Attachment 12

Declaration of **Dr. Ananya Roy and Dr. Tammy Thompson**, Environmental Defense Fund and attachments

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

DECLARATION OF DR. ANANYA ROY AND DR. TAMMY THOMPSON

We, Dr. Ananya Roy and Dr. Tammy Thompson, declare:

1. I, Dr. Roy, am a Senior Health Scientist at Environmental Defense Fund (EDF), a non-profit organization focused on protecting human health and the environment from airborne contaminants by using sound science. I received a Sc.D. in Environmental Health from the Harvard School of Public Health. I also have Master of Science and Bachelor of Science degrees from the Department of Pharmacology at the All India Institute of Medical Sciences. As a Senior Health Scientist for EDF, I lead research on the health effects of ambient air pollution. Prior to joining EDF, I was a research faculty at the Yale School of Public Health and the Environmental and Occupational Health Sciences Institute, NJ, where my work encompassed the effect of ambient and indoor air pollution on children's lung growth and cardiopulmonary effects, intergenerational transfer of lead, effects on neurodevelopment and associated genetic and nutritional susceptibility. My curriculum vitae is attached as Exhibit A.

2. I, Dr. Thompson, am a Senior Air Quality Scientist at EDF. I received a Ph.D. in Chemical Engineering, with a focus on atmospheric science and modeling, from the University of Texas at Austin. I also have a postdoc from

the Massachusetts Institute of Technology and a Bachelor of Science in Chemical Engineering from the University of Florida. As a Senior Air Quality Scientist for EDF, my work involves advancing our air quality modeling capabilities around estimating source contributions to hyperlocal air pollution measurements, including in the oil and gas sector. Prior to joining EDF, I worked on a wide range of air quality issues as an atmospheric scientist in academia, as a fellow in the Environmental Protection Agency's Office of Policy, and with the Congressional Research Service. As a Research Scientist funded by the National Park Service, I investigated the impact of oil and gas production on air quality, and human and ecosystem health in National Parks. My curriculum vitae is attached as Exhibit B.

EPA's Rescission of Key Provisions of the 2016 New Source Rule

1. We are aware that the Environmental Protection Agency (EPA) has issued a final rule (the Rescission Rule) that rescinds key elements of its 2016 rule (the New Source Rule) setting standards to reduce methane and volatile organic compound (VOC) emissions from new and modified sources in the oil and gas sector. Specifically, we understand that the Rescission Rule: (1) rescinds the requirement to regulate methane emissions from new and modified sources; and (2) removes the requirement to regulate methane and VOC emissions from transmission and storage facilities in the oil and gas sector. EPA, *Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review*, 85 Fed. Reg. 57,018 (Sept. 14, 2020) (Rescission Rule).

2. We are further aware that the New Source Rule triggered a legal obligation under Section 111(d) of the Clean Air Act, 42 U.S.C. § 7411(d), for EPA to issue emissions guidelines for existing sources (Methane Guidelines), but that EPA has not yet issued such guidelines. We are aware of EPA's position, expressed in the Rescission Rule, that the Rescission Rule eliminates its obligation to issue Methane Guidelines.

VOCs Form Ground-Level Ozone, or Smog, that Harms Human Health

3. Ozone forms when VOCs and oxides of nitrogen (NOx) react in the presence of sunlight. This process becomes more pronounced in the summertime.

4. A longstanding body of scientific research, including numerous EPA assessments, demonstrates that exposure to ground-level ozone harms human health. In its 2013 Integrated Science Assessment for Ozone (2013 ISA), EPA concluded that "a very large amount of evidence spanning several decades supports a relationship between exposure to [ozone] and a broad range of respiratory effects."[1] These effects range from decreases in lung function among healthy adults to increases in respiratory-related hospital admissions and emergency room visits, to premature death.[2]

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[1] U.S. EPA, EPA/600/R-10/076F, *Integrated Science Assessment (ISA) of Ozone and Related Photochemical Oxidants*, at 1-6 (2013), *available at* https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=247492 ("2013 *ISA*").

[2] *Id.* at 6-131 to 6-158, 6-162 to -163.

5. Multiple studies across various states (California, Georgia, North Carolina), counties (Maricopa County, AZ; Erie County, NY) and cities (Seattle, New York, Newark, Atlanta, Houston, Dallas, San Antonio, Austin, Indianapolis, St Louis) have found that changes in ozone concentrations were associated with higher asthma emergency room visits, most at concentrations below the current standard.[3] In studies with average daily maximum ozone concentrations between 31 and 54 parts per billion (ppb)—well below EPA's current ozone standard of 70 ppb—these effects were strongest among children between 5 and 18 years old.[4] It is estimated that up to 11% of all asthma emergency room visits in the United States are attributed to ozone.[5] According to the Centers for Disease Control and Prevention (CDC), 24 million Americans currently have asthma.[6] Of these, 5.5

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[3] Stephanie Holm, John Balmes, Ananya Roy, *Human Health Effects of Ozone: The State of Evidence Since EPA's Last Integrated Science Assessment*, EDF 2018.

[4] US EPA, EPA/600/R-20/012, *Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants*, at IS-26 tbl.IS-4 (2020), *available at* https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=348522 ("2020 *ISA*") (summarizing evidence from epidemiologic, controlled human exposure, and animal toxicological studies on the respiratory effects of short-term exposure to ozone).

[5] Susan C. Anenberg et al., *Estimates of the Global Burden of Ambient PM2.5, Ozone, and NO2 on Asthma Incidence and Emergency Room Visits*, Environmental Health Perspectives, 2018; 126 (10): 107004.

[6] CDC, *Fast Stats: Asthma*, https://www.cdc.gov/nchs/fastats/asthma.htm (last visited Sept. 8, 2020).

million are children and over half have uncontrolled asthma.[7] Asthma results in 1.6 million emergency room visits, 9.8 million visits to the physician,[8] and 188 thousand hospitalizations.[9] Asthma costs the U.S. economy more than $80 billion annually in medical expenses, missed work and school days, and deaths.[10]

6. Ozone pollution is particularly harmful for vulnerable populations, such as school-aged children, people with respiratory diseases or asthma, older adults, and people who are active outdoors, especially outdoor workers.[11] Children with asthma also face heightened risks from ozone exposure. Many studies have demonstrated that children with asthma experience decrements in lung function and increases in respiratory symptoms when exposed to ozone pollution.[12]

7. EPA has concluded that there is a causal relationship or likely causal relationship between both short- and long-term ozone exposure and a broad range

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[7] *Id.*

[8] *Id.*

[9] CDC, *Most Recent National Asthma Data*, https://www.cdc.gov/asthma/most_recent_data.htm (last visited Aug. 26, 2020)

[10] Tursynbek Nurmagambetov, Robin Kuwahara, Paul Garbe, *The Economic Burden of Asthma in the United States, 2008 -2013*, Annals of the American Thoracic Society, 2018.

[11] 2013 *ISA* at 1-8.

[12] K. Mortimer et al., *The Effect of Air Pollution on Inner-City Children with Asthma*, 19 EUR. RESPIRATORY J. 699 (2002), 2013 *ISA*, 6-120-21, 6-160.

of harmful respiratory effects in humans.[13] Short-term exposure is defined as hours, days, or weeks, and long-term exposure is measured in months to years.[14]

8. Short-term exposure to ozone can have critical health implications. For instance, there is evidence of an association between out-of-hospital cardiac arrests and short-term exposure to ozone.[15] Time scales of exposure up to three hours in duration and also at the daily level on the day of the event were significant. Other studies indicate higher rates of stroke in populations following higher exposures to ozone. A study in Allegheny County, Pennsylvania found that exposures to ozone on the current day increased the risk of total stroke hospitalization.[16] Another study in Nunces County, Texas found elevated risk of having a first stroke with higher ozone concentrations in the preceding 2 days.[17] Additional analyses support these conclusions.[18]

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[13] 2013 *ISA* at 1-5 to 1-8 & tbl. 1-1

[14] *Id.* at 1-4.

[15] Katherine B. Ensor et al., *A Case-Crossover Analysis of Out-of-Hospital Cardiac Arrest and Air Pollution*, 127 CIRCULATION 1192 (2013), https://pubmed.ncbi.nlm.nih.gov/23406673/.

[16] Xu X, Sun Y, Ha S, Talbott EO, Lissaker CT, *Association between ozone exposure and onset of stroke in Allegheny County, Pennsylvania, USA, 1994-2000,* Neuroepidemiology, 2013, 41(1):2-6.

[17] Wing JJ, Adar SD, Sánchez BN, Morgenstern LB, Smith MA, Lisabeth LD, *Short-term exposures to ambient air pollution and risk of recurrent ischemic stroke,* Environmental Research, Jan. 2017, 152:304-7.

[18] Shah, Anoop SV, et al., *Short term exposure to air pollution and stroke: systematic review and meta-analysis,* BMJ 350 (2015): h1295; Yang, Wan-Shui, et

9. This evidence augments the long-standing body of literature demonstrating the serious impacts from short-term exposure to ozone pollution, including the increased risk of premature death.[19] EPA has recognized that positive associations have been reported between "short-term [ozone] exposures and respiratory mortality, particularly during the summer months."[20]

10. Long-term exposure likewise has critical health implications. EPA has concluded that there is "likely to be a causal relationship between long-term exposure to [ozone] and respiratory effects."[21] A recent study of 5,780 adults followed for a decade across six U.S. metropolitan regions found that long-term ozone exposure was significantly associated with development of emphysema. This was equal to that of 29 pack-years of smoking or 3 years of aging.[22] Additionally, in a study of 11 million Medicare enrollees in the southeastern United States, long-term ozone exposure was associated with increased risk of first

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al., *An evidence-based appraisal of global association between air pollution and risk of stroke*, International Journal of Cardiology 175.2 (2014): 307-313.

[19] 2013 *ISA* at 1-14 (concluding that there is "likely to be a causal relationship between short-term exposures to [ozone] and total mortality").

[20] EPA, *National Ambient Air Quality Standards for Ozone*, 80 Fed. Reg. 65,292, 65,307 (Oct. 26, 2015); *see also* 2013 *ISA* 6-220 to 6-221.

[21] 2013 *ISA* at 1-8.

[22] Wang, Meng, et al., *Association between long-term exposure to ambient air pollution and change in quantitatively assessed emphysema and lung function*, JAMA 322.6 (2019): 546-556.

hospital admission for stroke, chronic obstructive pulmonary disease, myocardial infraction, lung cancer, and heart failure.[23]

11. Similarly, EPA notes that "recent evidence is suggestive of a causal relationship between long-term [ozone] exposures and total mortality."[24] Some longitudinal studies have further demonstrated that "long-term [ozone] exposure influences the risk of asthma development in children."[25]

12. A recent study of almost 61 million Medicare patients conducted nationwide indicates a significant association between short- and long-term ozone exposure and all-cause mortality, with effects strongest in minorities and those of low socio-economic status. These effects were seen at ozone concentrations well below the current standard of 70 ppb.[26]

13. Health effects other than cardiovascular or respiratory are also likely. A 2017 study suggested that ozone exposure may be linked to approximately 8,000 stillbirths per year.[27] Studies carried out in California and Florida of over 4,000

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[23] Yazdi, Mahdieh Danesh, et al., *Long-term exposure to PM2. 5 and ozone and hospital admissions of Medicare participants in the Southeast USA*, Environment International 130 (2019): 104879.

[24] 2013 *ISA* at 1-8.

[25] 2013 *ISA* at 7-2.

[26] Di et al., *Air Pollution and Mortality in the Medicare Population*, NEW ENGLAND J. OF MEDICINE (June 29, 2017); Di et al., *Association of short-term exposure to air pollution with mortality in older adults*, JAMA (Dec. 26, 2017) 318(24):2446-56.

[27] Mendola et al., *Chronic and Acute Ozone Exposure in the Week Prior to*

births each found that elevated exposure to ozone during pregnancy was associated with higher risk of pre-term birth.[28] Prolonged exposure to ozone may also accelerate cognitive decline in the early stages of dementia.[29] There is now accumulating evidence that suggests that ozone exposure during pregnancy can result in Autism Spectrum Disorders among children.[30]

14. In 2015, EPA strengthened the national health-based standard for ground-level ozone, lowering the standard from 75 ppb to 70 ppb.[31] The record for that rulemaking, however, along with subsequent scientific studies, demonstrates that health effects can occur at much lower levels, especially in sensitive populations. For that reason, EPA' s independent scientific advisors recommended

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Delivery is Associated with the Risk of Stillbirth, 14 INT'L J. ENVT'L RESEARCH AND PUB. HEALTH 731 (2017).

[28] Laurent O, Hu J, Li L, et al., *A statewide nested case-control study of preterm birth and air pollution by source and composition: California, 2001-2008*, Environ Health Perspect. 2016;124(9):1479-1486; Ha S, Hu H, Roussos-Ross D, Haidong K, Roth J, Xu X, *The effects of air pollution on adverse birth outcomes*, Environ Res. 2014;134:198-204.

[29] Galkina Cleary et al., *Association of Low-Level Ozone with Cognitive Decline in Older Adults*, 61 J. ALZHEIMERS DISEASE 1, 67-78 (2018).

[30] Becerra, Tracy Ann et al., *Ambient air pollution and autism in Los Angeles County, California*, Environmental Health Perspectives 121.3 (2012) 380-386; Volk HE, Lurmann F, Penfold B, Hertz-Picciotto I, McConnell R, *Traffic-related air pollution, particulate matter, and autism*, JAMA Psychiatry (Jan. 1, 2013) 70(1):71-7.

[31] EPA, *National Ambient Air Quality Standards for Ozone*, 80 Fed. Reg. 65,292 (Oct. 26, 2015).

that the agency establish the standard in the range of 60–70 ppb. Many health and medical associations suggested that lower standards may be appropriate.[32]

15. EPA has issued designations for counties that are not meeting the 2015 ozone standards, referred to as "ozone non-attainment areas."[33] According to EPA calculations, there are over 120 million people living in ozone non-attainment areas in the United States.[34] These individuals are at risk of acute respiratory illness and other damaging health outcomes due to unhealthy levels of ozone air quality. Additionally, given the evidence of adverse health effects even at levels below EPA's standard for ground-level ozone, the millions of Americans living outside of ozone nonattainment areas may also be at risk of experiencing the negative health effects of ozone exposure.

The Oil and Natural Gas Sector Is a Substantial Source of Smog-Forming Emissions

16. The oil and natural gas sector is a substantial source of smog-forming emissions. According to EPA' s most recent National Emissions Inventory (NEI),

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[32] *Id.* at 65,321–23, 65,355.

[33] EPA, *Air Quality Designations for the 2015 Ozone National Ambient Air Quality Standards*, 82 Fed. Reg. 54,232 (Nov. 16, 2017); EPA, *Additional Air Quality Designations for the 2015 Ozone National Ambient Air Quality Standards*, 83 Fed. Reg. 25,776 (June 4, 2018); EPA, *Additional Air Quality Designations for the 2015 Ozone National Ambient Air Quality Standards-San Antonio, Texas Area*, 83 Fed. Reg. 35, 136 (July 25, 2018).

[34] EPA, *Summary Nonattainment Area Population Exposure Report*, https://www3.epa.gov/airquality/greenbook/popexp.html (last updated July 31, 2020).

"Oil and Gas Production" is the largest source of human-caused VOCs nationally and a major contributor to NOx emissions.[35] Regional analyses likewise underscore the significant ozone-forming emissions from these sources, including work in the Uinta Basin in Utah,[36] the Barnett Shale in Texas,[37] the Upper Green River Basin in Wyoming,[38] and in Colorado.[39]

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[35] Calculation based on EPA, *National Emissions Inventory (NEI) Sector Data*, *available at* https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.

[36] Warneke, C. et al., *Volatile organic compound emissions from the oil and natural gas industry in the Uintah Basin, Utah: oil and gas well pad emissions compared to ambient air composition*, 14 Atmos. Chem. Phys., 10977-10988 (2014), *available at* www.atmos-chem-phys.net/14/10977/2014/; ENVIRON, *Final Report: 2013 Uinta Basin Winter Ozone Study* (Mar. 2014), *available at* https://deq.utah.gov/locations/U/uintahbasin/ozone/docs/2014/06Jun/UBOS2013FinalReport/Title_Contents_UBOS_2013.pdf.

[37] David T. Allen, *Atmospheric Emissions and Air Quality Impacts from Natural Gas Production and Use*, Annu. Rev. Chem. Biomol. Eng. 5:55-75 (2014), *available at* https://www.annualreviews.org/doi/abs/10.1146/annurev-chembioeng-060713-035938.

[38] See B. Rappengliick et al., *Strong wintertime ozone events in the Upper Green River basin*, Wyoming, Atmos. Chem. Phys. (2014), *available at* https://doi.org/10.5194/acp-14-4909-2014.

[39] Helmig, D., *Air quality impacts from oil and natural gas development in Colorado*, 8,4 Elem Sci. Anth. (2020), *available at* https://doi.org/10.1525/elementa.398; Brantley et al., *Assessment of volatile organic compound and hazardous air pollutant emissions from oil and natural gas well pads using mobile remote and onsite direct measurements*, Journal of the Air & Waste Management Association 1096-2247 (Print) 2162- 2906 (Online) (2015); Petron, G. et al., *A new look at methane and non-methane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin*, 119 J. Geophys. Res. Atmos., 6836-6852 (2014), *available at* http://onlinelibrary.wiley.com/doi/10.1002/2013JD021272/full.

17. Studies and analyses have linked ozone formation to emissions from oil and gas development. For example, a recent study by NOAA scientists at the Cooperative Institute for Research in Environmental Sciences (CIRES) found that, on high ozone days on Colorado's Northern Front Range, oil and gas operations contribute roughly 50% to regional VOC reactivity and that these activities are responsible for approximately 20% of ozone produced locally in the nonattainment area.[40] This CIRES study was one of many that was included in a review published this year documenting over a decade's worth of research demonstrating multiple lines of evidence that link regional production of ozone with emissions from oil and gas operations in the Colorado Front Range. Another study analyzing ozone impacts associated with unconventional natural gas development in Pennsylvania concluded that "natural gas emissions may affect compliance with federal ozone

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[40] McDuffie, E. E., et al. (2016), *Influence of oil and gas emissions on summertime ozone in the Colorado Northern Front Range*, J. Geophys. Res. Atmos., 121, 8712-8729, doi:10.1002/2016JD025265, *available at* http://onlinelibrary.wiley.com/doi/10.1002/2016JD025265/abstract; *see also* Gilman, J. B., B. M. Lerner, W. C. Kuster, and J. A. de Gouw (2013), *Source signature of volatile organic compounds from oil and natural gas operations in northeastern Colorado*, Environ. Sci. Technol., 47(3), 1297-1305, *available at* http://pubs.acs.org/doi/abs/10.1021/es304119a (finding 55% of VOC reactivity in the metro-Denver area is due to nearby oil and natural gas operations and calling these emissions a "significant source of ozone precursors"); Cheadle, LC et al., *Surface ozone in the Colorado northern Front Range and the influence of oil and gas development during FRAPPE/DISCOVER-AQ in summer 2014*, Elementa (2017), *available at* http://doi.org/10.1525/elementa.254 (finding on "individual days, oil and gas O3 precursors can contribute in excess of 30 ppb to O3 growth and can lead to exceedances" of the EPA ozone standards).

standards."[41]

18. Recent studies have documented high levels of wintertime ozone in locations with oil and gas production such as the Upper Green River Basin in Wyoming and the Uinta Basin in Utah.[42] VOC emissions from oil and natural gas operations are a critical factor driving wintertime ozone formation in these regions.[43] When combined with specific meteorological conditions, including snow cover and temperature inversions, VOC emissions can produce winter ozone concentrations of nearly twice the EPA ozone standard.[44]

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[41] Swarthout, R. F. et al., *Impact of Marcellus Shale natural gas development in southwest Pennsylvania on volatile organic compound emissions and regional air quality*, Environ. Sci. Technol., 49(5), 3175-3184 (2015), doi:10.1021/es504315f, *available at* https://www.ncbi.nlm.nih.gov/pubmed/25594231.

[42] *See* S.J. Oltmans et al., *O3, CH4, CO2, CO, NO2 and NMHC aircraft measurements in the Uinta Basin oil and gas region under low and high ozone conditions in winter 2012 and 2013*, Elementa (2016), *available at* http://doi.org/10.12952/journal.elementa.000132; B. Rappenglück et al., *Strong wintertime ozone events in the Upper Green River basin, Wyoming*, Atmos. Chem. Phys. (2014), *available at* https://doi.org/10.5194/acp-14-4909-2014.

[43] R. Ahmadov et al., *Understanding high wintertime ozone pollution events in an oil-natural gas-producing region of the western US*, Atmos. Chem. Phys. (2015), *available at* https://doi.org/10.5194/acp-15-411-2015.

[44] ENVIRON, *Final Report: 2013 Uinta Basin Winter Ozone Study* (Mar. 2014), *available at* https://deq.utah.gov/air-quality/2013-uinta-basin-winter-ozone-study-final-report.

Oil and Natural Gas Operations Emit Hazardous Air Pollutants like Benzene, a Known Human Carcinogen

19. Oil and natural gas operations also emit several different hazardous air pollutants (HAPs) from equipment leaks, processing, compressing, transmission and distribution, and storage tanks. HAPs emitted from oil and gas operations include benzene, a known carcinogen. When issuing the New Source Rule, EPA recognized the negative health and welfare consequences of HAPs emitted from oil and gas extraction and the health benefits the New Source Rule would provide by reducing HAP emissions in addition to methane and VOC emissions.[45]

20. There is no safe level of human exposure to many of the toxic pollutants released as a result of oil and gas extraction. Exposure to HAPs can cause cancer and seriously impair the human neurological system. For example, EPA has found that benzene, found naturally in oil and gas, is a "known human carcinogen (causing leukemia) by all routes of exposure, and . . . that exposure is associated with additional health effects, including genetic changes in both humans and animals."[46]

21. Further, a "number of adverse noncancer health effects including

[45] EPA, *Regulatory Impact Analysis of the Final Emission Standards for New and Modified Sources in the Oil and Natural Gas Sector Sources*, EPA-452/R-16-002, 4-28 to 4-37 (May 2016), available at https://www.epa.gov/sites/production/files/2020-07/documents/oilgas_ria_nsps_final_2016-05.pdf.

[46] *Id.* at 4-33.

blood disorders, such as preleukemia and aplastic anemia, have also been associated with long-term exposure to benzene."[47] Along with benzene, EPA has also catalogued the harmful effects of other specific air toxics emitted from oil and gas operations, including toluene, carbonyl sulfide, ethylbenzene, mixed xylenes, n-hexane, and other air toxics.[48] Each of these hazardous pollutants is harmful to human health. For example, the serious health effects associated with exposure to toluene range from the dysfunction of the central nervous system to narcosis, with effects "frequently observed in humans acutely exposed to low or moderate levels of toluene by inhalation."[49]

Recent Studies Suggest Proximity to Oil and Gas Development Is Associated with Adverse Health Outcomes

22. Recent studies document associations between proximity to nonconventional oil and gas development and human health effects. While some of these studies do not evaluate concentrations of specific air pollutants, they document health effects that are consistent with exposure to smog and HAPs.

23. Analysis carried out by the Clean Air Task Force found that 2,000 asthma-related emergency room visits and over 600 respiratory-related hospital admissions nationally were due to ozone smog resulting from VOC and NOx

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[47] *Id.* at 3-34.

[48] *See id.* 4-33 to 4-37.

[49] *Id.*

emissions from oil and gas. A recent study published by scientists at EPA found that 1,900 deaths in the year 2025 may be attributable to oil and gas emissions.[50]

24. Children miss 500,000 days of school each year due to poor health associated with smog pollution.[51] A study of children in Pennsylvania found that exposure to unconventional natural gas development was associated with increased odds of pediatric asthma-related hospitalization.[52]

25. Air pollutants associated with oil and gas operations are known to cause serious health impacts in sensitive populations such as pregnant women, babies, and children. Studies have documented that living near natural gas wells is associated with lower birth weight babies[53] and preterm birth.[54] Other studies have

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[50] Fann, Neal, et al., *Assessing human health PM2.5 and ozone impacts from US oil and natural gas sector emissions in 2025*, Environmental Science & Technology 52.15 (2018): 8095-8103, *available at* https://pubs.acs.org/doi/suppl/10.1021/acs.est.8b02050/suppl_file/es8b02050_si_001.pdf.

[51] Clean Air Task Force, *Gasping for Breath: An analysis of the health effects from ozone pollution from the oil and gas industry* (2016).

[52] Mary D. Willis, et al., *Unconventional natural gas development and pediatric asthma hospitalizations in Pennsylvania*, Environ Res. 166:402–408 (Oct. 2018), *available at* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6110967/.

[53] See Stacy, et al., *Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania*, PLoS ONE (June 3, 2015), *available at* https://doi.org/10.1371/journal.pone.0126425.

[54] Casey et al., *Unconventional Natural Gas Development and Birth Outcomes in Pennsylvania, USA*, Epidemiology (Mar. 2016), *available at* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4738074/.

found an association between oil and gas proximity and congenital heart defects in infants.[55] Congenital heart defects are the leading cause of death due to birth defects.[56]

26. A 2014 Colorado study found that babies whose mothers had large numbers of natural gas wells within a 10-mile radius of their home had an increased risk of birth defects of the heart, compared to babies whose mothers had no wells within 10 miles of their home.[57] A 2019 follow-up study by the same research team fortified these results.[58] Perhaps most notably, a study of over 1.1 million births in Pennsylvania demonstrated evidence of negative health effects (including low birth weight) from in utero exposure to fracking sites within 3 kilometers of a mother's residence, with the largest health impacts seen from in utero exposure within 1 kilometer of oil and gas sites.[59] Another recent study of 2.9

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[55] McKenzie et. al., *Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado*, Envtl. Health Perspectives (Jan. 28, 2014) ("McKenzie 2014"), *available at* https://ehp.niehs.nih.gov/1306722/; McKenzie et al., *Congenital Heart Defects and Intensity of Oil and Gas Well Site Activities in Early Pregnancy*, Environment International (July 28, 2019) ("McKenzie 2019"), *available at* https://www.sciencedirect.com/science/article/pii/S0160412019315429.

[56] McKenzie 2019.

[57] McKenzie 2014.

[58] McKenzie 2019.

[59] Currie, Janet, et al., *Hydraulic Fracturing and Infant Health: New Evidence from Pennsylvania*, Science Advances, American Association for the Advancement of Science (Dec. 1, 2017), *available at*

million births in California also found that among rural populations living in proximity to higher oil and gas production, oil and gas development was associated with increased odds of having a low birth weight baby.[60] A 2020 study of births in the Eagle Ford Shale play in south Texas found that living within 5 kilometers of oil and gas wells was associated with adverse birth outcomes, and that women living within 5 kilometers of natural gas flaring events had higher odds of having a baby preterm.[61]

27. Other studies also document correlations between proximity to oil and gas drilling and human health effects in otherwise healthy populations. This emerging body of scientific literature includes several new studies documenting negative human health impacts based on proximity to oil and gas wells. For example, a study from 2016 demonstrated that oil and gas well proximity was correlated with an increase in the likelihood of asthma exacerbations, including mild, moderate, and severe asthma attacks.[62] A 2018 study observed evidence

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https://advances.sciencemag.org/content/3/12/e1603021.

[60] Tran, Kathy V., et al., *Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006–2015 Births*, Environmental Health Perspectives 128.6 (2020): 067001.

[61] Laura J. Cushing et al., *Flaring from Unconventional Oil and Gas Development and Birth Outcomes in the Eagle Ford Shale in South Texas*, Environmental Health Perspectives 128(7) (July 2020), *available at* https://ehp.niehs.nih.gov/doi/pdf/10.1289/EHP6394.

[62] Rasmussen et al, *Association between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations*, 176 J. Am. Med. Assn. Internal Med. 1334-43 (Sept. 2016), *available at*

supporting an association between the intensity of oil and gas activity and several indicators of cardiovascular disease.[63] A 2015 study documented increased hospitalization rates in counties with a high density of oil and gas wells.[64] Similarly, other studies, including a 2017 study, have demonstrated an increase in the reporting of nasal, sinus, and migraine headaches, and fatigue symptoms in areas with high volumes of oil and gas drilling.[65]

28. A 2018 study in Colorado found that communities living in close proximity to oil and gas activity had higher measured exposures to HAPs and face increased risks to their health, including a heightened risk of cancer.[66] The study found that the lifetime cancer risk was 8.3 per 10,000 people for populations living

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https://www.ncbi.nlm.nih.gov/pubmed/27428612.

[63] Lisa M. McKenzie et al., *Relationships between Indicators of Cardiovascular Disease and Intensity of Oil and Natural Gas Activity in Northeastern Colorado*, Environ Res. 170: 56–64 (Mar. 2019), *available at* https://pubmed.ncbi.nlm.nih.gov/30557692/.

[64] Jemielita et al., *Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates*, PLoS ONE (July 15, 2015), *available at* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4503720/.

[65] *See* Tustin et al., *Associations between Unconventional Natural Gas Development and Nasal and Sinus, Migraine Headache, and Fatigue Symptoms in Pennsylvania*, 125 ENV. HEALTH PERSPECTIVES 189 (Feb. 2017), *available at* https://ehp.niehs.nih.gov/EHP281/.

[66] Lisa McKenzie et al., *Ambient Non-Methane Hydrocarbon Levels Along Colorado's Northern Front Range: Acute and Chronic Health Risks*, Envt'l Sci. & Tech. (Mar. 27, 2018), *available at* https://pubs.acs.org/doi/10.1021/acs.est.7b05983.

within approximately 500 feet of oil and gas activity, above EPA's allowable risk. The study also found elevated levels of acute and chronic blood system and developmental risks, and acute nervous system risks for the same population. Benzene exposures contributed to 80-95% of risks across the different health effects.

29. An important 2019 study, funded by the Colorado Department of Public Health and Environment, used weather and emissions data measured in Colorado with state-of-the-science dispersion modeling tools to map concentrations of air toxics from 3 sizes of oil and gas fields, finding both an elevated lifetime cancer risk and non-cancer health risks for the population living in close proximity to oil and gas fields.[67]

30. Benzene exposures from production emissions (from existing wells), and all activities combined (drilling, fracking, flow back and production), were associated with an increased lifetime risk (above one in a million) of leukemia for the average individual at 500 feet. Risks in the most exposed populations (people who live downwind and spend more time outdoors) only dropped below the one-in-a-million risk threshold after a distance of 2000 feet from the well.

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[67] *See* ICF, *Final Report: Human Health Risk Assessment for Oil & Gas Operations in Colorado* (Oct. 17, 2019), *available at* https://drive.google.com/file/d/1pO41DJMXw9sD1NjR_OKyBJP5NCb-AO0I/view (submitted to the Colorado Department of Public Health and Environment).

31. The study also found elevated non cancer risks due to VOC exposures. Benzene and 2-ethyltoluene emissions from oil and gas in Colorado resulted in maximal acute exposures higher than considered safe for most populations 500 feet away. Exposures of benzene were more than 10 times higher than considered safe for acute exposure and should be considered a risk for blood disorders. Blood disorders could result in anemia, disturbances in clotting or the ability to fight infections, and could manifest as fatigue, nose bleeds or infections. The study also found the potential for neurotoxic effects, such as headaches, blurred vision, and dizziness, from combined acute exposures of benzene and 2-ethyltoluene.

32. The study only assessed pollution dispersion from single well pads. This potentially underestimates the risks faced by almost two-thirds of the roughly 240,000 Coloradoans living within 2000 ft of two or more well pads.

33. The health impacts we describe may disproportionately affect minority communities living in the vicinity of oil and gas activity. For example, in Texas, there are over 800,000 Latinos living within half a mile of an oil or gas well, in Colorado nearly 3 out of 10 people living near a well are Latino, and in California 2 out of 5 people living in close proximity to a well are Latino.[68] The

[68] *Latino Communities at Risk: The Impact of Air Pollution from the Oil and Gas Industry*, Clean Air Task Force (CATF), League of United Latin American Citizens (LULAC), National Hispanic Medical Association (NHMA) 2016.

2020 study of birth outcomes in south Texas found that Hispanic women in the study were particularly vulnerable to the effects of flaring on preterm birth, noting that those findings were consistent with prior studies that found African Americans and residents of socioeconomically disadvantaged neighborhoods more vulnerable to the impacts of air pollution.[69]

EPA's Rescission Rule Will Increase Substantial Ozone-Forming and Other Harmful Air Pollution

34. Analysis completed by Dr. Renee McVay, Hillary Hull, and Kate Roberts and attached in a separate declaration estimates that by removing new transmission and storage facilities from regulation, the Rescission Rule will result in approximately 8,000 metric tons of VOC emissions in 2021, increasing to almost 12,000 metric tons of VOC emissions in 2030.[70] The McVay-Hull-Roberts analysis estimates that the Rescission Rule will result in over 100,000 metric tons of VOC emissions total over the ten-year period from 2021 to 2030.[71] The McVay-Hull-Roberts analysis also estimates that the Rescission Rule will result in nearly

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[69] Laura J. Cushing et al., *Flaring from Unconventional Oil and Gas Development and Birth Outcomes in the Eagle Ford Shale in South Texas*, Environmental Health Perspectives 128(7) (July 2020), *available at* https://ehp.niehs.nih.gov/doi/10.1289/EHP6394.

[70] Declaration of Dr. Renee McVay, Hillary Hull, and Kate Roberts at tbl.2 ("McVay-Hull-Roberts Decl.").

[71] *Id.*

3,000 tons of HAPs over the ten-year period from 2021 to 2030.[72]

35. The McVay-Hull-Roberts analysis also considered the likely effect of the Rescission Rule on EPA's promulgation of Methane Guidelines. The McVay-Hull-Roberts analysis estimates there are 101,850 wells that would be subject to Methane Guidelines that are located in areas that are not in attainment with the 2015 ozone standard.[73] Because EPA contends the Rescission Rule removes its obligation to issue Methane Guidelines, the effect will be to allow harmful VOC pollution from these wells to continue.

36. Many Americans will be adversely affected by these increases in ozone-forming VOC emissions and HAP emissions. Nationwide, it is estimated that almost 18 million people live within 1 mile of at least one active oil and/or gas site.[74] The McVay-Hull-Roberts analysis estimates that approximately 9.1 million people live within half a mile of an existing well in the United States, including 580,000 young children, 1.4 million elderly individuals, 1.4 million people living below the poverty line, and 2.7 million people of color.[75]

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[72] *Id.*

[73] *Id.* ¶ 38.

[74] Eliza D. Czolowsk et al., *Toward Consistent Methodology to Quantify Populations in Proximity to Oil and Gas Development: A National Spatial Analysis and Review*, 125 Envtl. Health Perspectives 6 (2017), *available at* https://doi.org/10.1289/EHP1535.

[75] McVay-Hull-Roberts Decl. ¶ 41.

37. If EPA applies less stringent standards to new and modified wells and continues to delay the promulgation of Methane Guidelines for existing wells, these individuals will suffer increased risk of experiencing adverse health outcomes. Sensitive populations including children, older adults, those suffering from respiratory diseases such as asthma, low-income populations including minority low-income communities, outdoor workers, and others recreating outdoors are likely to be disproportionately affected. This is particularly true for Americans living in areas that already experience unhealthy levels of ozone pollution.

Conclusion

38. EPA's Rescission Rule will lead to increases in harmful VOC and HAP pollution that would otherwise be abated. Individuals exposed to these emissions and the secondary pollutants that form from them face a higher risk of adverse health effects, including acute and immediate respiratory ailments like asthma and enhanced risk of longer term, deleterious health effects associated with toxic pollution exposures, such as neurotoxicity, cancer, or blood disorders.

I declare that the foregoing is true and correct.

Ananya Roy

September 14, 2020

I declare that the foregoing is true and correct.

Tammy Thompson

September 14, 2020

Exhibit A

ANANYA ROY
1875 Connecticut Ave NW suite 600, Washington DC 20009
Email: aroy@edf.org Phone:+1- 2025723367

EDUCATION

2008	Doctor of Science (Sc.D.) Environmental Health (Exposure, Epidemiology and Risk) Harvard University, Boston, MA, USA
2003	Master of Science (M.Sc.) Pharmacology All India Institute of Medical Sciences (AIIMS), New Delhi, India
2001	Bachelor of Science (B.Sc.) Human Biology All India Institute of Medical Sciences (AIIMS), New Delhi, India

EXPERIENCE

Non Profit:

2016- Present	Senior Health Scientist, Environmental Defense Fund, Washington DC

Academic:

2012-2013	Associate Research Scientist, Department of Chronic Disease Epidemiology, Yale School of Public Health, New Haven, CT
2009-2012	Research Associate II, Environmental and Occupational Health Sciences Institute, University of Medicine and Dentistry (now Rutgers University) New Jersey, Piscataway, NJ
2008 - 2009	Post-doctoral Research Fellow, Department of. Environmental Health Sciences, University of Michigan School of Public Health, Ann Arbor, MI

HONORS AND AWARDS

2009	Institute of Health Metrics Travel Grant, University of Washington, Seattle, WA,
2007	Best research award, Boston India symposium
2005- 2007	Cabot Scholarship, Harvard School of Public Health, Boston, MA
2004- 2005	Edmund J. Curley Award, Harvard School of Public Health, Boston, MA
2004- 2005	Mahindra Education Trust Scholarship, Harvard School of Public Health, Boston

MAJOR RESEARCH INTERESTS:

1. Air pollution epidemiology
2. Health impact assessments
3. Global environmental health
4. Heavy metal exposures and child development

Current Research:

EDF

2019-Present	Co PI with Prof Oliver Gao, Cornell University. Atkinson Center- EDF postdoctoral fellow. Advanced Fine Scale Intra-Urban Sustainable Transportation - Climate - Air Quality - Health Integrated Assessment Tool for Future Cities.
2019-Present	Co PI with Prof Susan Anenberg, GW Milken School of Public Health. High Resolution Assessment of Distribution of Air Pollution-Related Health Impacts in Houston and Bay Area
2016- 2019	Co PI with Dr. Stephen Van Den Eeden, Kaiser Permanente DOR, Novel air pollution mapping and health disparities in Oakland
2018-Present	Co-PI with Prof. Sarav Arunachalam, UNC. Assessing air quality and Health impacts of Ozone and $PM_{2.5}$ attributable to Oil and Gas emissions in the United States

External funding:

2019-2020 Overlook Foundation. Co-I with Dr. Jonathan Buonocore, Harvard Chan School of Public Health. Tracking oil and gas pollution and understanding health benefits of reducing methane

PUBLICATIONS

Peer-Reviewed Journals:

1. SE Alexeeff, A Roy, J Shan, X Liu, K Messier, J Apte, C Portier, S Sidney, SK. Van Den Eeden. High-Resolution Mapping of Traffic Related Air Pollution with Google Street View Cars and Incidence of Cardiovascular Events within Neighborhoods in Oakland, CA. ***Environ Health.*** 2018 May 15;17(1):38
2. Messier K, Chambliss S, Gani S, Alvarez R, Brauer M, Choi J, Hamburg S, Kerckhoffs J, LaFranchi B, Lunden M, Marshall J, Portier C, Roy A, Szpiro A, Vermeulen, R, Apte J. Mapping air pollution with Google Street View cars: Efficient approaches with mobile monitoring and land use regression. ***Env Sci & Tech*** 2018 Oct 24;52(21):12563-72.
3. Downward GS, van Nunen EJ, Kerckhoffs J, Vineis P, Brunekreef B, Boer JM, Messier KP, Roy A, Verschuren WM, van der Schouw YT, Sluijs I. Long-Term Exposure to Ultrafine Particles and Incidence of Cardiovascular and Cerebrovascular Disease in a Prospective Study of a Dutch Cohort. Environmental health perspectives. 2018 Dec 19;126(12):127007.
4. Roy A, Gong J, Zhang J, Kipen HM, Rich DQ, Zhu T, Huang W, Hu M, Wang G, Wang Y, Ping Zhu, Lu S, Ohman-Strickland P, Diehl SR, Thomas D, Eckel SP. The cardiopulmonary effects of ambient air pollution and mechanistic pathways: A comparative hierarchical pathway analysis. ***PLOS One*** 2014 Dec 12;9(12): e114913.
5. Lim SS, …., Roy A**,** …., Lopez AD, Murray CJ, Ezzati. M. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990—2010: a systematic analysis for the Global Burden of Disease Study 2010. ***Lancet.*** 2012 Dec 15;380(9859):2224-60
6. Roy A**,** Hi W, Wei F, Korn L, Chapman RS, Zhang J. Ambient particulate matter and lung function growth in children living in four Chinese cities***. Epidemiology***, 2012; 23(3):464-472
7. Roy A**,** Chapman RS, Hu W, Wei F, Liu X, Zhang J, Indoor air pollution and lung function growth among children in four Chinese cities. ***Indoor Air***, 2012; 22 (1): 3–11
8. Abid Z, Roy A, Herbstman JB, Ettinger AS. Urinary polycyclic aromatic hydrocarbon metabolites and attention/deficit hyperactivity disorder, learning disability, and special education in U.S. children aged 6 to 15. ***J Environ Public Health.*** 2014;2014: 628508. doi: 10.1155/2014/628508. Epub 2014 Jan 30.
9. Richardson JR, Roy A, Shalat SL, von Stein RT, Hossain MM, Buckley B, Gearing M, Levey AI, German DC. Elevated serum pesticide levels and risk for Alzheimer disease. ***JAMA Neurol***. 2014 Mar;71(3):284-90. doi: 10.1001/jamaneurol.2013.6030.
10. Ettinger AS, Roy A, Amarasiriwardena CJ, Smith D, Lupoli N, Mercado-García A, Lamadrid-Figueroa H, Tellez-Rojo MM, Hu H, Hernández-Avila M. Maternal blood, plasma, and breast milk lead: lactational transfer and contribution to infant exposure. ***Environ Health Perspect***. 2014 Jan;122(1):87-92. doi: 10.1289/ehp.1307187. Epub 2013 Oct 30.
11. Roy A, Ettinger AS, Hu H, Bellinger D, Schwartz J, Modali R, Wright RO, Palaniappan K, Balakrishnan K. Effect modification by transferrin C2 polymorphism on lead exposure, hemoglobin levels, and IQ. ***Neurotoxicology***. 2013 Sep;38: 17-22. doi: 10.1016/j.neuro.2013.05.005. Epub 2013 May 31.
12. Richardson, JR, Roy A, Shalat SL, Buckley B, Winnik B, Gearing M, Levey AI, Factor SA, O'Suilleabhain P, German DC β-Hexachlorocyclohexane levels in serum and risk of Parkinson's disease. ***Neurotoxicology***, 2011 Oct; 32 (5) 640-645.
13. Palaniappan K, Roy A, Balakrishnan K, Krishnan L, Mukherjee B, Hu H, Bellinger D. Lead exposure and visuo-motor abilities in children from Chennai, India. ***Neurotoxicology*** 2011 Apr 8;32(4):465-470.

14. Roy A, Bellinger DC, Hu H, Modali R, Schwartz J, Wright RO, Ettinger A, Palaniapan K, Balakrishnan K. Hemoglobin, lead exposure, and intelligence quotient: effect modification by dopamine receptor D2 TaqIA polymorphism. ***Environmental Health Perspectives*** 2011 Jan;119(1):144-9.
15. Roy A, Hu H, Bellinger D, Schwartz J, Wright RO, Palaniappan K, Balakrishnan K. Predictors of blood lead among 3-7-year-old children in Chennai, India. ***International Journal of Occupational Environmental Health.*** 2009 Oct-Dec;15(4):351-9.
16. Roy A, Bellinger DC, Hu H, Schwartz J, Ettinger AS, Wright RO, Bouchard M, Palaniappan K, Balakrishnan K. Lead exposure and behavior among young children in Chennai, India. ***Environment Health Perspectives***. 2009 Oct; 117(10):1607-11
17. Kaushik M, Roy A, Bang AA, Mahal A. Quality of medical training and emigration of physicians from India. ***BioMed Central Health Services Research 2008***; 8:279.
18. Roy A, Sood S, Dinda AK, Das TK, Maulik SK. Oxidative stress and histopathological changes in the heart following oral lindane (gamma hexachlorohexane) administration in rats. ***Med Sci Monit*** 2005; 11(9):BR325-329.

Manuscripts Under Preparation or Submitted:

1. A Hierarchical Spatio-Temporal Model for the 100×100 Black Carbon Network in West Oakland, California. Travis Hee Wai, Joshua Apte, Thomas Kirchstetter, Ananya Roy, Christopher Portier, Ramon Alvarez, Adam Szpiro
2. Association Between Long-term Air Pollution Exposure and Direct Health Care Costs in Northern California. Ananya Roy, Stacey E. Alexeeff, Jun Shan, G. Thomas Ray, Charles Q. Quesenberry, Joshua Apte, Chris Portier, Stephen K. Van Den Eeden
3. Mortality Risk from PM2.5 Among the Elderly: A Comparison of Modeling Approaches and Policy Applications. Beia Spiller, Jeremy Proville, Ananya Roy, Nicholas Z. Muller
4. Assessing the distribution of air pollution health risks within cities: a neighborhood-scale analysis leveraging high resolution datasets in the Bay Area, California. Veronica A. Southerland, Susan C. Anenberg, Maria Harris, Joshua Apte, Perry Hystad, Aaron van Donkelaar, Randall V. Martin, Matt Beyers, Ananya Roy.
5. Best Practices for neighborhood scale air pollution health risk assessments in cities. Roy A, Southerland V, Anenberg S.
6. Impacts of Oil and Gas Sector Emissions on Air Quality and Health in the United States. Buonocore J, Reka S, Roy A, Thompson T, Mcvay R, Hull H, Lyon D, Arunachalam S.

Reports:

1. Human Health Effects of Ozone: The State of Evidence Since EPA's Last Integrated Science Assessment. Stephanie M. Holm, John R. Balmes, Ananya Roy. Environmental Defense Fund. September 2018
2. The Lancet Commission on pollution and health. **The Lancet**. Oct 19, 2017.
3. 10 Policies to Prevent and Respond to Childhood Lead Exposure: An assessment of the risks communities face and key federal, state, and local solutions. Pew Charitable Trust. Aug 30, 2017

Conference Abstracts:

1. Palaniappan K, Balakrishnan K, Krishnan L, Bellinger D, Roy A, Wright R O, Hu H. Lead exposure, IQ, and neurobehavioral changes in children in Chennai, India. Epidemiology 2007;18(5): S42 (Abstract).
2. Roy A, Palaniappan K, Hu H, Wright R, Balakrishnan K. Predictors of blood lead in 3-7 year old children in Chennai, India. Epidemiology 2007; 18(5): S175 (Abstract).
3. Roy A, Palaniappan K, Hu H, Bellinger D, Wright R, Balakrishnan K. Current blood lead is associated with decline in stature among children in Chennai, India. Epidemiology 2007;18(5): S181 (Abstract).
4. Roy A. Lead Associated Deficits in Executive Function and Behavior in 3-7 Year Old Children in Chennai, India Epidemiology 2008;19(6): S306 (Abstract).
5. Roy A, Ettinger A, Hu H, Hernandez-Avila M. Dietary calcium as a modifier of the relationship between lead burden and blood pressure among postpartum women. Epidemiology 2008;17(6): S123 (Abstract).

6. Roy A, Bellinger DC, Hu H, Modali R, Schwartz J, Wright RO, Ettinger A, Palaniapan K, Balakrishnan K. Hemoglobin, lead exposure, and intelligence quotient: effect modification by dopamine receptor D2 TaqIA polymorphism. Epidemiology 2009;20(6): S77-78 (Abstract).
7. Thomas D, Roy A, Hu H, Mukherjee B, Modali R, Palaniappan K, Balakrishnan K IQ and Blood Lead Levels: Effect Modification by ALAD Amongst Children in Chennai, India. Epidemiology 2011 Jan; 22(1): S135-S136 (Abstract).
8. Roy A, Hu W, Leo K, Chapman RS, Wei F, Zhang J, Ambient air pollution and lung function growth among Ambient Air Pollution and Lung Function Among Children in 4 Cities in China (1993–1996) Epidemiology 2011 Jan; 22(1): S192 (Abstract).
9. M H Harris, B Beveridge, M Gordon, F Uennatornwaranggoon, G Zayas del Rio, A Roy. Street-Level Air Pollution, Health Disparities, and Advocacy. Environmental Health Perspectives. (https://ehp.niehs.nih.gov/doi/abs/10.1289/isesisee.2018.S01.03.17)
10. A Roy, S Alexeeff, J Shan, X Liu, K Messier, J S Apte, C Portier, S Sidney, S Van Den Eeden Google Street View Car Measurements of Traffic Related Air Pollution within Neighborhoods and Stroke in a Population with Preexisting Cardiovascular Disease. Environmental Health Perspectives. (https://ehp.niehs.nih.gov/doi/10.1289/isesisee.2018.P03.1670)
11. K Messier, S Chambliss, A Roy, J Marshall, M Brauer, A Szpiro, C Portier, J Kerckhoffs, R Vermeulen, J S Apte. Mapping Air Pollution with Google Street View Cars: Towards Efficient Mobile Monitoring. Environmental Health Perspectives. (https://ehp.niehs.nih.gov/doi/abs/10.1289/isesisee.2018.S02.03.10)
12. Saravanan Arunachalam, Srinivas Reka, Dongmei Yang, David Lyon, Hillary Hull, Ryan O Connell, Ananya Roy, Beth Trask, Jonathan Buonocore Air Quality Impacts of Oil and Gas Emissions in the United States, CMAS 2019
13. Veronica Southerland, Susan Anenberg, Joel Schwartz, Josh Apte, Maria Harris, Ananya Roy. Leveraging mobile monitoring and satellite remote sensing to estimate the health burden of air pollution on the hyper-local scale: case study for the California Bay Area. AGU 2019

Blogs:

1. Amid COVID-19, the Trump administration sets dangerous air pollution standards. What is at stake for Houstonians? EDF Health Blog. May 2020
2. New study finds elevated health risks due to pollution from oil and gas activity in Colorado. Energy Exchange Blog. Nov 2019
3. Are your workers making mistakes? Could be air pollution messing with their brains. EDF Voices Blog. June 2019
4. Traffic pollution causes 1 in 5 new cases of kids' asthma in major cities: How data can help. EDF Health. 2019
5. The science is clear: We need a stronger smog standard. Climate 411 blog. Sep 2018
6. New EPA Science Regulation: A Trojan Horse that Hurts Public Health. EDF Health Blog.May 2018
7. Sensors and electronic health records reveal block-by-block traffic air pollution health disparities among the elderly in Oakland. EDF Health Blog. May 2018

SPEAKING ENGAGEMENTS

Invited presentations, seminars, webinars, stakeholder briefings

Panelist. WRI. Greening Governance Seminar Series: A Return to Normal is Not Enough: The Hidden Impacts of Air Pollution, Inequality and COVID-19 July 23, 2020

PEPH, NIEHS Annual Conference. Workshop session Lead: Translating Sensor Air Pollution, and Health Data to Action with Communities, Youth, and Healthcare. Feb 2020.

Panelist. OpenAQ. "Imagining the Possibilities of a Low-Cost Air Quality Sensor Platform". Dec 2019.

Panelist. Clean Air is Our Natural Capital, Nesta, London. February 2019. "International perspectives on air pollution and health"

Invited speaker. Envirome Institute, U of Louisville, TN. November 2018 "Hyperlocal Air Pollution & Health in Cities: Harnessing Sensors and EMR to Drive Action"

Presenter. Chinese Ministry of Environment and Ecology, Department of Enforcement Delegation to USA. Nov 2018 "Hyperlocal Air Pollution and Health: Data for Decision Making"

Presenter. AB617 stakeholder consultation. April 2018 "High resolution air pollution mapping and health impacts in West Oakland"

Presenter. EDF public Webinar. May 2018." Street-Level Air Pollution & Cardiovascular Risk in Oakland, CA Application of Sensors & Electronic Medical Records to Understand Intra-Urban Environmental Health Disparities"

Presenter. BAAQMD stakeholder briefing May 2018." Street-Level Air Pollution & Cardiovascular Risk in Oakland, CA. Application of Sensors & Electronic Medical Records to Understand Intra-Urban Environmental Health Disparities"

Presenter. Asian Health Network. Stakeholder briefing. May 2018. "Air pollution and Cardiovascular health in Oakland, CA"

Presenter. Alameda County Public Health Department. Stakeholder briefing. May 2018. "Air pollution and Cardiovascular health in Oakland, CA"

Invited Speaker. Workshop on the Global Burden of Disease-Pollution and Health Initiative. March 2018. "India Case Study: Information gaps in addressing air pollution".

Presenter. China Ministry of Environment Ecology January 2018. Environmental Health Training. Guangzhou, China. "High resolution air pollution mapping and health impacts"

Presenter. China Ministry of Environment Ecology January 2018. Environmental Health Training. Guangzhou, China. "Health based decision making for air pollution control"

Presenter Environment Heath Seminar, University of Michigan School of Public Health, MI; February 2009. "Lead exposure and health effects in 3-7-year-old children in Chennai, India."

Presenter. University of Washington School of Public Health, Seattle, WA; January 2009. "Global Burden of disease due to lead exposure."

Presenter. Environment Heath Seminar, Harvard University School of Public Health, Boston, MA; October 2007. "Current lead exposure and neurobehavior in 3-7 year-old children in Chennai India."

Conference oral presentations

Roy A, Harris M (Symposium chairs) High Resolution Air Pollution Mapping: Translating Data to Action. International Society of Environment Epidemiology (ISEE), Ottawa, CA. 2018

Roy A, Chapman RS, Hu W, Wei F, Liu X, Zhang J. Indoor air pollution and lung function growth among children in four Chinese cities. Indoor Air 2011 Conference, Austin, TX; June 5-11, 2011.

Roy A, Bellinger DC, Hu H, Modali R, Schwartz J, Wright RO, Ettinger A, Palaniapan K, Balakrishnan K. Hemoglobin, lead exposure, and intelligence quotient: effect modification by dopamine receptor D2 TaqIA polymorphism. International Society of Environment Epidemiology 2009 Conference, Dublin, Ireland; August 25-29, 2009.

Roy A. Lead Associated Deficits in Executive Function and Behavior in 3-7 Year Old Children in Chennai, India International Society of Environment Epidemiology 2008 Conference, Pasadena, CA; October 12-16, 2008.

Roy A, Palaniappan K, Hu H, Bellinger D, Wright R, Balakrishnan K. Current blood lead is associated with decline in stature among children in Chennai, India. Oral Presentation, International Society of Environment Epidemiology 2007 Conference, Mexico City, Mexico; 5th-9th, September 2007

Roy A, Ettinger A, Hu H, Hernandez-Avila M. Dietary calcium as a modifier of the relationship between lead burden and blood pressure among postpartum women. Poster Presentation International Society of Environment Epidemiology 2006 Conference, Paris, France; 3-5th, September 2006.

PROFESSIONAL SERVICE

Input to regulatory process

Declaration on health impacts of air pollution from diesel trucks. (In support of EDF legislative actions to close the loophole on glider trucks.)

Submitted to EPA comment letter on Integrated Science Assessment for Particulate Matter

Testimonial. Public Hearing: National Ambient Air Quality Standards for Particulate Matter, 85 Fed. Reg. 24,094. May 21, 2020, Washington, D.C.

Declaration of Dr. Ananya Roy and Dr. Tammy Thompson. Plaintiffs Opposition to Defendants motion to stay pending conclusion of rulemaking (on Methane Guidelines).

Memberships

International Society of Environment Epidemiology (ISEE) 2007-present

American Geophysical Union

Peer review service

Epidemiology

Journal of Exposure Science and Environmental Epidemiology

Social Science and Medicine

Indoor Air

International Journal for Occupational and Environmental Health

Indian Journal of Pediatrics

Egyptian Journal of Forensic Medicine

Science of the Total Environment

TEACHING

2010-2011	Lecturer, Neuroepidemiology of Lead. Neural Injury and Repair Course, Ernest Mario School of Pharmacy at Rutgers, The State University of New Jersey, Piscataway, NJ
2011	Teaching faculty, Environmental Health, Sri Ramachandra University, India
2010	Invited Lecturer, Environmental Health, Yale University, New Haven, CT
2007	Head Teaching Assistant, Principles of Environmental Health, Harvard School of Public Health, Boston, MA
2006	Teaching Assistant, Human Health and Global Environmental Change, Harvard Medical School, Boston, MA
2001-2003	Lecturer, Masters-level Practical Pharmacology, All India Institute of Medical Sciences (AIIMS), New Delhi, India

Exhibit B

TAMMY M. THOMPSON
(303)447-7226
tthompson@edf.org

Education

Ph.D. Chemical Engineering, University of Texas at Austin, December 2008

- Thesis title: *Evaluating the Design of Emissions Trading Programs Using Air Quality Models*, Advisor: Prof. David T. Allen

BS Chemical Engineering, University of Florida, December 2002 with Honors

- 4.0/4.0 GPA

Professional Experience

Senior Air Quality Scientist, Environmental Defense Fund, Feb. 2019 - Present

- Develop and evaluate modeling tools to identify contribution of sources to air pollution at a hyper-local scale
- Design and oversee modeling studies with a focus on the human health impacts of oil and gas production and transportation

Environmental Policy Analyst, Congressional Research Service Library of Congress, July 2018 – Feb. 2019

- Respond to Congressional inquiries on topics related to air pollution and climate
- Developed reports on background ozone, methane, and contributions of LNG to air pollution

Science & Technology Policy Fellow, American Association for the Advancement of Science, Sept. 2016 – July 2018

- Published a review of global climate models in context of updating estimates of the Social Cost of Carbon
- Lead a team of EPA researchers to evaluate opportunities to reduce High Ozone Days in the Northeast U.S. under the current policy framework
- Working with Federal Land Managers to evaluate the state of science of emissions inventory estimations for NEPA
- Authored a white paper on the state of the science of reactive nitrogen source apportionment
- Lead a speaker series as Co-chair of AAAS Energy/Climate Affinity Group
- Co-convened a symposium on Ecosystem Services: From Concept to Policy

Research Scientist II, Colorado State University, Cooperative Institute for Research in the Atmosphere, May 2013 – Aug. 2016

- Worked with scientists from academia, and local, state and federal agencies to identify strategies to improve air quality in and around our National Parks
- Improved the representation of the nitrogen cycle in regional chemical transport modeling
- Investigated the impacts of energy development activity and increased availability of natural gas on air quality
- Evaluated the sensitivity of chemical transport model performance to meteorological modeling in complex terrain

Post Doctoral Associate, Massachusetts Institute of Technology, Joint Program for the Science and Policy of Global Change, Sept. 2010 – April 2013

- Developed integrated assessment capabilities for/ and conducted evaluations of potential human health co-benefits associated with air quality changes resulting from global change and climate policy
- Serve as the in house regional air quality and regional modeling expert, including mentoring grad students on modeling tools
- Evaluated the impact of model resolution on the uncertainty associated with human health impacts from changes in ozone and particulate matter

Post Doctoral Associate, University of Texas at Austin, Center for Energy and Environmental Resources, Jan. 2009 – Sept. 2010

- Evaluated impacts of transportation modeling assumptions and Texas on-road mobile source emission scenarios
- Worked with Austin Industry Leaders to design and implement policies to reduce local ozone
- Evaluated Smart Energy Grid Ideas for air quality impacts as part of Austin's Pecan Street Project

Graduate Researcher, University of Texas at Austin, Center for Energy and Environmental Resources, Sept. 2003 – Dec. 2008
- Integrated Air Quality and Economic models of Electricity Generating Units for the Northeast United States to maximize benefits obtained from regional cap and trade program
- Modeled Air Quality Impacts of Plug-In Hybrid Electric Vehicles using existing capacity in the Northeast and Texas
- Proposed policy changes to improve the viability of VOC emissions trading markets in Houston. Recommendations are based on analysis of historical emissions and air quality modeling done to test the impacts of temporal and spatial variability of emissions on the 8hr ozone attainment demonstration

Air Quality Team Leader, United States Agency International Development, Lima, Peru, Aug. 2006 – Feb. 2007
- Designed and developed an Air Quality model to estimate the air quality benefits of a switch to Natural Gas from traditional fuels
- Traveled to Lima to present findings and train Peruvian Environmental workers on the model

Independent Consultant
- Earth Justice: Served as an Expert Witness speaking to atmospheric chemistry and meteorological conditions that, along with oil and gas emissions, lead to high ozone events in the Colorado Front Range, Oct. 2017
- Clean Air Task Force: Evaluated proposed methane controls for regional air quality and human health co-benefits, Nov. 2015 – Aug. 2016
- Environmental Defense Fund: Served as an Expert Witness reporting and discussing the potential air quality impacts of statewide controls on hydrocarbon emissions from Oil and Gas Production in Colorado, Nov. 2013 – Feb. 2014
- National Parks Conservation Association: Evaluated the potential impacts on visibility in Class 1 Areas in the Southwest of emissions from select point source facilities in Texas, Feb. 2012
- Sierra Club: Evaluated the potential air quality impacts of a proposed and existing emissions point sources in Texas, March – Feb. 2012
- Perimeter Counties Industrial Group: Determined the extent of the contributions of emissions from both Harris county and the perimeter counties outside Harris to the ozone non-attainment status of the South-East Texas area, 2005-2006

Intern, United States Environmental Protection Agency Chemical Engineering Branch, Washington DC, June 2004 – Dec. 2004
- Determined the environmental and worker safety of new to the market chemicals during the production, transport, storage and use of the chemical's life cycle, using EPA developed software, ChemSTEER, as part of the Pre Manufacture Notice program (PMN)
- Helped to develop a Generic Scenario for a Refinery, used to estimate the type, location and quantity of emissions at a Refinery

Tool set includes: CAMx and CMAQ air quality models, WRF and Hysplit meteorological models, MOVES2010 and MOBILE6 on-road emissions models, Global climate models, EPS3 and SMOKE emissions preprocessing systems, GIS, python, R, fortran, oracle, perl and unix.

Service and Memberships
Appointed to the Denver Metropolitan Area Regional Air Quality Council by Governor John Hickenlooper in April 2014
Member: American Geophysical Union, American Meteorological Society
Reviewer: Atmospheric Environment, Energy Policy, Environmental Science & Technology, Atmospheric Chemistry & Physics
Technical Committee Member, Three State Air Quality Study, January 2014 – Aug. 2016
Grant Review Panel Member, EPA SBIR, November 2013

Publications (Peer Reviewed)
1. **Thompson, T.M.** "Modeling the Climate and Carbon Systems to Estimate the Social Cost of Carbon" Accepted for publication at Wiley Interdisciplinary Reviews: Climate Change.
2. Zhang, R., **Thompson, T.M.**, Barna, M.G., Hand, J.L., McMurray, J.A., Bell, M.D., Malm, W.C., Schichtel, B.A. "Source regions contributing to excess reactive nitrogen deposition in the Greater Yellowstone Area (GYA) of the United States", *Atmospheric Chemistry and Physics Discussions* 1–38, 2018.
3. **Thompson, T.M.**, Shepherd, D., Stacy, A., Barna, M.G., Schichtel, B.A. "Modeling to Evaluate Contribution of Oil and Gas Emissions to Air Pollution" *Journal of the Air & Waste Management Association,* 67, 445–461, 2017.

4. Li, Y., **Thompson, T.M.**, Van Damme, M., Chen, X., Benedict, K.B., Shao, Y., Day, D., Boris, A., Sullivan, A.P., Ham, J., Whitburn, S., Clarisse, L., Coheur, P.-F., and Collett Jr., J.L. "Temporal and spatial variability of ammonia in urban and agricultural regions of northern Colorado, United States", *Atmospheric Chemistry and Physics,* 17, 6197–6213, 2017.
5. Saari, R.K., **Thompson, T.M.**, Selin, N.E. "Human Health and Economic Impacts of Ozone Reductions by Income Group" *Environmental Science & Technology*, 51, 1953–1961, 2017.
6. **Thompson, T.M.**, Rausch, S., Saari, R.K., Selin, N.E. "Air quality co-benefits of subnational carbon policies" *Journal of the Air & Waste Management Association,* 66, 988–1002, 2016.
7. Malm W.C., Rodriguez M.A., Schichtel B.A., Gebhart K.A., **Thompson T.M.,** Barna M.G., Benedict K.B., Carrico C.M., Collett Jr. J.L. "A hybrid modeling approach for estimating reactive nitrogen deposition in Rocky Mountain National Park", *Atmospheric Environment* 126, 258–273, 2016.
8. **Thompson T.M**., Rodriguez M.A., Barna M.G., Gebhart K., Hand J., Day D., Malm, W., Benedict K., Collett Jr. J.L., and Schichtel B. "Atmospheric Modeling of Reduced Nitrogen Deposition Source Apportionment at Rocky Mountain National Park", *Journal of Geophysical Research: Atmospheres,* 120, 2015.
9. Saari R.K.**,** Selin N.E.**,** Rausch S. and **Thompson T.M.** "A self-consistent method to assess air quality co-benefits from US climate policies", *Journal of the Air & Waste Management Association,* 65, 74-89, 2015.
10. **Thompson T.M.**, Rausch S., Saari R.K., Selin N.E. "Air Quality Co-Benefits of US Carbon Policies: A Systems Approach to Evaluating Policy Outcomes and Uncertainties", *Nature Climate Change,* 4, 917-923. 2014.
11. **Thompson T.M.**, Saari, R.K., Selin, N.E. "Air Quality Resolution for Health Impacts Assessment: Influence of Regional Characteristics", *Atmospheric Chemistry & Physics*, 14, 969-978, 2014.
12. **Thompson T. M.** and Selin N. E. "Influence of air quality model resolution on uncertainty associated with health impacts", *Atmospheric Chemistry & Physics,* 12(20), 9753–9762, 2012.
13. Sun L., Webster M., McGaughey G., McDonald-Buller E.C., **Thompson T.M.**, Prinn R., Ellerman A.D. and Allen D.T. "Flexible NOx Abatement from Power Plants in the Eastern United States", *Environmental Science & Technology,* 46 (10): 5607–5615, 2012.
14. **Thompson T.M**., King C.W., Allen D.T., Webber M.E. "Air quality impacts of plug-in hybrid electric vehicles in Texas: evaluating three battery charging scenarios", *Environmental Research Letters,* 6, 024004, 2011.
15. **Thompson T.M.,** Kimura Y., Durrenberger C., Webb A., Tejela Matias A.I., and Allen D.T.: "Estimates of the Air Quality Benefits using Natural Gas in Industrial and Transportation Applications in Lima, Peru", *Clean Technologies and Environmental Policy*. January 2009.
16. **Thompson, T.M.,** Webber M.E., Allen D.T. "Air Quality Impacts of Using Overnight Electricity Generation to Charge PHEVs for Daytime Use", *Environmental Research Letters*. December 2008.
17. Wang L., **Thompson T.**, McDonald-Buller E.C., Webb A., and Allen D.T. "Photochemical Modeling of Emissions Trading of Highly Reactive Volatile Organic Compounds (HRVOCs) in Houston, Texas. Part 1. Potential for Ozone Hot Spot Formation and Reactivity Based Trading", *Environmental Science & Technology*, 41, 2095-2102, 2007.
18. Wang L., **Thompson T.**, McDonald-Buller E.C., Webb A., and Allen D.T. "Photochemical Modeling of Emissions Trading of Highly Reactive Volatile Organic Compounds (HRVOCs) in Houston, Texas. Part 2. Incorporation of Chlorine Emissions", *Environmental Science & Technology*, 41, 2102-2107, 2007.

Selected Presentations/Posters

1. **Thompson T.M.**, Barna M.G., Schichtel B.A. "Modeling Reduced Nitrogen in the Rockies", Poster at the American Geophysical Union conference San Francisco, December, 2015.
2. **Thompson T.M.,** Barna M.G., Schichtel B.A., Gebhart, K. "Sensitivity of Source Apportionment in Rocky Mountain National Park to Meteorological Modeling", Speaker at the Community Modeling and Analysis System (CMAS) Conference, Chapel Hill, NC, October 6, 2015.
3. **Thompson T.M.**, Barna M.G., Schichtel B.A. "2011 Model Performance of Reduced Nitrogen in the Grand Tetons: CAMx vs CMAQ", Poster at the Community Modeling and Analysis System Conference, Chapel Hill, NC, October 6, 2015.
4. **Thompson T.M**. "Protecting our National Parks: Air Quality Challenges", Invited Speaker at the Joint Program on the Science and Policy of Global Change, Boston, MA, February 20, 2015.
5. **Thompson T.M.**, Barna M.G., Schichtel B.A. "Nitrogen Deposition and Critical Loads in our National Parks: Contribution of Oil and Gas Production", Speaker at the American Meteorological Society Conference, Phoenix, AZ, January 9, 2015.
6. **Thompson T.M.**, Barna M.G., Schichtel B.A. "Modeled Contributions of Oil and Gas Production to Nitrogen Deposition in the Western U.S.", Speaker at the National Atmospheric Deposition Program Conference, Indianapolis, IN, October, 23, 2014.

7. **Thompson T.M.** "A Systems Approach to Evaluating Air Quality Co-benefits of Climate Policy", Invited speaker at the Joint Program on the Science and Policy of global Change Forum, Miami, FL, January 11, 2014.
8. **Thompson T.M.,** Rausch S., Saari R.K., Selin N.E.: "Air quality co-benefits of a carbon policy: Regional implementation", Speaker at the American Geophysical Union Annual Meeting, San Francisco, December 9-13, 2013.
9. **Thompson T.M.,** Rodriguez M., Barna M.G., Gebhart K.A., Malm W.C., Schichtel B.A.: "Source apportionment of ammonia at Rocky Mountain National Park", Poster at Hemispheric Transport of Air Pollutants (H-TAP) Meeting, San Francisco, December 5-6, 2013.
10. **Thompson T.M**., Barna M.G., Gebhart K.A., Malm W.C., and Schichtel B.: "Investigating the source of discrepancy in the diurnal profiles at Rocky Mountain National Park: Modeled versus Measured Ammonia", Poster presented at Community Modeling and Analysis System Conference, Chapel Hill, NC, 28 October 2013.
11. **Thompson T.M.,** Selin N.E.: "Evaluating Energy Policy: Quantifying Air Pollution and Health Co-Benefits", Poster at American Geophysical Union Science and Policy Conference, Washington DC, 2 May 2012.
12. **Thompson T.M.**, Selin N.E.: "Influence of Model Resolution on Uncertainty Associated with Human Health, Part II." Speaker at Community Modeling and Analysis System Conference, Chapel Hill, NC, 16 October 2012.
13. **Thompson T.M.,** Rausch S., Selin N.E.: "Air Quality Impacts of a Clean Energy Standard on Major U.S. Cities", Poster at American Geophysical Union Conference, San Francisco, CA, 7 December 2011.
14. **Thompson T.M.,** Rausch S., Selin N.E.: "Influence of Air Quality Model Resolution on Uncertainty Associated with Health Impacts", Poster at World Climate Research Program Conference, Denver, CO, 26 October, 2011.
15. **Thompson T.M.,** Webber M., Allen D.T.: "Air Quality Impacts of Using Electricity Generation to Charge PHEVs for Daytime Use". Speaker at the 2010 AWMA Conference in Calgary, AB.
16. **Thompson T.M.,** Wang L., Webb A., McDonald-Buller E.C. and Allen D.T.: "Photochemical Modeling of the Air Quality Impacts of an Emissions Trading Program for Highly Reactive Volatile Organic Compounds (HRVOCs) in Texas." Speaker at the 2006 AWMA Conference in New Orleans, LA.

Selected Other Publications

1. **Thompson T.M.**, Shepherd D., Stacy A., Schichtel, B.A. "Modeling to Evaluate Contribution of Oil and Gas Emissions to Air Pollution", CIRA Report, ISSN No. 0737-5352-89, June 2016.
2. **Thompson T.M.**, Allen D.T. "Lehigh Cement Hourly Impact Analysis" Report Prepared for Lehigh Cement and Capital Area Council of Governments, July 2010.
3. **Thompson T.M.,** McGaughey G., McDonald-Buller E.C. Allen, D.T. "Assessing the Contribution to Austin Area Ozone Concentrations in Austin, Texas from Twelve Point Sources using Anthropogenic Precursor Culpability Assessment (APCA). Technical Report for Austin's Big Push Initiative. December 2009.
4. **Thompson T.M**. and Allen D.T. "Dynamic Responses to Management of Ozone Formation". Final Report submitted to Austin Energy, May 2009.
5. Benavides M., **Thompson T.M.**, Sullivan D., McDonald-Buller E.C. and Yarwood, G. "Characterization of Fine Particulate Matter in the Texas Aerosol Research and Inhalation Epidemiology Study (Texas ARIES)" Submitted to The Texas Air Research Center. August 2008.