

Could Shale Gas Power the World?

Natural gas from shale rock promises to provide cleaner, abundant energy for the US and the world. But there's a catch. It could come with significant environmental and social costs. Can the energy industry be trusted to deliver the goods so that everyone benefits?

By Bryan Walsh
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For more than a decade, Bonnie Burnett and her husband Truman have owned a second home in the hilly farmland of Bradford County, in northeastern Pennsylvania. It was a getaway for the Burnetts (who live three hours to the south, in Stroudsburg), a place to take their grandchildren for a swim in the wooded pond that lies just a few steps from their front door. "It used to be heaven here," says Bonnie. "We were going to move here to live."

The Burnetts say their plans changed when a natural gas drilling operation on an adjacent property started less than 400 ft. (122 m) from their house. It was one of thousands of wells that have been drilled in Pennsylvania as part of a booming natural gas rush. In June 2009, when the Burnetts were home in Stroudsburg, tens of thousands of gallons of drilling water that had been stored on the well pad spilled, leaking downhill and into the Burnetts' trees and pond. Truman says that spill ruined a 50-ft. (15 m) swath of forest and affected their water. The pond seems lifeless, and the bass and perch that the Burnetts once fished with their grandchildren are gone. Even after the accident, the well is still running. The Burnetts can hear the hum of a gas compressor running 24 hours a day. "Did it ruin my life?" asks a tearful Bonnie. "I'd have to say yes."

Dave DeCristo of nearby Canton, Pa., can see wells from his home too, but that's where any similarity with the Burnetts ends. DeCristo moved to this rural community to work as a plumber before he launched a



gas station and a fuel-support outfit. He did well, but his businesses really took off in 2008, when drilling companies eager for the region's natural gas began setting up shop, and he's added dozens of employees. In addition, DeCristo — like other landowners around the region — has sold a gas company the right to drill on his land. There's a well not far from his front door. "I could never dream I was going to be able to grow this big," he says. "I've been a blessed person because of this."

Until recently, natural gas was the forgotten stepsister of fuels. It provides about a quarter of U.S. electricity and heats over 60 million American homes, but it's always been limited — more expensive than dirty coal, dirtier than nuclear or renewables. Much of Europe depends on gas for heating and some electricity — but the bulk of the supply comes from Russia, which hasn't hesitated to use energy as a form of political blackmail. The fuels of the future were going to be solar, wind and nuclear. "The history of natural gas in the U.S. has been a roller-coaster ride," says Tony Meggs, a co-chair of a 2010 Massachusetts Institute of Technology gas study. "It's been up and down and up and down."

Natural gas is up now — way up — and it's changing how we think about energy throughout the world. If its boosters are to be believed, gas will change geopolitics, trimming the power of states in the troubled Middle East by reducing the demand for their oil; save the lives of thousands of people who would otherwise die from mining coal or breathing its filthy residue; and make it a little easier to handle the

challenges of climate change — all thanks to vast new onshore deposits of what is called shale gas. Using new drilling methods pioneered by a Texas wildcatter, companies have been able to tap enormous quantities of gas from shale, leading to rock-bottom prices for natural gas even as oil soars. In a single year, the usually sober U.S. Energy Information Administration more than doubled its estimates of recoverable domestic shale-gas resources to 827 trillion cu. ft. (23 trillion cu m), more than 34 times the amount of gas the U.S. uses in a year. Together with supplies from conventional gas sources, the U.S. may now have enough gas to last a century at current consumption rates. (By comparison, the U.S. has less than nine years of oil reserves.)

Nor is the U.S. alone. Britain, India, China and countries in Eastern Europe have potential shale plays as well, while Australia, having invested in huge infrastructure projects, has started sending fleets of ships with liquefied natural gas around the world.

Over all this loom three factors: booming demand for energy as nations such as China and India industrialize; the accident at the Fukushima nuclear plant in Japan, which has dimmed prospects for a renaissance of nuclear power; and the turmoil in the oil-rich Middle East. Taken together, they have opened space for gas as a relatively clean, relatively cheap fuel that can help fill the world's needs during the transition to a truly green economy. (As important as renewable energy is, it will likely take years for green power to shoulder the electricity load.) Although gas isn't used for transport, boosters like Texas tycoon T. Boone Pickens think if heavy-duty vehicles were fueled with natural gas, the U.S. would be able to cut imports of oil. U.S. utilities worried about meeting regulations on carbon and air pollution are switching from dirty coal to gas as a power source. In a speech on March 30, President Barack Obama hailed natural gas as part of the solution to reducing America's oil addiction. "The potential for natural gas is enormous," he said.

They Weren't Ready for This

But there's a catch. As shale-gas drilling has ramped up, it's been met with a growing environmental backlash. There are complaints about spills and air pollution from closely clustered wells and fears of wastewater contamination from the hydraulic fracturing process — also known as fracking — that is used to tap shale-gas resources. In the U.S., the gas industry is exempt from many federal regulations, leaving most oversight to state governments that have sometimes been hard-pressed to keep up with the rapid growth of drilling. The investigative news site ProPublica has found over 1,000 reports of water contamination near drilling sites. New York State — spurred by fears about the possible impact of the industry on New York City's watershed — has put hydraulic fracturing on hold for further study, while

some members of Congress are looking to tighten regulation of drilling. "We were not ready for this," says John Quigley, former head of Pennsylvania's department of conservation and natural resources. "We weren't ready for the technology or the scale or the pace."

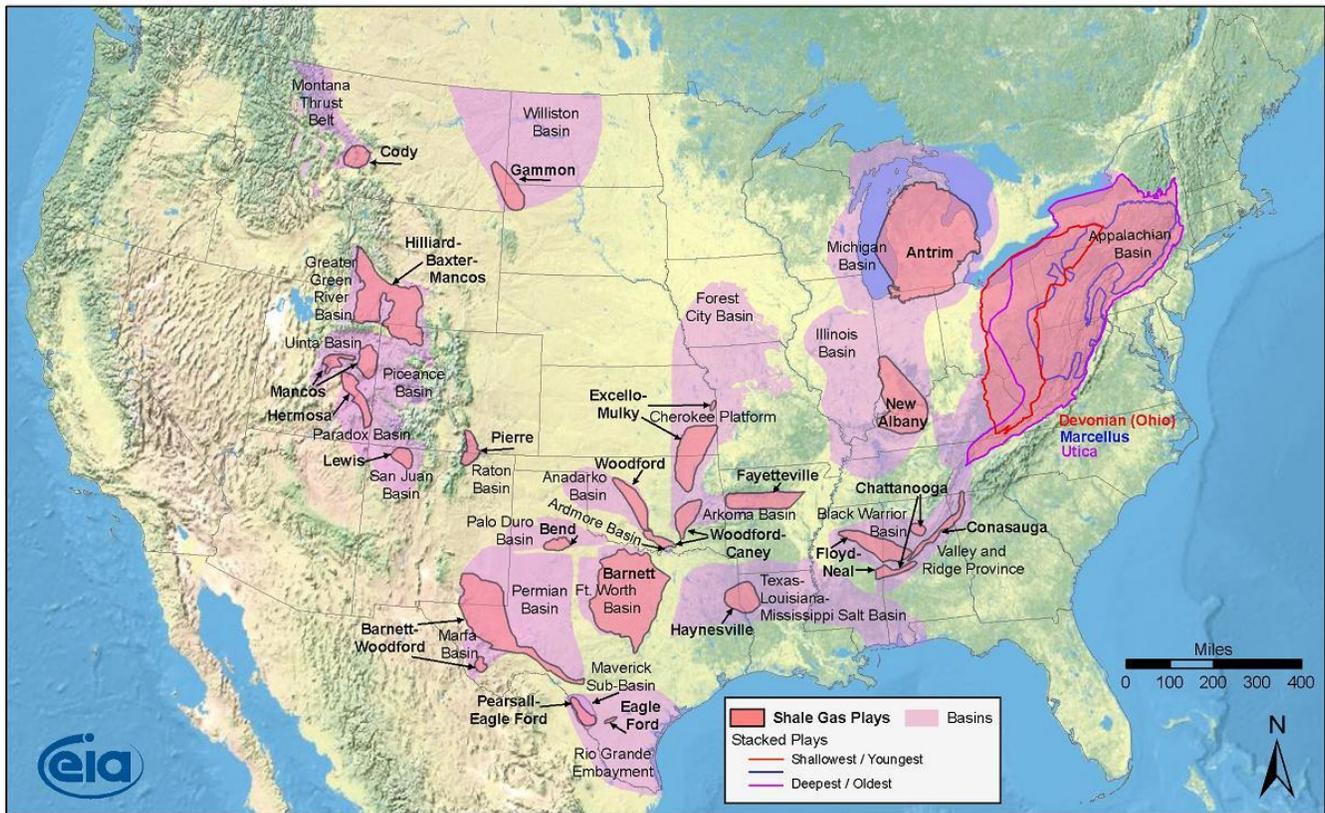
And that's what makes this new energy revolution — because that's what it is — so complex. The richest shale-gas play and potentially the second biggest natural gas field in the world is called the Marcellus, and its heart runs straight through parts of Pennsylvania and New York. This drilling isn't taking place in the Gulf of Mexico, the Saudi deserts or lightly populated western Canada. It's happening right in the backyard of the U.S. Northeast, a densely populated place accustomed to consuming fossil fuels, not producing them. But if the global appetite for gas and oil keeps growing, rural Pennsylvania won't be the last unlikely place we'll drill. Because for all our fears of running out of oil, we should be able to find more than enough fuel to keep the global economy humming — provided we're willing to drill in deeper, darker, more dangerous or more crowded places. The Arctic, the ultra-deep ocean off Brazil and New York City's watershed all could go under the drill as we enter what the writer Michael Klare has called the Era of Extreme Energy. The power will keep flowing — but with environmental and even social costs we can't yet predict.

It wasn't news to fossil-fuel experts that the Marcellus Shale — a 400 million-year-old narrow band of black rock that lies thousands of feet deep — could contain gas. Shallow natural gas wells have been drilled in the Northeast for decades. But shale like that of the Marcellus is made up of deep, hard rock, and it does not surrender its gas easily. Shale wasn't worth the trouble — until a veteran wildcatter named George Mitchell began experimenting with the Barnett Shale in Texas in the 1980s. Mitchell found that a mix of horizontal well drilling and hydraulic fracturing — more on that later — could allow him to pry gas from the shale. "It was lore in the gas industry that you would hurt a well by putting water down it," says Terry Engelder, a geoscientist at Penn State University. "These guys discovered that the more water they used, the better."



A suspected leak from a wastewater pond on Don and Carol Johnson's farm meant their cows had to be quarantined.

Shale Gas Plays, Lower 48 States



Source: Energy Information Administration based on data from various published studies
 Updated: May 28, 2009

Engelder should know; he played a key role in the discovery of the Marcellus Shale. At the beginning of the last decade, a Texas-based company called Range Resources began experimenting on Marcellus wells in western Pennsylvania. The company had little more than expensive holes to show for it until it began tweaking Mitchell's method. By August 2007, Range had a winner, even as Engelder, a gas-shale expert, began to realize just how huge the Marcellus play could be. During a December 2007 conference call with investors, Engelder estimated the recoverable amount of natural gas in the Marcellus at 50 trillion cu. ft. (1.4 trillion cu m). Estimates now range up to 10 times as high, which would provide the energy equivalent of 86 billion barrels of oil. "I remember thinking, Merry Christmas, America," Engelder says now. "It was absolutely an amazing thing."

The agents of drilling companies had already begun moving into Marcellus territory, snapping up gas leases. That's not unusual in Pennsylvania—most farmers and other large landholders have leased the gas rights to their land for decades, often for little more than a few dollars an acre (0.4 hectare). But not much actual drilling was ever done. (Landholders are paid an upfront bonus per acre for a lease, plus some percentage of the value of any produced gas as a royalty.) When word got out that the Marcellus was for real, the price for leases skyrocketed—rising to \$5,000 an acre by the summer of 2008, according to Engelder—and dozens

of gas companies jostled for territory. Once land was leased, the drilling rigs arrived, clustering in rural areas of southwestern and northeastern Pennsylvania. More than 2,400 Marcellus wells were drilled from 2006 to the end of 2010 in the state, and some 300 were drilled before March 10 of this year. "It's like a treadmill. Companies have to keep drilling wells and adding new ones to their inventory," says Tim Considine, an energy economist at the University of Wyoming. "That's a lot of activity that adds up."

Considine co-authored an industry-sponsored study in early 2010 that estimated that Marcellus drilling would create or support 88,000 jobs that year and more than 100,000 in 2011, plus billions of dollars in economic value for the state. Those numbers are debatable, but it's impossible to miss the buzz of economic activity in drilling regions. Relatively few of those jobs directly involve drilling and fracking—most of that work goes to roughnecks with Texas or Oklahoma license plates on their pickups—but there are work and wages for local truck drivers, subcontractors, waiters and bartenders. Rural Bradford County has long been one of Pennsylvania's poorer areas, but last year the county led the state in job creation. Gregg Murrelle manages the Riverstone Inn and Comfort Inn in Towanda, the Bradford County seat, and his hotels are fully booked for weeks on end, full of gas workers on 14-day stints. He's building another unit, and he estimates he's hired an additional 20

employees since the drillers moved in, with another 15 to 20 needed for the new hotel. "It's just been wonderful that these businesses have come into the area," says Murrelle, who has leased the land around his properties for drilling. "We're not being impacted by the recession at all."

For a state that is billions of dollars in debt, it's hard to resist the economic potential of drilling, drilling and more drilling — not that many politicians are trying. A just-released Penn State study found that sales-tax revenues from Pennsylvania counties with at least 150 Marcellus wells experienced an 11.36% increase from 2007 to 2010, while counties without wells experienced sharp declines. New Republican governor Tom Corbett — who has received hundreds of thousands of dollars in contributions from the gas industry over his career — sees the Marcellus as the key to Pennsylvania's economic rebirth, and he's already begun removing some limits on drilling. "The Marcellus is a resource, a source of potential wealth, the foundation of a new economy," said Corbett last month in his maiden budget address. "Let's make Pennsylvania the Texas of the natural gas boom."

Which, as some very unhappy Pennsylvanians see it, is exactly the problem.

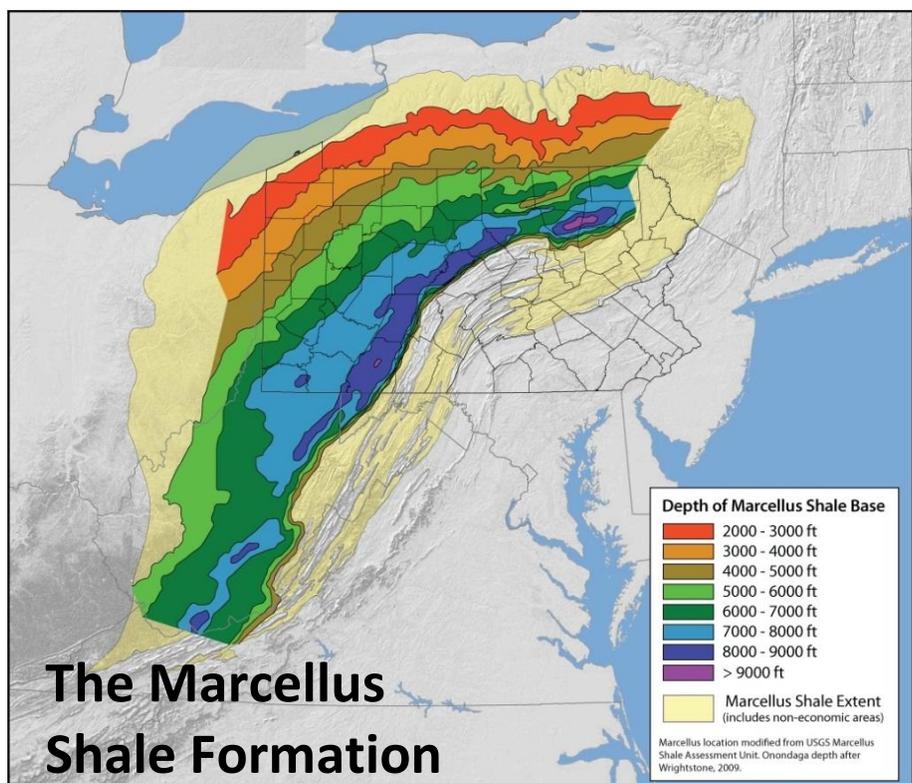
The Flowback

It wasn't the fact that the gas company used the family driveway to bring hundreds of trucks to the well being drilled on their property that annoyed the Johnsons so much. Nor was it that the multi-acre well pad was just a few hundred feet from their back door, even though the Johnsons had leased hundreds of acres on their dairy farm outside Wellsboro. But when their cows last summer ended up drinking from a suspected leak in a drilling wastewater pond — slurping up water contaminated with the radioactive element strontium — that was too much. You don't mess with a farmer's livestock, and dozens of the Johnsons' cows had to be kept in quarantine. "We wished the gas company had never come around here," says 75-year-old Don Johnson, who has lived in the area his entire life. "They affected the water, and without water you can't farm here and you can't live here."

It's water that's at the heart of the environmental impact of shale-gas drilling. To understand why, you need to understand how horizontal well drilling and hydraulic fracturing work. The name isn't accidental — as much as 5 million gal. (19 million L) of water is used in a typical

hydraulically fractured (or hydrofracked) well in the Marcellus. First a drilling rig will dig a vertical hole several thousand feet deep, gradually bending until the concrete-encased well reaches the shale layer. After burrowing horizontally for as much as a mile (1.6 km), the drillers lower a perforating gun down to the end of the well. That gun fires off explosions underground that pierce the concrete and open up microfractures in the shale. The drillers then shoot millions of gallons of highly pressurized water, mixed with sand and small amounts of additives known as fracking chemicals, down the well, widening the shale fractures. Natural pressure forces the liquids back up the well, producing what's known as flowback, and the gas rushes from the fractures into the pipe. The grains of sand included in the fracking fluid keep the shale cracks open — like stents in a clogged blood vessel — while the well produces gas for years, along with a steadily decreasing amount of wastewater from deep inside the shale.

Many environmental activists worry that fracking fluid could somehow contaminate nearby groundwater. Even though fracking chemicals make up only perhaps 0.5% of the overall drilling fluid, in a 5 million-gal. (19 million L) job, that would still amount to some 25,000 gal. (95,000 L). It's not always clear what those chemicals are, because the industry isn't required to release the precise makeup of its fracking formulas — and drilling-service companies like Halliburton have been reluctant to reveal the information. (It's not for nothing that a provision in the 2005 energy bill that prevents the Environmental Protection Agency from regulating hydraulic fracturing has been nicknamed the Halliburton loophole.) Gas companies compare fracking



additives to household chemicals, but some environmentalists and scientists believe the formulas can contain toxic ingredients. When the fracking fluid mixes with the shale, it may also become contaminated with radioactivity —the Marcellus is slightly radioactive — while growing increasingly brackish. "You bring everything the fluid encounters down there back to the surface along with the gas," Michel Boufadel, an environmental engineer at Temple University, told TIME last year.

The chance that fracking fluid could directly escape through the deep fractures created by the process and contaminate groundwater appears remote. The Marcellus Shale is separated from aquifers by thousands of feet of rock, much of it impermeable, and the gas industry argues that there has never been a proven case of water contamination through hydraulic fracturing. "I don't think it's scientifically plausible to suggest that could happen," says Don Siegel, a hydrogeologist at Syracuse University. In a 2009 study, the Ground Water Protection Council, a consortium that includes industry and state regulators, reported that the chance of aquifer contamination was extremely low, echoing the results of a 2004 EPA review of hydraulic fracturing. But that EPA report has been criticized, and the science is open enough that the agency is beginning a comprehensive new study of the relationship between hydraulic fracturing and drinking water.

Of greater concern is what may be happening closer to the surface. Wells need to be properly cemented to prevent any gas or fluid from escaping before it's collected. Cementing is one of the trickiest parts of drilling — a bad cement job helped lead to the Deepwater Horizon blowout last year — and it can and does fail over time. That seems to be what happened in the northeastern Pennsylvania town of Dimock, where the state government has said poor cementing around well casings by the drilling company Cabot allowed methane to contaminate the water wells of 19 families. Methane isn't dangerous to drink, but in high enough concentrations it can cause water to burn and even explode — which is exactly what happened to one Dimock family's well in 2009. (Cabot has denied that it caused the methane contamination, which the company claimed was naturally occurring, but it did offer the affected residents compensation.) "We were never forewarned about this risk," says Craig Sautner, one of 14 affected Dimock residents still suing Cabot. "I worry that this took years off our lives."

Beyond well problems, there's the threat of spills like those that struck the Burnetts and the Johnsons. The gas industry says such accidents are rare. "We drill 35,000 wells a year, and 95% are fractured," says Lee Fuller, executive director of Energy in Depth, a gas trade group. "We need to put this in a context that reflects all the successes as well as the failures." Still, in 2010 the Pennsylvania department of environmental protection issued 1,218 violations, out of 1,944 inspected Marcellus wells, for offenses ranging from littering to spills on drill sites. Wells have blown out,

and explosions from methane contamination have destroyed homes. Shale-gas drilling is an industrial process, and the more wells that are drilled, the more often something will go wrong — and in a populated state like Pennsylvania, those accidents will be felt.

Even if everything goes right, hydraulic fracturing can produce over 1 million gal. (3.8 million L) of toxic, briny wastewater over the lifetime of an individual well. In western states like Texas, companies can store the wastewater in deep underground control wells, but Pennsylvania's geology makes that difficult. As a result, drillers have had to ship much of their wastewater to municipal treatment plants —and as a recent New York *Times* investigation showed, those plants are often incapable of screening all drilling-waste contaminants. Although Pennsylvania has begun to tighten treatment regulations and gas companies are recycling increasing amounts of wastewater — reusing it in additional frack jobs — the problem is still one of the biggest challenges in drilling. "There are only a few thousand wells now, but there will be far more," says Anthony Ingraffea, a structural engineer at Cornell University. "What will life be like when there are 100,000 wells here?"

That's the fear of many Pennsylvania residents. It's not just the worries about what might be happening to their water; it's also what they know is happening to their communities. Trucks crowd country roads, ferrying drilling fluid and equipment to and from wells. Jobs are up, but some businesses have suffered as employees have fled for higher-paying jobs in the gas industry. As rig workers have snapped up every available room in tiny towns, rents have skyrocketed, punishing low-income families who don't own their homes. Those who had moved to the area for a quiet Pennsylvania — and those who've valued that peace for generations — feel betrayed. "I think it's been a good thing overall," says John Sullivan, a commissioner for Bradford County. "But I just wish we could keep the economic benefit and minimize everything else."

The Cleaner Fuel

Good luck with that. Make no mistake: in a post-Fukushima world, the U.S. will use this gas. It's important to cast the environmental controversies surrounding shale drilling against the backdrop of the fossil fuel that, if all goes well, gas should help displace: coal. From mountaintop-removal mining to its impact on climate change, cheap coal is toxic to the human race. Thousands die in coal mines annually around the world; in the U.S. alone, air pollution from coal combustion leads to thousands of premature deaths a year. Natural gas power plants, by contrast, emit far fewer air pollutants. Natural gas's benefit over coal when it comes to climate change is less clear-cut, but it's there, and gas can also coexist with renewable energy, providing inexpensive backup for wind and solar. "Natural gas could be crucial to integrating renewables into the power grid," says Ralph Cavanagh, a co-director of the Natural Resources Defense Council's energy program.

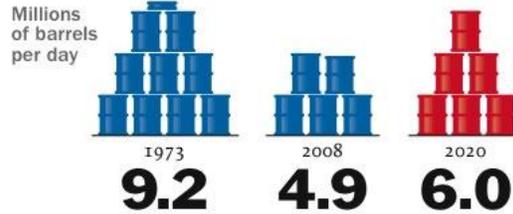
Still, Cavanagh has a warning: "Industry can blow this if it doesn't meet the public's environmental expectations." Those expectations will almost certainly include tougher regulations. In the U.S., that can be done, starting at the federal level, by giving the EPA the power to do a life-cycle analysis of hydraulic fracturing, looking at the cumulative impact of wide-scale drilling on water supplies. Representative Maurice Hinchey of New York and Senator Robert Casey Jr. of Pennsylvania have submitted commonsense pieces of legislation that would require industry to disclose the identities of chemicals used in fracking jobs. The bulk of the oversight may still be done by states, but governors will need to take care that drilling doesn't outpace regulators, as happened in Pennsylvania. The best gas players can keep improving their rates of recycling wastewater — Chesapeake Energy says it has a 100% recycling rate — while making use of new technologies like those offered by the Utah-based firm Purestream, which can evaporate and clean wastewater at the wellhead. Areas like the New York City watershed that are too valuable should be kept off-limits. "The gas is out there, and it can be accessed," says Dean Oskvig, president and CEO of Black & Veatch's energy business. "But we do need to solve the environmental issues surrounding that extraction."

If that can be done right, shale gas really could change the way we use energy for the better. But even if it does, the industry will still fundamentally remake parts of the U.S., and of the world, in ways we won't always like. But that's the price of extreme energy, and it's one we'll continue to pay until we can curb our hunger for fossil fuels or find a cheap, reliable and clean alternative to them.

For some people, though, the price may simply be too high. Cindy Copp's family had lived in northeastern Pennsylvania's Tioga County for five generations, and after selling her home in town recently, she'd planned to open an organic farm. But as the quiet 50-year-old learned more about what drilling might do to the land — and as the gas boom made her hometown unrecognizable — she surrendered. "I tried to start my community, but the community is fractured," she says, her eyes welling. "I don't see a future here."

Instead, Copp is moving to a rural commune near Hudson, N.Y. There's no shale-gas drilling there — yet.

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