Chapter 8. Public Health

8.1 Principles

Climate change will have vast and varied impacts on public health and is already affecting the people and resources of New York. New York continues to make progress on its goal to becoming the healthiest State through continued implementation of the New York State Prevention Agenda and recent adoption of the Health Across All Policies approach.[60,61] The Prevention Agenda is the State health improvement plan, the blueprint for State and local action to improve the health and well-being of all New Yorkers and promote health equity. It is based on several cross-cutting principles and has goals ranging from reducing worker injury and illness to reducing exposure to air pollution. The Health Across All Policies approach is a collaborative effort that considers health across many sectors such as housing, transportation, education, environment, parks, and economic development.

Cross-Cutting Principles of the Prevention Agenda

To improve health outcomes, enable well-being, and promote equity across the lifespan, the Prevention Agenda has several cross-cutting principles:

- Focuses on addressing social determinants of health and reducing health disparities
- Incorporates a Health Across All Policies approach
- Emphasizes healthy aging across the lifespan
- Promotes community engagement and collaboration across sectors in the development and implementation of local plans
- Maximizes impact with evidence-based interventions for State and local action
- Advocates for increased investments in prevention from all sources
- Concentrates on primary and secondary prevention, rather than on health care design or reimbursement

Embodiment of these principles is critical for developing a successful climate policy. The Climate Act provides a foundation that incorporates these principles in that it requires consideration of impacts to public health and Disadvantaged Communities, as well as mitigation actions that will address health impacts. This Scoping Plan goes further, identifying specific opportunities to reduce emissions, support communities, reduce existing health risks, and avoid introducing new risks. This chapter seeks to describe

[60] New York State Department of Health. 2019. "Prevention Agenda 2019-2024 New York State's Health Improvement Plan." Accessed at https://www.health.ny.gov/prevention/prevention_agenda/2019-2024/.

[61] New York State Department of Health. "Health-Across-All-Policies Initiative Launched to Support the Prevention Agenda Goal of Becoming the Healthiest State." Accessed on November 23, 2021 at https://www.health.ny.gov/prevention/prevention_agenda/health_across_all_policies/.

both the direct and indirect human health impacts of climate change and the health co-benefits of climate change mitigation and adaptation strategies and policies.

8.2 Climate Change Impacts on Public Health

Climate change directly and indirectly impacts physical, social, and mental health and will intensify some health stressors and cause other new health threats to emerge. Possible health impacts are far-reaching, even if not all are equally likely to occur among New Yorkers in the immediate future.

In 2021, the 26th Conference of Parties emphasized public health more than ever before and referred to climate change as a "public health emergency."[62] Recently, the editors of over 200 medical journals united to issue a call for urgent government action to address global warming and protect public health and nature.[63] The New York State Energy Research and Development Authority (NYSERDA) ClimAID report describes the impacts and adaptation strategies for New York's water resources, coastal zones, ecosystems, agriculture, energy, transportation, and telecommunications sectors, as well as vulnerabilities and adaptation strategies related to climate change and public health. According to the New York State Department of Health (DOH) Climate and Health Profile,[64] there are several potential climate-related health impacts in the State:

- Increased heat stress (such as heat edema, heat stroke, heat cramps, heat stress, and dehydration) and other heat-related morbidity and mortality
- Exacerbation of respiratory conditions (including pneumonia, asthma, and chronic obstructive pulmonary disease) and cardiovascular disease
- Increased risk for food- and water-borne diseases due to increasing temperatures and flooding
- Increased duration and severity of allergy symptoms due to increased duration and intensity of pollen season
- Increased risk for vector-borne diseases (such as Lyme disease, West Nile virus, and other pathogens)
- Increased risk of injury and death following extreme precipitation events and flooding

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[62] Romanello, M., et al. 2021. "The 2021 report of the *Lancet* Countdown on health and climate change: code red for a healthy future." *The Lancet*. 398(10311): 1619-1662.

[63] Atwoli, Lukoye, et al. "Call for Emergency Action to Limit Global Temperature Increases, Restore Biodiversity, and Protect Health." See for example the *New England Journal of Medicine,* September 5, 2021.

[64] New York State Department of Health. 2015. *Building Resilience Against Climate Effects (BRACE) – Climate and Health Profile.* Accessed at climatehealthprofile6-2015.pdf (ny.gov).

Other significant impacts associated with public health that are not listed above include droughts, rising sea levels that threaten infrastructure, saltwater intrusion of the State's groundwater resources (which may impact drinking water supplies), poor indoor air quality (such as mold and moisture), and deteriorating outdoor air quality, particularly ground-level ozone that increases with rising temperature.[65] Climate change will add uncertainty to the continuity of the food system, which may have impacts on food security, particularly in low-income communities.[66] Heatwaves and extreme heat events result in greater risk of heat stress, and there is a greater risk of death in those who have mental illness due, in part, to medications that interfere with the body's thermoregulation.[67,68,69,70,71] Heavy rainfall associated with the remnants of Hurricane Ida resulted in flooded subways and drowning deaths in basement apartments and cars. Superstorm Sandy resulted in the deaths of 44 New York City residents and caused $19 billion in damages.[72] These kinds of extreme weather events have been associated with anxiety and post-traumatic stress disorder. Some populations are more vulnerable to certain climate and health impacts than others, whether due to demographic factors, socioeconomic status, physiological condition, place, or occupation. Workers will be uniquely affected by climate change. Heat-related morbidity and mortality risks may be greatest in agriculture, but other outdoor occupational sectors, including construction, transportation, landscaping, firefighting, and other emergency response operations are also at risk.[73]

Many impacts of climate change disproportionally affect Disadvantaged Communities. In New York, as well as other parts of the U.S., significant disparities in health outcomes exist for certain groups by age, race, ethnicity, and socioeconomic status. Disparities are observed in life expectancy and rates of

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[65] Stowell, Jennifer D., et al. "The impact of climate change and emissions control on future ozone levels: Implications for human health." *Environment International* 108 (2017): 41-50.

[66] U.S. Department of Agriculture. 2015. *Climate Change, Global Food Security, and the U.S. Food System.* Accessed at https://www.usda.gov/sites/default/files/documents/FullAssessment.pdf.

[67] New York State Department of Health. Revised May 2020. "About Heat Stress." Accessed at https://www.health.ny.gov/statistics/environmental/public_health_tracking/about_pages/heat_stress/about_hs.

[68] American Psychological Association. 2017. *Mental Health and Our Changing Climate: Impacts, Implications, and Guidance.* Washington, DC.

[69] New York State Department of Health. Revised May 2020. "About Heat Stress." Accessed at https://www.health.ny.gov/statistics/environmental/public_health_tracking/about_pages/heat_stress/about_hs

[70] Bark, N. 1998. "Deaths of psychiatric patients during heat waves." *Psychiatr Serv*. 49(8):1088-90.

[71] Lõhmus, M. 2018. "Possible Biological Mechanisms Linking Mental Health and Heat-A Contemplative Review." *Int J Environ Res Public Health*. 15(7):1515.

[72] Centers for Disease Control and Prevention. October 2005. "Health concerns associated with mold in water-damaged homes after Hurricanes Katrina and Rita--New Orleans area, Louisiana." *MMWR Morb Mortal Wkly Rep.* 2006 Jan 20;55(2):41-4. PMID: 16424858.

[73] Applebaum, K.M., J. Graham, G.M. Gray, et al. "An Overview of Occupational Risks from Climate Change." *Curr Envir Health Rpt 3*, 13–22 (2016). https://doi.org/10.1007/s40572-016-0081-4.

diabetes, cancer, heart disease, asthma, infant mortality, and low birth weight.[74,75,76] Cardiovascular disease is the leading cause of death nationally and in New York.[77] Research studies have shown an association between exposure to air pollutants, which are released through combustion of fuels, and increased hospitalization rates and mortality from cardiovascular disease.[78,79,80,81] Nationally and in New York, there are disparities in heart disease mortality and stroke mortality by race. Rates are highest in Black non-Hispanics among all race and ethnic groups.[82,83] Hospitalization rates for heart disease are also highest in Black non-Hispanics.[84] In addition to cardiovascular disease, asthma is a major health problem nationally and in New York. Asthma is a multifactorial disease that has many contributing causes. This includes four components of air pollution – ozone, sulfur dioxide (SO_2), nitrogen oxides (NO_X), and particulate matter – that are known to exacerbate asthma and to cause eye and respiratory tract irritation,

[74] Centers for Disease Control. January 14, 2011. "Health Disparities and Inequities Report, United States." *Morbidity and Mortality Weekly Reports.* January 14, 2011.

[75] Insaf, TZ, T. Talbot. "Use of Spatial Epidemiology in Identifying Areas at Risk of Low Birth Weight: Small Area Surveillance Study." *Preventive Medicine 2016*, 88:108–114; doi: https://doi.org/10.1016/j.ypmed.2016.03.019.

[76] New York State Department of Health. 2007. *New York State Minority Health Surveillance Report: Public Health Information Group*. Accessed at http://www.health.state.ny.us/statistics/community/minority/docs/surveillance_report_2007.pdf.

[77] New York State Department of Health. 2018. "Vital Statistics of New York State: 2018 Tables." Accessed at https://apps.health.ny.gov/public/tabvis/PHIG_Public/lcd/reports/#state.

[78] He, M.Z., V. Do, S. Liu, et al. "Short-term PM2.5 and cardiovascular admissions in NY State: assessing sensitivity to exposure model choice." *Environ Health 20*, 93 (2021). https://doi.org/10.1186/s12940-021-00782-3.

[79] Brook, Robert. "Air Pollution and Cardiovascular Disease: A Statement for Healthcare Professionals from the Expert Panel on Population and Prevention Science for the American Health Association." Circulation: *Journal of the American Health Association*. 109:2655-2671. 2004.

[80] Al-Kindi, S.G., R.D. Brook, S. Biswal, et al. 2020. "Environmental determinants of cardiovascular disease: lessons learned from air pollution." *Nat. Rev Cardiol 17*, 656–672 (2020). https://doi.org/10.1038/s41569-020-0371-2.

[81] World Health Organization. Regional Office for Europe. 2018. "Environmental noise guidelines for the European Region. World Health Organization." Accessed at https://apps.who.int/iris/handle/10665/279952.

[82] New York State Department of Health. 2012. *New York State Minority Health Surveillance Report*. Accessed at https://www.health.ny.gov/ statistics/community/minority/docs/surveillance_report_2012.pdf.

[83] Centers for Disease Control. 2011. *CDC Health Disparities and Inequalities Report*. Accessed at https://www.cdc.gov/minorityhealth/chdir/2011/chdir2011.html.

[84] Ibid.

cough, shortness of breath, and reduced lung function.[85,86,87,88,89,90] Asthma hospitalization rates in New York are higher in low-income areas than in higher income areas.[91,92] Asthma surveillance in New York has shown that the age-adjusted asthma emergency department visit, hospital discharge and mortality rates were higher among non-Hispanic Black and Hispanic New Yorkers than non-Hispanic White.[93] For more detail, see Appendix F. In July of 2022, DOH established a new Office of Health Equity and Human Rights to address health disparities like these, and work to improve diversity, equity, and inclusion within the DOH. It will comprise the current offices of Minority Health and Health Disparities Prevention and Language Access, the AIDS Institute, and the Office of Gun Violence Prevention. The goal is to apply an equity lens across all DOH operations. The Office of Health Equity and Human Rights also has the responsibility to provide leadership in the development of culturally specific and culturally responsive policy and service delivery models, as well to as create standardized guidance. In consideration of these health disparities and environmental burdens, it is of critical importance that climate change mitigation policies that seek to reduce overall greenhouse gas (GHG) emissions in New York do not inadvertently increase emissions of co-pollutants, particularly in Disadvantaged Communities (i.e., create hotspots), and prioritize reductions of GHG emissions and co-pollutants in Disadvantaged Communities.

Climate change mitigation and adaptation policies are crucial in reducing the public health impacts described above, particularly for vulnerable communities, such as those that can be identified by the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry Social Vulnerability Index, and Disadvantaged Communities. DOH has worked to support public health adaptation efforts. For example, DOH's scientific research on the health effects associated with heat

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[85] U.S. Environmental Protection Agency. December 2019. *Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019).* Washington, DC. EPA/600/R-19/188, 2019.

[86] Guarnieri, M., J.R. Balmes. "Outdoor air pollution and asthma." *Lancet*. 2014;383(9928):1581-1592. doi:10.1016/S0140-6736(14)60617-6.

[87] U.S. Environmental Protection Agency. 2004. *Air Quality Criteria Document for Particulate Matter*.

[88] Burnett, Richard, et al. "Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter." Proceedings of the National Academy of Sciences 115.38 (2018): 9592-9597.

[89] Samet, M. Jonathan. 2000. *The National Morbidity, Mortality, and Air Pollution Study. Part II: Morbidity and Mortality from Air Pollution in the United States.* Research Report Health Effects Institute. 2000. 94(pt 2):5-70, 71-79.

[90] Gauderman, W. James. 2000. "Association between Air Pollution and Lung Function Growth in Southern California." *American Journal of Respiratory Critical Care Medicine*. 162(4Pt1):1383-1390.

[91] Lin, Shao, Edward Fitzgerald, Syni-An Hwang. 2002. "Asthma Hospitalization Rates and Socioeconomic Status in New York State 1987-1993." *Journal of Asthma*. 2002. 36:239-251.

[92] New York State Department of Health. 2013. *New York State Asthma Surveillance Summary Report*. Accessed at https://www.health.ny.gov/statistics/ny_asthma/pdf/2013_asthma_surveillance_summary_report.pdf.

[93] Lin, Shao, Edward Fitzgerald, Syni-An Hwang. 2002. "Asthma Hospitalization Rates and Socioeconomic Status in New York State 1987-1993. *Journal of Asthma*. 36:239-251.

contributed to the National Weather Service lowering its Heat Advisory Threshold and led to the development of County Heat and Health Profiles, where users can view county temperature trends and projections, along with heat-related health effects and vulnerabilities.[94] DOH staff are working with the New York State Association of County Health Officials to encourage local health departments to take action around climate and health adaptations at the local level, in coordination with local partners.[95] DOH staff have worked with local partners to enhance awareness of and accessibility to programs providing cooling in the home and cooling centers during heat advisories.[96] DOH also identified populations that are vulnerable to extreme heat by developing a Heat Vulnerability Index. Studies have sought to increase awareness about climate impacts on health in New York,[97] and they have explored associations between temperature and respiratory outcomes, cardiovascular outcomes, renal diseases, and birth defects. Additional studies have explored climate change trends in New York, impacts of air pollutants on health (which could assist in understanding co-benefits to improved air quality through climate policy), and impacts of specific events that could stem from extreme weather. Recently enacted legislation requires the State to conduct a study on the impacts of the urban heat island effect in Disadvantaged Communities.[98] The State could conduct additional studies to continue to increase its understanding of the health impacts of climate change and the health benefits of climate policy.

The health co-benefits of climate policy will have long term effects on health outcomes and may be reflected in health outcome data tracked by DOH. Health co-benefits can be estimated as progress is made toward climate objectives. Although the cause and exacerbation of many health outcomes are multifactorial, tracking health outcomes over time provides an indication of increasing or decreasing trends and potential changes in trends associated with the implementation of health policies. DOH

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[94] Chow, N.A., M. Toda, A.F. Pennington, et al. 2017. "Hurricane-Associated Mold Exposures Among Patients at Risk for Invasive Mold Infections After Hurricane Harvey - Houston, Texas." *MMWR Morb Mortal Wkly Rep*. 2019;68(21):469-473. Published 2019 May 31. doi:10.15585/mmwr.mm6821a1.

Nayak, S.G., S. Shrestha, P.L. Kinney, Z. Ross, S.C. Sheridan, C.I. Pantea, W.H. Hsu, N. Muscatiello, and S.A. Hwang. 2018. "Development of a heat vulnerability index for New York State." *Public Health*. 161:127-137.

[95] New York State Association of County Health Officials and New York State Department of Health. "Climate and Health Adaptation Initiative and Workshops." Available at https://www.nysacho.org/topic/climate-and-health-adaptation/.

[96] Nayak, Seema G., Srishti Shrestha, Scott C. Sheridan, Wan-Hsiang Hsu, Neil A. Muscatiello, Cristian I. Pantea, Zev Ross, et al. 2019. "Accessibility of cooling centers to heat-vulnerable populations in New York State." *Journal of Transport & Health* 14 (2019): 100563.

[97] Insaf, T.Z., S. Lin, and S.C. Sheridan. 2013. "Climate trends in indices for temperature and precipitation across New York State, 1948-2008." *Air Quality, Atmosphere & Health* 6(1): 247-257.

[98] Chapter 563 of the Laws of 2022.

currently maintains a dashboard to track progress on key indicators of the Prevention Agenda.[99] The dashboard includes a number of health outcomes, as well as other climate-related measures including "% population living in a certified Climate Smart Community" and "% population that uses alternate forms of transportation." New York's Environmental Public Health Tracking Program provides data for a number of environmental exposures, hazards, and health outcomes, including heat-related illness.[100] Ongoing work seeks to add more geographically granular, subcounty data, especially for health outcome metrics including respiratory and cardiovascular disease, while maintaining confidentiality as required by existing laws and policies. County level heat-related illness data has been published in the DOH County Heat and Health Profile reports and is updated periodically. Health Data NY also serves as a repository for a number of health-related datasets.[101] The DOH website also provides other datasets that may be useful for tracking progress on Climate Act requirements and goals.[102]

8.3 Considering Health in Climate Policy

The development of sound policy to mitigate GHG emissions and adapt to the changing climate will provide direct and indirect public health benefits. Direct benefits will result from mitigating GHG emissions and adapting to global climate change by reducing the many public health impacts associated with climate change. Indirect health benefits will occur when initiatives to mitigate GHG emissions also result in other beneficial outcomes such as reducing air pollutant emissions (co-pollutants), encouraging active transport (such as walking and cycling), and reducing home health risks through building energy efficiency retrofit interventions. Improved air quality will reduce premature mortality and incidences of asthma and cardiovascular disease and increased physical activity will reduce obesity and negative cardiovascular outcomes. Cardiovascular disease is the leading cause of death nationally and in New York, with almost 44,000 New Yorkers dying of cardiovascular disease every year. As previously stated, asthma is a major health problem nationally, and in New York 1.4 million adults and 315,000 children suffer from this disease.[103]

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[99] New York State Department of Health. Accessed at https://webbi1.health.ny.gov/SASStoredProcess/guest?_program=/EBI/PHIG/apps/dashboard/pa_dashboard&p=sh.

[100] New York State Department of Health. Accessed at https://www.health.ny.gov/environmental/public_health_tracking/.

[101] New York State Department of Health. Accessed at https://health.data.ny.gov/.

[102] New York State Department of Health. Accessed at https://www.health.ny.gov/prevention/prevention_agenda/2013-2017/sources.htm.

[103] Centers for Disease Control and Prevention. "Most Recent Asthma State or Territory Data." Accessed on November 23, 2021, at https://www.cdc.gov/asthma/most_recent_data_states.htm.

State and federal government programs to control air pollutant emissions through regulations and permitting have contributed to greatly improved air quality in New York over the last 40 years (see Appendix F). Although the State currently complies with the requirements of, or is "designated attainment for," the National Ambient Air Quality Standards for the criteria pollutants carbon monoxide, lead, nitrogen dioxide (NO_2), and particulate matter, substantial additional health benefits will be achieved through continued emission reductions. For SO_2, a small portion of St. Lawrence County has been designated as nonattainment. Nine counties, in which 65% of the state's population reside, are currently not in attainment for the 2015 ozone standard. Concentrations of non-criteria pollutants attributed to fuel combustion have also decreased significantly over the last decade, due in part to programs and regulations directed at reducing transportation source pollution, including the adoption of reformulated gasoline programs and improvements in vehicle emissions technology, the statewide adoption of the California Low Emission Vehicle program, and emission reductions from oil refineries and other stationary sources under federal and State air pollution control programs. Recent studies of long-term air quality trends in New York City demonstrate that enactment of local and regional clean air regulations, as well as changes in fuel usage (e.g., fossil natural gas out-competing coal), significantly reduced ambient levels of particulate matter.

COVID-19 is one of the most significant emerging diseases of the 21st century. Air pollution, in particular fine particulate matter ($PM_{2.5}$), which is released during combustion, can exacerbate symptoms of respiratory illness.[104] Long-term exposure to $PM_{2.5}$ from the 2020 wildfires in the western United States, which are increasing in frequency due to climate change, has also been shown to increase the risk of death from COVID-19. Disadvantaged Communities are likely to have greater health disparities (or inequities) and shoulder more significant environmental burdens than other communities. Elevated levels of NO_2,[105] found in Disadvantaged Communities due to fuel combustion, are associated with higher rates of

[104] Croft, D.P., W. Zhang, S. Lin, et al. 2019. "The Association between Respiratory Infection and Air Pollution in the Setting of Air Quality Policy and Economic Change." *Ann Am2 Thorac Soc*. 2019;16(3):321-330. doi:10.1513/AnnalsATS.201810-691OC.

[105] Liu, T., L.J. Mickley, M. Cooper, and F. Dominici. August 13, 2021. "Excess of COVID-19 cases and deaths due to fine particulate matter exposure during the 2020 wildfires in the United States." *Sci Adv.* 2021 Aug 13;7(33):eabi8789. doi: 10.1126/sciadv.abi8789.

COVID-19 infection and higher rates of death.[106,107] By mitigating climate change, New York can reduce air pollution and respiratory illnesses, including COVID-19 infection, address underlying economic and social inequities using asset-based approaches, and protect and improve public health.

8.4 Sector-Specific Health Co-Benefits of Climate Policies

In addition to the health impacts associated with climate change, the production, storage, distribution, use, and disposal of fossil fuels (and certain biofuels) can have many other health impacts. These impacts can arise from routine operations, accidents, and catastrophic events. Health impacts resulting from routine fuel use and production can range from local to global in scale and examples include degradation of air quality due to the combustion of fuels and accidents such as fires, fuel oil spills, contamination of groundwater and gas pipeline explosions, and other occupational and nonoccupational accidents. Reduction of these impacts through GHG emissions reductions strategies results in health co-benefits. Some of these impacts are discussed in the sections below. Table 3 summarizes the human health effects that are associated with GHG emissions (climate change) and exposure to some air pollutants commonly associated with fuel combustion.

[106] Liang, D., L. Shi, J. Zhao, P. Liu, J.A. Sarnat, S. Gao, J. Schwartz, Y. Liu, S.T. Ebel, N. Scovronick, H.H. Chang. 2020. "Urban Air Pollution May Enhance COVID-19 Case-Fatality and Mortality Rates in the United States." *The Innovation* 1(3), https://doi.org/10.1016/j.xinn.2020.100047.

[107] Lipsitt, J., A.M. Chan-Golston, J. Liu, J. Su, Y. Zhu, and M. Jerrett. 2021. "Spatial analysis of COVID-19 and traffic-related air pollution in Los Angeles." *Environ Int.* 2021 Aug;153:106531. doi: 10.1016/j.envint.2021.106531. Epub 2021 Mar 22. PMID: 33812043; PMCID: PMC7983457.

Table 3. Health Effects Associated with Fossil Fuel and Biofuel Combustion Pollutants

Air Pollutant	Human Health Effects
GHGs	Climate-related effects on morbidity and mortality (such as increased mold and pollen allergy incidence and severity, heat stress, heat-related mortality, vector-borne disease, injury, and death due to flooding)
Carbon monoxide[108]	Likely causal effects on existing cardiovascular disease
NO_2[109]	Respiratory effects (causal)
Ozone[110]	Respiratory effects (causal)
$PM_{2.5}$[111]	Cardiovascular effects and pre-mature mortality (cardio-pulmonary) (causal)
SO_2[112]	Respiratory effects (short-term exposures) (causal)
Metals[113]	Effects vary depending on specific metal
Polycyclic aromatic hydrocarbons[114]	Cancer (not all polycyclic aromatic hydrocarbons)
VOCs[115]	Effects vary depending on the specific chemical (some examples are central nervous system effects; liver or kidney toxicity; eye, skin, and respiratory tract irritation; and cancer)

Many volatile organic compounds (VOCs), such as toluene, can cause central nervous system effects, and some, like benzene, are carcinogens. In addition to VOCs and GHGs (discussed earlier), non-criteria pollutants that can be emitted from fuel combustion include chlorinated dibenzo-p-dioxins, chlorinated dibenzofurans, polycyclic aromatic hydrocarbons, and various metals, particularly mercury from coal combustion. Exposure to high levels of chlorinated dioxins and furans is associated with cancer and effects on the liver and skin. Health effects associated with exposure to metals vary by the metal. For example, mercury, after being transformed to methylmercury in the environment and entering the food chain, can cause effects on the nervous system, especially for children and fetuses. Exposure to high levels of some polycyclic aromatic hydrocarbons is associated with lung cancer. Polycyclic aromatic

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[108] U.S. Environmental Protection Agency. 2010. *EPA/600/R-019F/January 2010: Integrated Science Assessment for Carbon Monoxide.*

[109] U.S. Environmental Protection Agency. 2016. *EPA/600/R-15-068/January 2016: Integrated Science Assessment for Oxides of Nitrogen – Health criteria.*

[110] U.S. Environmental Protection Agency. 2020. *EPA/600/R-20/012, April 2020 U.S. EPA. Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants*.

[111] U.S. Environmental Protection Agency. 2019. *EPA/600/R-19/188, December 2019: Integrated Science Assessment (ISA) for Particulate Matter*.

[112] U.S. Environmental Protection Agency. 2017. *EPA/600/R-17/451/December 2017.: Integrated Science Assessment for Sulfur Oxides- Health Criteria.*

[113]Agency for Toxic Substances and Disease Registry. "Toxicological Profiles for Specific Metals." http://www.atsdr.cdc.gov/toxprofiles/index.asp.

[114] Agency for Toxic Substances and Disease Registry. "Toxicological Profiles for specific PAHs." http://www.atsdr.cdc.gov/toxprofiles/index.asp.

[115] Agency for Toxic Substances and Disease Registry. "Toxicological Profiles for specific VOCs." http://www.atsdr.cdc.gov/toxprofiles/index.asp.

hydrocarbons can have endocrine effects, as well.[116] Biomarkers for this type of exposure have been associated with incidence of diabetes.[117] Polycyclic aromatic hydrocarbons in air are usually found in the particulate phase, and a recent study determined that other indicators of combustion emissions, including $PM_{2.5}$ (fine particulate matter less than or equal to 2.5 microns in aerodynamic diameter), were associated with an increased risk of mortality from the endocrine disorder, diabetes.[118] There is evidence that $PM_{2.5}$, SO_2, carbon dioxide (CO_2), and NO_2 are associated with reduced fecundity and increased miscarriage and stillbirth.[119] Modeling changes in health outcomes associated with exposure to air pollutants can be helpful to inform policy, but modeling those for non-criteria pollutants is more challenging and uncertain.

Power Generation

The transition in the power generation sector away from fuel combustion to meet the requirements of the Climate Act will result in the same kinds of health co-benefits achieved through this transition across all sectors. However, there are health concerns specific to this sector, and they have been considered in the development of this Scoping Plan. The health risks associated with combustion emissions and combustion waste products are not associated with renewable power generation and will substantially decrease with large-scale reduction in combustion for power generation. Coal, a fuel with significant emissions and associated health impacts, has already been phased out in New York power generation following New York State Department of Environmental Conservation's (DEC) adoption of CO_2 emission limits for power plants, as part of 6 NYCRR Part 251. Although emissions from power plant stacks can travel great distances, power generation facilities also contribute to air quality impacts in nearby communities, including Disadvantaged Communities.

Health concerns associated with onshore generation of wind energy are limited. Physical safety concerns can be mitigated through the choice of appropriate minimum setbacks (the minimum allowable distances between turbines and roads, property lines, or structures). Annoyance,[120] associated with wind turbines

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[116] Teil, M.J., E. Moreau-Guigon, M. Blanchard, F. Alliot, J. Gasperi, M. Cladière, C. Mandin, S. Moukhtar, M. Chevreuil. 2016. "Endocrine disrupting compounds in gaseous and particulate outdoor air phases according to environmental factors." *Chemosphere*.146:94-104.

[117] Alshaarawy, O., M. Zhu, A.M. Ducatman, B. Conway, M.E. Andrew. 2014. "Urinary polycyclic aromatic hydrocarbon biomarkers and diabetes mellitus. *Occup Environ Med*. 71(6):437-41.

[118] Lim, C.C., R.B. Hayes, J. Ahn, Y. Shao, D.T. Silverman, R.R. Jones, C. Garcia, G.D. Thurston. 2018. "Association between long-term exposure to ambient air pollution and diabetes mortality in the US." *Environ Res*. 165:330-336.

[119] Conforti, A., M. Mascia, G. Cioffi, et al. 2018. "Air pollution and female fertility: a systematic review of literature." *Reprod Biol Endocrinol.* 16(117).

[120] Noise annoyance is defined by the World Health Organization as a (long term) feeling of displeasure, nuisance, disturbance, or irritation caused by a specific sound.

producing characteristic sounds or noise as wind passes over the rotating blades, is a health effect according to the *Environmental Noise Guidelines for the European Region*, published by the World Health Organization in 2018.[121] Data indicate that noise from wind turbines may be more noticeable, annoying, and disturbing than other community or industrial sounds of the same level. Reviewing acceptable noise thresholds for wind turbine siting as scientific understanding evolves will be important as onshore wind energy is increasingly adopted. DOH will continue to review the scientific literature on wind turbine noise and health effects like annoyance in order to inform siting policies and programs. Another potential health concern associated with renewable energy is related to the disposal of hardware and components. Toxic metals such as lead could leach from end-of-life solar panels if they are not disposed of properly.[122,123] However, proper recycling can reduce this hazard, and panels can be designed to facilitate future recycling of panel modules. In addition, batteries, such as lithium-ion batteries, which can be used for electric grid storage, can release as lithium, manganese, and cobalt if not recycled or disposed of properly.[124]

Finally, there are emerging energy technologies that may pose new opportunities as well as new risks that have yet to be fully understood. Hydrogen combustion does not directly generate most combustion byproducts such as particulate matter, thus conveying a potentially large health benefit, but does result in the formation of NO_X (which are precursors to ozone and particulate matter formation) at levels that may be higher than those from fossil fuel combustion because of hydrogen's high combustion temperature. Opportunities to further reduce NO_X emissions from hydrogen combustion exist and need to be further studied. Recent data indicate that turbines can be designed to combust hydrogen with substantially reduced NO_X emissions, even potentially below levels achieved from natural gas combustion.[125] The use of hydrogen for fuel cells would not result in any NO_X formation and would therefore be preferrable to

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[121] World Health Organization Regional Office for Europe. 2018. *Environmental Noise Guidelines for the European Region. Copenhagen*. Accessed at https://www.euro.who.int/__data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf.

[122] Sharma, H.B., K.R. Vanapalli, V.K. Barnwal, B. Dubey, J. Bhattacharya. 2021. "Evaluation of heavy metal leaching under simulated disposal conditions and formulation of strategies for handling solar panel waste." *Sci Total Environ*. 2021 Aug 1;780:146645. doi: 10.1016/j.scitotenv.2021.146645.

[123] Centers for Disease Control and Prevention. 2020. "ATSDR toxicological profile on lead." https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf.

[124] Wojciech, M., et al. 2021. "Environmental impacts, pollution sources and pathways of spent lithium-ion batteries." *Energy Environ. Sci*. 14: 6099-6121.

[125] National Energy Technology Laboratory. August 31, 2022. "Addressing NO_X Emissions from Gas Turbines Fueled with Hydrogen." August 31, 2022. https://www.energy.gov/eere/fuelcells/2022-hydrogen-and-fuel-cell-technologies-office-webinar-archives#09152022

hydrogen combustion from a public health perspective. The combustion of renewable natural gas (RNG) is likely to result in pollutant emissions similar to fossil natural gas combustion.

While transitioning away from fossil fuel use, maintaining reliable access to power, whether through centralized or distributed energy sources, is crucial for maintaining good public health in our energy-dependent society. Increasing the reliability of electric systems and delivery can reduce health effects during high temperatures, when air conditioning is the principal means to prevent heat-related morbidity and mortality. A study of citywide and localized power outages in New York City during warm weather found associations with respiratory disease, renal disease, and all-cause mortality, though these associations were not necessarily consistent across outages.[126] During summer, power outages pose specific health-related impacts such as spoiled food and digestive tract illness, spoiled vaccines, and increased rodent populations as a result of discarded perishables.[127,128,129] Winter outages also pose specific risks to public health.[130,131] One study found that the health risks are greater following winter storms with power outages, compared with winter storms alone.[132] Localized cold weather power outages in New York City were associated with all-cause mortality and cardiovascular disease hospitalizations but fewer respiratory disease hospitalizations.[133] Increases in carbon monoxide poisoning during storm-related power outages have been reported in several studies.[134,135] Following a 2006 winter storm in Western New York that resulted in extensive power outages, 264 people visited emergency departments

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[126] Dominianni C., et al. 2018. "Health Impacts of Citywide and Localized Power Outages in New York City." *Environ Health Perspect* 126(6): 067003.

[127] Bell, K.N. 2001. "Risk Factors for Improper Vaccine Storage and Handling in Private Provider Offices." *Pediatrics.* 107(6): art-e100.

[128] Marx, A. Melissa. 2006. "Diarrheal Illness Detected Through Syndromic Surveillance after a Massive Power Outage: New York City, August 2003. *American Journal of Public Health*. 96:547-553.

[129] Beatty, Mark. 2006. "Blackout of 2003: Public Health Effects and Emergency Response." *Public Health Reports*.

[130] Daley, W. Randolf. 2000. "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.

[131] Muscatiello, Neil, G. Babcock, R. Jones, E. Horn, and S.A. Hwang. 2010. "Hospital Emergency Department Visits for Carbon Monoxide Poisoning Following an October 2006 Snowstorm in Western New York." *Journal of Environmental Health*. Volume 72, Number 6, pages 43-48.

[132] Lin, S., et al. 2021. "The immediate effects of winter storms and power outages on multiple health outcomes and the time windows of vulnerability." *Environ Res.* 196: 110924.

[133] Dominianni, C., et al. 2018. "Health Impacts of Citywide and Localized Power Outages in New York City." *Environ Health Perspect.* 126(6): 067003.

[134] Daley, W. Randolf. 2000. "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.

[135] Graber, Judith M. 2007. "Results from a State-Based Surveillance System for Carbon Monoxide Poisoning." *Public Health Reports.* 122:145-154.

to be evaluated for carbon monoxide poisoning.[136] After Hurricane Sandy, 80 carbon monoxide poisoning cases were reported.[137,138] At least 57 deaths were attributed to this weather event, and there was over $195 million in property damage. By improving the reliability of the available electricity, the State can prevent millions of dollars in damages and prevent premature mortality.

Transportation

Opportunities for health co-benefits associated with transportation sector climate policies include reductions in traffic noise and accidents and reductions in morbidity and mortality associated with improved air quality and increased availability and use of active transportation options. Transportation sector emissions are usually concentrated at the ground level, often in densely populated areas, resulting in a tendency toward higher levels of exposure for more people than emissions associated with other pollutant sources. Some of the co-pollutants emitted are associated with an increased risk of respiratory and cardiovascular effects, among others. Numerous studies have investigated the increased risk of these effects by looking at the relationship between traffic patterns and the distance from roadways and the associated pollutant concentrations and health endpoints. 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[139] and diesel traffic density in particular.[140] Associations with other health effects have been found. For example, two Ontario-based studies demonstrated that, where air

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[136] Graber, Judith M. 2007. "Results from a State-Based Surveillance System for Carbon Monoxide Poisoning." *Public Health Reports.* 122:145-154.

[137] Center for Disease Control and Prevention. 2012. "Notes from the Field: Carbon Monoxide Exposures Reported to Poison Centers and Related to Hurricane Sandy - Northeastern United States." *2012 Morbidity and Mortality Weekly Report.* 66(44);905-905.

[138] The University of Texas at Austin Energy Institute. 2021. "The Timeline and Events of the February 2021 Texas Electric Grid Blackouts." Accessed at https://energy.utexas.edu/ercot-blackout-2021.

[139] Lin, S., J.P. .Munsie, S.A. Hwang, E. Fitzgerald, M.R. Cayo. 2002. "Childhood Asthma Hospitalization and Residential Exposure to State Route Traffic." *Environmental Research.* Section A (88): 73-81; Lwebuga-Mukasa, James S. 2003. "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; Kim, Janice. 2008. "Residential Traffic and Children's Respiratory Health." *Environmental Health Perspectives.* 16(9):1274-9.

[140] McCreanor, James. 2007. "Respiratory Effects of Exposure to Diesel Traffic in Persons with Asthma." *New England Journal of Medicine*. 357(23):2348-58.

pollution is generally low, living in close proximity to high-traffic roads and higher levels of $PM_{2.5}$ and NO_2 are associated with increased risk of developing dementia.[141,142]

The recommendations for reducing single-occupancy vehicle travel and reducing gasoline and diesel use, discussed further in this Scoping Plan, could improve health outcomes. Transportation emissions have been concentrated in Disadvantaged Communities for generations and decarbonizing the transportation sector provides an opportunity to focus emission reductions in the communities that have historically been overburdened by pollution.[143] In addition, transportation planning that use Complete Streets policies ensures that considerations are made for the safety of all roadway users (pedestrians, bicyclists, public transportation users, and motorists). Not getting enough physical activity is a risk factor for diabetes and obesity (which are also risk factors for those with high blood pressure and a family history of these health risks). Almost 1.7 million New Yorkers (10.5%) had diabetes in 2016, and obesity has reached epidemic proportions with more than half (60.8%) of New York adults reported to be overweight or obese in 2016. Being obese or overweight is currently the second leading preventable cause of death in the U.S. and may soon overtake cardiovascular disease as the leading cause of death. In addition, one-third of New York's children are obese or overweight. A reduction in the reliance on personal automobiles by incorporating smart growth and Complete Streets policies into transportation planning has the benefit of increasing opportunities for physical activity. In recent years, studies have begun to examine the relationship between neighborhood walkability and physical activity levels, body mass index, waist circumference, obesity, and hypertension. These studies have generally shown that neighborhood walkability is associated with increased physical activity and decreased body mass index, waist circumference, obesity, and hypertension.

Health risks associated with transportation emissions can be reduced with a shift toward technologies that do not rely on fuel combustion and the enhancement of public transportation systems and other low-carbon mobility options (e.g., walking, cycling). Currently, most mobile source emissions result from the combustion of gasoline and traditional petroleum-based diesel fuel. Compared with petroleum-based

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[141] Chen, H, J.G. Kwong, R. Copes, K. Tu, P.J. Villeneuve, A. van Donkelaar, P. Hystad, R.V. Martin, B.J. Murray, B. Jessiman, A.S. Wilton, A. Kopp, R.T. Burnett. 2017. "Living near major roads and the incidence of dementia, Parkinson's disease, and multiple sclerosis: a population-based cohort study." *Lancet*. Feb 18;389(10070):718-726. doi: 10.1016/S0140-6736(16)32399-6. Epub 2017 Jan 5. PMID: 28063597.

[142] Chen, H., J.C. Kwong, R. Copes, P. Hystad, A. van Donkelaar, K. Tu, J.R. Brook, M.S. Goldberg, R.V. Martin, B.J. Murray, A.S. Wilton, A. Kopp, R.T. Burnett. 2017. "Exposure to ambient air pollution and the incidence of dementia: A population-based cohort study." *Environ Int.* Nov;108:271-277. doi: 10.1016/j.envint.2017.08.020. Epub 2017 Sep 13. PMID: 28917207.

[143] New York State Department of Transportation. "Complete Streets." Accessed on November 23, 2021 at https://www.dot.ny.gov/programs/completestreets.

fuels, alternative fuels may not have lower co-pollutant emissions. Alcohol-based fuels have higher levels of combustion emissions of respiratory irritants and some ozone-precursors such as formaldehyde and acetaldehyde.[144,145] In 2007, it was estimated that increasing ozone levels from widespread use of concentrated ethanol in the transportation sector could lead to significant increases in ozone-related asthma, hospitalization, and mortality.[146] Formaldehyde and acetaldehyde are also carcinogens. At the time of the 2007 study, the estimated cancer risk associated with widespread use of higher ethanol fuel was offset by the decreased use of gasoline and associated carcinogenic benzene and butadiene emissions, with no net change in cancer risk.[147] However, the Federal Mobile Source Air Toxics standards phased in from 2007 to 2014 caused the average benzene levels in conventional gasoline to decrease by nearly 50% (and ethanol levels to increase to 10%).[148] This suggests that widespread replacement of gasoline with high ethanol fuel at the current time would result in an increase in risk for cancer as well as ozone-related respiratory outcomes, although recent emissions controls may also have had effects on ethanol combustion emissions. Substitution of biodiesel or renewable diesel for conventional diesel does not significantly reduce particulate matter emissions in most on-road transportation applications (where advanced emissions control technology prevails).[149] Renewable diesel does not significantly affect NO_X emissions in these on-road engines, but biodiesel likely increases NO_X emissions. Lower particulate matter emissions in older non-road engines are likely for both biodiesel and renewable diesel, but biodiesel use in these engines slightly increases NO_X emissions. This increase can be mitigated if

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[144] Karavalakis, G., et al. 2012. "Impacts of ethanol fuel level on emissions of regulated and unregulated pollutants from a fleet of gasoline light-duty vehicles." *Fuel.* 93: 549-558.

[145] Frutuoso, Felipe S., Camila M.A.C. Alves, Saul L. Araújo, Daniel S. Serra, Ana Luiza B.P. Barros, Francisco S.Á. Cavalcante, Rinaldo S. Araújo, Nara A. Policarpo, Mona Lisa M. Oliveira. 2002. "Assessing light flex-fuel vehicle emissions with ethanol/gasoline blends along an urban corridor: A case of Fortaleza/Brazil." *International Journal of Transportation Science and Technology*. ISSN 2046-0430, https://doi.org/10.1016/j.ijtst.2022.04.001.

[146] Jacobson, M.Z. 2007. "Effects of ethanol (E85) on cancer and mortality in the United States." *Environ. Sci. Technol* 41(11): 4150–4157.

[147] Jacobson, M.Z. 2007. "Effects of Ethanol (E85) versus Gasoline Vehicles on Cancer and Mortality in the United States." *Environ. Sci. Technol.* 41, 4150-4157; NYSERDA. "Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply for New York." Accessed on November 23, 2021, at https://www.nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Biomass-Reports/Renewable-Fuels-Roadmap; Vieira da Silva, M.A., B.L.G. Ferreira, L.G. da Costa Marques, A.L.S. Murta, and M.A.V. de Freitas. 2017. "Comparative study of NO_X emissions of biodiesel-diesel blends from soybean, palm and waste frying oils using methyl and ethyl transesterification routes." *Fuel* 194: 144-156.

[148] U.S. Environmental Protection Agency. October 2017. "Fuel Trends Report: Gasoline 2006 – 2016, EPA-420-R-17-005." https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100T5J6.pdf

[149] Biodiesel is produced by transesterification of vegetable oils and animal fats. Renewable diesel is a biomass-based diesel fuel similar to biodiesel that is chemically equivalent to petroleum diesel and can be used and transported as a drop-in biofuel with or without blending with petroleum diesel. Renewable diesel production uses a hydrogenation process rather than the esterification process used to produce biodiesel.

blending with renewable diesel, which slightly reduces NO_X emissions in uncontrolled engines.[150] (For a broad review of the potential effect of alternative fuels on criteria pollutant emissions, see NYSERDA's *Effect of Low-Carbon Fuels and Energy Technologies on Co-Pollutant Emissions* memo.[151]) It would be beneficial, from a public health perspective, to limit use of alternative fuels to those scenarios where it can be demonstrated that co-pollutant exposures are reduced or at least not increased when compared with fossil fuel use.

Widely used 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. Therefore, targeted geographic and temporal expansion of public transportation availability could reduce health risks associated with transportation emissions. Electrifying transit buses can ensure that emissions are reduced even further. Investments in transit bus electrification will benefit overburdened communities, both because many bus depots are located in these areas and because buses provide essential transportation services in these areas. Regulations limit school bus and heavy-duty vehicle idling, which produces harmful emissions, to protect the health of school children and others exposed to this type of air pollution and electrification of vehicles will reduce these harmful pollutants even further.[152] Electrification of school buses would also prevent exposure of school children to diesel exhaust, which often leaks into the cabin of buses posing a larger health threat than outdoor idling emissions. Electrification of heavy-duty equipment such as port, farm, and construction engines, that are typically diesel-powered, will protect the health of workers and reduce emissions (and noise) in rural and urban areas that are often in close proximity to residents and pedestrians. While not all engine types are currently available with electric or other zero-emission technology options, availability is increasing and will continue to do so in the future. In many construction settings, diesel generators can be eliminated in favor of temporary electrical grid connection. Emissions associated with transportation can also be reduced through carpools and investments in infrastructure that support safe walking and bicycling. These mechanisms can be supported through integrated local and regional transportation planning using Complete Streets principles.

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[150] Durbin, T.D., et al. 2021. *Low Emission Diesel (LED) Study: Biodiesel and Renewable Diesel Emissions in Legacy and New Technology Diesel Engines*. Prepared for California Air Resources Board.

[151] Abt Associates. October 18, 2022. Memorandum for NYSERDA: "Effect of Low-Carbon Fuels and Energy Technologies on Co-Pollutant Emissions, revised October 18, 2022." https://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Greenhouse-Gas-Emissions.

[152] New York State Department of Environmental Conservation. "Heavy Duty Vehicles." Accessed at https://www.dec.ny.gov/chemical/8585.html.

Reductions in fuel use and emissions can also be achieved through congestion mitigation and smart growth planning that facilitates the establishment of more walkable communities, with sidewalks, bike lanes, and bike paths. Policies and technologies to reduce congestion, such as congestion pricing and traffic signal synchronization, can alleviate major bottlenecks and improve local air pollution, especially in communities located near busy roads. Bike sharing programs have become a popular feature in cities across the nation, providing additional opportunities for physical activity. Active transport for shorter journeys has both the benefits of reduced emissions and of exercise, leading to reduced risk for obesity, cardiovascular disease, and other health impacts. Nevertheless, in spite of the emission reductions associated with bicycling and walking for transportation and the health benefits, exercising in polluted air can also have health impacts, especially for vulnerable populations.[153] However, among healthy adults, moderate to high-intensity exercise may neutralize any short-term negative effects of air pollution. While the benefits of increased physical activity have been found to outweigh the risks of exercise in polluted air,[154] air quality in areas of heavy traffic should still be considered in the choices made for siting of bicycle lanes and paths.[155] Further, traffic accidents have been found to increase in number and severity with increased active transport. Therefore, as active transport options continue to be made available, efforts to minimize accident potential become increasingly important.

Vehicle electrification can also contribute to reduced traffic noise, especially at slower and medium speeds where tire and wind noises are low. Particularly in cities, with high volumes of traffic, noise reduction is an important health co-benefit for the deployment of electric vehicles (EVs). However, silent EVs can also pose a safety risk for pedestrians. For this reason, minimum sound levels for EVs are required of manufacturers.[156] Charging lithium-ion batteries used in vehicles such as E-bikes can pose fire risks.[157] Also, it is important to properly recycle or dispose of the lithium-ion batteries that currently power most EVs.

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[153] Mittleman, Murray A. September 13, 2007. "Air Pollution, Exercise and Cardiovascular Risk." *New England Journal of Medicine* 357(11):1147- 9.

[154] Tainio, M., A. de Nazelle, T. Götschi, S. Kahlmeier, D. Rojas-Rueda, M. Nieuwenhuijsen, T. Hérick de Sá, P. Kelly, J. Woodcock. 2016. "Can air pollution negate the health benefits of cycling and walking?" *Preventive Medicine* 87:233-236.

[155] Hertel, Ole. 2008. "A Proper Choice of Route Significantly Reduces Air Pollution Exposure – A Study on Bicycle and Bus Trips in Urban Streets." *Science of the Total Environment* 389(1):58-70.

[156] National Highway Traffic Safety Administration, U.S. Department of Transportation. 2002. "Federal Motor Vehicle Safety Standards; Minimum Sound Requirements for Hybrid and Electric Vehicles." https://www.federalregister.gov/documents/2022/07/13/2022-14733/federal-motor-vehicle-safety-standards-minimum-sound-requirements-for-hybrid-and-electric-vehicles

[157] Rubin, April. "Lithium-Ion Batteries in E-Bikes and Other Devices Pose Fire Risks." November 14, 2022. *New York Times*.

Buildings and the Built Environment

The building industry presents a unique and largely untapped resource for integrating climate action and public health. Workforce education, training, job placement, and job development equips New York's current and future workforce to design, install, inspect, maintain, and operate healthy, comfortable, low-carbon buildings while increasing clean energy job placement for Disadvantaged Communities and advancing industry diversity. This could be accomplished by promoting broad public awareness and education to create strategic partnerships with trusted community leaders, and by scaling-up targeted outreach and decision-making to increase market demand and accelerate the transition to low-carbon, energy-efficient, all-electric buildings.

Outdoor Built Environment

The built environment is the primary environment people are exposed to because people spend approximately 90% of their time indoors.[158] However, outdoor green space is also part of the built environment, and it can have health benefits (mental health, exercise, etc.) for those who have access. Consequently, there are significant opportunities for improving public health while reducing GHG emissions by introducing green space, such as parks, especially in urban environments and Disadvantaged Communities. Green spaces, such as parks, urban greenery, and street trees, as well as blue space, that comprise water elements, can have beneficial health effects, particularly in urban environments. Effects include decreasing risk of cardiovascular disease and type 2 diabetes mellitus while improving mental

[158] U.S. Environmental Protection Agency. 1989. *Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C.* Washington, DC.

health and quality of sleep and increasing birth weight.[159,160,161,162,163,164,165,166] In urban environments, which experience the "heat island effect," trees and other green spaces can cool their surrounding areas by up to 1°C.[167,168] Disadvantaged Communities can have less access to green space, and poverty is associated with greater distances to parks.[169] A recent study found that visibility of green space was associated with fewer emergency visits for mental disorders in neighborhoods with high social vulnerability index in New York City.[170] To reduce inequality, New York State Department of Agriculture and Markets (AGM) and DEC have provided grants to support community gardens in urban areas, and more can be done to bring accessible green space to Disadvantaged Communities.[171,172]

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[159] Hartig, T. 2007. "Three Steps to Understanding Restorative Environments as Health Resources." In: Thompson, C. W., and P. Travlou (Eds.). *Open Space: People Space.* Abingdon: Taylor & Francis.

[160] Hartig, T., M. Mang, and G.W. Evans. 1991. "Restorative Effects of Natural Environment Experiences." *Environment and Behavior* 23, 3-26.

[161] Beyer, K. M., A. Kaltenbach, A. Szabo, S. Bogar, F.J. Nieto, and K.M. Malecki. 2014. "Exposure to neighborhood green space and mental health: Evidence from the survey of the health of Wisconsin." *International Journal Of Environmental Research & Public Health* 11, 3453-72.

[162] Völker, S., and T. Kistemann. 2015. "Developing the Urban Blue: Comparative Health Responses to Blue and Green Urban Open Spaces in Germany." *Health & Place* 35, 196–205.

[163] Astell-Burt, T., X. Feng, and G.S. Kolt. 2014. "Is Neighborhood Green Space Associated with a Lower Risk of Type 2 Diabetes? Evidence from 267,072 Australians." *Diabetes Care* 37, 197-201.

[164] Maas, J., R.A. Verheij, S. De Vries, P. Spreeuwenberg, F.G. Schellevis, and P.P. Groenewegen. 2009. "Morbidity Is Related to a Green Living Environment." *Journal Of Epidemiology And Community Health* 63, 967-973.

[165] Bodicoat, D.H., G. O'donovan, A.M. Dalton, L.J. Gray, T. Yates, C. Edwardson, S. Hill, D.R. Webb, K. Khunti, M.J. Davies, and A.P. Jones. 2014. "The Association between Neighbourhood Greenspace and Type 2 Diabetes in a Large Cross-Sectional Study." *British Medical Journal Open* 4, E006076.

[166] Dzhambov, A.M., D.D. Dimitrova, and E.D. Dimitrakova. 2014. "Association between Residential Greenness and Birth Weight: Systematic Review and Meta-Analysis." *Urban Forestry & Urban Greening* 13, 621-629.

[167] Bowler, D. E., L. Buyung-Ali, T.M. Knight, and A.S. Pullin. 2010. "Urban Greening to Cool Towns and Cities: A Systematic Review of the Empirical Evidence." *Landscape And Urban Planning* 97, 147-155.

[168] Lafortezza, R., G. Carrus, G. Sanesi, and C. Davies. 2009. "Benefits and well-being perceived by people visiting green spaces in periods of heat stress." *Urban Forestry & Urban Greening* 8, 97-108.

[169] Wen, M., X. Zhang, C.D. Harris, J.B. Holt, and J.B. Croft. "Spatial disparities in the distribution of parks and green spaces in the USA." *Ann Behav Med.* 2013 Feb;45 Suppl 1(Suppl 1):S18-27. doi: 10.1007/s12160-012-9426-x. PMID: 23334758; PMCID: PMC3590901.

[170] Yoo, E.H., J.E. Roberts, Y. Eum, X. Li, K. Konty. "Exposure to urban green space may both promote and harm mental health in socially vulnerable neighborhoods: A neighborhood-scale analysis in New York City." *Environ Res.* 2022 Mar;204(Pt C):112292. doi: 10.1016/j.envres.2021.112292. Epub 2021 Oct 30. PMID: 34728238.

[171] New York State Department of Agriculture and Markets. "Community Gardens and Urban Agriculture." Accessed at https://agriculture.ny.gov/community-gardens-and-urban-agriculture.

[172] New York State Department of Environmental Conservation. "Environmental Justice Grant Programs." Accessed at https://www.dec.ny.gov/public/31226.html.

Housing/Residential Built Environment

Building energy efficiency measures provide significant energy savings and health benefits. These include the basic benefits of affordably maintaining a comfortable living and working environment, preventing hypo- and hyperthermia, and combatting fuel poverty (facing the choice between heating the home or feeding the family).

Tight insulation in residential buildings without ensuring appropriate ventilation and filtration, and/or inadequate weatherproofing, can negatively impact indoor air quality. Ensuring adequate ventilation can provide substantial health benefits and can be coupled with heat exchange for energy efficiency. Disadvantaged Communities in particular experience indoor air quality issues related to poor ventilation and inadequate weatherproofing (causing mold), which can worsen health disparities. The New York Building Codes and Property Maintenance Code designates minimum air ventilation rates for new and existing buildings. Inadequate ventilation increases exposure to air contaminants such as VOCs (including but not limited to those from consumer care products and off-gassing from building materials), radon gas, dust, allergens, mold, carbon monoxide (e.g., from leaking fossil fuel heating systems), and CO_2.

NYSERDA has programs to use accrediting organizations to set standards and best practices for conducting energy efficiency upgrades. Program requirements concerning source removal, ventilation systems, minimum ventilation rates, and proper sizing and installing of HVAC systems help avoid and alleviate indoor air quality problems in existing buildings and associated health effects. NYSERDA also strives to support advanced sustainability standards and tools by partnering with organizations like the Collaborative for High Performance Schools, the U.S. Department of Energy, the U.S. Environmental Protection Agency (EPA), and the U.S. Green Building Council.

Energy efficiency upgrade programs could benefit public health, particularly if indoor air quality and other related environmental health factors are given adequate consideration. When effectively combined with other home intervention programs (such as the New York State Healthy Neighborhoods Program), energy efficiency upgrades can have direct and indirect health benefits for residents.[173] For example, these combined measures can reduce hot and cold thermal stress, arthritis symptoms, asthma hospitalization or emergency department visits, missed days of work, carbon monoxide poisonings, home fires, and trip and

[173] Gomez, Marta, MS; Amanda L. Reddy; Sherry L. Dixon, PhD; Jonathan Wilson, MPH; David E. Jacobs, PhD, CIH. 2017. "A Cost-Benefit Analysis of a State-Funded Healthy Homes Program for Residents with Asthma: Findings from the New York State Healthy Neighborhoods Program." *Journal of Public Health Management and Practice:* March/April 2017 - Volume 23 - Issue 2 - p 229-238.

fall injuries for residents.[174] These programs could also consider identifying code violations which increase risks associated with flooding, and thus contribute toward increased community resiliency. Public health and safety should be a primary consideration in the strict enforcement of building codes that are protective of residents during flood periods, particularly in flood-prone areas.

Electrification of the building sector will also reduce the health risks associated with combustion-based appliances for heating, cooking, and other uses. Leaking fossil fuel home heating systems were the primary cause listed among the 15,000 carbon monoxide poisonings resulting in emergency department visits in the United States annually.[175] In New York alone, there are approximately 1,500 emergency department visits and 160 hospitalizations for carbon monoxide poisoning annually.[176] Electrification of home heating systems could prevent many of these poisonings going forward.

In addition, combustion of fossil natural gas for cooking releases NO_X, $PM_{2.5}$, and carbon monoxide. Homes with gas stoves have, on average, 50% to 400% higher concentrations of NO_2 indoors than those without.[177] Residential indoor emissions of NO_X have been found to be linearly related to the amount of gas burned in stoves.[178] Adequately functioning range hoods have been shown to remove some but not all of this indoor air pollution.[179] Children living in homes with gas stoves have an increased risk of being diagnosed with asthma.[180] Individuals in Disadvantaged Communities are disproportionately affected by asthma and may be more likely to have unvented and/or piloted gas stoves. Thus, electrification of cooking appliances can reduce the risk of asthma in Disadvantaged Communities and improve the health

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[174] Bureau of Environmental and Occupational Epidemiology, Center for Environmental Health, New York State Department of Health. Based on Analysis of Statewide Planning and Research Cooperative System Hospital Outpatient Emergency Department Data. Statewide Planning and Research Cooperative System (ny.gov).

[175] Centers for Disease Control and Prevention. 2008. "Nonfatal, Unintentional, Non-Fire Related, Carbon-Monoxide Exposures-U.S."

[176] Bureau of Environmental and Occupational Epidemiology, Center for Environmental Health, New York State Department of Health. Based on Analysis of Statewide Planning and Research Cooperative System Hospital Outpatient Emergency Department Data. Statewide Planning and Research Cooperative System (ny.gov).

[177] U.S. Environmental Protection Agency. 2008. *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria.* Research Triangle Park, NC:.

[178] Lebel, Eric D., Colin J. Finnegan, Zutao Ouyang, and Robert B. Jackson. 2022. "Methane and NO_X Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes." *Environmental Science & Technology* 56 (4), 2529-2539. DOI: 10.1021/acs.est.1c04707

[179] Singer, Brett C., Rebecca Zarin Pass, William W. Delp, David M. Lorenzetti, Randy L. Maddalena. 2017. "Pollutant concentrations and emission rates from natural gas cooking burners without and with range hood exhaust in nine California homes." *Building and Environment,* Volume 122, Pages 215-229, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2017.06.021.

[180] Lin, W., B. Brunekreef, U. Gehring. "Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children." *Int J Epidemiol.* 2013 Dec;42(6):1724-37.

of all New Yorkers. Note that cooking itself also releases pollutants, especially particulate matter (including $PM_{2.5}$), from charring, grilling, and frying, regardless of the heat source.[181] While this indoor air quality impact cannot be addressed through building electrification, it underscores the importance of ensuring adequate ventilation in homes and commercial buildings, especially in coordination with building efficiency upgrades. Indoor concentrations can be significantly decreased with the use of range hoods, especially if they vent to the outdoors. However, even with range hoods, some pollution due to cooking and gas combustion will remain in the home.[182]

Gas stoves may also increase indoor air concentrations of some hazardous air pollutants found as trace constituents of leaking natural gas, such as formaldehyde, and in some cases, benzene. Any hazardous air pollutants introduced indoors due to leaking natural gas while not cooking would not be vented or removed with the use of a range hood, which typically only operates during cooking. In a recent study of California homes, estimated benzene concentrations due to leaking natural gas from stoves varied depending on the source of the natural gas, by gas leakage rates, and by natural and active ventilation rates. With poor ventilation, natural gas from one source with high levels of benzene (a carcinogen) was projected to result in indoor air concentrations exceeding a California eight-hour Reference Exposure Level in some homes.[183,184] Further study is needed to assess the potential for trace constituents of fossil natural gas sources in New York to impact the indoor air quality of homes through leakage from stoves during periods between cooking.

Biomass is burned in New York for heat and combined heat and power for the residential, commercial, and industrial sectors. Of these energy use sectors, the residential sector has the greatest use of wood for heating. New York is the nation's second largest consumer of wood for heating. While wood contributes less than 2% of the energy used for residential heating, estimated $PM_{2.5}$ emissions from residential wood heating in New York State are greater than the emissions from all other heating fuels in the residential,

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[181] Bhangar, S., N.A. Mullen, S.V. Hering, N.M. Kreisberg, W.W. Nazaroff. "Ultrafine particle concentrations and exposures in seven residences in northern California." *Indoor Air.* 2011 Apr;21(2):132-44. doi: 10.1111/j.1600-0668.2010.00689.x. Epub 2010 Oct 28. PMID: 21029183.

[182] Singer, Brett C., Rebecca Zarin Pass, William W. Delp, David M. Lorenzetti, Randy L. Maddalena. 2017. "Pollutant concentrations and emission rates from natural gas cooking burners without and with range hood exhaust in nine California homes." *Building and Environment, Volume 122*. Pages 215-229, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2017.06.021.

[183] The California Environmental Protection Agency Office of Environmental Health Hazard Assessment defines a Reference Exposure Level as an airborne concentration of a chemical that is not anticipated to result in adverse non-cancer health effects for specified exposure durations in the general population, including sensitive subpopulations.

[184] Lebel, E.D., et al. 2022. "Composition, Emissions, and Air Quality Impacts of Hazardous Air Pollutants in Unburned Natural Gas from Residential Stoves in California." *Environmental Science Technology.* https://doi.org/10.1021/acs.est.2c02581

commercial, and industrial sector combined, and greater than the emissions from the entire transportation sector.[185] $PM_{2.5}$ emissions from wood smoke vary by device and use conditions, with the highest intensity (emissions per energy unit) associated with hydronic heaters and fireplaces, followed by fireplace inserts and freestanding units, and the lowest intensity associated with pellet-fired units. While current EPA certification suggests that EPA-certified non-catalytic fireplace inserts and freestanding units have somewhat lower emissions, recent studies suggest that these units may have much higher emissions than suggested by the current testing methods. EPA is moving to adopt new testing protocols, developed by NYSERDA and the Northeast States for Coordinated Air Use Management, which will allow for better evaluation of real-world wood emissions from various systems and certification of cleaner systems.[186,187] In general, the $PM_{2.5}$ emissions intensity for all residential wood systems is higher than other heating fuels. Adverse health effects associated with exposure to wood smoke are consistent with those identified for $PM_{2.5}$ (a major component of wood smoke) including exacerbation of cardiovascular symptoms (e.g., chest pain, heart rhythm changes, heart attack, stroke), and respiratory symptoms (e.g., asthma). The elderly, people with heart and lung diseases, people of low economic status, and children are particularly vulnerable to the effects of fine particle exposures in wood smoke. Wood smoke is often found in particularly rural areas of the State, and some wintertime smoke impacts are significant.[188] Increasing electrification of the building sector could reduce the impacts of combustion of biomass.

Commercial/Industrial Built Environment

In the industrial sector, in addition to the potential use of green hydrogen as described above for the power generation sector, carbon capture and sequestration could reduce GHG emissions. Depending on the specific technology, carbon capture and sequestration may also reduce emissions of some other pollutants, but in many cases does not. While carbon capture technology requires energy, which can lead

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[185] Northeast States for Coordinated Air Use Management (NESCAUM). April 2016. *New York State Wood Heat Report: An Energy, Environmental, and Market Assessment Final Report.* Prepared for New York State Energy Research and Development Authority. NYSERDA Report 15-26 April 2016.

[186] "Special Issue on Wood Combustion." *Journal of the Air & Waste Management Association,* 72.

Burkhard, Ellen. "Introduction to Special Issue on Residential Wood Combustion." *Journal of the Air & Waste Management Association* 72(7), pp. 617–618

Marin, Arthur, Lisa Rector, Barbara Morin, and George Allen. "Residential wood heating: An overview of U.S. impacts and regulations." *Journal of the Air & Waste Management Association* 72(7), pp. 619-628

Morin, Barbara, Mahdi Ahmadi, Lisa Rector, and George Allen. "Development of an integrated duty cycle test method to assess cordwood stove performance." *Journal of the Air & Waste Management Association* 72(7), pp. 629-646.

[187] U.S. Environmental Protection Agency. "Process for Developing Improved Cordwood Test Methods for Wood Heaters." https://www.regulations.gov/docket/EPA-HQ-OAR-2016-0130. Accessed 11/16/2022.

[188] George, Allen, and Lisa Rector. "Characterization of Residential Woodsmoke PM2.5 in the Adirondacks of New York." *Aerosol and Air Quality Research* 20 (2020): 2419-2432.

to additional power sector emissions,[189] potential increases in emissions for powering carbon capture and sequestration would depend on the energy generation source.

[189] Jacobson, M.Z. "The health and climate impacts of carbon capture and direct air capture." *Energy Environ. Sci.* 2019,12, 3567-3574.