# Hunting a climate fugitive

## Plugging methane leaks in the urban maze could be key to making shale gas climate-friendly

*By* **Eli Kintisch,** ***in Boston***

On a windy morning in May, graduate student Kathryn McKain crouches by a ledge near the top of one of Boston's tallest skyscrapers, checking some air sampling equipment. McKain, of Harvard University's engineering department, likes more than just the commanding view: From 215 meters up, the greenhouse gas measurements she's making aren't biased by pollution from individual sources below. "You're really getting measurements representative of the whole city," she says.

Sometimes a falcon lands nearby, presumably using the perch to spot pigeons. The scientists are hunting something else: methane, an invisible but potent heat-trapping gas. They're trying to figure out how much is leaking from the city's vast network of natural gas pipes and tanks.

It's a question that is haunting academics, politicians, and executives who have hailed the boom in shale gas production (see p. 1467) as aiding a critical transition to climate-friendlier energy sources. Burning natural gas releases about half as much carbon dioxide ($CO_2$) per unit of energy as burning coal and a third less than oil. And as hydraulic fracturing (fracking) methods have helped flood energy markets with relatively cheap natural gas, it has begun to replace coal as the fuel of choice for producing power in the United States. About 28% of the nation's electricity now comes from natural gas, up from 19% in 2005. From 2005 to 2012, U.S. $CO_2$ emissions dropped by about 11%, and one study said that fuel-switching to gas is responsible for as much as half of that drop. President Barack Obama's proposed new restrictions on carbon pollution from power plants are likely to accelerate the transition.

Many climate policy analysts believe that natural gas can provide a "bridge" to a future energy economy by buying time to develop renewable energy technologies. But that bridge may be more rickety—and less helpful—than envisioned. The reason: Methane, the primary component of natural gas, is itself a potent greenhouse gas, with a warming effect between eight and 72 times stronger than that of $CO_2$, depending on the time period over which one does the accounting. And recent studies have suggested that large quantities of unburned methane are leaking into the atmosphere—not just from production wells and major pipelines but also from gas lines and tanks that distribute the fuel in cities. The leaks could negate much of the climate benefit of switching to gas.

"Clearly natural gas has potential to help," says Steve Hamburg, chief scientist of the Environmental Defense Fund (EDF) in Boston. "But to meet that potential we have to minimize methane emissions." EDF and other government and private groups have launched a flurry of studies, including McKain's research in Boston, to pin down just

Infrared imaging of pipes and tanks can reveal methane leaks (dark clouds, lower image).

PHOTOS: ENVIRONMENTAL DEFENSE FUND (2)

how much methane is escaping, and where. At the same time, the concerns are fueling fresh debate over methane's importance as a warming gas—and whether regulators should be doing more to control it.

**METHANE PLAYS AN OUTSIZED ROLE** in climate. Although it is 200 times less abundant in the atmosphere than $CO_2$, the way its four carbon-hydrogen bonds jiggle when struck by infrared radiation makes it a highly effective warmer. Overall, methane concentrations are now three times higher than in the preindustrial era, and the molecule may be responsible for as much as one-quarter of current global warming. So climate researchers took notice in 2008, when methane concentrations in Earth's atmosphere began rising after a decade of flat or declining levels.

Some of that atmospheric methane comes from natural sources, such as gas seeps or wetlands. But an estimated one-fifth of the global total—and about 30% of U.S. methane emissions—comes from the natural gas infrastructure, from wells to end users, and the fracking boom is adding thousands of potential new sources of emissions. Getting a handle on well emissions is proving particularly difficult, with recent studies coming to opposite conclusions. Last year, in the biggest study of its kind to date, researchers from the University of Texas, Austin, measured emissions at 190 gas industry sites, including 150 production sites. This bottom-up approach, part of the EDF effort, concluded that existing Environmental Protection Agency (EPA) estimates of industry methane emissions were a little low.

But a top-down study published last year, using more than 10,000 measurements taken from aircraft- and tower-mounted instruments nationwide, concluded that EPA estimates are roughly 1.5 times too low. The study, published in the *Proceedings of the National Academy of Sciences* (*PNAS*) and led by McKain's adviser, geochemist Steven Wofsy of Harvard, used a weather model to track emissions back to their sources.

What might explain the discrepancy? One answer may be so-called superemitters. Just a few components at a drill site—a leaky pipe, valve, or compressor, for example—may be responsible for the lion's share of emissions. Bottom-up studies that miss sites with superemitters may underestimate leaks, while top-down studies might come up with numbers that are dominated by a few major leaks. Overall, some researchers estimate that just 20% of production leaks could account for some 80% of emissions.

To resolve the issue, last October EDF convened 12 research teams using a variety of ground-, air-, and mobile-based measurement methods to conduct a coordinated analysis of emissions at one center of the fracking boom, the Barnett Shale formation in north Texas. The teams are expected to release results soon. But a major role for superemitters would raise hopes that production leaks might be relatively easy to plug. "It raises the possibility of … mitigating them for a big impact," Brandt says.

**PLUGGING PIPELINE LEAKS** could be a tougher task. A 2005 *Nature* study of Russia's massive pipeline system concluded that 1.4% of the total methane it moves escapes into the atmosphere—three times more than the estimated well losses. Researchers believe





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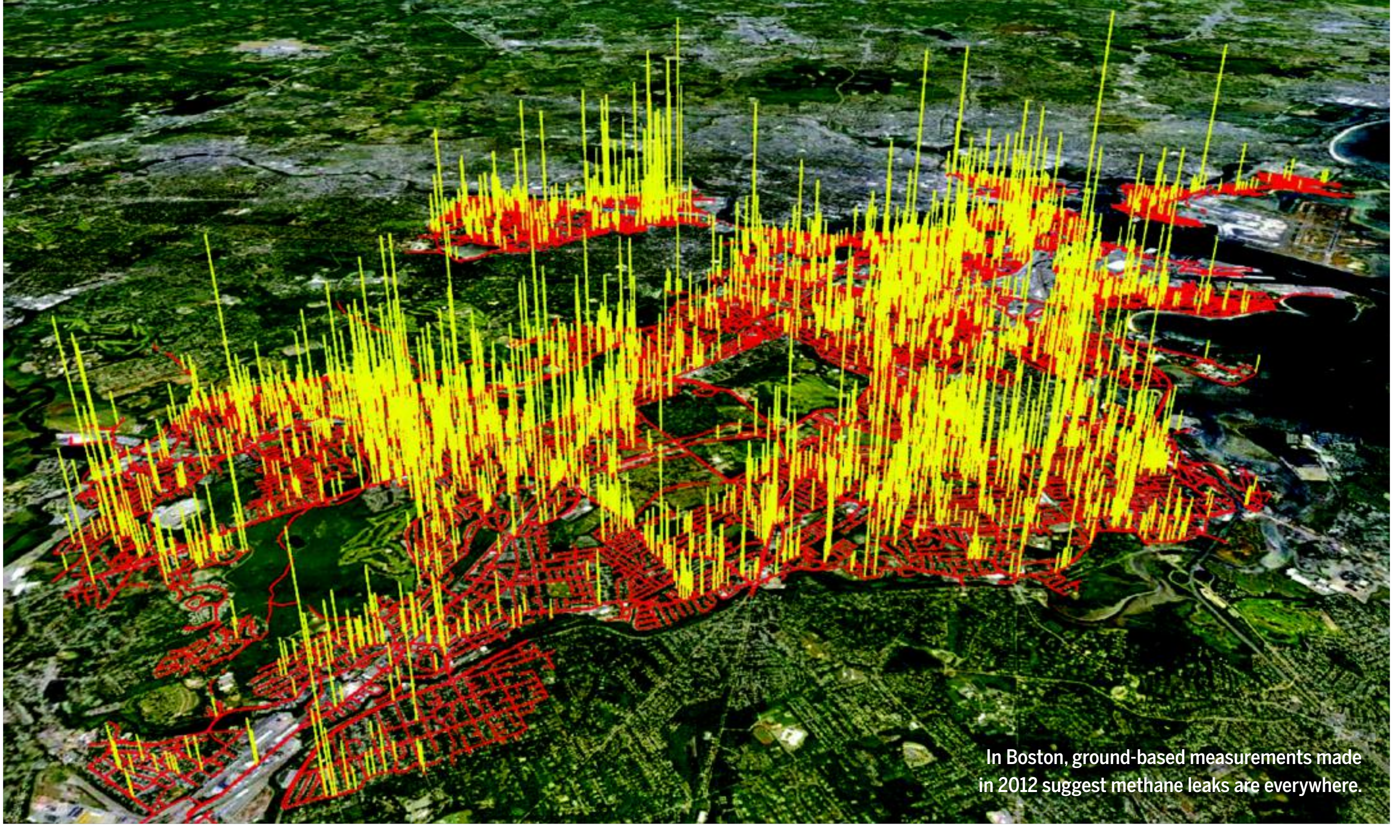

In Boston, ground-based measurements made in 2012 suggest methane leaks are everywhere.

PHOTO: N. G. PHILLIPS *ET AL.*, *ENVIRONMENTAL POLLUTION* **173** (FEBRUARY 2013). WITH PERMISSION FROM ELSEVIER

the loss rate is similar in the U.S. system, which includes nearly 500,000 kilometers of pipe. To confirm that suspicion, researchers at Colorado State University are now working with seven gas firms to use tracer gases to track leaks.

Meanwhile, Harvard's McKain and other researchers are trying to understand how much methane escapes at the far end of the supply chain, including the maze of small pipes and tanks that feed industrial and household consumers in major cities such as Boston, Los Angeles, and Washington, D.C. It's no simple task: It's challenging to differentiate emissions from natural gas systems from those originating in landfills, wetlands, or geologic formations. One solution is to track ethane, which is found alongside methane from natural gas pipelines, but usually not in emissions from other sources. In Los Angeles, however, gas from ubiquitous natural oil and gas seeps has virtually the same ethane signature as pipeline gas, making it very hard to tell the two apart.

As in gas well studies, urban researchers are taking bottom-up and top-down approaches. In Washington, D.C., and Boston, scientists have gotten behind the wheel to conduct street-by-street surveys with car-mounted instruments, uncovering previously undocumented—and occasionally dangerous—methane leaks. The Boston project, co-led by Harvard's Wofsy and biogeochemist Lucy Hutyra of Boston University, is taking a broader view, mounting static instruments on buildings in the city and suburbs to get the big picture. A computer model built by McKain combines weather patterns with methane measurements to infer where the emissions are coming from and how they vary over time.

The team is still crunching the numbers, but it appears that methane emissions in Boston "are really higher than people are expecting them to be," Wofsy says. The total includes leaks and deliberate venting by industry, but it's not clear that there are superemitters that will be easy to target for reductions, Hutyra says. "This is a distributed problem," she says, created by a multitude of relatively small sources.

That pattern could create huge headaches for companies and policymakers aiming to reduce methane emissions. The industry has made a "continued effort" to reduce leakage, says Richard Meyer of the American Gas Association in Washington, D.C. But the financial incentive for chasing down thousands of tiny leaks is essentially nonexistent—especially if gas prices remain relatively low. The irony, notes EDF's Hamburg, is that a 1% or 2% loss rate might do little damage to a company's bottom line—but have a real impact on warming. Still, his group has commissioned a study suggesting that the gas industry could cost-effectively plug about 40% of existing leaks, and it argues that society overall would reap even greater economic benefits if regulators stepped in to require greater reductions. Some states, meanwhile, are already taking steps to require gas companies to do more to identify leaks—sometimes by using infrared cameras that can "see" invisible methane—perhaps with stricter regulation in mind.

**JUST HOW MUCH ATTENTION** methane should get from regulators is the subject of debate. Many scientists argue for aggressively cutting methane leaks, saying that "could buy us time" to avoid climate tipping points, as atmospheric scientist Drew Shindell of NASA's Goddard Institute for Space Studies in New York City puts it.

Others say $CO_2$ should remain the key target. Although it is a weaker warmer than methane, it is fiendishly stable, able to survive in the atmosphere—and continue trapping heat—for centuries. Atmospheric methane, in contrast, dies relatively young, typically lasting just a dozen years or so before being dismantled by chemical reactions. What's more, asking policymakers to tackle methane might slow already lagging efforts to cut $CO_2$, these researchers note. That scenario is "[c]onsistent with limited capital and political will," wrote Harvard researchers Julie Shoemaker and Daniel Schrag last year in *Climatic Change*.

To see how a focus on methane might affect $CO_2$ mitigation, Shoemaker ran modeling experiments simulating various delays in cutting $CO_2$ pollution. Each 15-year delay in curbing $CO_2$, they found, caused the planet to warm by an additional 0.75°C by 2400. (A delay in cutting methane emissions has little long-term effect because methane doesn't accumulate.) Such sobering results suggest "it can't be cutting carbon dioxide or cutting methane," Schrag says. "We've got to develop policies that do both." ■