Health, Energy Production and Energy Use Issue Brief
New York State Energy Plan 2009

December 2009

1 Overview

Energy provides many public health benefits. Heating and cooling buildings makes indoor environments livable. Adequate, reliable and swift transportation depends on energy and is also critical in supporting public health, e.g., to move people to hospitals and blood specimens to laboratories. Energy is necessary to purify drinking water and treat wastewater to minimize exposure to harmful pathogens and chemicals. Providing food to consumers requires energy to power tractors and transport produce to market. An understanding and an appreciation of these public health benefits are fundamental to informed planning and decision making related to energy use and production.

Although there are many benefits, there are also health risks associated with energy use and production. These risks need to be considered as the future energy needs for the State are met. One source of health risk associated with energy use is the release of air pollutants from fuel combustion by the electricity, transportation and buildings sectors. Combustion of carbon-based fuels is responsible for a large fraction of the emissions or formation of many pollutants. Human exposure to some of these air pollutants has been associated with respiratory or cardiovascular health impacts and increased mortality in the United States and elsewhere. Twenty-nine counties in New York are not in attainment of the health-based National Ambient Air Quality Standard for ozone and ten counties are not in attainment of the standard for fine particulates,[1] putting residents at an increased risk for respiratory illness and cardiovascular disease.

Each energy use sector has its own characteristic impacts on air quality. The electric generating sector is the major contributor of sulfur dioxide emissions. The building sector is responsible for a large fraction of the estimated emissions of particulate matter. The transportation sector is responsible for the majority of the estimated emissions of nitrogen oxides, volatile organic compounds and carbon monoxide.

While the health impacts associated with pollutant emissions result from routine energy use practices, other health impacts may result from rare catastrophic events. Examples of catastrophic events are dam failure and a major radiation leak from a nuclear facility. While the impacts from such events could be substantial, safety standards ensure that they are rarely, if ever, encountered.

In general, known health risks that result from energy use and production are mitigated through federal and state regulatory processes and oversight mechanisms. However, as new information becomes available, the effectiveness of mitigation processes may need to be reevaluated. As new technologies emerge, less well understood risks may need to be considered. Ongoing public health research and evaluations of emerging risks are necessary to provide insights into the potential effects of energy use. New York collects data on health outcomes, and these data can be used in epidemiological studies and considered in the siting of energy-related projects and facilities. Communities can also help identify specific local health concerns for energy use and production (such as electric generating facilities, transportation corridors and activities and facilities associated with production, storage, transport, transmission or distribution of energy). Community input is an important consideration for energy-

[1] See the Environmental Impacts Issue Brief for a complete discussion.

related siting processes. Communities can also help identify and take advantage of opportunities to reduce energy use, for example through land use planning and car pooling initiatives.

A robust energy system is critical to the well being of New Yorkers. Public health benefits of maintaining adequate and reliable energy production, storage, transmission and distribution must be considered along with health risks when making energy-related decisions. New York has made great strides in reducing environmental health risks, including those associated with energy use, but still more opportunities for further reductions exist. The Issue Brief provides a broad summary of energy-related health issues, and strives to identify opportunities that afford the greatest health risk reductions without compromising the adequacy and reliability of energy systems. Some of those issues and opportunities are as follows:

1. **Reduced health risk electricity generation.**

   Currently, viable sources of energy for electricity generation include carbon-based fuels, controlled nuclear reaction, solar energy (photovoltaics) and the kinetic energy of wind and water. Continuing to increase the fraction of electricity need met by wind, solar and water will, in general, decrease health risks associated with electricity production.

   Of the electricity need met by burning of carbon-based fuels, increasing the fraction met by fuels associated with lower emissions versus those with higher emissions, e.g., natural gas versus coal, will, in general, decrease health risks. Also, in general, older electric generating facilities are less efficient and have weaker emission controls and greater emissions with respect to the amount of electricity generated and, therefore, greater health risks than newly constructed facilities. Re-powering or retrofitting older facilities with improved control technologies will reduce emissions and hence reduce health risks.

2. **Reduced health risk options for transportation.**

   Encouraging the development and enhancement of public transportation systems and land use policies that improve transportation system efficiency and reducing vehicle miles traveled will reduce emissions and associated health risks. A shift toward cleaner carbon-based fuels, increased implementation of emission control technologies and promotion of transportation technologies that are independent of carbon-based fuels will achieve similar results.

3. **Community involvement in siting and permitting processes.**

   Communities are concerned about potential health risks from proposed electric generating facilities, transmission lines, fuel storage facilities and transportation. Communities can provide valuable insight from their unique vantage point on these concerns. Communities are important stakeholders and their input is valuable for the decision-making processes associated with energy-related proposals.

4. **Community health outcome data and health outreach materials.**

   Health outcome data are an important resource for communities, scientists and government agencies for describing disease burdens, and can be considered along with other information in the siting of electric generating facilities and other energy-related projects. Health outreach and education materials can help communicate public health messages to empower communities and community members to make informed decisions to protect their health.

5. Health research and assisting other regulatory agencies.

The Department of Health (DOH) has carried out epidemiologic research related to energy production and use. It has also, in conjunction with the Department of Environmental Conservation (DEC) and other agencies, reviewed health risks from proposed energy facilities. These efforts improve understanding of the health implications of existing or proposed activities related to energy production and use.

2 Introduction

Energy use and energy production have innumerable public health benefits associated with different sectors of society and the economy. Energy is necessary to control indoor temperature, which can reduce morbidity and mortality associated with extreme cold or hot weather. Fuels are used in emergency vehicles to rapidly transport people to medical care. Health facilities depend on transportation of medical supplies and require electricity and emergency backup power supplies. Energy is required for mechanized agriculture and irrigation to meet the dietary needs of New York's population. Energy is also required for food transportation and preservation. Treatment of drinking water and wastewater is an essential public health action that depends on the use of energy. Access to electricity has been identified as a prerequisite for achieving good health and lack of access to it as "one of the principal barriers to the fulfillment of human potential and well-being."[2] A World Bank study of more than 60 low-income countries found that in urban areas, linking households to electricity was the key significant factor that reduced both infant and under-5 mortality rates, and that the effect was large and independent of incomes.[3] The study also reported a significant effect across all countries studied including both rural and urban areas.

Energy use and production can also have health risks. These risks can arise from routine operations, accidents, and catastrophic events. Health risks resulting from routine energy use and production can range from local to global in scale and examples include degradation of air quality due to emissions from the combustion of fossil fuels for transportation uses and electricity production, climate change from the release of greenhouse gases from the combustion of fossil fuels, and potential risks of noise associated with wind turbines. Accidents can include fires, explosions and other occupational and non-occupational accidents associated with energy production, storage, distribution and use. Possible catastrophic events associated with energy use can include a major radioactivity leak from a nuclear facility, a natural gas pipeline explosion or a rupture of a large dam used for hydropower.

Communities in New York have raised concerns about potential health impacts associated with energy use, distribution and storage. For example, some concerns have focused on proposed electric generating facilities, air quality impacts of emissions, cumulative health risks posed by new and existing emission sources and communities with vulnerable populations. Other concerns raised are those for potentially catastrophic events, including radiation releases from nuclear facilities, failure of fuel storage tanks and pipelines, and electromagnetic field radiation associated with electric transmission lines. Still other concerns have focused on transportation initiatives, for example vehicle traffic hubs like bus stations, noise, visual impacts and overall quality of life concerns. Communities can provide valuable insight from a unique perspective for energy initiatives and proposals. Community concerns about specific categories of energy use and production are discussed in the relevant sections of this Issue Brief.

New York and its people attain public health benefits from energy production and use. The State has programs in place to control most of the health risks that accompany energy production and use, although

[2] Markandya, A., Wilkinson, P. *Energy and Health 2 – Electricity Generation and Health: Lancet 370:979-990*. 2007.

[3] Wang, L. (The World Bank). *Health Outcomes in Poor Countries and Policy Options: Empirical Findings from Demographic and Health Surveys: WPS 2831*. 2002.

some risk remains. The challenge for this Issue Brief is to identify those opportunities that afford the greatest health risk reductions without compromising the adequacy and reliability of the energy system. This Issue Brief also summarizes what is known about human health risks and potential impacts related to energy production, storage, transmission and use in New York. Direct and indirect health risks are associated with energy and an in-depth discussion and evaluation of these impacts would delve into detailed life cycle assessments that are beyond the scope of this Issue Brief. For this Issue Brief, emphasis is placed on health risks that are most directly associated with energy production and use in New York.

3 Health Effects, Risks, and Concerns Associated with Energy Production and Use

3.1 Health Effects of Pollutants Associated with Carbon-based Fuels

Pollutants are released to the air when carbon-based fuels such as coal, oil, gasoline, natural gas, or biofuels are burned for electricity generation, transportation and commercial, residential and industrial use. These pollutants include particulate matter, sulfur dioxide, oxides of nitrogen, volatile organic chemicals, chlorinated dibenzodioxins and furans, polycyclic aromatic hydrocarbons, metals, greenhouse gases and others. In addition, some pollutants are released from fuels before they are burned, while others are formed in the atmosphere by chemical reactions after the primary pollutants are released. Exposure to air pollutants has an impact on human health; the likelihood of effects will depend on the ability of each pollutant to cause health effects; and the amount, frequency and duration of exposure; and an individual's health status. Table 1 and the text below summarize the human health effects that are associated with exposure to some "Criteria Pollutants" and other "Non-Criteria Pollutants"[4] commonly associated with carbon-based fuel combustion.

[4] "Criteria pollutants" (ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide and lead) are those pollutants which EPA regulates with human health-based air quality standards. "Non-criteria pollutants" are those pollutants for which there are no federal air quality standards.

Table 1. Health Effects Associated with Carbon-based Fuel Combustion Pollutants

Air Pollutant		Human Health Effects
Criteria Pollutants		
Carbon Monoxide [a]		▪ Effects on existing cardiovascular disease
Nitrogen Oxides [b]		▪ Increased symptom severity with respiratory infections ▪ Increased airway inflammation and responsiveness ▪ Asthma exacerbation, respiratory disease
Ozone [c]		▪ Eye, nose and throat irritation ▪ Decreased lung function ▪ Respiratory effects, e.g., shortness of breath, coughing ▪ Effects on existing cardiovascular disease ▪ Mortality
Particulate Matter [d]	**PM_{10}**	▪ Chronic bronchitis
	PM_{10} and $PM_{2.5}$	▪ Nose irritation ▪ Respiratory effects (coughing, difficulty breathing) ▪ Asthma exacerbation ▪ Premature mortality (cardio-pulmonary)
	$PM_{2.5}$	▪ Cardiovascular effects
Sulfur Dioxide [e]		▪ Respiratory tract irritation ▪ Asthma exacerbation ▪ Difficulty breathing/shortness of breath, cough ▪ Premature mortality
Non-Criteria Pollutants		
Greenhouse Gases [f]		▪ Indirect climate-related effects on morbidity and 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

[a] U.S. Environmental Protection Agency (EPA), Office of Research and Development. *Air Quality Criteria for Carbon Monoxide.: EPA 600/P-99/001F. 2000.*

[b] EPA. *Integrated Science Assessment for Oxides of Nitrogen - Health Criteria.: EPA/600/R-08/071.* 2008.

[c] EPA. *Air Quality Criteria for Ozone and Related Photochemical Oxidants.: EPA /600/R-05/004aF-cF.* 2006.

[d] EPA. *Air Quality Criteria Document for Particulate Matter, Volumes I & II.: EPA/600/p-99/002aF-bF.* 2004.

[e] EPA. *Integrated Science Assessment for Sulfur Oxides- Health Criteria: EPA/600/R-08/047F.* 2008.

[f] Basu, R., Samet, J.M.. *Relation Between Elevated Ambient Temperature and Mortality: A Review of the Epidemiologic Evidence.: Epidemiol Rev. 24:190-202.* 2002. Bell, M.L., Davis, D.L., Cifuentes, L.A., Krupnick, A.J., Morgenstern, R.D., Thurston, G.D.. *Ancillary Human Health Benefits of Improved Air Quality Resulting from Climate Change Mitigation.: Environ Health 7:41. 2008.*

[g] See the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services, Toxicological Profiles for specific metals: http://www.atsdr.cdc.gov/toxpro2.html

[h] See ATSDR Toxicological Profiles for specific PAHs: http://www.atsdr.cdc.gov/toxpro2.html

[i] See ATSDR Toxicological Profiles for specific VOCs: http://www.atsdr.cdc.gov/toxpro2.html

3.1.1 Criteria Pollutants

The U.S. Environmental Protection Agency (EPA) has designated six air pollutants as Criteria Pollutants and established health-based air concentration standards for them known as the National Ambient Air Quality Standards or NAAQS. Some of the NAAQS, e.g., for $PM_{2.5}$, are based on risk estimates derived from the collective findings of epidemiological studies which have reported increased rates of morbidity and mortality associated with pollutant concentrations, i.e., concentration-response functions. Ranges of excess morbidity and mortality risk estimates for Criteria Pollutants are presented in Table 2 These risk estimates indicate the percent increase in the occurrence of health effects associated with an increase in air pollutant concentration. For example, Table 2 indicates that a 10 $\mu g/m^3$ increase in the concentration of SO_2, compared to a previous day, increases the risk for acute asthma events by somewhere between 0.38 percent and 14 percent above the baseline rate. An excess risk of 7 percent (about midway between 0.38 percent and 14 percent) can be used to estimate a one-day increase in the acute asthma events if the air concentration of SO_2 increases by 10 $\mu g/m^3$. For a baseline rate of 250 asthma emergency department (ED) visits per day (the average rate in New York City in 2005[5]), about 17 additional asthma ED visits would be expected for that day. Air concentration increases of this size or greater occurred 70 times between 1999 and 2000 in a study of New York City air quality.[6]

[5] DOH. *New York State Asthma Surveillance Summary Report*. 2007. www.nyhealth.gov/statistics/ny_asthma/pdf/2007_asthma_surveillance_summary_report.pdf

[6] DOH. *A Study of Ambient Air Contaminants and Asthma in New York City. Agency for Toxic Substances and Disease Registry Technical Report. PB2006-113523*. 2006.

Table 2. Standardized Estimates of Excess Risk per 10 Microgram/M3 Increment in Air Concentration for Select Criteria Pollutants Extracted from EPA NAAQS Documentation for Ozone,[7] Particulate Matter,[8] Sulfur Dioxide,[9] and Nitrogen Dioxide.[10]

Pollutant	Averaging time	Health Outcome	Standardized percent Excess Risk (range) [a]
Ozone	24 hr	daily mortality	0.41 – 0.63
$PM_{2.5}$	24 hr	daily mortality	0.52 – 2.7
$PM_{10/15}$ [b]	24 hr	daily mortality	0.22 – 0.69
SO_2	24 hr	daily mortality	0.19 – 2.6
NO_2	24 hr	daily mortality [c]	0.13 – 0.92
Ozone	annual	mortality [d]	--[e]
$PM_{2.5}$	annual	mortality	4 – 14
$PM_{10/15}$	annual	mortality	0.80 – 19
SO_2	annual	mortality	-- [f]
NO_2	annual	mortality	-- [f]
Ozone	max 8 hr[g]	acute asthma [h]	-0.34 – 4.6
$PM_{2.5}$	24 hr	acute asthma	0.56 – 3.4
$PM_{10/15}$	24 hr	acute asthma	1.7 – 6.1
SO_2	24 hr	acute asthma	0.38 – 14
NO_2	24 hr	acute asthma	1.6 – 10

[a] Percent excess risk (= (Relative Risk – 1)*100%) per 10 microgram/m^3 standardized increment in air pollutant concentration. Extracted values represent range of central tendency estimates from studies summarized by EPA. Estimates include adjustment for one or more co-pollutants when available.
[b]Combines studies measuring PM_{10} and PM_{15}.
[c] Evidence considered by EPA as suggestive, but insufficient to infer a causal relationship, although the trend is toward positive associations.
[d] Long-term mortality estimates extracted from reanalysis of Harvard 6-cities and American Cancer Society studies only.
[e] No consistent evidence of an association.
[f] Evidence considered inadequate to infer a consistent association.
[g] Warm season estimates only.
[h]Combines studies reporting emergency department visits and hospitalizations for acute asthma exacerbations.

The health-based NAAQS values are presented in Table 3. Currently, all of the State complies with the requirements of (or is "designated attainment for") the NAAQS for PM_{10}, nitrogen dioxide, sulfur dioxide, lead and carbon monoxide. For example, maximum 24-hr average PM_{10} levels at New York

[7] EPA. *Air Quality Criteria for Ozone and Related Photochemical Oxidants: EPA /600/R-05/004aF, EPA /600/R-05/004bF, EPA /600/R-05/004cF*. 2006.

[8] EPA. *Air Quality Criteria Document for Particulate Matter, Volumes I & II: EPA/600/p-99/002aF, EPA/600/p-99/002bF*. 2004.

[9] EPA. *Integrated Science Assessment for Sulfur Oxides- Health Criteria: EPA/600/R-08/047*. 2008.

[10] EPA. *Integrated Science Assessment for Oxides of Nitrogen - Health Criteria: EPA/600/R-08/071*. 2008.

monitoring stations were recently (2007) no more than 70 $\mu g/m^3$. Annual SO_2 levels were no more than 27 $\mu g/m^3$ and maximum 24-hour concentrations were less than 100 $\mu g/m^3$. Annual NO_2 levels were less than 65 ug/m^3.[11] However, 29 counties in the State, in which 85 percent of the New York's population resides,[12] are in areas that have been designated "non-attainment" for the 1997 health-based 8-hour average ozone NAAQS. Air quality is improving and of these non-attainment counties, 20 have been determined to have data that suggest that they would meet the 1997 ozone NAAQS by the next designation, i.e., "monitoring attainment."[13] In 2008, EPA promulgated a stricter ozone NAAQS and DEC recommended to EPA to designate 32 counties as non-attainment in 2010.[14] Ten counties in and around New York City have been designated as non-attainment for the annual and 24-hour $PM_{2.5}$ standard. These same ten counties are monitoring levels above the 2006 24-hour $PM_{2.5}$ NAAQS[15] and designation for this NAAQS is expected in 2009. EPA has recently promulgated a revised lead NAAQS. DEC has recommended to EPA in accordance with its guidance that the metropolitan areas with populations over 500,000 that DEC monitors for ambient lead levels (New York City and Poughkeepsie-Newburgh-Middletown) be designated as attainment. DEC has also recommended that the Buffalo-Niagara Falls, Rochester, Syracuse and Albany-Schenectady-Troy metropolitan areas be designated as attainment/unclassifiable until it can expand the lead monitoring network and collect the appropriate monitoring data to determine compliance with the lead NAAQS. EPA has a statutory obligation to review each of the NAAQS every five years and these reviews may result in revised standards. For more information on NAAQS and attainment, see the Environmental Impacts Issue Brief.

3.1.2 Carbon Monoxide

Carbon monoxide (CO) can reduce the oxygen-carrying capacity of blood and the delivery of oxygen to the heart, brain and other organs and tissues. Associations have been found in a number of population-based studies between days with elevated CO levels in ambient air and increased hospital visits for acute heart problems such as chest pain, irregular heart rhythm, congestive heart failure or heart attack. In several of these studies, these associations persisted after controlling for other ambient air pollutants such as particulate matter. High levels of CO can result in central nervous system effects such as vision problems, reduced ability to learn, reduced manual dexterity and difficulty performing complex tasks. At extremely high levels, exposure to CO can cause death. Ambient CO also contributes to the formation of ground-level ozone.[16]

[11] DEC. *New York State Ambient Air Quality Report for 2007*. http://www.dec.ny.gov/chemical/8536.html

[12] U.S. Census Bureau. *Census 2000 Redistricting Data (Public Law 94-171) Summary File, Matrices PL1 and PL2, Summarized for New York State by County.* http://factfinder.census.gov/

[13] The counties that are not attaining the 1997 ozone NAAQS are Bronx, Nassau, New York, Queens, Kings, Richmond, Rockland, Suffolk and Westchester. Those monitoring attainment (but not yet re-designated to attainment) are Dutchess, Orange, Putnam, Chautauqua, Erie, Niagara, Albany, Greene, Montgomery, Rensselaer, Saratoga, Schenectady, Schoharie, Jefferson, Genesee, Livingston, Monroe, Ontario, Orleans and Wayne.

[14] The counties recommended as non-attainment are Bronx, Nassau, New York, Kings, Queens, Richmond, Rockland, Suffolk, Westchester, Dutchess, Orange, Putnam, Ulster, Albany, Columbia, Greene, Montgomery, Rensselaer, Saratoga, Schenectady, Schoharie, Warren, Washington, Genesee, Livingston, Monroe, Ontario, Orleans, Wayne, Chautauqua, Erie and Niagara.

[15] The $PM_{2.5}$ non-attainment counties are Bronx, Nassau, New York, Orange, Queens, Kings, Richmond, Rockland, Suffolk and Westchester.

[16] EPA. *Air Quality Criteria for Carbon Monoxide: EPA 600/P-99/001F*. 2000.

Table 3. National Ambient Air Quality Standards (NAAQS).[17]

	Primary Health Based Standards	
Pollutant	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour [a]
	35 ppm (40 mg/m^3)	1-hour [a]
Lead	1.5 µg/m^3	Quarterly Average
	0.15	Rolling 3 month Average[b]
Nitrogen Dioxide	0.053 ppm (100 µg/m^3)	Annual (Arithmetic Mean)
Particulate Matter (PM_{10})	150 µg/m^3	24-hour [c]
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual (Arithmetic Mean) [d]
	35 µg/m^3	24-hour [e]
Ozone	0.075 ppm (2008 std) (150 µg/m^3)	8-hour [f]
	0.08 ppm (1997 std) (160µg/m^3)	8-hour [g]
Sulfur Dioxide	0.03 ppm (80 µg/m^3)	Annual (Arithmetic Mean)
	0.14 ppm (372 µg/m^3)	24-hour [a]

[a] Not to be exceeded more than once per year.
[b] Not to be exceeded over 3 year period (effective 60 days from pending publication in federal regulations.
[c] Not to be exceeded more than once per year on average over 3 years.
[d] To attain this standard, the 3-year average of the weighted annual mean PM $_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
[e] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
[f] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).
[g] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm. The 1997 standard — and the implementation rules for that standard — will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.

3.1.3 Nitrogen Oxides

The term nitrogen oxides (NO_x) refers to a group of compounds that include nitrogen dioxide, nitrous oxide, nitrates and nitric oxide. Human health effects for NO_x include effects on breathing and the respiratory system, damage to lung tissue and premature death. Exposure to nitrogen dioxide (NO_2, the specific chemical for which a NAAQS is established) has been associated with increased susceptibility to respiratory infections, increased airway inflammation and responsiveness, and increased emergency department and hospital visits for asthma. Nitrogen oxides also have a role in atmospheric chemical reactions that form ozone, acids and particulates. Ozone is formed when NO_x and volatile organic compounds (VOCs) react in the presence of sunlight. Nitric acid and related particles form when NO_x

[17] EPA. *Technology Transfer Network. National Ambient Air Quality Standards (NAAQS).* 2008. http://www.epa.gov/ttn/naaqs.

reacts with ammonia, moisture and other compounds (see health effects discussion for ozone and particulate matter below).[18]

3.1.4 Ozone

Most ground level ozone is not emitted directly from a source, but is created by chemical reactions between NO_x and VOCs in the presence of sunlight. Eye, nose and throat irritation, respiratory symptoms and decreases in lung function have occurred in healthy, exercising people breathing air containing elevated levels of ozone. Respiratory symptoms include shortness of breath, chest pain and coughing and may occur in both adults and children. In community studies, days with high outdoor ozone levels tend to have increased hospitalizations for respiratory conditions and increased daily mortality rates. More limited evidence suggests that short-term exposure to elevated ozone levels might also aggravate heart symptoms in people with pre-existing heart disease or high blood pressure.[19] An increased risk of developing asthma was found among children who likely experienced long-term elevated ozone exposure because they participated in athletic programs in areas with high average ozone levels.[20]

3.1.5 Particulate Matter

Particulate matter (PM) varies in composition depending on its source and other factors. A subset of PM, referred to as fine particulate matter, or $PM_{2.5}$ (any particle with an aerodynamic diameter 2.5 micrometers (µm) or less), is primarily produced by combustion processes and from secondary chemical reactions in air. PM_{10} is a category of particles that range up to 10 µm in diameter and includes $PM_{2.5}$. For some emission sources - burning natural gas, biofuels or petroleum-based fuels - very small particles, called ultrafine particles (diameter of less than 0.1 µm), can be the predominant particles formed, in terms of the number of particles.[21]

Particles up to 100 µm in diameter may enter into the respiratory system. The larger particles tend to deposit in the upper airways of the respiratory tract, e.g., the nose and throat, and can cause irritation. The smaller respirable particles (less than or equal to 4 µm) travel further into the respiratory system and can cause other health effects.[22] Scientific studies have found exposure to airborne particles (especially respirable particles) to be associated with premature deaths in the elderly, increases in hospital and emergency room visits for respiratory and cardiovascular problems, asthma exacerbation, acute respiratory symptoms (coughing, difficulty breathing) and chronic bronchitis. People with heart or breathing problems, children and the elderly may be particularly sensitive. It is not clear whether the composition of particles, in addition to their size, determine the likelihood and type of health effects.

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[18] EPA. *Integrated Science Assessment for Oxides of Nitrogen - Health Criteria: EPA/600/R-08/071*. 2008.

[19] EPA. *Air Quality Criteria for Ozone and Related Photochemical Oxidant: EPA /600/R-05/004aF, EPA /600/R-05/004bF, EPA /600/R-05/004cF*. 2006.

[20] EPA. *Air Quality Criteria for Ozone and Related Photochemical Oxidant: EPA /600/R-05/004aF, EPA /600/R-05/004bF, EPA /600/R-05/004cF*. 2006.

[21] EPA. *Air Quality Criteria Document for Particulate Matter, Volumes I & II: EPA/600/p-99/002aF, EPA/600/p-99/002bF*. 2004.

[22] EPA. *Air Quality Criteria Document for Particulate Matter, Volumes I & II: EPA/600/p-99/002aF, EPA/600/p-99/002bF*. 2004.

Concerns are being raised about the potential health effects of ultrafine particles, although at this point they have not been well characterized.[23]

3.1.6 Sulfur Dioxide

Ambient air sulfur dioxide (SO_2) can be oxidized leading to the formation of sulfuric acid, and both chemicals can cause irritation to the respiratory tract, especially in people with respiratory diseases such as asthma.[24] Asthma symptoms have been associated with SO_2 exposure in people both with and without existing respiratory conditions. A recent study of acute asthma emergency department visits and ambient air pollution in New York City found the strongest association between daily emergency department visits and 24-hour average SO_2 levels.[25] Both children and adults may experience difficulty breathing or shortness of breath when exposed to elevated levels of SO_2, but whether children are more susceptible than adults is unclear. A DOH meta-analysis of epidemiological studies reporting associations between daily variation in SO_2 concentration and emergency visits and hospitalizations for acute asthma found a significant effect of SO_2 on acute asthma exacerbations in children, but not in adults.[26] Some studies in laboratory animals exposed to SO_2 found developmental effects, such as decreased body weight and delayed ossification of bones.[27]

3.1.7 Non-Criteria Pollutants

There are no federal air quality standards for non-criteria pollutants and their concentrations are evaluated by comparison to health-based criteria. Non-criteria pollutants that are emitted from fuel combustion include greenhouse gases, volatile organic compounds and others.

3.1.8 Greenhouse Gases

The primary GHG emitted as a result of carbon-based fuel combustion are carbon dioxide, methane and nitrous oxide. Inhalation exposure to carbon dioxide and methane at ambient background levels is generally thought to pose little, if any, health risks. However, these emissions are increasing and increasing concentrations of greenhouse gases in the atmosphere have been associated with changes in global climate.[28] Climate changes may impact human health in many ways that are only beginning to be understood. For example, episodes of increased ambient temperature and humidity in summer may lead to increased incidence of heat-stress-related morbidity and mortality.[29, 30, 31] Episodic higher summer

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[23] EPA. *Air Quality Criteria Document for Particulate Matter, Volumes I & II: EPA/600/p-99/002aF, EPA/600/p-99/002bF.* 2004.

[24] EPA. *Integrated Science Assessment for Sulfur Oxides-Health Criteria: EPA/600/R-08/047.*

[25] DOH. *A Study of Ambient Air Contaminants and Asthma in New York City. Agency for Toxic Substances and Disease Registry Technical Report: PB2006-113523.* 2006.

[26] Recer, G., Sivanamdam, S., Kinney, P.L., Hwang, S., Luttinger, D. *Associations Between Acute Asthma Exacerbations and Ambient Sulfur Dioxide Exposure: Possible Implications for National Ambient Air Quality Standards: Society for Toxicology Annual Meeting. Toxicologist, V96.* 2007.

[27] EPA. *Integrated Science Assessment for Sulfur Oxides-Health Criteria: EPA/600/R-08/047.*

[28] Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. 2007.

[29] Basu, R., Samet, J.M. *Relation between Elevated Ambient Temperature and Mortality: A Review of the Epidemiologic Evidence: Epidemiol Rev. 24(2):190-202.* 2002.

temperatures also can increase the natural emissions of ozone precursors and accelerate the reaction rate of formation of ozone and photochemical smog, resulting in additional impacts on morbidity and mortality.[32] On the other hand, warmer winters could result in reduced cold-weather mortality,[33] as well as lower heating requirements and associated fuel combustion and emissions. Other indirect impacts of climate change on health are also possible. For example, increased temperatures and humidity may lower or increase health risks through changes in vector-borne disease incidence, prevalence of allergies to mold, pollen and others. For more information on climate change see the Climate Change Issue Brief.

3.1.9 Volatile Organic Compounds

VOCs like octane, benzene and others are produced as evaporative emissions from carbon-based fuel and as emissions from incomplete combustion of fuel. The VOCs are important precursor compounds for ozone, which is formed in the atmosphere by reaction with NO_x in the presence of heat and sunlight.[34] The identity of individual VOCs emitted vary with fuel type, combustor type and operating conditions. Many VOCs, for example toluene, can cause central nervous system effects and some are carcinogens.[35, 36]

3.1.10 Other Non-Criteria Pollutants

In addition to VOCs and GHG, non-criteria pollutants that can be emitted from fuel combustion include chlorinated dibenzo-*p*-dioxins, chlorinated dibenzofurans, polycyclic aromatic hydrocarbons and various metals, e.g., mercury. Exposure to high levels of chlorinated dioxins and furans is associated with cancer and effects on the liver and skin.[37, 38] Health effects associated with exposure to metals varies with the metal and Toxicological Profiles from the Agency for Toxic Substances and Disease Registry provide thorough summaries of these health effects.[39] For example, mercury, after being transformed to methylmercury in the environment, can cause effects on the nervous system, particularly for children and

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30 Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H.G., Smith, D., Solomon, G., Trent, R., English, P. *The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits: Environ Health Perspect. 117: 61-67.* 2009.

31 Lin, S., Luo, M., Walker, R.J., Liu, X., Hwang, S., Chinery, R. *Extreme High Temperatures and Hospital Admissions for Respiratory/Cardiovascular Disease in New York City. Epidemiology.* 2009. http://ovidsp.tx.ovid.com

32 Bell, M.L., Goldberg, R., Hogrefe, C., Kinney, P.L,. Knowlton, K., Lynn, B., Rosenthal, J., Rosenzweig, C., Patz, J. A. *Climate Change, Ambient Ozone, and Health in 50 U.S. Cities: Climatic Change 82:61-76.* 2007.

33 Anderson, B. G., Bell, M.L. *Weather-Related Mortality: How Heat, Cold and Heat Waves Affect Mortality in the United States: Epidemiology 20:205-213.* 2009.

34 EPA. *Air Quality Criteria for Ozone and Related Photochemical Oxidants: EPA /600/R-05/004aF, EPA /600/R-05/004bF, EPA /600/R-05/004cF.* 2006.

35 Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services (HHS). *Toxicological Profile for Toluene.* 2000.

36 ATSDR, HHS. *Toxicological Profile for Benzene*. 2007.

37 ATSDR, HHS. *Toxicological Profile for Chlorodibenzofurans (CDFs).* 1994.

38 ATSDR, HHS. *Toxicological Profile for Chlorinated Dibenzo-P-Dioxins.* 1998.

39 ATSDR, HHS. *Toxicological Profile Information Sheet.* 2008. http://www.atsdr.cdc.gov/toxpro2.html

fetuses.[40] Exposure to high levels of some polycyclic aromatic hydrocarbons (PAHs) is associated with lung cancer.[41]

3.2 Electricity Generation

Central and distributed electricity generation can rely on a number of primary energy sources.[42] New York laws contain mandates to protect the public from health risks associated with facilities including those that generate electricity. DEC implements and enforces these legislative mandates through rules and regulations. To carry out its environmental protection responsibilities, DEC reviews a facility's operations, and its air emissions, soil and water impacts and other potential impacts to the environment and public health. If a facility's application for a permit to operate is approved, it is issued facility-specific environmental permits to control discharges to water, emissions to air and waste disposal operations. These approved permit limits are not to be exceeded. If a violation occurs, DEC enforcement may order compliance and may impose penalties against the violator, thereby helping to control and regulate emission levels from these facilities. Health risks associated with generation of electricity from some of these primary energy sources, as well as risks associated with electricity distribution, are discussed in the following sections.

3.2.1 Sources of Electricity

Examples of currently viable sources of energy for electricity generation are combustion of carbon-based fuels, nuclear power, hydropower and hydrokinetic energy, solar energy and wind. Specific public health risks and concerns for each source of electricity are discussed below.

Carbon-based Fuels

A number of carbon-based fuels are burned to generate electricity including coal, fuel oil and natural gas. Biofuels, refuse and other waste materials are also used. To quantitatively evaluate the health risks or health impacts of fuel use (primarily due to emissions from combustion) for electricity generation, resulting incremental air quality impacts and human exposures have to be estimated. Such estimates, even for a single emission source, require sophisticated mathematical models that take into account many site-specific factors. Characterizing incremental increases to air concentrations, human exposures and risks in such a way as to be representative of different carbon-based fuel electricity generation scenarios for New York is beyond the scope of this Issue Brief. Emissions levels are typically the primary determinants of incremental air concentration increases and therefore ambient air exposures. For this reason, we can draw preliminary conclusions for this Issue Brief from relative statewide emissions as a surrogate for exposure and risk associated with different energy use sectors, fuels and source categories. The section below discusses the health effects of some chemicals associated with the use of carbon-based fuels and provides a description of the nature and extent of emissions from the electric generating sector by fuel type and source category. Also included are qualitative descriptions of health issues related to waste generation, cooling towers, fuel production, storage and distribution and other community concerns. Because most carbon-based fuels can be used not only for electricity generation, but also for

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[40] ATSDR, HHS. *Toxicological Profile for Mercury*. 1999.

[41] ATSDR, HHS. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs)*. 1995.

[42] Primary energy refers to un-transformed energy used by the major energy use sectors, i.e., electric, transportation, and buildings.

other forms of primary energy use - including space heating, industrial processes, and transportation - some of the discussion below is relevant to those uses.

Emissions from Carbon-based Fuels

Combustion of carbon-based fuels for electricity generation emits certain pollutants directly to air and some of these pollutants can undergo chemical reactions to form secondary pollutants. The potential regional air quality impacts of fossil fuel combustion for electricity generation were suggested by data collected during the North American blackout of 2003, when approximately 100 electric generating facilities in the northeastern U.S. and Canada stopped operating. A day after the blackout, substantial reductions in ambient air concentrations were measured in Pennsylvania for SO_2 (>90 percent), ozone (approximately 50 percent) and PM (approximately 70 percent).[43]

DEC administers an extensive air pollution control-permitting program and many facilities are required to monitor air emissions. Monitoring results are submitted to DEC for review and to assess compliance with permitted emission levels.

Of the primary energy input (in Btu's) for New York electricity generation in 2007, coal makes up about 13 percent, natural gas 25 percent, petroleum products (primarily residual fuel oil) 5 percent and biofuels two percent.[44] The estimated aggregate emissions of primary[45] $PM_{2.5}$, primary PM_{10}, NO_x and SO_2 from electricity generation and other energy use sectors in New York are illustrated in Appendix A: Figures A-1 through A-6.[46]

The air pollutants associated with carbon-based fuel use, as well as the amounts of pollutants released to or formed in the atmosphere, will vary depending on several factors. For example, fuel type, e.g., coal, oil, natural gas, affects pollutant emission rates on a per-Btu (British thermal unit) basis. Whether the electricity generated is used on-site (distributed generation) or transmitted to the grid (central generation with associated efficiency losses) can also affect pollutant emission rates.[47] Other factors that affect pollutant emissions include the kind of combustion technology and pollution control technology used, facility size and age. This section characterizes pollutants emitted in Table 4, relative average emission rates for electricity production in New York for different carbon-based fuels in Table 5, and the difference between emissions from older versus newer units at "repowered" facilities in Appendix A: Figure A-7.

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[43] Marufu, L. T., Taubman, B. F., Bloomer, B., Piety, C.A., Doddridge, B. G., Stehr, J.W., Dickerson, R. R. *The 2003 North American Electrical Blackout: An Accidental Experiment in Atmospheric Chemistry: Geophys. Res. Lett. 31:L13106*. 2004.

[44] NYSERDA. *Patterns and Trends, New York State Energy Profiles: 1992-2007, Table 1-2*. 2009.

[45] "Primary emissions" (of $PM_{2.5}$ and PM_{10}) refer only to particulates directly emitted from sources and do not account for secondary formation of particles resulting from emissions of precursors such as SO_2 and NO_x. Secondary formation is more significant for $PM_{2.5}$ than PM_{10}.

[46] Figures A-1 through A-6 are based on analysis of the most recent EPA National Emissions Inventory of emissions estimates for fuel combustion in New York State (2002 data made available in 2006). Data representing emissions from sources other than fuel combustion are not represented in these figures. Fuel combustion contributed 94 percent of the emissions of SO_2, 61 percent of $PM_{2.5}$, 97 percent of NO_x and 61 percent of VOCs in New York State in 2002. Although data for six pollutants are shown, data for ammonia and condensable particulates are also available.

[47] Bourgeois, T.G., Hedman, B., Zalcman, F. *Creating Markets for Combined Heat and Power and Clean Distributed Generation in New York State: Environ Pollut. 123:451-462*. 2003.

Table 4. Select Pollutants Associated with Carbon-based Fuels

Fuel Type	Pollutant
Coal, Fuel Oil, Natural Gas, Biofuel/Biomass, Refuse	▪ Criteria pollutants [a] ▪ Polycyclic aromatic hydrocarbons ▪ Chlorinated dibenzo-p-dioxins and dibenzofurans ▪ Metals [b] ▪ Volatile and semivolatile organic compounds [c] ▪ Acid gases [d] ▪ Greenhouse gases

[a] CO, lead, NO_2, ozone, particulate matter, SO_2.
[b] e.g., antimony, arsenic, beryllium, cadmium, chromium, cobalt, magnesium, manganese, mercury, nickel.
[c] e.g., alkanes, alkenes, aldehydes, alcohols, benzene, toluene, xylene, ethylbenzene, formaldehyde.
[d] e.g., hydrogen chloride, hydrogen fluoride.

Source*:* EPA. *AP-42.*

Additional information about the nature and extent of pollutant emissions from different kinds of combustion sources and control technologies at facilities can be determined by evaluating emissions monitoring data or data such as the emission factors compiled in EPA's "Compilation of Air Pollutant Emission Factors" [48] (also known as "AP-42"). The more information the better the estimate of potential human health risks associated with emissions from a particular facility or type of facility.

Coal

The emissions generated from coal combustion include PM, SO_2, NO_x, CO, CO_2, metals, e.g., mercury, acid gases and a number of organic compounds, as shown in Table 4. Specific emissions and their levels from coal combustion depend on the type of coal, the type and size of the boiler, firing conditions, load, type of control technologies and the level of equipment maintenance. Emissions of SO_2 can reflect coal sulfur content. Lignite (brown coal) typically has sulfur concentrations of about 1.0 percent by weight. Bituminous coal used to generate electricity typically has a higher sulfur content of 1.4 percent, while sub-bituminous coal generally has low sulfur content, e.g., 0.4 percent (see Coal Assessment). Under DEC's permitting program, SO_2 emissions limits for a new coal-burning facility (0.1-0.2 lb/MMBtu), based on the best available control technology, would be two to three times higher than those from a new oil-burning facility (0.06 lb/ MMBtu) and approximately two to three hundred times higher than a new gas-burning facility (0.0006 lb/ MMBtu). Based on EPA's Emissions and Generation Resource Integrated Database (eGRID),[49] the average emission rates in New York for 2005 from coal-fired facilities for carbon dioxide, sulfur dioxide, nitrogen oxides and mercury were much higher than oil- and natural gas-burning facilities, as shown in Table 5.

[48] EPA. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources: AP-42, Fifth Edition.* 1995. http://www.epa.gov/ttn/chief/ap42

[49] EPA. *The Emissions and Generation Resource Integrated Database. Version 1.0 eGRID2007.* 2008. http://www.epa.gov/egrid

Fuel Oil

Two main grades of fuel oil are burned by electric generating facilities: distillate oils, i.e., fuel oil No. 2, and residual oils, i.e., fuel oil No. 6. Emissions depend on the grade and composition of the oil, type and size of the boiler used, firing and loading practices, and the level of equipment maintenance. Burning fuel oil produces many of the same criteria and non-criteria pollutants as coal, as shown in Table 4. Residual oil is used mainly in utility, industrial and large commercial applications.[50] Compared to residual oils, distillate fuel oils are more volatile, have lower nitrogen and ash content and usually contain less sulfur by weight. Combustion of distillate oils results in significantly lower particulate matter (PM) formation than does combustion of heavier residual oils.[51] Based on EPA's eGRID,[52] the average emission rates in New York for oil combustion for electricity generation in 2005 for CO_2, SO_2 and NO_x were considerably higher than those for natural gas, but lower than coal, as shown in Table 5. In addition, coal contains naturally occurring metals such as uranium and thorium that emit radiation. Studies in other countries have found slightly elevated amounts of these metals in soils near coal burning plants.[53, 54] This may not be occurring in New York because of stricter emission controls.

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[50] EPA. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources: AP-42, Fifth Edition.* 1995. http://www.epa.gov/ttn/chief/ap42

[51] EPA. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources: AP-42, Fifth Edition.* 1995. http://www.epa.gov/ttn/chief/ap42

[52] EPA. *The Emissions and Generation Resource Integrated Database. Version 1.0 eGRID2007.* 2008. http://www.epa.gov/egrid

[53] Ugur, A., Ozden, B., Yener, G., Sac, M.M., Kurucu, Y., Altinbas, U., Bolca, M. *Distributions of Pb-210 Around an Uraniferous Coal-Fired Power Plant in Western Turkey: Environmental Monitoring and Assessment 149:195-200.* 2009.

[54] Dai, L.J., Wei, H.Y., Wang, L.Q. *Spatial Distribution and Risk Assessment of Radionuclides in Soils Around a Coal-Fired Power Plant: A Case Study from the City of Baoji, China: Environmental Research 104:201-208.* 2007.

Table 5. New York Electricity Generation Average Emission Rates by Fuel Type 2005.[55]

Normalized to Electricity Output [a]				
Fuel	NO_x (lb/MWh)	SO_2 (lb/MWh)	CO_2 (lb/MWh)	Mercury (lb/GWh)
Coal	2.5	10.3	2116	0.046
Oil	1.9	5.1	1596	(Low)
Gas [b]	0.5	0.2	965	(Low)
Normalized to Fuel Input				
	NO_x (lb/MMBtu)	SO_2 (lb/MMBtu)	CO_2 (lb/MMBtu)	Mercury (lb/BBtu)
Coal	0.3	1.0	204.6	0.0044
Oil	0.2	0.5	152.0	(Low)
Gas [b]	0.1	<0.1	122.3	(Low)

[a] Emissions per MWh or GWh average in some emissions from fuel use for steam heat in co-generation facilities.
[b] Gas category includes natural gas, propane and butane. MMBtu = million British thermal units; BBtu=billion Btu; MWh=megawatt hour; GWh=gigawatt hour.

Natural Gas

Natural gas consists primarily of methane (generally above 85 percent), but also includes varying amounts of ethane, propane, butane, nitrogen, carbon dioxide and helium.[56] Emissions from natural gas combustion include criteria pollutants and some non-criteria pollutants, as shown in Table 4. Based on EPA's eGRID, CO_2 emission rates for natural gas combustion in New York are 40 percent lower than emissions from coal combustion and 21 percent lower than those from oil combustion, at nearly 1000 pounds per megawatt-hour (MWh), as shown in Table 5. Natural gas is currently being burned more cleanly than other fuels with respect to NO_x, with average New York emissions at 0.5 lbs/MWh, or 71 percent lower than oil and 79 percent lower than coal. When compared with other fossil fuels, natural gas has negligible emissions of SO_2, at only 2 percent of those of oil and less than 1 percent of those of coal. Methane, a primary component of natural gas and a greenhouse gas, is also released when natural gas is not burned completely.[57, 58]

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[55] The EPA Emissions and Generation Resource Integrated Database is based on available plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government. The majority of emissions are from EPA's Emissions Tracking System/Continuous Emissions Monitoring data. Sources that report these data are generally utility and non-utility steam units with at least 25 MW capacity, non-steam units- gas turbines, internal combustion engines that came on line after 1990 and independent power producers/ cogenerators that sell a specific amount of electricity to the grid. In general, eGRID plant level emissions reflect a combination of monitored and estimated data.

[56] EPA. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources: AP-42, Fifth Edition.* 1995. http://www.epa.gov/ttn/chief/ap42

[57] EPA. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources: AP-42, Fifth Edition.* 1995. http://www.epa.gov/ttn/chief/ap42

[58] Kirchgessner, D.A., Lott, R.A., Cowgill, R.M., Harrison, M.R., Shires, T.M. *Estimate of Methane Emissions from the U.S. Natural Gas Industry: Chemosphere. Sep 35(6):1365-90.* 1997.

Biomass, Biofuels and Refuse

Electricity generation from biomass is projected to increase significantly by the year 2020.[59,60] Wood is a biomass fuel that can take different forms such as firewood, chips, pellets and sawdust. Currently, there are three electric generating facilities in New York that burn wood-derived fuels, and two that are under development (see Renewables Assessment). As with combustion of any biomass, emissions include CO, CO_2, NO_x, SO_x, VOCs, PM and PM-bound chemicals (including PAHs, dioxins and furans). The amount of emissions depends on the nature of the wood fuel, moisture content, the temperature of the fire and the amount of oxygen available.[61] Compared with coal, biomass feedstocks contain less sulfur, resulting in lower SO_x emissions.[62] For some wood waste product fuels, burning of residual glues may increase emissions of nitrogen oxides.

The biofuels category includes landfill gas or biogas produced from anaerobic digestion of agricultural byproducts, food and beverage processing waste, and sludge waste or biogenic municipal solid waste.[63] Regardless of the feedstock source, the primary fuel produced by these methods is methane, sometimes referred to as biomethane. Emissions from biomethane combustion will predominantly resemble emissions from combustion of natural gas. Sulfur compounds and trace contaminants such as ammonia or siloxanes may also be present depending upon the non-methane components in the particular biofuel.[64, 65] Although combustion of landfill gas, like other carbon-based fuels, releases CO_2, it also reduces emissions of the more potent greenhouse gas methane that would otherwise be released un-burned from the landfill.

Combustion of municipal solid waste to generate electricity ("waste to energy") can release particulate matter, metals, organic compounds (including VOCs, dioxins and furans), acid gases and oxides of nitrogen and sulfur,[66] but at low-levels if properly controlled. Emissions have been greatly reduced, e.g., by >99 percent for dioxins and furans, over the last 25 years through retrofitting facilities with maximum achievable control technology.[67] Emissions data from modern, state-of-the-art municipal waste combustors demonstrate that they operate well within their permitted limits and in some instances, at a fraction of those limits.

[59] U.S. Department of Energy (DOE). *Annual Energy Outlook 2002 with Projections to 2020: DOE/EIA-0383*. 2001.

[60] Pace Energy and Climate Center. *The Environmental Impacts of Biofuels in New York State: Pre-Publication Draft*. 2009.

[61] EPA. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources: AP-42, Fifth Edition.* 1995. http://www.epa.gov/ttn/chief/ap42

[62] DOE. *Biomass for Electricity Generation.* 2008. http://www.eia.doe.gov/oiaf/analysispaper/biomass

[63] Tchobanoglous, G., Theisen, H., Vigil, S. *Integrated Solid Waste Management; Engineering Principles and Management Issues*. 1993.

[64] Dewil, R., Appels, L., Baeyens, J. *Energy Use of Biogas Hampered by the Presence of Siloxanes: Energy Conversion and Management 47:1711–1722*. 2006.

[65] Deublein, D. and Steinhauser, A. *Biogas from Waste and Renewable Resources: An Introduction*. 2008.

[66] Tchobanoglous, G., Theisen, H., Vigil, S. *Integrated Solid Waste Management; Engineering Principles and Management Issues*. 1993.

[67] EPA. *Emissions from Large and Small MWC Units at MACT: Compliance from Walt Stevenson, EPA Office of Air Quality Planning and Standards, to the Large MWC Docket.* 2007.

Older Electric Generating Facilities

All electric generating facilities, new and old, must receive air permits from DEC to operate. However, older existing facilities are not required to meet the same stringent emissions requirements that must be met by new facilities. Generally, older facilities that are less efficient and lack up-to-date pollution control systems release more pollutants than more modern facilities, or those that have been retrofit with pollution control devices or repowered with new units. For example, advanced, state-of-the-art sulfur removal technologies ("wet scrubbers") can provide SO_2 removal in excess of 95 percent.[68] Figure A-7 illustrates the difference between emissions from older units and newer units at two repowered older facilities. For the Bethlehem Energy Facility, newer gas-burning units with advanced combustion technologies, e.g., dry low NO_x burners, and controls, e.g., selective catalytic reduction, have very low NO_x and SO_2 emission rates compared to 2004 emission rates for the oil-burning units that they replaced. For the East River energy facility, 2005 emissions rates for SO_2 and NO_x from new gas-burning units are significantly lower than those from only moderately older oil-burning units brought on line in 1995. Emissions for CO_2 were also lower for the new units of both facilities, though the difference was less substantial than for the other pollutants. There are a number of older electric generating facilities in New York that have not been retrofit with new emissions controls, nor repowered with new units. DEC has developed a regulation for the installation of Best Available Retrofit Technology (BART) for pollution control on central station power plants and other stationary sources built between 1962 and 1977 that are not controlled under other programs (*See* Environmental Impact Brief). Other non-regulatory methods of encouraging retrofitting of older electric generating facilities with modern pollution control equipment to augment regulatory efforts like BART could also be instrumental in lowering emissions from these facilities.

Control Technologies

Pollution control technologies are used to reduce emissions, e.g., SO_2, NO_X, PM and acid gases, from electric generating facilities and other sources. While reducing the health risks associated with emissions, some of these technologies also have inherent health risks that must be considered and addressed in facility siting and permitting processes. For example, ammonia storage tanks for NO_x treatment have inherent risks of catastrophic failure and human health impacts.

Carbon capture and sequestration (CCS), a technology to reduce CO_2 emissions, consists of separating and capturing CO_2 from combustion sources and transporting it to a storage site to mitigate the greenhouse gas emissions from coal combustion facilities.[69] One method of CCS involves the capture of CO_2 and isolating it by injection into deep geological formations such as coal seams (known as geological sequestration or GS). Public health concerns associated with GS include catastrophic CO_2 leaks, which could result in asphyxiation, possible displacement of methane and brine and associated drinking water impacts. Dissolved CO_2 may also alter water pH, potentially mobilizing metals and affecting drinking water supplies.[70] The potential for such outcomes and the mechanisms by which they might manifest are the subject of recent and ongoing evaluations. Quantitative risk assessment is difficult and uncertain because there is little experience with the technology upon which to base estimates of risk, but it will become more feasible as information is generated from pilot- and commercial-scale projects. Based on

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[68] Srivastava, R.K., Jozewicz, W. *Flue Gas Desulfurization: The State of the Art. Journal of the Air & Waste Management Association 51 (12): 1676-1688.* 2001.

[69] A 50 MW CCS demonstration project is being developed with State support in Jamestown, N.Y. See the Coal Assessment for additional information.

[70] Bachu, S. *CO_2 Storage in Geological Media: Role, Means, Status and Barriers to Deployment: Progress in Energy and Combustion Science. 34: 254-273.* 2008.

existing information in 2005, Intergovernmental Panel on Climate Change (IPCC) concluded that, "with appropriate site selection based on available subsurface information, a monitoring program to detect problems, a regulatory system, and the appropriate use of remediation methods to stop or control CO_2 releases if they arise, local health, safety and environment risks of geological storage would be comparable to risks of current activities such as natural gas storage, enhanced oil recovery, and deep underground disposal of acid gas".[71] Recently, EPA developed a "vulnerability assessment" for GS to systematically identify those conditions that could increase the potential for adverse impacts, regardless of likelihood or broad applicability. They concluded that, "a large body of literature indicates that GS is a viable technology that can be conducted in a safe manner when coupled with a comprehensive approach to ensure protection of human health and the environment."[72] Research into risks of GS is ongoing. For example, scientists at Lawrence Berkeley National Laboratory are in the midst of a three year research program funded by the U.S. Department of Energy and EPA to study the potential for and outcomes associated with sequestration impacts on water.

Waste Generation and Disposal

Combustion of fuel, and coal in particular, in electric generating facilities produces fly ash and bottom ash.[73, 74] Fly ash is made up of fine particles collected from power plant exhaust gases for purposes of pollution control. Bottom ash is comprised of coarser particles that fall to the floor of coal burning furnaces.

People may be exposed to improperly managed coal ash if it is released into the air, or if constituents leach into groundwater.[75, 76] Inhalation of fly ash may result in lung irritation, and airway obstruction has been observed among heavily exposed workers.[77] Groundwater contamination can result when metals leach from coal combustion wastes placed in unlined landfills.[78] In addition, coal contains a number of naturally occurring radioactive elements including uranium and thorium. Coal fly ash and bottom ash may also contain somewhat higher concentrations than coal of these radioactive elements.[79] However, current DEC regulations for disposal facilities receiving ash require that the facilities employ liner systems to prevent groundwater contamination.[80]

EPA recently determined that coal fly and bottom ash disposed of in landfills and surface impoundments should be regulated under Subtitle D of the Resource Conservation and Recovery Act (RCRA), whereas

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[71] IPCC. *IPCC Special Report: Carbon Dioxide Capture and Storage. Summary for Policy Makers and Technical Summary*. B. Metz, O. Davidson, H. de Coninck, M. Loos, and L. Meyer (eds.). 2005.

[72] EPA. *Vulnerability Evaluation Framework for Geologic Sequestration of Carbon Dioxide,: Technical Support Document: EPA430-R-08-09*. 2008.

[73] EPA. *Materials Characterization Paper in Support of the Advanced Notice of Proposed Rulemaking – Identification of Nonhazardous Materials that are Solid Waste Coal Combustion Products - Coal Fly Ash, Bottom Ash, and Boiler Slag*. (2008). http://www.epa.gov/epawaste/nonhaz/pdfs/ccpash.pdf

[74] EPA. *Fossil Fuel Combustion Waste*. 2009. http://www.epa.gov/osw/nonhaz/industrial/special/fossil/index.htm

[75] MDE. *Facts about Coal Combustion Byproducts*. 2009. http://www.mde.maryland.gov/assets/document/CCBs_Fact_Sheet.pdf

[76] EPA. *Coal Combustion Waste Damage Case Assessments*. 2007. http://www.publicintegrity.org/assets/pdf/CoalAsh-Doc1.pdf

[77] Borm, P.J. *Toxicity and Occupational Health Hazards of Coal Fly Ash (CFA): Ann Occup Hyg. 41(6):659-76.* (1997).

[78] EPA. *Coal Combustion Waste Damage Case Assessments*. 2007. http://www.publicintegrity.org/assets/pdf/CoalAsh-Doc1.pdf

[79] Zielinski, R.A. and Budahn, J.R. *Radionuclides in Fly Ash and Bottom Ash: Improved Characterization Based on Radiography and Low Energy Gamma-ray Spectrometry: Fuel 77(4):259-261*. 1998.

[80] 6 NYCRR Part 360-2.

ash used to fill surface or underground mines (minefill) should be regulated under authority of Subtitle D of RCRA, the Surface Mining Control and Reclamation Act (SMCRA), or a combination of these authorities.[81] Under Subtitle D of RCRA, state and local governments are the primary planning, permitting, regulating, implementing and enforcement agencies for management and disposal of non-hazardous solid wastes such as coal combustion wastes.[82]

In New York, DEC established predetermined Beneficial Use Determinations (BUDs) for coal combustion bottom ash and coal fly ash placed in commerce for specified beneficial purposes, exempting such materials from solid waste regulations.[83] Beneficial purposes specified by DEC included use as a traction agent on roadways (for bottom ash) and use as structural fill within building foundations (for both bottom ash and fly ash). Generators and potential users of coal/oil bottom ash or fly ash placed into commerce for a beneficial purpose not specified in DEC's predetermined BUDs can petition the agency for a case-specific BUD.[84] As discussed in the Environmental Impacts Issue Brief, DEC is in the process of developing a new rule restricting the beneficial use of coal combustion fly ash in cement (clinker) manufacturing.

Cooling Towers

Electric generating facilities use cooling systems to transfer process waste heat to the environment. Broadly, there are two kinds of cooling systems – wet and dry. Wet cooling systems include once-through systems which withdraw water from a body of water, pass it through a condenser to cool steam produced at the facility and then return most of the water (now somewhat warmed) to the source. Wet systems also include evaporative cooling systems which withdraw cold water from a source and use it to dissipate heat to the atmosphere through a cooling tower. Dry cooling systems, which withdraw no water, use an air-cooled condenser to transfer heat. Wet/dry hybrid systems also are in use.

Potential human health concerns have primarily been associated with wet evaporative cooling systems. Chemicals present in cooling system source water (natural water bodies or sewage treatment plant effluent), as well as chemicals added to the cooling water (biocides, corrosion inhibitors, and scaling inhibitors) may be released to the atmosphere from the cooling tower. People may then be exposed to these chemicals, primarily by inhalation. These chemicals may be released as volatile emissions or in the droplets of mist ("drift") that rise from a cooling tower. The use of "drift eliminators" can substantially reduce drift emissions. A cooling tower system also provides an environment favorable for the potential growth of pathogens such as the *Legionella pneumophila*, the bacterium that causes Legionnaires' Disease. Implementing design and operational practices such as those contained in the "Guideline: Best Practices for Control of Legionella," published by the Cooling Technology Institute,[85] can help minimize the proliferation of *Legionella pneumophila* and other pathogens in cooling towers or its dissemination in drift.[86] Under certain ambient temperature and relative humidity conditions, wet evaporative cooling towers can also produce significant water vapor plumes. These plumes can result in potentially hazardous fogging and icing on nearby roadways. Optimal system design and operation can substantially reduce the potential for fogging and icing.

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[81] EPA. *Fossil Fuel Combustion Waste*. 2009. http://www.epa.gov/osw/nonhaz/industrial/special/fossil/index.htm

[82] EPA. *RCRA Statute, Regulations & Enforcement*. 2008. http://www.epa.gov/compliance/civil/rcra/rcraenfstatreq.html#rcraregs

[83] 6 NYCRR Part 360-1.15(b)

[84] 6 NYCRR 360-1.15(d)

[85] CTI, Cooling Tower Institute. *Guideline: Best Practices for Control of Legionella*. 2008

[86] CTI, Cooling Tower Institute. *Guideline: Best Practices for Control of Legionella*. 2008

Fuel Production

Human health concerns associated with production of fuels in New York (natural gas, oil and biofuels) are discussed below.

Natural Gas

In 2007, 54.9 billion cubic feet of natural gas were produced in New York, representing an increase of nearly 53 percent since 2003 and 202 percent since 1996.[87] Natural gas production can result in fugitive methane emissions [88] and presents a risk for explosions. Hydraulic fracturing, a method used to reach shale gas deposits and increase yield, involves a high-pressure injection of water, sand and chemicals followed by the release of gas and resulting waste waters ("flow-back" and "produced water") back to the surface.[89] Potential public health concerns primarily are related to quantity of water use, the composition and fate of the fluids used for fracturing the shale, and management of waste fracturing fluids in waste waters. Additionally, shale contaminants, such as naturally occurring radioactive materials, and brine, and residual fracturing fluids are brought to the surface during drilling in waste waters. Produced water generated after flow-back fluids have been collected has potential for leaking. In other parts of the U.S., health concerns have been raised about drinking water contamination from application of these brines to roads for deicing and dust suppression. The hydrofracturing process itself also can potentially lead to impacts on drinking water supplies (groundwater or surface water), surface water bodies and soils. Exposure to any of these contaminated media could result in a potential health risk, depending upon the identity of the contaminants present, their levels and the extent of exposure. DEC, in consultation with DOH, is currently updating its generic environmental impact statement for oil and gas drilling in the State to better address hydrofracturing associated with horizontal drilling, e.g., impacts to groundwater, surface water, air quality and others. A draft Supplemental Generic Environmental Impact Statement (SGEIS) for potential natural gas drilling activities was made available for public review and comment in October of 2009.

Oil

To protect public health and safety and prevent waste during drilling, each State permit includes conditions designed to prevent the escape of methane, other gases and any radioactive releases from wells. Gas flaring at the point of extraction is also a potential source of air contaminants.[90]

Biofuels

Production of biomass fuels can involve planting and harvesting biomass crops and/or transforming biomass into fuels through physical, chemical or biological processes. Ethanol production involves fermentation of biomass, primarily corn in the U.S. The flammability of ethanol poses a risk for workers involved in post-fermentation production. Potential health risks from short-term exposure to high concentrations of ethanol vapors include eye irritation, headache, drowsiness and stupor. Biodiesel

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[87] NYSERDA. *Patterns and Trends, New York State Energy Profiles: 1992-2007*. 2009.

[88] Kirchgessner, D.A., Lott, R.A., Cowgill, R.M., Harrison, M.R., Shires, T.M. *Estimate of Methane Emissions from the U.S. Natural Gas Industry: Chemosphere: Sep 35(6):1365-90.* 1997.

[89] Arthur, J.D., Bohm, B., Layne, M. *Hydraulic Fracturing Considerations for Natural Gas Wells of the Marcellus Shale. Ground Water Protection Council 2008 Annual Forum.* 2008. http://www.dec.ny.gov/docs/materials_minerals_pdf/GWPCMarcellus.pdf

[90] Epstein, P., Selber, J. *Oil-A Life Cycle Analysis of its Health and Environmental Impacts.* Center for Health and the Global Environment. Harvard Medical School, Boston, MA. 2002.

production involves mixing plant- or animal-derived oils with an alcohol (often methanol) and a catalyst. Methanol is flammable and exposure to associated corrosive catalysts can produce irritation and burns. Unlike petroleum diesel, biodiesel is readily biodegradable,[91] so spills may be less of a public health concern. Biogas or biomethane production poses an explosion risk similar to natural gas.

Fuel Storage and Distribution

Natural Gas

Natural gas pipelines and associated facilities such as tanks and compressor stations can release pollutants to the air and land. For example, the use of compressor drive engines results in air emissions of natural gas combustion products. Intentional and unintentional releases of pipeline fuels occur due to venting and losses from valves and seals. Compressor stations in transmission and storage are one of the largest sources of fugitive methane emissions from the U.S. natural gas industry [92] and thus contribute to global warming. Pipelines and associated facilities also have generated hazardous wastes in the past due to compressor oils containing polychlorinated biphenyls (PCBs) that contaminated soil.[93]

Oil

The limited amount of crude oil produced in New York is transported to refineries to produce all types of petroleum products. Refineries that supply the State are located near the Port of New York in New Jersey, Pennsylvania and in Canada[94] as well as the U.S. Gulf Coast area (see also Petroleum Assessment). Distillates are distributed to large storage terminals at several locations in the State, e.g., by tanker or pipeline, and from those locations, further distributed, typically by barge and tanker truck, to suppliers and end-users. Storage and distribution of crude and distillate petroleum products present several kinds of potential health risks. For example, there is a potential risk of explosions and fires that may result in release of contaminants to the air and widespread dispersion.[95, 96] Failures of oil pipelines can pose risks of explosions, contamination of soil and ground water and leakage into residential basements.[97] Terminals and pipelines can be sources of evaporative emissions of VOCs to the atmosphere.

Coal

Coal is often transported long distances and is stocked at various points between the mine and the user. Most coal enters New York by rail (see Coal Assessment) and is stocked in beds or piles. Locomotives transporting coal employ diesel fuel and discharge-related combustion products. Particulate matter emissions result from wind erosion of coal storage piles and the handling or agitation of coal in

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[91] Pace Energy and Climate Center. *The Environmental Impacts of Biofuels in New York State: Pre-Publication Draft*. 2009.

[92] Kirchgessner, D.A., Lott, R.A., Cowgill, R.M., Harrison, M.R., Shires, T.M. *Estimate of Methane Emissions from the U.S. Natural Gas Industry: Chemosphere: Sep 35(6):1365-90.* 1997.

[93] EPA. *Polychlorinated Biphenyl Inspection Manual. Office of Compliance*: *EPA-305-X-04-002*. 2004.

[94] ICF Consulting. *Petroleum Infrastructure Study.* 2006.

[95] Skrbic, B., Miljevic, N. *An Evaluation of Residues at an Oil Refinery Site Following Fires*. 2002.

[96] Cutchin, M.P., Martin, K.R., Owen, S.V., Goodwin, J.S. *Concern about Petrochemical Health Risk Before and After a Refinery Explosion.* 2008.

[97] Bobylev, L. M. *Avoiding Emergencies and Catastrophes due to Leaks of Oil, Gas, Water and Industrial Effluents from Pipelines: Chemical and Petroleum Engineering 38:300-306.* 2002.

preparation for use as fuel for boilers.[98] Depending on local geologic conditions, it is possible that leachate from coal piles may contaminate groundwater.[99] Coal stored in bins generates methane, an explosive gas, and coal dust is highly combustible.[100, 101]

Biofuels

Ethanol spills or leaks can impact groundwater, although diluted ethanol is readily biodegradable.[102] Other than significant releases in enclosed environments, it is unlikely that ethanol vapors would approach concentrations of concern. Storage and distribution of landfill or digester gas will have similar potential health impacts to natural gas. Additional issues arise from conversion of biomethane to methanol. The chronic exposure toxicity of methanol, e.g., based on visual disturbance effects, exceeds that of ethanol (based on liver and other effects),[103] as does the flammability. Acute exposures to ethanol or methanol through ingestion can produce gastrointestinal, visual and neurological effects.[104] The extent, duration and circumstances of the exposure will affect the severity of the effects. An accidental release of methanol to land could contaminate groundwater, or in an enclosed space could produce vapor concentrations of concern. Storage and distribution issues with biodiesel can be considered to be similar to that of diesel, with a slightly lower flammability risk.[105]

Community Health Concerns

Health concerns that have been raised by the public for electric generating facilities that burn carbon-based fuels are typified by those submitted to the Public Service Commission pursuant to Article X of the Public Service Law (PSL). These concerns included the air quality impacts of pollutants, noise, and potentially catastrophic events such as the failure of oil or ammonia (for air pollution control equipment) storage tanks. The concerns also included possible cumulative health risks (primarily from air pollutants) posed by proposed new generating facilities in addition to existing air pollution sources.

Community health concerns can be considered in the siting process for electric generating facilities through requirements established by legislation or by agency regulations. For example, the expired Article X of the PSL contained provisions to empower community and other stakeholder groups through an "intervenor" funding mechanism. This mechanism was recognized by DOH as having facilitated a positive contribution to the siting process. In contrast, other siting processes, for instance those that are governed by Article VII for electricity transmission, do not have provisions for intervenor funding.

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[98] U.S. Air Force. *Air Force Center for Engineering and the Environment. Clean Air Act Compliance Guidance. Federal CAA toolbox. Coal Piles/Coal Handling.* 2008. http://www.afcee.brooks.af.mil/products/air/federal/emisest/coalpiles.html

[99] Cook, A. M. and Fritz, S. J. *Environmental Impacts of Acid Leachate Derived from Coal-Storage Piles Upon Groundwater: Water, Air, & Soil Pollution 135: 371-388.* 2002.

[100] Kolada, R. J. and Chakravorty, R. N. *Controlling the Hazard of Methane Explosions in Coal Storage Facilities. Proceedings of the 3rd Mine Ventilation Symposium, Chapter 50 - Mine Methane II.* (1987).

[101] Cashdollar, K.L. *Coal Dust Explosibility: Journal of Loss Prevention in the Process Industries. 9(1): 65-76.* 1996.

[102] National Science and Technology Council (NSTC). *Interagency Assessment of Oxygenated Fuels*. 1997.

[103] NRC. *Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants: Volume 5.* 2008.

[104] Reese, E. and Kimbrough, R.D. *Acute Toxicity of Gasoline and Some Additives*: *Environ Health Perspect. 101(Suppl 6): 115–131.* 1993.

[105] U.S. Department of Transportation (U.S. DOT), *Clean Air Program -- Assessment of the Safety, Health, Environmental and System Risks of Alternative Fuel. Research and Innovative Technology Administration (RITA).* http://ntl.bts.gov/DOCS/afrisks.html

Project applicants and State agencies also can foster community participation in the facility siting process. The choice of appropriate methods for enlisting community participation can vary with the community, its history and its cultural makeup. Successful dialog between communities and developers often requires involvement of stakeholder groups throughout each phase of the siting process. Examples of important steps for project applicants and agencies to take to enlist community participation include identification of interested parties and initiation of discussion with public officials, community leaders and stakeholder groups, e.g., civic and economic development organizations, community boards, neighborhood associations, local environmental groups and churches. Community outreach efforts can rely on various communication tools, from notices on organization bulletin boards, web sites, document repositories, public meetings, media outreach and call in numbers. As the community involvement process proceeds, health and other community concerns can be considered through the siting process for a generating facility.

Nuclear Power

The primary health concern for nuclear power generation is exposure of the public to radiation. Significant radiation exposures can cause acute health effects such as cataracts, burns, sterility and even death. One method of evaluating the degree of acute hazard from exposure is to define the amount of exposure or dose that would cause death in 50 percent of the population within a certain time period. The dose that would cause death in 50 percent of the population within 60 days ($LD_{50,60}$) without treatment for radiation exposure is approximately 350,000 millirem.[106]

Radiation is a known carcinogen and mutagen. According to an approach often used by regulatory agencies to estimate cancer risk at low doses, the risk of developing a radiation-induced cancer is about one-in-one-million per millirem of exposure and the risk of developing a radiation-induced fatal cancer is about half as much.[107] For reference, the current overall lifetime risk of dying from cancer in the U.S. is 21 percent or about one in five.[108]

People are exposed to radiation every day from various sources, including medical applications, building materials and background radiation from outer space, soil, radon gas and the food we eat. Figure 1 shows the percent contribution of various sources of radiation exposure to the background dose per individual in the U.S. population for 2006. The average radiation exposure from all of these sources combined, in units of dose, for a person living in the U.S. is 620 millirem per year.[109] For comparison, a routine full mouth dental X-ray provides about nine millirem of radiation dose.

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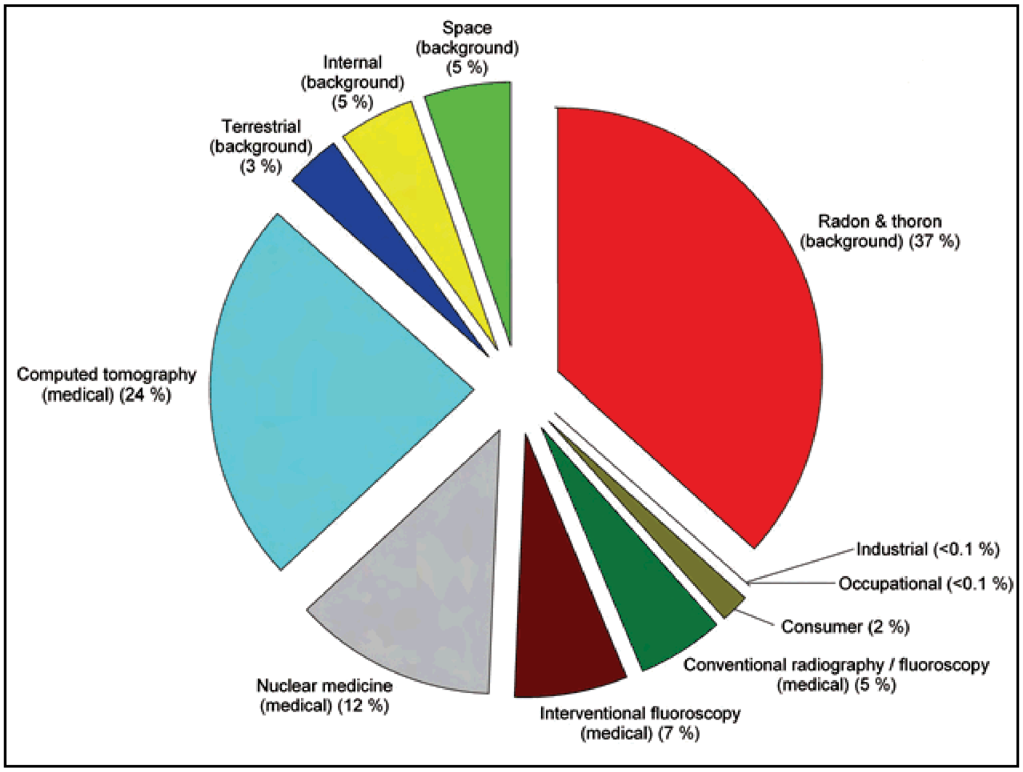
[106] Berger, M.E., Leonard, R.B., Ricks, R.C., Wiley, A.L., Lowry, P.C., Flynn, D.F. *Hospital Triage in the First 24 Hours After a Nuclear or Radiological Disaster.* 2008. http://orise.orau.gov/reacts/files/triage.pdf

[107] NRC. *Biological Effects of Ionizing Radiation. Health Risks from Exposure to Low-Levels of Ionizing Radiation: BEIR VII Phase 2.* 2006.

[108] Ries, L.A.G., Melbert, D., Krapcho, M., Stinchcomb, D.G., Howlader, N., Horner, M.J., Mariotto, A., Miller, B.A., Feuer, E.J., Altekruse, S.F., Lewis, D.R., Clegg, L., Eisner, M.P., Reichman, M., Edwards, B.K. (eds) *SEER Cancer Statistics Review, 1975-2005*. http://seer.cancer.gov/csr/1975_2005

[109] National Council on Radiation Protection and Measurements (NCRP). *Ionizing Radiation Exposure of the Population of the United States: NCRP Report No. 160.* 2009.

Figure 1. Percent Contribution of Various Sources of Radiation Exposure to the Background Dose per Individual in the U.S. Population for 2006



Note: Percent values have been rounded to the nearest one percent, except for those less than one percent. [110]

Permitted Radioactive Discharges to Air, Surface Water or Groundwater

Nuclear power plants have radioactive emissions that result from routine operations. To minimize radiation exposure to the public, nuclear power plants are regulated by the U.S. Nuclear Regulatory Commission (NRC), who requires radioactive emissions to be As Low As Reasonably Achievable (ALARA). To be considered ALARA, radioactive releases to the atmosphere must be limited to a quantity that will not result in an annual dose to a member of the public in excess of 10 millirem for gamma radiation and 20 millirem for beta radiation or a total dose to any organ in excess of 15 millirem. Radioactive releases to surface- or ground-water must be limited to a quantity that will not result in an annual dose to a member of the public in excess of three millirem to the whole body or 15 millirem total dose to any organ through all routes of exposure.[111] At these levels, there is no risk of acute health effects. If exposures occurred at the ALARA limits annually for a lifetime, excess risk of developing fatal cancer due to these exposures would be on the order of two in one thousand. The doses to a member of the public from radioactive emissions from New York nuclear plants in 2007 are summarized in the Table 6. These doses are about one percent of the ALARA requirements.

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[110] NCRP. *Ionizing Radiation Exposure of the Population of the United States: NCRP Report No. 160.* 2009.

[111] U.S. Code of Federal Regulations (USCFR). *Appendix I to Part 50--Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents: 72 FR 49507.* 2007.

Table 6. Doses to Members of the Public from Radioactive Emissions from New York Nuclear Plants in 2007.[112]

Nuclear plant	Whole body (millirem)	Maximum organ dose (millirem)
Indian Point (Units 1, 2 & 3 combined) [a]	0.06	0.27
Nine Mile Point and James A. Fitzpatrick (Nine Mile Point Units 1 & 2, and Fitzpatrick unit combined) [b]	1.52	0.09
Robert E. Ginna [c]	0.003	0.005

[a] Indian Point Energy Center (IPEC). *2007 Annual Radioactive Effluent Release Report*. 2008. http://adamswebsearch2.nrc.gov/idmws/doccontent.dll?library=PU_ADAMS^PBNTAD01&ID=081340200

[b] Nine Mile Point Nuclear Station, Unit 1 (NMP1). *Radioactive Effluent Release Report January-December 2007*. 2008. http://adamswebsearch2.nrc.gov/idmws/doccontent.dll?library=PU_ADAMS^PBNTAD01&ID=081400145

Nine Mile Point Nuclear Station, Unit 2 (NMP2). *Radioactive Effluent Release Report January-December 2007*. 2008. http://adamswebsearch2.nrc.gov/idmws/doccontent.dll?library=PU_ADAMS^PBNTAD01&ID=081400149

Entergy Nuclear Operations, Inc. James A. Fitzpatrick (JAF). *Nuclear Power Plant Annual Radioactive Effluent Release Report January 1, 2007 - December 31, 2007*. 2008. http://adamswebsearch2.nrc.gov/idmws/doccontent.dll?library=PU_ADAMS^PBNTAD01&ID=081350129

[c] GINNA, R.E. Ginna Nuclear Power Plant. *2007 Annual Radioactive Effluent Release Report.* 2008 http://adamswebsearch2.nrc.gov/idmws/doccontent.dll?library=PU_ADAMS^PBNTAD01&ID=081500108

Potential for Unscheduled Releases of Radioactive Materials

There is potential for unscheduled, unmonitored and undetected releases from nuclear power plants. Several minor nuclear power plant accidents in the U.S. have had atmospheric releases that were higher than those for routine operations, but still less than the ALARA limits described above. In New York, there was a Site Area Emergency at Ginna in 1982 [113] and at Indian Point in 2000.[114] Both of these accidents had atmospheric releases that were higher than those for routine operations, but less than the ALARA limits. A Site Area Emergency at Nine-Mile Point in 1991 did not result in the release of any radioactive materials.[115] Table 7 provides 2008 U.S. reactor emergency data.

[112] Estimates of whole body and maximum organ dose are based on procedures specified in each facility's Offsite Dose Calculation Manual, which defines facility-specific characteristics, exposure pathways and scenarios.

[113] Martin, T.T. *NRC Report on the January 25, 1982 Steam Generator Tube Rupture at R. E. Ginna Nuclear Power Plant:. NUREG-0909*. 1982.

[114] U.S. Nuclear Regulatory Commission (NRC). *Steam Generator Tube Failure at Indian Point Unit 2. NRC Information Notice 2000-009*. 2000.

[115] NRC. *Site Area Emergency Resulting from a Loss of Non-class 1E Uninteruptible Power Supplies. NRC Information Notice 91-64*. 1991.

Table 7. U.S. Reactor Emergencies in 2008.[116]

Emergency Classification	Description	Number of Occurrences in U.S. (and New York) [a]
Notification of Unusual Event	Events are in progress or have occurred which indicate a potential degradation of the level of safety of the plant. No releases of radioactive material requiring offsite response or monitoring are expected unless further degradation of safety systems occurs.	22 (3 in New York)[b]
Alert	Events are in progress or have occurred which involve substantial degradation of the level of safety of the plant. Any releases are expected to be limited to small fractions of the EPA Protective Action Guide exposure levels.	3 (0 in New York)
Site Area Emergency	Events are in progress or have occurred which involve actual or likely major failures of plant functions needed for protection of the public. Any releases are not expected to result in exposure levels that exceed the EPA Protective Action Guide exposure levels except within the site boundary.	0
General Emergency	Events are in progress or have occurred which involve actual or imminent substantial core damage or melting with potential loss of containment integrity. Releases can reasonably be expected to result in exposure levels that exceed the EPA Protective Action Guide exposure levels outside the site boundary.	0

[a] Currently, there are 104 operating reactors in the U.S. and six in New York.

[b] Two of these events were at the same reactor due to loss of communication.

In addition, leaks of radioactive liquid effluents into the groundwater on-site have occurred at several U.S. nuclear power plants. These liquid effluents are primarily contaminated with tritium, but may also contain small quantities of other radioactive materials. Liquid effluents may also seep into the large body of water that provides the heat sink for the nuclear power plant. Because these bodies of water are large lakes and rivers, any effluents released are diluted. There is potential for bioaccumulation of radioactive materials in aquatic life, which would in turn result in radiation exposures to persons who consume them. It is also possible to contaminate groundwater drinking water sources at levels that may require mitigation.

An example of potential exposure from one leak follows. The 2007 dose estimates from exposure to radioactive materials that migrated through groundwater and into the Hudson River from spent fuel pool leaks at Indian Point are less than 0.1 millirem for the year,[117] about 1,000 times lower than the average background radiation dose. This dose estimate considers all exposure pathways, including fish consumption, water consumption and swimming in the river.

If a major accident at a nuclear power plant occurred, large amounts of radioactive materials could be released and necessitate sheltering or evacuation of the population living near the plant in order to prevent radiation exposures at levels with the potential for causing acute health effects. An accident of this magnitude could also cause widespread contamination of the ground, foodstuffs in gardens and feed for grazing animals.

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[116] Operations Support Services, Inc. (OSSI). *Industry Operating Experience: Emergency Classifications and Related 50.72 Events Compiled from NRC Event Reports.* 2008.

[117] IPEC. *Annual Radioactive Effluent Release Report.* 2007.

Each nuclear power plant site must have an emergency plan that is approved by NRC and the Federal Emergency Management Agency (FEMA). These emergency plans are exercised regularly and the off-site response is evaluated by FEMA. The goal of these plans is to prevent acute health effects in the general population through shelter-in-place evacuation, administration of potassium iodide and quarantine of contaminated foodstuffs should an accident occur.

The Three Mile Island accident of 1979 was the most significant accident in the history of American nuclear power. It resulted in the release of an estimated 43,000 curies[118] of radioactive krypton and 20 curies of iodine-131 to the environment. There were no deaths or injuries to plant workers or members of the nearby community that could be attributed to the accident. The average radiation dose from this accident to people living within ten miles of the Three Mile Island was eight millirem, with no more than 100 millirem to any single individual.[119] Table 8 compares various radiation doses.

Table 8. Radiation Dose Comparison

Description	Radiation Dose
Background Radiation	620 millirem/year [a]
Indian Point Energy Center Spent Fuel Pool leaks to the Hudson River	>0.1 millirem/year [b]
Three Mile Island Accident	100 millirem [c]
Lumbar Spine X-ray	210 millirem/exam [d]
Full Mouth Dental X-Ray	9 millirem/exam [d]

[a] National Council on Radiation Protection and Measurements (NCRP). *Ionizing Radiation Exposure of the Population of the United States. NCRP Report No. 160.* 2009.
[b] IPEC. *Annual Radioactive Effluent Release Report.* 2007.
[c] NRC. *Three Mile Island Accident Fact Sheet.* 2008. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html
[d] U.S. Department of Veterans Affairs (VA). *Houston Veterans Affairs Medical Center Research and Development, Radiation Dose Table.* 2009. www1.va.gov/houston_va_rd/docs/dose_table.doc

Production, Transportation, Processing and Disposal of Radioactive Wastes and Nuclear Fuel

New nuclear fuel is primarily uranium-238 and uranium-235. Both of these materials have long half-lives. If a material has a long half-life, it is not very radioactive. The process used to produce nuclear power converts uranium-235 into radioactive materials such as cesium-137 and strontium-90 which have relatively short half-lives. Therefore, used or spent nuclear fuel is highly radioactive.

Nuclear fuel is not produced in New York; rather it is transported to the nuclear power plants via rail and truck in specialized shipping containers. These containers are designed to withstand severe accident conditions, including high temperature fires, collision and submersion in water. New fuel is stored in these shipping containers until it is transferred into the spent fuel storage pool prior to being loaded into the core of the nuclear power plant. Every two years, one-third of the fuel in the core is off-loaded and replaced with new fuel. Spent fuel (high-level radioactive waste) is stored on-site at the nuclear power plant. The fuel is transferred under water through a channel to the spent fuel pool, where it is stored in underwater racks. The water provides physical cooling and radiation shielding. Spent fuel pools are

[118] A curie is a unit of radioactivity equivalent to the activity of 1 gram of radium-226.

[119] NRC. *Three Mile Island Accident Fact Sheet.* 2008. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html

located inside a building adjacent to the reactor at pressurized water reactors and within the reactor building at boiling water reactors. If fuel is damaged during transfer, safety systems at the plant are in place to mitigate releases of radioactive materials.

In cases where the spent fuel pools are at or nearing capacity, spent fuel may be removed from the pool and stored in specialized or dry casks on plant property. All of the nuclear power plants in the State either have or are in the process of building interim spent fuel storage areas on plant property near the reactor. The containers used for dry cask storage are combination storage/transport containers and, as such, meet the requirements for storage containers described above. These casks are stored on large concrete pads within a secure area on the nuclear plant's property. Since the casked fuel has already been stored in the spent fuel pool for a long time, air-cooling is sufficient. There are normally no radioactive emissions from dry cask storage; but if there were any emissions, they would be subject to the same ALARA limits described above.

The Nuclear Waste Policy Act of 1982 established the national policies governing the permanent disposal of spent fuel. This Act, as amended, specifies that spent fuel will be disposed of underground, in a deep geologic repository and that Yucca Mountain, Nevada, will be evaluated as a potential geologic repository. The spent fuel disposal site at Yucca Mountain in Nevada has been under development by the U.S. Department of Energy (DOE) since 1978. However, the federal government has recently indicated that this project may be scaled back. With the uncertainty of the Yucca Mountain site, the only current spent fuel disposal option remains on-site storage.

Another option for spent fuel is reprocessing to reclaim unused uranium and plutonium for use in new fuel. Currently, reprocessing of commercial nuclear fuel does not occur in the United States.

Operations at nuclear power plants also produce low-level radioactive wastes. These wastes generally consist of materials such as ion exchange resins, HEPA filters, personal protective equipment such as gloves and shoe covers and contaminated trash and tools. In 1980, Congress passed the Low-Level Radioactive Waste Policy Act, which gave the states responsibility for managing the disposal of low-level radioactive waste and encouraged the formation of interstate compacts to handle wastes within their regions. However, progress has been slow and, in spite of an amendment to establish incentives in 1985, few compacts have formed. New York has not participated in a regional compact and until recently, a substantial portion of the commercial low-level radioactive waste from the State was packaged and shipped to a disposal site in Barnwell, South Carolina. On July 1, 2008, Barnwell was closed to all facilities not represented by the Atlantic Compact. As a result, New York nuclear plants can dispose of only lower activity (Class A) wastes at the Energy Solutions disposal facility in Clive, Utah and are consolidating and storing most of their radioactive wastes (Class B and C) on-site in buildings designed for this purpose. In 2007, most (98.7 percent) low-level radioactive waste disposed by nuclear power plants in New York was transported to a disposal facility in Utah.[120] At this time, no permanent solution for disposing of the remaining low-level wastes exists for New York plants.

Storage of spent fuel and other radioactive wastes is considered a part of normal plant operation and therefore subject to effluent limits previously described. Accidents involving spent fuel would not result in significant off-site radiation exposure unless a large quantity of fuel was involved. Off-site exposures from storage of low-level radioactive waste are unlikely unless the materials are burned in a fire. In this case, the level of exposure would depend on the quantity and types of radioactive materials burned in the fire.

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[120] NYSERDA. *New York State Low-Level Radioactive Waste Status Report for 2007*. 2008. http://www.nyserda.org/Energy_Information/LLRW%202007.pdf

Cooling Towers

All nuclear power plants require a heat sink to remove process heat. Once-through and wet evaporative cooling systems are commonly used at nuclear facilities. Some types of nuclear power plants have cooling towers. These can be up to 200 meters tall. Water in the cooling towers is treated with chlorine and sulfuric acid to maintain pH and prevent the growth of bacteria. The kinds of possible health concerns that may be associated with these towers, such as chemical emissions, pathogen growth, and fogging/icing, are generally the same as those associated with the smaller cooling towers used at other types of electric generating facilities, as discussed in Section 3.2.1.

Community Health Concerns

Radiation is an environmental risk factor that causes more concern than many others, possibly because of its association with cancer. The level of community concern about these risks would be site-specific, but in general would be sufficient to provide a substantive issue that would have to be addressed in the siting process for a new facility. Siting an additional unit at an existing nuclear power plant site is generally easier, since the entire infrastructure to support emergency response is already in place and approved by FEMA and the NRC. There are several new license applications to place additional nuclear power plants at existing U.S. facilities pending review by the NRC and more are expected. A license application to build a third unit at Nine-Mile Point was submitted to the NRC in October 2008.

Other Electricity Sources

The health risks associated with the combustion of carbon-based fuels, e.g., risks from exposure to combustion emissions, combustion waste products, and risks associated with nuclear power generation are not associated with solar energy (photovoltaics), wind and hydroelectric power (including hydrokinetic energy). However, aspects of each of these sources of electricity can have effects on public health that need to be considered.

Hydropower

Some potential health risks accompany development and use of dams and reservoirs. In spite of progress made to improve dam safety,[121] dam failure and earthquakes by reservoir-induced seismicity [122] are still the major catastrophic hazards associated with hydroelectric generation and these concerns increase with reservoir size. According to the Dam Safety Section of DEC, there are currently 218 federally regulated hydroelectric dams in the State and 35 percent of these dams are classified as having a high hazard potential due to dam height, reservoir capacity, downstream activities and other factors. However, according to DEC no catastrophic hydroelectric dam failure has occurred in New York in at least the last 20 years.

Hydrokinetic energy is another form of hydropower and includes wave and in-stream tidal energy and other ocean energy. To date, ten preliminary permits have been issued in New York for the use of

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[121] Uddin, N. *Lessons Learned: Failure of a Hydroelectricpower Project Dam: Journal of Performance of Constructed Facilities. 19:69-77*. 2005.

[122] Lamontagne, M., Hammamji, Y., Tournier, J. P., Woodgold, C. *Reservoir-induced Earthquakes at Sainte-Marguerite-3, Quebec, Canada. Canadian Journal of Earth Sciences 43:135-146*. 2006.

hydrokinetic energy from tides, waves and river currents.[123] While there may be impacts on local fisheries,[124] specific direct or indirect health risks of hydrokinetic energy have not been identified.

Solar Energy

The most established technologies to convert solar energy into electricity are photovoltaic and solar-thermal. Photovoltaic systems consist of wafers made of silicon or other conductive materials that absorb energy from sunlight and produce electrons as direct current. Solar-thermal technologies to produce electricity concentrate the sun's rays with mirrors to heat water to create steam, which is then used to turn a generator.[125]

Substances used in the manufacture of solar cells include silane, phosphine, diborane, copper indium diselenide, hydrogen selenide, copper indium gallium diselenide, gallium arsenide and cadmium telluride.[126] Workplace exposure to these chemicals is overseen by the Occupational Safety and Health Administration (OSHA). The general public is not likely to be exposed to any of these occupational chemicals.

Wind Turbines

In New York, some members of the public have expressed concerns about potential health effects associated with wind turbines. Concerns have been raised about noise from wind turbines and potential associated health effects, annoyance and sleep disturbance. Public documents have also suggested that there can be physical safety concerns for wind turbines including tower collapse, blade throw and ice shedding.[127] Turbine failure rates and blade-throw distances have been recorded, and models exist to estimate both parameters. A summary of published scientific articles, books and technical information on this topic was sponsored by the California Energy Commission.[128] Blade icing, ice shedding, and ice throw are potential hazards for wind turbines sited in areas where climate and geography dictates a higher likelihood of ice formation. Potential for icing has been mapped in other parts of the world, and models exist to estimate ice throw distances.[129, 130] Health risk related to blade throw and ice shedding could be mitigated through the choice of appropriate minimum setbacks (the minimum allowable distances between turbines and roads, property lines, or structures). Tower collapse can pose risks, but are rare.[131]

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[123] FERC. *Federal Energy Regulatory Commission White Paper on Hydrokinetic Pilot Project Licensing*. 2008. http://www.ferc.gov/industries/hydropower/indus-act/hydrokinetics.asp

[124] Cada, G., Ahlgrimm, J., Bahleda, M., Bigford, T., Stavrakas, S.D., Hall, D., Moursund, R., Sale, M. *Potential Impacts of Hydrokinetic and Wave Energy Conversion Technologies on Aquatic Environments*: *Fisheries 32:174-181*. 2007.

[125] Solar thermal technologies can also be used to provide hot water, e.g., for the residential sector, without generating electricity.

[126] Fthenakis, V.M. *Overview of potential hazards*: *In: Markvart, T., Castaner, L., editors: Practical Handbook of Photovoltaics: Fundamentals and Applications*. 2003.

[127] Steuben County Industrial Development Agency (SCIDA). *Draft Generic Environmental Impact Statement*. 2005.

[128] Larwood, S. *Permitting Setbacks for Wind Turbines in California and the Blade Throw Hazard. California Wind Energy Collaborative, University of California, Davis: Report Number CWEC-2005-01*. 2005.

[129] Dalili, N., Edrisy, A., Carriveau, R. *A Review of Surface Engineering Issues Critical to Wind Turbine Performance. Renewable and Sustainable Energy Reviews 13*. 2009.

[130] Finnish Meterological Institute. *Wind Energy Production in Cold Climate; WECO*. 2009. http://cordis.europa.eu

[131] NYSERDA. *Public Health and Safety. Power Naturally*. 2005.

Specific occupational hazards associated with wind turbines include falling and confined space hazards, and risks are mitigated by proper training and safety measures.[132,133]

Limited scientific, medical and other information about possible relationships between wind turbines and other types of health effects is emerging. However, definitive relationships between wind turbines and health effects have not been fully examined or established. For example, shadow flicker, produced when a wind turbine blade passes between a light source and the observer, has been suggested to pose a potential risk of precipitating epileptic seizures in sensitive individuals.[134] Although specific instances of seizures from shadow flicker from wind turbines have not been described, instances of seizures due to similar types of flicker caused by sunlight shining through trees into a moving vehicle and through rotating helicopter blades have been documented in passengers and pilots, respectively.[135] Thus, it has been suggested that when siting and operating wind turbines, the potential increased risk of inducing seizures in susceptible individuals be considered.[136]

Limited scientific studies and other information have raised concern that noise from wind turbines might increase the risk for other health effects, e.g., sleeplessness and headache. Wind turbines are associated with both audible (within 20-20,000 Hz) and low frequency (< 100-200 Hz) noise.[137,138] Recently, the Minnesota Department of Health issued a report on the Public Health Impacts of Wind Turbines. The report states:

> The most common complaint in various studies of wind turbine effects on people is annoyance or an impact on quality of life. Sleeplessness and headache are the most common health complaints and are highly correlated (but not perfectly correlated) with annoyance complaints. Complaints are more likely when turbines are visible or when shadow flicker occurs. Most available evidence suggests that reported health effects are related to audible low frequency noise. Complaints appear to rise with increasing outside noise levels above 35 dB(A).[139]

The relationship between noise or shadow flicker from wind turbines and health effects is not well understood. Better descriptions of noise and shadow flicker from wind turbines that may affect the health of nearby residents are warranted. This information will assist in developing a better understanding of the potential health effects of wind turbines on people.

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132 Jervis, S. *Fall Protection Consideration in the Wind Energy Industry: Occupational Health and Safety 78:26, 30, 32*. 2009.

133 Galman, D. *Cultivating Safety at Wind Farms: Occupational Health and Safety 78:28*. 2009.

134 Harding, G., Harding, P., Wilkins, A. *Wind Turbines, Flicker and Photosensitive Epilepsy: Characterizing the Flashing that May Precipitate Seizures and Optimizing Guidelines to Prevent Them: Epilepsia 49(6): 1095-1098*. 2008.

135 Cushman, J.T., Floccare, D.J. *Flicker Illness: An Underrecognized but Preventable Complication of Helicopter Transport*: *Prehospital Emergency Care, 2007; 11: 85-88*. 2007.

136 Harding, G., Harding, P., Wilkins, A. *Wind Turbines, Flicker and Photosensitive Epilepsy: Characterizing the Flashing that May Precipitate Seizures and Optimizing Guidelines to Prevent Them: Epilepsia 49(6): 1095-1098*. 2008.

137 British Wind Energy Association (BWEA). Low Frequency Noise and Wind Turbines. 2005. http://www.bwea.com/pdf/briefings/lfn_summary.pdf

138 Soysal, H., and Soysal, O. *Wind Farm Noise and Regulations in the Eastern United States: Second International Meeting on Wind Turbine Noise*. 2007.

139 Minnesota Department of Health, Environmental Health Division. *Public Health Impacts of Wind Turbines*. 2009.

3.2.2 Electric Transmission Lines

Extremely low frequency (ELF) electromagnetic fields (EMF) are present along all alternating current (AC) power transmission lines. The electric field strength is dependent on the line voltage, and if a line is operating at its design-specified line voltage, the maximum field strength will be constant. In addition, an alternating magnetic field will also be present, at a strength proportional to the magnitude of the current flow in the line, which will vary over the course of a day as the load changes. In 2007, the World Health Organization (WHO) released a report which reviewed the available exposure and health effects information for ELF fields.[140] The expert panel reviewed results from epidemiological, laboratory animal and in-vitro studies examining a variety of potential health impacts. The panel found that while there is support for an association between ELF magnetic field exposure and childhood leukemia, no such association is seen with ELF electric field exposure. In certain individuals, exposure to ELF fields (magnetic or electric) can produce faint flickering visual sensations called "phosphenes," which are not necessarily considered an adverse health effect, but are considered an indicator of an induced electric field in the central nervous system. Individuals with a diagnosis or family history of seizure or those on medications that reduce seizure threshold may be more susceptible to induced electric fields. The scientific evidence supporting an association of ELF fields with neuroendocrine, neurodegenerative, immunological, hematological, cardiovascular, reproductive and developmental effects, and with other cancers in adults or children, was considered by the panel as either inadequate, or as sufficient to indicate no association with causation.

Concerns have been raised about the generation of particles, or the charging of ambient particles, through corona discharge from high voltage transmission lines. The extent to which this occurs will be contingent on environmental and meteorological conditions. Based on the available research, there is likely to be little health risk for short- or long-term inhalation or dermal exposure to these particles.[141]

Transmission line rights of way may undergo pesticide applications to discourage the growth of woody and herbaceous plants below the power lines. Potential health effects from these practices would depend upon the pesticide used, the application mode and the proximity of nearby humans. Pesticides and their use are regulated on the state and federal level.

Community Health Concerns

Health concerns have focused primarily on EMF from existing power lines - transmission, distribution and residential lines. DOH staff routinely handles about six or seven citizens' questions per month about EMF health effects, State regulations and exposure reduction strategies. Concerns have focused on children's health, a safe distance from a power line for a house and how to shield or block EMF.

DOH provides an overview of radiation principles, information on state, federal and international exposure limits and scientifically based answers to health questions. Concerned citizens are advised to exercise "prudent avoidance," e.g., minimize potential risk when the magnitude of risk is unknown, and given suggestions for approaches to minimize exposure to EMF.

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140 World Health Organization (WHO). *Extremely Low Frequency Fields. Environmental Health Criteria Monograph 238*. 2007. http://www.who.int/peh-emf/publications/Complet_DEC_2007.pdf

141 National Radiological Protection Board (NRPB). *Particle Deposition in the Vicinity of Power Lines and Possible Effects on Health: Report of an Independent Advisory Group on Non-Ionizing Radiation and its Ad Hoc Group on Corona Ions*. 2004. http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1194947415038

3.2.3 Reliability

Reliable electricity production is critical to maintain good public health in our energy-dependent society. Power blackouts are associated with increased rates of accidents and violence. Potential stress to the power grids due to peak energy demands that occur at times of extreme weather may result in power outages. Increasing the reliability of the electric grid can reduce health effects during high temperatures, when air conditioning is the principal means to prevent heat-related morbidity and mortality. To gain a better understanding of the health impacts of power outages, DOH is planning a study of the health effects of the Northeast blackout of 2003, focusing on the resulting air conditioning loss and its impact on respiratory disease and mortality.

During summer, power outages pose specific health-related impacts such as: (1) increased digestive tract illness due to consumption of spoiled meat and seafood;[142] (2) spoiled vaccines due to loss of refrigeration; [143] and (3) potential for increased rodent populations as a result of large amounts of discarded perishables.[144] Electricity outages can also render furnaces inoperable in winter, resulting in risks of cold weather mortality and morbidity. Winter outages also pose specific risks to public health such as carbon monoxide poisoning due to the improper use of gasoline or diesel generators.[145,146]

Power outages affect private drinking water sources (wells) and may also affect public supplies and waste water treatment plants. In New York, approximately 88 percent of the total population (18.9 million, 2000 census) receive water from public water systems. Some systems are required to have a dedicated standby power system so that the water can be treated and/or pumped to the distribution system during power outages to meet demands. Some systems have alternate methods of providing water during short power outages. Systems serving a population greater than 3,300 are required to have emergency plans that address power outages. Power outages lasting one to two days should have minimal impact, however longer power outages are likely to interrupt services for some systems.

3.2.4 Conclusions

The combustion of carbon-based fuels for electricity production generally releases many of the same kinds of pollutants regardless of the specific fuel type or combustion technology. However, the emission rates of particular pollutants vary by fuel, combustion technology, air pollution control equipment and other factors. In general, newer combustion technologies are much more efficient and burn less fuel and newer control technologies provide greater reductions in emissions for the fuel burned. In addition, for approximately equivalent combustion and control technologies, emissions from coal combustion are equal to or greater than those from oil combustion, while emissions from oil combustion are equal to or greater than those from natural gas combustion. Health risks associated with air pollution from carbon-based fuel

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[142] Marx, M.A., Rodriguez, C.V., Greenko, J., Das, D., Heffernan, R., Karpati, A. M., Mostashari, F., Balter, S., Layton, M., Weiss, D. *Diarrheal Illness Detected Through Syndromic Surveillance after a Massive Power Outage: New York City, August 2003*: *American Journal of Public Health 96:547-553.* 2006.

[143] Bell, K.N., Hogue, C.J.R., Manning, C., Kendal, A.P. *Risk Factors for Improper Vaccine Storage and Handling in Private Provider Offices. Pediatrics 107(6): art-e100.* 2001.

[144] Beatty, M.E., Phelps, S., Rohner, C., Weisfuse, I. *Blackout of 2003: Public Health Effects and Emergency Response: Public Health Reports 121:36-44.* 2006.

[145] Graber, J.M., Smith, A.E. *Results from a State-Based Surveillance System for Carbon Monoxide Poisoning*: *Public Health Reports 122:145-154.* 2007.

[146] Daley, W.R., Smith, A., Argandona, E.P., Malilay, J. and McGeehin, M. *An Outbreak of Carbon Monoxide Poisoning after a Major Ice Storm in Maine: The Journal of Emergency Medicine, Vol. 18, No. 1, pp. 87–93.* 2000.

combustion can be reduced by encouraging replacement, repowering and/or retrofitting of older electric generating facilities and a shift in the distribution of fuels burned away from coal and towards more natural gas. It is important for New York to continue to maintain and improve understanding of the health impacts of decisions related to carbon-based fuel combustion for electricity generation and other purposes. DOH is currently planning to study the impacts of extreme temperatures on health outcomes (with implications for climate change). A study of changes in health outcome rates following initiation of the State Implementation Plan to reduce NO_x emissions ("NO_x SIP Call") will also soon be underway.

Given the lack of combustion emissions from nuclear power facilities, an increase in nuclear generating capacity could be considered. However, the risks associated with a potential major radioactive release and the need to have a long-term disposal plan for radioactive wastes should be taken into account.

The kinds of health risks associated with the combustion of carbon-based fuels, e.g., risks from exposure to combustion emissions and combustion waste products, or nuclear power generation are not associated with solar energy, wind and hydroelectric power. While the use of these means of producing electric power is not risk-free, increasing the fraction of electricity need met by wind, solar and water will, in general, decrease health risks associated with electricity production.

Electric generating facilities, associated facilities and processes, e.g., fuel production and storage facilities, waste handling processes, and electric transmission lines can have impacts on communities where they are sited, including health risks associated with air emissions, visual impacts, noise, quality-of-life impacts and others. Communities can provide valuable insight from their unique vantage point on these issues. Communities are important stakeholders and can provide input in the decision-making processes associated with the siting of electric generating facilities and transmission lines (see also Environmental Justice Issue Brief).

3.3 Transportation

The transportation sector was responsible for 28 percent of the primary energy use in New York in 2007, in addition to a small amount of electricity consumption.[147] The transportation sector releases air contaminants from burning carbon-based fuels and from evaporative fuel losses. The transportation sector as defined by NYSERDA is responsible for 37 percent of the greenhouse gas (GHG) emissions.[148] When compared to other energy uses, mobile sources (on-road vehicles, air, rail, marine transport and non-road sources such as lawnmowers) are responsible for the vast majority of emissions in New York of carbon monoxide (Figure A-6) and the ozone-precursors NO_x (Figure A-3) and VOCs (Figure A-5). Mobile sources are responsible for more primary $PM_{2.5}$ emissions than the electricity generating sector (Figure A-1). Of mobile sources, on-road gasoline vehicles contribute the most emissions of NO_x, VOCs and CO in the State. Non-road diesel engines contribute the majority of the primary $PM_{2.5}$ emissions from this sector.

Health effects from energy use by the transportation sector include accidental injuries and death (not discussed further in this Issue Brief) and increases in morbidity and mortality associated with the contaminants from combustion emissions. For the transportation sector, mobile source emissions are usually concentrated at ground level, often in densely populated areas, resulting in a tendency toward higher levels of exposure for more people than emissions associated with other energy use sectors. Air

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[147] NYSERDA. *Patterns and Trends, New York State Energy Profiles: 1992-2007*. 2009.

[148] NYSERDA. *Patterns and Trends, New York State Energy Profiles: 1992-2007*. 2009.

pollutants associated with the transportation sector include many of the criteria and non-criteria pollutants mentioned in the electricity generating sector, as shown in Table 4. Exposures to these air contaminants are associated with an increased risk of respiratory and cardiovascular effects, among others (see Table 2).

The increases in risk of these effects have been investigated by numerous studies that have looked at the relationship between traffic patterns or associated pollutant levels and health endpoints. For example, studies have found associations between asthma exacerbation or emergency room visits for respiratory illness and transportation-related factors such as traffic proximity or traffic density [149,150,151] and, in particular, diesel traffic density.[152]

3.3.1 Fuel Use

Currently, most mobile source emissions result from combustion of gasoline and traditional petroleum-based diesel fuel. Diesel fuel combustion has been associated with higher emissions of PM than gasoline combustion. Even with recent implementation of federal requirements for use of ultra low sulfur diesel (ULSD) fuel to reduce on-road vehicle PM emissions, diesel-burning cars still emit more than thirty times as much $PM_{2.5}$ per mile driven than gasoline-powered cars.[153] There are no requirements for ULSD currently in place for some non-road sources, though requirements for various source categories are being phased in over the next few years. Emission control technologies for new and existing diesel engines are available and the avoided potential health impacts associated with their use can be estimated.[154] Aggregate PM emissions from the transportation sector and associated potential health risks could be reduced through an accelerated shift away from traditional diesel fuel and less controlled diesel sources, toward more use of ULSD and diesel emissions control technologies, or cleaner alternative fuels.

Examples of viable alternative fuels that can be used for the transportation sector include biodiesel, biodiesel blends, ethanol, gasoline-ethanol blends and compressed natural gas (CNG). Each fuel has its own emissions characteristics. For example, substantially reduced emissions of GHGs and NO_x are produced by combustion of CNG compared with diesel or gasoline,[155] although availability of vehicles (through manufacturing or retrofitting) and necessary infrastructure for this fuel would need to be improved.

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[149] Lin, S., Munsie, J.P., Hwang, S., Fitzgerald, E., Cayo, M. R. *Childhood Asthma Hospitalization and Residential Exposure to State Route Traffic: Environmental Research. Section A (88): 73-81.* 2002.

[150] Lwebuga-Mukasa, J.S., Ayirookuzhi, S.J., Hyland, A. *Traffic Volumes and Respiratory Health Care Utilization among Residents in Close Proximity to the Peace Bridge Before and After September 11, 2001: Journal of Asthma. 40(8): 855-864.* 2003.

[151] Kim, J.J., Huen, K., Adams, S., Smorodinsky, S., Hoats, A., Malig, B., Lipsett, M., Ostro, B. *Residential Traffic and Children's Respiratory Health. Environ Health Perspect 16(9):1274-9.* 2008.

[152] McCreanor, J., Cullinan, P., Nieuwenhuijsen, M. J., Stewart-Evans, J., Malliarou, E., Jarup, L., Harrington, R., Svartengren, M., Han, I. K., Ohman-Strickland, P., Chung, K.F., Zhang, J. *Respiratory Effects of Exposure to Diesel Traffic in Persons with Asthma: N Engl J Med. 357(23):2348-58.* 2007.

[153] Estimated 2008 average New York State emissions for diesel and gasoline cars are 0.115 and 0.004 grams per mile, respectively. Source: Communication with DEC, Division of Air Resources, Mobile Source Planning Section and EPA Mobile 6.2 Vehicle Emission Modeling Program.

[154] Stevens, G., Wilson, A., Hammitt, J.K. *A Benefit-Cost Analysis of Retrofitting Diesel Vehicles with Particulate Filters in the Mexico City Metropolitan Area: Risk Anal. 25(4):883-99.* 2005.

[155] DOE. *Alternative Fuels and Advanced Vehicles Data Center*. 2008. http://www.afdc.energy.gov/afdc/vehicles/natural_gas_emissions.html

The differences between emissions and potential health risks from combustion of biofuels versus conventional petroleum-based fuels are less clear. While a review of 80 studies of emissions from heavy duty diesel engines concluded that emissions for a number of contaminants were substantially lower for a biodiesel fuel blend compared with 100 percent petroleum diesel,[156] more recent studies comparing ULSD with biodiesel have found smaller or less consistent differences.[157] When compared with petroleum-based fuels, biodiesel and alcohol-based fuels have higher levels of combustion emissions of respiratory irritants and some ozone-precursors such as formaldehyde, acetaldehyde and acrolein.[158,159] A recent health impact assessment study has suggested that regional replacement of gasoline with the 85 percent ethanol-gasoline blend (E-85), which is currently available for millions of flex-fuel vehicles in the U.S., could result in increased ozone concentrations and ozone-related mortality in the Northeast U.S. and other regions.[160] Work conducted as part of the draft New York "Biofuels Roadmap" is further characterizing emissions associated with biofuel production, transportation and distribution, processing and end uses - e.g., transportation, electric generation and space heating - and is providing some assessment of carcinogenic and non-carcinogenic population health impacts of these emissions.[161]

New York has several laws, regulations and programs in place to help control or reduce emissions associated with transportation sources. For example, the New York State Diesel Emissions Reduction Act of 2006 requires that all State-owned and contracted heavy-duty vehicles use ultra-low sulfur diesel fuel (ULSD) and be equipped with the best available retrofit technologies to reduce tailpipe emissions. DEC and the Department of Motor Vehicles jointly administer a State-run Inspection/Maintenance Program through which all vehicles registered in the State are required to pass an emission test. DEC also has programs for heavy-duty diesel vehicles, which include annual emission inspections in the New York City Metropolitan area and roadside emission inspections on roads throughout the State.

New York and New York City have taken measures to reduce transportation emissions through the promulgation of regulations addressing idling vehicles. The State law applies to all on-road heavy-duty vehicles and prohibits idling for more than five consecutive minutes, while the New York City law prohibits idling for longer than three minutes while parking, standing or stopping with specific exceptions for safety and operation of buses. New York City partners with community organizations and businesses, through the use of public service announcements, to educate the public on anti-idling laws and the health, economic and environmental benefits of reduced idling. These efforts have targeted behavioral changes, such as the increased use of mass transit or ride sharing, that may lead to a reduction in air quality impacts.

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156 EPA. *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions: Draft Technical Report EPA420-P-02-001*. 2002.

157 Durbin, T.D., Cocker, D.R., Sawant, A.A., Johnson, K., Miller, J.W., Holden, B.B., Helgeson, N.L., Jack, J.A. *Regulated Emissions from Biodiesel Fuels from On/Off Road Applications: Atmospheric Environment 41:5647-5658*. 2007.

158 Correa, S.M. and Arbilla, G. *Carbonyl Emissions in Diesel and Biodiesel Exhaust: Atmospheric Environment 42:769-775*. 2008.

159 Tang, S., Frank, B.P., Lanni, T., Rideout, G., Meyer, N., Beregszaszy, C. *Unregulated Emissions from a Heavy-Duty Diesel Engine with Various Fuels and Emission Control Systems: Environ Sci Technol. 41:5037-5043*. 2007.

160 Jacobson, M. Z. *Effects of Ethanol (E85) Versus Gasoline Vehicles on Cancer and Mortality in the United States: Environmental Science and Technology 41:4150-4157*. 2007.

161 Pace Energy and Climate Center. *The Environmental Impacts of Biofuels in New York State: Pre-Publication Draft*. 2009.

An acceleration of the shift toward more fuel-efficient vehicles is a mechanism by which fuel use, associated emissions and health risks can be decreased. Increased use of electric vehicles would affect significant net reductions in the emissions of CO and VOCs.[162]

3.3.2 Fuel Spills

There were approximately 2,700 gasoline and diesel fuel spills that were reported to DEC in 2007[163] that could be associated with the transportation sector, i.e., gas stations, passenger vehicles, tanker trucks, railroad cars, and marine vessels. Spills of transportation fuel and leaking storage tanks can contaminate groundwater, surface water and soil and result in human exposures and potential health risks. Vapors from spilled fuels can migrate underground and be drawn into nearby buildings ("vapor intrusion"), resulting in exposure to contaminates for building occupants.

3.3.3 Reduced-Health-Risk Options for Transportation

Use of public transportation results in considerably less fuel use and air contaminant emissions per person-mile traveled than other modes of transportation such as personal cars.[164] Therefore, targeted geographic and temporal expansion of public transportation availability could reduce health risks associated with transportation emissions. Car-pooling can also reduce fuel use and associated health risks and both of these mechanisms can be supported through integrated local and regional transportation planning.

In general, the fuel use and resulting emissions from the transportation sector can be controlled and reduced through maintaining and improving the overall energy efficiency of the transportation system. For example, poorly maintained roads can motivate drivers to take longer, less energy efficient alternative routes. Upgrading roads and bridges can reduce traffic bottlenecks and allow more energy-efficient travel speeds, resulting in reduced public health risks from exposure to air contaminants and reduced risks of traffic accidents and possible injuries or deaths. For further information on the energy efficiency of the transportation system, refer to the Transportation Issue Brief.

Thoughtful planning can also improve transportation system efficiency and result in less idling and more direct routing of traffic flows with associated reductions in vehicle miles traveled. Reductions in fuel use and emissions can also be achieved through "smart growth" planning that facilitates establishment of more "walkable" communities, with sidewalks and bike lanes and bike paths.[165,166,167] "Active transport" – walking and cycling – for shorter journeys has both the benefits of reduced emissions and exercise to cardiovascular health and other health endpoints. However, in spite of the emission reductions associated with bicycling and walking for transportation and the health benefits of exercise, exercising in polluted air

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[162] DeLuchi, M.A., Wang, Q., Sperling, D. *Electric Vehicles: Performance, Life-Cycle Costs, Emissions and Recharging Requirements.* 1989.

[163] Department of Environmental Conservation (DEC). *Inactive Hazardous Waste Disposal Site Database*. 2008. http://www.dec.ny.gov/chemical/8437.html

[164] Woodcock, J., Banister, D., Edwards, P., Prentice, A.M., Roberts, I. *Energy and Transport*: *Lancet 370:1078-1088.* 2007.

[165] Woodcock, J., Banister, D., Edwards, P., Prentice, A.M., Roberts, I. *Energy and Transport*: *Lancet 370:1078-1088.* 2007.

[166] Davison, K.K., Werder, J.L., Lawson, C.T. *Children's Active Commuting to School: Current Knowledge and Future Directions*: *Preventing Chronic Disease*. 2008. http://www.cdc.gov/pcd/issues/2008/jul/07_0075.htm

[167] Watson, M., Dannenberg, A.L. *Investment in Safe Routes to School Projects: Public Health Benefits for the Larger Community: Preventing Chronic Disease.* 2008. http://www.cdc.gov/pcd/issues/2008/jul/07_0087.htm

can also have health impacts, especially for vulnerable populations.[168,169] For this reason, air quality, particularly in areas of heavy traffic, should also be considered in the choices made for siting of bicycle lanes and paths.[170]

3.3.4 Community Health Concerns

The Department of Transportation and other entities such as the Thruway Authority consider community concerns, including health concerns, in developing Draft Environmental Impact Statements pursuant to the State Environmental Quality Review Act. Callers to the DOH Environmental Health Information Line have also raised concerns about health impacts of transportation-related issues. Concerns include air emissions and pollution (lead, idling diesel locomotives, buses and construction vehicles near schools and residences), soil and water pollution (oil releases, pesticides and road salt), and noise and light pollution. Community concerns provide motivation for anti-idling regulations, limitations on activities at transportation hubs, rerouting of trucks around residential neighborhoods and the expansion of public transportation.

3.3.5 Conclusions

Burning carbon-based fuels for transportation emits contaminants at ground level and these emissions are highest in heavily populated areas with the highest traffic densities. These increased exposures result in increased health risks for many people. Health risks associated with these emissions can be reduced with a shift toward the use of cleaner carbon-based fuels, increased implementation of effective emission control technologies, transportation technologies that do not rely upon carbon-based fuels, and the development and enhancement of public transportation systems. Transportation system energy efficiency can be supported and improved through continued and enhanced maintenance of roads and bridges and further development of land use policies to reduce traffic congestion. Vehicle miles traveled and the need to rely on individual commuting can be reduced. Community concerns also can be considered in decision making for transportation initiatives or proposals. Finally, knowledge of the relationships between transportation choices and health outcomes should continue to be improved through scientific studies. For example, DOH has examined associations between traffic density and a number of health outcomes and plans to continue this effort by examining associations with low birth weight. Further information about health and environmental issues related to transportation can be found in the Transportation Issue Brief.

3.4 Residential, Commercial and Industrial Energy Use

In 2007, the residential, commercial and industrial sectors accounted for 17 percent, 11 percent and four percent, respectively, of the primary energy use in New York and were likely to have been responsible for a similar or greater percentage of some air pollutant emissions. For example, these sectors, which collectively accounted for only 32 percent of the primary energy use, were responsible for 39 percent of the GHG emissions; in comparison, the emission levels from the transportation and electric generating

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[168] Mills, N.L., Törnqvist, H., Gonzalez, M.C., Vink, E., Robinson, S.D., Söderberg, S., Boon, N.A., Donaldson, K., Sandström, T., Blomberg, A., Newby, D.E. *Ischemic and Thrombotic Effects of Dilute Diesel-Exhaust Inhalation in Men with Coronary Heart Disease: N Engl J Med., Sept 13; 357(11):1075-82*. 2007.

[169] Mittleman, M.A. *Air Pollution, Exercise and Cardiovascular Risk: N Engl J Med., Sept 13; 357(11):1147-9*. 2007.

[170] Hertel, O., Hvidberg, M., Ketzel, M., Storm, L., Stausgaard, L. *A Proper Choice of Route Significantly Reduces Air Pollution Exposure – A Study on Bicycle and Bus Trips in Urban Streets: Sci. Total Environ. 389(1): 58-70*. 2008.

sectors were 37 percent and 24 percent, respectively.[171] For the residential sector, individual source emissions can be close to ground level, with relatively little opportunity for dilution and can affect local air quality, in some cases in densely populated areas. In addition, residential energy use can pose special risks, e.g., home heating systems were the primary cause listed among the fifteen thousand carbon monoxide poisonings resulting in emergency department visits in the U.S. annually.[172] Finally, emissions from residential and commercial sources are less likely to be treated for removal of pollutants.

According to EPA's 2002 National Emissions Inventory data for New York [173] the residential sector alone is responsible for more primary $PM_{2.5}$ emissions than the electric utility and transportation sectors combined (Figure A-1), and a substantial fraction of the PM_{10} emissions, as shown in Figure A-2. The vast majority of these residential PM emissions are from wood combustion, even though wood makes up only a small fraction of the primary energy use in this sector. Residential wood combustion is also estimated to be the second most significant source of VOC and CO emissions, as shown in Figures A-5 and A-6. However, aggregate wood combustion emissions estimates for this sector have large inherent uncertainty. The industrial sector is also a significant source of PM (particularly PM_{10}) and SO_2, as shown in Figure 4, even though it burns a relatively small amount of fuel compared to other sectors. The majority of these industrial PM and SO_2 emissions is from coal combustion, although coal accounted for only about 13 percent of the total energy used (in Btu) by industrial sources.[174] The commercial sector is a relatively small contributor to emissions of PM, NO_x, SO_2, VOCs and CO and most of its emissions of these pollutants are the result of fuel oil combustion.

3.4.1 Fossil Fuels

Combustion of fossil fuels, e.g., distillate and residual fuel oil, waste oil, kerosene, natural gas, liquefied petroleum gas and coal, by the residential, commercial and industrial sectors for space heating or other energy needs generates essentially the same suites of air pollutants, as shown in Table 4, with the same potential health effects (Table 1), that are associated with combustion of these fuels by electric generating facilities. The relative emission rates for different emissions constituents from sources in this sector will be influenced by differences in combustion chamber designs, combustion temperatures, fuel blends, air mixtures and other factors. In general, for uncontrolled combustion sources, combustion emission rates, e.g., for PM, SO_x, NO_x, can be the highest for coal, residual oil and waste oil.[175]

3.4.2 Biomass and Biofuels

Biomass and biofuels are burned in New York for heat and combined heat and power for the residential, commercial and industrial sectors and the use of some of these energy sources may be increasing. For example, residents are reported to be increasingly turning to wood to heat their homes.[176] Wood-fired home heating devices include wood stoves, pellet stoves, fireplaces, fireplace inserts and wood-fired

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[171] NYSERDA. Patterns and Trends, New York State Energy Profiles: 1992-2007. 2009.

[172] CDC. *Nonfatal, Unintentional, Non-Fire-Related, Carbon-Monoxide Exposures – U.S. – 2004-2006*. 2008.

[173] EPA. *National Emissions Inventory (NEI) 2002 Data: Data for New York State*. 2008. http://www.epa.gov/ttn/chief/net/2002inventory.html#inventorydata

[174] NYSERDA. Patterns and Trends, New York State Energy Profiles: 1992-2007. 2009.

[175] EPA. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42, Fifth Edition. 1995*. http://www.epa.gov/ttn/chief/ap42

[176] Barlyn, S. *Burning Issue: As Wood Stoves Gain Popularity, Air-Quality Concerns Rise: The Wall Street Journal*. 2008. http://online.wsj.com/article/SB122123941105728647.html

boilers/furnaces and only some of these use combustion and emission control technologies. Although EPA required reduced PM emissions (by 70-90 percent) for indoor wood stoves manufactured after 1990 [177], it is estimated that only about 20 percent of the wood stoves currently in use meet these limits.[178] Emissions from wood-burning devices are influenced by the same factors described above for fossil fuels, but include PM and a mixture of chemicals, as shown in Table 4.

One kind of wood-fired device, sometimes called an outdoor wood boiler, has become increasingly popular for residential heating in the State. According to a report issued by the State Attorney General's Office, sales of these devices have tripled in New York since 1999, with an estimated 14,500 sold from 1999 to 2007.[179] According to the Northeast States for Coordinated Air Use Management (NESCAUM), these appliances usually have significantly higher cumulative emissions than other EPA-certified wood burning appliances and, unlike wood and pellet stoves, are currently unregulated.[180] Estimated average emissions per hour for fine PM are higher than conventional wood stoves, EPA-certified wood stoves, oil furnaces and gas furnaces, by factors of about 4, 12, 1,000 and 1,800, respectively.[181] Higher PM emissions from outdoor wood boilers result from lower combustion efficiency and a tendency to cycle between oxygen-starved and oxygen-rich combustion conditions. In January 2007, EPA launched a voluntary (phased) program to encourage manufacturers of outdoor wood boilers to improve emissions and efficiency. According to EPA, outdoor wood boilers that meet Phase 1 emissions levels (0.60 lb/MMBtu of heat input) are 70 percent cleaner, and those that meet the Phase II emissions limits (0.32 lb/MMBtu of heat output) are 90 percent cleaner than unqualified units, though still more polluting than non-catalytic woodstoves.[182] Recognizing that some regulatory entities may choose to adopt regulations that deal with both existing outdoor wood boilers and new units, NESCAUM developed a model rule that state and local entities can use. The model rule contains provisions such as emission limits, setback requirements, stack height requirements, distributor and buyer notification instructions, label information and notice for buyers.[183] Although DOH and other State agencies have received numerous complaints about siting of and smoke from outdoor wood boilers, New York currently does not have specific regulations to address these emissions and provide siting criteria.

3.4.3 Fuel Spills

Public health impacts and potential risks are also associated with fuel oil spill accidents that may occur during energy production, storage, distribution and use. Of the approximately 15,000 petroleum-related spills that occur in New York each year, many are associated with residential, commercial or industrial fuel use. For example, in 2007, over 4,000 heating fuel spills occurred in the State, 3,000 of which

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[177] U.S. Federal Register. *Standards of Performance for New Stationary Sources, New Residential Wood Heaters: Final Rule.* 1988.

[178] Johnson, P.R.S. *In-Field Ambient Fine Particle Monitoring of an Outdoor Wood Boiler: Public Health Concerns: Human and Ecological Risk Assessment*. 2006.

[179] New York State Office of the Attorney General (OAG). *Smoke Gets in Your Lungs: Outdoor Wood Boilers in New York State: Revised version March, 2008.* 2008.

[180] Northeast States for Coordinated Air Use Management (NESCAUM). *Outdoor Woodboiler Factsheet*. 2006. http://www.nescaum.org/topics/outdoor-hydronic-heaters

[181] AG. *Smoke Gets in Your Lungs: Outdoor Wood Boilers in New York State: Revised version March, 2008.* 2008.

[182] EPA. *EPA's Phase 2 Voluntary Partnership Program: Outdoor Wood-fired Heaters*. 2008. http://www.epa.gov/woodheaters/pdfs/HH-flyer10-21-08.pdf

[183] NESCAUM. *NESCAUM Model Regulation for Outdoor Hydronic Heaters*. 2007. http://www.nescaum.org/topics/outdoor-hydronic-heaters

occurred at private residences and 1,000 at commercial, institutional, educational, governmental or industrial properties.[184] The most common sources of these spills are accidents during transport and delivery of fuel and leaks from storage tanks. For example, human error and improper delivery can result in over-pressurization and rupture of indoor tanks during filling. Accidental deliveries to homes where a fill pipe remains, but the tank was removed after a fuel source conversion are not uncommon. Indoor spills can also result from leaking piping and filters. Improperly installed outdoor aboveground tanks, e.g., for kerosene, can rupture after tipping during spring thaws. Oil leaks from indoor, above ground and underground tanks can occur due to rusting and old age. Any leaks and spills of fuel oil can result in human exposure through contamination of drinking water, indoor air, soils and physical property.

DOH responds to over 300 residential fuel oil spills per year (a fraction of those responded to by DEC) by conducting on-site investigations to evaluate potential public health impacts. Based on an assessment of drinking water quality, indoor air, or residential soils, recommendations are made for actions to reduce exposure and human health risk. For spills that pose health risks for residents, DOH negotiates with responsible parties and their insurance companies to facilitate relocation of affected residents. In the most recent fiscal year, DOH staff recommended temporary relocation for individuals in 24 affected residences.

3.4.4 Efficiency

Some energy efficiency improvements in residential and commercial buildings can impact indoor air quality (IAQ) as well as other aspects of indoor environmental quality (IEQ), e.g., noise and glare. New York State Building Code and Property Maintenance Code designate minimum air ventilation rates for new and existing buildings that generally minimize the occurrence of IAQ problems. However, problems still can arise when an older building is updated to make it more energy efficient without addressing the need for adequate ventilation. This is particularly true in buildings where there are pre-existing sources of air contaminants such as solvents, radon gas, dust, allergens, excess water or humidity (increasing chances for mold growth), carbon monoxide, and carbon dioxide. Exposure to these air contaminants can have health risks. Radon, for example, is a carcinogen and exposure to dust can exacerbate asthma. There are also health effects associated with exposure to carbon monoxide and solvents (volatile organic compounds), as discussed earlier. IAQ and other IEQ considerations must be addressed while efficiency improvements are implemented to correct existing IAQ problems and avoid creating new problems. NYSERDA has programs to utilize industry-accrediting organizations to set standards and best practices for conducting energy efficiency upgrades. Program requirements concerning source removal, ventilation systems, minimum ventilation rates, and sizing and installing of HVAC systems help avoid and alleviate indoor air quality problems in existing buildings. NYSERDA also strives to support advanced sustainability standards and tools by partnering with organizations like Collaborative for High Performance Schools, DOE, EPA and the U.S. Green Building Council.

3.4.5 Conclusions

Energy use in the residential, commercial and industrial sectors is responsible for a large amount of pollutant emissions in New York. These sectors include a variety of emissions sources, from small residential sources with local impacts to large industrial sources with regional air quality impacts. Potential health risks associated with energy use in these sectors can be reduced through a shift to more efficient and controlled combustion of cleaner burning fuels. For example, residential wood combustion is an important source of $PM_{2.5}$ and PM_{10} emissions. A shift from burning wood in uncertified wood

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[184] DEC. *Chemical and Petroleum Spills*. 2008. http://www.dec.ny.gov/chemical/8428.html

stoves and fireplaces to other energy sources or EPA-certified wood stoves could substantially reduce statewide emissions of PM and other pollutants. Reduction of the potential health risks associated with local emissions from outdoor wood boilers can be achieved through use of low emissions units instead of high emission units and appropriate siting for new units. Coal burning in the industrial sector is also a significant source of emissions of pollutants and public health benefits could be achieved by reducing these emissions. Emissions from the commercial sector could be reduced through a shift from oil combustion (particularly residual oil) to natural gas. Finally, the number of residential fuel oil spills and associated potential health risks could be reduced by educational outreach efforts for fuel oil consumers or heating contractors and suppliers pointing out the common causes of spills.

3.5 Communities with Health Disparities

In New York, as well as other parts of the U.S., significant disparities exist in some health outcomes for certain groups by race, ethnicity and socioeconomic status. Disparities are observed in life expectancy and rates of diabetes, cancer, heart disease, asthma, infant mortality and low birth weight.[185,186] Studies in New York have found that asthma death rates and hospitalization rates are higher among low income and minority residents than white, higher-income residents.[187,188] DOH released the Minority Health Surveillance Report in 2007 [189] and has begun to develop a comprehensive plan to eliminate minority health disparities in the State, with input from a variety of stakeholders.

In addition, studies of the distribution of potential sources of air emissions, e.g., industrial facilities, inactive hazardous waste sites, high traffic roadways, power plants, and waste transfer stations, have found that these facilities are more likely to be located in low income and minority areas.[190,191] The disproportionate representation of industrial facilities in low income and minority areas and the siting of new facilities are key concerns of DEC's Office of Environmental Justice and environmental justice advocacy groups. More detailed information on environmental justice efforts and activities, including maps of environmental justice areas in New York, can be found in the Environmental Justice Issue Brief. DOH's involvement with the review of health outcome data in DEC's permitting process is described in Appendix B.

Many communities burdened with disparities in health outcomes such as asthma, diabetes and heart disease also have increased concentrations of stationary and mobile sources of air contaminants, as well as industrial zones that include smaller sources of potential air pollution. Awareness of and sensitivity to the needs of these communities are essential as New York moves forward with energy related decisions.

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185 HHS. *Healthy People 2010*. 2009. http://www.healthypeople.gov/default.htm

186 DOH. *New York State Minority Health Surveillance Report*: *Public Health Information Group*. 2007. http://www.health.state.ny.us/statistics/community/minority/docs/surveillance_report_2007.pdf

187 Claudio, L., Tulton, L., Doucette, J., Landrigan, P. J. *Socioeconomic Factors and Asthma Hospitalization Rates in New York City: Journal of Asthma 36:343-350.* 1999.

188 Lin, S., Fitzgerald, E., Hwang, S., Munsie, J.P., Stark, A. *Asthma Hospitalization Rates and Socioeconomic Status in New York State (1987-1993). Journal of Asthma 36:239-251.* 1999.

189 DOH. *New York State Minority Health Surveillance Report*: *Public Health Information Group*. 2007. http://www.health.state.ny.us/statistics/community/minority/docs/surveillance_report_2007.pdf

190 Maantay, J. *Mapping Environmental Injustices: Pitfalls and Potential of Geographic Information Systems in Assessing Environmental Health and Equity*: *Environ Health Perspect 110 (Suppl. 2):161-171*. 2002.

191 Morello-Frosch, R., Pastor, M., Porras, C., Sadd, J. *Environmental Justice and Regional Inequality in Southern California: Implications for Future Research: Environ Health Perspect 110 (Suppl. 2):149-154*. 2002.

To help meet the needs of these communities and others, New York should provide information and services to facilitate energy-related and health-related decision making. For example, the State should make health outcome data (see Appendix B) available to the public. The State should make educational materials available to the public to improve health, e.g., to better manage asthma. New York should support its' interagency task force to create a state-wide environmental justice database and corresponding maps that include energy production and use-related information.

4 Overall Conclusions

Governor Paterson's Executive Order 2 established the State Energy Planning Board and determined that the Board shall create a State Energy Plan that shall include "assessments of the impacts associated with electricity production and energy use on public health and the environment, including on communities that are burdened disproportionately by health and environmental impacts." This Issue Brief identifies opportunities to reduce health risks while meeting needs for adequate and reliable energy. A summary of the findings is displayed in Table 9.

Potential public health risks and benefits associated with energy use and production are important considerations in the process of meeting energy needs for New York. In keeping with other considerations necessary for adequate and reliable energy, the human health risks and potential morbidity and mortality associated with energy production, storage, transmission and use can be further reduced. Some of the specific considerations and opportunities to minimize health risks from energy use and production identified in this Issue Brief are:

- Reduced-health-risk electricity generation
- Reduced-health-risk options for transportation and enhanced transportation efficiency
- Community health concerns in siting and permitting processes
- Community health status data and health educational materials
- Cleaner burning fuels and equipment for residential, commercial and industrial energy users
- Health research and assistance for other regulatory agencies, as needed, to address the health risks associated with energy production and use

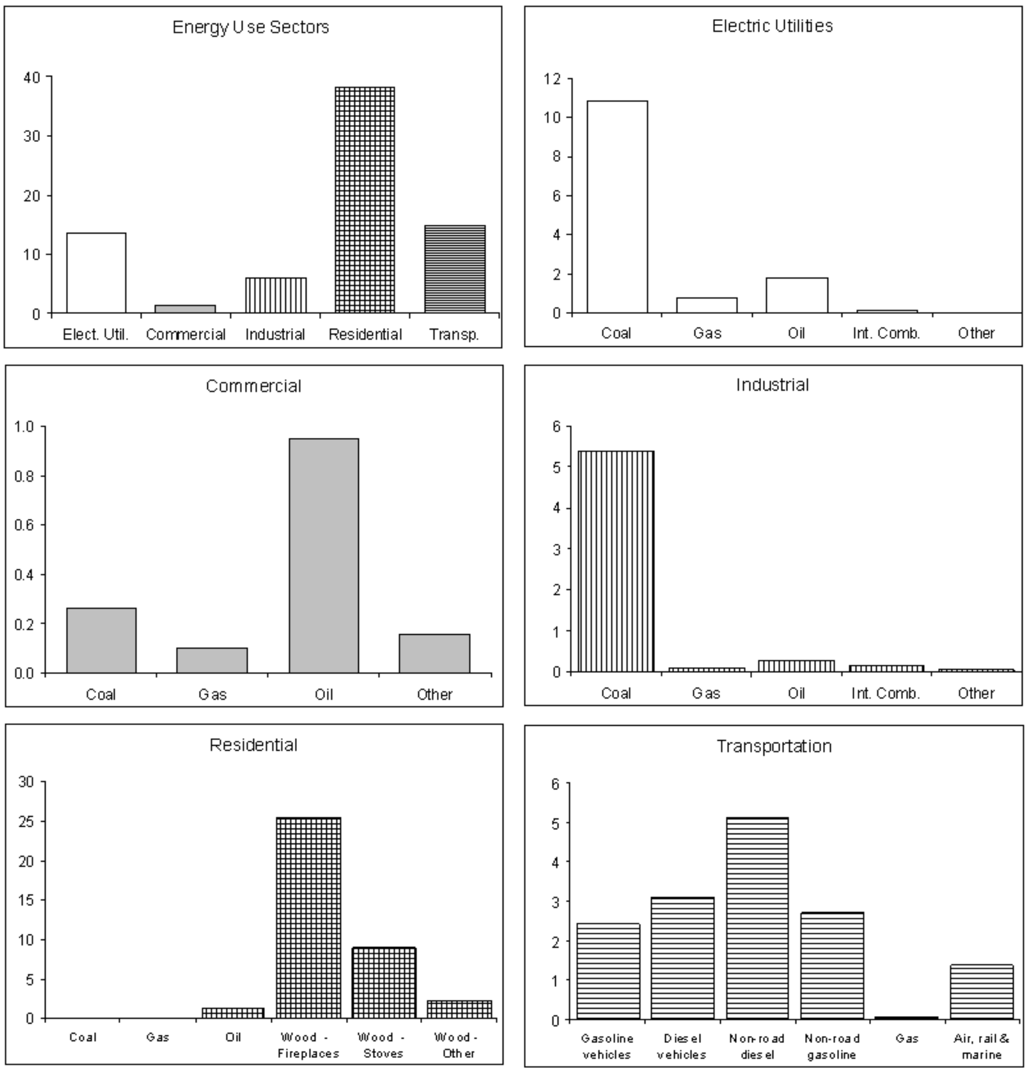
Table 9. Summary of Key Health Related Findings

Primary Energy Use [a]			***Health Issue*** [b]
Electric Generation	*Carbon-based Fuels*		▪ *Carbon-based fuel combustion by the electric generating sector is the dominant source (60%) of emissions of SO_2.* ▪ *Contaminants from fuel combustion include NO_x, SO_x, ozone, particulate matter, greenhouse gases and others.* ▪ *Those contaminants are associated with a number of health effects including exacerbation of asthma, other respiratory and cardiovascular effects.*
		Coal, Oil and Natural Gas	▪ *The majority of electric generation SO_2 emissions is from coal combustion (78%) and almost all of the rest is from oil combustion (21%).* ▪ *Average emission rates from coal-burning facilities compared to natural gas-burning facilities are more than 30 times higher for SO_2, nearly 4 times higher for NO_x and 2 times higher for carbon dioxide.* ▪ *SO_2 permitted limits for a new coal-burning facility, using best available control technology, would be 2 to 3 times higher than a new oil-burning facility and 200 to 300 times higher than a new, natural gas-burning facility.* ▪ *Within this energy use sector, coal combustion contributes the greatest amount of $PM_{2.5}$ and PM_{10}.* ▪ *Emission rates at older facilities can be reduced (e.g., by over 95% for SO_2) by retrofitting older combustion units with emission controls or by replacing older units with more efficient and controlled modern units.*
		Biofuels, Biomass and Refuse	▪ *Net emissions of CO_2 are generally lower than from fossil fuel combustion.* ▪ *Landfill gas combustion reduces emissions of the potent greenhouse gas, methane, which would otherwise be released un-burned.* ▪ *Combustion of some biofuels may have higher levels of some pollutants such as aldehydes.*
	Nuclear		▪ *None of the direct air pollutant emissions associated with fuel combustion.* ▪ *Permitted low-level radioactive releases.* ▪ *A major accident could result in significant radioactive releases and public health impacts.* ▪ *Plans for disposal of highly radioactive spent fuel waste in the U.S. have not been well defined and there currently is no long-term strategy for disposal of low-level radioactive waste generated in New York.*
	Wind, Solar, Hydroelectric		▪ *None of the direct air pollutant emissions associated with fuel combustion.* ▪ *Health risks differ and include noise for wind and dam failure for hydroelectric.*
Transportation			▪ *The transportation sector is the dominant source of emissions of the ozone precursors NO_x (68%), VOCs (61%) and of carbon monoxide (92%).* ▪ *Studies have shown elevated incidence of respiratory health effects in people who live in close proximity to heavy traffic.* ▪ *Of the transportation emissions of NO_x, VOCs and CO, the largest source is on-road gasoline vehicles.* ▪ *Of the transportation emissions of $PM_{2.5}$, the largest source is non-road diesel engines.*
Residential, Industrial and Commercial			▪ *For these three energy use sectors, industrial use of coal is a substantial source of PM_{10}.* ▪ *Across all energy use sectors, wood combustion may be the largest source of particulate matter, but estimates are uncertain.* ▪ *PM emissions are nearly 2000 times higher for outdoor wood boilers than gas furnaces and annual sales of outdoor wood boilers have tripled since 1999.* ▪ *4,000 heating oil fuel spills occurred in 2007.*

[a] *Across all energy use sectors, fuel combustion generates approximately 94% of emissions of SO_2, 97% of NO_x, 61% of VOCs, 61% of primary emissions of fine particulate matter and is the primary contributor to ozone formation.* [b] *Data are specific to New York if available. See Brief text for reference citations.*

5 Appendix A [192]

Figure A-1. Estimated Aggregate Primary $PM_{2.5}$ Emissions for Fuel Combustion in New York for 2002 (Thousands of Tons/Year)

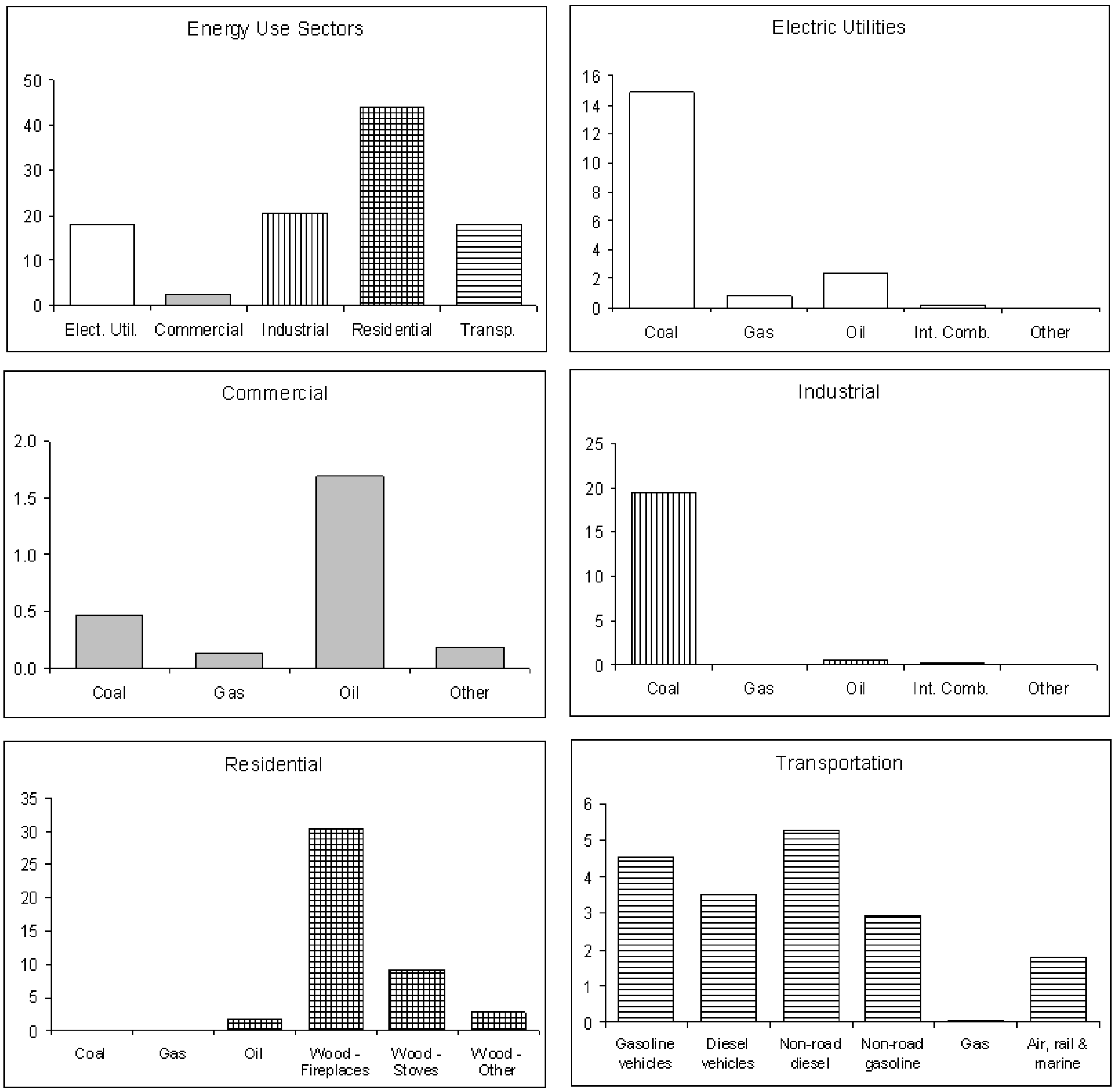


Source: Data from EPA National Emissions Inventory.

Notes: Int. Comb.=Internal Combustion. Gas includes one or more of the following: natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas.

[192] Figures A-1 through A-6 are based on analysis of data from EPA. *National Emissions Inventory (NEI) 2002 Data: Data for New York State*. http://www.epa.gov/ttn/chief/net/2002inventory.html#inventorydata

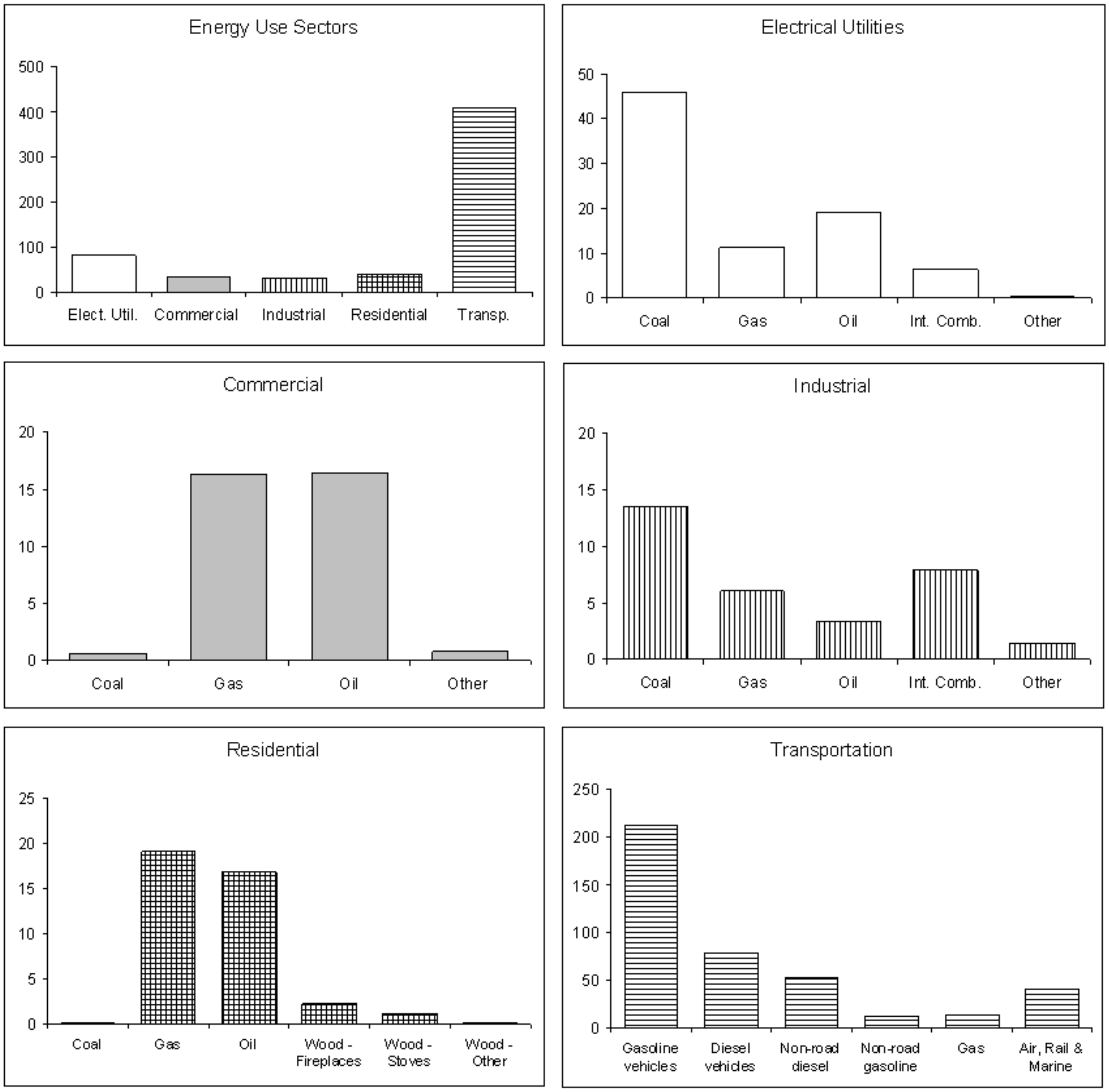
Figure A-2. Estimated Aggregate Primary PM_{10} Emissions for Fuel Combustion in New York for 2002 (Thousands of Tons/Year)



Source: Data from EPA National Emissions Inventory.

Notes: Int. Comb. = Internal Combustion. Gas includes one or more of the following: natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas.

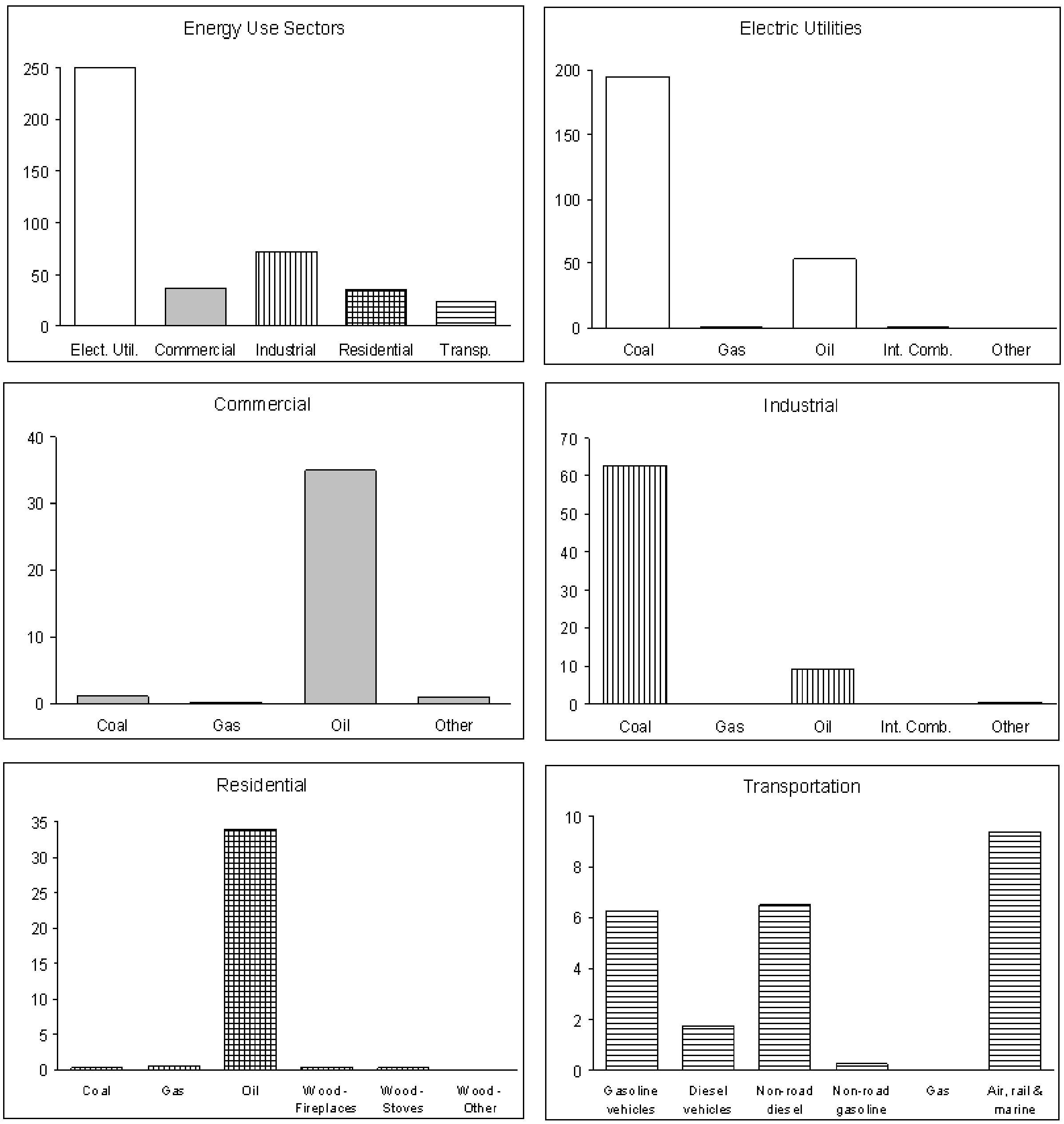
Figure A-3. Estimated Aggregate Primary NOx Emissions for Fuel Combustion in New York for 2002 (Thousands of Tons/Year)



Source data from EPA National Emissions Inventory.

Notes: Int. Comb. = Internal Combustion. Gas includes one or more of the following: natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas.

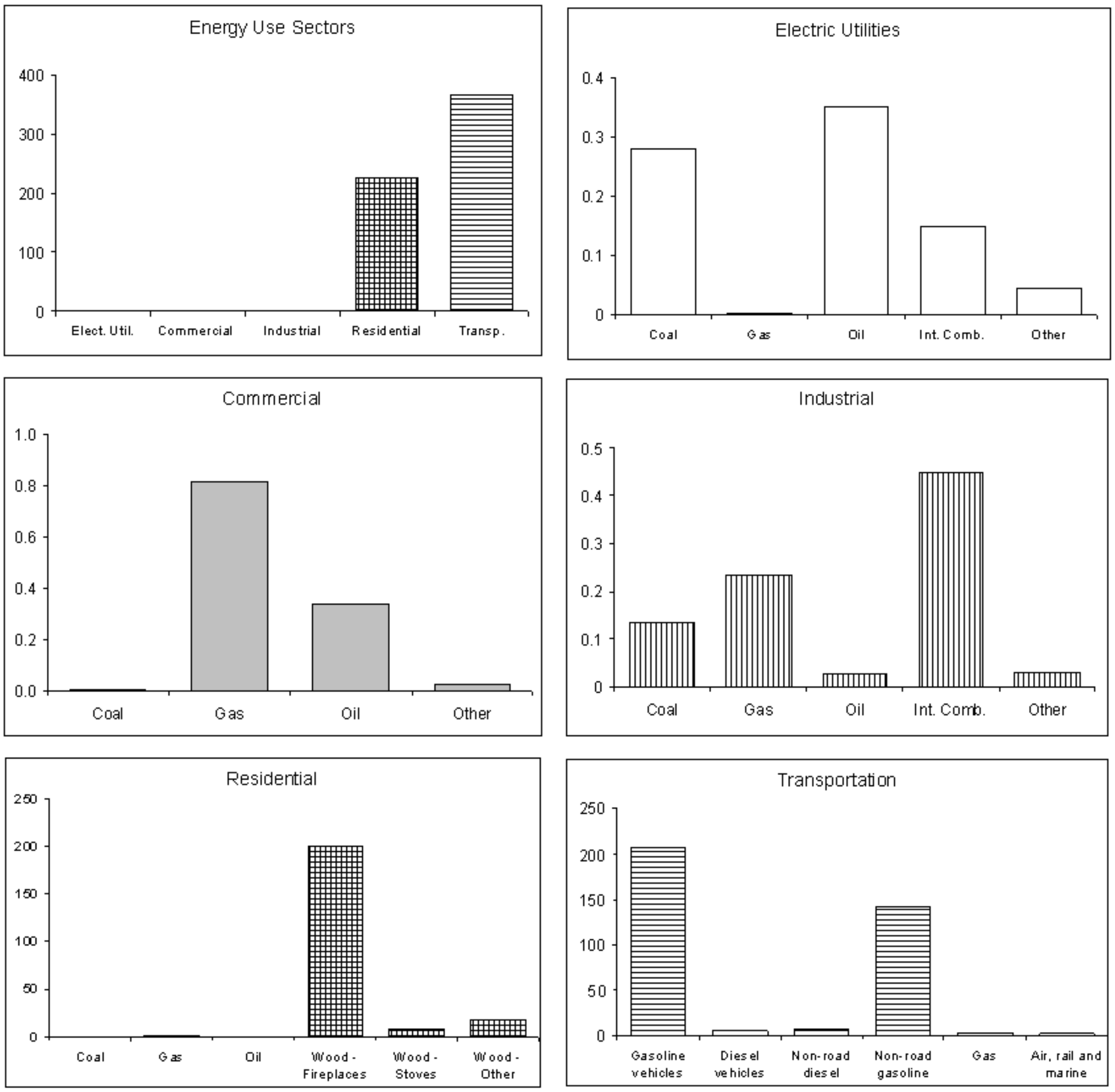
Figure A-4. Estimated Aggregate Primary SOx Emissions for Fuel Combustion in New York for 2002 (Thousands of Tons/Year)



Source: Data from EPA National Emissions Inventory.

Notes: Int. Comb. = Internal Combustion. Gas includes one or more of the following: natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas.

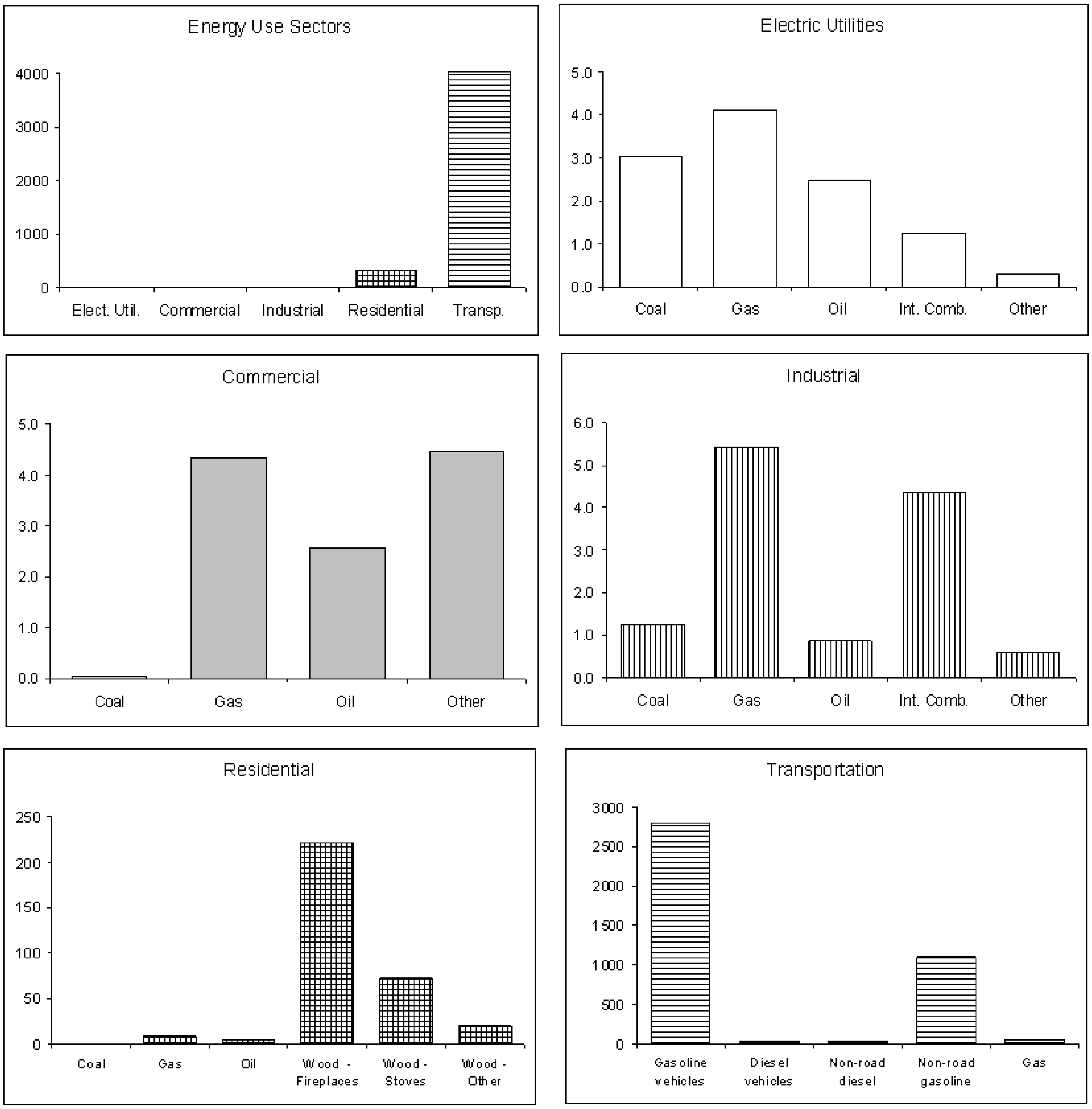
Figure A-5. Estimated Aggregate Primary VOC Emissions for Fuel Combustion in New York for 2002 (Thousands of Tons/Year)



Source: Data from EPA National Emissions Inventory.

Notes: Int. Comb. = Internal Combustion. Gas includes one or more of the following: natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas.

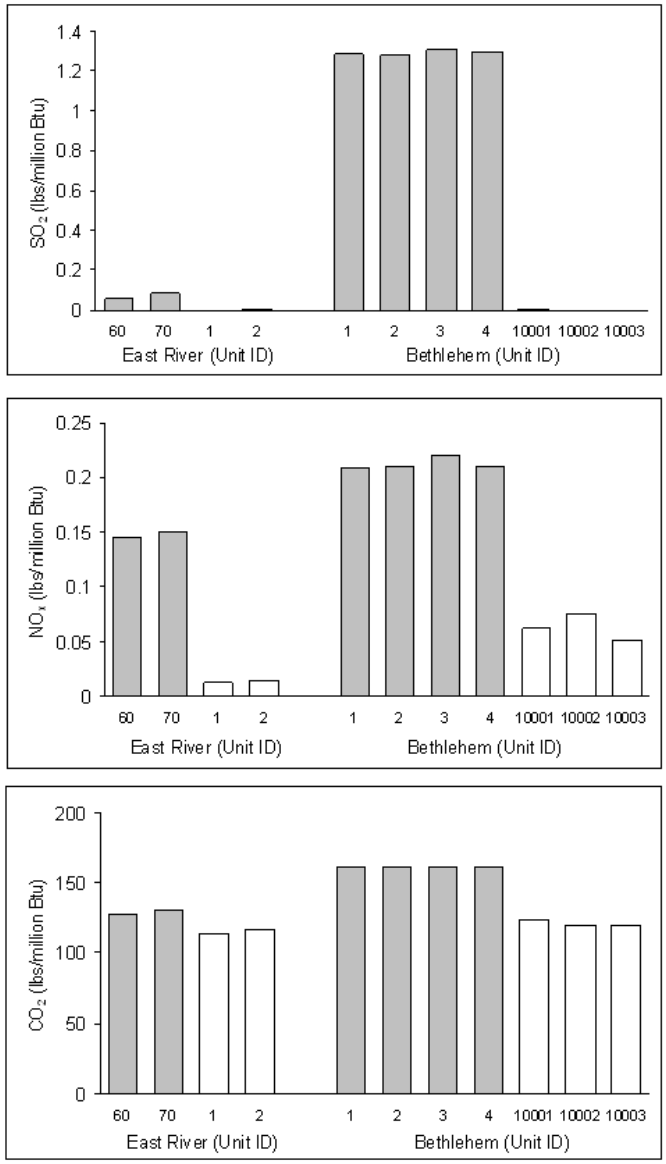
Figure A-6. Estimated Aggregate Primary CO Emissions for Fuel Combustion in New York for 2002 (Thousands of Tons/Year)



Source: Data from EPA National Emissions Inventory.

Notes: Int. Comb. = Internal Combustion. Gas includes one or more of the following: natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas.

Figure A-7. Emission Rate Comparison for SO_2, NO_x and CO_2 Between Older Residual-Oil-Burning Units (Gray) and New Natural Gas-Burning Units (White) for Two Re-Powered Electric Generating Facilities (East River and Bethlehem).



Source: DEC, Division of Air Resources.

Notes: The older East River units came on line in 1995 and continue to operate and the newer units replaced other older units (emissions data not shown) in 2005. The older Bethlehem units were replaced with the newer units in 2005. All emissions data are from 2005, with the exception of the older Bethlehem units (from 2004).

6 Appendix B - Methods to Evaluate Health Risks, Assess Health Impacts and Consider Health Status

The field of environmental public health is concerned with the potential impacts on human health and well being of all aspects of the environment. The environment is generally considered to include both the natural and "built" environments, but can even be more broadly defined as including the physical, psychological, social and aesthetic environment.[193] Health risk assessment is one tool that can be used in environmental public health to estimate human health risks associated with existing or proposed, conditions or actions - such as the siting of an electric generating facility. Another tool can be used to estimate potential population health impacts of broad policy scenarios (often called health impact assessment). Both of these approaches have inherent uncertainties. Finally, health outcome data (counts and rates of health-related events in a population) can describe the health status of the community and can be used as a hypothesis generating tool for epidemiology studies to examine the associations between environmental factors, health status and vulnerability. Heath risk assessment, health impact assessment, uncertainties associated with these tools and the uses of health outcome data are described below.

6.1 Health Risk Assessment and Health Impact Assessment

Human health risk assessment is the process of characterizing the nature of and estimating the potential for, adverse health effects including those that could result from an environmental exposure, such as an exposure to radiation or a chemical, physical or biological agent. Health impact assessments for environmental exposures typically consider the nature and size of a potentially exposed population and estimate the incremental increase in disease incidence or mortality in that population over a given time. Both kinds of information can be used as part of decision-making processes.

In general, human health risk assessment for exposure to chemicals includes hazard identification, dose-response assessment, exposure assessment and risk characterization. Hazard identification involves developing information regarding the adverse health effects that are associated with the chemicals of concern. Dose-response assessment evaluates each effect and determines the relationship between dose and the probability of the occurrence of the effect in the range of doses identified in the exposure assessment. Data considered may originate from studies of laboratory animals, occupational exposures, or general population exposures. Relevant data are evaluated and summarized to estimate toxicity values, e.g., chronic or acute inhalation reference doses. Exposure assessment estimates what exposures are experienced by each population of interest under existing conditions. Data are evaluated to determine the amount of a chemical an individual takes in by relevant exposure routes (oral, inhalation and dermal absorption) for a single event (acute exposure) or for chronic exposure. The degree of confidence in the dose-response and exposure assessments is summarized as part of risk characterization, which describes the nature, strength of evidence and the potential for adverse health effects from particular exposures. Exposure and toxicity information can be combined to calculate health-based chemical concentrations,

[193] Corburn, J., Bhatia, R. *Health Impact Assessment in San Francisco: Incorporating the Social Determinants of Health into Environmental Planning: Journal of Environmental Planning and Management 50:323-341*. 2007.

e.g., guidelines, and standards, in an environmental medium, e.g., ambient air, to compare to measured or estimated concentrations. Criteria based on cancer effects are generally expressed as concentrations associated with a specific, excess lifetime cancer risk. Criteria based on non-cancer effects of inhalation exposure are generally expressed as reference concentrations - air concentrations that are expected to be without an appreciable risk of non-cancer health effects. These quantitative criteria do not consider factors, such as whether the concentration can be measured, or whether it is above typically occurring levels.

The bases of regulatory standards are set by law and some are determined only on health risks, e.g., the National Ambient Air Quality Standards or NAAQS, and some by a combination of risk and risk management, e.g., Drinking Water Standards under the Safe Drinking Water Act (SDWA) rule. The starting point in the derivation of a standard is often a criterion based on non-cancer or cancer effects. However, the standard is not necessarily equivalent to one of the criteria, because other factors such as the analytical detection limits, feasibility and costs may also be considered. In Section 3.1.2, Table 3 lists the health-based NAAQS set by EPA to protect public health including the health of "sensitive" populations such as asthmatics, children and the elderly. Some of these standards, e.g., for $PM_{2.5}$, were developed using a weight-of-evidence approach to evaluate "concentration-response functions" (or increases in morbidity and mortality associated with increases in air concentrations) derived from epidemiological studies of general populations.

In practice, risk assessment for a single source of chemical emissions to the air starts with site-specific characterization of emissions and resulting air quality impacts. For example, for a proposed electric generating facility that will burn carbon-based fuel, the emissions of pollutants can be estimated from previous measurements of emissions at similar facilities for the relevant fuels combined with site-specific factors, e.g., the amount of fuel burned. Emissions information is then combined with other facility-specific information such as stack height and emissions exit velocity, local meteorological data and terrain information and entered into an air dispersion model to estimate air concentrations in the surrounding region. Representative exposure scenarios are chosen, e.g., a resident at the point of maximum impact, and the concentrations relevant to the exposure scenario can then be compared to health-based air criteria and standards. Additional exposures by other pathways, e.g., deposition of mercury to waterbodies, biomagnification and consumption of mercury-contaminated fish, may also be estimated. Risks can be evaluated under the assumption that people are continuously exposed to the chemical all day, every day for a lifetime or for a fraction thereof, as appropriate.

While risk for a single source of exposure, e.g., a facility, is often evaluated for hypothetical individuals intended to be representative of an exposed population or sub-population,[194] risk can also be evaluated for a potentially impacted population as a whole, considering its size and other characteristics.[195,196] This type of population risk assessment, when used to evaluate the potential health impacts or reduction of impacts associated with government programs, regulations, or other actions, is sometimes called health impact assessment.[197,198] Health impact assessment can consider population-specific baseline prevalence of a disease and the estimated excess relative risk for that disease per unit of exposure to an environmental

[194] EPA. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities: EPA530-R-05-006.* 2005.

[195] NRC. *Science and Judgment in Risk Assessment: Committee on Risk Assessment of Hazardous Air Pollutants, Board on Environmental Studies and Toxicology, Commission on Life Sciences* 1994.

[196] Kajihara, H., Ishizuka, S., Fushima, A., Masuda, A., Nakanishi, J. *Population Risk Assessment of Ambient Benzene and Evaluation of Benzene Regulation in Gasoline in Japan: Environmental Engineering and Policy 2:1-9.* 2000.

[197] WHO. *Evaluation and Use of Epidemiological Evidence for Environmental Health Risk Assessment: WHO Guideline Document.* 2000.

risk factor.[199] Excess relative risks for air pollution are usually based on concentration-response functions described in epidemiological studies (such as those considered in developing the $PM_{2.5}$ NAAQS). Examples of excess risk estimates for air concentration increases of the kind that could be used in a health impact assessment are presented in Section 3.1.1 (Table 2) of this Issue Brief. These risk estimates were derived from concentration-response functions summarized by EPA in the documentation for the NAAQS.[200, 201,202,203] Health impact assessments can estimate impacts as excess or avoided cases of disease or premature death, years of reduced or increased life expectancy and other measures. In cost-benefit analysis, these kind of impacts can be translated into economic terms[204] by considering information such as medical expenses, lost productivity and other costs. For example, an asthma-related event requiring hospitalization cost an average of $12,699 in New York in 2005, without consideration of lost productivity.[205] Monetized population health impacts can be considered along with other costs and benefits associated with a proposed action, regulation or program.

A number of computer models have been developed to translate estimated changes in air emissions associated with different emission scenarios to monetized health impacts. For example, models developed by EPA include the Co-benefits Risk Assessment Tool (COBRA) and the Environmental Benefits Mapping and Analysis Program (BenMAP). EPA has used health impact assessment and cost-benefit analysis to evaluate the impacts of a number of environmental statutes and regulations, e.g., the Clean Air Act.[206] EPA, in partnership with the World Resource Institute (WRI) and several government agencies in China, evaluated alternative energy use scenarios for Shanghai and Beijing. The final report for Shanghai compared various energy-use and pollution-control scenarios with a baseline scenario and estimated hundreds to thousands of averted premature deaths and thousands of other averted health outcomes due to air quality improvements associated with electricity generating facility efficiency upgrades, fuel transitions and pollution control measures.[207,208] In the future, similar analyses could be conducted for energy use scenarios for New York, although the multidisciplinary nature and technical complexity of these analyses would require significant resources. Furthermore, while resulting health

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[198] Scott-Samuel, A. *Health Impact Assessment – Theory Into Practice*. 1998.

[199] WHO. *Evaluation and Use of Epidemiological Evidence for Environmental Health Risk Assessment: WHO Guideline Document.* 2000.

[200] EPA. *Air Quality Criteria for Particulate Matter, Volumes I & II.: EPA/600/p-99/002aF, EPA/600/p-99/002bF*. 2004.

[201] EPA. *Air Quality Criteria for Ozone and Related Photochemical Oxidant: EPA /600/R-05/004aF, EPA /600/R-05/004bF, EPA /600/R-05/004cF*. 2006.

[202] EPA. *Integrated Science Assessment for Oxides of Nitrogen - Health Criteria: EPA/600/R-08/071.* 2008.

[203] EPA. *Integrated Science Assessment for Sulfur Oxides- Health Criteria: EPA/600/R-08/047F*. 2008.

[204] Arrow, K.J., Cropper, M.L., Eads, G.C., Hahn, R.W., Lave, L.B., Noll, R.G., Portney, P.R., Russell, M., Schmalensee, R., Smith, V.K., Stavins, R.N. *Is there a Role for Benefit-Cost Analysis in Environmental, Health And Safety Regulation?: Science 272:221-222*. 1996.

[205] The highest rate of hospitalization for any age group was for children four years old and under; the average hospitalization stay in 2005 was 3.7 days; The total cost of asthma hospitalization based on hospital billing data in New York in 2005 was $502 million. DOH. *New York State Asthma Surveillance Summary Report*. 2007. www.nyhealth.gov/statistics/ny_asthma/pdf/2007_asthma_surveillance_summary_report.pdf

[206] EPA. *The Benefits and Costs of the Clean Air Act 1990 to 2010: EPA-410-R-99-001*. 1999.

[207] Chen, C., Fu, Q., Chen, M., Chen, B., Hong, C., Kan, H. *The Integrated Assessment of Energy Option and Health Benefit – Full Report. Integrated Environmental Strategies: National Renewable Energy Laboratory*. 2001. http://www.epa.gov/ies/pdf/shanghai/full_report_chapters/fullreport.pdf

[208] Kan, H.D., Chen, B.H., Chen, C.H., Fu, Q.Y., Chen, M. *An Evaluation of Public Health Impact of Ambient Air Pollution under Various Energy Scenarios in Shanghai, China: Atmospheric Environment 38:95-102*. 2004.

cost estimates can provide important information for decision-makers, the cost estimates may be accompanied by additional uncertainty.

6.2 Uncertainties in Health Risk Assessment and Health Impact Assessment

The specific nature of human health risk assessment has many limitations and inherent sources of uncertainty. In some cases, the risk is largely unknown, such as may be the case with a new technology or process. When the nature of the risk, e.g., environmental contaminants, is known, estimations of human exposure to those factors incorporate uncertainty from other sources. Uncertainty in exposure estimates from measured concentrations of chemicals in environmental media can result from sampling and analytical error. Environmental sampling can be incomplete with regard to temporal and geographical coverage. Uncertainty also arises from modeled environmental media concentrations, which can reflect error inherent in the assumptions of the model. Uncertainty in exposure estimates is further compounded by the limited understanding of highly variable exposures within populations.

Evaluation of the toxicity or potency of a chemical or agent is generally based on human or animal data and the quality and availability of these data varies for the chemicals or agents to which people may be exposed. Assessment of toxicity from animal studies is based on the premises that 1) effects in animals can be used to estimate the likelihood of effects in humans, 2) all critical effects and the critical effect with the lowest dose have been identified, and 3) high exposure levels can be used to estimate the effects of low exposure levels.

Assumptions and uncertainties are also associated with the determination of dose-response or concentration-response functions from human epidemiological studies. For example, numerous sources of uncertainty have been identified for the determination of concentration-response functions for air pollutants in non-occupational epidemiological studies. These have been described as 1) a poor understanding of physiological mechanism of toxicity, 2) potential for multiple physiological mechanisms of toxicity, e.g., for PM, due to both chemical and physical characteristics, 3) the confounding effects of multiple pollutants, 4) the relevance of the exposure estimates, e.g., ambient monitoring versus personal exposure, 5) assumption regarding the shape of the concentration-response function, 6) extrapolation of findings from one point in time and space to others, 7) the potential for both acute and chronic effects in the same population, 8) health effects that are difficult to detect in a study, and 9) the choices made in characterizing observed effects, e.g., increased mortality versus decreased life expectancy.[209] The degree of confidence in a risk or impact assessment must be considered along with the outcome of the assessment as part of the decision making process.

6.3 Health Outcome Data

Health outcome data are counts and rates of health-related events in a population, for example, deaths due to cardiovascular disease, hospitalizations for asthma, new diagnoses of cancer, or births of premature infants. DOH collects information on many health outcomes on an ongoing basis and maintains a variety of databases. These include Vital Records, which contains information from birth and death certificates, Statewide Planning and Research Cooperative System (SPARCS), which contains information reported

[209] Bell, M.L., Davis, D.L., Cifuentes, L.A., Krupnick, A.J., Morgenstern, R.D., Thurston, G.D. *Ancillary Human Health Benefits of Improved Air Quality Resulting from Climate Change Mitigation: Environ Health 7:41*. 2008.

by hospitals on hospital stays and emergency department visits and disease registries such as the Cancer Registry and the Congenital Malformations Registry. DOH disease registries generally receive reports from hospitals, physicians and laboratories. Health outcome data are available at different levels of geography, such as the State as a whole, county, or zip code. Many of the DOH databases have information on the DOH public web site about how the data are collected, presented and checked for accuracy, including the Cancer Registry[210] and SPARCS.[211] Table B-1 is an inventory of selected health outcome data that cover either the entire State or all of New York City, are of good quality (have documented quality assurance/quality control procedures) and are on the DOH public web site. The potential for energy production and use to be associated with these health outcomes was not considered in developing the inventory; see Table B-1 for health outcomes associated with pollutants from energy use (fuel combustion).

In epidemiological studies, which test specific hypotheses, health outcome data are used along with environmental data or other surrogate measures of exposure to examine the effect of environmental factors on health. For example, two DOH studies conducted through New York's Environmental Public Health Tracking program examined the relationship between different components of air pollution, e.g., ozone, particulate matter, and asthma hospitalizations using ambient air monitoring data and SPARCS data.[212,213] DOH has also studied the effects of traffic on asthma hospitalization and temperature on respiratory disease hospitalization.[214,215]

Health outcome data are also used in environmental health surveillance. Trends in health conditions in a population are examined for relationships with trends in environmental measures, such as levels of air pollutants, which are used as estimates (or surrogates) of exposure. With this type of surveillance, an association can be observed between an increased rate of a health outcome and an elevated level of a pollutant, but causation cannot be shown. Results from surveillance activities can be used for generating hypotheses for epidemiological studies that are designed to test hypotheses. These studies generally include individual-level information that allows for better exposure assessment and evaluation of other factors that may be related to the health outcome being studied, such as occupational exposures, lifestyle exposures such as smoking, and alcohol consumption and socioeconomic status.

Environmental health surveillance is generally considered more useful for outcomes that occur closer in time to the environmental measures. For example, when examining trends in birth outcomes, such as prematurity and low birth weight, the gestational period can be examined for associations with environmental factors, since it is a defined time period occurring close in time to the health outcome. With an outcome such as cancer, which has a long latency period, the exposures that may be related to a newly diagnosed case are difficult to estimate because they are likely to have occurred 20 years or more previously and possibly at a location distant from the person's location at the time of diagnosis. It is also important to be aware of other factors that influence the rate of specific diseases. For example, asthma

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210 DOH. *About the New York State Cancer Registry*. 2009. http://www.health.state.ny.us/statistics/cancer/registry/about.htm.

211 DOH. *Statewide Planning and Research Cooperative System (SPARCS)*. 2009. http://www.health.state.ny.us/statistics/sparcs/

212 Lin, S., Bell, E., Liu, W., Walker, R., Kim, N., Hwang, S. *Ambient Ozone Concentration and Hospital Admissions Due to Childhood Respiratory Diseases in New York State, 1991-2001: Environmental Research 108:42-47*. 2008.

213 Lin, S., Liu, X., Le, L., Hwang, S. A. *Chronic Exposure to Ambient Ozone and Asthma Hospital Admissions Among Children: Environmental Health Perspective*. 2008.

214 Lin, S., Munsie, J.P., Hwang, S., Fitzgerald, E., Cayo, M. R. *Childhood Asthma Hospitalization and Residential Exposure to State Route Traffic: Environmental Research*. 2002.

215 Lin, S., Luo, M., Walker, R.J., Liu, X., Hwang, S., Chinery, R. *Extreme High Temperatures and Hospital Admissions for Respiratory/Cardiovascular Disease for New York City: Epidemiology*. 2009. http://ovidsp.tx.ovid.com

hospitalization can also be affected by differences in medical management and access to and source of medical care.

Health outcome data can also be used to examine the health status of a community. Data from DOH's health outcome databases can be incorporated into tables of counts and rates of health conditions for a community and for comparison areas, such as another community, the county, New York City, or the State as a whole. At the DOH public web site, the Community Health Assessment Clearinghouse [216] has links to tables, maps and graphs containing health statistics relating to a variety of health outcomes that are divided into categories, including maternal and infant health, heart disease and stroke, cancer and chronic conditions.

6.4 Health Outcome Data in the DEC Permitting Process

DOH has worked with DEC to incorporate the review of health data into environmental permitting to address environmental justice issues. In 2003, DEC issued its policy on Environmental Justice and Permitting (CP-29).[217] The policy was developed after DEC's Environmental Justice Advisory Group recommended that closer scrutiny be given to environmental decisions in minority and low-income communities and that DEC expand the types of information used in the permit approval process to address environmental justice concerns. DEC defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. The policy established two work groups: the Disproportionate Adverse Environmental Impact Work Group and the Health Outcome Data (HOD) Work Group. Staff members from DOH participated on the HOD Work Group, which was charged with identifying reliable sources of human health data and recommending to DEC ways to incorporate these data into the environmental permitting process.

In its report, the HOD Work Group discussed available health outcome data, developed a method to display and review health outcome data for use in DEC's permit review process and provided recommendations to the State.[218] The report and a subsequent Guidance Document from DOH describe a method to produce displays of health outcome data to describe the health status of the community of concern and to compare the health data for it to health data for multiple comparison areas.[219] The HOD Work Group specified that only health outcome data available at the zip code level be used in the health outcome data displays. Currently available on DOH's public web site are data at the zip code level for asthma hospitalizations and four types of cancer (lung, colorectal, female breast and prostate cancers). Additional types of health outcome data will be available at the zip code level in the future; these data can be incorporated into the method as they become available.

The Work Group recommended that the health outcome data be considered as part of the permitting process, recognizing that the data provide no information about the causes of any increase or decrease in rates between the community of concern and comparison area populations. If the population of the

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[216] DOH. *Community Health Assessment Clearinghouse*. 2009. http://www.health.state.ny.us/statistics/chac/index.htm

[217] DEC. *CP-29 Environmental Justice and Permitting, Albany, NY: New York State Department of Environmental Conservation.* 2003. http://www.dec.ny.gov/docs/permits_ej_operations_pdf/ejpolicy.pdf

[218] DEC – DOH. *Report of the Health Outcome Data Work Group*. 2006. http://www.dec.ny.gov/docs/permits_ej_operations_pdf/hodreport.pdf

[219] DOH. *Guidance for Health Outcome Data Review and Analysis Relating to DEC Environmental Justice and Permitting*. 2008. http://www.health.state.ny.us/environmental/investigations/environmental_justice

community of concern has low health status, it may be more vulnerable to the effects of environmental exposures. The report lists conditions that can result from comparing the rates of health outcomes in the community of concern and the comparison areas. The greater the number of conditions that are met, the greater the likelihood is that the health status of the community is actually lower than that found in other areas. The report states that, if any of the conditions are met, consideration of additional options for the permitting conditions should be reviewed as part of the permitting process. The results of the health outcome data review and analysis should be used in making a permitting decision along with other considerations such as regulatory standards, environmental impacts, mitigation, benefits, needs and costs. The significance of the difference between the community and the comparison area populations should be considered in determining which action is appropriate. A list of possible actions is included in the Work Group report and the guidance document.[220,221]

[220] DEC – DOH. *Report of the Health Outcome Data Work Group*. 2006. http://www.dec.ny.gov/docs/permits_ej_operations_pdf/hodreport.pdf

[221] DOH. *Guidance for Health Outcome Data Review and Analysis Relating to DEC Environmental Justice and Permitting*. 2008. http://www.health.state.ny.us/environmental/investigations/environmental_justice

Table B-1. Selected Health Outcome Data Available on the DOH Public Web Site.[222]

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Asthma hospitalizations	County	Table, map, graph	Number of hospitalizations per year, 3-year total, rate per 10,000 population	Multiple age groups	Statewide	2005-07	Public Health Information Group	SPARCS
Asthma hospitalizations	ZIP code	Table, map, graph	Total number of hospitalizations for 3-year period, rate per 10,000 population	Multiple age groups	Statewide	2005-07	Public Health Information Group	SPARCS
Asthma emergency department visits	County	Table, map, graph	Number of visits per year, 3-year total, rate per 10,000 population	Multiple age groups	Statewide	2005-07	Public Health Information Group	SPARCS
Asthma emergency department visits	ZIP code	Table, map, graph	Total number of visits for 3-year period, rate per 10,000 population	Multiple age groups	Statewide	2005-07	Public Health Information Group	SPARCS
Asthma mortality	County	Table, map, graph	Number of deaths per year, 3-year total, crude and adjusted rates per 1,000,000 residents	Multiple age groups	Statewide	2005-07	Public Health Information Group	Vital Statistics
Cancer incidence	County	Table	Average annual number of cases of all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender	Statewide	2002-06	Cancer Registry	Cancer Registry

[222] The potential for energy production and use to be associated with these health outcomes was not considered in developing the inventory. See Table 1 for health outcomes associated with pollutants from energy use (fuel combustion).

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Cancer incidence	New York City United Hospital Fund Neighborhood	Table	Average annual number of cases of all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender	New York City	2002-06	Cancer Registry	Cancer Registry
Cancer incidence	City	Table	Average annual number of cases of all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender	Selected cities in New York State	2002-06	Cancer Registry	Cancer Registry
Cancer incidence by race	New York State, New York City, New York State excluding New York City, selected counties	Table	Average annual number of cases of all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender; racial groups: Blacks, Whites, Asians and Pacific Islanders	Statewide	2002-06	Cancer Registry	Cancer Registry
Cancer incidence by ethnicity	New York State, New York City, New York State excluding New York City, selected counties	Table	Average annual number of cases of all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender; ethnic groups: Non-Hispanics, Hispanics, Non-Hispanic Whites, Non-Hispanic Blacks	Statewide	2002-06	Cancer Registry	Cancer Registry

Health outcome or indicator, type of data	**Spatial resolution**	**Display**	**Description**	**Additional breakdowns**	**Geographic extent**	**Years currently available**	**Program**	**Data source**
Cancer incidence by age group	New York State, New York City, New York State excluding New York City, New York City boroughs	Table	Average annual number of cases of all cancers, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender; multiple age groups	Statewide	2002-06	Cancer Registry	Cancer Registry
Cancer incidence for children and adolescents 0-19 years old	County	Table	Average annual number of cases of all cancers by age group, 5-year average adjusted rate for 0-19 year olds per 100,000 population, 95% confidence interval	Multiple age groups	Statewide	2002-06	Cancer Registry	Cancer Registry
Cancer incidence for children and adolescents 0-19 years old	New York State, New York City, New York State excluding New York City	Table	Average annual number of cases of all cancers and selected types by age group, 5-year average adjusted rate for 0-19 year olds per 100,000 population, 95% confidence interval	Multiple age groups	Statewide	2002-06	Cancer Registry	Cancer Registry
Cancer incidence for children and adolescents 0-19 years old	New York City United Hospital Fund Neighborhood	Table	Average annual number of cases of all cancers by age group, 5-year average adjusted rate for 0-19 year olds per 100,000 population, 95% confidence interval	Multiple age groups	New York City	2002-06	Cancer Registry	Cancer Registry

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Cancer incidence for expanded list of cancer sites	New York State, New York City, New York State excluding New York City, New York City boroughs	Table	Average annual number of cases of cancer by site, 5-year adjusted rate per 100,000 population, 95% confidence interval	Gender	Statewide	2002-06	Cancer Registry	Cancer Registry
Cancer incidence for selected types of cancer	County	Table, map, graph	Cancer of the lung and bronchus, breast (female), uterine cervix, colorectal: number of cases per year, 5-year total, crude and adjusted rates per 100,000 residents		Statewide	2002-06	Community health dataset - cancer indicators	Cancer Registry
Cancer mortality	County	Table	Average annual number of deaths from all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender	Statewide	2002-06	Cancer Registry	Vital Statistics
Cancer mortality by race	New York State, New York City, New York State excluding New York City, selected counties	Table	Average annual number of deaths from all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender; racial groups: Blacks, Whites, Asians and Pacific Islanders	Statewide	2002-06	Cancer Registry	Vital Statistics

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Cancer mortality by ethnicity	New York State, New York City, New York State excluding New York City, selected counties	Table	Average annual number of deaths from all cancers and selected types, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender; ethnic groups: Non-Hispanics, Hispanics, Non-Hispanic Whites, Non-Hispanic Blacks	Statewide	2002-06	Cancer Registry	Vital Statistics
Cancer mortality by age group	New York State, New York City, New York State excluding New York City, New York City boroughs	Table	Average annual number of deaths from all cancers, 5-year average adjusted rate per 100,000 population, 95% confidence interval	Gender; multiple age groups	Statewide	2002-06	Cancer Registry	Vital Statistics
Cancer mortality for children and adolescents 0-19 years old	New York State, New York City, New York State excluding New York City	Table	Average annual number of deaths from all cancers and selected types by age group, 5-year average adjusted rate for 0-19 year olds per 100,000 population, 95% confidence interval	Multiple age groups	Statewide	2002-06	Cancer Registry	Vital Statistics
Cancer mortality for children and adolescents 0-19 years old	New York City United Hospital Fund Neighborhood	Table	Average annual number of deaths from all cancers by age group, 5-year average adjusted rate for 0-19 year olds per 100,000 population, 95% confidence interval	Multiple age groups	New York City	2002-06	Cancer Registry	Vital Statistics

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Cancer mortality for expanded list of cancer sites	New York State, New York City, New York State excluding New York City, New York City boroughs	Table	Average annual number of deaths by cancer site, 5-year adjusted rate per 100,000 population, 95% confidence interval	Gender	Statewide	2002-06	Cancer Registry	Vital Statistics
Cancer mortality for selected types of cancer	County	Table, map, graph	Lung and bronchus, breast (female), uterine cervix, colorectal: number of deaths per year, 5-year total, crude and adjusted rates per 100,000 residents		Statewide	2003-07	Community health dataset - cancer indicators	Vital Statistics
Cancer - observed and expected numbers of cases of selected types	ZIP code	Table	Colorectal, lung and bronchus, breast (female), prostate: observed and expected numbers of cases for a 5-year period, percent difference from expected	Gender	Statewide	2002-06	Cancer Registry	Cancer Registry
Asthma hospitalizations	County	Table, map, graph	Number of hospitalizations for a 6-year period, adjusted rates per 10,000 population	3-year breakdowns, age groups, age and sex groupings, month	Statewide	2000-05	Environmental public health tracking	SPARCS
Birth defects prevalence	County	Table, map, graph	Number and prevalence of children born with one or more of 45 selected birth defects per 10,000 live born infants		Statewide	2000-04	Environmental public health tracking	Congenital Malformations Registry

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Cancer incidence	County	Table, map, graph	Number of cases of selected types of cancer for a 5-year period, adjusted rate, 95% confidence interval; number of combined cases of selected childhood cancers (0-19 years) for a 5-year period	Gender, some age breakdowns	Statewide	2001-05	Environmental public health tracking	Cancer Registry
Heart attack hospitalization	County	Table, map, graph	Number of hospitalizations for a 6-year period, adjusted rates per 10,000 population	3-year breakdowns, age groups, age and sex groupings, month	Statewide	2000-05	Environmental public health tracking	SPARCS
Prevention Quality Indicators: hospitalizations for diabetes	ZIP code	Table, graph; ZIP codes and ZIP code groupings selected by map	Number of observed and expected hospital admissions for all diabetes conditions combined and short-term complications, long-term complications, uncontrolled, lower-extremity amputations; admissions as percent of expected	Race/ethnicity	Statewide	2005-06	Prevention Quality Indicators	SPARCS
Prevention Quality Indicators: hospitalizations for circulatory conditions	ZIP code	Table, graph; ZIP codes and ZIP code groupings selected by map	Number of observed and expected hospital admissions for hypertension, congestive heart failure, angina and all circulatory conditions combined; admissions as percent of expected	Race/ethnicity	Statewide	2005-06	Prevention Quality Indicators	SPARCS

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Prevention Quality Indicators: hospitalizations for respiratory conditions	ZIP code	Table, graph; ZIP codes and ZIP code groupings selected by map	Number of observed and expected hospital admissions for chronic obstructive pulmonary disease, asthma, and all respiratory conditions combined; admissions as percent of expected	Race/ethnicity	Statewide	2005-06	Prevention Quality Indicators	SPARCS
Prevention Quality Indicators: other hospitalizations	ZIP code	Table, graph; ZIP codes and ZIP code groupings selected by map	Number of observed and expected hospital admissions for dehydration, bacterial pneumonia, urinary tract infection; admissions as percent of expected	Race/ethnicity	Statewide	2005-06	Prevention Quality Indicators	SPARCS
Children receiving blood lead screening tests	County	Table	Number and percent of children who received blood lead screening tests by age	Multiple age groups	New York State excluding New York City	2003-04 birth cohorts (2003-07 test data)	Childhood Lead Poisoning Prevention	Childhood Lead Poisoning Prevention
Incidence of elevated blood lead levels among children under age 6 years	County	Table	Three-year average incidence rate of children under age 6 years with blood lead level ≥10 micrograms per deciliter per 1,000 children tested	Additional blood lead level groupings	New York State excluding New York City	2005-07	Childhood Lead Poisoning Prevention	Childhood Lead Poisoning Prevention

Health outcome or indicator, type of data	**Spatial resolution**	**Display**	**Description**	**Additional breakdowns**	**Geographic extent**	**Years currently available**	**Program**	**Data source**
Infant, neonatal, and post-neonatal mortality	County	Table, map	Number of deaths per year, 3-year total, rate per 1,000 live births		Statewide	2005-07	Community health dataset - maternal and infant health indicators	Vital statistics
Low birthweight births	County	Table, map	Number of infants weighing less than 2,500 grams at birth per year, 3-year total, percent of live births		Statewide	2005-07	Community health dataset - maternal and infant health indicators	Vital statistics
Very low birthweight births	County	Table, map	Number of infants weighing less than 1,500 grams at birth per year, 3-year total, percent of live births		Statewide	2005-07	Community health dataset - maternal and infant health indicators	Vital statistics
Births with short gestation	County	Table, map	Number of infants per year born at less than 37 weeks gestation, 3-year total, percent of live births		Statewide	2005-07	Community health dataset - maternal and infant health indicators	Vital statistics
Births with late or no prenatal care	County	Table, map	Number of births per year with late or no prenatal care, 3-year total, percent of live births		Statewide	2005-07	Community health dataset - maternal and infant health indicators	Vital statistics

Health outcome or indicator, type of data	**Spatial resolution**	**Display**	**Description**	**Additional breakdowns**	**Geographic extent**	**Years currently available**	**Program**	**Data source**
Mortality from chronic diseases	County	Table, map, graph	Cirrhosis, diabetes, chronic lower respiratory disease: number of deaths per year, 3-year total, crude and adjusted rates per 100,000 residents		Statewide	2005-07	Community health dataset - chronic disease indicators	Vital statistics
Hospitalizations from chronic diseases	County	Table	Cirrhosis, diabetes: crude and adjusted hospitalization rates per 10,000 population for 3-year period		Statewide	2005-07	County Health Assessment Indicators	SPARCS
Heart disease and stroke mortality	County	Table, map, graph	Cardiovascular disease, disease of heart, cerebrovascular disease: number of deaths per year, 3-year total, crude and adjusted rates per 100,000 residents		Statewide	2005-07	Community health dataset - heart disease and stroke indicators	Vital statistics
Heart disease and stroke mortality	County	Table	Cardiovascular disease, disease of heart, coronary heart disease, congestive heart failure, cerebrovascular disease: crude and adjusted mortality rates per 100,000 population for 3-year period	Premature death (ages 35-64), pretransport mortality	Statewide	2005-07	County Health Assessment Indicators	Vital statistics
Heart disease and stroke hospitalizations	County	Table	Cardiovascular disease, disease of heart, coronary heart disease, congestive heart failure, cerebrovascular disease: crude and adjusted hospitalization rates per 10,000 population for 3-year period		Statewide	2005-07	County Health Assessment Indicators	SPARCS

Health outcome or indicator, type of data	Spatial resolution	Display	Description	Additional breakdowns	Geographic extent	Years currently available	Program	Data source
Respiratory disease mortality	County	Table	Asthma and chronic lower respiratory disease (CLRD): crude and adjusted mortality rates per 100,000 population for 3-year period		Statewide	2005-07	County Health Assessment Indicators	Vital statistics
Respiratory disease hospitalizations	County	Table	Asthma and chronic pulmonary disease (COPD): crude and adjusted hospitalization rates per 10,000 population for 3-year period	Age groups for asthma	Statewide	2005-07	County Health Assessment Indicators	SPARCS
Occupational health - hospitalizations	County	Table, map, graph	Number of hospitalizations for pneumoconiosis and asbestosis per year, 3-year total, rate per 100,000 persons age 15+ years; number of work-related hospitalizations per year, 3-year total, rate per 10,000 employed persons age 16+ years		Statewide	2005-07	Community health dataset - occupational health indicators	SPARCS
Occupational health - fatalities	County	Table	Number of fatal work-related injuries per year, 3-year total, rate per 100,000 employed persons age 16+ years		New York State excluding New York City	2005-07	County Health Assessment Indicators	U.S. Department of Labor, Bureau of Labor Statistics