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DIRTY AIR

By Mark Jaffe The Denver Post

The shale drilling boom that is sweeping across the country and unlocking vast oil and gas reserves also has unleashed a wave of air pollutants. Scientific studies from research groups around the country are documenting higher emissions of volatile chemicals, including methane and air toxins, than estimated by state and federal regulators.

Scientists have been combing shale regions from Pennsylvania to Texas, Utah and Colorado, measuring leaks from tiny valves and using satellites to assay the air over entire regions.

"There are a whole lot of hydrocarbons coming out of these wells," said Pieter Tans, a senior scientist with the National Oceanographic and Atmospheric Administration in Boulder. "They are contributing to air pollution on the Front Range."

Colorado is on pace to have another record-setting year for oil production based on state data, and as the rigs, tanks and pipelines move closer to homes, concerns over the industry's impacts grow.

In February, Colorado adopted the most comprehensive oil and gas air emission rule in the country and some companies are moving to clamp down on pollution.

Still, the scientific studies are finding oil and gas operations are the source of much larger volumes of pollutants than estimates compiled by state and federal regulators.

For people living near oil and gas operations it is more than a scientific exercise.

Len Toews was working in the front yard of his Fort Lupton home in 2012 when he was overcome by fumes from a K.P. Kauffman Co. oil and gas tank battery across the road.

"I came into the house and told my wife I was feeling strange," Toews said. He ended up in the emergency room at Platte Valley Medical Center with a severe headache and nausea.

In 2013, after inspections prompted by a Toews complaint, state regulators cited the Denver-based Kauffman, for violations — including venting tank fumes for an entire weekend — and levied a \$44,800 fine. The accidental venting was caused by unscheduled pipeline shutdowns that backed up gas, said Kevin Kauffman, chief executive of the company.

Since then, new equipment has been installed to control pressure and emissions.

"We've tried to work with Mr. Toews," Kauffman said. "We are committed to the highest level of public safety."

Toews isn't convinced.

"We don't even open the windows anymore," he said. "We don't think it's safe."

What researchers are finding is that the levels of chemicals such as benzene and toluene, which may pose health risks, can be higher around oil and gas sites than in big cities.

Benzene levels high

A University of Colorado study measured levels of benzene, a known carcinogen, over the Front Range oil fields seven times higher than state estimates.

A study in Utah's Uintah Basin, also by CU scientists, found benzene levels above a long-term exposure health standard in three-quarters of the 329 air measurements made.

These measurements do not translate directly into exposure levels to people, although studies measuring that are now underway by other university research groups, including Colorado State University.

The federal Environmental Protection Agency estimates about 1.8 percent of the methane, a potent greenhouse gas linked to climate change, is escaping from oil and gas sites. Studies in Utah, Colorado, Texas and Pennsylvania indicate the rate may be two to six times higher.

Colorado has adopted the nation's first rule to control oil and gas air emissions, including methane, requiring 95 percent capture.

The rule will cut 92,000 tons of volatile organic chemicals and 65,000 tons of methane a year, according to Will Allison, director of the state's Air Pollution Control Division.

Much of the rule's focus is on tanks, pipelines, compressors and processing plants.

"We are trying to go where the data leads us," Allison said. "Clearly this an industry that is dynamic, where there is change."

The state's biggest operators — including Anadarko Petroleum Corp., Encana Corp. and Noble Energy Inc. — are moving to consolidate operations into larger facilities with more effective air pollution controls.

All three companies supported the new Colorado emission rules.

"We are always looking for ways to reduce our footprint," said Korby Bracken, Anadarko's director of health and environment for the Rockies.

Andarko and the other operators say they are switching to drill rigs powered by compressed natural gas and electricity, compressors powered by electricity instead of diesel, low-emission valves on oil field facilities and cutting truck traffic.

"Going forward, we will continue to look at these and other technologies that help reduce emissions," Encana spokesman Doug Hock said.

Still, the oil field research is showing that the volume of emissions is far greater than the state and federal estimates.

"We are looking at emissions that are significantly larger — perhaps 50 percent larger," than state estimates, said NOAA's Tans.

The state and federal estimates are based on an inventory of company estimates of emissions from their facilities.

"Industry tends to conservatively report emissions," Tans said.

Bottom-up, top-down

Scientists are using two approaches to measure oil and gas field emissions: "bottom-up" and "top-down" studies.

"It is really coming together," said Detlev Helmig, a researcher at the University of Colorado. "It is one of the success stories in atmospheric research."

The bottom-up studies try to measure leaks and releases from wells and equipment, while the top-down studies, using towers, balloons, airplanes and satellites, attempt to measure total emissions.

One of the largest bottom-up studies was done by the University of Texas and the Environmental Defense Fund, a national environmental group.

The researchers measured methane emissions around the country on 190 natural gas sites, 150 production sites, 489 wells and 27 sites where wells were being hydrofractured, or fracked.

Hoods, covers and bags were placed over various pieces of equipment to catch and measure escaping methane.

The study was done with the cooperation of nine major oil companies, including Anadarko and Encana, Colorado's second- and third-largest operators after Noble.

The study multiplied the measurements across all operations and estimated methane-escape rates lower than EPA's inventory — primarily because of lower emissions from fracking operations.

But the escape rates for all the other sources — leaks, valves, pumps — were higher than EPA estimates.

"Bottom-up studies are telling us the sources of some emissions are higher than we thought," said David Allen, the University of Texas professor who led the study.

The study also indicated that a few operations produced a large share of the emissions.

"It is going to be a lot better to go after those facilities than try to change every valve" in an oil field, Allen said.

The findings are beneficial for the companies, Encana's Hock said.

"New data helps us better understand our impacts on air," he said.

CU study uses mobile lab

Another bottom-up study, led by CU researchers, used a mobile laboratory to measure emissions at about 60

sites in Utah's Uintah Basin.

The lab in a van recorded high levels of methanol, benzene and toluene, as well as methane.

In one four-day period, the benzene and toluene levels were more than 3 parts per billion — almost double the average for benzene in urban areas.

The researchers recorded short-term spikes of benzene at 10 parts per billion and toluene, which can irritate the eyes and skin and can affect the nervous system at higher levels, at 40 parts per billion.

Meteorological conditions played a big role in the readings, with higher readings on calm days and lower ones when it was windy.

"What the research is showing is that we need much better monitoring, real-time monitoring, of oil and gas operations," said Robert Jackson, a Stanford University environmental sciences professor.

The top-down studies take atmospheric readings over entire oil fields and try to determine from which sources emissions are coming.

"The top-down studies don't tell you where the emissions are coming from, and there are more sources than just oil and gas," said Anadarko's Bracken.

Also contributing to the Colorado methane levels are beef and dairy operations (cows belch a lot of methane), landfills, manure management facilities and wastewater treatment plants.

Researchers using the top-down method say that bottom-up studies consistently underestimate emissions.

"There is no good way to do a bottom-up study," said CU's Helmig, who has worked on top-down studies in Colorado and Utah. "There are too many variables, too much equipment, too many different operators."

For two days in May 2012, an airplane flew over the Denver-Julesburg Basin, with its 20,000 operating wells, sampling the air.

The CU and NOAA research team, headed by Gabrielle Petron, recorded oil and gas methane emission rates double EPA's estimated emission rate of 1.8 percent.

The Colorado Department of Public Health and Environment calculates that oil and gas operations generate about 13.1 tons an hour of volatile organic emissions. The CU study measured a rate 50 percent higher.

The study also measured benzene in the air at levels seven times higher than CDPHE's estimate of 380 pounds an hour.

A CU airplane study in Utah's Uintah Basin measured methane emissions at rates up to six times the EPA estimate, and a Purdue University study found methane levels in Pennsylvania's Marcellus Shale comparable to those in the Colorado studies.

Using satellite readings, German researchers calculated the methane rates in North Dakota's Bakken formation and Texas' Eagleford Shale at seven times the EPA emission estimate.

In a top-down study using balloons floating 623 feet over the Uintah Basin, CU researchers measured 10 chemicals in the air above the oil and gas fields.

The basin is wrestling with winter ozone levels higher than those in Los Angeles, and the study concluded 99 percent of the ozone-linked chemicals were coming from the oil and gas fields.

The level of those compounds, excluding methane, were higher than in the 28 largest U.S. cities and Mexico City.

"The picture is similar across the country," said CU's Helmig, who headed the Uintah study. "The emissions vary from region to region but not widely."

One finding was that with increasing methane emissions came increasing volumes of air toxins.

While these studies do not measure the exposure to people, efforts to get a handle on that are underway.

Western Slope study

A study being conducted by CSU researchers in cooperation with Garfield County and Western Slope drillers is looking at how toxic air emissions disperse over a half-mile.

"The results could be used for a health study," said Jeff Collette, the CSU researcher heading the project.

The three-year study will be completed in 2015. A similar study is underway on the Front Range.

Colorado's new emission-control regulation depends upon self-reporting and 12 inspectors to cover the state's tens of thousands of wells and oil and gas operations.

Four of the state's inspectors are equipped with infrared cameras, which can see plumes of leaking gas.

Environmental groups question how effective four inspectors can be in a state with 50,000 oil and gas wells and thousands of tank batteries, compressors and plants.

On Sept. 13, Sharon Wilson, an organizer with the environmental group Earthworks, pointed an infrared camera at a Noble Energy well 650 feet from Eric Ewing's home south of La Salle.

Wilson is a trained "optical gas imaging thermographer" for the environmental group.

"People know they are being exposed, and we are trying to document it," Wilson said.

The camera detected wispy emissions from tanks at the site.

The emissions came from an "upset" during the flowback of fracking fluids and was brought under control the evening of Sept. 13, according to a statement from Noble.

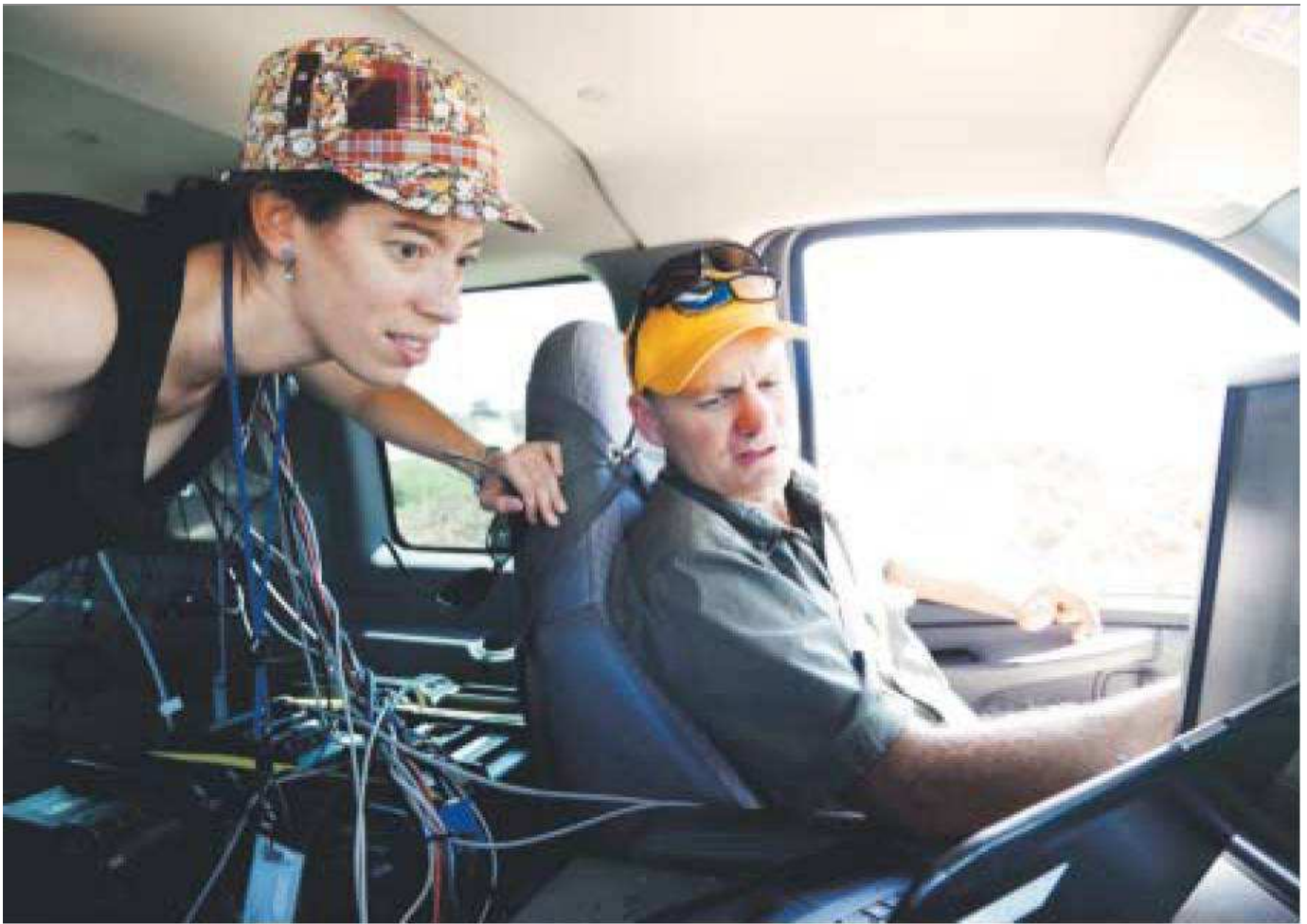
"We get this paint thinner smell from time to time," Ewing said. "Now you can see it.

"I'd like to grab a bag full of that and send it to a lab," he said.

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Ozone measurements are taken in Utah. CIRES/NOAA



University of Colorado researchers Gabrielle Petron and John Kofler track oil field air emissions in Weld County in August using a mobile lab in a van. **University of Colorado**



The red "SkyDoc" balloon has been used for vertical profiling experiments in Alaska, Greenland and Antarctica. It lifts small instruments that provide continuous measurements at various heights.

Institute of **Arctic and Alpine Research**, **University of Colorado**