



**New York State
Energy Plan**

VOLUME II | Plan Analyses and Impacts

Health Impacts Analysis

18

2025 NEW YORK STATE ENERGY PLAN

Key Terms Used in This Chapter

[FOR THE COMPLETE GLOSSARY →](#)

Fine particulate matter (PM_{2.5}): Airborne particles less than 2.5 micrometers in diameter can travel into the lungs, infiltrate the bloodstream, and cause cardiovascular and respiratory health effects. PM_{2.5} is directly emitted from combustion sources (primary PM_{2.5}) and also forms in the atmosphere through reactions of precursor pollutants, including nitrogen oxides (NO_x), sulfur dioxide (SO₂), ammonia (NH₃), and volatile organic compounds (VOCs).

Ozone: A respiratory irritant when it reaches elevated concentrations in surface air. Ozone is not emitted directly into the air, rather it is produced by chemical reactions between NO_x and VOCs in the presence of sunlight. Ozone is most efficiently formed on hot sunny days in areas with high concentrations of emission sources.

Key Findings → Health Impacts Analysis

Exposure to air pollution from fuel combustion is harmful to human health and can increase risks of cardiovascular and respiratory symptoms and diseases including heart attacks, asthma exacerbation, and premature mortality. New York State’s economy-wide energy policies that increase energy efficiency and shift vehicles, buildings, electricity generation, and other sources to clean energy are lowering air pollutant emissions—and will continue to do so. This analysis estimates how recent, ongoing, and future State energy policies could impact air pollutant concentrations and public health outcomes in communities throughout New York State.

- All communities in New York State would experience public health benefits as a result of implementing State energy policies that would substantially reduce air pollutant emissions relative to the No Action scenario, lowering pollutant concentrations. As a result of policies in the Plan’s core planning scenario, Additional Action, population-level health risks associated with exposure to air pollutants would be lower, including cumulatively from 2025–2040 avoiding approximately 6,500 cases of premature mortality, 2,700 nonfatal heart attacks, and nearly 8,700 emergency room visits for asthma, and leading to further improvements in other metrics. Under all planning scenarios, health benefits are expected to increase over time from 2025 to 2040 and continue beyond 2040. These projections represent statistical estimates of health benefits based on modeled changes in air pollution exposure, reflecting risk reductions across populations rather than definitive outcomes for specific individuals.
- The health analysis estimates the benefits from reduced exposure to fine particulate matter (PM_{2.5}) concentrations at the community scale and ozone concentration reductions at the county scale for three scenarios of the Plan: Current Policies, Additional Action, and Net Zero B. In general, the cumulative projected air pollution concentration reductions and ensuing health benefits from the Additional Action scenario are 60 percent greater than those from the Current Policies scenario, and the estimated potential benefits from the Net Zero B scenario are approximately triple the Additional Action scenario’s benefits.

- While roughly 37 percent of the statewide population is projected to live in geographic areas designated as disadvantaged communities (DACs) in analysis years, DAC areas would accrue approximately 50 percent of the physical health benefits under all scenarios because DAC areas would often experience greater improvements in air quality and also have higher baseline incidence rates for the health conditions analyzed compared to non-DAC areas. Higher benefits within DAC areas are expected in all areas of the state. Accounting for differences in population, DAC areas would experience approximately 70 percent higher benefits than non-DAC areas under all scenarios.
- The greatest benefits would occur in urban areas where air pollutant emission reductions and population are greatest. Approximately 80-90 percent of the health benefits would come from emission reductions in the transportation and buildings sectors. The Additional Action and Net Zero B scenarios include additional policies that reduce emissions from the industrial, aircraft, and non-road (Net Zero B only) sectors. Benefits in DAC areas from the use of sustainable aviation fuel are more than double the benefits compared to non-DAC areas per capita.
- The combined societal value of the public health benefits from reductions in PM_{2.5} and ozone concentrations from 2025 to 2040 is estimated to be nearly \$52 billion for Additional Action (net present value 2024\$).
- Public health benefits would have been approximately 47 percent higher in 2040, relative to the Current Policies scenario, if federal energy policy rollbacks as of October 2025 had not occurred. Further federal policy rollbacks could potentially decrease 2040 health benefits by approximately 27 percent relative to the Current Policies scenario. These differences amount to thousands of cases of premature mortality, nonfatal heart attacks, and other public health impacts. Overall, current federal policies may have set back public health benefits that may have been achieved by 2040 by 4 years, and further federal rollbacks could result in the same level of benefits being set back beyond 2050.

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1. Overview of Public Health Analysis Approach

This public health analysis evaluates the benefits associated with the future energy scenarios developed in the Pathways Analysis, described in greater detail in the Pathways Analysis chapter of this State Energy Plan (Plan). The health analysis estimates the potential impact of changes in fuel combustion from economywide energy policies on air pollutant emissions and ensuing public health outcomes. This public health analysis followed the same general approach used previously in the New York Scoping Plan,¹ while applying an improved analysis modeling framework aimed at providing more detailed community-scale effects.

The basic framework of the health analysis is as follows:

- Estimate reductions of air pollutant emissions based on changes in fuel consumption from the Pathways Analysis (see Pathways Analysis chapter of this Plan).
- Model changes in air quality resulting from reductions in air pollutant emissions.
- Model changes in public health effects resulting from changes in air quality.
- Calculate the value of the change in health effects using standard economic values.

NYSDERDA used a newly developed air quality and health impacts modeling framework—the New York Community-Scale Health and Air Pollution Policy Analysis (NY-CHAPPA) model²—to conduct the health analysis. The NY-CHAPPA modeling framework estimates benefits at a community scale, which enables evaluation of potential health benefits within geographic disadvantaged communities (DACs) as defined under the Climate Leadership and Community Protection Act (Climate Act).³ Emissions were estimated based on regional changes in fuel consumption from the Pathways Analysis for each scenario and downscaled to the census tract level.

The health analysis in the Plan uses NY-CHAPPA v2.0, which uses 2020 census tract definitions and emissions sources, receptors, and updated geographic DAC definitions. The model is an update from NY-CHAPPA v1.0, which used 2010 census tracts and was used for the health analysis in the Draft Plan.

To calculate changes in health effects for the Plan scenarios, NY-CHAPPA projects the change in fine particulate matter (PM_{2.5}) concentration resulting from changes in air pollutant emissions. The air quality model accounts for primary (directly emitted) PM_{2.5} and precursor pollutants, including nitrogen oxides (NO_x), sulfur dioxide (SO₂), volatile organic compounds (VOCs), and ammonia (NH₃) that react in the atmosphere to form secondary PM_{2.5}. Dispersion of local emissions sources, transport of pollutants between New York State regions, the influx of pollutants from outside New York State, and chemical transformation are combined in the modeling framework to estimate the change in PM_{2.5} concentrations in each census tract.

NY-CHAPPA then applies functions that correlate the change in PM_{2.5} concentrations to changes in health effects in each census tract. The health impact functions included in NY-CHAPPA are those from the U.S. Environmental Protection Agency's (EPA) CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), as well as some New York City-specific functions for respiratory-related

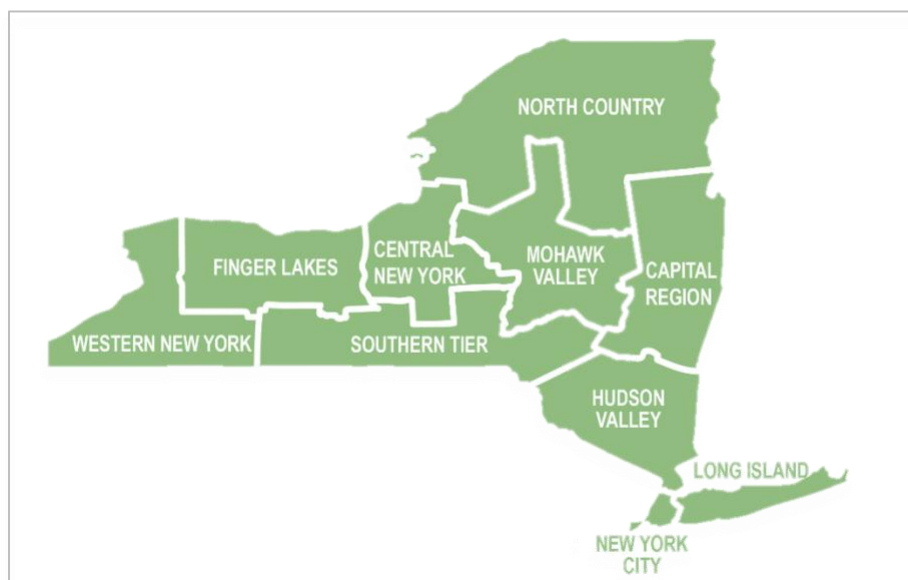
emergency room visits and hospitalizations for cardiovascular events (see the appendix to this chapter for additional information on the health impact functions used in this analysis).^{4,5} These individual physical health effects are also evaluated as a societal value, which enables combining the various health effects into a single metric that can also be used for the benefit-cost analysis of the Plan. NY-CHAPPA calculates both a low and high value, based on different approaches for estimating avoided mortality and nonfatal heart attacks.

The methodology used to estimate public health impacts and their societal value is based on current scientific understanding of the relationship between PM_{2.5} or ozone and human health and the economic valuation of these health effects drawn from the U.S. EPA's Integrated Science Assessment for Particulate Matter,⁶ Integrated Science Assessment for Ozone and Related Photochemical Oxidants,⁷ and methodology that has been extensively reviewed by independent scientific bodies. Additional information on the health impact functions and monetary values is in the appendix to this chapter.

NY-CHAPPA examines the change in health effects due only to changes in PM_{2.5} concentrations. The emission reductions under the Plan scenarios will have additional air quality benefits not captured by NY-CHAPPA, including reductions in ozone concentrations. To provide an estimate of the benefits from reduced ozone concentrations, COBRA was used.⁸ Ozone benefits from COBRA are limited to the county-level spatial resolution, which is not sufficient to estimate DAC benefits because DAC areas are defined at the census tract scale. Because NY-CHAPPA has a higher geographic resolution than COBRA in terms of both emissions inputs and health outputs, most of the results discussed below are focused on the PM_{2.5} results from NY-CHAPPA. The ozone benefits, which tend to be relatively smaller than the PM_{2.5} benefits under the scenarios examined in this analysis (see Section 3.4), are included in the results for physical benefits and their societal value, and the results are clearly marked to indicate whether the results are from PM_{2.5}, ozone, or both.

COBRA was also used to quantify the benefits of the Plan's policy scenarios on out-of-state regions. Emissions differences under the policy scenarios relative to the No Action scenario within New York State were modeled in COBRA to estimate the value of societal benefits of lower PM_{2.5} and ozone concentrations downwind in the continental U.S. outside of the state. The physical health benefits shown in Sections 3.1, 3.2, and 3.3 are for New York State only and out-of-state results are shown for societal values in Sections 3.4 and 3.5.

In many cases, results are presented at the regional level to show the geographic distribution of the benefits. Figure 1 shows the regions used in this health analysis. Results are aggregated to the regional and community-type level because of uncertainties in the local details of the policies scenarios. For more information on the health analysis methodology and uncertainties see the appendix to this chapter.

Figure 1. New York State Regions for Health Analysis Results

The health analysis evaluated the change in health effects in five-year increments between 2025 and 2050 and interpolated results in between years to estimate the cumulative benefits. The results presented below are for 2025–2040. More information on benefits for 2040–2050, as well as more detailed geographic results at the county level are available in the appendix to this chapter and public health impacts analysis data annex.

Estimates of public health benefits in this health analysis only include benefits from reduced concentrations of PM_{2.5} and ozone in outdoor air and do not include other potential benefits of reduced air pollutant emissions from State energy policies, including reductions in concentrations of nitrogen dioxide (NO₂) and other hazardous air pollutants or improvements to indoor air quality. In addition to health benefits from reductions in fuel consumption, policies in the Plan may result in additional health benefits not quantified here, including benefits from increased physical activity due to increased active transportation modes and energy efficiency interventions in residential buildings, which were both shown to contribute additional health benefits in analysis done for the Scoping Plan.¹ To the extent that programs resulting from the Plan invest in improving energy security, there may also be additional public health benefits. Climate-related public health impacts avoided are accounted for separately as the total value of avoided damages from greenhouse gas pollution within the benefit-cost analysis (see Pathways Analysis chapter). Overall, the public health benefits quantified in this analysis should be considered a conservatively low estimate of health benefits from the State’s energy policies.

2. Overview of the Public Health Analysis Scenarios

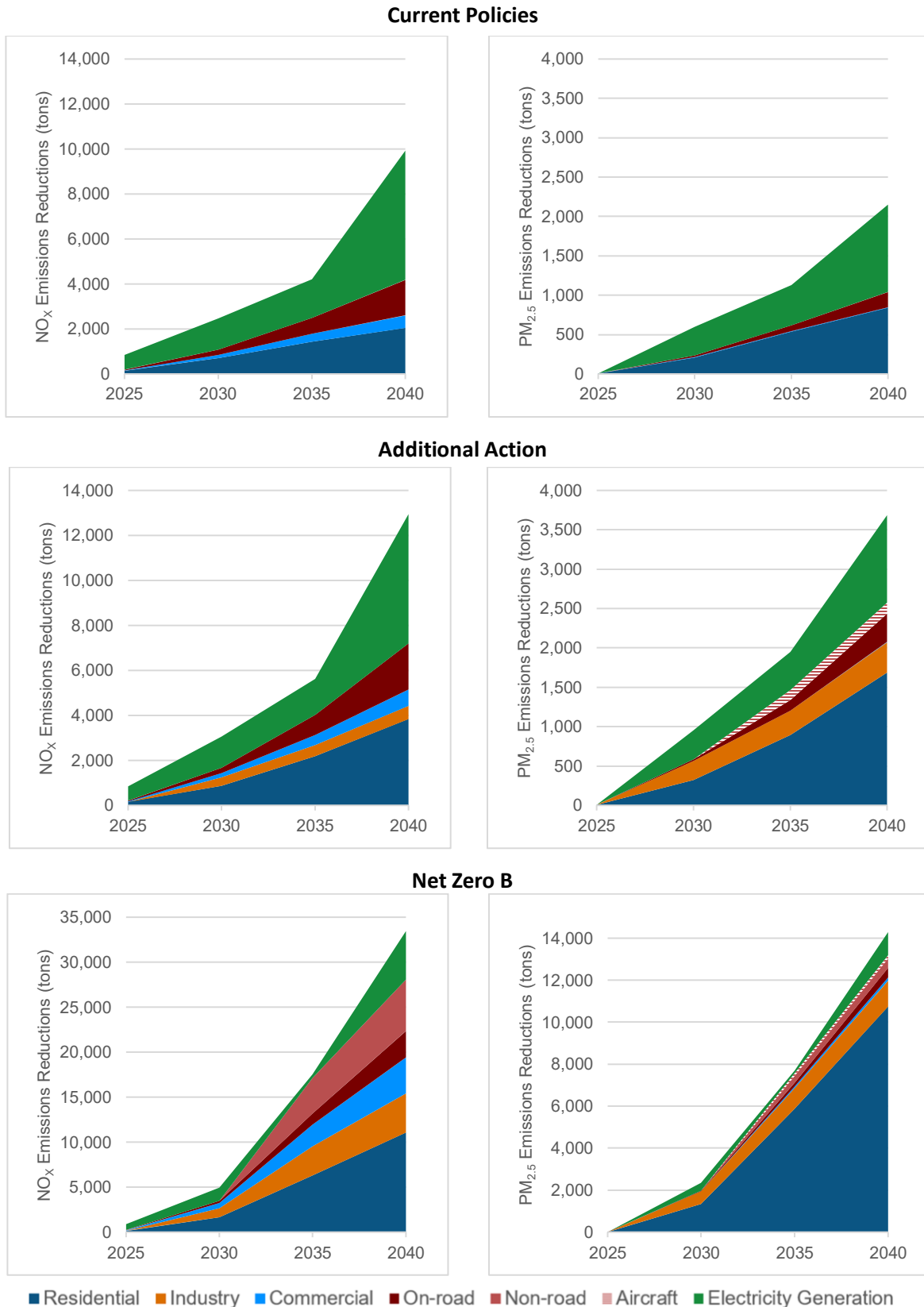
The health analysis focused on three scenarios of the Plan, described in detail in the Pathways Analysis chapter of this Plan and briefly summarized in Table 1.⁹ For all policy scenarios, the change in health effects is estimated relative to the No Action scenario, which excludes recent State and local policies. The core planning scenario for the Plan is represented by the Additional Action scenario. Additional sensitivity cases exploring the impacts of federal policies are presented in Section 3.5.

Table 1. Scenarios Considered in the Health Analysis

Scenario	Description
No Action	Includes federal incentives (as of October 2025) and legacy New York State policies but excludes the Climate Act and more recent additional State and local policies.
Current Policies	Current progress toward achievement of enacted State and local policies (e.g., Clean Energy Standard progress, building code updates, Advanced Clean Cars/Trucks).
Additional Action	All actions included under Current Policies scenario plus additional progress toward adoption of clean technologies through a mix of future programs and investments aligned with recommendations in the Plan.
Net Zero B	Accelerates adoption of clean energy technologies in all sectors toward achievement of economywide net zero by 2050.

Statewide annual air pollutant emissions were estimated based on projected fuel consumption from the scenarios in Table 1 and emission factors for each sector and fuel (see the appendix to this chapter for a full description of emissions inputs). Figure 2 shows the change in NO_x and PM_{2.5} emissions by sector for each policy scenario relative to the No Action scenario emissions. In 2040, annual NO_x emissions would be nearly 10,000 tons, 12,950 tons, and 33,500 tons lower under the Current Policies, Additional Action, and Net Zero B scenarios, respectively, than in the No Action scenario. Annual PM_{2.5} emissions in 2040 would be nearly 2,200 tons, 3,700 tons, and 14,300 tons lower under the Current Policies, Additional Action, and Net Zero B scenarios, respectively, than in the No Action scenario. Changes in sectoral emissions over 2025-2040 are driven by the policies described in the Pathways chapter and Section 3.3 includes additional discussion of health benefits by sector. These lower air pollutant emissions drive lower PM_{2.5} and ozone concentrations and result in health benefits discussed in the results sections below.

Figure 2. Statewide Annual NO_x and PM_{2.5} Emission Reductions by Sector and Scenario Relative to the No Action Scenario Emissions in the Same Year



3. Public Health Impact Analysis Results and Discussion

The results in this section show the estimated air quality and public health benefits of the Current Policies, Additional Action, and Net Zero B scenarios relative to the No Action scenario absent recent State and local policies. This section provides an overview of the results of this analysis for 2025–2040, including estimated public health effects and the societal value of those benefits, along with breakdowns of benefits by region and sector. The results are also presented in terms of the share of benefits expected in geographic DAC areas.

NY-CHAPPA provides both low and high estimates of health benefits as described above.¹⁰ Where only one value is shown, the high estimate is used—generally, the difference between the high and low estimates is in magnitude only, and the estimates’ distribution will otherwise be the same temporally and geographically.

Estimates of health cases refers to the avoided number of new cases of a health outcome over a specified time period due to reduced exposure to PM_{2.5} or ozone. A change in cases reflects changes in statistical risk that are aggregated over an entire population. For example, a reduction in premature mortality risk for a certain population and its associated monetary value represents the sum of many small risk reductions and does not correspond to the loss or value of an individual life.

The results presented below are for 2025–2040. More information on benefits for 2040–2050, as well as more detailed geographic results at the county level are available in the appendix to this chapter and data annex. The section begins with an overview of the statewide results followed by regional results and results by sector. The section concludes with a discussion and analysis of the findings and their implications for the core policy scenarios as well as additional results from a sensitivity analysis of the impacts of federal policies.

3.1. Statewide Health Benefits

Under all scenarios in the Plan, lower air pollutant emissions relative to the No Action scenario are projected to lower PM_{2.5} and ozone concentrations and result in public health benefits.

Figure 3 shows the avoided annual cases of premature mortality (from PM_{2.5} and ozone), nonfatal heart attacks (from PM_{2.5} only),¹¹ and emergency room visits for asthma (from PM_{2.5} and ozone) for the three scenarios in 2030, 2035, and 2040. The health benefits from all scenarios would increase over time and the cumulative benefits from Net Zero B are expected to be more than triple those of Additional Action, which in turn are approximately 60 percent greater than the health benefits expected for Current Policies. Figure 4 shows the cumulative number of avoided health effects from 2025–2040 for these three health endpoints.

Figure 3. Statewide Annual Avoided Cases from Lower PM_{2.5} and Ozone Concentrations by Scenario Relative to the No Action Scenario (2030, 2035, 2040)

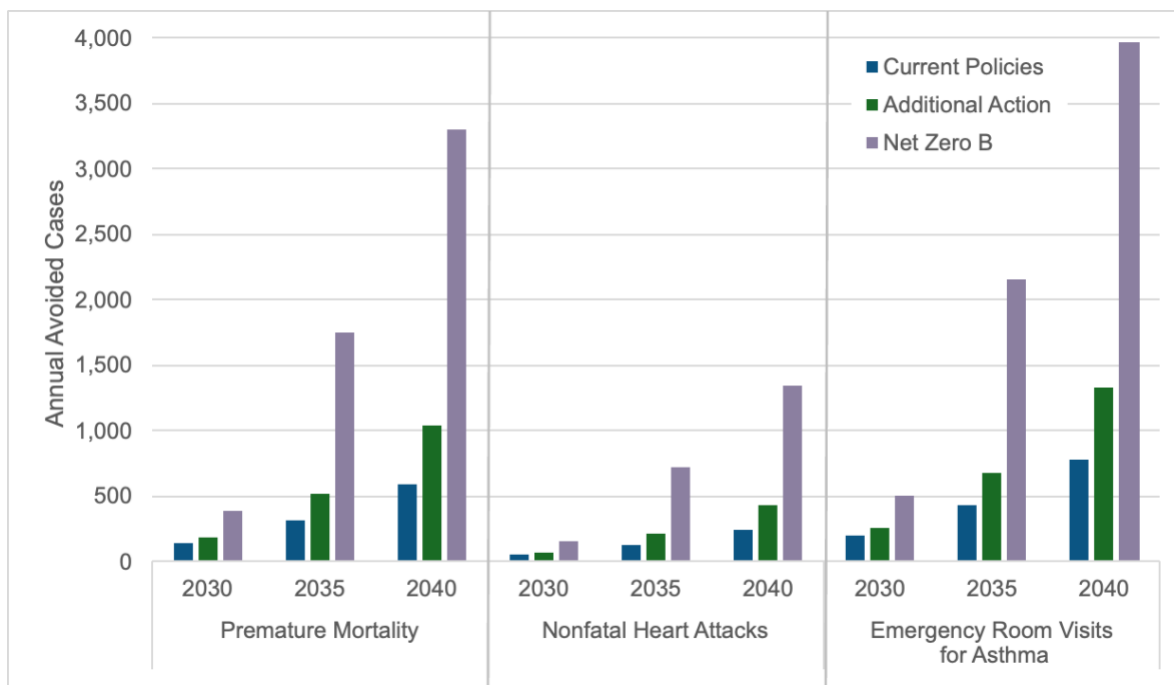


Figure 4. Statewide Cumulative Avoided Cases from Lower PM_{2.5} and Ozone Concentrations by Scenario Relative to the No Action Scenario (2025–2040)

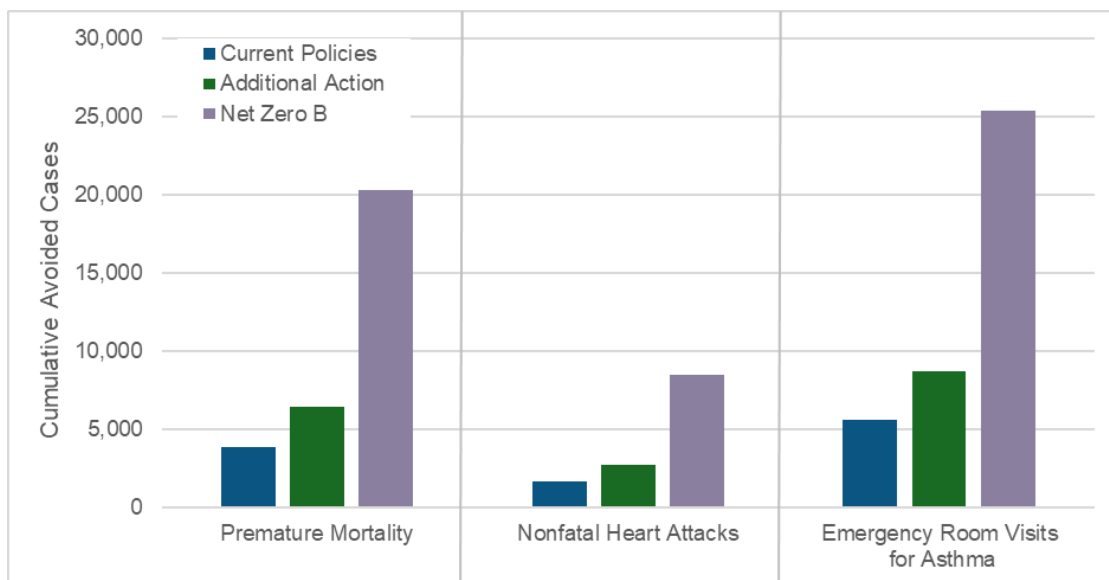


Table 2 shows annual avoided health effects from lower PM_{2.5} and ozone concentrations for all three scenarios in 2040 including additional health endpoints. Note that the fraction of benefits in DAC areas is only due to benefits from lower PM_{2.5} concentrations because the results for ozone are only available at

the county level. All scenarios are projected to result in health benefits across the range of endpoints, and the magnitude of benefits increases from Current Policies to Additional Action to Net Zero B as the reductions in economywide fuel combustion increase. In 2040, for example, Net Zero B is expected to result in approximately 3,200 avoided premature mortality cases, and the Current Policies and Additional Action scenarios have estimated avoided mortality of approximately 570 cases and 1,000 cases per year, respectively. See the data annex for county level avoided health cases for all model years.

Table 2. Statewide Annual Avoided Public Health Effects from Lower PM_{2.5} and Ozone Concentrations by Scenario Relative to the No Action Scenario (2040)

Health Effect	Avoided Cases in 2040			Fraction in DAC Areas (from PM _{2.5})
<i>Geographic Population of Disadvantaged Communities in New York:</i>				37%
Scenario:	Current Policies	Additional Action	Net Zero B	0% 25% 50% 75%
Premature Mortality	570	1,000	3,200	50%
Nonfatal Heart Attacks	240	430	1,300	48%
Hospitalizations	160	280	880	50%
Acute Bronchitis	260	450	1,400	50%
Respiratory Symptoms	8,000	14,100	44,000	50%
Emergency Room Visits, Asthma	780	1,300	4,000	72%
Asthma Exacerbation	4,900	8,600	27,000	50%
Minor Restricted Activity Days	160,000	280,000	870,000	49%
Work Loss Days	27,000	48,000	150,000	49%

Under all scenarios, geographic DAC areas would experience greater avoided health effects than their share of the state’s population (37 percent) because DACs have higher baseline incidence for the health endpoints analyzed. For example, DAC areas would experience 72 percent of the benefits from avoided emergency room visits for asthma because DACs have a particularly high baseline incidence of emergency room visits for asthma (Table 2). The fraction of health benefits accruing to DAC areas shown in Table 2 would be similar across all scenarios. This higher fraction of benefits within DAC areas relative to population fraction is also evident at the regional and county level. For more details see Section 3.2 and the appendix to this chapter.

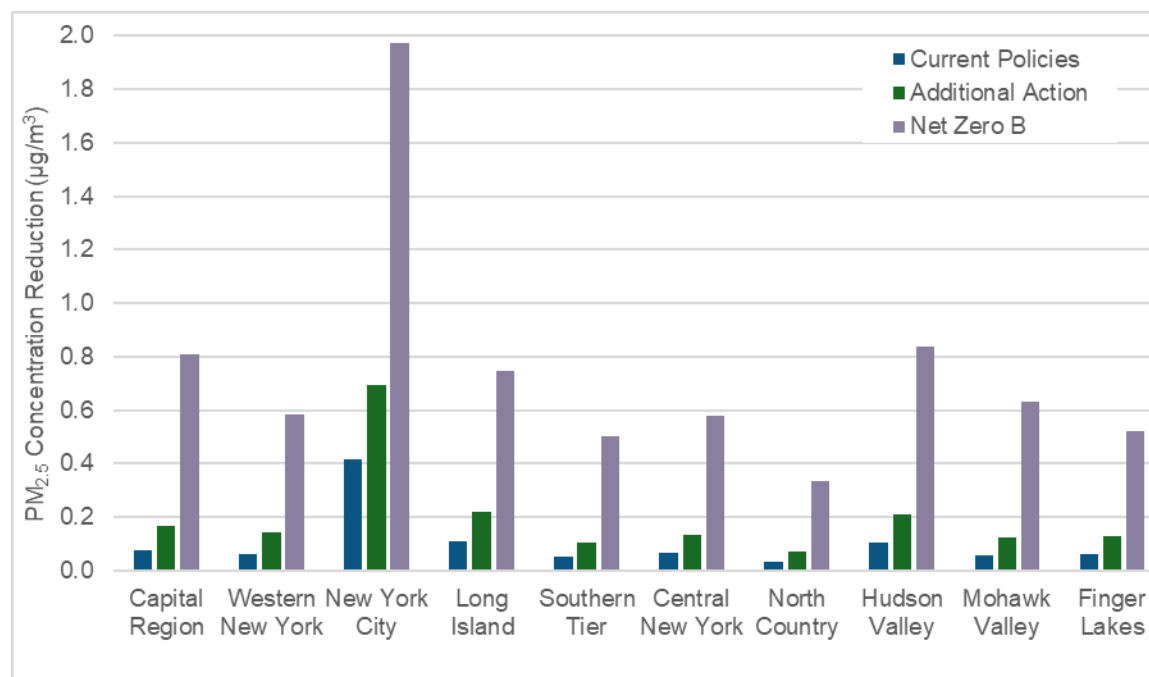
The physical benefits shown in this section are for New York State only and there would be additional out-of-state health benefits not included here.

3.2. Public Health Benefits by Region

Every region of the state would experience air quality improvements in all scenarios relative to the No Action scenario. Figure 5 shows the population-weighted distribution of lower annual average PM_{2.5} concentrations relative to the No Action scenario across each state region in 2040 for all three scenarios.

Within regions, PM_{2.5} concentration reductions would be largest in urban areas, including but not limited to New York City, where both population and air pollutant concentrations are greatest. Under the Additional Action scenario, for example, New York City would experience a 0.7 µg/m³ lower annual average PM_{2.5} concentrations, whereas the other regions are expected to experience approximately 0.1-0.2 µg/m³ lower annual average PM_{2.5} concentrations in 2040 relative to the No Action scenario. This is because the New York City region is a dense urban area with higher air pollutant concentrations relative to other regions of the state under the No Action scenario, so New York City is more sensitive to lower emissions under the policy scenarios. While other regions of the state would experience lower magnitudes of annual average PM_{2.5} concentration reductions compared to New York City, within these regions, air quality improvements would be greater in urban counties where air pollutant concentrations are higher compared to non-urban counties. Additional data at the county level can be found in the appendix to this chapter and data annex.

Figure 5. Population-Weighted Average PM_{2.5} Concentration Reductions by Region and Scenario Relative to the No Action Scenario (2040)



Due to lower PM_{2.5} concentrations in the policy scenarios relative to the No Action scenario, each region would also experience population-level public health benefits (Figure 6). While all the regions would experience net positive health benefits, most of the benefits for all health endpoints in all scenarios would accrue in the New York City region because it has the highest population density and would experience the greatest change in air pollution emissions relative to the No Action Scenario, followed by

the Long Island and Hudson Valley regions. On a per capita basis, the benefits gap across regions is somewhat smaller than in absolute terms (Figure 6). While the New York City region is expected to experience higher benefits than other regions in all scenarios analyzed, that discrepancy is somewhat less pronounced under the Additional Action scenario relative to the Current Policies, and substantially less pronounced under the Net Zero B scenario. For example, in the Net Zero B scenario, DAC areas in Mohawk Valley experience the greatest per capital benefits compared to all other regions. In general, closing the gap in benefits between regions is more pronounced for DAC areas where benefits outside the New York City region increase proportionally more than in New York City in the Additional Action and Net Zero B scenarios.

Across regions, air quality improvements are generally greater in geographic DAC areas in all three scenarios. In the New York City region, while there are differences in local exposure, on average, DAC and non-DAC areas would experience similar annual average PM_{2.5} concentration reductions.

DAC areas in general benefit from larger reductions in PM_{2.5} concentrations because in most regions, those communities tend to be clustered in urban counties where air pollutant concentrations and population density are higher.

Figure 6. Per Capita Annual Health Benefits for Disadvantaged Community and Non-Disadvantaged Communities Areas from Lower PM_{2.5} Concentrations by Region and Scenario Relative to the No Action Scenario (2040)



Using the Additional Action scenario as a representative example, Figure 7 shows that in each region, geographic DAC areas receive a larger share of 2025–2040 cumulative monetary value from lower PM_{2.5}

concentrations relative to their share of the population. In regions outside of New York City, Long Island, and Hudson Valley, the fraction of cumulative benefits accruing to DAC areas is 14 percent or greater than the geographic DAC share of the population. Statewide, 50 percent of cumulative benefits accrue to DAC areas compared to 37 percent of the statewide population projected to live in geographic DAC areas. Similar relationships are observed for the Current Policies and Net Zero B scenarios (see the appendix to this chapter).

Figure 7. Fraction of Cumulative Benefits from Lower PM_{2.5} Concentrations Accruing in DAC Areas Compared to Fraction of Population in DAC Areas by Region and Statewide (Additional Action Scenario Relative to the No Action Scenario, 2025–2040)

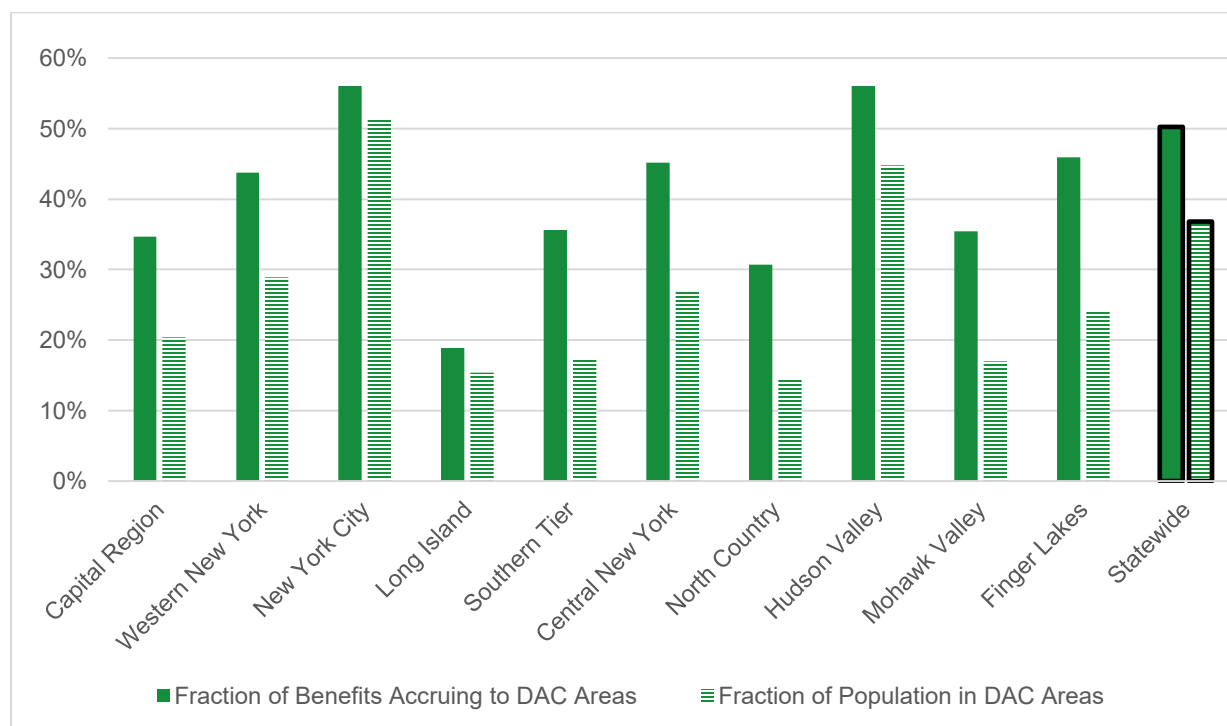
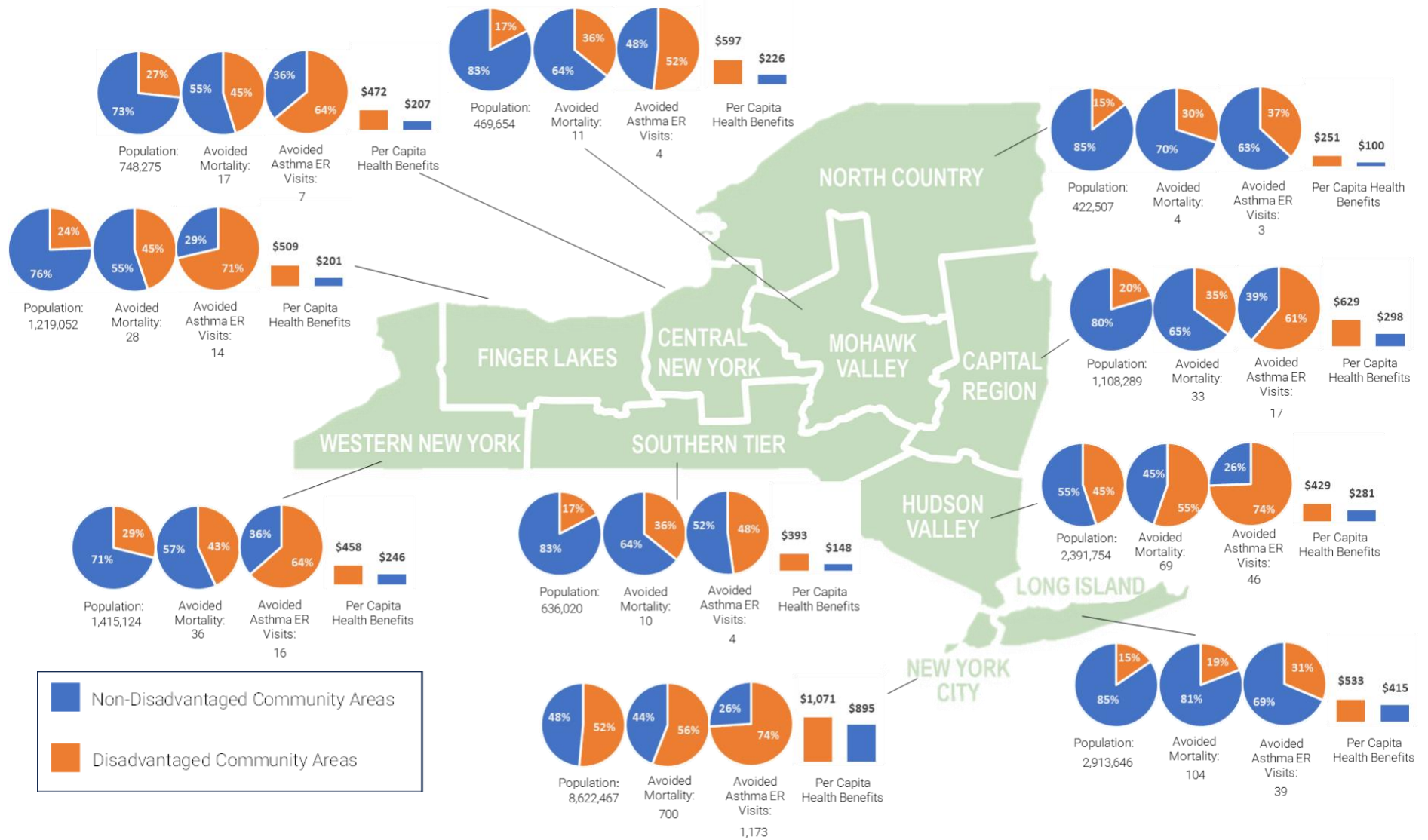


Figure 8 summarizes the physical benefits from lower PM_{2.5} concentration experienced by geographic DACs in the 10 regions across the state from the Additional Action scenario relative to the No Action scenario in 2040. The pie charts show DAC and non-DAC area fractions of regional population, avoided premature mortality cases, and avoided asthma emergency room (ER) visits, with regional totals beneath each pie chart. The bar charts show annual per capita monetary values for DAC and non-DAC areas for each region, representing the combined value of all avoided health effect types. The fraction of health benefits experienced within DAC areas are expected to be greater than their fraction of the population and per-capita benefits would be higher in DAC areas relative to non-DAC areas in every region of the state. While the per-capita values vary in magnitude by scenario, DAC areas are estimated to receive greater per capita benefits compared to non-DAC areas in all scenarios. See the appendix to this chapter for additional details for other scenarios. Figure 8 shows annual benefits for 2040 only, but DAC and non-DAC area fractional benefits are similar in other years.

Figure 8. Summary of Annual Public Health Benefits from Lower PM_{2.5} Concentrations (Additional Action Scenario Relative to the No Action Scenario, 2040)



3.3. Health Benefits by Sector

For the three policy scenarios, the building and transportation sectors together account for most of the statewide public health benefits from lower PM_{2.5} concentrations relative to the No Action scenario by 2040 (Figure 9), with increasing benefits from other sectors in the Additional Action and Net Zero B scenarios, respectively. The 2025–2040 cumulative statewide benefits from buildings account for 72 percent of the benefits from Current Policies, 59 percent of the benefits from Additional Action and 71 percent of the benefits from Net Zero B. The cumulative statewide benefits from transportation account for 21 percent, 30 percent, and 17 percent for Current Policies, Additional Action, and Net Zero B, respectively. As energy policies are implemented from 2025 to 2040, the magnitude of health benefits associated with emission reductions from all sectors increases over time under all three scenarios (Figure 11) (note the fractions of benefits from a given sector are affected both by the overall increase and by the relative increase in the sector). The contribution of different sectors as a fraction of the total benefits is shown by community type (Figure 9), as well as how it differs by region (Figure 10) and over time (Figure 11). These variations are described for each sector below. See the appendix to this chapter for additional information on all scenarios.

3.3.1. Buildings

The buildings sector accounts for 72 percent of the total statewide value associated with health benefits from PM_{2.5} from 2025 to 2040 under Current Policies, 59 percent under Additional Action, and 71 percent of the total value under Net Zero B. The health benefits associated with the buildings sector is dominated by lower emissions in the residential subsector relative to the No Action scenario, and commercial buildings represent a small contributor to benefits in the overall buildings sector. Residential benefits are mostly from less fossil fuel heating relative to the No Action scenario, with a substantial contribution from less residential wood combustion, which has outsized emissions relative to its energy use, and is more prevalent in upstate regions. While mitigation characterized by the Pathways Analysis is not focused on reducing wood combustion, benefits are associated with energy efficiency improvements along with reduction in the use of wood when cleaner heating systems are installed, and wood may continue to be used in a more limited way for supplemental heating. Despite the wood benefits representing a very small fraction of shift in energy use, the high emission factors associated with wood combustion result in outsized benefits relative to residential fossil fuels. Note, health benefits associated with buildings represent benefits from pollutant emissions reductions in outdoor air; additional health benefits from lower pollutant emissions in indoor air are not included in this analysis and would be expected to provide additional benefits.

Figure 11 shows the benefits associated with the buildings sector increase from 2025 to 2040. Under all policy scenarios, the fractional benefits from the residential subsector, including from both lower fossil fuel and wood combustion emissions, would increase over time as buildings decarbonize and increase energy efficiency (see Figure 2). The fractional benefits from buildings relative to other scenarios would be greatest under Current Policies and Net Zero B. Under Net Zero B, residential and commercial heat pumps would reach 100 percent sales share by 2035, whereas in Current Policies, absolute benefits from all sectors are lower and buildings account for a larger relative fraction (Figure 11). However, even under the Additional Action scenario, while emission reductions from buildings are slightly lower in magnitude

compared to Net Zero B, reductions in fossil fuel heating account for a large fraction of benefits (53 percent) in New York City (Figure 10).

Figure 9. Cumulative Societal Value from Lower In-State PM_{2.5} Concentrations by Sector and Scenario Relative to the No Action Scenario, and Additional Breakdown for DAC Areas vs. Non-DAC Areas for Additional Action (2025–2040)

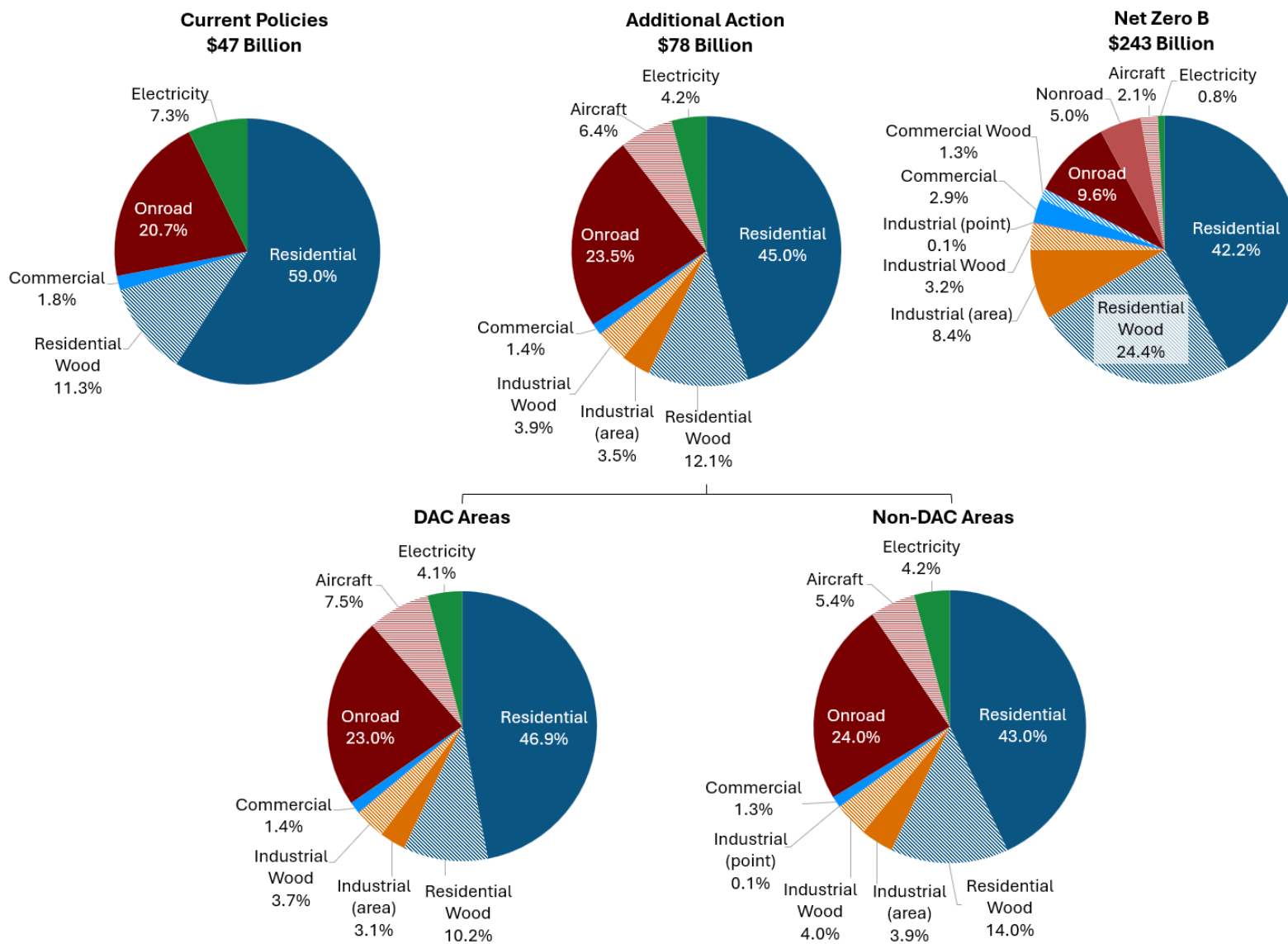


Figure 10. Distribution of the Cumulative Value of Benefits from Lower In-State PM_{2.5} Concentrations by Region and Sector (Additional Action Scenario Relative to the No Action Scenario, 2025–2040)

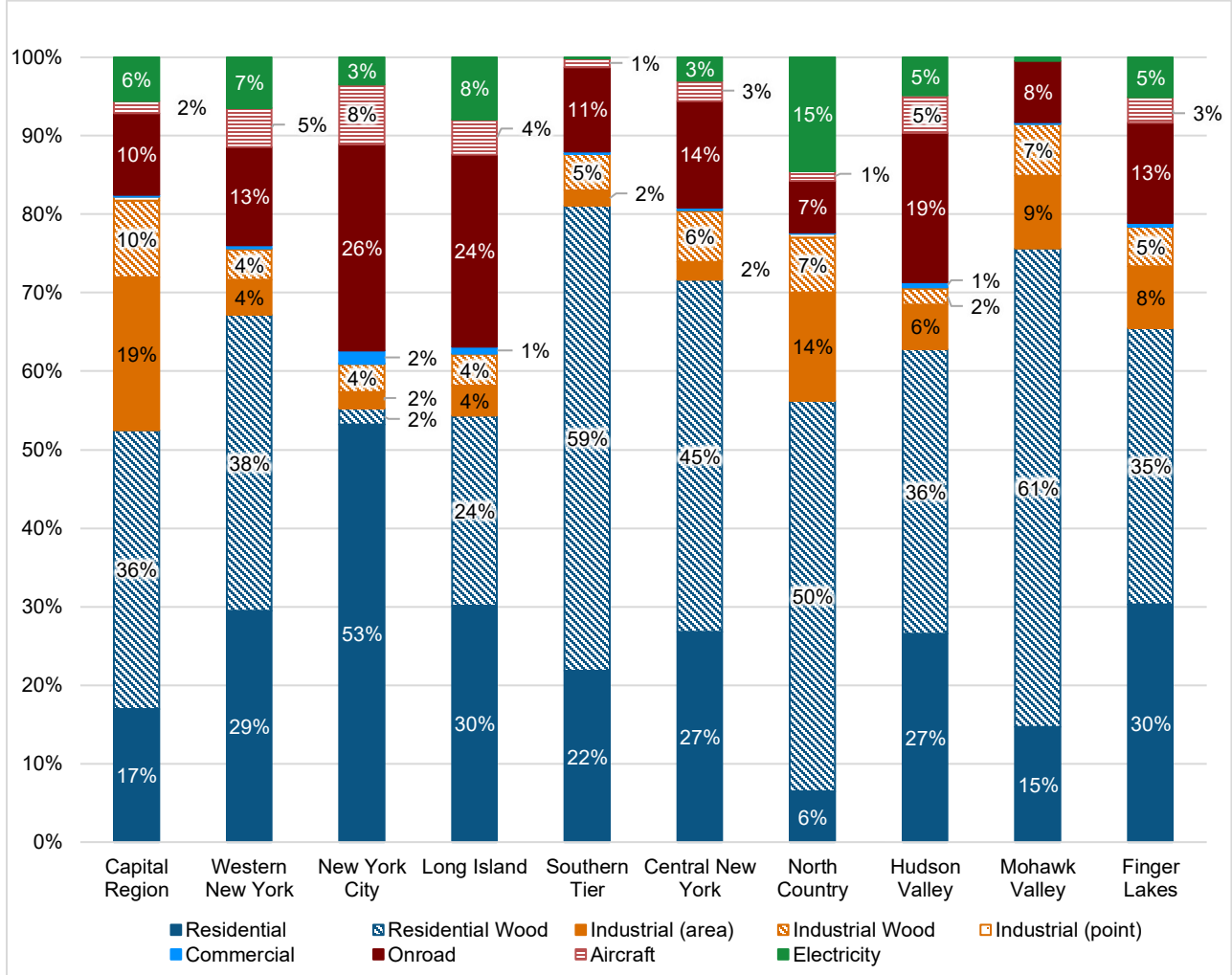
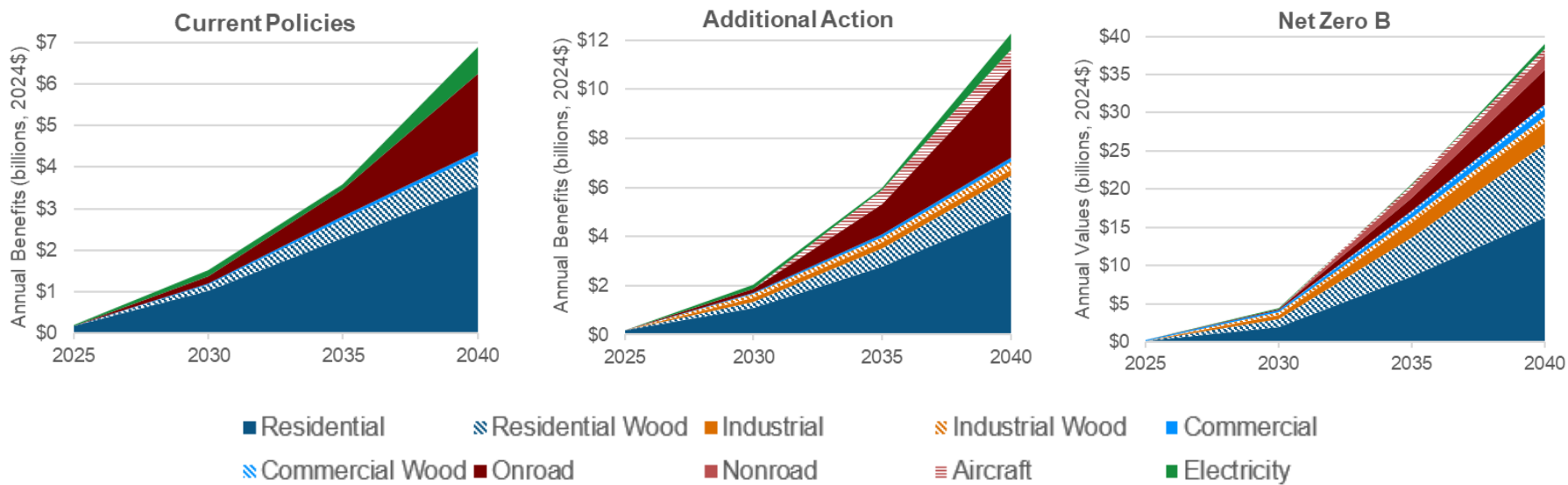


Figure 11. Distribution of Annual Value of Benefits from Lower In-State PM_{2.5} Concentrations by Sector and Scenario Relative to the No Action Scenario (2025-2040)



Regionally, lower emissions from residential wood relative to the No Action scenario account for most residential buildings benefits in some upstate regions including Southern Tier, Central New York, North Country, and Mohawk Valley under Current Policies and Additional Action (Figure 10). Emissions from commercial wood combustion under Current Policies and Additional Action are the same as in the No Action scenario. Under Net Zero B, lower emissions from commercial wood relative to the No Action scenario account for approximately 1 percent of the benefits starting in 2035.

DAC and non-DAC areas would experience a similar fraction of benefits from lower emissions from buildings overall; however, under all scenarios, more of the benefits accruing in DAC areas would be from less fossil fuel heating than from less residential wood heating relative to the No Action scenario, which is more prevalent in non-urban areas with lower geographic DAC populations.

3.3.2. Transportation

On-road vehicles account for 21 percent, 24 percent, and 12 percent of the total statewide value associated with health benefits from PM_{2.5} from 2025 to 2040 under Current Policies, Additional Action, and Net Zero B, respectively. The transportation sector will undergo varying degrees of transformation under the policy scenarios as zero emission vehicle stock shares grow over time from 2030 to 2040 and benefits from on-road vehicles increase over time in all scenarios (Figure 11). The impact of the loss of federal EV tax credits is explored in Section 3.5. Regionally, relative benefits from lower emissions from on-road vehicles relative to the No Action scenario are larger in urban regions where denser road networks are geographically closer to populations compared to rural regions.

The use of sustainable aviation fuel (SAF) is expected to lower air pollutant emissions near airports, and the impacts from the use of SAF were modeled in NY-CHAPPA (see the appendix to this chapter). SAF accounted for 15.1 TBtu and 14.9 TBtu of the total projected fuel for domestic flights in 2035 under Additional Action and Net Zero B, respectively, and 32.2 TBtu and 31.4 TBtu of the total jet fuel for domestic flights in 2040 under Additional Action and Net Zero B, respectively. Lower emissions from the use of SAF relative to the No Action scenario account for approximately 6 percent and 2 percent of total 2025–2040 projected benefits under Additional Action and Net Zero B, respectively. A small portion of the projected aircraft benefits from Net Zero B are due to decreases in total jet fuel use in addition to the use of SAF. Health benefits from SAF would likely be pronounced in areas surrounding large airports and have a notably larger benefit within DACs in areas like New York City.

In addition to aircraft, other emissions from the non-road sector include marine, rail, and non-road engines used in construction, agriculture, and mining. The non-road sector accounts for approximately 5 percent of the total value associated with health benefits from PM_{2.5} from 2025 to 2040 under the Net Zero B scenario only and does not contribute benefits under the other scenarios where non-road emissions are the same as the No Action scenario. As described in the appendix to this chapter, data on non-road sources are limited, particularly for non-road equipment, so the estimates of exposure to and potential for emission reductions from this sector are likely conservative. Furthermore, given the uncertainty regarding location of non-road engines over the years (e.g., construction) and model limitations regarding emission reduction projections for specific facilities, there are likely more benefits

from this sector and varying distribution of those benefits by community that cannot be represented in this analysis.

DAC and non-DAC areas would experience a similar fraction of benefits from lower emissions in the transportation sector overall under all scenarios (Figure 9). Note that benefits from lower emissions from on-road vehicles were not differentiated by vehicle type (i.e., light duty versus medium and heavy duty) in this analysis. Benefits in DAC areas from SAF are more than double the benefits compared to non-DAC areas per capita under both the Additional Action and Net Zero B scenarios in which SAF is included.

3.3.3. Electricity

The electricity sector accounts for 7 percent, 4 percent, and 2 percent of the cumulative health benefits from 2025 to 2040 under Current Policies, Additional Action, and Net Zero B, respectively. Under all three scenarios, the electric sector will undergo changes in annual loads and resource mix. For example, electricity accounts for approximately 8 percent of benefits in 2030 and 5 percent in 2040 under the Additional Action scenario (Figure 11). This temporal pattern reflects the varying timelines in which different sectors decarbonize and changes in annual loads (see the Pathways Analysis chapter of this Plan). Under all policy scenarios, there are lower emissions from the electricity sector relative to the No Action scenario, but in the earlier model years before 2040, these reductions are tempered by increased load from other sectors, which are expected to increasingly electrify.

Furthermore, while there are substantial emission reductions relative to the No Action scenario in the electricity sector, as shown in Figure 2, above, the resulting air quality and public health benefits from this sector are smaller compared to other sectors. This is due in part to the fact that emissions from the electricity sector tend to be released from taller smokestacks, which disperse the emissions more broadly than other sectors, such as residential buildings or on-road vehicles, which release their emissions at or near the ground level. In addition, emissions from the electricity sector are, in some cases, released in less densely populated areas, while the emissions from the residential and on-road sectors tend to be released in more densely populated areas.

The cumulative benefits from reduced emissions from electricity are similar in DAC areas and non-DAC areas statewide (Figure 9). Regionally, benefits from the electric sector are a larger fraction of relative benefits in the North Country, Long Island, and Western New York regions, compared to relative benefits from electricity in other regions (Figure 10). However, in absolute terms, the New York City, Long Island, and Hudson Valley regions have the highest benefits from lower emissions in the electricity sector.

A subset of the benefits from lower electricity sector emissions in the policy scenarios relative to the No Action scenario are from lower emissions from combustion turbines (CTs) and steam turbines (STs)¹² that typically operate to provide electricity during times of highest electricity demand. Lower emissions from these plants account for approximately 35 percent, 37 percent, and 45 percent of the projected cumulative (2025-2040) benefits from the electricity sector, for the Current Policies, Additional Action, and Net Zero B scenarios, respectively. Lower emissions from facilities that generate baseload power account for the remainder of the benefits in the electricity sector. Note that the share of the benefits from lower emissions from CTs and STs changes over time relative to facilities that generate baseload power. For example, in the Additional Action scenario, lower emissions from CTs and STs account for 56

percent of the benefits from the electricity sector in 2030, decreasing to 20 percent by 2040. This is due in part to the fact that many of these plants are retired over time in the No Action scenario, which reduces the impact of lower emissions from the policy scenarios relative to the No Action scenario in the later years.

Note that the scenarios considered here assume hydrogen combustion starting in 2040 for the remaining thermal generation needs. The analysis conservatively assumed that emission rates of NO_x from those sources (emissions per unit of energy) would be double those from similar natural gas units, though indications are that hydrogen-specific combustion turbines, control technology, and other approaches can mitigate the bulk of this impact. NO_x is a precursor contributing to the formation of PM_{2.5} and ozone, and therefore the assumption of higher NO_x emissions conservatively results in higher PM_{2.5} and ozone concentrations. However, given the elimination of direct PM_{2.5} emissions from hydrogen combustion, this change still has a net positive effect on air pollutant formation and health outcomes.

In addition, due to some differences in electric sector model representation in the later years of the Pathways Analysis, the benefits from the electric sector in 2040 may be somewhat conservatively low (see the appendix).

3.3.4. Industry

Both No Action and Current Policies include the same energy efficiency and fuel switching policies in the industrial sector, so only Additional Action and Net Zero B show the value associated with benefits from industry relative to No Action from 2025–2040 (Figure 9). Additional Action includes modest energy efficiency improvements for industry over Current Policies, resulting in approximately 7 percent of total benefits from 2025–2040. Net Zero B includes additional electrification, conversion to hydrogen, and efficiency improvements for industry, resulting in approximately 12 percent of total benefits from 2025 to 2040. Of the industrial sources, industrial point sources account for a small fraction of benefits relative to other sources at a statewide level. Industrial area and wood sources account for similar fractional benefits under Additional Action, and industrial area sources account for increasing fractional benefits by 2040 compared to industrial wood under Net Zero B (Figure 11). Industrial sources account for larger fractional benefits in some upstate regions, including the Capital Region, Mohawk Valley, and North Country (Figure 10), and additional benefits to local communities may be larger than those aggregated to the regional level shown here. Additional benefits from potential reductions in emissions of toxic air pollutants from industrial sources were not modeled as part of this analysis.

3.4. Societal Value of Total Public Health Benefits

The public health benefits from lower air pollutant concentrations described above are also evaluated as a societal value that can be combined into a single metric to evaluate and compare total public health benefits. Figure 12 shows the estimated public health benefits for 2025–2040 (net present value 2024\$) from lower PM_{2.5} and ozone concentrations under each scenario relative to the No Action scenario.¹³ Geographic DAC areas receive 49–51 percent of the in-state net present value benefits from reduced PM_{2.5} concentrations, depending on the scenario, which is a larger share of the benefits relative to their share of the population (37 percent). This is because most DAC areas benefit from greater emission reductions and these communities have higher baseline incidence rates for the health outcomes

analyzed, meaning air quality improvements in DAC areas will have a relatively larger effect in those areas compared to similar effects in non-DAC areas.

In addition to the benefits from lower in-state $PM_{2.5}$ concentrations estimated by NY-CHAPPA, the health analysis also applied EPA's COBRA tool to estimate additional benefits from lower ozone concentrations, both for New York State and other continental U.S. states, as well as the benefits to other states from lower $PM_{2.5}$ concentrations from state policies. Due to atmospheric transport of air pollutants, lower pollutant emissions in New York under the policy scenarios relative to the No Action scenario will result in lower pollutant concentrations and public health benefits downwind and outside of New York State in addition to the in-state benefits shown above. The air quality and public health benefits in other states from the policy scenarios relative to the No Action scenario tend to be concentrated in mid-Atlantic and Northeastern states, with the highest benefits in New Jersey, Connecticut, and Pennsylvania.

Figure 12 shows that most of the benefits from lower $PM_{2.5}$ and ozone concentrations would be experienced in New York State, accounting for 90 percent, 88 percent, and 84 percent of the total net present value (high value) of the benefits for the Current Policies, Additional Action, and Net Zero B scenarios, respectively. The combined in- and out-of-state ozone benefits tend to be relatively small compared to the $PM_{2.5}$ benefits, accounting for approximately 6 percent – 10 percent of the total net present value (low value) and approximately 3 percent – 5 percent of the total net present value (high value) of all benefits.

Figure 12. Net Present Value of Health Benefits from PM_{2.5} and Ozone by Scenario Relative to the No Action Scenario and by In-State and Out-of-State Benefits (2025–2040)

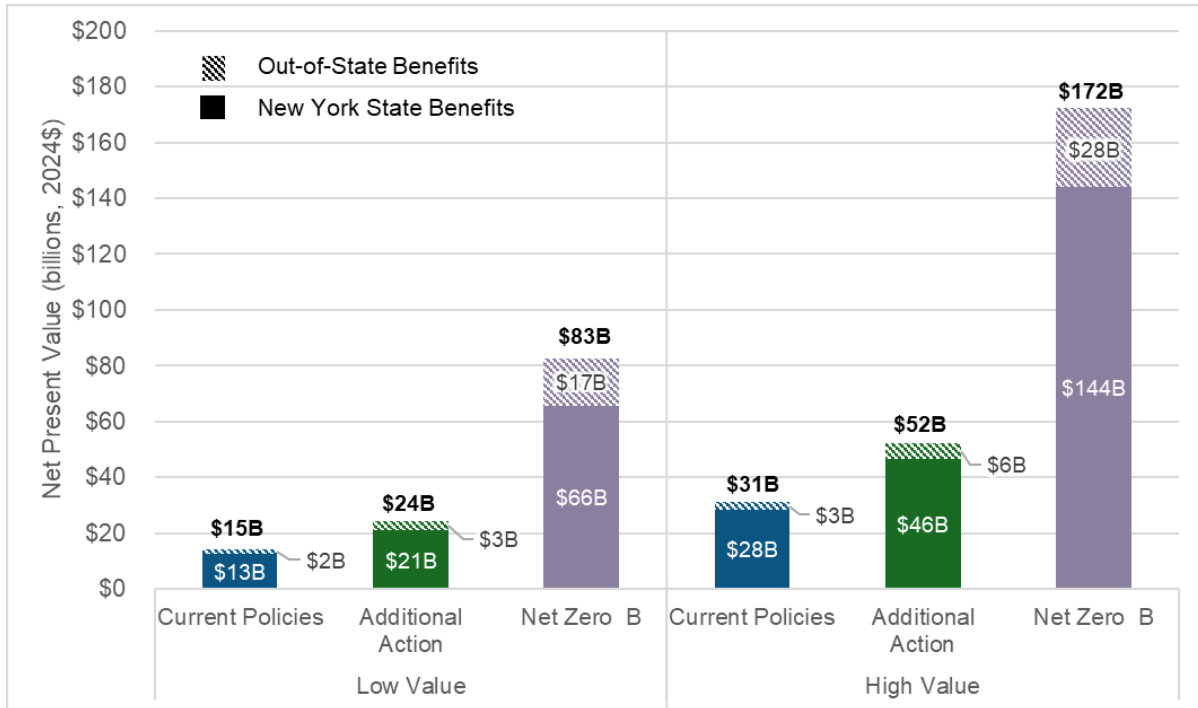
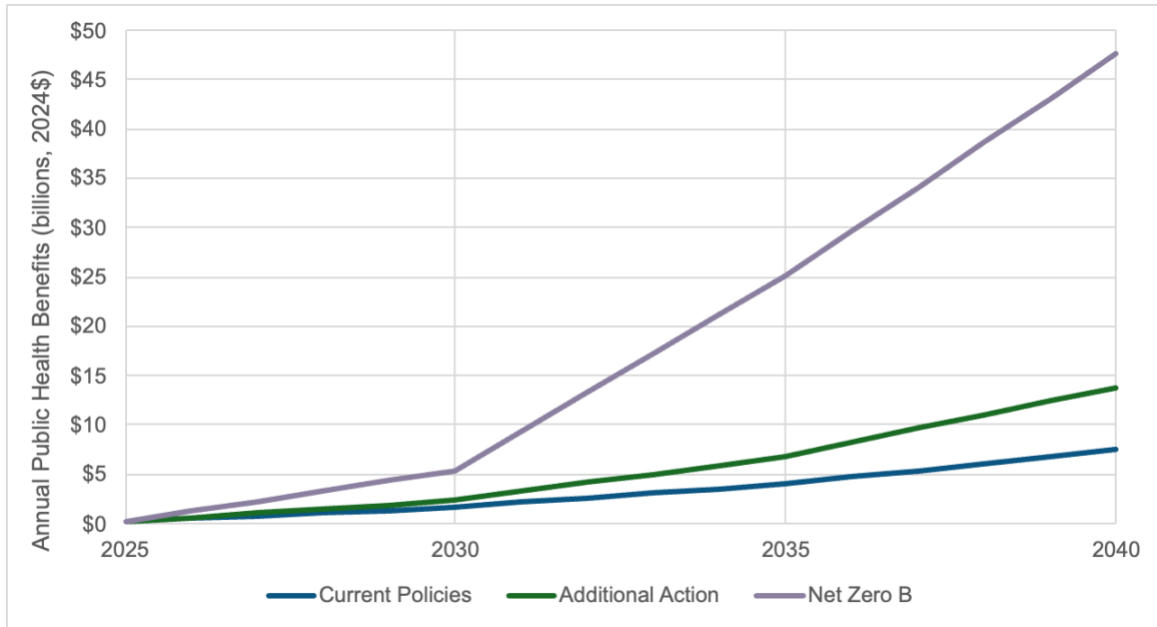


Figure 13 shows the total annual monetary value associated with lower PM_{2.5} and ozone concentrations for each scenario between 2025 and 2040, including both in-state and out-of-state benefits. The modeling indicates that benefits will accrue at faster rates beginning in 2030 under the Net Zero B scenario and beginning in 2035 under Current Policies and Additional Action with the implementation of additional energy policies. By 2040, the total annual public health benefits associated with the Current Policies scenario are valued at more than \$7.6 billion. For the same year, the Additional Action scenario projected benefits are valued at nearly \$14 billion for the State—80 percent more than Current Policies. At over \$47 billion, Net Zero B would provide the greatest amount of annual public health benefits for the State by 2040.

Figure 13. Annual Health Benefits Value from In- and Out-of-State PM_{2.5} (High Value) and Ozone by Scenario Relative to the No Action Scenario (2025–2040)



3.5. Health Impacts of Federal Policies

In addition to the core scenarios, the health analysis also considered two sensitivities built off the Current Policies scenario, one that assesses the impact of federal policies already enacted and a second that evaluates potential impacts of future federal policy uncertainty (see Table 3 and the Pathways Analysis chapter for complete scenario descriptions). In general, there are fewer state policy backstops included in the Current Policies scenario compared to the other core policy scenarios (see Pathways Analysis chapter), so Current Policies is expected to be relatively more sensitive to changes in federal policies than the other policy scenarios.

Table 3. Sensitivity Scenario Descriptions

Sensitivity Scenario	Description
Current Policies Pre-Federal Rollback	Federal policies such as the Inflation Reduction Act are re-instated to illustrate what a Current Policies world would look like if federal policies were consistent with those in January 2025.
Current Policies with Further Federal Rollback	Explores the potential for future federal policy rollbacks that could negatively impact State energy and climate objectives, including the repeal of the Advanced Clean Cars/Trucks waiver and appliance standards.

3.5.1. Impacts of Federal Policies on Public Health Benefits

Figure 14 shows the 2025–2040 cumulative avoided cases of premature mortality (from PM_{2.5} and ozone), nonfatal heart attacks (from PM_{2.5} only), and emergency room visits for asthma (from PM_{2.5} and

ozone) for Current Policies and the two sensitivity scenarios, all relative to the No Action scenario. Physical health benefits under the Pre-Federal Rollback scenario would have been approximately 50 percent greater than under the Current Policies scenario, and under the Further Federal Rollback scenario, physical health benefits would be approximately 30 percent lower than under the Current Policies scenario.

While the magnitude of changes in fuel consumption under the federal sensitivity cases are modest relative to the total fuel consumption in the Current Policies scenario (see Pathways Analysis chapter), the relationships between air pollution exposure and health impacts, accounting for population and baseline health incidence, mean that small changes in fuel consumption are magnified when translated to health impacts (see appendix to this chapter for additional information on health impact functions).

Figure 14. Statewide Cumulative Avoided Cases from Lower PM_{2.5} and Ozone Concentrations by Scenario Relative to the No Action Scenario (2025–2040)

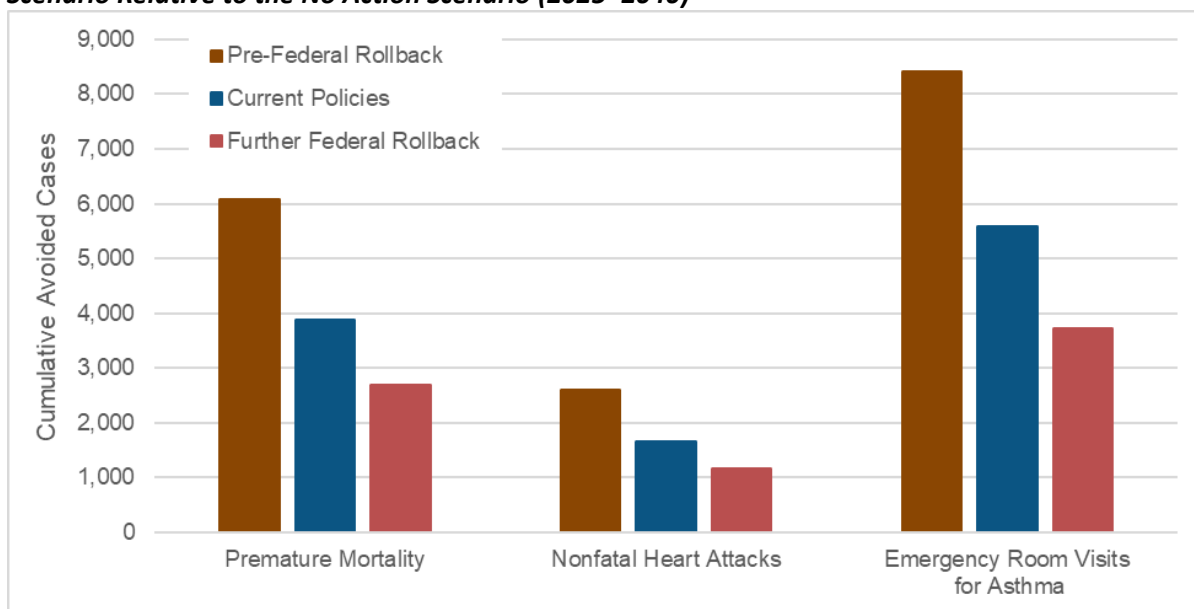
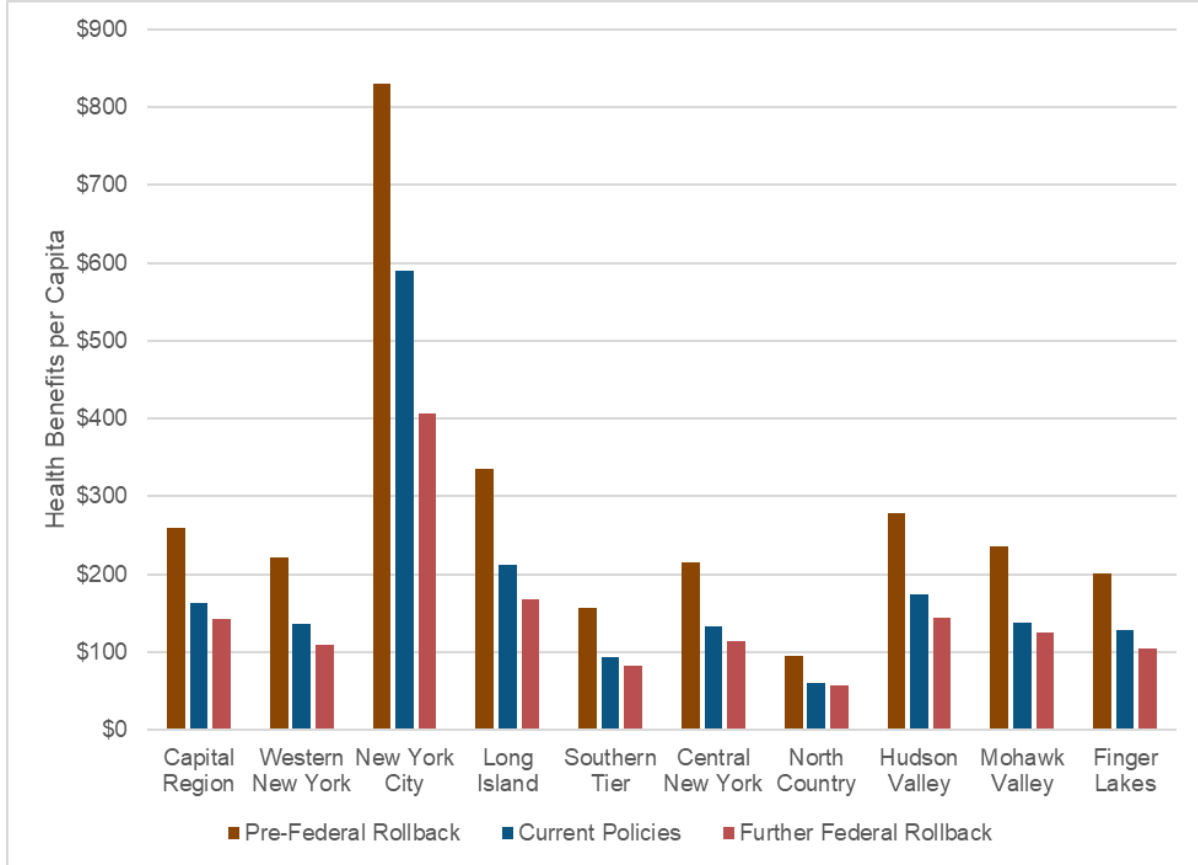


Figure 15 shows federal policies impact public health benefits in all regions of the state. The distribution of physical health benefits accruing within DAC and non-DAC areas under the two sensitivity cases is expected to be similar to the distribution under the Current Policies scenario. While the geographic distribution of benefits under the federal sensitivity cases is similar to Current Policies, there are some regional differences. Under the Current Policies scenario, 74 percent of the physical health benefits in 2040 accrue in New York City. Under the Pre-Federal Rollback scenario, 66 percent of the additional benefits would accrue within New York City and 34 percent in the rest of the state. Lower benefits under a potential Further Federal Rollback scenario would have a greater impact on New York City, which would see 83 percent of the disbenefits (see the appendix to this chapter and data annex for additional information by region and county).

Figure 15. Per Capita Annual Health Benefits from Lower PM_{2.5} Concentrations by Region and Scenario Relative to the No Action Scenario (2040)



3.5.2. Impacts of Federal Policies by Sector

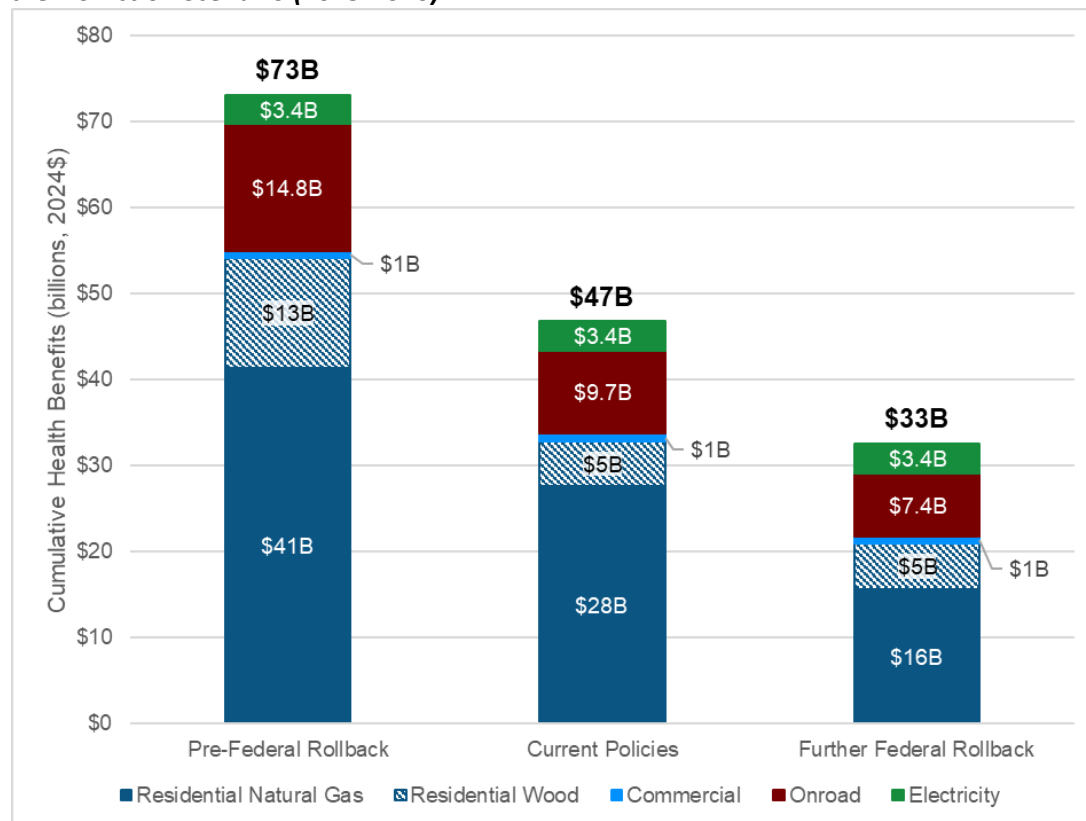
The federal sensitivity cases explored the impacts of federal policies on the electricity, on-road transportation, and building sectors (see Pathways Analysis chapter). The impact of federal policies on health benefits from the electricity sector is expected to be small, given the 0x40 State backstop, so the health analysis uses the same electric sector emissions for the sensitivity scenarios as in the core Current Policies scenario and does not attribute additional health impacts to the electric sector.

The residential buildings and on-road transportation sectors account for 91 percent of statewide health benefits from PM_{2.5} under the Current Policies scenario (see Section 3.3). In the Pre-Federal Rollback scenario, federal support for EVs, heat pumps, and energy efficiency as of January 2025 are included, as compared to the Current Policies scenario that includes State and local policies including ACCII/ACT, building regulations, and state incentives for EVs, heat pumps, and energy efficiency. The Further Federal Rollback scenario explores the impacts of repealing the ACCII/ACT waiver and Department of Energy appliance standards.

Figure 16 illustrates how sensitive each sector’s public health benefits are to the federal policies described above. Benefits from both the on-road transportation and residential sector are highly

sensitive to the federal policy changes explored here, particularly benefits from changes in natural gas heating compared to Current Policies. Health benefits from the commercial sector are minimally affected by the federal policy changes explored in these scenarios.

Figure 16. Cumulative Societal Value from Lower In-State PM_{2.5} by Sector and by Scenario Relative to the No Action Scenario (2025-2040)



The Pre-Federal Rollback scenario would add \$26.4B in additional cumulative statewide health benefits from PM_{2.5} from 2025-2040. The residential sector accounts for 80 percent of those additional benefits, with lower natural gas fuel combustion accounting for 52 percent (\$13.8B) and lower wood fuel combustion accounting for 28 percent (\$7.4B). Inclusion of federal support for electrification and weatherization of residential buildings would result in the Pre-Federal Rollback scenario achieving the 2040 residential sector health benefits for Current Policies (\$32.9B) in 2034, 6 years earlier. The on-road transportation sector accounts for the remainder of the additional benefits achieved by the Pre-Federal Rollback scenario, \$5.1B or 19 percent. Inclusion of federal EV tax credits would accelerate the achievement of ACCII ZEV goals to 2039, 4 years earlier than Current Policies (2043). As a result, the Pre-Federal Rollback scenario achieves the 2040 on-road transportation health benefits for Current Policies (\$9.7B) in 2037, 3 years earlier.

Compared to the State and local backstops of the Current Policies, the Further Federal Rollback scenario would decrease cumulative statewide health benefits from PM_{2.5} from 2025-2040 by \$14.2B, a 30 percent decrease from Current Policies. The residential sector accounts for 83 percent of the decrease in benefits, mostly from higher natural gas fuel consumption (\$12B). The Further Federal Rollback scenario

would achieve the 2040 residential sector health benefits for Current Policies (\$32.9B) in 2044, delaying achievement by 4 years. The on-road transportation sector accounts for the remainder of the reduction in benefits in the Further Federal Rollback scenario, amounting to \$2.3B or 16 percent. The Further Federal Rollback scenario would achieve the 2040 on-road transportation health benefits for Current Policies (\$9.7B) in 2044, delaying achievement by 4 years.

3.5.3. Impacts of Federal Policies on the Societal Value of Health Benefits

Figure 17 shows the impact of federal policies on the value of public health benefits in 2040, including in- and out-of-state benefits from PM_{2.5} and ozone, as described above. Under the Current Policies scenario, the annual value of benefits would reach \$7.6 billion in 2040. The inclusion of federal policies under the Pre-Federal Rollback scenario would increase 2040 health benefits by \$3.6 billion compared to Current Policies for a total of \$11.2 billion, a 47 percent increase. If federal policies were further rolled back as illustrated under the Further Federal Rollback scenario, 2040 health benefits would decrease by \$2.0 billion compared to Current Policies for a total of \$5.6 billion, a 27 percent decrease.

Figure 17. Annual Health Benefits Value from In- and Out-of-State PM_{2.5} and Ozone by Scenario Relative to the No Action Scenario (2040)

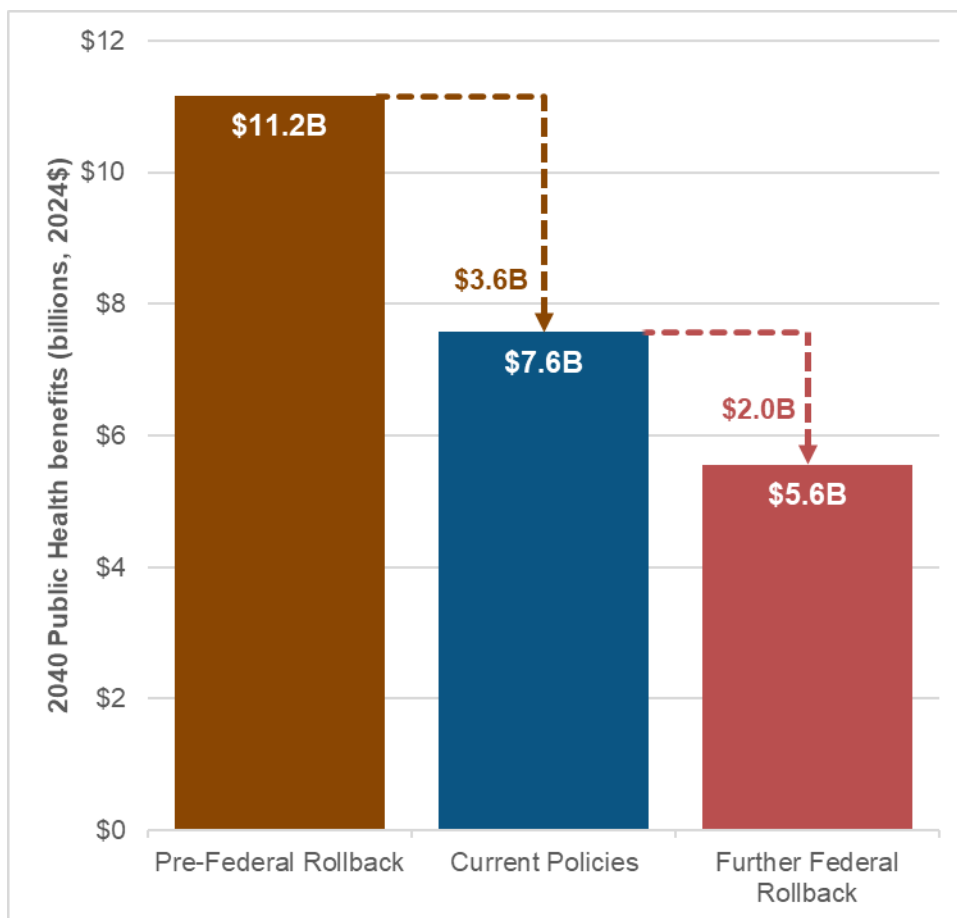


Figure 18 shows the estimated public health benefits for 2025–2040 (net present value 2024\$) from lower PM_{2.5} and ozone concentrations under each scenario relative to the No Action scenario. The 2025–

2040 cumulative societal value of the health benefits from reductions in PM_{2.5} and ozone under Current Policies is \$31 billion (net present value, 2024\$). The Pre-Federal Rollback scenario would add \$19 billion in 2025-2040 total benefits, while the Further Federal Rollback would reduce total benefits by \$9.5 billion. The distribution of health benefits accruing in-state versus out-of-state under the two sensitivity cases is expected to be similar to the distribution under the Current Policies scenario (approximately 90 percent of benefits accrue in-state and 10 percent accrue out-of-state).

Figure 18. Net Present Value of Health Benefits from PM_{2.5} and Ozone by Scenario Relative to the No Action Scenario and by In-State and Out-of-State Benefits (2025–2040)

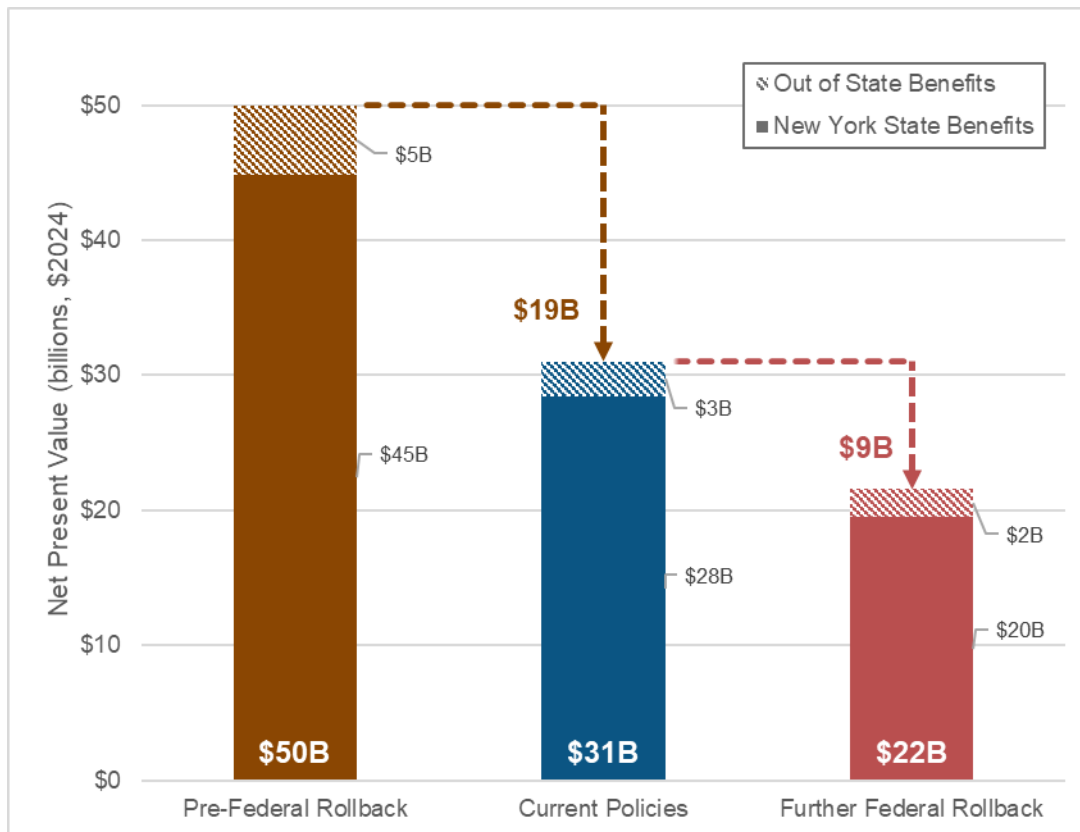
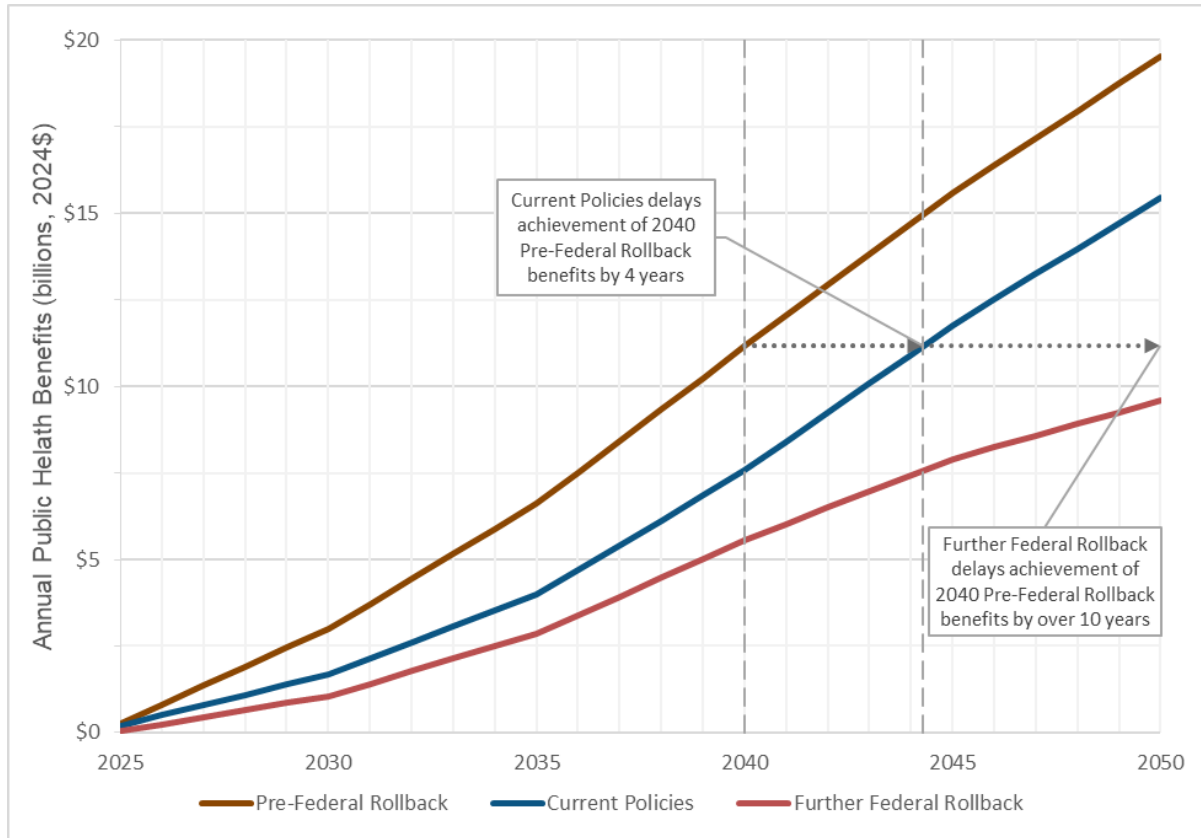


Figure 19 shows the total annual value associated with lower PM_{2.5} and ozone concentrations for each scenario from 2025 to 2050, including both in-state and out-of-state benefits. Compared to the health benefits that would have been achieved under the Pre-Federal Rollback scenario in 2040 (\$11 billion), the federal rollbacks in the Current Policies scenario delay achievement of the same level of benefits by 4 years and the Further Federal Rollback scenario would further delay achievement of the same level of benefits beyond 2050.

Figure 19. Annual Health Benefits Value from In- and Out-of-State PM_{2.5} (High Value) and Ozone by Scenario Relative to the No Action Scenario (2025–2050)



4. Summary of Public Health Analysis Results

All three scenarios of the Plan considered in this health analysis (Current Policies, Additional Action, and Net Zero B) are projected to result in air quality improvements and public health benefits in all regions of the state relative to the No Action scenario absent New York State policies under the Climate Act.

4.1. Statewide Health Benefits

Economywide reductions in fuel combustion would lead to lower PM_{2.5} and ozone concentrations throughout the state, benefiting public health across a range of outcomes including reducing premature mortality, hospitalizations, emergency department visits, and cases of various respiratory conditions. From 2025 to 2040, health benefits increase over time under all scenarios. For example, under Additional Action, avoided premature mortality increases from less than 200 cases annually in 2030 to over 1,000 cases annually in 2040.

Cumulative physical health benefits under the Additional Action scenario would be 60 percent higher than the benefits from the Current Policies scenario, and physical benefits under the Net Zero B scenario would be approximately triple those from the Additional Action scenario. The differences in the magnitude of health benefits between scenarios reflects the differences in each scenario’s energy policies.

4.2. Benefits in DAC Areas

In all scenarios, a larger share of physical health benefits accrues to the state's geographic DAC areas compared to their share of the population (statewide and in every region). DAC areas generally benefit from greater improvements in air quality, and DACs have higher baseline incidence rates for the health outcomes analyzed, meaning DAC areas receive a larger proportion of health benefits. As an example, DAC areas would experience approximately 72 percent of avoided emergency room visits for asthma under all scenarios, which is significantly higher than their fraction of the statewide population (37 percent).

Air quality improvements are generally greater in DAC areas in all three scenarios. In the New York City region, while there are differences in local exposure, DAC and non-DAC areas would experience similar annual average PM_{2.5} concentration reductions. DAC areas in general benefit from larger reductions in PM_{2.5} concentrations because in most regions, those communities tend to be clustered in urban areas that would experience larger emissions changes and have higher population density.

4.3. Benefits by Region

There would be air quality improvements in every region of the state under all scenarios relative to the No Action scenario. Urban areas of the state would experience the largest air quality improvements because those areas have higher air pollutant emissions. Larger reductions in pollutant concentrations combined with higher populations in urban areas mean these areas would experience greater physical health benefits. For these reasons, the New York City region would experience the largest physical health benefits across all three scenarios.

4.4. Benefits by Sector

Emission reductions from buildings and transportation account for most statewide benefits under all scenarios, with a larger fraction associated with building emissions in the Net Zero B scenario. From 2025–2040, cumulative benefits from lower emissions from residential fossil fuel heating account for 43–59 percent of benefits across all scenarios, and benefits from lower emissions from on-road vehicles account for approximately 21–24 percent of benefits under Current Policies and Additional Action.

In urban areas where total air pollutant emissions under the No Action reference scenario are higher, there are larger reductions in air pollutant concentrations. In these areas, lower emissions from on-road vehicles and residential fossil fuel heating account for most of the benefits. In upstate regions, lower emissions from buildings account for the largest fractional share of benefits, and in these regions most of these benefits are from lower emissions from residential wood heating. While air pollutant concentrations are generally lower in these regions, less residential wood combustion has an outsized impact on air quality and ensuing public health benefits because of their larger emissions of PM_{2.5} relative to other local sources, despite not representing a focus of mitigation policies and a small part of the energy transition.

While DAC and non-DAC areas have similar fractional benefits from buildings overall across scenarios, more of the benefits accruing to DAC areas are from residential fossil fuel heating than from residential wood. DAC and non-DAC areas have similar fractional benefits from transportation overall across

scenarios. Benefits in DAC areas from the use of sustainable aviation fuel are more than double the benefits compared to non-DAC areas per capita.

4.5. Societal Monetary Value of Health Benefits

The population-level physical public health benefits from all three policy scenarios of the Plan also translate to societal values. The 2025–2040 cumulative societal value of the health benefits from reductions in PM_{2.5} and ozone is over \$31 billion for Current Policies, over \$52 billion for Additional Action, and over \$172 billion for Net Zero B (net present value 2024\$). The value of benefits is greatest for Net Zero B due to the higher level of ambition needed across all sectors to achieve the net zero by 2050 target under the Climate Act. The value of benefits increase from 2025–2040 but they do not accrue at a steady rate; rather, value associated with public health benefits accrues more rapidly after 2030 for Net Zero B, and after 2035 for Current Policies and Additional Action, reflecting the temporal pattern of lower emissions in the building and transportation sectors from the energy policies in the underlying scenarios (Figure 13). Most of the 2025-2040 cumulative benefits would be experienced in New York State, accounting for 84-90 percent of the total net present value of the benefits across scenarios.

Approximately 50 percent of the value of public health benefits would accrue to DAC areas under all scenarios, which is a larger share of the benefits relative to their 37 percent share of the geographic population. In each region of the state, the fraction of benefits accruing to DAC areas is also larger than their fraction of the region's population. All regions of the state would receive per capita benefits, and in all regions, higher per capita benefits accrue to DAC areas compared to non-DAC areas.

While these health benefits represent a substantial societal value, it is important to recognize that achieving some of these outcomes may require significant investment in the energy system. Ensuring that these costs are managed equitably – especially for low-income and energy-burdened households – will be critical. This analysis focuses on quantifying potential benefits to inform those broader cost-benefit and policy tradeoff discussions.

4.6. Impacts of Federal Policy

Federal energy policies are projected to impact the public health benefits experienced by New York State. Compared to the Current Policies scenario, if federal policies consistent with those in January 2025 were re-instated, 2025-2040 cumulative public health benefits would have been approximately 50 percent greater. If some federal policies were further rolled back, 2025-2040 cumulative public health benefits could be up to 30 percent lower compared to Current Policies. Under the federal sensitivity scenarios explored in the Plan, differences in statewide health benefits from PM_{2.5} are due to differences in emissions from residential buildings and on-road vehicles. The inclusion of pre-rollback federal policies would increase the value of public health benefits in 2040, including in- and out-of-state benefits from PM_{2.5} and ozone, by \$3.6 billion compared to Current Policies (\$7.6 billion), while further rollback of federal policies would decrease health benefits by \$2.0 billion compared to Current Policies.

Appendix

1. Introduction

The public health analysis evaluated the potential for lower air pollutant emissions under three scenarios developed in the Pathways Analysis (Current Policies, Additional Action, and Net Zero B relative to the baseline No Action scenario) to affect changes in public health outcomes. The public health analysis followed the same basic approach used in the New York Scoping Plan,¹⁴ while applying an improved analysis modeling framework.

The basic framework of the analysis is:

- Estimate reductions of air pollutant emissions based on changes in fuel consumption from the Pathways Analysis (see Pathways Analysis chapter of this Plan).
- Model changes in air quality resulting from reductions in air pollutant emissions.
- Model changes in public health effects resulting from changes in air quality.
- Calculate the value of the change in health effects using standard economic values.

A key difference from the approach used for the Scoping Plan is that this analysis was conducted using a newly developed air quality and health impacts modeling framework—the NY Community-Scale Health and Air Pollution Policy Analysis (NY-CHAPPA) model¹⁵—rather than using the Environmental Protection Agency’s (EPA’s) CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)¹⁶ to analyze health outcomes from changes in fine particulate matter (PM_{2.5}) concentrations. In addition, COBRA was used to evaluate the impact from changes in ozone concentrations at a county level (this is a new capability now available from COBRA but is limited to the county scale).

The NY-CHAPPA modeling framework estimates benefits at a sub-county scale, which enables evaluation of potential health benefits by community type, allowing evaluation of health effects within geographic disadvantaged community (DAC) areas as defined under the Climate Act.¹⁷

The health analysis modeled the change in air quality and ensuing health effects in five-year increments between 2025 and 2050, and the impact of the Plan focused on the Plan years (2025 to 2040).

This appendix describes the methodology used in the NY-CHAPPA modeling framework (Section 2), and detailed results of the health analysis (Section 3). The accompanying data annex provides additional data beyond those shown in Section 3.

2. Methodology

This section outlines the health analysis methodology. Section 2.1 describes the overall modeling framework, Section 2.2 describes the specific data inputs and scenarios used for the Plan health analyses, and Section 2.3 notes limitations and uncertainties of the health analysis methodology.

2.1. Modeling Framework

The modeling framework, NY-CHAPPA, was developed for NYSERDA by Abt Global and the University of North Carolina (UNC) to quantify how changes in PM_{2.5} associated with lower air pollutant emissions such as those expected from decarbonization policies could impact health outcomes at the community scale.

The NY-CHAPPA modeling framework is based on the framework used by the Zip-code Air Pollution Policy Analysis tool (ZAPPA), also developed by UNC and Abt Global for NYSERDA and New York City.¹⁸ The ZAPPA framework combines two existing models: Community Tools (C-TOOLS)¹⁹ developed by UNC in collaboration with the EPA, and EPA's COBRA tool (v5.2). These existing models have been previously evaluated and have been used in dozens of peer-reviewed studies.^{4,5,20} The sections below provide an overview of the statewide modeling framework developed for NY-CHAPPA.

The health analysis uses NY-CHAPPA v2.0, which updated the modeling framework as compared to the analysis in the Draft Plan, which used NY-CHAPPA v1.0. NY-CHAPPA v1.0 used 2010 census tracts whereas NY-CHAPPA v2.0 uses 2020 census tracts. NY-CHAPPA v2.0 includes revised source and receptor representation and geographic DAC areas consistent with the updated census tracts. In addition, NY-CHAPPA v2.0 uses an updated version of COBRA (v5.1) to model the transport of pollutants from outside of the modeled region, discussed in more detail below, whereas NY-CHAPPA v1.0 used COBRA v4.1. However, testing done using the two methods for transported pollutants show minimal impact on modeled changes in projected PM_{2.5} concentrations.

2.1.1. Underlying Models and Model Framework Design

In the NY-CHAPPA modeling framework, New York State was divided into eight regions (Figure A-1).²¹ To calculate the annual average PM_{2.5} concentration in each census tract in each scenario, C-TOOLS was used to model dispersion of primary PM_{2.5} and secondary PM_{2.5} precursor pollutants nitrogen oxides (NO_x), sulfur dioxide (SO₂), volatile organic compounds (VOCs), and ammonia (NH₃) within each region. C-TOOLS models dispersion of pollutants from sources and calculates the effect on concentrations of PM_{2.5} and precursors at receptor census tracts from emissions in each source census tract in New York State (see following sections).

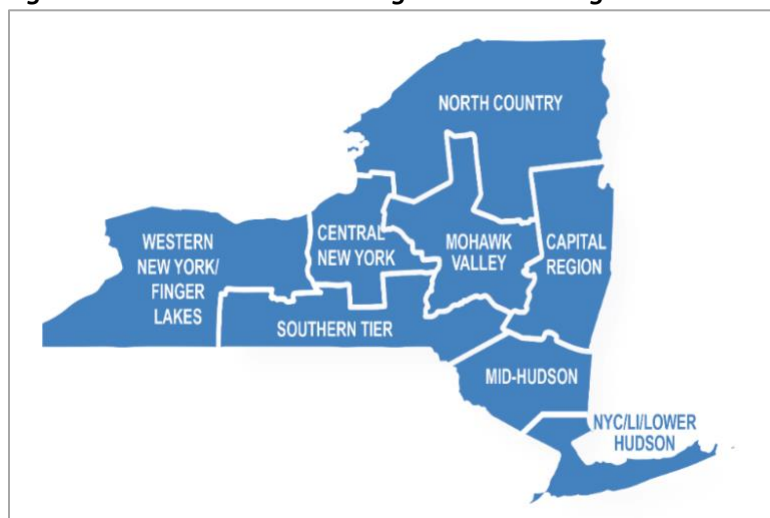
After census tract concentrations are calculated for local sources within a region, transported concentrations by county are added to account for emissions from outside the region and/or outside of the state. These concentrations are calculated using COBRA (v5.1) for each model year and policy scenario. The calculations involved running COBRA with zero emissions within each region across all sectors (effectively eliminating local dispersion within the region being analyzed). The resulting concentrations of PM_{2.5} in each county represent the concentrations transported into the region from outside of the region (either from another region or outside of New York State).

The total PM_{2.5} concentration for a census tract is calculated as the sum of the concentrations of total PM_{2.5} from local dispersion from C-TOOLS and total PM_{2.5} from transported sources from the COBRA model. Note that although the COBRA tool currently provides results at the county level, the underlying

total PM_{2.5} concentration calculations can be done with the tool at any resolution; therefore, this approach is used to calculate total PM_{2.5} concentrations at the census tract scale.

The above process is used to calculate total PM_{2.5} concentrations for each census tract within a region for the baseline scenario and the policy scenarios for each model year. The change in total PM_{2.5} is calculated by subtracting the total PM_{2.5} concentration for the scenario and year from the baseline concentration for that year for each census tract.

Figure A-1. NY-CHAPPA Modeling Framework Regions



NY-CHAPPA then multiplies the change in PM_{2.5} concentrations in each census tract by the health impact functions in COBRA and some NYC-specific functions for respiratory-related emergency room visits²² and hospitalizations for cardiovascular events,²³ and by the population and incidence data described in Section 2.2, to calculate the change in health effects within each census tract. The health impact functions from COBRA are standard functions used by EPA in regulatory analysis, and include functions for premature mortality, respiratory and cardiovascular hospitalizations, emergency room visits for asthma, asthma exacerbation, nonfatal heart attacks, acute bronchitis, minor restricted activity days, and work loss days. COBRA includes more than one health impact function for calculating avoided mortality and nonfatal heart attacks. Rather than average the values of those functions together, this analysis reports them separately, as the high and low values.

Lastly, NY-CHAPPA estimates the monetary value of the avoided health effects by multiplying them by standard economic values for each health effect from EPA's COBRA tool. These economic values were developed from economic studies of the cost of medical care and/or the public's willingness to pay to avoid certain health outcomes. See Section 2.2 for more information about the health impact functions and economic values used in this analysis.

While NY-CHAPPA estimates benefits due to reductions in PM_{2.5} concentrations in policy scenarios, there are additional potential benefits from reduced air pollution, including reductions in ozone concentrations. To develop a high-level estimate of these benefits, COBRA is used to model ozone concentration reductions and associated public health benefits. This approach used the same emissions

inputs as those used in NY-CHAPPA, but aggregated to the county scale, which is the scale used in COBRA. Because COBRA currently provides the outputs at the county scale, the distribution of these benefits to DAC areas could not be determined. Nevertheless, these results provide additional information on the total health benefits from improved air quality under policy scenarios. Health benefits from reduced ozone concentrations modeled by COBRA include avoided premature mortality, respiratory hospital admissions, emergency room visits for asthma, asthma symptoms, new diagnoses of asthma, and school loss days. The data annex (described in more detail below) includes regional data on the modeled number of avoided cases of each health outcome for both PM_{2.5} and ozone in each model year.

COBRA was also used to estimate benefits outside of NYS. Emissions changes from the policy scenarios within NYS were modeled in COBRA to estimate the value of societal benefits of reductions in PM_{2.5} and ozone concentrations to the continental U.S. outside of NYS.

Additional benefits such as benefits associated with reductions in NO₂ or toxic pollutant concentrations are excluded; therefore, the results provided using this framework are conservative and do not account for additional potential benefits.

2.1.2. Source Representation

NY-CHAPPA's dispersion model calculates pollutant concentrations based on emissions from sources (see Section 2.2.3) represented as point sources, line sources, and area sources using different algorithms for each source type.

Point Sources: NY-CHAPPA used the point source location, stack parameters, and emission estimates for all emissions from fuel combustion associated with electricity generation and industrial operations that reported stack parameters to New York State Department of Environmental Conservation (DEC) (see Section 2.2.3).

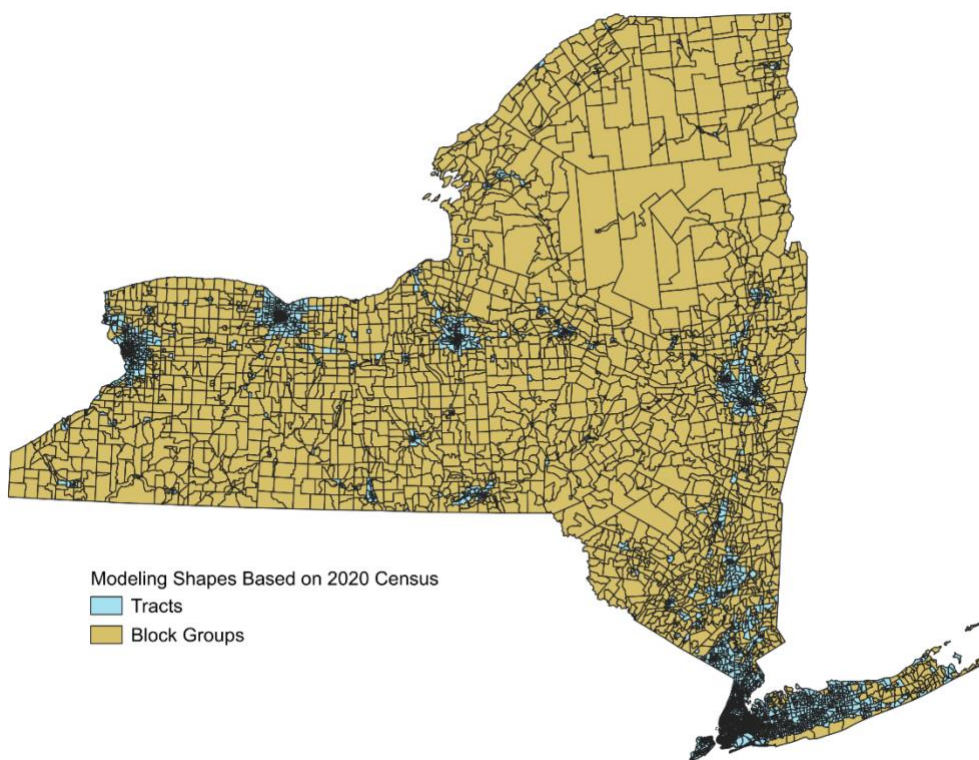
Line Sources: On-road emissions from major and secondary road categories (interstates, arterials, and major collectors) were modeled as line sources. Line segment data from the Federal Highway Administration's Highway Performance Monitoring System (HPMS) for the state of New York was post-processed to split any polyline representations of roads into segments with a single start and end point, since NY-CHAPPA's line source algorithm is designed for simple line sources. Road segments were mapped to an individual county based on the midpoint of the road segment, and then to the census tract scale as described in Section 2.2.3.

Area Sources: Sectors for which point or line source data were not available were modeled as area sources. This includes the residential, commercial, and non-road sectors, as well as non-point industrial sources. In addition, on-road emissions from minor collector and local roads were also modeled as area sources. Cartographic boundary files representing census tracts and census block groups were downloaded from the U.S. Census Bureau to serve as the basis for area source geometries. New York State has a total of 5,411 census tracts and approximately 15,800 block groups in the 2020 census. Due to a modeling constraint in NY-CHAPPA, multi-polygon representations in the dataset were split apart into separate polygon shapes (e.g., census tracts with multiple islands). In addition, some census tract polygon geometries were simplified further by using the outer ring geometry to avoid instances where

the polygon shape included an inner ring (like a donut), since shapes with inner rings can yield unexpected modeling results. NY-CHAPPA modeling then attributed census tract-level emissions to the outer ring geometries of the census tracts (in effect this combines the emissions sources of the inner and outer rings into a single source). For larger census tracts (with an area greater than 20 square kilometers), block group geometries were used instead of tract geometries to ensure high resolution modeling. Block group geometries were also simplified to avoid multi-polygon representations and inner rings. Figure A-2 shows the larger census tracts with an area greater than 20 square kilometers (which are modeled at the block group level) in brown and smaller tracts (which are modeled at the census tract level) in blue.

Figure A-2. NY-CHAPPA Modeling Shapes Based on 2020 Census Tracts and Block Groups in New York State

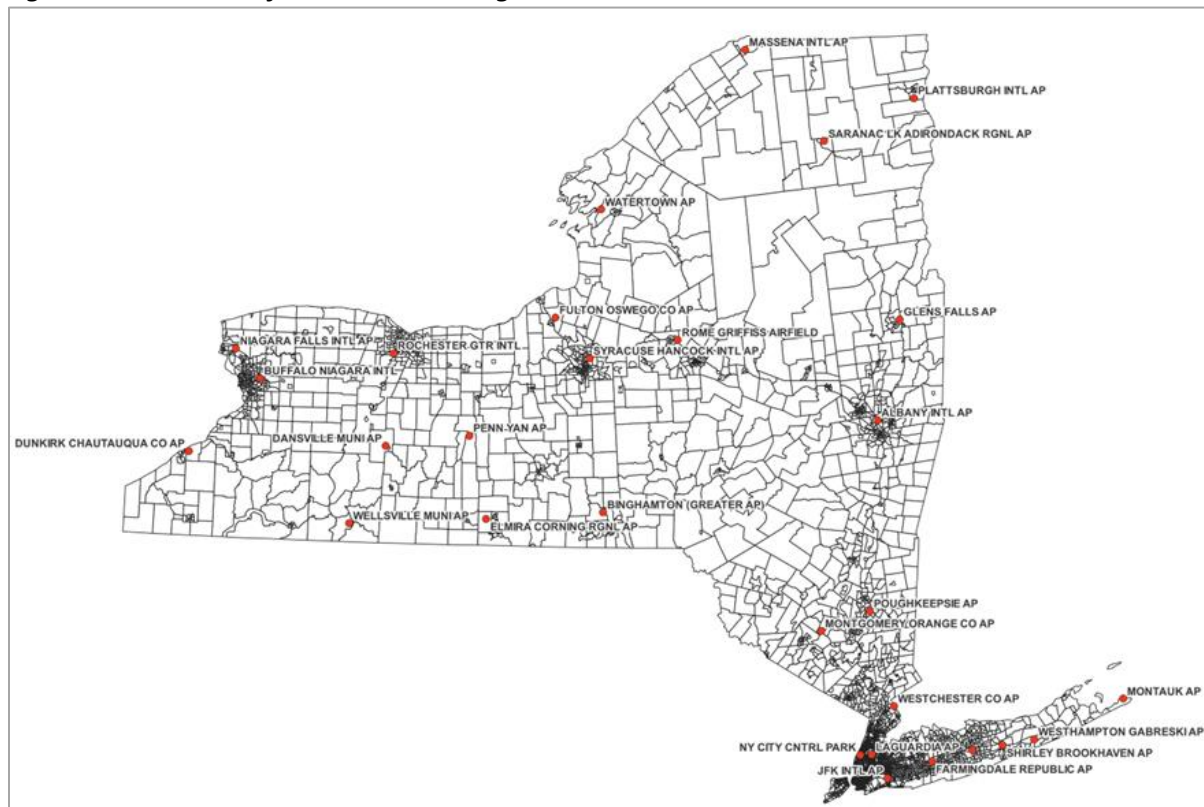
Note: Blue shows the census tracts of area less than or equal to 20 km², while brown shows census tracts with area greater than 20 km². Areas in brown were modeled at census block group resolution.



Area sources were modeled at varying heights depending on the source of the emissions. County-wide average heights were calculated based on county-level data from the EPA's National Emissions Inventory (NEI) for each sector (e.g., residential, commercial, industrial). Emissions for a census tract within a given county used this county average height. Emissions without average height data (e.g., the transportation sector) were modeled at ground level.

Each source was matched with its nearest meteorological station (see Figure A-3), and METEorologically-weighted Averaging for Risk and Exposure (METARE)-processed annual meteorology data (see Section 2.1.4) from that station was used to disperse emissions from each source.

Figure A-3. Location of the 29 Meteorological Stations in New York State



2.1.3. Receptor Network

NY-CHAPPA calculates pollutant concentrations at discrete point locations called receptors. In this modeling framework, census tract centroid locations (using the 2020 census tract definitions) were used when that tract's area was less than or equal to 20 square kilometers and block group centroid locations were used when the census tract's area was greater than 20 square kilometers. This approach ensured a dense receptor network even in larger census tracts. Using this hybrid approach, the modeling receptor network consisted of approximately 7,200 receptor points. Census tract concentrations, as calculated by NY-CHAPPA, represent the average of all receptors within that census tract.

Receptors were modeled at a height of 1.8 meters, a common receptor height for air quality modeling to represent the average height of a person.²⁴ For census tracts containing multiple receptors, the concentrations from all receptors were averaged to calculate the census tract concentration. Note that averaging to the census tract levels creates population-homogenized results which can then be appropriately analyzed and averaged since census tracts are designed to be roughly equal in population.

2.1.4. Meteorology

To develop the meteorological inputs needed to model the dispersion of pollution from sources to receptors, first, hourly meteorological data was generated through AERMET using data from the National Weather Service (NWS) from 29 airports. The list of stations and their locations are shown in Figure A-3 and Table A-1, below. Data from 2017-2021 was analyzed to determine the interannual variability in the meteorological data, as discussed in the following section, “Meteorological Sensitivities.” Based on the results of this analysis, a single year of meteorological data (2016) was selected for use in NY-CHAPPA.

Table A-1. List of the 29 Meteorological Stations with Coordinates

WBAN	Name	State	County	Latitude	Longitude
14735	Albany International Airport	NY	Albany	42.7472	-73.7991
04725	Binghamton (Greater Airport)	NY	Broome	42.2068	-75.9799
14733	Buffalo Niagara International	NY	Erie	42.9300	-78.7361
94704	Dansville Municipal Airport	NY	Livingston	42.5699	-77.7143
14747	Dunkirk Chautauqua Co Airport	NY	Chautauqua	42.4932	-79.2762
14748	Elmira Corning Regional Airport	NY	Chemung	42.1566	-76.9029
54787	Farmingdale Republic Airport	NY	Suffolk	40.7344	-73.4164
54773	Fulton Oswego Co Airport	NY	Oswego	43.3504	-76.3832
14750	Glens Falls Airport	NY	Warren	43.3385	-73.6102
04781	Islip-LI Macarthur Airport	NY	Suffolk	40.7939	-73.1018
94789	JFK International Airport	NY	Queens	40.6392	-73.7639
14732	LaGuardia Airport	NY	Queens	40.7795	-73.8803
94725	Massena International Airport	NY	St. Lawrence	44.9334	-74.8484
54780	Montauk Airport	NY	Suffolk	41.0731	-71.9235
04789	Montgomery Orange Co Airport	NY	Orange	41.5091	-74.2646
04724	Niagara Falls International Airport	NY	Niagara	43.1083	-78.9382
94728	NY City Central Park	NY	New York	40.7790	-73.9693
54778	Penn Yan Airport	NY	Yates	42.6441	-77.0529
64776	Plattsburgh International Airport	NY	Clinton	44.6392	-73.4631
14757	Poughkeepsie Airport	NY	Dutchess	41.6257	-73.8816
14768	Greater Rochester International Airport	NY	Monroe	43.1172	-77.6754
64775	Rome Griffiss Airfield	NY	Oneida	43.2242	-75.3956
94740	Saranac Lake Adirondack Regional Airport	NY	Franklin	44.3928	-74.2029
54790	Shirley Brookhaven Airport	NY	Suffolk	40.8212	-72.8674
14771	Syracuse Hancock International Airport	NY	Onondaga	43.1111	-76.1038
94790	Watertown Airport	NY	Jefferson	43.9887	-76.0261
54757	Wellsville Municipal Airport	NY	Allegany	42.1078	-77.9842
94745	Westchester Co Airport	NY	Westchester	41.0624	-73.7045
14719	Westhampton Gabreski Airport	NY	Suffolk	40.8506	-72.6193

The meteorological outputs for 2016 from AERMET were then processed using the METARE method previously developed and published in Chang et al.²⁵ to obtain 100 representative hours throughout the year.

The METARE approach defines 5 bins for wind speed, 4 bins for wind direction, and 5 bins for Monin-Obukhov length, resulting in 5 x 4 x 5 = 100 representative conditions (Table A-2). These conditions represent a series of representative meteorological inputs with similar wind speed, wind direction, and

Monin-Obukhov length. Initial screening of the AERMET output file identifies how often the 100 representative conditions occur in the NWS hourly meteorology data in 2016 at each meteorological station. If any of the 100 representative conditions do not occur in the station data, that representative condition is eliminated for that meteorological station, meaning there are less than 100 representative conditions for some meteorological stations. The METARE approach weights the 100 representative conditions by how many hours in the year the median Monin-Obukhov length occurs in the station data (# of hours falling into that condition / # of all the valid hours of the years). If for a given condition no data is available due to data missing, no representative hour will be selected, and the weight will be 0. Chang et al. showed the METARE approach performs well when compared to a model simulation that uses all 8,760 meteorological hours for the year, and this approach was used previously in the initial development of ZAPPA, the precursor model for NY-CHAPPA.

Table A-2. Meteorological Bins Used in METARE Approach

Parameter	Bin
Wind Speed (m/s)	0–1
	1–2
	2–4
	4–7
	>7
Wind Direction (degree)	0–90
	90–180
	180–270
	270–360
Monin-Obukhov length	0–100 (stable)
	100–500 (slightly stable)
	>500 or < (-500) (neutral)
	(-500) – (-100) (slightly unstable)
	(-100) – 0 (unstable)

Meteorological Sensitivities

While NY-CHAPPA uses a single year of meteorology, a sensitivity analysis was conducted to analyze the variability in meteorology data over time. The analysis examined differences in wind speed and direction at different meteorological stations in New York State from 2017-2021. Figure A-4 shows wind rose plots for LaGuardia Airport for 2017–2021. These plots show that the annual distribution of wind speed and direction did not change substantially from 2017 to 2021. Similar plots were developed for all other meteorological stations in New York State, and they show a similar lack of variability in wind speed and direction.

We also compared the number of hours with Monin-Obukhov length values in different stability ranges for the years 2016–2021 and shown in Figure A-5, below. Monin-Obukhov length is an indication of stability in the atmosphere and the dispersion model relies on this value to compute the extent of dispersion. Similar to the wind rose plots shown, above, the Monin-Obukhov plots also do not show

significant year-to-year change at individual stations. The New York City Central Park station has the most interannual variability in Monin-Obukhov lengths of all of the stations, but it does not have as much variation in wind speed or direction, and it is therefore not expected to have a large impact on the dispersion modeling in NY-CHAPPA.

Figure A-4. Annual Distribution of Hourly Wind Speed by Direction, LaGuardia Airport, 2017–2021

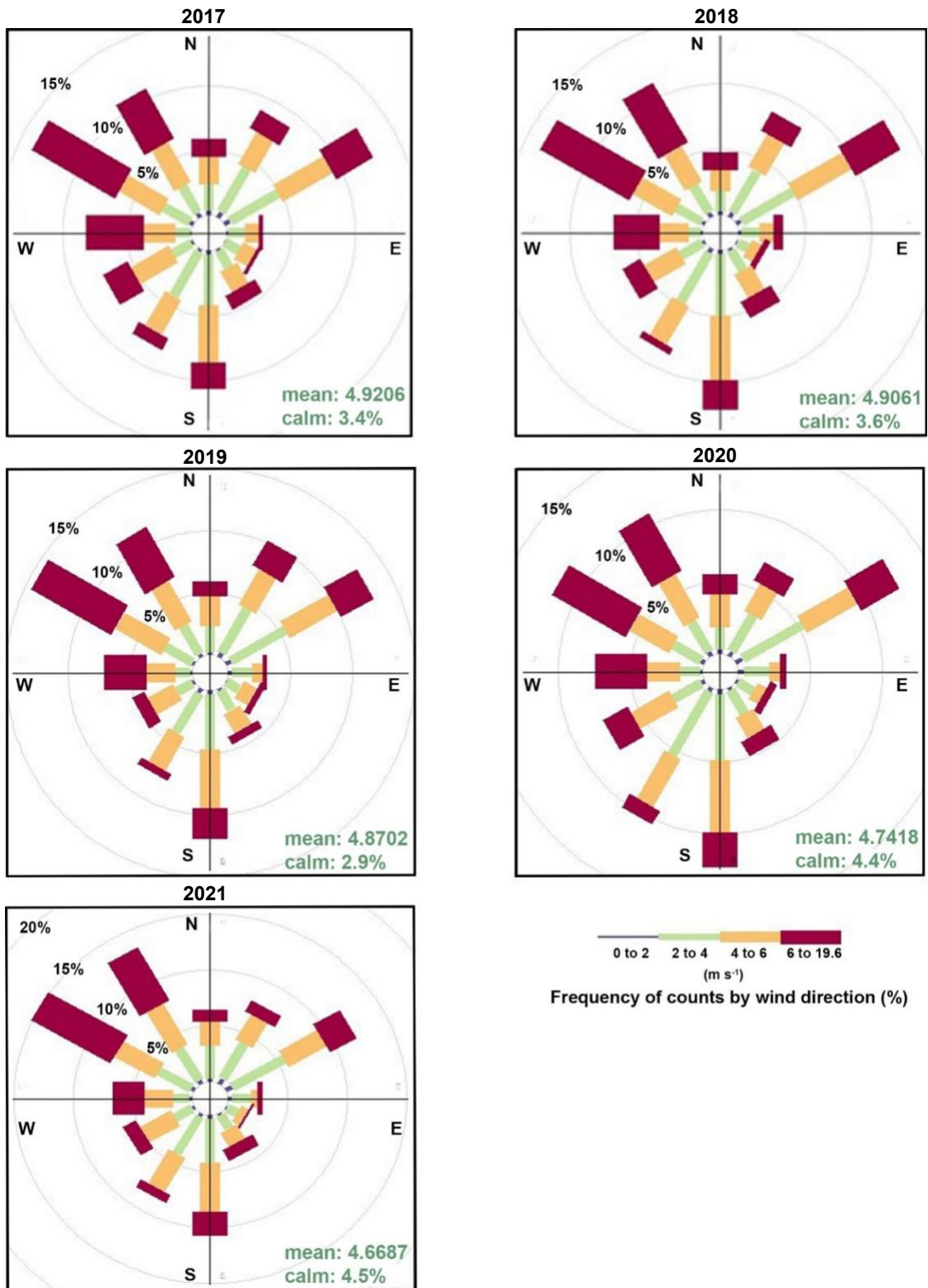


Figure A-5. Distribution of the Number of Hours per Year with Monin-Obukhov Length Values in Different Stability Ranges (Subset of Meteorological Stations in NYS, 2016-2021)



Given the lack of substantial interannual variability in wind speed, wind direction, and Monin-Obukhov length, which are key input parameters that drive dispersion in the model, the health analysis was conducted with NY-CHAPPA using a single year of meteorology, 2016.

2.1.5. Model Validation

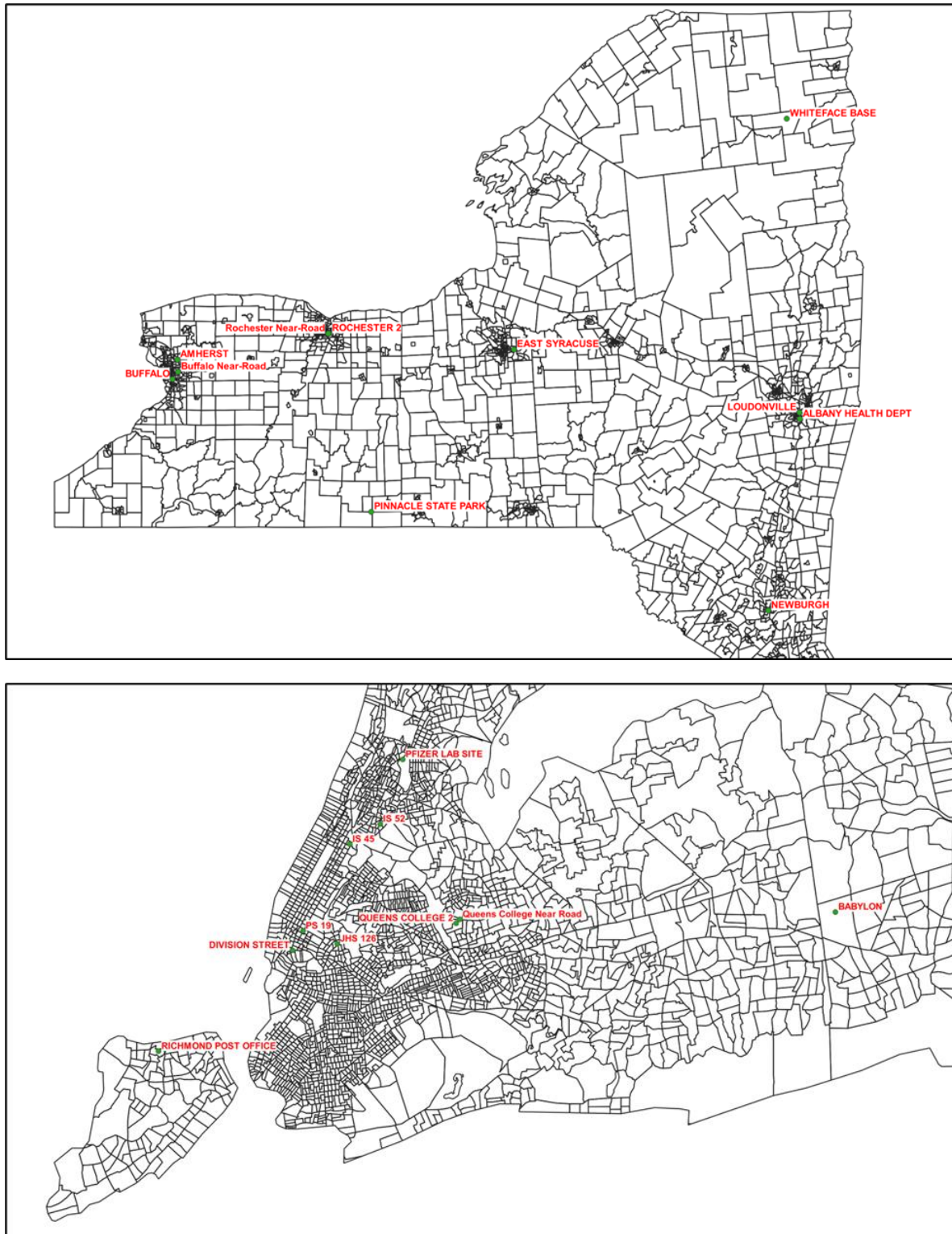
To evaluate the performance of NY-CHAPPA, the projected PM_{2.5} concentrations using emissions from the No Action scenario in 2025 from the Plan were compared to PM_{2.5} observations from 2020-2024 from 19 PM_{2.5} monitoring sites throughout New York State,²⁶ shown in Table A-3 and Figure A-6. The model validation shown here is for NY-CHAPPA v2.0 with 2020 census tracts. The projected and observed PM_{2.5} concentrations were compared using five standard model performance evaluation metrics routinely used for air quality model validation: (1) fractional bias, (2) geometric mean bias, (3) normalized mean square error, (4) geometric variance, and (5) fraction of modeled data within a factor of 2 of the observations.²⁷ Each of these metrics is a measure of the distribution of the difference in PM_{2.5} concentrations estimated by the model and observed PM_{2.5} concentrations from air quality monitor(s) in the same census tract.

Table A-3. Observed (2020–2024) and Modeled (2025) PM_{2.5} Concentrations (µg/m³) in New York State

Note: Near-road monitoring sites, indicated with stars (*), are included in this table for completeness but are excluded from summary statistics of the model validation in Table A-4 because they are not intended to capture average ambient concentrations.

Air Quality Monitoring Site	Observed PM _{2.5} Concentrations					NY-CHAPPA v2.0 Modeled PM _{2.5} Concentrations (2025)
	2020	2021	2022	2023	2024	
IS 45	6.98	7.43	6.94	9.07	6.67	16.95
JHS 126	7.34	7.62	7.29	9.23	6.85	14.54
IS 52	6.65	7.74	6.89	8.99	7.12	12.84
Newburgh	6.45	6.30	5.83	7.57	5.70	10.16
Pfizer Lab Site	6.96	7.14	6.90	9.04	6.43	9.95
Richmond Post Office	7.72	8.38	6.90	9.49	6.91	9.71
Queens College Near Road*	7.37	7.72	7.05	8.92	7.17	9.02
Queens College 2	6.86	7.50	7.31	9.36	7.62	8.83
Albany County Health Dept	6.11	6.70	5.96	7.88	6.51	7.65
Rochester Near-Road*	5.94	7.15	6.07	8.37	6.53	6.05
Buffalo Near-Road*	6.83	7.70	6.65	8.89	6.36	5.39
Loudonville	4.97	5.48	5.64	7.44	5.43	5.33
Rochester 2	5.62	6.25	5.54	7.75	5.39	5.30
Buffalo	6.48	7.43	6.53	8.16	6.62	5.20
Babylon	6.38	6.91	5.99	8.00	5.91	5.00
Amherst	6.04	6.79	5.74	8.97	5.81	4.28
East Syracuse	5.07	5.87	5.07	7.51	5.10	3.42
Pinnacle State Park	4.37	5.66	4.80	7.33	4.67	3.21
Whiteface Base	3.21	3.66	3.51	4.89	3.87	1.94

Figure A-6. PM_{2.5} Monitoring Sites in New York State



Each metric has thresholds against which model performance is evaluated. For example, it is generally accepted that air quality models should have a fractional bias with ± 0.3 .²⁸ Because model projections

were only available starting with year 2025, these results were compared against multiple years of observational data, starting with the year 2020. EPA’s standard approach for evaluating the performance of dispersion models is to compare the distributions of the highest hourly observed and modeled concentrations (unpaired in time).²⁹ NY-CHAPPA was evaluated here with a paired comparison of annual average observed and modeled PM_{2.5} concentrations. Table A-3 shows the comparisons of observed and projected PM_{2.5} concentrations for the years 2020–2024, and Table A-4 shows the average of the model performance evaluation metrics calculated for each year.

Table A-4. Summary of Metrics for Evaluating Model Performance in Comparison to Observed Air Quality Data

Note: Near-road monitors were excluded from the data to develop these summary metrics.

Comparison Measure	Value from Model Validation	Threshold	Does Model Satisfy Threshold?
Fractional bias	-0.25	within ± 0.3	Yes
Geometric mean bias	0.92	closer to ± 1	Yes
Normalized mean square error	0.26	closer to 0	Yes
Geometric variance	1.24	ranges between ± 1	Yes
Fraction of data within a factor of 2 of observations	0.9	closer to 1	Yes

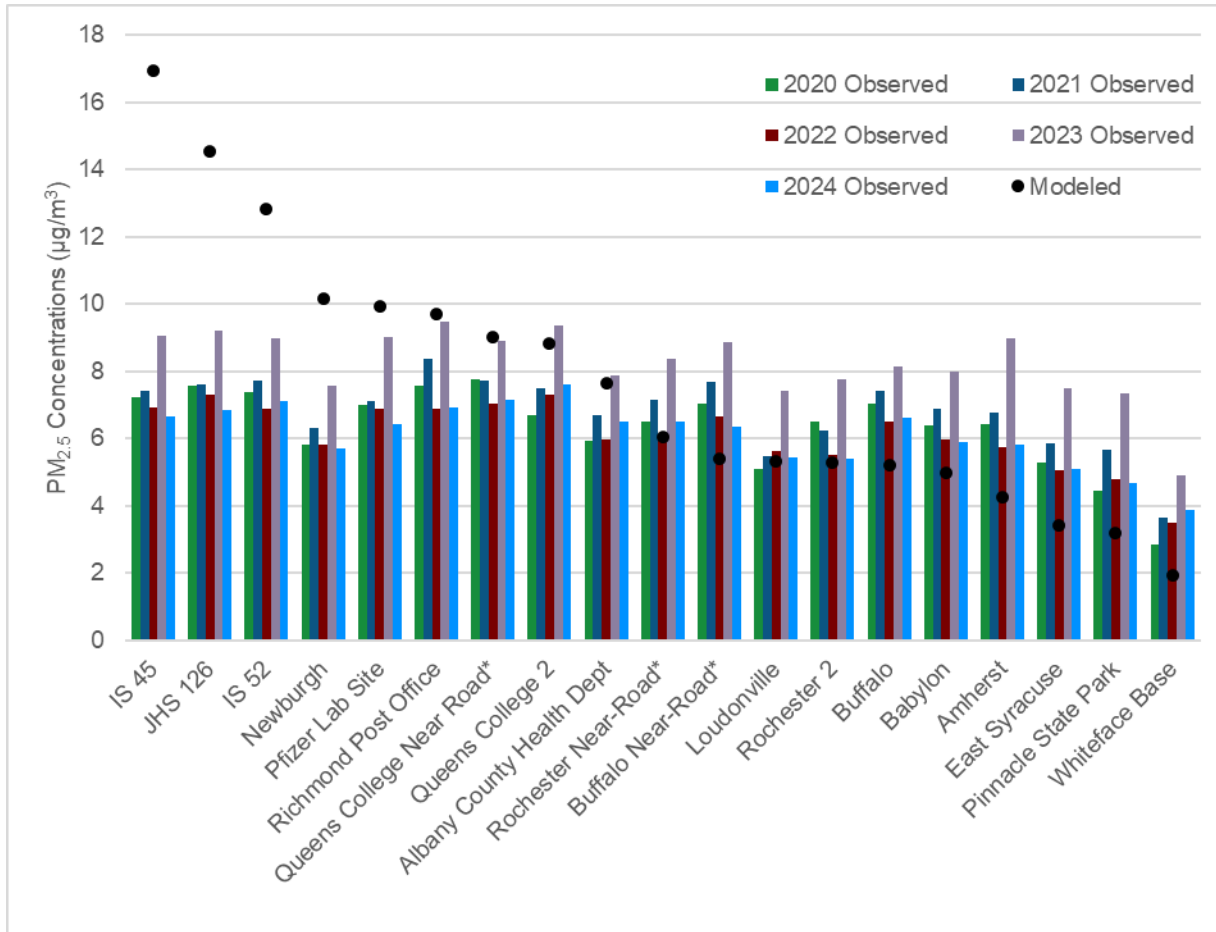
Figure A-7 shows the PM_{2.5} concentrations observed at each monitoring station for 2020–2024 and the modeled 2025 concentration for the corresponding census tract. Figure A-7 demonstrates that for most locations, modeled PM_{2.5} concentrations are generally aligned with the observed data. As shown in Table A-4, the summary statistics across all monitoring stations in the network meet the standard thresholds for performance of an air quality model in each year, 2020–2024.

Note that some of the air quality monitors shown in Figure A-7 are source-oriented monitors, which are situated close to roadways specifically to measure near-road concentrations close to highways and not to measure average ambient concentrations from all sources. These near-road monitors were included in Figure A-7, but were not included in the summary statistics displayed in Table A-4 because the source-oriented monitors have different siting procedures and would not necessarily be comparable to randomly placed receptors not specifically placed near a line source.

The model also has similar performance metrics to the Community Multiscale Air Quality model (CMAQ), a state-of-the-science comprehensive multi-scale and multi-pollutant photochemical model, developed by the EPA and used for both scientific and regulatory applications in the U.S. and elsewhere. According to an evaluation of CMAQ for multiple years and for different studies, that model had a median fractional bias of -12 percent and a median normalized mean error of 41.2 percent.³⁰ This is compared to the baseline case values used for NY-CHAPPA v2.0 of -25 percent and 26 percent, respectively, suggesting that NY-CHAPPA performs comparably or better in this use case, despite its reliance on reduced form dispersion modeling approaches.

Figure A-7. Comparison of Observed (2020-2024) and Modeled (2025) Annual Average PM_{2.5} Concentrations in New York State

Note: Near-road monitoring sites, indicated with stars (*), are included in this figure for completeness but are excluded from summary statistics of the model validation in Table A-4 because they are not intended to capture average ambient concentrations.



2.2. Inputs and Scenario Design

To model changes in PM_{2.5} concentrations and ensuing public health effects, NY-CHAPPA requires four sets of input data:

- Population;
- Baseline health incidence;
- Baseline case (No Action scenario) emissions of primary PM_{2.5} and secondary PM_{2.5} precursors NO_x, SO₂, VOCs, and NH₃; and
- Scenario emission of those pollutants.

The following subsections discuss the approach for developing each of these data inputs used in this health analysis.

2.2.1. Population

Population estimates by age group were developed for each of the analysis years for all counties in New York State. County-level population data for 2021 was from the U.S. Census Bureau.³¹ The Pathways Analysis assumes total statewide population in 2040 remained flat at 2021 levels, but estimates population changes within the state based on the most recent available county level projection data from Cornell University's County Projects Explorer.³² An annual growth rate by county was derived based on the change between the 2021 population data and the 2040 population projections and used to estimate the county level population for each health analysis year. Population projections from NY-CHAPPA v1.0, which used 2010 census tract definitions, were converted to 2020 census tract definitions for use in NY-CHAPPA v2.0.

2.2.2. Baseline Health Incidence

Baseline health incidence is required for each health endpoint to determine the change in public health impacts from changes in PM_{2.5} concentrations. Baseline health data was obtained at a sub-county level from New York State Department of Health (DOH) for mortality, asthma emergency room visits, asthma hospitalizations, and chronic lung disease hospitalizations. For all other health outcomes, sub-county-level data was not available, and the county-level baseline health incidence data from COBRA was used. Most of the sub-county-level data was not at the census tract level, but rather at aggregations of census tracts developed by DOH to protect patient confidentiality.³³ In cases where the sub-county-level data had between 1 and 4 cases, the exact number was not provided, and a value of 2.5 (the midpoint of the range) was used instead. Table A-5 lists the sources of incidence data and the associated years for each health endpoint included in NY-CHAPPA v2.0. Table A-6 lists the sources of the health impact functions used in NY-CHAPPA, along with the monetary value of each avoided health outcome. As shown in Tables A-5 and A-6, the incidence and health impact functions for avoided mortality are for all-cause mortality. In some contexts, the term "premature mortality" refers specifically to deaths occurring before the age of 75; however, in the Plan, that term is used to indicate reductions in mortality risk due to reduced air pollution exposure for populations up to age 99. The monetary values come from COBRA v5, inflated to 2024\$. Note that this is a difference from NY-CHAPPA v1.0, which used monetary values from COBRA v4.

The economic value of health impacts is estimated by multiplying changes in the number of cases of each health endpoint by its monetary value listed in Table A-6. The benefits of avoiding premature mortality are valued using the Value of a Statistical Life, an estimate that represent how much people are willing to pay for small reductions in their risks of dying from harmful health conditions that may be caused by environmental pollution. Monetary values for other health endpoints are based on economic valuation studies that estimate cost of illness (e.g., hospitalizations, emergency department visits) or estimate people's willingness to pay for reducing mortality risk or avoiding other adverse health effects (e.g., asthma exacerbation, respiratory symptoms). Some health endpoints (adult mortality and non-fatal heart attacks) are assumed to occur over a 20-year period and a discount rate of 5.03% is used for consistency with the discount rate used to express total value of health benefits as net present value.

Table A-5. Sources of Incidence Data used in NY-CHAPPA

Health Endpoint	Pollutant	Source of Incidence Data	Years of Incidence Data
Mortality, all cause	PM _{2.5} , O ₃	NY Department of Health	2008-2012
Nonfatal Heart Attacks	PM _{2.5}	EPA COBRAv5	2014
Hospital Admits, Respiratory (except for asthma and chronic lung disease) and Cardiovascular (except for heart attacks)	PM _{2.5} , O ₃	EPA COBRAv5	2011-2014
Hospital Admits, Asthma	PM _{2.5}	NY Department of Health	2008-2012
Hospital Admits, Chronic Lung Disease	PM _{2.5}	NY Department of Health	2008-2012
Acute Bronchitis	PM _{2.5}	EPA COBRAv5	2014
Upper and Lower Respiratory Symptoms	PM _{2.5}	EPA COBRAv5	1991
Emergency Room Visits, Asthma	PM _{2.5} , O ₃	NY Department of Health	2008-2012
Minor Restricted Activity Days	PM _{2.5}	EPA COBRAv5	1989
Work Loss Days	PM _{2.5}	EPA COBRAv5	1996
School Loss Days	O ₃	EPA COBRAv5	1996
Asthma Exacerbation	PM _{2.5} , O ₃	EPA COBRAv5	2006-2013
Asthma Onset	O ₃	EPA COBRAv5	2016
Hay Fever/Rhinitis Incidence	O ₃	EPA COBRAv5	2009

Table A-6. Health Impact Functions used in NY-CHAPPA v2.0 for PM_{2.5} and COBRAv5 for Ozone

Note: The monetary values for nonfatal heart attacks depend on age.

Health Endpoint	Pollutant	Source of Health Impact Function	Age Ranges	Monetary Value (2024\$)
Mortality, all cause (low)	PM _{2.5}	Krewski et al. (2009) ³⁴	30-99	\$11,995,364
Mortality, all cause (high)	PM _{2.5}	Lepeule et al. (2012) ³⁵	25-99	\$11,995,364
Nonfatal Heart Attacks	PM _{2.5}	Peters et al. (2001) ³⁶	18-99	\$53,290-\$421,473
Nonfatal Heart Attacks	PM _{2.5}	Pope et al. (2006) ³⁷	18-99	\$53,290-\$421,473
Nonfatal Heart Attacks	PM _{2.5}	Sullivan et al. (2005) ³⁸	18-99	\$53,290-\$421,473
Nonfatal Heart Attacks	PM _{2.5}	Zanobetti and Schwartz (2006) ³⁹	18-99	\$53,290-\$421,473
Nonfatal Heart Attacks	PM _{2.5}	Zanobetti et al. (2009) ⁴⁰	18-99	\$53,290-\$421,473
Nonfatal Heart Attacks	PM _{2.5}	Peters et al. (2001) ³⁶	18-99	\$53,290-\$421,473
Hospital Admissions, All Cardiovascular (except heart attacks)	PM _{2.5}	Moolgavkar (2000) ⁴¹	18-64	\$64,609
Hospital Admissions, All Cardiovascular (except heart attacks)	PM _{2.5}	Bell et al. (2008) ⁴²	65-99	\$60,591
Hospital Admissions, All Cardiovascular (except heart attacks)	PM _{2.5}	Peng et al. (2008) ⁴³	65-99	\$60,591
Hospital Admissions, All Cardiovascular (except heart attacks)	PM _{2.5}	Peng et al. (2009) ⁴⁴	65-99	\$60,591

Health Endpoint	Pollutant	Source of Health Impact Function	Age Ranges	Monetary Value (2024\$)
Hospital Admissions, All Cardiovascular (except heart attacks)	PM _{2.5}	Zanobetti et al. (2009) ⁴⁰	65-99	\$60,591
Hospital Admissions, All Respiratory	PM _{2.5}	Zanobetti et al. (2009) ⁴⁰	65-99	\$50,791
Hospital Admissions, All Respiratory	PM _{2.5}	Kloog et al. (2012) ⁴⁵	65-99	\$50,791
Hospital Admissions, Asthma	PM _{2.5}	Babin et al. (2007) ⁴⁶	0-17	\$23,931
Hospital Admissions, Asthma	PM _{2.5}	Sheppard (2003) ⁴⁷	0-17	\$23,931
Hospital Admissions, Chronic Lung Disease	PM _{2.5}	Moolgavkar (2000) ⁴⁸	18-64	\$31,578
Emergency Room Visits, Asthma	PM _{2.5}	Mar et al. (2010) ⁴⁹	0-99	\$683
Emergency Room Visits, Asthma	PM _{2.5}	Slaughter et al. (2005) ⁵⁰	0-99	\$683
Emergency Room Visits, Asthma	PM _{2.5}	Glad et al. (2012) ⁵¹	0-99	\$683
Acute Bronchitis	PM _{2.5}	Dockery et al. (1996) ⁵²	8-12	\$740
Asthma Exacerbation, Cough	PM _{2.5}	Mar et al. (2004) ⁵³	6-18	\$89
Asthma Exacerbation, Cough	PM _{2.5}	Ostro et al. (2001) ⁵⁴	6-18	\$89
Asthma Exacerbation, Shortness of Breath	PM _{2.5}	Mar et al. (2004) ⁵³	6-18	\$89
Asthma Exacerbation, Shortness of Breath	PM _{2.5}	Ostro et al. (2001) ⁵⁴	6-18	\$89
Asthma Exacerbation, Wheeze	PM _{2.5}	Ostro et al. (2001) ⁵⁴	6-18	\$89
Minor Restricted Activity Days	PM _{2.5}	Ostro and Rothschild (1989) ⁵⁵	18-64	\$105
Lower Respiratory Symptoms	PM _{2.5}	Schwartz and Neas (2000) ⁵⁶	7-14	\$32
Upper Respiratory Symptoms	PM _{2.5}	Pope et al. (1991) ⁵⁷	9-11	\$51
Work Loss Days	PM _{2.5}	Ostro (1987) ⁵⁸	18-64	\$243
Mortality, Long-term exposure	O ₃	Turner et al. (2016) ⁵⁹		\$11,995,364
Mortality, Short-term exposure	O ₃	Katsouyanni et al. (2009) ⁶⁰	30-99	\$11,995,364
Mortality, Short-term exposure	O ₃	Zanobetti and Schwartz (2008) ⁶¹	0-99	\$11,995,364
Hospital Admissions, All Respiratory	O ₃	Katsouyanni et al. (2009) ⁶⁰	65-99	\$50,791
Emergency Room Visits, Asthma	O ₃	Barry et al. (2018) ⁶²	0-99	\$683
Asthma Exacerbation	O ₃	Lewis et al. (2013) ⁶³	5-12	\$89
Asthma Onset	O ₃	Tetreault et al. (2016) ⁶⁴	0-17	\$73,225
Asthma Onset	O ₃	Garcia et al. (2019) ⁶⁵	9-18	\$73,225
Hay Fever/Rhinitis Incidence	O ₃	Parker et al. (2009) ⁶⁶	3-17	\$992.61

2.2.3. Baseline and Policy Scenario Emissions

NY-CHAPPA estimates the changes in PM_{2.5} concentrations and ensuing health effects based on changes in emissions of primary PM_{2.5} and precursors to secondary PM_{2.5} formation, including NO_x, SO₂, NH₃, and VOCs. Statewide annual emissions were estimated based on projected fuel consumption modeled in the

Plan scenarios (see Pathways Analysis chapter) and emission factors for each fuel and source type (described below). The emissions were downscaled to the census tract scale, as described in more detail below. The change in emissions for each analysis year is the difference between a given policy scenario and the baseline—in this analysis the No Action scenario.

The approach for estimating emissions and downscaling the emissions to the census tract level, differed by sector as follows:

Electricity generation sector emissions inputs were calculated based on outputs from the PLEXOS electricity sector model. PLEXOS is an additional production/cost model that uses the electric sector capacity builds identified in the Pathways analysis using the RESOLVE model (see Pathways Analysis chapter) to estimate unit-level dispatch needed for the spatial resolution of the health analysis. PLEXOS modeling done for the Plan was calibrated to RESOLVE inputs to project generally similar dispatch findings from the two models. Some differences were observed between PLEXOS and RESOLVE results for in-state hydrogen generation in 2040 and later years because of different model representations. These differences led to higher in-state hydrogen generation in the policy cases observed in 2040 and later in PLEXOS, which means that benefits from emission reductions in the electric sector may be conservatively low. The relatively small contribution of hydrogen emissions to health impacts and the fact that these generation differences are projected in later years of the analysis are expected to reduce the significance of this difference in terms of the overall projected benefits.

All generation sources in NYS were simulated as point sources with explicit emissions data for each source, and, therefore, downscaling was not necessary for this sector. The emissions point sources were placed based on latitude and longitude coordinates for each power plant analyzed, applying the specific heights of the exhaust stacks from NEI or the Energy Information Administration (EIA).^{67,68} Emissions were calculated based on the fuel consumption projections and emission rates derived from sources including the latest EPA Emissions & Generation Resource Integrated Database (eGRID) for NO_x and SO₂.⁶⁹ Generator-level PM_{2.5} emission rates were developed from eGRID's latest PM_{2.5} data for 2021.⁷⁰ Emission rate data was supplemented with the latest data from EPA's National Electric Energy Data System.⁷¹ and cross-referenced and verified with the 2020 NEI.⁷² and historical data derived from EPA's Clean Air Markets Data.⁷³

The Pathways scenarios assume hydrogen combustion for remaining thermal generation needs starting in 2040 (see the Pathways Analysis chapter of this Plan). Hydrogen combustion may increase emissions of NO_x compared to natural gas due to the higher flame temperatures. The health analysis conservatively assumes that emission rates of NO_x (emissions per unit of energy) would be double those from similar natural gas units. We expect that dedicated units combusting hydrogen would be designed for hydrogen and would have appropriate emissions controls as required, resulting in NO_x emissions that are similar to those from the same electricity generation using natural gas. A sensitivity analysis of NO_x emissions from hydrogen combustion in the Draft Plan found that if NO_x emission rates from hydrogen combustion were similar to natural gas units, health benefits associated with the electric sector would increase by three percent in 2040, yielding an overall health benefits increase of less than half a percent, indicating that health benefits in general would not be sensitive to the NO_x emission rate assumption. Furthermore, the

sensitivity analysis demonstrates that overall health benefits are not very sensitivity to hydrogen combustion because NO_x is the only pollutant emitted and the magnitude of NO_x emissions is low.

Industrial sector emissions were downscaled using two separate approaches for point sources and area sources. Larger industrial facilities report their emissions and fuel consumption by fuel type as point sources to DEC. These sources are modeled in NY-CHAPPA using their reported locations and stack heights, similar to the electricity generation sector, and their reported emissions. The modeled emission reductions under the Plan scenarios are assigned to specific point sources based on the fraction of fuel consumed by each facility. For example, if a facility consumed 0.1 percent of the industrial natural gas in NYS, it was assigned 0.1 percent of the emission reductions from industrial natural gas associated with the scenario (relative to the facility's reported emissions). The remaining industrial emissions from non-point sources were modeled as area sources, in which emissions were calculated using emission factors from the 2020 NEI for each of the industrial fuel types (coal, natural gas, distillate oil, and wood).⁷² The resulting emissions were downscaled from state to county scale based on proportion of employment in the industrial sector in each county. Emissions were then downscaled from the county scale to the census tract scale based on the proportion of land area in each county designated as industrial, according to the NYS Department of Taxation and Finance (DTF).⁷⁴

Commercial sector emissions were calculated using emissions factors from the 2020 NEI for wood combustion and for emissions of NH₃ and SO₂ from all fuel types,⁷² and emission factors developed by Brookhaven National Laboratory (BNL) for emissions of primary PM_{2.5}, NO_x, and VOCs from natural gas and fuel oil combustion.⁷⁵ This is a difference from the Draft Plan, which used emission factors from the 2020 NEI for all commercial fuel types. The BNL emission factors for PM_{2.5}, NO_x, and VOCs from distillate and natural gas are lower than the NEI emission factors by 50% or greater on an energy content basis. The resulting emissions were downscaled from the regional scale to the county scale based on the proportion of employment in the commercial sector in each county. Emissions were then downscaled from the county scale to the census tract scale based on the proportion of land area in each county designated as commercial, according to the DTF.

Residential sector emissions were calculated using emissions factors from BNL for emissions of primary PM_{2.5}, NO_x, and VOCs from fuel oil and natural gas combustion,⁷⁵ and the 2020 NEI for liquid petroleum gas, as well as for emissions of NH₃ and SO₂ from all fuel types.⁷² The emission factors for fuel oil and natural gas combustion have been updated since the Draft Plan. The BNL emissions factors for NO_x and VOCs from distillate and natural gas and for PM_{2.5} from distillate are lower than the NEI emission factors whereas the emission factor for PM_{2.5} from natural gas is higher than the NEI emission factor. For wood, the analysis used emission factors provided to NYSERDA from the Northeast States for Coordinated Air Use Management (NESCAUM), based on equipment testing supported by NYSERDA. Residential sector emissions were downscaled from the regional scale to the census tract scale using data from the U.S. Census Bureau's American Community Survey,⁷⁶ which provides data on the number of occupied homes in each block group. The regional-scale emissions were downscaled to the census tract scale based on the proportion of occupied homes in each census tract relative to the regional total. One exception to this approach is for residential wood consumption, which was first downscaled from the state to the county scale based on data from a survey conducted by the Commission for Environmental Cooperation

and NESCAUM.⁷⁷ The county scale emissions were then downscaled to the census tract scale based on the proportion of occupied homes in each census tract relative to the county total.

On-road sector county scale emissions were estimated using EPA's Motor Vehicle Emissions Simulator (MOVES) to develop emission factors by vehicle type, road type, and speed bin. These emission factors were multiplied by county scale projections of vehicle miles traveled (VMT) from the Pathways Analysis to estimate county scale emissions. The county scale emissions were downscaled to the census tract scale using two separate approaches:

- For most road types (except local and minor collector roads), emissions were downscaled using VMT data from the Federal Highway Administration's Highway Performance Monitoring System (HPMS) by road link for more than 400,000 road links in New York State. The county scale emissions were assigned to specific road links based on the proportion of VMT on that road link to the total VMT for that road type. For example, for a specific segment of an interstate in a given county, a portion of the emissions from interstates in that county estimated from MOVES were assigned to that segment based on the proportion of VMT for that segment to the total VMT for interstates in all segments in that county.
- HPMS data is not available for local and minor collector roads. Emissions from these road types were downscaled to the census tract scale using the following multi-step process which sought to ensure that emissions from these road types were properly distributed to urban and rural areas within each county.
 1. The census tracts that are considered urban were identified based on data from the U.S. Census Bureau.
 2. The total 2025 population by census tract was summed up to the county level based on urban and rural designations in step 1.
 3. The total urban county population and total rural county population from step 2 was divided by the total county population to get urban and rural population ratios.
 4. The ratios from step 3 were then multiplied by the county scale emissions (described above) to estimate the county scale emissions in the urban and rural areas in each county.
 5. The area of each census tract was then used to sum the urban census tracts and the rural census tracts (based on the designations from step 1) to get the total urban and rural areas for each county. The urban and rural areas for each county were then divided by the total area for each county to get the ratio of the urban and rural land area.
 6. Lastly, these land area ratios from step 5 were multiplied by the county scale urban and county scale rural emissions from step 4 to distribute the urban and rural emissions to each census tract based on their proportion of land area.

Aircraft emissions for domestic flights in NYS were downscaled using Federal Aviation Administration (FAA) data on landings and takeoffs at airports. Emissions were distributed into three altitude bins:

surface level; up to 500 feet; and 500 to 2,000 feet based on emissions profile data from the FAA's Aviation Environmental Design Tool (AEDT).⁷⁸ Emissions were modeled as area sources occurring within the census tract where each airport is located, with the exception of the 2,000-foot altitude bin for LaGuardia and JFK airports. Those emissions were uniformly distributed within a 5.5 land mile radius around each airport to account for landing and takeoff emissions within these airports' airspace. This analysis does not include emissions from cruising altitudes above 2,000 feet, as those emissions are more broadly dispersed and are expected to have little impact on local concentrations.

Reductions in emissions from sustainable aviation fuel (SAF) blends were based on a literature review summarized in the memorandum, *Co-Pollutant Impacts of Low-Carbon Fuels and Technologies—2025 Update*.⁷⁹ Based on data reported in relevant studies, this analysis estimates an average 66 percent reduction in PM_{2.5} emissions during idling and a 59 percent reduction in PM_{2.5} from landing and takeoff operations for 50 percent SAF blends relative to 100 percent fossil jet fuel. Reductions in aircraft SO₂ emissions from SAF are expected to be directly proportional to the reduced sulfur content of the SAF-fossil jet fuel blend and be consistent across all operating modes. This analysis estimates aircraft SO₂ emissions reductions of approximately 36 percent for 50 percent SAF blends. No emission reductions were included for NO_x because SAF is not expected to significantly impact NO_x emissions. These emission reductions were applied to the SAF consumption projections from the Pathways Analysis.

Marine and rail emissions were calculated using emissions factors from the 2020 NEI.⁷² The emissions for each scenario were downscaled to the census tract scale based on census tract area. Emissions were distributed only to census tracts with marine shipping lines or rail lines, respectively.

Emissions inputs for *other non-road sectors*, including non-road engines used in construction, agriculture, and mining, were calculated using emissions factors for non-road distillate fuel from the 2020 NEI.⁷² The regional scale fuel consumption was downscaled to the county scale using data derived from the NONROAD module of EPA's MOVES model. The county scale emissions were downscaled to the census tract scale based on proportion of population, as data on non-road equipment populations were not available.

2.3. Limitations and Uncertainty

This analysis involves modeling changes in air quality and health effects under different future scenarios of energy consumption and air pollutant emissions. Each of the steps in the analysis has some uncertainty and limitations.

The changes in air pollutant emissions are estimated using modeled changes in fuel consumption from the Pathways Analysis. However, there are some simplifying assumptions made to translate the Pathways Analysis fuel combustion data to census tract scale emissions inputs for NY-CHAPPA that represent sources of uncertainty. The details of how the policies embedded in the scenarios will play out locally are unknown; thus, as described in the section above, fuel consumption data was downscaled to the census tract scale following simplifying assumptions that differ by sector as appropriate. As an example, in the industrial sector, emissions from smaller facilities that do not report their emissions to DEC are represented as area sources in which changes in statewide fuel consumption are downscaled

based on employment and land area designations. As another example, non-road emissions from construction, agriculture, and mining are downscaled by population because the distribution of equipment and its turnover time due to state policies is unknown. Results in the health analysis are aggregated by state, region, and community-type because of uncertainties in local results.

In addition, the health analysis assumes no change in emissions from alternative fuels, such as renewable diesel, compared to fossil fuels. This may be a conservative assumption as some research has suggested that renewable diesel may have lower emissions when used in uncontrolled non-road engines.⁷⁹ (Note that one exception to this approach is for sustainable aviation fuels, as discussed in the previous section.)

There are also limitations in the modeling of emissions from the electricity sector. In particular, the modeling approach was able to estimate emission reductions in PM_{2.5}, NO_x, and SO₂, but not VOC and NH₃. The electricity sector modeling conservatively assumes emission rates of NO_x would be double those from similar natural gas units. As described above, a sensitivity analysis conducted for the Draft Plan indicated that if NO_x emissions rates from hydrogen combustion plants were similar to natural gas units, the total benefits would increase only slightly; for example, relaxing this assumption would increase electric sector-related health benefits by three percent and total health benefits by less than half a percent in 2040. In addition, NY-CHAPPA only accounts for changes in emissions in New York State. For this reason, the analysis does not account for any emissions changes in the electricity sector outside of the state, including, for example, changes in electric sector imports into New York State over time.

While care was taken to downscale the estimated air pollutant emissions to the census tract scale, the approach described above does not necessarily fully represent all emissions sources or account for all variation in emissions within census tracts. In particular, this analysis focused on changes in energy-related emissions that would be impacted by the policy scenarios. There may be other changes to emissions in other sectors; however, these emissions changes are outside the scope of this analysis.

Similarly, the air quality model used in NY-CHAPPA estimates how changes in air pollutant emissions result in changes in ambient PM_{2.5} concentrations. Although the model performs well in estimating current air quality against observations and other models (described in Section 2.1.5), no model will perfectly predict air quality concentrations. In particular, NY-CHAPPA appears to somewhat overpredict baseline PM_{2.5} concentrations in the NYC area and underpredict concentrations in some of the upstate areas. Furthermore, the future changes in PM_{2.5} concentrations under the policy scenarios will be impacted by multiple factors, including changes in meteorology, which are difficult to predict, especially for future years. The health analysis does not account for future changes in meteorology given large uncertainties and instead uses a single meteorological year.

Furthermore, NY-CHAPPA and COBRA were used to estimate the benefits of reduced PM_{2.5} and ozone concentrations, respectively, but neither of these tools account for other potential benefits of reduced air pollutant emissions, including reductions in NO₂ concentrations and other hazardous air pollutants (also referred to as “air toxics”) nor does it account for potential benefits from improvements in indoor air quality.

The approach to estimating changes in health effects also includes uncertainty. The health impact functions used in NY-CHAPPA are taken from EPA’s COBRA tool and/or the published epidemiological literature, based on studies that determine the effect of changes in air quality on changes in health effects. The health impact functions derived from these studies are useful, but the actual observed health impact of changes in air quality can be affected by multiple other factors, such as individual risk factors within populations and the implementation of other public health programs. Additionally, the baseline health incidence data used from COBRA and DOH does not reflect incidence data from more recent years (Table A-5).

Therefore, results of NY-CHAPPA and COBRA are best represented at aggregated spatial scales and by community type and should not be interpreted at the individual census tract scale, to minimize false precision of results.

Lastly, the approach used to estimate the monetary value of the health benefits relies on standard economic values developed by the EPA for the COBRA tool. These economic values are based on studies of the cost of medical care and/or the public’s willingness to pay to avoid certain health effects. These economic values are averages, and they may not represent the actual costs of each health effect in all cases.

Beyond the air quality benefits modeled by NY-CHAPPA, policies in the Plan may result in additional health benefits—for example, from active transportation, energy efficiency interventions in residential buildings, and energy security—are not quantified here. Future work could assess health benefits beyond those captured in this analysis. In addition, while this analysis focused on aggregated benefits, future work may also consider more localized impacts from sectoral policies.

3. Additional Results of the Public Health Impacts Analysis

In addition to the results of the public health analysis discussed in the chapter above, the sections below provide additional results for all policy scenarios considered in the health analysis: Current Policies, Additional Action, and Net Zero B (Sections 3.1, 3.2, and 3.3), and the two federal sensitivity scenarios (Section 3.4). All results are shown relative to the No Action scenario. The associated data annex includes additional results at the county level and for additional model years for all scenarios.

3.1. Statewide Health Benefits

Table A-7 provides a summary of the annual avoided public health effects due to reduced PM_{2.5} and ozone concentrations for each scenario in 2040, as well as the fraction of benefits accruing in DAC areas for each health effect under each scenario. Note that the fraction of benefits in DAC areas is only due to benefits from lower PM_{2.5} concentrations because the results for ozone are only available at the county level. These results are presented in Table 2 in this chapter, but includes the DAC area fraction for each scenario, which can be considered relative to the 37 percent geographic population of DACs statewide. Table A-8 provides the same information for 2050.

Table A-7. Summary of Annual Statewide Avoided Public Health Effects due to Lower PM_{2.5} and Ozone Concentrations by Scenario Relative to the No Action Scenario (2040)

Note: The DAC area fraction represents the fraction of avoided cases due to lower PM_{2.5} concentrations within those areas and can be compared with the statewide fraction of population within DAC areas, approximately 37 percent.

Health Effect	Current Policies		Additional Action		Net Zero B	
	Avoided Cases Per Year	DAC Area Fraction	Avoided Cases Per Year	DAC Area Fraction	Avoided Cases Per Year	DAC Area Fraction
Premature Mortality	570	51%	1,000	50%	3,200	49%
Nonfatal Heart Attacks	240	49%	430	48%	1,300	47%
Hospitalizations	160	50%	280	50%	880	49%
Acute Bronchitis	260	50%	450	50%	1,400	49%
Respiratory Symptoms	8,000	50%	14,100	50%	44,000	49%
Emergency Room Visits, Asthma	780	72%	1,300	72%	4,000	72%
Asthma Exacerbation	4,900	50%	8,600	50%	27,000	49%
Minor Restricted Activity Days	160,000	49%	280,000	49%	870,000	48%
Work Loss Days	27,000	49%	48,000	49%	150,000	48%

Table A-8. Summary of Annual Statewide Avoided Public Health Effects due to Lower PM_{2.5} and Ozone Concentrations by Scenario Relative to the No Action Scenario (2050)

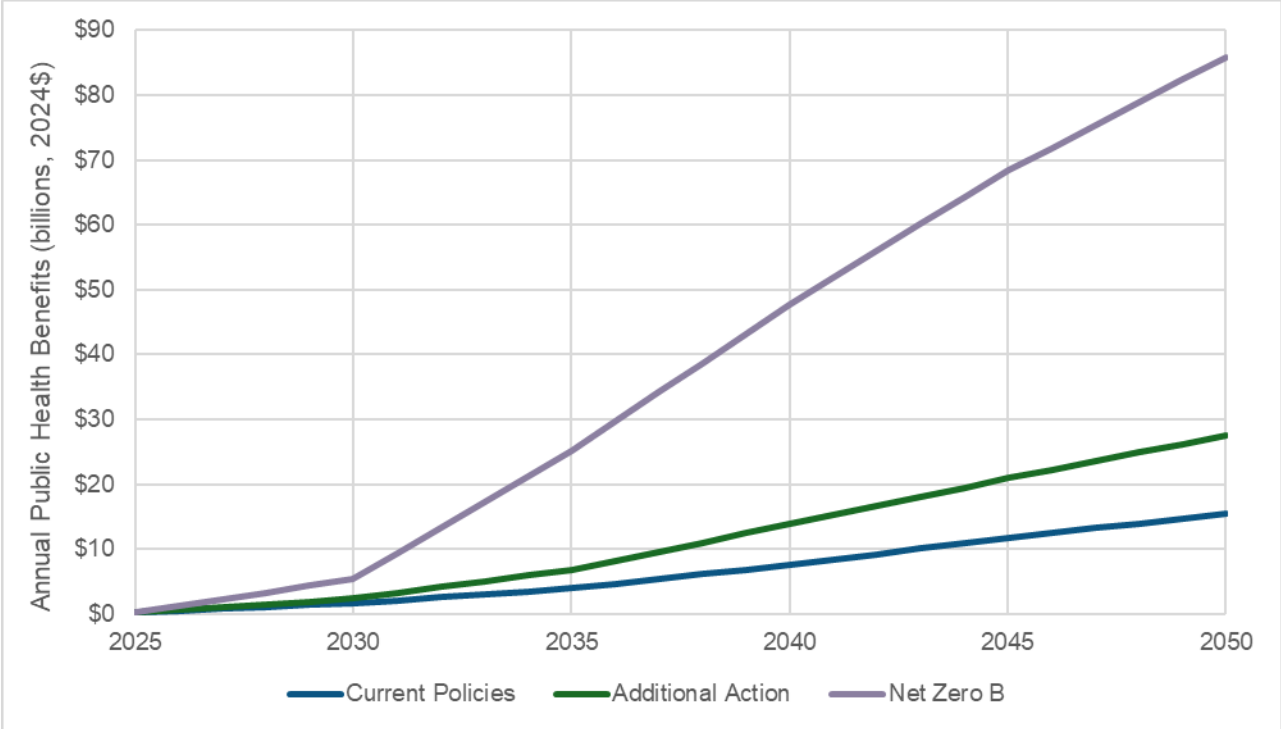
Note: The DAC area fraction represents the fraction of avoided cases due to lower PM_{2.5} concentrations within those areas and can be compared with the statewide fraction of population within DAC areas, approximately 37 percent.

Health Effect	Current Policies		Additional Action		Net Zero B	
	Avoided Cases Per Year	DAC Area Fraction	Avoided Cases Per Year	DAC Area Fraction	Avoided Cases Per Year	DAC Area Fraction
Premature Mortality	1,200	50%	2,000	50%	5,900	49%
Nonfatal Heart Attacks	490	49%	820	48%	2,400	47%
Hospitalizations	320	50%	540	50%	1,600	49%
Acute Bronchitis	470	50%	790	50%	2,200	49%
Respiratory Symptoms	15,000	50%	25,000	50%	71,000	49%

Health Effect	Current Policies		Additional Action		Net Zero B	
	Avoided Cases Per Year	DAC Area Fraction	Avoided Cases Per Year	DAC Area Fraction	Avoided Cases Per Year	DAC Area Fraction
Emergency Room Visits, Asthma	1,400	72%	2,300	72%	6,400	72%
Asthma Exacerbation	9,000	50%	15,000	50%	44,000	49%
Minor Restricted Activity Days	290,000	49%	480,000	49%	1,300,000	48%
Work Loss Days	49,000	49%	81,000	50%	230,000	48%

Figure A-8 shows the total annual benefits values associated with lower PM_{2.5} and ozone concentrations for each scenario relative to the No Action scenario between 2025 and 2050, including both in-state and out-of-state benefits. The chapter shows a similar figure, covering the period 2025 to 2040. The data annex provides annual benefits values by scenario for in-state, out-of-state, and total benefits associated with projected reduced exposure to PM_{2.5} and ozone.

Figure A-8. Projected Annual Health Benefits Value from PM_{2.5} (High Value) and Ozone by Scenario Relative to the No Action Scenario (2025–2050)



3.2. Benefits by Region and Community

Figure A-9 shows the annual average PM_{2.5} concentration reductions by region and community from each scenario in 2040 relative to the No Action scenario. The data annex provides this information for all scenarios at the county level. The magnitude of PM_{2.5} concentration reductions increases from Current Policies to Additional Action to Net Zero B, illustrated in the different y-axis scales. These figures show that in all regions DAC areas tend to receive a higher reduction in PM_{2.5} concentrations relative to non-DAC areas. While there are differences in local exposure, the New York City region has similar PM_{2.5} concentration reductions between DAC and non-DAC areas.

Figure A-10, Figure A-11, and Figure A-12 show maps of the county scale average reduction in PM_{2.5} concentrations in 2040 in each scenario. While each county would experience a reduction in average ambient PM_{2.5} concentrations in each scenario, urban areas would experience the largest reductions, with the highest reductions in New York City. These areas also tend to have the highest baseline emissions and therefore would see the largest emissions reductions in each scenario.

Figure A-13 shows the total annual value of health benefits in 2040 for each region under each scenario relative to the No Action scenario. The data annex provides this information for all scenarios at the county level. The charts on the left in each figure show the annual benefits for all regions except New York City, and the charts on the right show the annual benefits for the New York City region on a different scale. The value of benefits under Additional Action are at least 60 percent higher than under Current Policies across all regions, and the value of benefits under Net Zero B are approximately triple compared to those under Additional Action.

Figure A-9. Population-Weighted Average PM_{2.5} Concentration Reductions by Community, Region, and Scenario Relative to the No Action Scenario (2040)

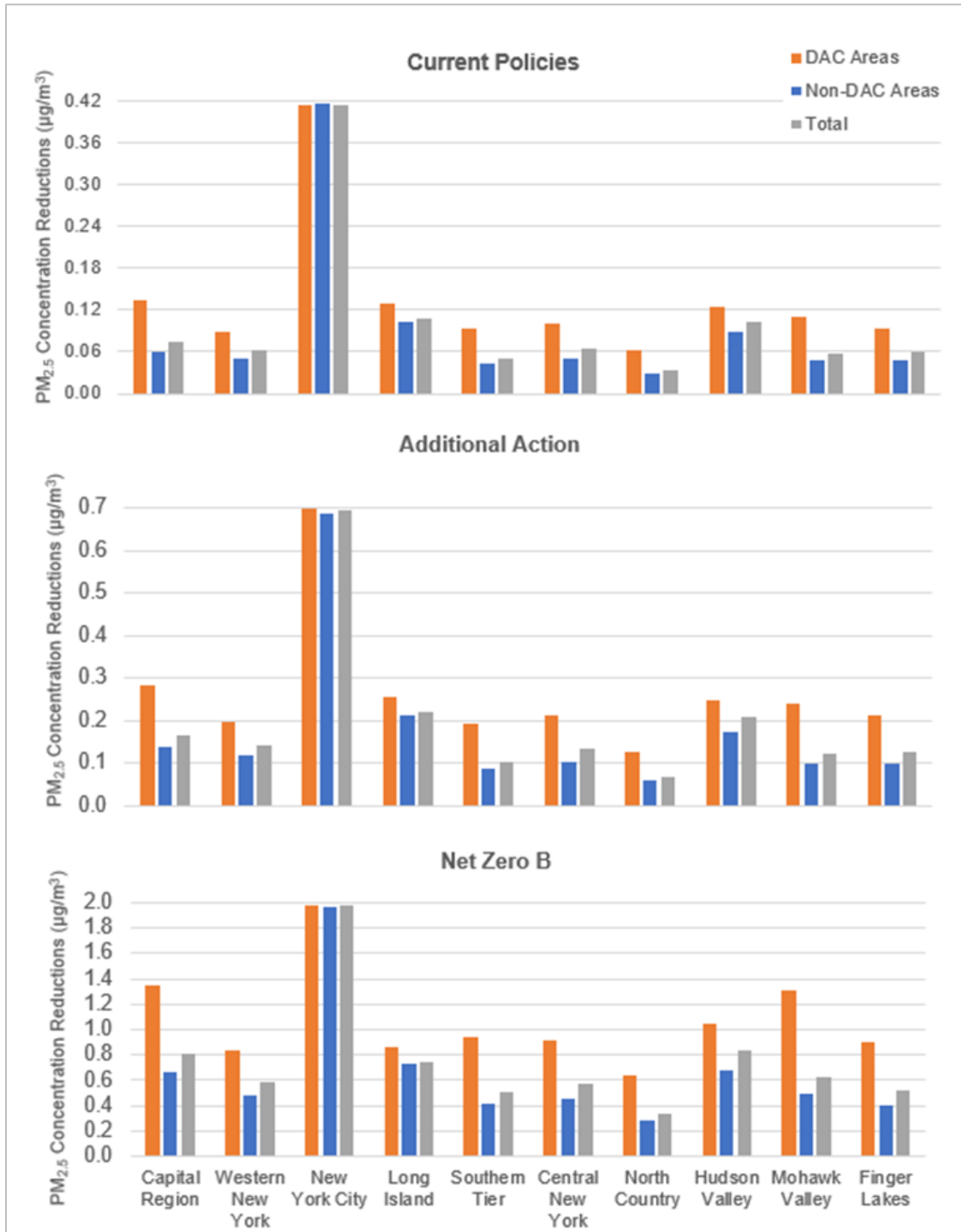


Figure A-10. Population-Weighted PM_{2.5} Concentration Reductions (µg/m³) by County (Current Policies Scenario Relative to the No Action Scenario, 2040)

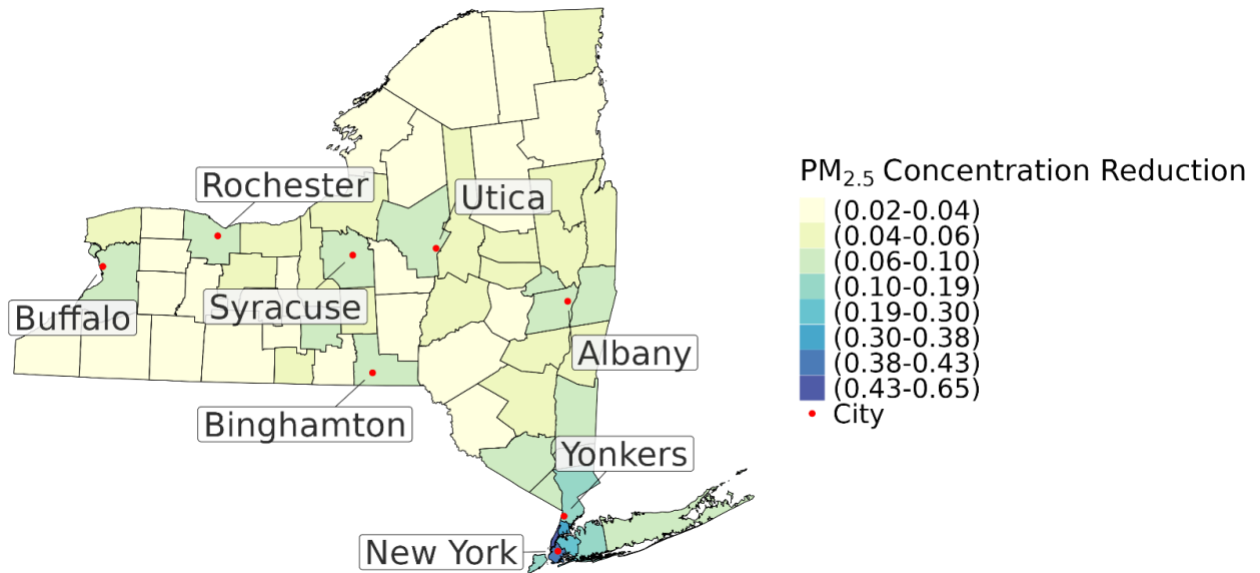


Figure A-11. Population-Weighted PM_{2.5} Concentration Reductions (µg/m³) by County (Additional Action Scenario Relative to the No Action Scenario, 2040)

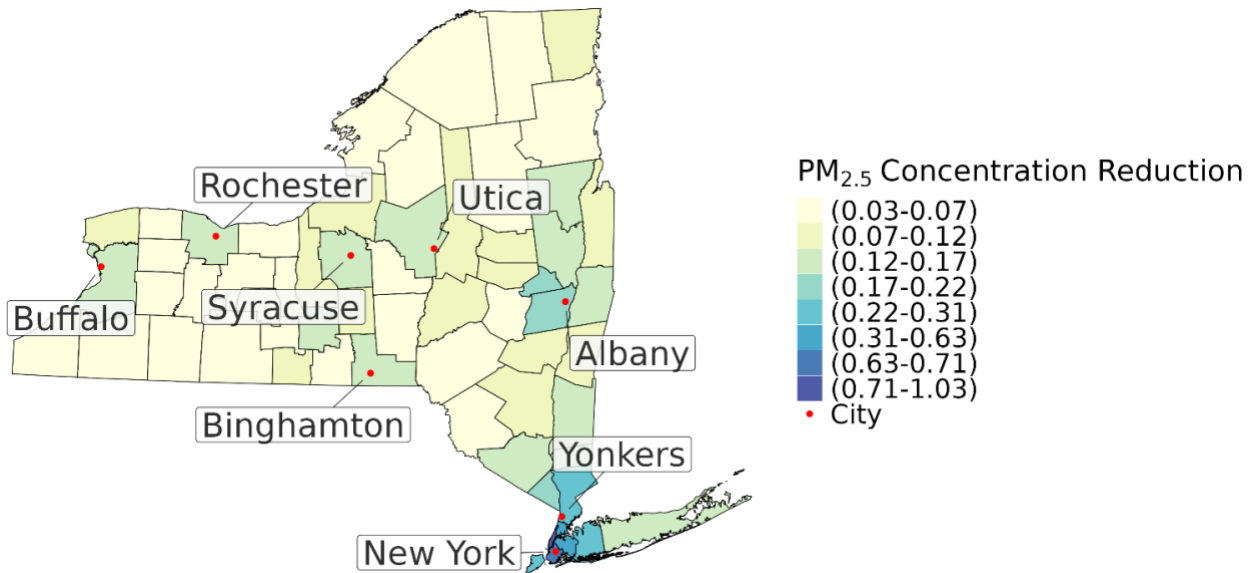


Figure A-12. Population-Weighted PM_{2.5} Concentration Reductions (μg/m³) by County (Net Zero B Scenario Relative to the No Action Scenario, 2040)

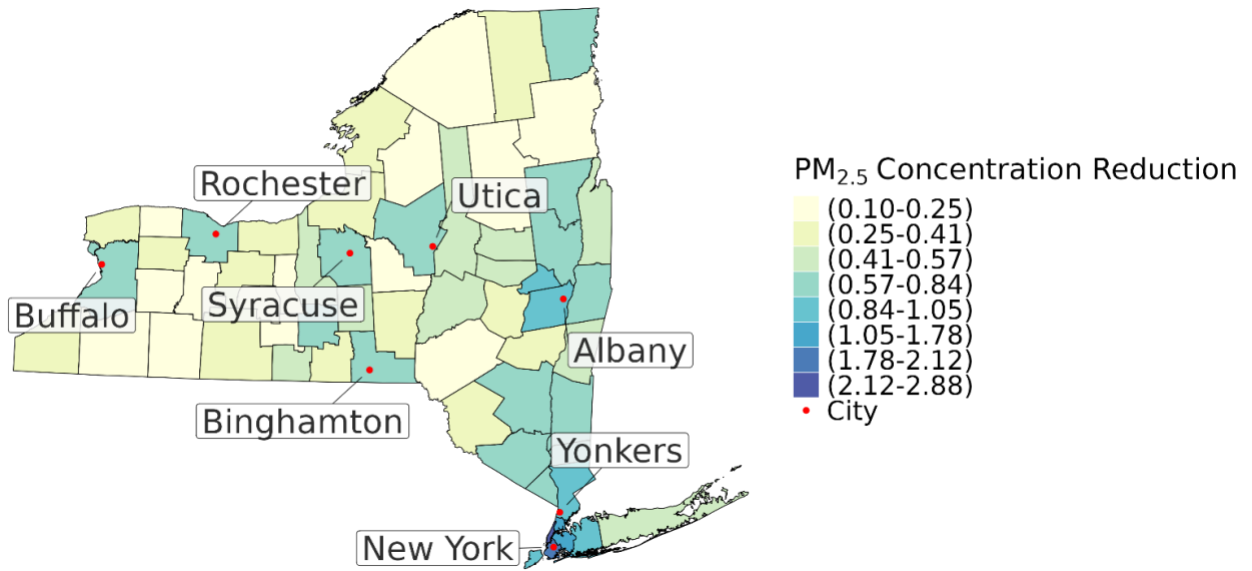


Figure A-13. Annual Value of Health Benefits from Lower PM_{2.5} Concentrations by Region and by Scenario Relative to the No Action Scenario (2040)

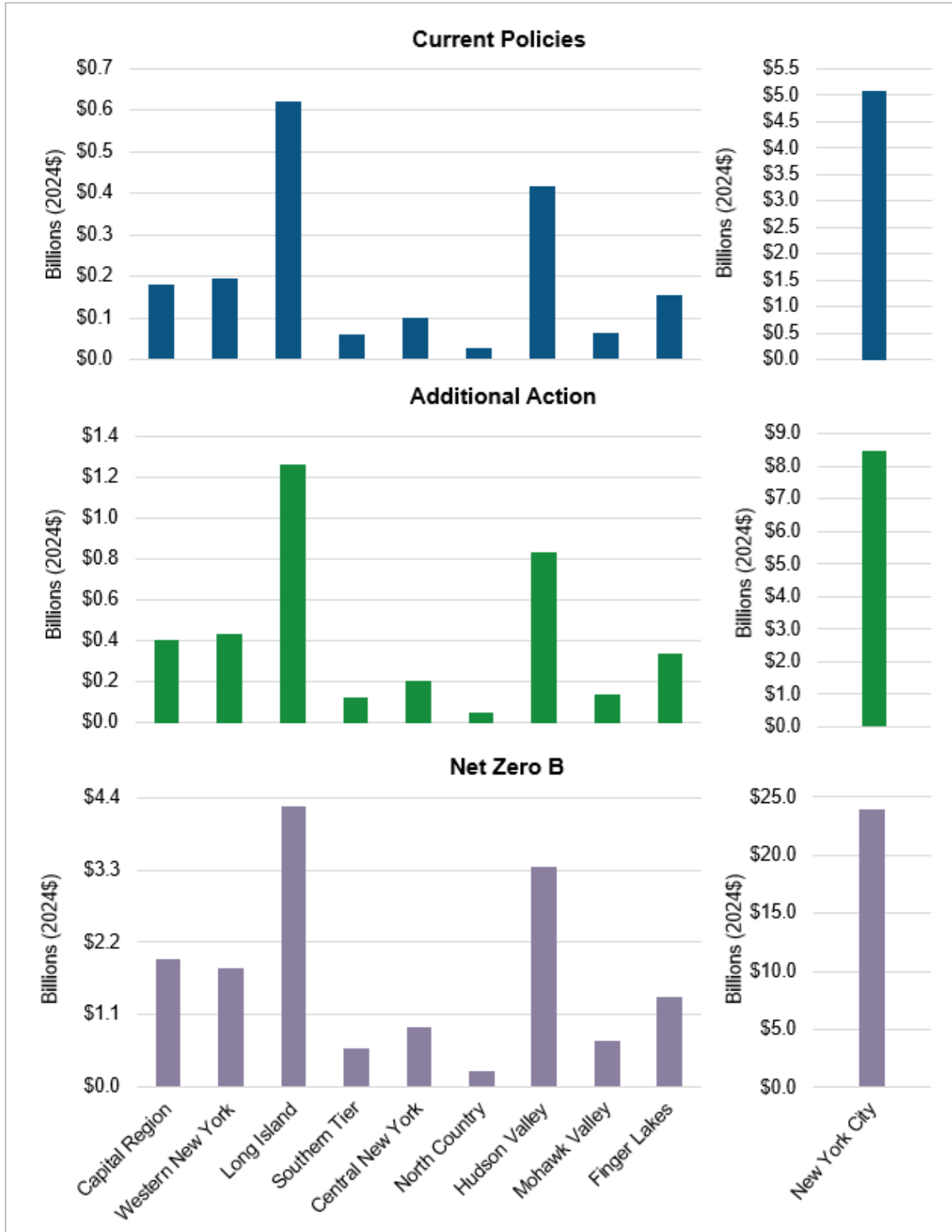


Figure A-14, Figure A-15 and Figure A-16 show maps of the county scale per-capita value of public benefits of each scenario in 2040. Similar to the distribution of PM_{2.5} reductions shown in Figure A-10, Figure A-11, and Figure A-12, each county would see positive per-capita health benefits in each scenario. However, the urban areas tend to see higher per-capita benefits, due to the greater reductions in PM_{2.5} concentrations in these areas.

Figure A-14. Per Capita Health Benefits Value (\$) by County (Current Policies Scenario Relative to the No Action Scenario, 2040)

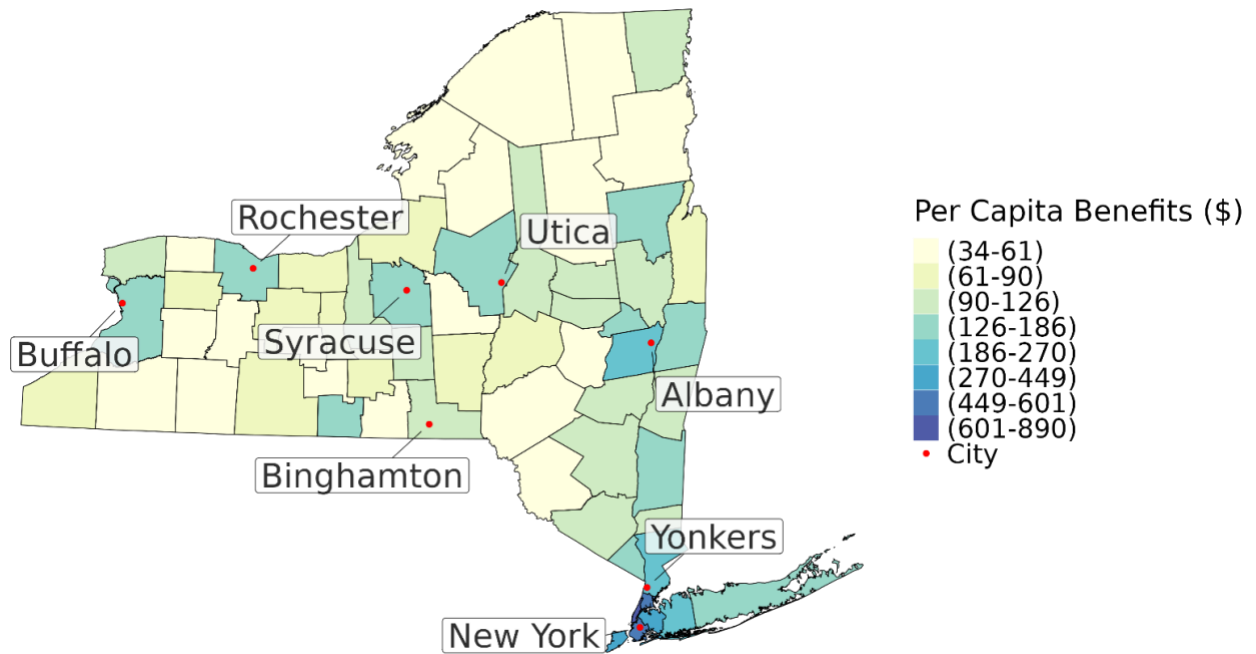


Figure A-15. Per Capita Health Benefits Value (\$) by County (Additional Action Scenario Relative to the No Action Scenario, 2040)

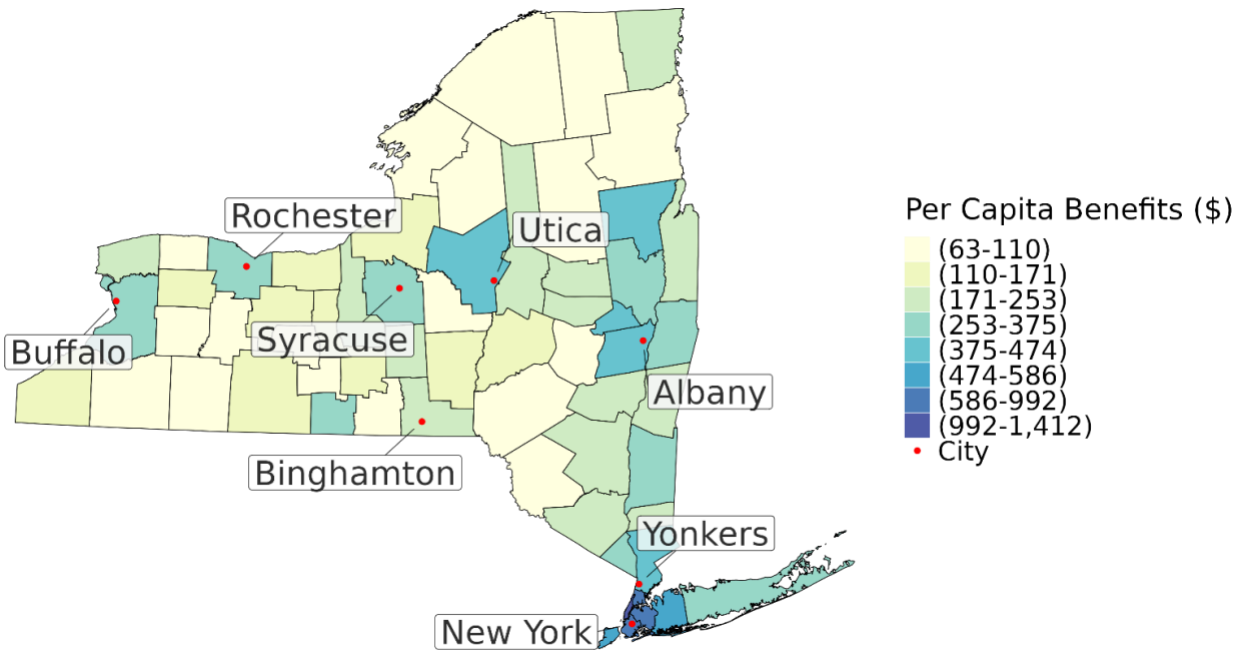


Figure A-16. Per Capita Health Benefits Value (\$) by County (Net Zero B Scenario Relative to the No Action Scenario, 2040)

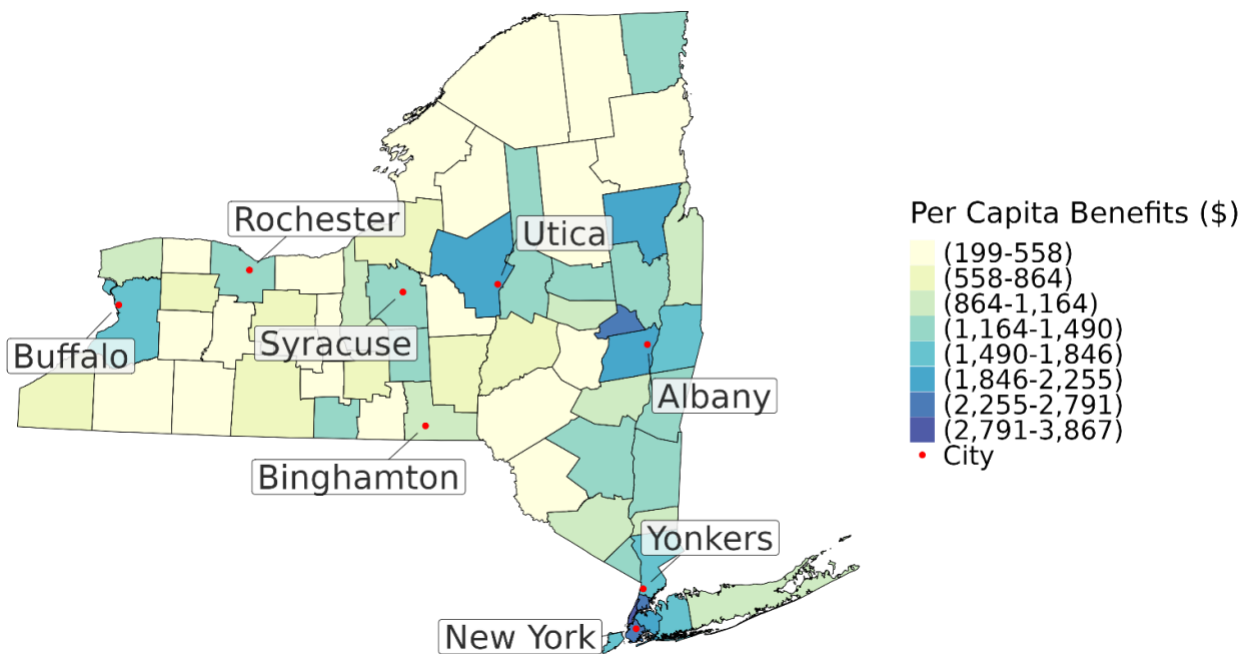


Figure A-17 shows the fraction of the value of benefits from lower PM_{2.5} concentrations accruing to DAC areas compared to their fraction of the population in each region under all scenarios. The data annex provides this information for all scenarios at the county level. These figures show that for all regions, DAC areas receive a larger share of benefits relative to their share of the population. The distribution of fractional benefits accruing to DAC areas is similar across all scenarios.

Figure A-17. Fraction of Cumulative Benefits due to Lower PM_{2.5} Concentrations Accruing to DAC Areas by Scenario Relative to the No Action Scenario Compared to the Fraction of Population in DAC Areas (2025–2040)

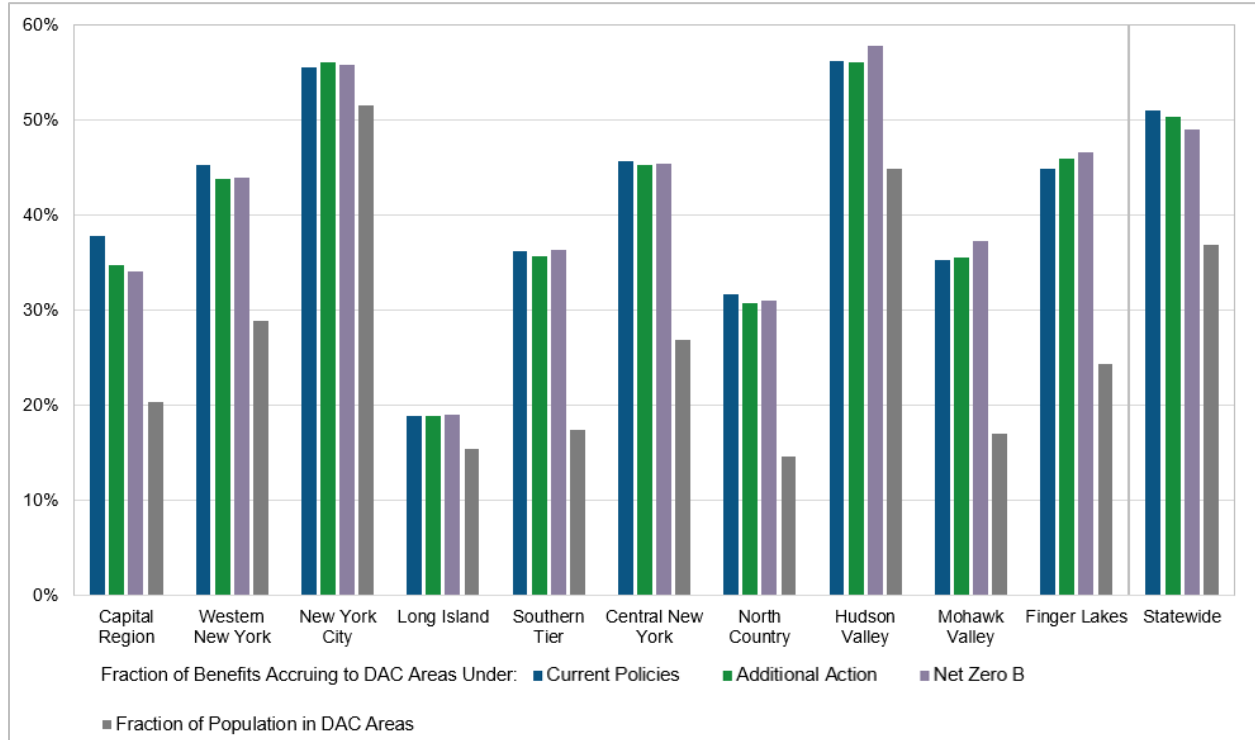


Figure A-18 and Figure A-19 summarize the regional-level distribution of public health outcomes to geographic DACs and non-DACs in 2040 under the Current Policies and Net Zero B scenarios (the chapter shows a similar figure for the Additional Action). The pie charts show DAC and non-DAC area fractions of regional population, avoided premature mortality cases, and avoided emergency room visits for asthma, with regional totals beneath each pie chart. The bar charts show annual per capita monetary values for DAC and non-DAC areas for each region, representing the combined value of all avoided health effect types. DAC areas receive higher per capita benefits than non-DAC areas under all scenarios; under Net Zero B, the difference in per capita benefits for DAC areas compared to non-DAC areas is even larger than under Current Policies and Additional Action.

Figure A-18. Summary of Annual Public Health Benefits from Lower PM_{2.5} Concentrations (Current Policies Scenario Relative to the No Action Scenario, 2040)

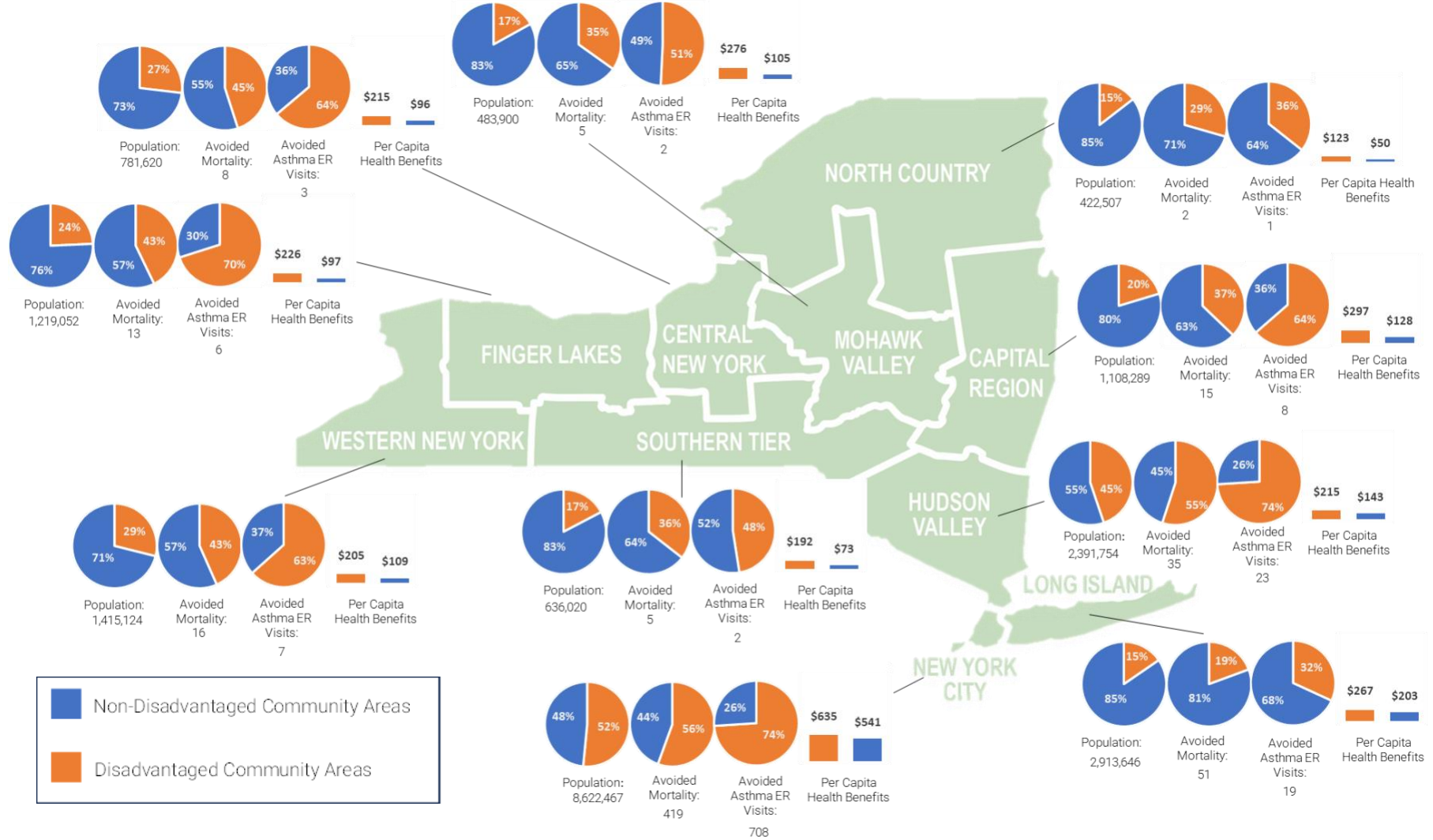
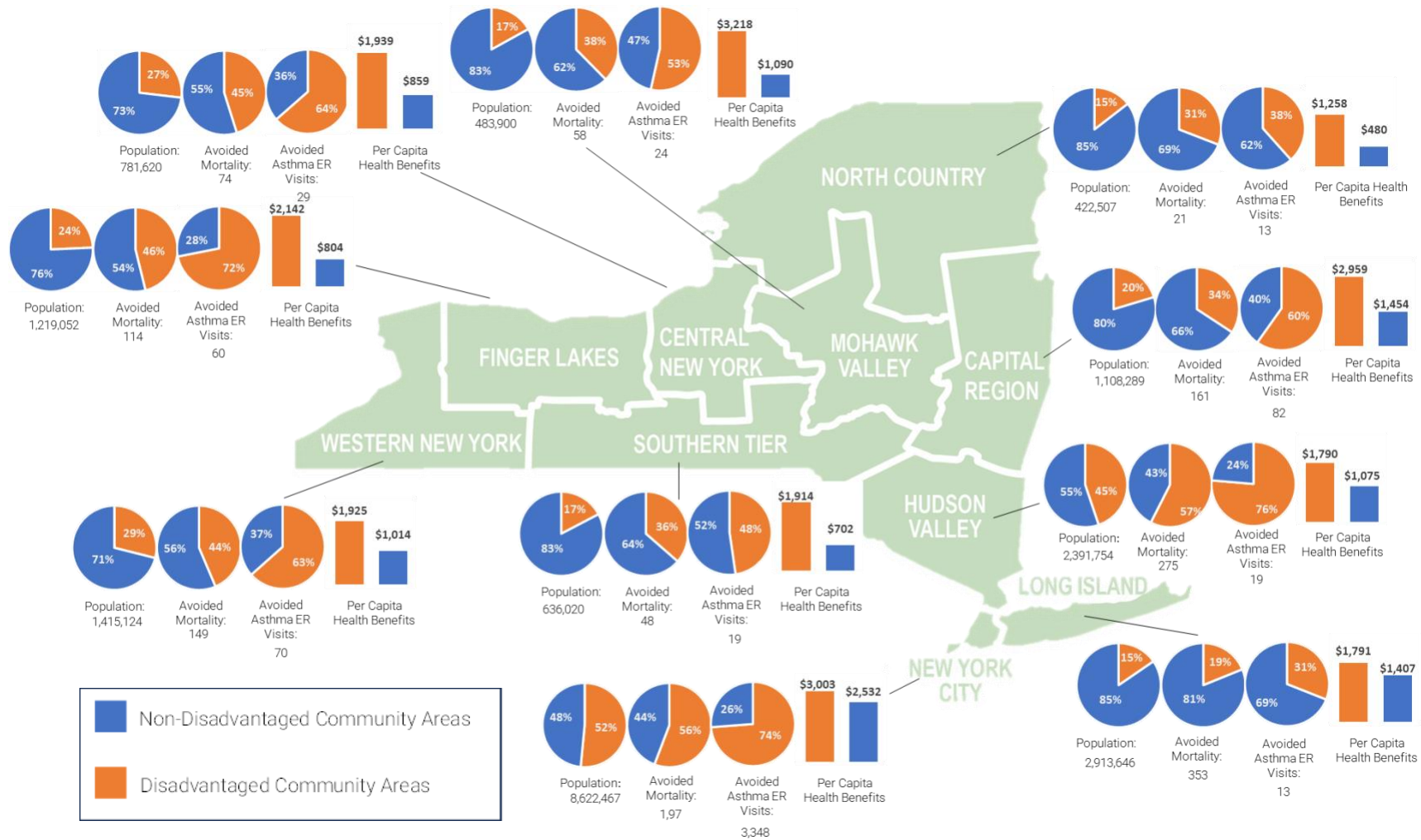


Figure A-19. Summary of Annual Public Health Benefits from Lower PM_{2.5} Concentrations (Net Zero B Scenario Relative to the No Action Scenario, 2040)



3.3. Benefits by Sector

Table A-9 and Figure A-20 through Figure A-25 present the distribution of the public health benefits for each scenario by sector. Table A-9 shows the cumulative 2025-2040 value of benefits by sector and scenario. Figure A-20 through Figure A-22 show the proportion of cumulative benefits by sector and community, both with and without the benefits of reduced wood combustion.

Table A-9. Cumulative Societal Public Health Benefits Value (million \$) from Lower In-State PM_{2.5} Concentrations by Sector and Scenario Relative to the No Action Scenario (2025–2040)

Sector	Current Policies	Additional Action	Net Zero B
Buildings			
Commercial Fossil Fuels	\$836	\$1,057	\$7,009
Commercial Wood	\$0	\$0	\$3,215
Residential Fossil Fuels	\$27,581	\$34,935	\$102,496
Residential Wood	\$5,282	\$9,371	\$59,388
Buildings Total	\$33,670	\$45,363	\$172,109
Transportation			
On-road	\$9,675	\$18,268	\$23,408
Non-road	\$0	\$0	\$12,131
Aircraft	\$0	\$4,997	\$5,050
Transportation Total	\$9,675	\$23,265	\$40,588
Industry			
Industrial (area)	\$0	\$2,733	\$20,399
Industrial (point)	\$0	\$36	\$268
Industrial Wood	\$0	\$3,010	\$7,811
Industry Total	\$0	\$5,779	\$28,477
Electricity	\$3,399	\$3,240	\$1,937
Total	\$46,774	\$77,647	\$243,113

Generally, the buildings and transportation sectors account for the highest share of the benefits in all scenarios, and the sectoral results are described in more detail in the chapter. The Net Zero B scenario has significantly higher total benefits than the other scenarios, and as shown in Table A-9, the largest fraction of those benefits are from reductions in emissions in the buildings sector, most of which are from the residential sector, both from fossil fuels and wood. Net Zero B also has much larger benefits from industry compared to the other scenarios.

Although reducing wood combustion is not a focus of mitigation characterized by the Pathways Analysis, the reductions in emissions from wood combustion are a co-benefit of improved energy efficiency and the reduction in wood use when cleaner heating systems are installed. Despite the wood benefits representing a very small fraction of shift in energy use, the high emission factors associated with wood combustion result in outsized benefits relative to residential fossil fuels. The figures below show that when the benefits from reductions in wood combustion are excluded, the other sectors account for a relatively higher share of the total non-wood benefits.

Figure A-23 through Figure A-25 show the regional and sectoral distributions of the public health benefits with and without the benefits of reduced wood combustion.

Figure A-20. Cumulative Societal Value from Lower In-State PM_{2.5} Concentrations Relative to the No Action Scenario by Sector and Community, with (top) and without (bottom) the Benefits from Lower Wood Combustion (Current Policies Scenario, 2025–2040)

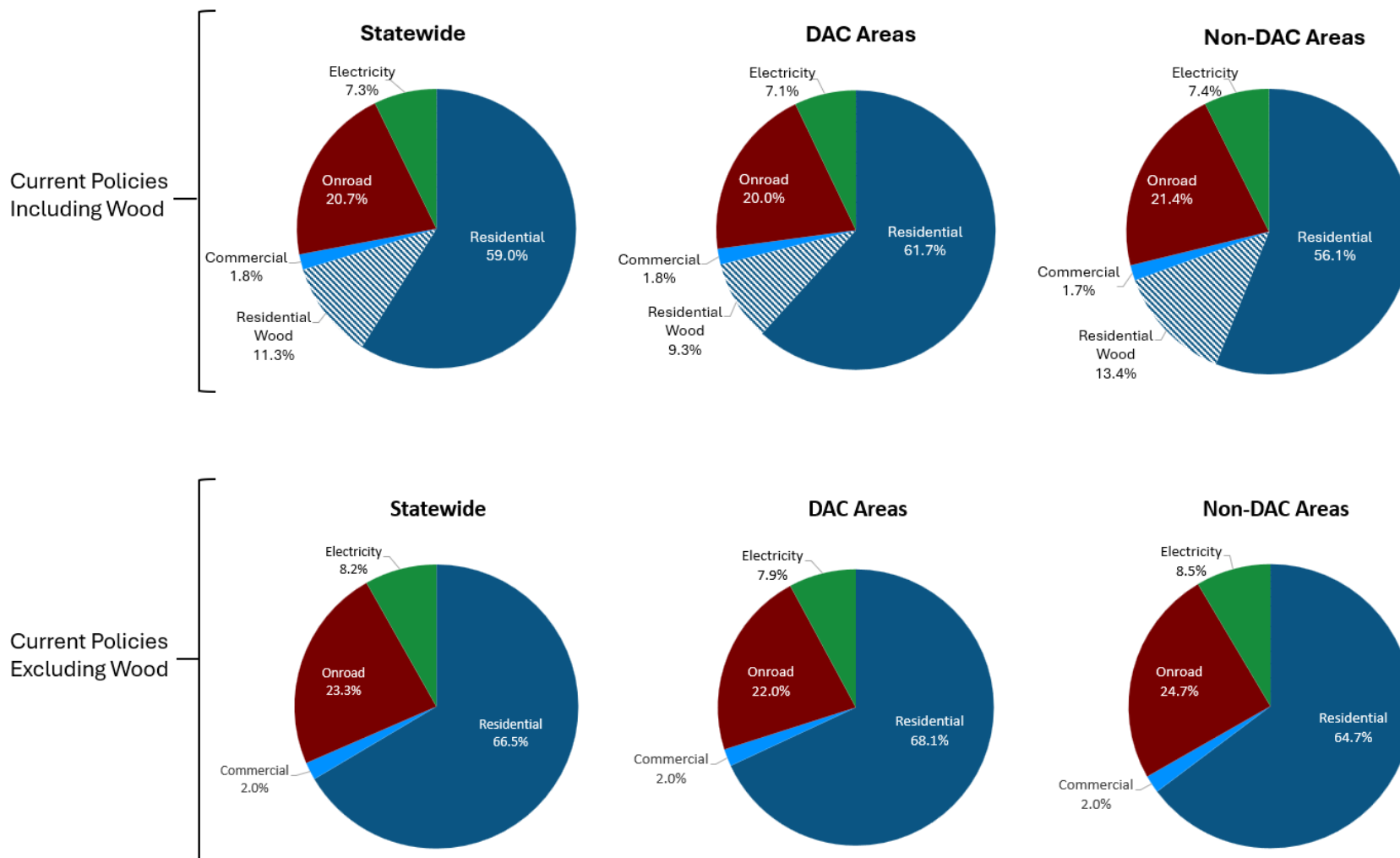


Figure A-21. Cumulative Societal Value from Lower In-State PM_{2.5} Concentrations Relative to the No Action Scenario by Sector and Community, with (top) and without (bottom) the Benefits from Lower Wood Combustion (Additional Action Scenario, 2025–2040)

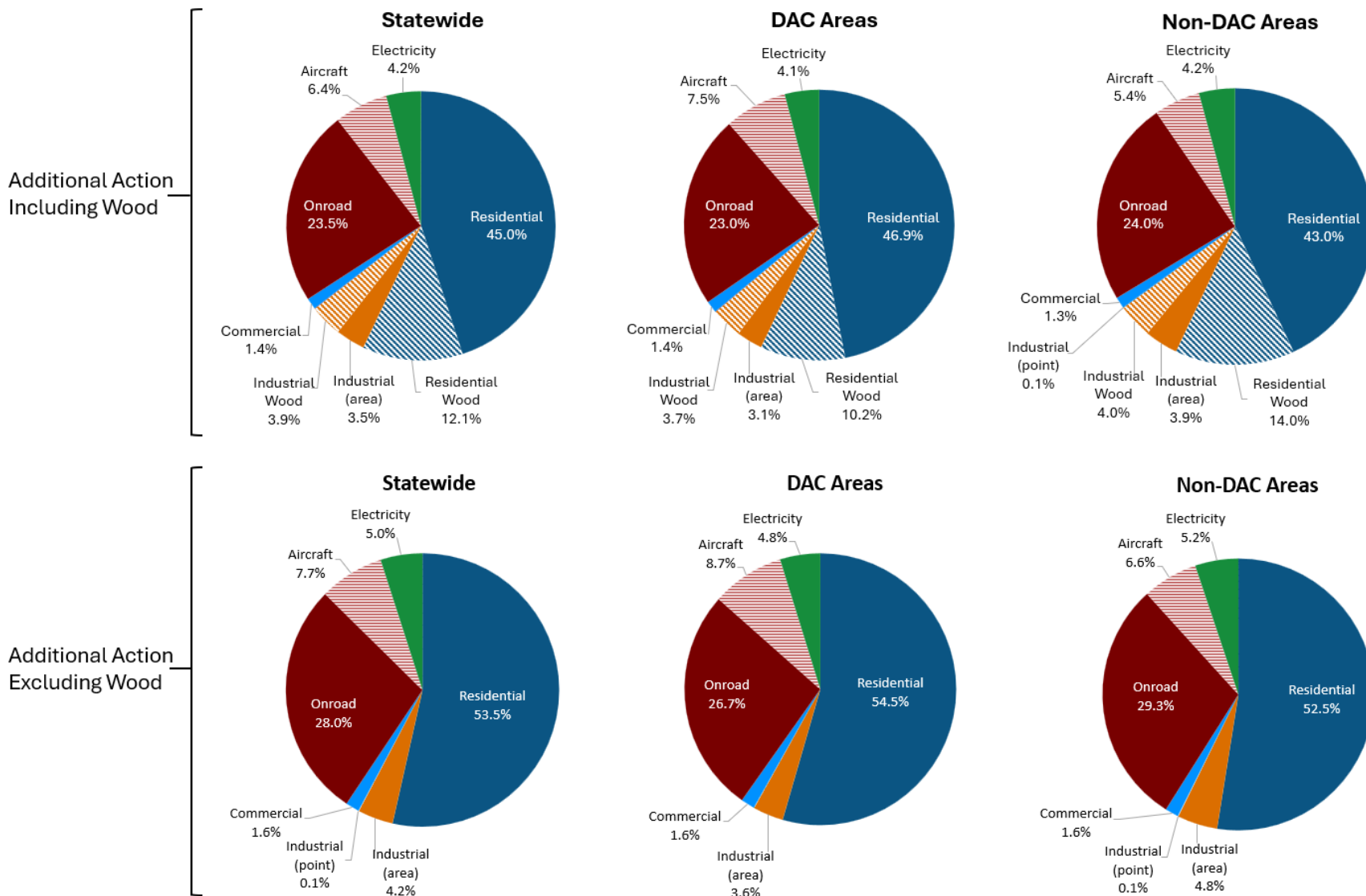


Figure A-22. Cumulative Societal Value from Lower In-State PM_{2.5} Concentrations Relative to the No Action Scenario by Sector and Community, with (top) and without (bottom) the Benefits from Lower Wood Combustion (Net Zero B Scenario, 2025–2040)

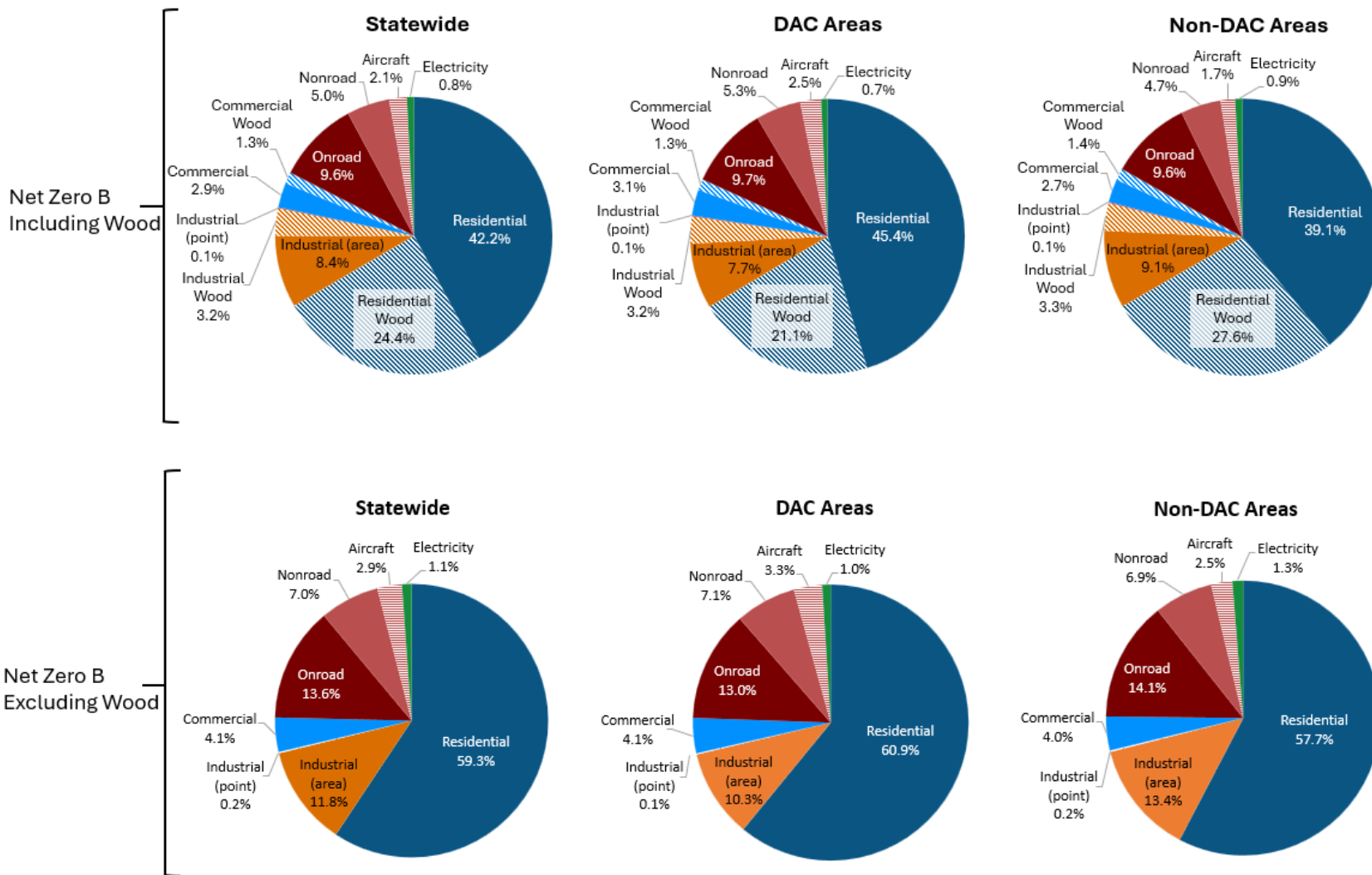


Figure A-23. Regional Distribution of Cumulative Value of Benefits from Lower In-State PM_{2.5} Concentrations Relative to the No Action Scenario by Sector with (top) and without (bottom) the Benefits of Lower Wood Combustion (Current Policies Scenario, 2025–2040)

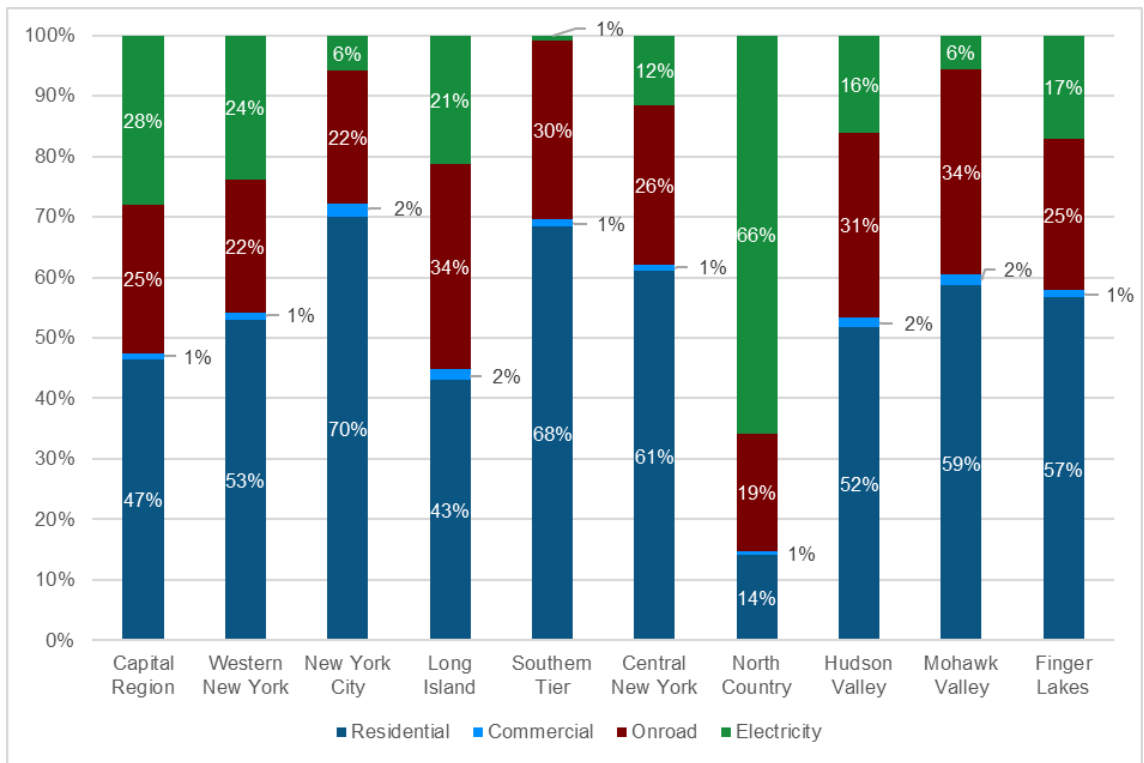
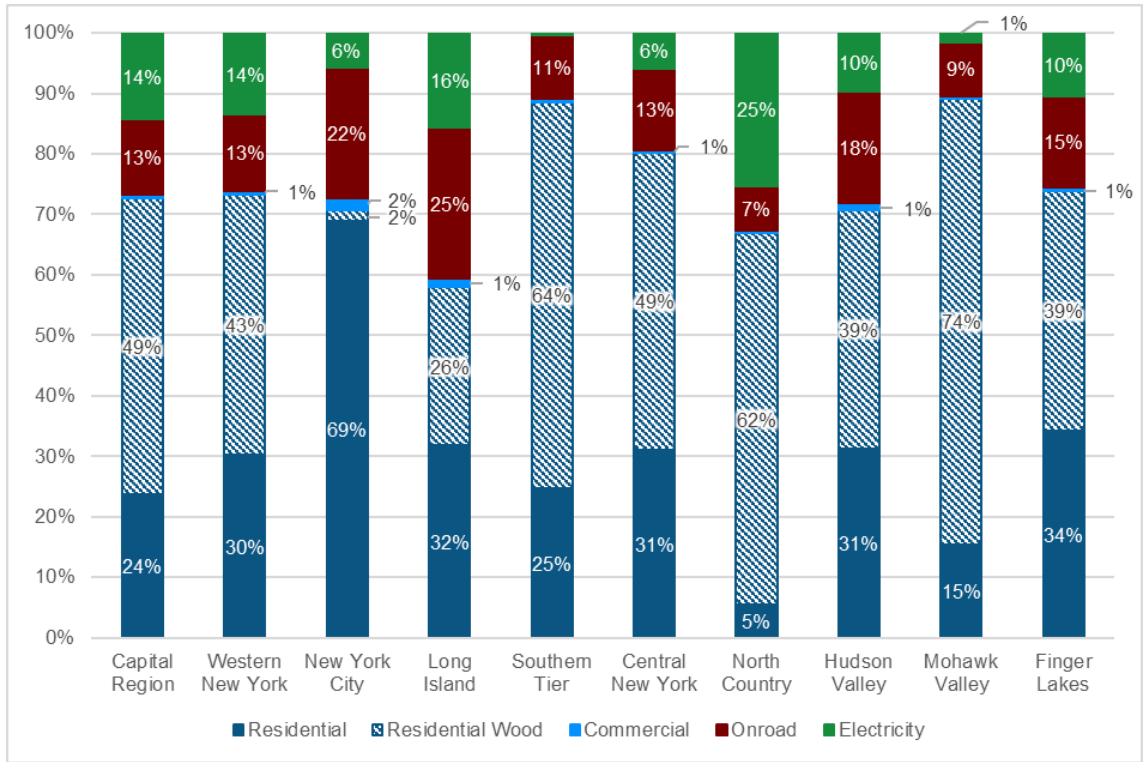


Figure A-24. Regional Distribution of Cumulative Value of Benefits from Lower In-State PM_{2.5} Concentrations Relative to the No Action Scenario by Sector with (top) and without (bottom) the Benefits of Lower Wood Combustion (Additional Action Scenario, 2025–2040)

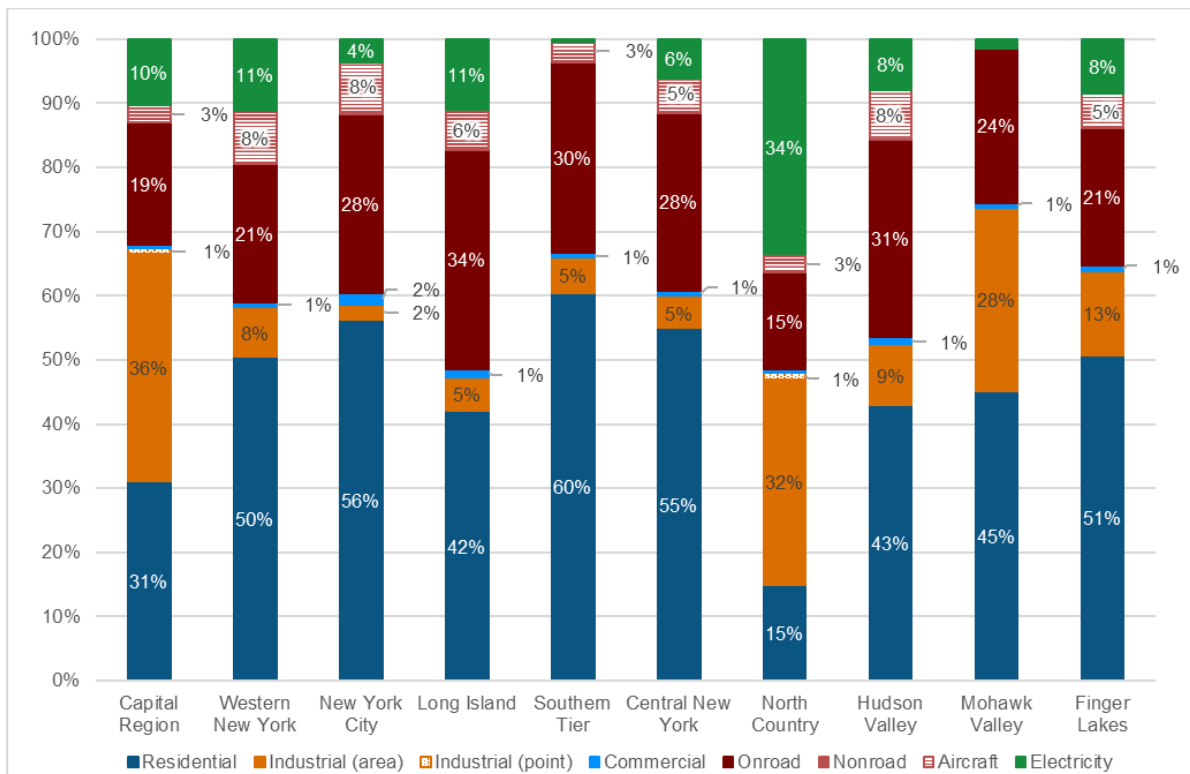
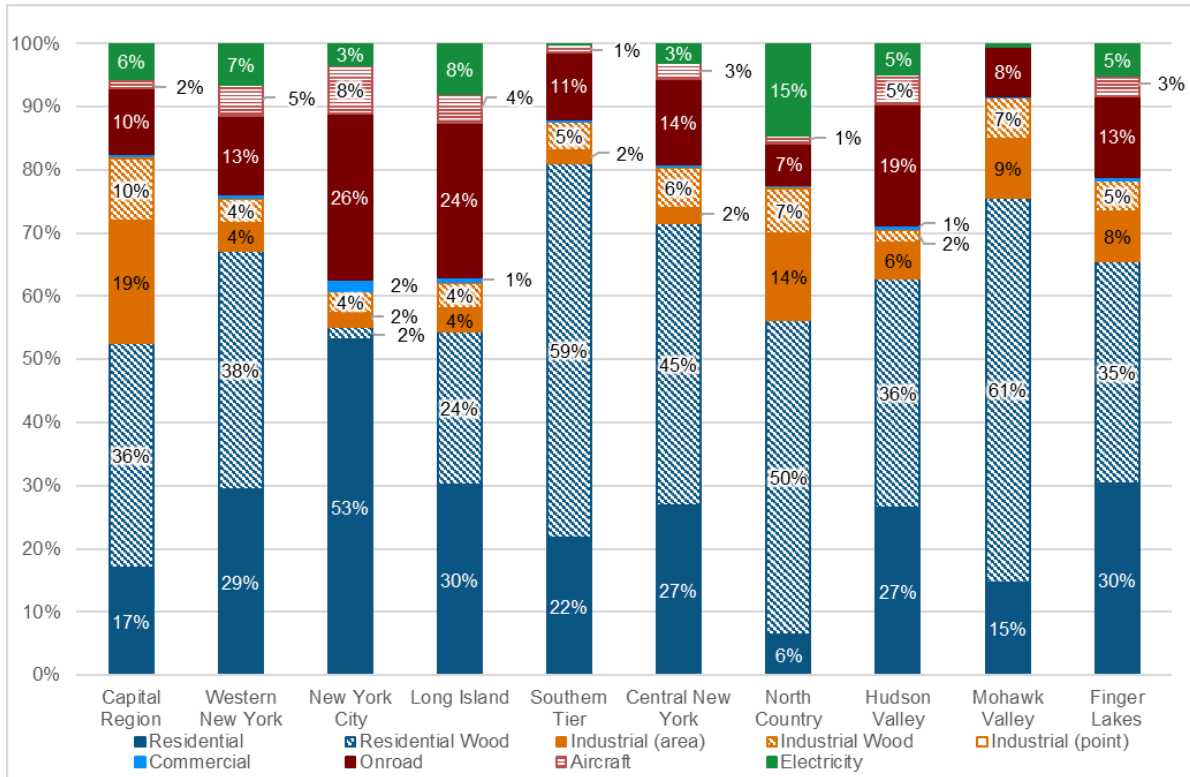
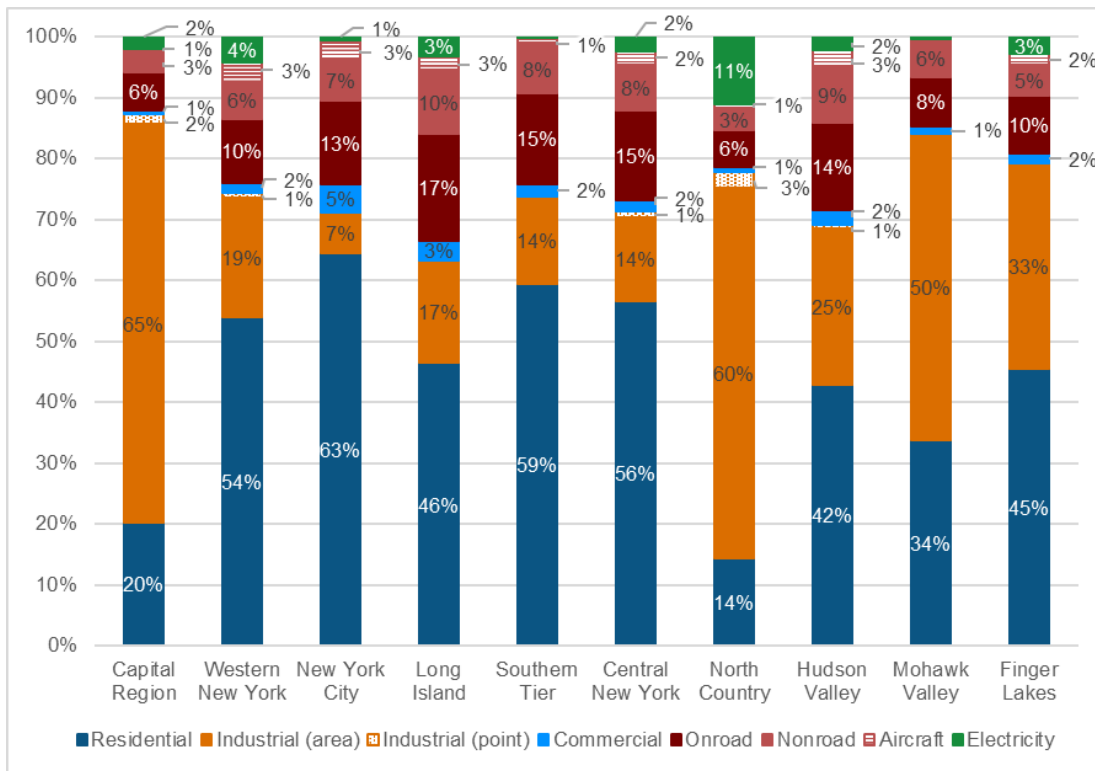
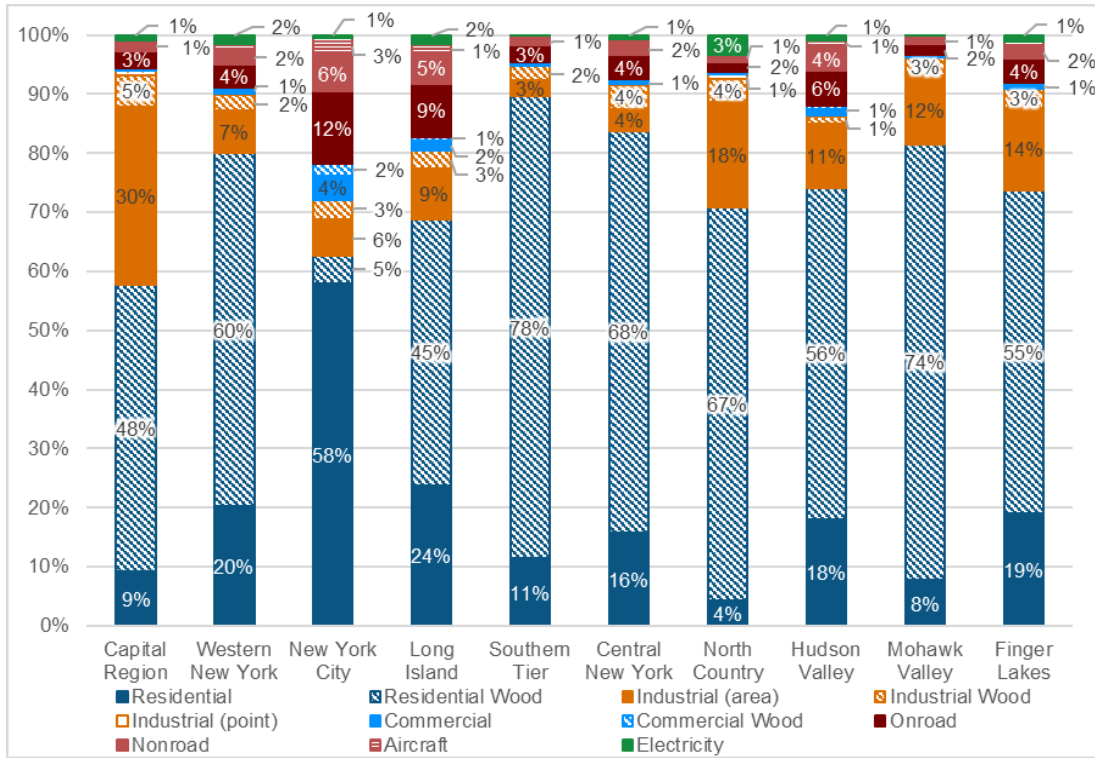


Figure A-25. Regional Distribution of Cumulative Value of Benefits from Lower In-State PM_{2.5} Concentrations Relative to the No Action Scenario by Sector with (top) and without (bottom) the Benefits of Lower Wood Combustion (Net Zero B Scenario, 2025–2040)



3.4. Health Impacts of Federal Policies

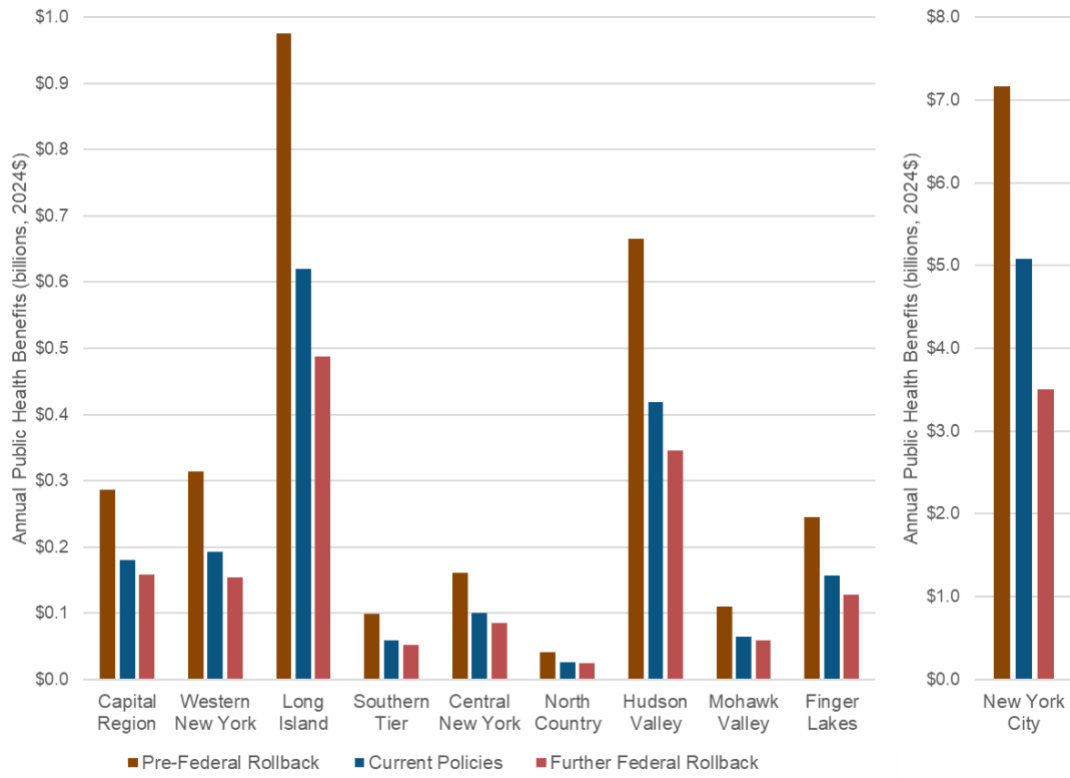
Table A-10 summarizes the annual public health effects avoided due to reduced PM_{2.5} and ozone concentrations for the Current Policies scenario, as well as the differences in avoided cases under each federal sensitivity scenario from Current Policies in 2040, the end of the Plan’s assessment period. The data annex provides the physical benefits for all scenarios at the county level. Both federal sensitivity scenarios diverge from Current Policies in 2025, the beginning of the Plan’s assessment period, with differences growing annually through 2040. Table A-10 also reports the fraction of PM_{2.5}-attributable benefits accruing in DAC areas in 2040. The fractional benefits accruing to DAC areas under both federal sensitivity cases is similar to those under Current Policies. Results for ozone are only available at the county level and not suitable for calculating impacts in DAC areas.

Table A-10. Annual Statewide Avoided Public Health Effects due to Lower PM_{2.5} and Ozone Concentrations for Current Policies Relative to the No Action Scenario and Differences in Avoided Cases by Sensitivity Scenario from Current Policies (2040)

Health Effect	Pre-Federal Rollback		Current Policies		Further Federal Rollback	
	Difference in Avoided Cases Per Year	DAC Area Fraction	Avoided Cases Per Year	DAC Area Fraction	Difference in Avoided Cases Per Year	DAC Area Fraction
Premature Mortality	+260	50%	570	51%	-160	50%
Nonfatal Heart Attacks	+110	48%	240	49%	-70	48%
Hospitalizations	+70	50%	240	50%	-50	50%
Acute Bronchitis	+110	50%	260	50%	-70	50%
Respiratory Symptoms	+3,600	50%	8,000	50%	-2,300	50%
Emergency Room Visits, Asthma	+330	72%	780	72%	-230	72%
Asthma Exacerbation	+2,200	50%	4,900	50%	-1,400	50%
Minor Restricted Activity Days	+72,000	48%	160,000	49%	-47,000	49%
Work Loss Days	+12,000	48%	27,000	49%	-8,000	48%

Figure A-26 shows the annual value of health benefits in 2040 for each region under the Current Policies scenario and each federal sensitivity case relative to the No Action scenario. The data annex provides this information for all scenarios at the county level. The charts on the left show the annual benefits for all regions except New York City, and the chart on the right shows the annual benefits for New York City (on a different scale). Similar to the results for the core scenarios shown above, the largest annual health benefits would occur in New York City under both federal sensitivity scenarios.

Figure A-26. Annual Value of Health Benefits from Lower PM_{2.5} Concentrations by Region and Scenario Relative to the No Action Scenario (2040)



Statewide in 2040, the value of benefits under the Pre-Federal Rollback scenario would be 47 percent larger than under Current Policies and the value under the Further Federal Rollback scenario would be 27 percent smaller than under Current Policies. Figure A-27 shows differences in the value of benefits under the federal sensitivity scenarios by region. In 2040, the value of benefits under the Pre-Federal Rollback scenario ranges from 41 to 70 percent larger than under Current Policies, depending on the region, and the value of benefits under the Further Federal Rollback scenario ranges from 7 to 31 percent smaller than under Current Policies. As discussed in the chapter, the Further Federal Rollback scenario would have a greater relative impact on health benefits in New York City compared to other regions, whereas the Pre-Federal Rollback scenario would have a greater relative impact on health benefits in regions outside New York City.

Figure A-27. Loss of Health Benefits due to Federal Policy Changes as the Percent Difference in Annual Value of Health Benefits from In-State PM_{2.5} Concentrations from Current Policies by Region and by Scenario (2040)

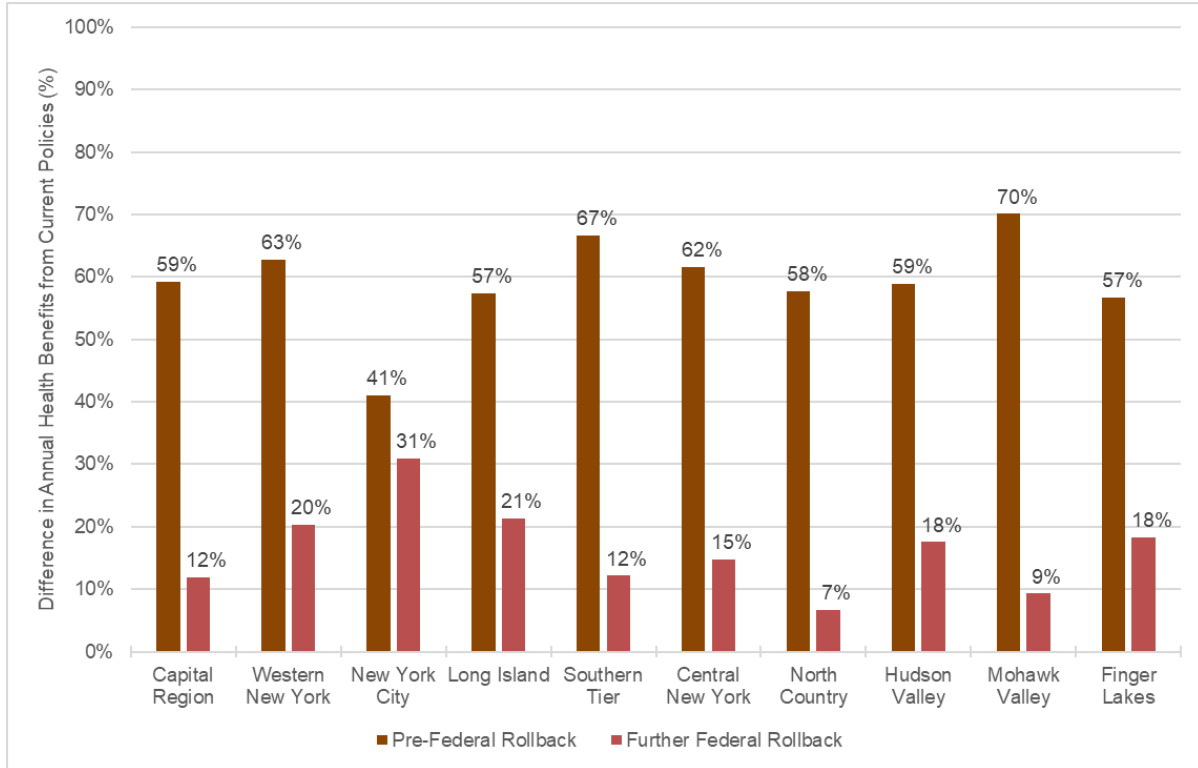


Table A-11 and Figure A-28 and Figure A-29 present the distribution of the public health benefits for the Current Policies scenario and each federal sensitivity case by sector. Table A-11 stratifies the cumulative 2025-2040 value of benefits by sector and scenario.

As shown in the chapter, on-road transportation and residential buildings accounting for the majority of the change, in benefits under the two federal sensitivity scenarios. The regional distribution of relative benefits by sector under the federal sensitivity scenarios is similar to the results of the Current Policies scenario shown in the section above.

Table A-11. Cumulative Value of Societal Public Health Benefits (million \$) from Lower In-State PM_{2.5} Concentrations by Sector and Scenario Relative to the No Action Scenario (2025–2040)

Sector	Pre-Federal Rollback	Current Policies	Further Federal Rollback
Buildings			
Commercial Fossil Fuels	\$835	\$836	\$732
Residential Fossil Fuels	\$41,427	\$27,581	\$15,600
Residential Wood	\$12,708	\$5,286	\$5,391
Buildings Total	\$54,970	\$33,703	\$21,722
Transportation	\$14,756	\$9,675	\$7,384
Electricity	\$3,409	\$3,399	\$3,438
Total	\$73,136	\$46,777	\$32,545

Figure A-28 and Figure A-29 show the annual value of health benefits from 2025 to 2050 for the on-road transportation and residential sectors for the Current Policies scenario and each federal sensitivity case. The chapter shows combined annual health benefits from lower in-state PM_{2.5} from all sectors from 2025-2050. The federal rollbacks in the Current Policies scenario delay achievement of the health benefits that would have been achieved under the Pre-Federal Rollback scenario in 2040 for the on-road transportation sector (\$3.0 billion) and residential buildings sector (\$6.3 billion) by 2 years and 8 years, respectively. For both sectors, the Further Federal Rollback scenario would further delay achievement of the same level of benefits beyond 2050.

Figure A-28. Annual Health Benefits from Lower In-State PM_{2.5} from On-road Transportation by Scenario Relative to the No Action Scenario (2025–2050)

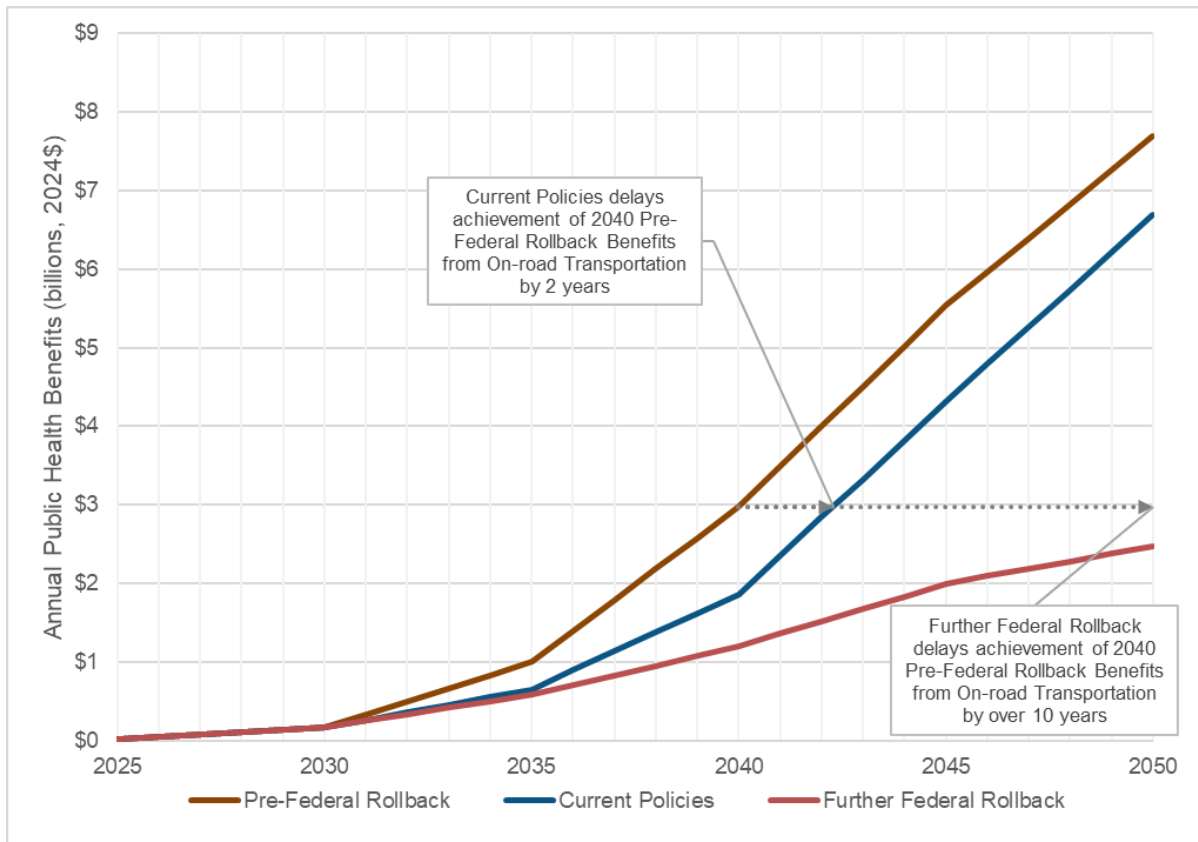
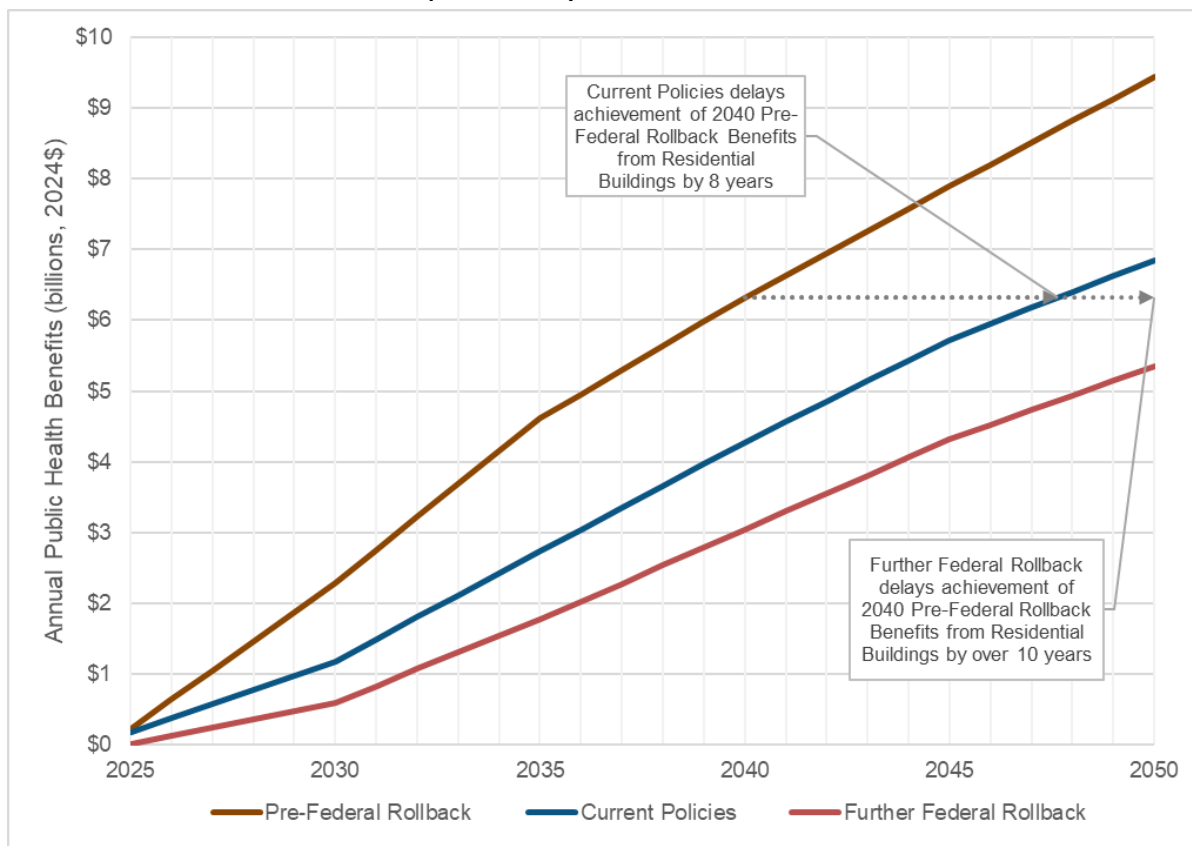


Figure A-29. Annual Health Benefits from Lower In-State PM_{2.5} from Residential Buildings by Scenario Relative to the No Action Scenario (2025–2050)



¹ *Scoping Plan, Appendix G: Integration Analysis Technical Supplement* (New York Climate Action Council, 2022), <https://climate.ny.gov/resources/scoping-plan/>.

² S. Arunachalam et al. “A Census Tract-Level Modeling Framework for Estimation of Health Co-Benefits of Decarbonization in New York State.” ChemRxiv. Preprint. doi:10.26434/chemrxiv-2025-8sbv82025; <https://treehug-app.its.unc.edu/chappa/>.

³ Climate Justice Working Group (CJWG), *Disadvantaged Communities Criteria* (Department of Environmental Conservation, New York State Energy Research and Development Authority [NYSERDA], 2025), <https://climate.ny.gov/Resources/Disadvantaged-Communities-Criteria>. New York Community-Scale Health and Air Pollution Policy Analysis (NY-CHAPPA) developed geographic disadvantaged communities (DACs) areas based on the criteria developed by the CJWG and the 2020 census tract definitions from the U.S. Census. Throughout this chapter, estimates of potential impacts in DACs refer to impacts that accrue in designated geographic DAC areas. For purposes of clean energy and energy efficiency investments, the CJWG additionally included in the DAC criteria low-income households located anywhere in the state; however, this spatial health impacts analysis uses only the geographic criteria for analyzing DAC areas.

⁴ Ito, K., G. Thurston, R. Silverman. Characterization of PM_{2.5}, gaseous pollutants, and meteorological interactions in the context of time-series health effects models. *Journal of Exposure Science and Environmental Epidemiology*, 17: S45-S60. 2007.

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- ⁵ Ito, K., R. Mathes, Z. Ross, A. Nádas, G. Thurston, and T. Matte. Fine particulate matter constituents associated with cardiovascular hospitalizations and mortality in New York City. *Environmental Health Perspectives*, 119(4), 467-473. 2011.
- ⁶ *Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019)* (U.S. Environmental Protection Agency [EPA], 2019), Washington, DC, EPA/600/R-19/188; *Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022)* (U.S. EPA, 2022), Washington, DC, EPA/635/R-22/028.
- ⁷ *ISA for Ozone and Related Photochemical Oxidants (Final Report, Apr 2020)* (U.S. EPA, 2020), Washington, DC, EPA/600/R-20/012.
- ⁸ “CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA),” U.S. EPA, last updated 2024, <https://www.epa.gov/cobra>.
- ⁹ The Pathways Analysis, described in the Pathways Analysis chapter of this Plan, considers two net zero scenarios (A and B) that differ primarily in the extent of hybrid heat pump use. Because of the similarities in energy consumption between Net Zero A and B, Net Zero A was excluded from the analysis and its health benefits are expected to be similar to those of Net Zero B.
- ¹⁰ NY-CHAPPA calculates both a low and high value based on different approaches for estimating avoided mortality and nonfatal heart attacks.
- ¹¹ Avoided cases of nonfatal heart attacks shown in Figures 2 and 3 are only due to reductions in PM_{2.5} concentrations. There is not a concentration response function available that describes the impacts of reductions in ozone concentrations on nonfatal heart attacks.
- ¹² Generator technologies such as internal combustion engines are also included with combustion turbines and steam turbines due to similar operating characteristics and marginal contribution to overall capacity.
- ¹³ The net present value of future monetized physical health benefits was estimated using a real discount rate of 5.03 percent, consistent with the present value cost and benefits estimates calculated elsewhere in the Plan. Use of alternative discount rates reflecting other perspectives on the social rate of time preference for health benefits would result in different net present values.
- ¹⁴ New York Climate Action Council, *Scoping Plan, Appendix G*.
- ¹⁵ Arunachalam et al., “A Census Tract-Level Modeling Framework.”
- ¹⁶ U.S. Environmental Protection Agency. *CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool*. 2014. Model updated 2024.
- ¹⁷ CJWG, *Disadvantaged Communities Criteria*. NY-CHAPPA developed geographic DAC areas based on the criteria developed by the NY CJWG and the 2020 census tract definitions from the U.S. Census. Throughout this chapter, estimates of potential impacts in DACs refers to impacts that accrue in designated geographic DAC areas. For purposes of clean energy and energy efficiency investments, the CJWG additionally included in the DAC criteria low-income households located anywhere in the state; however, this spatial health impacts analysis uses only the geographic criteria for analyzing DAC areas.
- ¹⁸ K. Shukla et al., “ZIP Code-Level Estimation of Air Quality and Health Risk Due to Particulate Matter Pollution in New York City,” *Environmental Science & Technology* 56, no. 11 (2022): 7119–30.
- ¹⁹ T. M. Barzyk et al., “A Near-Road Modeling System for Community-Scale Assessments of Traffic-Related Air Pollution in the United States,” *Environmental Modelling & Software* 66 (2015): 46–56.
- ²⁰ Vlad Isakov et al., “A Web-based Modeling System for Near-Port Air Quality Assessments,” *Environmental Modelling & Software* 98 (2017): 21–34, <http://www.sciencedirect.com/science/article/pii/S1364815216311367>
- ²¹ Note that the regions used in NY-CHAPPA are slightly different from the regions used to aggregate and present the results. NY-CHAPPA uses larger regions, including combining the Western New York and Finger Lakes regions, and the New York City region combines New York City, Long Island, and part of the Hudson Valley region. This was done to minimize edge effects in cases when urban areas are near the edge of a regional border.
- ²² Ito et al., “Characterization of PM_{2.5}, Gaseous Pollutants,” S45–60
- ²³ Ito et al., “Fine Particulate Matter Constituents,” 467–73.

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- ²⁴ *Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in PM_{2.5} and PM₁₀ Nonattainment and Maintenance Areas* (U.S. EPA, 2010), EPA-420-B-10-040.
- ²⁵ S. Y. Chang et al., "A Modeling Framework for Characterizing Near-Road Air Pollutant Concentration at Community Scales," *Science of the Total Environment* 538 (2015): 905–21.
- ²⁶ "PM_{2.5} Design Values," U.S. EPA, <https://www.epa.gov/air-trends/air-quality-design-values>.
- ²⁷ J. C. Chang and S. R. Hanna, "Air Quality Model Performance Evaluation," *Meteorology and Atmospheric Physics* 87 (2004): 167–96.
- ²⁸ Chang and Hanna, "Air Quality Model Performance Evaluation," 167–96.
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- ³¹ "County Population Totals and Components of Change: 2020–2024," U.S. Census Bureau, March 2025, <https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-total.html#v2023>.
- ³² Cornell University. 2018. County Projections Explorer. Ithaca, New York: Cornell Program on Applied Demographics. <https://pad.human.cornell.edu/counties/projections.cfm>.
- ³³ Census-tract level data was provided for 125 census tracts out of nearly 4,919 tracts in New York State, with the rest provided in aggregated census tract groups. Note that the incidence data provided by the Department of Health used 2010 census tract definitions. These data were transformed to 2020 census tract definitions for this analysis.
- ³⁴ D. Krewski et al., "Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality," *Research Reports from the Health Effects Institute* 140 (2009): 5–114, discussion 115–136.
- ³⁵ J. Lepeule et al., "Chronic Exposure to Fine Particles and Mortality: An Extended Follow-Up of the Harvard Six Cities Study from 1974 to 2009," *Environmental Health Perspectives* 120 no. 7 (2012): 965–70.
- ³⁶ A. Peters et al., "Increased Particulate Air Pollution and the Triggering of Myocardial Infarction," *Circulation* 103, no. 23 (2001): 2810–15.
- ³⁷ C. A. Pope, 3rd, et al., "Ischemic Heart Disease Events Triggered by Short-Term Exposure to fine Particulate Air Pollution," *Circulation* 114, no. 23 (2006): 2443–48.
- ³⁸ J. Sullivan et al., "Relation Between Short-Term Fine-Particulate Matter Exposure and Onset of Myocardial Infarction," *Epidemiology* 16, no. 1 (2005): 41–48.
- ³⁹ A. Zanobetti and J. Schwartz, "Air Pollution and Emergency Admissions in Boston, MA," *Journal of Epidemiology and Community Health* 60, no. 10 (2006): 890–95. doi: 60/10/890 [pii] 10.1136/jech.2005.039834.
- ⁴⁰ A. Zanobetti et al., "Fine Particulate Air Pollution and Its Components in Association with Cause-Specific Emergency Admissions," *Environmental Health* 8 (2009): 58–60.
- ⁴¹ S. H. Moolgavkar, "Air Pollution and Hospital Admissions for Diseases of the Circulatory System in Three U.S. Metropolitan Areas," *Journal of the Air & Waste Management Association* 50, no. 7 (2000): 1199–06.
- ⁴² M. L. Bell et al., "Seasonal and Regional Short-term Effects of Fine Particles on Hospital Admissions in 202 US Counties, 1999–2005," *American Journal of Epidemiology* 168, no. 11 (2008): 1301–10.
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- ⁴⁶ S. M. Babin et al., "Pediatric Patient Asthma-Related Emergency Department Visits and Admissions in Washington, DC, from 2001–2004, and Associations with Air Quality, Socio-Economic Status and Age Group," *Environmental Health* 6 (2007): 9.

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- 47 L. Sheppard, "Ambient Air Pollution and Nonelderly Asthma Hospital Admissions in Seattle, Washington, 1987–1994," in *Revised Analyses of Time-Series Studies of Air Pollution and Health* (Boston, MA: Health Effects Institute, 2003), 227–30.
- 48 S. H. Moolgavkar, "Air Pollution and Hospital Admissions for Chronic Obstructive Pulmonary Disease in Three Metropolitan Areas in the United States," *Inhalation Toxicology* 12, Supplement 4 (2000): 75–90.
- 49 T. F. Mar et al., "Associations Between Asthma Emergency Visits and Particulate Matter Sources, Including Diesel Emissions from Stationary Generators in Tacoma, Washington," *Inhalation Toxicology* 22, no. 6 (2010): 445–48.
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