Thousands of gas leaks under Boston and San Francisco

06 July 2011 by Phil McKenna
Magazine issue 2820.

IF YOU are reading this in the US, the chances are there is a natural gas leak on your street. The US Energy Information Administration estimates that more than 8 billion cubic metres of gas are lost each year somewhere between the point of production and reaching homes across the nation. Some of this "unaccounted-for gas", as the EIA has dubbed it, is probably down to faulty meters and accounting errors. But not all.

Leaky streets of San Francisco

Picarro's sensor reveals widespread gas leaks (methane) across the city. The peaks along Embarcadero Street (dotted) range from 1.9 to 2.6 ppm. The average global methane background level is 1.86 ppm

Thousands of unreported leaks are turning up under Boston and San Francisco, according to Nathan Phillips of Boston University. Together with documents from the Massachusetts Department of Public Utilities, it suggests that some of the gas is leaking into the atmosphere from ageing pipelines beneath urban centres.

The leaked gas represents 1.4 per cent of the nation's total distribution but the methane it contains could scupper one of the best hopes for clean energy.

When burned, natural gas emits roughly half the carbon dioxide of coal, making it a promising "bridge fuel" until cleaner renewable energy sources come online. Germany is poised to use it as a substitute for the nuclear plants it will shut down by 2022 (see "Germany will use coal and gas to plug nuclear power gap"). But natural gas is made mostly of methane, which has more than 20 times the global warming potential of CO2 over a 100-year period. So gas that leaks from the system instead of being burned has a significant environmental impact.

Robert Howarth of Cornell University in Ithaca, New York, studies shale gas, which is extracted by injecting a mix of highly pressurised water, chemicals and sand underground to crack open the hydrocarbon-rich rock. The process, known as hydrofracking, is controversial because the chemicals could enter drinking water supplies. Nevertheless, shale deposits under the eastern US and in more than a dozen countries, including China, Brazil and Australia, have raised prospects of a "golden age of gas" where global use could rise by more than 50 per cent by 2035.

Howarth has calculated that 2.2 to 3.8 per cent of shale gas leaks out at the well site and an additional 1.4 to 3.6 per cent leaks during transport, storage and distribution - enough to make shale gas a bigger contributor to global warming than coal (Climatic Change, DOI: 10.1007/s10584-011-0061-5).

The study was pilloried by the natural gas industry, which noted the figures for leaks were based on limited data from pipelines in Texas and Russia. Howarth concedes the point, but he says the problem is the reluctance of companies to share their leak data. "This is a really secretive industry, they don't like regulators and the public looking too closely at what they do and don't do," he says.

Enter Picarro, a San Francisco-based start-up with a laser-based device that makes it possible to take rapid

measurements of gas concentrations on any street, and so begin to plug the leak data gap. Picarro's cavity ring-down spectrometer can be mounted on a car, detects concentrations at the parts per billion level in a fraction of a second, and doesn't require the driver to slow down to take a measurement. As a result, it is possible to map a city centre in a day or two rather than weeks.

Picarro is collaborating with Phillips to map the otherwise invisible methane plumes in US cities. Data collected in recent months from Boston and San Francisco show concentrations of up to 30 parts per million, more than 15 times global background levels. Phillips says such concentrations are unusually large for unconfined spaces, though they are unlikely to be a health concern and are nowhere near the threshold for causing an explosion, which stands around 50,000 ppm.

Should methane leak into confined spaces like manholes, however, it can quickly build up. One of four manholes surveyed by Phillips and a former gas worker in June registered 70,000 ppm - an explosion risk. National Grid, which is responsible for the pipes running adjacent to the manhole, says it is aware of the problem and is addressing it.

Concentration data alone is not enough to assess the climate change risks associated with the leaks, though: you need to know the volume of leaking gas. Phillips has begun collecting these measurements, but it is slow work: leaks need to be monitored individually. So far he has measured the volume of three leaks in Boston. On average they emitted a minimum of 4.9 m^3 per day - only slightly less than the 5.7 m^3 an average American home uses daily, according to the EIA. In the next one to two years, Phillips hopes to develop a method to characterise representative leaks so he can then estimate total leak volumes for the entire system.

What's clear already is that the ageing gas infrastructure is leaking across large areas of major US cities. Phillips's and Picarro's gas sniffers are not the only ones to point in that direction. In recent months, the New England Gas Workers Association got hold of documents showing more than 20,000 non-explosive-hazard leaks from utility pipelines in Massachusetts alone. The documents, obtained from the Massachusetts Department of Public Utilities, show that just 13,000 of these leaks were responsible for an estimated annual loss of 32 million m^3 of gas.

The EIA requires gas companies to report all estimated leak volumes, yet none of the losses from the Massachusetts utility companies show up in the agency's records.

When asked about the omission Amy Sweeney of the EIA told New Scientist that she was not sure why the agency had no record of the losses. "[My] best guess is that the leaks wound up in the unaccounted-for pile," she wrote.

The picture that is emerging is one of uncertainty. Phillips's data and the documents both suggest that at least some unaccounted-for gas comes from methane leaking into the atmosphere. If volume measurements show that leaked gas makes up most of the "unaccounted-for pile", it will provide direct evidence that Howarth's critical assessment of shale gas's green credentials was valid.

"It's important to have an outside assessment," concludes Howarth. "I think we've just hit the tip of the iceberg."

When this article was first posted, it mentioned "hundreds" of gas leaks in the second paragraph. This has now been changed to "thousands".

Global gas renaissance

The potential dangers of leaking gas are not just a problem for the US. The gas renaissance is going global. But it is anybody's guess how well countries' infrastructure can cope with the increased supply.

In June the International Energy Agency (IAE) predicted global gas demand will rise 55 per cent between 2010 and 2035. Almost half that will be met by "unconventional gas", which was considered too difficult and expensive to extract until recently. Much of the growth will be in Asia.

How secure are countries' distribution systems? Under the UN Framework Convention on Climate Change (UNFCCC), rich nations must disclose all greenhouse gas emissions, including methane leaks. The IEA used this data to look at the leakiness of gas pipes in seven of the world's largest gas producers.

The IEA's figures show that Russia and the US, the two largest gas producers by far, are also the leakiest of the seven. But perhaps the greatest concern is that many countries cannot be assessed, for want of data. The most glaring omission is Iran, the world's third largest producer of gas. China and India are also planning to use much more gas, but they are not UNFCCC signatories so there is no data on their systems. **Michael Marshall**

Robot gets to work sealing pipes

Mapping methane plumes on the streets of Boston and San Francisco paints a picture of "clean" streets with few natural gas leaks, and more common "dirty" streets where methane concentrations can be more than 15 times global background levels. The difference is largely down to pipe work. Cast iron pipes, some more than 100 years old, are the oldest and leakiest pipes under US cities. The pipes were originally sealed with jute, which dries out over time allowing gas to escape.

Now the Cast Iron Joint Sealing Robot or CISBOT, developed by ULC Robotics in Bay Shore, New York, is sealing leaky pipes from the inside. Gas workers inject the bot into active gas pipes and use on-board cameras to guide it to pipe joints. CISBOT then drills into the joint and adds sealant.

A special launch tube keeps air out of the pipeline, so the device can operate without the risk of explosion. CISBOT has repaired more than 3000 pipe joints, including some under New York City, since the device was first used in 2000. It has a range of 50 metres in either direction from the point of injection, reducing the cost of a repair by 30 to 40 per cent.

"Instead of digging up the entire street we can do it in one hole," says **ULC Robotics** president **Gregory Penza**.