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Testimony on: *"Federal Regulation: Economic, job, and energy security implications of federal hydraulic fracturing regulation"*

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Mr. Chairman and Members of the subcommittee, I am honored to be asked to testify before you today on the potential health risks from natural gas development air emissions.

I am Lisa McKenzie, a Research Associate in the Department of Environmental and Occupational Health at the Colorado School of Public Health. In addition to my PhD in Environmental Chemistry and MPH in Epidemiology, I have many years of experience in the private sector as a human health risk assessor and chemist. I am the lead author of the paper "Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources" recently published in Science of the Total Environment, an international journal for scientific research. Like all papers published in reputable scientific journals, our paper underwent a rigorous peer review process prior to publication. Today, I will be testifying on the findings and recommendations presented in our paper.

Potential for health risks

With the recent expansion of natural gas development, it is becoming increasingly common for natural gas development to occur near where people live, work, and play. The Colorado Oil and Gas Conservation Commission's review of 4956 well locations revealed that 26% of the well locations reviewed are located 150 to 1000 feet from a building intended for human occupancy, including homes, out buildings, businesses, residential living facilities, schools, and hospitals. This illustrates the potential to expose people to various stressors resulting from natural gas development. One potential stressor is exposure to air pollutants.

As shown by ambient air studies in Colorado, Texas, and Wyoming, natural gas development processes can result in direct and fugitive air emissions of a complex mixture of petroleum hydrocarbons and other pollutants. The natural gas resource itself contains petroleum hydrocarbons, including alkanes, benzene, and other aromatic hydrocarbons. Petroleum hydrocarbons and other pollutants also may originate from diesel engines, tanks containing produced water, and on site materials used in production, such as drilling muds and fracking fluids. This complex mixture of chemicals can result in the formation of secondary air pollutants, such as ozone. The public health concern is the transport of these air pollutants to nearby residences and population centers.

Multiple studies on inhalation exposure to petroleum hydrocarbons in occupational settings as well as homes near refineries, oil spills and gas stations, indicate an increased risk of eye irritation and headaches, asthma symptoms, leukemia, and myeloma. Many of the petroleum hydrocarbons, such as benzene, observed in these studies are the same as those that have been

observed in and around natural gas development sites. Previous risk assessments and health consultations performed by the Colorado Department of Public Health and Environment, the ATSDR, and scientists at the Saccomanno Institute concluded that ambient benzene levels observed in the natural gas development area of Garfield County, Colorado demonstrate an increased potential risk of developing cancer as well as chronic and acute non-cancer health effects.

Health effects associated with benzene include leukemia, anemia, and other blood disorders and immunological effects. In addition, a recent study in Texas has observed a link between maternal exposure to ambient levels of benzene and an increase in prevalence of neural tube birth defects. Inhalation of trimethylbenzenes and xylenes can irritate the respiratory system and mucous membranes with effects ranging from eye, nose, and throat irritation to difficulty in breathing and impaired lung function. Inhalation of trimethylbenzenes, xylenes, benzene, and alkanes can adversely affect the nervous system with effects ranging from dizziness, headaches, fatigue at lower exposures to numbness in the limbs, incoordination, tremors, temporary limb paralysis, and unconsciousness at higher exposures. Subchronic health effects, such as headaches and throat and eye irritation reported by residents during well completion activities occurring in Garfield County, are consistent with some of these health effects.

In the 2007 Garfield County emission inventory, the Colorado Department of Public Health and Environment attributed the bulk of benzene, xylene, toluene, and ethylbenzene emissions in the county to natural gas development. Natural gas development point and non-point sources contributed five times more benzene than any other emission source, including on-road vehicles, wildfires, and wood burning.

How the health risk assessment was conducted

Previous assessments were limited in that they did not distinguish between risks from ambient air pollution and well completions or risks between people living near wells and people living farther from wells. My colleagues at the Colorado School of Public Health and I addressed these limitations by conducting a screening level human health risk assessment according to EPA's well established guidance for screening level risk assessments. This guidance has been in place since 1989, with some amendments and revisions over the years. It has been the go to guidance for risk assessors over the past four administrations.

We performed our risk assessment for Battlement Mesa, a community of approximately 5,000 people located in rural Garfield County, Colorado where a natural gas operator has proposed developing 200 gas wells on 9 well pads located as close as 500 feet from town residences. We used petroleum hydrocarbon data from samples collected by Garfield County's Department of Public Health and the natural gas operator to estimate and compare chronic and subchronic non-cancer hazard indices and cancer risks from natural gas air emissions for two residential populations: (1) people living near the well pads and (2) people living farther from well pads. We defined a distance of ≤ ½ mile from wells as living near wells, based odor complaints filed by residents living ½ mile from a well pad in the summer of 2010.

We used 163 samples collected by the Garfield County Department of Public Health every six days between January 2008 and November 2010 and analyzed for hydrocarbons to estimate health risks for people living further from the well pads. These samples were collected from a fixed monitoring station located in the midst of rural home sites and ranches and natural gas development. The site is located on top of a small hill and 4 miles upwind of other potential emission sources, such as Interstate-70 and the town of Silt, Colorado.

We used 24 ambient air samples collected at each cardinal direction along five well pad perimeters in rural Garfield County during well completion activities conducted by four different companies in summer 2008 and summer 2010 to estimate subchronic health risks to nearby residents during well completions. These samples also were analyzed for hydrocarbons. These samples were collected at distances ranging from 130 to 500 feet from the well pad center during uncontrolled flowback of one to three natural gas wells into tanks vented directly to the air. All five well pads are located in areas with active gas production, approximately one mile from Interstate-70. Residents approximately ½ mile of the well pad where the 2010 samples were collected filed odor complaints with the Colorado Oil and Gas Conservation Commission at the time of well completions.

We calculated a time-weighted average using the 163 samples collected at the fixed monitoring station and the 24 samples collected at well pad perimeters to calculate the chronic health risks for people living near well pads.

For the exposure scenarios we assumed a 30-year project duration based on an estimated 5-year well development period for all well pads, followed by 20 to 30 years of production. We assumed a resident lives, works, and otherwise remains within the town 24 hours/day, 350 days/year and that the lifetime of a resident is 70 years, based on standard EPA reasonable maximum exposure defaults. To evaluate subchronic health risks from well completion emissions, we estimated that a resident may live $\leq$ ½ mile from 2 well pads resulting a 20 month exposure duration based on 2 weeks per well for completion and 20 wells per pad, assuming some overlap between activities.

Health Risk Assessment Findings

Our screening health risk assessment resulted in three major findings.

(1) Noncancer health risks

Our results show that the non-cancer hazard index from air emissions due to natural gas development is greatest for residents living near wells during the relatively short-term, but high emission, well completion period. Furthermore, this hazard index is driven principally by exposure to trimethylbenzenes, alkanes, and xylenes, all of which have neurological and/or respiratory effects.

The total subchronic hazard indices were 5 for residents near wells and 0.2 for residents farther from wells. The total chronic hazard indices were 1 for residents near wells and 0.4 for residents farther wells. Hazard indices are a qualitative tool used to compare health hazards. A hazard

index below one indicates that health effects are unlikely. A hazard index of one and above indicates that health effects may occur as a result of exposure. The chronic hazard index of 1 and the subchronic index of 5 indicate a potential for adverse health effects to residents living near wells pads.

(2) Cancer health risks

We estimated higher cancer risks for residents living nearer to wells as compared to residents residing further from wells. Benzene is the major contributor to lifetime excess cancer risk for both scenarios.

The excess lifetime cancer risk estimates were 10 in a million for residents near wells and 6 in a million for residents farther from wells. The level of cancer risk that is of concern is a matter of individual, community, and regulatory judgment. However, the EPA typically considers risks below 1 in a million to be so small as to be negligible. Therefore, the EPA uses a cancer risk of 1 in a million as a regulatory goal. Regulatory programs, such as the Superfund program, are generally designed to try to reduce risk to this level. When it is not feasible to meet this regulatory goal, the EPA may consider cancer risks lower than 100 in a million to be acceptable.

(3) Samples collected during well completions compared to samples collected at fixed monitoring location

There is clearly a high potential for exposure to air emissions during the well completion period of natural gas development. Concentrations of petroleum hydrocarbons, including benzene, trimethylbenzenes, most alkanes, and xylenes, were significantly higher in the samples collected from the perimeter of the well pads during the well completions than in the samples collected from the fixed monitoring station. Two thirds more hydrocarbons were detected at a frequency of 100 percent in the samples collected during well completions (38 hydrocarbons) than in the samples collected from the fixed monitoring station (23 hydrocarbons). The highest alkane and aromatic hydrocarbon median concentrations were observed in the samples collected during well completions. Median concentrations of benzene, ethylbenzene, toluene, and m-xylene/p-xylene were 2.7, 4.5, 4.3, and 9 times higher in the well completion samples than in the samples collected at the fixed monitoring location, respectively.

Recommendations

Based on our findings, we recommend that air emissions from natural gas development be reduced, particularly during the high emission well completion period, in order to lessen potential health risks for people living near well sites and to improve overall ambient air quality in natural gas development areas. EPA's new rules (4/17/2012) for Source Performance Standards and National Emissions Standards for Hazardous Air Pollutants directed at reducing air pollution for the Oil and Natural Gas Industry have the potential to reduce emissions of air toxics, such as benzene, during well completions.

We recommend further studies to: (1) reduce the uncertainties in the health effects of exposures to natural gas air emissions, (2) to better direct efforts to prevent exposures, and (3) to determine

the effectiveness of new rules and regulations in protecting public health. Next steps should include the modeling of short- and longer-term exposures as well as collection of area, residential, and personal exposure data, particularly for peak short-term emissions. Furthermore, studies should examine the toxicity of hydrocarbons, such as alkanes, including health effects of mixtures of hazardous air pollutants and other air pollutants associated with natural gas development. Emissions from specific emission sources should be characterized and include development of dispersion profiles of hazardous air pollutants. This emissions data, when coupled with information on local meteorological conditions and topography, can help provide guidance on minimum distances needed to protect occupant health in nearby homes, schools, and businesses. Studies that incorporate all relevant pathways and exposure scenarios, including occupational exposures, are needed to better understand the impacts of natural gas development of unconventional resources, such as tight sands and shale, on public health. Prospective medical monitoring and surveillance for potential air pollution-related health effects is needed for populations living in areas near the development of unconventional natural gas resources.

Limitations of Health Risk Assessment

As with all risk assessments, scientific limitations may lead to an over- or underestimation of the actual risks. EPA's methodology is designed to overestimate health risks. However, several factors may have lead to an underestimation of risk in our study results. We were not able to completely characterize exposures because several criteria of hazardous air pollutants directly associated with the natural gas development process via emissions from wells or equipment used to develop wells, including formaldehyde, acetaldehyde, crotonaldehyde, naphthalene, particulate matter, and polycyclic aromatic hydrocarbons, were not measured. No toxicity values appropriate for quantitative risk assessment were available for assessing the risk to several alkenes and low molecular weight alkanes (particularly < C_5 aliphatic hydrocarbons). We did not consider health effects from acute (i.e., less than one hour) exposures to peak hydrocarbon emissions because there were not appropriate measurements. We did not include ozone or other potentially relevant exposure pathways such as ingestion of water and inhalation of dust in this risk assessment because of a lack of available data. Elevated concentrations of ozone precursors (specifically, volatile organic compounds and nitrogen oxides) have been observed in Garfield County's natural gas development area and the 8-hr average ozone concentration has periodically approached the 75 ppb National Ambient Air Quality Standard.

This risk assessment also was limited by the spatial and temporal scope of available monitoring data. For the estimated chronic exposure, we used 3 years of monitoring data to estimate exposures over a 30 year exposure period and a relatively small database of 24 samples collected at varying distances up to 500 feet from a well head (which also were used to the estimate shorter-term non-cancer hazard index). Our estimated 20-month subchronic exposure was limited to samples collected in the summer, which may have not have captured temporal variation in well completion emissions. Our ½ mile cut point for defining the two different exposed populations in our exposure scenarios was based on complaint reports from residents living within ½ mile of existing natural gas development sites, which were the only data available. The actual distance at which residents may experience exposures from air emissions may be less than or greater than a ½ mile, depending on dispersion and local topography and

meteorology. This lack of spatially and temporally appropriate data increases the uncertainty associated with the results.

Lastly, this risk assessment was limited in that appropriate data were not available for apportionment to specific sources within natural gas development (e.g diesel emissions, the natural gas resource itself, emissions from tanks, etc.). This increases the uncertainty in the potential effectiveness of risk mitigation options.

These limitations and uncertainties in our risk assessment highlight the preliminary nature of our results. However, there is more certainty in the comparison of the risks between the populations and in the comparison of subchronic to chronic exposures because the limitations and uncertainties similarly affected the risk estimates.

The results presented here today indicate that health effects resulting from air emissions during development of unconventional natural gas resources are most likely to occur in residents living nearest to the well pads during the short term well completion period and warrant further study. Risk prevention efforts should be directed towards reducing air emission exposures for persons living and working near wells during well completions.

Thank you again for giving me the opportunity to appear here today.

Respectfully Submitted,

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