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SHALE GAS AND U.S. NATIONAL SECURITY

INTRODUCTION

The past decade has yielded substantial change in the natural gas industry. Specifically, there has been rapid development of technology allowing the recovery of natural gas from shale formations. Since 2000, startling growth in the production of natural gas from shale formations in North America has dramatically altered the global natural gas market landscape. Indeed, the emergence of shale gas is perhaps the most intriguing development in global energy markets in recent memory.

Beginning with the Barnett shale in northeast Texas, the application of innovative new techniques involving the use of horizontal drilling with hydraulic fracturing has resulted in significant growth in the production of natural gas from shale. Knowledge of the shale gas resource is not new. Geologists have known about the existence of shale formations for years but accessing those resources was long held to be an issue of technology and cost. In the past decade, innovations have yielded substantial cost reductions, making shale gas production a commercial reality. In fact, shale gas production in the United States has increased from virtually nothing in 2000 to more than 10 billion cubic feet per day (bcfd) in 2010, and is expected to more than quadruple by 2040—accounting for over 50 percent of total U.S. natural gas production by the 2030s.

Natural gas—if not disadvantaged by government policies that protect competing fuels, such as coal—stands to play a very important role in the U.S. energy mix for decades to come. Rising shale gas production has already delivered large beneficial impacts to the United States. Shale gas resources are generally located in close proximity to end-use markets where natural gas is utilized to fuel industry, generate electricity, and heat homes. This offers both security of supply and economic benefits.

Rising shale gas supplies have significantly reduced U.S. requirements for imported liquefied natural gas (LNG), a move that has already had geopolitical implications. This shift has played a key role in weakening Russia's ability to wield an "energy weapon" over its European customers by offering European customers an alternative supply in the form of LNG displaced from the U.S. market. Rising shale gas supply has also led to lower domestic natural gas prices, which decreases the costs of initiatives to diversify the American automobile fleet with non-oil-based fuels such as electricity and compressed natural gas. In both the United States and abroad, the promise of growing shale gas production has raised the prospects for greater use of natural gas, an outcome with significant implications for global environmental objectives since lower-cost natural gas can displace fuels associated with higher air pollution and greater carbon intensity, such as coal and oil.

Without doubt, the natural gas supply picture in North America has changed substantially, and it has had a ripple effect around the globe, not only through displacement of supplies in global trade but also by fostering a growing interest in shale resource potential in other parts of the world. Thus, North American shale gas developments are having effects far beyond the North American market, and these impacts are likely to expand over time. Prior to the innovations leading to the recent increases in shale gas production, huge declines were expected in domestic production in the United States, Canada, and the North Sea. This would have meant an increasing reliance on foreign supplies at a time when natural gas was becoming more important as a source of energy.

Shale gas developments stand to exert enormous influence on the structure of the global gas market. Throughout the 1990s, natural gas producers in the Middle East and Africa, anticipating rising demand for LNG from the United States in particular, began

investing heavily in expanding LNG export capability, concomitant with investments in regasification being made in the United States. But the rapid growth in shale gas production has since turned such expectations upside down and rendered many of those investments obsolete. Import terminals for LNG are now scarcely utilized, and the prospects that the United States will become highly dependent on LNG imports in the coming years are receding, with some proposals now emerging for exports of LNG from North America.

Rising shale gas production in the United States is already impacting markets abroad. In particular, LNG supplies whose development was anchored to the belief that the United States would be a premium market are now being diverted to European and Asian buyers. Not only has this immediately presented consumers in Europe with an alternative to Russian pipeline supplies, it is also exerting pressure on the status quo of indexing gas sales to a premium marker determined by the price of petroleum products. In fact, Russia has already had to accept lower prices for its natural gas and is now allowing a portion of its sales in Europe to be indexed to spot natural gas markets, or regional market hubs, rather than oil prices. This change in pricing terms signals a major paradigm shift.

The recent developments around shale in the United States are also having another, potentially market structure-altering effect. Revelations about the existence of technically—and possibly commercially—viable shale gas resources are also occurring in other regions around the world, with shale gas potential being discussed in Europe, China, India, Australia, and elsewhere. To be sure, the enormity of global shale gas potential will have significant geopolitical ramifications and exert a powerful influence on U.S. energy and foreign policy.

Utilizing scenario analysis based on peer-reviewed, scientific assessments of the properties of shales (which the James A. Baker III Institute for Public Policy at Rice University then uses to develop its own technically recoverable estimates and associated finding-and-development cost curves), this Baker Institute study, sponsored by the U.S. Department of Energy, is able to demonstrate that U.S. shale gas can help abate the enhancement of geopolitical power wielded by key petro-states as global primary energy use shifts increasingly to natural gas. Specifically, shale gas will play a critical role in diminishing the petro-power of major natural gas producers in the Middle East, Russia, and Venezuela, and will be a major factor limiting global dependence on natural gas supplies from the same unstable regions that are currently uncertain sources of the global supply of oil. In this way, shale gas can play a critical role in averting a reinforcement of the political risk we currently face in the global oil market.

The geopolitical repercussions of expanding shale gas production include the following:

- Virtual elimination of U.S. requirements for imported LNG for at least two decades
- Reduced competition for LNG supplies from the Middle East, thereby moderating prices and spurring greater use of natural gas, an outcome with significant implications for global environmental objectives
- Lower likelihood of a long-term potential monopoly power of a "gas OPEC" or a single producer such as Russia that exercises dominance over large natural gas consumers in Europe or elsewhere
- Falling market share for Russian gas in non-former Soviet Union (FSU) Europe from 27 percent in 2009 to about 13 percent by 2040, diminishing the likelihood that Moscow can use energy as a tool for political gain
- A reduced future share of world gas supply from Russia, Iran, and Venezuela; without shale discoveries, these nations would have accounted for about 33 percent of global gas supply in 2040, but with shale, this is reduced to 26 percent
- Less opportunity for Venezuela to become a major LNG exporter and thereby lower longer-term dependence in the Western Hemisphere and in Europe on Venezuelan LNG
- Easing of U.S. and Chinese dependence on Middle East natural gas supplies, limiting the incentives for geopolitical and commercial competition between the two largest consuming countries and providing both countries with new opportunities to diversify their energy supply
- Reduced ability by Iran to tap energy diplomacy as a means to strengthen its regional power or to buttress its nuclear aspirations

It should be pointed out that the sustained, rapid development of shale gas is not a certainty. A stable regulatory environment that fosters responsible development of domestic resources is critical to achieving the potential benefits presented by shale. There are several factors that could stymie development not only in the United States, but

also elsewhere in the world. While comprehensive discussion of these factors is beyond the scope of this report, we do note that these variables could greatly impact the pace of shale gas development in the United States and in Europe and other international locations. In particular, environmental concerns regarding the use and potential contamination of water resources have recently dominated the news headlines in the United States and France and, therefore, are among the kinds of major issues that will need to be addressed before governments will allow full realization of shale's growth potential.

Our study finds that under scenarios where environmental and other political factors inhibit the development of shale gas resources north of Virginia, U.S. natural gas production will see less growth over time and import requirements will be substantially higher after 2030, with more demand for natural gas from Venezuela, Iran, and Qatar. As a result, overall U.S. natural gas prices will be about 50 cents/million cubic feet (mcf) higher than they would otherwise be under scenarios where shale gas can be developed across the United States. U.S. Mid-Atlantic states and the Northeast will see a 70 cents/mcf price premium to the U.S. benchmark Henry Hub spot prices.

A prime, often underappreciated, factor that has positively benefited growth in shale gas production in the United States is the unique North American market structure. For example, ownership of transportation capacity rights is unbundled from ownership of the pipeline itself. If such a regulatory structure were not in place, it is arguable that shale gas developments would not have occurred at their recent pace. Unbundling of capacity rights from facility ownership makes it possible for a producer to access markets through a competitive bid for pipeline throughput capacity. Absent this, many of the small producers that first ventured into shale might not have been willing to do so, specifically because access to markets could have been limited. This is inherently a problem in most other markets globally, where pipeline capacity is not unbundled from facility ownership and large incumbent monopolies control much of the transportation infrastructure.

More generally, the United States has a well-developed, competitive regulatory framework governing natural gas infrastructure development, transportation services, marketing, and mineral rights ownership and acreage acquisition. This environment has promoted the rapid development of shale resources, and it may not be fully or quickly replicable in other markets around the globe where state involvement in resource development and transportation is more prevalent. For example, investor access to shale resources is likely to be more heavily controlled in China and most European countries, where land ownership is generally distinct from the ownership of mineral rights, than in the United States, where landowners can directly negotiate terms for access to minerals under their acreage.

Another potential impediment to shale development comes in the form of demand-side policies toward energy use. In particular, many European countries have proactive policies that in some cases favor competing resources (renewables, nuclear, etc.). These types of policies could also serve as a brake on shale investment by limiting overall demand for the resource. Beyond Europe's environmental regulations, any new U.S. or Chinese policies that reduce demand for natural gas—possibly including renewable portfolio standards or carbon dioxide (CO_2) cap-and-trade programs that grandfather coal resources—could also hamper future investments in shale gas resources.

One last point related to market structure is also worth mention. In particular, changes in certain tax policies in the U.S. upstream sector—such as proposed changes to expensing rules, investment credits, and/or royalty rates—could also render investments in shale exploration and production unprofitable at current prices. The richness of the U.S. shale gas play owes its roots to small, independent energy companies who took on the risk to pioneer early entry to the technically challenging and initially costly play in the 1990s. Those companies are helped by rules such as the intangible drilling cost (IDC) expensing rule. IDCs typically represent over 70 percent of well development costs, and are costs that are necessary for drilling and initiating production including, but not limited to, wages, supplies, contractor services, and other similar expenses for which there is no salvage value. Proposed changes to the IDC expensing rule would greatly constrain smaller risk-taking firms that engage in the kinds of investment programs that brought the shale play to fruition. Smaller independent firms have played a critical role in identifying new resource plays over the decades.

Study Approach

In this study on U.S. energy security, the Baker Institute examines the geopolitical consequences of rising supplies of natural gas from shale and the

implications for U.S. security and foreign policy. To investigate this subject quantitatively, we utilize the Rice World Gas Trade Model (RWGTM) to investigate how development of extensive global shale gas resources could alter geopolitical relationships over the coming decades and map out specific implications for U.S. energy security.

The RWGTM is a dynamic spatial general equilibrium model where supply and demand are balanced at each location in each time period such that all spatial and temporal arbitrage opportunities are eliminated. The model, therefore, proves and develops resources, constructs transportation routes and associated infrastructure, and calculates prices to equate demands and supplies while maximizing the present value of producer rents within a competitive framework. Thus, new infrastructure must earn a minimum return to capital for its development to occur. By developing supplies, pipeline transportation routes, and LNG delivery infrastructure, the RWGTM provides a framework for examining the effects of critical economic and political influences on the global natural gas market within a framework grounded in geologic data and economic theory.

The RWGTM allows the examination of potential futures for U.S. and global natural gas in a manner that facilitates quantification of geopolitical influences on resource development and trade flows. The RWGTM predicts regional prices, regional supplies and demands, and interregional flows. Since geopolitical influences can alter market outcomes in many different ways, the nonstochastic nature of the RWGTM facilitates analysis of multiple scenarios and allows the model to characterize how events alter previous, current, and future investment decisions. In this way, the intertemporal nature of the RWGTM allows a complete analysis of the impact on investment decision pathways of specific scenarios. This follows from the fact that capacity and reserve expansions are determined by current and future prices along with capital costs of expansion, operating and maintenance costs of new and existing capacity, and revenues resulting from future outputs and prices.

The Baker Institute conducts its own analysis of supply costs for over 135 regions in three primary categories: (1) proved reserves; (2) growth in existing fields; and (3) undiscovered resources. For this assessment work, we rely on peer-reviewed, scientific assessments of the properties of shales to develop technically recoverable estimates and associated finding and development cost curves. We distinctly avoid nontechnical publications such as investor relations reports. Rather, the resource data derives from sources such as the *Oil & Gas Journal* (OGJ), U.S. Geological Survey (USGS), National Petroleum Council (NPC), Australian Bureau of Agriculture and Resource Economics (ABARE), and Baker Institute research on unconventional resources in North America and globally. Costs have been econometrically related to play-level geological characteristics and applied globally to generate costs for all regions of the world.

The fact that geologists have been writing about the properties of shales since at least the early 1970s is indicative of the fact that, to many of them, shale becoming technically and commercially exploitable was largely an issue of technology, not necessarily geology. Indeed, innovations continue at a pace that is, on average, raising the initial production rate and expected ultimate recovery of wells drilled every year. These two things combined drive down the per-unit cost of development, thereby making a greater amount of resources economically viable at a given price. The importance of this cannot be understated from a geopolitical, environmental, and market development perspective. It is the systematic study of these trends that allows us to model projections of how shale production may develop and influence global LNG movements.

For this study, we use the RWGTM to provide analysis of the recent revelations about shale gas and the role it will play to bolster U.S. energy security in the coming decades. To achieve this purpose, we compare results in an analysis based on three scenarios, which are described below.

- Scenario One: The Reference Case for this study posits a scenario in which all known global shale gas resources can be developed, given prevailing commercial technologies and open tendering practices. This scenario will include all global shale resources that have been identified in Europe and Asia and thereby present a full picture of the current expectations for changing geopolitical and market implications of a full-scale development of known shale gas resources.
- Scenario Two: Under this scenario, projections cover what the world would have looked like had shale developments been strictly limited to the Barnett, Woodford, and Fayetteville shale plays in the United States. Under this scenario, no shale gas outside of North America is open or available for development. This counterfactual scenario aimed to demonstrate what the world would look like if shale gas developments had never progressed to the levels currently under way.

In comparing the first and second scenarios, we provide detailed analysis of what the full exploitation of North American and global shale resources will mean for U.S. energy security by demonstrating what the U.S. gas balance and global flows of LNG would have been had shale resources never been developed. This approach allows a clear delineation of the importance of shale resources to U.S. energy security. By comparing the results from these two scenarios, this study is able to highlight dramatic changes that shale gas stands to bring to the geopolitical landscape by demonstrating how it alters the flows of natural gas worldwide.

- Scenario Three: Under a third scenario, geopolitical implications of only a partial development of U.S. shale resources are explored. In this scenario, specific U.S. shale plays located north of Virginia are blocked from development by environmental and/or other political, fiscal, or regulatory factors. Commercial investment in all other U.S., Canadian, and other global shale gas is permitted in the scenario. While it is possible that environmental obstacles may, at some point, also impact development of resources in other countries, this scenario focuses solely on the consequences of limiting U.S. Mid-Atlantic resource development to highlight the U.S. energy security implications of such policy choices. By comparing this third scenario to the first two scenarios, U.S. policymakers will have the benefit of understanding the costs to U.S. energy security if all American shale gas resources cannot be developed to their fullest extent.

Defining the Resource

Despite very large assessments of resources in-place, the commercial viability of shale is determined as a subset of resources in-place. In particular, technically recoverable resources define the boundary of those resources that can be recovered with existing technology, but economically recoverable resources define the boundary of what is commercially accessible. Thus, large resource in-place estimates do not necessarily imply large-scale production is forthcoming because technical innovations and cost reductions are critical to commercial viability.

Perhaps the earliest example of where innovation made shale resources commercially viable was seen in the Barnett shale in northeast Texas. The application of innovative new techniques involving the use of horizontal drilling and hydraulic fracturing propelled the Barnett shale into the largest single producing natural gas play in North America, a distinction it held until being recently surpassed by production in the Haynesville shale earlier this year. This subsequently altered producers' expectations about the viability of shale resources in other locations, and triggered a virtual rush to shale. Innovations aimed at lowering costs continue, with longer laterals, increased frac stages, and better proppants. For example, Schlumberger Ltd. recently reported very promising results in test wells from the use of its innovative new "HiWAY" fracking technique, yielding up to double the daily production and greater-than-expected ultimate recovery when compared to standard slickwater fracs. In North America, breakeven prices for some of the more prolific shales are currently estimated to be as low as $3, with a large majority of the resource accessible at below $6. Ten years ago, costs were significantly higher. As firms continue to make cost-reducing innovations, greater quantities of the shale resource will become both technically and economically viable.

There has been a wide range of assessments of shale resources in the United States by numerous organizations. Modeling done at the Baker Institute indicates an estimate of technically recoverable shale resource of 637 trillion cubic feet (tcf) in the United States.

Shale gas resources are not limited to only the United States. A notable example is Canada, which is an integrated piece of the broader North American market. Shale gas developments are already underway in western Canada in the Horn River and Montney basins, and are even being linked to a proposed export project at Kitimat on the west coast of British Columbia. Shales in Mexico—while having been identified in the Burgos and Sabinas basins in northern Mexico and Tampico basin farther south—have not been explored to date, making their viability somewhat questionable. Accordingly, the data represented in the RWGTM may understate the potential of shale gas production in Mexico. Nevertheless, the combined U.S., Canadian, and Mexican shale assessments bring the total North American assessment of shale to about 937 tcf, with 165 tcf in Canada and 135 tcf in Mexico.

In fact, the dearth of commercial activity in shale plays outside of the United States and Canada renders any assessment in those regions highly uncertain, meaning the data represented in the RWGTM may actually understate the potential. However, in-depth studies are currently underway to fully assess shale

resource potential in Europe, Asia, and Australia. In Europe, there is active research into assessing shale potential in Austria, Sweden, Poland, Romania, Germany, Croatia, Denmark, France, Hungary, the Netherlands, Ukraine, and the United Kingdom, to name a few locations. Currently, our work at the Baker Institute indicates a technically recoverable assessment in Europe of roughly 220 tcf split between Sweden, Poland, Austria, and Germany, with the largest proportion (about 55 percent) in Poland, and entry costs in the $6–$7.50/mcf range. Data for the Asia-Pacific region is generally even more preliminary, but, as of the date of the modeling done for this study, potential has been identified in China (230 tcf of recoverable resources) and Australia (50 tcf of recoverable resource).

The estimates for regions outside of the United States and Canada in particular are very preliminary and are thus full of uncertainty, but it is possible that estimates of commercially accessible resources in these regions will grow over time, particularly as technologies are developed to lower costs. It is also important to note that in regions where water resources are deemed scarce, the assessment included in the model is reduced, and in some cases where water constraints are extremely severe, no resources from that region are permitted into production at all. In China, water availability for hydraulic fracturing may considerably diminish the potential for domestic shale development in certain regions. For example, in the case of the shale resources in western China, water constraints are likely to make shale development cost-prohibitive. Such constraints might also restrict the potential of the gas-prone Sichuan Basin to a lesser extent. China has already awarded acreage to Chinese firms for shale development in Chongqing, Guizhou, and Hunan provinces.

A decrease of the technically recoverable shale gas resource base in areas with potential water constraints is done primarily because the cost of development has been deemed prohibitive due to the necessity of technologies that reduce the water requirements, which may be in development but are not yet proven. For example, it is possible that breakthroughs in the use of briny water from deep-source aquifers, top-side water recycling capability, and/or the use of super-critical nitrogen or liquefied petroleum gas (LPG) to hydraulically fracture the shale will make much of this resource more viable at some point in the future. Indeed, the emphasis on such technologies could carry with it some environmental benefit as well. While discussion of environmental issues related to shale gas production are beyond the scope of this study, the U.S. government might gainfully investigate the role it could play in promoting these new fracking technologies, given shale gas's positive contribution to U.S. energy security.

To the point of technical recoverability, a recent assessment performed by Advanced Resources International, Inc., (ARI) for the U.S. Energy Information Administration (EIA) indicates that there is as much as 6,600 tcf of technically recoverable shale gas resource globally, with over 4,600 of that outside North America. This speaks to the nature of the shale gas resource—it is large—but assessment of commercial feasibility is still filled with uncertainty in many areas, leaving technology with a critical role to play. The full assessment identified in the ARI/EIA report is not included in this study. The properties for those identified shale resources are still under review, but a preliminary assessment indicates that the cost of development is likely much higher in certain regions, thus challenging its economic viability. For example, shale that is clay-rich is generally not prone to yield high production rates, which in turn tends to reduce its attractiveness commercially, even if there is a large assessment of technically recoverable resource.

Geopolitical Trends: Overview

Prior to the innovations that led to the recent growth in shale gas production, the United States, Canada, and the North Sea were experiencing huge output declines in mature production areas. That meant an increasing reliance on foreign-sourced supplies, which, in turn, left two countries with an apparent stranglehold over future supplies: Russia and Iran. Before the revelations about shale, these nations were expected to account for more than half of the world's known gas resources. Russia made no secret about its desire to leverage its position and create a cartel of gas producers—a kind of latter-day OPEC. This seemed to set the stage for a matriculation to the gas market of the oil issues that have worried the world over the past 40 years—geopolitical instability, the policing of sea lanes, and hand-wringing about the security of supply.

Geopolitically, the repercussions of expanding shale gas production are profound. To begin, the United States will be able to avoid growth in LNG imports for at least two decades.

Additionally, under the Reference Case scenario where shale is developed unfettered, LNG exports originate from a wide diversity of sources instead of

being concentrated in any one geographical region, and no single supplier gains significant market leverage. U.S. shale gas, by displacement, delays for well over a decade the world's reliance on regions that have historically been volatile and greatly reduces the chance of any individual or group of producers exercising decisive monopoly powers. Had this competition from shale not emerged, Russia and Iran would have been dominant forces in the global market, with potentially negative geopolitical consequences for major consuming countries. Moreover, the emergence of shale gas also limits the near-term possibility of a successful natural gas cartel by increasing the elasticity of supply of natural gas in countries outside the Gas Exporting Countries Forum (GECF), thereby reducing the monopoly power that can be exerted by the GECF countries, which include Russia, Iran, and Algeria, among others. Thus, shale gas yields security benefits more broadly than just to the United States.

U.S. ally Qatar remains the world's largest LNG exporter while Australia, notable for its strong support of U.S.-led security coalitions, emerges as a close second. Moreover, the rise in U.S. shale gas supplies means Iran experiences significant delays (15 to 20 years) in mobilizing buyers for its LNG. This limits Tehran's ability to tap natural gas resources as a means of energy diplomacy, giving it less leverage to use in the short run to counter U.S. diplomatic efforts at containment.

In fact, in the Reference Case, world dependence on Middle East natural gas remains below 20 percent until the late 2030s, when rising demand from Asia finally makes its mark. Reliance on Middle East natural gas is significantly lower in a world where U.S. shale gas production can grow unfettered than under Scenario Two, where U.S. shale gas output is greatly constrained. In particular, in Scenario Two, the Middle East supplies about 27 percent of all natural gas by 2040. By contrast, under the unconstrained shale gas case, Middle East supplies only constitute 20 percent of the market by 2040. The Middle East country that is disadvantaged the most as a result of rising shale gas production is Iran, whose exports are effectively delayed by over a decade relative to Scenario Two.

For the United States, the geopolitical impacts of rising domestic shale gas production are dramatic. U.S. natural gas imports from the Middle East are virtually nil from 2011 to 2030 under the Reference Case and then only rise modestly in the 2030s. This is in contrast to markedly higher foreign dependency conditions that might have emerged had U.S. shale developments not occurred. In fact, under Scenario Two where shale gas is not developed, U.S. LNG imports rise substantially, increasing U.S. exposure to events in the Middle East and Russia. Under Scenario Three, where shale gas development is restricted in U.S. northern states, U.S. LNG imports begin to rise after 2030 and, by 2040, substantially higher supplies are needed from Venezuela, Qatar, and Iran than under conditions where shale gas is developed across the United States. Under this third scenario, Russian pipeline exports to Europe and China are also noticeably higher.

The U.S. economy already faces challenges from the high costs of importing foreign oil. Large trade deficits driven by expensive oil imports contribute to the overall weakening of the dollar, and the threat of oil supply disruptions remains a risk factor to overall economic growth and stability. Increasing U.S. exposure to events in the Middle East or Russia through rising purchases of imported LNG is a less desirable outcome than being able to rely on domestic energy supplies that are not subject to geopolitical risks and where monies paid for energy remain inside the U.S. economy. Thus, to the extent that natural gas supplies can be sourced from North America and not in the form of imported LNG, the United States is—all things considered—better off.

The availability of cheaper, ample domestic natural gas supplies could also give the United States greater flexibility to forge policies to diversify its transportation sector away from overwhelming reliance on oil-based fuels. According to our analysis, the price of natural gas is up to one dollar lower, and sourced domestically, when shale developments occur unfettered. The difference in both price and source can be important when trying to encourage fuel switching, particularly if policy measures are involved. Previous Baker Institute studies have demonstrated that an effective way to reduce U.S. oil demand and foreign imports would be an aggressive campaign to launch electric vehicles into the automotive fleet.[1] Since the United States uses barely any oil to generate electricity, ample natural gas for electricity generation means a shift to electrified vehicles would lessen our dependence on imported oil at a lower cost than might otherwise have been possible. Similar benefits could come from increasing

[1] See "Energy Market Consequences of an Emerging U.S. Carbon Management Strategy," http://bakerinstitute.org/emerging-carbon-policy.

the number of compressed natural gas (CNG) vehicles or LNG vehicles. However, differences in vehicle efficiency mean that an increase in the number of electric cars would have less impact on U.S. energy markets and prices than a high penetration of CNG passenger vehicles.[2]

Geopolitical Trends: The Outlook for Russian Exports

Given the impacts across scenarios already highlighted, it is quite obvious that shale development has already had, and will continue to have, significant impacts on regional production, demand, and pricing. Shale gas development has already had a major impact on Russia's status as a global gas exporter and will bring about a more dramatic weakening of Russia's position in Europe over time. If the shale potential now being examined in Europe and Asia reveals any resemblance to what has come to fruition in North America, the impact will be potentially far reaching. In particular, it will carry implications for U.S. allies in Europe, who face a litany of energy security dilemmas surrounding the delivery of natural gas from Russia, North Africa, and the Middle East.

In fact, had the shale play not emerged as a major new source of supply for North America, Europe's dependence on Russia would have remained a major feature of global gas markets and natural gas geopolitics.

Under the Reference Case, Russian exports continue to grow, but the main destination for export growth is the Far East. The prime means of exports from Russia to the Far East is via the development of pipeline transport routes in both West and East Siberia. In particular, the case sees development of the Altai project from West Siberia to western China as well as pipeline development from Sakhalin and Kovykta beginning in 2014. Russia's market share in non-FSU Europe continues to erode, declining to less than 13 percent by 2040. None of the proposed Russian pipelines aimed at feeding the European market, except Nord Stream, are developed. Russian LNG exports from Murmansk, tied to the development of fields in the Barents Sea, and development of resources and LNG export capability from the Kara Sea and Yamal Peninsula, do not occur until well after 2030, based on lack of demand to justify development of expensive Russian Arctic gas resources.

The dramatic lessening of Europe's dependence on Russian gas will likely have considerable geopolitical implications in thwarting Russia's ability to exercise an "energy weapon" or to unduly influence political outcomes on the Continent. European buyers will have ample alternatives to Russian supplies, thereby reducing Moscow's political leverage. This outcome would also contribute positively to the balance of power between Russia and the EU, putting Europe in a stronger position to influence Russian foreign policy near Europe's borders. To wit, Europe's high dependence on Russian pipeline natural gas supplies made it difficult for certain European leaders to engage in diplomacy objecting to Russia's invasion of Georgia in 2008 and weakened their support of the shaky election of pro-Western Ukrainian president Viktor Yushchenko, who was negatively targeted by Moscow for his anti-Russian stances.

A more diverse energy supply for Europe enhances U.S. interests by buttressing Europe's abilities to resist Russian interference in European affairs and to help border states in the Balkans and Eastern Europe assert greater foreign policy independence from Moscow. Coalitions with European nations are an important element to U.S. national security, including efforts to combat international terrorism and prevent humanitarian crises. An energy-independent Europe will be better positioned to join with the United States in global peacekeeping and other international initiatives that might not have the full support of Russia.

Russia's footprint in Northeast Asia (defined here as China, Korea, Japan, and Taiwan) grows as pipeline export opportunities increase, even as shale gas developments begin in Asia. However, Russia's market share in Northeast Asia only increases to 13 percent by 2040, again giving it less geopolitical sway than if exports are higher. Importantly, the assessments for shale gas resources in China are highly preliminary. In fact, if shale gas resources prove to be as robust in China as they are in North America, the

[2] CNG vehicles still rely on internal combustion engine technology, which is less efficient in fuel requirements than electric vehicles, whose engines gain energy from braking and have higher operational efficiency. In fact, a recent analysis of best-in-class vehicle technologies indicates that the well-to-wheel energy efficiency of electric vehicles is roughly three-and-a-half times greater than CNG vehicles. Thus, a shift to a comparable penetration of CNG vehicles would require more energy production than the same penetration of fuel-efficient electric vehicles powered by electricity generated in high efficiency natural gas combined-cycle power plants. For more detailed discussion of this point, see "Energy Market Consequences of an Emerging U.S. Carbon Management Strategy," available at http://bakerinstitute.org/emerging-carbon-policy.

outlook for Russian gas to Northeast Asia would dim significantly.

In stark contrast to the Reference Case, if no new shale is developed (Scenario Two), Russia would be by the far the biggest winner both in geopolitical terms and in terms of improvements in market share. With less competition from emerging shale resources, Russia's market share in non-FSU Europe remains at more than 20 percent into the 2020s and stabilizes at around 19 percent longer term. Moreover, Moscow benefits from higher European prices. In Northeast Asia, Russia's market share increases to about 16 percent as it takes advantage of greater competition for LNG from the United States and develops greater pipeline capacity to meet growing demands in China in particular.

Geopolitical Trends: Implications for Caspian Infrastructure and Resources

The Nabucco pipeline project has been discussed for over a decade as a further solution to diversifying the EU's access to a variety of natural gas supplies from Central Asia and Iraq. An intergovernmental agreement for the project was signed by Turkey, Romania, Bulgaria, Hungary, and Austria in July 2009, and was intended to both reduce Europe's dependence on Russian gas as well as create new transportation outlets for Caspian resources, thereby strengthening the political links between the Caspian nations and the EU. The 2,050-mile-long pipeline was aimed to carry 1.1 tcf of gas a year from the Middle East and the Caspian to Europe. However, the high expense of the project and doubts about the viability and timing of gas supplies have presented the project with substantial obstacles.

But given possible scenarios for the rise of alternative supplies to Europe as shale gas production accelerates, it becomes even less clear whether the Nabucco project will make either geopolitical or commercial sense. Ultimately, the availability of shale gas under the Reference Case scenario means that Caspian flows will not make economic sense as a competing supply to Europe. Rather, under the Reference Case, the Nabucco pipeline project is not constructed until after 2020, at which time lower-cost Iraqi gas would be able to flow into the line. It should be noted that, for the purposes of this modeling exercise, it is assumed that political and other obstacles will prevent Iraqi natural gas to be available in large quantities until 2020.

Shale gas is also a definitive factor influencing the development of outlets for Caspian natural gas exports. Gas exports from Turkmenistan are about 15 percent greater in Scenario Two where no new shale development is permitted, a result driven by a greater need for gas supplies in both Asia and Europe. In fact, the constrained shale case sees the majority of incremental Turkmen exports flow to China, largely because the increased competition for LNG from the United States puts China in a position of securing more of its supply from pipeline sources. Natural gas exports from Azerbaijan are also disadvantaged by shale gas developments, dropping by just over 10 percent when shale is developed unfettered. Thus, Azerbaijan is the exporter most hurt by the advent of shale gas because it blocks the country's opportunity to export its supply via a Nabucco-type project. All together, shale gas development impacts gas suppliers from FSU countries in the Caspian region similar to the manner in which it impacts Russia—lower production and reduced market share in end-of-pipe markets in Asia and Europe.

The implications for U.S. foreign policy of the negative impact on the Nabucco project from shale gas availability are complex. First and foremost, the United States needs to better articulate what its goals are for backing of the Nabucco project. If the primary purpose of the Nabucco line is to diversify European supply away from heavy dependence on Russian gas exports, chances are shale gas availability will remove the primary impetus toward this aim—making Nabucco a relatively unimportant geopolitical priority and strengthening the case for the United States to abandon its proactive support for the pipeline. Instead, the United States may want to focus more on Nabucco's potential as a conduit for the economic development of western Iraq and solidifying Iraqi relations with the West. In this case, the commercial realities will be under less duress from the changing economics brought to Europe by the wider availability of shale gas, and it is more feasible that the line might make sense at some later date once Iraqi gas is ready to flow amply and securely.

However, shale gas plays will mean that the EU and the United States will have greater difficulty developing energy corridors to link the Caspian region countries more closely to the West, and therefore other economic and political avenues will need to be developed to achieve this geopolitical goal, as natural gas exports are unlikely to play a major role in strengthening ties between the two regions.

Geopolitical Trends: Implications for Iran

At the present time, economic sanctions against Tehran have been inhibiting natural gas export project development in Iran. This includes both its previously planned South Pars LNG export projects and a proposed pipeline to Pakistan and India. With no signs of conflict resolution between Iran and the West in sight, it is assumed that the development of Iranian export projects could not begin until 2020 at the earliest.

Greater shale gas production in the United States, and eventually Europe, will also make it more difficult for Iran to profit from exporting natural gas. Iran is currently hampered by Western sanctions against investment in its energy sector, so by the time it can get its natural gas ready for export, the marketing window to Europe will likely be closed by the availability of shale gas. This reality may give the United States and its allies more leverage over Iran for a longer period of time, helping to shape more positive outcomes in the Middle East for U.S. and allied interests. By contrast, Iran is more likely to become a much larger exporter in the case in which no new shale is developed (Scenario Two), primarily because of greater LNG demand from the United States. In the constrained shale case (Scenario Two), Iranian LNG exports grow quickly and, by 2040, they are about 75 percent higher than in the Reference Case. Thus, shale gas plays an instrumental role in delaying the opening for Iran to sell its natural gas, thwarting the country's ability in the near term to use natural gas exports as a means to develop bilateral relations with major gas-consuming countries and limiting its opportunity to use energy diplomacy to strengthen its regional position or buttress its pursuit of nuclear weapons.

Although there are many complex factors that influence Iran's political leverage globally, the circumstance of lower market requirements for Iranian natural gas could make it easier for the United States to achieve buy-in for continued economic sanctions against Iran. Lower interest in Iranian gas reduces the chances that Iran can use its energy resources to drive a wedge in the international coalition against it. By delaying the need for Iranian gas for over a decade, the United States buys time to find a better solution to the Iranian nuclear problem and leaves open the possibility that political change will take place in Iran before its influence as a major global natural-gas supplier grows. In addition, the long delay in the commerciality of Iranian gas means that Tehran will have trouble getting pipelines to India or Pakistan off the ground with mutually acceptable terms, thereby reducing—for at least the time being—a potential source of tension between the United States and India.

Geopolitical Trends: Implications for Chinese Energy Security

Under all scenarios, China becomes a major importer of natural gas both via pipeline and LNG. In fact, China is the largest driver of growth in LNG trade going forward under all scenarios. Like the United States, China benefits from growing shale gas production, which reduces its overall reliance on potentially volatile Middle East suppliers such as Iran.

However, in all cases examined herein, strong Chinese demand for natural gas leads to the strengthening of energy ties between Russia and China. Although this is not necessarily directly against U.S. interests, it could nonetheless make it more difficult for the United States to promote U.S.-China energy cooperation. China may be less interested in strong bilateral or multilateral consumer energy relations involving the United States if it has strong pipeline-oriented dependencies. One can also imagine that a deeper relationship between China and Russia in general might influence the balance of power in Northeast Asia in a manner that is detrimental to U.S. allies in the region.

Shale Gas and Geopolitics: Policy Recommendations and Concluding Thoughts

This Baker Institute study on U.S. energy security has examined some of the geopolitical consequences of rising supplies of natural gas from shale and the implications for U.S. security and foreign policy.

The study finds that full development of commercial shale gas resources in the United States will have multiple beneficial effects for U.S. energy security and national interests. The full and timely development of U.S. shale gas resources will limit the need for expensive imports of LNG, reducing the energy-related swelling of the U.S. trade deficit and thereby helping to strengthen the U.S. economy. Shale gas will also lower the cost to average Americans of reducing greenhouse gases as the country switches to cleaner fuels. Moreover, as greater shale gas production increases competition among suppliers in global markets, U.S. and

international prices for natural gas are kept from rising substantially. However, under a scenario where shale gas development is curtailed in states north of Virginia, consumers can expect to pay higher energy costs, especially in the U.S. Mid-Atlantic states and Northeast, and dependence on Venezuelan LNG will rise significantly. Increased competition among world natural gas suppliers due to shale gas developments also reduces the threat that a "gas OPEC" can be formed, and it will trim the petro-power of energy-producing countries such as Russia, Iran, and Venezuela to assert themselves using an "energy weapon" or "energy diplomacy" to counter U.S. interests abroad. In particular, shale gas's role in global markets will greatly reduce Russia's leverage over Europe, eventually limiting Moscow's share of the non-FSU European market to less than 13 percent, down from its recent peak of 26 percent in 2007.

The dramatic lessening of Europe's dependence on Russian gas will likely reduce Russia's ability to unduly influence political outcomes. European buyers will have ample alternatives to Russian supplies, thereby reducing Moscow's leverage in the balance of power between Russia and the EU. Europe's high dependence on Russian pipeline natural gas supplies has in recent years made it difficult for certain European leaders to engage in diplomacy to forcefully object to Russian interference on the European continent, including Russia's invasion of Georgia in 2008. A more diverse energy supply for Europe enhances U.S. interests by buttressing Europe's abilities to resist Russian interference in European affairs and to help border states in the Balkans and Eastern Europe assert greater foreign policy independence from Moscow. In general, a more energy-independent Europe will be better positioned to join with the United States in global matters that might not have the full support of Russia.

Rising U.S. shale gas supplies will also assist the United States in its policies toward Iran. Given global market economics under a full development-of-shale scenario, the commercial window for Iran to export large amounts of natural gas is likely to remain closed for an additional 20 years, making it easier for the United States to achieve buy-in for continued economic sanctions against Iran. Shale gas development lowers the chances that Iran can use its energy resources to drive a wedge in the international coalition that has mobilized against its current government. By delaying the need for Iranian gas, the United States buys time to find a better solution to the Iranian nuclear problem and leaves open the possibility that political change will take place in Iran before its influence as a major global natural gas supplier grows. In addition, the long delay in the commerciality of Iranian gas means that Tehran will have trouble moving forward with the development of pipelines to India or Pakistan until at least the mid-2020s, thus reducing a potential source of tension between the United States and India.

Finally, the rise of shale gas will lower the global requirements for natural gas from the volatile Middle East and North Africa over the next few years, giving the region time to sort out its current political and social turmoil before its importance as an energy supplier expands beyond its already high levels. Natural gas stands to play a positive role in the global energy mix, making it easier to shift away from more polluting, higher carbon-intensity fuels and increasing the near-term options to improve energy security and handle the challenge of climate change. The ample geologic endowment of shale gas in North America and potentially elsewhere around the globe means that natural gas prices will likely remain affordable and that the high level of supply insecurity currently facing world oil supplies could be eased by a shift to greater use of natural gas without fear of increasing the power of large natural gas resource holders such as Russia, Iran, and Venezuela.

To tap this benefit, it will be essential for the United States to promote a stable investment climate with regulatory certainty. In particular, the United States will need adopt policies that ensure shale gas exploitation can proceed steadily and predictably with sound environmental oversight. The United States should focus squarely on setting the policies needed to ensure that shale gas can play a significant role in the U.S. and global energy mix, thereby contributing to greater diversification of global energy supplies and to the long-term national interests of the United States.

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