

Responding to Change: The New World of Oil and Gas



Bill White, Chair
Leonard Coburn, Rapporteur

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2013 Forum on Global Energy, Economy and Security

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Foreword

The unconventional oil and gas boom in North America continues to reverberate and suggested the topic for the Aspen Institute's ninth annual Global Forum on Energy, the Economy, and Security. About 75 energy experts with various viewpoints and areas of expertise convened in Aspen June 23-26, 2013 to discuss "Responding to Change: The New World of Oil and Gas." The goal was to share information and encourage new, cross-disciplinary, and non-partisan thinking about critical energy and environmental issues.

Five half-day sessions covered production challenges and opportunities; transportation, refining, and chemicals; demand for natural gas; the environmental costs of energy; and global economics and politics. Each session began with a few brief presentations, but a majority of the time was dedicated to dialogue among all the participants. Discussion continued outside the meeting room, and the collegial atmosphere and clear mountain air were conducive to clear thinking. To encourage candor, participants were asked not to attribute specific statements to anyone by name, and this report follows that rule.

Bill White, Chairman of Lazard Houston and former Houston Mayor and U.S. Deputy Secretary of Energy, served as chair. His wealth of experience in energy allowed him to guide the discussion and extract key information and insights from the diverse participants, and his skill at moderating kept the meeting on track.

The Forum could not take place without the support of our sponsors, and the Institute is grateful for their generosity and their commitment to our work.

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I also thank Leonard Coburn, who has written the reports for this Forum since its beginning in 2005. His extensive experience in domestic and international energy policy, both as an official of the U.S. Department of Energy and as a private consultant, enabled him to understand and capture the highlights of a rich and extensive discussion.

On behalf of the participants and myself, I thank Nikki De Vignes for her gracious and efficient management of all the details so essential to a pleasant and smoothly run meeting. As always, Tim Olson was a rock, anticipating and solving problems for this meeting even as he was making arrangements for ones that followed.

This report is issued under the auspices of the Aspen Institute. The Forum speakers, participants, and sponsors are not responsible for its content. It is an attempt to represent fairly views expressed during the Forum, but all views expressed were not unanimous, not everything could be included in a summary, and participants were not asked to agree to the wording of the report.

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Rapporteur

The New World of Oil and Gas

Improved technology has led to enhanced oil and gas productivity at lower cost and significant production increases in the United States and Canada, dramatically changing energy perspectives. The shift from energy scarcity toward abundance is requiring new energy policies. The potential for the United States to become a net exporter of oil and gas changes American views of energy dependency. Shifts in global energy demand growth from developed to less developed countries, and especially to the Asia-Pacific region, require understanding of changing global energy trade. American energy will flow to markets where scarcity is the largest. Canada and the United States are reaping the benefits of this new world of oil and gas. Mexico will lag behind unless it addresses its chronic problems. Without reform, Mexico could become a net importer of all its hydrocarbons, a fundamental change from its current status. Responding to these changes will require knowledge, foresight, and strategies that are bold and comprehensive.

Technology

Technology is the great enabler of the current revolution in production. The shift from conventional to unconventional resource development is made possible by advances in horizontal drilling and hydraulic fracturing (fracking). The ability of drillers to extend the reach of wells thousands of feet along a shale deposit and then crack the impermeable rocks to enhance the flow of hydrocarbons is changing the U.S. oil and gas picture from scarcity toward abundance. American industry is still in the early stages of understanding this resource and developing the technology to exploit it.

Supporters believe that fracking can be done safely; opponents question whether industry can manage its risks. Prudent regulation can assuage these concerns, allowing governments, industry and stakeholders to address the environmental and social impacts of unconventional hydrocarbon development. Industry knows one bad actor or one bad well can have enormous consequences.

Advances in technology are improving industry performance. Industry identifies the best places to drill before drilling a single well. Pre-drilling analysis leads to better well performance and more robust production with enhanced environmental management, all at lower cost. Horizontal drilling is fast, efficient and can be executed from small multi-well pads to reduce surface footprint. More multiple fractures can be created and monitored in real time using micro-

seismic techniques. New well construction techniques can reduce water requirements, reduce emissions and protect groundwater.

Still, questions remain. Problems include low producing wells, high water usage, and disposal of produced water. Waterless fracturing is being demonstrated along with water-neutral operations (reusing injected water to minimize the need for produced water disposal). Using brackish water rather than fresh water in arid environments resolves some water concerns. Studies are underway to determine the level of methane releases during drilling, production, and transportation and how it can be eliminated. (Methane is a much more potent greenhouse gas than carbon dioxide in the short term. One pound of methane released has the climate-forcing impact of 21 pounds of CO₂ emissions, although CO₂ stays much longer in the atmosphere.) Surface spills and their ensuing environmental damage still can occur and are a significant reason why some local communities oppose shale development.

Technological innovation created the revolution in unconventional oil and gas resource development. Technology can assist in solving lingering concerns, but not without engagement by all stakeholders. Industry must learn to be more collaborative and cooperative if the United States is to continue down the path of widespread unconventional resource development.

The Outlook and Public Policy Choices

Global energy demand growth is projected to continue through 2040, increasing overall by thirty-five percent. Energy use in developed countries will stabilize while developing nations will see a sixty-five percent increase in demand. Global population will increase from 7 billion to about 9 billion, and this growth combined with higher economic activity will drive the energy demand growth.

In the developed world energy efficiency gains in transportation, appliances, and electric power generation are expected to keep energy use flat even as economic output grows by 80 percent. The world's energy mix will evolve, with oil remaining number one while gas replaces coal in the number two position, followed by renewables and nuclear.

Globally, electricity generation will lead energy demand growth, followed by the industrial and transportation sectors. Developing countries will account for the entire rise in electricity demand. Coal will remain the dominant fuel for electric power, but gas will catch up while nuclear and renewables grow the fastest. Asia-Pacific transport growth will lead all regions. World-wide, light-duty vehicle fuels will peak and decline as more hybrids are introduced. The largest increases in transport fuels will be in the heavy-duty vehicle segment. With the continued heavy reliance on hydrocarbons, CO₂ emissions will continue to increase, led by China, India and other

developing countries. In the developed countries CO₂ emissions will remain flat and eventually decline.

To meet the need for gas and liquid fuels, unconventional supplies are projected to grow substantially. Unconventional gas will overtake conventional gas in North America. Unconventional oil will become an increasing component of total supply. By 2020 North America is likely to be in a position to be a net exporter of gas; net oil exports are likely to follow a decade later.

Internationally, significant shale gas potential exists in China, Argentina and Europe. China is likely to move forward aggressively after it overcomes its own geological hurdles. China's shales differ from America's, necessitating a better understanding of production techniques. But China's shale gas is found in remote, arid areas, which poses serious infrastructure and water problems. Argentina's potential is big but it needs infrastructure, capital and drilling experience. Europe will be more difficult to penetrate given the polarized debate throughout Europe over fracking, its population density and differences in mineral rights ownership.

Mexico will not participate in this regional energy balance shift. Mexican oil production is stagnant, oil exports have contracted, and refined product and gas imports have surged. Large increases in electric power demand are driving the need for more gas. The shale revolution occurring in the United States is currently bypassing Mexico. Without energy sector reform these trends will continue.

Energy reform requires a change in the Mexican Constitution, which vests ownership of oil and gas resources in the government and forbids foreign participation in these resources through concessions or contracts. Reforms could alleviate these obstacles; however, they will take time and careful planning to succeed. Mexico's biggest problem is lack of investment in new resource development that will alter its current downward trajectory. Pemex, the national oil company, is being drained of revenues to support the federal government—30 percent of the budget comes from Pemex. Without

sufficient investment by Pemex and other international oil companies, Mexico's ability to expand oil and gas production will continue to suffer.

Just as Mexico requires new energy policies to participate in North America's energy revival, the United States must develop policies to respond to the new world of oil and gas. The unconventional oil and gas revolution occurred in the United States despite the lack of a comprehensive, integrated energy plan, but a plan going forward should emphasize economic growth, energy security and environmental stewardship. To facilitate these goals, the U.S. government needs to encourage technology and innovation. Light-duty vehicles could improve fuel economy by 60 to 90 percent by 2050 through hybridization, light-weighting, and aerodynamic vehicle improvements. Heavy-duty vehicle fuel economy could improve by as much as 100 percent with both engine and vehicle design enhancements. Government supported research can assist in achieving these goals as well as the development of alternative fueled vehicles and infrastructure—natural gas, electric and fuel cells.

Hydraulic fracturing and horizontal drilling led to today's energy abundance. Government regulation could foster or impede using these technologies in the future. Industry generally believes that regional geological differences require regulations accounting for these variations and that states are best suited to develop and enforce regulations that keep up with the rapid change in technology. Others are convinced that the federal government should establish minimum standards. Clear, science-based regulations specific to each region reflecting best practices are in the best interests of all.

Infrastructure

The development of transportation infrastructure for fuels needs clear policies. Existing infrastructure needs a framework to ensure safety, reliability and resiliency. New infrastructure is needed to move energy from growth areas to areas of high demand. Canadian oil sands and American tight oil and shale gas production are increasing faster than the construction of new pipeline capacity.

Liquid pipelines are generally the safest, most cost-effective and environmentally sound means of transporting hydrocarbons. Gas pipelines have similar characteristics but do not compete with trucks or rail. Today, more than 2.5 million miles of gas and oil pipelines are operating throughout the United States and Canada with fewer accidents or spills than trucks or rail. Liquid pipelines are 47 percent less likely than trucks to spill.

Production in the Bakken and Eagle Ford tight oil formations and Marcellus shale gas deposits is rapidly rising. Pipeline capacity is lagging. By one estimate, more than \$40 billion of investment in new capacity, representing 8 million barrels per day of new or upgraded liquid capacity, is on the drawing boards. In the past decade, more than 12,000 miles of new gas transmission pipelines have been built, with much additional capacity planned. In the past three to five years, rail movements have grown 350 percent as permitting slowed new liquid pipeline capacity. Rail shipments are likely to continue to rise until additional liquid pipeline capacity is built, but one thou-

sand rail cars per day are needed to transport the same volume carried through a pipeline. Some shippers prefer rail as a temporary solution since these movements offer more flexibility and less up-front capital cost.

Pipelines are the optimal long-run solution. In the short run they confront serious headwinds due to permitting delays and organized opposition at the local and national level. Federal permitting of gas pipelines slowed from an average of two years to an average of three to three-and-a-half years due to budget shortfalls, personnel change-over, loss of expertise and more active opposition by participants in the permitting process. Liquid pipelines require permits at the state level, where local agencies also are slowing down issuance of permits due to local opposition.

Local opposition is often based on “not in my backyard” (NIMBY) sentiments, but it also is sometimes based on specific incidents such as recent oil pipeline spills in Arkansas and Montana. Greater outreach and clearer and detailed information on safety and environmental impacts can help address these concerns. For example, the most common reason for breaks and spills in liquid pipelines is strikes from machinery operated by third parties.

At the national level, the environmental debate over continued use of fossil fuels and their climate change impacts engenders a more profound and determined opposition. Many environmental opponents will not be satisfied by industry’s efforts to introduce and rely on enhanced safeguards. Their opposition is more fundamental, opposing any hydrocarbon development no matter how necessary or safe, or particular projects considered to have greater climate impacts. Development will occur despite this opposition. Industry must move forward to address environmental concerns and continue to develop oil and gas resources in the most environmentally responsible manner in order to allay the concerns of the majority. If the newly abundant resources are going to be produced and transported, then policies satisfying the majority are needed that will minimize their environmental and societal impacts.

Refining and Petrochemicals

The new world of oil and gas is creating new opportunities for refining and petrochemicals. Some East Coast refineries relying on more expensive imported crude oil are shutting down, but in one case private equity investors are changing the way a refinery operates. They are refining Bakken oil carried by rail and running the refinery using gas from the Marcellus. By using Bakken oil, they are paying domestic crude oil prices linked to WTI (West Texas Intermediate) rather than higher prices linked to Atlantic Basin Brent, and they are reducing their foreign crude oil bill by \$6 billion annually. Rail provides more flexibility and lower investments in loading facilities. High-speed unit train loading facilities will be able to handle two unit trains daily with 120 cars carrying over 70,000 barrels of crude oil per car. Capital markets like what they see and are responding by oversubscribing the capital demands.

The petrochemical industry is also responding to the resurgence in unconventional oil and gas production. Naphtha and ethane, its most important inputs, are cheaper. More oil production produces condensates (light oil products) and naphtha, a feedstock for ethylene. Increased wet gas production (gas with associated natural gas liquids, or NGLs, including ethane, butane, and propane) produces ethane, another feedstock for ethylene. The industry can use either naphtha or ethane as a primary feedstock for ethylene that can be turned in plastics or many consumer goods.

The availability of low cost ethane encouraged the petrochemical industry to return some production to the United States from foreign locations. The U.S. advantage compared to the rest of the world, except the Middle East, is now about \$600 per ton. About 25 chemical plants potentially are coming on line by 2018, costing \$1.5 billion each and adding 150 permanent jobs per plant. Construction requires about 3,000 jobs per project. The largest impact will be in the Gulf Coast region, with some spillover in the Marcellus region.

The petrochemical industry's need for NGLs and condensates is helping drive both American gas and oil production. The result is a global transformation of the petrochemical industry with a reorientation to the United States. America will increase its existing global markets and will develop new export markets. The ripple effect from the new world of oil and gas continues apace.

Gas Demand

Electric Power and Industrial Sectors

Abundant low-priced shale gas supplies meant more gas demand in the last five years in the American electric power and industrial sectors. In both sectors, availability and price are the drivers of gas demand. Together the two sectors are responsible for between 57 and 65 percent of national consumption now, while higher levels are possible in the future.

In the power sector, gas-fired generation dominated new capacity growth over the last two decades, adding 66 percent of net new capacity. Gas-fired power plants have the largest share of generation capacity at over 39 percent with coal at 30 percent. Electric power generation represents between 33 and 40 percent of daily natural gas demand in 2013.

Not all of this capacity is used on a daily basis. Dispatch of power plants occurs based on several factors. The most important, price per kilowatt hour, is mostly based on fuel price. The generation market is extremely sensitive to prices. Low coal prices mean using more coal-fired power plants. Declining gas prices mean using more gas-fired capacity. For a short period in April 2012 gas-fired dispatch equaled coal-fired dispatch at about 33 percent each of total power generation—an historic first. As gas prices increased due to slowing gas production, gas-fired power plant use retreated.

Two other developments could lead to more power sector gas use. One is the retirement of old coal-fired coal plants due to age or new environmental rules. The second is operational limits on generation mix imposed by legislators, regulators or market managers.

The industrial sector comprises about 27 percent of total gas demand. It is expected to increase more than 25 percent over the next decade due to abundant, inexpensive gas. Much of the rapid growth originates from new petrochemical plants and specialty steel production. The latter will be driven largely by demand for the equipment and pipe needed for gas and oil development.

Industrial demand is extremely sensitive to future expectations of price. The high capital cost of new plant construction and the long lifetime of plants require future gas prices that remain low and stable. The continuation of low cost shale development as well as greater certainty about the impact of potential gas exports on future gas prices will be critical in stabilizing expectations.

Natural Gas Vehicles

The potential for using gas in transportation is enormous. Today, liquids comprise 99 percent of the transportation market. Gas and other fuels comprise only one percent. Although the hurdles for gas are high, the possibilities in the heavy-duty truck market are greater than in the larger light-duty vehicle market.

The Future Transportation Fuels Study of the National Petroleum Council found gas could be used as easily as liquids in both heavy and light-duty vehicles. Technology is not dissimilar; similar powertrains are used. No major breakthroughs are required. The biggest obstacle is infrastructure to support the conversion to gas.

Focusing on heavy-duty vehicles first led to some market penetration. Sales of gas powered refuse trucks are approaching 50 percent. Many bus operators are switching to gas as fuel costs remain low compared to diesel. New interest is occurring in rail and marine transportation. Heavy-duty truck corridors are developing due to

the combination of new gas-powered engines, fueling infrastructure, and low gas prices. Overcoming the inertia caused by the heavy investment in diesel infrastructure will take time, but the abundance of low cost gas eventually will give more cost-conscious diesel truck owners a financial incentive to switch.

The light-duty vehicle market, comprising 60 percent of liquid fuel demand, will be more difficult to penetrate. Fuel cost comparisons favor compressed natural gas (CNG) over gasoline by as much as \$2.00 per gallon equivalent, but infrastructure hurdles for natural gas vehicles (NGVs) are much higher. Currently, out of 150,000 gasoline stations, only 1,000 have CNG available and only half of those are available to the public. Stations with CNG cost considerably more to build than traditional stations. The biggest challenges for light-duty NGVs come from costs associated with refueling infrastructure and the cost and space requirements of onboard tank storage.

Home refueling currently costs about \$5,500. Research goals are to lower costs to \$500. On-board storage costs average \$3,500. The goal is to lower these costs to \$1,500. Today's payback for NGV systems is more than 15 years; the goal is to reduce this period to less than five years. New research will result in future NGV refueling and storage systems being competitive with today's liquid fuel systems. When these systems become competitive, an entire new source of gas demand will take off.

Natural Gas Exports

The United States is likely to become a net exporter of gas by the end of the decade. Demand for gas will not keep up with its supply growth. Exports of liquefied natural gas (LNG) will be necessary to maintain balance in U.S. gas markets.

LNG export permits are required from the Department of Energy (DOE) and from the Federal Energy Regulatory Commission (FERC). DOE permitting for facilities with sales agreements with Free Trade Agreement (FTA) countries has been swift. Approval of

applications for facilities with sales agreements with non-FTAs has lagged considerably. Once the DOE approvals are in hand, facilities must apply to the FERC where the entire process can take years. Currently two facilities have been fully approved by the FERC. Applications have been filed for six more, representing 9.8 bcf/d (billion cubic feet per day), and eight are in pre-filing, representing 10.5 bcf/d. Applications for about 33 bcf/d, or half of United States daily consumption, have been filed with the DOE and FERC, although no one believes that all of this capacity will be permitted or built. Nevertheless, the slow permitting process threatens to limit the benefits of the gas boom for the economy in terms of spending and jobs while tarnishing America's free trade credentials.

At some level industry, electric generation, transportation, and exports will compete for new gas supplies. Many industrial and electric power gas users are concerned over the possible impact of excessive LNG exports on the gas market. They argue that too many exports will drive up prices to the point that using gas will be too expensive. Sustained high prices could drive away investment in petrochemicals, steel, and transportation and reverse the trend toward greater gas use in generating electric power.

Supporters of LNG exports argue that price increases resulting from increased demand will be self-correcting as the higher prices call forth greater production. Moreover, global competition will limit the number of viable export projects. Other projects under construction in Australia or proposed in Africa will vie with American projects for buyers. Not all facilities that have applied for export licenses will be able to find long-term buyers, perhaps one in nine, and financing will be impossible without long-term contracts. Supporters of exporting LNG say there will be enough low cost shale gas to support several export projects. Initial decline rates in shale gas wells were high. Additional experience, though, shows slower and longer decline rates. The shale gas revolution is not a flash in the pan that is likely to dissipate quickly due to quick exhaustion of wells.

Environmental Costs of Energy

Surface disturbance, water use, methane emissions, and high carbon content are some of the environmental costs associated with gas and oil resource development. Public perceptions of industry performance in handling these challenges are critical if industry wants to maintain or increase production.

Surface Disturbance: All energy production entails some surface disturbance ranging from minimal to extensive impacts. Shale gas and tight oil development appear to be at the low end of surface disturbances due to the use of horizontal drilling. Field development with only vertical wells requires multiple well pads spread out over a significant area. Using horizontally drilled wells, one well pad of 5 to 7 acres can access the same subterranean resource as 32 vertical wells with pads of 1 to 2 acres each. Comparing vertical and directional wells, a Marcellus conceptual shale gas study found production levels as much as 600 percent higher using more directional wells on the same number of well pads while disturbing the same number of acres.

Water Use: Nationally, oil and gas systems are responsible for less than five percent of all water withdrawals. Extraction entails less than one percent while refining and petrochemicals are responsible for four percent. At the local level, however, oil and gas production can represent significant water use. The shale revolution is putting pressure on local aquifers and engendering strong local reactions.

The extraction process involves several environmental risks, mostly involving water. Drilling and completion of a single well requires close to two million gallons of fluids, of which over 98 percent is water. In comparison to biofuels such as corn ethanol, soy biodiesel, or algae, water use in shale gas extraction is extremely low. But two million gallons of water used in fracking can create environmental risks once large portions of the water, chemicals, and sand return to the surface. Waste water removed from the production site by truck creates noise, air pollution, dust, road damage, and accident risk, and the water must still be disposed of safely. Even if the liquids are stored in pits on site, there is a possibility of leakage.

Reinjection in separate wells and water treatment are two additional ways to handle waste water. Reinjection can reduce costs. Water treatment facilities are expensive to run and can be easily overwhelmed by large volumes. Reinjection, however, has its own problems. Some states permit it (Texas, Ohio); others do not (Pennsylvania). Reinjection caused seismicity problems in some areas where the injection well tapped into a fault line.

A proposed solution to the water use conflicts between oil and gas production, agriculture, and other uses could be the creation of water markets. Setting up a market for water could ensure that the water goes to its highest value uses and reduce local fights over access and use of water.

Greenhouse Gas Emissions: Emissions from gas and oil production can be a serious environmental cost. Substituting gas for coal has enormous benefits. In electric power production, coal produces an average of 2,200 pounds of CO₂ per megawatt hour, while gas produces only 950 pounds, a 57 percent reduction. Electric power generation is only part of the picture since methane, a more powerful greenhouse gas, can leak from each segment of the entire chain of production, processing, transmission, and combustion. Leakage above a small percentage can eliminate the climate change advantage of replacing coal in power plants with natural gas. Current research is delving into the level of methane leakage in every stage of

the gas production to combustion chain. With more data, corrective measures can be taken to deal with methane leakage, reducing even more GHG emissions from gas production and usage.

Comparative Study: The degree of concern about environmental risks associated with hydraulic fracturing and horizontal drilling was tested in a study comparing two states—Pennsylvania and Texas. After extensive surveys were done the conclusion was that in general the public is supportive of gas development in both states, but they want more certainty that industry is doing it right.

State regulation is an important factor in gaining public support. Twenty-five regulatory elements were evaluated in twenty-seven core oil and gas producing states. The top five states by number of gas wells regulate more production elements than the national average. Most states use command-and-control or case-by-case methods while very few use performance-based standards. The top five producing states are not among the most stringent in their regulations, although Texas and Pennsylvania are more stringent than most. This examination concluded that there is great heterogeneity of regulation among the states, but this is not necessarily bad. It allows various states and their citizens to compare their regulatory practices with those of other states.

High Carbon Content: Should a producer of high carbon oil be expected to shut in its production to reduce environmental risks while acceding to more production of lower carbon oil? Higher levels of CO₂ and other GHG emissions come from using Canadian oil sands than Bakken tight oil. The Canadian oils are heavier (more viscous), with higher levels of carbon involved in both their production and combustion, than the lighter tight oils from Bakken. Diluents that add to GHG emissions must be combined with the heavy oils to make them flow through pipelines. The additives are not necessary with the lighter oils. Petroleum coke, an extremely high-carbon product, is produced when heavy Canadian oil is refined. Would it be more beneficial from an environmental viewpoint to produce less Canadian oil sands or even shut in current production until

absolutely necessary as a way of reducing the environmental impact of global energy production? What are the economic consequences of such a decision? While shutting in Canadian oil sands production may be theoretically desirable from an environmental perspective, the practicality of this course of action is highly speculative. Discussion among the experts did not find a definitive answer to these questions.

Geopolitical and Economic Impacts

Geopolitical Impacts: Unconventional gas and oil production in the United States is developing in a dynamic energy environment and volatile geopolitical landscape. Today, the United States is a net energy importer. By 2030, the shift to unconventional energy will make it a net energy exporter. It will find stiff competition for its energy from many other exporters as global energy demand shifts away from the developed world to the developing world and especially to China and India. Middle East and African energy will become more important to Asia than to the United States. These shifts portend changes in international relations as China and other nations become more import dependent and the United States less so. Will the United States remain the protector of the Middle East if Middle Eastern energy is less important to America? Is China likely to assume America's role as protector of Middle East energy producers and sea lanes? Or will the U.S. role continue due to the importance of Middle East energy to American allies in Europe and Asia and due to the continuing, albeit reduced, vulnerability of the U.S. economy to oil price shocks? No definitive answer came from the assembled experts.

Europe remains dependent on energy imports. Russia, North Africa and the Middle East currently supplement indigenous supplies. Europe's future sources will become increasingly diverse as imports from North America, South America and Central Asia are added to the mix. What does this mean for Russian exports of oil and

gas and the leverage they provide over Europe on pricing and other issues? Will lessening European demand require Russia to shift its exports to Asian markets?

Russian Gas and its Implications: Russia is experiencing a surplus of gas with limited market options. Most is sold into the domestic market, with only 30 percent exported. Russian gas is demand constrained due to a variety of domestic and international factors. Domestically, there is little opportunity for expansion as economic growth slows and Russia becomes more energy efficient. To balance markets, Gazprom is reducing production as independent producers continue to increase production and market share, now nearing 30 percent of total production. Despite these changes, surplus production continues. More Russian producers are turning to the export market to sell their surplus.

Gazprom remains the sole vehicle for all gas exports, although recent policy proposals opened the export door a crack with the opportunity of independents to export LNG from Yamal via the Arctic route to Asia. Gazprom is facing strong headwinds in Europe, its largest traditional market. European gas demand looks increasingly weak due to the ongoing recession, the switch to renewables to control GHG emissions, and the impact of low American gas prices forcing more American coal into European markets where it substitutes for gas in power generation. These factors are leading to declines in European gas markets—down about nine percent in 2012 as almost all European countries reduced their Russian gas imports—and in the future will lead to slower growth.

With over 90 percent of Russian gas exports going to Europe in 2012, Russia's dilemma is how to diversify its markets. Future exports to Europe, especially as European gas production declines, could improve since Russian gas is the most competitive incremental source. In expectation of this future growth, Russia is building new, high cost pipelines into Europe (Nord Stream and South Stream), bypassing Ukraine and Belarus, which have reduced the netback to Russia. But Europe's desire to diversify its gas sources

may offset these actions and result in continuing pressure on Russia's gas exports.

China holds the greatest potential for Russian pipeline gas exports. The two countries have been negotiating for more than a decade with little movement on price to resolve differences. The recent visit by Chinese President Xi Jinping in March 2013 reduced differences but did not seal any deal. China's diversification strategy to import pipeline gas from Central Asia and LNG from multiple sources prevented resolution of Russian-Chinese price disparities. Russia is looking to enhance its "Go East" strategy by building a gas pipeline all the way to the Pacific coast and to export LNG, bypassing China entirely. The extraordinary expense of this strategy as well as intense competition for Asia-Pacific LNG markets could leave Russian gas uncompetitive. Russia has great ambitions in all its export markets, but the increasing supply of low-cost unconventional gas in North America is challenging their plans.

Economic Impacts: The impacts of enhanced oil and gas production on the American economy are significant in the short run. As domestic tight oil and shale gas production increases, it is acting as a stimulus for the U.S. economy similar in size to the American Reinvestment and Recovery Act of 2009. The estimated level of GDP from 2013 to 2020 will be between 0.6 percent and 2.1 percent higher than it would have been without the boom. Short-run GDP growth will be stimulated by an average 10 to 20 basis points annually due to the increased production. Growth beyond 2020 is not expected to be meaningfully affected.

The short-term growth is not spread evenly, either geographically or among industries. Low-population producing states are the biggest winners geographically, and the chemical industry is the most advantaged industry, with lower input costs for ethane and naphtha. Energy intensive industries such as fertilizer, steel, and glass also benefit from lower cost energy inputs. Since these industries account for only a little over one percent of U.S. GDP, there will be little lasting impact on overall American competitiveness. Although

the short term impact is positive, like the 2009 stimulus package, the shale revolution will not be as economically transformative as the shift from wood to coal, or coal to oil and gas, or the IT revolution with its productivity benefits.

Foreign Investment in United States: The United States has a long history of openness to foreign direct investment with episodic legislation directed at particular risks. China's increased need for oil and gas imports and the attractiveness of U.S. technology and resources has led to efforts by China to buy or invest in American companies, starting in 2005 when China first attempted an acquisition in the energy industry. American policymakers and the public have viewed such attempts with varying levels of concern. The Committee on Foreign Investment in the United States (CFIUS), an advisory committee to the President created in 1975, is the vehicle relied upon to review proposed acquisitions or investments.

CFIUS is made up of many Executive agencies including Defense, Commerce, Homeland Security and Energy. CFIUS examines a transaction by a foreign person who acquires control in a U.S. company to determine whether the acquisition "threatens to impair" national security. Based upon the recommendation of CFIUS, only the President can prohibit or place conditions on the transaction. For the last eight years, Chinese investment has been the focus, even though many other foreign companies have invested in U.S. energy assets. CFIUS reviews have led to only a few situations where the acquisition of an American company by a Chinese company was not allowed. The United States still remains the most open economy for foreign direct investment.

Policy Choices: American energy policy since the 1960s has been a search for decreasing vulnerability and dependency and even independence. As both dependency and vulnerability appear about to become historical obsessions and independence a possibility, will the shift from scarcity to energy abundance alter American perceptions of its world role? Will OPEC and other producing nations view the United States differently? Will swing oil or gas producers con-

tinue to invest in spare capacity? If not, how will this change world energy markets? Will future energy markets be more or less stable? If less stable, will destabilization undermine politics in nations highly dependent on oil or gas revenues? Will gas pricing remain regional or transition to a global price? Will gas prices still be linked to oil prices or more to gas-on-gas pricing? All these questions heighten the uncertainty surrounding future global energy markets and make policy choices difficult, and they led to wide-ranging discussion in the Forum with few definitive answers.

Conclusion

The new world of oil and gas is causing dynamic upheavals. Technological advances in horizontal drilling and hydraulic fracturing in the United States are turning energy scarcity to energy abundance. Continued development of Canadian oil sands in conjunction with the American shale revolution will lead to North American energy exports by the end of the decade. Mexico appears likely to lag behind due to obstructionist energy policies and slow reforms. Technological progress will continue as industry gains experience with fracking and regulators better understand the health, safety and environmental implications of sustained unconventional gas and oil production. Developing an integrated energy policy will enable the United States to understand and respond to the changes occurring as a result of the shift from conventional to unconventional resource development and from energy scarcity to abundance.

Increased resource production poses challenges to the oil and gas transportation system as it strives to keep up with the huge increases in both unconventional oil and gas production. Oil and gas pipelines may be the safest, cheapest, and least environmentally harmful method of transportation, yet some oil shippers prefer the flexibility and lower capital requirements of rail or are forced to it by permitting difficulties. Old refineries may find new life as they rely on new supplies of tight oil shipped by rail. The petrochemical industry is moving back to the United States for cheaper ethane and naphtha

inputs, and the resulting lower chemical prices are enhancing the competitiveness of American products.

More American gas poses a happy challenge as multiple new markets compete for its use. Electric generation is the largest domestic market for gas, and net capacity additions over the last decade create the potential for significant additional demand. But it is not a certainty. Coal cannot be counted out, since the choice to run existing coal or gas plants is extremely sensitive to gas prices, as experience in the last two years has demonstrated. For industrial uses and especially petrochemicals, it is the long-term expectations for gas prices that matter because of the long lead time for building new plants and the need to compete with other gas-rich countries. The light- and heavy-duty vehicle market can be an enormous source of gas demand if infrastructure hurdles can be overcome. LNG exports will start by 2018 as construction of the first licensed facility is completed. The looming question is whether large numbers of export facilities will be built and raise gas prices, potentially reducing the incentives for expanded industrial, power plant, and transportation use, or whether competition in the global LNG market will limit the quantity of exports and their impact on the domestic gas market.

The shift to more unconventional production brings more concern over the environment. Unconventional resource development brings surface disturbance, water use impacts, increased methane emissions, and high carbon oil development. Regulators are learning how to cope with all these issues while the public is becoming more involved in finding solutions.

The changes occurring in North America are raising a host of geopolitical issues, many of which have no definitive answer. In the United States, the economic impact from unconventional resource development has been positive, acting like a stimulus package on short-term GDP and employment growth. In Russia, domestic gas surpluses and the growth of American shale gas disturbed its traditional European gas market, forcing it to look elsewhere to market its surplus gas. The drive for gas export markets in the Far East

will force Russia to build expensive pipelines and LNG facilities on its eastern coast while competing in Asia-Pacific markets with less costly gas from Australia, the Middle East, and Africa.

The impact of the new world of oil and gas is positive and productive. Yet questions remain. There is much more to be learned and assimilated by all stakeholders if this transformation is to continue and reach its full potential.

APPENDICES

Agenda

Responding to Change: The New World of Oil and Gas

Chair: Bill White, Lazard Houston

Former Houston Mayor and Deputy US Energy Secretary

Sunday, June 23

6:30 – 9:00 PM

Opening Reception and Dinner

Monday, June 24

8:30 AM – Noon

SESSION I: PRODUCTION CHALLENGES AND OPPORTUNITIES

The opening session will examine the North American oil and gas renaissance and the potential for continued increases here and globally. A view of supply and demand prospects to 2040, consideration of policy impacts on production, and a closer look at challenges and opportunities involving shale gas, tight oil, oil sands, and Mexico will lay the ground for participant discussion.

A View to 2040

**Pete Trelenberg, Manager
Environmental Policy & Planning
ExxonMobil**

Policy Influences	Clarence Cazalot, Jr. Chairman and CEO, Marathon Oil
Unconventional Oil and Gas	Rod Nelson, Vice President Government & Community Relations Schlumberger
Mexico	Adrian Lajous President, Petrometrica, and former CEO, Pemex

1:30 — 5:00 PM

SESSION II: MIDSTREAM AND DOWNSTREAM

Increased oil and gas production in new locations is imposing burdens and opportunities on pipeline companies as well as refiners and petrochemical companies. Existing pipeline networks are not ideally configured to connect new sources of supply with demand. Matching types of oil with refinery capabilities creates challenges for both pipelines and refiners, and different oils and refined products generate different levels of greenhouse gas emissions.

Transportation	Russ Girling, President and CEO TransCanada Corporation Jimmy D. Staton Executive VP, NiSource, and Group CEO Columbia Pipeline Group
Refining	Philip Rinaldi, CEO Philadelphia Energy Solutions
Petrochemicals	Porter Bennett, President and CEO Ponderosa Advisors
Type of Oil and Products and Carbon Emissions	Deborah Gordon, Energy & Climate Program, Carnegie Endowment

Tuesday, June 25

8:30 AM – Noon

SESSION III: GAS DEMAND

The ongoing U.S. shale gas revolution creates the potential for increased use of gas in the electricity, manufacturing, and transportation sectors as well as a demand for LNG exports. The discussion will include possible tradeoffs among these uses, the pros and cons of exports, the effect on price, and the process for considering permits for export facilities.

Electricity and Manufacturing	Rick Smead, Director - Energy Navigant
Transportation	Mike Gallagher, Senior Adviser and Former President, COO and Director, Westport Innovations Dane A. Boysen, Program Director ARPA-E
Exports	Pat Outtrim, Vice President Government and Regulatory Affairs Cheniere Energy

1:15 — 5:00 PM

SESSION IV: ENVIRONMENTAL COSTS OF ENERGY

The sustainability of the oil and gas boom depends in part on public acceptance of the level of environmental impact. Presentations on the surface impact and water impact of oil and gas compared to other fuels and on the climate impact of methane emissions from gas production and transportation will introduce a broader discussion of the environmental costs of various types of energy production.

Public Concerns and Regulatory Differences	Alan Krupnick, Director Center for Economics and Policy Resources for the Future
Surface Impact of Gas and Local Control Issues	Mike G. Brownell, Senior Director Environmental and Regulatory Affairs, Chesapeake Energy

Water Impact of Energy

Michael Webber
Deputy Director
UT Energy Institute
University of Texas-Austin

Methane Emissions

Drew Nelson
Clean Energy Project Manager
Environmental Defense Fund

Wednesday, June 26

8:00 – 11:30 AM

SESSION V: GLOBAL ECONOMICS AND POLITICS

The North American oil and gas boom has broad implications for national and global economics and on geopolitics. These effects, along with changes in the Middle East, the growing demand for oil and gas from East Asia, and political and economic factors affecting Russian production and exports will highlight a discussion of changes in the global energy picture.

**Changing Geopolitics of Oil
and Gas**

Sarah Ladislaw, Co-Director
Energy and National Security
Program, CSIS

**Economic Implications of Oil
and Gas Revolution**

Trevor Houser, Partner, RHG, and
Visiting Fellow, Peterson Institute
for International Economics

**Direct Foreign Investment in
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