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 +

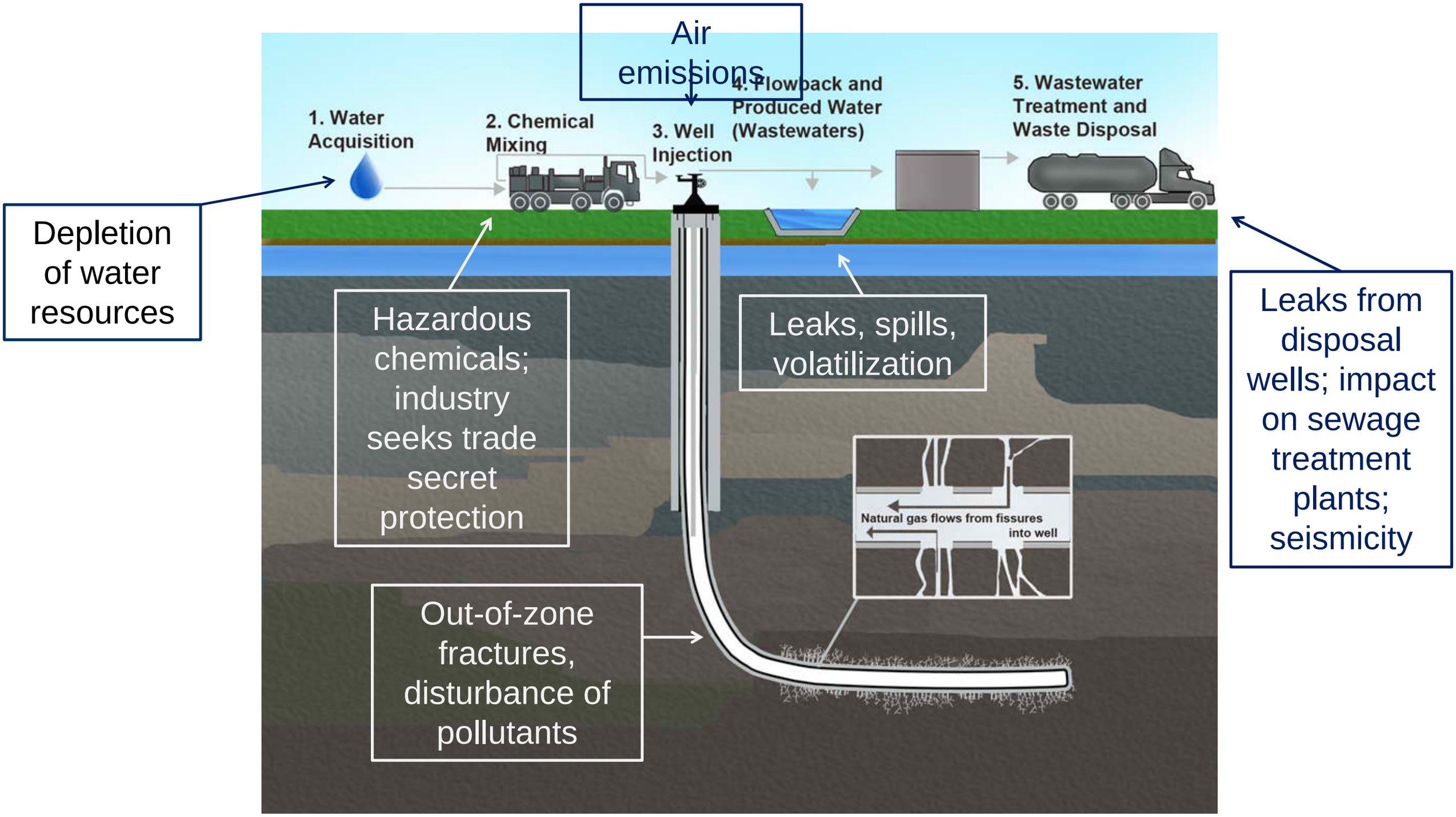
Staff:
Close to 500, mix of scientists, attorneys, policy advocates

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



Health risks: who is concerned

INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

CDC

NIOSH

The National Institute for Occupational Safety and Health (NIOSH)

National Environmental Public Health Tracking Network

PEHSU
Pediatric Environmental Health Specialty Units

ATSDR

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
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

Human health risk assessment of air emissions from development of unconventional natural gas resources
Lisa M. McKenzie, Roxana Z. Witter, Lee S. Newman, John L. Adgate (2012)

→ Cancer risk from VOCs

Highly elevated atmospheric levels of volatile organic compounds in the Uintah Basin, Utah.
Helmig D, Thompson CR, Evans J, Boylan P, Hueber J, Park JH.(2014)

→ Levels of VOCs

Source signature of volatile organic compounds (VOCs) from oil and natural gas operations in northeastern Colorado
Gilman, Jessica, Brian M. Lerner, William C. Kuster, and Joost de Gouw (2013)

→ Source of VOCs

A new look at methane and non-methane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin
Petron et al. (2014)

→ Levels of VOCs

Impact of Natural Gas Extraction on PAH Levels in Ambient Air
Paulik, L.B., Carey E. Donald, Brian W. Smith, Lane G. Tidwell, Kevin A. Hobbie Laurel Kincl, Erin N. Haynes, and Kim A. Anderson. (2015)

→ Cancer risk from PAHs

Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study
Macey, Gregg P., Ruth Breech, Mark Chemaik, Caroline Cox, Denny Larson, Deb Thomas, and David O. Carpenter (2014)

→ Levels of VOCs/H_2S

Influence of oil and gas field operation on spatial and temporal distributions of atmospheric non-methane hydrocarbons and their effect on ozone formation in winter
Field, R.A., J. Soltis, M.C. McCarthy, S. Murphy, D.C. Montagu. (2015)

→ Source of VOCs

Associations of Short-Term Exposure to Ozone and Respiratory Outpatient Clinic Visits — Sublette County, Wyoming, 2008–2011
Wyoming Dep't of Public Health (2013)

→ O_3 impacts

Air quality studies: key findings

- Presence of proximate air toxics:
  - Levels of benzene and H_2S 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 O_3 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, H_2S 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

Pollutant	Target organ/system	carcinogen
Particulate matter (Pm)		
Diesel pM	Respiratory system; Cardiovascular system	•
pM_{10} and smaller	Respiratory system; Cardiovascular system	
volatile organic compounds (vocs)		
Benzene	Immune system; Blood; Fetal development, Nervous System	•
Toluene	Brain and nervous system; Respiratory system; Fetal and child development; Reproductive system	
Ethylbenzene	Fetal and child development; Liver; Kidney; Endocrine system; auditory system	•
Xylene	Brain and nervous system; Fetal and child development	
Other VOCs (incl. Formaldehyde, Methanol)	Immune system; Respiratory system; Brain and nervous system; Fetal and child development; Liver; Kidney; Endocrine system	•
other		
Hydrogen sulfide (H_2S)	Respiratory system; Brain and nervous system; Gastrointestinal system	
NO_x	Respiratory system	
Ozone (O_3)	Respiratory system; Cardiovascular system	
Respirable Silica	Respiratory system; Kidneys; Immune system	•
paHs (incl. Naphthalene)	Immune system*, Reproductive system*; Brain and nervous system*; Developmental effects*	•**

Birth outcome studies

Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania
Shaina L. Stacy, LuAnn L. Brink, Jacob C. Larkin, Yoel Sadovsky, Bernard D. Goldstein, Bruce R. Pitt, Evelyn O. Talbott (2015)

→ Birth weight

Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado
McKenzie, Lisa M., Ruixin Guo, Roxana Z. Witter, David A. Savitz, Lee S. Newman, and John L. Adgate (2014)

→ Birth defects

Princeton/Columbia/MIT study
Janet Currie, Katherine Meckel, John Deutch. and Michael Greenstone (2014)

→ Birth weight, Apgar scores

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

Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing
Osborn, Stephen G., Avner Vengosh, Nathaniel R. Warner, and Robert B. Jackson (2011)

→ Methane concentrations

The effects of shale gas exploration and hydraulic fracturing on the quality of water resources in the United States
Vengosh, Avner, Nathaniel Warner, Rob Jackson, and Tom Darrah (2013)

→ Migration pathways; methane concentrations

Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region
Kassotis, Christopher D., Donald E. Tillitt, J. Wade Davis, Annette M. Hormann, and Susan C. Nagel. (2014)

→ Levels of endocrine disruptors

An Evaluation of Water Quality in Private Drinking Water Wells Near Natural Gas Extraction Sites in the Barnett Shale Formation
Fontenot, Brian E., Laura R. Hunt, Zacariah L Hildenbrand., Doug D. Carlton Jr., Hyppolite Oka, Jayme L Walton., Dan Hopkins, et al. (2013)

→ Levels of TDS, arsenic, selenium, strontium…

Analysis of BTEX Groundwater Concentrations from Surface Spills Associated with Hydraulic Fracturing Operations
Gross, Sherilyn A., Heather J. Avens, Amber M. Banducci, Jennifer Sahmel, Julie M. Panko, and Brooke E. Tvermoes (2013)

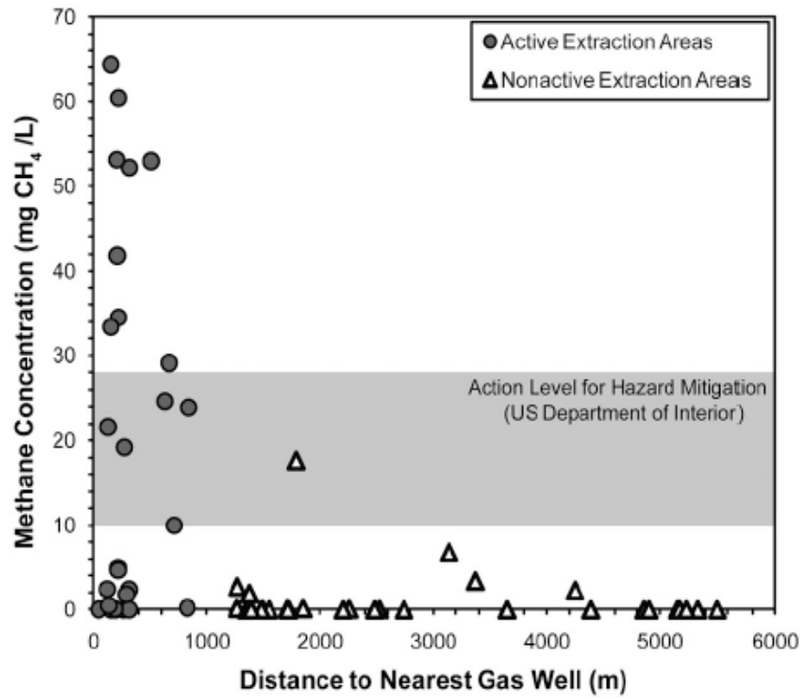
→ Levels of BTEX associated with spills

Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources (US EPA External Review Draft) (2015)

→ Systemic water impacts

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
Muehlenbachs, L.; Krupnick, A. J. (2013)

→ Traffic accidents (community)

Motor vehicle fatalities among oil and gas extraction workers
Retzer, K. D.; Hill, R. D.; Pratt, S. G. (2013**)**

→ Traffic fatalities (workers)

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

→ Silica exposure (workers)

The 2001–Present Induced Earthquake Sequence in the Raton Basin of Northern New Mexico and Southern Colorado
Justin L. Rubinstein, William L. Ellsworth, Arthur McGarr and Harley M. Benz (2014)

→ Seismicity/ injection link (CO)

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

→ Seismicity/ injection link (OK)

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

→ Seismicity/ fracturing link (OH)

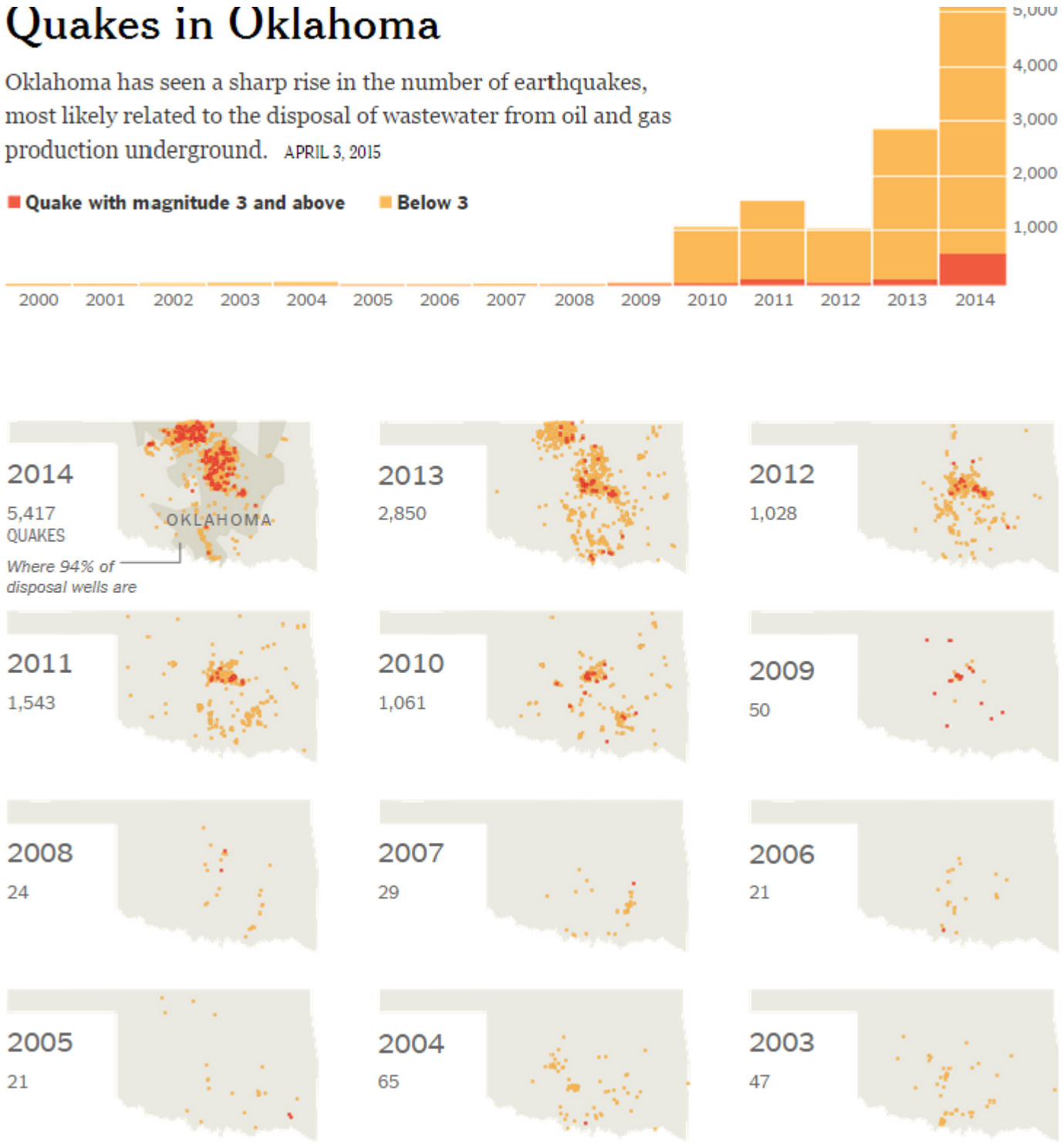
Earthquake hypocenters and focal mechanisms in central Oklahoma reveal a complex system of reactivated subsurface strike-slip faulting
D. E. McNamara, H. M. Benz, R. B. Herrmann, E. A. Bergman, P. Earle, A. Holland, R. Baldwin, A. Gassner (2015)

→ Risk of larger quakes (OK)

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)



Chemicals used in fracking: key findings

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

Potential effects

- 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)

Potential effects

- 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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→ Hospitalizations

- Findings:
  - Hospitalizations for heart conditions, neurological illness, skin conditions, cancer, and urologic problems associated with well density.
  - Example: well density > .79/km^2 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 km^2
- 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, O_3 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

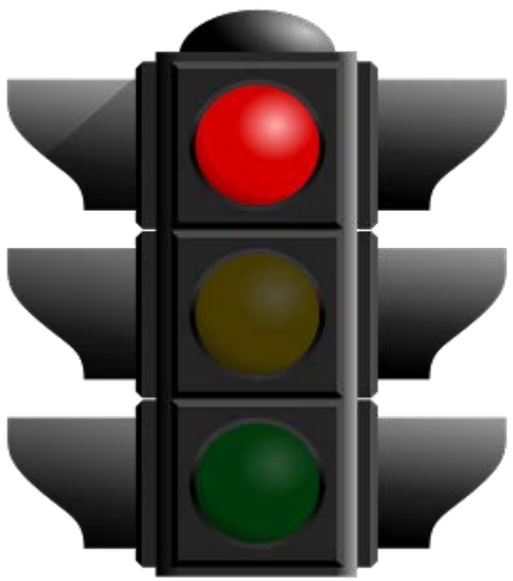
Source	NOx	VOC	PM	Air Toxics	Data Quality
Well development					
Drill Rigs	●	○	●	●	Medium
Frac Pumps	●	○	●	●	Medium
Truck Traffic	●	○	●	●	Medium
Completion Venting		●		●	Poor
Frac ponds		○		?	Poor
Gas Production					
Compressor Stations	●	○	○	●	Medium
Wellhead compressors	○	○	○	○	Medium
Heaters and dehydrators		○	○	○	Medium
Blowdown venting		●		●	Poor
Condensate Tanks		●		○	Poor
Fugitives		●		○	Poor
Pneumatics		○		○	Poor

● = major source ○ = minor source

Carnegie Mellon

Precautionary principle

"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
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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

(http://nca2014.globalchange.gov/report/sectors/human-health#intro-section-2)

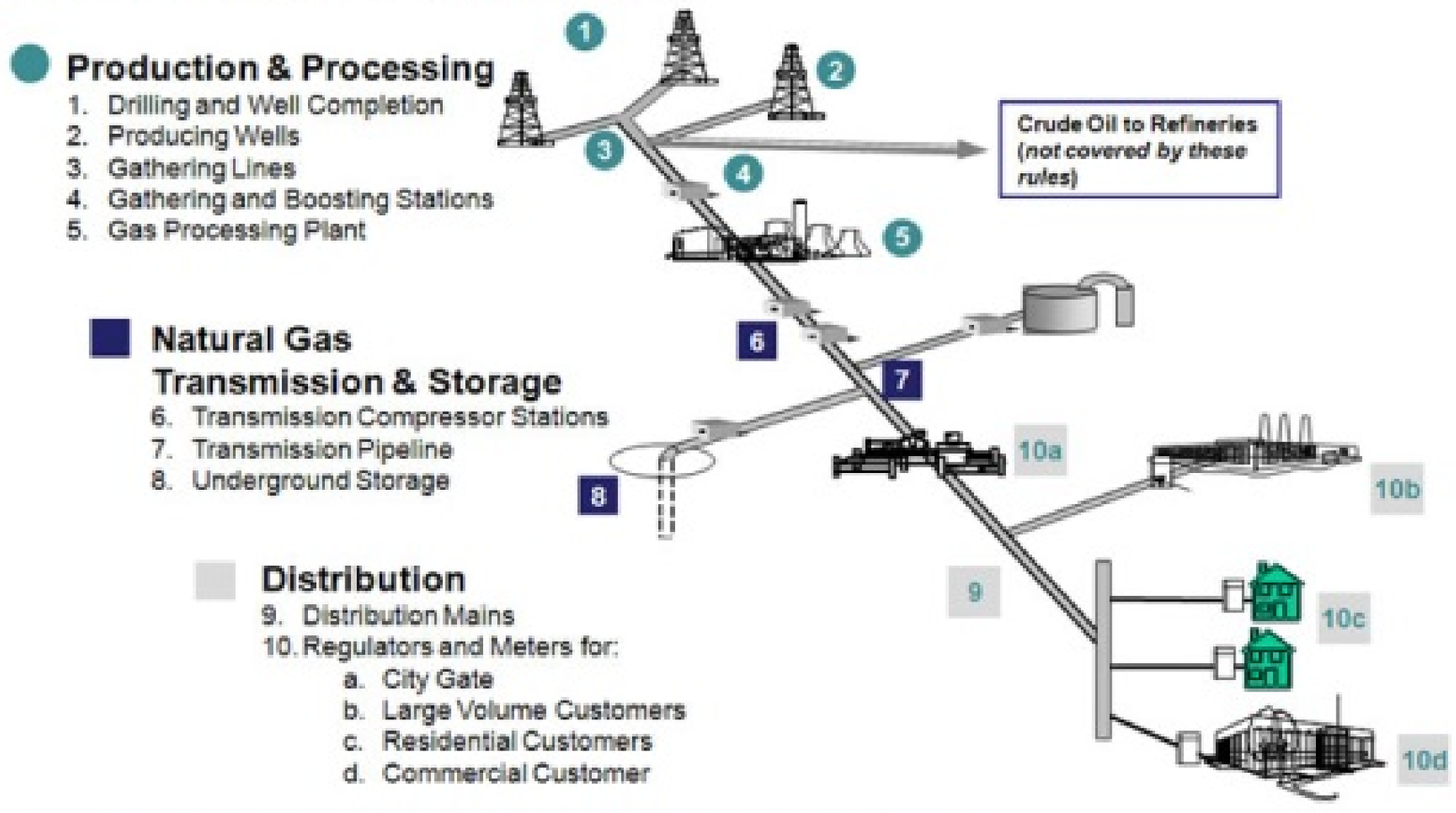
- Air Pollution
- Allergens
- Wildfires
- Temperature Extremes
- Precipitation Extremes
- Vector-borne Diseases
- Food- and Waterborne Diarrheal Disease
- Food Security
- Mental Health and Stress-Related Disorders

For more: see Kim Knowlton's blog, http://switchboard.nrdc.org/blogs/kknowlton/

Overview of the Gas Industry

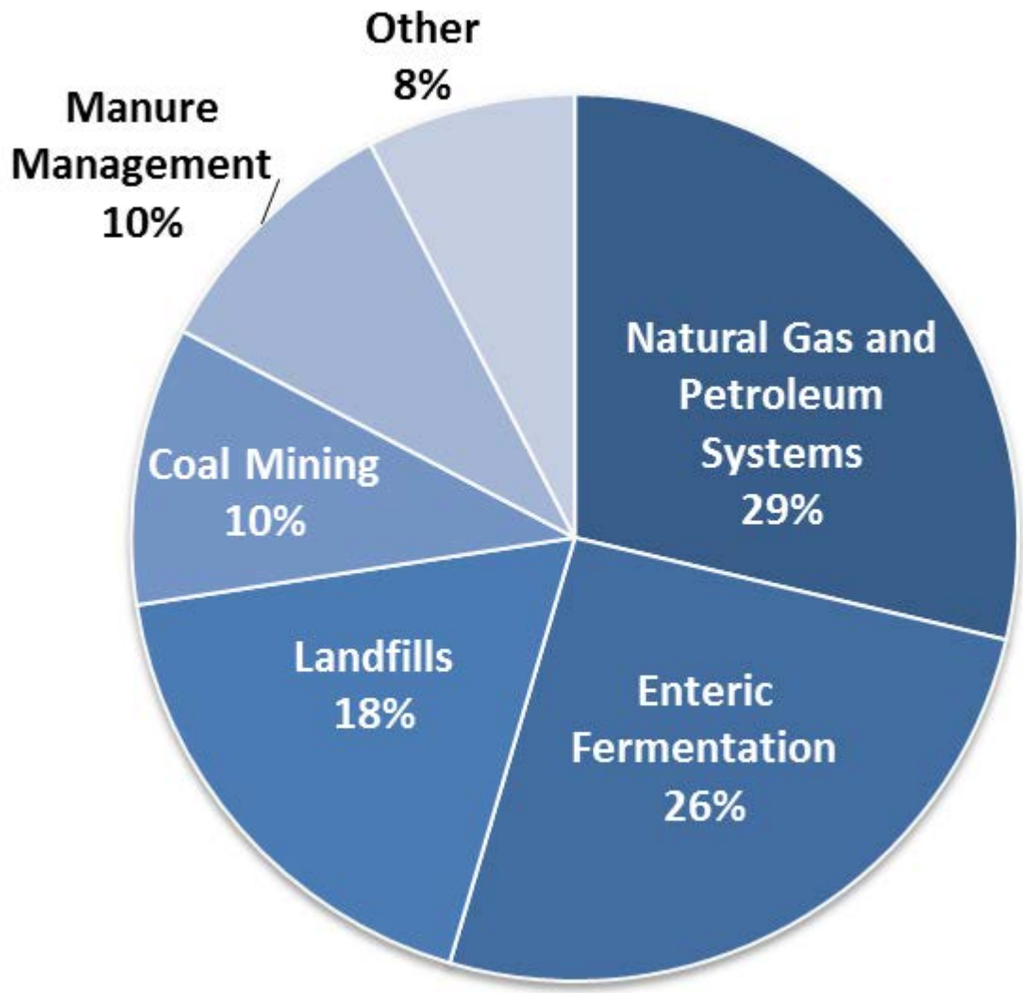
The Natural Gas Production Industry

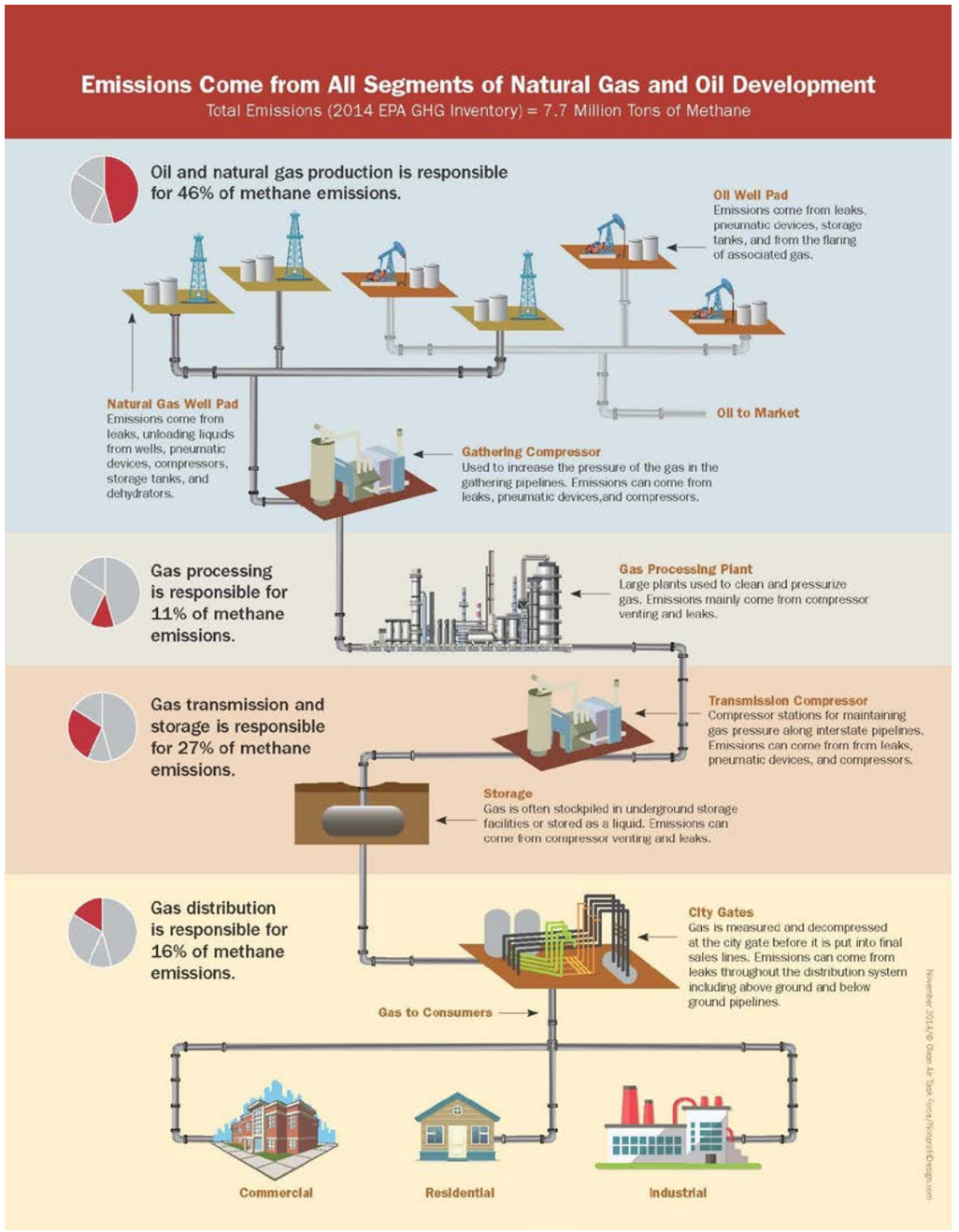
Natural gas systems encompass wells, gas gathering and processing facilities, storage, and transmission and distribution pipelines.



Source: Adapted from American Gas Association and EPA Natural Gas STAR Program

Overview of Methane Pollution





Climate Change and the Oil and Gas Industry

- Methane is a highly potent greenhouse gas, with about 85 times the warming potential of CO_2 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_2S > 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.**

Controls for Methane from Oil and Gas Operations

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.

(See Waste Not report, http://docs.nrdc.org/energy/files/ene_14111901a.pdf)

- 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.

Cleaning Up Methane from Oil and Gas

- 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.

Cleaning Up Methane from Oil and Gas (Cont.)

- 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?