Concerned Health Professionals of NY

Comments on the

New York State Energy Plan

THE NEGATIVE HEALTH IMPACTS OF INCREASED RELIANCE ON NATURAL GAS AS AN ENERGY SOURCE ARE LARGELY IGNORED

The Energy Plan puts New York on a path to increased reliance on natural gas extracted through unconventional drilling and hydraulic fracturing. The Energy Plan concedes that gas development will occur in New York (see pg. 88 of Sources): "The natural gas model reflects a conservative Marcellus Shale natural gas production level to account for potential permitting and production difficulties related to horizontal drilling and hydraulic fracturing. If these difficulties are minimized, Marcellus production levels could potentially be higher."

However, even if unconventional gas development with hydraulic fracturing is never permitted in New York, the consequence of using more shale gas extracted through fracking will mean greater exposure of people—both in New York and elsewhere—to polluted air and water, gas drilling waste on roads and in landfills, exposure to radionuclides, and the industrialization of rural areas. The plan fails to comprehensively address the many issues relating to emissions, water contamination, safety, and environmental degradation from increased reliance on natural gas including extraction and related infrastructure, such as industrial plants to process, store, and distribute liquefied natural gas and petroleum gas (LNG and LPG), fueling stations, compressor stations, and pipelines. The Plan also fails to address the health impacts on vulnerable populations, especially children.

Gas development is already taking place in our neighboring as well as more distant western states. This is occurring without attention to the large-scale health problems emerging as a result of gas development in those states. New York State must carefully assess the potential health impacts of natural gas extraction, processing and delivery on New Yorkers, directly and as a result of such activities outside our borders, prior to taking a decision to rely on such gas for the future of New York's energy needs. The emerging literature indicates that the risks outweigh any benefits.

The medical community in NY State has been researching the issue of health impacts of fossil fuels, and shale gas in particular, for the past three years[1]. We have requested that New York perform a comprehensive Health Impact Assessment[2] [3] that would include all the risks, including the costs of lives shortened or otherwise impacted by gas development activities**.** Until such an assessment is completed we think it is improper to commit New York to increased reliance on natural gas.

Provided below in Section I are comments on specific language in the Plan. Section II presents a summary of the peer-reviewed literature on health impacts from fossil fuel development, with attention to unconventional gas extraction using hydraulic fracturing, and the related infrastructure, which should have been addressed by the Plan.

I. SPECIFIC COMMENTS ON THE PLAN

Volume I: Shaping the Future of Energy [PDF][4]

Page 20—New York's Vision lists five items:
1) Improving energy affordability
2) Unleashing the power of private sector energy financing
3) Providing a more resilient and flexible power grid
4) Giving customers more control over their energy use
5) Aligning energy innovation with market demand

Comment: Improving health outcomes for all New Yorkers should be included as a Vision.

Page 31, the Plan lists Areas of Focus and Initiatives…which it plans to pursue and implement through the cooperation of agencies and authorities, New York's colleges and universities, and private sector stakeholders across the State…specifically, Initiative 15 addresses a clean energy workforce.

Comment: Workers in the natural gas sector have 7-8 times the on-the-job mortality rate compared to the average worker in the US [5] [6], the State should consider this when "shaping curricula at the State University of New York, City University of New York, community colleges, and technical institutes" for these dangerous jobs.

[1] http://concernedhealthny.org/timeline/
[2] http://concernedhealthny.org/call-for-a-comprehensive-health-impact-assessment/
[3] http://concernedhealthny.org/letters-to-governor-cuomo/
[4] http://energyplan.ny.gov/Plans/2014.aspx
[5] http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5716a3.htm
[6] http://www.cdc.gov/niosh/programs/oilgas/risks.html

Volume II: Technical Appendix [PDF][7]

Page 84 Sources , the Energy Plan states: "Horizontal well completions combined with hydraulic fracturing can provide the best means for producing economic volumes of natural gas from the Marcellus Shale."

Comment: The total economic risks have not been taken into account. For example, the health impacts, short and long-term, have not been monetized.

Further on that page, the Plan states: "To assess the potential environmental concerns related to the development of the Marcellus Shale formation in New York, the DEC and the NYS Department of Health are reviewing horizontal drilling and hydraulic fracturing in the context of a Supplemental Generic Environmental Impact Statement (SGEIS)."

Comment: The SGEIS did not address health impacts adequately and the medical and environmental communities have requested that the process of the health review take the form of a Health Impact Assessment so that stakeholders could have input, for transparency of process and for scientific verification.

Volume II: Impacts and Considerations

Page 46: discusses implementation of National Ambient Air Quality Standards (NAAQS)[8] …
Comment: Regarding shale gas development, individual wells and some infrastructure are not adequately monitored[9] and they are not considered cumulatively. That infrastructure, including well sites, compressor stations, processing plants, gas-powered power plants and LNG plants emit significant pollutants[10] [11] [12] [13] such as Nitrogen Oxides (NOx), Carbon Monoxide (CO), Volatile Organic Compounds (VOC), Formaldehyde (H2CO), Particulate Matter (PM 10 and 2.5) and Sulfur Dioxide (SO2) and their impacts are not aggregated. Yet the exposure is cumulative, as we know from surveys[14] and personal communications[15] [16].

Page 49: Non-criteria pollutants

[7] http://energyplan.ny.gov/Plans/2014.aspx
[8] EPA. *National Ambient Air Quality Standards.* http://www.epa.gov/air/criteria.html .
[9] Brown et al, 2014 Understanding exposure from natural gas drilling puts current air standards to the test, Reviews on Env Health, DOI: 10.1515/reveh-2014-0002
[10] http://www.iom.edu/~/media/Files/Activity%20Files/Environment/EnvironmentalHealthRT/2012-04-30/Robinson.pdf and http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30/Day-1/Session-5/1-Robinson.aspx
[11] http://sape2016.files.wordpress.com/2013/10/algonquin_incremental_market_project.pd
[12] http://courses.washington.edu/envir300/papers/Steinzor_et_al_2013.pdf
[13] http://sape2016.files.wordpress.com/2013/10/air_quality_and_climate_impacts_of_shale_gas_operations.pdf
[14] http://www.earthworksaction.org/library/detail/gas_patch_roulette_full_report#.UvwhS_ldWSp
[15] http://www.post-gazette.com/news/state/2013/10/06/Marcellus-gas-facilities-near-to-one-another-or-even-linked-are-evaluated-individually-for-pollution/stories/201310060050
[16] http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/ and http://www.fractracker.org/2013/03/pacwas-list-of-the-harmed-now-mapped-by-fractracker

Comment: These are of particular concern for pregnant women and children, and gas development has been shown to produce these chemicals. These groups should be specifically addressed for risk and short and long-term health impacts.

Comment: Re: criteria pollutants mentioned on p. 69, in Volume 2 (Impacts)—again children were not mentioned. Children are a large and vulnerable group which needs adequate attention. In addition, the costs of such pollutants should be monetized to include impacts on children, with consideration of their physiology, longer years of exposure, and the newest research included.

Comment: Page 69 graph does not list the effects of air pollutants on children…

Table 5 | Health Effects Associated with Carbon-based Fuel Combustion Pollutants

AIR POLLUTANT	HUMAN HEALTH EFFECTS
Greenhouse Gases[a]	Indirect climate-related effects on morbidity and mortality e.g., increased mold and pollen allergy incidence and severity, heat stress, heart-related mortality, vector-borne disease
Carbon Monoxide[b]	Effects on existing cardiovascular disease
Nitrogen Oxides[c]	Increased symptom severity with respiratory infections, increased airway inflammation and responsiveness, asthma exacerbation, other respiratory effects
Ozone[d]	Eye, nose and throat irritation, decreased lung function, respiratory effects, e.g., shortness of breath, coughing, asthma exacerbation, effects on existing cardiovascular disease, mortality
Particulate Matter[e] PM_{10}	Chronic bronchitis
Particulate Matter[e] PM_{10} and $PM_{2.5}$	Nose irritation, respiratory effects e.g., coughing, difficulty breathing, asthma exacerbation, premature mortality (cardio-pulmonary)
Particulate Matter[e] $PM_{2.5}$	Cardiovascular effects
Sulfur Dioxide[f]	Respiratory tract irritation, asthma exacerbation, difficulty breathing/shortness of breath, cough, premature mortality
Metals[g]	Effects vary depending on specific metal
Polycyclic Aromatic Hydrocarbons[h]	Cancer (not all polycyclic aromatic hydrocarbons)
Volatile Organic Compounds (VOCs)[i]	Effects vary depending on the specific chemical. Some examples are: Central nervous system effects, liver and/or kidney toxicity, eye, skin, and respiratory tract irritation, cancer

II. SUMMARY OF LITERATURE AND SCIENTIFIC DATA THAT THE PLAN SHOULD HAVE CONSIDERED

Shale gas development causes adverse health impacts. Due to the rapid expansion gas development using high volume hydraulic fracturing and the lack of necessary studies by federal or state regulators before these processes were commenced, it has taken some time to develop evidence of the impacts on human health. Initially, reports of ill health were compiled by grassroots organizations. Lists were generated by activists (List of the Harmed[17]) and surveys taken (Earthworks' Survey of Health Impacts[18]).

[17] http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/

[18] Steinzor, N, et al., Investigating Links Between Shale Gas Impacts and Health through a Community Survey Project in Pennsylvania, New Solutions, Vol. 23(1) 55-83 (May 2013). Access at: http://www.earthworksaction.org/files/publications/SteinzorSubraSumiShaleGasHealthImpacts2013.pdf

A Health Impact Assessment[19] in Battlement Mesa Colorado showed that air pollution was a significant stressor on human health. That Assessment was never completed because it was blocked by industry and pulled by the Garfield County Board of County Commissioners during the second draft.

Despite the obstacles at the state and federal levels, including lack of adequate funding for research[20], and lack of the health profession's inclusion on key decision-making committees[21], reports of adverse health impacts are now appearing in the peer-reviewed literature, the gold standard in medicine. Physicians, Scientists and Engineers for Healthy Energy have just published a database of literature related to shale gas development.[22] Additional resources have been compiled by Concerned Health Professionals of NY[23] and the Southwest Pennsylvania Environmental Health Project.[24]

Air Pollution

The early reports on air pollution and health impacts concerned fossil fuels more generally. In October 2011 George Thurston of NYU addressed Congress: "The human evidence includes impacts revealed by epidemiologic studies, natural experiments and controlled chamber exposures, all showing consistent associations between air pollution and increases in adverse health impacts across a wide range of human health outcomes, including illness and death."[25]

The effects of ozone and its association with premature death are well documented and should no longer be considered questionable. Anenberg et al (2010) estimated a global mortality from anthropogenic ozone equal to 6.3 million years of lost life annually. PM2.5 is related to 3.5 million cardiopulmonary deaths and 220,000 deaths from lung cancer annually.[26] According to a 2013 study, aggressive measures designed to reduce greenhouse gas emissions could prevent as many as 3 million premature deaths annually by 2100.[27] According to the results, aggressive cuts in greenhouse gas emissions could prevent 300,000-700,000 premature deaths annually by 2030; 800,000-1.8 million by

[19] Witter R, et al, Battlement Mesa HIA 2011 http://www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-draft2.aspx

[20] Bernard Goldstein, January 2014 op-ed: When it comes to the public health implications of gas drilling, Pa. has its head in the shale http://www.pennlive.com/opinion/index.ssf/2014/01/when_it_comes_to_the_public_health_implications_of_gas_drilling_pa_has_its_head_in_the_shale.html

[21] Goldstein et al, 2012. Missing from the Table: Role of the Environmental Public Health Community in Governmental Advisory Commissions Related to Marcellus Shale Drilling. Environ Health Perspect; DOI:10.1289/ehp.1104594. Access at http://ehp.niehs.nih.gov/1104594/

[22] Physicians, Scientists and Engineers for Healthy Energy, 2014, access at http://www.psehealthyenergy.org/site/view/1180

[23] www.concernedhealthny.org

[24] www.environmentalhealthproject.org

[25] Thurston, G.D., Statement of Professor George D. Thurston to the Subcommittee on Energy and the Environment of the United States House of Representatives Committee on Science Space and Technology, Re: the science of air pollution health effects and the role of Casac in EPA standard setting, (October 4, 2011). Access at http://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/100411_Thurston.pdf

[26] Anenberg SC et al 2010. An Estimate of the Global Burden of Anthropogenic Ozone and Fine Particulate Matter on Premature Human Mortality Using Atmospheric Modeling. Environmental Health Perspectives. 118:9 1189-1195

[27] Lamarque et al, 2013. Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health. Nature Climate Change 3, 885–889 (2013) doi:10.1038/nclimate2009

2050; and between 1.4 million and 3 million by 2100. The authors estimate significant cost benefits as a consequence of the GHG reductions. The main source of the compounds that cause air pollution (ozone, particulate matter, nitrogen oxides, volatile organic compounds, formaldehyde and polycyclic aromatic hydrocarbons) is from fossil fuels.

Recently, there have been observations and studies specific to air pollution from gas development. One of the first papers that found air pollution from gas drilling was a significant risk to human health was from Colorado, in the Witter et al White Paper[28] and the Battlement Mesa Health Impact Assessment.[29]

In a follow-up to that study, MacKenzie found that residents living < ½ mile from wells were at greater risk for health effects from gas development than residents living >½ mile from wells. Subchronic exposures to air pollutants presented the greatest potential for illness, with benzene as the major contributor to the risk.[30] The study by Dr Colborn in 2013 tested air before and after the start of drilling and fracking operations. Once drilling operations started, 44 air pollutants were detected at a house located about 1 kilometer from a well pad.[31]

A report from the federal agency, NOAA (National Oceanographic and Atmospheric Administration), discussed a study in Utah where high ozone levels were present during the winter, an anomalous situation. Because ozone precursor pollutants are emitted in large quantities by the region's oil and natural gas drillers, the regulators concluded that they were the main contributors to the toxic emissions. High concentrations of ozone can trigger asthma attacks and inflame conditions for people with bronchitis, emphysema and other respiratory ailments.[32]

Total air pollution in an area of Texas which is heavily drilled, is more than double all the auto and truck exhaust. That area has seen a recent increase in the incidence of asthma to 25%, compared to half that in other Texas cities.[33] The World Health Organization has classified diesel exhaust as a definite carcinogen, raising additional concerns for gas field workers and other vulnerable groups exposed to diesel exhaust.[34]

The infrastructure, including compressor stations, processing plants and gas-powered power plants emit significant pollutants[35] [36] [37] [38]such as Nitrogen Oxides (NOx), Carbon Monoxide (CO), Volatile Organic

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[28] Witter, 2008, http://docs.nrdc.org/health/files/hea_08091702A.pdf
[29] Witter R, et al, Battlement Mesa HIA 2011 http://www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-draft2.aspx
[30] McKenzie LM, et al, Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources 2012 http://www.ncbi.nlm.nih.gov/pubmed/22444058
[31] Colborn T, et al, An Exploratory Study of Air Quality near Natural Gas Operations 2012 http://www.endocrinedisruption.com/chemicals.air.php
[32] NOAA ozone study http://www.eenews.net/public/Landletter/2011/04/21/1
[33] Fort Worth air quality study 2011 http://fortworthtexas.gov/uploadedFiles/Gas_Wells/AirQualityStudy_final.pdf
[34] IARC: Diesel Exhaust Carcinogenic 2012 http://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf
[35] http://www.iom.edu/~/media/Files/Activity%20Files/Environment/EnvironmentalHealthRT/2012-04-30/Robinson.pdf and http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30/Day-1/Session-5/1-Robinson.aspx
[36] http://sape2016.files.wordpress.com/2013/10/algonquin_incremental_market_project.pd
[37] http://courses.washington.edu/envir300/papers/Steinzor_et_al_2013.pdf
[38] http://sape2016.files.wordpress.com/2013/10/air_quality_and_climate_impacts_of_shale_gas_operations.pdf

Compounds (VOC), Formaldehyde (H2CO), Particulate Matter (PM 10 and 2.5) and Sulfur Dioxide (SO2) and their impacts are not aggregated. Yet the exposure is cumulative[39] and costly[40].

The following are some of the health impacts associated with infrastructure pollutants:

NOx is a group of highly reactive gasses known as "oxides of nitrogen." Alone it is associated with respiratory disease and increased visits to the hospital. Ozone is formed when NOx and volatile Organic compounds react in the presence of heat and sunlight. (Ozone itself for this situation is not monitored so it can only be inferred by NOx and VOCs.)

VOCs --"It is well known that all of the chemicals in this group are neurotoxins. They impact the central and peripheral nervous system. They have significant cognitive and behavioral effects…
They are known hepatotoxins. Most have been identified as reproductive toxins both in males and females. They are recognized as fetotoxins, and have been associated with teratogenesis and fetal wastage following large or critically timed occupational or accidental exposures. All are dermatotoxins." … "little meaningful information on chronic, low level, exposure in the general environment has been developed"- (Witter et al, 2008 white paper).

SO2 is associated with respiratory illness, increased visits to the ED and hospitalizations. It is toxic.
"Even small increases in exposure to these pollutants, human risks increase for the following:
• Respiratory disease: Including respiratory disease-related hospital admission, mortality due to respiratory disease, worsening of illness in people with lung disorders (e.g. asthma, chronic obstructive pulmonary disease), asthma, bronchiolitis and respiratory infections, reduced lung function (especially in asthmatic children), allergic nasal and airways inflammation, allergies, symptoms (e.g. cough, wheeze, shortness of breath, eye irritation, headache).
• Childhood Asthma: Some of the most compelling evidence, reinforced by publications in the past five years, relates to ozone's impact on children with asthma. While there is evidence for some 'adaptation' to the effects of ozone as people age, and heterogeneity in peoples' responses to ozone (that may be related to genetics), the overall impact of ozone related to childhood asthma is noteworthy. It includes increases in pediatric emergency room visits and pediatric hospital admissions, asthma exacerbations of symptoms and use of rescue inhalers, impaired lung development, and airways inflammation in addition to asthma, including bronchiolitis.
• Cardiovascular disease: Including cardiovascular hospital admission, mortality due to cardiovascular disease, arrhythmias (heart rhythm disturbances, heart rate variability), and blood pressure elevation.
• Genotoxicity: Damage to chromosomes and DNA.
• Fetal and neonatal health: Preterm birth, low birth weight, hospitalization of newborns, and respiratory illness in infants born to asthmatic mothers who were exposed to ozone during pregnancy.

Particulate matter -- "Recent data demonstrates that while particles with diameters </= 10 microns (PM10) pose health risks, particles with diameters </= 2.5 microns (PM2.5) and particles with diameters </= 1 micron (ultrafine particles) contribute disproportionately to human health risks.

[39] http://www.post-gazette.com/news/state/2013/10/06/Marcellus-gas-facilities-near-to-one-another-or-even-linked-are-evaluated-individually-for-pollution/stories/201310060050
[40] Litovitz, Curtright, 2013, "Estimation of regional air-quality damages from Marcellus Shale natural gas extraction in Pennsylvania". Access at http://iopscience.iop.org/1748-9326/8/1/014017/pdf/1748-9326_8_1_014017.pdf and also http://iopscience.iop.org/1748-9326/8/1/014017

Due to their small size and large surface area, these smaller particles are carried deeper into the lungs when inhaled, and are capable of carrying toxic pollutants to the lung and elsewhere in the body as they enter the bloodstream."

"Even small increases in airborne particulate matter exposure, human risks increase for the following:

• Cardiovascular disease: Including cardiovascular hospital admission, mortality due to cardiovascular disease, premature death from heart disease, cardiac ischemia (reduce blood flow to the heart), arrhythmias (heart rhythm disturbances, heart rate variability), hypercoagulability, atherosclerosis, myocardial infarction (heart attack), blood pressure.

• Respiratory disease: Including respiratory disease-related hospital admission, mortality due to respiratory disease, premature death from respiratory disease including lung cancer, worsening of illness in people with lung disorders (e.g. asthma, chronic obstructive pulmonary disease), asthma, bronchiolitis and respiratory infections, reduced lung function (especially in asthmatic children), allergic lung inflammation, allergies, symptoms (e.g. cough).

• Fetal and neonatal health: Preterm birth, restricted fetal growth, lower infant term birth weight, and increased neonatal death especially when it is associated with respiratory illness.

• Childhood illnesses: Pediatric allergies, ear/nose/throat and respiratory infections early in life, pediatric emergency room visits and pediatric hospital admissions, impaired lung development in children that affects lung function in adulthood, asthma, bronchiolitis, exacerbation of existing asthma and exacerbation of cystic fibrosis.

• Geriatric illnesses: Including exacerbation of chronic obstructive pulmonary disease, congestive heart failure, heart conduction disorders, myocardial infarction and coronary artery disease, and diabetes in the elderly."

(The above is adapted from a presentation by Sarah Buckley RN.)

In the study from the Univ of California at Irvine[41], researchers working in the Alberta gas and oil fields (called the Industrial Heartland) found that, "based on a 13-year record (1994-2006) at the county level, the incidence of male hematopoietic cancers (leukemia and non-Hodgkin lymphoma) was higher in communities closest to the Industrial Heartland compared to neighboring counties. While a causal association between these cancers and exposure to industrial emissions cannot be confirmed, this pattern and the elevated VOC levels warrant actions to reduce emissions of known carcinogens, including benzene and 1,3-butadiene." They also state that it is "important and responsible to improve health surveillance and VOC exposure measurements, to utilize epidemiological studies that can better link environmental factors to disease, and to reduce exposures to pollutants that might plausibly be related to adverse health impacts."

At the end of 2013, a report by the University of Pittsburgh School of Public Health, established significantly increased air pollutant levels associated with adverse health statistics in Southwest Pennsylvania[42] where shale gas extraction and other infrastructure are under accelerated development. In a March 2014 Utah study, the authors conducted observations of VOCs from the Uintah Basin in Utah. Their measurements identified highly elevated levels of atmospheric alkane hydrocarbons, build-up of

[41] Simpson I et al, Air quality in the Industrial Heartland of Alberta, Canada and potential impacts on human health 2013 http://concernedhealthny.org/wp-content/uploads/2013/07/Simpson2013-AE-in-press.pdf

[42] Univ of Pittsburgh 2013 http://fortworthtexas.gov/uploadedFiles/Gas_Wells/AirQualityStudy_final.pdf

ozone, and aromatic compounds benzene and toluene, considered air toxics, were also elevated. There was a strong causal link between oil and gas emissions, accumulation of air toxics, and significant surface production in the atmospheric surface layer.[43]

Also just published is a review by David Brown and his colleagues at SWPA – EHP…they have seen more patients impacted by gas drilling operations than any other group. They note that human health risks near gas development sites are derived from average population risks without adequate attention to the processes of toxicity in the body. They report that current methods of collecting emissions data, as well as the analyses of these data, are not sufficient for accurately assessing risks to individuals or protecting the health of those near gas development sites.[44]

Effects Of Air Pollution On Children And Other Vulnerable Populations

Children and pregnant women are particularly affected in adverse ways by environmental toxins[45]. Children are especially vulnerable to air pollution because their lungs continue to grow and enlarge until about age 18. Plus they breathe faster and are closer to the ground.[46] The result of chronic ozone exposure can be brittle lungs like those of an elderly adult.

Low birth weight infants and prematurity present a major and increasing problem. From the pediatric literature it is known that this group is susceptible to a host of problems including respiratory problems and developmental disorders, such as cerebral palsy and autism. There is substantial evidence that gestational age is affected by environmental exposures.

Perera et al of Columbia University (2003)[47] studied air-borne polycyclic aromatic hydrocarbons (PAHs) in the personal air of the pregnant mother. The authors found a significant association with LBW as well as smaller head circumference. Edwards et al (2010)[48] used the same methodology in Poland and found that high exposures to PAHs in utero resulted in a 4 point lower IQ at age 5, which is consistent with the findings in NY.

Air pollution has also been shown to be associated with birth problems[49], neurodevelopmental disorders, lower IQ in babies born to mothers with polycyclic aromatic hydrocarbon exposure during pregnancy[50] [51] and learning disorders in exposed children. A study in 2010 compared residential

[43] Helmig D, et al, 2014 Highly Elevated Atmospheric Levels of Volatile Organic Compounds in the Uintah Basin, Utah. Environ. Sci. Technol., DOI: 10.1021/es405046r 10.1021/es405046r
[44] Brown D et al, 2014, http://www.degruyter.com/view/j/reveh.ahead-of-print/reveh-2014-0002/reveh-2014-0002.xml
[45] CEH, 2013, http://www.ceh.org/legacy/storage/documents/Fracking/fracking_final-low-1.pdf
[46] World Health Organization http://www.who.int/ceh/capacity/Children_are_not_little_adults.pdf
[47] Perera FP et al 2003 Effects of Transplacental Exposure to Environmental Pollutants on Birth Outcomes In a Multiethnic Population. Environmental Health Perspectives 111:2 201-205
[48] Edwards SC et al 2010 Prenatal Exposure to Airborn Polycyclic Aromatic Hydrocarbons and Children's Intelligence at 5 years of age in a Prospective Cohort Study in Poland. Environmental Health Perspectives 118:9 1326-1331
[49] Wilhelm at UCLA report on air pollution and premature births
http://www.environment.ucla.edu/reportcard/article.asp?parentid=1700
[50] Perera, 2009 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2864932/

proximity to a freeway with the incidence of autism, and found that for those living within 300 meters of the freeway during the third trimester, the odds ratio of being born with autism was more than twice as great as controls.[52]

Neurodevelopmental disorders such as autism, attention deficit disorder, dyslexia, and cerebral palsy affect one in six children worldwide, and some diagnoses seem to be increasing in frequency. Industrial chemicals that injure the developing brain are among the known causes for this rise in prevalence. Co-authors of a paper just published in Lancet Neurology,[53]Grandjean and Landrigan, write: "The vast majority of the more than 80,000 industrial chemicals in widespread use in the USA have never been tested for their toxic effects on the developing fetus or child. Exposure to these chemicals during early development can cause brain injury at levels much lower than those affecting adults, and the real impact on children's health is just beginning to be uncovered."

Elaine Hill, PhD candidate in the Department of Applied Economics and Management at Cornell University has studied birth outcomes (birth weight, gestational age at birth, low birth weight and premature birth) in two states, Pennsylvania (Hill, 2012)[54] and Colorado (Hill 2013)[55]. To define exposure, she used detailed vital statistics and mother's residential address to define proximity to drilling activity. Using a difference-in-differences approach (before and after and close versus less-close), her papers compare health at birth of infants born to residences within 1 km of the well head versus 1.5 km to identify the impact of drilling. She found that proximity to wells reduces birth weight and gestation length on average and increases the prevalence of low birth weight and premature birth.

Building on Hill's preliminary study, Currie and her colleagues, including Katherine Meckel of Columbia University, and John Deutch and Michael Greenstone of the Massachusetts Institute of Technology, looked at Pennsylvania birth records from 2004 to 2011 to assess the health of infants born within a 2.5-kilometer radius of natural-gas fracking sites. According to the report, "(t)hey found that proximity to fracking increased the likelihood of low birth weight by more than half, from about 5.6 percent to more than 9 percent. The chances of a low Apgar score, a summary measure of the health of newborn children, roughly doubled, to more than 5 percent." (Bloomberg report of the study at the American Economic Association conference January 2014).[56]

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[51] Perera et al, 2006. Effect of prenatal exposure to airborne polycyclic aromatic hydrocarbons on neurodevelopment in the first 3 years of life among inner-city children. Environ Health Perspect. Doi:114(8):1287–1292. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1551985/

[52] Volk, HE et al (2010) Residential Proximity to Freeways and Autism in the CHARGE study. Environmental Health Perspectives Dec 13 (Epub ahead of print)

[53] Grandjean and Landrigan, "Neurobehavioural effects of developmental toxicity", Lancet Neurol 2014; 13: 330–38, doi:10.1016/S1474-4422(13)70278-3. Published Online February 15, 2014. Access online at http://download.thelancet.com/pdfs/journals/laneur/PIIS1474442213702783.pdf?id=baaj7wRR-UTIz8M5y3Zqu

[54] Hill, E, PhD Candidate, Unconventional Natural Gas Development and Infant Health: Evidence from Pennsylvania, (July 2012) Work in Progress available at http://dyson.cornell.edu/research/researchpdf/wp/2012/Cornell-Dyson-wp1212.pdf

[55] Hill, E, PhD Candidate, The Impact of Oil and Gas Extraction on Infant Health In Colorado, Job Market Paper (Oct. 2013) preliminary draft available at https://sites.google.com/site/elainelhill/research

[56] Bloomberg news report, Study Shows Fracking Is Bad for Babies, by Mark Whitehouse, January 4, 2014. Access at http://www.bloomberg.com/news/2014-01-04/study-shows-fracking-is-bad-for-babies.html

A study just published by the Colorado School of Public Health[57] links congenital birth defects with gas drilling: they found a 30% increase in congenital heart disease in babies whose mothers lived in the most exposed tertile (> 125 wells/mile) compared to mothers with no wells within a 10-mile radius of their residence. They also observed a higher prevalence of neural tube defects in the highest exposure tertile.... Births in the highest tertile (> 125 well/mile) were 2 times more likely to have a NTD than those with no wells within a 10-mile radius.

Overall, although the evidence is just emerging for an association between air pollution and low birth weight, birth defects and neurodevelopmental problems, there is clearly a trend of association with some pollutants at some points during pregnancy. These findings clearly demonstrate the need for additional studies as the public health implications of increasing the numbers of premature and low birth weight babies, as well as children with autism and birth defects are enormous.

In addition to the public health problems, there is the cost to the government and the taxpayer. A child disabled because of preventable environmental exposure is not only a tragedy, but a significant cost for the state. In 2011 Sheffield & Landrigan wrote that "(c)limate change is increasing the global burden of disease and in the year 2000 was responsible for > 150,000 deaths worldwide. Of this disease burden, 88% fell upon children. Heat-related health effects for which research is emerging include diminished school performance, increased rates of pregnancy complications, and renal effects. Stark variation in these outcomes is evident by geographic region and socioeconomic status, and these impacts will exacerbate health disparities. Prevention strategies to reduce health impacts of climate change include reduction of greenhouse gas emissions and adaptation through multiple public health interventions."[58]

Landrigan & Goldman[59] and Trasande & Liu[60] in 2011 also published papers on the health impacts of air pollution, and have monetized the health impacts of air pollution on children, though not referring specifically to gas development. Since health impacts from other sources of air pollution have been monetized, it should be possible to do the same for pollution from gas development.

Water contamination

In addition to the air pollution associated with fossil fuels, and gas development in particular, there is growing evidence in peer-reviewed literature from major US universities that water has become contaminated when gas drilling occurs nearby. In a 2011 paper on methane migration, Jackson et al[61] found evidence that aquifers overlying the Marcellus shale formations have explosive levels of methane

[57] McKenzie et al, http://ehp.niehs.nih.gov/1306722/
[58] Sheffield, P. and Landrigan, P., Global Climate Change and Children's Health: Threats and Strategies for Prevention, Environ Health Perspect 119:291–298 (2011). doi:10.1289/ehp.1002233
[59] Landrigan, P. and Goldman, L., Children's Vulnerability To Toxic Chemicals: A Challenge And Opportunity To Strengthen Health And Environmental Policy. Health Aff (May 2011). doi:10.1377/hlthaff.2011.0151
[60] Trasande, L. and Liu, Y., Reducing The Staggering Costs Of Environmental Disease In Children, Estimated At $76.6 Billion In 2008, Health Aff (May 2011), doi:10.1377/hlthaff.2010.1239
[61] 2011 Duke study http://www.biology.duke.edu/jackson/pnas2011.html

contamination in drinking water and this was associated with shale gas extraction. A study a year later further documented methane migration.[62]

In the July 2013 paper on brine migration, 141 drinking water wells were analyzed across Pennsylvania. They detected thermogenic methane in 82% of drinking water samples, with the highest concentrations in homes <1 km from natural gas wells. Methane is a problem for humans when it displaces oxygen and breathing becomes difficult. People in Pennsylvania have lost consciousness in their homes. In other cases methane which accumulated in the home has caused explosions.[63]

Authors from the University of Texas, in their 2013 paper, determined that arsenic, selenium, strontium, barium, and total dissolved solids (TDS) reached their highest concentrations in water coming from areas in close proximity to natural gas wells.[64] Arsenic causes bronchitis, gastroenteritis, skin changes, neuropathy, various cancers, and death. Excessive selenium causes growth retardation, hair and skin changes, and neurological disturbances. Strontium accumulates in bones and can weaken them, and the effects are worse on children's bones. The signs of barium toxicity include low blood potassium, cardiac arrhythmias, respiratory failure, gastrointestinal dysfunction, paralysis, muscle twitching, and elevated blood pressure.

Michelle Bamberger and Robert Oswald researched several cases where chemicals associated with drilling were implicated in negative health outcomes.[65] They focused mostly on animals because they are the sentinels of disease in humans due to the fact that their reproductive cycles and their lives are shorter. One of several cases they describe was the death of 17 cows within one hour from direct exposure to hydraulic fracturing fluid. The final necropsy report listed the most likely cause of death as respiratory failure with circulatory collapse. The hydraulic fracturing fluid contained petroleum hydro-carbons and quaternary ammonium compounds plus other toxins.

Two cases provided inadvertent control experiments since herds of cows were kept in different pastures. In brief, cows exposed to gas drilling chemicals had significantly more deaths, stillbirths and congenital malformations. Two other cases involved deaths and congenital malformations of companion animals and one of the implicated routes of exposure was waste spreading on roads which the animals either drank or licked off their paws; and in the other case it was from an aerated impoundment of waste. In addition, their water had turned after drilling but they had continued to use it.

In one of the homes, a child became ill with fatigue, confusion, abdominal and back pain. After several animals in the household had died, the doctor became suspicious of toxins and testing revealed arsenic in the child. The family then stopped drinking the water despite results which showed the well water was safe and he eventually recovered, having lost a year of school.

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[62] 2012 Duke and CalStatePolytech http://www.pnas.org/content/early/2012/07/03/1121181109.full.pdf

[63] Increased stray gas abundance in water wells near Marcellus shale gas wells—2013 Duke, U of Rochester, CalStatePolytech and Max Planck Institute http://www.pnas.org/content/110/28/11250.full.pdf

[64] Schug, 2013. Environ. Sci. Technol., 2013, 47 (17), pp 10032–10040
DOI: 10.1021/es4011724 http://pubs.acs.org/doi/abs/10.1021/es4011724

[65] Bamberger and Oswald—2012 New Solutions
http://www.psehealthyenergy.org/Impacts_of_Gas_Drilling_on_Human_and_Animal_Health

In these cases, there were 25 wells within two miles of the homes, and there was also the aerated impoundment, and two compressor stations within a mile. While checking for other toxins in these two homes, random urine tests on family members revealed phenol, a metabolite of benzene; symptoms observed by families in both homes included extreme fatigue, headaches, nosebleeds, rashes, and sensory deficits (smell and hearing). Were it not for the deaths of the animals, the human health effects would not have been found. Their study illustrates several plausible links between gas drilling and negative health effects.

The US Environmental Protection Agency (EPA) has studied several cases of water contamination—in Texas, Dimock Pennsylvania and Pavillion Wyoming. Yet, when the evidence pointed to contamination, EPA retreated under industry and political pressure.[66] Of serious concern are the hundreds of chemicals used in gas exploration and production which are not disclosed and which include many toxic chemicals. Dr Theo Colborn[67] has written about the chemicals that are toxic. They include benzene (a known carcinogen), ethylbenzene, toluene (causes miscarriages, placenta previa), xylene, diesel (recently classified by WHO as a carcinogen), naphthalene (a neurotoxin and carcinogen), polynuclear aromatic hydrocarbons (carcinogens), formaldehyde (known carcinogen), 2-Butoxyethanol (hematopoietic dyscrasias; carcinogenesis), and 2-BE is the active component of Corexit which was used as a dispersant in the Exxon Valdez and BP Gulf disasters and is used in all phases of gas extraction.

Additional information about some of these chemicals: Benzene primarily affects the central nervous system (CNS) and the hematopoietic system, resulting in anemia and leukemia. Acute benzene toxicity is characterized by CNS depression. Symptoms may progress from light-headedness, headache, and euphoria to respiratory depression, apnea, coma, and death. Benzene concentrations of about 20,000 ppm are fatal to humans within 5 to 10 minutes. With gas drilling, it is the subchronic exposures to benzene that are most likely to occur, and this was documented in the recent Colorado study by MacKenzie; some of the health problems that might be encountered are rather non-specific, like fever, blood disorders, fatigue, and anorexia.

Evidence suggests that toluene creates a risk for pregnancy, and the incidence of developmental delays and neurobehavioral difficulties is higher for the children of women who were exposed to high concentrations of organic solvents during pregnancy than for those who were not.[68] Xylene exposure can occur via inhalation, ingestion, eye or skin contact. The main effect of inhaling xylene vapor is depression of the central nervous system, with symptoms such as headache, dizziness, nausea and vomiting. The effects can begin to occur with exposure to air levels of about 100 ppm. Long-term exposure may lead to headaches, irritability, depression, insomnia, agitation, extreme tiredness, tremors, impaired concentration and short-term memory. Levels of 200 ppm or greater can irritate the lungs, causing chest pain and shortness of breath.[69]

[66] http://www.propublica.org/article/epas-abandoned-wyoming-fracking-study-one-retreat-of-many
[67] http://endocrinedisruption.org/assets/media/documents/cP02591Colborn20021022coalbedmethane2-BEcommments.pdf
[68] 2010 http://www.ncbi.nlm.nih.gov/pubmed/20377315
[69] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2996004/

Dr. Theo Colborn has studied the endocrine disrupting chemicals associated with gas development.[70] And a University of Missouri School of Medicine study released in December 2013 linked fracking with dangerous hormone-disrupting chemicals in the water near gas drilling sites, including the Colorado River.[71]

Silicosis

Large quantities of silica sand are used during the hydraulic fracturing process. It is mined primarily in Minnesota and Wisconsin, and local residents are concerned about their air. In the course of transport silica dust is released into the air, causing a hazard to those employees involved in handling silica sand. Silicosis is an incurable but preventable lung disease.

In addition to being an occupational lung carcinogen, inhaling silica dust causes chronic obstructive pulmonary disease (COPD), chronic renal disease and various autoimmune diseases. Individuals with silicosis are known to be at higher risk of tuberculosis. And these illnesses can impact the community in which the workers live. The Occupational Safety and Health Administration has proposed rules to limit crystalline silica, which would prevent nearly 700 deaths a year.[72] No health agency has looked at the residents living nearby.

Waste

The waste generated by this industry is enormous, and it is hazardous.[73] [74] It contains radioactive brines and gases.[75] [76] It is exempt from federal oversight.[77] It has been documented that disposal in underground injection wells can, and has caused earthquakes.[78] [79] [80] [81] which have impacted the foundations and cracked walls in homes. A recent review of gas development waste, with an eye on the radioactivity, was just published in Environmental Health Perspectives.[82]

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[70] Colborn et al, 2011. Natural Gas Operations from a Public Health Perspective. Human and Ecological Risk Assessment: an International Journal http://endocrinedisruption.org/chemicals-in-natural-gas-operations/journal-article

[71] Nagel et al, 2013. Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region. DOI: http://dx.doi.org/10.1210/en.2013-1697

[72] http://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html

[73] http://www.shalegas.energy.gov/resources/060211_earthworks_petroleumexemptions.pdf

[74] http://www.dcbureau.org/201308148881/natural-resources-news-service/new-york-imports-pennsylvanias-radioactive-fracking-waste-despite-falsified-water-tests.html#more-8881

[75] http://www.grassrootsinfo.org/pdf/radioactivewaste.pdf

[76] http://www.grassrootsinfo.org/pdf/whitereport.pdf

[77] http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf

[78] Katie M. Keranen, Heather M. Savage, and Geoffrey A. Abers et al., "Potentially Induced Earthquakes in Oklahoma, USA: Links between Wastewater Injection and the 2011 Mw 5.7 Earthquake Sequence," Geology, vol. 41, no. 3 (March 26, 2013)

[79] http://geology.gsapubs.org/content/early/2013/03/26/G34045.1.abstract

[80] http://www.ldeo.columbia.edu/news-events/wastewater-injection-spurred-biggest-earthquake-yet-says-study

[81] http://stateimpact.npr.org/texas/tag/earthquake

[82] Brown VJ. 2014. Radionuclides in fracking wastewater: managing a toxic blend. Environ Health Perspect 122:A50–A55; http://dx.doi.org/10.1289/ehp.122-A50

Radioactivity

There are additional risks due to the radioactive nature of the Marcellus shale in particular which have not been adequately studied, although we do know that radium and radon are elevated in the Marcellus shale region. According to the Agency for Toxic Substances and Disease Registry (ATSDR), "(r)adon is also present in natural gas. Natural gas had previously been in contact with underground uranium and thorium-bearing rock and soil that continually release radon. The radon and its progeny remain with the natural gas as it travels through distribution pipes and into homes. Radon and its progeny are released to breathing air when the gas is burned in Fireplaces, Furnaces, Heaters, Stoves, and Water heaters."[83]

Radon is a leading cause of lung cancer and is preventable.[84] [85] Paschoa, in Radiological Impact due to Oil and Gas Extraction, 2 0 0 3, wrote that "…gaseous radon (222Rn)is concentrated in ethane and propane fractions due to the fact that the boiling point of radon lies between those of propane and ethane. Elevated radon activity concentration values have been measured at several processing plant sites. It is well known today that the radiological impact of the oil and gas-extracting and processing industry is non-negligible. Two steps should be taken to improve the current situation in most oil-producing countries: 1) establish a common basis for the international regulation of TENORM in the oil and gas industry, taking into proper account the natural radioactive background with its spatial and temporal variations; and 2) improve the international database on extraction and production processes in the oil and gas industries, for example in the framework of a co-ordinated research project under the auspices of a well-recognised international organisation…"[86] Steinhausler has written that workers and those living nearby are at risk from exposure to radioactive materials.[87] ATSDR lists stoves and furnaces as a source of radon.[88]

Elevated levels of radioactivity, salts and metals have been found in river water and sediments at a site where treated water from oil and gas operations is discharged into a western Pennsylvania creek.[89] "Radium levels were about 200 times greater in sediment samples collected where the Josephine Brine Treatment Facility discharges its treated wastewater into Blacklick Creek than in sediment samples collected just upstream of the plant," according to Dr Vengosh, professor of geochemistry and water quality at Duke University's Nicholas School of the Environment.

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[83] ATSDR, http://www.atsdr.cdc.gov/csem/csem.asp?csem=8&po=5

[84] National Academy of Sciences, Health Effects of Exposure to Radon: BEIR VI, NATIONAL ACADEMY PRESS, Washington, D.C. 1999 http://www.nap.edu/catalog/5499.html

[85] http://www.epa.gov/radon/pubs/citguide.html

[86] Paschoa, A, *Radiological Impact due to Oil and Gas Extraction, report in B U S I N E S S B R I E F I N G : E X P L O R A T I O N & P R O D U C T I O N 2 0 0 3*

[87] Steinhäusler, F, RADIOLOGICAL IMPACT ON MAN AND THE ENVIRONMENT FROM THE OIL AND GAS INDUSTRY: RISK ASSESSMENT FOR THE CRITICAL GROUP, Published in *M.K. Zaidi and I. Mustafaev (eds.), Radiation Safety Problems in the Caspian Region,* 129-134.
© 2004 *Kluwer Academic Publishers. Printed in the Netherlands.*

[88] http://www.atsdr.cdc.gov/csem/csem.asp?csem=8&po=5

[89] Vengosh et al, 2013, http://www.nicholas.duke.edu/news/radioactive-shale-gas-contaminants-found-at-wastewater-discharge-site

In a 2014 paper by Andrew Nelson and Michael Schultz, the authors describe the difficulty of measuring radioactivity in flowback water (FBW) from Marcellus shale drilling.[90] The typical and current method used is EPA 903.0, and it is useful for the detection of radium in drinking water; however, analysis of FBW by this method was questioned by these authors because of the remarkably high ionic strength and dissolved solid content observed, particularly in FBW from the Marcellus Shale region.

A US Dept of Energy paper from 1982 lists some of the sources of radon in the home; for example, combustion of gas in buildings with unvented appliances may be a source of radon. The concentration of radon depends on the wellhead concentration and transmission time from the well to the point of consumption. Concentrations ranging from 1 to 1500 pCi/1 have been reported. In the Northeastern States radon from natural gas is not an important source because of considerable radioactive decay occurring from the wellhead (Texas and Louisiana) to the distribution point.[91] This statement reflected gas transiting from the western US; with the exploitation of the Marcellus shale, the gas travels shorter distances, for example, from PA, to homes in NY State which may already have high average radon http://www.wadsworth.org/radon/ and to NYC, and will have a significant added negative health impact. EPA has set the action level at 4pCi/L; the World Health Organization (WHO) has set it at 2.7pCi/L [92]

A study from Pakistan in 1993 obtained results which showed that less ventilated places have higher radon concentrations; the second highest value of radon concentration was found in kitchens; further, danger of indoor radon and its daughters is even higher in energy-saving houses and those having poor ventilation systems. [93]

Effects Of Radioactivity On Vulnerable Populations

Potential health problems from radioactivity exposure, specifically exposure to radon include DNA damage. The body's response is to try to repair the damage, and we have mechanisms in place to do that, but it may result in an altered sequence which can result in mutations which can lead to tumor initiation.

There are also possible teratogenic effects caused by radon exposure.
If dissolved in a mother's blood stream, radon can pass through the placenta and into the developing child. If the developing child is only in the embryo phase, and a radon particle forms a progeny and deposits anywhere, emitting alpha radiation, the formation of DNA lesions will most likely kill it….On the other hand, if the developing child is in the fetal stages, most of the bodily development has already

[90] Nelson A et al, Matrix Complications in the Determination of Radium Levels in Hydraulic Fracturing Flowback Water from Marcellus Shale, *Environ. Sci. Technol. Lett.*, **2014**, *1* (3), pp 204–208
DOI: 10.1021/ez5000379. Access at http://pubs.acs.org/doi/abs/10.1021/ez5000379
[91] Andreas C. George, Environmental Measurements Laboratory, U. S. Department of Energy Characterization of Radon Levels in Indoor Air. 1982. Access at http://www.osti.gov/scitech/biblio/6437894 ; full text http://www.osti.gov/scitech/servlets/purl/6437894
[92] http://www.prlog.org/10349595-world-health-organization-who-sets-radon-action-level-of-27-less-lung-cancer-risk-than-epa-40.html
[93] HAMEED A. KHAN, INDOOR RADIOACTIVE POLLUTION DUE TO RADON AND ITS DAUGHTERS, Journal of Islamic Academy of Sciences 5:4, 249-255, 1993. Access at http://www.medicaljournal-ias.org/Belgelerim/Belge/KhanEASOXCLQAV83122.pdf

occurred. In this case, a radon particle passing into the fetus would likely move to lipid portions of the unborn child, namely the brain and other organs. Since brain development is most crucial in this phase, ionizing radiation at this point might not kill the fetus but may cause severe inhibition in brain development leading to mental retardation after birth. Exposure of radon to a developed child after the first year of birth, when the brain is less lipid-like and the blood-brain-barrier is fully formed, follows the same pathways as for adults.

Several studies have shown that children are more susceptible to radon exposure than adults. Children have different lung architecture and breathing patterns, resulting in a larger dose of radiation to the respiratory tract. Children also have longer latency periods in which to develop cancer. And, on average, children spend 70% more time in the house than adults. For these reasons, radon exposure for vulnerable populations like children and pregnant women is especially risky.[94]

NORM And Worker Safety Issues

NORM management in production and pipelines was described in a paper published by the International Association of Oil and Gas Producers.[95] A USGS article from 1999 shows areas with abundant NORM; although the Marcellus was producing oil and gas at that time, there is no data on radioactivity from that time.[96] In a journal of the Society of Petroleum Engineers, also in 1993, petroleum engineers considered radioactivity a widespread problem.[97]

The gas which flows through the pipeline carries gaseous radon with it, and as radon decays within the pipeline, the solid daughter elements, polonium and lead, accumulate along the interior of the pipes. As the pigs ('Pipeline Inspection Gauge/Gizmo/Gadget' http://en.wikipedia.org/wiki/Pigging) inspect or clean out the pipe, they become collectors of these toxins. These pigs--and pipe film, scale and sludge—are handled by workers. At the very least, these workers should wear protective clothing and carry radiation dosimeters.

There is debris that must be removed after pigging--it is likely being handled by workers without adequate protective measures . http://www.rigzone.com/training/insight.asp?insight_id=310&c_id=19

[94] http://enhs.umn.edu/hazards/hazardssite/radon/radonmolaction.html
[95] http://www.ogp.org.uk/pubs/412.pdf
[96] http://pubs.usgs.gov/fs/fs-0142-99/fs-0142-99.pdf
[97] http://www.onepetro.org/mslib/servlet/onepetropreview?id=00022880&soc=SPE

… more debris from a pipeline pig cleaning: http://www.pigtek.com/pre-inspection_pipeline_cleaning.php , http://www.pigtek.com/advanced_pipeline_cleaning.php

It would be important to assess the risk to workers and vulnerable populations living nearby, and then to determine the cost of such exposure. The cost of lung cancer from radon in Oregon was determined, and is reported in this 2011 public service brochure on radon.[98]

Areas At Risk From Additional Radon Exposure

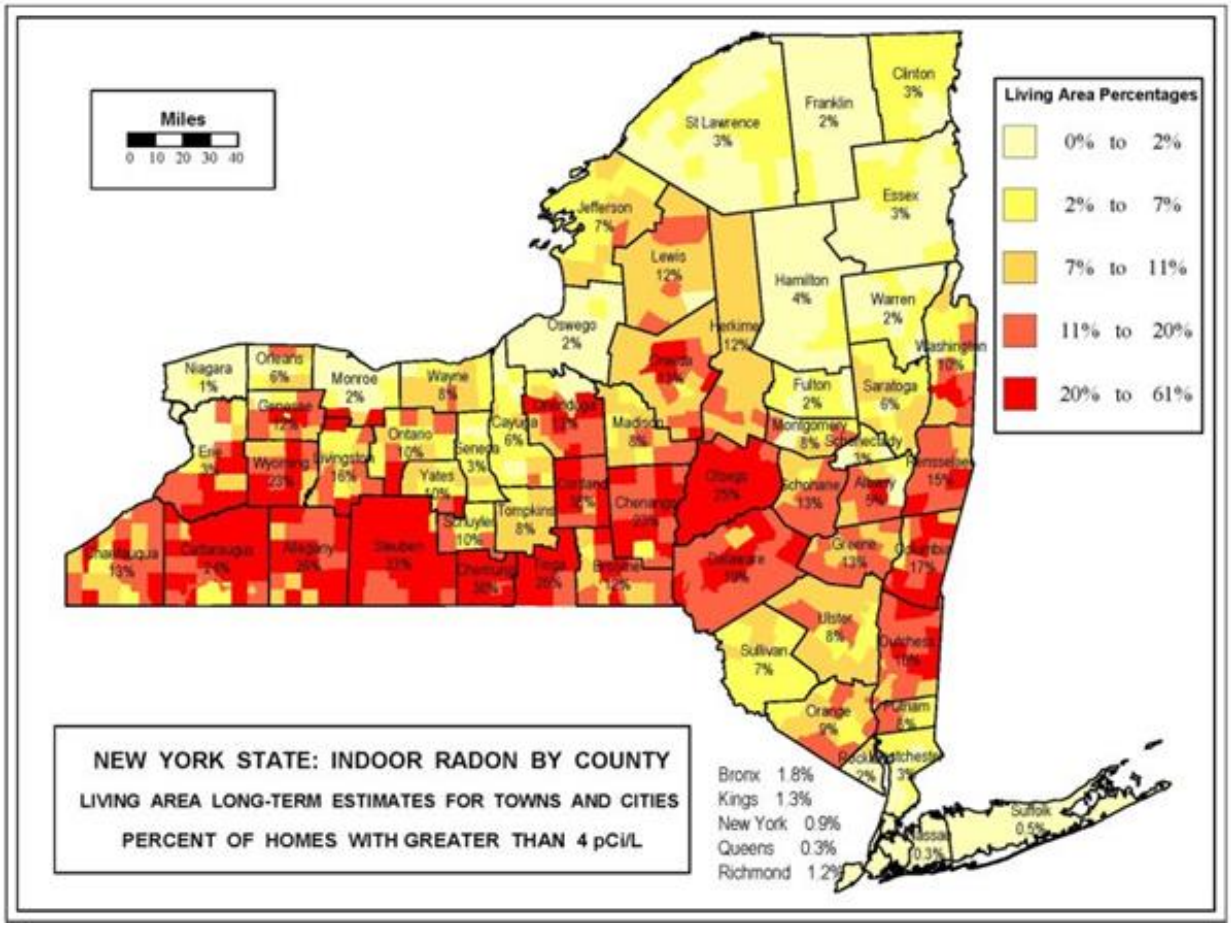
There is no safe level of exposure to radon except zero. Radon has been found to be elevated in the areas where gas extraction using hydraulic fracturing is occurring. In a recent article from Australia[99], where they measured radon (and CO2) to determine fugitive emissions from fracking for coal bed methane, Tait found, among other things, a significant relationship between the number of wells within 3 km of sampling sites and the maximum radon concentration over the 24 h period, and this led them to hypothesize that the high concentrations of ^{222}Rn measured inside a CSG field during this study are derived not only from gas extraction infrastructure, but also from the depressurization (horizontal drilling, hydraulic fracturing, groundwater extraction) of the coal seams which may increase diffuse soil emissions.

Elevated levels of radon during the fracking process and near the separation/storage stations were also observed in a study from the Univ of Colorado[100]. The authors observed radon to be at 10 times above the normal outdoor level, indicating that outdoor radon is being adversely influenced by the gas/oil production process. These elevated levels could pose a risk for the workers and for the residents living nearby.

[98] http://public.health.oregon.gov/HealthyEnvironments/HealthyNeighborhoods/RadonGas/Documents/RadonInOregon.pdf

[99] Tait et al, 2013. Enrichment of Radon and Carbon Dioxide in the Open Atmosphere of an Australian Coal Seam Gas Field, Environ Sci Technol. Apr 2, 2013; 47(7): 3099–3104.
doi: 10.1021/es304538g. Access at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3621574/

[100] James Burkhart, Thomas Huber, and George Bolling (Department of Physics and Department of Geography and Environmental Studies, University of Colorado-Colorado Springs), POTENTIAL RADON RELEASE DURING FRACKING IN COLORADO. 2013. Access at http://www.aarst.org/proceedings/2013/03_POTENTIAL_RADON_RELEASE_DURING_FRACKING_IN_COLORADO.pdf



This EPA radon map for New York shows that certain areas, for example the Southern Tier which would likely supply the gas, and the Hudson Valley (likely related to extensive fractures and faulting) are already at mitigation levels in several counties. These areas with high indoor radon, on average, already --those areas shown as orange and dark red-- and will be at even greater risk from exposure to radioactivity, such as via exposure to Marcellus Shale gas.

And since there is no safe level for radon gas and its daughters, exposure to additional radon from Marcellus shale gas via gas stoves in small and often poorly ventilated New York City apartments must also be prevented.

Community Impacts

The potential impacts of any land use decision could be both positive and negative. In this particular land use-- shale gas development-- the gains are often in the form of a short-term boom for some, but a

resultant bust for most of the community. Jacquet described the boom and bust impact on rural communities in 2009.[101]

A cornerstone of this industrialization is all the truck traffic -- hundreds of trucks a day travel on country roads never built for large trucks or the amount of wear and tear.[102] Accidents are common.[103] Loopholes in highway safety rules allow truck drivers in the oil and gas industry to work longer hours than drivers in most other industries.[104]

Community character changes, with increased rate of crime. There is also an increase in sexually transmitted diseases with the influx of workers for which the community's healthcare system is not prepared. In a recent report[105], Adgate observed that as the number of wells increased, so did crime and incidence of sexually transmitted infections. As the number of wells (and also workers) started to decrease, so did crime and sexually transmitted infections.

Further Studies Are Needed

There are many examples of a growing but significant body of scientific evidence which shows harms to public health and communities from gas development. Despite this evidence, the monetary costs associated with the health impacts--premature death, birth defects, prematurity of birth, cancer, autism, learning disabilities, community impacts and other problems--have never been entered into an economic analysis of shale gas development.

In a recent article by Adgate[106] et al, the researchers tell us that what is needed are more studies, particularly comprehensive studies that examine possible connections between chemical exposures and community health trends. This will require substantial funding and good baseline data, both of which are hard to obtain.

According to an article in Public Integrity[107], "(r)egulators are well aware of the knowledge gap. In 2012, the Government Accountability Office — an investigative arm of Congress — reviewed more than 90 studies from government agencies, the industry and academic researchers and concluded that[108] oil and gas development 'pose inherent environmental and public health risks, but the extent of these risks … is

[101] Jacquet, 2009, http://aese.psu.edu/nercrd/publications/rdp/rdp43/view
[102] "Drilling trucks have caused an estimated $2 billion in damage to Texas roads", access at http://www.star-telegram.com/2012/07/02/4075195/drilling-trucks-have-caused-an.html#storylink=cpy
[103] "Traffic Accidents Increase as Texas Oil and Gas Industry Grows", access at http://www.texaslawfirm.com/CM/Custom/Traffic-Accidents-Increase-as-Texas-Oil-and-Gas-Industry-Grows.asp
[104] Amy Mall blog (NRDC), http://switchboard.nrdc.org/blogs/amall/another_loophole_for_the_oil_a_1.html
[105] Adgate, Goldstein, and McKenzie, Public Health Risks of Shale Gas Development, May 2013. Access at http://sites.nationalacademies.org/xpedio/groups/dbassesite/documents/webpage/dbasse_083399.pdf and http://sites.nationalacademies.org/xpedio/groups/dbassesite/documents/webpage/dbasse_083235.pdf
[106] Adgate et al, Feb, 2014, Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development, *Environ. Sci. Technol.*, **DOI:** 10.1021/es404621d. Access at http://pubs.acs.org/doi/abs/10.1021/es404621d?prevSearch=%255BContrib%253A%2BAdgate%255D&searchHistoryKey=
[107] http://www.publicintegrity.org/2014/02/27/14302/natural-gas-boom-advances-little-study-public-health-effects-report-finds
[108] http://www.gao.gov/assets/650/647791.pdf

unknown, in part, because the studies GAO reviewed do not generally take into account the potential long-term, cumulative effects.'"

And in a just released comprehensive review of public health literature related to unconventional gas development, Shonkoff et al[109] focus on exposure pathways to evaluate the potential environmental public health impacts of shale gas development. Their paper highlights what is currently known and identifies data gaps and research limitations by addressing matters of toxicity, exposure pathways, air quality, and water quality. They note the particular need for "epidemiological studies on vulnerable populations including pregnant women, young children, the elderly, and those with compromised immune systems that live, work, and play in close proximity to shale gas development. Further occupational health studies are also needed, as workers are likely to be the first and the most exposed demographic from shale gas development." A Common Dreams article summarized this and other recent research and emphasized the enormous scale of the dangers, and the need for more research.[110] On April 18, 2014, the Albany Times Union opined that "(t)he state's deliberative study of natural gas drilling is appropriate to insure the safety and health of residents."[111]

Health Impact Assessment—A Useful Tool for New York

A process which can be used in any policy or land use decision to determine how human health will be impacted by the specific land use or policy is called a Health Impact Assessment (HIA). This process would inform New York State leaders and the public about the risks to human health from this most significant land use decision of our time:

"An HIA aims to identify how development induces unintended changes in health determinants and resulting changes in health outcomes. HIA provides a basis to proactively address any risks associated with health hazards. HIA also addresses health improvement opportunities in development."

Adapted from the WHO, Gothenburg Consensus Paper 1999 [112]

In 2011 the National Research Council of the National Academy of Sciences prepared a policy document on Health Impact Assessment (HIA)[113]. The HIA may be defined as a combination of procedures, methods and public health tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan, program or project on the health of a population and the distribution of those effects within the population. The HIA very importantly addresses how the most vulnerable, including

[109] Seth B. Shonkoff, Jake Hays, and Madelon L. Finkel, Environmental Public Health Dimensions of Shale and Tight Gas Development, Env Health Perspectives, Advance Publication: 16 April 2014. Access at http://dx.doi.org/10.1289/ehp.1307866
[110] http://www.commondreams.org/headline/2014/04/17-3
[111] http://blog.timesunion.com/opinion/caution-on-fracking-wise/28695/
[112] Lehto, Juhani, Ritsatakis, Anna *Health impact assessment as a tool for intersectoral health policy* A discussion paper for a seminar on "Health impact assessment: From theory to practice", Gothenburg, Sweden, 28-30 October, 1999
[113] National Research Council. *Improving Health in the United States: The Role of Health Impact Assessment*. Washington, DC: The National Academies Press, 2011. Access at http://www.nap.edu/catalog.php?record_id=13229

children, the elderly and medically underserved or already challenged will be affected by the land use. The HIA identifies appropriate actions to manage those effects.[114] [115] [116]

The practice of a Health Impact Assessment elevates the role of health in decision-making and is a practical tool that can provide a structured process to

- determine a policy or project's impact on health;
- bring both immediate and long term health benefits;
- maximize positive health impacts and minimize negative ones; and
- ensure project dollars are used efficiently to provide the highest benefit to communities.

It helps create healthier communities by addressing the root causes of many health problems. HIAs have demonstrated success in a variety of issue areas, ranging from land use and transportation to housing policies, labor standards, natural resource extraction, and energy, education and economic policies. It should be done wherever permitting is sought in order to determine whether the people and the government wish to take the risks to human health which may ensue if this development proceeds.

The **major steps** in conducting an HIA (are similar to those in an EIS) include[117]:

- Screening (identify projects or policies for which an HIA would be useful),
- Scoping (identify which health effects to consider),
- Assessing risks and benefits (identify which people may be affected and how they may be affected),
- Developing recommendations (suggest changes to proposals to promote positive or mitigate adverse health effects),
- Reporting (present the results to decision-makers), and
- Evaluating (determine the effect of the HIA on the decision)

The **timing** of an HIA is best when it is done before a policy, process or regulation is implemented. An HIA uses existing data sources[118] such as population data, surveys, risk assessment, literature review, and expert opinions to predict the impact on a population from a particular land use decision. An HIA is inclusive of all stakeholders; it provides for environmental justice; it is a transparent process; it brings public health to the table. These factors ensure the success of the process and greater likelihood that the recommendations will be implemented.

Examples of HIAs include: Health Impact Assessment of Coal and Clean Energy Options in Kentucky[119], an HIA combined with a federal EIS[120] on gas drilling in Alaska[121] [122], Chukchi Sea Oil and Gas Lease Sale HIA

[114] http://www.who.int/hia/en/

[115] http://www.healthimpactproject.org/
[116] http://www.hiaguide.org/methods-resources/journal-articles
[117] http://www.cdc.gov/healthyplaces/hia.htm
[118] http://www.humanimpact.org/component/jdownloads/finish/14/40
[119] http://www.healthimpactproject.org/resources/document/Coal-and-Clean-Energy-Optionsin-KY.pdf

with EIS[123], the 2010 Battlement Mesa CO HIA on gas drilling[124], and a Eugene Oregon Climate and Energy Action Plan HIA[125].

A comprehensive Health Impact Assessment would include consideration of all vulnerable groups, direct and indirect impacts on health, with a view on the determinants of health[126], as presented by Dr Eilish Cleary, Chief Medical Officer of New Brunswick Canada. The medical community in New York continues to support the inclusion of a Health Impact Assessment so that health impacts of shale gas extraction and production can be adequately, transparently and comprehensively addressed.[127] [128] The American Public Health Association in October 2012 issued a policy statement [129] urging the inclusion of an HIA in all policy decisions.

Comment:

The Energy Plan includes references to Health Impact Assessments, beginning on pg. 89, "Methods to Evaluate Health Risks, Quantify Health Impacts and Consider Health Status". However, the author of this section seems to prefer the process called "Quantitative Impact Assessment".

The National Research Council of the National Academy of Sciences explains the difference in Improving Health in the United States: The Role of Health Impact Assessment[130], and concludes:

"Because of the limitations of existing tools in their ability to evaluate the health consequences of an array of policies, programs, projects, and plans systematically, health impact assessment (HIA) is a tool that holds promise for scientists, communities, and policy-makers. By its very nature, HIA lies at the intersection of science, policy, and stakeholder and community engagement. It includes attributes of health risk assessment, cost-benefit analysis, and LCA but differs from them in important ways, including its applicability to a variety of policies, projects, programs, and plans; its consideration of beneficial and adverse health consequences; its ability to consider and incorporate different types of evidence; and its engagement of communities and stakeholders in a deliberative process. HIA offers a way to engage agencies and individuals that do not normally work together, may not share a common expertise and knowledge, and often have differing priorities, authority, and objectives. It seeks to correct the fundamental problem of failing to consider health at all in decision-making. The committee concludes that HIA is valuable even with a lack of perfect forecasting data and tools because it is better to consider potential health risks and benefits than to ignore them routinely."

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[120] http://www.blm.gov/ak/st/en/prog/planning/npra_general/ne_npra/northeast_npr-a_final.html
[121] http://link.springer.com/article/10.1007%2Fs10393-007-0132-2
[122] http://www.hiaguide.org/hia/national-petroleum-reserve-alaska-oil-development-plan
[123] http://www.hiaguide.org/hia/chukchi-sea-oil-and-gas-lease-sale
[124] http://www.hiaguide.org/hia/battlement-mesa-health-impact-assessment
[125] http://www.upstreampublichealth.org/resources/eugene-climate-and-energy-action-plan-hia
[126] http://leg-horizon.gnb.ca/e-repository/monographs/31000000047096/31000000047096.pdf
[127] http://www.riverkeeper.org/news-events/news/safeguard-drinking-water/frackinggas-drilling/groups-urge-nys-senate-and-governor-to-include-health-impact-assessment-on-fracking-in-budget/
[128] See resolution 171 http://www.mssny.org/mssnycfm/mssnyeditor/File/2013/About/HOD/2013_General_Information/Public_Health_Education.pdf and http://readme.readmedia.com/MSSNY-Continues-its-Support-of-Moratorium-on-High-Volume-Hydraulic-Fracturing/5976953
[129] http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1444
[130] NAS, 2011, http://www.nap.edu/catalog.php?record_id=13229

In fact, the citations provided by the author(s) of the Energy Plan section on tools and methods to assess health actually advocate for the Health Impact Assessment, rather than solely for a quantitative impact assessment. The rationale for excluding a comprehensive Health Impact Assessment is therefore not clear. While there is value to policy-makers in having quantifiable evidence, and risk assessment should be included, if possible, in a rigorous and comprehensive Health Impact Assessment, "not everything that is important can be quantified: rigorous qualitative HIA will still be needed for a thorough assessment."[131]

If the intent of policy-makers, especially where a major land-use decision such as shale gas exploitation is concerned, or an Energy Plan that is considering shale gas in its equations, is to gain public acceptance, it seems that it would be wise to involve the public as stakeholders and to make the process as transparent as possible. A Health Impact Assessment would do that. On the other hand, if the only evaluation done is a quantitative risk or impact assessment, it would not.

A Health Impact Assessment would assure that all aspects of health are considered, as well as impacts on all groups. It would be accepted by the public because they would be involved as stakeholders. This process has been used successfully to inform many policy decisions, and should be used to inform the 2014 Energy Plan.

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[131] Mindell, http://eprints.ucl.ac.uk/892/1/HIA_Workshop_JPHM.pdf