Fracking article I

Source: Science Daily

**Tapping a Valuable Resource or Invading the Environment? Research Examines the Start of Fracking in Ohio**

*Sep. 25, 2013* — A new study is examining methane and other components in groundwater wells, in advance of drilling for shale gas that's expected over the next several years in an Ohio region.

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Amy Townsend-Small, a University of Cincinnati assistant professor of geology, will present on the study on Sept. 27, at the 10th Applied Isotope Geochemistry Conference in Budapest, Hungary.

The team of UC researchers spent a year doing periodic testing of groundwater wells in Carroll County, Ohio, a section of Ohio that sits along the shale-rich Pennsylvania-West Virginia borders. The study analyzed 25 groundwater wells at varying distances from proposed fracking sites in the rural, Appalachian, Utica Shale region of Carroll County. Because the region is so rural, the majority of the population relies on groundwater wells for their water supply.

"This is a major area for shale gas drilling in Ohio, and one reason is because shales in the area are thought to have a good amount of liquid fuel as well as natural gas," says Townsend-Small.

The researchers are currently analyzing samples from groundwater wells over a one-year period, with water samples drawn every three-to-four months.

The samples are being analyzed for concentrations of methane as well as hydrocarbons -- a carcinogenic compound -- and salt, which is pulled up in the fracking water mixture from the shales, which are actually ancient ocean sediments.

"We're examining changes over time resulting from fracking, and since this is just beginning in Ohio, we have the opportunity to make some baseline assessments," says Townsend-Small.

Hydraulic fracturing, or fracking, involves using millions of gallons of water mixed with sand and chemicals to break up organic-rich shale to release natural gas resources. Proponents say fracking promises a future in lower energy prices, cleaner energy and additional jobs amid a frail economy. Opponents raise concerns about the practice leading to increased methane gas levels (known as the greenhouse gas) and other contamination -- resulting from spillover of fracking wastewater -- of groundwater in shale-rich regions.

Townsend-Small explains that some groundwater wells naturally hold a certain level of methane due to the decomposition of organic matter. It's not toxic in drinking water, but high levels can result in explosion. The study includes measurements of stable isotopes, which can indicate whether methane is derived from natural organic matter decomposition or from fossil fuels.

Other chemicals in fracking wastewater are toxic and dangerous for drinking water. Future UC research includes measurements of some of these compounds, as fracking progresses in the region.

The U.S. Energy Information Administration reported this summer that natural gas reserve additions in 2011 ranked as the second-largest annual increase since 1977, with hydraulic fracturing adding to increased oil and gas reserves.

The Ohio Department of Natural Resources reports that 882 sites in the state of Ohio have been awarded permits for fracking. In Carroll County, 327 sites have been awarded permits and 236 have been drilled.

Funding for the UC study was supported in coordination with UC Foundation by a $20,000 grant from the Missouri-based Deer Park Foundation, a $2,500 grant from the Cincinnati-based David and Sara Weston Foundation and an $85,714 grant from the Ohio Board of Regents.

Townsend-Small and her colleagues in the UC Department of Geology were also awarded a $400,000, 3-year grant from the National Science Foundation (EAR-1229114) for an isotope ratio mass spectrometer. The instrument measures the stable isotope composition of methane, which can indicate whether it is derived from biological activity or natural gas.

# Source: the New York Post.

# Gas Leaks in Fracking Disputed in Study



Jim Wilson/The New York Times

Oil fields in the Permian Basin of Texas and New Mexico, an Apache Energy site where wells were drilled in February last year.

###### **By**[**MICHAEL WINES**](http://topics.nytimes.com/top/reference/timestopics/people/w/michael_wines/index.html)

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Drilling for shale gas through hydraulic fracturing, or fracking, appears to cause smaller leaks of the greenhouse gas methane than the federal government had estimated, and considerably smaller than some critics of shale gas had feared, according to a peer-reviewed study released on Monday.

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###### **Brennan Linsley/Associated Press**

Workers tended to a well head in a hydraulic fracturing operation at Enana Oil and Gas well near Rifle, Colo., in March.

[The study](http://www.pnas.org/content/early/2013/09/10/1304880110.full.pdf), conducted by the[University of Texas](http://topics.nytimes.com/top/reference/timestopics/organizations/u/university_of_texas/index.html?inline=nyt-org) and sponsored by the Environmental Defense Fund and nine petroleum companies, bolsters the contention by advocates of fracking — and some environmental groups as well — that shale gas is cleaner and better than coal, at least until more renewable-energy sources are developed. More than 500 wells were analyzed.

The Texas study concluded that while the total amount of escaped methane from shale-gas operations was substantial — more than one million tons annually — it was probably less than the Environmental Protection Agency estimated in 2011.

In particular, it indicated that containment measures captured 99 percent of methane that escaped from new wells being prepared for production, a process known as completion.

The Environmental Protection Agency has begun to require drillers to control leaks during completions, which are believed to be one of the major sources of methane losses at fracking wells. Although controls will not be required until January 2015, a number of companies already capture escaped gases at wells being prepared for production.

“Can we control it? Thanks to new E.P.A. regulations coming online, the answer to that is good news,” Eric Pooley, a senior vice president at the Environmental Defense Fund, said in an interview.

The report was published Monday in The Proceedings of the National Academy of Sciences. With the study, which ran from May through December of last year, the university was the first to conduct detailed examinations of individual drilling sites. It did so with the consent of petroleum companies, which provided about 90 percent of the financing for the study. Previous E.P.A. estimates relied on engineering calculations, and other studies gathered data via aircraft flights over drilling sites.

The study’s connection to the petroleum industry — among its sponsors and financiers are Shell, Anadarko Petroleum Corporation, Exxon Mobil and Chevron — may lead some to question its objectivity, some outside experts said. But most said the research and the reputations of the researchers appear solid.

“Previous studies that have gotten a lot of attention have had red flags jumping out all over them. This one didn’t,” said Michael A. Levi, the director of the program on energy security and [climate change](http://topics.nytimes.com/top/news/science/topics/globalwarming/index.html?inline=nyt-classifier) at the Council on Foreign Relations. In an e-mailed statement, Shell’s president, Marvin Odum, called the study “a prime example of key groups — that may not have the exact same interests — working collaboratively and taking a science-based approach” to the methane problem.

Mr. Odum said that collecting actual emissions data, rather than relying on estimates, would “ensure that both improvement efforts and regulatory changes can be focused on the areas that will have the biggest impact.”

The report comes at a time when shale-gas drilling is growing at a breakneck pace — production, now 30 percent of all United States [natural gas](http://topics.nytimes.com/top/news/business/energy-environment/natural-gas/index.html?inline=nyt-classifier), is expected to reach 50 percent by 2040 — but also when the industry is beset by controversy.

Citizen groups accuse drillers of despoiling streams and water supplies, and suppliers of wrecking local roads with parades of massive trucks. Environmental groups have split sharply over whether to support shale-gas development as a cleaner fuel that will suffice until wind and [solar power](http://topics.nytimes.com/top/news/business/energy-environment/solar-energy/index.html?inline=nyt-classifier) assume a greater share of the nation’s energy supply.

The Texas study is the most comprehensive look to date at a contentious issue in the debate over fracking: the extent to which methane leaks during drilling and production offset the environmental benefits of the clean-burning natural gas the wells produce.

When burned as fuel, methane — the main component of natural gas — is comparatively clean, producing less carbon dioxide than coal and [oil](http://topics.nytimes.com/top/news/business/energy-environment/oil-petroleum-and-gasoline/index.html?inline=nyt-classifier). But vented to the air, it is a short-lived but extremely potent greenhouse gas, trapping heat at a much higher rate than carbon dioxide, the main greenhouse gas.

Such potency means that even a small loss of methane to the air — just 3.4 percent, scientists say — can negate its climate-changing advantage over coal.

Some previous studies suggested that as much as 7.9 percent of all shale gas was lost to the atmosphere, a figure that included every stage of the gas process, from well to stove or furnace burner.

The Texas study did not examine potential losses outside the drilling pad. But its conclusion that losses at the well were comparatively low could remove one issue from the debate. The Environmental Defense Fund is leading other research efforts that should address losses elsewhere, including a look at methane leaks in municipal gas-distribution lines.

The American Petroleum Institute hailed the study’s conclusions, saying in a statement that its own efforts to reduce methane emissions “are paying off.” But while E.P.A.-mandated measures appear to have reduced emissions during well completions, the study also concluded that leaks elsewhere in the fracking process were higher than the E.P.A. had previously estimated.

Estimates of leaks from chemical pumps, while small, were twice past estimates, while leaks from pneumatic controllers, or valves, were pegged at more than 639,000 tons a year, roughly a third greater. None of those components are currently subject to federal regulation.

Fracking article II

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# Fracking’s Future

Natural gas, the economy, and America’s energy prospects

SUPPLIES OF NATURAL GAS now economically recoverable from shale in the United States could accommodate the country’s domestic demand for natural gas at current levels of consumption for more than a hundred years: an economic and strategic boon, and, at least in the near term, an important stepping-stone toward lower-carbon, greener energy.

But even though natural gas is relatively “clean”—particularly relative to coal burned to generate electricity—the “fracking” process used to produce the new supplies poses significant environmental risks. We must ensure that procedures and policies are in place to minimize potential damage to local and regional air quality and to protect essential water resources. We need to make sure that extraction of the gas (consisting mainly of methane, with small amounts of other gases) from shale and its transport to market does not result in a significant increase in “fugitive” (inadvertent) emissions of methane (CH4)—which is 10 times more powerful as a climate-altering agent, molecule per molecule, than carbon dioxide (CO2, the most abundant greenhouse gas). Further, we will need to recognize from the outset that cheap natural gas may delay the transition to truly carbon-free, sustainable solar- and wind-energy supplies that remain crucial in light of our worsening climate-change crisis.

### The Gas Gift

PRODUCTION and consumption of natural gas in the United States were in approximate balance up to 1986. Production then lagged consumption during the following 20 years; the deficit was made up largely by imports from Canada, delivered by pipelines. The situation changed dramatically in 2006 as companies using new drilling technologies moved aggressively to tap the vast supplies of previously inaccessible gas trapped in underground shale deposits. Natural gas extracted from such sources accounted for 10 percent of U.S. production in 2007, and rose to 30 percent of production by 2010—an enormous, swift change in our huge market. There are few signs that the trend is likely to reverse in the near future.

 Partly as a result of that surge in supply, domestic natural-gas prices are now lower than at any time in the recent past. The spot price for natural gas traded on the New York Mercantile Exchange hit a record low of $1.82 per million British thermal units (MMBTU) last April 20—down 86 percent from a high of $12.69 in June 2008. Even at recent, somewhat higher prices, natural gas is now significantly cheaper than either diesel fuel or gasoline on an energy-equivalent basis: a little more than one-tenth the wholesale, spot prices of about $3 per gallon for those liquid fuels.

Lower-priced natural gas has had important consequences for the U.S. economy. Approximately one-quarter of primary energy (mainly coal, gas, oil, nuclear, and hydro) consumed in the United States in 2011 was supplied by natural gas. Electricity generation accounted for 31 percent of total natural-gas demand, followed by consumption in the industrial (28 percent), residential (19 percent), and commercial (13 percent) sectors. Natural gas is used as an industrial energy source in manufacturing products ranging from steel and glass to paper and clothing. It is the raw material for fertilizer, paints, plastics, antifreeze, dyes, photographic film, medicines, and explosives. More than half of all commercial establishments and residences are heated using gas, which is widely deployed as well for cooking and as fuel for water heaters, clothes driers, and other household appliances. Consumers have benefited directly from lower gas-utility bills, and industrial customers have benefited by switching fuels—as have chemical and other processors that use gas as a feedstock. Abundant, cheap natural gas has been of general benefit to electric-utility customers as power suppliers have substituted it for coal to fire their generators.

The shift from coal to gas in the electricity sector has also yielded an environmental bonus—a significant reduction in emissions of CO2, because CO2 emissions per unit of electricity generated using coal are more than double those produced using gas. Approximately half of U.S. electricity was produced using coal in 2005, but by last March, coal’s contribution had dropped to an unprecedented low of 34 percent. Meanwhile, the U.S. Energy Information Administration (EIA) reported that domestic emissions of CO2 during the first quarter of 2012 fell to the lowest level recorded since 1992. An ancillary benefit of the coal-to-gas switch has been a significant reduction in emissions of sulfur dioxide, the cause of acid rain, because many of the older coal-burning plants selectively idled by the price-induced fuel switch were not equipped to remove this pollutant from their stack gases.

### Supply and Demand

A KEY QUESTION is whether the current low price for gas can persist.

Shales in different regions are characterized by variable combinations of hydrocarbons. Some are gas- (methane-) rich, described as “dry.” “Wet” formations yield significant concentrations of condensable heavier hydrocarbons—such as ethane, pentane, and propane—referred to collectively as natural gas liquids (NGLs). Still others—notably the Bakken field in North Dakota—are gas-poor but oil-rich and are being developed primarily to extract that valuable resource. (In fact, only Texas outranks North Dakota now among U.S. oil-producing states.)

The hydrocarbon mix matters, because the break-even price for profitable extraction of natural gas from a dry shale well is estimated at about $5/MMBTU—about one and a half times the spot-market price in October. The bulk of the natural gas produced from shale today is derived from wet sources: marketing of the liquid products (which command higher prices) justifies the investments.

That means that the economic momentum of the shale-gas industry can be sustained for the long term only by decreasing production (ultimately causing prices to adjust—a process that may be under way as drilling diminishes at current prices) or by increasing sales of its product.

Increased use of natural gas for transportation could provide an additional domestic market, taking advantage of the significant price disparity versus gasoline or diesel fuels (as noted above). Doing so would require not only an investment in facilities to produce and deliver compressed natural gas (CNG), which is in limited use now, but also the introduction of vehicles capable of running on this energy source. Buses, taxis, and public vehicles (police cars, for example), suitably equipped, that could be charged at central stations would appear to provide an attractive early marketing opportunity. The benefits of such conversions would include reduced demand for imported oil, improved urban air quality, and a further decrease in CO2 emissions.

An even larger opportunity may lie in exports. Natural-gas prices in Europe and Asia were five to seven times those in the United States during the first half of 2012; Japan is an especially eager consumer, given the wholesale closure of its nuclear-electric generating capacity in the wake of the Fukushima earthquake, tsunami, and power-plant crisis in March 2011. But exports require multibillion-dollar investments in facilities for liquefaction of gas and in the ports through which liquefied natural gas (LNG) can be shipped. Exxon Mobil Corporation, the largest producer of natural gas in the United States, has taken steps to form a $10-billion partnership for LNG exports. If this and other investments proceed, and the prices realized for LNG are high enough to justify further shale-gas drilling, the U.S. economy could benefit from significant energy exports—and the importing countries might also realize environmental benefits. China, where coal is the principal fuel source, could profit in particular: a cleaner source of energy would mean less local pollution from coal (including emissions of particulates, sulfur, mercury, etc.). And the global environment would benefit overall from a reduction in—or lessened growth of—CO2 emissions. (China became the leading source of such emissions in 2006.)

To date, then, we can say conclusively that a shift to natural gas from coal has changed the U.S. energy system in ways that yield economic and environmental gains. But there are serious environmental challenges associated with freeing that gas from the shale and distributing it to consumers.

### A Fracking Primer

THE FIRST STEP in extracting gas from shale involves drilling vertically to reach the shale layer, typically a kilometer or more below the surface. Drilling then continues horizontally, extending a kilometer or more from the vertical shaft, and the vertical and horizontal components of the well are lined with steel casing, cemented in place. The horizontal extension of the casing is then perforated, using explosives; thereafter, water, carrying sand and proprietary chemicals, is injected into the well at high pressure. The water encounters the shale through the perforations, generating a series of small fractures in the rock (hence the nickname, “fracking”); the sand in the water keeps the cracks open, while the chemicals enhance release of gas from the shale. The injected water flows back up to the surface when the pressure in the well is released following completion of the fracking procedure. Then the well starts to produce natural gas.

As many as 25 fracture stages (per horizontal leg) may be involved in preparing a single site for production, each requiring injection of more than 400,000 gallons of water—a possible total of more than 10 million gallons before the well is fully operational. A portion of the injected water flows back to the surface, heavily contaminated with the fracking chemicals and others it has absorbed from the shale. Depending on the local geology, this “return water” may also include radioactive elements.

Drillers developing a well must take exceptional care to minimize contact between the wellbore and the surrounding aquifer—often the source of nearby residents’ fresh water. Serious problems have arisen in the past from failures to isolate the drilling liquids, including cases where well water used for drinking became so contaminated that human and animal health was threatened. It is essential that monitoring be in place to ensure the continuing integrity of the seal isolating the well from the aquifer even after the well has been fully exploited and abandoned.

A fraction of the contaminated water that returns to the surface is recycled and reinjected into the well to facilitate the next phase of the fracking process. But a larger proportion is stored temporarily in lined ponds on site for eventual transfer (most commonly by truck) to conventional water-treatment facilities. Care must be exercised to protect groundwater from spillage and to guard against potential leakage from the ponds. Moreover, the facilities to which the contaminated water is eventually transferred may be ill-prepared to deal with the challenges posed by its unusual chemical composition; for instance, conventional treatment facilities are not equipped to deal with radioactive materials—which under the circumstances could be transferred to the water bodies receiving the treated effluent.

Finally, careless drilling and production from fracked wells can result in fugitive emissions of methane from the shale below. Such inadvertent releases of methane could more than offset the advantages otherwise realized by reducing emissions of CO2 through substituting natural gas for other fuels.

The International Energy Agency (IEA) recently proposed steps to ensure responsible extraction of gas from shale. If these procedures are implemented, the IEA concluded that the increase in production costs should be relatively modest—7 percent or less—and that the integrity of the environment could be protected. The IEA conclusions appear overly optimistic in the U.S. context: the costs for design and implementation of sensible regulations for the domestic shale-gas industry are likely to be significantly greater—but still tolerable. The problems are neither technical nor economic, but essentially political.

### Beyond Shale Gas: Carbon-Free Energy

A RECENT STUDY by the National Renewable Energy Laboratory (NREL) suggests that with suitably targeted investments, emissions of CO2 from the U.S. power sector could be reduced by as much as 80 percent by 2050. The dominant source of electricity as envisaged in this analysis would come from a combination of wind and solar, with gas-fired plants called on to provide backup whenever the intrinsically variable source of power from wind and solar might not be sufficient to meet peak demand (on a hot summer evening, for example). Coal would be replaced initially by gas, continuing the trend observed over the past several years. Successful implementation of this strategy will depend critically, however, on future trends in relative prices for electricity generated using coal, gas, wind, and solar.

The break-even price for production of electricity using a modern coal-fired plant is about 5.9 cents per kilowatt hour. This means that coal cannot compete economically with gas under conditions where gas prices are lower than about $5/MMBTU, our estimate of the break-even price for production of gas from a dry well (at $5/MMBTU, the price for production of electricity from gas would be about the same as that from coal). Gas replaces coal as the fuel of choice in this case.

The cost for production of electricity using wind is about 8.0 cents per kilowatt hour. Wind therefore can compete with $5/MMBTU gas only if it can continue to benefit from the existing production tax credit (PTC), currently 2.2 cents per kilowatt hour. If gas prices were to rise above $8.3/MMBTU, wind would be competitive even in the absence of the PTC. The problem in this case is that generation of power from coal would be cheaper than that from either gas or wind.

Thus free-market forces alone may not be sufficient to grease the path to a low-carbon future. Should gas prices rise above $5/MMBTU, a carbon tax may be required to ensure a continuing competitive edge for gas relative to coal. Similarly, the PTC subsidy or similar initiatives—such as quotas for minimum contents of renewable energy in specific power markets (often on a state-by-state basis)—may be needed to ensure the continuing viability of wind and solar should gas prices persist below about $8.3/MMBTU. If we are to navigate safely and successfully to the future envisaged by the NREL, gas prices must be low enough to disenfranchise coal but not so low as to make it impossible for renewable sources to compete.