An IHS CERA Special Report

Fueling North America's Energy Future

The Unconventional Natural Gas Revolution and the Carbon Agenda

Executive Summary

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FUELING NORTH AMERICA'S ENERGY FUTURE: THE UNCONVENTIONAL NATURAL GAS REVOLUTION AND THE CARBON AGENDA

A major new factor—unconventional natural gas—is moving to the fore in the US energy scene and the national energy discussion. It is also of growing significance in Canada. It was only proved out over the course of the first decade of the twenty-first century. The scale was not even really recognized until 2007–08; and it did not enter the US national energy discussion until the second half of 2009. And yet it ranks as the most significant energy innovation so far this century—and one that, because of its scale, requires a reassessment of expectations for energy development. It has the potential, at least, to cause a paradigm shift in the fueling of North America's energy future.

This is the unconventional natural gas revolution—specifically, the emergence of shale gas. A veritable "shale gale" is transforming the supply and price outlooks for natural gas and the competition among energy options. Shale gas accounted for only 1 percent of US natural gas supply in 2000; today it is 20 percent. By 2035 it could be 50 percent. Shale gas and other forms of unconventional natural gas would underpin a significant increase in US natural gas consumption—and could allow the electric power industry to almost double its use of natural gas, from 19 billion cubic feet (Bcf) per day at present to 35 Bcf per day by 2035. An abundant natural gas resource shifts the choices for power generation technologies to meet both growing demand for electricity and the needs from retirements of aging power plants. It changes the relative costs for addressing greenhouse gas (GHG) emissions. It could also have an effect on transportation fuels—whether in the form of natural gas vehicles or via the turbine blades of a gas-fired power station that is, among other things, recharging the batteries of an electric vehicle.

The unconventional natural gas revolution has lowered the natural gas price outlook and made gas more competitive while encouraging higher expectations for security of supply—a dramatic shift from just half a decade ago. Furthermore most power producers have begun to expect that GHG limits in the future are less a matter of "if" than a question of "when and how much."

Yet, at the same time, there are also limits to the impact of shale gas that are imposed by the relative economics of fuels; the configuration of the power system and the requirements of reliability; the structure of the transportation system; and the uncertainties and potential imperatives of public policy, particularly in terms of GHGs.

This report seeks to address the impact of the "shale gale" on the energy system. It aims to provide a framework for understanding the potential impact of the unconventional gas revolution, a common basis for dialogue on the issues raised by it, and a context for fitting the changed outlook for natural gas into the discussion about power generation choices and reducing GHGs. The study does not seek to address the entire energy system and the full range of future options; that is beyond the scope.

CRITICAL ISSUES AND THE "SHALE GALE"

The issues around our central topic are critical. The emergence of the resource takes on particular significance at a time when the United States and Canada are grappling with the paths to a lower carbon future. Natural gas has about half the carbon content of coal, the mainstay of US power generation, which in turn accounts for about 40 percent of US GHG emissions. A new role for natural gas is emerging as the required "partner" for expanding renewable generation, which, while zero carbon, is also intermittent, depending on when the wind blows or the sun shines.

At the same time, in contrast to demand for transportation fuels, US power demand remains on a growth track. Even with increased efficiency, US power demand could grow over the next two decades by about a third, requiring 270 gigawatts of new capacity—equivalent to 540 new gas-fired or coal-fired units or more than 200 nuclear units. What will make up that capacity? That is a question that threads through this study.

IHS CERA has developed this report using a two-track process. We have drawn together stakeholders from all sides of the energy and environment spectrum—policymakers, electric utilities, natural gas producers and consumers, regulators, and nongovernmental organizations—to discuss the unconventional natural gas revolution, possible roles for natural gas and other fuels in the future energy mix, the drivers of the electric power industry and the interaction with emerging GHG policy, and transportation. Workshops were held in Washington, DC; Calgary; San Francisco; and Chicago to address the uncertainties and to identify areas of consensus and differences in viewpoint.

At the same time, IHS CERA carried out its own independent research and analysis. This study reflects that analysis, informed by the discussion and questions raised in the workshops. This study represents solely the views of IHS CERA. In this study, we may use US-specific illustrations of the United States' issues because of its greater overall scale, because the gas consumption is so much greater, and because it is more carbon intensive than the Canadian energy sector. However, the insights are as applicable to the issues Canada faces in achieving its own low-carbon future.

We hope that *Fueling North America's Energy Future* will make a substantive contribution to the national energy dialogue in both countries and provide a framework and basis for continuing discussion. We realize that the picture will continue to evolve. After all, only four years ago this topic would not even have been on the agenda. With so much changing, there is no singular moment for a definitive report. We welcome the dialogue and debate that this study will engender and encourage contribution by others to further elucidating and understanding these issues. But the study does start with the recognition of a new reality—how, through continual innovation and experimentation, a new energy option that was not obvious even half a decade ago has turned into a veritable "shale gale."

THE ROLE OF NATURAL GAS

Natural gas is one of the United States' major energy sources. It keeps about a quarter of the country running; that is, it provides almost 25 percent of total US primary energy demand. Natural gas demand was built up over the second half of the twentieth century, reaching

more than 60 Bcf per day in 2009. Prior to that it was a local fuel. During World War II, as pressure mounted on US oil supplies, President Franklin Roosevelt wrote to his Secretary of the Interior, "I wish you would get some of your people to look into the possibility of using natural gas. I am told that there are a number of fields in the West and the Southwest where practically no oil has been discovered but where an enormous amount of natural gas is lying idle in the ground because it is too far to pipe to large communities."*

It was only after World War II that these fields were connected to markets. With that came a great expansion. For in the decades that followed, natural gas turned into a continental energy resource, facilitated by the development of an expanding network of major pipelines that tied producing areas to demand centers. It became a major fuel source for homes, industry, and power plants.

But from the beginning of the twenty-first century until 2007, it was generally thought that natural gas was in tight supply and that, as a result, the United States would become a growing importer of liquefied natural gas (LNG) in order to meet the increasing gap between rising demand and constrained US and Canadian supply.

SIX KEY QUESTIONS

The unconventional revolution shifts natural gas from a constrained energy resource to an abundant one. In so doing it raises many questions. This study addresses six sets of questions that are key to the energy future:

- How large is the gas resource base opened up by the shale gas revolution, and what are the financial costs and the footprint of its development?
- What factors could limit the realization of the potential of unconventional natural gas? What are the environmental issues associated with its development?
- Does this greater abundance of natural gas mean that gas prices are now on a lower and more stable trend, or is this the bottom of a cycle?
- What are the growth markets for natural gas, and in particular, what are the prospects in transportation?
- What are the growth prospects in electric power? Under what constraints—technical, economic, and political—do electric power providers operate, and how might the changed fuel supply picture affect investment decisions that utilities make and regulators approve?
- How significant a role can natural gas play in achieving reductions in GHG emissions along with such other options as nuclear energy, renewable energy, and carbon capture and storage (CCS)?

*Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Free Press, 2009, new edition), p. 361.

Changes can occur relatively quickly in the overall energy system, but large changes require time. The vast sums invested in the energy supply chain and the long investment lead times prevent major overnight changes in the fuel and technology mix—today's investment decisions will, to a great extent, determine the outcome 20 or 30 years from now. Greater certainty in government policy would certainly facilitate the investment process. This particularly applies to the policy decisions that will determine how, at what cost, and to what degree North America will decarbonize its energy system. Uncertainty about the policy framework creates delay and postpones investment decisions.

KEY FINDINGS

The New Natural Gas Resource Is a Game Changer

- North American discovered natural gas resources have increased by more than 1,800 trillion cubic feet (Tcf) over the past three years, bringing the total natural gas resource base to more than 3,000 Tcf, a level that could supply current consumption for well over 100 years.
- Development of this expanded resource may be able to meet significantly increased levels of demand without significant increases in prices.
- Shale gas alone is expected to grow to more than 50 percent of the supply portfolio by 2030.
- Indigenous natural gas supplies reduce the need for LNG imports into North America—which become a matter of choice rather than necessity.

The combination of hydraulic fracturing (fraccing) and horizontal drilling has opened up vast new resources of natural gas from shale formations and tight sandstones. These innovations have unlocked the potential of natural gas shales that have greatly increased the potential supply of natural gas in North America and at a much lower cost than conventional natural gas. IHS CERA's analysis of the emerging natural gas plays in North America points to an aggregate discovered resource base of some 2,000 Tcf and a total, including what is expected to be found in the future, of more than 3,000 Tcf. In the United States alone the new natural gas plays have increased the resource base by more than 1,100 Tcf. This is an order of magnitude larger than the proved reserves recognized by the US Energy Information Administration (EIA) only two years ago. In addition, the estimated shale gas resources in Canada exceed 500 Tcf. If there were sufficient market demand, the scale of the resource would allow North American natural gas supply to grow dramatically.

At the same time, the outlook for the cost of supply has fallen from more than $6 per million British thermal units (MMBtu) to less than $5 per MMBtu because shale gas development is lower cost than most conventional sources of natural gas supply. Unconventional gas changes the supply risks from those of the traditional exploration and production business to those more akin to the manufacturing business. Great focus will be directed to improving efficiencies throughout the supply chain and to continuing to drive down costs.

Shale Gas Brings Benefits and Environmental Impacts

- Natural gas has a lower carbon footprint—about half that of coal—and results in negligible emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury, and particulates in contrast to other fossil fuels.
- The local impacts—land disruption, air quality, and noise disturbance—occur during the drilling and completion phase (two or three months) rather than the production phase (20 to 40 years).
- Water has emerged as the highest visibility environmental issue with shale gas. A comprehensive regulatory framework for well construction and water management is already in place with the objective of protecting drinking water supplies. Deeper dialogue between industry and other stakeholders is required, as well as greater transparency and understanding of the technology, geology, and the current highly regulated system of water management.

The greatest attraction of natural gas, from an environmental perspective, is that it results in the lowest carbon dioxide (CO_2) emissions of any fossil fuel, meaning that it has significant potential to help address global climate change concerns. All types of energy involve trade-offs among local environmental impacts, economic development, and wider impacts on the environment or climate. Shale gas resources are no exception, and raise both positive and negative issues for the environment and for local communities and local economies.

Environmental concerns focus on two water issues: Will the water and chemicals used in fraccing seep into drinking water? And is the "produced water" that comes out of the wells sufficiently well-managed to avoid contamination? There is considerable geological separation, including impermeable rocks, between the underground fraccing sites and drinking water aquifers. "Produced water" requires management in all oil and gas drilling. The well-drilling process, including water management, is regulated at the state and local levels. Prior to drilling, operators must obtain a permit that generally includes approval of the well location, well design, and plan for restoring the location after drilling is complete. Environmental impact statements review the potential environmental impacts and establish plans to mitigate them. The states regulate the fraccing process and the US Environmental Protection Agency (EPA) regulates produced water management under the Safe Drinking Water Act and the Clean Water Act. The EPA has delegated its regulatory authority to most of the states with oil and gas production.

Oil and gas operations are widespread throughout North America, and drinking water supplies appear to have been safeguarded from contamination. This suggests that the risks can be managed and that shale gas development can proceed safely, with proper industry management and regulatory safeguards in place. These issues will be better understood and handled through collaboration, research, and transparency, and with an understanding of the current regulatory system.

New Shock Absorbers for Natural Gas Supplies

- Price spikes for natural gas are of particular concern to electric power generators and other large end users.
- Volatility and price variations are essential mechanisms that send signals to consumers and suppliers to balance the market. The extremes, however, can be destabilizing with very adverse results—and thus the need for "shock absorbers" to reduce the impact of hurricanes or other events that might temporarily disrupt supplies.
- The newfound expansion of unconventional gas, combined with the expansion of LNG import facilities in the United States and Canada and increased storage, has introduced new supply shock absorbers to respond to disruptions and market imbalances.
- Past experience of natural gas prices raises a question among large users as to whether relatively more stable prices are at hand, as opposed to the bottom of a cycle. As the giant new shale gas plays are brought into production, end-user confidence in the long-term sustainability of shale gas supply will likely grow.

Based on experience, a prevalent anxiety about natural gas concerns the lack of adequate "shock absorbers" that allow the supply system to respond to sudden unexpected increases in demand or loss of supply. Such a lack makes the market vulnerable to demand increases, creating high and sometimes protracted price increases that undermine investment by power generators and other end users. But the advent of shale gas brings on a major new shock absorber—an abundant new supply source that can respond relatively quickly to changes in demand compared to more traditional sources of gas supply. Combined with expansion of LNG regasification and storage capacity, shale gas means that the natural gas market will now have a more complete set of shock absorbers that should shorten the time needed to rebalance the market.

These shock absorbers will not eliminate price volatility. Indeed, price volatility will continue to signal the existence of market imbalances that require a supply or demand response. However, the new market dynamics made possible by these shock absorbers will allow quicker supply responses to price signals indicating shortage and may help to prevent an unexpected sustained step up in natural gas prices.

New Supply Potential and Demand Options

- Residential, commercial, and industrial natural gas demand have registered long-term declines that may be moderated but are unlikely to be reversed.
- The major source for rapid growth in natural gas demand is the electric power sector. Power demand growth is extremely likely as new uses for electricity (possibly including electric vehicles) overcome the effects of energy efficiency and conservation.
- Much of any electricity demand growth will be met by gas-fired generation. Natural gas demand from the US power sector could grow from roughly 19 Bcf per day today to as much as 35 Bcf per day by 2030.
- Natural gas–fired power plants have cost, timing, and emissions advantages compared to coal-fired plants. However, natural gas use for power generation over the long term depends on how strict GHG emissions targets will be and how other competing or complementary technologies (nuclear, CCS, and renewables) develop over time.
- The infrastructure needs and higher costs will likely limit significant growth in natural gas vehicles, which now number a few hundred thousand in the United States. Very significant policy support would be needed, which would compete with policy support for higher efficiency, biofuels, and electric vehicles. The most likely growth market for natural gas in transportation would be through the electric power sector.
- LNG exports from either British Columbia or Alaska (already an LNG exporter) may be competitive into high priced oil-linked Asian markets, but significant exports from the US Lower 48 are problematic.

The "shale gale" creates opportunities for a range of new uses for natural gas. Residential, commercial, and industrial demand all appear to be in long-term decline (with the possible exception of demand in the Canadian oil sands). There is renewed interest in using natural gas in vehicles, both providing a market for natural gas and reducing oil usage. However, the very large infrastructure costs associated with natural gas usage on a large scale in transportation, combined with the time lags to change the auto fleet, constitute a major obstacle. Moreover, natural gas vehicles have to compete with increased auto efficiency, which affects the economics as well as policy commitments to biofuels and electric vehicles. The most obvious area of growth would be urban fleets, which can be fueled from a central source. Natural gas may gain its largest role in transportation fueling electric power plants that, among other things, help recharge electric vehicles.

The power sector holds the greatest potential for growth in natural gas consumption in both the short and long term. The power sector is reevaluating its future generation mix, in light of environmental and cost considerations, as well as shifting fuel options. The new outlook for natural gas expands the opportunities for natural gas in the climate change debate.

There Is No Single Fuel or Technology of Choice in the Power Sector

- The abundance of new natural gas will increase the share of natural gas–fired generation in the North American power sector.
- It will expand the role of natural gas–fired generation technologies to back up renewable power resources—a new role for natural gas
- Natural gas–fired generation consumed 3 Bcf per day more natural gas in 2009 than in 2008 when adjusted for the impact of the Great Recession. Displacement of coal-fired generation contributed significantly to this number. But there is a limited pool of "spare" gas-fired capacity that prevents wholesale displacement of coal with natural gas.
- In addition to this fuel switching, the power sector can reduce near-term CO_2 emissions by replacing existing coal-fired plants with new gas-fired plants and converting existing coal-fired plants to burning gas. This would require substantial investment and would result in growth of natural gas use. But power companies would be concerned about longer-term requirements to further reduce CO_2, which would also affect gas-fired facilities.
- The power industry has a multiple-decade planning horizon. If the goals include cutting carbon emissions substantially over the long term, such as the often-cited 80 percent reduction by midcentury, aggressive development and deployment of zero-carbon technologies, including nuclear and CCS, will need to take place today.
- But a gas-based solution, on its own, does not provide a long-term path to a low-carbon future. To get there will require a portfolio of options including not only natural gas but also some mix of nuclear power, renewables, and breakthroughs in CCS.

Economic and technical factors create roles for a spectrum of power generation technologies—to provide base load, cycling, and peaking capacity and to maintain grid stability. No single technology or fuel provides the lowest cost of electric production to meet all requirements of the power supply process. However, the desired portfolio of generating options changes over time as technological innovation alters expected cost and performance of different generating technologies and as expectations for capital, fuel supply, and (prospectively) GHG emissions costs change.

The power industry will likely increase the share of natural gas in the fuel mix because of the carbon footprint of natural gas–fired generation and because it can be built more quickly and easily than coal, nuclear, or hydro and will benefit from credible expectations of lower long-term natural gas prices. This will help meet carbon targets in the next two decades. However, an 80 percent national target for carbon reduction by 2050 would imply that the entire CO_2 output from a much larger power system would equal today's CO_2 output just from natural gas generation—which represents only 20 percent of power sector emissions. Thus, power companies face a quandary in making their longer-term fuel choices. Every choice brings challenges. Given demand outlooks, just to keep nuclear power at its current 20 percent share of total US generation would require building 40 gigawatts of new nuclear plants over the coming two decades. The pace of nuclear additions needs to pick up beyond the next two decades to maintain nuclear's 20 percent share because of anticipated retirements.

One version of the quandary therefore comes down to this: Should power companies build combined-cycle gas turbine plants, which are much easier to permit and quicker to build, and take the risk that they may be unable to operate for their planned technical life span because of the encroachment of GHG emissions limits? Or should they build nuclear power plants, which are more expensive and take longer to build and are more difficult to permit, that are not subject to this risk but may turn out not to have been necessary if GHG emissions limits are less stringent than currently proposed?

Carbon Capture and Storage—The Scale and Uncertainties

- If the often-mentioned 80 percent reduction target for CO_2 emissions are to be met, either fossil fuel usage—including natural gas—will have to be dramatically reduced or CCS will be required.
- The state of technology for CCS needs to advance significantly if it is to be cost competitive with clean energy alternatives such as nuclear or hydropower.
- Commercial, utility-scale CCS has not been demonstrated. The scale of North American CO_2 daily emissions from the power sector alone (in dense phase, "liquid" conditions) exceeds three quarters of global daily oil supply volumes.
- Policy to deal with legal liability and pore space ownership issues will be required just as much as support for expansion of research and development (R&D) efforts to demonstrate utility-scale CO_2 injection.

If fossil fuels—natural gas or coal in the power sector—are to be viable in a future era in which GHG emissions are significantly limited, technologies must be developed to remove their intrinsic carbon. Demonstration plants to strip the CO_2 from the flue gases of coal-fired power stations have confirmed the technical feasibility of carbon capture. Similarly, geological CO_2 storage (by injecting it into subsurface formations) has been demonstrated. However, the size of demonstrations has been at least an order of magnitude smaller than utility scale.

Moreover, given the requirements of CCS at utility scale, a new system of regulation and ownership would have to be developed, including perhaps a concept of "eminent subdomain," which would certainly be controversial.

Innovation is required to dramatically reduce the costs of CCS at scale. But the size of the challenge and levels of R&D investment to make the required breakthroughs may be significantly underestimated. Innovation can often deliver surprises. The "shale gale" is an obvious case in point. If the objective is to meet the 80 percent target for reducing GHG emissions, what will be required is a range of options that includes some form of CCS, nuclear, renewables including hydropower (the most readily available source of reliable, dispatchable, renewable power), and natural gas—and, no doubt, technologies that are not yet mature or even evident.

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