municipal Bonds

The highlighted areas of the map below show where conventional and unconventional gas and oil reserves have been identified in the continental United States.[2] Approximately 25 states, and many of the municipalities within them, have the potential to be directly impacted. The states most likely to have their economic and credit characteristics affected (should large-scale development of shale gas go forward) are Wyoming, Arkansas, West Virginia, Oklahoma, Louisiana, New Mexico, North Dakota, Colorado, Texas and Pennsylvania.



KBRA used several sources to determine the estimated total gas in-place and recoverable shale gas for each state. Sources included the US Geological Survey, US Energy Information Administration (EIA), Department of Energy (DOE), National Energy Technology Laboratory, National Petroleum Council, and the Potential Gas Committee.

There are significant differences between these sources on estimated recoverable gas reserves by basin/shale. For example, the EIA published a report in July 2011 stating the Marcellus Shale had 421 Tcf (trillion cubic feet) of recoverable shale gas. With the US consuming 24 Tcf of natural gas a year, Marcellus alone would yield almost an 18-year supply of natural gas for the US. However, in August 2011, the US Geological Survey reported the Marcellus Shale had only 84 Tcf of recoverable shale gas.

[2] Most formations and wells contain gas, oil, and other liquid petroleum products.

Values reported in Table 1 may underestimate future value of production; however, with shale gas technology evolving at a rapid pace, all the estimates listed are likely to change over the next few years. Investors can use total gas reserves as a more concrete number of how much natural gas is in place since estimates of recoverable gas are subject to greater and more frequent revisions.

KBRA has identified the following metrics that may help determine what impact, if any, fracking could have on the credit quality of municipal debt issuers. These metrics are listed in Table 1 and include:

- Estimates of total gas reserves by state;
- Estimates of recoverable shale gas reserves by state;
- Dollar value of the recoverable gas by state using a price of $4 per Mcf (thousand cubic feet);
- Projections of annual value ($ billions) from shale gas production by state, assuming a field is developed over a 30-year time frame;[3] and
- Ratio of the estimated annual value of production from shale gas as a percent of each state's 2010 GDP, in order to provide an indication of the relative financial impact on each state.

It should be noted that the focus of this report is on the annual value of production from the potential large-scale development of shale gas and that all values are given in 2010 dollars. No assumptions were made as to additional revenues derived from oil and other liquid petroleum products recovered with the gas nor costs incurred by municipalities that choose to permit fracking, as these will vary considerably by state and municipality.

Although this report does not explicitly address state and local tax collections related to shale gas development, we expect a high correlation. We also anticipate significant variation by state.

Furthermore, we excluded all indirect and induced additional "values" caused by shale gas production (new housing, shopping centers, non-gas related jobs, etc.), which could significantly increase each state's GDP above the production values shown in Table 1.[4]

Finally, it remains unclear if shale gas development will cause a net increase in municipal bond issuance to fund associated infrastructure needs—such as improvements to roads due to an increase in heavy truck traffic. However, future tax policies on shale gas production, which will vary by state, may reduce or eliminate the need for new "taxed-backed" municipal bond financings.

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[3] Actual production is more likely to be shaped like a Gaussian bell curve but average annual production was used to simplify modeling.

[4] The IHS-CERI study projects that the total value added to national GDP in 2025, including indirect and induced sources, would be $158 billion annually, more than double the $72 billion of direct annual value of production shown in Table 1.

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Table 1: Estimated Total Economically Recoverable Shale Gas and Value of Production by State

State	2010 Real GDP* by State ($ Billion)	Total Gas Reservs (Tcf)	Est. Recov. Shale Gas Reserves (Tcf)	Value of Recov. Shale Gas at $4/ mcf ($ Billions)	Est. Annual Production over 30 years ($ Billions)	Est. Annual Production as a % of State's 2010 Real GDP
Wyoming	$34	5,399	26	$104	$3.5	**10.1%**
Arkansas	$92	330	55	$220	$7.3	**8.0%**
West Virginia	$56	390	31	$124	$4.1	**7.4%**
Oklahoma	$133	450	35	$140	$4.7	**3.5%**
Utah	$103	1,719	21	$84	$2.8	**2.7%**
Louisiana	$195	359	38	$152	$5.1	**2.6%**
New Mexico	$73	58	12	$48	$1.6	**2.2%**
North Dakota**	$31	1,350	5	$20	$0.7	**2.1%**
Colorado	$235	304	30	$120	$4.0	**1.7%**
Texas	$1,106	802	134	$536	$17.9	**1.6%**
Pennsylvania	$506	770	52	$208	$6.9	**1.4%**
Michigan	$345	76	20	$80	$2.7	**0.8%**
Kentucky	$145	8	8	$32	$1.1	**0.7%**
Ohio	$426	19	14	$56	$1.9	**0.4%**
Montana	$32	899	1	$4	$0.1	**0.4%**
New York	$1,034	375	30	$120	$4.0	**0.4%**
Indiana	$245	62	7	$28	$0.9	**0.4%**
Alabama	$154	800	4	$16	$0.5	**0.3%**
Nebraska	$80	2	2	$8	$0.3	**0.3%**
Iowa	$128	2	2	$8	$0.3	**0.2%**
Missouri	$217	2	2	$8	$0.3	**0.1%**
Illinois	$581	62	4	$16	$0.5	**0.1%**
Virginia	$381	2	2	$8	$0.3	**0.1%**
Maryland	$265	2	1	$4	$0.1	**0.1%**
California	$1,732	2	2	$8	$0.3	**0.0%**
TOTAL	**$8,329**	**14,244**	**538**	**$2,152**	**$72**	**0.8%**

*Source: U.S. Bureau of Economic Analysis

**Values shown for North Dakota are for shale gas only. They do not reflect the the Bakken Shale's oil fields recent development via fracking and horizontal drilling, has dramatically changed the states' economic condition, unemployment rate (3.4% as of November 2011 according to the US Bureau of Labor Statistics), finances, and demographics,and show the credit impact shale gas development could have on municipals.

Potential Impact on Public Power Bonds

Increased natural gas production due to fracking could be a boon to many electric utilities as it eliminates the need for them to build large coal and nuclear plants—often multi-year, multi-billion dollar construction projects with considerable financing, licensing, and operational risks. Instead, utilities could build less expensive and more efficient gas-fired plants that can be constructed on a smaller modular basis to meet demand.

Listed below are some of the key factors that may affect the industry:

- Availability of a low-cost, relatively clean-burning fuel source with projections indicating supply may remain ample and price relatively stable for the next few decades. This could remove many of the costs and risks associated with hedging fuel supply and price uncertainty, such as gas-prepays, as well as reduces the need for costly pollution control equipment.

- The combustion of natural gas reduces emissions of pollutants such as mercury and SOXs (sulfur oxides), and produces about half as much CO_2 per unit of energy than coal. However, there is uncertainty regarding the lifecycle greenhouse-gas footprint from shale gas production and if it represents a net improvement over coal. Natural gas from shale may not have the attribute of reducing climate-related concerns from greenhouse-gases as touted by many of its supporters.[5]

- Removal of financing, construction and operational risks associated with large, multi-year, multi-billion dollar coal and nuclear projects. Most new capacity, except as mandated by RPSs (Renewable Portfolio Standards) and/or local political factors, will probably be relatively low-cost, simple and combined cycle gas-fired turbines.[6]

- Gas-fired units can be added in small increments to better match actual demand needs and, typically, can be installed and operating within 18 to 24 months. In addition, these modular units usually have high quality control because most are factory built and assembled on site.

- Gas turbines have significantly lower capital costs ($/kW) than generating capacity from comparable coal and nuclear plants. Consequently, future capital needs and bond issuance may be lower than previously forecast and electric power bonds may benefit from a scarcity premium due to a reduction in new supply.

- Although there are still significant capital needs to update transmission and distribution systems (grid) as well as build alternative energy sources as prescribed by RPS laws in the majority of states, it is unclear if municipal utilities will own, operate or even finance (i.e., issue tax-exempt bonds) these facilities. Many municipal utilities may find it more advantageous to allow "for profit" companies to build, own and/or operate the majority of those projects and instead pay a usage or energy fee.

- Growth in alternative energy projects may slow materially since low gas prices adversely affect their economic viability, particularly solar and wind, although it does reduce the cost of backup power needed to improve their reliability. However, they will be needed for future energy sources due to their minimal environmental impact, particularly as it pertains to greenhouse-gas emissions, and inexhaustible fuel supply.

Potential Impact on Selected Projects and Utilities

Prairie State and Vogtle 3 & 4 Projects

The participants in the Prairie State coal-fired project and the Vogtle 3 & 4 nuclear project may see some reduction in their competitive positions. It is uncertain if this will cause a material effect on credit quality of the participants. However, the

[5] Reference Cornell University study "Methane and greenhouse-gas footprint of natural gas from shale formations"

[6] Prairie State and Vogtle 3 & 4 may be among the last large coal and nuclear plants built in the nation for the foreseeable future

facilities act as hedges should gas production fall below current estimates due to regulation or revised forecasts—both of which could result in higher gas prices. Generally:

- Almost all the participants need the power that will be produced by those projects to meet existing demand; and

- Their ownership/contractual shares represent only a portion of their respective systems' total capacity. Consequently, in most cases, it will increase their systems' fuel diversification but only cause a modest increase in electric rates since it will be averaged in with the cost of other power sources.

Puerto Rico Electric Power Authority (PREPA)

The availability of low cost shale gas prices in the continental United States could be a major opportunity or concern for the Puerto Rico Electric Power Authority. PREPA currently uses oil to generate the majority of its electricity with the rest of its power coming from a coal-fired unit and several LNG (liquefied natural gas) fueled plants.

If PREPA can complete planned gas pipelines that will allow the majority of its plants to be fueled by lower cost LNG, it should be able to drop its system wide rates significantly. However, if political and/or regulatory hurdles stop or significantly delay the pipelines' construction, its already high electrical rates and dependence on oil could have an increasingly adverse impact on both the utility and the Commonwealth.

Conclusions

Within the scientific community as well as among policymakers and the public, there is a divergence of opinions about the costs and benefits of shale gas development. At a minimum, additional scientific studies and public debates are needed to enhance the understanding of the potential environmental ramifications and claimed benefits. The increasing polarization on this issue by policymakers and the public, where for many of the participants it is either an "all" or "nothing" position, could preclude a middle ground solution that will provide the optimal societal benefits with minimal or manageable environmental damage.

As stated earlier in this report, KBRA does not take a position on whether increased shale gas production from fracking is a policy that should be encouraged or discouraged on a state and/or national basis. However, given the nation's current political and economic environment, investors should take into consideration the potential ramp-up of this technology in analyzing municipal credit quality despite significant uncertainties about the environmental costs and the ability to mitigate them.

References

Listed below are the primary studies, journal and publications we reviewed in generating this report. Investors who want to explore further into this issue may find these sources useful.

Table 2: Recent Publications on Natural Gas and Fracking

Title	Organization	Published
The Future of Natural Gas: An Interdisplinary MIT Study	Massachussets Institute of Technology	2011
U.S. Supply Forecast and Potential Jobs and Economic Impacts (2012-2030)	Wood and Mackenzie	2011
Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays	U.S.Energy Information Administration	2011
Energy Policy at a Crossroads: An Assessment of the Impacts of Increased Access versus Higher Taxes on U.S. Oil and Natural Gas Production, Government, Revenue, and Employment	Wood and Mackenzie	2011
The Truth About Fracking	Scientific American, Chris Mooney,author of *The Republican War on Science*	2011
Rapid Expansion of Natural Gas Development Poses a Threat to Surface Waters	Ecological Society of America	2011
Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing	Perodical of the National Academoy of Science	2011
Notes from Underground: Hydraulic Fracturing in the Marcellus Shale	Minnesoda Journal of Law, Science, & Technology	2011
Shale Gas and U.S. National Security	James A. Baker Institute for Public Policy at Rice University	2011
American Law and Jurisprudence on Fracing	Haynes and Boone, LLC	2011
The Economic and Employment Contributions of Shale Gas in the United States	IHS Global Insight Inc.	2011
PEHSU Information on Natural Gas Extraction and Hydraulic Fracturing for Health Professionals	Pediatric Environmental Health Speciality Units	2011
Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and US Manufacturing	American Chemistry Council	2011
Methane and Greenhouse-Gas Footprint of Natural Gas from Shale Formations	Department of Ecology and Evolutionary Biology at Cornell University	2010
Developing America's Unconventional Gas Resources Benefits and Challenges	Center for Strategic & International Studies	2010
The Economic Impacts of the Oil and Natural Gas Industry on the U.S. Economy: Employment, Labor Income, and Value Added	National Economics and Statistics	2009
Unconventional Gas	National Petroleum Council	2007

Appendix 1: Impact of America's Energy Position

Four years ago, it was almost inconceivable that America's non-petroleum energy "crisis" could be potentially resolved in the very near future. The expectation was that any significant improvement would come from a new technological breakthrough in solar, wind, cellulosic biofuels, or other alternative technologies. Virtually no one expected this dramatic and rapid change in the nation's energy status would be caused by the evolution of two fossil fuel recovery technologies that have been around for decades but were only recently combined on a large-scale basis, hydro-fracking and horizontal drilling. Few, if any, energy pundits even had fracking on their radar.

Most were forecasting non-petroleum energy prices to be higher than current levels due to supply constraints and related economic and geopolitical challenges. The development of large-scale fracking has caused natural gas prices to collapse.[7] In the past few weeks, the commodity was trading at around $3 per Mcf due to abundant production compared to $12 per Mcf as recently as 2008.[8]

In terms of new energy supply, the revised estimates of economically recoverable domestic gas have increased by an average of approximately 900 Tcf (trillion cubic feet), with the expectation that the total estimate could increase further over the next few years. To put that value in perspective, the EIA states the US consumed only 24 Tcf of natural gas in 2010 with the majority of that used for electric power generation (31%), industrial (27%), and residential (41%).

Several of the studies we reviewed concluded that the further development of fracking could result in lower net energy prices in the US and boost GDP and employment in the near term[9], reduce our foreign energy dependence[10], and possibly affect the credit quality of those states and municipalities that sit on top of these huge, undeveloped reserves. Most also agreed that penetration in the transportation sector, particularly cars and aircraft, is likely to be constrained in the short-term due to gas' low energy density[11] although a significant number of trucks and buses will likely be converted to run on compressed natural gas in the near future.

Consequently, the US will remain a net importer of oil for years to come. However, imports should diminish steadily due to greater penetration of gas in the transportation sector, increased efficiency in our transportation vehicles, and improvements in technologies to make room temperature liquid fuels from natural gas (such as diesel via Fisher-Trope) economically more competitive over the next few years.

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[7] In spite of an anemic global economy, oil is currently over $110/BBL due to geopolitical concerns, whereas at the start of 2007, in a stronger economic environment, it was only $50/BBL.

[8] Monthly average settlement price on the continuous front-month contract. Source: EIA.

[9] Additional jobs created and increased annual GDP caused by shale gas development in the United States was estimated to be nearly 870,000 and $118 billion by 2015, respectively. Page V, Economic and Employment Contributions of Shale Gas in the United States, IHS-CERI, 2011.

[10] "Shale gas will play a critical role in diminishing the petro-power of major gas producers in the Middle East, Russia and Venezuela" as well as "reduce Iran's ability…to strengthen its regional power": Page 13, Shale Gas and U.S. National Security, James Baker Institute for Public Policy, Rice University, July 2011.

[11] Energy density is a term used for energy stored per unit volume. For transportation fuels, the energy per unit volume is a useful parameter since most vehicles have to carry their own fuel in a finite amount of space (i.e., their fuel tank). The energy density of gasoline, compressed natural gas and LNG are 34.2 MJ/L , 9 MJ/L and 22.2 MJ/L, respectively, measured in mega-Joules per liter.

Appendix 2: Economic and Environmental Impacts of Fracking

Economic

The studies, journals, and publications reviewed in generating this report (see Table 2) had different perspectives on the development of shale gas and the associated costs and benefits. Differences included estimates on the specific number and location of new jobs created, revenues generated and collected by the government and industry, the impact on the national GDP, capital costs needed to develop shale gas in the US, and estimates of environmental damage and the ability (or lack of) to mitigate them.

However, despite these significant differences in many of their conclusions, when the issues below were discussed in the referenced material, the following themes and observations were generally agreed on:

- Estimates of economically recoverable natural gas (and oil) in the US have increased dramatically over the past few years primarily due to the combination of horizontal drilling and fracking.

- The power industry will be the primary user of this increased supply of natural gas, and its use will result in electricity prices below prior forecasts. It will also benefit manufacturing, chemical feedstock for plastics, pharmaceuticals and fertilizers, and industrial and residential heating.

- Natural gas' low energy density (MJ/L) will make it difficult to use in the near-term in significant volumes for automobiles or aircraft, although there will be increasing penetration in this sector, particularly compressed gas in buses and trucks in the short-term.

- The development of these "unconventional" natural gas sources will generate a significant number of new jobs and additional tax revenues (at the federal, state and local levels), and could add materially to the GDP and the economic competiveness of the United States.[12]

- The further development of shale gas supply could enhance the United States' national security as well as reduce its dependence on geopolitically, unstable regions for hydrocarbon-based fuels. [13]

- Natural gas burns cleanly and efficiently, reducing emissions of criteria pollutants such as mercury and SOXs, and produces significantly lower emissions of greenhouse gases (during combustion) relative to coal or oil.[14]

[12] The IHS-CERI study concluded that total additional jobs created and the increase in annual GDP caused by shale gas development in the United States would be nearly 870,000 and $118 billion by 2015, respectively. Page V, Economic and Employment Contributions of Shale Gas in the United States, HIS-CERI, 2011

[13] "Shale gas will play a critical role in diminishing the petro-power of major gas producers in the Middle East, Russia and Venezuela" as well as "reduce Iran's ability…to strengthen its regional power": Page 13, Shale Gas and U.S. National Security, James Baker Institute for Public Policy, Rice University, July 2011.

[14] The Future of Natural Gas – An Interdisciplinary MIT Study, 2011, Executive Summary Page xiii

Environmental

The vast majority of the studies we reviewed also pointed out that there are significant regulatory and environmental challenges surrounding the fracking process. On the question *"are the environmental impacts from shale gas development– particularly those related to water contamination– well understood and can they be adequately mitigated,"* there was a broad spectrum of conclusions.

Some of the studies, such as MIT's Future of Natural Gas stated, "The environmental impacts of shale development are challenging but manageable."[15] Others, such as the peer reviewed article printed by the Ecological Society of America concluded, "Federal and state environmental regulations may not prevent or mitigate damaging effects to surface water" and further stated, "the data required to fully understand these potential threats are currently lacking."[16]

Concerns about environmental and water issues are particularly acute in regions that have not previously experienced large-scale oil and natural gas development, especially those overlying the massive Marcellus Shale, and those areas that do not have a well-developed subsurface water disposal infrastructure. In those areas, the focus is on the containment, storage and treatment of "flowback"—the water removed from the well after fracking that is contaminated with chemical additives and minerals (some of them toxic) picked up by the water while it was in the well.

There have also been articles in the press linking water disposal to seismic activity although there is currently insufficient scientific data to confirm or dispute these assertions. In those areas, the public and policymakers are unlikely to allow further shale gas development unless best practices for returned and recycled fracture fluids be developed, monitored, and regulated.

Many opponents of fracking are concerned that even if "best available technologies" are used, and industry practices are in compliance with new and existing regulations, they would still be insufficient to mitigate the potential environmental impact. These observers also raise legitimate questions about the ability of regulators to adequately monitor and regulate shale gas development. Furthermore, they point out that, given the high capital costs, there will be strong economic incentive for some developers to "game" the regulatory system and cut corners in order to minimize expenses and maximize profits.

Even on the issue of greenhouse gas emissions, touted by many supporters of fracking as a major environmental advantage, there was significant discourse. Although none of the reports disputed that natural gas burns more cleanly with less pollution and greenhouse gas emission, Cornell University scientists calculated in their life-cycle study that due to increased leakage into the atmosphere of methane from shale production, the greenhouse "footprint" from shale gas is at least 20% greater than coal on a 20-year horizon.[17]

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[15] The Future of Natural Gas – An Interdisciplinary MIT Study, 2011, Executive Summary Page xiii

[16] Natural gas development and surface water; The Ecological Society of America (www.fronteirsinecology.org); 2011, Page 503

[17] Methane and greenhouse-gas footprint of natural gas from shale formations; Climate Change (2011) 106.679-690, Department of Ecology and Environmental Biology at Cornell University.