# The New World of Natural Gas

**2010 Forum on Global Energy, Economy and Security**

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# *Foreword*

The Aspen Institute's sixth annual Global Energy, Environment and Security Forum took as its topic "The New World of Natural Gas," focusing on the recent dramatic change in perceptions of U.S. and global gas supply. Technological advances in horizontal drilling and hydraulic fracturing had led to recent dramatic increases in gas production from shales in various regions of the country. Evaluation of shale resources in other countries was being rapidly undertaken. The discussions in Aspen from July 18 to 21, 2010, provided an opportunity to evaluate the potential impact of these changes.

Just three years ago, at the 2007 Forum, a principal conclusion was that the U.S. would have to import increasingly large amounts of liquefied natural gas to meet its growing gas demand in the face of depleting reserves. This increasing global gas trade was further expected to bring about, sooner rather than later, a single world market for gas in place of the North American, European, and Asian markets. The sudden reversal in supply projections since 2007 suggested another look at the world of natural gas, including related geopolitical issues, prospects for increased demand, the impact of possible climate change legislation, and the potential for greater use of natural gas in vehicles.

The Forum is an opportunity for an international group of experts to share information on issues at the intersection of energy, national security, economic and environmental concerns. A dialogue format

is used to encourage new, collaborative, cross-disciplinary thinking. A few brief discussion-starting presentations begin each half-day session, but the majority of the time is reserved for discussion. An informal atmosphere and a not-for-attribution rule encouraged candid exchanges and creative thinking. Discussion continues outside the meeting room, and many participants believe that the relaxed atmosphere and clear mountain air enhances clear thinking.

John Deutch, Institute Professor at MIT and a former Undersecretary of Energy, Deputy Secretary of Defense, and Director of Central Intelligence, chaired the 2010 Forum. His wealth of experience in the areas of energy, technology and security, coupled with his skill at moderating, allowed him to guide the discussion and extract key information and insights from the highly qualified speakers and diverse participants. We thank him for his service.

The Institute also acknowledges and thanks the Forum sponsors:

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Without their belief in the value of informed dialogue among knowledgeable people with different perspectives, and their financial support, the Forum could not have taken place.

I also thank Leonard Coburn, rapporteur for the Forum since its inception. Although no summary can do full justice to a rich and extensive discussion over several days, his experience in domestic and international energy policy enabled him to understand and capture the highlights in this report. On behalf of the participants as well as myself, I thank Julia Bien-Aime and Timothy Olson as well, whose efficient handling of arrangements contributed to a pleasant and smoothly run Forum.

This report is issued under the auspices of the Aspen Institute, and neither the Forum speakers, participants, nor sponsors are responsible for its contents. Although it is an attempt to represent views expressed during the Forum, opinions were often not unanimous and participants were not asked to agree to the wording of the report.

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# The New World of Natural Gas

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# *The New World of Natural Gas*

The development of natural gas from shale is providing new possibilities for gas use in the United States and throughout the world. The largest conventional natural gas deposits are concentrated in the Middle East and Russia, but unconventional natural gas, including shale, is spread throughout the world, potentially permitting development in many different countries.

Some of the largest and most thoroughly studied gas shale resources are located in the United States. They are widely dispersed and situated near existing infrastructure, making it easier to transport the gas once developed. In recent years, new techniques for hydraulic fracturing and horizontal drilling brought the cost of developing and producing shale gas down to economic levels. Due to increased shale production, the United States was the world's largest natural gas producer in 2009. Some projections estimate that the enormous American shale resource base will keep United States gas production sufficient for more than 100 years.

This new development may bring with it enhanced energy security and attractive environmental benefits at affordable prices. A large domestic resource will reduce or eliminate the previously anticipated need for greater gas imports. Large supplies can lower costs, providing expanded opportunities in the electric power sector to displace coal, in the transportation sector as compressed natural gas (CNG), or for greater use in the residential, commercial or

industrial sectors. Although no fuel is without environmental challenges, natural gas has the lowest emissions among all fossil fuels. Land and water use is relatively small, although water sourcing and disposal can be a challenge. A secure, affordable, domestic source of natural gas can be a game changer for the United States if public policy does not erect barriers that undermine competition with other fuels and if irresponsible operators do not jeopardize development of the resource.

This new resource can help to meet growing future global demand, but for the next decade increasing natural gas demand in China, the Middle East and Europe will be met by conventional natural gas resources. By 2020, China's relatively small demand will double or even triple. Imports by pipeline from Central Asia and liquefied natural gas (LNG) from the Middle East and Asia will complement domestic supplies. China has a large unconventional natural gas resource, but mature development is not expected before 2020.

The Middle East, despite containing about two fifths of the world's conventional gas reserves, is a large consumer of its own resources. Gas use is growing rapidly, with the Middle East now second in growth to the Asia Pacific region. Most of the natural gas produced in the Middle East will stay there to meet regional needs. The exception is Qatar, the largest LNG exporter in the world. The Middle East's conventional gas resources are so large that no unconventional gas development is forecast any time in the near future.

Europe's primary concern is security of natural gas supply, since about one quarter of its gas now comes from Russia. Recent disruptions in supplies due to Russia's turbulent relations with Belarus and Ukraine created substantial uncertainty among European policy makers. Their search for alternative natural gas supplies led them to Central Asia and the Caucuses with possible new long distance high volume pipelines bypassing Russia. Economically these pipelines may be problematic; however, geopolitics may supersede economics in Europe's search for enhanced energy security. Europe has uncon-

ventional gas deposits; however, so much uncertainty surrounds their development that it is unlikely that any development will occur before 2020.

Natural gas pricing continues to be an important issue, with North America, Europe, and Asia using different pricing models. The open question is whether these regional markets will evolve into a global market with one pricing model. There are different prices in the North American, European, and Asian markets because the gas price is determined by the cost of the alternative fuel. In North America, gas is used for power and competes against coal; in Asia and to a lesser extent Europe gas competes against the price of oil as set in the import contracts.

The U.S. public, the environmental community, policy makers at the state and federal level, and industry worry about the environmental consequences of enhanced shale gas development and production, particularly the hydraulic fracturing used to create cracks in the targeted hard shale rock to increase permeability and gas production flow. All agree that credible regulation and enforcement are essential. While excessive or conflicting regulations can inhibit the responsible development of this large, affordable, relatively clean domestic resource, so too can irresponsible actions by developers and producers.

# *I. Natural Gas Supply: A Game Changer?*

Advances in technologies for the extraction of natural gas from shale have made gas an energy game changer. Worldwide gas resources are enormous, with some estimates ranging from 20,000 to 30,000 trillion cubic feet (tcf).* But one estimate is that just unconventional shale resources exceed 30,000 tcf globally, spread out in 142 basins, although not all these resources are currently economic. Although there is little agreement on the size of the resource, the estimates are large and growing. Based on current consumption, the world may have 175 years of supplies; the United States may have supplies for 100 years.

Forecasting energy demand growth is difficult. Virtually all forecasts for the years 2030-2035, however, reach the same conclusion: although all energy sources will have important roles to play, fossil fuels will continue to provide the overwhelming majority of energy. Developed nations in the OECD will account for very little overall energy growth but will provide the most energy savings through increased efficiency.

Global gas demand is predicted to grow 88 percent by 2030, from

* Resources include reserves that are economically recoverable now as well as others that are not necessarily economically recoverable today but may be recoverable as technology and prices change. Characterization of natural gas as conventional or unconventional is based upon the permeability of the rock containing the resource, that is, the ease with which gas can flow through pore spaces. Natural gas from coal beds, tight sands and shales are unconventional resources since all come from low permeability sources.

250 billion cubic feet per day (bcfd) today to 470 bcfd. Growth in the non-OECD countries will be 130 percent versus only 35 percent in the developed world. Use for electric power generation will grow fastest, followed by industrial use and then residential and commercial use. Gas-fired electric power will increase at the expense of coal in the United States and Europe. In Asia-Pacific, coal is the winner due to significant increases in China and India, where domestic coal supplies are plentiful and cheaper than imported natural gas. In the United States, natural gas increasingly will be preferred to coal for new electric power units as the cost of emitting $CO_2$ increases.

Forecasts for future supplies are decidedly brighter for North America than for Europe and Asia Pacific. In the United States unconventional gas will play an increasingly important role. In Europe and Asia Pacific the unconventional resource is less well explored and conventional supplies delivered by pipeline and LNG (liquefied natural gas) will account for most of the growth in the near term.

The supply revolution in the United States depends on the recent development of improved technologies, particularly hydraulic fracturing and horizontal drilling, to produce natural gas shales in an efficient and economic manner. Producing unconventional reservoirs requires a mindset change. A factory-type approach is necessary, with new technologies acting as the enablers. Environmental and community concerns must be met, while market demand and infrastructure development will control the rate of expansion.

One challenge is in managing the rapid initial depletion of shale gas wells to sustain long-term production. Most production from a well, roughly 70 percent, may occur during the first few years, but the remaining 30 percent can take decades to produce. (Some early shale wells are still producing 100 years later). Additional challenges include different permeability and the need for different strategies to achieve success. No two reservoirs are exactly alike.

The growth in the development of these unconventional gas resources is forcing a renewed examination of the role of natural

gas in energy policy. In the United States, gas can enhance energy security at affordable costs while providing attractive environmental benefits. The development of shale resources provides an abundant, domestic source of energy. Its affordability comes from low production costs and its relatively low cost as a fuel for electric power generation. Environmentally it has the lowest carbon footprint (about one half the $CO_2$ emissions of coal) and air emissions among fossil fuels. The broadly dispersed nature of the resource provides the opportunity to site the facilities closer to end-users and reduce the need for new long transmission corridors. These characteristics resulted in the United States becoming the top world producer of natural gas in 2009.

Shale resources are located in many basins around the United States, providing a diverse resource near existing infrastructure. Production from these various basins is expected to triple between 2010 and 2020 and account for the largest share of domestic supplies by 2030, making North America self-sufficient in natural gas supplies and enhancing U.S. energy security.

For new electric power generation, natural gas-fired plants are the clear winner if gas is below $4-6/mcf. Their relatively low capital and operating costs make them very affordable compared to alternatives. If governments impose a price on carbon in the future, the advantage of natural gas over coal will increase as the price of carbon increases. Existing coal-fired power plants remain cheap to operate, but as they reach the end of their useful lives and as $CO_2$ regulation increases costs, gas-fired power plants can reduce emissions more cheaply.

The high proportion of their costs attributable to fuel makes gas plants more vulnerable to price volatility. Gas price volatility has moderated in recent years, however, due to increased storage, pipeline capacity and connections, LNG deliverability, and diversity of production. In the long-term, price risk can be managed using futures instruments, and through the potential for future supply increases, both domestic and foreign.

One future domestic source of natural gas is located in Alaska, where 35 tcf of proven reserves exist on the North Slope with an

additional potential of more than 100 tcf. By 2020, this could translate into a potential 4.5 bcfd, or eight percent of United States production. Other benefits include an existing federal and state regulatory structure that can support both producers and customers, an existing pipeline network stretching from Boston and New York to the West Coast with sufficient capacity to accommodate the additional gas, and substantial financial benefits for the State of Alaska in the form of extraction payments. North Slope producers claim that the gas will be competitive with shale gas and will be necessary for future domestic consumption.

Customers must decide whether this gas, projected by pipeline developers at $3 per million btu over the long-term, will in fact be competitive with shale and other gas. The Alaska natural gas pipeline system is extremely expensive, with overall project costs of $30 to $40 billion. Equity will comprise 25 percent of this total; debt will make up 75 percent. Long-term contracts will be critical to finance the debt portion. Federal loan guarantees will be necessary since capital markets are not likely to support such large debt without the additional assurance.

Existing law provides for $18 billion in federal loan guarantees; however, new legislation is pending increasing this amount to $30 billion, now required for project success. Proponents of the project argue that this is a good investment, providing a new domestic resource and enhancing energy security while providing the opportunity for even more discoveries of both oil and gas. The project still has a long way to go before gas can be delivered in 2020. Customers are currently bidding for gas volumes during the current open season, and the Federal Energy Regulatory Commission must still complete the regulatory process for construction permits.

Government policy will play an important role in fulfilling the expectations for enhanced gas production and use. Implementing a carbon price in the foreseeable future can have a significant positive impact on the choice of natural gas-fired power plants as alternative choices become more expensive. If future government policies also require a renewable electricity standard (RES)— a requirement

that a significant percentage of new electric power generation comes from renewable energy sources—the choice of natural gas instead of coal for electric power generation may be reduced by 6% to 16% in 2030 depending upon program implementation. For example, a RES with no price on carbon or a very low price would reduce the use of gas in power generation as new renewables plants displaced new gas-fueled plants.

Most participants in the Forum believe that the potential cost of economic and environmental regulation can be reduced if it allows competition among fuels on a level playing field at whatever carbon price is levied. The inherent economic and environmental characteristics of each fuel will then permit rational economic decision making for the development of all fuels necessary to meet economic and social needs.

# *II. Economic and Security Issues: Different Strategies for Different Regions*

Natural gas resources are distributed around the world, with the largest resource base in North America if unconventional resources are included. Russia and the fifteen other countries that were part of the Former Soviet Union (FSU) contain the next largest, with the Middle East third. The rest of the world has an amount equivalent to Russia/FSU. The Forum focused on the Middle East, China, and Europe and Russia, each with a different set of issues and strategies.

## A. Middle East: Growing Demand Requires New Strategies

The Middle East contains about 41 percent of the world's proven conventional natural gas reserves, a subset of the larger resource base that includes both proven and possible conventional and unconventional natural gas. Iran and Qatar dominate with over two thirds of Middle East reserves—Iran at 39 percent and Qatar at 33 percent. Other significant reserve holders include Saudi Arabia with 10 percent, UAE with 8 percent and Iraq with 4 percent. Unconventional natural gas resources currently are not important for Middle East supplies.

The challenge facing the Middle East today comes from its substantial growth in oil and gas consumption, second in the world behind China. For the last decade, overall energy consumption grew at a rate of 6 percent per year, with natural gas consumption right

behind at 5 percent per year. For natural gas, most of this growth was in the power and industrial sectors primarily due to low prices throughout the region. Five countries—Bahrain, UAE, Oman, Iran, and Saudi Arabia—rely on natural gas for at least 50 percent of their power generation. Electric power generation is expected to grow faster than overall energy growth at 7 percent per year. In Iran and UAE massive amounts of natural gas are required for re-injection in their oil fields to maintain production. In Iran, now the third largest natural gas consumer in the world, natural gas re-injection requirements could reach 20 bcfd by 2020; for UAE it could reach 1.7 bcfd. Other Middle East nations also require natural gas for re-injection. All will be challenged to find sufficient supplies in the coming decade.

Natural gas supplies will struggle to keep up with demand because of the region's rapidly growing needs for its industrial and power sectors. New local supplies will be more costly due to large increases in drilling costs (doubled since 2000), gas pipeline construction costs (increased by 80-100 percent since 2000), and gas processing plants (up 100-120 percent since 2000). Several countries have turned to imports. Iran, the second largest reserve holder in the world, is a net importer of natural gas. Kuwait also now imports LNG. UAE and Bahrain are likely to turn to LNG imports in the near future.

Middle East natural gas prices have been artificially restrained as all countries in the region subsidized users. This strategy is changing due to higher production costs and the high prices required for LNG imports. Iran is moving to increase all domestic energy prices over five years starting in 2010. This strategy, although politically difficult, could reduce domestic subsidies and raise prices on exported gas.

The Middle East until recently was regarded as a prime source for gas exports to world markets. Qatar, the leading LNG exporter in the world, is changing its strategy and is not making any export commitments beyond the previous commitment to develop 77 million tons per year (3.7 tcf) of LNG by 2012. Its export strategy is based primarily on long-term contract commitments, with less

than half of its exports going into the spot market. It can increase or decrease exports based on prices in the United States, Europe or Asia, providing the ability to meet variable market demand.

The ability of other Middle East countries to export is unclear. Iraq has a large export pipeline potential with several fields available for new pipelines to Syria, Turkey and Europe. The question is whether Iraq's domestic requirements for electric power and industry will preclude natural gas availability for exports. Iran also has significant export pipeline potential with some pipelines operating today to Turkey, Armenia and Azerbaijan. Many other pipeline projects have been announced, but few deals have moved forward due to domestic demand for gas (industrial and power) and political problems. Iraqi and Iranian LNG export potential is significant, but domestic demand and geopolitics (including sanctions) are likely to forestall any LNG projects in either country.

Except for Qatar, the Middle East no longer can be assumed to be a supplier of natural gas to the rest of the world. An open question is the consequences for the region and the world if Saudi Arabia, currently self sufficient in natural gas, becomes a net importer. Another question is how natural gas pricing in the region will be resolved and whether domestic price increases will be sustained if confronted by strong local opposition.

## B. China: Continued Growth Requires both Domestic and Foreign Supplies

Future gas demand growth in China depends upon market factors and government policy with its command and control policies. Although consumption is relatively small today, at 9 bcfd, it grew at 15 percent per year during the past decade. Growth in urbanization led to increased residential demand. Other growth factors included government's push to increase greener fuels in the energy mix to reduce its carbon footprint, rapid power plant construction, and pricing reform. The government declared that by 2020 natural gas

use will increase to 8-10 percent of the total energy mix, or about 30 bcfd, and also that energy intensity will decrease by 45 percent.

Infrastructure development will be critical to support this growth. Several domestic pipelines are already carrying supplies from distant fields to population centers. Import pipelines either are operating (a pipeline from Turkmenistan opened in late 2009) or are planned—from Myanmar in 2014, and two from Russia sometime after 2020. These import pipelines will add 4 bcfd to China's supplies. Three LNG terminals are operational, two are under construction and three are planned, adding another 6 bcfd to China's natural gas supplies. Assuming 2020 natural gas demand of 30 bcfd, about 20 bcfd will have to come from domestic sources.

China's domestic gas resources will be adequate to meet this demand growth. Its total resources are about 3700 tcf. Most of this resource is unconventional—about 2700 tcf—with conventional resources of about 1000 tcf. Large capital expenditures will be necessary, and China is developing its conventional resources first. The unconventional resource will take a long time to exploit, although China is slowly developing and producing its coalbed methane (CBM) as PetroChina joins forces with experienced foreign companies. It is likely that China will move quickly to ramp up CBM production as it acquires more experience. China is also beginning to acquire the appropriate technology to exploit its enormous gas shale potential. The United States and China signed agreements recently for American assistance in mapping shale resources and for technology transfer. Companies such as PetroChina are joining with foreign companies to begin shale gas development, and shale gas will begin to make an impact after 2020, although water scarcity may limit its potential.

China also needs to resolve its natural gas pricing. Gas demand is likely to increase two- to three-fold in the next decade. Import prices are substantially above average domestic prices, for example, $12 per million btu versus $7 per million btu for the Shanghai city gate price. Most domestic prices are below the average. China depends

upon a blended price to maintain its current price structure. The challenge is to find the appropriate balance between low-priced domestic natural gas and high priced imported natural gas, especially in view of the government policy to increase natural gas use.

## C. Europe: Energy Security and Decarbonization—A Dual Natural Gas Strategy

No European energy growth is predicted through 2030. Future gas demand may increase or decrease marginally depending upon government policies. Current overall energy policies have three strategies: demand reduction, fostering renewable energy growth and reliance on natural gas. But because of energy insecurity and the desire to decarbonize rapidly, the European political establishment is not eager to increase natural gas use. The source of the energy insecurity derives from Europe's strong reliance on Russian imports to meet its natural gas demand. The environmental skepticism about natural gas is due to the political elite not having been persuaded that gas can lower Europe's carbon footprint sufficiently, in other words, that gas can be decarbonized.

Russia supplies about 25 percent of Europe's natural gas and about 30 percent of its imports. Despite its record of stability dating back to the 1980s, Europeans view Russia as an unstable supplier that is willing to use gas as a political weapon to re-assert its power and influence. Dependence on Russian gas is most pronounced in Central and especially Eastern Europe.

Disruptions in imports in 2006 and 2009 due to conflicts between Russia and Ukraine over gas prices and other contract issues are still foremost in discussions of European energy security. A flare-up between Russia and Belarus in June 2010 was resolved quickly but was another reminder of the precarious situation that exists. Ukraine's natural gas pipeline system transports 80 percent of Russian natural gas exports to Europe; the Europeans feel vulnerable at any sign of political or economic tensions between the two countries. The political winds in Ukraine shifted towards Russia after the

February 2010 elections, with new natural gas contracts put in place in the spring of 2010. But long-term uncertainty persists.

The development of a new international gas system to supply Europe depends on the economics of the projects and the ability to secure supplies. Geopolitics is a now a critical element in the desire for energy security. Straight cost estimates for delivering gas from the Caspian region to Europe show that the Russian route through Ukraine is the lowest cost. But both Europe and Russia view their political security interests overriding these economic estimates, since both are proceeding with higher cost solutions.

Russia is building new pipelines to alleviate its reliance on transit through both Belarus and Ukraine. Nordstream, a pipeline from Russia under the Baltic Sea to Germany, bypassing Belarus, is under construction. First deliveries are expected in 2011-12. A second line is expected in 2013-14. Russia built Blue Stream under the Black Sea connecting it with Turkey. Its capacity is under-utilized and, with the cooperation of Turkey, could be used for shipments to Europe in the future. A more direct pipeline, South Stream, from Russia to Bulgaria, is planned to bypass Ukraine. Its capacity will not be sufficient to eliminate all Ukrainian volumes. Its cost is very high, and the Europeans doubt its completion.

Europe is developing alternatives to its heavy reliance on Russia and is focusing on Nabucco, a large diameter pipeline from the Caspian through Turkey terminating at the Austrian pipeline hub. This pipeline is expensive and its source of supply is uncertain. Supply possibilities exist in Azerbaijan, Iran, Iraq, Kazakhstan and Turkmenistan. New natural gas supplies available for export from Iran and Iraq are highly speculative. Azeri natural gas is more certain, but may not be sufficient to support the pipeline. Natural gas from Kazakhstan and Turkmenistan requires construction of a pipeline under the Caspian Sea. Without a settlement of sub-sea national boundaries (agreement from the five bordering countries would be necessary to permit construction of a pipeline) sourcing natural gas from the eastern side of the Caspian is problematic at best. A guaranteed volume of only 10 bcm (354 bcf) of natural gas

may not be sufficient to finance Nabucco. Other smaller pipelines in the southern corridor are possible, but none meets the need of Europe to provide future energy security certainty.

New sources of LNG delivered to Europe also can be a useful diversification strategy. LNG provides access to a variety of sources, and LNG terminals can provide much needed storage within Europe. The development of many terminals increases flexibility of supply. But LNG may not be a sufficient long-term strategy since the supplies can be bid away by others offering higher prices. Price security is a major issue for Europe, and a world market for LNG is the mechanism that leads to a global gas price.

Europe does have unconventional natural gas resources, but there are more questions than answers concerning their development. How big is the resource and where is it located? How much will it cost to develop? Is sufficient water available? What is the lead time for development? Can the United States business model transfer to Europe, or will new models be necessary? It is unlikely that unconventional natural gas will be available before the 2020s, if at all.

European pricing questions linger. Natural gas prices are linked to oil prices in all long-term contracts. Recent history demonstrates that there are perils in such linkage. Gas demand declined in 2009-2010 by more than 20 percent. Suppliers were forced to renegotiate long-term contracts to permit some spot market pricing to alleviate high prices linked to oil. The issue is whether a new pricing model is evolving. If so, it could take a decade or more for it to become established, and it would have to overcome strong resistance to any price changes from some historic suppliers. But a new price model is essential if Europe wants to take advantage of lower prices based on surpluses in the United States and elsewhere.

Natural gas pricing is still regional rather than global. Different price models exist in the United States, Europe and Asia. Economic theory suggests that as more spot LNG cargoes move among markets, regional markets should merge into a global market. Arbitrage

among markets can even out price fluctuations. But constraints within regional markets continue. The United States uses gas-on-gas spot market pricing. Europe and Asia link natural gas to oil prices in long term contracts. The question is how long different regional pricing policies can persist.

For natural gas to remain a significant part of a sustainable energy future for Europe, the dependence on Russian gas will need to be mitigated: pipelines in the southern corridor, additional LNG terminals, and unconventional gas resources will need to be developed. Supporters will also have to develop a strategy for taking the carbon out of natural gas. Europe is more committed to early action on climate change than is the United States, and there is opposition to building any new fossil-fueled power plants, even as a bridge. It will not be sufficient for gas to assert that it is not coal or oil.

# *III. United States Natural Gas Demand: Sources of New Growth*

Gas shale development is changing the supply picture in the United States. Will this new supply change demand? A recent MIT study, *The Future of Gas*, stated:

> In a carbon-constrained world, a level playing field – a $CO_2$ emissions price for all fuels without subsidies or other preferential policy treatment – maximizes the value to society of the large U.S. natural gas resource. In the absence of such a policy, interim energy policies should attempt to replicate as closely as possible the major consequences of a level playing field approach … that would entail facilitating demand reduction and displacement of coal generation with natural gas.

In today's political climate is it likely that a level playing field for all fuels will emerge? The simple answer is no, due to a variety of existing and proposed policy instruments providing differing incentives for different fuels and strongly defended by their champions. Politics overrides economics.

Natural gas began to compete against coal and nuclear for electricity generation following the repeal of the Fuel Use Act in 1987, but its prominence increased after 2000 when most new power plant construction turned to natural gas. Gas fuels about 22 percent of power generation today but is a larger percentage of installed capac-

ity. Baseload coal and nuclear plants have utilization rates of 73 and 93 percent respectively, while gas power plants are utilized only 25 percent of the time.

The electricity industry has an opportunity to substantially reduce $CO_2$ and other emissions (NOx, SOx, mercury, fine particulates) by switching from coal to natural gas. Not only does gas have about 50 percent of the $CO_2$ emissions of coal plants, but various studies indicate that just by increasing the capacity of natural gas combined cycle plants, $CO_2$ emissions from power plants can be reduced from 5 percent to 14 percent.

New natural gas fired power plants are typically less costly to build than coal and, depending upon fuel costs and carbon reduction policies, can be cheaper on a life-cycle cost basis. Gas-fired plants have a clear cost advantage if natural gas costs between $4 and $6 per million btu and coal plants are required to implement some form of carbon capture and storage (CCS). This advantage will be temporary, though, if the cost of complying with $CO_2$ policies for gas-fired plants rises to a level that makes the use of CCS more economical than paying the tax or buying allowances. The timing of this opportunity for natural gas will depend upon when government policies impose a price on carbon emissions, and how high that price is. These policies could take the form of cap-and-trade legislation, a direct carbon tax, EPA regulation of $CO_2$ emissions under the Clean Air Act, or a combination of state and regional policies. Analyses of some legislative proposals show that a carbon price of at least $25 to $30 per ton is needed to create the incentive to change electric power plant dispatch from coal to natural gas.

The coal industry views these public policy proposals with trepidation, seeing coal as an abundant, reliable, cheap resource that could be much cleaner than currently used. They argue that today's public policy focus is on making clean fuels abundant, reliable, and cheap. Insufficient attention is being given to making abundant, reliable, and cheap fuels clean. Consequently they urge support for the development of technology for getting the $CO_2$ out of coal.

Some gas advocates suggest that a national road map on the future of natural gas be developed by establishing a Blue Ribbon Commission. They do not believe current legislative or regulatory proposals provide sufficient guidance for the future use of all fuels for meeting future economic growth and environmental goals in a balanced way.

Another possible opportunity to increase natural gas demand is the use of compressed natural gas (CNG) to power vehicles. CNG vehicles have lower emissions than gasoline or diesel vehicles. About eleven million vehicles use CNG today in countries such as Pakistan, Argentina, Iran, Brazil, and India. The largest growth markets include China and Italy, as well as countries already using CNG—India, Pakistan and Iran. Only about 120,000 CNG vehicles are in operation in the United States, and that number has remained flat since 2000. This represents less than one half of one percent of vehicles on the road. Only about 1,000 CNG fueling stations were built. About half are only for private fleets.

Severe challenges exist for expanding CNG vehicles in the American market. Price is a major obstacle. The only dedicated CNG light duty vehicle (car or pickup truck) offered in the United States costs about $4,000 more than its comparable gasoline powered counterpart. The range is only 180-200 miles, half that of the gasoline vehicle. Government-certified aftermarket conversion kits are available for some sedans and light trucks to allow operation on both gasoline and CNG, but costs can exceed several thousand dollars, depending on the desired range and corresponding CNG cylinder size. In addition, cargo capacity is reduced by the fuel cylinders in the trunk. CNG vehicle performance is also lower. To achieve performance similar to a gasoline powered car, CNG vehicles would likely have to include a costly turbocharger, currently far too expensive to be included in a retrofit kit.

The resale value of CNG vehicles is another challenge. Since only 25 percent of annual light duty vehicle sales are new, most vehicle transactions in the United States are used vehicle sales, which occur in a nationwide system of trade. However, the market for used CNG

vehicles is limited by the location of available infrastructure. Finally, available infrastructure is one of the largest barriers for CNG, with only three states having more than 100 stations. There is a significant expense for installing re-fueling facilities at service stations.

Some suggest that CNG could substitute for some large, intercity, diesel trucks if CNG corridors were established to fuel these vehicles. The major constraint is the diesel after-market. Most large diesel powered trucks are sold after about one million miles of use. The ability to find CNG fuel in the countries where these vehicles are re-sold is problematic at best.

A key challenge is how to develop a policy strategy to balance security, climate, criteria emissions, and consumers that allows options to compete. In the emerging vehicle market, a portfolio approach may work best. CNG vehicles can be a part of the portfolio of vehicles available, including high-mileage gasoline or diesel vehicles, hybrids, plug-in hybrids, and all-electric vehicles. Within this portfolio, CNG's role may be best for fleets—buses and small delivery trucks—where central fueling can be justified. The cost of fuel is the number one operating expense for fleet vehicles, and CNG usually is significantly less costly than gasoline and diesel. In addition many fleet vehicles are larger than the average automobile with more space for CNG fuel tanks.

Natural gas has long been an important input in the industrial sector. The largest use for natural gas in the chemical industry is as a feedstock, including for ethane, propane, and butane. Other needs include for steam and power. Gas price stability at globally competitive levels is the critical element to draw new investment in the petrochemical industry. High U.S. gas prices can force significant portions of the U.S. chemical industry to move to other countries where prices are lower. A stable price regime can provide the certainty necessary for relying on domestic natural gas. Increased demand for gas in the electricity and transportation sector could work against this goal for industrial users.

In the U.S. residential and commercial sector, natural gas consumption today is the same as in 1970 even though the customer base has increased by about 70 percent. The average residential consumer uses 40 percent less energy than in 1970 due to enhanced building codes and standards, appliance standards, utility efficiency programs, and higher prices. There is a significant opportunity for gas demand growth in increasing the displacement of oil used for water and space heating. Fuel switching could theoretically displace the approximately 150 million barrels of oil that are used annually in residential buildings in the United States, primarily in the Northeast. On a full fuel cycle basis, gas water heating uses one half of the energy and has one half of the $CO_2$ emissions of electric water heating.

Gas can be converted to a liquid (GTL) producing an ultra clean, diesel-like hydrocarbon that can be easily shipped globally. The GTL process is currently very expensive and produces high levels of $CO_2$. A GTL project is under development in Qatar using inexpensive Qatari gas; however, everywhere else GTL has been analyzed it has been deemed too expensive.

# *IV. Gas Shale: Meeting the Environmental Challenge for Future Growth*

The U.S. natural gas industry is at a crossroads for development of the country's world class shale resource. It cannot proceed without public confidence that environmental regulation will ensure safe and responsible techniques. Most knowledgeable observers also want to see this resource developed, but only with strong environmental safeguards. Regulators say that both industry and the public need these safeguards.

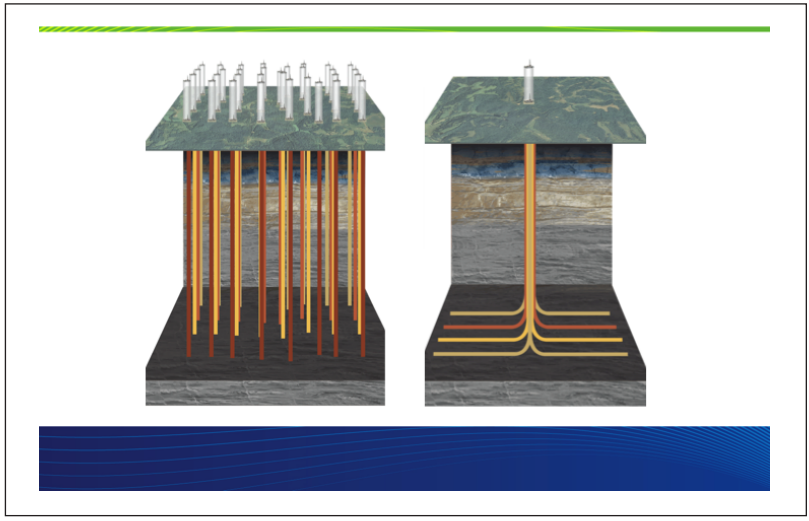
The industry wants regulation that is sensitive to the differences in production techniques, not a one-size-fits-all model. Each shale reservoir is different, and even within each reservoir different techniques are necessary to optimize production. Any regulation that does not take these differences into account will reduce production flexibility and adversely affect resource development. Industry and regulators need to work together to provide credible regulation that satisfies public opinion and environmental community concerns while providing flexibility for the industry.

The benefits from gas shale development can be very important to state economies, especially when other forms of industrial production are sluggish. States want to make sure that mistakes made in the development of other resources such as coal are not repeated with shale gas. Regulators view the safety record of each operator as the single most important factor in whether the company will be welcome to operate in the state.

There is a long list of issues for the industry. These include disclosure of the chemicals used, water disposal, operating in state forests, and providing sufficient revenues to the state. States where gas shale formations are located, such as Alabama, Colorado, Pennsylvania, Texas, and Wyoming, are in various stages of regulating these and other issues.

Natural gas advocates argue that shale resource development has a smaller land footprint and lower lifetime water usage than most other fuels. During combustion in power plants, natural gas also has lower water usage as well as lower carbon emissions than coal or oil. Its other emissions are lower than those from coal including NOx (80 percent lower), SOx (99.9 percent lower), particulates (99.4 percent lower), and mercury emissions (none). To maximize these benefits, natural gas shale development must proceed, but must do so credibly and responsibly. At the federal and state level a great deal of regulation already is in place to deal with water discharges and air emissions. New regulation is emerging dealing with important

**Vertical vs. Horizontal Drilling**



Source: Chesapeake Energy

Horizontal drilling reduces the footprint of gas wells.

aspects of natural gas shale production, including hydraulic fracturing and chemical disclosure.

Hydraulic fracturing (often referred to "hydro fracking" or just "fracking") is a process used to stimulate natural gas from hard shale. Water is mixed with sand and pumped into the shale reservoir under pressure. Water and sand normally comprise 99.5 percent of the material used in the fracking process; the other 0.5 percent can include acid, friction reducer, surfactant, gelling agent, scale inhibitor, pH adjusting agent, breaker, iron control, corrosion inhibitor, antibacterial agent, and clay stabilizer. The fracking process fractures the shale to release the captive gas. After the fracturing occurs, additional treatment takes place to maximize the flow of gas.

Regulators, the public and the environmental community are concerned about how fracking is done, because a small number of incidents have been publicized where drinking water contamination occurred. Although anecdotal evidence can be misleading and by itself is not a sound basis for policy making, publicity about these incidents is legitimately forcing policymakers and the industry to focus seriously on regulation, enforcement, and industry best practices.

Industry claims that most producers follow best management practices and rely on techniques to reduce the impact of drilling, fracking and production. Accidents and carelessness can occur, and it is these situations that undermine public confidence. Although deepwater drilling occurred for decades with few serious problems, the Macondo oil catastrophe in the Gulf of Mexico has increased public skepticism about industry practices. Another example occurred in June 2010 in Pennsylvania with a natural gas shale well that gave the entire industry a black eye.

Historically, water regulation was viewed as a state issue. Pressure continues to regulate fracking only at the state level without federal interference. State regulators understand their obligation and role in regulating water and do not want to see more federal regulation that would take away their ability to regulate locally. In the Energy Policy Act of 2005, Congress exempted hydrofracking from regula-

tion under the Safe Drinking Water Act and other laws, leaving the regulation of injection wells used in hydrofracking to the states.

There are not enough regulators to monitor all wells all the time, and some argue that industry must address its own practices. One suggestion is for the industry to develop a review board similar to one in the nuclear industry to develop and monitor best operating practices. Once the Institute of Nuclear Power Operations was established, operating practices were standardized and problems were reduced. Many gas industry participants welcome efforts to strengthen oversight, because negligent operators undermine confidence in the entire industry and a credible certification process could contribute to permit approvals. They add, though, that a violation by a negligent operator does not necessarily justify stronger regulations; it may just call for stronger enforcement and penalties.

Fracking uses large quantities of water. Disposal of water coming back up out of the well is a serious issue and must be done in a manner that does not contaminate surrounding areas, especially nearby streams and rivers. Holding ponds need to be constructed using best practices. Water cleanup must occur before the water is released back into the environment. One practice is to partially clean and reuse the water for additional fracking, reducing the quantity of water needed for continuing operations.

Another issue concerns the disclosure of chemicals used in fracking. Regulators, the public and the environmental community want the industry to disclose what they are using. Some industry participants are willing to comply, but others are reluctant because some chemical mixtures are considered proprietary and they do not want to disclose competitive secrets.

Credible management of the environment will be critical to the public, to policy makers, to the environmental community and to industry in meeting the enormous expectations for the future of natural gas shale development. Some argue for Federal regulation, believing it can provide regulatory uniformity, especially when states are reluctant to pass strong regulations. Others believe that strong regulation is called for, but that another layer of regula-

tion can undermine state flexibility and can inhibit the successful development of this important domestic resource. They argue that the environmental regulation should remain at the state level where each state can deal with the issues and problems particular to its region. How the regulatory environment evolves will be critical for future development of this important, domestic, secure natural gas resource.

# *V. Conclusions*

Although the world of natural gas is changing rapidly and a variety of opinions were expressed during the Forum, the participants reached several major conclusions:

- Shale gas is a gift to the United States and other countries and can be a game changer if its development and production are managed properly. If its production is not environmentally sustainable, it will not be politically sustainable.

- Innovative technology—hydrofracking and horizontal drilling—has dramatically enhanced domestic gas supply. As producers become more technologically knowledgeable, production costs and environmental impacts will continue to decrease.

- Production from shale gas wells is initially high and decline curves are steep; however, production continues for long periods, enhancing energy security and dampening price volatility. Thousands of wells create a portfolio effect that can help to stabilize prices.

- An Alaska gas pipeline can provide an additional major source of gas and strengthen domestic supplies, although significant obstacles must first be overcome.

- The United States is likely to impose a price on carbon at some time in the future. If carbon is priced correctly, gas will gain in the competition with coal for electric power generation.
    - The application of carbon capture and storage (CCS) to coal combustion will increase the cost advantage of gas.
    - The eventual need to decarbonize gas is likely to require the application of CCS to gas combustion at some future date, decreasing its cost advantage over nuclear and renewables.
- Even with abundant supplies of gas and its environmental advantages, all alternatives will be needed to meet future American energy needs.
- Global natural gas demand is increasing, especially in China and the Middle East.
    - In the near term, China's conventional gas supplies will not meet its rapidly growing demand, requiring imports to balance its supply mix. Unconventional gas development will not take off before 2020.
    - Middle East gas demand is growing almost as fast as China's. While rich in conventional gas supplies, Middle East countries are becoming net importers. Pricing is also a sensitive issue as countries struggle to eliminate huge subsidies and increase domestic prices.
    - Future European gas demand will be relatively flat. Gas security remains a hot issue due to the uncertainty of supplies from Russia, and a desire to decarbonize fuel quickly makes gas a less attractive option for new electricity generation.
- As global natural gas trade develops and there is greater competition for LNG, it is unclear how long two different pricing systems will persist (oil-linked pricing in Europe and Asia versus gas-on-gas pricing in the United States).

- Gas will be used more in the power sector in the United States due to its environmental advantages.

- Compressed natural gas (CNG) as a transportation fuel is more likely in centrally fueled fleets than for individual light duty vehicles.

- Industrial gas demand may be undermined by gas price volatility, but more supply may dampen this volatility.

- To achieve its potential, shale gas development needs to be accomplished in an environmentally sensitive and smart way.

- Regulation is necessary. Federal regulation can establish some principles, but states need to issue the permits and inspect and enforce the regulations. This allows producers to deal with one regulator and allows for flexibility and differences among basins.

- The answer to violations is usually better enforcement rather than new regulations. Industry can be useful in helping to enforce the rules, perhaps with the creation of a best practices monitor.

# Appendices

# *Agenda*

## *The New World of Natural Gas*

### Monday, July 19

**8:30 am—noon**

**SESSION I: Natural Gas Supply**

| | |
|---|---|
| The Growing Global Role for Natural Gas | **Emma Cochrane**<br>Planning Manager, ExxonMobil Gas & Power Marketing Company |
| U.S. Shale Gas – Basis For a New Energy Reality | **Rannveig Stangeland**<br>Vice President, Natural Gas Communications, Statoil |
| Technological Challenges of Gas Shales | **Rod Nelson,** Vice President Communications, Innovation and Collaboration, Schlumberger |
| The Role of Natural Gas in the U.S. | **Marianne Kah**<br>Chief Economist<br>ConocoPhillips |
| Alaska Natural Gas Pipeline | **Tony Palmer**<br>Vice President, Alaska Development<br>TransCanada |

**1:30—5:00 pm**

**SESSION II: Global Economic and Security Issues**

| | |
|---|---|
| Middle East Supply and Demand Changes | **Fereidun Fesharaki**<br>CEO, FACTS Global Energy Group, and Senior Fellow, East West Center |
| Chinese Gas Demand and Sources of Supply | **Gary Dirks,** Director, LightWorks, Arizona State University, and Former President, BP Asia-Pacific and BP China |
| Decarbonization and Supply Security in Europe | **Jonathan Stern**<br>Director, Gas Research<br>Oxford Institute for Energy |
| Economics and Politics of Pipeline vs. LNG transport in Asia | **James T. Jensen**<br>Jensen Associates |

## Saturday, July 3

**8:30 am—noon**

**SESSION III: U.S. Demand Factors**

| | |
|---|---|
| Policy Incentives for Gas Use in Electricity | **Gregory C. Staple,** CEO<br>American Clean Skies Foundation |
| Policy Incentives for Coal Use in Electricity | **Jonathan Wood,** Vice President<br>Government and External Affairs<br>Alpha Natural Resources |
| Prospects for Gas as a Transportation Fuel | **Tom Stricker,** Director<br>Technical and Regulatory Affairs and Energy and Environmental Research<br>Toyota |
| Industrial Gas Demand | **Doug May,** Vice President<br>Energy and Climate Change<br>Dow Chemical |

**1:30—4:00 pm**

**SESSION IV: Environmental Questions with Unconventional Gas**

| | |
|---|---|
| A Regulator's Perspective | **John Hanger,** Secretary<br>Pennsylvania Department of<br>Environmental Protection |
| An Environmentalist's Perspective | **Dusty Horwitt,** Senior Counsel<br>Environmental Working Group |
| A Producer's Perspective | **Paul D. Hagemeier**<br>Vice President – Regulatory<br>Compliance, Chesapeake |

## Wednesday, July 21

**8:30 am—11:30 am**

**SESSION V: Observations and Conclusions**

| | |
|---|---|
| Summary of key points | **Russ Ford**<br>Executive Vice President – Onshore<br>Gas Shell Energy Resources Company |
| Discussion | |

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