HEI STATEMENT

Synopsis of Research Report 231

Characterizing Air Pollution, Radiation, and Noise Associated with Unconventional Oil and Natural Gas Development (UOGD)

BACKGROUND

Unconventional oil and natural gas development (UOGD) has been associated with a wide range of potential exposures to air pollutants, greenhouse gases, radioactivity, and noise. The rapid expansion of UOGD activities in recent decades has caused concerns about their potential effects on human health. In August 2020, HEI Energy issued Request for Applications E20-1, the goal of which was to better understand the nature, extent, and frequency of potential exposures related to UOGD on air quality and noise.

This Statement highlights a study led by Dr. Meredith Franklin at the University of Southern California* and colleagues. Franklin and colleagues proposed to address critical research needs by improving the characterization of UOGD-related exposures in oil-producing regions over space and time. They proposed to use stationary, passive, and satellite monitoring along with modeling approaches to estimate potential human health exposures. The main focus of the study was to characterize air pollutants, greenhouse gas emissions, airborne radioactivity, and noise associated with UOGD in two shale production basins, the Permian Basin (eastern New Mexico and western Texas) and Eagle Ford Shale (south central Texas). These two production basins are among the most active drilling and oil production regions in the United States.

What This Study Adds

- Franklin and colleagues measured air pollutants such as ozone and volatile organic compounds; greenhouse gas emissions such as methane, carbon dioxide, and nitrous oxide; airborne radioactivity; and noise associated with UOGD activities in two shale production basins during a yearlong study period.
- Concentrations of most of the air pollutants and noise varied during the day and between seasons, with frequent occurrences of high concentrations (spikes).
- The investigators conducted source apportionment analysis, which allowed them to identify and quantify specific sources of emissions contributing to environmental pollutant data observed at the field laboratory.
- The study showed that UOGD, along with older oil and gas operations, is the dominant source of air pollution in the study area.

APPROACH

To obtain detailed concentration and exposure data, Franklin and colleagues conducted sampling campaigns at a field laboratory and various locations in populated areas close to UOGD activities. At the field laboratory, they used a combination of continuous fixed-site monitoring instruments to identify UOGD processes that resulted in outdoor air pollution, radioactivity, and noise. This laboratory was deployed on an area of active UOGD activity in the Permian Basin and was in operation from May 1, 2023, to May 31, 2024. The investigators measured approximately 30 different components, including 20 volatile organic compounds. They also compared their observations with measurements collected at other UOGD sites and in nearby urban areas.

The investigators recruited local volunteers to deploy passive samplers for approximately 1 year at 12 locations in populated areas in the Permian Basin and Eagle Ford Shale. They coupled the resulting measurements of 15 hydrocarbon concentrations with data on meteorology and well density within about 10 km of the samplers to better understand the factors influencing UOGD-related exposures in the area and to inform future health studies.

This Statement, prepared by HEI Energy, summarizes a research project funded by HEI Energy and conducted by Dr. Meredith Franklin at the University of Southern California* and colleagues. Research Report 231 contains the detailed Investigators' Report and a Commentary on the study prepared by the HEI Energy Review Committee.

*Dr. Franklin is now based at the University of Toronto.

The investigators also conducted source apportionment analysis — which is a statistical technique to identify and quantify the contributions of different sources (e.g., traffic exhaust or industrial emissions) — to observed environmental pollutant data to see how much each source contributed to the observed sample.

A third component of the study focused on flaring, which is the burning of waste gas (mostly methane) from wells. This is a common waste disposal practice associated with oil and gas development, but its effect on air quality is not well characterized. To address this question, the investigators used remote sensing observations of thermal sources to identify gas flaring locations associated with UOGD. They combined these observations with concentration data collected from the stationary and passive sampling of flaring emissions to identify exposures related specifically to flaring.

KEY RESULTS

Franklin and colleagues observed high daily and seasonal variability in the average concentrations of most components measured over the year of sampling. There were frequent occurrences of short-term spikes in concentrations among many of these components. The means and medians during the study period, however, remained below health benchmarks.

The investigators collected over 300,000 1-minute observations of noise levels during the study period. Average noise levels were approximately 60–70 decibels, which is generally comparable to what might be experienced as background noise in a typical office setting.

The radioactivity data, measured as alpha radiation, showed high daily and seasonal variability, with values ranging from below the detection limit up to 173 Becquerel m^3 for gas-phased radioactivity and up to 99 Becquerel m^3 for particle-associated radioactivity. For reference, and in the absence of a health-based benchmark for radon in outdoor air, the EPA estimates that the average concentration of indoor radon among homes in the United States is about 50 Becquerel/$m^{3,}$ and they recommend that action be taken to mitigate concentrations in homes greater than 150 Becquerel/m^3.

Many of the components measured at the field laboratory were significantly correlated with each other, which suggested that nearly all the components measured were emitted from similar or co-located sources.

Measurement of hydrocarbons in populated areas close to UOGD activity indicated that concentrations of n-hexane and 2-methylpentane were the highest and most variable, whereas concentrations of ethylbenzene and the xylenes were the lowest. The concentrations of most hydrocarbons were strongly correlated with each other. The highest average concentrations were found at sites with higher numbers of wells in the surrounding area. For example, concentrations of benzene were highly correlated (r = 0.87) with the number of wells within 10 km of the samplers.

In the source apportionment analysis, the investigators identified five factors representing various sources of UOGD emissions. These factors together explained about 95% of the overall variance in the data: oil and gas fugitive emissions and venting (45%); handling, storage, and evaporation from produced water ponds (39%); traffic emissions (10%); flaring (9%); and widespread combustion and radon emissions (4%) (**Statement Figure**). Note that the sum of factor-specific variance explained values can exceed 100% due to shared explanatory power between factors.

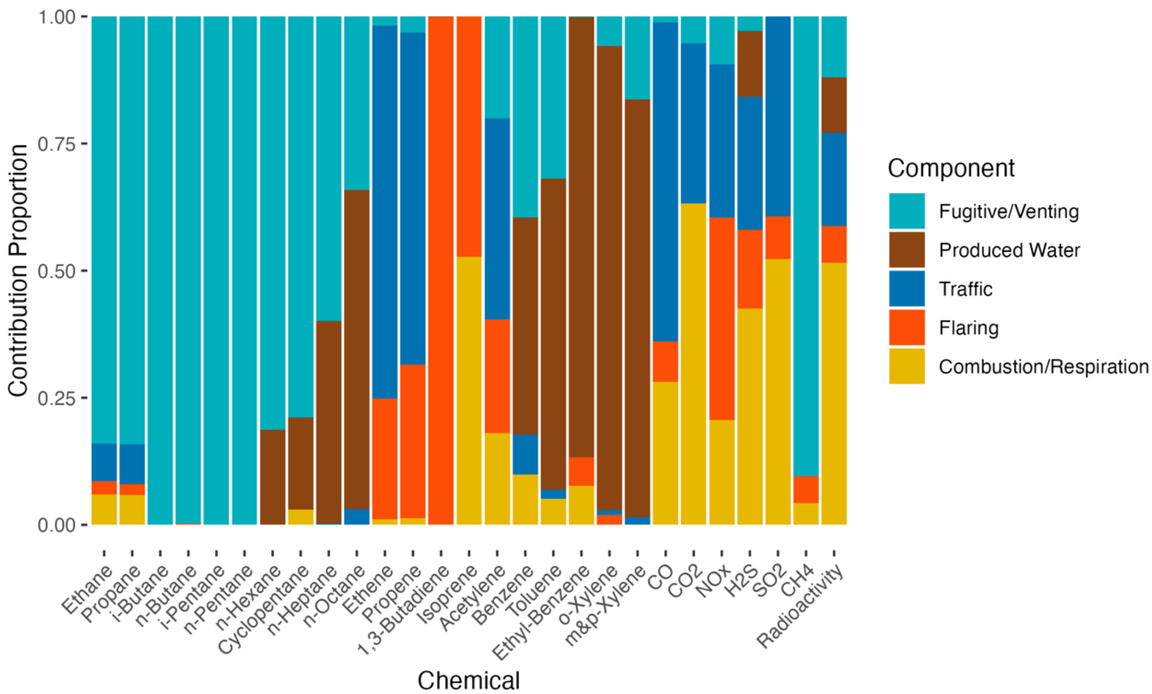
Franklin and colleagues detected a total of 71,401 gas flares during the study period and collected detailed information on temperature, source area, and radiant heat for each flare. They found that nightly average concentrations of several volatile organic compounds (benzene, ethane, and ethene), methane, carbon monoxide, carbon dioxide, nitrogen oxides, and total radioactivity were correlated with the number of flares and with the estimated flared gas volume within 50 km of the field laboratory.

INTERPRETATION AND CONCLUSIONS

In its independent evaluation of the report, the HEI Energy Review Committee identified several strengths of the study design. One strength was the use of multiple measurement methods, such as stationary, passive, and satellite monitoring. Others were the long, continuous sampling period of over 1 year and the use of creative and novel exposure modeling approaches. Committee members were impressed with the large number of components the investigators measured, including several criteria air pollutants and many volatile organic compounds, along with detailed measurements of weather and noise, using a wide variety of different instruments.

The Committee also appreciated the comparisons of samples collected at the study sites with those collected at locations in other UOGD regions and with urban air quality stations. An additional strength of the study was the involvement of volunteers from the local communities to support the collection of samples.

The Committee thought the detailed analysis of flaring events was an important contribution. They also liked the analyses that linked well pad locations and their levels of activity with the measured concentrations of air pollutants and noise. This approach was effective for linking these components directly to the UOGD activities.



Statement Figure. Contribution proportions of each compound to the five factors identified through the source apportionment analysis. Source: Investigators' Report, Figure 32.

In summary, this study contributed to knowledge about potential exposures to a variety of emissions from UOGD activities at local and regional scales. It showed that UOGD, along with older oil and gas operations, are the dominant source of air pollution in this study area. The Committee agreed with the findings and conclusions, which should be of value to industry, local landowners, and community members, and to potential policymakers.