

Briefing Paper

The Role of Natural Gas in a Low-Carbon Energy Economy

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Natural Gas and Sustainable Energy Initiative

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Executive Summary

Growing estimates of natural gas resources, including a new category of “unconventional” gas, suggest that accessible supplies of this least carbon-intensive of the fossil fuels may be far more abundant than previously assumed. This unexpected development creates opportunities for deploying natural gas in a variety of sectors—including power generation, industry, and transportation—to help displace oil and coal, thereby reducing greenhouse gas emissions and improving air quality.

Beyond providing a cleaner, market-ready alternative to oil and coal, natural gas can facilitate the systemic changes that will underpin the development of a more energy-efficient and renewable energy-based economy. For example, smaller, distributed generators, many producing usable heat as well as electricity, could generate economical, low-emission replacements for a large fraction of currently operating conventional power plants, providing flexible back-up to the variable output of the solar and wind generators that will comprise a growing share of the electric power system.

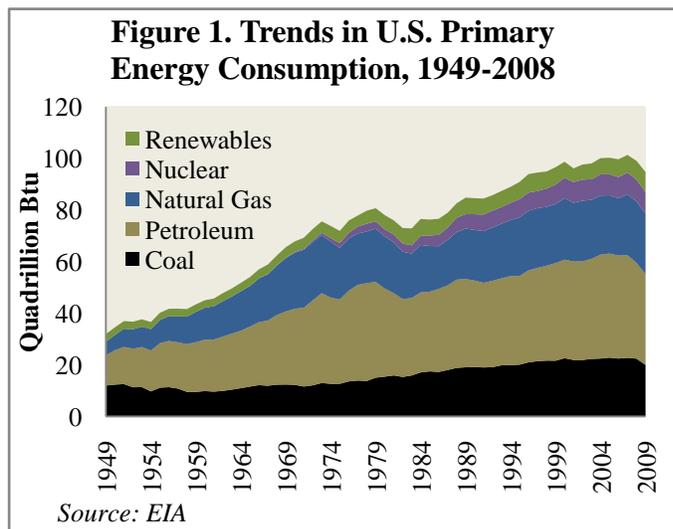
All of these gains are contingent on the development of sound public policy to incentivize and guide the transition. Critical policy decisions that are now pending include: electric power regulation at the local, state, and federal levels; effective federal and state oversight of the natural gas exploration and extraction process; future Environmental Protection Agency (EPA) regulatory decisions under the U.S. Clean Air Act; and putting a price on greenhouse gas emissions.

* This is the first in a series of briefing papers to be issued by the Worldwatch Institute’s Natural Gas and Sustainable Energy Initiative examining the complementary roles of natural gas, renewables, and efficiency. This first paper provides an overview of the role that natural gas currently plays in the energy system and a roadmap for the role that gas could play in spurring the transition to a low-carbon economy in the decades ahead. Future papers will focus on a range of specific issues, from the local environmental problems caused by shale gas development to options for integrating natural gas generation with large wind farms.

I. The Renaissance of Gas

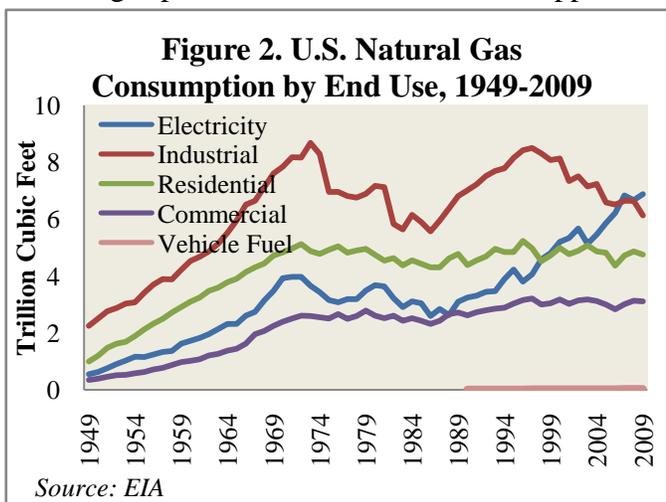
Natural gas was first developed as a modern fuel, together with oil, in the late 19th century. Most of the early gas resources were co-located with oil, and this associated gas was extracted almost as an afterthought as the oil industry took off in the early 20th century. Like oil, natural gas began to be used to a limited extent in the industrial, residential, and commercial sectors as a feedstock and to heat buildings prior to World War II.

Following the war, the United States and a few other countries began to build the extensive and expensive pipelines needed to make gas a mainstay of the U.S. energy economy, and the first generation of gas-fired power plants was built. As a byproduct of oil production, natural gas was cheap, and by the early 1970s, provided 30 percent of the U.S. energy supply, most of it in industry and buildings.¹ (See Figures 1 and 2.) But that was the peak. As U.S. oil supplies dwindled, so did gas, hampered by government price controls that discouraged exploration.



By the late 1970s, most experts believed that natural gas had entered a period of inevitable decline. Policymakers were so worried that, for a time, Congress made it illegal to build gas power plants in the United States.² While gas maintained its dominant position as an industrial fuel and the most economical means of heating homes, by the 1990s, it had fallen to less than 24 percent of the U.S. energy supply and stayed close to that level for the next decade and a half.³ Modest demand growth in the 1990s and early 2000s was met by Canadian imports.⁴

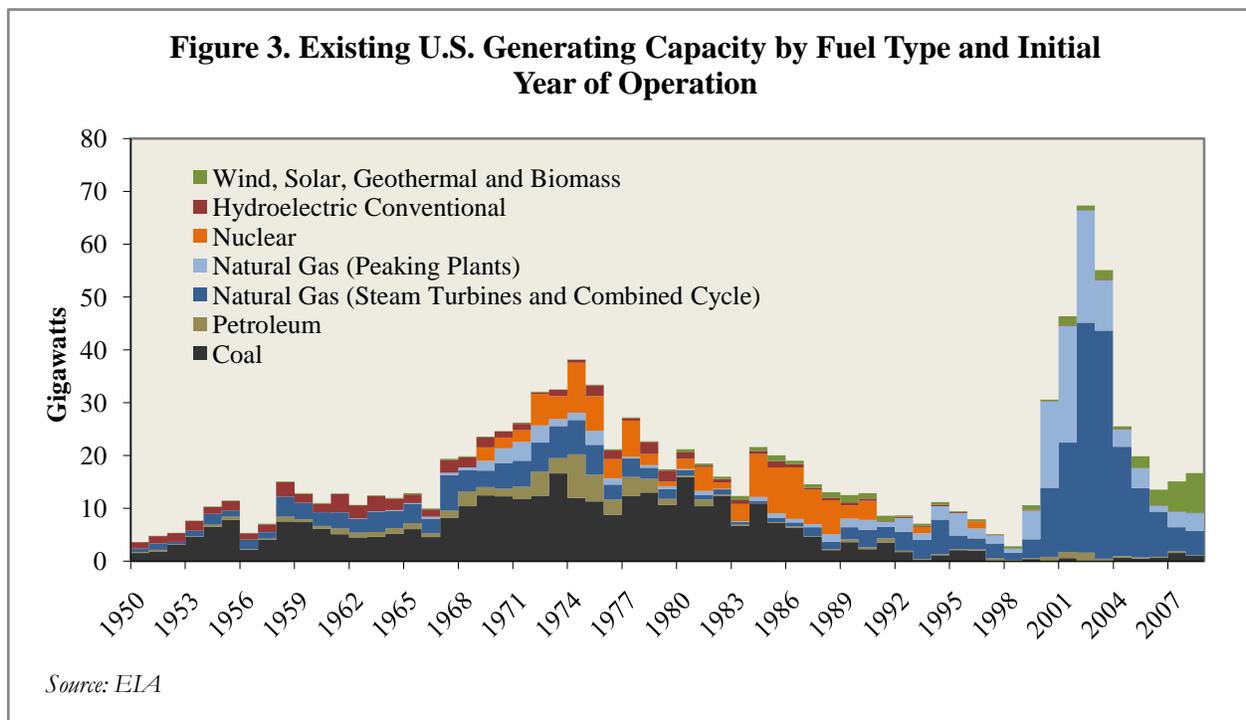
The 1990s were marked by relatively low and stable gas prices as U.S. and Canadian suppliers easily kept up with demand growth. But soaring oil prices, together with falling reserves of conventional natural gas, drove gas prices from just over \$2 per million BTU in 2002 to as high as \$13 per million BTU in 2008, making many potential users reluctant to invest in the fuel.⁵ Since then, gas prices have moderated somewhat—ranging between \$2.50 and \$6 per million BTU in 2009 and 2010.⁶ Still, price volatility remains the Achilles’ heel of natural gas, particularly when compared with coal.



Tempering coal's price advantage are the substantial environmental advantages of natural gas, which have gained economic significance as clean air standards have become progressively tighter in recent decades. Burning natural gas produces virtually none of the sulfur, mercury, or particulates that are among the most health-threatening of pollutants that result from coal combustion.⁷ A National Research Council study published in 2009 estimated that the environmental damages associated with electricity from natural gas are 95 percent lower than from coal.⁸ Although natural gas does produce nitrogen oxides and carbon monoxide and is an important contributor to ozone pollution in some areas of the United States, these can be reduced substantially with widely available emissions controls.

Growing concern about climate change in recent years has also worked in favor of natural gas. Gas contains 25 percent less carbon than oil and half as much carbon as coal.⁹ Planned and proposed federal and state actions to curb greenhouse gas emissions—from stricter requirements for emissions control technology to renewable or clean energy portfolio standards to a cap on carbon—all expose oil and coal investments to much higher risk than natural gas.

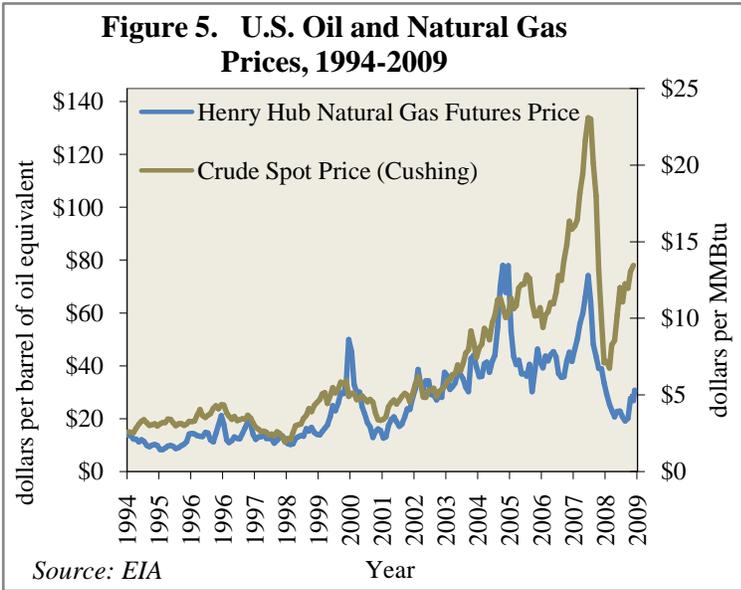
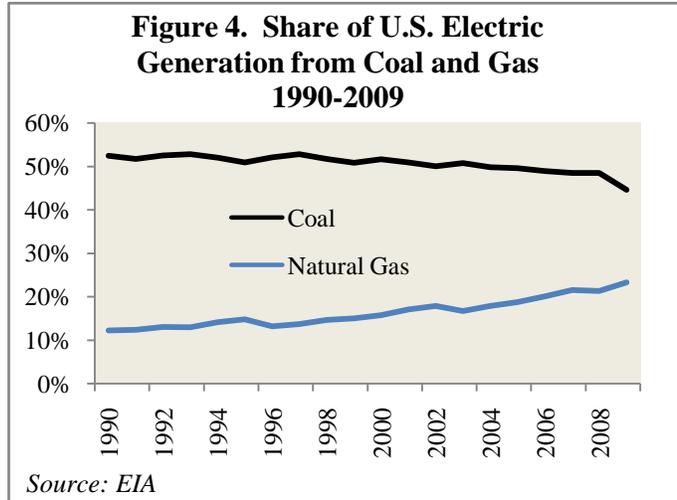
Environmental considerations have helped revive interest in natural gas as a source of electricity in recent years. Since the 1990s, 65 percent of the new capacity added to the U.S. power grid has consisted of a new generation of efficient gas-fired power plants, compared with 2 percent for coal.¹⁰ (See Figure 3.) While much of this capacity remains underutilized due in part to relatively high gas prices, the decline in prices in 2009 boosted natural gas to 23 percent of U.S. power generation, up from 20 percent in 2007 and just 12 percent as recently as 1990. During the same period, coal declined from 52 percent of U.S. electricity to 45 percent.¹¹ (See Figure 4.)



Outside of the power sector, other applications of natural gas have begun attracting interest as well—particularly in the face of dramatically higher oil prices. From 1995 to 2005, oil cost an

average of 34 percent more than natural gas.¹² (See Figure 5.) And in the past few years, as world oil prices have skyrocketed, North American gas prices have not risen as rapidly. In 2008 and 2009, the average price of oil was more than double the price of gas, and by March 2010, oil was nearly three times as expensive.¹³

Transportation, the sector where oil is dominant, will likely be affected most by the widening price gap between oil and gas. Boosted by a new generation of compressed-gas fuel tanks, natural gas vehicles have already become popular in countries such as Italy and Pakistan, where they are seen as an economical way to reduce dependence on oil.¹⁴



In the United States, where gasoline prices have been relatively low by international standards, natural gas vehicles have never been as popular, but many local governments have turned to gas-powered buses to reduce fuel costs and the local air pollution from diesel buses.¹⁵ Texas businessman T. Boone Pickens has proposed a nationwide effort to convert heavy-duty trucks to run on natural gas, in part to minimize U.S. dependence on foreign oil.¹⁶

Recent studies conclude that, beyond their ability to reduce local air pollution, natural gas vehicles also

lower greenhouse gas emissions by roughly 25 percent compared with oil, far less than the reductions possible in power generation but significant nonetheless.¹⁷ The big question now facing energy planners is whether sufficient natural gas will be available at a competitive price to allow for significant displacement of oil in transportation and coal in power generation. The answer to that question will likely be determined in large measure by efforts to develop new sources of natural gas, which has already had profound effects on the U.S. energy industry in recent years.

II. The Unconventional Gas Revolution

A newfound abundance of natural gas promises to tip the fossil fuel balance further in its favor. Gas production in the United States peaked in the early 1970s, along with oil, but in recent years technology advances have dramatically reversed the decline.¹⁸ Advances in horizontal drilling and hydraulic fracturing have unlocked gas resources in “unconventional” reservoirs, such as tight sands, coal bed methane, and shale rock rich in organic materials. As a result, resource estimates have increased sharply, and as lessons learned in the United States are applied to exploration and production of unconventional resources internationally, natural gas has the potential to shed the supply, price volatility, and energy security concerns that have surrounded it during the last few decades.

Unconventional gas is found in low-porosity sedimentary rock formations that act as both sources and reservoirs for hydrocarbon deposits. Because of their low porosity, gas is more difficult to extract from unconventional formations than from conventional gas reservoirs, which generally contain stores of hydrocarbons that originated in other formations. But as conventional resources have been exhausted, the industry has turned its attention to new sources of gas that were previously dismissed as too difficult and expensive to extract. In the 1970s, gas producers began to develop tight sands that they had discovered in the course of exploration for conventional gas. Using hydraulic fracturing and horizontal drilling, they were able to recover gas from these resources economically, largely in the Rocky Mountain states. Since then, tight sands have grown to account for more than 30 percent of all gas production in the United States.¹⁹

Natural gas is also found in coal seams, where it can pose serious health and safety risks to coal miners and can, if leaked to the atmosphere, contribute to climate change. Methane is adsorbed onto the pores of the coal, which has very low porosity. This methane, which would otherwise leak into the atmosphere over time, can be extracted economically by drilling into the coal seam. Coal bed methane development, most of it at relatively shallow depths, has been expanding since 1989, starting in Alabama, New Mexico, and Colorado, and later in Utah, Virginia, and Wyoming. Total U.S. production of coal bed methane reached almost 2 trillion cubic feet in 2008—10 percent of total U.S. gas production.²⁰

In the past few years, the focus of the gas industry has turned to a third unconventional source: deep shale formations, or non-porous sedimentary rock that mostly lies thousands of feet underground. Starting in the 1990s, independent gas producers began to develop a technique, known as hydraulic fracturing, for injecting high-pressure water into these deep formations, allowing the gas to be released and brought to the surface. First deployed on a large scale in Texas’s Barnett Shale, the technique has subsequently been adapted to a range of shales in other parts of the country, each of which has its own geological distinctions. When natural gas prices shot upward after 2005, the shale “gold rush” was on. The largest gas-bearing shale formation, the Marcellus Shale, extends across five states from West Virginia to New York, and is attracting great attention in the northeastern region where energy prices are high and most gas is imported from over 1,000 miles away.²¹ (See Map 1.)

Map 1. Major U.S. Shale Gas Resources and Existing Pipeline Infrastructure

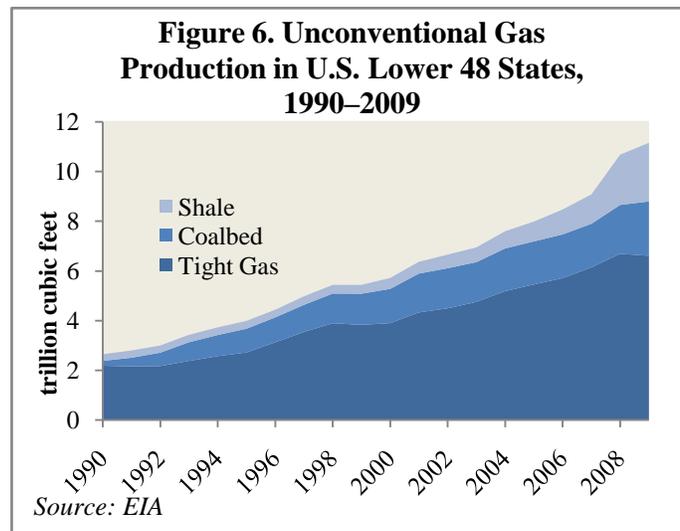


Source: Navigant Consulting

While shale rock does not give up its methane easily, this is more than balanced by its abundance. The Potential Gas Committee, an independent authority on gas supplies based at the Colorado School of Mines, estimated potential U.S. natural gas resources in 2008 to be 1,836 tcf, up 39 percent from 2006—with the difference due mainly to a steep increase in estimates of recoverable shale gas.²² Proven reserves have increased 13 percent to 238 tcf, bringing total gas resources to 2,074 tcf. Assessments by ICF International, the U.S. Energy Information Administration (EIA),

and Navigant Consulting Inc. confirm the magnitude of this resource.²³ These figures suggest that U.S. supplies of natural gas could last for 90 years at current rates of consumption.²⁴ And some experts expect the resource estimates to continue rising as exploration proceeds and as extraction techniques are further developed.²⁵

Since 1990, unconventional gas production has already increased fourfold, with an even steeper rise in the past few years contributing to a sharp decline in gas prices and a collapse in the North American market for imported liquefied natural gas.²⁶ (See Figure 6.) Surprisingly, the boom has only slowed marginally in the face of a steep recession and a sharp decline in the price of natural gas since 2008, suggesting that unconventional gas may be cheaper to produce than conventional gas.²⁷ The breakeven price for shale gas in various U.S. basins is reported to range from just under \$3 to \$4.50 per million BTU.²⁸ Notably, some of the most recent basins to be tapped, including the Marcellus, are among the least expensive.

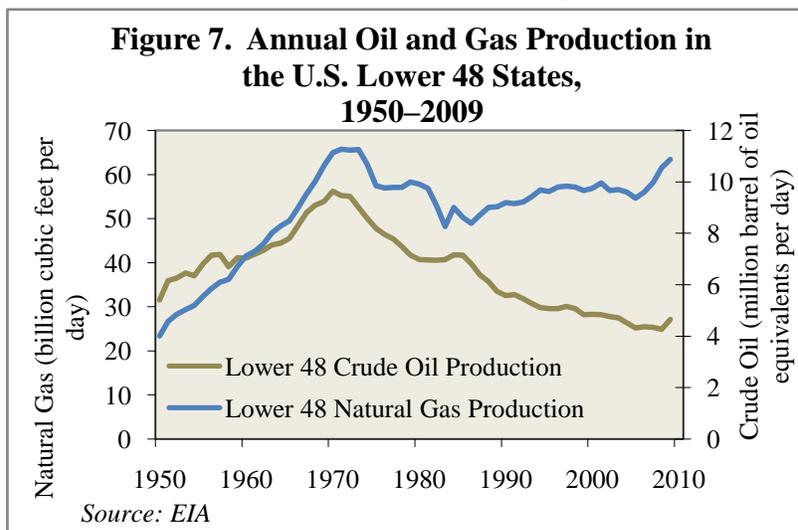


Moreover, unconventional gas costs are likely to continue to decline since the technology is still relatively immature and is continuing to advance. If these new gas supplies are sufficiently abundant and economical to end the boom-and-bust cycle that's marked the industry for decades, gas could make major inroads in energy markets in the years ahead.

The rise of gas stands in sharp contrast to the three-decade decline in U.S. oil production. Since 1990, total U.S. gas production has increased 20 percent while oil production fell 33 percent.²⁹

(See Figure 7.) Today, the United States produces more than twice as much gas as it does oil, and that gap will almost certainly widen in the coming years.³⁰ After decades of selling their domestic fields to independent producers, major oil companies such as ExxonMobil and BP have signaled a significant shift in their thinking about the future

evolution of energy markets by purchasing tens of billions of dollars of gas reserves from those same independents in the past few years.



III. Generating Low-Carbon Electricity

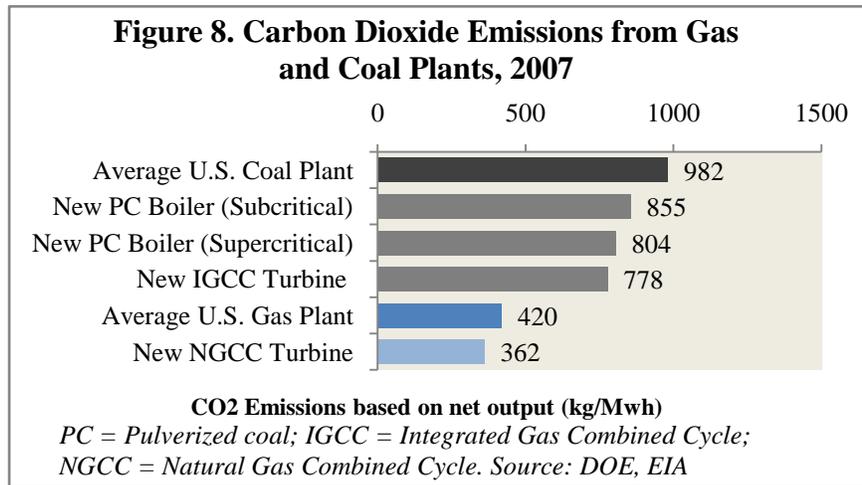
The prospect of more abundant and economical gas supplies, together with the increasing urgency of the climate problem, is drawing increased attention to the role that natural gas might play in the transition to a low-carbon power sector. In addition to the emissions reductions it offers over coal, natural gas is a more flexible fuel, with the ability to provide backup power on a range of scales to an electricity system that will include a rising share of variable wind and solar energy, combined heat-and-power, and distributed generation.

Generating electricity from natural gas rather than coal yields dramatic reductions in carbon dioxide emissions. Natural gas contains only half as much carbon per unit of energy as coal does, and gas also lends itself to a more efficient form of power generation known as combined-cycle technology. This consists of one or more combustion turbines (similar to jet engines) that are equipped with heat-recovery steam generators to capture heat from the combustion turbine exhaust. The heat-recovery steam generator powers a steam-turbine generator to generate additional electric power. Use of the otherwise wasted heat in the turbine exhaust gas results in high thermal efficiency compared to other combustion technologies, yielding efficiencies above 45 percent (compared with 30–35 percent for most coal plants). New combined-cycle gas plants produce 55 percent less carbon dioxide than new coal plants do and 62 percent less than the average U.S. coal plant.³¹ (See Figure 8.)

Although coal is the leading source of electricity in the United States, most of the new power plants added to the U.S. electricity grid since 1990 are powered by natural gas.³² This includes 201 gigawatts (GW) of highly efficient combined-cycle power plants and 107 GW of relatively inefficient gas-turbine peaking plants that are typically turned on only when needed during peak demand periods.³³ Altogether, natural gas power plants now represent 31 percent of U.S. generating capacity (excluding gas-fired peaking plants, which contribute another 13 percent),

compared with 33 percent for coal.³⁴ Even with the peaking plants excluded, gas-fired power generators are under-utilized, operating at an average of only 42 percent of their capacity.³⁵

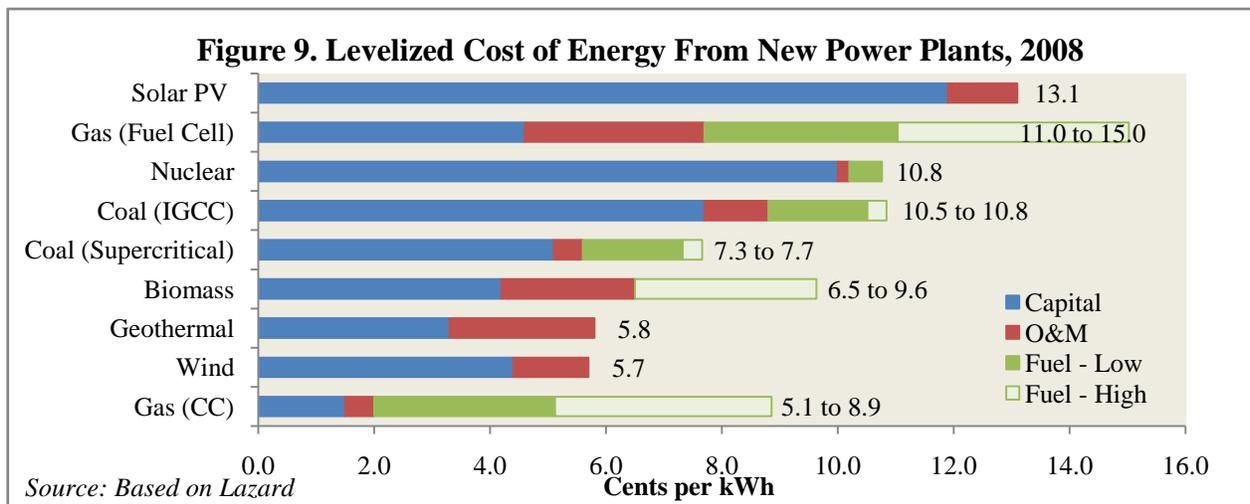
The carbon emissions of the U.S. power sector could be decreased significantly simply by running some of the existing plants more frequently and operating coal plants less, which would have a significant impact on carbon emissions. In a 2010 study, the Congressional Research Service found that if existing combined-cycle plants could be operated at 85 percent of their capacity, gas could replace nearly one-third of coal generation and reduce power sector carbon dioxide emissions by 19 percent. Taking into account transmission and siting constraints, however, the author estimated that the amount of current coal generation that could be displaced by natural gas might be closer to 9 percent.³⁶ As the disparity in these numbers illustrates, reforming power generation will necessitate a systemic approach to the entire power sector.



Besides being more efficient and cleaner than their coal counterparts, combined-cycle power plants are also cheaper and quicker to build. A survey of actual fossil, nuclear, and renewable power projects in 2008 determined that natural gas combined-cycle plants had the lowest construction costs of any available generating technology, under half the cost of a new pulverized coal plant and just one-fifth the estimated cost of a new nuclear plant.³⁷

Under most assumptions for construction costs, government incentives, and carbon controls, combined-cycle plants are an extremely competitive source of electricity.³⁸ However, the cost of gas-fired power is extremely sensitive to the price of gas, which has been highly volatile in recent years.³⁹ (See Figure 9.) At the average price of gas in 2009, the levelized cost was 5.5 cents per kilowatt-hour, compared with 8.6 cents per kilowatt-hour based on average 2008 gas prices.⁴⁰

The recent decline in gas prices has already led utilities to increase the utilization of their gas plants, raising the gas share of generation in 2009 to 23 percent, higher than at any time in the past three decades.⁴¹ The resulting drop in coal-fired power generation was responsible for almost half of the nearly 10-percent decline in U.S. carbon dioxide emissions from energy consumption between 2007 and 2009.⁴² And some utilities are deciding to make these changes permanent. Faced with the steep cost of installing pollution controls on its coal plants, North Carolina-based Progress Energy announced plans to permanently close 11 of its dirtiest coal plants over the next eight years, a total of almost 1,500 megawatts (MW), replacing them primarily with natural gas plants.⁴³



In addition to the emissions savings they represent over coal plants, natural gas generators are better suited to play a complementary role in a generation mix that includes a growing amount of wind and solar power. Unlike coal plants, gas plants can be more easily turned on and off, enabling utilities to use them to balance variable generation from renewable energy sources. For this reason, nine solar thermal power plants built in California during the 1980s and early 1990s were designed as gas-solar hybrids, with auxiliary natural gas boilers or heat transfer fluid heaters to provide backup generation.⁴⁴ Existing combined-cycle and peaking plants already provide de facto backup electricity for wind power in some parts of the country.

In some cases, utilities may also be able to retrofit existing conventional power plants with renewable generators to reduce fossil fuel consumption and greenhouse gas emissions. The Florida Power and Light (FPL) Company is adding a 75-megawatt solar thermal field to a much larger natural gas plant in Indiantown, Florida.⁴⁵ However, the potential of such large-scale retrofits will be limited by the land and resource requirements of renewable generating technologies. In the future, a new generation of gas-fired generators—from gas turbines to fuel cells—can be deployed as a complement to wind and solar power, both in dedicated gas-renewable hybrid systems and as independent components of a renewable-rich energy portfolio.

Natural gas also lends itself to applications that increase overall energy efficiency. Like all thermal power plants, natural gas plants create heat as a byproduct while generating electricity. While most plants discard this heat as waste, they can instead be designed to capture it for use in space heating, a process called cogeneration or combined heat-and-power (CHP). Because it can be scaled more easily than coal, natural gas is the most common fuel used in combined heat-and-power applications, which are typically industrial scale or smaller. Cogeneration has enjoyed little policy support in the United States, and as a result it provides just 8 percent of the country's electricity.⁴⁶ However, the figure is much higher in other countries where cogeneration has received more support: 39 percent in Finland and 52 percent in Denmark.⁴⁷

A new generation of smaller, “distributed” gas-fired generators that harness waste heat for heating and cooling can provide better environmental performance than even the most efficient central-station plants while adding an economical and flexible element to the power grid.

Technologies ranging from reciprocating engines (similar to those used in automobiles) to gas turbines and fuel cells can be added to factories, commercial buildings, and even family homes.

Located within the local power distribution system, micro-power plants avoid the need to add expensive and hard-to-site transmission lines and—unlike “baseload” coal and nuclear plants—can easily be turned on and off as needed to meet fluctuating power demand. Compared with electricity from a conventional power plant and heat from a separate gas-fired furnace, a cogeneration system typically has an efficiency of between 65 and 80 percent and would allow even greater emissions reductions than combined-cycle plants.⁴⁸

Volkswagen announced plans in 2009 to produce 10,000 miniature 20-kilowatt gas-fired power plants per year, based on the internal combustion engines it uses in its Golf automobiles. These units are designed for use in individual residences and will operate at up to 94-percent efficiency, providing heat, hot water, and electricity.⁴⁹ Dubbed “schwarpower,” this network of tiny power plants could, within a decade, provide 2,000 MW of capacity (equivalent to two nuclear plants) that will be digitally controlled and used to back up the variable wind power that already provides some 40 percent of the electricity in three German states.⁵⁰

The prospect of widespread deployment of small-scale solar power plants in and near the world’s cities in the years ahead will likely spur growing interest in micro-power plants using natural gas. As small-scale solar and gas generators are integrated into local, low-voltage power systems, both will require new laws that allow small businesses and consumers to access the local grid at a competitive price.

IV. Overcoming Environmental Challenges

While natural gas has many environmental advantages over the other fossil fuels, it is not without problems of its own. The rapid development of unconventional gas in recent years has raised a host of environmental and health concerns, generating extensive controversy at the local, state, and national levels. Gas development has been particularly controversial in the northeastern states of Pennsylvania and New York, where state regulators and citizens who had no experience with oil and gas development were ill-prepared for the unconventional gas boom. Communities that welcome the jobs and income that are flowing from the new industry are also struggling with the disruptions and environmental problems that often accompany expanded gas development.

To extract natural gas from tight sand, shale, and some coal bed formations, engineers utilize two key technologies: horizontal drilling and hydraulic fracturing. Shale gas extraction is begun by drilling a vertical well to the depth of the reservoir, then gradually turning the drill bit 90 degrees until it is oriented parallel to the productive layer. Horizontal wells offer greater contact area with the reservoir than vertical wells, providing an important boost to production in strata that have low permeability. In addition, they greatly reduce the surface impact of drilling operations because engineers can drill multiple wells from a single well pad and extend those wells laterally for thousands of feet. According to estimates from the U.S. Departments of Interior and Energy, in the Fayetteville Shale a four-well horizontal drilling pad with roads and corridors would disturb about 7.4 acres on the surface, whereas the 16 vertical drilling pads that would be

necessary to produce the same square mile of the formation, together with roads and utility corridors, would disturb some 77 acres.⁵¹

To free up the gas that is tightly bound in the impermeable rock, developers typically inject wells with millions of gallons of water mixed with chemical additives and sand under high pressure. The fracturing or “fracking” fluid widens and props open tiny fractures in the shale, increasing the reservoir’s permeability and allowing gas to escape more freely. Fracking fluids can contain small concentrations of toxic chemicals that improve the effectiveness of the procedure, including biocides, corrosion inhibitors, and thickening agents.⁵² No federal law currently requires companies to disclose the chemicals used in fracturing fluids—a condition that companies argue is necessary to protect their trade secrets.

Once fracking fluid has come into contact with the rock formations through which the wellbore travels, it can mix with methane, highly concentrated salts, and naturally occurring radioactive materials (NORM).⁵³ While some portion of injected fracking fluid remains underground, produced water brought up from the target formation must be disposed of safely. Depending on the state regulations in place, companies may be required to re-inject produced water into disposal wells or to send it to wastewater treatment facilities, where it must generally be transported in tankers. If a leak or spill occurs at any point during the production, transportation, or disposal processes, produced water can pollute groundwater and surface waters. Similarly, the volumes of produced water generated by increased levels of gas drilling can overwhelm wastewater treatment facilities, as occurred in Pennsylvania’s Monongahela River during the fall of 2008.⁵⁴ As gas production expands to new regions, improving wastewater disposal and treatment practices and capacity will be critical.

Produced water or natural gas can contaminate underground aquifers if improperly lined and cased wellbores to leak under the pressure of hydraulic fracturing. In 2007 in Bainbridge, Ohio, a well that had been drilled almost 4,000 feet into a tight sand formation through a layer of gas-bearing shale was not properly sealed with cement, allowing gas from the shale layer to leak into an underground source of drinking water. The methane eventually built up until an explosion in a resident’s basement alerted state officials to the problem.⁵⁵

The sheer volume of water consumed during hydraulic fracturing could make unconventional gas production costly and unsustainable in many areas of the world that are water-constrained. Each well requires an average of 2–4 million gallons of water to fracture, depending on the characteristics of the shale formation. Although these volumes are significant, the Department of Energy estimates that they will represent less than 1 percent of all water usage in each basin.⁵⁶ Nevertheless, producers must work with regulators to ensure that shale gas production does not encroach on other regional demands for water. Gas companies have begun experimenting with reusing produced water in subsequent fracturing jobs, a practice that could greatly reduce water consumption, transportation costs and emissions, and contamination risks.

The extraction and transport of natural gas also generates local air pollution and greenhouse gases. Natural gas itself is made up mostly of methane, a greenhouse gas 23 times more potent than carbon dioxide. During the production process, natural gas may be intentionally vented or unintentionally leaked. According to the EPA, natural gas systems were responsible for 178.9

million metric tons of CO₂-equivalent of methane in 2008—61 percent of the energy sector’s methane emissions and 24 percent of total U.S. methane emissions.⁵⁷ Efforts are underway to capture this methane, including the EPA’s Natural Gas STAR program, which has worked with industry to reduce methane emissions from the U.S. gas industry by 822 billion cubic feet, or 334 million metric tons of CO₂-equivalent, since 1993.⁵⁸

Aside from methane, the natural gas production process also emits carbon dioxide and other air pollutants. Diesel-powered compressors, which enable gas to be transported via pipeline, emit significant amounts of CO₂ and smog-forming pollutants if they are not equipped with control technologies. Diesel fuel, drilling equipment, and water for hydraulic fracturing all must be trucked to drilling sites, adding additional emissions from vehicle exhaust. An Environmental Defense Fund study found that oil and gas production in the Barnett shale basin generates more smog-forming compounds than motor vehicles in the five counties it occupies, as well as high levels of air toxics, and greenhouse gases equivalent to the expected impact from two 750 MW coal-fired power plants.⁵⁹ These could likely be reduced significantly if pollution controls were required. And if widely dispersed unconventional resources allow gas to be produced closer to the point of use, the emissions associated with transporting it could be significantly reduced.

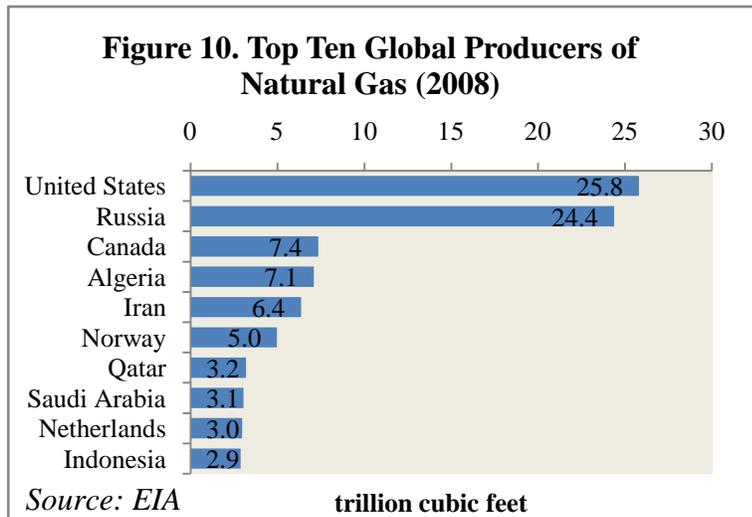
Increased seismic activity from hydraulic fracturing is another concern. Thus far, seismic activity from fracturing is well below the level that would be noticeable to humans and can be detected only by very sensitive instruments. Data from these instruments can be used to predict whether there is a risk of a larger earthquake being triggered by hydraulic fracturing. This, too, is an area that requires responsible oversight from industry and regulators.⁶⁰

Important legal and regulatory issues surrounding the production of shale gas remain unresolved. For example, although the underground injection of fluids produced during fracturing activities are regulated by the EPA under the Safe Drinking Water Act, the hydraulic fracturing procedure itself is exempt, and as a result is only regulated at the state level.⁶¹ State-level regulation currently varies widely, and the sharing and emulation of best practices among states—particularly those in which these resources are first developed—are essential. Additional research and industry transparency are needed to improve understanding of and decision-making about hydraulic fracturing at the local, state, and federal levels. Unless trust can be established between local stakeholders and gas producers, natural gas’s ability to fulfill its potential contribution to a low-carbon energy system will be weakened.

V. Beyond North America

Although the natural gas industry has its deepest historical roots in North America, it has become an important global fuel in recent decades. In 2008, global production of natural gas totaled 137 trillion cubic feet, with the United States and Russia responsible for 19 and 18 percent of global production, respectively. Other leading producers include Canada, Iran, and Norway.⁶² (See Figure 10.) In most countries, however, natural gas plays a much smaller role than it does in North America, which often means higher levels of dependence on oil and coal and consequently higher emissions of greenhouse gases.

Global proven reserves of natural gas—defined as gas that geological and engineering analyses indicate are recoverable from known reservoirs under existing economic and operating conditions—have risen significantly in the last three decades. According to the International Energy Agency (IEA), only 14 percent of the world’s ultimately recoverable conventional resources have been extracted. At current global rates of production, remaining conventional gas resources alone could last up to 130 years.⁶³ Many countries with extensive gas resources have



hardly begun to exploit them, and in some cases burn them off as an unwanted byproduct of oil production. This is because using gas requires extensive investment in pipelines for distribution while exporting it means building complex and expensive facilities for super-cooling and liquefying it.

The recent growth of unconventional gas resources in the United States has already had a significant impact on global markets. Surging gas supplies

contributed to a 30-percent reduction in net imports of gas to the United States between 2007 and 2009, putting downward pressure on the price of internationally traded gas in Europe and Asia.⁶⁴

At the same time, efforts to identify and acquire unconventional gas resources have risen in many countries where domestic gas has until now played little role in meeting energy needs. Much of this effort is being led by major oil companies such as BP, ExxonMobil, Statoil, and Total, all of which have recently gained technical expertise via acquisitions and partnerships in North America. And much of the technology for unconventional gas production is held by international oil and gas service companies such as Halliburton and Schlumberger, which are actively deploying it for client companies around the globe.

Much of the exploration activity outside of North America has occurred in Europe. Most European countries have legal systems that allow and encourage private development of gas resources. In addition, concerns about over-dependence on Russian gas, highlighted by recent supply disruptions caused by pricing disputes, have encouraged European governments to seek new sources of gas. Early assessments suggest that unconventional gas resources are significant in Europe, though not likely as abundant as in North America. Among the countries where exploration efforts have shown the most promise are Austria, Germany, Hungary, Poland, and Sweden.⁶⁵

The IEA’s 2009 *World Energy Outlook* estimates that global coal bed and shale gas production, which at 13 tcf in 2007 contributed 12 percent of worldwide natural gas supplies, will rise to 22 tcf in 2030, or 15 percent of global supplies, with most of the predicted growth coming from North America.⁶⁶ These estimates now appear conservative. Knowledge of international

unconventional resources is extremely limited in most countries, and more research will be required to quantify the location and volume of available supplies.

In many developing countries, even modest new supplies of natural gas could significantly reduce dependence on imported oil and gas, providing more energy security and improving the balance of trade. In addition, early evidence suggests that some of the world's most coal-dependent countries, including China, India, and South Africa, may have extensive natural gas resources that could contribute to reduced greenhouse gas emissions. As recently as 2007, natural gas provided only 8 percent of power generation in India and 1 percent in China, suggesting a large potential for expansion.⁶⁷ In New Delhi, the municipal government has required that most small two-wheelers be fueled with natural gas in order to reduce air pollution, and the city recently announced plans to replace its coal-fired power plants with natural gas.⁶⁸

The United States and China have already begun to collaborate on unconventional gas resources. On November 17, 2009, Presidents Barack Obama and Hu Jintao announced the launch of the U.S.-China Shale Gas Resource Initiative.⁶⁹ Through this program, Chinese experts will be able to benefit from U.S. expertise in shale gas science and technology to assess and develop Chinese shale gas resources. Similar collaborative initiatives could speed the development of unconventional gas in other parts of the world.

VI. Unlocking the Potential

For decades, natural gas has been a neglected element of the U.S. energy portfolio. In policy deliberations, natural gas has been linked closely to oil and sometimes to coal. The distinction between gas and the other fossil fuels is often blurred, as is its potential to accelerate the transition to low-carbon energy.

Together with renewable energy and energy efficiency, natural gas could transform the energy economy over the next few decades, drastically reducing climate pollution and lowering dependence on imported oil. Natural gas lends itself to a range of high-efficiency applications, and it can provide the flexible backup power that will allow high levels of reliance on wind and solar power even before economical storage technologies are developed. Moreover, in the future, fossil natural gas could be supplemented by renewable methane gas that is extracted from landfills, feedlots, and other biological sources.

Unfortunately, the logical alliance between natural gas and the clean energy community has been strained in recent years as both grew rapidly at a time when electricity demand was falling. The growth of wind power in Texas, for example, has led to charges by natural gas generators that wind farms are getting preferential treatment from state regulators. At the same time, the environmental controversies being stirred up by the questionable practices of some shale gas developers have exacerbated mistrust in local communities and led some environmental groups to oppose additional gas development. Unless these tensions can be resolved and effective clean energy alliances are created, the potential for natural gas to contribute to a low-carbon economy will never be realized.

To reach that potential, building new policy frameworks will be essential. And for that to occur, an innovative and strategic partnership between the gas, renewables, and efficiency industries—and the environmental community—is needed. For environmentalists, gas can broaden the range of tools available to reduce carbon emissions and bring a strong industry to the alliance that supports climate legislation. And for the gas industry, allying itself with those who are working to build a low-carbon economy will facilitate a policy environment in which gas plays a growing role even as the United States gradually reduces its dependence on oil and coal.

Important policy changes will be needed to achieve these goals:

1. Putting an Effective Price on Carbon

By attaching a cost to carbon dioxide emissions, a cap-and-trade system or a carbon tax will tend to favor natural gas at the expense of coal and oil. According to some analysts, fuel switching in the power sector could contribute significantly to the 17-percent emissions reductions called for by climate legislation passed by the U.S. House of Representatives in June 2009.⁷⁰ However, other studies have found that because that bill includes a range of allowance giveaways to coal-burning power companies based on their historic emissions, it would actually discourage fuel switching, forcing utilities to turn to more expensive alternatives such as carbon capture and storage (CCS). Moreover, by protecting the market for coal, such legislation could leave gas, efficiency, and renewables fighting among themselves for limited market share, rather than working together to build a better energy system.⁷¹

As the U.S. Senate considers a range of approaches to assembling climate and energy legislation that can garner 60 votes, it should seek to avoid repeating the House bill's mistakes. One alternative is the CLEAR Act introduced by Senators Cantwell (D-WA) and Collins (R-ME) in December 2009, which auctions all emission allowances rather than giving any for free to traditional coal plants, as the House bill would. Senators Kerry (D-MA), Graham (R-SC), and Lieberman (I-CT) are meanwhile negotiating an alternative bill that is designed to attract bipartisan support. Their opportunity is to create a carbon market with a level playing field, reducing the cost to consumers and spurring rapid emissions reductions. Such a policy would allow the replacement of the oldest, least-efficient coal-fired power plants with a robust combination of gas and renewable generators.

2. Advancing Clean Air Standards

Installing pollution controls can significantly increase the construction and operating costs of coal-fired power plants.⁷² Both the EPA and Congress are moving forward on measures to mandate large reductions in electric utilities' emissions of sulfur dioxide (SO₂), nitrogen-dioxide (NO_x), particulate matter, and mercury—all air pollutants associated with coal. In addition, a multi-pollutant power plant bill introduced in the Senate in February 2010 would create the Clean Air Interstate Rule (CAIR), a cap-and-trade program for SO₂ and NO_x.⁷³

The need to purchase allowances for these pollutants would make coal plants even more expensive. More recently, a Supreme Court decision has extended the EPA's jurisdiction under the Clean Air Act to cover carbon dioxide. As the EPA and Congress consider stricter

regulations on SO₂, NO₂, mercury, and CO₂, coal plants will become increasingly riskier investments for utilities and rate-payers. In general, fuel-neutral standards that do not allow indefinite grandfathering of older plants are likely to have the biggest impact on emission trends—in part because they will motivate fuel switching from coal to gas.

3. Reforming Electric Utility Dispatch Rules

Utility regulation at the state level and to a lesser extent at the federal level has a major impact on utility decisions regarding which plants they build and dispatch, and consequently on their emissions. In most states, electric utilities are strictly required to “dispatch” their power plants based on the cost of generation, which means that a gas-fired plants will be idled if it is even slightly more expensive to operate than a coal plant. Because natural gas plants are generally more efficient, an analysis by the Energy Information Administration concluded that in some areas of the United States, even a slight convergence in coal and gas prices would move many gas plants up in the dispatch order.⁷⁴ Shifting dispatch requirements so that environmental performance is a consideration in these decisions—with resulting costs passed through to consumers—could have a substantial environmental benefit even beyond the impact of putting a price on carbon.

4. Strengthening Environmental Controls and Transparency in the Gas Industry

Environmental problems caused by the natural gas extraction process are damaging the gas industry’s reputation in many communities and must be addressed promptly. During the past decade, the industry successfully obtained key exemptions for hydraulic fracturing, including under the Safe Drinking Water Act. Although several other parts of the shale development process are federally regulated under the Safe Drinking Water Act, Clean Water Act and Clean Air Act, hydraulic fracturing is left to the states, not all of whose environmental agencies are adequately equipped to deal with the range and scale of environmental issues posed by the rapid development of unconventional gas.

A bill introduced in the U.S. House and Senate last year, known as the FRAC Act, would require producers to publically disclose a list of all chemical constituents, though not proprietary formulas, in their fracking fluids. It also demands that companies disclose the details of their proprietary formulas to treating physicians in the case of medical emergencies. In the meantime, the EPA has embarked on a new study of the potential environmental and health impacts of hydraulic fracturing.⁷⁵ Members of Congress have also requested eight service companies to provide information about the chemicals they use in fracturing fluids.⁷⁶

The industry has so far resisted efforts to regulate hydraulic fracturing at the federal level, creating concern among local stakeholders and environmental groups about the process’s lack of transparency. Gas companies would be well advised to take a more cooperative approach to these issues, both at the state and federal levels. More transparency and tighter regulations are needed if unconventional natural gas is to play a constructive, sustainable role in a low-carbon energy future.

This is the first in a series of briefing papers that the Worldwatch Institute Natural Gas and Sustainable Energy Initiative will produce on critical environmental and policy issues surrounding natural gas. For more information on this paper and the Worldwatch initiative, please contact:

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Endnotes

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