

## Highlights from the “Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking – Sixth Edition

### **Air pollution**

Air pollution associated with fracking is a grave concern with a range of impacts. Researchers have documented more than 200 different air pollutants near drilling and fracking operations. Of these, 61 are classified as hazardous air pollutants with known health risks, and 26 are classified as endocrine disruptors. Areas with substantial drilling and fracking build-out show high levels of ground-level ozone (smog), striking declines in air quality, and, in several cases, increased rates of health problems with known links to air pollution. Air sampling surveys find high concentrations of volatile organic compounds (VOCs), especially carcinogenic benzene and formaldehyde, both at the wellhead and at distances that exceed legal setback distances from wellhead to residence. In some cases, VOC concentrations exceeded federal safety standards by several orders of magnitude. In 2018, researchers in Colorado documented that air pollution increased with proximity to drilling and fracking operations and was sufficiently high to raise cancer risks in some cases. Exposure to emissions from natural gas flares and diesel exhaust from the 4,000-6,000 truck trips per well pad also pose respiratory health risks for those living near drilling operations. The United States leads the world in the number of flare stacks. Air pollutants from flaring operations include VOCs, polycyclic aromatic hydrocarbons, carbon monoxide, toxic heavy metals, formaldehyde, and soot.

Evidence implicates the U.S. shale gas boom in the recent global spike in atmospheric ethane and propane. Drilling and fracking operations in North Dakota’s Bakken oil and gas field alone contribute two percent of global ethane emissions and directly impact air quality across North America. Like methane, ethane is both a greenhouse gas and a precursor for ozone formation. The accelerating pace of drilling and fracking activities and the current policy plan to reverse course on proposed regulations to reduce methane emissions are likely to exacerbate the air pollution problems that fracking creates, along with attendant health risks.

### **Water contamination**

Substantial evidence shows that drilling and fracking activities, and associated wastewater disposal practices, inherently threaten groundwater and have polluted drinking water sources. Repudiating industry claims of risk-free fracking, studies from across the United States present irrefutable evidence that groundwater contamination occurs as a result of fracking activities and is more likely to occur close to well pads. In Pennsylvania alone, the state has determined that 343 private drinking water wells have been contaminated or otherwise impacted as the result of drilling and fracking operations over an eight-year period. As determined by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), the chemical contamination of some private water wells in Dimock, Pennsylvania posed demonstrable health risks, rendering the water unsuitable for drinking.

Evidence of instances and pathways of water contamination exist even though scientific inquiry is impeded by industry secrecy and regulatory exemptions. The 2005 Energy Policy Act exempts hydraulic fracturing from key provisions of the Safe Drinking Water Act. As a result, fracking chemicals have been protected from public scrutiny as “trade secrets.” The oil and gas sector is the only U.S. industry permitted to inject known hazardous materials near, or directly into, underground drinking water aquifers. At the same time, in most states where fracking occurs, routine monitoring of groundwater aquifers near drilling and fracking operations is not required, nor are companies compelled to fully disclose the identity of chemicals used in fracking fluid, their quantities, or their fate once injected underground.

Nevertheless, of the more than 1,000 chemicals that are confirmed ingredients in fracking fluid, an estimated 100 are known endocrine disruptors, acting as reproductive and developmental toxicants. Adding to this mix are heavy metals, radioactive elements, brine, and volatile organic compounds (VOCs), which occur naturally in deep geological formations and which can be carried up from the fracking zone with the flowback fluid. As components of the fracking waste stream, these toxic substances also pose threats to surface water and groundwater. A 2017 study found that spills of fracking fluids and fracking wastewater are common, documenting 6,678 significant spills occurring over a period of nine years in four states alone. In these states, between 2 and 16 percent of wells report spills each year. About five percent of all fracking waste is lost to spills, often during transport. Spills and intentional discharges of fracking waste into surface water have profoundly altered the chemistry and ecology of streams throughout entire watersheds, increasing downstream levels of radioactive elements, heavy metals, endocrine disruptors, toxic disinfection byproducts, and acidity, and decreasing aquatic biodiversity and populations of zooplankton and sensitive fish species, such as brook trout. Recent studies documenting changes in the bacterial flora in groundwater following drilling and fracking operations represent an emerging area of concern.

Demand for water to use in U.S. fracking operations continues to rise and has more than doubled since 2016. Unlike water used for agriculture or other industrial uses, the water used for fracking that remains in the shale bedrock is permanently lost to the hydrologic cycle. A suite of new studies now show that fracking can deplete streams and aquifers in ways that contribute to water stress and water scarcity. A 2018 study found that water use for fracking 69 operations increased by 770 percent per well between 2011 and 2016 across all U.S. shale basins. At the same time, the volume of fracking wastewater generated during the first year of extraction increased by up to 1440 percent. There is no known solution for the problem of fracking wastewater. It cannot be filtered to create clean, drinkable water, nor is there any safe method of disposal. Recycling is an expensive, limited option that increases radionuclide levels of subsequent wastewater. Underground reservoirs that receive fracking wastewater via injection into disposal wells, a practice that is linked to earthquakes, are reaching capacity in many regions of the United States.

### **Inherent engineering problems that worsen with time**

Studies show that many oil and gas wells leak, allowing for the migration of natural gas and potentially other substances into groundwater and/or the atmosphere. About five percent of wells leak immediately, 50 percent leak after 15 years, and 60 percent leak after 30 years. The act of fracking itself can redistribute stress and create underground pathways for fluid migration, which, in turn, can communicate with pathways caused by deterioration of cement in aging well casings, leading to both groundwater contamination and atmospheric emissions.

The problem of leaking wells, first identified by industry, has no known solution. Data from Pennsylvania's Department of Environmental Protection (DEP) agree, showing over nine percent of shale gas wells drilled in the state's northeastern counties leaking within the first five years. Leaks pose serious risks, including potential loss of life or property from explosions and migration of gas and other harmful chemicals into drinking water supplies. Methane leaking into aquifers can, under some conditions, be transformed by bacteria into hydrogen sulfide and other poisonous byproducts. Microbes from deep shale formations can likewise generate sulfides contributing, over time, to corrosion of pipes and casings.

There is no evidence to suggest that the problem of cement and well casing impairment is abating. Industry has no solution for rectifying the chronic problem of well casing/cement failures and resulting leakage. Plugging old, inactive wells is an imperfect solution because, as research shows, the cement plugs themselves degrade over time and because many wells leak from outside the well casing.

### **Radioactive releases**

Exemptions from federal hazardous waste laws mean that no national regulatory framework exists for handling the radioactive materials in solid and liquid fracking waste. Instead, regulation is the responsibility of individual states, which vary widely in their approaches. High levels of radiation documented in fracking wastewater from many shale formations raise special concerns in terms of impacts to groundwater and surface water. Measurements of radium in fracking wastewater in New York and Pennsylvania, from the particularly radioactive Marcellus Shale, have been as high as 3,600 times the regulatory limit for drinking water, as established by the U.S. Environmental Protection Agency (EPA). Studies have found toxic levels of radiation in Pennsylvania waterways even after fracking wastewater was disposed of through an industrial wastewater treatment plant.

A study found high levels of radon in buildings located in heavily drilled areas of Pennsylvania, with levels of radon rising since the start of the fracking boom. Unsafe levels of radon and its decay products in natural gas produced from the Marcellus Shale may also contaminate pipelines and compressor stations, as well as pose risks to end-users when allowed to travel into homes. Increasing evidence documents illegal, haphazard dumping of radioactive fracking waste, along with its disposal in municipal landfills not engineered to contain radioactivity. Drill cuttings—the pulverized rock pulled up during the drilling process—are a special concern as this form of solid waste, generated in prodigious amounts, is typically disposed of in municipal landfills lacking special protections for hazardous waste. Radioactivity in drill cuttings has been shown to exceed, in some cases, the regulatory limits for landfills that accept fracking waste. New research suggests that the chemical composition of fracking fluid itself helps to mobilize radioactive materials in the shale.

### **Occupational health and safety hazards**

Drilling and fracking jobs are among the most dangerous jobs in the nation with a fatality rate that is four to seven times the national average. Irregularities in reporting practices mean that counts of on-the-job fatalities among oil and gas workers are likely underestimates. Contract workers are especially at risk. Occupational hazards include head injuries, traffic accidents, blunt trauma, burns, inhalation of hydrocarbon vapors, toxic chemical exposures, heat exhaustion, dehydration, and sleep deprivation. An investigation of occupational exposures found high levels of benzene in the urine of wellpad workers, especially those in close proximity to flowback fluid coming up from wells following fracturing activities. Exposure to silica dust, which is definitively linked to silicosis and lung cancer, was singled out by the National Institute for Occupational Safety and Health (NIOSH) as a particular threat to workers in fracking operations where silica sand is used. At the same time, research shows that many gas field workers, despite these serious occupational hazards, are uninsured or underinsured and lack access to basic medical care.

In 2018, the first independent investigation of its kind showed that pipeline construction workers die on the job 3.6 times more often than the average U.S. worker. Pipeline worker deaths occur from crushings, fires, and heat exhaustion. The number of miles of U.S. pipelines tripled from 2006 to 2016, and newer pipelines are less safe than older ones. Pipelines built after 2010 suffer higher failure rates than pipelines built at any other time.

### **Public health effects, measured directly**

By several measures, evidence for fracking-related health problems has emerged across the United States and Canada. Studies of birth outcomes in regions of intensive unconventional oil and gas extraction continue to point to reproductive risks, including low birth weight and preterm births. In Oklahoma and Colorado, birth defects were elevated among infants whose mothers lived near drilling and fracking sites while pregnant.

As shown by multiple studies in Pennsylvania, as the number of gas wells increase in a community, so do rates of hospitalization, and community members experience sleep disturbance, headache, throat irritation, stress/anxiety, cough, shortness of breath, sinus problems, fatigue, wheezing, and nausea. Also in Pennsylvania, hospitalizations for pneumonia among the elderly are elevated in areas of fracking activity, and one study found significantly elevated rates of bladder and thyroid cancers. In Colorado, children and young adults with leukemia were 4.3 times more likely to live in an area dense with oil and gas wells. Drilling and fracking operations in multiple states are variously correlated with increased rates of asthma; increased hospitalizations for pneumonia and kidney, bladder, and skin problems; high blood pressure and signs of cardiovascular disease; elevated motor vehicle fatalities; symptoms of depression; ambulance runs and emergency room visits; and incidence of sexually transmitted diseases. Benzene levels in ambient air surrounding drilling and fracking operations are sufficient to elevate risks for future cancers in both workers and nearby residents, according to studies. Animal studies show numerous threats to fertility and reproductive success from exposure to various concentrations of oil and gas chemicals at levels representative of those found in drinking water. A recent study found that 43 chemicals used in drilling and fracking operations are classified as known or presumed human reproductive toxicants, while 31 others are suspected human reproductive toxicants. An earlier study identified two dozen chemicals commonly used in fracking operations as endocrine disruptors that can variously disrupt organ systems, lower sperm counts, and cause reproductive harm at realistically expected exposure levels.

#### **Noise pollution, light pollution, and stress**

Drilling and fracking operations and ancillary infrastructure expose workers and nearby residents to continuous noise and light pollution that is sustained for periods lasting many months. Chronic exposure to light at night is linked to adverse health effects, including breast cancer. Sources of fracking-related noise pollution include blasting, drilling, flaring, generators, compressor stations, and truck traffic. Exposure to environmental noise pollution is linked to cardiovascular disease, cognitive impairment, and sleep disturbance. In Colorado, noise measured during construction and drilling of a large, multi-well pad in a residential area exceeded levels known to increase the risk of cardiovascular diseases and hypertension. In rural Canada, residents living near drilling and fracking operations experienced community upheaval and showed multiple signs of trauma. Oil and gas production noise may be disrupting wildlife health in protected areas. Workers and residents whose homes, schools, and workplaces are in close proximity to well sites are at risk from these exposures as well as from related stressors. Existing “setback distances” may not be adequate to reduce public health threats, especially for vulnerable populations. A UK Health Impact Assessment (HIA) identified stress and anxiety resulting from drilling-related noise—as well as from a sense of uncertainty about the future and eroded public trust—as key public health risks related to fracking operations

#### **Earthquakes and seismic activity**

Definitive evidence from Ohio, Arkansas, Texas, Oklahoma, Kansas, and Colorado links fracking wastewater disposal wells to earthquakes of magnitudes as high as 5.8, in addition to swarms of minor earthquakes. Both the U.S. Geological Survey (USGS) and state geological agencies such as the Oklahoma Geological Survey now acknowledge that earthquakes can be caused by wastewater injection into disposal wells. Many recent studies focus on the mechanical ability of pressurized fluids to trigger seismic activity by unclamping stressed faults. In some cases, and especially in Canada, Oklahoma, Ohio, and China, the fracking process itself has been linked to earthquakes. Emerging evidence suggests that risk of earthquakes can continue to rise for years after waste injection and cannot be prevented through “proper” fracking protocols or by solely limiting the rate or volume of injected fluid. Injecting fracking waste into shallower zones is one method for reducing earthquake risk, but shallow injection raises the

risk for groundwater contamination. The question of what to do with fracking wastewater remains a problem with no viable, safe solution.

### **Abandoned and active wells as pathways for gas and fluid migration**

Most fracking operations take place in oil and gas fields with a long history of conventional drilling and therefore with many abandoned wells. These can serve as potential pathways for contaminants to migrate vertically. Of the estimated 2.6 million oil and gas wells across the United States that are no longer in production, the location and status of the vast majority are not recorded in state databases, and most remain unplugged. Whether plugged or unplugged, abandoned wells are a significant source of methane leakage into the atmosphere and, based on findings from New York and Pennsylvania, may exceed cumulative total leakage from oil and gas wells currently in production. No state or federal agency routinely monitors methane leakage from abandoned wells. Abandoned wells also serve as underground pathways for fluid migration, heightening risks of groundwater contamination. Fluid can migrate upward through vertical channels when fractures from new drilling and fracking operations intersect with old wells. The most probable pathway of contaminant transport takes place outside the well casing. Industry experts, consultants, and government agencies including the U.S. Environmental Protection Agency (EPA), the U.S. Government Accountability Office (GAO), Texas Department of Agriculture, New York State Department of Environmental Conservation (NYS DEC), Pennsylvania Department of Environmental Protection (PA DEP), Illinois Environmental Protection Agency, and the British Columbia Oil and Gas Commission have all warned about problems with abandoned wells due to the potential for pressurized fluids and gases to migrate through inactive and, in some cases, active wells.

### **Flood risks**

Fracking exacerbates flood risks in two ways. First, massive land clearing and forest fragmentation that necessarily accompany well site preparation increase erosion, run-off, and risks for catastrophic flooding. The construction of access roads, easements for pipelines, and build-out of other related infrastructure further contribute to the problem. Compared to an acre of forest or meadow, an acre of land subject to fracking construction activity releases 1,000-2,000 times more sediment during rainstorms. In addition, in some cases, operators choose to site well pads on flood-prone areas in order to have easy access to water for fracking, to abide by setback requirements intended to keep well pads away from inhabited buildings, or to avoid productive agricultural areas.

Second, the vulnerability of fracking sites to flooding increases the known dangers of unconventional gas extraction, heightening the risks of contamination of soils and water supplies, the overflow or breaching of containment ponds, and the escape of chemicals and hazardous materials. During Hurricane Harvey flooding in Texas in 2017, Eagle Ford operators reported 31 spills at oil and gas wells, storage tanks, and pipelines. Rising sea levels, more powerful hurricanes, and increased storm surges in coastal areas, a consequence of climate change, are expected to represent an increasing threat to oil and gas infrastructure, especially along the Gulf coast. According to a 2018 study, natural gas processing plants in U.S. coastal areas are among the most vulnerable energy infrastructure to inundation by sea level rise.

### **Threats to agriculture, soil quality, and forests**

Drilling and fracking operations pose risks to farming, soil, and forests. In California, fracking wastewater illegally injected into aquifers threatens crucial irrigation supplies to farmers in a time of severe drought. Fracking wastewater reused for irrigation and livestock watering in California's San Joaquin Valley may contain at least ten known or suspected chemical carcinogens, as well as over a dozen chemicals with no available toxicological data and many unidentified compounds currently classified as "trade secrets."

Agricultural uses of wastewater, as well as flowback water spills, raise questions about direct exposure of affected soils, contamination of food crops via bioabsorption through plant roots, and impacts on livestock due to ingestion. Studies and case reports from across the country have highlighted instances of deaths, neurological disorders, aborted pregnancies, and stillbirths in farm animals that have come into contact with wastewater. Additionally, farmers have expressed concern that nearby fracking operations can hurt the perception of agricultural quality and invalidate value-added organic certification. Land use changes and transport of invasive species by drilling and fracking operations have led to documented ecological and monetary harm to soils, forests, and natural areas. In forested areas of Pennsylvania, drilling and fracking operations have greatly reduced canopy covers and thereby diminished the carbon storage capacity of photosynthesizing forest trees. Soil compaction in cleared areas is detrimental to new plant growth and encourages the growth of invasive species.

### **Threats to the climate system**

Natural gas is not a climate-friendly fuel. Methane, which escapes from all parts of the natural gas extraction and distribution system, is a powerful greenhouse gas that traps 86 times more heat than carbon dioxide over a 20-year time frame. According to the best available evidence, fuel-switching that replaces coal with natural gas to generate electricity offers no clear climate benefits and likely represents a step backwards. As is now documented in many studies, fugitive methane emissions from U.S. drilling and fracking operations, storage, and ancillary infrastructure are higher than previously supposed. A significant proportion of these leaks are not preventable through engineering fixes. Indeed, some represent intentional venting during routine maintenance or during attempts to control pressure and prevent explosions during malfunctions. Venting takes place at all points along the supply chain, from well pads, pipelines, and compressor stations to liquefied natural gas (LNG) export terminals. A 2018 analysis of methane emissions from the U.S. oil and gas supply chain that used a combination of measurement methodologies found leakage rates 60 percent higher than reported by the U.S. Environmental Protection Agency (EPA) and concluded that natural gas is just as damaging as coal for the climate over a 20-year time frame. Collectively, a range of studies disprove the claim that natural gas is a transitional “bridge” fuel that can lower greenhouse gas emissions while renewable energy solutions are developed.

A sharp rise in global atmospheric methane concentrations began in 2007 and has accelerated since 2014. The causes for this spike are not yet fully understood and likely include both biogenic sources (livestock, agriculture, wetlands, landfills, forest fires) and fossil fuel sources. As both satellite and ground measurements reveal, U.S. methane emissions are responsible for 30-60 percent of the recent upsurge in global atmospheric methane concentrations. Most of this excess methane appears to represent fugitive emissions from U.S. oil and gas operations.

Many lines of evidence point to the important role of unconventional oil and gas extraction in driving greenhouse gas emissions upward. These include the atmospheric pattern of increased methane concentrations directly over intensively fracked areas of the United States; sharp upticks in global methane and co-occurring ethane levels that correspond to the advent of the U.S. fracking boom; and documentation of large pulses of methane released from storage facilities and other “super-emitting” sites. A major study from the National Aeronautics and Space Administration (NASA) in 2017 found that methane from biomass sources, such as fires, decreased over the time period 2001-2016 while fossil fuel sources of methane increased. Further, the widely touted claim that the U.S. fracking boom has contributed to recent declines in carbon dioxide emissions in the United States has been invalidated by research showing that almost all of the reductions in CO<sub>2</sub> emissions between 2007 and 2009 were the result of economic recession rather than coal-to-gas fuel switching. Other lines of research show that expanded use of natural gas impedes rather than encourages investments in, and deployment of,

renewable energy infrastructure. In sum, fracking, as a major driver of rising methane emissions, is incompatible with climate stability and the goal of rapid decarbonization that it requires.

### **Threats from fracking infrastructure**

The infrastructure for drilling and fracking operations is complex, widespread, and poses its own risks to public health and the climate. Beginning where silica sand is mined and processed and ending where gas is burned or liquefied for export, infrastructure includes pipelines, compressor stations, dehydrators, processing plants, flare stacks, gas-fired power plants, and storage depots through which oil or gas is moved, filtered, pressurized, warehoused, refined, and vented. It also includes injection wells and recycling facilities that dispose and treat the prodigious amounts of liquid waste that fracking generates. Air pollution is produced at every stage of the process. [Note: harm from flare stacks is included in Air Pollution and is not taken up in the sub-sections that follow.]

#### **Sand mining and processing**

In the Upper Midwest, the boom in silica sand mining threatens both air and water quality. It has transformed rural areas into industrialized zones and introduced complex public health risks that are not well understood. Silica dust is a well-known cause of both lung cancer and silicosis. Precise exposures to downwind communities remain uncertain. Until recently, the center of frack sand mining was western Wisconsin. However, sand mines in the Permian Basin of west Texas now provide one quarter of the total U.S. supply of frack sand. Texas sand is considered inferior to Wisconsin sand, which is crush-resistant and ideally shaped to prop open fractures to allow oil and gas to flow up the borehole. However, Texas sand is up to 50 percent cheaper as it does not incur the cost of rail transport to reach the booming Permian Basin oil wells

#### **Pipelines and compressor stations**

There are more than 300,000 miles of natural gas transmission pipelines in the United States. They are serviced, every 40 to 100 miles, by compressor stations that maintain the pressure of the gas flowing through them. (Pump stations do the same for oil pipelines.) Compressor stations and pipelines are significant sources of air pollutants, including benzene and formaldehyde, constituting potential health risks to those living nearby while offering no economic benefits. Instead, they are associated with loss of tax revenue and economic development for the communities where they are sited and which they traverse. Pipelines and compressor stations vent methane into the atmosphere as part of routine maintenance operations and represent a climate risk. They are also accident prone. The Medical Society of the State of New York, the Massachusetts Medical Society, and the American Medical Association have each called for comprehensive health impact assessments regarding the health and safety risks associated with natural gas pipelines, which include fires, explosions, and leaks.

#### **Gas storage**

Gas storage facilities include not only manmade holding tanks but also geological formations, most notably, aquifers, abandoned salt caverns, and depleted oil fields left over from mining and drilling operations. These unlined cavities were not created with the intent to store pressurized hydrocarbon gases, nor are they engineered for this purpose. The 3,600-acre Aliso Canyon gas storage facility, located in a depleted oil field in southern California, released more than 100,000 metric tons of methane into the air of the San Fernando Valley over a four-month period beginning in October 2015 before it was finally contained in February 2016. This massive methane leak—the largest in U.S. history—is the greenhouse gas equivalent of a half million cars driving for a year. The plume itself was visible from space. More than 8,000 families in the nearby community of Porter Ranch were evacuated and relocated, thousands were sickened, and two public schools closed. The immediate cause of the Aliso Canyon blowout was a cracked well casing and lack of a shut-off valve. Data released in 2018 as part of a new U.S. Department

of Transportation rule reveal that there are more than 10,000 Aliso-style storage wells with gas flowing through only a single unprotected pipe—that is, with a single point of failure. Of the nearly 400 natural underground storage facilities in the United States, 296 of them have one or more of these wells, and they are located in 32 states.

### **Liquefied natural gas (LNG) facilities**

LNG is methane vapor that has been turned into liquid through a cryogenic process that lowers the temperature of the gas to its condensation point (– 259o F). Chilling natural gas to its liquid state shrinks its volume by a factor of 600, allowing LNG to be transported to places where pipelines don't reach, as when it is exported overseas on massive tanker ships. LNG is also sometimes used as vehicle fuel in, for example, long-haul trucks. LNG facilities encourage fracking by creating storage for the glut of gas that fracking has created, by enabling its export, and by driving up prices and profit margins. LNG facilities are capital intensive and consist of liquefaction plants, import/export terminals, tanker ships, regasification terminals, and inland storage equipment.

LNG liquefaction requires immense energy in order to achieve the ultra-low temperatures required for condensation. An LNG facility typically requires its own power plant. Because they rely on evaporative cooling, LNG tanks are leaky by design: to maintain the liquid at super-chilled temperatures and prevent explosions, vaporized gas is vented from storage tanks directly into the atmosphere. Larger tanks are engineered to capture boiled-off gas, but this process is not leak-proof. Before it is combusted or sent down a pipeline, LNG must be regasified via an energy-intensive process that requires massive infrastructure of its own, including periodic flaring to control pressure. Refrigeration, venting, leaks, flaring, and shipping make LNG more energy intensive than conventional natural gas. A recent analysis shows that exporting large quantities of LNG from the United States will likely cause global greenhouse gas emissions to rise not only because of its energy penalty but also because LNG exports add more fossil fuels to the global market and extend the lifespan of U.S. coal-fired plants.

LNG creates acute public safety risks. LNG explodes when spilled into water and, if spilled on the ground, can turn into rapidly expanding, odorless clouds that can flash-freeze human flesh and asphyxiate by displacing oxygen. If ignited at the source, LNG vapors can become flaming “pool fires” that burn hotter than other fuels and cannot be extinguished. LNG fires burn hot enough to cause second-degree burns on exposed skin up to a mile away. LNG facilities pose significant risks to nearby population centers and have been identified as potential terrorist targets.

### **Gas-fired power plants**

Found in every state except Vermont, natural gas-fired power plants surpassed coal-burning plants as the leading source of electrical generation in the United States in 2016. There are two types of gas-fueled power plants: combined cycle plants and simple cycle plants. Both types are major emitters of carbon dioxide, uncombusted methane, and nitrogen oxides, which contribute to the formation of ground-level ozone (smog). Combined cycle gas plants reuse waste heat to generate additional electricity and are roughly equivalent in efficiency to an older coal plant. Simple cycle gas plants—also called peaker plants—can be turned on and off faster to meet fluctuating energy demands when electricity needs peak, but they are much less efficient and more polluting than combined cycle plants. Simple cycle peaker plants can often generate more nitrogen oxides and more carbon monoxide than coal plants.

Gas-fired combined cycle plants were formerly promoted as a bridge to reduce emissions while renewables ramp up. However, within the last four years, renewable prices have fallen low enough to allow a transition directly from coal to solar and wind power, revealing that gas plants, with long returns on investment, are more barrier than bridge to renewable energy. At the same time, the lifecycle emissions of both types of gas-fired power plants have been shown



to be far higher than previously estimated. New natural gas plants lock in demand for gas for longer than current climate scenarios dictate, which call for net-zero carbon emissions by mid-century. Gas plants thus risk becoming stranded assets, meaning that they would need to be decommissioned well before the end of their lifespan.

Gas-fired simple cycle plants used on demand as peakers are becoming obsolete as battery technology now allows for the storage of renewable energy, decreasing the need for gas plants to provide power in times of peak demand.

Emerging evidence shows a variety of health impacts to people living near gas-fired power plants.

### **Inaccurate jobs claims, increased crime rates, threats to property values and mortgages, and local government burden**

According to multiple studies in multiple states, the oil and gas industry's promises of job creation from drilling for natural gas have been greatly exaggerated. Many of the jobs are short-lived, have gone to out-of-area workers, and, increasingly, are lost to automation. With the arrival of drilling and fracking operations, communities have experienced steep increases in rates of crime, variously including assault, rape, sex trafficking, larceny, and auto theft. In the Marcellus Shale region, violent crime increased 30 percent in counties that experienced a fracking boom compared to those without fracking. Aggravated and sexual assaults were the crimes primarily responsible for this increase. Crime rates have increased even with additional allocation of funds for public safety. Financial and other strains on municipal services include those on law enforcement, road maintenance, emergency services, and public school district administration. In Texas alone, road damage and other transportation impacts costs an estimated \$1.5-\$2 billion a year. In shale boom areas across the United States, school districts report heightened stress, regardless of whether student funding increased or decreased. Economists are increasingly quantifying community quality of life impacts and the unequal distribution of costs and benefits associated with drilling and fracking. Drilling and fracking pose an inherent conflict with mortgages and property insurance due to the hazardous materials used and the associated risks. With the departure of drilling and fracking operations from these communities, some of the challenges are eased. However, such departures can also lead to additional economic harms, such as by sharp upticks in foreclosures, late car and mortgage payments, empty housing units, and failed or diminished local businesses.

### **Inflated estimates of oil and gas reserves and profitability**

Industry projections of oil and gas reserves and profitability of drilling have proven undependable. Over time, well production has become increasingly short-lived, which has led companies drilling shale to reduce the value of their assets by billions of dollars, creating shortfalls that are largely filled through asset sales and mounting debt load. Throughout the ten-year fracking boom, the industry as a whole has spent more money drilling wells than selling oil and gas. Beginning in 2014, a fall in oil and gas prices led to a two-year downturn in fracking operations. As interest payments consumed the revenue of many smaller companies, more than 70 U.S. oil and gas companies declared bankruptcy, and the number of oil and gas rigs declined by 75 percent or more. When companies abandoned operations, they also abandoned the wells they drilled, raising questions about who serves as the custodian of inactive wells and their associated infrastructure, now and hereafter.

Beginning in 2017, a modest recovery in prices brought renewed industry enthusiasm for fracking. However, because of the rapid depletion of individual shale wells and the falling output of major shale basins, including the Bakken and the Marcellus, operators must reinvest profits to drill new wells at an increasingly rapid pace just to maintain the same level of extraction. More than half of all U.S. oil is now

produced by wells that are two years old or younger, and they are pumping less oil than forecast. In the first half of 2018, despite rising oil prices, fracking-focused companies continued to lose cash. The need to stabilize economic fundamentals by increasing production and lower costs is contributing to the shift toward “mega-fracking,” with ever-longer laterals to allow one well to access more oil or gas—and with requirements for higher volumes of water, sand, and chemicals per well.

### **Disclosure of serious risks to investors**

A snapshot of the dangers posed by natural gas drilling and fracking can be found in the annual Forms 10-K that oil and natural gas companies are required to file with the U.S. Securities and Exchange Commission (SEC). The information so contained in these reports, which provide a comprehensive summary of a company’s financial performance, provides a window into the harms and risks of fracking that are otherwise shielded from view by “gag order” clauses in court settlements, non-disclosure agreements between industry and landowners, and trade secret claims in regards to the chemical ingredients of fracking fluid. In this way, the Form 10-K can serve as an imperfect surrogate for right-to-know data. Recently, Forms 10-K have been used to warn investors about risks from climate change lawsuits.

### **Medical and scientific calls for more study, reviews confirming evidence for harm, and calls for increased transparency and science-based policy**

With increasing urgency, groups of medical and other health professionals and scientists are issuing calls for comprehensive, long-term study of the full range of potential health and ecosystem effects of drilling and fracking. These appeals underscore the accumulating evidence of harm, point to the major knowledge gaps that remain, and decry the atmosphere of secrecy and intimidation that continues to impede the progress of scientific inquiry. Published reviews and international governmental reports underscore the mounting evidence of health risks including developmental, neurological, carcinogenic, respiratory, reproductive, and psychological. Health professionals and scientists in the United States and around the world increasingly call for the suspension of unconventional gas and oil extraction activities in order to limit, mitigate, or eliminate its serious, adverse public health hazards, including health threats from climate change.