# The North American Oil and Gas Renaissance and its Implications



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**Energy and Environment Program**

**2012 Forum on Global Energy, Economy and Security**

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Published in the United States of America in 2012
By The Aspen Institute



Printed in the United States of America

12/023
ISBN: 0-89843-578-1

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# *Foreword*

In recognition of increasingly globalized energy markets and of the strong links between energy and national economic and security concerns, The Aspen Institute organized the first annual Forum on Global Energy, Environment and Security in 2005. A group of experts has assembled each subsequent year to share information on these intersecting issues. An informal atmosphere, a dialogue format, and a not-for-attribution rule encourage candor and new, collaborative, cross-disciplinary thinking. A few brief presentations begin each half-day session, but the majority of the time is reserved for discussion.

Dramatic increases in the production of shale gas and tight oil in the United States and oil sands in Canada suggested the topic for 2012: "The North American Oil and Gas Renaissance and its Implications." The Forum co-chairs were John Deutch, Institute Professor at the Massachusetts Institute of Technology and former U.S. Undersecretary of Energy, Deputy Secretary of Defense, and Director of Central Intelligence; and Robin West, Founder and Chairman of PFC Energy and former U.S. Assistant Secretary of Interior. Their many years at the center of U.S. and global energy, financial, and security policy discussions gave them the experience to focus the discussion, and their skill and good humor in chairing the meeting facilitated a productive and enjoyable exchange. Highly

qualified and informative speakers provided a wealth of information and a variety of perspectives, and the diverse expertise of the participants contributed substantially to the richness of the dialogue.

The Institute acknowledges and thanks the following Forum sponsors for their financial support. Without their generosity and commitment to our work, the Forum could not have taken place.

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On behalf of the Institute and the Forum participants, I also thank the rapporteur, Leonard Coburn. Although no written document can capture the richness of the wide-ranging discussions, his extensive knowledge of energy enabled him to distill the highlights into an informative summery. Thanks also to Timothy Olson and Avonique DeVignes, whose efficient and cheerful handling of the administrative arrangements contributed to a pleasant and smoothly run Forum.

This report is issued under the auspices of the Aspen Institute. The Forum speakers, participants, and sponsors are not responsible for its contents. Although it is an attempt to represent views expressed during the Forum, all views expressed were not unanimous and participants were not asked to agree to the wording.

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# The North American Oil and Gas Renaissance and its Implications

Leonard Coburn
*Rapporteur*

# *The North American Oil and Gas Renaissance*

Led by the "shale gale" in the United States and the oil rebound in both Canada and the United States, North America is undergoing a revival in oil and gas production not experienced for decades. Natural gas production in the United States has increased by over 20 percent in the last five years, with today's wellhead price less than a quarter of its 2008 high. Unconventional oil production, largely from North Dakota's Bakken and Texas's Eagle Ford fields, has nearly doubled in two years, with U.S. oil imports declining to their lowest level in fifteen years. In the same period, increased production from Alberta's oil sands has allowed Canada to increase its oil exports by about a third. North America is now the primary destination for energy capital in the world. This phenomenal increase in oil and gas production is changing global energy trade, with dramatic implications for the United States, North America, and the world.

# *Technology*

After many years of experimentation, using technology initially developed with government assistance, independent oil and gas companies responding to recent high energy prices brought about a series of breakthroughs in drilling that led to today's renaissance. Even as energy prices subsequently declined and fewer drilling rigs were used, production continued to go up.

The companies used new ideas for drilling in shale formations that were previously considered too difficult or uneconomic to develop. These shales are distributed throughout the United States, with 87 percent of the production located on private or state lands and the remainder on federal and Indian lands. The shale rocks are impermeable, so that conventional vertical well drilling techniques produce very little gas or oil. Something different was needed, something that would split open the rocks and allow the gas or oil to flow more easily to the well bore. Hydraulic fracturing (fracking) was the answer. While not a new technology, the independents worked with new ways to fracture the rocks and inject water, sand or other proppants, and chemical additives to improve the flow of hydrocarbons. They coupled fracking with horizontal drilling to widen the exposure of the fractured rock to a much longer well bore. The combination of these two techniques—horizontal drilling and fracking—led to the surge in unconventional oil and gas production.

Past technological advances led to the current renaissance, but technology continues to improve, lowering costs, increasing well production, and mitigating risks. Advances in drilling system integration will allow for complete modeling of wells, providing a complete picture of the entire drilling process. This will make it possible to drill highly complex wells at lower cost and with less environmental impact. Technology can compensate for differences in shale rocks, allow the placement of wells for optimal recovery, reduce the quantity of sand and water needed to create pathways for the gas or oil to flow, and reduce the quantity of fracking chemicals used.

Some chemicals such as diesel are being eliminated and replaced with chemicals that are much more benign. "Green completions" relying on closed systems for water re-cycling or injection (pipelines that do not expose the surrounding environment to water discharges) cut down on the risk of ground and surface water contamination. These green completions also can reduce other emissions such as methane escaping from the drilling process. As the melting of the Arctic ice cap increases access for exploration and development, new environmental concerns arise regarding the impact on the fragile environment; technology advances can also reduce these impacts.

Technology can also minimize seismic risks from drilling. Sensors placed within the well to map real-time fracking cracks can limit seismic activity. While these sensors are not used in every well, they are being used in new areas to measure the impact of fracking in new rock formations. Some seismic activity has been found to be associated with reinjection wells returning water below ground, but only in one instance, in the United Kingdom, was mini earthquake-like activity detected from the fracking process.

# *North America*

Gas shale production started its dramatic increase in 2006. By 2011, 30 percent of United States gas production came from shale, and by 2035, shale gas may comprise almost 50 percent. Even with this acceleration there is a level of uncertainty surrounding ultimate production due to the depletion of the best reserves first and due to the price needed to maintain high levels of production. Even with low prices, rich gas shale deposits are economic; however, economic viability declines with poorer deposits, requiring higher prices for these wells to be drilled.

Production increases from oil shales or tight oil occurred more recently. Oil and gas prices previously tended to move together; however, starting in 2008, prices diverged to the point that today there is a disparity between oil and gas of almost $100 per barrel of oil equivalent. [Gas at $2.50/million btus is equivalent to oil at $15/barrel.] With today's low gas prices—monthly prices for the first half of 2012 were $2.50 mmbtus or lower—only the best gas shales are economic; however, with today's high oil prices, companies can produce oil from not only the best oil shales but those of lower quality as well. The oil-gas price disparity led to a shift in production from "dry" gas wells (gas-only wells) to "wet" gas and to oil wells. Oil well completions in the United States grew 13 percent in the second quarter of 2012 from the previous year, while gas well completions fell by 24 percent during the same period.

"Wet" gas contains natural gas liquids (NGLs—butane, ethane, propane, pentane, natural gasoline, and condensates) in addition to gas. Some tight oil fields also contain associated gas and NGLs. The oil and NGLs have significantly higher market value than today's low-priced gas and can increase returns for producers. There will be a continued shift to oil and wet gas wells, limiting the increased production of natural gas, as long as the large oil-gas price differential remains. Although there will be a continuous stream of gas from fields also containing oil or NGLs, the decline in dry gas production may begin to increase natural gas prices and to reduce the oil-gas price differential. As one Forum participant noted, nothing cures low prices like low prices.

## U.S. impact

Production in the Bakken oil shale province has taken off, making North Dakota the second largest oil producing state in America, behind only Texas. The Eagle Ford deposits in Texas are now experiencing similar production increases due to high oil prices and the susceptibility of these shale plays to the combination of fracking and horizontal drilling. Production from other tight oil deposits is on the horizon. Tight oil development is replicating America's gas shale experience, and the development may be occurring even faster than reported due to a one or two year lag in reporting from some producing areas. Between 2011 and 2013, the largest liquids growth of all non-OPEC countries will come from the United States.

The implications of this revolution for the United States and North America are dramatic. America already is seeing renewed investment by petrochemical companies. The United States now has the best petrochemical economics outside of the Middle East. Large companies such as Dow, Chevron, Phillips, and ExxonMobil all are making renewed investments based on both gas supplies and price. This re-investment in petrochemicals is returning as many as 500,000 jobs to the United States.

Enhanced gas production, along with stricter actual or anticipated environmental regulation, is leading to dramatic changes in the power sector as more companies switch from coal to gas. Benefits of gas-fired generation include the abundant supply, construction cycles half as long as for coal-fired power plants, constant availability on very short notice (not intermittent like wind or solar or with substantial ramp-up times like coal), and a levelized cost of electricity lower than nuclear or coal. Dispatch of power is based on marginal cost, with nuclear being dispatched first, then coal when gas prices are $6 per million btus (mmbtus), then combined cycle gas, and finally single cycle gas. With gas prices at $3 per mmbtu, gas is being dispatched ahead of coal. Today, the capacity utilization of gas-fired generation is at 85 percent, the highest since data were collected.

Cheap gas will put pressure on solar and wind penetration; this will be offset to some extent by the expanded opportunities for these renewable technologies, with natural gas generation acting as supplementary power when the sun or wind is not available. Wind power is now competitive at 5 cents/kwh, and turbine performance has improved by 50 percent with 99 percent reliability. Gas generation also has positive environmental attributes, as it lowers $CO_2$ emissions by half compared with coal. The combination of gas and wind can reduce these emissions even further. There were differences among the group on the appropriateness of subsidies for wind, solar, and other renewables, but there was wide agreement on the need for the government to continue basic research in these areas.

The long-term supply and price of natural gas may make light-duty and heavy-duty natural gas vehicles (NGVs) attractive to both retail and fleet consumers. Globally there are about 15 million NGVs on the road, but only about 100,000 in the United States, primarily in commercial fleets such as buses, waste management vehicles, or heavy-duty trucks. No domestic manufacturers are building and selling light-duty NGVs in the United States now, although some manufacturers—Ford and General Motors—have expressed interest. They are moving slowly because light-duty vehicles have a longer pay-back from lower fuel prices than do commercial or heavy-duty vehicles.

The economic competitiveness of NGVs in the United States will be contingent on the sustained price spread between natural gas and gasoline or diesel.

Development of fueling facilities is also a significant challenge to increased use of NGVs. Infrastructure construction is more cost effective for heavy-duty vehicles where corridors or central fueling facilities can be developed catering to their needs. One projection estimates that NGVs will comprise 31 percent of the heavy-duty fleet by 2035, up from 2 percent today. Light-duty NGV penetration requires broader fueling infrastructure, a much more costly endeavor. A study by the National Petroleum Council of the challenges associated with NGVs and other alternative transportation fuels provides a detailed analysis of the transportation issues associated with NGVs and is available at www.npc.org.

## U.S. gas exports

The United States is likely to become a net gas exporter by the end of the decade. Determining factors will be gas prices, the rate of economic growth, continued increases in gas production, continuing gas price disparities between the United States and the rest of the world, and permitting and financing of export terminals. A key factor will be the landed cost of the LNG at its destination, which will be significantly higher than Henry Hub prices. Two types of federal permits are required—an export permit from the Department of Energy (DOE) and a facilities permit from the Federal Energy Regulatory Commission (FERC). The DOE permit is relatively easy to obtain—45 days and no more than $300,000. The facilities permit from the FERC is time consuming and costly due to the necessity to spell out in detail all project design, engineering, and environmental impacts. The FERC process can take 18 to 22 months and cost $100 million. While the DOE has approved 13 projects, only one (Cheniere Energy's Sabine Pass) has made it through the FERC process while another six are undergoing pre-FERC filing analysis.

The other crucial step is obtaining financing based on LNG sales contracts from prospective buyers. To date only two projects, Cheniere's Sabine Pass and Freeport LNG, have announced contracts with LNG purchasers. The Cheniere contracts have two components—a fixed fee for the service of processing gas into LNG and exporting it through the LNG terminal, and a variable fee for the commodity. This is a different construct than the traditional long-term take-or-pay LNG contract indexed to an oil price. It is likely that only 5-6 projects will be completed by 2020-2025, with about 8 to 12 bcfd of capacity and an average of about 6 bcfd of gas exported.

Petrochemical companies argue that substantial gas exports are likely to reduce America's gas surpluses and significantly raise domestic prices, deterring new petrochemical investments and the associated jobs. Exporters and others argue these export projects are unlikely to have a significant impact on the price of gas in the United States, partly because higher gas prices would delay the construction or full operation of the projects. Several studies estimated that exports of 6 bcfd over the 2015-2035 time period would likely increase gas prices to a range of $5.10 to $7.21 mmbtu, or 2% to 11% above projected 2015 prices. These prices are much lower than the $10 or more per mmbtu that initially drove petrochemical investment away from the U.S. These increases will occur very incrementally, since export capacity is expected to increase by only about 0.5 bcfd per year until the full level of capacity is reached. Domestic gas production should have no trouble keeping pace. Small price increases over the long term will not deter investments in petrochemicals, gas-fired power generation, or NGVs.

## Reduced U.S. oil imports

With increased domestic production, the United States will not have to import as much oil in the future, improving its energy security. As a percentage of consumption, oil imports peaked at 60 percent in 2005-2006. Today, with improvements in production and declines in consumption due to enhanced vehicle efficiency standards, the accelerated use of biofuels, and the economic slowdown,

the United States imports only 49 percent of its needs. By 2035, the figure is likely to be only 35 percent. If a North American perspective is taken — after all, it is an integrated market — imports from other sources would be roughly 20 percent in 2035. This level could be as low as 14 percent if U.S. recoverable resources turn out to be higher than currently estimated and additional demand restraint polices are adopted. Lower oil imports, however, will not eliminate interdependence. According to a Harvard Kennedy School report ("Oil: the Next Revolution," June 2012), "…quasi oil self-sufficiency will neither insulate the United States from the rest of the global oil market (and world oil prices), nor diminish the critical importance of the Middle East to its foreign policy."

Unlike with gas, the United States will not be able to export crude oil any time soon. It is currently legally prohibited. Until legislation is enacted changing the law, American crude oil exports cannot occur even if crude oil surpluses occur. Product exports, however, are allowed. Part of the controversy over the Keystone XL pipeline is the expectation that some of the crude will be refined in the United States and some of the products exported. Critics see this as the equivalent of exporting crude, while supporters see it as an opportunity for the United States to add value and keep some products at home while exporting others.

While more production definitely increases jobs at home and reduces imports, there is some question about the extent of the resulting increase in United States global power and the change in the balance of power among nations. While not dramatic, it will not be insignificant. For example, greater domestic oil production helps the United States pursue its Iranian sanctions policies as it persuades purchasers of Iranian crude oil to buy from other countries rather than Iran. Ten to 40 percent of the production shut in by Iran due to the sanctions will not return without substantial new investment. Since Iran's NOC has been starved for capital for years, it is unlikely that Iran's full oil production will return in the near term.

## Mexico

Mexico and Canada present very different situations. Traditional Mexican energy self-sufficiency with significant crude oil exports is changing. Crude oil reserves and production are declining due to underinvestment and lack of technical skills to exploit deep-water reserves. Net exports of crude oil are declining, reducing Pemex's (Petroleos Mexicanos) income stream. Refineries are aging. Production of products, especially gasoline, is declining, leading to greater imports from the United States.

Mexican gas sales are increasing, but production is not keeping pace. Low North American gas prices are inhibiting investors, meaning that development of both conventional and unconventional gas will not occur as in the United States. Meeting future demand growth will require more imports from the United States, perhaps to as much as 4 bcfd in 2018 from current levels of 1 bcfd. Mexican gas cannot compete with U.S. production costs and may not be developed as long as gas prices remain in the $2-3 mcf range. The Mexican picture is unlikely to change without political reform. A new president with strong political backing might be able to change the constitutional prohibitions on foreign ownership of the means of oil and gas production and thereby increase investment and improve technology; however, change, if it occurs, will take time with little impact on near or mid-term results.

## Canada

Canada's situation is far different. Crude oil production is expected to double from the current 3 mmb/d to 6 mmb/d by 2030. Virtually all of this new production will come from development of Alberta's oil sands, which are economic to produce at an oil price of $75 per barrel. New investment of $55-60 billion will be required. Oil sands development and new pipelines will keep Canada as the top exporter of crude oil to the United States. While the integrated oil market will not achieve oil independence for North America, it will mean significant reductions in import dependency on Africa and the Middle East and the redirection of exports from these regions to the fast-growing Asian markets.

Canada's gas prospects are also bright. Development of shale gas and LNG export facilities in British Columbia will lead to its being a net exporter of LNG—1 to 2 bcfd—by as early as 2018. Declines in conventional gas production will be exceeded by increases in gas shale production, which together will reach historic levels of 16 bcfd. New markets in Asia will attract these Canadian gas exports that might otherwise go to the United States. Assuming forecasts are achieved, the integrated North American gas picture foretells both Canada and the United States increasing their gas shale production and becoming exporters of LNG before 2020. The combined export capacity of the two countries will be well below Qatar's capacity but large enough to make them individually the largest new exporters after Australia.

The development of Canada's oil sands and gas shales confronts economic, environmental and political challenges that may lead to slower growth. The cost of oil sands development is rising, making economic viability less certain if global oil prices decline. Gas shale development is dependent upon access to Asian markets. Three West Coast LNG terminals are proposed, all dependent upon pipelines to move the gas from the British Columbia gas shale reserves.

Growing opposition by the some Canadians to these developments may slow or even stop some projects. Opponents believe that recent legislation giving the Prime Minister's office the power to override local and National Energy Board decisions may lead to a public backlash. Opponents also argue that the Canadian public is losing trust in industry to develop resources in a responsible manner and in the provincial and federal governments to regulate and maintain adequate levels of safety and environmental protection. The perception that oil sands and gas shale projects lead to enhanced greenhouse gas emissions is widespread, and as production increases, the public debate is accelerating. There is also a financial inequity, with the benefits from development centered primarily in Alberta while all of Canada feels of the effects of higher wages and a stronger currency that are undermining Canadian manufacturing competitiveness. Energy development may have a significant impact in the next election cycle.

# *Global Prospects*

The North American oil and gas renaissance is merely an inkling of what may eventually occur globally. According to a recent EIA analysis, China has a larger shale resource base than the United States but is just at the inception of its development. Europe, Latin America, and Russia all have sizeable gas shale resources. The unanswered question is whether these or other regions will reach their potential. The American experience may not be transferrable. What made America's development take off was a multitude of independent producers, access to privately owned mineral resources, technology development, access to finance, fiscal stability, rule of law, and a service sector constantly innovating.

## Europe

Development of Europe's gas shale resources faces a variety of obstacles. In the United Kingdom, three shale gas wells were drilled in the northwest and then halted due to a mini earthquake. A restart is highly uncertain even though there is evidence of more than 330 trillion cubic feet (tcf) in place and the possibility of shale gas production reaching 1 tcf/year by 2030, about half of today's conventional gas production. In Hungary, the initial excitement over gas shale prospects dwindled as the reality of the cost of development set in. In Poland, there was much enthusiasm in early 2012; however, enthusiasm declined when ExxonMobil withdrew after

drilling only three wells. In the Netherlands, gas shale prospects are limited by high population density, with the manufacturing nature of drilling and production sites being more disruptive than in the United States.

Additional challenges raise the cost per well in Europe, including water scarcity and central government ownership of mineral rights, which removes the financial incentive for landowners to support development. Shale gas breakeven prices are very high. For example, they range from $8.30 to $11.45/mmbtu (one million btus) in Germany; and from $8.70 to $12.10/mmbtu in Poland. With limited gas shale development in Europe, pipeline gas from Russia and LNG imports will meet increased demand.

## China

Gas shale is but one option for meeting China's future gas needs. Other options include pipeline gas from Central Asia, Myanmar, and Russia, and LNG imports from the Middle East and Asia. In 2009, China's government announced that about 10-15 percent of its 2020 consumption, or roughly 20-40 bcm (billion cubic meters), should come from shale gas. This projection was raised in 2011 to 50-80 bcm in 2020. Many question the feasibility of this much production this soon. The national oil companies (NOCs) already have sufficient land rights in Sichuan province, the center of production, where there is sufficient water, and the foreign oil service industry is ready and able to assist. But there is high population density in Sichuan, there is a large need for educated and experienced geoscientists and fracking crews, and the cost of a recent horizontal well was $11 million versus a United States average of $4-6 million. To achieve the goal of 50 bcm by 2020, China would have to drill 10-12,000 wells—possible, but unlikely. Some analysts think that substantial gas shale development in China is more likely after 2020.

China became a net oil importer in 1993. In 2011, 57 percent of its oil consumption came from foreign sources. Starting in 2000, to cope with its increasing dependence, China developed a "Going

Out" strategy involving state agencies, NOCs, and state supported financing. China's three large NOCs—China National Petroleum Corporation (CNPC), Chinese Petrochemical Corporation (Sinopec), and Chinese National Offshore Oil Corporation (CNOOC)—and several smaller companies led the foreign direct investment efforts. They were supported by three state finance entities—China Development Bank, the Export-Import Bank of China, and China Investment Corporation. These companies and agencies have interests and goals that are sometimes at odds with each other.

China's NOCs took advantage of the financial downturn and China's large cash reserves to go on a global shopping spree, making about 12 percent of all global energy acquisitions in 2011. The "Going Out" strategy succeeded in a significant diversified investment portfolio in Asia ($7.3 billion), Canada ($15.1 billion), Middle East and Africa ($16.2 billion), Latin America ($17.9 billion), and Europe/Former Soviet Union ($25.7 billion). The NOCs prefer equity oil. By 2010 they amassed about 1.3 mmbpd, although this is only 1.5 percent of world oil production. The NOCs use a variety of strategies for their investments, sometimes working directly with the target countries' NOCs or joining with international oil companies. The government backs up the NOCs with government-to-government arrangements for other infrastructure projects or lines of credit or direct loans to the companies in the target countries. The government's goal is to increase China's energy security. The NOCs are more concerned about improved financial results. It is doubtful that the "Going Out" strategy has been successful in meeting either goal.

## Middle East

From a Saudi Arabian perspective, the strong increase in United States oil production is positive. It takes pressure off the Saudis to expand their capacity beyond the current 12.5 mmb/d. Saudi Arabia increased production to offset the reduction in Libyan production during 2011 and is maintaining its high level of production (over 10 mmb/d) to counter the reduction in Iranian exports (down to 1.2 mmb/d from 2.2 mmb/d). The combination of enhanced Saudi

production and increased American production is helping maintain stable world oil prices. Most of the world's oil producers do not want to see oil prices at $125/bbl or higher due to the significant negative impact on world economic growth.

Increased Saudi oil production is also used for its own internal demand. Saudi and Middle East demand growth is second only to Asia, with the Middle East accounting for about 300 mbd increased demand in 2012 compared to Asia's 500 mbd. Saudi Arabia alone uses about 35 percent of its production, or 3.5 mmb/d, primarily for power generation, refined products, and industrial applications. Increases in internal consumption limit Saudi Arabia's ability to export and to balance global crude oil markets.

## Others

The evidence at present does not support optimistic projections of oil or gas shale development elsewhere. Each region will have to experiment with what works best, but experience will be the key. In the United States it took 100 to 150 wells to prove up a play. The United States drilled 32,500 gas shale wells between 2008 and 2012. Canada drilled 1,400. China has drilled about 60 wells, Argentina about 33, Brazil 3, Europe about 35, and Australia 15. Based on the American experience, other areas have a long road ahead before success can be achieved.

# *Environmental Issues*

Frustration has been building in the U.S. environmental community since the collapse of climate change legislation. Many think that any development of fossil fuels will contribute to the climate change problem, and they will oppose all efforts to develop new hydrocarbon projects. They focus on high profile projects such as the Keystone XL oil pipeline, LNG export terminals, and coal export terminals in order to highlight the impact of enhanced hydrocarbon use on climate change. To them, a hydrocarbon is a hydrocarbon, and any new development elicits opposition, even if it can reduce net carbon dioxide emissions or has significant non-climate benefits.

Other environmentalists differentiate among projects, believing that developing some hydrocarbons, such as gas, can be a bridge towards the ultimate goal of a low-carbon economy. They also acknowledge that it is not economically feasible to abandon America's oil and gas abundance and substitute alternative forms of energy quickly. Many alternatives are not economically competitive in today's market place without significant subsidies or consumer willingness to pay higher energy prices. These environmentalists are willing to consider supporting new development when there is a net environmental benefit, as in developing new gas supplies to substitute for coal. There is less support when the net benefit is less clear, as in substituting natural gas for diesel in vehicles. They also insist, though, that the projects be developed in an environmentally

responsible manner. Most producers also support responsible development but often differ with environmentalists on what is necessary to achieve it.

Industry and the environmental community agree that regulatory and environmental issues are important components to gas shale and tight oil development. Environmentalists and most in industry argue that voluntary best practices are not sufficient. The roles of the states and the federal government in ensuring responsible development are a hot issue. Many producers and state regulators argue that state regulation is more effective and efficient as it can be implemented faster and directed towards unique state situations. Federal regulations may be broader and more uniform, but they take longer to develop, are more difficult to adjust to new developments, and may not be able to address specific state conditions or variations within a state.

The type of regulation in question may determine what is best done at each level. For example, uniform disclosure rules for chemicals may best be done at the federal level, but regulations that are particularly sensitive to the geographical or geological characteristics of a gas shale or tight oil play may be better able to achieve the needed flexibility if done at the state level. Advocates of federal regulation, however, argue that many federal environmental laws already have to take into account state and regional variations, and that monitoring and enforcement of federal laws is often done by state agencies.

Sixteen states have developed regulations covering 96 percent of all domestic drilling activity. Since Colorado updated its regulations starting in 2008 using a comprehensive, non-partisan approach, several other states have undertaken similar efforts or are studying Colorado's regulations to determine their applicability. Colorado has four national parks and 41 wilderness areas, in addition to significant recreational areas for skiing, fishing, and camping. Its regulations seek to safeguard these important wilderness areas by imposing stricter regulations for water, air, and land use in these areas.

Issues surrounding disclosure and data measurement are important to safe and responsible development. Most industry participants and critics alike agree that public disclosure of chemicals used in fracking fluids is essential. Some also believe that chemicals use in well-bore cements, drilling muds, or other production processes should be disclosed. They argue that more data need to be gathered and disclosed to back up industry claims that production processes are safe. EPA may have a role in studying and understanding the toxicity of chemicals and providing information to the states, which, in turn, can develop rules and regulations.

No one knows how much methane is released during natural gas production. Methane emissions are much more damaging to the climate than carbon dioxide ($CO_2$) in both the short and long term. Good data on methane emissions from gas shale development are lacking, and some argue that the same is true for other segments of the gas industry (conventional production, transmission, and distribution). Unlike other emissions, methane has a value, and producers have a financial incentive to capture it. But collecting and disclosing these data would go a long way to enhancing confidence in industry's claims of responsible development and in the assumption that gas is less damaging to the climate than coal. Once the facts are known and understood, any needed regulations can follow.

Water pollution is the most frequently discussed environmental impact of unconventional gas and oil development, but the public often conflates two aspects of the issue. Some fear the pollution of underground aquifers due to migration of fracking fluids. Although such pollution is highly unlikely, industry representatives who point this out are often not believed because of very real examples of ground and surface water pollution from well construction and wastewater management. Industry claims that it is following required procedures; however, many state regulations are out-of-date and need to be updated. The EPA is studying fracking's impact on groundwater. If states regulate well construction properly, additional EPA regulation would be superfluous. But where states are lagging in regulatory development or enforcement, EPA may have to step in.

The cumulative impacts of land use are also a concern. Attempts to override local planning with uniform state regulations are misguided in the view of many and in one state, Pennsylvania, have been struck down by the courts. They argue that local government planning, with industry working cooperatively to avoid undue disturbance, is a good model to pursue.

Money to develop and enforce state and local regulations is essential for responsible development. In some states, the lack of qualified personnel to review permits, track activity, and enforce regulations is a serious shortcoming. In other states, fees charged to oil and gas developers are being used to expand these functions.

In addition to the reality of responsible regulation and industry practice, public perceptions matter. Isolated stories of pollution can be extremely damaging. Claims by industry that fracking does not lead to water contamination will not be believed by citizens who lump all aspects of gas shale development under the term fracking and who have seen evidence of improper well completion or handling and disposal of wastewater. Even pictures of a water truck overturned on a local road can damage industry's credibility on broader issues. Similarly, a claim that fracking fluids do not jeopardize water supplies is likely to be doubted as long as the types and amounts of chemicals are not disclosed and data on water use and composition is not collected. Despite the best efforts of responsible companies, the large number of producers and service companies, large and small, can add to the belief that development is not being done responsibly. Adequate regulation and enforcement as well as industry performance are necessary to overcome public opposition to development.

# *Conclusion*

Increases in North American oil and gas production are having widespread impacts on economic growth, jobs, energy security, and the environment. The petrochemical, power generation, and transportation industries are undergoing major changes due to the availability of large volumes of low-cost gas. Petrochemical companies are re-investing in the United States due to low gas prices and significant availability. Existing gas-fired power generation is being used more fully and additional plants are under construction as gas replaces coal. This reduces carbon dioxide emissions directly as well as helping deal economically with the intermittency of renewables, leading to a bright future for wind and solar despite current low gas prices. Significant numbers of heavy-duty NGVs are likely to penetrate the transportation market. Increases in the market share of light-duty vehicles will take longer due to more extensive infrastructure requirements.

The days of United States import dependency are rapidly receding. The United States and Canada will be LNG exporters by the end of the decade. The resulting price impacts in both countries are expected to be minimal and should not significantly undermine the enhanced domestic use of gas, and gas importers in Europe and Asia should benefit from more diverse sources of supply. The gas shale experience so far is unique to North America and the rest of the world will take at least eight to ten years to catch up, but the existence of poten-

tially large reserves in China, Europe, and elsewhere suggests that the power of current energy exporters may be on the wane.

The prospect of the United States reducing its oil imports still further and conceivably even joining Canada as an oil exporter will also shift the world balance of economic and political power slightly away from traditional oil exporting countries. Although the United States still cannot ignore political and economic fluctuations in the global oil market or ignore political upheavals in the major world oil producing regions, reduced import dependency can reduce the economic impact of oil price increases and allow the United States somewhat more freedom to pursue foreign policy goals.

The risks of inadequate attention to environmental issues associated with the new production are not only environmental; they also could threaten the industry with a loss of credibility and of its social license to operate. Producers and governments need to pursue responsible development with adequate regulation at all levels to back up claims of minimal environmental impact and to allay public concerns. Technological advances can also help achieve more efficient and environmentally responsible production. Federal and state or provincial regulators need to cooperatively seek efficient methods of ensuring the viability of this valuable resource with less regard to protecting their own turf. The environmental community appropriately is insisting on adequate regulation of this production, and it must concurrently take into account the value of displacing coal with gas and other benefits of enhanced oil and gas production.

Policymakers must understand the economic implications of long-term increases in oil and gas production—more jobs, increased economic growth, and greater energy security—and the environmental risks associated with these benefits. The North American oil and gas renaissance is an enormous opportunity that should not be underestimated or jeopardized.

# Appendices

# *Agenda*

## *The North American Oil and Gas Renaissance*

### Thursday, July 19

| | |
|---|---|
| **6:30 – 9:00 pm** | **Opening Reception and Dinner**<br>**Sponsored by Statoil**<br>**Hosted by Lady Barbara Judge** |

### Friday, July 20

**8:30 am – noon**

**SESSION I: Supply Prospects and Challenges (1)**

| | |
|---|---|
| **Chairman's Introduction** | **Robin West, Chairman and Founder**<br>**PFC Energy** |
| **Global and U.S. Production Outlook** | **Bill Colton, Vice President**<br>**Corporate Strategic Planning**<br>**ExxonMobil** |
| **U.S. Production Outlook** | **Adam Sieminski, Administrator**<br>**U.S. Energy Information Administration**<br>**Department of Energy** |
| **Challenges** | **Mark Brownstein,**<br>**Deputy Director, Energy Program**<br>**Environmental Defense** |

**1:30—5:00 pm**

**SESSION II: Supply Prospects and Challenges (2)**

| | |
|---|---|
| **Mexican Production Outlook and Challenges** | **Pedro Haas, Principal McKinsey & Co.** |
| **Canadian Production Outlook** | **Dennis McConaghy, Executive VP TransCanada** |
| **Challenges** | **Dan Woynillowicz, Director Strategy and Communications Pembina Institute** |
| **6:30 – 9:00 pm** | **Reception and Dinner Ramiiilaj in Starwood Hosted by Robert and MeiLi Hefner** |

## Saturday, July 21

**8:30 am—noon**

**SESSION III: Global Impacts**

| | |
|---|---|
| **Global Shale Gas Prospects** | **John Knight, EVP - Global Strategy and Business Development, Statoil** |
| **Global Technology Challenges** | **Rod Nelson, VP - Government and Community Relations, Schlumberger** |
| **Middle East** | **Jamie Webster, Senior Manager Markets and Country Strategies PFC Energy** |
| **China and Asia** | **Bo Kong, School of Advanced International Studies Johns Hopkins University** |

**1:30—5:00 pm**

**SESSION IV: Gas Demand**

| | |
|---|---|
| **Power Generation** | **Paul Browning, President and CEO – ThermalProducts, GE Energy** |
| **Petrochemicals** | **Seth Roberts, Director<br>Energy and Climate Change Policy<br>Dow Chemical** |
| **Transportation** | **Mike Gallagher, Senior Advisor<br>Former President and COO<br>Westport Innovations** |
| **6:30 – 9:00 pm** | **Reception and Dinner<br>Pine Creek Cookhouse** |

## Sunday, July 22

**8:00—11:30 am**

**SESSION V: Gas Production and Transportation**

| | |
|---|---|
| **Regulating Shale Gas Production** | **David Neslin, Former Director<br>Colorado Oil and Gas Conservation Commission** |
| **Responsible Development** | **Kevin Kennedy, Director<br>U.S. Climate Policy<br>World Resources Institute** |
| **Reducing the Environmental Footprint** | **John Satterfield, Director<br>Environmental and Regulatory Affairs<br>Chesapeake Energy** |

| | |
|---|---|
| **Gas for Export** | **Patricia (Pat) Outtrim**<br>**Vice President**<br>**Government and Regulatory Affairs**<br>**Cheniere Energy** |
| **Chairman's Summary** | **Robin West**<br>**Chairman and Founder**<br>**PFC Energy** |

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