CAUSE FOR PAUSE
Scientific Research on Fracking’s Health Risks

ANN ALEXANDER, SENIOR ATTORNEY, NRDC

AMERICAN MEDICAL STUDENTS ASSOCIATION • CLIMATE CHANGE WEEK
OCTOBER 5, 2015
• **Overview** of fracking public health risks
• **Scientific research** documenting potential risks
• **Policy recommendations** to address the risk
Who we are

Members and online activists: 2 million +

Staff: Close to 500, mix of scientists, attorneys, policy advocates

Offices: New York, Washington DC, San Francisco, Santa Monica, Chicago, Beijing

Issues and priorities:
- Climate change
- Green energy
- Oceans
- Wildlife/wild places
- Preventing pollution
- Water
- Sustainable Communities
Fracking overview

Depletion of water resources

Hazardous chemicals; industry seeks trade secret protection

Out-of-zone fractures, disturbance of pollutants

Leaks, spills, volatilization

Air emissions

Leaks from disposal wells; impact on sewage treatment plants; seismicity
Health risks: who is concerned

The National Institute for Occupational Safety and Health (NIOSH)

National Environmental Public Health Tracking Network

Pediatric Environmental Health Specialty Units

Agency for Toxic Substances and Disease Registry
Areas of concern

**Air Quality**
- Diesel Particulate Matter (PM) (*respiratory and cardiovascular*)
- Ozone (*respiratory*)
- Air Toxics (*respiratory, neurological and immune system, carcinogens*)
- Silica (*lung disease*)

**Noise & Light Pollution**
- *Sleep disturbances, cardiovascular impacts*

**Public Safety**
- Accidents, Explosions, Fires, Seismicity

**Water and Soil Contamination**
- Spills, Leaks, Chemical Migration, and Waste Disposal
- Methane in Drinking Water (*explosive & asphyxiation hazard*)
## Air quality studies

<table>
<thead>
<tr>
<th>Study Title</th>
<th>Authors</th>
<th>Key Findings</th>
</tr>
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<tbody>
<tr>
<td>Source signature of volatile organic compounds (VOCs) from oil and natural gas operations in northeastern Colorado</td>
<td>Gilman, Jessica, Brian M. Lerner, William C. Kuster, and Joost de Gouw (2013)</td>
<td>Source of VOCs</td>
</tr>
<tr>
<td>A new look at methane and non-methane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin</td>
<td>Petron et al. (2014)</td>
<td>Levels of VOCs</td>
</tr>
<tr>
<td>Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study</td>
<td>Macey, Gregg P., Ruth Breech, Mark Chemaik, Caroline Cox, Denny Larson, Deb Thomas, and David O. Carpenter (2014)</td>
<td>Levels of VOCs/H₂S</td>
</tr>
<tr>
<td>Associations of Short-Term Exposure to Ozone and Respiratory Outpatient Clinic Visits — Sublette County, Wyoming, 2008–2011</td>
<td>Wyoming Dep’t of Public Health (2013)</td>
<td>O₃ impacts</td>
</tr>
</tbody>
</table>
Air quality studies: key findings

• Presence of proximate air toxics:
  - Levels of benzene and H₂S in proximity to operations (> 150m CO setback distance) exceeding levels in major urban areas
  - Inventories underestimated benzene emissions 4-9X

• Source of air pollution:
  - Source signatures indicate oil and gas production is a primary source of wintertime regional O₃ production
  - Source signatures indicate elevated PAH levels at nearby properties (.04-3.2 miles) are associated with gas extraction

• Health impact of proximate air pollution:
  - Elevated cancer risk in proximity (.5 miles) to wells, associated with VOCs
  - Elevated respiratory health care visits during ozone spikes in rural Wyoming (which exceeded LA basin spike levels)
  - Lifetime cancer risk of proximate PAH exposure > 2.9/10,000
  - Lifetime cancer risk of proximate formaldehyde exposure > 1/10,000
  - Levels of benzene, H₂S in proximity exceeding CDC/ATSDR risk levels
# Air quality studies: what we already know

## Table 2: Health impacts of the main air pollutants by target organ and system

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Target organ/system</th>
<th>carcinogen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Particulate matter (Pm)</strong></td>
<td></td>
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<tr>
<td>Diesel pM</td>
<td>Respiratory system; Cardiovascular system</td>
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<td>pM10 and smaller</td>
<td>Respiratory system; Cardiovascular system</td>
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<tr>
<td><strong>volatile organic compounds (vocs)</strong></td>
<td></td>
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<tr>
<td>Benzene</td>
<td>Brain and nervous system; Respiratory system; Fetal and child development; Reproductive system</td>
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<tr>
<td>Toluene</td>
<td>Fetal and child development; Liver; Kidney; Endocrine system; auditory system</td>
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<tr>
<td>Ethylbenzene</td>
<td>Brain and nervous system; Fetal and child development</td>
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<tr>
<td>Xylene</td>
<td>Brain and nervous system; Fetal and child development</td>
<td></td>
</tr>
<tr>
<td>Other VOCs (incl. Formaldehyde, Methanol)</td>
<td>Immune system; Respiratory system; Brain and nervous system; Fetal and child development; Liver; Kidney; Endocrine system</td>
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<tr>
<td><strong>other</strong></td>
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<tr>
<td>Hydrogen sulfide (H2S)</td>
<td>Respiratory system; Brain and nervous system; Gastrointestinal system</td>
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<tr>
<td>NOx</td>
<td>Respiratory system</td>
<td></td>
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<tr>
<td>Ozone (O3)</td>
<td>Respiratory system; Cardiovascular system</td>
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<tr>
<td>Respirable Silica</td>
<td>Respiratory system; Kidneys; Immune system</td>
<td></td>
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<tr>
<td>pAHs (incl. Naphthalene)</td>
<td>Immune system*, Reproductive system*, Brain and nervous system*; Developmental effects*</td>
<td></td>
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# Birth outcome studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td><em>Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania</em></td>
<td></td>
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<tr>
<td><em>Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado</em></td>
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<tr>
<td><em>Princeton/Columbia/MIT study</em></td>
<td></td>
</tr>
<tr>
<td>Janet Currie, Katherine Meckel, John Deutch, and Michael Greenstone (2014)</td>
<td>Birth weight, Apgar scores</td>
</tr>
</tbody>
</table>
Birth outcome studies: key findings

- **McKenzie study:** Frequency of congenital heart defects and possibly neural tube defects (but not oral clefts, preterm birth, and low birth weight) associated with well density.
  - Controlled for demographic, education, and behavioral information available in the vital records

- **Stacy study:** Frequency of low birth weight and small for gestational age associated with degree of maternal exposure.
  - Controlled for age, education, smoking history, WIC assistance, gestational diabetes, prenatal visits, pre-pregnancy weight, child’s gestational age, child’s gender

**Currie study:** Maternal proximity increased the likelihood of low birth weight from ~5.6% to >9%; and roughly doubled the chances of a low Apgar score to ~5%
  - Controlled for, *inter alia*, geographical differences in mothers' initial health characteristics, private vs. public water supply
  - No correlation with drinking water exposure
## Water quality studies

<table>
<thead>
<tr>
<th>Study Title</th>
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<th>Key Findings</th>
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</thead>
<tbody>
<tr>
<td>Methane contamination of drinking water accompanying gas-well drilling and</td>
<td>Osborn, Stephen G., Avner Vengosh, Nathaniel R. Warner, and Robert B.</td>
<td>Methane concentrations</td>
</tr>
<tr>
<td>hydraulic fracturing</td>
<td>Jackson (2011)</td>
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<tr>
<td>The effects of shale gas exploration and hydraulic fracturing on the</td>
<td>Vengosh, Avner, Nathaniel Warner, Rob Jackson, and Tom Darrah (2013)</td>
<td>Migration pathways; methane concentrations</td>
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<tr>
<td>quality of water resources in the United States</td>
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<tr>
<td>Estrogen and Androgen Receptor Activities of Hydraulic Fracturing</td>
<td>Kassotis, Christopher D., Donald E. Tillitt, J. Wade Davis, Annette M.</td>
<td>Levels of endocrine disruptors</td>
</tr>
<tr>
<td>Chemicals and Surface and Ground Water in a Drilling-Dense Region</td>
<td>Hormann, and Susan C. Nagel. (2014)</td>
<td></td>
</tr>
<tr>
<td>An Evaluation of Water Quality in Private Drinking Water Wells Near</td>
<td>Fontenot, Brian E., Laura R. Hunt, Zacariah L Hildenbrand., Doug D.</td>
<td>Levels of TDS, arsenic, selenium, strontium…</td>
</tr>
<tr>
<td>Analysis of BTEX Groundwater Concentrations from Surface Spills</td>
<td>Gross, Sherilyn A., Heather J. Avens, Amber M. Banducci, Jennifer</td>
<td>Levels of BTEX associated with spills</td>
</tr>
<tr>
<td>Associated with Hydraulic Fracturing Operations</td>
<td>Sahmel, Julie M. Panko, and Brooke E. Tvermoes (2013)</td>
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<tr>
<td>Gas on Drinking Water Resources</td>
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Water quality studies: key findings

• Methane migration:
  ➢ In active extraction areas (1+ wells within 1 km), average and max methane concentrations in drinking water wells increased with proximity
  ➢ Levels of methane were a potential explosion hazard
  ➢ Elevated shallow groundwater methane in proximity linked to wells
  ➢ Migration pathways exist between shallow and deep groundwater

• Groundwater contamination:
  ➢ Proximate groundwater sampling revealed greater incidence of androgens and estrogens
  ➢ Private well samples exceeding MCLs for TDS, arsenic, selenium, strontium, and barium increased with proximity
  ➢ BTEX levels elevated near spills, but can be reduced via remediation

• Systemic impacts:
  ➢ EPA: “Specific instances” of impacts, but no evidence of “widespread, systemic impacts” on drinking water resources
Public and occupational safety

Shale gas development linked to traffic accidents in Pennsylvania

Motor vehicle fatalities among oil and gas extraction workers

Occupational exposures to respirable crystalline silica during hydraulic fracturing
Esswein, Eric J, Michael Breitenstein, John Snawder, Max Kiefer, and W Karl Sieber (2013)

The 2001–Present Induced Earthquake Sequence in the Raton Basin of Northern New Mexico and Southern Colorado

Oklahoma’s recent earthquakes and saltwater disposal
F. Rall Walsh III and Mark D. Zoback (2015)

Earthquakes Induced by Hydraulic Fracturing in Poland Township, Ohio
Robert J. Skoumal, Michael R. Brudzinski, and Brian S. Currie (2015)

Earthquake hypocenters and focal mechanisms in central Oklahoma reveal a complex system of reactivated subsurface strike-slip faulting
Public and occupational safety: key findings

• Traffic accidents:
  - 1 additional well drilled per month increase truck accident frequency in counties by > 2%

• Worker safety:
  - Motor vehicle fatality rate in hydraulic fracturing industry 8.5X that of all private wage and salary workers
  - Gas industry has fatality rate 2 ½ X construction industry, 7X general industry rate

• Seismicity
  - Injection correlates with seismicity in CO, OK
  - Hydraulic fracturing correlates with seismicity in OH
  - Injection-induced seismicity “increased the probability for a damaging earthquake”
Oklahoma seismicity data (NYT/OK Geophysical Survey)

Quakes in Oklahoma

Oklahoma has seen a sharp rise in the number of earthquakes, most likely related to the disposal of wastewater from oil and gas production underground.  

APRIL 3, 2015

- Quake with magnitude 3 and above
- Below 3

- 2000: 1
- 2001: 2
- 2002: 2
- 2003: 3
- 2004: 3
- 2005: 21
- 2006: 21
- 2007: 29
- 2008: 24
- 2009: 50
- 2010: 1,061
- 2011: 1,543
- 2012: 1,028
- 2013: 5,061
- 2014: 5,417

Where 94% of disposal wells are...
Chemicals used in fracking: key findings

Natural Gas Operations from a Public Health Perspective
T. Colborn, D. Kwiatkowski, K. Schultz, and M. Bachran (2011)

- Reviewed 944 (non-trade secret protected) products containing 632 chemicals
- 75% could affect skin, eyes, and respiratory and gastrointestinal systems.
- ~40-50% could affect the brain/nervous system, immune and cardiovascular systems, and kidneys
- 37% could affect the endocrine system
- 25% could cause cancer and mutations

Chemicals Used in Hydraulic Fracturing
House of Representatives, Energy and Commerce Cmte. Minority Staff (2011)

- Reviewed 2,500 (mostly non-trade secret protected) products, 750 chemicals
- 29 chemicals, in 650 products, are either:
  1. Known or possible carcinogens
  2. Regulated under the Safe Drinking Water Act for risks to human health, or
  3. Listed as hazardous air pollutants under the Clean Air Act
Disclosure to health professionals: the big chill

- State trade secret laws allow companies to keep chemical identities secret.
- Limited disclosure to health professionals
- Restrictive and vague re-disclosure provisions create conflicting obligations.
Overall health indicia

Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates
Thomas Jemielita, George L. Gerton, Matthew Neidell, Steven Chillrud, Beizhan Yan, Martin Stute, Marilyn Howarth, Pouné Saberi, Nicholas Fausti, Trevor M. Penning, Jason Roy, Kathleen J. Propert, Reynold A. Panettieri, Jr (2015)

Hospitalizations
Overall health indicia: key findings

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Thomas Jemielita, George L. Gerton, Matthew Neidell, Steven Chillrud, Beizhan Yan, Martin Stute, Marilyn Howarth, Pouné Saberi, Nicholas Fausti, Trevor M. Penning, Jason Roy, Kathleen J. Propert, Reynold A. Panettieri, Jr (2015)

- **Findings:**
  - **Hospitalizations** for heart conditions, neurological illness, skin conditions, cancer, and urologic problems associated with well density.
  - **Example:** well density > .79/km² associated with an excess 9.51 inpatient admissions for heart conditions within a zip code

- **Method:**
  - **Used databases** that contained over 198,000 hospitalizations from 2007-2011
  - **Compared** inpatient hospitalization rates against wells per zip code and per km²

- **Limitations (self-identified):**
  - **Zip code analysis** is less precise than evaluating individuals
  - **Identifies association only** not causation
What we know: ongoing research raises concerns

- **Air quality:**
  - **Evidence:** Fracturing contributes to locally harmful levels of air toxics, O₃ precursors
  - **What we don’t know:** What are the on-site sources of these pollutants? What are the actual impacts on public health? Can they be mitigated?

- **Birth outcomes:**
  - **Evidence:** Proximity to O&G operations associated with adverse birth outcomes
  - **What we don’t know:** Does the association signify causation? If so, what is the specific cause and mode of exposure?

- **Water quality:**
  - **Evidence:** Documentation of migration pathways, correlation with local contamination
  - **What we don’t know:** Causation, frequency, severity, public health impacts

- **Seismicity:**
  - **Evidence:** Injection and possibly fracturing have caused low-level seismicity
  - **What we don’t know:** Is there potential for more severe induced seismicity? Why some places and not others?
Data uncertainty: air pollution sources

<table>
<thead>
<tr>
<th>Source</th>
<th>NOx</th>
<th>VOC</th>
<th>PM</th>
<th>Air Toxics</th>
<th>Data Quality</th>
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<tr>
<td><strong>Well development</strong></td>
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<tr>
<td>Drill Rigs</td>
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<td>Medium</td>
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<td>Frac Pumps</td>
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<td>Truck Traffic</td>
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<td>Completion Venting</td>
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<td>Poor</td>
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<td>Frac ponds</td>
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<td>●</td>
<td>Poor</td>
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<td><strong>Gas Production</strong></td>
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<td>Compressor Stations</td>
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<td>●</td>
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<td>Medium</td>
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<td>Wellhead compressors</td>
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<td>Medium</td>
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<td>Heaters and dehydrators</td>
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<td>Blowdown venting</td>
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<td>Condensate Tanks</td>
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<td>Fugitives</td>
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<td>Pneumatics</td>
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<td>Poor</td>
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● = major source
● = minor source
“If an action has a suspected risk of causing harm, in the absence of scientific consensus that the action is not harmful, the burden of proof that it is not harmful falls on those taking an action.”
NRDC policy position

• “Unconventional development using advanced fracking methods poses threats to water, air, land, and the health of communities.”

• “NRDC supports moratoria on fracking to give states and communities time to fully evaluate the risks and determine whether it’s possible -- and if so, how -- to protect against them.”

• “Where moratoria are not in place, we are also fighting for state and federal safeguards...”

• “Communities should have the right to protect themselves when their state and federal governments fail them...”
Some policy recommendations

- **Moratorium** until more is known about risks and ability to mitigate them.
- **Heightened air emissions controls:** address both flowback and fugitive emissions from all sources
- **Larger setbacks:** should be based on emerging air quality research
- **Transparency:** end trade secret protection of additives, require extensive application information and full reporting
- **Discretion to protect public health:** agency authority to deny permits that may not be protective despite compliance
- **Robust enforcement:** includes both sufficient agency resources and public rights to challenge permits and bring citizen suits
- **Presumption of liability:** reverse the burden of proof for water contamination
- **Collection of baseline data:** mandatory pre- and post-frac testing
- **Federal regulatory programs:** an end to exemptions for oil and gas
- **Community self-determination:** communities should retain traditional authority to limit, zone, and prohibit risky activities within their borders
Thank you

questions?
MOVING FORWARD ON METHANE:
Climate and Health Benefits from Cleaning Up the Oil and Gas Industry

MELEAH GEERTSMA, J.D., M.P.H.
SENIOR ATTORNEY, NRDC

AMERICAN MEDICAL STUDENTS ASSOCIATION • CLIMATE CHANGE WEEK
OCTOBER 5, 2015
NRDC’s Climate and Clean Air Program

- Lawyers, scientists, policy analysts, etc. focused on reducing greenhouse gases and other air pollutants in the U.S. and internationally

- Priority: cleaning up and transforming the power sector by moving away from dirty fossil fuels
Health Impacts from Climate Change

National Climate Assessment

- Air Pollution
- Allergens
- Wildfires
- Temperature Extremes
- Precipitation Extremes
- Vector-borne Diseases
- Food- and Waterborne Diarrheal Disease
- Food Security
- Mental Health and Stress-Related Disorders

For more: see Kim Knowlton’s blog, http://switchboard.nrdc.org/blogs/kknowlton/
Overview of the Gas Industry

The Natural Gas Production Industry

Natural gas systems encompass wells, gas gathering and processing facilities, storage, and transmission and distribution pipelines.

Production & Processing
1. Drilling and Well Completion
2. Producing Wells
3. Gathering Lines
4. Gathering and Boosting Stations
5. Gas Processing Plant

Natural Gas Transmission & Storage
6. Transmission Compressor Stations
7. Transmission Pipeline
8. Underground Storage

Distribution
9. Distribution Mains
10. Regulators and Meters for:
   a. City Gate
   b. Large Volume Customers
   c. Residential Customers
   d. Commercial Customer

Crude Oil to Refineries (not covered by these rules)

Source: Adapted from American Gas Association and EPA Natural Gas STAR Program
Overview of Methane Pollution

- Natural Gas and Petroleum Systems: 29%
- Landfills: 18%
- Enteric Fermentation: 26%
- Coal Mining: 10%
- Manure Management: 10%
- Other: 8%

Emissions Come from All Segments of Natural Gas and Oil Development

- Oil and natural gas production is responsible for 46% of methane emissions.
- Gas transmission and storage is responsible for 27% of methane emissions.
- Gas distribution is responsible for 16% of methane emissions.
- Other segments such as gas processing and transportation contribute to the remaining emissions.
Climate Change and the Oil and Gas Industry

- Methane is a highly potent greenhouse gas, with about 85 times the warming potential of CO₂ on a 20-year basis and about 35 times on a 100-year basis.

- The oil and gas sector is the country’s second largest industrial contributor to climate change, after power plants, due to its methane pollution problem.

- The sector emits close to 8 million tons of methane each year.

- That’s enough gas to heat about 6 million homes per year.
Other Air Pollutants from Oil and Gas Industry

**Volatile Organic Compounds** > ozone > respiratory impacts

**Hazardous Air Pollutants**, e.g., benzene and H$_2$S > eye/nose/respiratory irritation, headaches, fatigue, dizziness, cancer, blood disorders

- Found throughout the sector, though in varying amounts, typically with higher levels seen upstream of gas processing plants

- Co-emitted with methane, so controls for methane will reduce VOCs and HAPs to some extent as well
Sources of Methane

- **Leaks.** Can be large or small; ubiquitous and hard to predict.

- **Compressors and Pneumatic Devices.** Used to move gas throughout the system.

- **Well Completions.** “Whoosh” of gases following hydraulic fracturing.

- **Tanks.** Throughout the system.

- **Liquids Unloading.** Process of removing accumulated liquids from an existing well to restore/increase production.

- **Others.**
Using the below measures, NRDC and our colleagues have estimated that we can control 40-50% of the sector’s methane problem in a few years, at a low cost to industry.


- Leak Detection and Repair (LDAR) programs
- Low Bleed/Emission Rate Equipment Design
- “Green” Completions or Reduced Emission Completions
- Proper Tank Design and Maintenance
- Capture and Reuse
- Plunger Lifts and other similar techniques
Clean Air Act Section 111

• Precautionary Principle: EPA Administrator lists categories of industrial sources based on a determination that they “cause[,] or contribute[,] significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare”

• EPA then sets “standards of performance” for new and modified sources of pollution in each category.

• Section 111 also requires EPA to address existing sources of pollution from listed categories by issuing emissions guidelines, which states then implement.

• Following *Massachusetts v. EPA* Supreme Court decision, there has been a cascade of legal and regulatory events making clear that greenhouse gases qualify for regulation under Section 111.

• EPA proposed its Clean Power Plan under Section 111’s provision regarding existing sources.
In 2012, EPA finalized standards for VOCs from the oil and gas sector after several decades of delay.

- Most notably a requirement to use “green completions” for hydraulically fractured gas wells.
- Estimated to eliminate 1 to 1.7 million tons of methane, with approximately $440 million in climate benefits, along with significant reductions in VOCs and HAPs.
- EPA did NOT commit to adopting methane standards.

NGO community and others continued their campaign for federal methane standards to reach the remaining sources of methane, which make up the majority of the sector’s methane problem.

In March 2014, the White House announced its Methane Strategy, outlining a number of steps that federal agencies would take to address methane. Key was the beginning of EPA’s process for setting methane standards.
In April 2014, EPA released white papers detailing methane emissions from oil and gas sources, and ways to control them.

In January 2015, the White House announced a commitment to reduce methane from the oil and gas sector by 40-45% from 2012 levels by 2025, including EPA standards for methane from new and modified sources, along with several other actions. The announcement did NOT commit to adopting emission guidelines for existing sources of methane.

In August 2015, EPA proposed the methane standards for new and modified oil and gas sources. Standards are based on the controls discussed earlier, and will achieve some VOC and HAP reductions.
Thank you

questions?