The Environmental and Occupational Health Impacts of Unconventional Oil and Gas Industry

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Abstract
The process of extracting oil and gas by unconventional methods from underground formations involves injecting high volumes of fresh water, chemicals, and proppants at high pressure into deep geological formations as a means of enhancing the extraction of hydrocarbons. This technique has vastly increased the potential for domestic oil and gas production and has been promoted as a way to decrease dependence on foreign energy sources, replace dirtier energy sources such as coal, and generate new jobs and economic development. At the same time, unconventional oil and gas (UOG) poses various known and unknown risks to public health and the environment, including water quality and quantity concerns, worker health and safety issues, air quality problems and methane leaks, health effect concerns (including those for vulnerable populations), physical hazards, community-level impacts, and climate change effects. This policy statement is intended to cover the risks associated with the entire UOG process, including site preparation, drilling and casing, well completion, production, transportation, storage and disposal of wastewater and chemicals, and site remediation. In lieu of a strategic, national transition away from UOG—and other fossil fuel—development, policies that anticipate public health threats, require greater transparency, involve a precautionary approach, require comprehensive environmental impact assessments, and provide for monitoring and adaptation as understanding of risks increases are suggested to prevent or mitigate the negative occupational and public health impacts of UOG development.

Relationship to Existing Policy Statements
This statement is related to APHA Policy Statements 7845(PP) (The Public Health Impact of Energy Policy), 20046 (Affirming the Necessity of a Secure, Sustainable and Health Protective Energy Policy), and 20157 (Public Health Opportunities to Address the Health Effects of Climate Change) but delves more deeply into health concerns related to the unconventional oil and gas (UOG) industry (as opposed to energy more broadly), including concerns related to this industry's specific contributions to climate change. This policy statement is intended to supplement these statements.

Problem Statement

A push for energy independence and innovations in extractive technologies have led to the development of UOG reserves that were previously inaccessible. During the recent expansion of this fossil fuel resource, UOG development—encompassing well site preparation and components; drilling and casing of wells; hydraulic fracturing (colloquially known as "fracking"); well completion; hydrocarbon production and distribution by way of pipelines and other methods; supplies and personnel transportation; storage and disposal of wastewater, products, and chemicals; and site remediation—has simultaneously brought about both the promise of an affordable domestic fuel source and various environmental and occupational risks for public health. This policy statement reviews the evidence on environmental and public health impacts from UOG development related to water quality and quantity, worker health and safety, air quality and methane leaks, health effects, physical hazards, community-level impacts, climate change, and vulnerable populations. While traditional offshore oil and gas drilling introduces a variety of known and unknown public health risks, as evidenced by the 2010 BP Deepwater Horizon oil spill,[1] this statement does not address the myriad concerns associated with offshore drilling; it does, however, recommend that an APHA offshore drilling policy statement be developed. Also, this statement does not cover how UOG development is intricately linked to the expansive plastics industry, which involves its own environmental and public health issues.

Water quality and quantity: UOG development's impacts on water quantity and quality have been some of the most highly publicized environmental effects with potential health consequences from this industry. In terms of water quantity, UOG wells used a median of 1.5 million gallons of water per well between 2011 and 2013.[2] Estimates vary significantly based on region and formation, however, from 2–13 million gallons per unconventional well according to a study published in 2014.[3] These figures are likely climbing as laterals become longer and formations are depleted.[4] In fact, a recently published study showed that UOG operations used 770% more water per well in 2016 than in 2011 across all U.S. major gas- and oil-producing regions, which means that the amount of wastewater returning to the surface is also increasing exponentially.[5] It should be noted that these

numbers often represent consumptive water loss; most of this water is not returned to the water cycle. As a result, in areas with limited water resources such as California and Texas, UOG's expenditure of groundwater and surface water is a serious public health concern and social justice issue.[6]

Additional concerns related to UOG's effect on water focus on the potential for UOG to impact water quality. In some cases, research suggests that drilling activity can cause methane to seep into drinking water supplies.[2] For example, one study indicates that drinking water wells within a 1-km radius of a drilling site have 17 times higher concentrations of methane than wells outside of this radius.[7] The chemicals and proppants added to the freshwater used in UOG drilling have also raised public health concerns related to surface water and groundwater quality[8] as well as soil contamination. While chemical additives used in hydraulic fracturing fluids typically make up less than 2% by weight of the total fluid, this may amount to hundreds of thousands of gallons of chemical additives over the life of a well depending on injection volumes. More than 1,000 different chemicals have been identified in UOG fluids and wastewater, including proppants, biocides, surfactants, viscosity modifiers, and emulsifiers.[9] These chemicals vary in toxicity, with many lacking basic toxicity data. Some are believed to be safe, while others are known or suspected carcinogens, endocrine disruptors, or additives otherwise toxic to humans, including silica, benzene, lead, ethylene glycol, methanol, boric acid, and gamma-emitting isotopes.[10] Often, the precise identity, quantity, and mixture of the fluids used to fracture each well are not disclosed. From a public health perspective, this lack of information and transparency prevents establishing baseline levels of a substance in the environment prior to hydraulic fracturing and documenting changes that occur as a result of UOG activity. Without these details, it is difficult to assess the safety of these chemicals, both individually and how they interact, and therefore public health professionals and regulators cannot fully apprise UOG workers or the public of potential health hazards from exposures.

How wastewater is handled and treated is another concern related to water quality, as well as public safety. About 30% of the fluids used in drilling return to the surface depending on the formation; this "flowback" water (containing the chemicals of concern sent down the well) is followed by "produced water" (i.e., water that is extracted along with oil and/or gas from the formation at depth during production), which contains toxic heavy metals, salts, and naturally occurring radioactive material.[3] Open-air wastewater impoundments (e.g., "lagoons," "sumps," or "evaporation ponds") pose a risk of inhaling these radionuclides,[11] along with groundwater contamination via seepage if the pit's lining is damaged or not installed.[12] Treatment and/or disposal of wastewater has the potential to affect the quality of lakes, rivers, and streams; damage public water supplies; and overwhelm public wastewater treatment plants. Underground injection has traditionally been the primary disposal option for liquid waste, but these fluids have also been treated in self-contained wastewater treatment systems at well sites or through local municipal wastewater treatment plants and commercial treatment facilities.[13] In addition, concerns have been raised about the potential risks associated with using wastewater for de-icing roads[14] as well as contamination threats related to UOG solid waste in landfills and on site.[15–17] The potential for UOG activity to cause human health impacts has been of large concern, but chemicals threaten health only when humans are exposed to them. To obtain a better understanding of human exposure and UOG-related water contamination, in 2016 the U.S. Environmental Protection Agency (EPA) published an extensive review of UOG development's threat to drinking water.[2] This report concluded that, despite data gaps, there is sufficient evidence that UOG activities are impacting drinking water in certain situations as a result of (1) water withdrawals being made in times or areas of low water availability, (2) spilling of large volumes or high concentrations of chemicals from produced water and other fluids, (3) hydraulic fracturing fluids being injected into wells with inadequate mechanical integrity as well as directly into groundwater, (4) hydraulic fracturing wastewater being inadequately treated and discharged into surface water, and (5) hydraulic fracturing wastewater being disposed of or stored in unlined pits and leaching into groundwater.

Worker health and safety: Working on site in the oil and gas extraction industry is inherently dangerous, with a fatality rate of 15.6 per 100,000 workers (four times higher than the overall rate among U.S. workers).[18] The occupational health and safety implications of UOG, therefore, are a topic of significant public health importance,[19] especially considering that oil and gas extraction activities are exempt from a number of Occupational Safety and Health Administration (OSHA) regulations and OSHA's Process Safety Management standard.[20]

Beyond physical hazards, such as falls, published studies conducted at UOG sites have reported high concentrations of and increased exposures to airborne toxic chemicals that often exceed existing health standards or acceptable risk levels.[21,22] These exposures include respirable silica, nitrogen oxides, sulfur dioxide, particulate matter, formaldehyde, heavy metals, carbon monoxide, volatile organic compounds (e.g., benzene, trimethyl benzene, xylenes, aliphatic hydrocarbons, and polycyclic aromatic hydrocarbons), ozone, and methane. Hydrogen sulfide exposure is also a known—and sometimes deadly—occupational hazard among oil and gas workers, including those in the UOG industry.[23] Inhalation of silica sand is of particular concern for UOG workers, especially those without full respirator protection when working with the sand. Transporting, moving, and filling tons of sand onto and through sand movers, along transfer belts, and into blenders, as well as using the sand as a proppant during hydraulic fracturing, generates dust containing respirable crystalline silica; inhaling this dust can cause silicosis and even cancer.[21,22] While not extensively covered in this policy statement, mining of the sand for hydraulic

fracturing also poses risks, including air quality degradation, land-use change, and water contamination concerns, and should be researched and addressed further. There are also unique occupational health concerns associated with the potential for exposure to the chemical constituents of hydraulic fracturing fluids as well as hydrocarbon gases and vapors.[21] For example, exposures to hydrocarbon gases and vapors and/or oxygen-deficient atmospheres during manual gauging or sampling of production tanks are believed to be primary or contributory factors in nine workers' deaths in recent years.[24]

As a result of the aforementioned nondisclosures of the precise compositions and toxicity of chemicals in hydraulic fracturing activities, uncertainty remains regarding full exposures and long-term health impacts on workers and emergency responders to incidents at UOG sites.

Air quality and methane leaks: Air pollutants reported during various phases of UOG operations, including carbon dioxide, methane, other hydrocarbons, particulate matter, ozone, nitrogen oxides, hydrogen sulfide, sulfur dioxide, and silica, are of public health concern.[17] UOG development has significant potential to impact local and regional air quality throughout its life cycle. In addition, UOG operations are "spatially intense," in that wells are drilled in a concentrated area and include the use of generators, trucks, and other equipment that create an industrialized effect near well sites, leading to localized air pollution. Air pollution can be related to activity type, wind speed and direction, and cloud cover. Several studies, including those cited here, have documented higher than average levels of benzene and volatile organic compounds associated with UOG production near development areas, leading to elevated levels of ambient ozone[25,26] as well as a greater risk of respiratory, neurological, and hematological health impacts, such as cancer among residents living less than half a mile from UOG wells.[27] While there is a need for more studies measuring direct exposures from UOG air pollution across the production process, asthma patients in one case-control study were noted to have more frequent exacerbations related to proximity to well sites.[28] Volatizing compounds from open-air impoundments, including sludge that has dried, present air quality concerns.[12] Elevations in particulate matter and volatile organic compounds have also been noted near compressor and processing stations. Emissions from processing stations were shown to be significantly higher than those from well sites, and the peaks were found to be of serious concern.[29]

Development of UOG resources has increasingly become an important contributor to fugitive emissions and releases of methane, carbon dioxide, and other greenhouse gases known to exacerbate global warming (as discussed in further detail below). In addition, flaring of natural gas during UOG activities potentially releases radioactive particles and other toxic chemicals that diminish local air quality and invariably contribute to public health problems.[30] In 2012, the EPA estimated that the 60,801 natural gas wells alone in the United States emit 273.6 gigagrams of methane per year, although methane data from across North America suggest that this figure may be underestimated.[31] When underground natural gas storage well leaks and failures are factored in, such as the major Aliso Canyon leak in California in 2015–2016,[32,33] the issue of methane leakage into the atmosphere grows exponentially.

Health studies: Approximately 17.6 million people in the United States live within about a mile of at least one active oil and/or gas well.[34] A 2015 review of the human health literature suggested that early studies linking UOG to adverse health outcomes were not sufficiently rigorous while at the same time pointing out that the literature did not rule out health effects.[35] As of February 2018, however, more than a dozen original epidemiological studies on the impacts of UOG had been published in the scientific literature, mostly involving populations in Pennsylvania, Colorado, and Texas. Overall, symptoms of exposure to UOG pollutants include dermal and respiratory symptoms[36] as well as chronic rhinosinusitis, migraine, and fatigue.[37] Several recent studies have identified links between UOG development and various pregnancy and birth outcomes, including but not limited to the investigations cited here.[38–41] Asthma exacerbation is also of concern.[28] Another study indicated that maternal proximity to oil and gas wells was associated with 30% increased odds of congenital heart defects; also, there was a significant small-magnitude negative association with preterm births along with a positive association with neural tube defects. This study, however, did not distinguish between conventional and UOG wells.[42]

Additional studies have revealed correlations between UOG development and health outcomes, but their designs were more exploratory or hypothesis generating in nature. For example, ecological studies have shown that cardiology inpatient rates are associated with the number of UOG wells per zip code area and per square kilometer, that neurology inpatient rates are associated with the number of UOG wells per square kilometer, and that vehicle crash rates are elevated in counties with increased levels of drilling.[43,44] Additional evidence from self-reports indicates correlations between UOG development and stress effects, although pathways are not clear at present.[45,46]

Also, a number of studies have examined the potential for human health implications using animal models, with the bulk of these investigations focusing on the possibility of endocrine disruption. Using environmentally relevant doses of 23 commonly used UOG chemicals, for example, one group of researchers exposed mice prenatally and found postpubertal changes in the breast tissue of the exposed mice, considered a marker for breast cancer risk.[47] Other studies on prenatal exposures in mice to common UOG chemicals have revealed impacts with respect to pituitary gland functioning, altered size of uterus and ovaries, increased body weight, decreased sperm counts, and disrupted receptors to hormones such

as estrogen and testosterone.[48] As a result of limited space, not all recent health effect studies could be included in this section; additional UOG studies can be found in the PSE Healthy Energy Study Citation Database[49] and the TEDX FrackHealth Database.[50]

Physical hazards: UOG development is an intensive industrial process producing significant amounts of noise and light pollution, as well as noxious odors, raising health concerns for residents.[51] These physical hazards can be a significant source of stress, contributing to human illness among nearby community members. Light pollution and noise pollution have been linked to a variety of health concerns, including disruptions in circadian rhythms, mental health effects, and cardiovascular harm.[52]

Additional physical hazards have been linked to UOG development due to the geology in which the drilling is occurring. There has been an increase in seismicity in several states where UOG development is active, including Texas, Ohio, and Oklahoma; this issue has been linked to both UOG production and deep well injection of wastewater.[53–55] Not only can severe earthquakes cause injuries, but they may also affect health through stress pathways and anxiety.[56] The formations that are being targeted for UOG extraction include radioactive elements, and while these compounds are naturally occurring and harmless at this depth in the earth, they can pose a hazard to humans after returning to the surface as tailings and flowback fluids.[57]

Community-level impacts: There are a variety of both opportunities and concerns within UOG communities. Some residents acknowledge the economic opportunity of higher-paying jobs and increased utilization of community businesses such as hotels, restaurants, auto repair companies, and health services.[58] However, these economic benefits have come with community burdens such as rising housing costs, forcing low-income residents into unstable housing, and increased use of human services without increased funding to support growing and changing demographics. Evidence from Texas, for example, suggests that oil and gas wastewater disposal wells were disproportionately sited in communities of color and lower socioeconomic status.[59] A Pennsylvania study showed that residents who live in census tracts potentially placing them at risk of being exposed to UOG well pollution are significantly less wealthy than residents of other areas in the state.[60] Such inequities put nearby residents at higher risk of health problems and may increase their health care costs disproportionately. In addition, obtaining private drinking water tests is expensive. If drilling companies are not required to pay for and/or conduct these water quality tests, the results may be incomplete (e.g., failing to cover water quality constituents directly related to oil and gas development) and may add an undue economic burden to residents who live near drilling activity.

In several focus groups and interviews, residents have noted the stress that UOG activity has created in their communities, including concerns about air and water quality, mistrust of the oil and gas industry, and changing community dynamics related to industrial development close to their homes.[58,61,62] In West Virginia, the complex interactions among these changing dynamics, a shifting sense of place, and noticeable impacts such as increased truck traffic have been shown toplay a crucial role in reported stress and perceptions of environmental health risks.[63] Rising rent costs and increases in substance abuse, motor vehicle crashes, and sexually transmitted diseases, each of which can impact stress, have been reported in UOG development communities as well.[64,65] Residents have also reported disruptions in sleep from constant noise and acute respiratory symptoms from chemical odors[62,66], and risk of depression has been shown to increase with a person's increasing proximity to a drilling site.[67] These problems are not limited to well sites; residents living near compressor stations, pipelines, and associated infrastructure are also at risk of leaks, poor air quality, and emergencies. First responders do not always have adequate training to address UOG emergencies in residential communities, and they are often inhibited by a lack of full disclosure of proprietary chemicals used in UOG processes.[68]

Overall, community-wide industrialization related to UOG development has led to individual- and community-level disruptions and anxiety. Residents have reported a loss of tight-knit rural communities and sense of place.[61,69] The combination of these issues has resulted in community members feeling powerless over changing demographics, disruptions, and limited regulatory support within their communities.[69]

Decisions and regulatory frameworks regarding new energy infrastructure, including UOG development, are of significant local, regional, and national importance. In the United States, several federal, state, and local regulations govern UOG extraction and development, but this complex web of rules has either challenging or no clearly outlined processes for public participation. It is noteworthy that community concerns with respect to UOG processes have raised ethical issues of public health importance regarding the need for policy developers involved with risk assessments to set levels of acceptable risks to protect citizens. In addition, ethical questions have emerged regarding appropriate governance systems to manage the risks of UOG development, as well as the need for adequate representation of communities to engage and participate in such systems.[70] To ensure future development of UOG resources, which are nonrenewable, safe production technologies should be applied, and the process should be viewed with a sustainable lens that protects public health and ultimately respects the integrity of the environment.[71] Such an approach will involve integration of the concept of social justice, which stipulates fair treatment, meaningful involvement, and equal economic, political, and social rights for all human beings, as well as their right to benefit from a safe and pleasant environment where they live, learn, and work.

Cotton and Chanry-Parry note that UOG health impacts have been well documented, and they suggest closing the existing knowledge gap among environmental health professionals through ethnographic and longitudinal research into the influence of UOG development on the behaviors and social practices of local residents and the best ways to communicate public and environmental health messages to diverse communities.[72]

Climate change: As the implications of accelerating climate change are becoming more apparent and urgent to address, the transition away from traditional fossil fuels to low-carbon energy choices becomes a necessary action.[73] While carbon dioxide is currently the most abundant and longest-lasting greenhouse gas in the atmosphere, methane emissions pose significant harms to our climate. Methane, a relatively short-lived greenhouse gas, is 84 times more potent than carbon dioxide over a 20-year time frame.[74] During both typical and abnormal (e.g., blowouts) UOG processes, methane is released into the atmosphere.[75,76] Yet, UOG development has been mistakenly promoted as a transition from fossil fuel–intensive forms of energy such as coal to cleaner and renewable energy sources[77] without a full understanding of its impacts on climate disruption. The problem is exacerbated by public misunderstanding and lack of knowledge about the climate-disrupting effects of methane. Promotion of UOG development has also reduced allocation of resources and delayed the transition to and use of real sustainable and clean energy sources such as wind, solar, geothermal, and wave.[78] Thus, to prevent worsening climate change and to truly transition to a clean energy economy, reducing or eliminating methane emissions from oil and natural gas infrastructure will be essential.

In addition, in certain areas oil and gas infrastructure and operations are more vulnerable to threats made worse by climate change. In a technical assessment of California's existing and operating natural gas underground facilities, for example, the California Council on Science and Technology found that flooding hazards from sea-level rises remain a concern for underground gas sites in low-lying areas and noted that further mitigation strategies may be necessary to protect facilities. Another hazard identified was the threat of wildfires, as many facilities are located in areas at increased risk for wildfires.[79] The vulnerability of oil and gas facilities to climate threats across the country provides further support for the need to transition to renewables as a more resilient means of fulfilling the country's energy needs.

Vulnerable populations: Public health professionals have voiced concerns about the rapid expansion of UOG, both in communities with a long history of oil and gas development and in those with a more limited history, especially considering the difficulty in determining the causality of health consequences.[17] Vulnerable populations—particularly children, pregnant women, individuals who are chronically ill, those with asthma, the elderly, low-income populations, and UOG workers—are most likely to be negatively affected by UOG (based on a yet-to-be-determined combination of proximity to wells and well density).[44] For example, one study published in October 2018 revealed an association between UOG and asthma hospitalizations among young children and adolescents in Pennsylvania.[80]

From an environmental justice standpoint, not everyone shares the same burden of exposure to oil and gas pollution, placing some at greater risk. As mentioned previously, for example, low-income populations in Pennsylvania are more likely to be exposed to pollution from UOG wells.[60] In California, communities with high proportions of Latinos/Hispanics, African Americans, and Asian Americans are more likely to live near traditional drilling activity, with additional UOG activity proposed in those areas.[81] But how close is too close, especially for vulnerable populations? That is an issue currently under debate, and regulation varies substantially state to state; however, recent literature suggests that current regulatory setbacks of less than a quarter of a mile are permitting UOG drilling facilities and other facilities to be cited too close to human activity.[82]

While researchers have begun to quantify the risks posed specifically to vulnerable populations by UOG development,[30,39,42,83,84] much more research is needed in this area. Evidence gathered from similar areas of research (such as the effect of noise on vulnerable populations[85]), as well as the rapidly growing experience with UOG, comparisons with other activities involving similar emissions, and projections based on environmental models, can help prevent potential environmental and occupational UOG health impacts.

Evidence-Based Strategies and Interventions

This policy statement has briefly summarized the various known environmental and public health concerns and research gaps associated with UOG development in order to assess how best to reduce or eliminate environmental risks, including risks among populations that are especially vulnerable. A broader compilation of UOG impacts is available in the Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction).[17] While transitioning away from the use of fossil fuels such as UOG as soon as possible is crucial from a climate change and public health standpoint,[86] such a proposal in the United States probably will not have the necessary support from elected officials at the national level or from industry.[87] This policy statement, overall, advocates that regulatory bodies (federal, state, and local agencies) see beyond the potential economic benefits of UOG development and consider the broader, longer-lasting, and likely serious social and public health implications of UOG extraction and use. It calls for agencies to enact policies that require use of comprehensive environmental impact assessments and community-informed research agendas[88] during discretionary decision making to determine whether the various mining, drilling, and distribution activities associated with the UOG industry bring about unnecessary risks for those closest to the operations as well as from a climate change perspective.

In contrast to the precautionary principle employed through most of Europe, the United States employs a risk-based approach wherein, in most cases, companies utilizing unconventional drilling and its associated technologies are issued drilling permits and extraction is conducted before there is a full understanding of potential risks to the environment and human health.[89] For example, the EPA's study of the risks posed by hydraulic fracturing on water was not published until 2016,[2] several years after unconventional drilling was being used regularly by the industry. Due to the highly politicized nature of domestic energy production and UOG development, academic research centers and nonprofit organizations often take the lead in conducting environmental health research in this arena. Relatively few environmental/public health studies have been produced by U.S. federal agencies about UOG effects[2,21,90–92] in comparison with the hundreds published by other researchers.[93] Despite the gap in federally conducted research, ample evidence points to the need for multidisciplinary and extensive approaches to addressing the health concerns associated with unconventional drilling (e.g., health impact assessments and life-cycle assessments), especially for those closest to extraction and processing facilities as well as children and other vulnerable populations.[36,94,95] Increasing setback distances between UOG operations (based on facility size and impact) and human activity should also be considered as a way to reduce potential exposures and risks from explosions and other incidents.

Furthermore, one could argue that public health was not at the table early in the discussions about whether unconventional drilling is in the best interests of the nation, its people, and the climate.[96] It is paramount that agencies at all levels of the government, research institutions and public health professionals, nonprofit organizations, and communities collaborate more closely to protect public health, mitigate exposures and impacts where possible, and significantly reduce the industry's climate change contributions.

Opposing Arguments/Evidence

One of the key arguments against banning or highly regulating the UOG industry has been one of economic development and job creation.[97] While some economic benefits at the local level can be found, most jobs created by the UOG industry are hazardous and are filled by a limited number of specialized out-of-state employees.[98] Many employment projections have been significantly overstated, and actual data suggest only modest increases in employment.[99] Property and rental values may increase (so long as pollution events are minimized), adding to the tax base. Some mineral rights owners will have revenue opportunities from property leases and royalties, although such benefits may not be seen by the individuals who live on those properties—an inequity issue referred to as a "split estate."[100] As new workers enter the community, hotels, restaurants, and local businesses are expected to see revenue increases. The increase in demand will also allow many businesses to expand and hire.[97] Through this economic development, UOG may have indirect positive public health impacts. For example, the fees and taxes associated with extraction can be directed back into the local public health infrastructure, including schools, hospitals, and clinics. Increased tax revenue can also be used to hire more firefighters, emergency medical technicians, and police officers to serve the community and address population and traffic increases. The likelihood of these potential benefits hinges greatly upon industry's willingness to invest in the community and/or local lawmakers' actions that ensure such investments are made shrewdly. To the extent that improved economic status leads to better nutrition, preventive behaviors and services, and access to health care, UOG development may result in improvements in the health status of some groups. There are concerns, however, that the "boom and bust" cycle typical of extractive industries will not produce long-term economic benefits and that unequal distribution of these benefits may cause community conflict.[61,101]

Proponents of the UOG industry also maintain that the natural gas produced will improve public health by replacing coal as a domestic energy source.[102] Originally, UOG was promoted as a "bridge fuel" until more renewable, sustainable energy options were available mainstream[77]; however, more recent research has questioned whether UOG is any better than coal in terms of their climate change footprints, partly owing to UOG's methane leaks and partly because gas competes with not only coal but also cleaner renewable energy sources.[103–106] Burning gas instead of coal for electricity may improve some health outcomes for those downwind of coal-fired power plants, and burning natural gas instead of coal has a smaller climate footprint (producing roughly half the carbon dioxide emissions as burning coal).[107] The benefits and drawbacks of use of natural gas in energy generation are complex and multifaceted; consideration must be given, for example, to its contributions to poor air quality during extraction and improved air quality (relative to coal/petroleum) during electricity generation, its high methane leakage rate, and its grid-balancing potential.[108] Presenting the options as a dichotomy (either coal or natural gas) without considering renewable energy sources is unrealistic. In addition, UOG is often cited as a means to grow domestic energy production, decreasing U.S. reliance on foreign imports of oil and gas.[109] However, as a result of its health and climate effects, use of UOG production as a way to reduce energy reliance is not a long-term, sustainable option.

Action Steps

UOG Cessation/Avoidance

Considering the various risks and impacts laid out in this problem statement and the absence of evidence demonstrating effective strategies to eliminate these issues, APHA recommends that new UOG development cease and that a strategic phase-out of existing development and infrastructure be promoted where possible. APHA's commitment to improving the health of the public and achieving equity in health status requires the public

health community to clearly and unequivocally communicate the urgent need to transition away from fossil fuels to clean and equitable renewable energy sources. UOG development is exacerbating climate change and its associated health impacts. Those concerns and the direct health risks the industry poses justify this statement's action steps and recommendations. This action step aligns not only with the organization's mission but also with its actions, including APHA's entire year devoted to "Climate Change and Health" and divestment from fossil fuels.

UOG development is regulated by a number of entities within the United States depending on where UOG activity is occurring. Most production is overseen by states, for example, with some authority held by federal agencies such as the Bureau of Land Management (for resources obtained from public and American Indian lands). To effectively transition away from UOG development, either a national decree would need to be issued by the administration or individual states would need to take measures to eliminate the process within their boundaries over a designated period of time, such as was the case for UOG extraction in New York State in 2014 and Maryland in 2017. Health professionals and other concerned parties need to advocate for policies that help accelerate the move away from new UOG development and incentivize an equitable and prompt transition toward cleaner, more renewable energy sources. This process may include advocating for bans in affected states and supporting national regulations, such as the Clean Power Plan, that encourage renewable energy development in order to cap greenhouse gas emissions. Barring a complete transition away from UOG development, APHA urges that the actions outlined below be taken to mitigate risks.

Policy-Making Tradeoffs

APHA suggests that policies regarding UOG explicitly compare tradeoffs among the economic, strategic, public health, equity, agricultural productivity, liquid and solid waste, land-use/reclamation, water security/public water supply, and global climatological implications of energy alternatives under different extraction scenarios over the long term.

- Where new or expanding UOG projects are proposed, regulations should require that comprehensive environmental impact assessments be conducted.
- In accordance with APHA Policy Statements 20078 (Addressing the Urgent Threat of Global Climate Change to Public Health and the Environment) and 20046 (Affirming the Necessity of a Secure, Sustainable and Health Protective Energy Policy), the association suggests that policies with respect to domestic UOG production should minimize the nation's greenhouse gas emissions. APHA recommends that the administration and the Department of Energy model and include the implications of UOG in terms of long-term greenhouse gas emissions in national energy policies, as well as the various public health and environmental tradeoffs sacrificed for the sake of domestic UOG development.
- In addition, wells need to be restimulated every few years to keep up production, but whether this occurs is driven largely by market forces. One way to encourage the transition away from fossil fuels toward renewable energy sources is to subsidize current oil and gas pads and facilities and their rights of way for conversion to wind (or other renewables), which would benefit local communities on the same limited footprint as current facilities using existing land use permits for connections to grid and local users.

Precautionary Approach

APHA recommends that federal, state, and local environment, health, and development agencies adopt a precautionary and adaptive approach in the face of uncertainty regarding the long-term public health impacts of the UOG industry, particularly with respect to the following proposals:

- In accordance with APHA Policy Statement 200011 (The Precautionary Principle and Children's Health), use of chemicals with unknown health impacts, particularly those with the potential for long-term and endocrine-disrupting effects , should be discouraged.
- UOG companies should be required to disclose and receive approval for the chemicals proposed in each UOG operation (see APHA Policy Statement 20025 [Preserving Right to Know Information and Encouraging Hazard Reduction to Reduce the Risk of Exposure to Toxic Substances]).
- Consistent with APHA Policy Statement 20038 (Supporting a Nationwide Environmental Health Tracking Network to Identify Links Between the Environment and Human Health), baseline monitoring of air quality, soil quality/chemistry, crop chemistry/productivity, water quantity and quality, forest health, wildlife resilience, land resources, and human health should be conducted prior to, during, and following all UOG activities.
- Where at all possible, development should proceed at a scale and pace that allow for effective monitoring, surveillance, and adaptation of regulations to anticipate and prevent negative health effects.
- Increasing setback distances to a minimum of a quarter mile between UOG operations and human activity may help mitigate concerns.
- Should negative health/environmental effects be observed, UOG activities should cease until further evidence indicates that operations can resume safely.
- Health impact assessments should be conducted at a local and regional scale prior to expansion or new UOG development.

- A national health registry should be established for active surveillance of community and worker health influenced by UOG-related activities. This registry should be supplemented with data from previously established nonprofit health registries, health insurance systems, research studies, and other big data caches.

Industry Variability

Geological, geographic, climatological, technological, economic, social, and political differences between communities in which UOG development occurs result in diverse human health impacts. Improved data transparency, reporting, and flexible planning would help address some of these concerns.

- APHA urges all agencies at the federal, state, and local levels to share data and analyses of experiences with UOG across locations, accounting for known local differences and the uncertainties resulting from variations in geography and other factors. Extensive measures should be taken by regulatory agencies, public health researchers, and the UOG industry to improve transparency regarding the chemical formulations and mixtures used at all stages of UOG development and production, as well as the nature and destination of UOG waste streams.
- APHA recommends that the public health community advocate for planning and policy approaches that consider the industry's variability, including issues associated with UOG's supporting infrastructure (e.g., pipelines and liquefied natural gas export facilities).
- APHA suggests that all state and federal regulatory agencies require immediate digital reporting to appropriate agencies and local communities of any potentially toxic discharges to air, water, or soil from any UOG facility or structure.
- Nondisclosure agreements should not be allowed as a condition of restitution when exposures such as well water contamination are being addressed by the contaminating party.

Public Health Participation

APHA proposes increased participation of public health professionals in all regulatory processes and policies at the local, state, and federal levels pertaining to UOG development, production, transportation, and end use.

- Federal, state, and local commissions and agencies charged with regulating the UOG industry should include strong representation by professionals with training and experience in public health.
- APHA recommends that the role of local and state public health professionals in responding to public health concerns arising from UOG be recognized and supported accordingly.

Regulation of Cumulative Impacts

Individually, drilling operations, staging areas, and other midstream and downstream infrastructure may not produce levels of pollution that trigger regulation under existing environmental laws. However, the cumulative impacts of emissions or releases may create significant public health threats and contribute to climate change.

- APHA recommends that projections of aggregate emissions under expected extraction scenarios be the basis for regulation of individual sources. Overall density, real-time biomonitoring, the effect of extreme emission peaks, and projected development over time should be considered.
- APHA urges that state and federal environmental regulations be amended to close loopholes exempting oil and gas activities from oversight or reporting. Regulatory exemptions include the Clean Water Act; the Clean Air Act; the Comprehensive Environmental Response, Compensation, and Liability Act; the Resource Conservation and Recovery Act; the Toxic Release Inventory under the Emergency Planning and Community Right-to-Know Act; the National Environmental Policy Act; and the Safe Drinking Water Act.
- APHA suggests that all regulatory bodies mandate aggregation of drilling operations within a set distance of each other as a single source under Clean Air Act regulations and base emissions regulations on models of cumulative impacts under expected development scenarios.

Protecting Worker Health

In accordance with APHA Policy Statement 20106 (Occupational Injury, Illness, and Fatality Prevention Through Design), training of local health departments, emergency responders, health care providers, and occupational health centers and open ongoing communication between health professionals and the UOG industry are essential to protecting worker and public health.

- APHA proposes that exemptions from OSHA regulations related to oil and gas extraction work be removed. Companies involved in UOG should provide training for workers, emergency responders, and local health care providers.
- To further protect workers' health, APHA urges the industry to pay for additional monitoring, training, and enforcement and to support health care providers' needs.

- A transparent, industry-wide worker health registry (including contractors) should be established and managed by the National Institute for Occupational Safety and Health.

- APHA advises that studies be conducted by federal agencies and academic institutions to further characterize the risks faced by UOG workers and contractors and determine whether these risks differ significantly from those experienced by workers in the conventional oil and gas industry. OSHA should include oil and gas drilling and servicing in future revisions of its Process Safety Management standard.

Community Engagement

To prevent or reduce "research fatigue," misrepresentation, inequity, and frustration among people living near UOG sites:

- APHA encourages that impacted communities be engaged to establish community-based participatory research agendas and community-based participatory approaches to public health issues in accordance with APHA Policy Statement 200412 (Support for Community Based Participatory Research in Public Health).

- APHA recommends that governmental bodies, the UOG industry, and researchers engage with UOG-impacted communities and workers through transparent policy-making and provide an avenue for iterative public input throughout the decision-making and research agenda-setting processes in support of social justice.

Building Capacity

To build public health capacity, APHA proposes that the public health workforce be better educated about UOG development and its potential for public health impacts.

- Federal and state legislatures should provide adequate funding to local public health agencies in areas of active UOG development to support education, outreach, surveillance and monitoring, needs assessments, and ways to prevent or mitigate exposures.

- APHA suggests that a portion of bonding funds from UOG drilling permits be allocated toward funding independent research regarding environmental and health impacts on communities where UOG-related activities are currently taking place.

- UOG companies should provide continuous, real-time monitoring and public reporting of releases and emissions from all infrastructure related to UOG development, production, transportation, and end use.

Supporting Research

As identified in the problem statement, a significant amount of research is still needed to fully understand the spectrum of health issues associated with UOG development throughout its life cycle if UOG activity is to continue.

- APHA urges that environmental impact assessments and life-cycle assessments be employed readily by the appropriate regulatory bodies.

- Findings must be communicated clearly to the public. The National Institutes of Health, the Environmental Protection Agency, and other federal agencies should fund bench science and applied research, including health impact assessments, on the projected impacts of UOG and potential mitigating approaches.

Offshore Drilling Policy Statement

Offshore drilling, while overlapping in some ways with UOG drilling, poses a myriad of risks unique to that industry. Additional research studies are necessary to focus on the chemicals that are employed in offshore wells during the drilling process, their health impacts, and other chemical by-products potentially generated during the entire process. It is recommended that an offshore drilling policy statement be produced for APHA by its members.

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