The Good News About Gas

The Natural Gas Revolution and Its Consequences

John Deutch

Good news about energy is rare. Energy use and its cost are rising worldwide, most countries remain dependent on oil imports, and little progress has been made toward curbing climate change. So the world should take notice of the recent dramatic increase in estimates of unconventional sources of natural gas in North America and elsewhere, perhaps the greatest shift in energy-reserve estimates in the last half century. In the past few years, thanks to technological advances, vast amounts of natural gas—particularly gas trapped in underground shale basins—have become economically viable.

This development is an unmitigated boon for consumers interested in affordable energy, environmentalists looking for energy sources that emit less carbon dioxide than either oil or coal, and governments that hope to reduce the political and market power of today's major oil- and gas-producing countries. The prospects for a greatly increased global supply of natural gas have dramatic implications for both international energy markets and the energy policies of individual nations. Over time, natural gas use will expand into the power sector and may then displace oil in the transportation and chemical sectors.

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As more natural gas becomes available and more of it is traded, the regional gas markets that exist today may well merge into a more integrated and open international gas market with a single price.

Countries that import natural gas should anticipate more competing sources of it, which will lower prices and reduce concerns about the security of the gas supply. No longer, it seems, will the world be dependent on a few nations—Iran, Qatar, Russia, Saudi Arabia, and Turkmenistan—that control the bulk of conventional natural gas reserves. Countries that produce natural gas will need to adjust to lower revenues from natural gas exports; for some of them, the adjustment may be quite severe and potentially destabilizing. As gas acts as a substitute for oil, demand for oil will fall, putting downward pressure on oil prices. This will lessen, but certainly not eliminate, the geopolitical influence that major oil-exporting countries enjoy today. It is perhaps a permissible exaggeration to claim a natural gas revolution. But like all revolutions, whether and to what extent the benefits are realized will depend on how rapidly the economic and political systems adapt to the change.

THE SHALE GAS BOOM

MOST NATURAL gas is extracted from so-called conventional deposits, usually from gas fields or oil reservoirs, and is typically found in highly porous rocks, such as sandstone. Producers need only to tap into the natural pressure of the reservoirs to release this trapped gas. "Unconventional deposits," in contrast, traditionally refers to either tight gas, which is found in relatively impermeable rock formations that release gas slowly; coal-bed methane, which has been absorbed into coal seams; or shale gas, which exists in fine-grained sedimentary rock. (Methane hydrate, a crystalline solid found on the ocean floor and in the Arctic, is another type, but it is even more difficult to extract.) Unconventional gas is technically difficult to recover, but once extracted, it is identical to conventional natural gas. It can be distributed by pipelines or condensed into liquefied natural gas (LNG) and exported internationally.

Just a few years ago, the U.S. oil and gas industry was concerned about the depletion of conventional natural gas reserves in the United States. Most experts believed that North America would soon have to become

a net importer of natural gas, in the form of LNG carried by massive refrigerated tankers. Twelve LNG regasification facilities, which gasify the LNG into natural gas suitable for pipelines, were constructed and put into operation in the United States (as well as two in Mexico and one in Canada), mostly in the last decade. Believing that natural gas prices would rise, U.S. gas producers also began exploiting unconventional sources.

To nearly everyone's surprise, unconventional gas turned out to be much more promising than expected. Beginning in 2008, experience in the field made the gas industry realize that shale gas was a large and economically feasible source of domestic supply. Today, all three types of unconventional gas are significant sources of supply in the United States, but shale gas attracts the most attention, since its potential resource base is believed to be especially massive.

Two technological advances made shale gas economically feasible to produce: horizontal drilling and hydraulic fracturing (or "fracking"). To extract the gas, workers must drill down until they hit a thin layer of shale, 1,000 to 12,000 feet underground, and then steer the drilling horizontally for several thousand more feet. Fracking fluid—water, sand, and chemical additives—is injected into the layer at high pressure, perforating the formation and opening tiny cracks in the shale, thus allowing the trapped gas to escape.

The new technologies that made this procedure possible drove down dramatically the cost of producing shale gas. Today, although the average cost of production depends on many factors and varies from region to region, it tends to range from $2 to $3 per thousand cubic feet of gas—around one-half to one-third the production cost associated with new conventional gas wells in North America. And given that much is left to be understood about the character of this resource and how to produce it most efficiently, operating experience and additional technical advances are likely to drive the costs of production down even further.

With such low production costs for shale gas, the United States' enormous quantities of natural gas in shale deposits have become commercially recoverable. The country's regions of possible reserves, or "plays," as they are called in the industry, extend across the United States and include the Marcellus play in New York and Pennsylvania,

the Barnett and Haynesville plays in Texas, and the Bakken play in Montana and North Dakota.

It is not yet clear exactly how large North America's shale gas reserves are. Canada is beginning to explore its shale gas resources, but as yet there is little activity in Mexico. Estimates of U.S. shale gas reserves, meanwhile, keep increasing. In 2007, the U.S. Energy Information Administration estimated that out of the United States' approximately 250 trillion cubic feet of proven natural gas reserves, there were 22 trillion cubic feet of proven reserves of all types of unconventional gas. ("Proven" means that geological and engineering data suggest that, with a reasonable degree of certainty, the reserves are recoverable under existing economic and operating conditions.) In 2008, as expanding exploration and production field activity provided new data, the estimate jumped to 33 trillion cubic feet. Future estimates of proven unconventional gas reserves in the United States will almost certainly continue to increase. As for the total technically recoverable shale gas reserves in the United States (natural gas that could be recovered in the future using today's technology without considering economic constraints), estimates fall in the range of 600 to 700 trillion cubic feet, out of a total 2,500 trillion cubic feet of technically recoverable natural gas from all sources.

Companies have been quick to take note of shale gas' potential. In just one year, shale gas production in the United States doubled, from about five percent of total U.S. natural gas production in 2007 to about ten percent in 2008. This caused the price of natural gas in North America to collapse; by 2009, it was down to about $4 per thousand cubic feet. It no longer made economic sense to import LNG, and the utilization of U.S. LNG regasification terminals fell from over 50 percent of capacity in 2005 to only 11 percent in 2009.

Current U.S. shale gas production, at about ten billion cubic feet per day, makes up 20 percent of total U.S. natural gas production. Major oil companies in the United States (such as ExxonMobil and ConocoPhillips) and abroad (such as Statoil, the China National Offshore Oil Corporation, and Reliance Industries) are aggressively acquiring shale gas acreage in North America. The 2010 MIT study "The Future of Natural Gas" estimates that compared with today, shale gas production from five major plays in the United States will double by 2015 and triple by 2030.

But the rate at which shale gas production will increase depends on several factors, including how successfully the industry meets the environmental challenges of production. In the United States, the greatest threat to robust expansion is concerns about fracking. The process, which involves dozens of trucks, is by no means a gentle operation. Communities are especially concerned about the fracking fluid—that it uses too much water (a typical well may require 3–4 million gallons), that it will not be cleaned up, that it contaminates drinking water, and that the chemicals used in it have not been publicly disclosed. U.S. states are beginning to regulate fracking, but it is difficult to design a regulatory structure that works for both small and large companies. If the industry is to avoid onerous regulation, it should establish safety and environmental standards on its own.

Still, the conclusion is clear: North America has sufficient natural gas that can be produced at reasonable cost to meet its needs for the foreseeable future. In fact, far from needing to import natural gas, as was previously expected, North America may well become an exporter of gas to the rest of the world.

Many other countries could benefit from this bounty, too. There are no reliable estimates about the size of the economically recoverable shale resource base worldwide, but shale deposits are found all over the globe. And they are not geologically or geographically correlated with conventional oil and gas deposits. Already, companies are developing shale gas operations in Australia, China, Germany, India, Poland, Romania, and Russia; for the moment, the shale-rich regions of Africa and Latin America remain untouched.

A MORE UNIFIED MARKET

THIS NATURAL gas boom will have important consequences for the international natural gas trade. Today, the world is essentially divided into three natural gas markets: North America, Asia, and Europe. Historically, supply and demand have balanced in each of these markets separately, leading to different natural gas prices, trade patterns, and political tensions between suppliers, who wield their resources as a political tool, and consumers, who worry about the cost and security of this supply. In this respect, natural gas is unlike oil, which

is traded at the same price everywhere. The difference is due to the relatively high cost of transporting natural gas long distances; gas pipelines are more expensive than oil tankers. To be sure, the three natural gas markets are not completely independent. LNG is gradually eroding price differences between the Atlantic and the Pacific basins; tankers can be diverted from one destination to another depending on prices. But for the most part, the prices are determined in each of these markets separately.

In the North American market, demand is essentially satisfied by domestic production, and the price of natural gas is set by its value as a fuel in the power sector, where it competes with coal. In the Asian market, where most natural gas is imported, it competes against oil for electricity generation or for industrial use. Suppliers sell their natural gas there at prices set by the value of the gas relative to the so-called Japanese crude cocktail, a weighted average of oil imports to Japan, the region's benchmark. In the European market, 50 percent of the natural gas is produced within Europe; 30 percent is imported by pipeline from Russia, Algeria, and Libya; and 20 percent is imported as LNG. So Europe's market is an intermediate position between North America (where there is ample regional production) and Asia (where consumers are pressed by suppliers to pay oil-linked prices for natural gas imports). Because these three regional markets largely function separately, gas

prices vary greatly between the regions, and each experiences significant price fluctuations.

Two developments are likely to disrupt this global disequilibrium in gas prices. First, the LNG trade should expand substantially as countries with huge conventional gas reserves, such as Nigeria, Qatar, Russia, and Trinidad and Tobago, seek to bring their gas to market. The projected annual capacity of liquefaction facilities is estimated to grow from about 280 billion cubic feet in 2008 to over 400 billion cubic feet in 2015 (when it will supply about 15 percent of total consumption). In time, this LNG trade will lead to a global market for natural gas similar to that for oil. As gas is increasingly traded globally by pipeline or tanker, it will become impossible for prices in the three regional markets to differ widely. If trade is freely permitted, a difference between $4 per thousand cubic feet in New York and $10 per thousand cubic feet in Tokyo, for example, simply cannot survive.

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The second change is the recent and rapid development of cheap unconventional gas resources. Unconventional gas production, coupled with increased interregional natural gas pipeline capacity and expanded LNG liquefaction facilities, will make it progressively more difficult to continue linking gas prices to oil prices. Since natural gas is cheaper than oil on an equivalent energy basis (meaning the price per BTU is lower), over time, natural gas will begin to replace oil, first in the power sector and then in the industrial and transportation sectors.

Many countries, such as the United States, do not use appreciable amounts of oil in the power sector. In these places, the most likely use for newfound gas in the near term is electricity generation, since power plants that burn natural gas are an economically competitive substitute for those that burn coal. Especially promising are "natural gas combined cycle" plants, which are less capital-intensive and more efficient than other sources of power. These plants also emit less carbon dioxide—compared with coal plants, they produce less than one-half as much per kilowatt-hour of electricity.

The consequences that cheaper natural gas will have for renewable energy are more complex. On the one hand, since today it is more

expensive to generate electricity from wind, geothermal, or solar power, natural gas will be a competitor to renewable energy. On the other hand, cheap electricity from natural gas will make hybrid power plants—which generate electricity from intermittent wind or solar electricity as well as from natural gas—more attractive.

In the longer term, natural gas could substitute for gasoline or diesel in vehicles (most likely in the form of compressed natural gas). Yet in the United States, where less than one-tenth of one percent of natural gas is used for transportation, there are several barriers to the widespread adoption of such cars: there is no easily accessible natural gas fueling infrastructure, retrofitting existing internal combustion engines is expensive, and no one knows if natural gas will remain so much cheaper than oil as to make investments in vehicles powered by natural gas profitable.

But for the moment, natural gas has economics on its side. In the United States today, oil is three times as costly as natural gas for a given amount of energy ($12 per million BTUs, compared with $4 per million BTUs), and that is almost double the ratio that has prevailed over the past 20 years. Such a differential is a powerful economic incentive to develop new technology to substitute natural gas for gasoline used in the transportation sector. It could also spur development of new processes in the chemical sector, where natural gas could replace oil in the production of polymers, plastics, and other petrochemicals.

WINNERS AND LOSERS

THE RADICAL increase in the global supply of natural gas will require governments to make significant adjustments to their policies. But the effects will not be uniform. Countries that export large amounts of natural gas will suffer from lower than expected revenues and a reduced ability to use energy as a tool of foreign policy. Countries that import natural gas will benefit from the worldwide increase in reserves and production because prices will be lower than previously anticipated. And since there will be more sources of supply, these countries' concerns about the security of supply will be dampened.

For years, major natural gas holders—such as Australia, Bolivia, Iran, Russia, Saudi Arabia, and the United States—anticipated a future of high, oil-linked gas prices. They invested in expensive LNG

liquefaction facilities and pipeline projects. But now, these countries are facing a reduction of the value of the resource in the ground. A dramatic increase in the global availability of unconventional gas and lower natural gas prices could put these and other planned investments under water, although the effect will not be immediate because of long-term contracts. For producers, shutting down these export facilities is not an economical choice, once the investment has been made.

In the long run, however, investors have an enormous economic incentive to develop technologies that will exploit the price difference between natural gas and oil. For example, the industry is sure to consider new uses for natural gas that were previously uneconomical, including gas-to-liquid conversion processes such as producing methanol from natural gas.

The United States, for its part, will need to reexamine its domestic policy. Because of the anticipated increase in natural gas use, the United States should encourage technology that improves the efficiency of using natural gas, better defines and characterizes all types of natural gas reserves, and reduces the environmental burden of production. Policies designed to stimulate the domestic supply of natural gas should be reconsidered. This includes the federal loan guarantee that Congress approved in 2004 for a proposed pipeline to transport Alaskan gas to the lower 48 states, since these states now have lower-cost sources of gas readily available. Having made little progress on climate-change legislation, Congress should also recognize that natural gas offers an opportunity to reduce carbon emissions.

U.S. foreign policy must be adjusted as well. A transparent global gas market would be beneficial to Washington and its allies because it would lead to the economically efficient use of resources and prevent major exporters from exploiting their resources for political gain. So the United States should join other countries in the Organization for Economic Cooperation and Development and the new major gas-importing countries (most important, China and India) in an effort to encourage open markets and to avoid long-term bilateral arrangements. And although doing so will be politically contentious, the United States should refrain from erecting barriers to the natural gas trade, by imposing either import or export duties. If it adopts protectionist measures, other countries will be encouraged to do so, too.

For Russia, the world's largest holder of natural gas, the impending lower gas prices and availability of natural gas elsewhere present many challenges, even though the country likely has plenty of shale gas. Russia should anticipate a drop in the significant revenue it currently receives from gas exports to Europe, under contracts that are not the result of an open bidding process and are linked to oil prices. As unconventional gas becomes available in Europe, consuming countries will insist on an open market with competition from diverse suppliers to meet demand. The Russian government needs revenue from natural gas exports to modernize the aging production and distribution network of its state-controlled gas company, Gazprom (at the very least to stop its pipelines from leaking methane, a powerful greenhouse gas). It also needs revenue to fund massive initiatives already under way, such as the Sakhalin Island oil and gas project, which includes liquefaction plants intended to ship LNG to Japan and other Asian markets.

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As the second-largest holder of natural gas, Iran will be affected, too. But because sanctions have largely kept the country from developing its huge natural gas reserves, it will suffer only a paper loss; if Iran manages to export its gas in the future, it will receive less revenue than previously thought. Saudi Arabia, another major gas producer, is in a more fortunate position since it has long favored the conversion of natural gas to liquid products in its domestic chemical industry rather than exporting its gas as LNG. This now appears to have been a wise choice.

Gas importers, by contrast, stand to gain from the increased availability of natural gas. Europe, with significant but as yet unproven shale gas prospects, should see its security concerns about dependence on Russian gas imports subside—especially concerns in Germany, which gets 40 percent of its natural gas from Russia. Over the past five years, disputes between Russia and Ukraine over gas have led to periodic cutoffs of gas to Europe. Europe can look forward to a more open market, one with competition among widespread gas production in Europe, LNG imports, and piped gas from Russia and North Africa.

In Asia, countries that consume natural gas will find it cheaper to do so. The developed Asian states—Japan, South Korea, and Taiwan—are large importers of natural gas and have long paid oil-linked prices for it. They can anticipate more favorable terms from Australian, Middle Eastern, and Russian suppliers when existing contracts expire. China and India, rapidly growing Asian economies that are becoming the largest global gas consumers, should especially welcome the greater availability of natural gas. For them, it presents an opportunity to replace aging and inefficient coal-fired power plants and reduce their carbon dioxide emissions.

The news for Asian natural gas exporters is not as good. Most of the natural gas traded in Asia is in the form of LNG. Asia has over 60 LNG regasification facilities planned or in operation, and significant investments have been made in liquefaction terminals in Australia, Brunei, Indonesia, Malaysia, and Papua New Guinea. As elsewhere, in Asia, producers supplying LNG should anticipate earning less when natural gas prices fall as they delink from oil prices. In some cases, the drop in gas prices may mean that certain projects will no longer make economic sense. Energy companies in Australia, for example, may need to reassess their ambitious Gorgon conventional gas project, which is intended to extract gas from far offshore and export it as LNG, and their similarly ambitious coal-bed methane projects.

THE LONG VIEW

IN ADDITION to affecting natural gas markets, the increased supply of natural gas will dramatically change the outlook for oil markets. As natural gas edges out oil in the power, transportation, and chemical sectors, oil prices will fall and the price disparity between oil and gas will close.

The major oil-producing countries, of course, will need to readjust their expectations. Most of them operate through national oil companies that serve their government's political and economic interests. The newfound natural gas reserves, dispersed around the world, will reduce the market power these companies have enjoyed. There will be difficult negotiations between natural gas suppliers and consumers over new contract terms. Accordingly, past concerns that the Gas

Exporting Countries Forum, an OPEC-like cartel formed by major natural gas producers, could control supplies and prices of gas the way oil producers have with oil appear far less serious. International oil companies caught with major investments in the exploration and production of natural gas in the Arctic and deep offshore are quickly shifting their exploration and production activities to shale and other forms of unconventional gas that are cheaper to produce.

Nobody knows how significant this prospective shift from oil to natural gas might become. But two points deserve emphasis. First, although the explosion of shale gas production will lead to gas substituting for oil and erode the market and political power of today's major oil- and gas-exporting countries, this market penetration will not be so large that the security concerns of the United States and other oil importers about dependence on foreign oil will disappear. And second, in the long run, the world will need to transition from fossil fuels to carbon-free sources of energy, such as wind, solar, geothermal, and nuclear energy. In this sense, shale gas is a way station en route to a new energy future—not a permanent solution to the problem.

None of these changes will occur rapidly. There are significant uncertainties about how much shale gas around the world can be produced economically, the environmental implications of widespread production, and the economics of substituting natural gas for other sources. The large investments required for natural gas exploration, production, and distribution depend on financing supported by long-term contracts. Established industry practices change slowly. There will continue to be fierce competition over pipeline routes, LNG projects, and supply contracts—which means that there will continue to be difficult commercial, financing, and political negotiations between supplier and consuming nations. The countries and international oil companies that are large producers of conventional natural gas will resist delinking the price of the gas they sell from the price of oil.

But at the end of the day, economic reality should prevail, and a global market for gas will develop just as it did for oil. Eventually, there will be a transparent and integrated global gas market with diverse supplies that is governed by economic considerations and is free of subsidies. And gas consumers everywhere will be better off.