



Fossil Fumes (2022 update)

A public health analysis of toxic air pollution
from the oil and gas industry

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CLEAN AIR
TASK FORCE

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Abbreviations

AEO	Annual Energy Outlook
HAP	Hazardous Air Pollutant
LDAR	Leak Detection and Repair
NATA	National Air Toxics Assessment
NEI	National Emissions Inventory
PM	Particulate Matter
STEO	Short-Term Energy Outlook
URE	Unit Risk Estimate
VOC	Volatile Organic Compound



SECTION 1

Executive Summary

As the United States works toward implementing ambitious climate goals, methane pollution from the oil and gas supply chain has received increased attention, and for good reason — methane is a greenhouse gas **80 times more potent than carbon dioxide** over its first 20 years in the atmosphere,¹ and the oil and gas industry is the largest industrial source of methane pollution in the U.S.² But methane is just one harmful air pollutant emitted by oil and gas production. This report sheds light on the health impacts of hazardous and toxic air pollutants, including benzene, formaldehyde, and acetaldehyde, that are typically emitted from oil and gas sites alongside methane. These hazardous toxic air pollutants harm the health of people living near oil and gas facilities such as oil and gas wells, compressor stations, and processing plants.

This report presents estimates, based on recent analysis carried out by the Environmental Protection Agency (EPA), of the cancer risk that can be traced back to air toxics from the oil and gas industry for residents of every

county in the United States. Specifically, the analysis here is based on EPA's most recent Air Toxics Screening Assessment (AirToxScreen), formerly called the National Air Toxics Assessment (NATA), updated to reflect the latest emissions data from EPA's National Emissions Inventory (NEI).³

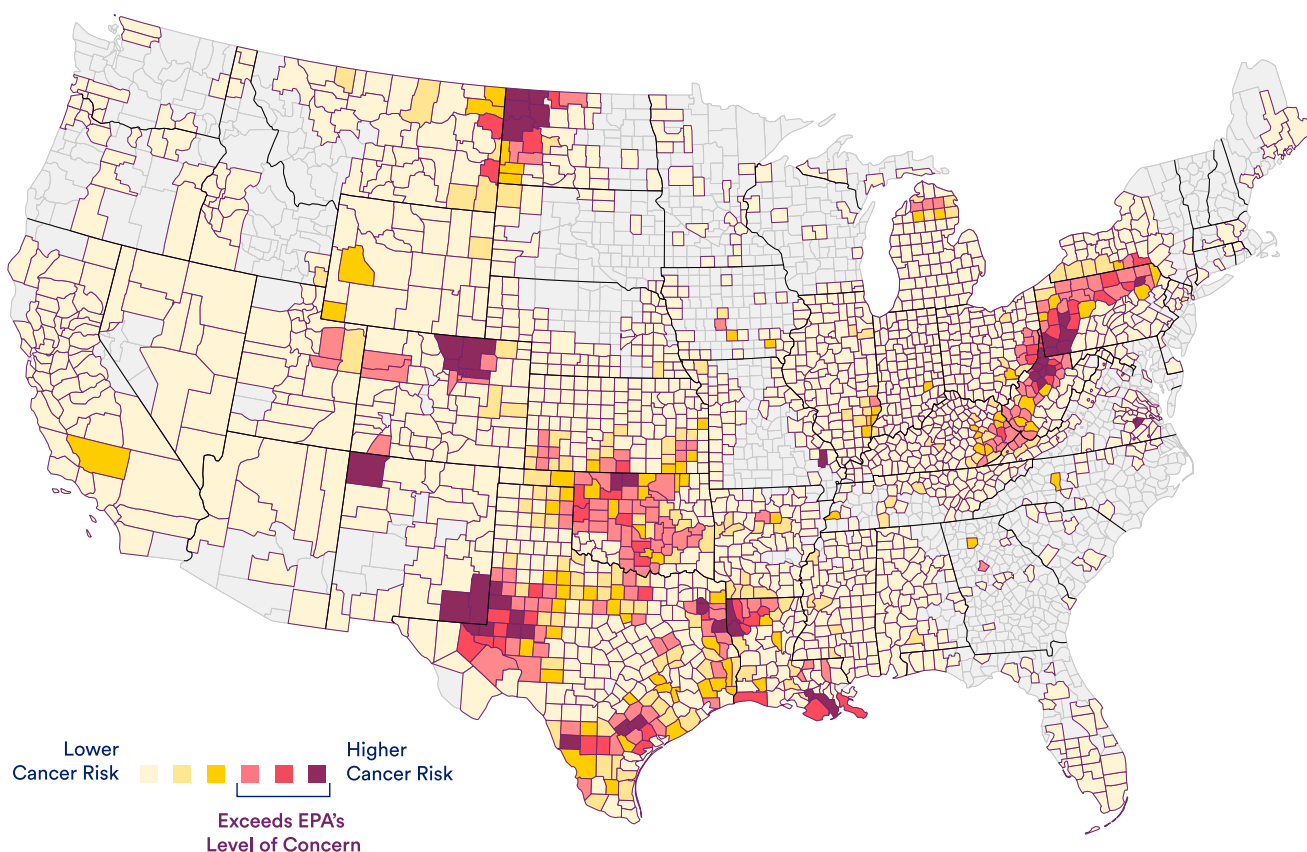
The analysis finds:

- **236 counties in 21 states face cancer risk** exceeding EPA's one-in-a-million threshold level of concern, just due to oil and gas pollution;
- These counties have a population of nearly **14 million people**;
- In 33 counties, the cancer risk due to oil and gas pollution exceeds one in 250,000 and in 3 counties the risk exceeds one in 100,000;
- The areas with the greatest health risk are generally located in states with the **greatest amount of oil and gas infrastructure** including New Mexico, Texas, Colorado, Pennsylvania, Oklahoma, Louisiana, West Virginia, and North Dakota.

^a The AirToxScreen also includes respiratory risk caused by the release of high levels of toxic air emissions at the tract level; however, this analysis does not investigate the respiratory risk associated with the oil and gas sector.

Map ES-1: National Map of Risk Level by County

The 236 counties that face cancer risk above EPA's 1-in-a-million level of concern are pink, red, or dark red.



Between the original publication of Fossil Fumes in 2016 and this current update, the total number of people living in counties with elevated cancer risk increased significantly: from 9 million to 14 million. This change primarily follows from overall growth in the size of the oil and gas industry. Although the industry declined in some geographic areas, it grew in many more locations than it shrank.

The AirToxScreen assessment only takes into account the cancer risk related to toxic air emissions from the oil and gas industry. It does not account for the other health impacts, such as respiratory risks, from air toxics emitted from oil and gas industry. It also does not account for health impacts from particulate matter and ozone-related air emissions, and it does not account for the health impacts of soil and water contamination caused

by oil and gas development. Furthermore, it does not take into account the health impacts from secondary pollutants that form as a result of the chemical reactions of direct oil and gas pollutants that occur in the atmosphere. As such, AirToxScreen is an underestimate of the full health impact of oil and gas operations.

Hazardous air pollution is emitted from dozens of types of equipment and processes throughout the oil and gas sector, such as wells, completion operations, storage tanks, compressors, and valves. Many proven, low-cost technologies and practices that are available to reduce methane emissions, the main constituent of natural gas, also reduce hazardous air pollution. Thus, policies that aim to reduce methane pollution from the oil and gas industry will help protect the health of local communities while addressing global climate change. Relying on

technologies and practices that are in use today, CATF has laid out a pathway by which regulatory standards—all based on regulations in place today—can reduce methane emissions from the industry by 65% relative to 2012 levels.³ These methane standards would also significantly cut toxic hazardous air pollution.

While we do not lay out specific measures EPA should take to address HAP emissions, beyond the methane-targeted measures described above, EPA should thoroughly review its regulations, especially for toxic pollutants emitted throughout the oil and gas supply chain, to ensure they are protecting local communities.

Table ES-1: List of Top 5 Oil and Gas Hazardous and Carcinogenic Air Pollutants in 2017 National Emissions Inventory

Note: These 5 pollutants account for 99% of the cancer risk from oil and gas facilities.

Hazardous Air Pollutant	Tons Emitted Per Year from Oil & Gas Industry	Health Impacts
Formaldehyde	37,826	Cancer and respiratory symptoms
Benzene	28,021	Cancer, anemia, brain damage and birth defects, and respiratory tract irritation
Acetaldehyde	5,491	Cancer and respiratory irritant
Ethylbenzene	2,200	Respiratory irritant, and increased risk of blood and neurological disorders
1-3 Butadiene	650	Increases risk of cancer and cardiovascular diseases

Table ES-2: List of High-Risk Counties

Counties with Cancer Risk Above 1 in 100,000					
CO, Weld*	NM, Eddy*	WV, Doddridge			
Counties with Cancer Risk Above 1 in 250,000					
CO, Adams*	LA, De Soto	NM, Lea*	PA, Greene	TX, Karnes	TX, Yoakum
CO, Boulder*	LA, Lafourche	NM, San Juan*	PA, Washington	TX, Loving	VA, Prince George
CO, Broomfield*	ND, McKenzie	OK, Alfalfa	PA, Westmoreland	TX, Martin	WV, Ritchie
CO, Larimer*	ND, Mountrail	OK, Grant	PA, Wyoming	TX, Panola	WV, Tyler
LA, Assumption	ND, Williams	PA, Fayette	TX, DeWitt	TX, Upshur	WV, Wetzel
Counties above EPA Level of Concern for Cancer Risk (County-wide average cancer risk is equal to or greater than 1 in 1 million)					
AR, Van Buren	LA, East Feliciana	OK, Carter	PA, Bradford	TX, Gonzales	TX, Winkler
CO, Arapahoe*	LA, Lincoln	OK, Coal	PA, Butler	TX, Gregg	TX, Wise
CO, Denver*	LA, Plaquemines	OK, Custer	PA, Cameron	TX, Harrison	TX, Wood
CO, Garfield*	LA, Red River	OK, Dewey	PA, Clarion	TX, Hemphill	TX, Zapata

* State level rules that were not included in EPA's 2023 projection may result in lower emissions and/or cancer risk. See page 15 on *Further Considerations*.

Table continued

Counties above EPA Level of Concern for Cancer Risk (County-wide average cancer risk is equal to or greater than 1 in 1 million)					
CO, Jefferson*	LA, Tangipahoa	OK, Ellis	PA, Clinton	TX, Hockley	TX, Zavala
CO, La Plata*	LA, Terrebonne	OK, Garfield	PA, Elk	TX, Howard	UT, Carbon
CO, Morgan*	LA, Union	OK, Garvin	PA, Forest	TX, Irion	UT, Duchesne
CO, Rio Blanco*	LA, Webster	OK, Grady	PA, Indiana	TX, Jackson	VA, Buchanan
GA, Henry	LA, W Baton Rouge	OK, Harper	PA, Jefferson	TX, Johnson	VA, Dickenson
IA, Dallas	MI, Antrim	OK, Haskell	PA, Lackawanna	TX, Kent	WV, Barbour
IL, Crawford	MI, Montmorency	OK, Hughes	PA, Lycoming	TX, La Salle	WV, Boone
KS, Allen	MI, Otsego	OK, Jefferson	PA, McKean	TX, Lavaca	WV, Brooke
KS, Barber	MO, Bollinger	OK, Kingfisher	PA, Mercer	TX, Limestone	WV, Calhoun
KS, Grant	MT, Fallon	OK, Latimer	PA, Potter	TX, Live Oak	WV, Clay
KS, Harper	MT, Richland	OK, Lincoln	PA, Sullivan	TX, Marion	WV, Gilmer
KS, Haskell	ND, Billings	OK, Logan	PA, Susquehanna	TX, McMullen	WV, Hancock
KS, Kearny	ND, Bottineau	OK, Love	PA, Tioga	TX, Midland	WV, Harrison
KS, Kingman	ND, Burke	OK, Major	PA, Warren	TX, Montague	WV, Jackson
KS, Stevens	ND, Divide	OK, Marshall	TX, Andrews	TX, Pecos	WV, Lewis
KS, Wilson	ND, Dunn	OK, McClain	TX, Borden	TX, Reeves	WV, Lincoln
KS, Woodson	ND, Renville	OK, Okfuskee	TX, Camp	TX, Refugio	WV, Marion
KY, Bell	ND, Stark	OK, Osage	TX, Chambers	TX, Rusk	WV, Marshall
KY, Floyd	NY, Broome	OK, Pawnee	TX, Cochran	TX, San Augustine	WV, McDowell
KY, Knott	NY, Tioga	OK, Payne	TX, Crane	TX, Scurry	WV, Mingo
KY, Letcher	OH, Belmont	OK, Pittsburg	TX, Crockett	TX, Shelby	WV, Monongalia
KY, Magoffin	OH, Carroll	OK, Pontotoc	TX, Dawson	TX, Stephens	WV, Ohio
KY, Martin	OH, Guernsey	OK, Roger Mills	TX, Denton	TX, Sterling	WV, Pleasants
KY, Perry	OH, Harrison	OK, Seminole	TX, Dimmit	TX, Terry	WV, Preston
KY, Pike	OH, Jefferson	OK, Stephens	TX, Ector	TX, Tyler	WV, Roane
LA, Bienville	OH, Monroe	OK, Washita	TX, Freestone	TX, Upton	WV, Taylor
LA, Bossier	OH, Noble	OK, Woods	TX, Gaines	TX, Victoria	WV, Upshur
LA, Caddo	OK, Beckham	PA, Allegheny	TX, Garza	TX, Ward	WV, Wayne
LA, Cameron	OK, Caddo	PA, Armstrong	TX, Glasscock	TX, Wheeler	WV, Wirt
LA, Claiborne	OK, Canadian	PA, Beaver	TX, Goliad	TX, Wilson	

* State level rules that were not included in EPA's 2023 projection may result in lower emissions and/or cancer risk. See page 15 on *Further Considerations*.



SECTION 2

Introduction

The Air Toxics Screening Assessment (AirToxScreen)

In March 2022, the U.S. Environmental Protection Agency (EPA) released the results of its Air Toxics Screening Assessment (AirToxScreen)—formerly National Air Toxics Assessment (NATA)—for 2017, based on air pollution estimates collected through the National Emissions Inventory (NEI). The purpose of AirToxScreen is to identify and prioritize air toxics, emission source types, and locations that are of greatest potential concern when looking at overall health risk in populations. AirToxScreen estimates cancer risk that can result from toxic air emissions. The metric for cancer risk is the number of cancer cases per million people exposed; areas with cancer risk above 1-in-one-million are considered to be above EPA’s level of concern.

In this study, we focus on toxic air pollution sources in the oil and gas industry, and we explore the health impacts of these emissions in the latter sections of this

report. This report focuses on the elevated cancer risk attributed to toxic air emissions from the oil and gas industry: oil and natural gas production and natural gas processing, transmission, and storage, including major sources like large compressor stations and gas processing plants, and dispersed sources like wells.^b The results presented here are estimates for the health risk from oil and gas that communities will face in 2023, based on the AirToxScreen report for 2017 and EPA’s projections of the changes in the level of HAPs released by oil and gas sources between 2016 and 2023 (see Appendix C for a discussion of our methodology).

Toxic Emissions Sources in the Oil and Gas Industry

Raw natural gas (i.e., gas as it is produced from underground formations, before significant processing) usually contains significant amounts of volatile organic compounds (VOCs) and toxic hazardous air pollutants (HAPs), though gas varies in composition

^b Throughout this report, we refer to 2 types of oil and gas sources: major sources and dispersed sources. Major sources are also known as “point” sources; these sources have the potential to emit 10 or more tons per year of one HAP or 25 or more tons per year of some combination of HAPs. Dispersed sources are also known as “non-point” sources; these sources are expected to emit less HAPs than sources emitting above these thresholds. See <https://www.epa.gov/AirToxScreen/airtoxscreen-glossary-terms>.

Details of the Air Toxics Screening Assessment

The 2017 AirToxScreen represents the seventh installment of the national assessment, building on earlier years of 2014, 2011, 2005, 2002, 1999, and 1996. Each update included improved modeling protocols and expanded coverage of hazardous air pollutants (HAPs). The 2017 AirToxScreen modeled 181 air toxic compounds from dozens of separate emissions sources, including point sources (large, distinct facilities such as power plants), non-point (the large number of dispersed smaller facilities), various classes of vehicles, non-road mobile sources (such as construction equipment), fires, and biogenic sources, including species formed in the atmosphere and transported from distant emissions regions. These emission data were collected as part of the NEI. Then, AirToxScreen estimated both the cancer and non-cancer effects of 127 air toxics (for which health data based on chronic exposure exists).

The 2017 AirToxScreen relies on two air quality models, the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) atmospheric dispersion model and the Community Multiscale Air Quality (CMAQ) photochemical model, to determine the ambient distribution of air toxics. The models incorporate emissions information with meteorological data to determine the dispersion of pollution and chemical transformations that result in estimated annual concentrations at the census tract level across the United States. The modeled ambient concentrations are then used in an exposure model to estimate population exposure to the pollutants.

The EPA developed AirToxScreen to inform national and local data collection and policy efforts. However, the agency emphasizes that because of data quality issues and uncertainties in the model, the data should be used cautiously—it should be used to screen for geographic areas with high risk, not as a measure of actual risk in specific locations.⁴ In addition, there are other limitations including incomplete assessment of emissions, limited ability to evaluate threats to vulnerable populations, and reliance on potentially outdated health thresholds.⁵

from source to source.⁶ The HAPs in raw gas include hexane, benzene, and other aromatic chemicals; poisonous gases like hydrogen sulfide can also be present.^c These pollutants are also emitted from crude oil production operations. Peer-reviewed analysis indicates that toxic HAP emissions from oil and gas operations can harm the health of people living and working in and near oil and gas production areas.⁷

While natural gas processing plants separate much of the toxic components from raw natural gas, some of those pollutants remain in the gas even after processing. As such, emissions from facilities further downstream in the natural gas supply chain, like transmission compressor stations and local distribution equipment, still include some toxic pollutants.

All four segments of the oil and gas industry emit hazardous toxic air pollutants, though in varying amounts:

Oil and Gas Production: The oil and gas production segment includes production of hydrocarbons from underground geologic formations; separation of natural gas, oil, and water; and collection of gas from multiple wells through natural gas gathering pipeline and compressor systems. These activities in turn involve processes such as well drilling, hydraulic fracturing or other well stimulation, and well workovers; and they require equipment such as tanks, piping, valves, meters, separators, dehydrators, pipelines, and gathering compressors. The process of extracting oil and gas from a reservoir requires the injection of hazardous chemicals, like formaldehyde and methanol, that flow back to the surface with the fluid and require additional processing. Such chemicals are added at several other parts of the production chain to control the quality and flow of the oil and gas. In addition, HAPs, like formaldehyde, acetaldehyde, and benzene, are also found in combustion engine exhaust from equipment and vehicles used in oil and gas production.⁸ As natural gas

^c Hydrogen sulfide is not included in EPA's list of Hazardous Air Pollutants due to a directive from Congress. See <https://www3.epa.gov/airtoxics/pollutants/atwsmmod.html>. This does not reflect a determination that hydrogen sulfide does not have toxic properties.

is vented, combusted, or leaks during production and transportation, the hazardous chemicals combined with the gas are also released into the air impacting the health of communities in the surrounding area.

Natural Gas Processing: Gas processing plants separate raw natural gas into natural gas liquids and processed natural gas that meets specifications for transport in high-pressure pipelines and consumption in furnaces and power plants. Natural gas liquids are hydrocarbons such as propane and butane, which are valuable products of gas processing. The processing removes most of the toxic components from the gas, but some toxics still remain.

Transmission and Storage: Natural gas transmission pipelines carry gas from production regions to markets. This segment also includes facilities where gas is stored, either underground or in tanks. Compressor stations along pipelines maintain pressure and provide the energy to move the gas.

Natural Gas Distribution: Finally, natural gas is delivered to customers (residential, commercial, and light industrial) via low-pressure underground distribution pipelines. Recent research has found detectable levels of benzene and other toxic air pollutants in gas in distribution pipelines that leads to residential use.⁹

Pollutants

Natural gas development and transmission release a host of pollutants—toxics, ozone smog forming pollutants, and greenhouse gases—that take a toll on our environment and our health. For example, hazardous gases, like hydrogen sulfide, that are separated from the oil and gas during processing are concentrated and injected back into a reservoir for storage potentially causing contamination of natural resources, such as aquifers, in the surrounding areas. In this analysis, we focus specifically on toxic air pollutants, i.e. those pollutants that are known carcinogens, probable carcinogens, or that cause other serious health problems through either short-term or long-term exposure.¹⁰ More specifically, we focus on the toxic air pollutants that are responsible for elevated cancer risk. The pollutants of greatest concern are acetaldehyde, benzene, and formaldehyde; direct emissions of these

three pollutants are responsible for 96% of the cancer risk estimated by AirToxScreen Assessment.

Benzene: Benzene has been linked to cancer, anemia, brain damage, and birth defects, and it is associated with respiratory tract irritation.¹¹ Over time, benzene exposure can also lead to reproductive, developmental, blood, and neurological disorders. A 2012 study estimated a 10 in one million cancer risk for residents near a well pad, attributable primarily to benzene.¹² According to the NEI, over 28,000 tons of benzene was emitted by oil and gas sources, accounting for 29% of the elevated cancer risk from oil and gas based on 2017 reported emissions. Benzene is a constituent of raw natural gas, so leaks and deliberate releases of gas (venting) are the primary source of benzene pollution from the oil and gas industry.

Formaldehyde: Formaldehyde has been linked to certain types of cancer, and chronic exposure to it is known to cause respiratory symptoms.¹³ Over 37,000 tons of formaldehyde was emitted by oil and gas sources, accounting for 65% of the elevated cancer risk from oil and gas based on 2017 reported emissions. Over 37,000 tons of formaldehyde was emitted by oil and gas sources, accounting for 65% of the elevated cancer risk from oil and gas based on 2017 reported emissions. Formaldehyde is primarily emitted from combustion sources such as flares and compressor engines.^d

Other oil and gas industry toxic pollutants were also emitted in lower amounts, including acetaldehyde (a probable carcinogen and respiratory irritant¹⁴), ethylbenzene (respiratory irritant, as well as increased risk of blood and neurological disorders), 1,3-butadiene (increases risk of cancer and cardiovascular diseases¹⁵), toluene (increased risk for neurological disorders), and methanol (a respiratory irritant and probable developmental and neurological disorders¹⁶).

Some of this pollution is emitted from major facilities like gas processing plants and large compressor stations. However, the majority of this pollution (78% of the emissions highlighted in Table ES-1) comes from the large number of dispersed smaller facilities located, such as well sites, tank batteries, and small compressor stations, in communities throughout the country.^d

^d In addition to being directly emitted from oil and gas engines and flares, a much larger amount of formaldehyde is formed when other pollutants from oil and gas (VOCs) are broken down in the atmosphere. However, the AirToxScreen process does not attribute this second, larger quantity of formaldehyde to oil and gas. Therefore, AirToxScreen underestimates the impacts from oil and gas formaldehyde.

Results

National

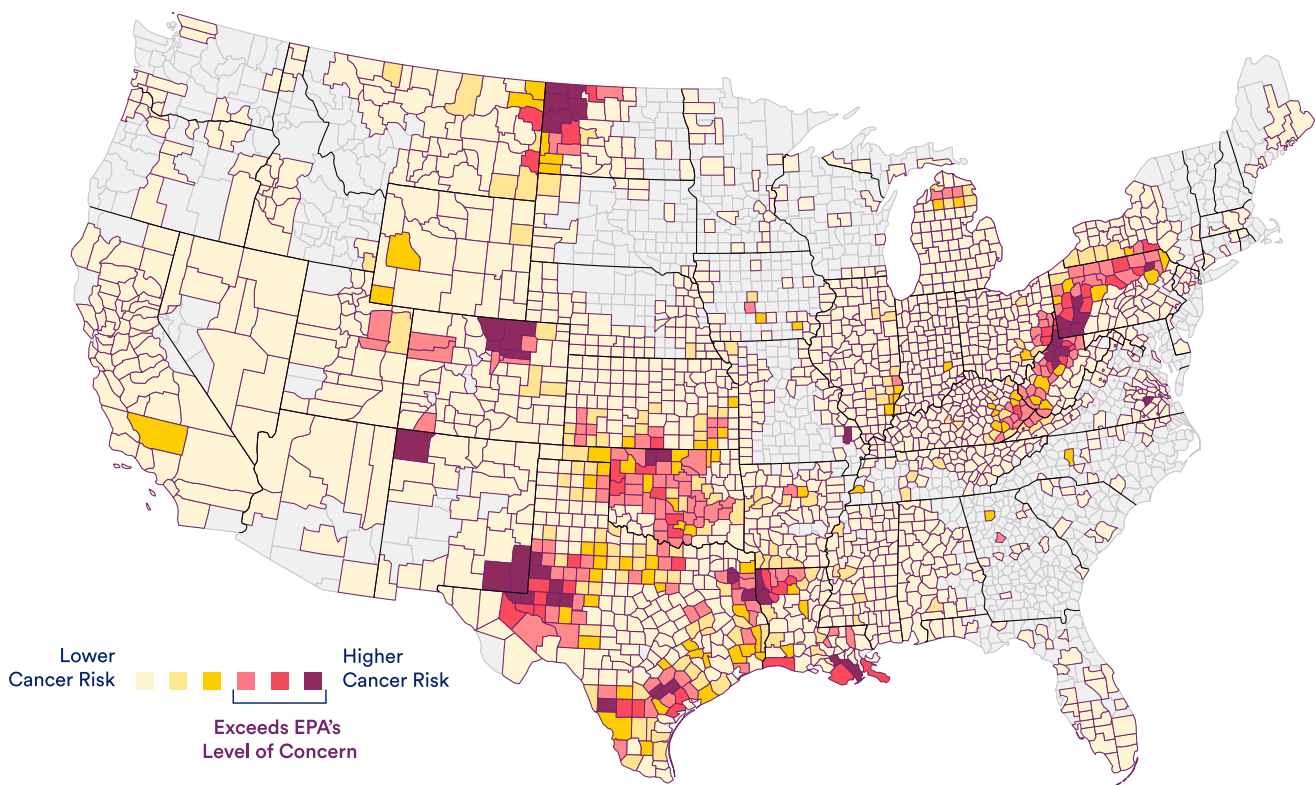
Using projections of toxic air emissions from EPA's National Emissions Inventory (NEI) for 2023, we estimate that 236 counties in 21 states face cancer risk above EPA's one-in-one-million level of concern due to toxic emissions from oil and gas operations. Of these counties, 33 counties face a risk that exceeds one in 250,000 and three counties face a cancer risk that exceeds one in 100,000. The total population of the counties above EPA's level of concern is nearly 14 million (see Appendix A). The areas with the greatest health risk are generally located in states with the largest amount of oil and gas infrastructure including New Mexico, Texas, Colorado, Pennsylvania, Oklahoma, Louisiana, West Virginia, and North Dakota. Areas of high risk include cities such as Dallas, Texas; Shreveport, Louisiana; Denver, Colorado; Pittsburgh, Pennsylvania; and Fairmont, West Virginia.

Between the original publication of Fossil Fumes in 2016 and this current update, the total number of people living in counties with elevated cancer risk increased significantly: from 9 million to 14 million. This change follows the growth or decline of the oil and gas industry in different geographical areas, but the industry grew in many more locations than it shrank.

Some air emissions standards have been put in place in the recent years to reduce methane pollution from the oil and gas facilities, but most of these regulations have been limited, leaving the vast number of sources and sites unaddressed. With this limited scope, air emissions from the oil and gas sector, including methane and air toxics, have continued to grow.

Map 1: National Map

The 236 counties that face cancer risk above EPA's 1-in-a-million level of concern are pink, red, or dark red.



New Mexico

According to the NEI data, in 2017 over 3,180 tons of hazardous toxic air pollution – benzene, formaldehyde, acetaldehyde, methanol, toluene, 1-3 butadiene, and ethyl benzene – were emitted by oil and gas facilities in New Mexico. This emissions estimate represents a 56% increase since the 2011 NEI. Oil and gas production has skyrocketed due to increased activity in the Permian basin and optimization of fracking technology to access crude oil from shale formation. Between 2017 and 2023, oil production is projected to increase by 151% while gas production will increase by 29%. EPA projections reflect this increase, showing total toxic air pollution from the oil and gas industry increasing over these years due to this growing energy industry.

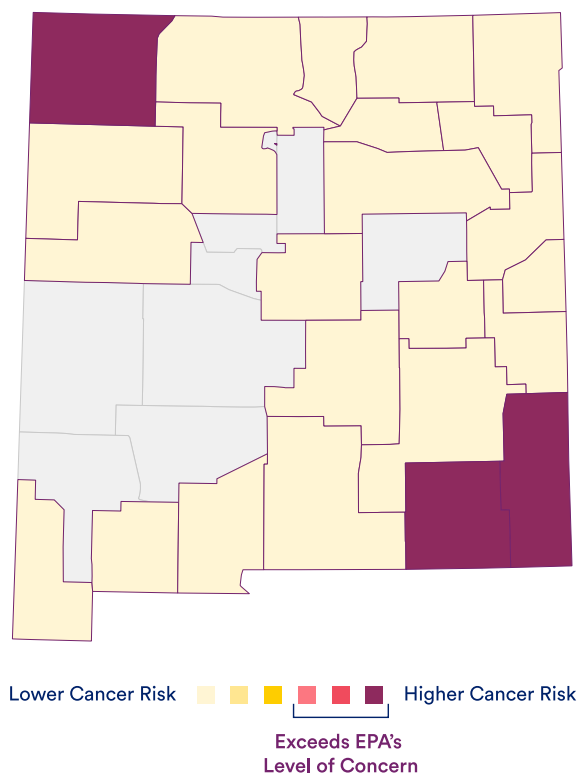
Three counties in New Mexico – Eddy, Lea, and San Juan – ranked in the top 6 for having the highest cancer risk from

oil and gas facilities in the U.S. These counties above EPA's level of concern have a total population of over 250,000.

In Summer 2022, New Mexico finalized strong, protective standards for air emissions from oil and gas sites. These rules were preceded by strong rules finalized in 2021 that limit venting and flaring of natural gas.[°] As these rules are implemented, they should significantly decrease emissions of toxic HAPs in New Mexico, reducing cancer risk due to oil and gas pollution. Because the 2022 rules were finalized after EPA prepared the emissions projections used in our analysis, it is possible that our results somewhat overestimate 2023 New Mexico impacts (to the extent that the 2022 rules are implemented by 2023). However, this overestimate is very likely outweighed by the factors which lead these results to be underestimated (see page 15 on *Further Considerations*).

Map 2: New Mexico Map

The 3 counties that face cancer risk above EPA's 1-in-a-million level of concern are dark red.



[°] New Mexico's Environmental Improvement Board issued regulations in 2022 to reduce ozone precursor pollutants from the oil and gas industry: <https://www.env.nm.gov/air-quality/ozone-draft-rule/>

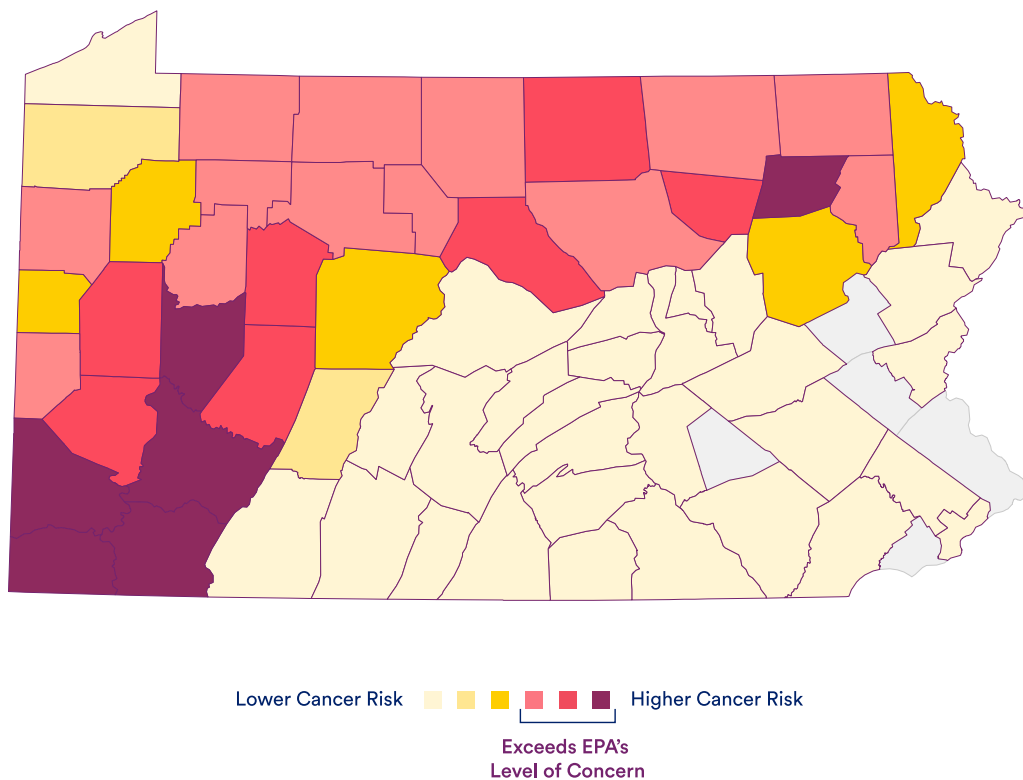
Pennsylvania

According to the NEI, in 2017 over 9,270 tons of hazardous toxic air pollution — benzene, formaldehyde, acetaldehyde, methanol, toluene, 1-3 butadiene, and ethyl benzene — were emitted by oil and gas facilities in Pennsylvania. This emissions estimate represents a 619% increase since the 2011 NEI. Between 2017 and 2023, oil production was projected to decline slightly, while gas production is projected to increase by 44%. Based on EPA's estimate of 2017 emissions and our projection to 2023, 26 counties in Pennsylvania will face a high cancer risk due to toxic emissions from oil and gas operations. These counties above EPA's level of concern have a total population of over 3.3 million.

Pennsylvania has worked for some time on state regulations to reduce air emissions from existing oil and gas operations, which would have the co-benefit of reducing toxic HAP emissions and the cancer risk faced by Pennsylvanians. Unfortunately, currently no state regulations are in place to reduce air emissions from the oil and gas industry.^f If the state finalizes and rapidly implements these regulations, the state may reduce emissions in 2023. However, since the prognosis of these standards is not clear at this point, our projections do not include any accounting for Pennsylvania state rules.

Map 3: Pennsylvania Map

The 26 counties that face cancer risk above EPA's 1-in-a-million level of concern are pink, red, or dark red.



^f In 2019, Pennsylvania Department of Environmental Protection proposed regulations to control VOC emissions from oil and gas source: https://files.dep.state.pa.us/PublicParticipation/Public%20Participation%20Center/PubPartCenterPortalFiles/Environmental%20Quality%20Board/2019/December%2017/7-544_OG_CTG_EQB_Dec172019.pdf

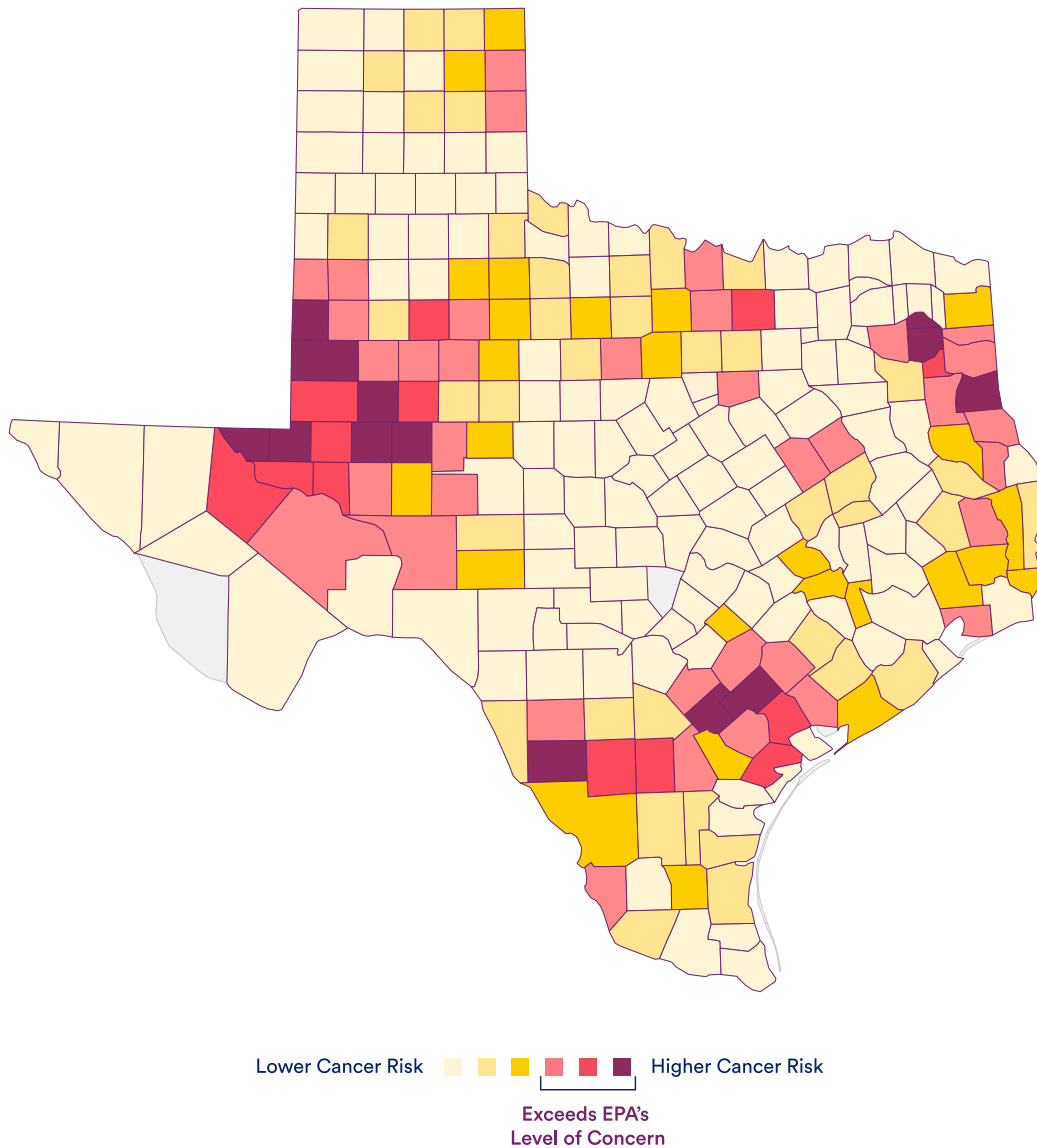
Texas

According to the NEI, in 2017 over 26,110 tons of hazardous toxic air pollution — benzene, formaldehyde, acetaldehyde, methanol, toluene, 1-3 butadiene, and ethyl benzene — were emitted by oil and gas facilities in Texas. This is a 204% increase in oil and gas hazardous air pollution since the 2011 NEI. Oil and gas production

are projected to increase by 50% in the state between 2017 and 2023. Based on 2017 emissions and projections to 2023, we estimate that 62 counties in Texas will face elevated cancer risk due to toxic emissions from oil and gas operations. These 62 counties above EPA's level of concern have a population of over 2.6 million.

Map 4: Texas Map

The 62 counties that face cancer risk above EPA's 1-in-a-million level of concern are pink, red, or dark red.



Further Considerations for AirToxScreen and Fossil Fumes Results

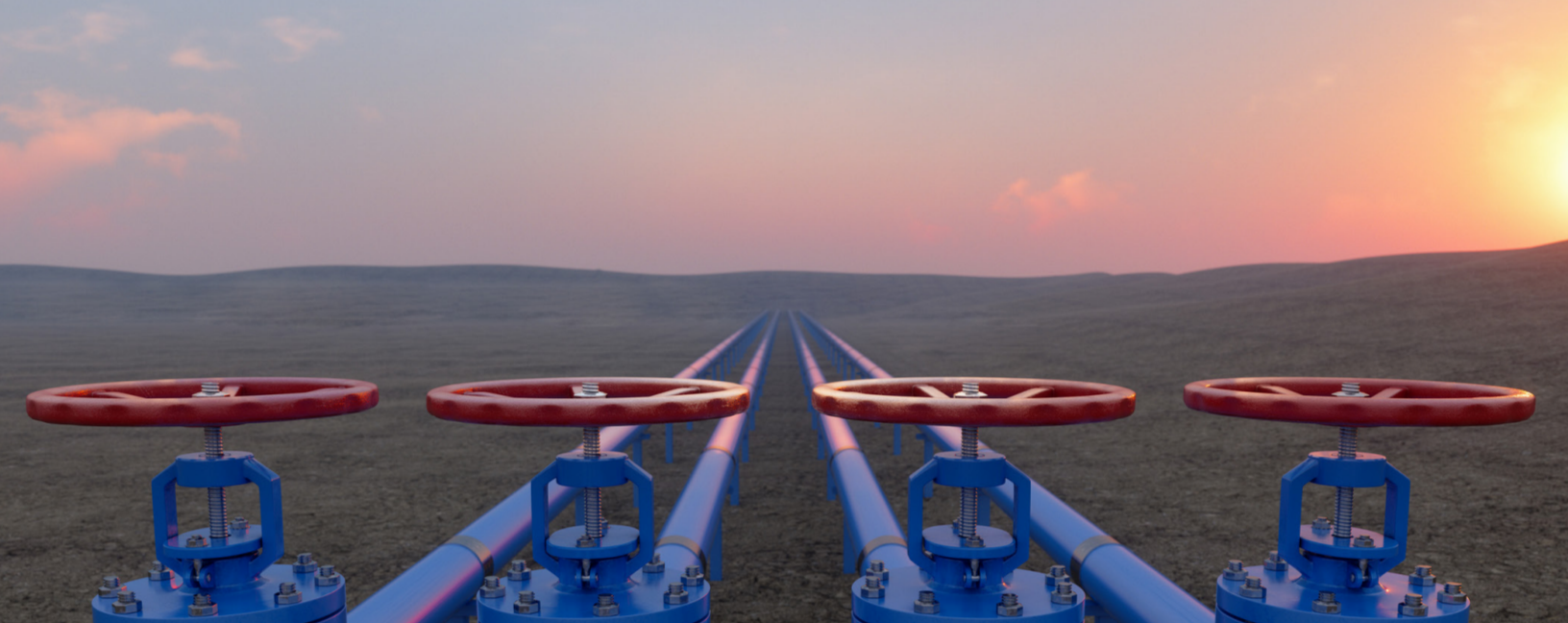
AirToxScreen is an underestimate of overall health impact from oil and gas for a variety of reasons:

- **First, this report does not account for the impact of oil and gas operations on respiratory health risk.** Oil and gas infrastructure is responsible for hazardous toxic air emissions, particulate matter (PM) emissions, and emissions of pollutants that create ozone smog. Hazardous pollutants, like formaldehyde and toluene, PM and ozone smog exacerbate respiratory diseases, including asthma and chronic lung disease. Silica dust from hydraulic fracturing and sand mining operations can also cause lung diseases. Furthermore, it also does not take into account the health impacts from secondary pollutants that form as a result of the chemical reactions of primary oil and gas pollutants in the atmosphere.
- **Second, AirToxScreen only accounts for risk associated with inhalation of these pollutants**—the exposure risks from water contamination may also be relevant for communities living near oil and gas facilities.
- **Third, we only included health impacts directly associated with oil and gas facilities.** Oil and gas development may also entail increased truck traffic and changes in land use, neither of these are accounted for in the present analysis.

- **Fourth, AirToxScreen and the inventories it relies on may underestimate the total emissions of toxics from oil and gas.**¹⁷ Its emissions estimates are based on data reported by counties and states, and it is not always based on measurement/monitoring data.
- **Finally, the projections we used to estimate emissions impacts in 2023 underestimate emissions nationwide,** since current projections of oil and gas production in 2023 are higher than was anticipated when the emissions projections we used were produced (See Appendix C). In New Mexico and Colorado, this nationwide underestimate of 2023 emissions may be offset to some degree by recently adopted state standards for oil and gas pollutants, which will reduce emissions in 2023 to some degree. These state regulations were not accounted for in 2021 when EPA prepared the emissions projections we used for this analysis.

In addition, there are many communities affected by oil and gas toxic air pollution that are missed when we look only at county-level risk results. In many places, the county-level average impact may be moderate, but individuals living in close proximity to oil and gas infrastructure will face elevated risk of both cancer and other health hazards.⁹ AirToxScreen did present data on health impacts for geographical units smaller than counties (census tracts), but because of data limitations and our conservative approach, we did not produce estimates of health impacts at the census tract level for 2023 (see Appendix C).

⁹ See Oil and Gas Threat Map for more on population living in close proximity to oil and gas infrastructure. Available at: <http://oilandgasthreatmap.com/>.



SECTION 4

Approaches to Reduce Toxic Air Pollution from Oil and Gas

As outlined in the 2020 report, *Reducing Methane from Oil and Gas A Path to a 65% Reduction in Sector Emissions*, air pollution from oil and gas can be greatly reduced by widely implementing a handful of straightforward measures that have already been proven in one or more North American jurisdictions. These technologies and practices will reduce the total amount of natural gas that leaks and is released from facilities throughout the oil and gas supply chain. Thus, these policy recommendations will also reduce emissions of hazardous toxic air pollutants from the oil and gas industry. As such, these measures would have important benefits for air quality and public health in and downwind of oil and gas producing areas. EPA should move quickly to require these measures.

These measures are briefly described below.

Frequent Leak Detection and Repair (LDAR).

Leak detection programs can be used to find and fix everything from simple leaking components, such as valves, to super-emitters – the infrequent but very large emissions events that arise from some improper condition at an oil and gas site. Super-emitters can

be caused by valves and hatches that are stuck open, flares that are blown out (so gas simply is vented, rather than being combusted), or other abnormal operating conditions at a site. Alvarez et al. noted that these types of emissions are probably the cause for much of the “missing emissions” that are observed from oil and gas sites, but not reflected in inventories. Frequent and regular surveying of facilities for leaks using instruments that detect methane and other hydrocarbons in natural gas can help reduce needless toxic emissions.

Replacement of gas-driven pneumatic equipment.

Traditionally, oil and gas operations have relied heavily upon automated equipment which uses pressurized natural gas to pump liquids or open and shut valves. This was particularly useful at isolated sites which did not have power from the grid available. Since the equipment is using the pressure of the gas to do work, it is designed to release the gas into the air as it works. Across the industry, pneumatic equipment emits a huge amount of methane pollution – over two million metric tons per year. Replacing high-emitting pneumatic equipment with zero-emitting equipment will greatly reduce toxic emissions.

Reducing venting from storage tanks. At most oil and gas production well sites, oil and condensate are separated from gas and collected in tanks, where it is stored until it is trucked away. During this process, methane and other air pollutants, including air toxics, dissolved in the oil or condensate will evaporate. Without controls to limit emissions, these pollutants are released into the air. These emissions can be controlled by capturing the stream of pollutants and using specialized compressors to inject the hydrocarbons into the natural gas pipelines at the well sites. Alternatively, gas can be incinerated (flared), largely preventing release of many of these air pollutants. Since incinerators emit CO₂ and other pollutants, and they waste the energy contained in the gas that they destroy, incineration is clearly not as beneficial an option as capturing gas, but it is far better than venting the gas.

Minimizing emissions from well completions. When oil and gas wells are hydraulically fractured, large volumes of water, sand, and chemicals are pumped into the well at high pressure, fracturing the rocks containing the oil and gas. The next step is to allow this liquid to flow back to the surface. However, the liquid is mixed with significant amounts of natural gas, which was typically vented to the atmosphere – resulting in large emissions of methane and toxic air pollutants – before states and U.S. EPA put in place rules requiring operators to control emissions of this gas by capturing or flaring it. These rules have reduced emissions, but the rules grant industry a great deal of flexibility in the way they are applied, and there is reason to believe industry is abusing this flexibility in some cases. Future regulations should ensure that operators diligently apply emissions controls to truly minimize emissions. Measurements have confirmed that when operators carefully work to limit emissions from well completions, emissions will be quite low – a 99% reduction compared to uncontrolled completions.

Compressors and dehydrators. In general, this equipment is designed to release gas, which includes both methane and toxic air pollutants. Compressors vent gas that passes through seals for moving parts (which are not designed to be hermetic), and dehydrators release hydrocarbon pollutants, including methane and significant quantities of toxics, as they vent the water vapor that they remove from natural gas. These emission points can be effectively controlled, and rules in several jurisdictions require operators to do so for certain dehydrators and compressors. However, EPA's current nationwide standards exempt thousands of older compressors and only cover larger dehydrators at certain large sites. There are a number of approaches to reducing emissions from dehydrator venting, such as adjusting circulation

rates of the glycol fluid; routing the vent gas to a burner used to heat the glycol, so toxics are combusted; and routing emissions to a flare or incinerator. The emissions from compressors can also easily be reduced or eliminated by employing a mix of modern seal design, capture of gas that escapes from seals so it can be utilized, and proper maintenance practices.

Reducing venting and flaring of gas from oil wells.

As oil production has boomed in the Permian Basin in Texas and New Mexico and in the Bakken formation in North Dakota, wells have been drilled and completed so rapidly that the gas these wells co-produce overwhelms the pipelines and other infrastructure needed to handle and transport it. In some cases, new oil wells are built without any gas infrastructure. As a result, many regulators allow oil producers to simply flare off this gas, rather than requiring operators to plan oil development so that gas infrastructure keeps pace with well drilling or utilize alternative approaches to handle gas when pipelines are not available. An even more harmful practice is simply dumping gas from oil wells into the air (venting), without even flaring it off. This is more commonplace at older wells, but it certainly happens at newer wells too; high rates of unlit or malfunctioning flares have been observed in the Permian basin.¹⁸

Reducing venting during maintenance operations.

Natural gas operators routinely vent wells and equipment before performing maintenance work. Blowdown is the routine venting of gas that is accumulated in oil and gas process equipment to relieve pressure. This process can be planned or unplanned and releases large amounts of gas into the air if it is not directed to the flare for combustion. Wells are vented primarily to make it quicker and easier to get water out of wells in a process referred to as “wellbore liquids unloading”. Numerous technologies and management practices have been identified to reduce or eliminate emissions from this practice. At least two states have also put in place regulations requiring operators to generally use ‘best practices’ to minimize emissions, however these regulations lack clear performance standards, and their benefits are difficult to quantify. More defined and enforceable emissions standards to eliminate unwarranted toxic air pollution from this practice are needed.

While these measures would achieve important reductions in emissions of air toxics as a co-benefit of methane reductions, EPA should also review its regulations for toxic pollutants emitted throughout the oil and gas supply chain to ensure they are protecting local communities.

Appendix

A. Counties with Cancer Risk above EPA's Level of Concern: *In order of population from most populous to least populous¹⁹*

State	County	2020 Population
PA	Allegheny	1,211,358
TX	Denton	919,324
CO*	Denver	735,538
CO*	Arapahoe	657,452
CO*	Jefferson	583,283
CO*	Adams	519,883
CO*	Larimer	360,428
PA	Westmoreland	347,087
CO*	Weld	333,983
CO*	Boulder	327,479
GA	Henry	239,139
LA	Caddo	237,479
PA	Lackawanna	208,989
PA	Washington	206,803
NY	Broome	189,420
PA	Butler	189,135
TX	Johnson	179,575
TX	Midland	177,863
TX	Ector	167,701
PA	Beaver	162,575
OK	Canadian	153,192
LA	Tangipahoa	136,765
PA	Fayette	128,126
LA	Bossier	127,275
TX	Gregg	124,229

State	County	2020 Population
NM*	San Juan	123,312
PA	Lycoming	113,209
LA	Terrebonne	109,859
PA	Mercer	108,545
WV	Monongalia	106,819
LA	Lafourche	97,596
IA	Dallas	96,963
TX	Victoria	91,936
PA	Indiana	83,664
OK	Payne	81,755
CO*	Broomfield	72,236
NM*	Lea	71,830
TX	Wise	71,084
WV	Harrison	66,870
TX	Harrison	66,386
OH	Belmont	65,932
OH	Jefferson	64,939
PA	Armstrong	64,162
OK	Garfield	60,366
CO*	Garfield	60,366
PA	Bradford	60,221
NM*	Eddy	58,418
KY	Pike	57,057
CO*	La Plata	56,564
WV	Marion	55,962

* State level rules that were not included in EPA's 2023 projection may result in lower emissions and/or cancer risk.
See page 15 on *Further Considerations*.

Table continued

State	County	2020 Population
OK	Grady	55,906
TX	Rusk	54,324
TX	Wilson	52,023
OK	Logan	48,777
OK	Carter	48,353
NY	Tioga	47,904
OK	Osage	46,642
LA	Lincoln	46,552
TX	Wood	46,291
TX	Chambers	45,590
OK	Pittsburg	43,679
PA	Jefferson	43,108
OK	Stephens	43,100
TX	Upshur	42,166
OK	McClain	41,348
WV	Ohio	41,182
PA	Tioga	40,381
PA	McKean	40,333
PA	Susquehanna	40,006
WV	Wayne	39,054
PA	Warren	38,911
OH	Guernsey	38,779
ND	Williams	38,700
VA	Prince George	38,686
OK	Pontotoc	38,397
PA	Clarion	38,305
PA	Clinton	37,957
LA	Webster	37,943
TX	Howard	36,540
PA	Greene	35,621
OK	Lincoln	35,045

State	County	2020 Population
KY	Floyd	34,974
WV	Preston	33,380
ND	Stark	32,107
WV	Marshall	30,103
PA	Elk	29,607
CO*	Morgan	28,941
OK	Caddo	28,684
OK	Custer	28,648
WV	Hancock	28,571
WV	Jackson	28,453
OK	Garvin	27,691
LA	De Soto	27,650
OH	Carroll	26,897
LA	West Baton Rouge	26,792
PA	Wyoming	26,557
KY	Bell	25,482
KY	Perry	25,465
TX	Shelby	24,915
MI	Otesego	24,765
OK	Seminole	24,248
WV	Upshur	24,230
MI	Antrim	23,449
TX	Limestone	23,340
TX	Panola	23,187
LA	Plaquemines	23,113
WV	Mingo	22,951
TX	Hockley	22,921
LA	Union	22,170
TX	Gaines	21,996
WV	Brooke	21,674
LA	Assumption	21,621

* State level rules that were not included in EPA's 2023 projection may result in lower emissions and/or cancer risk.
See page 15 on *Further Considerations*.

Table continued

State	County	2020 Population
TX	Tyler	21,591
OK	Beckham	21,468
KY	Letcher	21,213
WV	Boone	21,055
TX	Gonzales	20,948
UT	Carbon	20,760
VA	Buchanan	20,613
TX	Lavaca	20,216
TX	DeWitt	20,174
WV	Lincoln	20,043
TX	Montague	19,962
UT	Duchesne	19,874
TX	Freestone	19,874
LA	East Feliciana	18,882
TX	Andrews	18,879
IL	Crawford	18,512
OK	Marshall	17,114
WV	McDowell	16,916
WV	Taylor	16,699
TX	Scurry	16,662
AR	Van Buren	16,541
PA	Potter	16,453
WV	Lewis	15,805
TX	Pecos	15,718
TX	Karnes	15,562
LA	Claiborne	15,508
ND	McKenzie	15,242
OH	Harrison	15,014
WV	Wetzel	14,904
TX	Jackson	14,854
KY	Knott	14,512
OH	Noble	14,364

State	County	2020 Population
TX	Zapata	14,172
VA	Dickenson	14,078
OH	Monroe	13,586
WV	Roane	13,482
OK	Hughes	13,126
TX	Camp	13,060
LA	Bienville	12,983
TX	Dawson	12,974
OK	Haskell	12,652
KS	Allen	12,399
TX	Live Oak	12,324
TX	Terry	12,183
MO	Bollinger	12,111
TX	Ward	12,097
KY	Magoffin	12,017
TX	Zavala	11,840
OK	Okfuskee	11,765
MT	Richland	11,043
KY	Martin	11,031
OK	Washita	10,830
ND	Mountrail	10,502
OK	Love	10,230
OK	Latimer	10,132
TX	Marion	9,960
TX	Dimmit	9,925
WV	Ritchie	9,499
MI	Montmorency	9,337
TX	Stephens	9,334
TX	Yoakum	8,702
OK	Woods	8,687
WV	Tyler	8,533
WV	Doddridge	8,368

Table continued

State	County	2020 Population
KS	Wilson	8,362
WV	Clay	8,341
LA	Red River	8,286
TX	San Augustine	8,248
TX	Winkler	7,887
WV	Gilmer	7,811
TX	Goliad	7,626
OK	Major	7,579
TX	La Salle	7,500
WV	Pleasants	7,438
KS	Grant	7,077
LA	Cameron	7,003
KS	Kingman	6,974
PA	Forest	6,965
WV	Calhoun	6,945
TX	Refugio	6,877
CO*	Rio Blanco	6,342
ND	Bottineau	6,287
TX	Garza	6,222
OK	Jefferson	5,949
PA	Sullivan	5,913
TX	Martin	5,816
OK	Alfalfa	5,718
KS	Stevens	5,388
KS	Harper	5,336
TX	Wheeler	4,946
OK	Dewey	4,815
TX	Crane	4,765

State	County	2020 Population
ND	Dunn	4,465
OK	Grant	4,372
KS	Barber	4,358
PA	Cameron	4,330
KS	Haskell	3,923
OK	Ellis	3,830
TX	Hemphill	3,777
KS	Kearny	3,745
TX	Upton	3,623
OK	Harper	3,611
OK	Roger Mills	3,570
TX	Crockett	3,513
KS	Woodson	3,015
TX	Cochran	2,897
MT	Fallon	2,826
ND	Renville	2,283
ND	Divide	2,277
ND	Burke	2,118
TX	Irion	1,564
TX	Glasscock	1,439
TX	Sterling	1,315
ND	Billings	890
TX	Kent	786
TX	McMullen	721
TX	Borden	706
TX	Loving	181
Total Population: 13,999,840		

* State level rules that were not included in EPA's 2023 projection may result in lower emissions and/or cancer risk. See page 15 on *Further Considerations*.

B. Counties with Cancer Risk above EPA's Level of Concern: *By State*

Arkansas

Van Buren

Colorado*

Adams

Arapahoe

Boulder

Broomfield

Denver

Garfield

Jefferson

La Plata

Larimer

Morgan

Rio Blanco

Weld

Georgia

Henry

Iowa

Dallas

Illinois

Crawford

Kansas

Allen

Barber

Grant

Harper

Haskell

Kearny

Kingman

Stevens

Wilson

Woodson

Kentucky

Bell

Floyd

Knott

Letcher

Magoffin

Martin

Perry

Pike

Louisiana

Assumption

Bienville

Bossier

Caddo

Cameron

Claiborne

De Soto

East Feliciana

Lafourche

Lincoln

Plaquemines

Red River

Tangipahoa

Terrebonne

Union

Webster

West Baton Rouge

Michigan

Antrim

Montmorency

Otsego

Missouri

Bollinger

Montana

Fallon

Richland

North Dakota

Billings

Bottineau

Burke

Divide

Dunn

McKenzie

Mountrail

Renville

Stark

Williams

New Mexico*

Eddy

Lea

San Juan

New York

Broome

Tioga

Ohio

Belmont

Carroll

Guernsey

Harrison

Jefferson

Monroe

Noble

Oklahoma

Alfalfa

Beckham

Caddo

Canadian

Carter

Coal

Custer

Dewey

Ellis

Garfield

Garvin

Grady

Grant

Harper

Haskell

Hughes

Jefferson

Kingfisher

Latimer

Lincoln

Logan

Love

Major

Marshall

McClain

Okfuskee

Osage

Pawnee

Payne

Pittsburg

Pontotoc

Roger Mills

Seminole

Stephens

Washita

Woods

* State level rules that were not included in EPA's 2023 projection may result in lower emissions and/or cancer risk.
See page 15 on *Further Considerations*.

Pennsylvania

Allegheny
Armstrong
Beaver
Bradford
Butler
Cameron
Clarion
Clinton
Elk
Fayette
Forest
Greene
Indiana
Jefferson
Lackawanna
Lycoming
McKean
Mercer
Potter
Sullivan
Susquehanna
Tioga
Warren
Washington
Westmoreland
Wyoming

Texas

Andrews
Borden
Camp
Chambers
Cochran
Crane
Crockett
Dawson
Denton
DeWitt
Dimmit
Ector
Freestone
Gaines
Garza
Glasscock
Goliad
Gonzales
Gregg
Harrison
Hemphill
Hockley
Howard
Irion
Jackson
Johnson
Karnes
Kent
La Salle
Lavaca
Limestone
Live Oak
Loving

(Texas continued)

Marion
Martin
McMullen
Midland
Montague
Panola
Pecos
Reeves
Refugio
Rusk
San Augustine
Scurry
Shelby
Stephens
Sterling
Terry
Tyler
Upshur
Upton
Victoria
Ward
Wheeler
Wilson
Winkler
Wise
Wood
Yoakum
Zapata
Zavala

Utah

Carbon
Duchesne

Virginia

Buchanan
Dickenson
Prince George

West Virginia

Barbour
Boone
Brooke
Calhoun
Clay
Doddridge
Gilmer
Hancock
Harrison
Jackson
Lewis
Lincoln
Marion
Marshall
McDowell
Mingo
Monongalia
Ohio
Pleasants
Preston
Ritchie
Roane
Taylor
Tyler
Upshur
Wayne
Wetzel
Wirt

C. Calculating 2023 Cancer Risk

The results of our analysis are based on the modeled cancer risk presented by AirToxScreen in its 2017 risk assessment. We made two adjustments to this data to more fully reflect the impact of the oil and gas industry. We combined EPA's risk assessment for oil and gas "non-point" sources with EPA's data on toxic emissions from oil and gas "point" sources, and we used EPA's 2023 emissions inventory projection to estimate 2023 health impacts.

The AirToxScreen results as presented only include "non-point" emissions sources in the oil and gas industry—these are the large number of relatively small and dispersed facilities and oil and gas activities, such as oil and gas well pads and smaller compressor stations. The cancer risk figures by tract, county, and state can be downloaded directly from the EPA website.²⁰ These results represent the impact from non-point sources, which make up the majority of toxic emissions from the oil and gas industry.

However, emissions from the less numerous but larger "point" sources are also significant. To determine the full impact of the oil and gas industry, we estimated the impact of emissions from oil and gas point sources and added that to the impacts from non-point sources. Since the AirToxScreen calculation of point source cancer risk includes risk due to emissions from all industries, we used the following methodology to estimate the cancer risk specifically from oil and gas point sources:

- [Download data](#) from the National Emissions Inventory by pollutant for Oil and Gas Point sources and All Point sources by county.²¹
 - As downloaded, the Oil and Gas Point Source data includes emissions for facilities with the NAICS Codes and facility descriptions listed below.

NAICS Code	Facility Description
211	Oil and Gas Extraction
2111	Oil and Gas Extraction
2212	Natural Gas Distribution
4862	Pipeline Transportation of Natural Gas
21111	Oil and Gas Extraction
22121	Natural Gas Distribution
48611	Pipeline Transportation of Crude Oil
48621	Pipeline Transportation of Natural Gas
211111	Crude Petroleum and Natural Gas Extraction
211112	Natural Gas Liquid Extraction
213111	Drilling Oil and Gas Wells
213112	Support Activities for Oil and Gas Operations

NAICS Code	Facility Description
221210	Natural Gas Distribution
486110	Pipeline Transportation of Crude Oil
486210	Pipeline Transportation of Natural Gas
21112	Crude Petroleum Extraction
4861	Pipeline Transportation of Crude Oil
21113	Natural Gas Extraction
211130	Natural Gas Extraction
211120	Crude Petroleum Extraction
237120	Oil and Gas Pipeline and Related Structures Construction
23712	Oil and Gas Pipeline and Related Structures Construction

- Based on these NAICS codes, each entrant in the All Point sources by county dataset was categorized as an "Oil and Gas" or "Non-Oil and Gas" source. Continuing with this dataset, we multiply the annual pollutant tonnage for each pollutant by the pollutant's toxicity to get the weighted sum of toxicity for each pollutant from each county. To calculate the cancer risk, we used Unit Risk Estimate^h (URE) as an estimate of pollutant toxicity. The EPA uses URE in its dose-response assessments for chronic exposure to toxic air pollutants, and it periodically re-examines and updates the values for individual substances as knowledge improves.²²
 - All reported pollutants with an EPA designated URE were included as part of this analysis to calculate the cancer risk from Oil and Gas point sources.

^h "The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/m³ in air." See: <https://www.epa.gov/AirToxScreen/airtoxscreen-glossary-terms>.

- Calculate the percentage of point source cancer toxicity in each county that come from oil and gas facilities by taking the percentage of total (all-source) emissions toxicity in each county resulting from oil and gas emissions.
- Multiply this percentage by the total cancer risk in each county from all point sources provided in the 2017 AirToxScreen Assessment. This is the estimate of cancer risk in each county from oil and gas point sources.
- For each county, add the estimate of cancer risk from oil and gas point sources to the cancer risk for oil and gas non-point sources that was presented directly in the 2017 AirToxScreen Assessment to get the total 2017 oil and gas cancer risk.

The total estimate of 2017 oil and gas cancer risk, as calculated using this methodology, averaged 26% higher than the risk from non-point sources alone. As a result of adding in oil and gas point sources, the estimate of the number of counties that exceeded the threshold of EPA's level of concern for cancer risk due to oil and gas emissions in 2017 increased from 170 to 236.

Next, we know that the oil and gas industry has changed substantially from 2017 to today, both in terms of the volume of oil and gas being produced and the geographic distribution of oil and gas production. For example, oil production has increased 20%, from 3,415 million barrels in 2017 to 4,083 million barrels in 2021.²³ Gas production has increased 25%, from 33.29 trillion cubic feet in 2017 to 41.48 trillion cubic feet in 2021.²⁴ Thus, a risk assessment based on 2017 emissions does not accurately reflect the current impacts of the oil and gas industry. We used NEI's projections for 2017 and 2023 to estimate the change in risk between 2017 and 2023.ⁱ

- We downloaded EPA's 2023 projection of toxic emissions by county for both oil and gas point and non-point sources.^j
- We calculated weighted toxicity for oil and gas in each county for both point and non-point sources (using the same URE factor and method as above). To simplify analysis, we focused on only the most consequential pollutant species: benzene, formaldehyde, and acetaldehyde. These three pollutants account for 96% of national cancer risk in the oil and gas sector.
- For each county we compared the total 2023 toxicity for the 3 pollutants (benzene, formaldehyde, acetaldehyde) to the total 2017 toxicity for the 3 pollutants, and calculated percent increase or decrease for cancer toxicity.
- We multiplied this percent increase (or decrease) by the 2017 oil and gas risk estimate for the cancer risk. This is the 2023 cancer risk estimate.
 - Note: in cases where the change in the URE weighted emissions between 2017 and 2023 was below 0.2%, we assume that 2023 risk is essentially the same as 2017 and therefore simply use the 2017 value.

The NEI 2023 emissions projection accounts for the assumptions and regulations reflected in the Annual Energy Outlook 2021, EPA's New Source Performance Standards (NSPS) for oil and gas sources, and future year inventories for Western Regional Air Partnership (WRAP) states.^k The NEI 2023 emissions projection for oil and gas industry is an underestimate of overall emissions since current Short-Term Energy Outlook (STEO) projection of 2023 oil production is 3% higher than the projection in AEO 2021, and current STEO projection of 2023 gas production is 6% higher than the projection in AEO 2021.^l In New Mexico and Colorado, this nationwide underestimate of 2023 emissions may be offset to some degree by recently adopted state standards for oil and gas pollutants, which will reduce emissions in 2023 to some degree. These state regulations were not accounted for in 2021 when EPA prepared the emissions projections we used for this analysis.

ⁱ Note, EPA does not publish a projection for each year, the 2023 projection reflects the closest possible case to current year emissions.

^j Using the 2016 NEI v2 as a starting point, the U.S. EPA developed a 2023 future case by projecting population and production growth. Technical Support Document: https://www.epa.gov/system/files/documents/2022-02/2016v2_emismod_tsd_february2022.pdf. Files Downloaded from: <https://gaftp.epa.gov/Air/emismod/2016/v2/2023emissions/>

^k Refer to page 157 of the "Technical Support Document (TSD): Preparation of Emissions Inventories for the 2016v2 North American Emissions Modeling Platform" for a description of the projection methods for 2023: https://www.epa.gov/system/files/documents/2022-02/2016v2_emismod_tsd_february2022.pdf

^l 2021 Annual Energy Outlook (AEO) projected 2023 oil production to be 12.3 million barrels per day while Short-Term Energy Outlook (STEO) released in August 2022 projected oil production to be 12.7 million barrels per day resulting in a 3% difference in production estimates for 2023. Similarly, 2021 AEO projected 2023 natural gas production to be 34.02 trillion cubic feet (Tcf) while STEO released in August 2022 projected natural gas production to be 36.05 Tcf resulting in a 6% difference. <https://www.eia.gov/outlooks/aeo/data/browser/#/?id=13-AEO2022&sourcekey=0>

References

- ¹ 4 IPCC, WGI, Full Report Table 7.15 (2021), https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf.
- ² US EPA. Overview of Greenhouse Gases. Methane Emissions. Available at: [https://www.epa.gov/ghgemissions/overview-greenhouse-gases#:~:text=Methane%20Emissions,-Properties%20of%20Methane&text=In%202020%2C%20methane%20\(CH4,sources%20such%20as%20natural%20wetlands](https://www.epa.gov/ghgemissions/overview-greenhouse-gases#:~:text=Methane%20Emissions,-Properties%20of%20Methane&text=In%202020%2C%20methane%20(CH4,sources%20such%20as%20natural%20wetlands).
- ³ Clean Air Task Force. "Oil & Gas Methane: Mapping the Path to a 65% Reduction" (2020). <https://www.catf.us/resource/reducing-methane-from-oil-and-gas/>
- ⁴ US EPA. Air Toxics Screening Assessment: AirToxScreenLimitations. Available at: <https://www.epa.gov/AirToxScreen/airtoxscreen-limitations>.
- ⁵ National Research Council. *Science and Decisions: Advancing Risk Assessment*. Washington, DC: The National Academies Press, 2009. doi:10.17226/12209. Janssen, Sarah, et al. (2012) "Strengthening Toxic Chemical Risk Assessments to Protect Human Health." Available at: <https://www.nrdc.org/sites/default/files/strengthening-toxic-chemical-risk-assessments-report.pdf>.
- ⁶ Brown, H.P. (2011) "Composition of Natural Gas for use in the Oil and Natural Gas Sector Rulemaking." Available at <http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2010-0505-0084>.
- ⁷ McKenzie LM, Blair B, Hughes J, Allshouse WB, Blake NJ, Helmig D, Milmoe P, Halliday H, Blake DR, Adgate JL. "Ambient Nonmethane Hydrocarbon Levels Along Colorado's Northern Front Range: Acute and Chronic Health Risks." *Environ Sci Technol*. 2018 Apr 17;52(8):4514-4525. doi: 10.1021/acs.est.7b05983. Epub 2018 Apr 9. Erratum in: *Environ Sci Technol*. 2018 Dec 18;52(24):14568-14569. PMID: 29584423. <https://pubmed.ncbi.nlm.nih.gov/29584423/>
- ⁸ Diane A. Garcia-Gonzales, Seth B.C. Shonkoff, Jake Hays, Michael Jerrett. "Hazardous Air Pollutants Associated with Upstream Oil and Natural Gas Development: A Critical Synthesis of Current Peer-Reviewed Literature." *Annual Review of Public Health* 2019 40:1, 283-304. Available at: <https://www.annualreviews.org/doi/10.1146/annurev-publhealth-040218-043715>
- ⁹ Drew R. Michanowicz, Archana Dayalu, Curtis L. Nordgaard, Jonathan J. Buonocore, Molly W. Fairchild, Robert Ackley, Jessica E. Schiff, Abbie Liu, Nathan G. Phillips, Audrey Schulman, Zeyneb Magavi, and John D. Spengler. "Home is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User." *Environmental Science & Technology* 2022 56 (14), 10258-10268 DOI: 10.1021/acs.est.1c08298. Available at: <https://pubs.acs.org/doi/10.1021/acs.est.1c08298>.
- ¹⁰ US EPA. "AirToxScreen Glossary of Terms." Available at: <https://www.epa.gov/AirToxScreen/airtoxscreen-glossary-terms>.
- ¹¹ US EPA. Benzene Hazard Summary. Available at: <https://www.epa.gov/sites/default/files/2016-09/documents/benzene.pdf>.
- ¹² Holder C, Hader J, Avanasri R, Hong T, Carr E, Mendez B, Wignall J, Glen G, Guelden B, Wei Y. "Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations." *J Air Waste Manag Assoc*. 2019 Dec;69(12):1503-1524. doi: 10.1080/10962247.2019.1680459. Epub 2019 Nov 7. PMID: 31621516. Available at: <https://pubmed.ncbi.nlm.nih.gov/31621516/>.
- ¹³ US EPA. Formaldehyde Hazard Summary. Available at: <https://www.epa.gov/sites/default/files/2016-09/documents/formaldehyde.pdf>.
- ¹⁴ US EPA. Acetaldehyde Hazard Summary. Available at: <https://www.epa.gov/sites/default/files/2016-09/documents/acetaldehyde.pdf>.
- ¹⁵ US EPA. 1,3-Butadiene Hazard Summary. Available at: <https://www.epa.gov/sites/default/files/2016-08/documents/13-butadiene.pdf>.
- ¹⁶ US EPA. Methanol Hazard Summary. Available at: <https://www.epa.gov/sites/default/files/2016-09/documents/methanol.pdf>.
- ¹⁷ Yuanlei Chen, Evan D. Sherwin, Elena S.F. Berman, Brian B. Jones, Matthew P. Gordon, Erin B. Wetherley, Eric A. Kort, and Adam R. Brandt. "Quantifying Regional Methane Emissions in the New Mexico Permian Basin with a Comprehensive Aerial Survey." *Environmental Science & Technology* 2022 56 (7), 4317-4323. DOI: 10.1021/acs.est.1c06458. Available at: <https://energy.stanford.edu/news/stanford-led-study-methane-leaks-are-far-worse-estimates-least-new-mexico-there-s-hope>.
- ¹⁸ Chen, Chen, David C. McCabe, Lesley E. Fleischman, and Daniel S. Cohan. 2022. "Black Carbon Emissions and Associated Health Impacts of Gas Flaring in the United States" *Atmosphere* 13, no. 3: 385. <https://doi.org/10.3390/atmos13030385>
- ¹⁹ U.S. Census Bureau, Population Division. (2020) Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2020. Available at: <https://www.census.gov/data.html>
- ²⁰ US EPA. 2017 AirToxScreen Assessment Result. "2017 AirToxScreen National Cancer Risk by Source Group" & "2017 AirToxScreen National Respiratory Hazard Index by Source Group ". Available at: <https://www.epa.gov/AirToxScreen/2017-airtoxscreen-assessment-results>
- ²¹ US EPA. 2017 National Emissions Inventory (NEI) Data. Available at: <https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data>.
- ²² US EPA. "AirToxScreen Frequent Questions, Q10: How does EPA estimate cancer risk?" Available at: <https://www.epa.gov/AirToxScreen/airtoxscreen-frequent-questions>.
- ²³ US EIA. U.S. Field Production of Crude Oil. Available at: <http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=p&s=mcrfpus1&f=a>.
- ²⁴ US EIA. Natural Gas Gross Withdrawals and Production. Available at: http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm.