Draft New York State Energy Plan for Public Comment

Volume II – Topic Area Chapters

Listed below are the Topic Area Chapters of the Draft State Energy Plan available for the State Energy Planning Board's consideration.

Acronyms and Glossary of Key Terms

Topic Area Chapters – Topical Chapters

- Electricity
- Nuclear
- Natural Gas
- Petroleum Fuels
- Low-Carbon Alternative Fuels
- Climate Change, Adaption, and Resilience
- Energy Security Planning and Emergency Preparedness
- Buildings
- Transportation
- Smart Growth
- Economic Development, Industry, and Agriculture
- Clean Energy Jobs and a Just Transition
- Energy Innovation
- Environmental Justice and Climate Justice
- Local, Regional, and Federal Government Collaboration

Topic Area Chapters – Analysis Chapters

- Pathways Analysis
- Energy Affordability Impacts Analysis
- Public Health Impacts Analysis
- Economic Impacts – Jobs Analysis
- Environmental Impacts

Acronyms and Glossary of Key Terms

Acronyms

AC	alternating current
ACC	Advanced Clean Cars
ACET	Agricultural and Clean Energy Technology
ACT	Advanced Clean Trucks
AEDT	Aviation Environmental Design Tool
AEO	Annual Energy Outlook
AGM	New York State Agriculture and Markets
AI	artificial intelligence
AMEEP	Affordable Multifamily Energy Efficiency Program
AMI	advanced metering infrastructure
ANSC	Advanced State Nuclear Collaborative
ARL	adoption readiness level
ASHP	air source heat pump
ATSP	Active Transportation Strategic Plan
ATT	advanced transmission technology
bcf	billion cubic feet
BEEM	Building Efficiency and Electrification Model
BESS	battery energy storage system
BEV	battery-electric vehicles
BIL	Bipartisan Infrastructure Law
BILD	Building Information and Land Use Database
BOA	brownfield opportunity area
BOCES	Boards of Cooperative Education Services
BOEM	Bureau of Ocean Management
BRACE	Building Resilience Against Climate Effects
BRT	bus rapid transit
BTM	behind-the-meter
BTU	British thermal unit
CAC	Community Advisory Committees
CAIDI	Customer Average-Interruption Duration Index
CAM	Community Air Monitoring
CARIS	Congestion Assessment and Resource Integration Study

CBECS	Commercial Building Energy Consumption Survey
CBO	Community Based Organizations
ccASHP	cold climate air source heat pump
ccf	hundred cubic feet
CCGT	combined cycle combustion turbines
CCRP	Climate Change Resilience Plan
CCUS	Carbon capture utilization and storage
CCVS	Climate Change Vulnerability Study
CDG	community distributed generation
CDTA	Capital District Transportation Authority
CEF	Clean Energy Fund
CEMP	Comprehensive Emergency Management Plan
CEPA	County Emergency Preparedness Assessments
CES	Clean Energy Standard
CESER	Cybersecurity, Energy Security and Emergency Response
CEZ	clean energy zone
cf	cubic feet
CGPP	Coordinated Grid Planning Process
CHGE	Central Hudson Gas and Electric
CHIPS	Consolidated Local Street and Highway Improvement Program
CHP	combined heat and power
CHPE	Champlain Hudson Power Express
CISA	U.S. Department of Homeland Security Cybersecurity and Infrastructure Security Agency
CISBOT	cast iron sealing robot
CJWG	Climate Justice Working Group
Climate Act	Climate Leadership and Community Protection Act (2019)
CMAQ	Community Multiscale Air Quality Model
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COBRA	Co-Benefits Risk Assessment Health Impacts and Mapping Tool
COP	coefficient of performance
CPCN	Certificate of Public Convenience and Necessity
CRF	Climate Resilient Farming
CRIS	Capacity Resource Interconnection Service
CRL	Commercial Readiness Level
CRP	Comprehensive Reliability Plan

CSAPR	Cross-State Air Pollution Rule
CSC	Climate Smart Communities
CSRP	Commercial System Relief Program
CT	Combustion Turbines
CTOOLS	Community Tools
CUNY	City University of New York
DACs	Disadvantaged Communities
DADRP	Day-Ahead Demand Response Program
DAM	Day-Ahead Market
DC	direct current
DCFC	Direct Current Fast Charging
DEC	New York State Department of Environmental Conservation
DER	distributed energy resource
DG	distributed generation
DHSES	Division of Homeland Security and Emergency Services
DLM	dynamic load management
DLRP	Distribution Load Relief Program
DOB	Decommissioning Oversight Board
DOE	U.S. Department of Energy
DOH	New York State Department of Health
DOL	New York State Department of Labor
DOS	New York State Department of State
DOT	New York State Department of Transportation
DPS	New York State Department of Public Service
DR	direct response
DRV	Demand Reduction Value
DSASP	Demand-Side Ancillary Services Program
DSIP	Distributed System Implementation Plan
DSM	Demand-Side Management
Dth	decatherms
EAP	Energy Affordability Policy
EBC	Empire Building Challenge
EDA	US Economic Development Administration
EDRP	Emergency Demand Response Program
EE	energy efficiency
EEAC	Energy Emergency Assurance Coordinators Program
EE-BE	energy efficiency and building electrification

EEC	Energy Equity Collaborative
EEPS	Energy Efficiency Portfolio Standard
EHAP	Extreme Heat Action Plan
EIA	U.S. Department of Energy, Energy Information Administration
EITE	Energy-Intensive and Trade-Exposed
ELCC	Effective Load-Carrying Capability
EMAC	Emergency Management Assistance Compact
EMP	electromagnetic pulse
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Declarations
EPF	Environmental Protection Fund
EPPAC	Energy Policy Planning Advisory Council
ERP	Emergency Response Plan
ESA	Endangered Species Act
ESB	electric school buses
ESCO	Energy Service Company
ESD	Empire State Development
ETP	Empire Tech Prize
EUE	expected unserved energy
EUI	energy use intensity
EV	electric vehicle
EVSE	Electrical Vehicle Supply Equipment
FCEV	fuel cell electric vehicle
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
GCEW	Growing the Clean Energy Workforce
GEIS	General Environmental Impact Statement
GET	grid-enhancing technology
GHG	greenhouse gas
GI	green infrastructure
GJGNY	Green Jobs-Green New York
GOTF	Grid of the Future
GPS	global positioning system
GSHP	ground source heat pump
GW	gigawatt
GWh	gigawatt-hour

GWP	global warming potential
HALEU	High-Assay Low Enriched Uranium
HCR	Homes and Community Renewal
HEAP	Home Energy Assistance Program
HFC	hydrofluorocarbon
HPD	New York City Department of Housing Preservation and Development
HPMS	Highway Performance Monitoring System
HVAC	heating, ventilation, and air conditioning
HVDC	high-voltage direct current
ICAP	installed capacity
ICE	internal combustion engine
ICS	New York State Reliability Council Installed Capacity Subcommittee
IDA	Industrial Development Agency
IEDR	Integrated Energy Data Resource
IIJA	Infrastructure Investment and Jobs Act
IOU	investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
IRM	install reserve margin
IRR	installed reserve requirement
ITC	independent transmission company
JU	Joint Utilities
KEDLI	National Grid Long Island
KEDNY	National Grid New York
kV	kilovolt
LBMP	locational-based marginal prices
LBW	land-based wind
LCA	life cycle analysis
LCOE	levelized cost of energy
LDC	local distribution company
LDES	Long Duration Energy Storage
LDV	light-duty vehicle
LECCLA	Low-Embodied Carbon Concrete Leadership Act
LEED	Leadership in Energy and Environmental Design
LiHEAP	Low-Income Home Energy Assistance Program
LIPA	Long Island Power Authority
LIRR	Long Island Rail Road

LMI	low- to moderate-income
LNG	liquified natural gas
LOEE	loss of energy expectation
LOLE	loss of load expectation
LPA	labor peace agreement
LPP	leak-prone pipe
LSE	load serving entity
LSR	large-scale renewables
LSRV	local system relieve value
LTO	landing and takeoff cycle
LTP	local transmission plan
LTP	long-term plan
LTPP	local transmission planning process
LWR	light water reactors
MBtu	thousand British thermal units
METARE	MET-eorologically-weighted Averaging for Risk and Exposure
MHDV	Medium- and Heavy-Duty Vehicles
MMBtu	million British thermal units
MMBtu/h	Million British Thermal Units per Hour
MMRV	International Measuring, Monitoring, Reporting, and Verification
MMT CO_2e	million metric tons of carbon dioxide equivalent
MOVES	U.S. EPA Motor Vehicle Emissions Simulator
MPO	Metropolitan Planning Organizations
MTA	Metropolitan Transportation Authority
MW	megawatt
MW/h	megawatt hour
MWBE	Minority/Women-owned Business Enterprises
MWe	Megawatt Electrical
NAAQS	National Ambient Air Quality Standards
NARUC	National Association of Regulatory Utility Commissioners
NASEO	National Association of State Energy Officials
NEI	National Emissions Inventory
NEMA	National Emergency Management Association
NEMS	National Energy Modeling System
NERC	North American Electric Reliability Corporation
NERC-CIP	North American Electric Reliability Corporation Critical Infrastructure Protection
NESCAUM	Northeast States for Coordinated Air Use Management

NFG	National Fuel Gas Distribution Corporation
NFTA	Niagara Frontier Transportation Authority
NGA	National Governors Association
NH_3	ammonia
NHTS	National Household Transportation Survey
NIETC	National Interest Electric Transmission Corridor
NIST	National Institute of Standards
NMPC	National Grid Upstate
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide
NPA	non-pipeline alternative
NPCC	Northeast Power Coordinating Council
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratories
NSF	National Science Foundation
NSPS	new source performance standards
NWA	non-wires alternative
NYCA	New York Control Area
NYCEDC	New York City Economic Development Corporation
NYCHA	New York City Housing Authority
NY-CHAPPA	New York Community-Scale Health and Air Pollution Policy Analysis
NYCRR	New York Codes, Rules and Regulations
NYCRRA	New York Community Risk and Resiliency Act
NYGATS	New York Generation Attributes Tracking System
NYISO	New York Independent System Operator
NYPA	New York Power Authority
NYSARP	New York Statewide Adaptation and Resilience Plan
NYSCH	New York State Clean Heat
NYSCIA	New York State Climate Impacts Assessment
DHSES	New York State Department of Homeland Security and Emergency Management
NYSEEP	New York State Energy Emergency Plan
NYSEG	New York State Electric and Gas
NYSERDA	New York State Energy Research and Development Authority
NYSESP	New York State Energy Security Plan
NYSRC	New York State Reliability Council
NYSTAR	New York State Division of Science, Technology and Innovation
NYTVIP	New York Truck Voucher Incentive Program

O&R	Orange & Rockland Utilities, Inc.
OCT	NYS Office of Counter Terrorism
OEM	New York State Office of Emergency Management
OEM	original equipment manufacturer
OGS	New York State Office of General Services
OJET	Office of the Just Energy Transition
OREC	Offshore Wind Renewable Energy Credit
OREP	Office of Resilience and Emergency Preparedness
OREP USS	OREP Utility Security Section
ORES	Office of Renewable Energy Siting and Electric Transmission
OSW	Off-Shore Wind
OSWD	Office of Strategic Workforce Development
OTDA	New York State Office of Temporary and Disability Assistance
OWTI	Offshore Wind Training Institute
PAD	Program on Applied Demographics at the Cornell Jeb. E. Brooks School of Public Policy
PEM	Performance Engineered Mixture
PEV	plug-in electric vehicles
PFC	perfluorocarbons
PHEV	plug-in hybrid EVs
PHMSA	U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration
PII	personally identifiable information
PLA	project labor agreement
$PM_{2.5}$	Particulate Matter less than 2.5 micrometers
PPTN	public policy transmission need
PPTPP	public policy transmission planning process
PSC	New York State Public Service Commission
PSL	Public Service Law
PTC	Production Tax Credit
PV	photovoltaic
RABA	Regional Assessment and Barriers Analyses
RAPID	Renewable Action through Project Interconnection and Deployment
RD&D	research, development, and demonstration
REC	renewable energy certificates
RECAP	Renewable Energy Capacity Planning Model
RECS	Renewable Energy Consumption Survey
RED	resource efficient decarbonization
REDC	Regional Economic Development Council

REP	Radiological Emergency Preparedness
RES	Renewable Energy Standard
RETI	renewable energy training initiatives
REV	Reforming the Energy Vision
RFI	request for information
RFP	request for proposals
RFS	Renewable Fuel Standard
RGE	Rochester Gas and Electric Corporation
RGGI	Regional Greenhouse Gas Initiative
RGRTA	Rochester-Genesee Regional Transportation Authority
RMD	Residential Methane Detector
RNA	reliability needs assessment
RNG	renewable natural gas
ROP	Reactor Oversight Process
RPM	reliability performance mechanisms
RPP	reliability planning process
RPS	renewable portfolio standard
RRAP	Regional Resiliency Assessment Program
RTM	real-time market
RTO	regional transmission operation
SAF	Sustainable Aviation Fuel
SAIFI	System Average-Interruption Frequency Index
SBC	system benefits charge
SCADA	Supervisory Control and Data Acquisition
SCR	special case resource
SDVOB	Service-Disabled Veteran-Owned Businesses
SEPA	State Emergency Preparedness Assessment
SEPB	State Energy Planning Board
SEQRA	State Environmental Quality Review Act
SGIPA	Smart Growth Infrastructure Policy Act
SHMP	State Hazard Mitigation Plan
SIR	Standardized Interconnection Requirements
SMR	Small Modular Reactors
SMS	Statewide Mobility Services
SNAP	Supplemental Nutrition Assistance Program
SO_2	sulfur dioxide
SOV	single-occupant vehicles

SPR	State Preparedness Report
STARS	Short-Term Assessment of Reliability
SUNY	State University of New York
SWAP	State Action Wildlife Plan
SWC	Soil and Water Conservation
TANF	Temporary Assistance for Needy Families
tBtu	trillion British thermal units
TCL	Transportation Corporations Law
TCO	Total Cost of Ownership
TEN	thermal energy network
th	therms
THIRA	Threat and Hazard Identification and Risk Assessment
TIM	Traffic incident management
TMA	Transportation Management Area
TO	transmission owner
TOD	transit-oriented development
TOP	transmission operator
TOU	time of use
TRL	technology readiness level
TSMO	Transportation System Management and Operations
TW	terawatt
TWG	Technical Working Group
TWh	terawatt hour
UAS	unmanned aircraft systems (aka drones)
ULSD	ultra-low sulfur diesel
UNC	University of North Carolina
UNFCCC	United Nations Framework Convention on Climate Change
UPV	Utility-Scale Solar Photovoltaics
USACE	US Army Corps of Engineers
USCA	United States Climate Alliance
USDA	United States Department of Agriculture
USGBC	U.S. Green Building Council
USGCRP	U.S. Global Change Research Program
USS	utility security section
UTEN	United Thermal Energy Network
UTENJA	Utility Thermal Energy Network and Jobs Act
V2B	Vehicle to building

V2G	vehicle to grid
VDER	value of distributed energy resource
VGI	vehicle grid integration
VMT	vehicle miles traveled
VOC	volatile organic compound
VPP	virtual power plant
WAP	Weatherization Assistance Program
WARN	Worker Adjustment and Retraining Notification
WQC	water quality certification
ZAPPA	Zip-Code Air Pollution Policy Analysis Tool
ZEC	zero-emissions credit
ZEV	zero-emission vehicle

Key Terms

Active Transportation	Active Transportation is both human-powered modes of transportation—walking, bicycling, and operating a wheelchair—along with small-scale electric vehicles such as e-bikes and e-scooters (also known as “micromobility”)
Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; the process by which a system moves toward resilience.
Agricultural sector	Grows crops, raises livestock, and harvests plants and animals from their natural habitats.
Agrivoltaics	The simultaneous use of land for solar photovoltaic power generation and agricultural production of "crops, livestock, and livestock products”
Alternative Fuels	Alternative Fuels: Liquid or gaseous fuel derived from biomass or clean energy such as biodiesel, renewable natural gas (RNG), renewable diesel, hydrogen, and sustainable aviation fuel (SAF).
Apprenticeship utilization	A program that requires a certain percentage of labor hours for a given project be performed by participants of approved apprenticeship programs.
At-risk community	A population particularly vulnerable to disruptions in energy supply, including but not limited to senior populations, Disadvantaged Communities, and communities at or below the poverty line.

Biogas	Biogas is gas resulting from the decomposition of organic matter, most commonly under anaerobic conditions (such as in a landfill, manure storage, or wastewater recovery facility). The principal constituents are methane and carbon dioxide. Some end-uses can use biogas directly as a fuel source with minimal processing, though its lower energy density and purity compared to conventional natural gas or renewable natural gas precludes it from most end-uses.
Brownfield Opportunity Area Program	Created to support community planning for the reuse and redevelopment of known or suspected contaminated areas.
Brownfield	A former industrial or commercial site where future use is affected by real or perceived environmental contamination.
Bulk Power System	Operated by the NYISO, which generally consists of transmission lines operating at 230 kilovolt (kV) and above and certain lower voltage facilities, which the NYISO manages to ensure system reliability. The bulk power system in New York consists of approximately 4,100 miles of high-voltage transmission lines.
Bulk Terminal	Petroleum facility designed for the storage and distribution of refined petroleum fuels such as heating oil, motor gasoline, diesel and other products.
Carbon capture utilization and/or storage (CCUS)	technologies capture carbon dioxide (CO_2) emissions from large sources, like power plants and industrial facilities, or directly from the atmosphere, which is then either repurposed or stored.
City gate	The point at which gas utilities or local distribution companies take operational responsibility for safely and reliably transporting gas to customers.
Clean energy worker (job)	defined as any worker (job) that is directly involved with the research, development, production, manufacture, distribution, sales, implementation, installation, or repair of components, goods, or services related to the following sectors of the clean energy economy.
Climate mitigation	A human intervention to reduce emissions or enhance the sinks of greenhouse gases. (*See also* “Greenhouse Gas Mitigation”).
Climate resilience	A system’s ability to anticipate, prepare for, respond to, recover from, and adapt to a disruption, such as an extreme climate hazard, with minimum damage to social well-being, public health, the economy, and the environment.
Commercialization	Commercialization programs help bring beneficial energy technologies and services to market through technical assistance, financing, customer discovery, and further product development.

Community Lifelines	The most fundamental services in the community that, when stabilized, enable all other aspects of society to function; they include Safety and Security; Health and Medical; Energy; Communications; Transportation; Food, Hydration, Shelter; Hazardous Materials and Water Systems.
Consequence	The effect of the loss or degradation of an energy infrastructure asset on energy supply or service, and the associated indirect impacts of those losses on society.
Consequence	The effect of the loss or degradation of an energy infrastructure asset on energy supply or service, and the associated indirect impacts of those losses on society.
Conventional Fuels	The fossil fuel that is typically used today. E.g., conventional diesel, conventional jet fuel, conventional natural gas.
Co-Pollutant Emissions	Air pollutants that are a byproduct from combustion of fossil fuels and most alternative fuels. These include fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_x), volatile organic compounds (VOC), sulfur dioxide (SO_2), and various toxic compounds. These pollutants contribute to a range of health issues, including respiratory conditions, asthma, heart attacks, and other serious illness.
Cross-Sector Interdependency	One energy sector (Electric, Gas or Liquid Fuel) relying on another energy sector; for example, the electric sector has a cross-sector interdependency with the natural gas sector.
Decommissioning	The radiological clean-up and dismantling of a nuclear facility, has four basic aspects: radiological cleanup and removal, fuel storage, non-radiological cleanup and removal, and site restoration.
Direct Entry Program	A New-York-State-approved apprenticeship preparation program that can help workers get the skills they need to meet the minimum requirements of a New-York-State Registered Apprenticeship program. Successful participants have a direct opportunity to interview with a sponsor of a New York State Registered Apprenticeship Program. Direct Entry providers are required to have agreements with New York State Registered Apprenticeship program sponsors to ensure the availability of jobs with those sponsors. New York State Direct Entry Programs cannot charge tuition.
Disadvantaged communities	State-defined interim criteria for disadvantaged communities (pending finalization by the Climate Justice Working Group): Communities located within census block groups that meet the HUD 50% AMI threshold, that are also located within the DEC Potential Environmental Justice Areas; or Communities located within New York State Opportunity Zones.

Ecosystem	a dynamic complex of plant, animal [including human], and microorganism communities interacting with each other and the nonliving environment as a functional unit
Efficient electric heat pumps	Include ground source heat pumps and heat pump water heater systems that meet or exceed the U.S. Environmental Protection Agency's ENERGY STAR specification, and cold climate air-source heat pumps, packaged terminal heat pumps, and variable refrigerant flow products that meet or exceed standard specifications for heat pumps that are best suited to heat efficiently in cold climates.
Efficient electrification	Electrification of a building with an adequately efficient thermal envelope to conserve energy use, keep occupants comfortable, and enable an efficient electric heat pump system to operate effectively.
Electric Peak Demand	The highest actual average hourly load that occurred during a calendar year. Given that the electric transmission and distribution systems are designed and built to serve peak load, reducing peak demand is important for improving system efficiency, reducing wholesale electricity prices, and delaying the need for additional infrastructure.
Electric Vehicles (EVs)	Vehicles powered by electricity from an external source stored onboard in a battery, including both battery-electric vehicles (BEVs), which run exclusively on electricity, and plug-in hybrid electric vehicles (PHEVs), which run exclusively on electricity for a limited range and then are powered by an internal combustion engine.
Embodied emissions	The total greenhouse gas emissions generated throughout the entire life cycle of a product, particularly emphasizing the stages before its operational use. This includes the extraction of raw materials, manufacturing, transportation, construction, and disposal at the end of its life.
Emergency	A serious, unexpected, and often dangerous situation requiring immediate action.
Energy Burden	The percentage of gross income that a household spends on energy. It is calculated by dividing the average housing energy cost by the average annual household income. When a household is described as energy burdened, that generally means that it spends more than 6 percent of household income on energy
Energy Insecurity	The inability to meet basic energy needs. It may mean having to choose between energy and other expenses, keeping your house at an unsafe or unhealthy temperature to save expenses, or being unable to pay energy bills.
Energy Justice	The goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health

burdens on those communities historically disadvantaged by the energy system. Energy justice in New York explicitly centers the concerns of disadvantaged communities and aims to make energy more accessible, affordable, clean, and democratically managed for all communities. The practitioner and academic approaches to energy justice emphasize these process-related and distributive justice concerns.

Energy Security Planning and Emergency Preparedness

Plans and actions that ensures a reliable and resilient supply of energy that protects public health, safety, and welfare while minimizing economic disruption. Energy Security Planning identifies, assesses, and mitigates risks to energy infrastructure, and plans for, responds to, and recovers from events that disrupt energy supply. New York State Energy Emergency Preparedness includes energy emergency planning and response as well as energy security risk and mitigation planning through the New York State Energy Emergency Plan and the New York State Energy Security Plan.

Environmental justice community

A community bearing a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs, and policies, most often low-income communities of color. Negative environmental consequences may include higher rates of asthma, heart disease, and cancer resulting from proximity to polluting facilities, highways, and fossil fuel energy infrastructure due, in part, to structural racism in land use practices and real estate.

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 (SO_2), ammonia (NH_3), and volatile organic compounds (VOCs).

Fossil fuel workers (jobs)

Any worker (job) that is directly involved with the research, development, production, manufacture, distribution, sales, implementation, installation, or repair of components, goods, or services related to energy derived from fossil fuels, including electric generation, delivered fuels, internal combustion vehicles, and natural gas distribution.

Fossil Fuels

Fuels produced from the decay of prehistoric organic materials. These fuels can be liquid (example: petroleum) or gaseous (example: natural gas).

Frontline community	A community or population that has experienced systemic socioeconomic disparities, environmental injustice, or another form of injustice, including low-income communities, Indigenous communities, and communities of color. Frontline communities also include communities that are the most vulnerable and will be the most adversely impacted by environmental and climate injustice and inequitable climate actions, including deindustrialized communities, depopulated rural communities, vulnerable elderly populations, unhoused populations, individuals with disabilities, and communities economically dependent on fossil fuel industries.
Green infrastructure	Measures that strategically utilize plantings, soils, and other media to capture and treat stormwater by relying on the natural processes of filtration, infiltration, and evapotranspiration. Green infrastructure can also help cool communities and mitigate the urban heat island effect.
Greenhouse gas mitigation	A human intervention to reduce emissions or enhance the sinks of greenhouse gases. (*See also* “Climate Mitigation”)
Greenhouse gases	Gases that trap some of the Earth’s outgoing energy, thus retaining heat in the atmosphere. This heat trapping, known as the greenhouse gas effect, alters climate and weather patterns at global and regional scales. Greenhouse gases include carbon dioxide, methane, nitrous oxide, and certain synthetic chemicals, such as fluorocarbons and sulfur hexafluoride.
Hazard mitigation	Any sustained action taken to reduce or eliminate long-term risk to life and property from hazard events. It is an on-going process that occurs before, during, and after disasters and serves to break the cycle of damage and repair in hazardous areas.
Home Rule	The Home Rule form of government establishing cities, towns, and villages is embedded in New York’s Constitution, Article IX (Section) 2. The Legislature has granted local governments certain powers, including local legislation, land use authority, ownership and maintenance of municipal property and roadways, and powers of local taxation. Due to local control over land use, the State often plays an advisory role.

Indigenous knowledge	A body of observations, oral and written knowledge, innovations, practices, and beliefs developed by Indigenous peoples through interaction and experience with the environment. It is applied to phenomena across biological, physical, social, cultural, and spiritual systems. Indigenous knowledge can be developed over millennia, continues to develop, and includes understanding based on evidence acquired through direct contact with the environment and long-term experiences, as well as extensive observations, lessons, and skills passed from generation to generation. Coordination with Indigenous Nations, and the respectful incorporation of Indigenous knowledge should honor Indigenous Nation sovereignty.
Industrial sector	Businesses focused on the mass production of goods, often involving machinery, technology, and a significant workforce.
Innovation Ecosystem	Innovation ecosystems are communities of interacting stakeholders engaged in producing, enhancing, and creating novel methods, products, and processes.
Installed Capacity	The amount of electric power that can be generated in the state.
Installed Reserve Margin	The amount of generation capacity that must be in place to ensure an acceptable level of reliability. The IRM is measured by the amount of generation and other capacity resources above 100% of forecasted peak load that must be available to serve all customers without interruption.
Intra-Sector Interdependency	One part of an energy sector (Electric, Gas or Liquid Fuel) relying on or controlled by another part of the energy system within the same sector; for example, the liquid fuel inventory in NY has an intra-dependency with refinery production and pipeline operations in the Gulf states.
Joint Utilities (JU)	The Joint Utilities are comprised of Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc. ("Con Edison"), New York State Electric & Gas Corporation, Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid"), Orange and Rockland Utilities, Inc. and Rochester Gas and Electric Corporation. Together, the Joint Utilities provide electric service to over 13 million households, businesses, and government facilities across New York State.
Labor peace agreement	An agreement between employers and a union limiting certain actions from both sides for a specified period of time. Labor peace agreements may require management to remain neutral and not interfere in any union organizing, and the union to avoid strikes or other activities that could seriously interrupt workplace operations.
Life cycle analysis (LCA)	Evaluates the potential environmental impacts associated with a product, process, or service throughout its entire life cycle.

Light Water Reactors (LWRs)	A term used to describe reactors using ordinary water as a moderated coolant.
Light-Duty Vehicles	On-road vehicles under 8,500 lbs. gross vehicle weight rating (GVWR), Class 1 and 2a, per the U.S. Environmental Protection Agency (US EPA) classification system.
Liquid Fuels	Another name for delivered fuels. A group of fuels that, at surface temperatures, are in the liquid phase with little or no pressurization, as a result, these fuels can be transported by a variety of modes.
Load Factor	A measure of the degree of uniformity of demand over a period of time, usually one year, and equivalent to the ratio of average demand to peak demand expressed as a percentage. It is calculated by dividing the total energy provided by a system during a period by the product of peak demand during the period and the number of hours in the period.
Load Serving Entity	A retail electric service provider (e.g., a utility) that is obligated to procure or purchase wholesale electricity to serve its end-use customers.
Local distribution company	An entity responsible for procuring gas supply on behalf of their customers, delivering gas to end users from the city gate, and keeping their distribution systems balanced by matching demand with supply.
Location-efficient areas	Compact and resilient neighborhoods that offer walkability, a mix of uses, proximity to daily destinations, and reduced reliance on automobiles.
Low-carbon fuels and energy sources	Produce significantly fewer greenhouse gas emissions during their lifecycle compared to traditional fossil fuels.
Managed Charging	The practice of controlling the speed and/or time at which an EV is charged for the purpose of minimizing charging during times of peak electricity usage and minimizing charging costs for the EV driver.
Manufacturing sector	Encompasses firms that transform raw materials into finished goods.
Medium- and Heavy-Duty Vehicles	On-road vehicles over 8,500 lbs. gross vehicle weight rating (GVWR), Class 2b through 8, per the U.S. Environmental Protection Agency (US EPA) classification system.
Megawatt Electrical	The electric output capability of the nuclear power plant.
Microcredentials	Flexible and compact academic credentials created to meet specific workforce needs that are taught by faculty. Often credit bearing, these empower

individuals with essential skills, knowledge and practical experience in high-demand fields and are designed to be stackable and build into degrees.

Micromobility — Any low-speed, human or electric-powered transportation device, including bicycles, scooters, electric-assist bicycles (e-bikes), electric scooters (e-scooters), and other small, lightweight, wheeled conveyances.

Mitigation — The action of reducing the severity, seriousness, or painfulness of a risk.

New York State Energy Emergency Plan — An emergency response plan outlining State activities and responsibilities in response to an energy emergency. The scope includes emergency response planning and coordination with Federal and industry partners, it does not identify the major risks to the current energy system or include longer term resilience or mitigation activities. It is an annex to the State's Comprehensive Emergency Management Plan.

New York State Energy Security Plan — A plan focused on identifying and protecting the state energy systems by providing a detailed, comprehensive risk assessment of critical energy infrastructure and cross-sector interdependencies and providing a framework for evaluating risk mitigation approaches to enhance reliability and end-use resilience.

Nuclear Generations — Nuclear technology discussions often refer to "generations" of nuclear designs, with current operating large LWRs referred to as "Gen II" or "Gen III." Newer advanced technologies are categorized as either "Gen III+," defined as large or small modular light water reactors that offer improved economics and safety over conventional large light water reactors, or "Gen IV," defined as small modular reactors (SMRs) or microreactors that offer improved sustainability, economics, safety, and proliferation and use non-water coolants. Gen IV technologies include high temperature gas reactors, liquid sodium metal reactors, and molten salt reactors.

Operational flow order — A mechanism used in the natural gas industry to manage and maintain the operational integrity of a pipeline system. It requires shippers to balance their gas supply with their customers' usage on a daily basis, within a specified tolerance band, to prevent system imbalances and potential operational issues.

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.

Petroleum Fuels — Another name for crude oil. This liquid extracted from wells is a mixture of organic molecules that can be separated into specific fuels through a refining

	process. Petroleum fuels include fuels such as diesel, gasoline, kerosene, and propane.
Phased electrification	Projects wherein the building electrification process is carried out over time. This staged approach aims to electrify most or all a building’s energy systems while minimizing disruptions to building operations and occupant experience. This may be a multifamily or commercial building where certain units of the building are converted to electric heat pumps for space heating (e.g., at the time of tenant turnover), or as part of a phased more comprehensive renovation project. This may also result in instances where full electrification of the building may not be possible due to available electric capacity or limitations related to customers’ capital cycles.
Pre-apprenticeship program	A program that recruits and orients new workers, helps them identify the apprenticeship program most suited to them, prepares them to take the test, and supports their initial career efforts. They can also provide life skills and job readiness training.
Prevailing wage	The wage standard required by federal and state law for publicly funded or publicly assisted projects. Prevailing wages represent the hourly wages, benefits, and overtime paid to the majority of workers in a particular area, for a particular trade, as determined by a survey conducted by the federal Department of Labor. In New York State, the Department of Labor Bureau of Public Work & Prevailing Wage Enforcement handles the enforcement of state prevailing wage rules.
Priority Populations	Veterans; Individuals with disabilities; Low-income individuals, whose household’s total income is below or at 60% of the State Median Income, or whose household has been determined eligible for or is receiving assistance through the Home Energy Assistance Program (HEAP), Temporary Assistance for Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP), or other human service benefit programs; Incumbent or unemployed fossil fuel workers; Previously incarcerated individuals; 16- to 24-year-olds who are enrolled in or have completed a comprehensive work preparedness training program such as those offered by Boards of Cooperative Education Services (BOCES), technical high schools, Conservation Corps, YouthBuild, and AmeriCorps; Homeless individuals; and Single parents.[1]
Procedural Equity	Fair and transparent processes used for decision-making, resource allocation, and policy development. Decision makers create inclusive and accessible processes for developing and implementing clean energy programs such that all stakeholders have equitable access to participate

Project labor agreement	A comprehensive, legally binding document negotiated and signed by a developer or project owner, the general contractor, and labor unions, specifically for construction projects. These agreements typically require labor peace on a project and set the terms of work, including working conditions, hiring requirements, pay rates, safety rules, and the process for resolving conflicts that may arise. Project labor agreements are used exclusively for construction activities and do not apply to ongoing operations or non-construction work.
Regional Planning Commission	(also referred to as a committee, board, or council) is a quasi-governmental body that supports municipalities within a defined region by providing planning, coordination, and technical assistance. These organizations help local governments, often facing capacity constraints, address issues that cross jurisdictional boundaries, including transportation, land use, environmental sustainability, economic development, and regional infrastructure
Registered apprenticeship program	A program that meets minimum state and federal requirements around equal opportunity, related training, and relevance of on-the-job training. Registered apprenticeship programs offer a standardized curriculum for workers to learn the skills and abilities they will need to be a fully functioning worker in a specific trade. They utilize an "earn-while-you-learn" model, including classroom training as well as training on a job site. They can be operated by unions or non-union contractors and in New York State, they must be registered with the New York State Department of Labor.
Reliability	The energy system's ability to function consistently during normal conditions. In many cases, adaptation strategies that improve resilience also have the benefit of improving reliability.
Resilience	The capacity to withstand or to recover quickly from negative events such as natural disasters, climate change, and other threats/hazards.
Resource Efficient Decarbonization	A phased approach to eliminating greenhouse gas emissions from large buildings in cold climates that creates a path toward cost-effective decarbonization.
Risk	The potential for the loss or degradation of energy supply or services, and the associated indirect impacts of those losses on society, resulting from the exposure of energy infrastructure to a threat.
Risk Mitigation Strategy	A proactive approach to enhance the State's energy reliability and end-use resilience through which Risk Mitigation Measures are identified, evaluated, and may be prioritized for implementation.
Small Modular Reactors (SMRs)	Smaller, more advanced, nuclear reactors that offer improved sustainability, economics, safety, and proliferation and use non-water coolants.

Smart growth	An approach to planning and development that supports and integrates equity, economy, environment, energy, and climate to create livable and sustainable communities.
Spot market / spot price	A market where assets are traded for immediate delivery and payment. (As contrasted with futures markets, where transactions are settled at a future date.)
Sprawl	The development of automobile-centric, low-density, dispersed residential and commercial uses that occurs outside of urbanized areas, encroaching onto natural and working lands.
Strike Price	A predetermined fixed price at which the owner of an option can buy or sell an underlying asset.
Subsidized affordable housing	Housing that is affordable because of government subsidy. This can include, but is not limited to, housing units receiving support under the U.S. Department of Housing and Urban Development programs (e.g., Section 8 Housing Choice Voucher, tenant-based vouchers, project-based vouchers, and HOME), including units owned or overseen by Public Housing Authorities.
Supplemental heat	A heating system that is installed or left in place to complement a heat pump heating system that is not sized to meet the full heating load of the building, providing heat to supplement the main heating system during the coldest hours of the year.
Targeted hiring programs	Programs that promote the hiring of individuals who meet certain criteria (geographic, socioeconomic, etc.) for jobs associated with a development project. Targeted hiring policies often provide employment opportunities for groups commonly facing employment challenges.
The New York Control Area	The New York Control Area (NYCA) is comprised of eleven geographic zones (also referred to as “load zones”) from western New York (Zone A) through Long Island (Zone K).
Thermal energy network	A network of equipment and pipes that connects multiple buildings together to thermal energy sources such as geothermal, surface water, waste heat, and the air, to provide space heating cooling and domestic hot water. This technology can be an effective way to reduce energy costs and greenhouse gas emissions from a set or groups of buildings at scale.
Threat	Anything that can damage, destroy, or disrupt energy systems, including natural, technological, human/physical, and cybersecurity events.
Threatened	Under the Endangered Species Act, plant and animal species that are likely to become endangered within the foreseeable future

Transit-oriented development	Dense, pedestrian-oriented, mixed-use development located near (usually within a quarter- or half-mile radius) of direct transit access.
Transportation Demand Management (TDM)	Managing demand is about providing travelers, regardless of whether they drive alone, with travel choices, such as work location, route, time of travel and mode. In the broadest sense, demand management is defined as providing travelers with effective choices to improve travel reliability.
Transportation Systems Management and Operations (TSMO)	Focuses on operational improvements that can maintain and even restore the performance of the existing transportation system before extra capacity is needed.
Vehicle Miles Traveled (VMT)	The amount of travel for all vehicles in a geographic region; calculated by adding up all miles driven by all motorized vehicles.
Vehicle-Grid Integration	Vehicle-to-Grid (V2G) technology allows EVs to both draw electricity from the electric grid to charge the EV's battery and also discharge the EV's battery to sell power back to the electric grid.
Vulnerability	The susceptibility of an energy infrastructure system to damage, loss, or degradation caused by a threat due to weaknesses within the system or due to the system's dependence on critical supporting systems or material, technical, or workforce resources affected by the threat.
Weatherization	Protecting a building's interior from outside temperatures and moisture to cut energy use and enhance indoor comfort through measures like air sealing, insulation, and window upgrades.
Wetlands	An area that is saturated or inundated by water, either surface or ground, at a frequency and duration sufficient to support vegetations adapted to saturated soil condition
Zero-Emissions Vehicles (ZEVs)	Vehicles powered by energy sources that result in no tailpipe emissions, such as battery-electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs). Plug-in hybrid electric vehicles (PHEVs), which run exclusively on electricity for a limited range and then are powered by an internal combustion engine, are also considered ZEVs under certain regulations.

Pathways Analysis

1. Overview

The 2025 State Energy Plan Pathways Analysis provides an analytic lens on how New York's energy system could change over the coming decades using a scenario-based approach. The analysis focuses on identifying common themes and major drivers of change. It highlights the challenges and benefits associated with reducing fossil fuel dependence, scaling clean energy technologies, and meeting growing energy demand from new large commercial and industrial loads as well as building and transportation electrification.

This analysis draws on the best available data through early 2025. Conducted by Energy and Environmental Economics, Inc. (E3), informed by input and analysis across State agencies, this work estimates stocks and sales of key energy technologies, energy demand, supply, greenhouse gas (GHG) emissions, and cost implications across multiple scenarios. The modeling integrates technical assumptions, policy trajectories, and sectoral detail, providing a foundation for evaluating tradeoffs and informing energy planning.

This chapter outlines the modeling framework, summarizes core scenarios, and presents key findings to inform decisions about energy investments and infrastructure planning in the years ahead and the discussion in other chapters of this Plan. The Annexes offer greater detail on the modeling methodology, input data, data sources, scenario assumptions, and results. Model inputs and assumptions are compiled in more detail in Annex 1, and key outputs in Annex 2.

The Pathways Analysis aggregates key input data from NYSERDA's industry studies and programs and uses a stock turnover approach to model equipment stocks over time across key energy sectors, such as buildings and transportation. This approach helps in understanding the deployment of technologies like heat pumps, electric vehicles (EVs), and efficiency measures. The Pathways Analysis produces an outlook on fuel use, electric loads and peaks, and gross and net greenhouse gas emissions by sector.

In addition, the Pathways Analysis includes an assessment of the energy supply sectors and how the energy supply across the economy changes over time to meet projected demand. This energy supply outlook captures changes in the gas system, fuel system, and electric sector. The electric sector toolkit includes capacity expansion and dispatch capability, which builds out an electric system to meet demand load shapes while maintaining reliability standards and achieving scenario-specific constraints such as specified renewable build or policy targets like a zero-emissions grid by 2040. It enables exploration of contributions from various resources, such as solar, wind, batteries, and thermal units, to the generation mix over time.

While the Plan primarily focuses on energy sectors, it also includes high-level representations of emissions from non-energy sectors like waste and agriculture, based on New York State Department of Environmental Conservation (DEC) forecasts. This comprehensive approach allows for an assessment of the impacts of non-energy sectors on economy-wide emissions limits. The toolkit also includes modules for analyzing refrigerant emissions and fugitive gas system emissions, while receiving information on air quality and health outcomes from parallel analysis.

2. Scenario Design

Given future uncertainty, the Pathways Analysis takes a scenario-based approach which allows exploration of outputs across different potential energy futures. These scenarios are briefly summarized in the table below, with more details available in Annex 1.

Table 1. Summary of scenarios

Scenario	Assumptions	Purpose
No Action	Includes Federal incentives (e.g., IRA) and legacy NY policies, but excludes the Climate Act and more recent additional State and Local climate measures. Federal incentives reflect those in place during the first quarter of 2025 when the analysis was conducted.	Counter-factual baseline to gauge relative impacts and incremental benefits and costs of State action
Current Policies	Layers on top of the No Action case current progress toward achievement of enacted State and local policies (e.g. Clean Energy Standard, building code updates, Advanced Clean Cars/Trucks)	Illustrates what existing commitments achieve under current market conditions and headwinds
Additional Action	Includes Current Policies plus ongoing progress toward adoption of clean technologies through a mix of future programs and investments aligned with recommendations in the State Energy Plan.	Core planning case for the Energy Plan, reflecting ambitious but achievable progress
Net Zero A	Accelerates adoption of clean energy technologies in all sectors toward achievement of economywide net zero by 2050, emphasizing all electric space heating	Reflects what would be needed for full achievement of the 2050 emission limit with a smaller gas network
Net Zero B	Accelerates adoption of clean energy technologies in all sectors toward achievement of economywide net zero by 2050 with greater use of supplementary gas heating systems	Reflects what would be needed for full achievement of the 2050 emission limit with a larger gas network

The first scenario is No Action. It includes historical policies, market-driven adoption, and federal programs like the Inflation Reduction Act (IRA) but excludes New York's Climate Act and other recent State and local clean energy policies. This scenario provides a baseline to assess the incremental benefits and costs of state action. While the future of federal clean energy and emissions programs remains uncertain, this analysis includes them in the Draft as of the first quarter of 2025, with plans to explore any changes to those federal programs through sensitivity analysis. The impacts of federal rollback of the IRA are not included in the modeling at this time but will be explored in the final State Energy Plan.

The second scenario, Current Policies, builds on the No Action case by incorporating progress toward achievement of enacted State policies and local actions across sectors. In the buildings sector, this includes the implementation of all-electric new construction, advanced building codes, and utility- and state-funded programs promoting energy efficiency and heat pump adoption. Examples include Clean Heat, Empower+, Direct Injection, and housing programs implemented through Housing and Community Renewal (HCR). In the transportation sector, the scenario includes progress toward meeting Advanced Clean Cars (ACC) and Advanced Clean Trucks (ACT) standards. Although future implementation of these standards carries uncertainty due to federal actions, they are included as current policy—consistent with the treatment of federal policies in the No Action case—since outcomes of legal and regulatory processes are not yet determined. In the electricity sector, this scenario assumes progress toward the Climate Act's zero-emission electricity goal by 2040 ("0x40"), consistent with near-term Clean Energy Standard (CES) Biennial Review trajectories. These trajectories account for deployment challenges and reach the 70% renewable electricity projection by 2033 in line with the CES Biennial review. Comparing this scenario to No Action helps clarify the added benefits and costs of current State and local policies. As a bottom-up assessment of the energy future under current policies, this case is one of the two main planning cases developed for the State Energy Plan.

The third scenario, Additional Action, builds on Current Policies by showing consistent and steady improvements in the adoption of clean energy technologies. This acceleration could result from new policies, investments, environmental market mechanisms, or other initiatives as described in the State Energy Plan. As a forward-looking case that assumes continuous improvement, it serves as the core planning scenario for the State Energy Plan.

The final two scenarios, Net Zero A and Net Zero B act as a point of comparison to understand what would be needed to achieve 2050 emissions targets, including 85% reductions in gross emissions and net-zero, including significant increases in electricity use and the steep declines in other fuel consumption, driven by widespread efficiency and electrification.

The key difference between the two lies in building heating technologies:

- **Net Zero A** emphasizes all-electric heating.
- **Net Zero B** assumes greater adoption of supplementary heating systems, where customers retain a gas backup for the coldest days.

Although heat pump customers with supplementary heating systems use significantly less gas in Net Zero B, managing their backup use would require careful coordination. However, this approach may reduce peak electricity demand and underscore the potential value of maintaining a larger residual gas network.

3. Energy Demand Sectors

Based on information in NYSERDA Patterns and Trends for New York State, the sectors with the most energy consumption today include buildings (50%) and transportation (40%), with industry making up much of the remainder (Figure 1). The analysis of the energy demand sectors utilizes E3 PATHWAYS model, a bottom-up, technology-rich tool that operates on a stock-turnover framework to project long-term energy consumption.

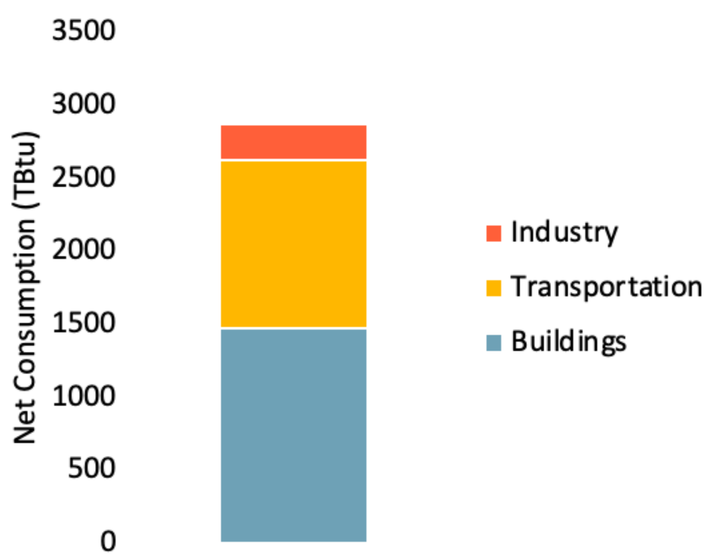

Figure 1. Energy consumption by sector in New York (2025)

3.1. Buildings

Residential and commercial buildings remain the largest energy consumers in the state, primarily due to space conditioning (heating, ventilation, and air conditioning, or HVAC) and water heating. While the state's overall population is expected to remain stable, based on projections from Cornell's Program on Applied Demographics, a shift from upstate to downstate will increase aggregate cooling loads and reduce heating demand.[1] Multiple studies conclude that climate change will increase the frequency and severity of extreme summer temperatures.[2,3] Climate trends are expected to increase summer cooling demands, and warmer winters are expected to reduce overall winter heating demands. The Pathways analysis, consistent with the NYSERDA Climate Impacts Assessment, accounts for increased summer load due to warming, but this effect remains relatively modest within the 2040 timeframe of the State Energy Plan. Further information on modeling methods is available in the Appendix.

Across all scenarios, key drivers of change include energy efficiency investments, HVAC equipment turnover and new technology adoption, and new construction with improving building codes. In the No Action case—absent State policy—heat pump and efficiency adoption continue at a moderate pace, driven by federal incentives and consumer preferences. New construction is largely natural gas, and many buildings with existing oil and electric resistance switch to gas. However, even as gas customer counts increase, replacements in kind of gas equipment lead to lower consumption due to the impact of federal appliance standards.

In contrast, the Current Policies and Additional Action scenarios feature stronger State and local policy influence. Measures such as all-electric new construction, advanced building codes, efficiency and electrification programs drive higher rates of heat pump and efficiency adoption. The projected trajectories for heat pump and efficiency sales and stock under these varying policy conditions are detailed in Figure 2 and Figure 3, respectively. Energy efficiency remains foundational, with whole home building envelope upgrades across the building stock (shell measures) outpacing heat pump adoption due to their lower cost and higher project returns. New building codes taking effect in the mid-2020s will further improve both envelope and equipment efficiency, helping reduce the increased electricity demand from electrified heating. By 2040, heat pump sales outpace the sales of gas equipment in the Additional Action scenario.

Achieving net-zero emissions economywide requires more aggressive action, as reflected in the Net Zero scenarios. These require near-universal efficiency upgrades with a focus on building shell upgrades and, due to the long service life of HVAC systems, 100% heat pump sales by 2035 to achieve the 2050 limits—a significant step beyond current policy trajectories.

[1] Statewide projections show relatively flat to declining population statewide https://pad.human.cornell.edu/state_projections/datatools.cfm. Accessed June 2025

[2] NYISO, Climate Change Impact Study, Phase 1: Long-Term Load Impact, December 2019, available at: https://www.nyiso.com/documents/20142/10773574/NYISO-Climate-Impact-Study-Phase1-Report.pdf

[3] NYSERDA, Impacts of Climate Change on the New York Energy System, December 2023, available at: https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions

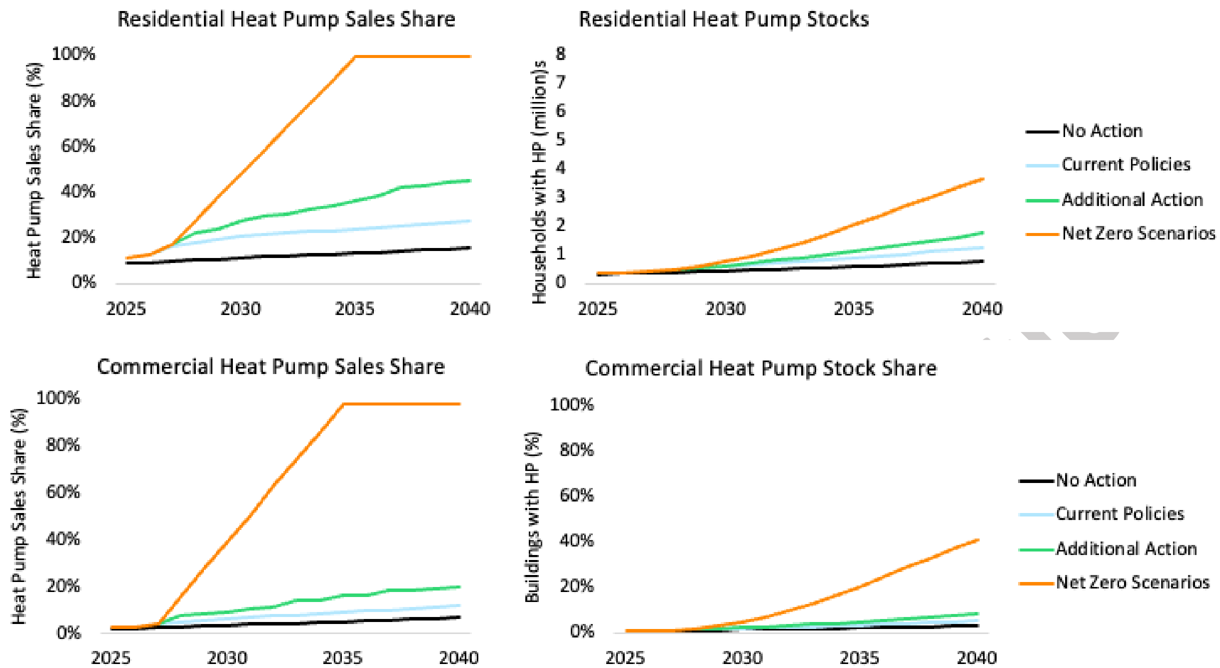

Figure 2. Residential and commercial heat pump sales and stock trajectory

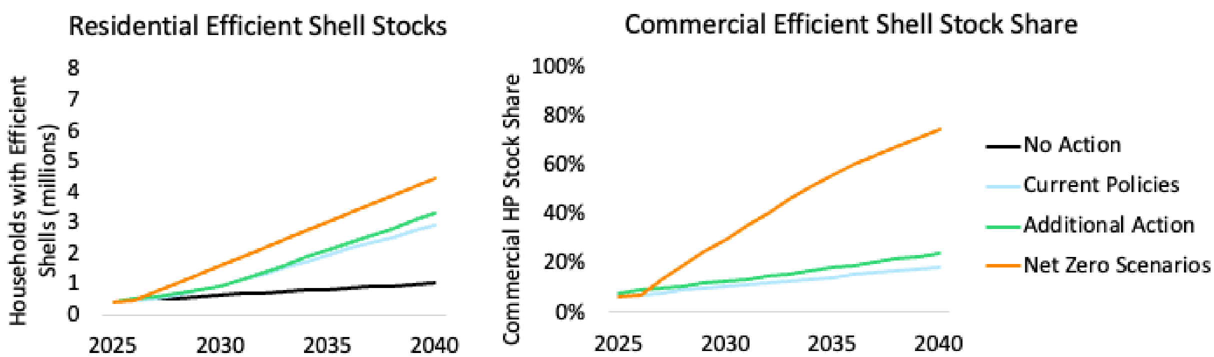

Figure 3. Residential and commercial efficient building shells stock trajectory

Heat pump adoption varies substantially by scenario. In all cases, cold-climate air source heat pumps (ASHPs) dominate, with a notable role for ground source heat pumps (GSHPs). Most heat pumps sold in the state are already cold-climate models, so all ASHPs discussed in this analysis are cold-climate.[4] ASHPs are more efficient than electric resistance heating but lose efficiency during the coldest periods, increasing peak electricity demand although still less than resistance-only systems. Heat pumps with supplementary heating backup rely on combustion or thermal systems to provide heat during the coldest periods. GSHPs, by contrast, maintain efficiency even in extreme cold with minimal performance loss and in this analysis also serve as a proxy for thermal networks. To represent potential for a lower range of electric peak system impacts in the more highly electrified Net Zero scenarios, Net Zero

[4] Cold-climate heat pumps must meet stringent criteria set by the Northeast Energy Efficiency Partnerships, ensuring the unit can operate efficiently and reliably even when outside temperatures drop significantly.

Scenario B includes a larger share of ASHPs with fuel backup than Net Zero Scenario A. For reference, the total number of households in New York is roughly 7.3 million.

Table 2. Summary of residential heat pump and efficient shell retrofits

Scenario	2040 heat pump share of annual sales	2040 heat pump stock	2040 efficient shell stock
No Action	15%	760 thousand	1 million
Current Policies	27%	1.2 million	2.9 million
Additional Action	45%	1.7 million	3.3 million
Net Zero A/B	100% (by 2035)	3.6 million	4.5 million

Table 3. Residential household heating stocks, 2040

Device	No Action	Current Policies	Additional Action	Net Zero A	Net Zero B
Heat Pumps	0.76	1.26	1.76	3.66	3.66
ASHP	*0.61*	*0.96*	*1.30*	*2.54*	*2.17*
ASHP with supplemental heating system	*0.03*	*0.06*	*0.09*	*0.31*	*0.68*
GSHP	*0.13*	*0.25*	*0.37*	*0.81*	*0.81*
Electric	0.57	0.57	0.54	0.40	0.40
Gas	4.81	4.33	3.87	2.46	2.46
Other	1.15	1.14	1.13	0.78	0.78

Another important lever for decarbonizing the buildings sector is renewable fuel blending. All scenarios include current state policy of at least 20% biodiesel blending (B20) for heating fuels by 2030. The Additional Action case layers in a targeted role for renewable natural gas at a blending of 20 TBtu, or 3% of building pipeline gas use, by 2040, while the Net Zero cases build upon this to hit a blending of 100 TBtu, or 33% of building pipeline gas use, by 2040. Blending at rates up to 33% is only achievable in the Net Zero cases alongside significant reductions in gas throughput from increased efficiency and electrification.

3.2. Transportation

The transportation sector consumes the second most energy in the state, behind buildings. Most of this energy use comes from fuel consumption in light-, medium-, and heavy-duty vehicles, with the remaining transportation sector energy consumption coming from non-road vehicles such as airplanes, trains, and boats. More detail on methods is available in the Appendix.

Across all scenarios, many fundamental drivers of transportation demand remain consistent. Fleet size per capita in each region stays flat, while aviation demand continues to grow. The downstate migration of households relocates on-road transportation energy demand, especially for the light duty vehicle fleet, towards the downstate zones and reduces vehicle population over time as there are fewer vehicles per capita downstate.

The major driver of change between the scenarios is the accelerating shift towards zero emission vehicles (ZEV) across vehicle segments, a shift which is already underway. Electric vehicles are the most common ZEV, but there is also a targeted role for hydrogen fuel cell vehicles, especially in the heavier duty truck segment. The No Action case sees some adoption of electric vehicles driven by federal incentives and organic market adoption (Figure 4).

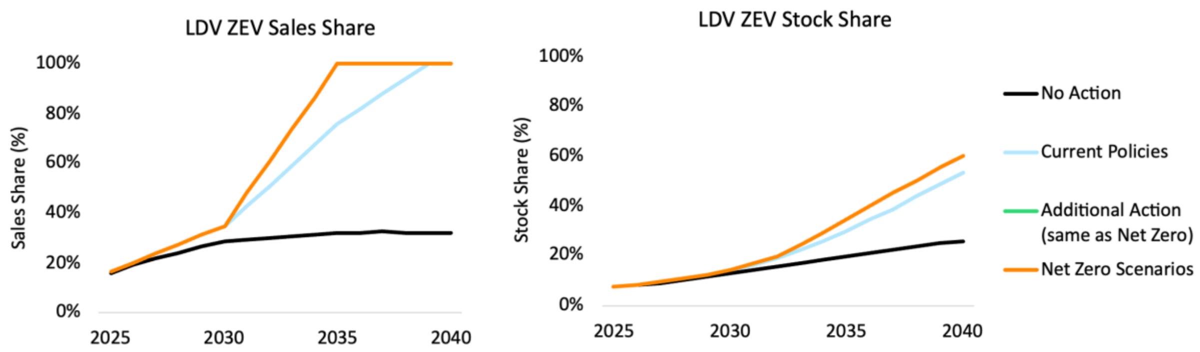

Figure 4. Light Duty Vehicle Zero Emission Vehicle (ZEV) sales and stock shares

The Current Policies case sees significant additional electrification across vehicle segments driven by ACC II and ACT.[5,6] While federal action could impact the future of these programs, they are still included in the policy cases given uncertain outcomes. Different trajectories towards achievement are assumed across the cases, reflecting uncertainty on current and near-term progress towards achieving the ACC II and ACT policy targets. Further uncertainty from federal impacts to these programs will be explored in the final State Energy Plan. Specifically, Current Policies assumes a 4-year delay in achievement based on a comparison of current progress toward deployment relative to deployment pace seen in California. The Additional Action case assumes that the gap is consistent through 2030, but acceleration post-2030 results in achievement of both the ACC target by 2035 and ACT target by 2045.

The Net Zero cases further accelerate the pace of adoption, especially in the medium and heavy-duty vehicle fleet where these sectors achieve 100% ZEV sales shares by 2040 (Figure 5). In these heavier vehicle classes, where battery-electric solutions face greater challenges for long-haul and heavy-load duty cycles, hydrogen fuel cell vehicles are expected to constitute a more substantial share of new ZEV sales. The gap between the impacts of current policies and the Net Zero cases are narrower than what was seen in buildings, especially through the 2040 planning horizon, reflecting the ambition of existing policies.

[5] Advanced Clean Cars II was enacted by NYSDEC as 6 NYCRR Part 218, available at: https://extapps.dec.ny.gov/docs/air_pdf/218acc2.pdf

[6] Advanced Clean Trucks was enacted by NYSDEC as 6 NYCRR 218, available at: https://dec.ny.gov/sites/default/files/2024-01/218act.pdf

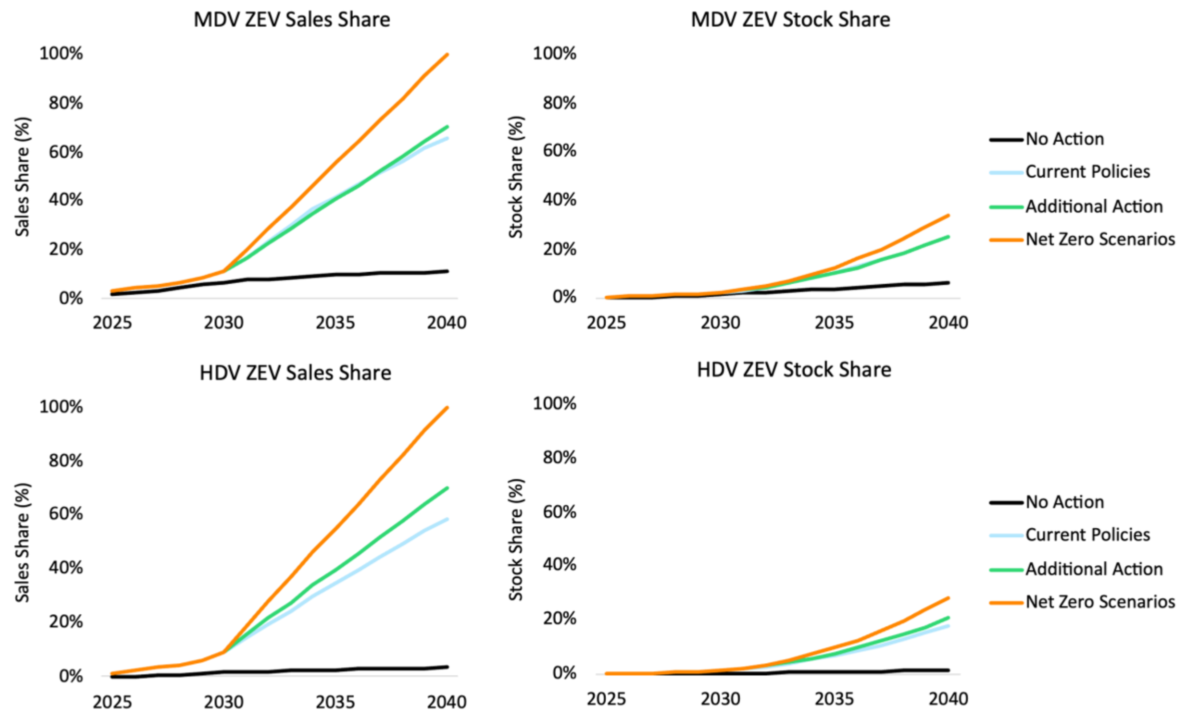

Figure 5. Medium and Heavy-duty vehicle ZEV sales and stock shares

Another important lever for decarbonizing the transportation sector is renewable fuel blending. The Additional Action case layers in renewable fuel blending at a scale of 20% renewable distillate and 35% sustainable aviation fuel by 2040, while the Net Zero cases build upon this to hit 33% renewable distillate and hit the same 35% sustainable aviation fuel target by 2040; due to the significant growth in ZEVs, the share of total transportation energy demand met by electricity and hydrogen grows to 16% by 2040 in the Additional Action case, and reaches 29% in the Net Zero cases (Figure 6).

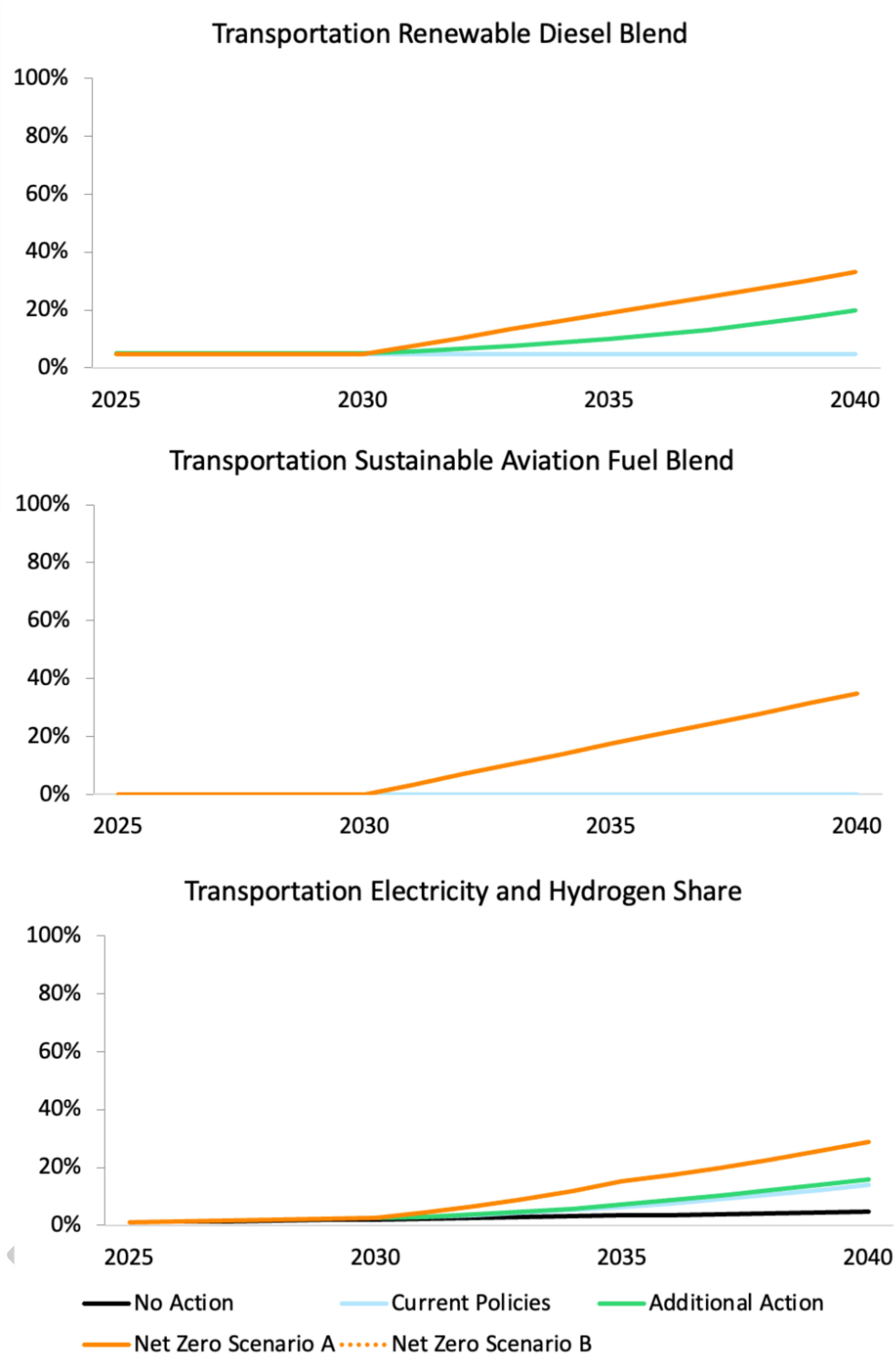

Figure 6. Transportation low carbon fuel blends

3.3. Industry

Industry currently accounts for 10 percent of statewide energy use but accounts for a disproportionate share of expected new load growth: several large manufacturing and data-center projects entering service this coming decade add roughly 16 TWh of electricity demand, which is over 75% of total industrial electricity demand today.[7] Planning for this new energy use is key to ensuring continued opportunities for economic growth in the state.

On top of these discrete large loads, all scenarios see further growth based on the Energy Information Administration (EIA) Annual Energy Outlook (AEO).[8] Industrial actors are often seeking process improvement opportunities, and some amount of efficiency is assumed to be baked into energy trends adopted from AEO to inform No Action and Current Policies.

The Additional Action scenario introduces more cost-effective energy efficiency as identified in the State's Industrial Potential Study while the Net Zero cases layer on more energy efficiency and fuel switching to electricity, hydrogen, and renewable fuels.

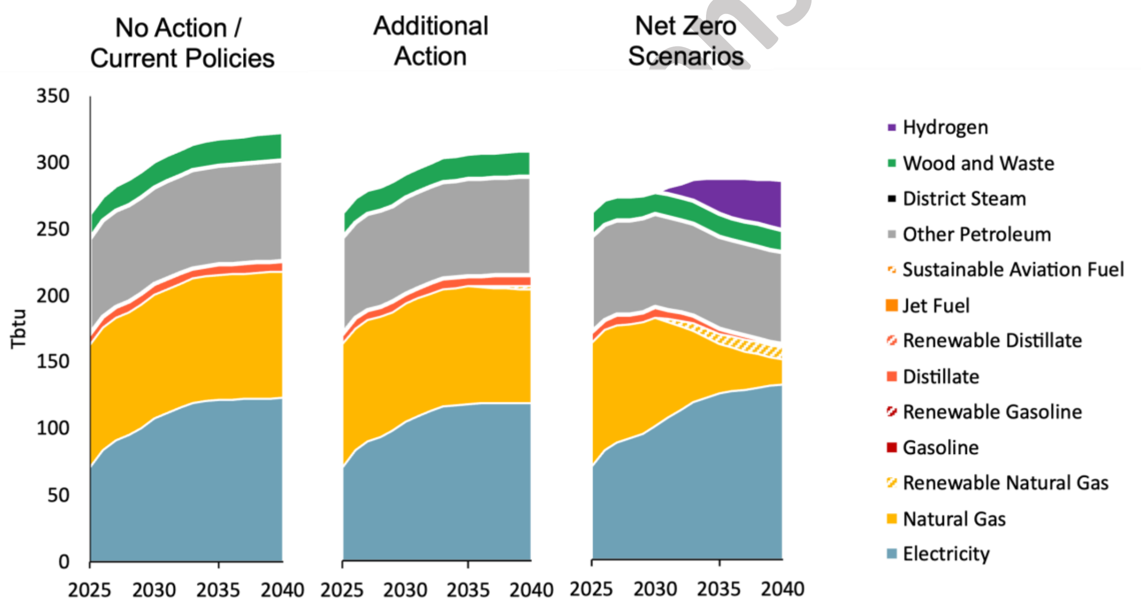

Figure 7. Annual industrial energy demand across scenarios

Note: industrial activity grows consistently across all scenarios.

4. Energy Supply Sectors

4.1. Gas

New York's natural gas system is a critical energy-delivery asset that requires continued investment to ensure safe and reliable service. When planning for system reliability, utilities distinguish between firm

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[7] NYISO 2025 Load and Capacity Data ("Gold Book"): https://www.nyiso.com/documents/20142/2226333/2025-Gold-Book-Public.pdf/088438e1-02f1-5316-211b-dbca17c01b4b

[8] EIA Annual Energy Outlook: https://www.eia.gov/outlooks/aeo/

customers, who are guaranteed an uninterrupted supply for essential needs like heating, and interruptible customers, who agree to have their service curtailed during periods of system stress in exchange for lower rates. Firm customers are predominantly residential and commercial users. Their demand defines the system's peak capacity requirements. Interruptible customers, by contrast, are typically large industrial facilities, power plants, or manufacturers that can switch to a backup fuel like oil or propane on short notice. The number of residential and commercial customers serves as an important indicator of the system's core service obligations.

As seen in Figure 8, in the No Action case, absent new state and local policies, the number of firm residential customers is projected to grow due to new construction and conversions from oil or electric-resistance heating. By contrast, the Current Policies and Additional Action scenarios show that well-executed all-electric new construction and electrification programs could check this near-term growth. The most pronounced contraction occurs in the Net Zero scenarios, driven by the acceleration of building electrification. In Net Zero B, which anticipates a larger remaining gas network as many heat pump customers retain a supplementary gas backup, each customer would need to use substantially less gas to stay within the economywide emissions caps.

A comparison to utility forecasts reveals significant regional uncertainty. The most conservative, highest throughput cases from individual utility long-term plans (LTPs, as of the first quarter of 2025) collectively suggest a flat statewide gas customer count, roughly aligned with the projections in the Current Policies case. However, this topline number masks wide regional divergences, with some utilities forecasting customer gains while others project declines. Notably, when more ambitious cases from the utility LTPs are considered, they show declines in both customer counts and gas throughput that are similar to the policy scenarios modeled in the Pathways Analysis. Even with a potential statewide leveling-off of customer numbers, regional demand shifts, peak day needs, and the enduring need for firm supply may necessitate targeted infrastructure investments to maintain service reliability.

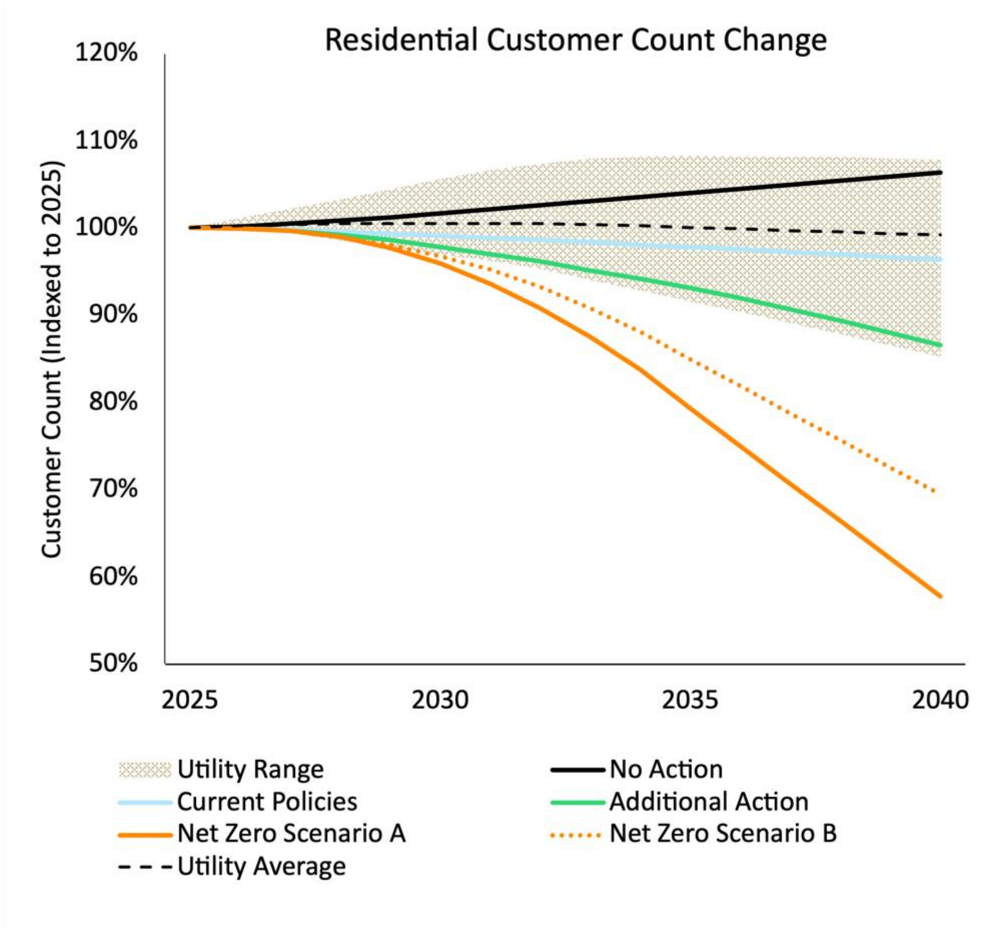

Figure 8. Residential gas customer count[9]

Just as there is uncertainty in the amount of firm gas customers, there is a range in the amount of buildings gas consumption that occurs in these scenarios. In combination, as seen in Figure 9, statewide Residential and Commercial gas consumption declines across all scenarios modeled for the State Energy Plan due to improved energy efficiency and electrification. By 2040, gas throughput to buildings in the Current Policies and Additional Action scenarios falls 14-19 percent below 2025. Electric sector modeling suggests an additional 360-450 TBtu of potential reductions from non-firm electric customers in Additional Action, but while this will lead to meaningful carbon benefits, it may not have a significant impact on system infrastructure needs as these customers typically have interruptible service, and gas distribution networks are more strongly indexed to firm customer counts. The Net Zero cases see transformational consumption declines with accelerated building electrification and shell adoption. Comparison to utility LTP forecasts suggest a range of potential consumption scenarios. As with the gas customer counts, there is regional variability in the gas throughput change seen in the most conservative cases in utility LTPs, as highlighted in Figure 9, below.

[9] Utility range reflects aggregate residential and commercial data due to lack of disaggregated data across all utilities

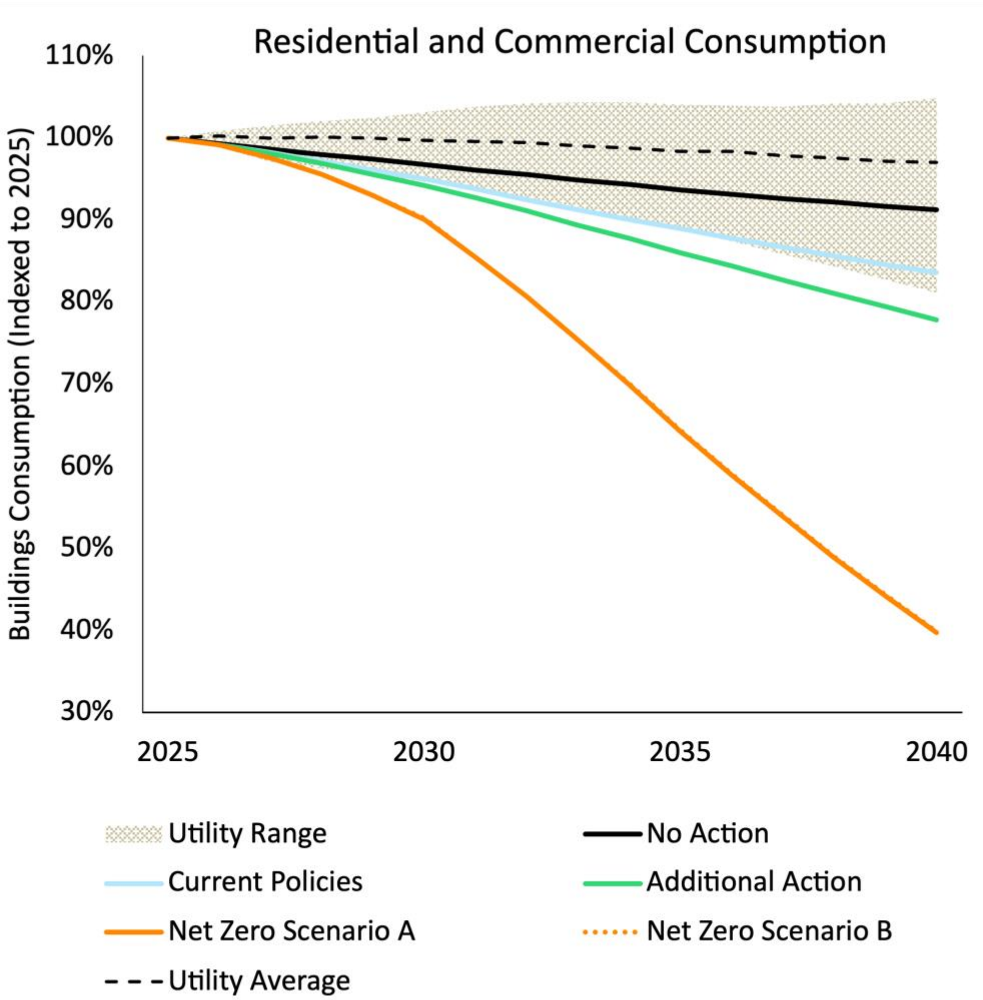

Figure 9. Buildings gas throughput

Renewable Natural Gas (RNG) blending can be another mechanism for decarbonizing the gas system, reaching 110 TBtu in the Net Zero cases by 2040. Due to the Climate Act treatment of biogenic consumption, RNG consumption still produces GHG emissions under the gross emissions target. This means RNG blending alone, without significant reductions in pipeline throughput, would not be a feasible pathway to achieving long term Climate Act emissions targets.

Methane leakage, counted on a 20-year global-warming-potential basis, magnifies the gas system's climate impact. State action can play a significant role in mitigating these emissions. Under the No Action baseline scenario, methane system leakage is forecast to decline slightly, from roughly 14 million metric tons in 2024 to 12 million metric tons in 2040, due to federal policies such as the IRA methane emissions reductions program and the U.S. Environmental Protection Agency (EPA) methane regulations. In the various policy scenarios this decline is accelerated due to the impacts of a reduced gas system size and state actions to reduce leakage, including the impacts of NYSDEC Part 203 on upstream and midstream gas, New York State Public Service Commission (PSC) leak-prone pipe replacement programs, and utility voluntary commitments; all of these scenarios achieve significant emissions reductions of 65% relative to 2024 levels by 2030 and ranging from 85-90% reductions by 2040.

4.2. Electricity

The electric supply analysis relies on an optimization modeling framework designed to identify the most cost-effective generation portfolios to reliably meet growing electricity demand and policy considerations.

4.2.1. Load and Peak

After decades of relatively flat electricity demand, New York's electricity sector is entering a new era of significant growth (Figure 10). Driven by increases in large commercial and industrial loads coupled with the electrification of transportation, buildings, and industry, all future scenarios point towards a substantial increase in electricity consumption and the need for a corresponding expansion of the electric system.

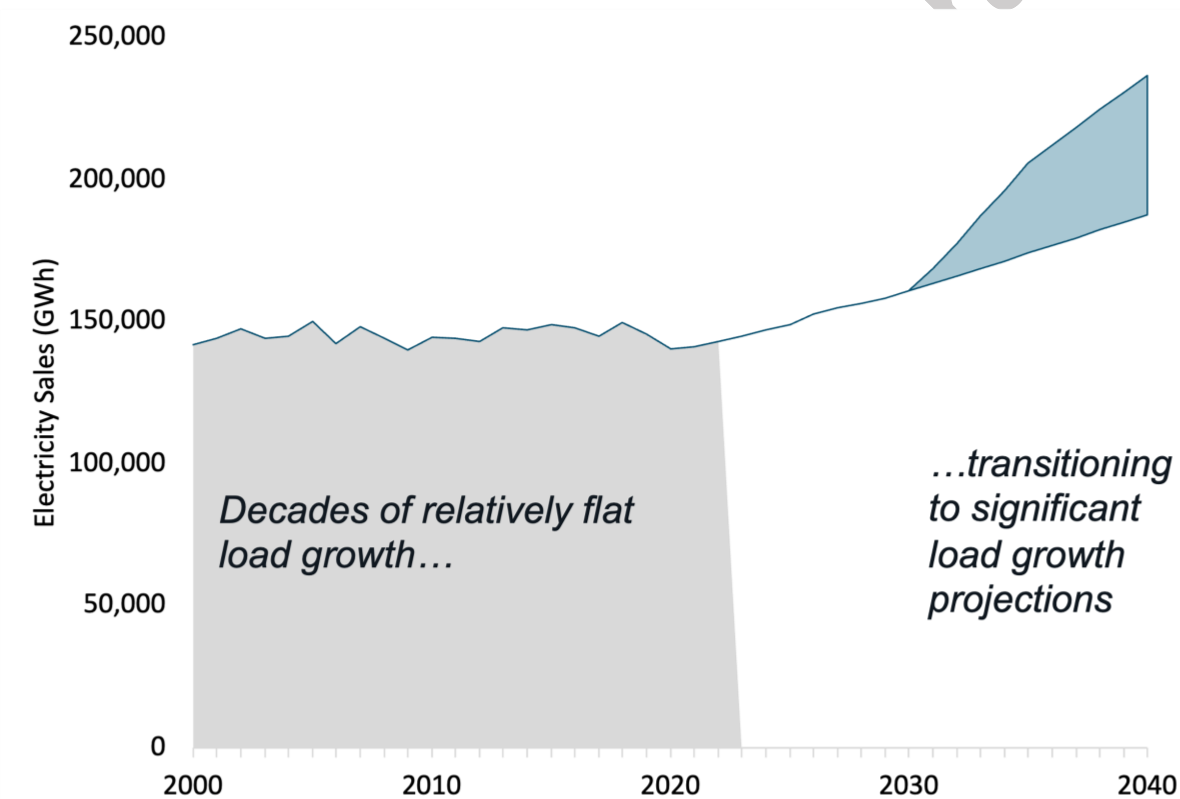

Figure 10. Historical New York State load growth [10]

All scenarios project significant load growth. By 2030, electricity demand is expected to increase by approximately 12-14 TWh from 2025 levels, reaching a total of 172-174 TWh. This initial increase is largely driven by new commercial and industrial projects, as forecast in the New York Independent System Operator (NYISO) 2025 Gold Book's "Large Loads" projections, as well as the initial wave of EV adoption.

Beyond 2030, the scenarios diverge more significantly:

[10] Data for historical load from EIA State Energy Data System: http://eia.gov/state/seds/seds-data-complete.php?sid=NY

- The **No Action** scenario sees demand reaching 181 TWh by 2040, driven by continued EV adoption and additional large industrial loads.
- The **Current Policies** scenario projects 197 TWh by 2040, with more aggressive vehicle electrification. Growth from residential and commercial customers switching to heat pumps is largely offset by concurrent gains in building shell efficiency across the entire stock.
- The **Additional Action** scenario anticipates 202 TWh by 2040. As in the Current Policies scenario, growth from residential and commercial customers switching to heat pumps is largely offset by concurrent gains in building efficiency across the entire stock.
- The **Net Zero** scenarios show the highest demand, with both reaching 255 TWh by 2040 due to the comprehensive electrification of buildings and industry.

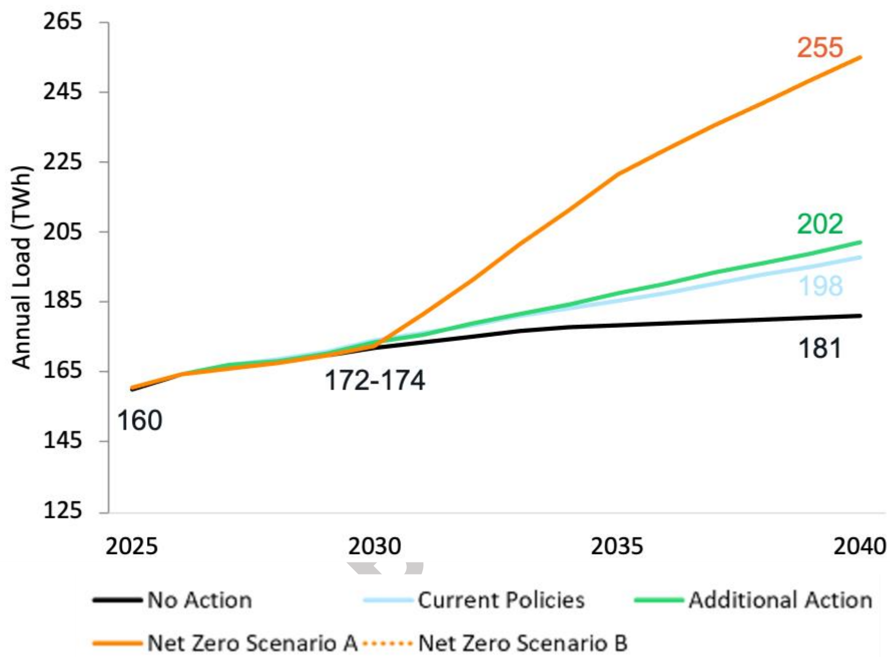

Figure 11. Annual load forecast (without electrolysis demands)

Median peak demand also varies with similar drivers as annual loads. By 2040, the No Action scenario projects a median peak of 35 GW. Both Current Policies and Additional Action scenarios forecast median peaks around 37 GW. Large loads and vehicle electrification are major contributors to peak growth, with building shell efficiency across the entire stock largely offsetting heat pump contributions to peak. Net Zero Scenario A shows a significantly higher peak at 44 GW, while Net Zero Scenario B projects 41 GW, with 3 GW reduction achieved from customers with supplemental heat backup who can switch to gas on the coldest days.

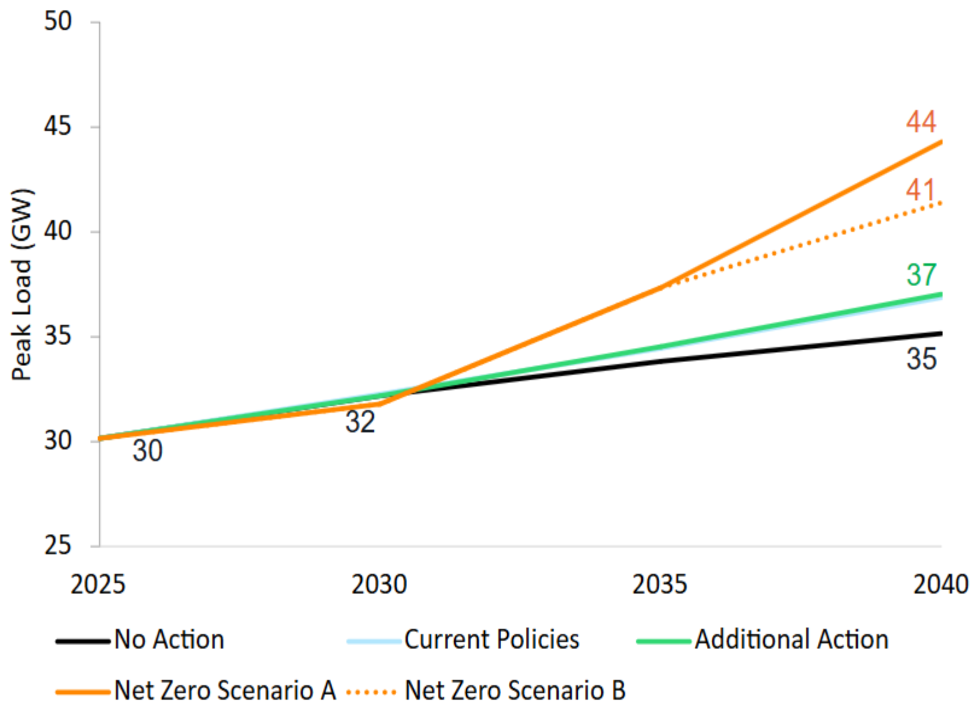

Figure 12. Annual peak load forecast (without flexible load impacts)

The timing of system peak is critical for electric system planning. No Action, Current Policies, and Additional Action remain summer-peaking through 2040. However, the gap between summer and winter peaks declines meaningfully in the policy cases which may necessitate a review of the potential risk of non-firm generators that do not have oil backup. Net Zero Scenario A, with its high degree of building electrification, demonstrates a clear shift to being winter-peaking by 2040, with a median winter peak of 44 GW compared to a summer peak of 41 GW. Net Zero Scenario B, with a 2040 winter peak of 41 GW and a summer peak also of 41 GW, is a dual peaking system, where both seasons' peaks could conceivably occur depending on the weather and must be carefully planned for.

Table 4. Peak demand projections by scenario, 2030 and 2040: annual peak bolded

Seasonal Peak (GW)	2030		2040	
	Winter	Summer	Winter	Summer
No Action	23	**32**	24	**35**
Current Policies	24	**32**	30	**37**
Additional Action	24	**32**	32	**37***
Net Zero A	25	**32**	**44**	41
Net Zero B	24	**32**	**41**	**41**

Note: *Additional Action remains summer peaking through 2040, but by mid-century the winter peak continues to grow faster than the summer peak and this scenario becomes dual peaking.

All state policy cases (Current Policies, Additional Action, and Net Zero) include flexible buildings and vehicle loads. The Current Policies and Additional Action cases assume that, by 2040, up to 20% of light duty vehicles and 10% of water heaters have some capacity to shift their charging behavior to avoid system peak impacts. Under the Net Zero cases this penetration of flexibility increases to 40% of light duty vehicles, 30% of water heaters, and 30% of space heaters.[11] These demand-side resources provide similar hourly and sub-hourly balancing services to the system as battery storage, supporting the integration of renewable energy by shifting demand to better align with times of high renewable output.

4.2.2. Electricity Supply Resource Mix

The analysis identifies portfolios of resources and infrastructure investments across the scenarios that meet projected loads and peaks at lowest cost, subject to reliability constraints and compliance with specified policy requirements applicable under each scenario.

Renewable electricity capacity grows in every pathway analyzed, but the magnitude and composition of the resource builds varies greatly. In Current Policies, Additional Action, and the Net Zero Cases, headwinds affecting the pace of builds are anticipated to delay the target of 70% renewable electricity by 2030 (70x30), consistent with the findings for the CES Biennial Review. By 2040, the divergence in resource mix across scenarios becomes even more pronounced.

No Action Scenario

This scenario, which excludes the Climate Act and more recent New York State clean energy policies, such as 0x40 and firm resource requirements, and reflects only modest adoption of clean energy technologies, projects a substantial increase in natural gas-fired capacity and generation through 2040. By 2040, a net increase of approximately 1.5 GW statewide in combustion capacity relative to current levels is anticipated, with most additions occurring upstate and some in Zone J. As existing units retire when they reach an age threshold of 60 years, total new combustion-based capacity (including replacements for retiring units) reaches about 13 GW. These fossil fuel-fired units provide an additional 30 TWh of generation in 2040 compared to current levels. This increased reliance on natural gas is driven by overall load growth, nuclear retirements, the assumed absence of power imports via the Champlain Hudson Power Express (CHPE), and a lack of policy drivers for alternative resource additions. Wind and solar capacity in the No Action scenario reaches 13 GW in total by 2040, with about 10.5 GW sourced from existing and near-term contracted additions. Only 2.5 GW of utility solar and 4 GW of battery storage are economically selected absent State policies. Without any policy support for low-carbon energy, it is assumed that all nuclear facilities retire at the end of their 60-year licenses, which expire between 2029 and 2046. Summarized capacity and generation results for the No Action scenario are included in Figure 13 and Figure 15 below, while incremental capacity addition and retirements are included in Figure 14.

[11] These flexibility penetrations are in line with the ranges seen in the Grid of the Future study.

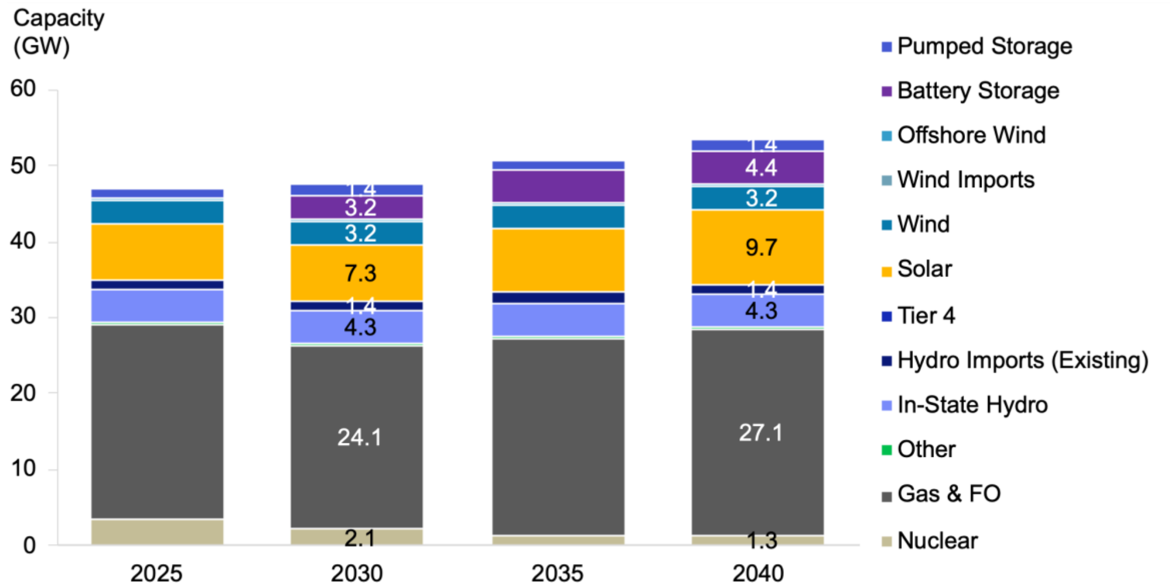

Figure 13. No Action Total Installed Capacity

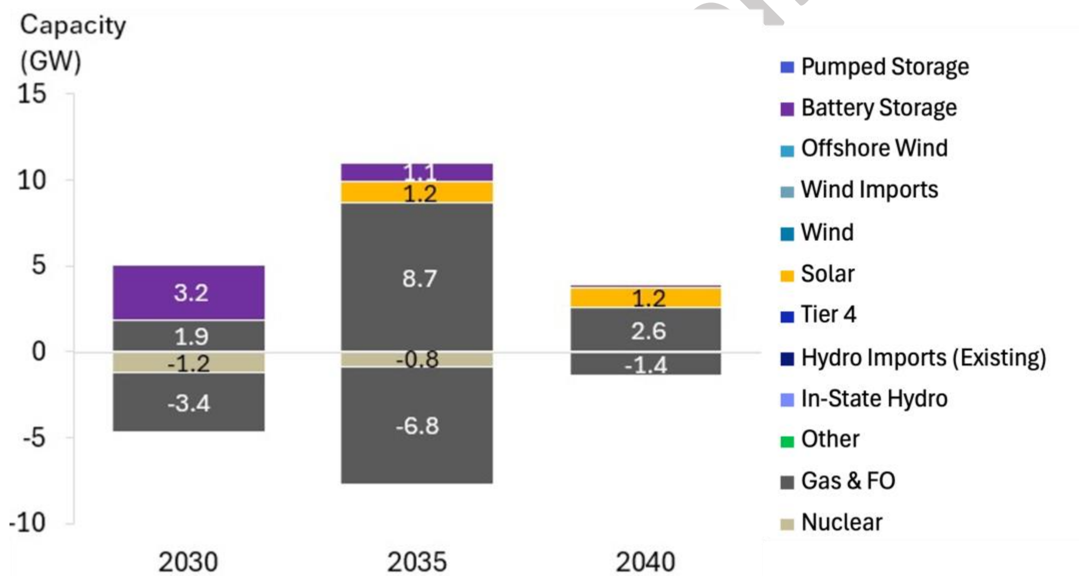

Figure 14. No Action Incremental Capacity Additions and Retirements

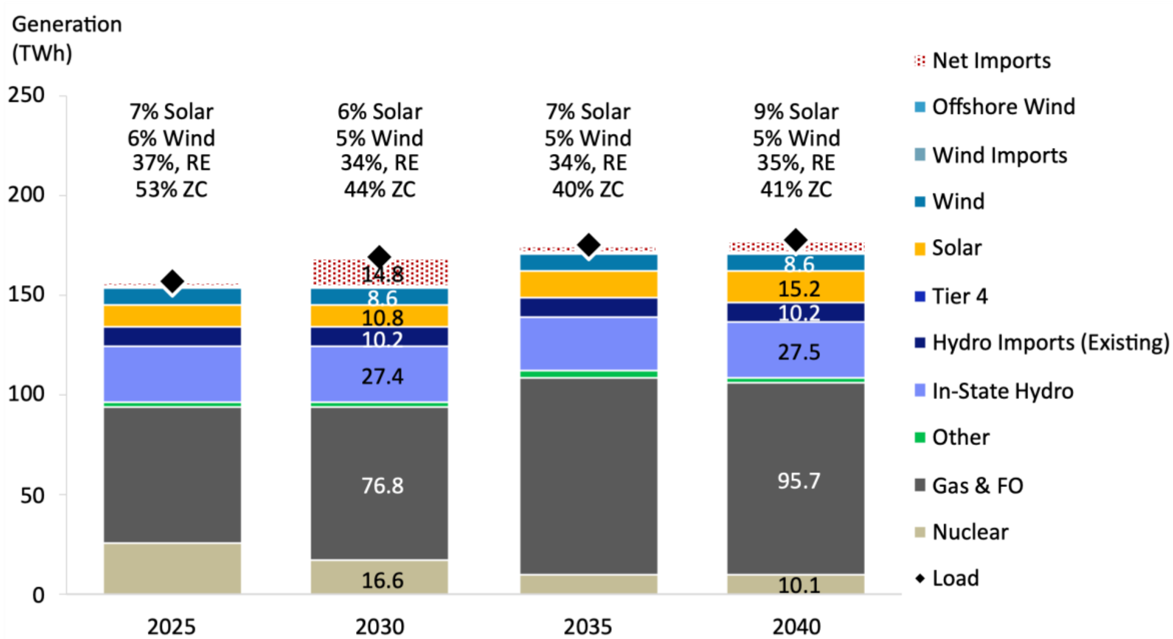

Figure 15. No Action Generation

Current Policies Scenario

Relative to the No Action scenario, this scenario has greater load and peak growth driven by State actions, including policies influencing vehicle electrification. Electric sector policies are also included. It assumes the achievement of 70% renewable electricity by 2033 in line with the CES Biennial Review and a zero-emission electricity sector by 2040 (0x40 Emissions target), as well as interim resource targets, such as 9 GW offshore wind by 2035.

Relative to the No Action scenario, the Current Policies scenario adds an incremental 5 GW of land-based wind and 8.8 GW of offshore wind (the latter driven by the 9 GW by 2035 target), alongside 25 GW of incremental solar capacity and 5 GW of battery storage toward achievement of 0x40.[12] While the renewable fraction in 2030 is below the 70% target, planned additions from future RFPs for land-based and offshore resources would meet the CES Biennial Review projection of 70% by 2033. To achieve the zero emissions 2040 target, 16 GW of zero-carbon firm resources, primarily existing gas CCGTs and CTs, are converted to run on hydrogen by 2040 to provide reliability. The total combustion capacity in 2040 is approximately 9.5 GW lower than at the start of the modeling period, with all NYISO zones having comparable or lower combustion capacity than today even as peak demand grows, reflecting the value of new resources like CHPE and storage that can provide contributions to reliability. For instance, by 2040, NYISO A-E is projected to have 3.6 GW of combustion capacity, NYISO J 5.3 GW, and NYISO K 2.5 GW. Between 2036 and 2040, in addition to converting existing thermal generation assets to be able to combust hydrogen, an additional 3.4 GW of hydrogen-ready thermal generation must be built to meet reliability needs. Statewide installed capacity and capacity changes by period for the Current Policies

[12] Across scenarios, deployment of solar and battery energy storage includes both distributed and utility-scale projects.

scenario are included in Figure 16 and Figure 18, below, while incremental capacity addition and retirements are included in Figure 17.

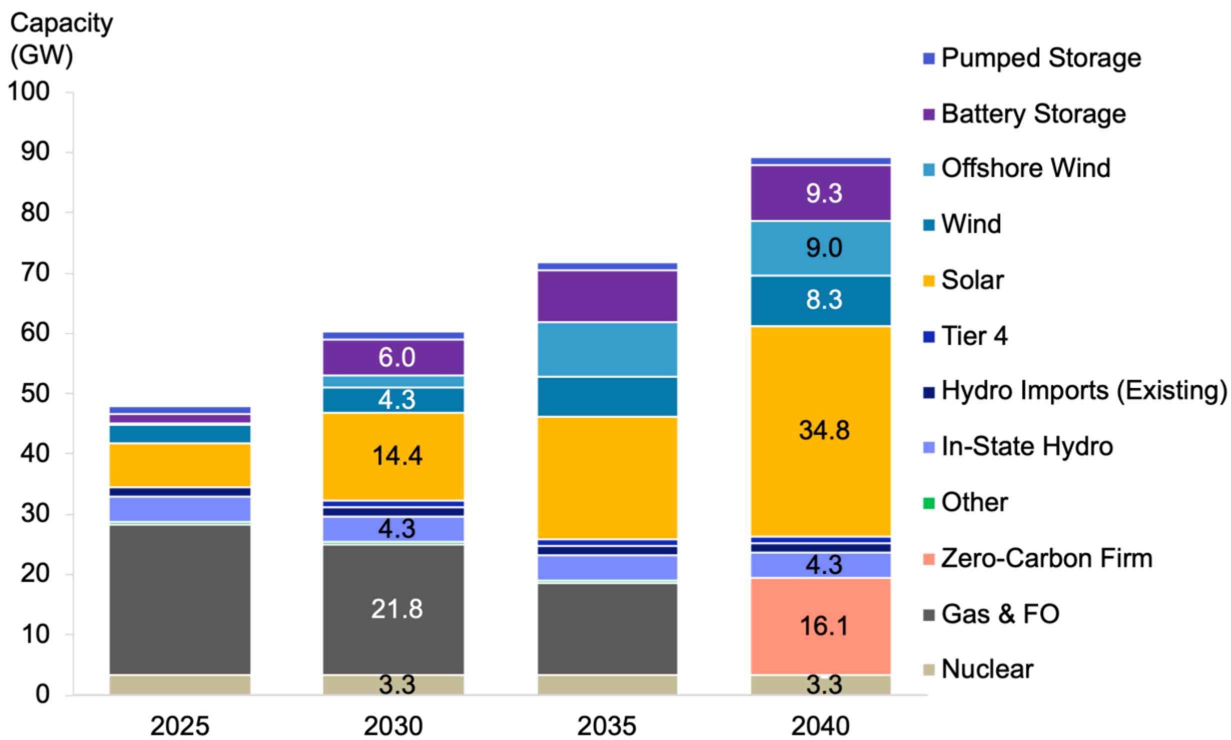

Figure 16. Current Policies, Total Installed Capacity

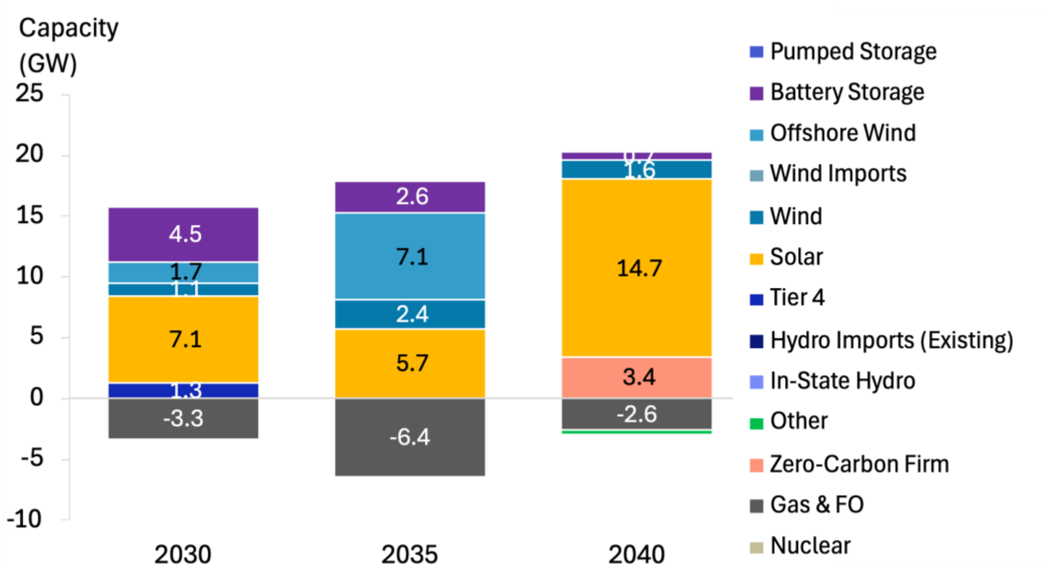

Figure 17. Current Policies, Incremental Capacity Additions and Retirements by Period

Hydrogen-based combustion resources are just one of many emerging technologies that could provide firm dispatchable power to support achievement of a zero-emissions electricity system. Consistent with past analysis practices, green hydrogen is used in this modeling as a proxy resource.[13] Due to the high costs of hydrogen, those units are rarely dispatched except during the most challenging reliability periods, providing 330 GWh of power.

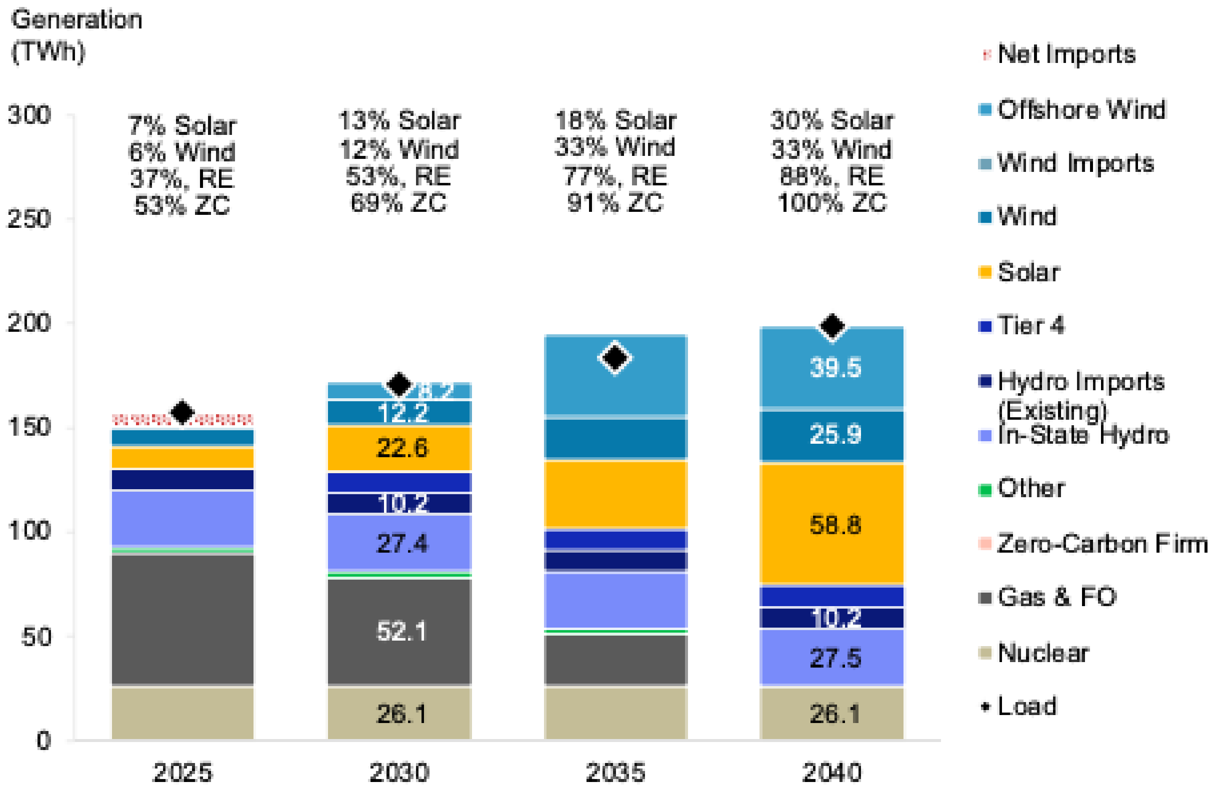

Figure 18. Current Policies, Annual Generation

The model also selects 1.1 GW of incremental transmission between Zone I and Zone J to alleviate congestion in the downstate region; however, additional modeling tools are needed to fully assess the value of transmission additions.

Additional Action Scenario

Annual and peak load growth is higher as a result of additional policy actions relative to the Current Policies scenario, but the electricity generation mix to meet higher demand is broadly similar to the Current Policies scenario. An additional 700 MW of land-based wind and 350 MW of hydroelectric upgrades are selected relative to current policies to meet slightly larger peaks and loads. Total capacity and capacity changes by period are summarized in Figure 19 and Figure 21 below, while incremental capacity addition and retirements are included in Figure 20.

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[13] The color of hydrogen refers to its production method. Green hydrogen is produced through electrolysis powered by renewable energy, making it a zero carbon fuel.

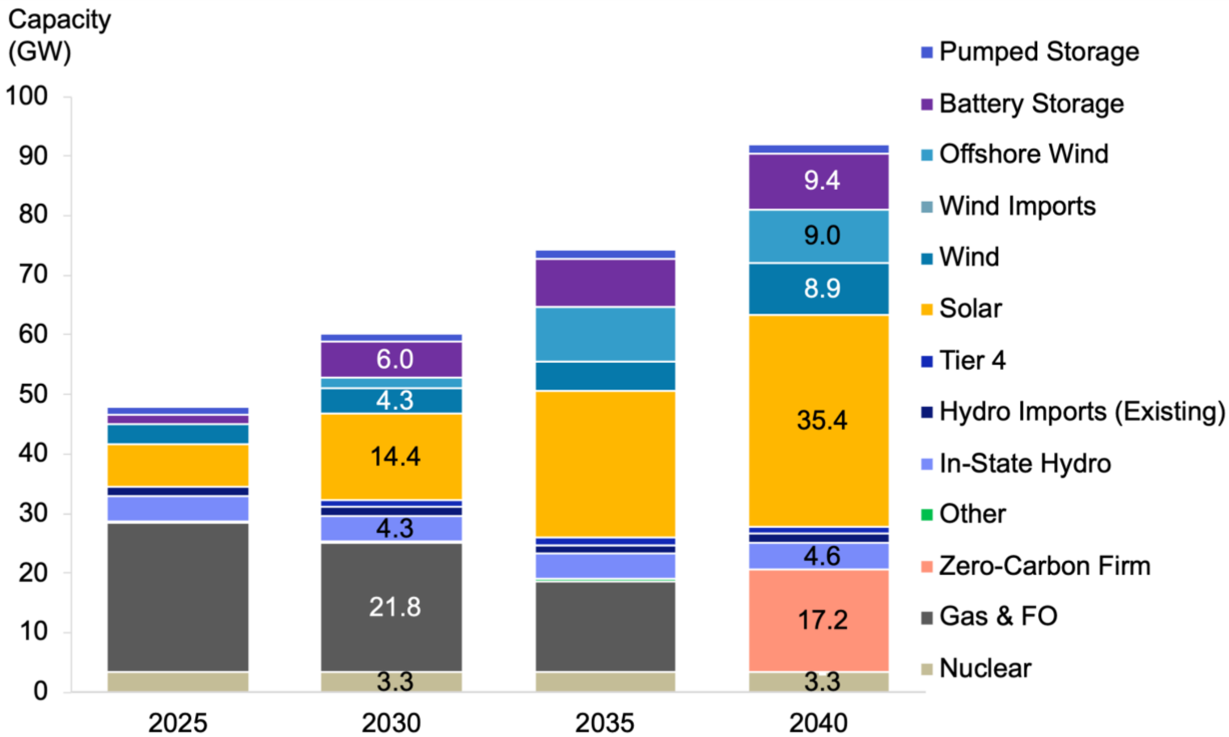

Figure 19. Additional Action, Total Installed Capacity

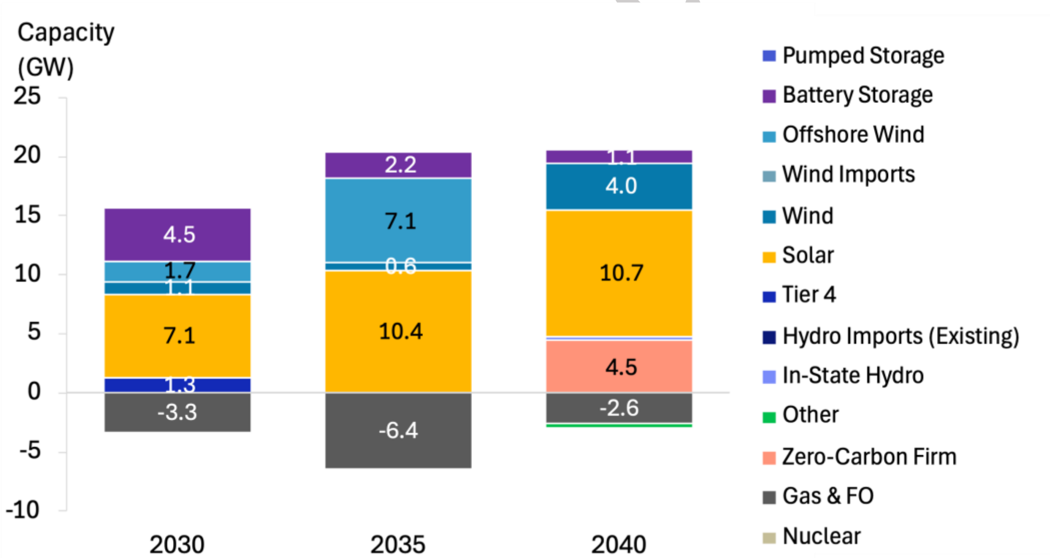

Figure 20. Additional Action, Incremental Capacity Additions and Retirements by Period

Combustion resource builds by 2040 are very similar to those in the Current Policies scenario, resulting in a total combustion fleet that is significantly lower than today. Of the 17 GW of statewide capacity, Zones A-E are projected to have 3.2 GW of combustion capacity, Zone F has 3 GW, Zones G-I have 1.7 GW, Zone J has 5.3 GW, and Zone K has 2.5 GW by 2040. However, beginning in 2036 or quickly thereafter, 4.5 GW of additional hydrogen-ready thermal generation must be built on top of conversions of existing gas generation units to hydrogen-ready facilities. Transmission additions are also similar to Current Policies, with a +1.1 GW upgrade from Zone I to Zone J selected. Similar to Current Policies, these combustion resources are dispatched infrequently to meet needs in the most constrained hours; these resources provide 750 GWh of power annually. It should be noted that this analysis was conducted before the Governor's announcement directing NYPA to pursue a new nuclear plant, which is therefore not included in this analysis but can be explored further in the final State Energy Plan. Full generation results for the Additional Action scenario are included in Figure 21.

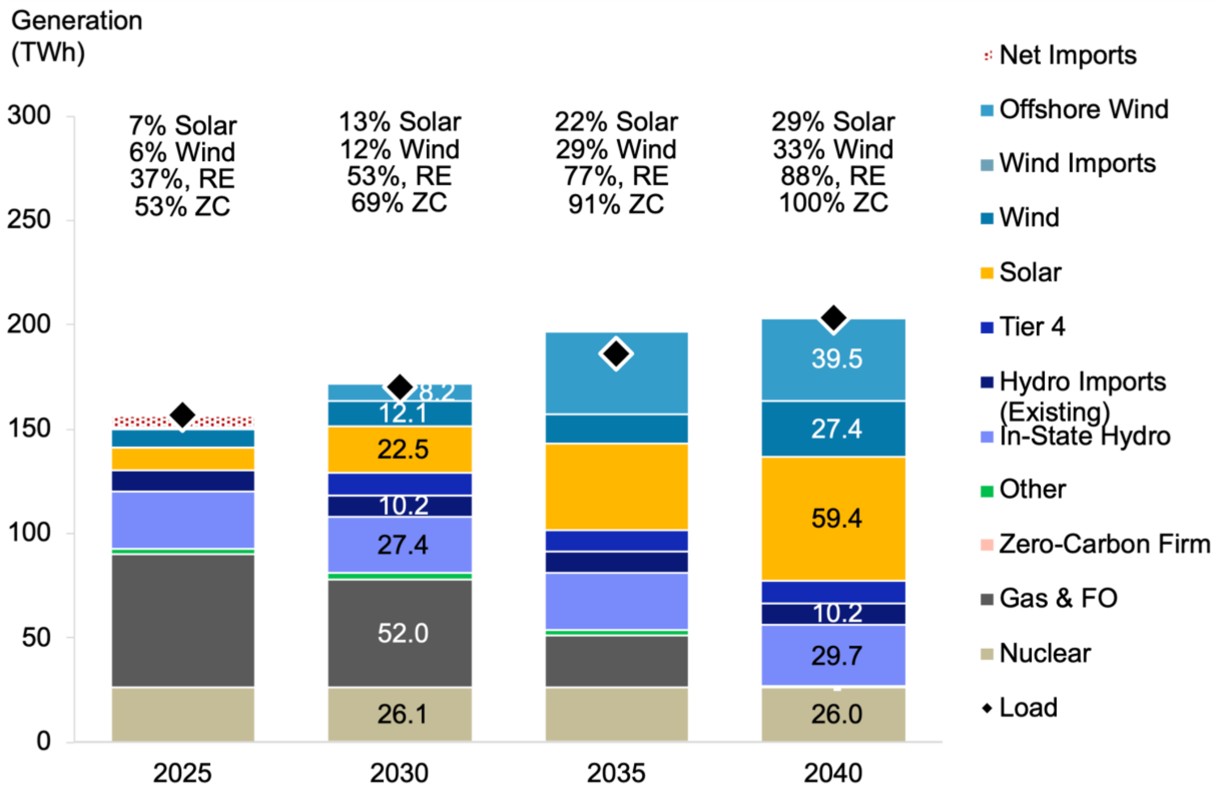

Figure 21. Additional Action, Annual Generation

Additional Action Scenario (constrained build sensitivity)

Given deployment headwinds from economic and federal uncertainty, a constrained build sensitivity was performed on the Additional Action case. In this case, build limits were imposed on the maximum annual capacity additions for all renewable resources, as summarized in the table below. The 70% projection set forth in the CES Biennial Review and the 9 GW by 2035 offshore wind target were also removed from this case, though it still aims to achieve the 0x40 emissions target.

Table 5. Additional Action constrained annual renewable sensitivity build limits

	Existing and Near-term Planned	Annual Build Limits
Distributed Solar	Achievement of 10 GWdc target by 2030	1 GWdc/yr, starting 2031
Utility Solar	Contracted additions through 2028, less 30% attrition and with 1 year re-contracting delay imposed 2026-2027	Contribution of 2.8 TWh/yr starting 2028, at least 20% of which is land-based wind
Land Based Wind		
Offshore Wind	Only South Fork, Sunrise, and Empire 1 online through 2035, totaling 1.87 GW	1.4 GW/yr, starting 2036

A delay in the availability of renewable resources presents significant challenges to achieving the 0x40 zero emissions grid target. In the medium term, this scenario necessitates an increase of nearly 23 TWh in natural gas generation in 2035, leading to over 10 million metric tons of higher GHG emissions and increased reliance on energy imports from neighboring states. To ensure reliability, an additional 1,900 MW of thermal units would also need to be repowered in 2035. Statewide installed capacity results from this case are provided in Figure 22, and incremental capacity addition and retirements are included in Figure 23.

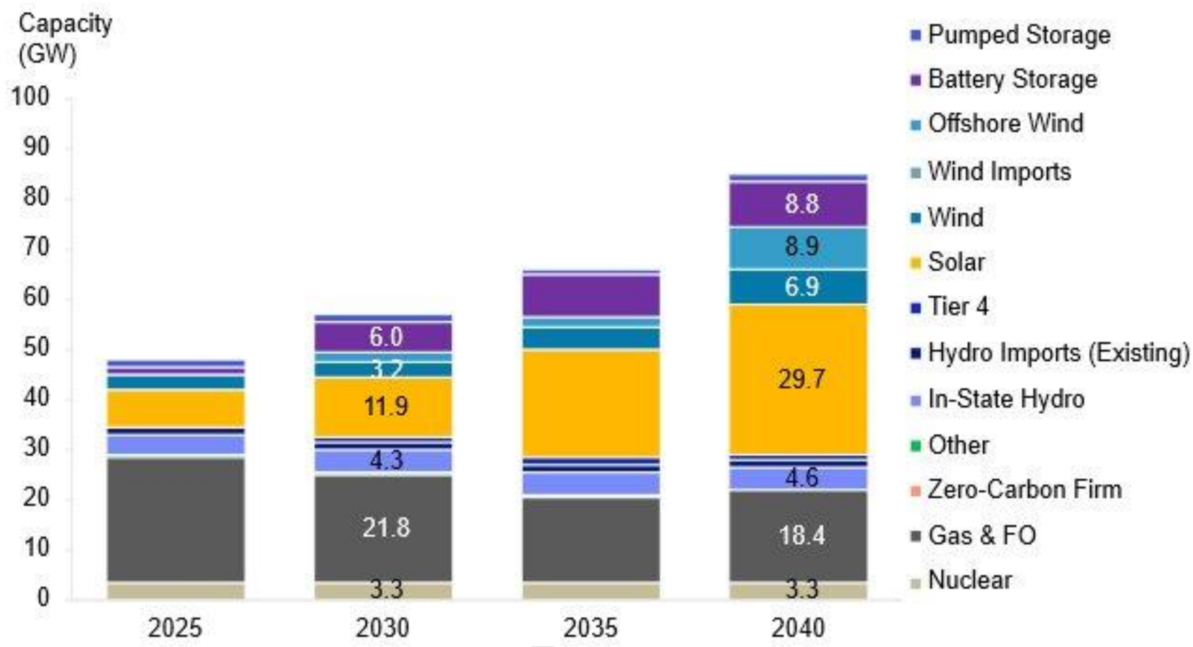

Figure 22. Constrained Annual Build Sensitivity, Total Installed Capacity

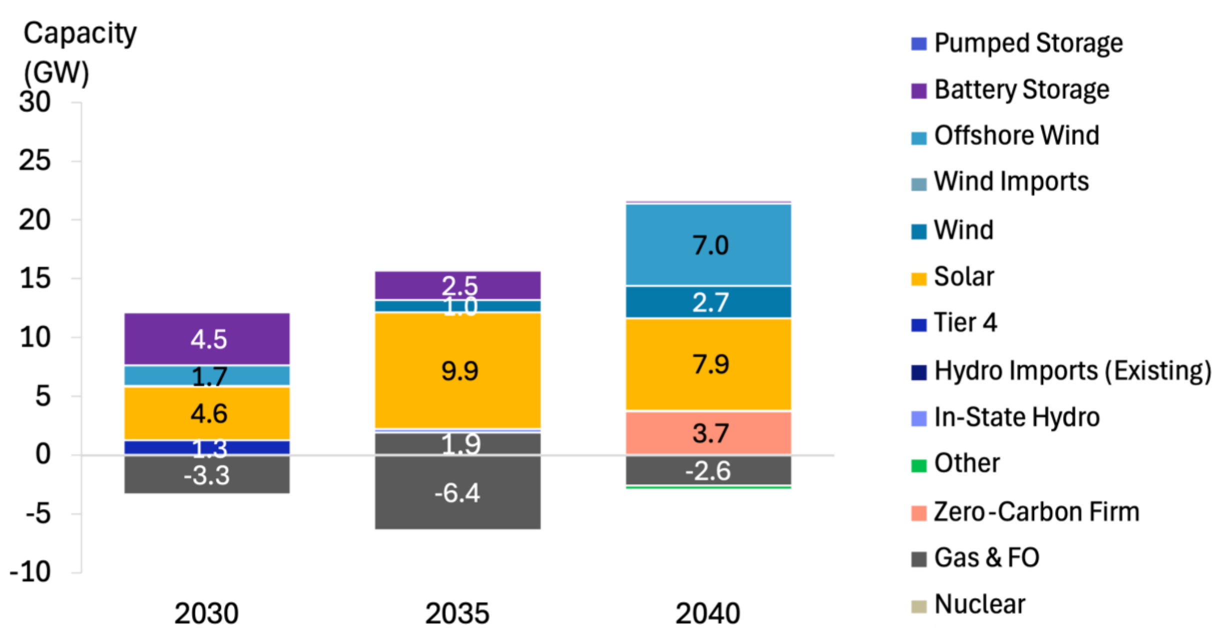

Figure 23. Constrained Annual Build Sensitivity, Incremental Additions and Retirements by Period

By 2040, the persistent shortfall in renewable energy limits green hydrogen availability. To meet load requirements in all hours, the power system continues depending on natural gas-fired plants, resulting in a failure to meet the statutory 2040 zero-emissions constraint. This would amount to 8% of load not met by zero-carbon power, or approximately 17 TWh of natural gas generation in 2040, producing over 7 million metric tons of greenhouse gas emissions. Full generation results from this sensitivity are provided in Figure 24 below. To avoid this outcome, the energy gap could instead be filled by other resources that were not available in the modeling run, such as 2 GW of new nuclear capacity accompanied by additional transmission, dispatchable generation using renewable natural gas, or a combination of these resources. Nevertheless, even under these annual build constraints, continued renewable additions beyond 2040 could lead to the achievement of a zero-emission system by 2045, provided loads remain consistent with the Additional Action case, though a gap would persist if load growth accelerates, e.g. if the pace of electrification converges to the trajectory of the Net Zero cases.

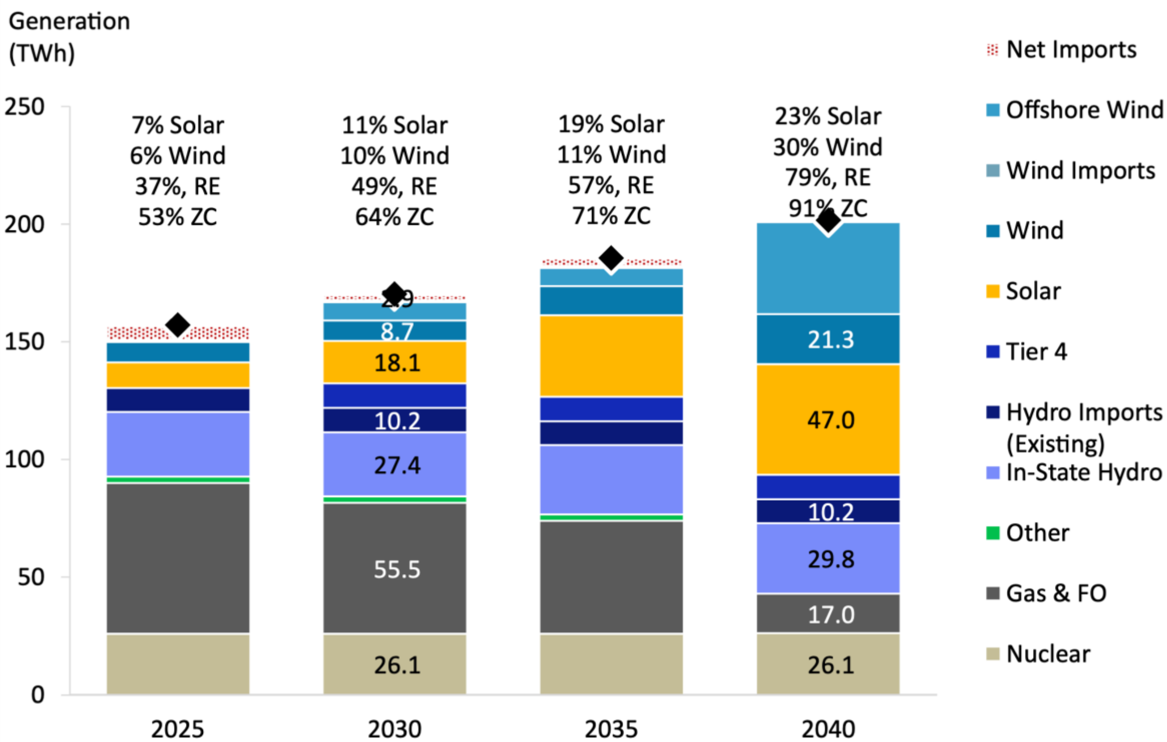

Figure 24. Constrained Annual Build Limit Sensitivity, Annual Generation

Net Zero Scenarios (A and B)

These scenarios see the most transformational load growth necessitating a significant system expansion. Varying degrees of supplementary heating impact firm resource builds.

Net Zero A exhibits substantially higher annual and peak loads compared to the Additional Action scenario. By 2040, peak loads are approximately 7 GW higher. This drives the deployment of an additional 2 GW of battery storage and 7.6 GW of zero-carbon firm capacity additions on top of the Additional Action case. Renewable capacity also sees significant increases through 2040 compared to Additional Action: +6.7 GW of land-based wind, +5.6 GW of offshore wind (exceeding the 2035 target), and +10 GW of solar. Meeting this accelerated pace of additions would require land-based resource procurements to roughly double the currently projected rate every year between now and 2040. Net Zero B sees a similar build trajectory, though requires lower levels of Zero-carbon Firm Resources and storage due to lower peak load requirements, reflecting the value of backup gas heating to mitigate electric system needs. Full portfolio results for both scenarios are shown in Figure 25 below, while incremental capacity addition and retirements are included in Figure 26.

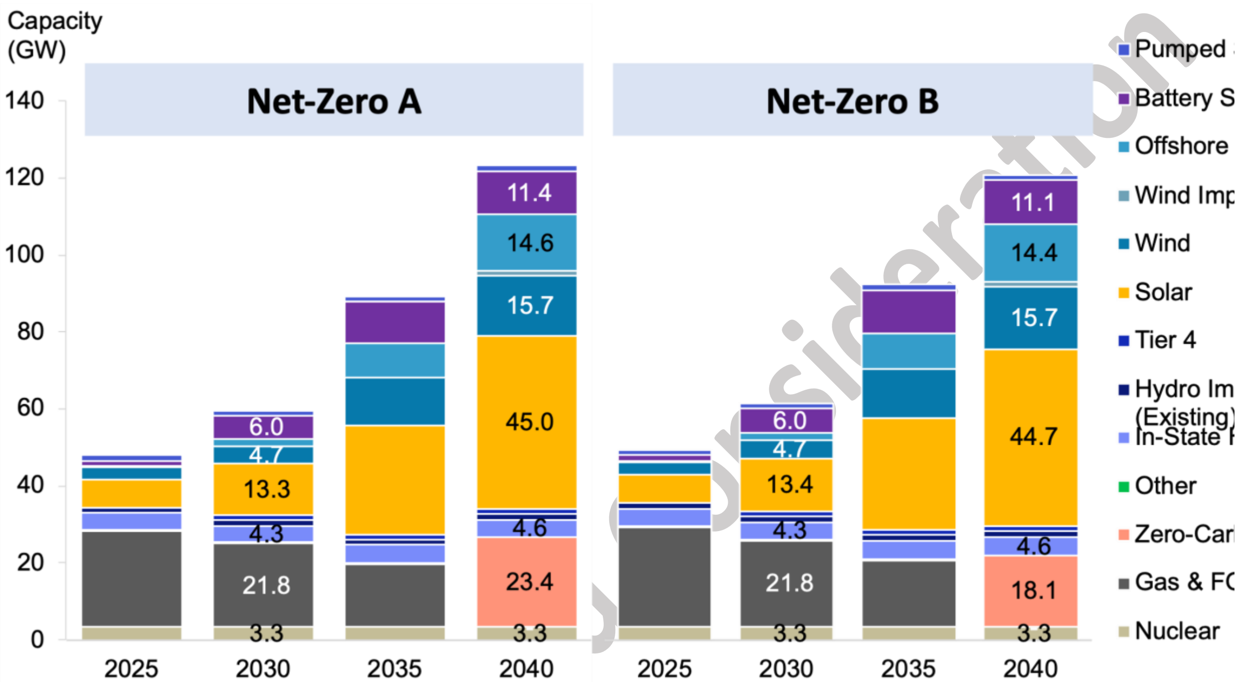

Figure 25. Net-Zero A and B, Installed Capacity Results

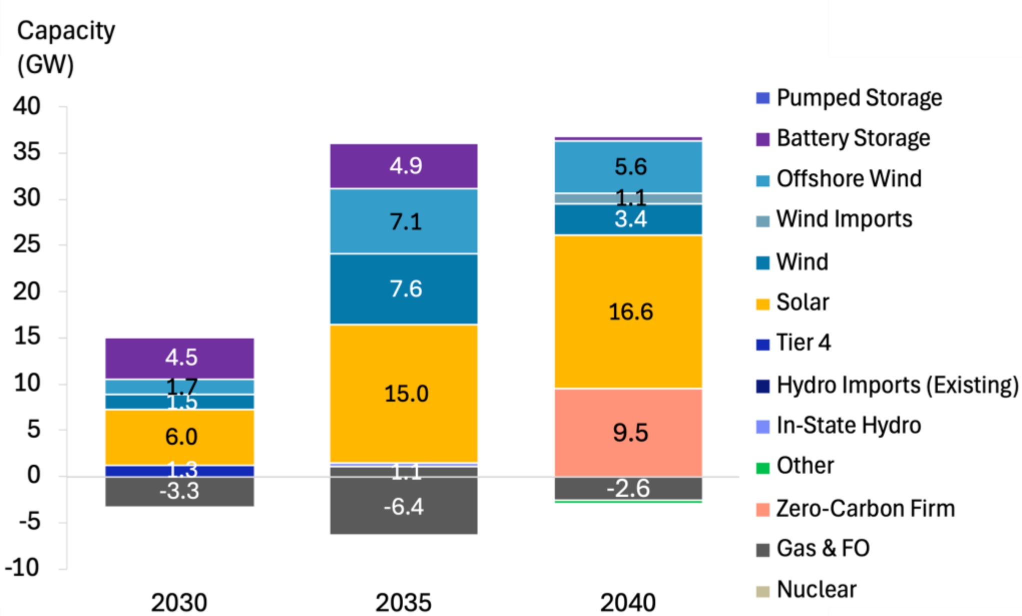

Figure 26. Net Zero A, Incremental Capacity Additions and Retirements by Period

Combustion capacity additions are more substantial, with upstate zones seeing the largest combustion turbine additions and significant repowering also occurring in both Zone J and Zone K. There is 23 GW of total combustion capacity in 2040 statewide in the Net Zero A scenario, including: 7.4 GW in Zones A-E, 3 GW in Zone F, 2.4 GW in Zones G-I, 6.5 GW in Zone J, and 4 GW in Zone K. 1 GW of newly built combustion capacity in this scenario must be deployed starting in 2035, with total new builds reaching nearly 10 GW by 2040. Transmission upgrades include +0.6 GW from Zone I to Zone J and +0.2 GW from Zone E to Zone G by 2035/2040, although additional modeling is needed to fully assess the value of potential transmission additions.

Net Zero B has similar total energy requirements to Net Zero A but features lower system peak needs due to the 3 GW of peak reduction from more heat pump heating customers with supplementary heating systems. This reduction avoids the need for about 5.3 GW of zero-carbon firm capacity statewide relative to Net Zero A by 2040, and also leads to minor reductions in offshore wind, solar, and storage builds compared to Net Zero A.

The zonal pattern of combustion additions is similar to Net Zero A, but with smaller total volumes, reaching 18 GW statewide in 2040. Of this 18 GW, Zones A-E have 3.5 GW, Zone F has 3 GW, Zones G-I have 2.2 GW, Zone J has 6 GW, and Zone K has 3.4 GW of combustion capacity. Transmission additions include +0.6 GW from Zone I to Zone J and +0.2 GW from Zone E to Zone G.

The Net Zero cases see the largest levels of annual load growth, with total loads approaching 270 TWh by 2040 in both cases, a more than 70% increase relative to today's levels. On an annual basis, these loads are met predominantly with renewables, which serve 91% of loads by 2040 (inclusive of both in-state and imported hydro). Existing nuclear generators – all of which are assumed to receive license extensions in these cases – provide most of the rest of the needed generation. Due to the high costs of hydrogen fuel, combustion resources are still only utilized sparingly even in cases with higher annual demand, and generate primarily during challenging periods of high load and low renewable output. In both Net Zero A and B, these resources contribute 3.6 TWh in 2040. Full generation results for Net Zero A are included in Figure 27, below. Net Zero B generation results are nearly identical as the cases have minimal differences in annual loads.

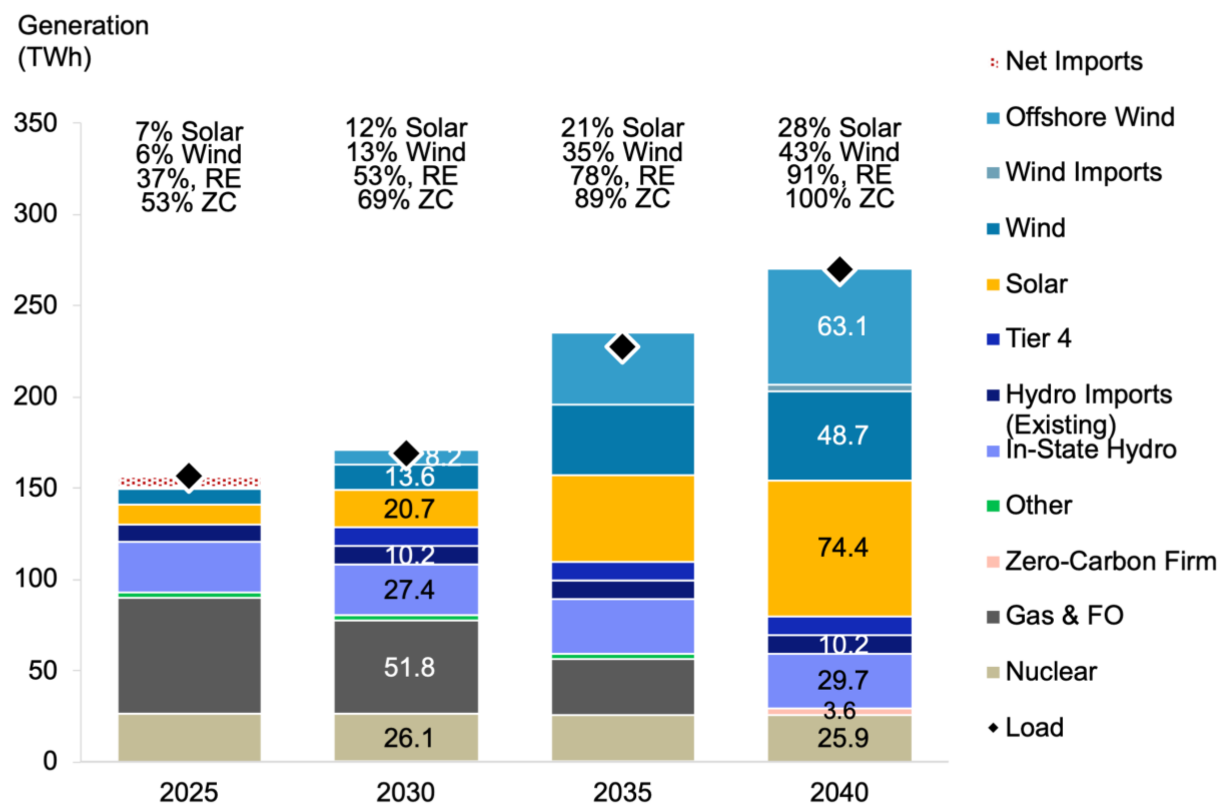

Figure 27. Net Zero A, Annual Generation

Utilization of Zero-Carbon Firm Resources

Across all scenarios that achieve a zero-emissions electricity sector by 2040, there is a need for firm resources that can provide power to maintain system reliability during multi-day periods of high load and low renewable output. In this modeling, this need for zero-carbon firm capacity is met by hydrogen in combustion-based generation resources; however, the need could also be met by a number of other emerging clean firm technologies.

This analytical framework pairs a capacity expansion model with a resource adequacy model, which simulates hundreds of years of plausible weather conditions to ensure systemwide and local reliability criteria are met. Below, the resource adequacy model has been used to examine the utilization of zero-carbon firm capacity over a wider distribution of weather for a few select scenarios and model years. Due to its high fuel costs, hydrogen utilization is generally limited to the most challenging reliability periods, as seen in Figure 28 and Figure 29. Under typical weather conditions, hydrogen generation reaches 1.25 TWh/year in the Additional Action scenario and grows to 3.28 TWh/year during a 1-in-10 weather year (in which winter temperatures may be colder than average, and solar and wind output may be lower than average). In addition to weather conditions, sub-zonal and local transmission constraints may also impact the utilization of zero-carbon firm resources if other resources cannot be delivered into load pockets. Local transmission constraints are best suited for further analysis using a more granular representation of the New York transmission system, such as the models being used as part of the Coordinated Grid Planning Process.

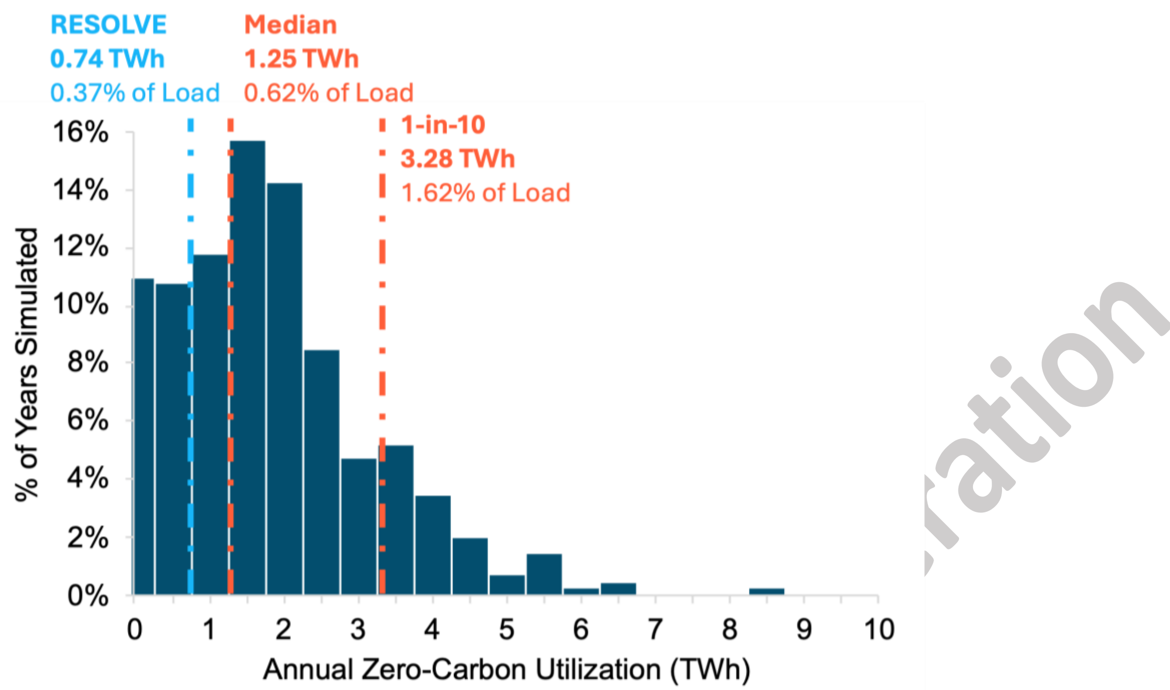

Figure 28. Additional Action, Zero-Carbon Firm Utilization Across 400 Simulated Weather Years

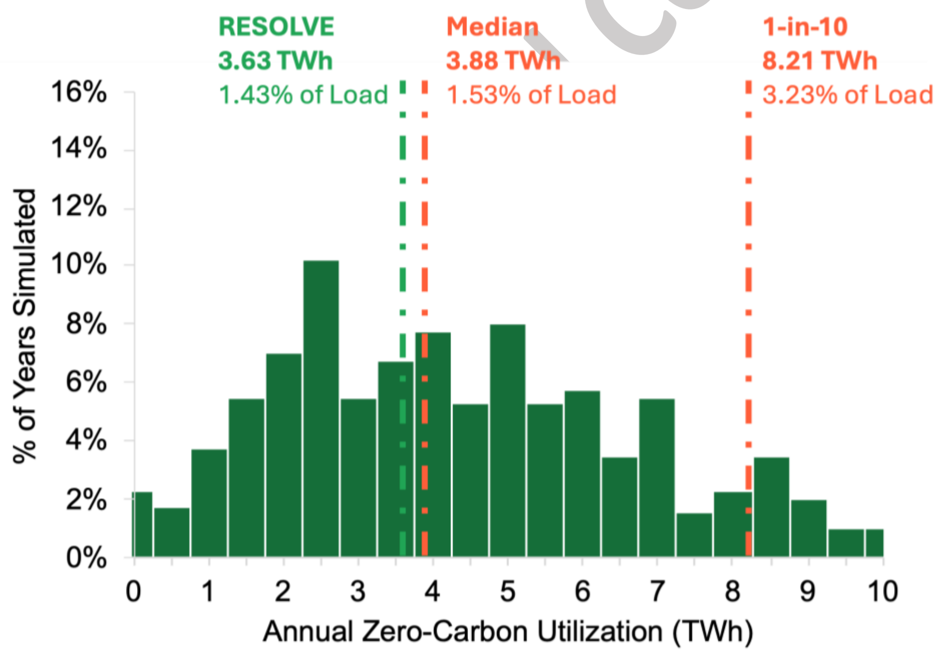

Figure 29. Net Zero A, Zero-Carbon Firm Utilization Across 400 Simulated Weather Years

4.3. Fuels Overview

Electrification and efficiency drive significant reductions in the use of petroleum and other fossil fuels across all scenarios over time (Figure 30). Current Policies layers on statewide biofuel blending mandates, while Additional Action includes renewable fuel blending across natural gas, distillate, and jet fuel as a potential decarbonization lever. The supply of low-carbon fuels is approximately 34 TBtu in 2030 and approximately 100 Tbtu in 2040 in Additional Action, with further blending in the Net Zero Cases (Figure 31). Biofuel feedstock supply was sourced from the 2023 US Department of Energy (DOE) Billion Ton Report and NYSERDA Potential Studies. The Additional Action scenario focused on in-state supply of wastes and residues, while the Net Zero scenarios included a regional supply of wastes, residues, and purpose grown biomass.

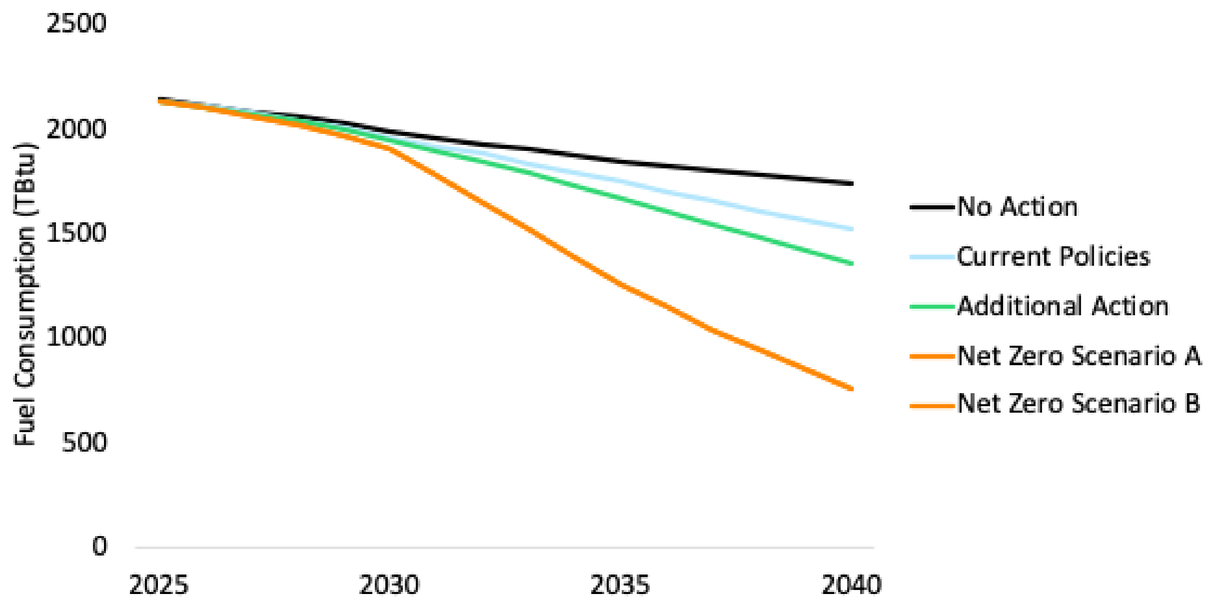

Figure 30. Fossil fuel consumption by scenario

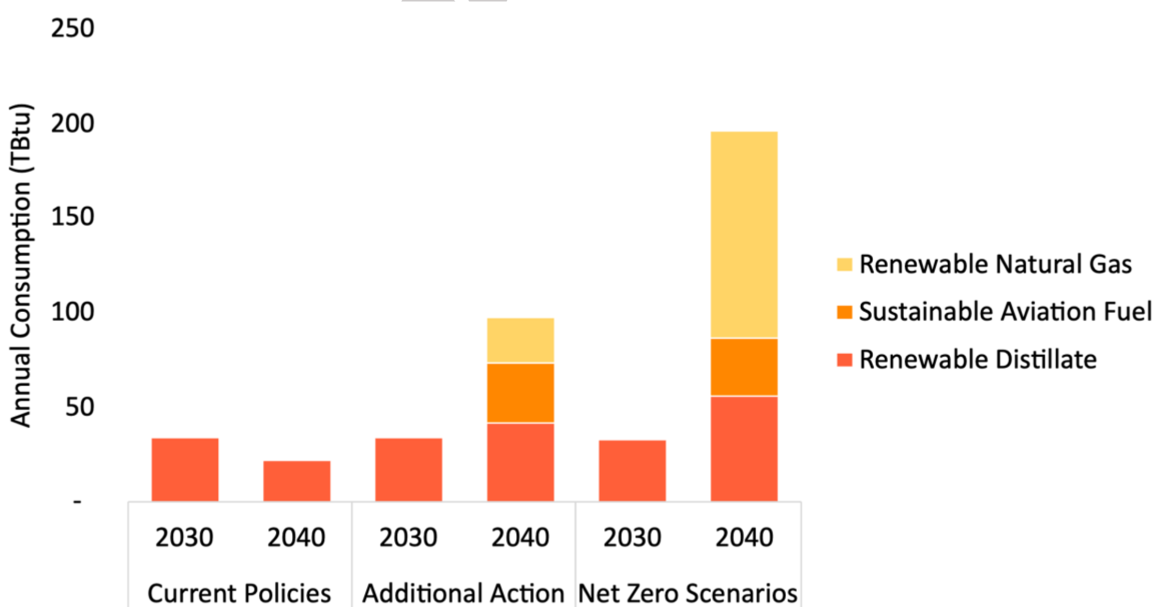

Figure 31. Low-carbon fuel consumption, 2030 and 2040

5. Economy-wide

While the Plan is focused on the implications of State policies and actions on energy demand and supply, it is important to consider emissions in the non-energy sectors, especially in tracking progress towards achieving the economywide decarbonization goals as outlined in the Climate Act.

5.1. Non-Energy Sectors

Emissions for Agriculture, Waste, and Land Use were provided by DEC using updated forecasts based on the trajectories modeled in the Final Scoping Plan.

Hydrofluorocarbon (HFC) emissions were sourced from an analysis performed by Guidehouse. A key finding is that even the No Action case sees significant declines in HFC emissions through the modeling horizon, driven by EPA rulemaking in 2023-2024. If EPA rules are rolled back, emissions would be expected to increase in the No Action case, in the absence of New York State rules. The Current Policies scenario reflects New York State rules including the HFC regulations in 6 NYCRR Part 494, which support a meaningful reduction in HFC emissions. The Additional Action scenario builds upon the 2024 rules by including more stringent constraints on leakage reduction in HFCs, while the Net Zero cases see further emissions reductions driven by including reclamation of HFCs at end of life (Figure 32).

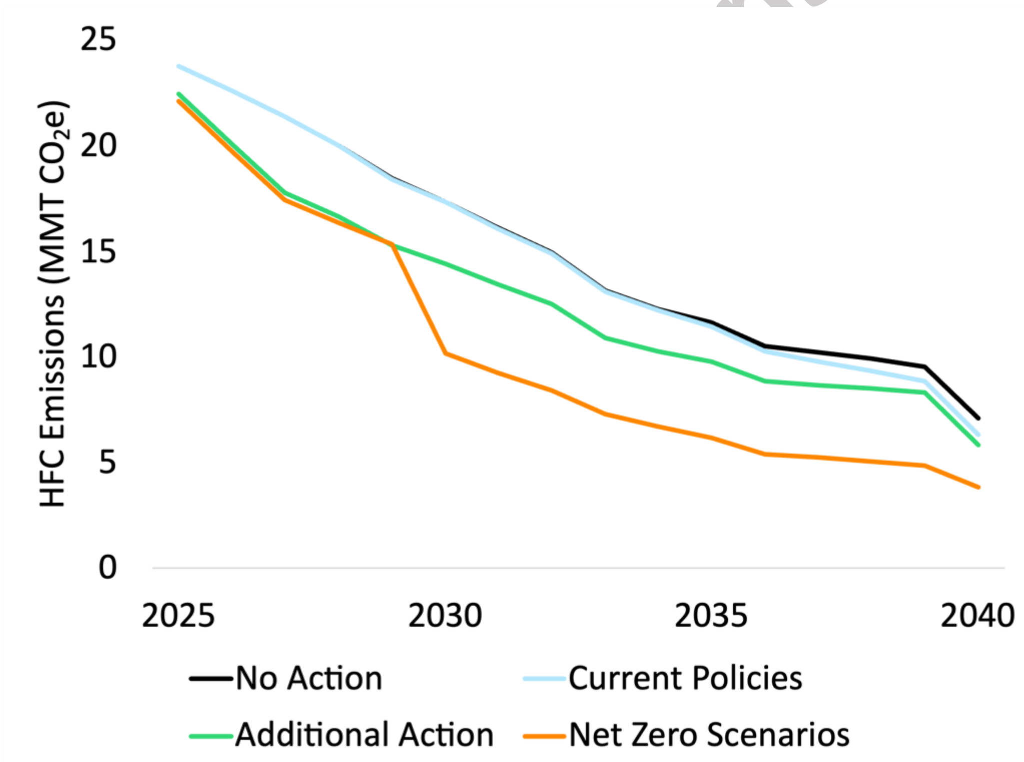

Figure 32. HFC emissions forecast

5.2. Total Emissions

According to the 2024 Statewide GHG Emissions Report, under Climate Act accounting, New York has already reduced its emissions by more than 9 percent relative to the 1990 baseline and 20% relative to emission peaks in 2005. Across all scenarios, 2030 gross reductions total between 15–28 percent. In the No Action scenario, the most significant near-term emissions reductions come from transportation electrification, efficiency gains in end-use devices, and tighter building envelopes, In the Current Policies and Additional Action scenarios, deeper savings also flow from faster renewable-electricity buildout, more ambitious electrification of buildings and vehicles, and stronger building codes. As a result, Current Policies and Additional Action are projected to achieve the 40 percent reduction target between 2036 and 2038. The Net Zero cases achieve the target in 2033, reflecting the time it would take for any new actions to translate into emission reductions (Figure 33).

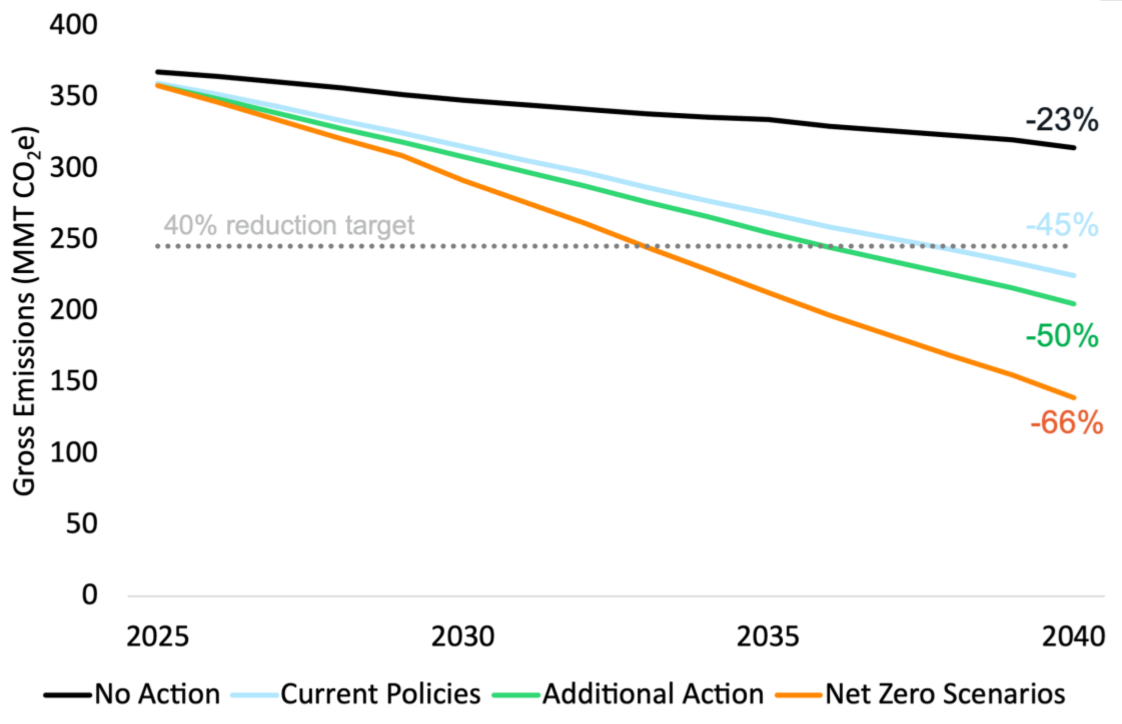

Figure 33. Economy-wide emissions under Climate Act accounting

Emission reductions were also calculated using Intergovernmental Panel on Climate Change (IPCC) accounting to allow for more direct comparison with other jurisdictions. Calculating emissions consistent with the IPCC accounting framework requires excluding out of state upstream fossil emissions, treating biofuel combustion as carbon neutral, and applying 100-year (rather than 20-year) global-warming potentials. Using this accounting framework, New York's current net emissions already stand 23 percent below 1990 levels, and the modeled pathways achieve greater reductions: by 2030, the Additional Action scenario attains 40 percent net emissions reduction and the Current Policies scenario misses that mark by just 2 million metric tons. By 2040, both of these scenarios drive emissions roughly 60–70 percent below the 1990 baseline, and the Net Zero scenarios achieve emissions reduction of 88% (Figure 34).

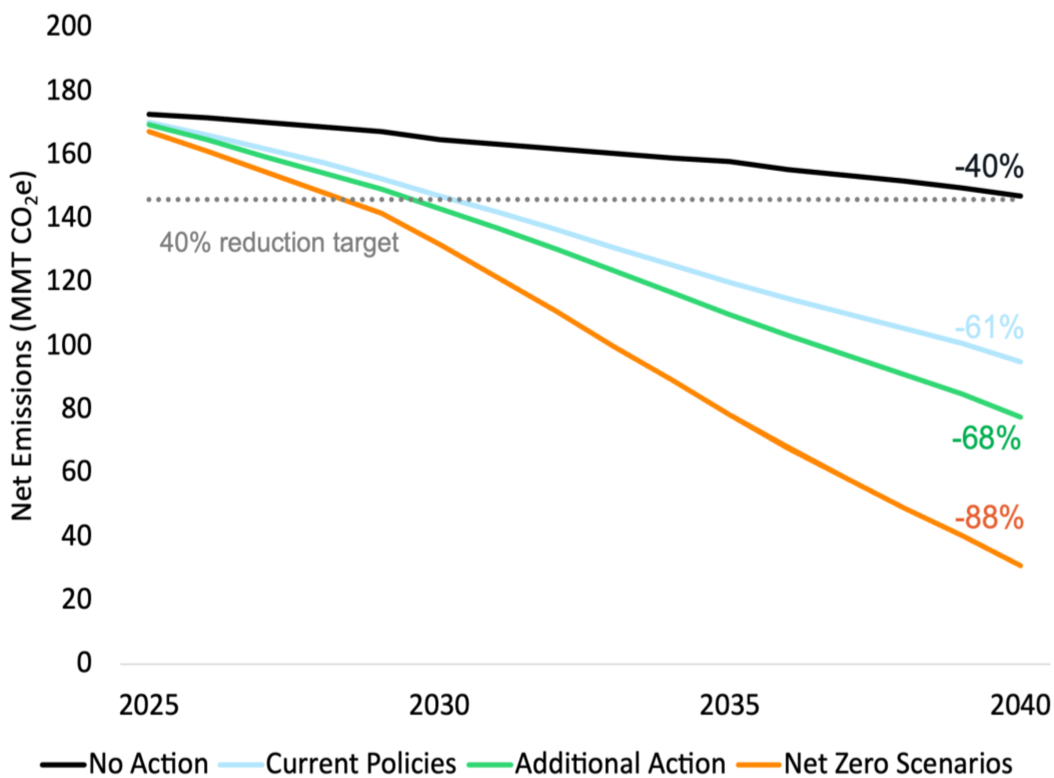

Figure 34. Economy-wide emissions under IPCC accounting

5.3. Benefit and Cost Analysis

Regardless of the scenario, New York State has substantial energy investment needs over the course of the planning period. Aging infrastructure across all energy sectors, including electricity and natural gas, will require investment to maintain safety and reliability. Economic development, while creating new opportunities for workers and communities across New York, will require substantial expansion in energy infrastructure to ensure abundant, accessible supply. Building owners will need to replace aging space heating and water heating systems, and individuals and fleet owners will need to purchase new vehicles. All of these systems will need to adapt to a new paradigm with warmer winters and more extreme heat in the summer. As a result, while the planning scenarios include modest increases in annual spending, the bulk of energy system investment will be required regardless of the pathway the state ultimately pursues.

Figure 35 shows the annual gross costs across scenarios in 2030 and 2040. Costs are net of federal IRA incentives which were in place at the time of modeling, adjustments to the modeling will occur in the final to reflect federal policy changes. The No Action scenario sees relatively flat economywide costs; increases in capital expenditures and increases in electric system costs are offset by reduced fuel costs due to electrification of buildings and transportation reducing the quantity of fossil fuels required for purchase. Note that this analysis does not include changing costs for existing pipeline gas systems or existing electric infrastructure assets; any such changes in costs would be consistent across scenarios so including those dynamics would impact overall gross costs but not impact the comparison across scenarios. The Current Policies and Additional Action scenarios have similarly flat costs, with a 1% and 3% increase in gross annual costs over the same time period, respectively.

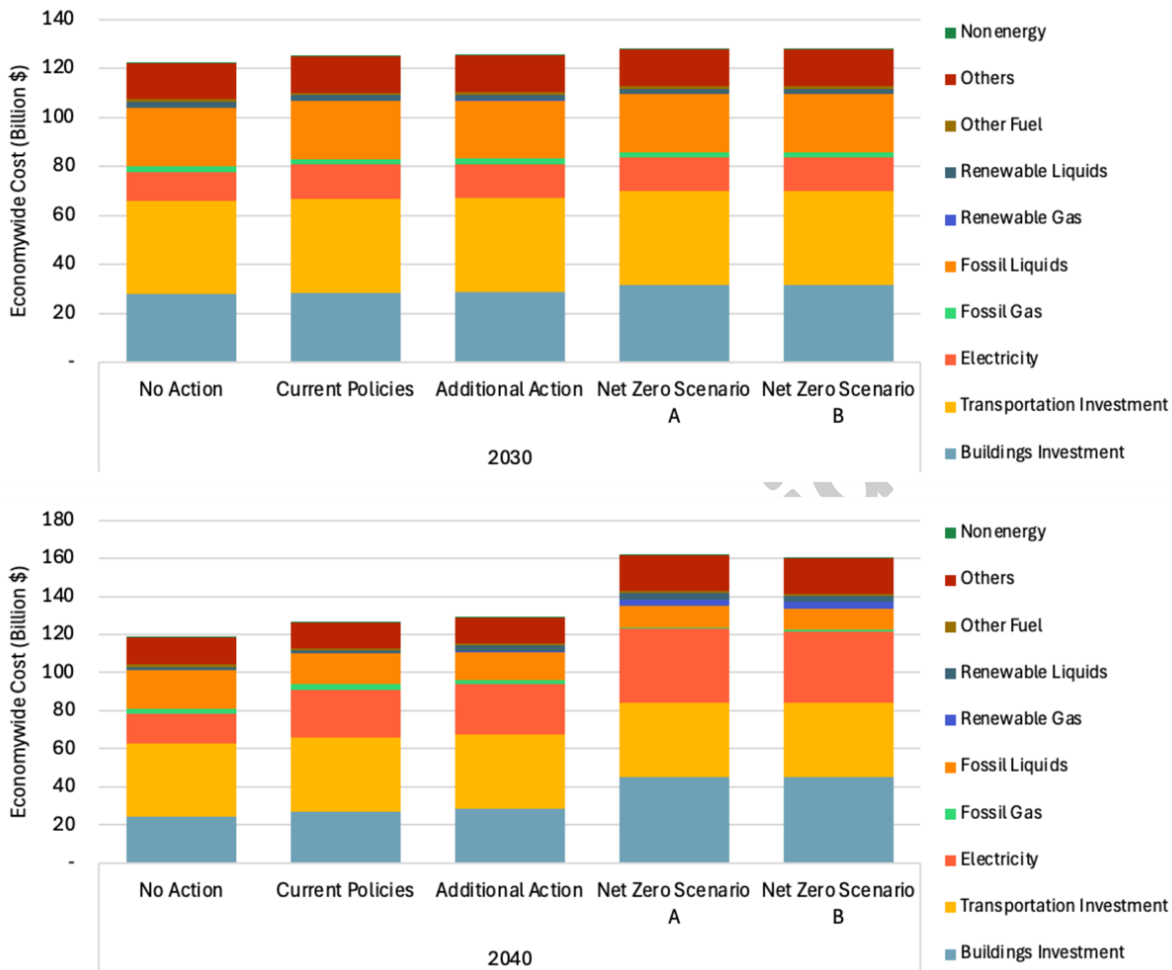

Figure 35. Gross annual costs across scenarios in 2030 and 2040 (2024$)

Most added costs when comparing the planning cases to the No Action scenario are from higher capital outlays—chiefly for heat pumps—and incremental power sector costs. These capital costs are partially offset by lower fuel and operations-and-maintenance expenses and by the projected decline in EV and heat-pump prices over time. In 2030 and 2040, incremental costs of the Additional Action scenario relative to the No Action scenario are $3.1 billion and $10.3 billion, which represents a modest 2% and 9% premium, respectively.

While the costs shown above show the gross system costs required under each scenario, these metrics do not include the benefits attributed to reducing emissions, in particular the health benefits and avoided social cost of emissions benefits. Decarbonization can result in substantial health benefits to New Yorkers from improved air quality relative to the No Action case. The health benefits associated with air quality improvements are documented in more detail in the Public Health Impacts Analysis chapter of this Plan. The social cost of emissions (SCE) is meant to measure the economic impact of climate change. The reduction in SCE can be significant for scenarios with increased emissions abatement.

Figure 36, Figure 37, and Figure 38 below show the annual costs, benefits, and net benefits relative to the No Action scenario across scenarios in the key years of 2030, 2035, and 2040. As shown, each of the planning scenarios provides a net benefit relative to the No Action scenario. Across scenarios, the net benefit increases in later years. This is due to higher annual greenhouse gas emission reductions, leading to higher SCE savings and health benefits. The costs in Net Zero B are slightly lower than in Net Zero A, reflecting potential value of electric system reductions that can be achieved from coordinated use of backup gas heating equipment.

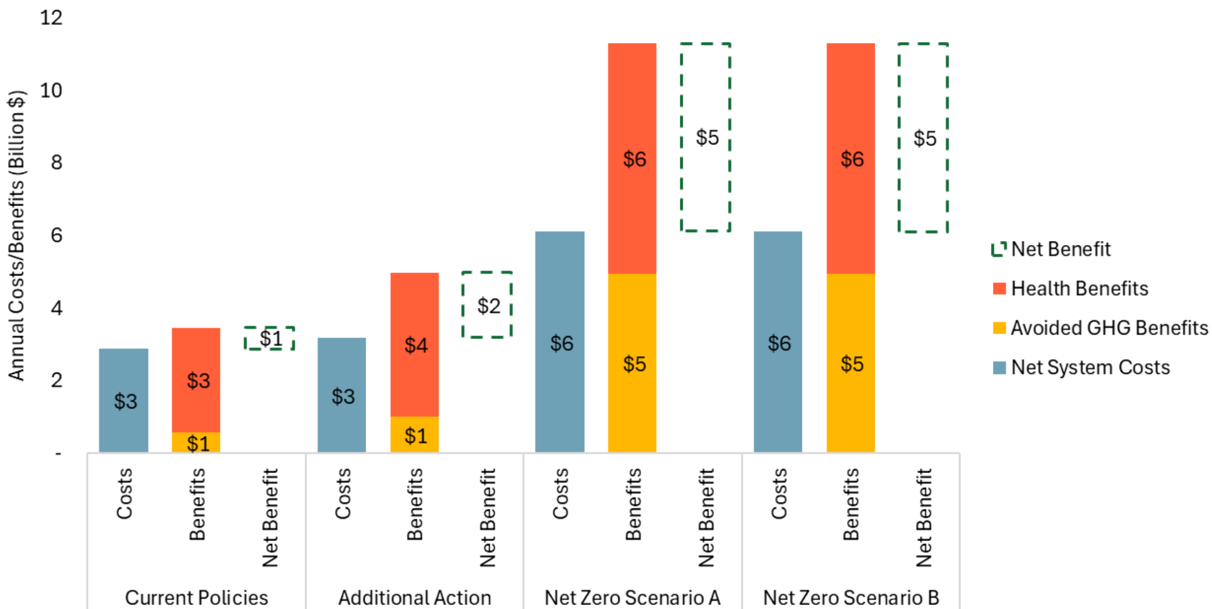

Figure 36. 2030 annual net costs and benefits by scenario (billion 2024$)

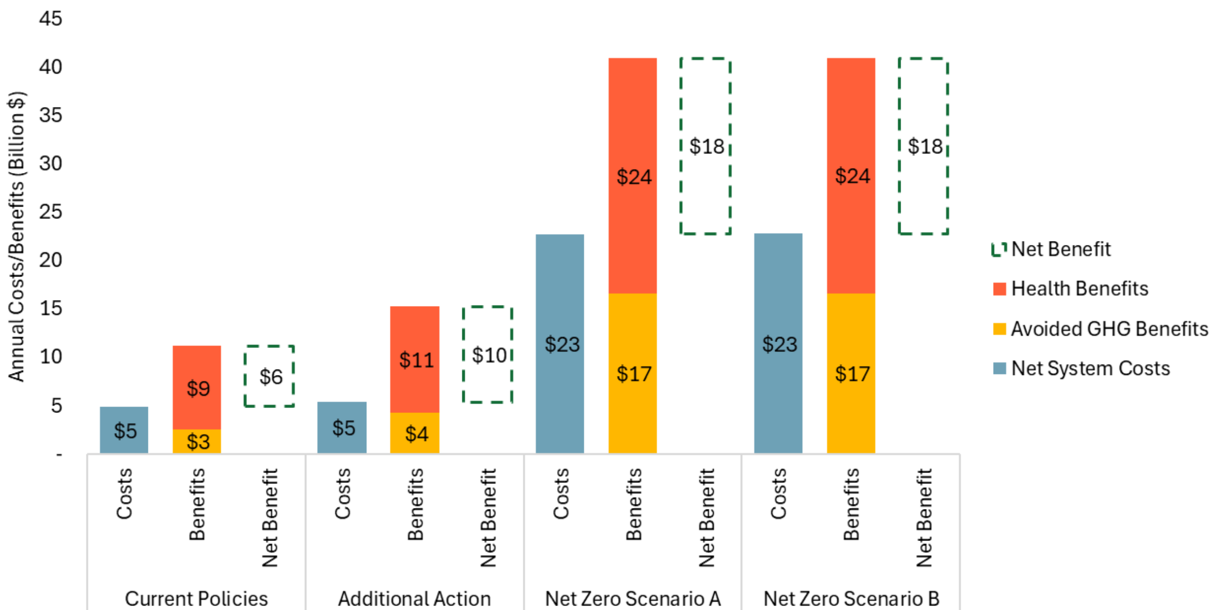

Figure 37. 2035 annual net costs and benefits by scenario (billion 2024$)

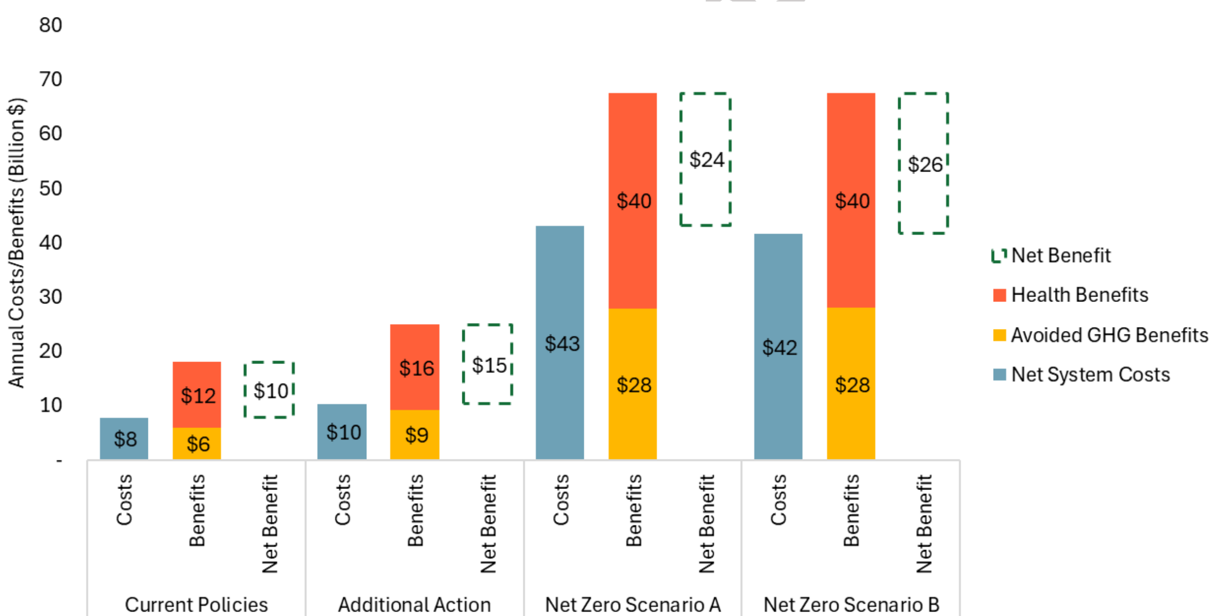

Figure 38. 2040 annual net costs and benefits by scenario (billion 2024$)

When calculating net benefits over the planning horizon of the State Energy Plan, 2025-2040, the net present value of net benefits for the Additional Action case relative to the No Action case is +$48.1 billion (in 2024$). This reflects population-level estimates, indicating that the combined public health and SCE benefits are expected to outweigh the net costs associated with Additional Action. These estimates do not reflect impacts at the individual level but rather reflect modeled outcomes at the societal level.

6. Summary of Findings

The Draft Plan is underpinned by analysis of possible future energy demand and supply across a range of future scenarios. Through economywide modeling of multiple future energy pathways for New York, this analysis simulates possible future energy systems that meet energy needs and advance policy objectives. The two planning scenarios include a Current Policies scenario reflecting progress toward achievement of enacted policies and Accelerated Action reflecting further acceleration of adoption of clean energy technologies from some mix of future policies aligned with the Draft Plan recommendations. The core planning scenario is Accelerated Action. The analysis also includes a No Action scenario absent New York actions from the Climate Act as a reference point and the net zero scenarios reflecting what would be needed for full achievement of the 2050 emission reduction targets for comparison.

As shown in Figure 39 for the planning scenarios, the energy system undergoes a meaningful transformation in final energy demand between 2025 and 2040.

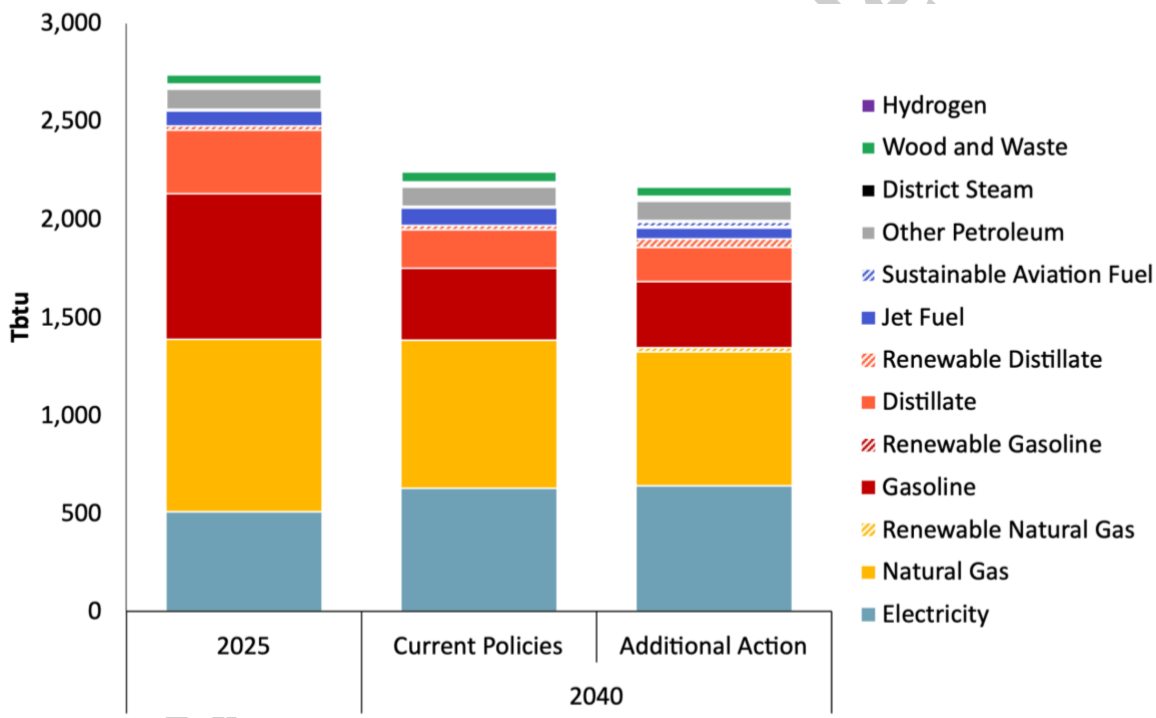

Figure 39. 2025 vs 2040 Final Energy Demand by Fuel

6.1. Annual and Peak Electricity Demands

In all pathways, new large loads interconnecting to the system drive growing electricity demand, across both annual loads and peaks (Figure 40). Planning early for abundant supply for these projects can ensure continued opportunities for economic growth.

Electricity demand is also projected to grow due to electrification of transportation and buildings. Adoption of clean energy technologies, such as electric vehicles, building energy efficiency, and heat pumps, is already underway driven by consumer preferences and federal, State, and local policies and programs. As existing heating and cooling appliances and vehicles age out and are replaced, State actions—such transportation initiatives and investments, all electric new construction and advanced building codes, and heat pump incentive programs—will accelerate adoption of more efficient and electrified alternatives. By 2040 in the planning scenarios, 17-24% of the residential heating stock is heat pumps and 53-59% of the light-duty vehicle (LDV) stock is a zero-emission vehicle (ZEV). These shifts lead to further electric system growth.

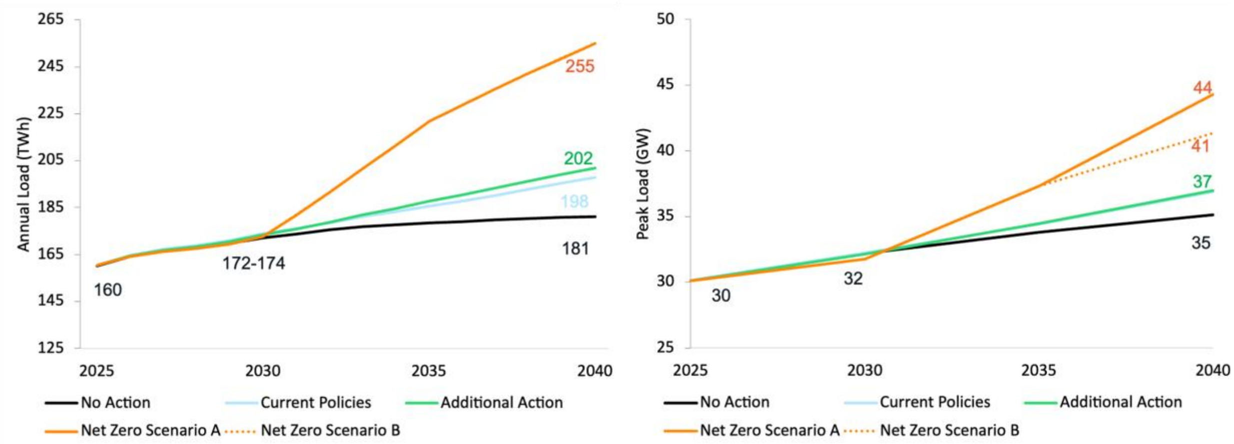

Figure 40. Annual Electric Loads (TWh, left) and NYCA Peak Loads (GW, right) for each Pathway

6.2. Electricity Supply

Meeting this growing electricity load, while maintaining system reliability, will require investments in expansion of the electricity system under all pathways. Moreover, progress toward a zero-emission electric grid will necessitate a transformation of the generation mix, building upon the deployment of renewables already underway from the CES program. Consistent with the findings of the CES biennial review, the modeling shows achievement of a 70% renewable grid in 2033 and provides insight into the continued build-out of generation and transmission infrastructure to support the decarbonization of the electricity system.

In the core planning scenario, additions of renewable energy and battery storage are foundational to decarbonizing the state's electricity system. By 2040, 35 GW of solar and 9 GW each of storage, offshore wind, and onshore wind have been added to New York's generation mix, which add to the system's resource diversity (Figure 41, left). Reliably integrating large quantities of variable renewable energy into the electricity system requires flexibility and balancing over multiple timescales, including sub-hourly and hourly balancing as well as ensuring that firm, dispatchable capacity is available to provide adequate amounts of power during multi-day periods of low renewable output.

Battery storage and demand-side flexibility provide key contributions to system reliability and support the balancing of renewables with demand. Existing nuclear and hydroelectric generation provide large quantities of zero-emissions energy and firm, dispatchable capacity during prolonged periods of low renewable output. While the process for establishing a zero-emission generation definition is still underway, the modeling assumes that the remainder of multi-day reliability needs are met by generators powered by green hydrogen. Under this assumption, the combustion generation fleet remains critical, with 17 GW of repowered and new capacity available to run on hydrogen. The size of the overall combustion fleet declines relative to today's levels (~25 GW) even as peak demand increases, reflecting the reliability contributions of other new resources like the Champlain Hudson Power Express transmission project, new battery storage, and additional renewable capacity.

However, a sensitivity off of the core planning scenario shows that if deployment headwinds persist (as experienced through delayed renewable generation build rates due to challenges such as changes in federal policy for permitting offshore wind), there would be greater reliance on combustion units than in the core scenario, including 2.2 GW of additional repowered capacity in Zone J in 2035 and an overall 1.2 GW larger fleet in 2040 (Figure 41, right). Given insufficient renewable energy generation, natural gas units would need to provide 15 TWh of electricity under this sensitivity; or alternatively, this electricity could be supplied by other resources like new nuclear with transmission and/or renewable natural gas.

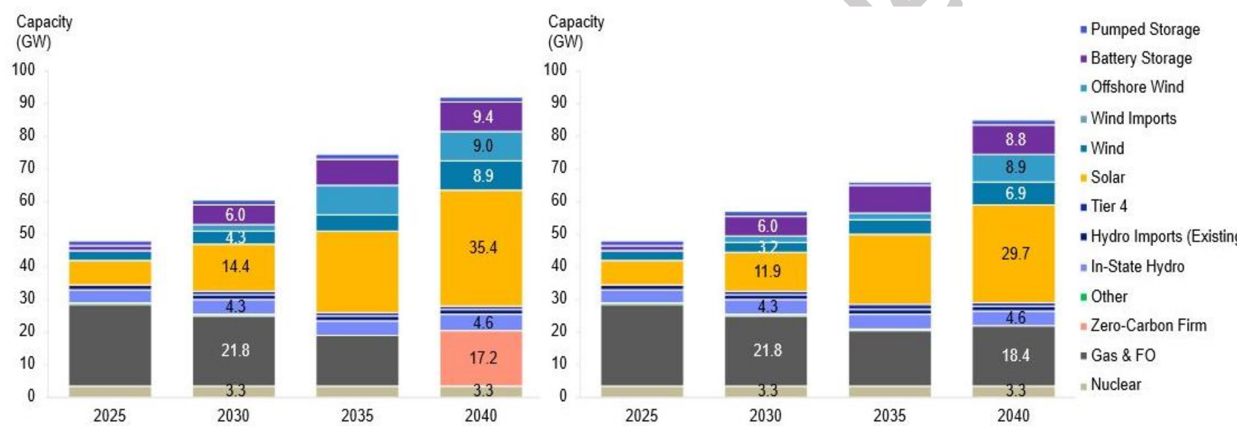

Figure 41. Total Installed Capacity - Additional Action (left) vs Constrained Build Sensitivity (right)

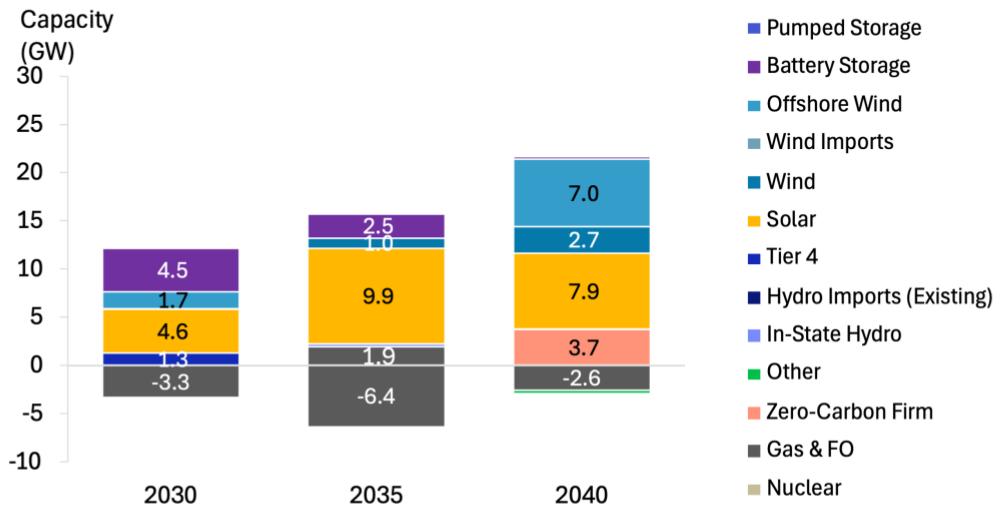

Figure 42. Constrained Build, Incremental Capacity Additions and Retirements by Period

6.3. Gas Supply and Delivery

While the electricity system is expected to grow in all scenarios, the gas system transformation is pathway-dependent. In all scenarios, the gas system remains an important energy delivery system, necessitating investments for reliable ongoing provision of service. Residential and commercial consumption declines in all cases with efficiency improvements and customers switching to heat pumps to varying degrees (Figure 43). Throughput declines even further with electric system progress toward 0x40, although electric generators typically have interruptible service which lowers their impact on overall system infrastructure needs. Residential customers grow in the No Action case absent more recent State action, with new construction and conversions from electric resistance and heating oil driving new connections. Residential customers decline over time in the remaining cases, reflecting the potential for well-implemented all electric new construction and heat pump programs to stem growth. However, regional variability is expected based on the findings of the utility Long Term Plans (LTPs), and targeted regional investment in system expansion may be needed to increase supply diversity and meet peak demand.

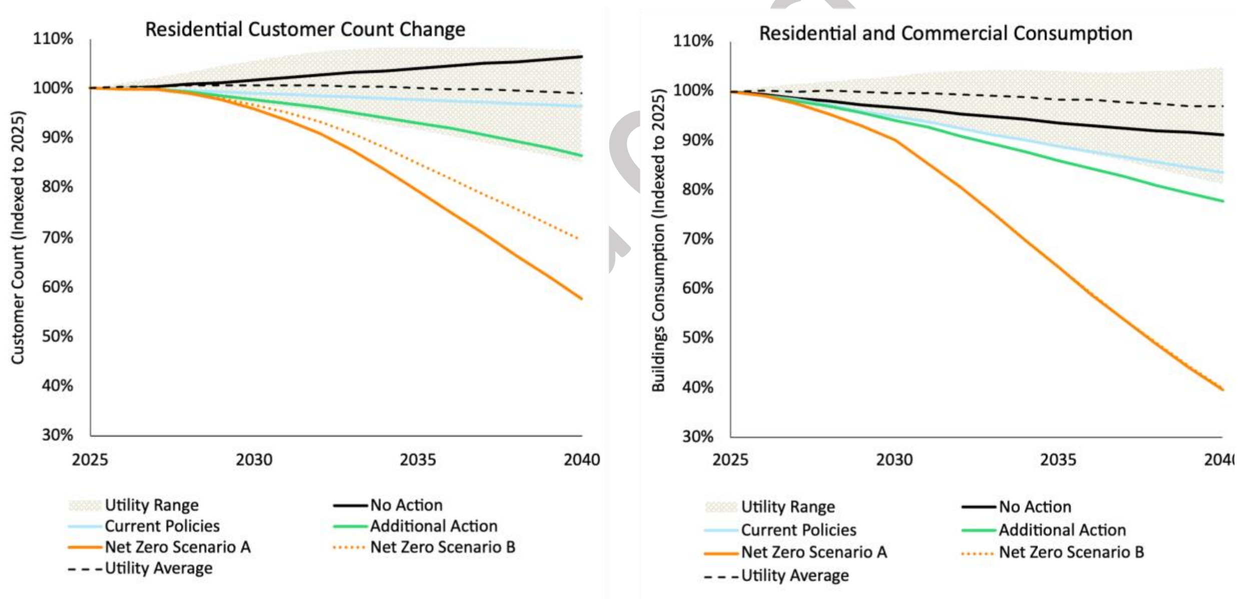

Figure 43. Residential gas customer count change and Residential/Commercial Consumption for all Pathways

Overall, in the Current Policies and Additional Action cases, final energy served by electricity increases from 19% in 2025 to 28-29% in 2040, and final energy served by direct fossil fuel consumption decreases from 78% in 2025 to 63-67% in 2040.

6.4. Greenhouse Gas Emissions

New York's economywide emissions today have already declined more than 9% from 1990 levels and 20% relative to 2005 peak emissions. The modeling finds that existing New York State policies are laying the groundwork for further economywide emissions reductions, with significant contributions from power generation, transportation, buildings, and fugitive emissions including methane and HFCs (Figure 44).

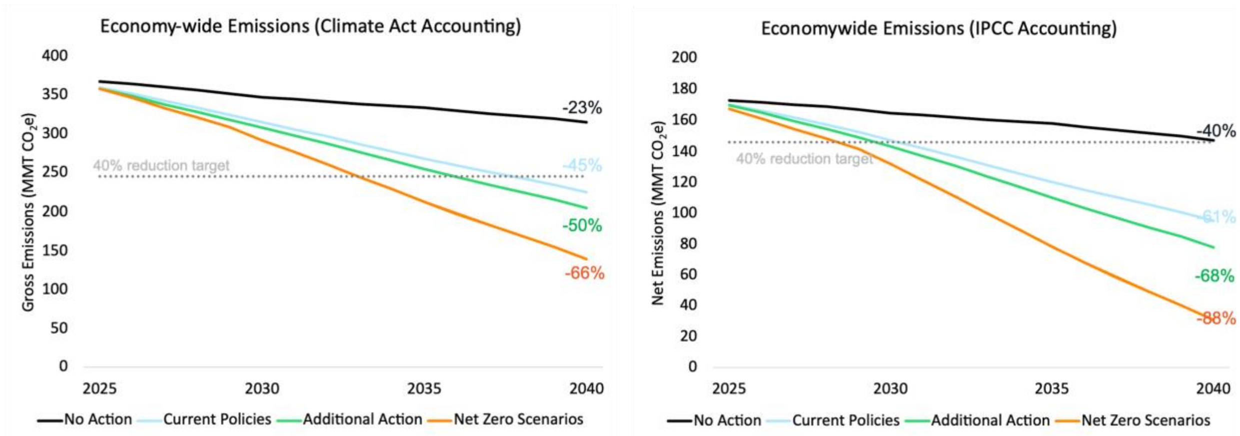

Figure 44. Economy-wide Emissions for all Pathways

Achievement of the net zero economywide emissions target will require significant incremental policy action and technology development beyond what is currently contemplated, including further electrification and decarbonization in buildings and industry, pursuing electrification and fuel-switching in on-road and non-road transportation sectors, and pursuing ambitious non-energy sector mitigation. Recent federal uncertainty and loss of funding will impact New York State policies.

6.5. Societal Costs of the Plan

Regardless of the specific future pathway for New York's energy system, continued investment to maintain and modernize existing infrastructure, replace aging equipment, and purchase fuels to meet energy needs will be necessary. As shown in Figure 45, analysis found that the No Action scenario requires annual spending of approximately $120 billion every year through 2040, with annual spending seeing a slight downward trend over the time period. These funds support replacing end use equipment at end of useful life, constructing new and replacement natural gas generators to meet electricity needs which are being transformed by new large loads and other needs. Because end use equipment is anticipated to grow more efficient over the time period as a result of existing policies, operating fuel expenses trend downwards over time.

By 2030 and 2040, the Additional Action scenario raises costs modestly by 2% and 9%, respectively, relative to the No Action scenario. Additional Action meets over 90% of its investment needs every year by reallocating anticipated spending from legacy energy sources and equipment to energy efficiency and clean alternatives, replacing spending on combustion generators with renewable generation, gas appliances with energy efficient heat pumps, and internal combustion vehicles for battery electric alternatives. In contrast, the cost premium for the Net Zero scenarios reaches in excess of 35% by 2040.

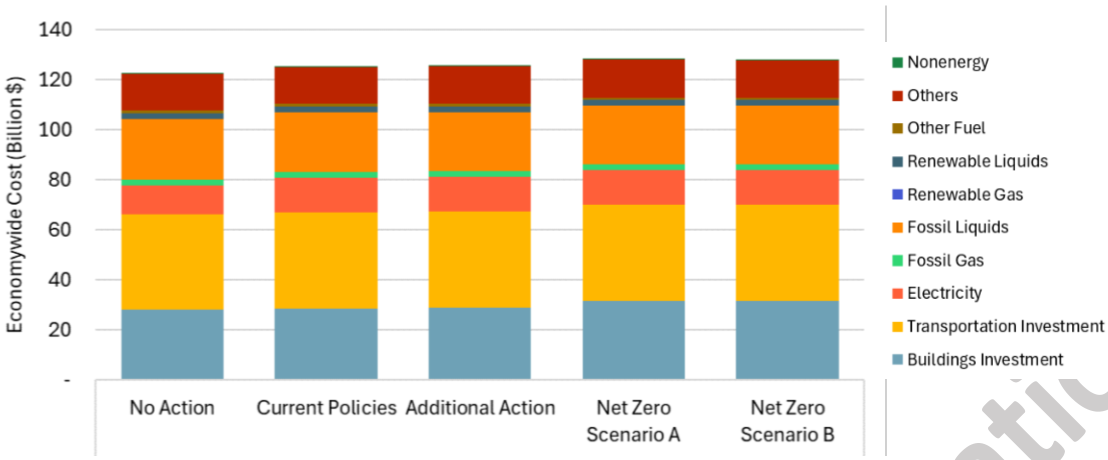

Figure 45. 2030 Gross Annual Costs by Scenario (2024$)

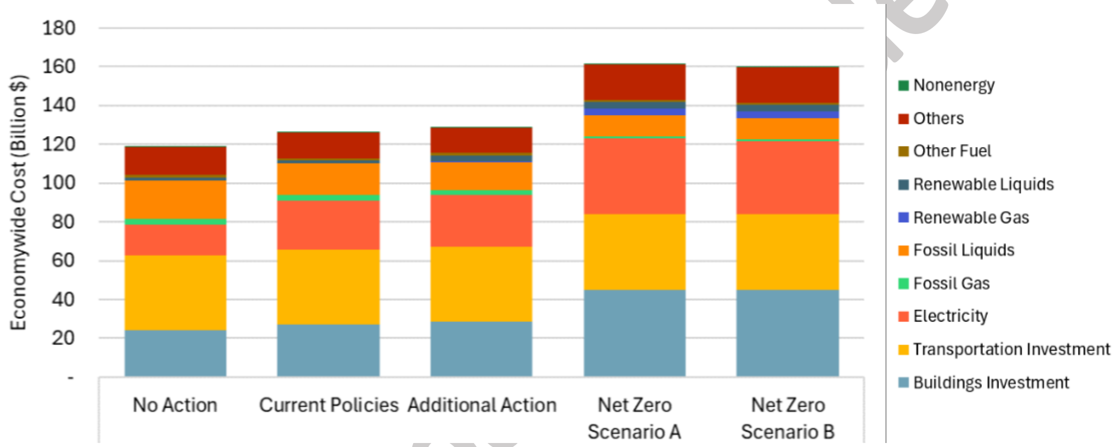

Figure 46. 2040 Gross Annual Costs by Scenario (2024$)

Across each of the scenarios, the emissions mitigation achieved via State policies yields benefits that exceed the incremental costs of the scenario in total over the planning period and in each individual year. The core planning case, Additional Action, sees the total net present value of net benefits reach $48 billion by 2040. These benefits grow substantially over the planning period as greater amounts of clean energy substitute for fossil fuel use across the scenarios. As shown in Figure 47 and Figure 48, Additional Action's 2030 incremental spending of $3 billion secures approximately $5 billion in benefits; by 2040, incremental spending of $10 billion provides benefits of $25 billion. While greenhouse gas emission reductions provide a meaningful share of the cumulative benefits over the full planning period, more than two thirds of the benefits are associated with health improvements, including avoided premature mortality, lost work days, emergency room visits, non-fatal heart attacks and more. For more information on these health benefits see the Public Health Impacts Analysis chapter of this Plan.

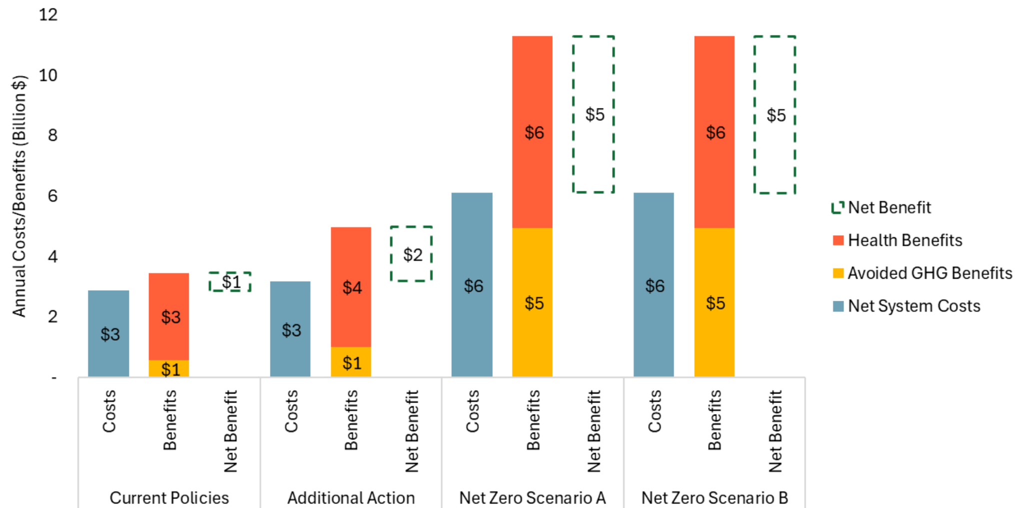

Figure 47. 2030 annual net costs and benefits by scenario (billion 2024$)

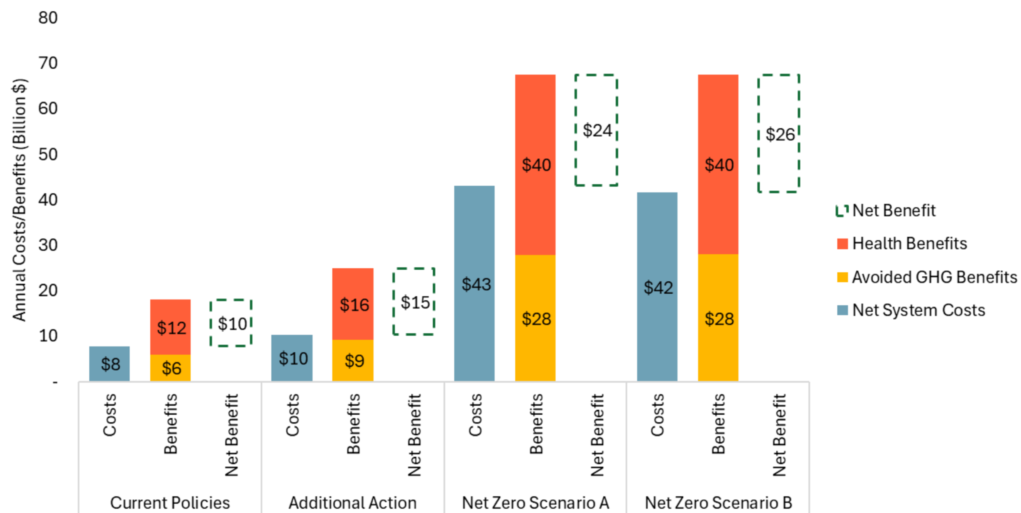

Figure 48. 2040 annual net costs and benefits by scenario (billion 2024$)

6.6. Ability of Energy Systems to Meet Forecast Energy Demand

Across electricity, natural gas, petroleum, and alternative fuels, medium- to long-term demand forecasts are uncertain. Future demand is highly dependent on factors such as economic trends, policy shifts, technology adoption rates, and consumer behavior. To ensure that the state's energy systems are able to reliably meet demand at reasonable cost, New York State policy makers, system operators, and stakeholders will pursue planning and strategies that remain adaptable across a broad set of potential futures.

New York's electricity demand is forecast to grow significantly through 2040 – a marked change from the relatively flat electricity usage over the past decade. New York State is prepared to meet this growing electricity demand while maintaining system reliability and making progress toward a zero-emission grid. New York State likewise will support the reliable provision of natural gas and petroleum fuels, as all major fuels used in the state today are forecast to provide meaningful volumes of energy throughout the planning period.

The core planning scenario developed to inform this Draft Plan projects a 26 percent increase in annual electricity demand and a 23 percent increase in peak demand by 2040 as compared to 2025. This forecast incorporates anticipated new large loads, expanded use of electric vehicle and heat pumps, and energy efficiency upgrades that help manage load growth in buildings. There is uncertainty as to whether the continuous growth in clean energy supply resources will meet growing demand given the federal policy context, broader economic headwinds, and the need for new clean firm technologies to become commercially available. As a result, the State and electricity system operators will continue to pursue careful coordination and planning to adapt as the energy system evolves.

While the State Energy Plan provides statewide and regional forecasts and broad policy direction, multiple ongoing planning processes exist to inform specific decisions such as electricity system investments or whether a given generating unit is needed for system reliability. The NYISO conducts regular reliability planning on both a near-term and long-term basis, including the biennial Reliability Needs Assessment (RNA); if the RNA identifies a reliability need for the bulk system, the NYISO issues competitive solicitations for projects to address it. Importantly, the PSC has initiated changes to the utilities' planning practices in response to clean energy policies and grid modernization needs. For example, the first statewide Coordinated Grid Planning Process (CGPP) is underway.

The scenarios modeled for this Draft Plan suggest declining demand through 2040 for natural gas and petroleum products, though these fuels remain important energy sources. However, notable variability exists across the forecasts that each New York gas utility has developed for natural gas demand in their service area (Figure 43). As directed by the PSC, the gas utilities produced and will regularly update LTPs with gas demand and supply forecasts for multiple scenarios over a 20-year horizon. These LTPs are important to inform gas system investments because they include utility-specific attention to supply sources needed to meet peak day needs during the winter heating months, with consideration of different scenarios that allow for a variety of contingencies to meet energy needs at all times. Electric and gas system planners also need to strengthen coordination measures to ensure fuel adequacy and maintain reliability across both systems.

Appendix

This study models New York's energy system and GHG emissions on an annual basis. Key model outputs include annual energy demand, emissions by fuel, stocks and sales of energy-consuming equipment, and necessary electricity supply infrastructure upgrades. Key inputs include sales forecasts for new technologies (e.g., vehicles, building systems), cost and performance data for supply- and demand-side infrastructure, and fuel price projections.

To perform this analysis, E3 used an integrated suite of modeling tools to analyze the evolution of energy demand, energy supply, and non-energy GHG emissions. A demand-side module calculated direct energy use, associated GHG emissions, and non-combustion emissions and sequestration. This module interacted with models for electricity, low-carbon fuels, and negative emissions technologies. The electricity module used the demand projections to co-optimize investment and operations for the power system, ensuring reliable load service while meeting GHG and renewable energy targets. The low-carbon fuels module assessed the availability of alternative fuels, which the demand-side module could use to reduce emissions by substituting for fossil fuels.

The core analytical tool for energy demand was the New York PATHWAYS model, which projects scenarios to 2050 to align with the Climate Act's targets. The model outputs energy use and GHG emissions for all sectors of the economy, excluding emissions from electricity generation, which were handled by the RESOLVE model. A key feature of PATHWAYS is its characterization of stock rollover, the process of replacing old equipment. By accounting for the long lifetimes of devices like vehicles and heating systems, the model captures the rate of change needed to meet decarbonization goals and highlights the limited window of opportunity to replace fossil-fueled equipment before mid-century. To characterize energy demand, this study used two methods:

1. Stock Rollover Approach: For subsectors with sufficient data, this approach modeled the evolution of infrastructure, energy use, and emissions as new devices are adopted and old ones are retired.
2. Total Energy Approach: For subsectors with less granular data, this approach directly calculated energy consumption based on scenario inputs for energy efficiency, electrification, and fuel switching.

Non-energy sectors were represented by annual emissions by pollutant, informed by parallel modeling efforts which tracked changes in these emissions as driven by policy or infrastructure changes in the scenarios themselves.

1. Buildings

The buildings sector analysis is subdivided into residential and commercial building types, covering energy services such as space conditioning, water heating, lighting, refrigeration, and cooking.

The model calculates building energy demand by first establishing the demand for energy services (e.g., the amount of hot water needed) and then determining the energy demand (e.g., the amount of fuel a water heater consumes) required to meet that service. Energy demand is calculated by dividing the energy service demand by the efficiency of the device providing the service.

The stock rollover approach tracks the lifetimes and efficiencies of the fleet of devices within each end use device type and calculates the energy demand by summing the energy demand for each constituent end use device. For end uses where the total energy approach was applied, E3 characterized energy demand by fuel type directly based on scenario-specific user inputs characterizing energy efficiency, potential for electrification, and potential for switching from fossil fuel combustion to low-carbon fuel combustion.

The analysis begins with a detailed baseline of the current building stock, segmented by type, vintage, and geography across New York's 11 NYISO load zones for a granular assessment. Because residential space heating is a major component of energy consumption that varies by housing type and location, the analysis uses an enhanced segmentation of households into five categories: single-family detached, single-family attached, 2–4 unit buildings, low- to mid-rise multifamily (1–7 stories), and high-rise multifamily (8+ stories).

To generate the distribution of heating devices and building shells across these housing types and fuel sources, the analysis utilizes National Renewable Energy Laboratories (NREL) ResStock database, with targeted adjustments. For other technologies such as cookstoves and lighting, the analysis leveraged federal data sources such as DOE lighting trends reports, EIA National Energy Modeling System (NEMS), and Residential Energy Consumption Survey (RECS). For commercial buildings, the analysis leveraged the New York State Commercial Baseline Survey and federal data sources including NEMS and the Commercial Building Energy Consumption Survey (CBECS) to characterize the existing commercial building stock and energy consumption.

The model then simulates the evolution of this capital stock over the analysis period using a turnover approach. As existing equipment for end uses like space heating, water heating, cooling, and cooking reaches the end of its useful life, it is retired and replaced with new technologies according to defined scenarios. This same turnover logic is also applied to the building shells. The analysis modeled multiple shell types to account for differences in insulation. The reference shell package represents existing buildings prior to 2005 building codes, while the space heating savings for basic, medium, and deep shell packages are summarized by housing type in the table below. All new construction from 2010 onward is assumed to have energy efficiency savings consistent with a medium shell retrofit, while the policy scenarios from 2028 and beyond assume new construction is consistent with deep shell efficiency savings, in line with advanced building codes.

Table A-1. Shell Retrofit Heating Savings

Shell type	Reduction in heating demand (%)
Basic shell	
Single-Family Attached	14%
Single-Family Detached	14%
Single-Family with 2-4 Units	22%
Multifamily with 5+ units, 1-7 stories	9%
Multifamily with 5+ units, 8+ stories	9%
Medium shell	
Single-Family Attached	35%
Single-Family Detached	30%
Single-Family with 2-4 Units	29%
Multifamily with 5+ units, 1-7 stories	13%
Multifamily with 5+ units, 8+ stories	15%
Deep shell	
Single-Family Attached	42%
Single-Family Detached	43%
Single-Family with 2-4 Units	33%
Multifamily with 5+ units, 1-7 stories	50%
Multifamily with 5+ units, 8+ stories	50%

Future technology performance is a key input to the model. For technologies like electric heat pumps, the analysis assumes that their efficiency, or coefficient of performance (COP), will improve over time due to continued technological advancements. For this analysis, an increase in annual average COP was assumed in line with performance improvement growth rates as seen in the NREL Electrification Future Study Moderate Advancement scenario. By calculating the annual energy consumption for each end use within every building segment and tracking the evolution of equipment stock and efficiency, the model creates an aggregate, bottom-up forecast of total energy demand in the buildings sector through 2050. Costs for building shells and heat pumps were aligned with modeling performed in other State energy analyses (BEEM), while costs for other building technologies were sourced from federal data sources (EIA NEMS).

2. Transportation

The transportation sector analysis is conducted using the PATHWAYS model, which projects energy consumption, costs, and emissions by modeling the evolution of the vehicle and equipment stock over time. The model is divided into distinct sub-models for on-road vehicles and non-road transport modes to capture their unique characteristics.

For the on-road stock subsectors, which include light-duty, medium-duty, and heavy-duty vehicles, the model employs a detailed stock-turnover framework. The analysis begins with a detailed inventory of the current on-road vehicle fleet, disaggregated by vehicle class, size, vintage, and fuel type, leveraging data sources including USDOT Vehicle Inventory and Use Survey, EIA State Energy Data System, DEC MOVES modeling. The model then projects future vehicle sales and retirements annually, using survival curves to determine when existing vehicles are removed from the stock and replaced with new ones. Total energy consumption is calculated by multiplying the number of vehicles in each category by their projected annual vehicle miles traveled (VMT) and their fuel economy. For this analysis, VMT per vehicle was assumed to hold constant over time, consistent with recent historical experience suggesting economic growth and VMT growth are not causally correlated in New York. Vehicle classes modeled include light duty autos and trucks, medium and heavy-duty trucks, and buses.

For non-road subsectors such as aviation, rail, and marine transport, a detailed stock-turnover model is not employed. Instead, these "non-stock" subsectors are modeled based on projections of future energy demand. The model accounts for improvements in energy intensity over time and potential fuel switching to alternatives like electricity, hydrogen, or biofuels. By combining the outputs from both the on-road and non-road sub-models, a comprehensive, bottom-up forecast of total energy demand for the entire transportation sector is developed.

3. Industry

Electricity and natural gas use in the starting year are drawn from the NYSERDA statewide Industrial Potential Study performed by DNV, while demand for all other fuels is taken from the EIA SEDS.

The resulting set of modeled subsectors comprises agriculture; primary metals; computer and electronic products; chemicals; construction; food processing; transportation equipment; fabricated metal products; mining and upstream oil and gas; paper; petroleum and coal products; nonmetallic mineral products; and a residual “other” category. An additional large loads category is included to capture new large electricity users, with their projected demand taken directly from NYISO’s annual Gold Book.

4. Electricity

To develop a detailed understanding of future electricity demand, this analysis translates annual energy forecasts into hourly load profiles. This process begins with annual projections for the adoption of new technologies, such as EVs, heat pumps, large loads, and savings from energy efficiency measures. These annual figures are combined with historical hourly usage patterns to create detailed hourly demand profiles. This method captures both the increase in electricity use from new electric technologies and the offsetting savings from efficiency. For the most impactful technologies, namely EVs and electric space heating, a specialized tool called RESHAPE was utilized to generate more granular hourly load profiles by considering factors like local weather patterns, housing characteristics, and driving behavior.

The analysis pairs a least-cost capacity expansion model (RESOLVE) with a resource adequacy model (Renewable Energy Capacity Planning Model, RECAP) to ensure that the selected portfolios maintain system reliability under a wide range of weather conditions. This framework captures the level of temporal detail needed to ensure resource adequacy standards are met under an extensive set of weather conditions, without explicitly modeling all weather conditions within the capacity expansion model. The analytical linkages between the resource adequacy modeling and capacity expansion modeling are described below.

1. **Reliability Modeling (RECAP)**: The first step of the modeling process is conducted in RECAP, which performs Monte Carlo simulations of future loads and renewable outputs under hundreds of years of plausible weather conditions. This modeling is used to identify the reliability contributions of weather-dependent and limited-duration resources, which are measured using an effective load-carrying capability (ELCC) metric. ELCC curves are developed to represent the reliability value of renewable and storage resources as a function of their penetration on the system.

2. **Least-Cost Capacity Expansion (RESOLVE)**: Using annual and hourly load projections from the PATHWAYS analysis coupled with ELCC curves from RECAP, the capacity expansion framework in RESOLVE is then used to identify the least-cost portfolio of investments across New York State to reliably meet projected electricity demands while complying with applicable policy objectives.

3. **Iterative Validation (RECAP)**: The portfolio of generation, storage, and transmission investments selected by RESOLVE is passed back to RECAP to validate that the portfolio meets resource adequacy criteria under the full set of simulated weather conditions. RECAP simulates the reliability performance of the selected portfolio to determine whether the portfolio meets or exceeds the 1-day-in-10-years reliability standard required by the New York State Reliability Council across its thousands of simulations. This step is an iterative step and the portfolio is not finalized until the reliability standard is met.

This integrated process ensures that investment decisions are grounded in a deep, probabilistic understanding of resource reliability, yielding a plan that is both achievable and dependable.

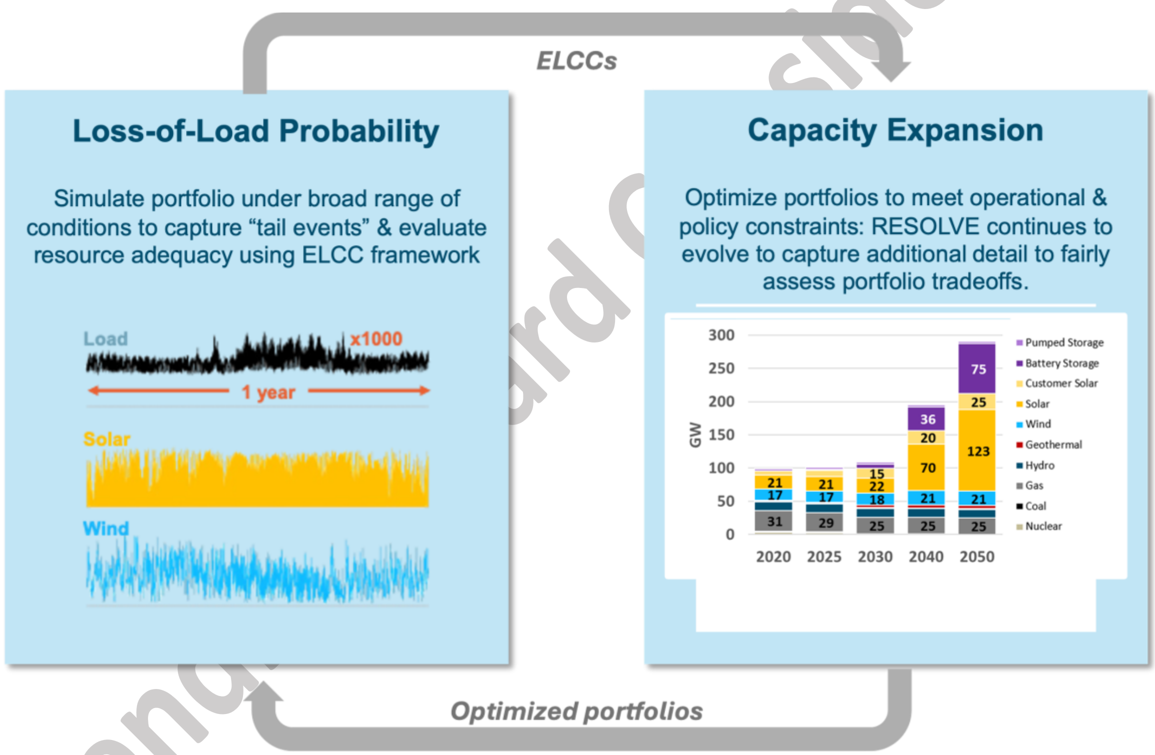

Figure A-1. Interactions between capacity expansion and reliability within electricity modeling

The resource adequacy modeling performed using RECAP leverages a probabilistic Monte Carlo simulation method. RECAP performs hundreds of unique simulations of a full year of grid operations. In each run, it randomly combines historical weather patterns (affecting wind/solar output and electricity demand) with potential unexpected power plant or transmission outages. By analyzing when and how often supply fails to meet demand across these thousands of simulations, RECAP calculates the effective load carrying capacity (ELCC) for variable resources like wind and solar, and for limited-duration resources like batteries.[14] The ELCCs of variable and limited-duration resources serve as inputs into the capacity expansion modeling. After the least-cost portfolios of resources are identified within the capacity expansion analysis, RECAP is then used to validate that a given portfolio of resources is adequate to meet demand under a comprehensive set of weather conditions, including to ensure the system meets the statewide standard (a loss-of-load expectation of no more than 1 day in 10 years).

The capacity expansion modeling performed in RESOLVE uses optimization methods to identify a least-cost portfolio of generation facilities, energy storage, and/or transmission lines to meet New York's electricity demand. It considers both the upfront capital cost to build new infrastructure and the long-term operational costs (e.g. fuel, operations, and maintenance) of both existing and new facilities. The portfolios must meet the statewide reserve margin as well as local capacity requirements in the Lower Hudson Valley, New York City, and Long Island localities, consistent with the structure of NYISO capacity market requirements. The contributions of the selected portfolio of resources towards resource adequacy constraints are measured using an ELCC framework, leveraging inputs from the RECAP modeling as described above.

The model leverages a "pipe-and-bubble" framework to capture the transmission system and account for physical constraints on moving power from where it's generated (e.g., remote wind farms) to where it's consumed (e.g., cities). This framework reflects key transmission constraints both within New York and between New York and neighboring markets. New York is represented as a series of distinct electrical zones or "bubbles" interconnected by transmission "pipes", aligned with the 11 NYISO load zones (A-K), as shown in Figure A-2, below. RESOLVE also includes a simplified representation of neighboring power systems—PJM, ISO-New England, Hydro-Quebec, and Ontario—to capture the ability for New York to trade power with those markets.

[14] ELCC represents the capacity contribution as an equivalent amount of "perfect" capacity (capacity that is always available); for example, if solar has an ELCC of 50%, then 100 MW of solar provides the same reliability contributions as 50 MW of perfect capacity. The ELCC of a resource is not fixed; it changes based on a number of factors including the penetration of that resource on the system, its interactive effects with other resources, and the timing of system reliability needs (e.g. as loads change over time).

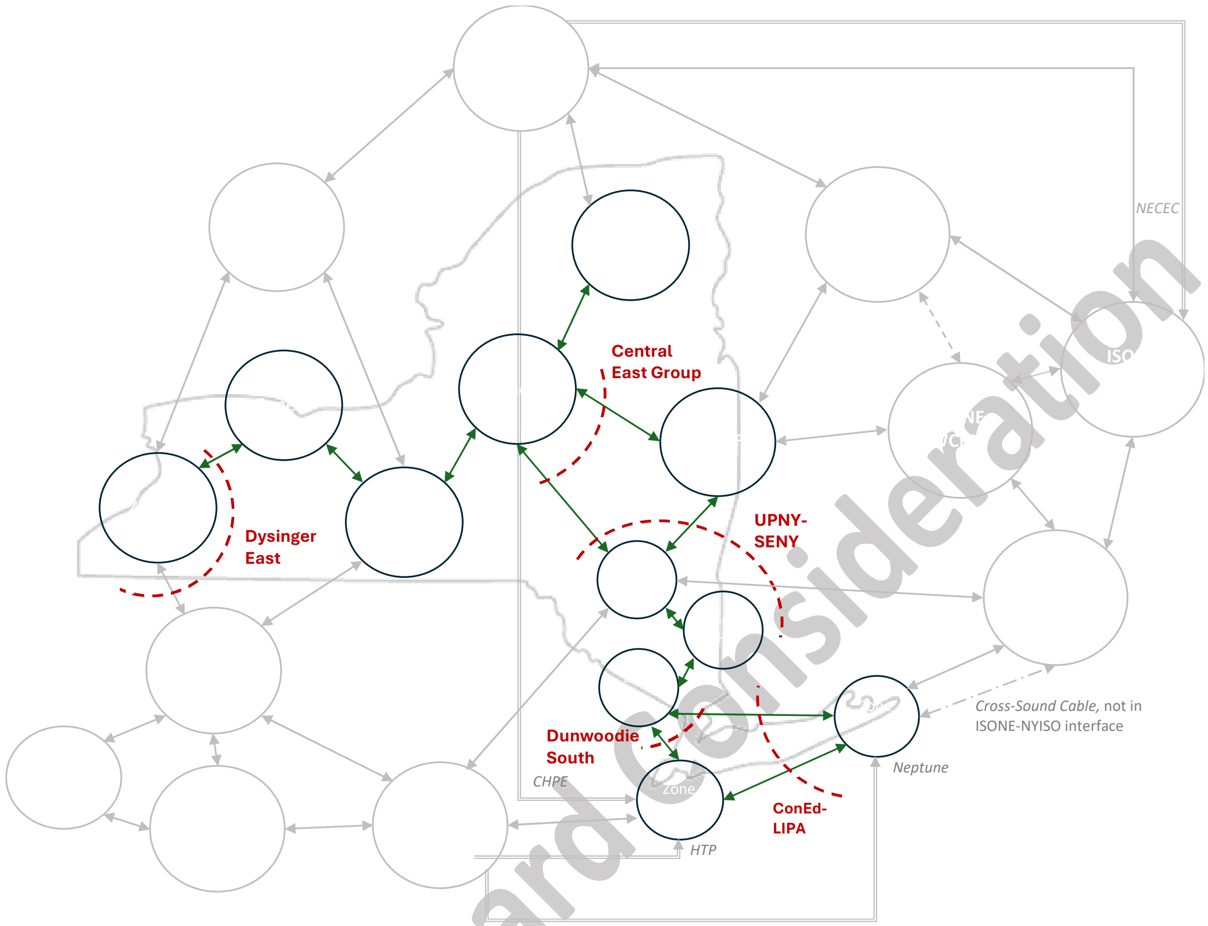

Figure A-2. Zonal Topology Representation[15]

Combustion units are aggregated into generator blocks in order to simulate their operations while reducing the model size. In each zone, combustion resources are first grouped by their primary fuel—natural gas, residual fuel oil (RFO), or distillate fuel oil (DFO)—and then by technology—combined-cycle gas turbine (CCGT), combustion turbine (CT), or steam turbine (ST). Within every fuel-technology pair, existing units are further stratified into three efficiency tiers defined by heat-rate performance. The representation of combustion resources also reflects units' announced retirement dates and those reaching end-of-life, assuming a 60-year lifetime from commercial-operation date and deferring end-of-life retirements until after 2025. Starting in 2030 upstate and 2035 downstate, the model may choose to retire additional capacity based on their going-forward economics, with the extent of these retirements varying by scenario.

The model chooses from a wide menu of candidate resources to create a portfolio that meets reliability and policy constraints while minimizing total cost. Inputs and assumptions come from a variety of sources including alignment with NYSERDA's Large-Scale Renewables Supply Curve Analysis, with adjustments to reflect recent procurement; detailed performance and cost data for these resources can

[15] Sources for this topology include the NYISO 2024 RNA, Energy Exemplar, and MA CECP 2050 [add more formal citations if needed]

be found in Annex 1. Note that the federal investment tax credit (ITC) and production tax credit (PTC) are both included as at the time of modeling they are current federal policy.

- Land-based and offshore wind
- Imported wind resources with dedicated transmission
- Utility-scale and distributed solar
- Battery storage (between 2–8 hour duration)
- Upgrades to existing hydropower
- New transmission within the state
- Zero-carbon firm resources like hydrogen fuel cells

In cases subject to the 0x40 emissions constraint, hydrogen consumption in the power sector is supplied in part by in-state electrolyzers. The demand from in-state electrolyzers is dynamically reflected in RESOLVE, and this integration ensures that the electric sector's hydrogen budget is tied to actual consumption patterns. The model takes a comprehensive approach to co-optimizing hydrogen consumption and production in the power sector by considering both the commodity price of hydrogen (aligned with data from the NYSERDA Hydrogen Roadmap) and the marginal cost of energy required for the electrolysis process.

Within the capacity expansion framework, the model simulates the operations of the system over 30 representative days. These days are chosen through rigorous statistical analysis and then weighted such that they span a broad range of historical load and renewable-generation conditions while keeping the computations tractable. The dispatch and operations of the selected portfolios can then also be examined over the entire year, e.g. to better understand the operations of the combustion fleet during challenging periods, especially under achievement of the Zero by 2040 requirements.

5. Low-carbon fuel modeling

Mitigation scenarios can incorporate different amounts of advanced biofuels, specifically renewable natural gas (RNG), renewable diesel, and renewable jet fuel, with consumption levels varying significantly between scenarios. Feedstock supply estimates were based on the U.S. Department of Energy's 2023 Billion-Ton Report and the NYSERDA Renewable Natural Gas Potential report, with scenario-specific adjustments to the amount of each feedstock category which is available for use.

The feedstocks considered are classified into three categories:

1. Wastes: Includes animal manure, landfilled or incinerated municipal solid waste (MSW), and byproducts from wastewater treatment. These feedstocks are byproducts of existing economic activities and require no additional land or agronomic inputs.
2. Forest and Agricultural Residues: Consists of logging residues, mill wood waste, and materials from forest management (e.g., thinning and fuel reduction). It also includes agricultural residues

like corn stover, cereal straws, and sugarcane bagasse. As byproducts of current forestry and agriculture, these require no new land cultivation.

3. Dedicated Energy Crops: Encompasses cellulosic crops (miscanthus, switchgrass, sorghum) and woody crops (willow, poplar, eucalyptus) grown specifically for energy production. Unlike wastes and residues, these crops require land, which could include marginal agricultural lands or land converted from other uses. These are distinct from conventional biofuel crops like corn (for ethanol) and soybeans (for biodiesel).

An in-house biofuel production model was used to convert biomass feedstocks into one of the three eligible fuels (RNG, renewable diesel, or renewable jet kerosene). The model optimizes this conversion by selecting feedstock-to-fuel pathways that deliver the greatest greenhouse gas emissions mitigation at the lowest cost. Feedstocks from the NYSERDA report, already quantified in energy units of RNG, were not processed through this tool.

Finally, the model generates an average price for each biofuel. This price is determined by the average of the price for feedstock-to-fuel conversion pathways utilized to meet the scenario's demand. These prices serve as key inputs for the broader economy-wide costing analysis and are detailed in Annex 1.

6. Benefit-Cost Approach

This study estimated benefits for two categories: avoided damages from GHG pollution and avoided public health impacts. These benefits were then compared with energy system costs, which include the capital costs of energy-consuming devices and energy supply infrastructure (including electricity generation and electricity imports) in addition to fuel costs. More information on underlying cost assumptions can be found in Annex 1, and more information on the health co-benefits analysis can be found in the Public Health Impacts Analysis chapter.

The value of avoided GHG emissions calculations are based on DEC Value of Carbon guidance, developed under the Climate Act.[16] The DEC Value of Carbon guidance recommends a damages-based approach to valuing avoided GHG emissions, which means that the values are estimates of the monetary impacts on society of GHG pollution. In this study, the total value of avoided GHG emissions is measured in each scenario relative to the No Action Case. The total value of avoided GHG emissions was calculated individually for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). For other GHGs, avoided emissions were converted to carbon dioxide equivalent (CO_2e) using the AR5-20year GWP values. The avoided GHG emissions time series in each year was multiplied by the annual social cost of GHG based on the DEC Value of Carbon guidance appendix, using the central case estimate for each GHG (2% discount rate for GHG emissions). When calculating NPV of avoided GHG emissions benefits to compare with NPV of costs, NPV calculations apply a discount rate of 5.03% to all annual benefit and costs streams.

[16] The value of avoided GHG emissions calculations are based on DEC guidance: https://www.dec.ny.gov/regulations/56552.html, accessed June 2025.

Energy Affordability Impacts

Key Findings

- **Across the U.S. and New York, households face affordability challenges.** There are many drivers of household affordability, and expenditures in areas such as housing, transportation, food, and healthcare are significant. As a subset of housing and transportation costs, energy is an important, but not a primary, driver of affordability challenges. To understand how energy costs impact people, it is important to look comprehensively at both household and transportation energy spending. On average, total energy spending, accounting for household and transportation energy costs, in New York is lower than the national average, as well as the top outmigration states from New York.
- **Low- and moderate-income households are more likely to experience energy affordability challenges.** Across the U.S. and New York, although low- and moderate-income households on average use less energy and spend less on energy than higher income households, their household energy and transportation energy burdens are still often many times greater. In addition, lower income and vulnerable populations experience energy insecurity at above average rates. These dynamics further exacerbate disparities in health and quality of life. Existing programs that promote energy efficiency and offer bill assistance play a key role, but more action is needed to make energy services more affordable, in particular for low-income households, vulnerable populations, and disadvantaged communities.
- **Energy saving measures, such as building envelope efficiency, efficient appliances and equipment, fuel efficient and electric vehicles, and public transit use, can lower overall household energy costs.** Many households pursuing these measures are likely to see net reductions in operating costs on a real dollar basis due to the combined impacts of a variety of efficiency measures, including efficient electrification, on household and transportation energy spending. However, the actual savings and energy costs will vary depending on the unique circumstances of the household when pursuing energy efficiency and electrification projects. These factors include building envelope and insulation, home size and occupancy, type of home (e.g., single-family vs. multi-family), efficiency of existing and new equipment, extent of equipment replacement, and usage of equipment. For some low- and moderate-income households, such as transit dependent households and those that do not currently pay a heating bill, continued attention will be needed to there are no negative affordability impacts for households pursuing efficient electrification. New York should continue to investigate and develop affordability programming and electric rate designs that enhance low- and moderate-income households' ability to manage electricity costs.
- **Policy and market solutions that focus on lowering up-front costs and other barriers to adoption for a range of energy efficiency measures have the potential to enable households to realize more affordable operating costs.** This can in turn help to alleviate energy insecurity and energy burdens.

Key Terms

- **Household and transportation energy expenditures** are the total amount households spend on both household energy (such as electricity and heating fuel) and transportation energy (such as gasoline and electricity). This metric is a useful indicator of a household's overall energy spending.
- **Energy Insecurity** is the inability to meet basic energy needs. It may mean having to choose between energy and other expenses, keeping your house at an unsafe or unhealthy temperature to save expenses, or being unable to pay energy bills.
- **Energy Burden** is the percentage of gross income that a household spends on energy. It is calculated by dividing the average housing energy cost by the average annual household income. When a household is described as energy burdened, that generally means that it spends more than 6 percent of household income on energy.[1]
- **Transportation Energy Burden** is the percentage of gross income that a household spends on energy for transportation. It is calculated by dividing the average transportation energy cost by the average annual household income.
- **Disadvantaged Communities (DACs):** The Climate Act defines disadvantaged communities as communities that bear burdens of negative public health effects, environmental pollution, impacts of climate change, and possess certain socioeconomic criteria, or comprise of high-concentrations of low- and moderate-income households. DACs are identified using criteria as established by the Climate Justice Working Group.[2] On March 27, 2023, the CJWG voted to approve the DAC criteria.[3]
- **Household income strata:**
  - **Low-income** includes households with incomes at or below 60 percent of State Median Income.
  - **Moderate-income** includes households with incomes above 60 percent but below 80 percent of State Median income or Area Median Income, whichever is higher.
  - **Average income** uses the average income of a household in an analysis region to represent households with incomes that fall above the low- or moderate-income range.

[1] U.S. Department of Energy, *Low-Income Energy Affordability Data (LEAD) Tool*, https://www.energy.gov/scep/low-income-energy-affordability-data-lead-tool.
[2] New York State, *Environmental Conservation Law* § 75-0101(5) (2019).
[3] New York State Climate Act, *Disadvantaged Communities Criteria*, https://climate.ny.gov/Resources/Disadvantaged-Communities-Criteria.

1. Overview

Affordable, clean energy is foundational to ensuring that New Yorkers have access to safe, healthy homes and neighborhoods, clean air, and economic opportunity. Delivering affordable, clean energy will involve necessary upgrades across the energy system to ensure that it is resilient to disruption and that modern, reliable energy services are accessible to households and industries across the state.

Household energy costs are a subset of housing and transportation costs, which in addition to other categories like food and healthcare contribute to overall cost of living. Figure 1 below illustrates household spending by category as a share of income in New York State and in the United States on average.

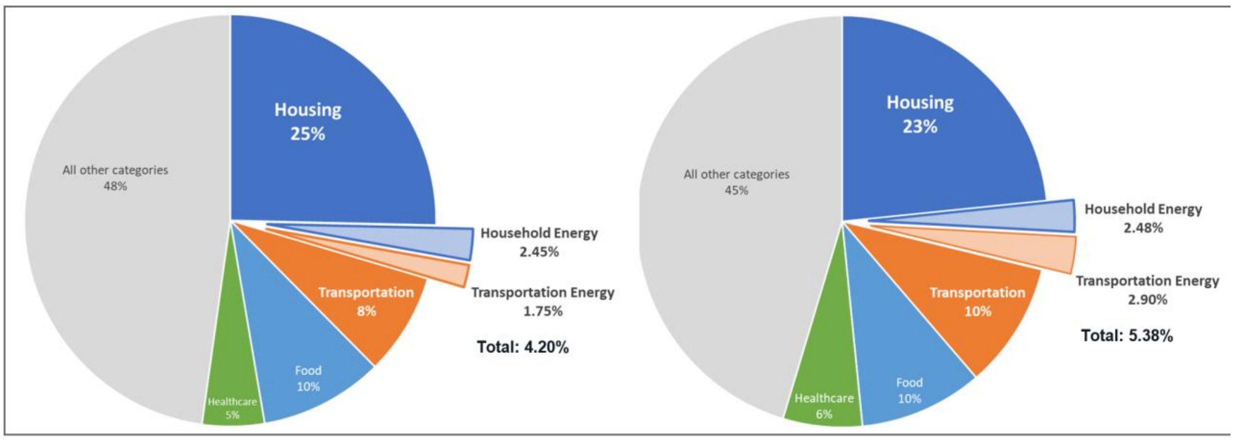

***Figure 1. Household spending as share of income, New York State and United States*[4]**

Although there are broad similarities between average household spending in New York State (NYS) and the United States (U.S.) as a whole, there are some small but notable differences. The share spent on housing is slightly higher in New York State while the transportation share is slightly lower as compared to the US. Total household energy and transportation energy expenditures are a relatively small share of household income relative to other categories, and energy spending in New York State is slightly lower than the US average.

Within the State, household energy consumption patterns differ by region due to factors such as climate, dwelling size and differences in the built environment, and access to public transit. These characteristics contribute to differences in energy expenditures and energy affordability in different regions of the state.

For many low- and moderate-income households, energy affordability remains a challenge. Two concepts used to assess the nature and extent of energy affordability challenges are **energy insecurity**, or the inability to meet basic energy needs, and **energy burden**, the proportion of household income that a household spends on energy. Low- and moderate-income (LMI) households and disadvantaged

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[4] U.S. Bureau of Labor Statistics. Consumer Expenditure Surveys. New York and U.S.: 2021 & 2022. Accessed 4/16/25, https://www.bls.gov/cex/tables.htm#geo.

communities (DAC) experience energy insecurity and energy burden at higher-than-average rates. LMI households and DACs are also more likely to face barriers that access to affordable clean energy services.

2. State of energy affordability in New York

2.1. Overall affordability

New York State strives to provide affordable clean energy to families across the state. The Climate Act sets NYS on a path to decarbonize its energy system by midcentury, while ensuring that 35–40% of investments flow to DACs. The State has adopted a target of limiting energy burden for low-income households, so that energy costs do not exceed 6% of household income, and affordability is the Governor's top priority in the development of key policies. New York provides support for programs that save energy and save families money, such as efficiency in buildings and vehicle electrification.

Across the U.S. and across New York, households face affordability challenges. As illustrated in Figure 1 above, there are many drivers of household affordability, including significant expenditures in areas such as housing, transportation, food, and healthcare. As a subset of housing and transportation costs, energy is an important, but not a primary, driver of affordability challenges. Energy affordability can be understood as a focus on the energy cost components of the overall cost of living.

To understand how energy costs impact people, it is important to look holistically at both household energy expenditures and transportation energy expenditures. On average, 2.5 percent of income goes toward household energy spending in both NYS and the U.S., while the share of income devoted to transportation energy spending is 1.8 percent in NYS and 2.9 percent in the U.S. In total, the combined average household and transportation energy expenditures as a percent of income are 4.2 percent in NYS and 5.4 percent in the U.S. Together, household and transportation energy expenditures provide a comprehensive perspective on the ways energy policy impacts household expenditures to meet energy needs and provides an opportunity to evaluate tradeoffs between different consumer choices households may make.

As illustrated in Figure 2 below, on a combined basis, New York compares favorably to the national average in terms of total energy spending. At $4,231 annually (comprised of $2,466 for household energy and $1,765 for transportation energy), New York households on average spend less annually on energy expenses than the national average of $4,884 (comprised of $2,249 for household energy and $2,635 for transportation energy), according to the Consumer Expenditure Survey, a longstanding measure of consumer spending across common categories of goods and services.[5]

[5] We use Consumer Expenditure Survey (CE) data throughout this chapter to characterize combined household and transportation energy expenditures, as well as associated energy burden, transportation energy burden and combined household energy and transportation energy burdens. The CE data has a number of key features that make it useful for this analysis: It is an internally consistent data set that situates energy expenditures within household spending more broadly and includes both household energy and transportation fuel spending. Although not identical, energy burden calculated using CE data is broadly in line with other approaches to calculate energy burden, such as the approach based on Census data used in the Low-Income Energy Affordability Data tool, a commonly used Federal Government resource for understanding energy burden that as of the time of this writing was removed from publication by the current administration.

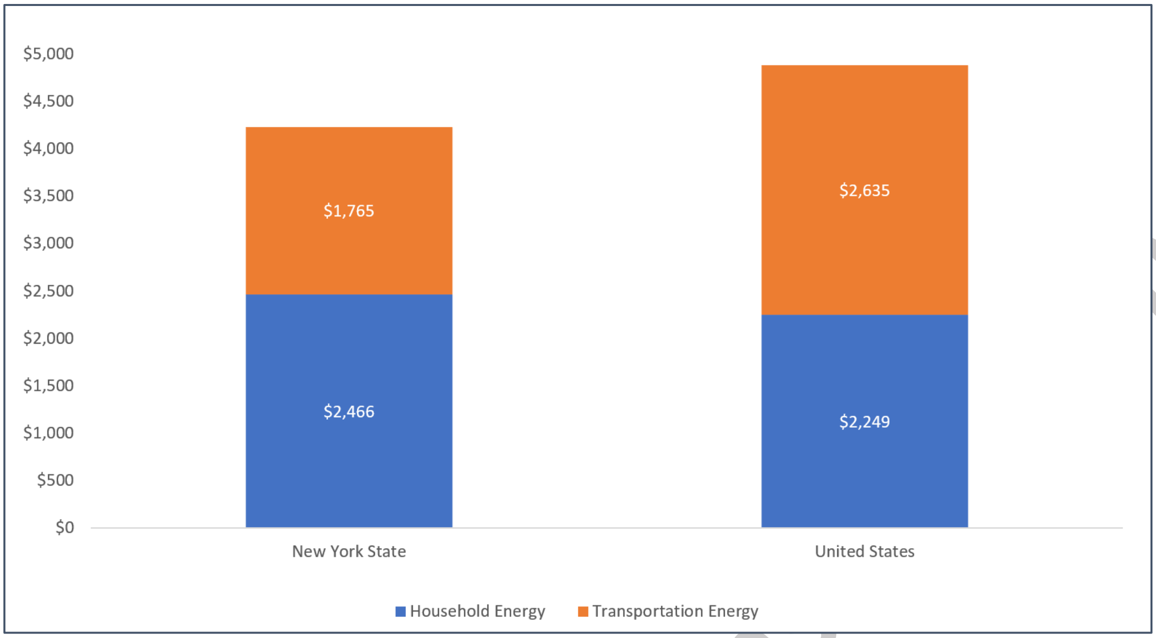


Figure 2. Average household and transportation energy expenditures, New York State and United States, 2021-2022

Energy prices can be higher in parts of NYS than the US average, but energy consumption is lower, leading to lower total household and transportation energy expenditures than the national average. Lower transportation spending offsets slightly higher household energy spending on a statewide basis in NYS. On average, NYS has the lowest average household Vehicle Miles of Travel (VMT) and transportation energy expenditures as a percentage of income in the nation.[6] Within the State, these dynamics vary: Average transportation energy expenditures as a percentage of income downstate is 50 percent lower than upstate, where it is comparable to the national average. This variation reflects the greater access to transit and less reliance on personal vehicles downstate relative to upstate.

As noted in Figure 3, New York households also spend less on energy compared to states that are the predominant targets of outmigration from the state. That is, households migrating to these other states would expect to spend more on energy after their move. These dynamics are similar to the comparison between average New York and U.S. households above: substantially lower household transportation energy offsets higher household energy spending.

[6] Zhou, Y., et al. Argonne National Laboratory. 2020. Affordability of Household Transportation Fuel Costs by Region and Socioeconomic Factors. Accessed 4/16/25, https://publications.anl.gov/anlpubs/2021/01/165141.pdf.

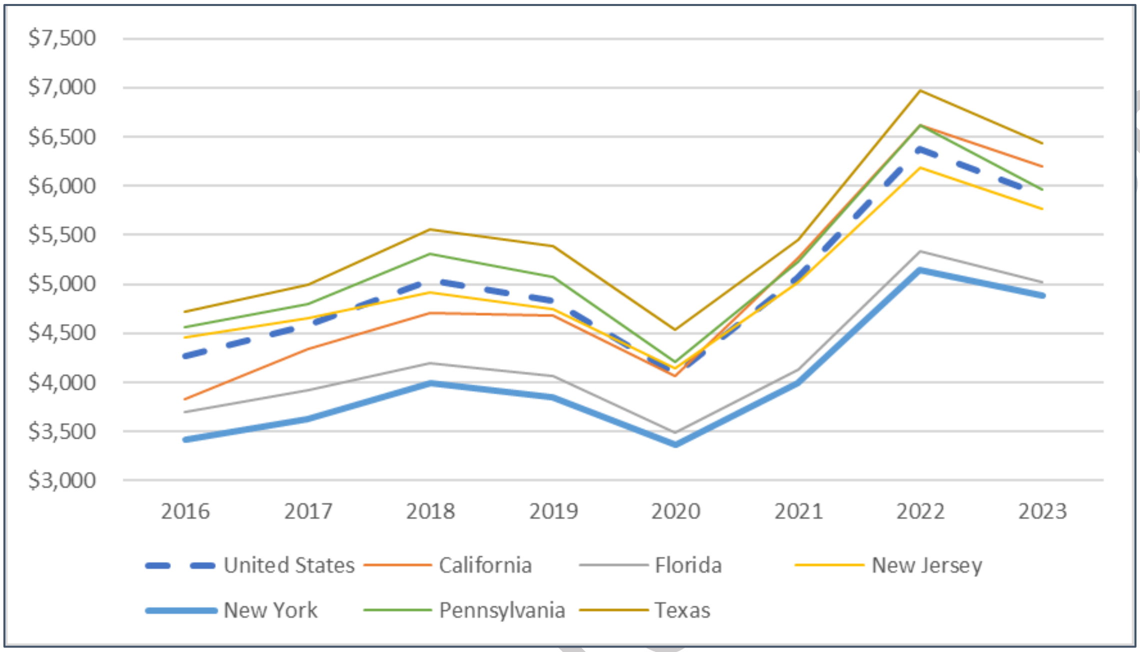


Figure 3. Total household energy and transportation energy cost per household, US, NYS, and top outmigration states from NYS[7]

2.2. Energy burden and energy insecurity

Across the U.S. and across New York, low- and moderate-income households are more likely to experience energy affordability challenges. As shown in Figure 4 below, energy expenditures and burdens follow a pattern of lower expenditures but disproportionate burdens at lower incomes. While on average and across all income levels, total household and transportation energy expenditures are lower in NYS than the US, the energy affordability needs of all New Yorkers are not always being met. In NYS, energy burdens experienced by households in the lowest income quintile are approximately 10 percent, or four times higher than average, and transportation energy burdens experienced by the lowest income quintile are approximately 6 percent, or three times higher than average. At nearly 16 percent, the total household energy and transportation energy burden experienced by the lowest income households is nearly four times higher than average. Notably, on average households in the second lowest income quintile experience energy burdens close to six percent.[8] [9]

[7] Source: U.S. Bureau of Economic Analysis. Regional Data, GDP and Personal Income. Accessed 5/2/25, https://www.bea.gov/itable/regional-gdp-and-personal-income.

[8] In the CE data, incomes in the lowest and second lowest quintile, together representing 40 percent of NYS households, were $12,749 and $35,983, respectively. The comparable U.S. incomes in the lowest and second quintiles were slightly higher at $13,678 and $36,104. The average income for CE households in NYS was $100,630 versus $90,718 for the US.

[9] Researchers are increasingly considering the total combined household energy and transportation energy burden to be a useful complement to energy burden that represents a comprehensive perspective on household energy spending. See, for example, Bell-Pasht, A., ACEEE. 2024. Combined Energy Burdens: Estimating Total Home and Transportation Energy Burdens. Accessed 5/1/25, https://www.aceee.org/topic-brief/2024/05/combined-energy-burdens-estimating-total-home-and-transportation-energy-burdens. See also, NREL. 2025. SLOPE: State and Local Planning for Energy. Energy Affordability – Household Energy and Transportation Burden. Accessed 5/1/25, https://maps.nrel.gov/slope/data-viewer?layer=eej.household-energy-burden.

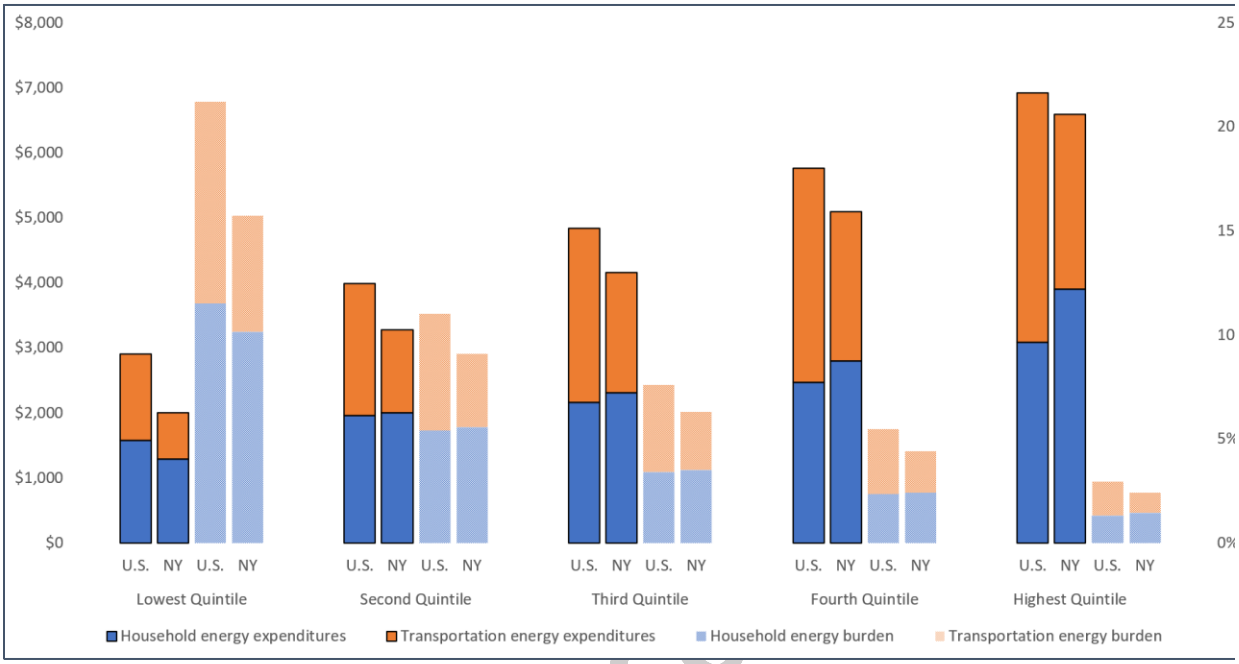


Figure 4. Energy and transportation expenditures and associated burdens by income quintile, United States and New York State, 2021-2022[10]

In addition to energy burden, lower income and more vulnerable households experience energy insecurity—for example, foregoing other expenses to pay for energy, keeping one's home at an unsafe temperature, or getting behind on an energy bill—at above average rates.[11] Indeed, at the end of 2024, nearly 1.4 million NYS households were in arrears with outstanding balances on their utility bills greater than 60 days overdue, representing a total amount owed of nearly $1.9 billion. These dynamics further exacerbate disparities in health and quality of life for vulnerable populations.

It is important to note that the energy expenditures and burdens presented above represent average, population-scale data as opposed to individual household experience. For example, in addition to households that pay for all of their utilities and drive daily, this data will necessarily include households who rent, don't pay a heating bill, and primarily use transit instead of driving. In addition, there is some time lag between the current moment and the most recently available data. For these reasons, these metrics are not directly comparable to any one individual household or segment of households, including those household profiles analyzed as part of the outlook in this chapter.

2.3. Mitigating barriers impacting access to affordable clean energy services

A variety of programs are available to advance energy affordability, either through bill assistance, or by advancing efficiency and electrification of buildings and transportation. Existing programs focused on

[10] US Bureau of Labor Statistics. Consumer Expenditure Surveys. New York: Quintiles of Income before taxes, 2021-2022 and US: Quintiles of Income before taxes, 2021 & 2022. Accessed 4/16/25, https://www.bls.gov/cex/tables.htm#geo.

[11] U.S. Census Bureau, Household Pulse Survey. Accessed 4/16/25, https://www.census.gov/data/experimental-data-products/household-pulse-survey.html. US Energy Information Administration, Residential Energy Consumption Survey. Accessed 4/16/25. https://www.eia.gov/consumption/residential/data/2020/. Households experiencing higher than average rates of energy insecurity from these data include minorities, people with disabilities, women, larger households, and households with children.

low-income households include the Weatherization Assistance Program, Empower+, Low-Income Home Energy Assistance Program, Energy Affordability Program, and the Energy Affordability Guarantee Pilot. Even more programs provide support for moderate-income households or households in general, such as Inflation Reduction Act rebates and tax credits, as well as a host of NYS-specific programs. NYSERDA maintains a list of programs here (https://www.nyserda.ny.gov/All-Programs) and a set of dashboards that track clean energy programs and investments here (https://www.nyserda.ny.gov/ny/dashboards).

However, low- and moderate-income households experience a range of barriers that inhibit access to affordable clean energy services. Often resulting from historical patterns of exclusion, segregation, and disinvestment in communities, these barriers can be linked by common themes: **Physical and Economic Structures and Conditions** (e.g., split incentives,[12] limited access to public transit or Electric Vehicle charging), **Financial and Knowledge Resources and Capacity** (e.g., lack of time, expertise, access to credit), **Perspectives and Information** (e.g., lack of trust[13]), and **Programmatic Design and Implementation** (e.g., program complexity, awareness gaps).[14] More action is needed to overcome barriers to affordable clean energy. More information on barriers to access and adoption can be found throughout the plan, and in the transportation, buildings, and environmental and climate justice chapters in particular.

3. Outlook

3.1. Analytic approach

The outlook is informed by a household energy affordability analysis, which assesses household and transportation energy expenditures for a set of household profiles and journeys that are representative of scenarios from the economywide pathways analysis.

As illustrated in Figure 5, The analytic approach starts with technology and measure characterization data and considers technology adoption over time from the economywide model, supplements this with household scale data, such as household energy and transportation energy demand, and energy price projections, and calculates household and transportation energy demand and expenditures.

[12] Split incentives occur when the benefits do not accrue to the party that makes an investment.
[13] Households may not always experience a high level of trust in clean energy programs, installers, and contractors to deliver promised performance.
[14] New York State Disadvantaged Communities Barriers and Opportunities Report. 2021. Accessed 4/16/25, https://climate.ny.gov/-/media/Project/Climate/Files/21-35-NY-Disadvantaged-Communities-Barriers-and-Opportunities-Report.pdf.

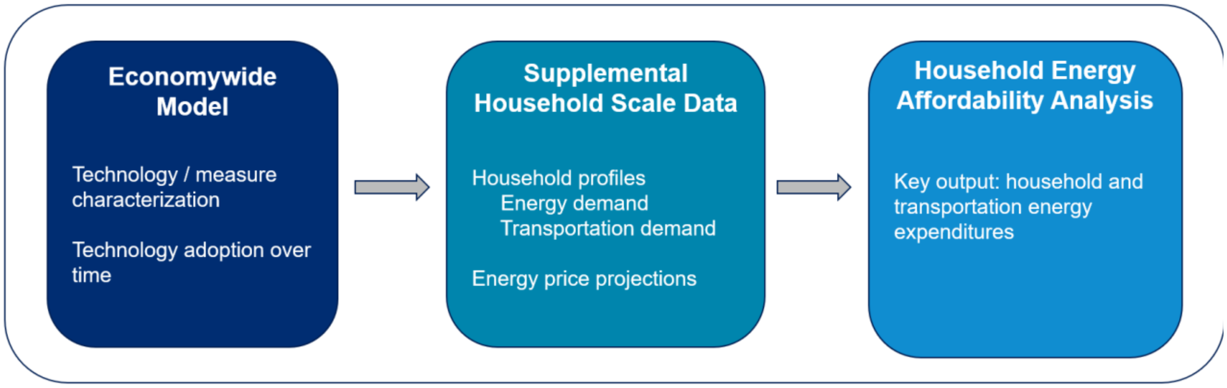
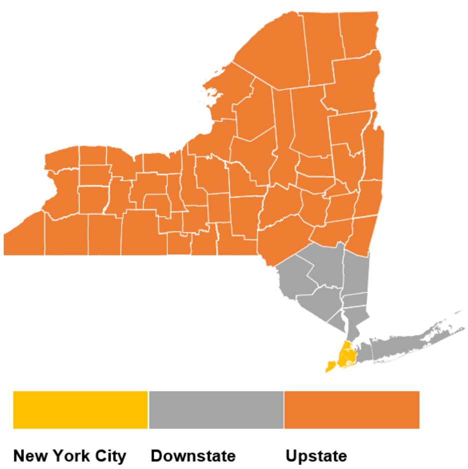


Figure 5. Household energy affordability analysis approach

In this way, the analysis represents household journeys that are consistent with the range of household technology adoption within the economywide scenarios.

The analysis includes household profiles for three income levels, low-, moderate-, and average income, across three regions of the State, Upstate, Downstate, and New York City, for a total of nine profiles. Figure 6 below illustrates the factors that represent and differentiate these household profiles.

Analysis Regions



Household Profiles

Region	Income Level	Housing Type	VMT *
Upstate	Low Income	Multifamily	16,954
Upstate	Moderate Income	Single Family	25,394
Upstate	Average Income	Single Family	29,114
Downstate	Low Income	Multifamily	13,702
Downstate	Moderate Income	Single Family	21,433
Downstate	Average Income	Single Family	32,728
NYC	Low Income	Multifamily	11,217
NYC	Moderate Income	Multifamily	13,178
NYC	Average Income	Multifamily	13,879

* Annual Vehicle Miles Traveled (VMT) for driving households in that region at that income level.

Figure 6. Analysis regions and household profiles

For each household profile, future household and transportation energy expenditures are calculated for four illustrative journeys involving different technology mixes and fuel types.

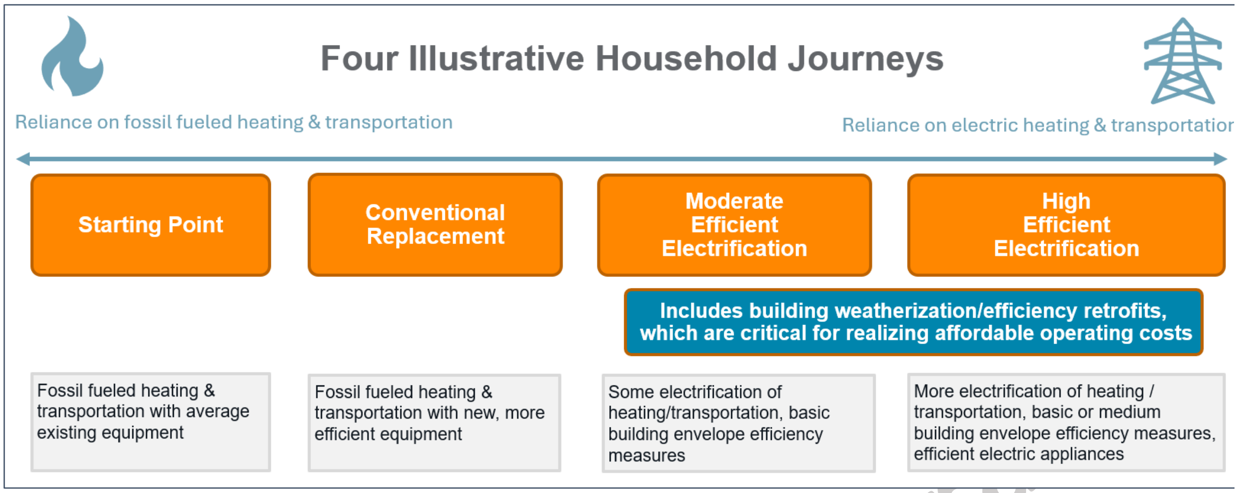


Figure 7. Household journeys

As Figure 7 shows, these journeys range from more reliant on fossil fueled heating and transportation to more reliant on efficient electric heating and transportation, with the critical role of building weatherization and efficiency retrofits reflected in each efficient electrification journey. A more detailed matrix of assumptions can be found in the appendix and the energy affordability data annex.

- Household journeys
  - **Starting Point:** Fossil fueled heating and transportation with average existing equipment
  - **Conventional Replacement:** Fossil fueled heating and transportation with new, more efficient equipment
  - **Moderate Efficient Electrification:** Some electrification of heating and transportation, with basic building envelope efficiency measures
  - **High Efficient Electrification:** More electrification of heating and transportation, with basic or medium building envelope efficiency measures, and efficient electric appliances

The analysis explores the cost impacts of these journeys across household profiles in a starting point year of 2026 and a five-year time step of 2031. More detailed assumptions can be found in the appendix and the energy affordability data annex.

3.2. Summary of findings

Energy saving measures, such as weatherization and building envelope efficiency, efficient appliances and equipment, fuel efficient and electric vehicles, and transit use, can lower overall household and transportation energy costs. Households pursuing these measures are likely to see gradually declining levels of energy consumption and operating costs in real dollar terms over time due to the combined impacts of adopting more efficient equipment. The nature and extent of these cost savings differs by profile, with dynamics that vary across regions, building types, and income levels. In addition, it is important to note that the actual savings and energy costs will vary depending on the unique circumstances of the household when pursuing energy efficiency and electrification projects. These factors include building envelope and insulation, home size and occupancy, type of home (e.g., single-family vs. multi-family), efficiency of existing and new equipment, extent of equipment replacement, and usage of equipment.

Table 1 shows changes in both total expenditures, and expenditures disaggregated household energy and transportation energy, across household profiles and journeys. These include variations that examine heating with oil as opposed to natural gas. Note that detailed results and additional sensitivities can be found in the energy affordability data annex.

The analysis shows significant opportunities for households to lower transportation energy expenditures. For driving households, both conventional replacement of gasoline vehicles with a more fuel-efficient option and vehicle electrification can lower transportation energy spending relative to the average starting point, and vehicle electrification can further reduce transportation energy spending relative to conventional replacement outside of NYC. In addition, households well-served by public transit, including in NYC, can keep overall energy costs lower than average by minimizing or avoiding transportation energy expenditures.

Household energy expenditures vary across profiles and journeys. Households that heat with a delivered fuel, such as heating oil, can realize substantial savings from efficient electrification. For some households that use natural gas heating, household energy costs could increase with heat pump adoption alone; however, the combined impacts of heat pump adoption, building envelope efficiency, and more efficient lighting and appliances can potentially lower household energy expenditures.

Although all household profiles see savings in combined total household and transportation energy spending relative to the 2026 Starting Point in the Conventional Replacement, Moderate Electrification, and High Electrification journeys, there are some instances where household energy spending increases. These are the upstate Moderate Electrification journey across income levels and the upstate High Electrification journey for low-income and average income households. In these cases, cost savings in transportation energy offset household energy spending increases. The expenditure values from which the percentage changes in Table 1 are derived can be found in Table 2, which also includes disaggregated household and transportation energy expenditures. Detailed results may be found in the energy affordability data annex.

Table 1. Changes in monthly household energy and transportation energy expenditures by profile and journey (real 2025 $)

Compared to Starting Point in 2026		2031			
Household Profile	**Expenditures**	**Starting Point**	**Conventional Replacement**	**Moderate Efficient Electrification**	**High Efficient Electrification**
Upstate, Moderate Income with Oil	Household	6%	-8%	-27%	-50%
	Transportation	1%	-39%	-48%	-63%
	Total	**4%**	**-22%**	**-36%**	**-56%**
Upstate, Low Income	Household	2%	-15%	4%	6%
	Transportation	1%	-39%	-56%	-69%
	Total	**1%**	**-30%**	**-32%**	**-39%**
Upstate, Moderate Income	Household	2%	-13%	10%	-8%
	Transportation	1%	-39%	-48%	-63%
	Total	**1%**	**-29%**	**-25%**	**-41%**
Upstate, Average Income	Household	2%	-13%	10%	1%
	Transportation	1%	-39%	-48%	-63%
	Total	**1%**	**-30%**	**-27%**	**-39%**
Downstate, Moderate Income with Oil	Household	6%	-8%	-18%	-34%
	Transportation	1%	-39%	-39%	-46%
	Total	**4%**	**-20%**	**-26%**	**-39%**
Downstate, Low Income	Household	5%	-13%	-6%	-11%
	Transportation	1%	-39%	-39%	-54%
	Total	**4%**	**-23%**	**-19%**	**-28%**
Downstate, Moderate Income	Household	5%	-11%	-7%	-23%
	Transportation	1%	-39%	-39%	-46%
	Total	**4%**	**-23%**	**-20%**	**-33%**
Downstate, Average Income	Household	5%	-11%	-7%	-17%
	Transportation	1%	-39%	-39%	-46%
	Total	**3%**	**-26%**	**-24%**	**-32%**
NYC, Low Income	Household	5%	-12%	-9%	-14%
	Transportation	1%	-39%	-19%	-35%
	Total	**4%**	**-20%**	**-12%**	**-20%**
NYC, Moderate Income	Household	5%	-12%	-9%	-14%
	Transportation	1%	-39%	-19%	-35%
	Total	**4%**	**-21%**	**-12%**	**-21%**
NYC, Average Income	Household	5%	-12%	-9%	-11%
	Transportation	1%	-39%	-19%	-35%
	Total	**4%**	**-21%**	**-12%**	**-19%**

3.3. Results and discussion

3.3.1. Monthly energy demand and expenditures

Figure 8, Figure 9, and Figure 10 below Illustrate the monthly energy expenditures in detail for a selection of profiles and journeys.[15] Although the analysis considers nine total household profiles and two additional variations with oil heat,[16] these selected profiles illustrate some key overall dynamics. Each figure displays average monthly expenditures for all relevant fuels and categorizes them as household energy and transportation energy. Detailed tables and figures for all profiles and journeys are available in the energy affordability data annex.

Relative to the Starting Point, energy efficiency drives sequentially greater reductions in energy consumption in the Conventional Replacement, Moderate Efficient Electrification, and High Efficient Electrification journeys. In the Conventional Replacement journey, energy consumption is reduced due to the replacement of existing equipment, such as more efficient lighting, heating systems, and vehicles, with new, more efficient versions. In the Moderate Efficient Electrification journey, energy consumption is further reduced by basic building envelope efficiency and including efficient electric equipment replacement to meet a portion of heating and transportation demand. The High Efficient Electrification journey results in the lowest energy consumption of the journeys, driven by a more efficient building envelope retrofit[17] and more fully electrifying heating, transportation, and other end-uses with efficient electric appliances.

Reductions in household and transportation energy expenditures generally follow these reductions in energy consumption relative to the starting point. However, there are some exceptions due to differences in energy prices by fuel and region. For example, as shown in Figure 8, household energy costs increasingly decline with the level of efficient electrification for households that heat with oil. However, for households that use natural gas in the starting point, cost dynamics vary by profile and journey. As illustrated in Figure 9, for an upstate household that heats with gas, Conventional Replacement results the greatest reduction in household energy costs, followed by High Electrification, which includes a more efficient building envelope retrofit than the Moderate Electrification profile. This highlights the importance of building envelope efficiency as a key factor in whether conversions to heat pumps from natural gas see operating cost savings. In this profile, savings from transportation electrification offset an incremental cost increase in household energy costs in the Moderate Electrification journey.

[15] Because of substantial differences in condition and energy use patterns across real-world households, not all households will experience the level of savings modeled..

[16] Note that additional sensitivities, such as low-income households in single-family homes, can be found in the appendix and energy affordability data annex.

[17] In the High Efficient Electrification Journey, the low- and moderate-income household profiles include a medium level of building envelope efficiency, while the average income household profiles include a basic level of building envelope efficiency. This distinction reflects the priority to pair heating electrification with weatherization and efficiency retrofits for low- and moderate-income households to ensure that operating costs remain reasonable.

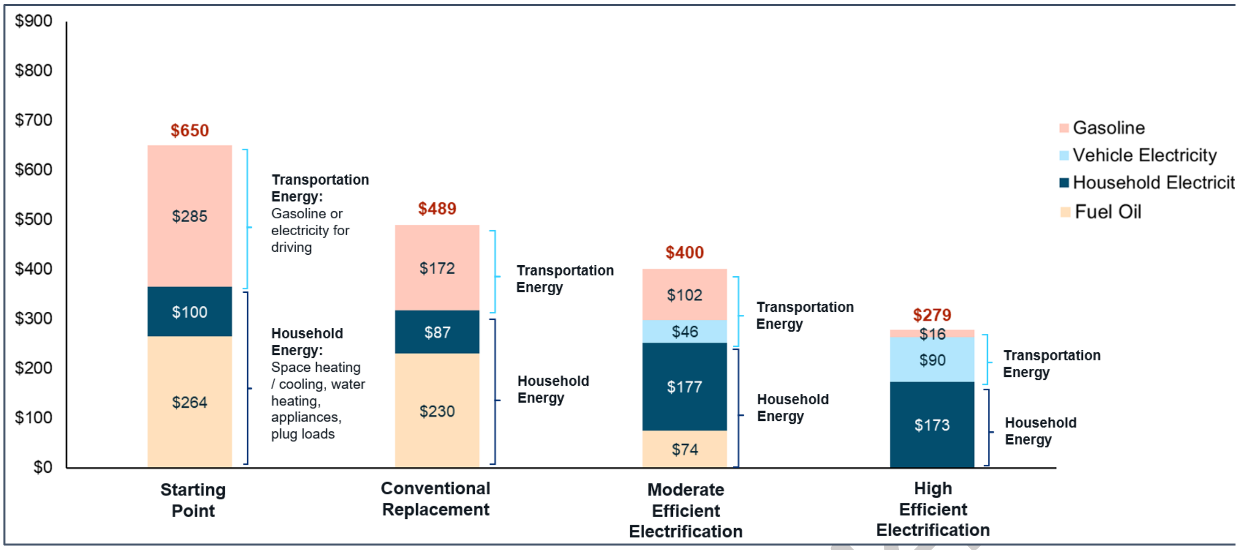


Figure 8. Total monthly household energy and transportation energy expenditures, Upstate, Single Family, Moderate Income, Oil Heat, 2031 (real 2025 $)

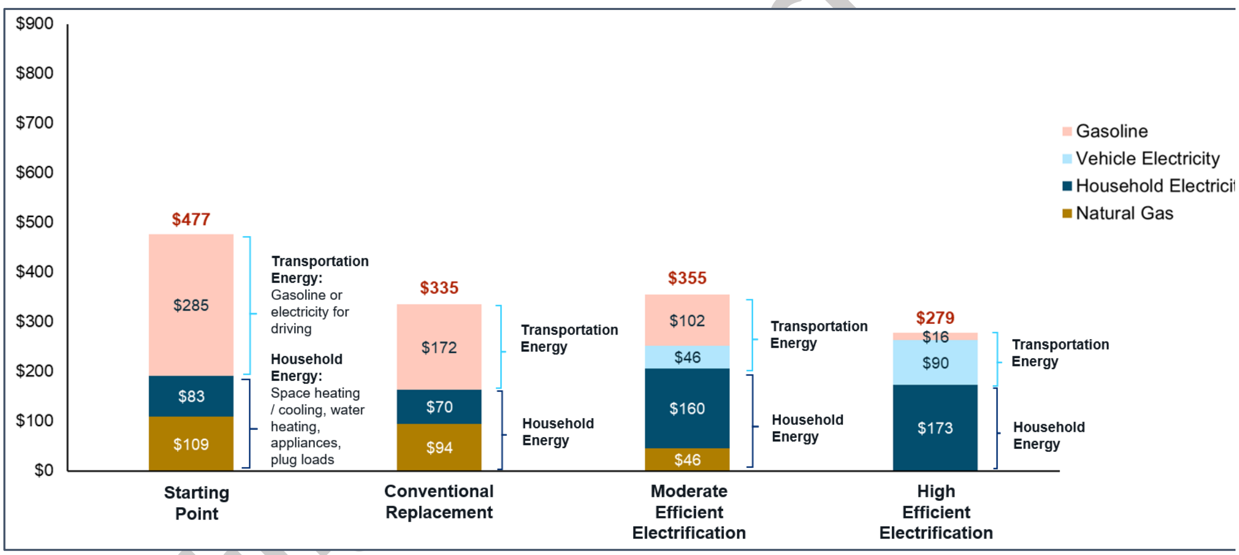


Figure 9. Total monthly household energy and transportation energy expenditures, Upstate, Single Family, Moderate Income, Natural Gas, 2031 (real 2025 $)

The New York City profile shown in Figure 10 presents a special case for a few reasons. First, although the profiles assume a driving household, a high share of households already manage their transportation energy costs by using public transit. In addition, for driving households, the efficiency of electric vehicles results in lower transportation energy expenditures relative to the Starting Point, even in NYC where electricity prices are higher than in other regions. However, in NYC, the transportation energy expenditures in the Conventional Replacement journey are lower than in either of the efficient electrification journeys, due in part to the impact of federal fuel economy standards on vehicle efficiency over time. However, even non-driving households in NYC would see reductions in household energy expenditures in all journeys beyond the Starting Point.

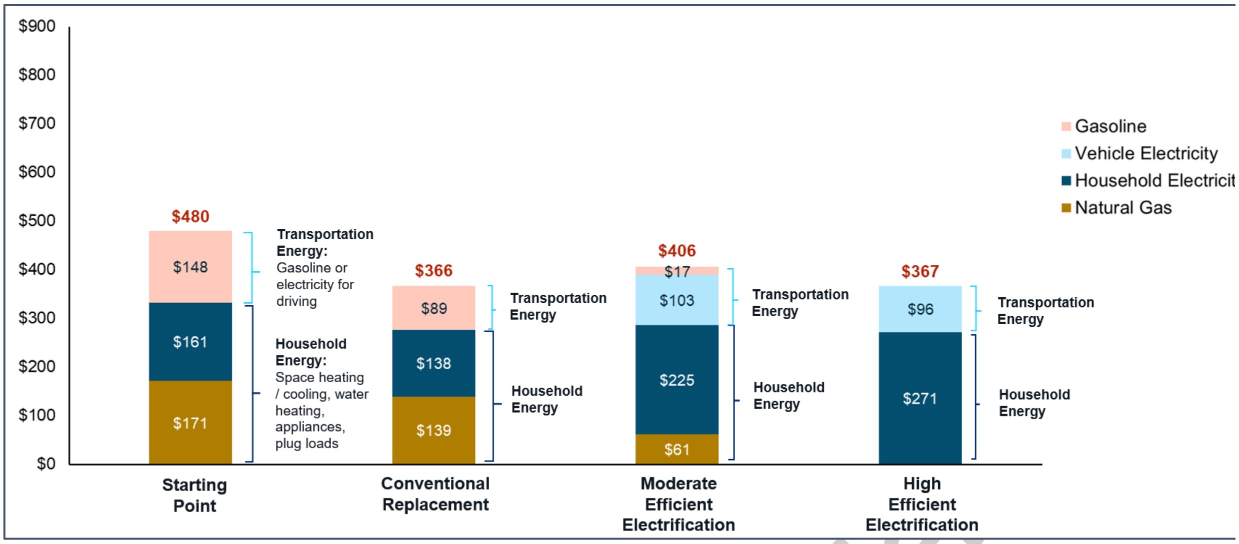


Figure 10. Total monthly household energy and transportation energy expenditures, NYC, Multifamily, Moderate Income, Natural Gas, 2031 (real 2025 $)

Table 2 shows both the total expenditures and expenditures disaggregated by household energy and transportation energy, across household profiles and journeys. Notably, although upstate low-income households in multifamily buildings that drive see operating cost declines in all journeys relative to the Starting Point, household energy expenditures in the Moderate and High Electrification journeys increase for this profile, due in part to the relatively lower energy savings levels realized by the medium level building shell package in multifamily relative to single family homes.

Results such as these underscore the need to pay special attention to transit-using households to ensure that these households experience overall operating cost reductions alongside efficient electrification. Similarly, households that do not currently pay a heating fuel bill (e.g., renters for whom heating is included in the rent), could see an increase in energy expenditures as more end uses are included in their electricity bill if heating fuel savings are not commensurately reflected in rents.

Table 2. Summary of expenditures by type and household profile (real 2025 $)

		2026	2031			
Household Profile	**Expenditures**	**Starting Point**	**Starting Point**	**Conventional Replacement**	**Moderate Efficient Electrification**	**High Efficient Electrification**
Upstate, Moderate Income with Oil	Household	*$344*	*$365*	*$317*	*$252*	*$173*
	Transportation	*$283*	*$285*	*$172*	*$148*	*$106*
	Total	***$627***	***$650***	***$489***	***$400***	***$279***
Upstate, Low Income	Household	*$126*	*$128*	*$107*	*$131*	*$133*
	Transportation	*$189*	*$190*	*$115*	*$84*	*$58*
	Total	***$315***	***$319***	***$222***	***$215***	***$191***
Upstate, Moderate Income	Household	*$188*	*$192*	*$164*	*$206*	*$173*
	Transportation	*$283*	*$285*	*$172*	*$148*	*$106*
	Total	***$471***	***$477***	***$335***	***$355***	***$279***
Upstate, Average Income	Household	*$188*	*$192*	*$164*	*$206*	*$190*
	Transportation	*$325*	*$327*	*$197*	*$170*	*$121*
	Total	***$512***	***$519***	***$360***	***$376***	***$311***
Downstate, Moderate Income with Oil	Household	*$392*	*$415*	*$360*	*$321*	*$258*
	Transportation	*$239*	*$241*	*$145*	*$145*	*$128*
	Total	***$631***	***$655***	***$505***	***$467***	***$385***
Downstate, Low Income	Household	*$226*	*$238*	*$198*	*$212*	*$201*
	Transportation	*$153*	*$154*	*$93*	*$93*	*$70*
	Total	***$379***	***$392***	***$290***	***$305***	***$271***
Downstate, Moderate Income	Household	*$336*	*$355*	*$300*	*$314*	*$258*
	Transportation	*$239*	*$241*	*$145*	*$145*	*$128*
	Total	***$575***	***$595***	***$445***	***$459***	***$385***
Downstate, Average Income	Household	*$336*	*$355*	*$300*	*$314*	*$279*
	Transportation	*$365*	*$367*	*$221*	*$222*	*$195*
	Total	***$701***	***$722***	***$522***	***$536***	***$474***
NYC, Low Income	Household	*$316*	*$332*	*$277*	*$286*	*$271*
	Transportation	*$125*	*$126*	*$76*	*$102*	*$82*
	Total	***$441***	***$458***	***$353***	***$388***	***$353***
NYC, Moderate Income	Household	*$316*	*$332*	*$277*	*$286*	*$271*
	Transportation	*$147*	*$148*	*$89*	*$119*	*$96*
	Total	***$463***	***$480***	***$366***	***$406***	***$367***
NYC, Average Income	Household	*$316*	*$332*	*$277*	*$286*	*$282*
	Transportation	*$155*	*$156*	*$94*	*$126*	*$101*
	Total	***$470***	***$488***	***$371***	***$412***	***$383***

3.3.2. Outlook including equipment cost

Figure 11 illustrates the impact of a sensitivity analysis that assesses the impact of up-front capital costs on monthly expenditures. Although households pursuing Efficient Electrification may experience lower total operating costs, the analysis shows these households would see a net cost increase relative to a Conventional Replacement journey when including the combined up-front costs for vehicles, heating systems, efficient appliances, and building envelope measures.

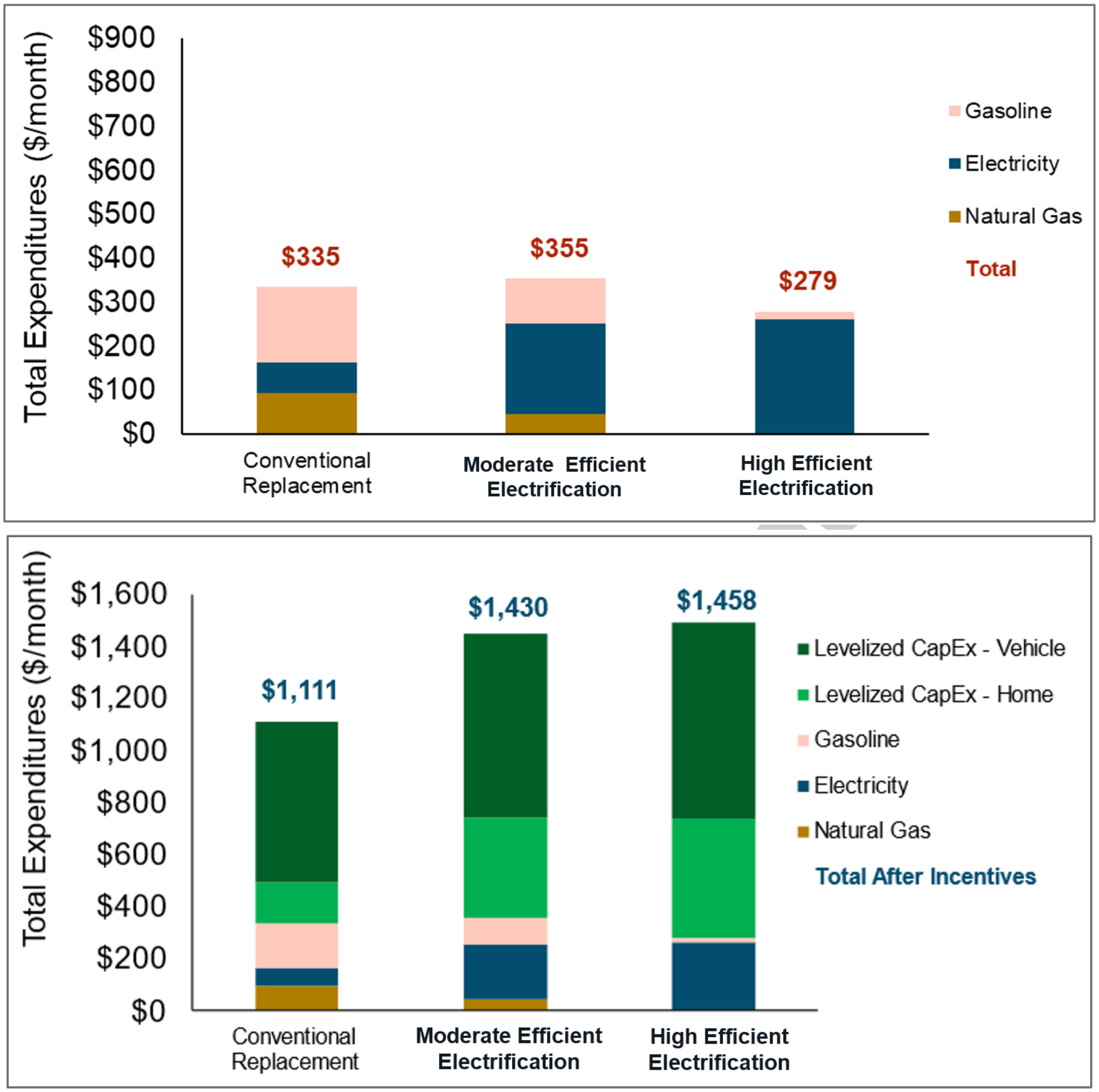


Figure 11. Total monthly household energy and transportation fuel expenditures, without and with levelized capital expenditures in 2031 for an illustrative upstate, single family, moderate income household (real 2025 $)

4. Energy affordability conclusions

Across the U.S. and New York, households face affordability challenges. As a subset of housing and transportation costs, energy is an important, but not a primary, driver of affordability challenges. To understand how energy costs impact people, it is important to look comprehensively at both household and transportation energy spending, which is lower in New York than the national average, as well as lower than the top outmigration states from New York.

Low- and moderate-income households are more likely to experience energy affordability challenges. Across the U.S. and New York, although low- and moderate-income households on average use less energy and spend less on energy than higher income households, their combined energy burdens are still often many times greater. In addition, lower income households and vulnerable populations experience energy insecurity at above average rates. These dynamics further exacerbate disparities in health and quality of life.

Energy saving measures, such as building envelope efficiency, efficient appliances and equipment, fuel efficient and electric vehicles, and transit use, can lower overall household energy costs. Many households pursuing these measures are likely to see net reductions in operating costs due to the combined impacts of a variety of efficiency measures, including efficient electrification, on household and transportation energy spending. However, the actual savings and energy costs will vary depending on the unique circumstances of the household when pursuing energy efficiency and electrification projects. These factors include building envelope and insulation, home size and occupancy, type of home (e.g., single-family vs. multi-family), efficiency of existing and new equipment, extent of equipment replacement, and usage of equipment. For some low- and moderate-income households, such as transit -dependent households and those that do not currently pay a heating bill, continued attention will be needed to there are no negative affordability impacts for households pursuing efficient electrification. New York should continue to investigate and develop affordability programming and electric rate designs that enhance low- and moderate-income households' ability to manage electricity costs.

Policy and market solutions that focus on lowering up-front costs and other barriers to adoption for a range of energy efficiency and efficient electrification measures have the potential to enable households to realize more affordable operating costs. This can in turn help to alleviate energy insecurity and energy burdens.

5. Themes and recommended actions

1. **Understanding energy affordability**

   - Although Federal data provides some insights on energy affordability, energy insecurity, and energy burden, these data have limitations in resolution and their continued availability is not guaranteed.
   - New interdisciplinary pilot research efforts are underway to develop capacity for New York State to better understand energy affordability.
   - However, sustained research to better understand the dynamics of energy affordability and household experiences over time is needed to ensure that New York State has access to timely and relevant information and policy-relevant insights.

2. **Advancing household energy affordability**

   - Weatherizing homes and buildings is a cornerstone of energy affordability and will lead to long term energy burden reduction by decreasing energy consumption and associated costs.

- Pursuing efficient electrification across household energy and transportation can drive reductions in overall operating costs for households.
- Continued attention will be needed to ensure there are no negative affordability impacts for households pursuing efficient electrification that are transit dependent or who don't currently pay heating bills.
- Continued investigation and development of affordability programming and electric rate designs can enhance low- and moderate-income households' ability to manage electricity costs.

3. **Opportunities to improve access to affordable clean energy services.**
    - Low- and moderate-income households experience a range of barriers that inhibit access to affordable clean energy services. More action is needed to overcome these barriers.
    - Inclusive program planning with representatives of disadvantaged communities will be key to pursuing opportunities to overcome barriers.
    - Interagency coordination will also be key to reducing program complexity and ensuring streamlined access to resources for LMI households and DACs.

Further recommendations for advancing energy affordability via household and transportation energy savings can be found in the Buildings, Transportation, and Environmental and Climate Justice chapters of this Plan.

Appendix

The household energy affordability analysis assesses household and transportation energy expenditures for a set of household profiles and journeys that are representative of scenarios from the economywide pathways analysis. The household profiles include representative housing types, income levels, and geographies across the state of New York, while the household journeys are scenarios with different technology mixes, fuel types, and levels of electrification and efficiency.

This appendix provides results for additional sensitivity analyses and describes the methodology for the analysis. Results for all household profiles are provided in the energy affordability data annex, along with inputs, assumptions, and sources.

1. Additional sensitivity analysis

1.1. Low-income single family household profile

The low-income household profiles in the primary analysis utilize energy demand levels for multi-family homes, as these align best with available energy demand benchmarks for low-income households, and a higher share of low-income households live in multi-family housing. This sensitivity analysis examines energy affordability for low-income single-family households. Table A1 shows changes in both total expenditures, and expenditures disaggregated by household energy and transportation energy, across household profiles and journeys. These profiles include variations that examine heating with fuel oil as opposed to natural gas.

Although all household profiles see savings in combined total household and transportation energy spending relative to the 2026 Starting Point in the Conventional Replacement, Moderate Efficient Electrification, and High Efficient Electrification journeys, household energy spending increases in the upstate single family natural gas profile in the Moderate Efficient Electrification journey. In this case, cost savings in transportation energy offset household energy spending increases. These results differ slightly from the primary analysis due to the energy savings levels realized by the medium level building shell package in single family relative to multifamily buildings.

The expenditure values from which the percentage changes in Table A1 are derived can be found in Table A2, which also includes disaggregated household and transportation energy expenditures.

Detailed results may be found in the energy affordability data annex.

Table A1. Changes in monthly household energy and transportation energy expenditures by profile and journey, low-income single family household sensitivity (real 2025 $)

Compared to Starting Point in 2026		2031			
Household Profile	**Expenditures**	**Starting Point**	**Conventional Replacement**	**Moderate Efficient Electrification**	**High Efficient Electrification**
Upstate SF, Low Income with Oil	Household	*6%*	*-8%*	*-27%*	*-50%*
	Transportation	*1%*	*-39%*	*-56%*	*-69%*
	Total	***4%***	***-19%***	***-37%***	***-57%***
Upstate SF, Low Income	Household	*2%*	*-13%*	*10%*	*-8%*
	Transportation	*1%*	*-39%*	*-56%*	*-69%*
	Total	***1%***	***-26%***	***-23%***	***-39%***
Downstate SF, Low Income with Oil	Household	*6%*	*-8%*	*-18%*	*-34%*
	Transportation	*1%*	*-39%*	*-39%*	*-54%*
	Total	***4%***	***-17%***	***-24%***	***-40%***
Downstate SF, Low Income	Household	*5%*	*-11%*	*-7%*	*-23%*
	Transportation	*1%*	*-39%*	*-39%*	*-54%*
	Total	***4%***	***-20%***	***-17%***	***-33%***

Table A2. Summary of expenditures by type and household profile, low-income single family household sensitivity (real 2025 $)

		2026	2031			
Household Profile	**Expenditures**	**Starting Point**	**Starting Point**	**Conventional Replacement**	**Moderate Efficient Electrification**	**High Efficient Electrification**
Upstate SF, Low Income with Oil	Household	*$344*	*$365*	*$317*	*$252*	*$173*
	Transportation	*$189*	*$190*	*$115*	*$84*	*$58*
	Total	***$533***	***$555***	***$432***	***$335***	***$231***
Upstate SF, Low Income	Household	*$188*	*$192*	*$164*	*$206*	*$173*
	Transportation	*$189*	*$190*	*$115*	*$84*	*$58*
	Total	***$377***	***$382***	***$278***	***$290***	***$231***
Downstate SF, Low Income with Oil	Household	*$392*	*$415*	*$360*	*$321*	*$258*
	Transportation	*$153*	*$154*	*$93*	*$93*	*$70*
	Total	***$544***	***$569***	***$453***	***$414***	***$328***
Downstate SF, Low Income	Household	*$336*	*$355*	*$300*	*$314*	*$258*
	Transportation	*$153*	*$154*	*$93*	*$93*	*$70*
	Total	***$489***	***$508***	***$393***	***$407***	***$328***

2. Methodology

This section summarizes the methods and data for the household energy affordability analysis. The following sections describe key inputs and assumptions, with additional details provided in the energy affordability data annex. The analytic approach incorporates technology and measure characterization data from the New York Pathways model. It also considers technology adoption over time from the economywide pathways analysis. The analysis then supplements this information with household scale data including household energy demand, transportation energy demand, and energy price projections, and then calculates household and transportation energy demand and expenditures.

2.1. Household profiles

Because energy spending varies by region and income, the analysis includes household profiles across three regions of the State and three income levels: Upstate, Downstate, and NYC; and low-income, moderate-income, and average income. Key assumptions were developed to align with region- and income-specific demand profiles for household energy and transportation energy. For household energy, energy demand profiles for each region for single-family and multifamily housing were reviewed and selected for alignment with energy demand benchmarks that reflect average demand patterns and typical housing types for each region and income level. For transportation energy, region- and income-specific household vehicle miles traveled (VMT) were developed that reflect average demand patterns for each region and income level. Table A3 summarizes key attributes of the nine core household profiles.

Table A3. Household profile matrix

Region	Income Level	Housing Type	Vehicle Miles Traveled
Upstate	Low Income	Multifamily	16,954
Upstate	Moderate Income	Single Family	25,394
Upstate	Average Income	Single Family	29,114
Downstate	Low Income	Multifamily	13,702
Downstate	Moderate Income	Single Family	21,433
Downstate	Average Income	Single Family	32,728
NYC	Low Income	Multifamily	11,217
NYC	Moderate Income	Multifamily	13,178
NYC	Average Income	Multifamily	13,879

The three income level definitions are:

- **Low-income** includes households with incomes at or below 60 percent of State Median Income.
- **Moderate-income** includes households with incomes above 60 percent but below 80 percent of State Median Income or Area Median Income, whichever is higher
- **Average income** uses the average income of a household in an analysis region to represent households with incomes that fall above the low- or moderate-income range.

Buildings

This analysis draws on a variety of sources to represent the components of total household energy expenditures, energy demand, and technology and measure characteristics from buildings. These include the NYSERDA Building Efficiency and Electrification Model (BEEM), which provides data based on empirical research and building simulations on energy demand by end use for different building types and regions in New York, and the New York Pathways model. The household scale BEEM data was used as a starting point and adjusted using assumptions from the New York Pathways model, including equipment efficiencies and costs. This approach represents specific household types while also aligning with building sector assumptions from the pathways analysis.

In this analysis, calculations were normalized to a per-housing unit basis for ease of comparison across household types. For master metered multifamily buildings, this means allocating building-wide bills equally across all building units. In addition, this analysis assumes that the resident pays for electricity and heating fuels, such as natural gas or oil, even though in reality some energy costs may be built into rent. In some real-world situations where heating fuel bills are included in rent, there may be a cost shift from owners to renters after electrification. For example, this could occur in multifamily units where the owner pays the gas bill, but the tenant pays the electricity bill.

The initial primary heating fuel for each profile is assumed to be natural gas. However, versions of the Upstate and Downstate moderate-income profiles with heating oil as the primary heating fuel are also included. In addition, a sensitivity analysis is included in this Appendix for Upstate and Downstate low-income households with a single-family housing energy demand profile.

Energy demand, equipment efficiency assumptions, and building shell measure savings are included in the energy affordability data annex.

Transportation

This analysis uses a variety of sources to represent the components of total energy expenditures, energy demand, and technology characteristics from transportation. These include the National Household Transportation Survey (NHTS) and the New York Pathways Model. The NHTS provides data on household transportation behavior, including household transportation demand, expressed as VMT, and number of vehicles per household, including for regions within New York State at different levels of household income. The VMT are multiplied by vehicle efficiencies drawn directly from the economywide pathways analysis to calculate energy demand, and subsequently, transportation energy expenditures. This approach represents regional- and income-differentiated transportation demand from different household types while also aligning with the light-duty vehicle assumptions from the pathways analysis.

Households were assumed to have either one or two vehicles based on region- and income-specific data.

Energy demand, vehicle efficiency assumptions, and VMT values are included in the energy affordability data annex.

2.2. Household journeys

For each household profile, household and transportation energy expenditures were calculated for four illustrative journeys with different technology mixes, fuel types, and levels of electrification and efficiency:

- ***Starting Point:*** a scenario with existing equipment in which natural gas or fuel oil and gasoline are the predominant energy sources for home heating and transportation, respectively.
- ***Conventional Replacement:*** a scenario with new equipment in which natural gas or fuel oil and gasoline are the predominant energy sources for home heating and transportation, respectively.
- ***Moderate Efficient Electrification:*** a scenario with basic building envelope and appliance efficiency measures where heat pumps meet most of the annual heating load and natural gas or fuel oil is used for heating in the coldest hours of the year. Transportation is partially decarbonized with a plug-in hybrid electric vehicle.

- ***High Efficient Electrification:*** a scenario with basic or medium building envelope efficiency measures and efficient electric appliances where heat pumps meet all heating and cooling loads, heat pump water heaters meet all water heating loads, and transportation is decarbonized with battery electric vehicles and plug-in hybrid electric vehicles.

Although the economywide pathways model includes a simulation of stock rollover at the sector, subsector, and end-use level, it does not explicitly model households. Therefore, the household energy affordability analysis cannot directly incorporate specific technology adoption profiles from the New York Pathways model. Instead, the analysis represents potential household journeys that are consistent with the range of household technology adoption within the economywide scenarios. Table A4 summarizes the equipment, vehicle, and shell measure assumptions by household profile and journey in greater detail.

While many variables determine household energy bills, a primary driver of home energy costs is heating and cooling. In the Starting Point journey, the home was assumed to have existing equipment, heated using natural gas or fuel oil and cooled with a central air conditioner (AC) for single-family homes and a window AC for multifamily homes. In the Conventional Replacement journey, the home was assumed to have new equipment including a boiler or furnace fueled with natural gas or fuel oil as well as a central or window AC. In the Moderate Efficient Electrification journey, the home was assumed to have a ducted air source heat pump (ASHP) for single-family homes and a ductless ASHP for multifamily homes, where the heat pump provides 80% of space heating requirements and a natural gas or fuel oil furnace or boiler provides backup for the remaining 20%. In the High Efficient Electrification scenario, the home was assumed to have a ducted ASHP for single-family homes and a ductless ASHP for multifamily homes, without any fossil fuel backup.

In the Starting Point and Conventional Replacement journeys, the home was assumed to have an existing building shell without any efficiency improvements. In the Moderate Efficient Electrification journey, single-family homes were assumed to have a shell improvement consisting of air sealing, ceiling/attic insulation, and rim joist insulation. Multifamily homes were assumed to have a shell improvement consisting of air sealing and roof insulation. In the High Efficient Electrification journey, single-family low- and moderate-income homes were assumed to have a shell improvement consisting of air sealing, ceiling/attic insulation, rim joist insulation, and wall insulation. Multifamily low- and moderate-income homes were assumed to have a shell improvement consisting of air sealing, roof insulation, and double-pane windows. Average income homes were assumed to have the same shell improvements as the Moderate Efficient Electrification scenario. This distinction reflects the priority to pair heating electrification with weatherization and efficiency retrofits for low- and moderate-income households to ensure that operating costs remain reasonable.

For transportation, energy bills were calculated for the number of vehicles that are typical for each area. In New York City, expenditures include transportation costs for one vehicle per household. For the Downstate and Upstate regions, expenditures include transportation costs for one vehicle per household for low-income households and two vehicles per household for moderate- and average-income households. In the Starting Point journey, the home was assumed to have existing internal combustion engine (ICE) vehicles. In the Conventional Replacement journey, the home was assumed to have new ICE vehicles with higher efficiency. In the Moderate Efficient Electrification journey, the home was assumed to have either one plug-in hybrid electric vehicle (PHEV) or one ICE vehicle and one PHEV, depending on whether the home has one or two vehicles. In the High Efficient Electrification scenario, the home was assumed to have either one battery electric vehicle (BEV) or one PHEV and one BEV, depending on whether the home has one or two vehicles.

In addition to space heating, space cooling, and transportation, this analysis also included appliances and plug loads. In the Starting Point journey, the home was assumed to have an existing gas or electric stove and a mixture of incandescent, CFL, and LED lighting. Additionally, single family homes were assumed to have a gas or electric clothes dryer. In the Conventional Replacement and Moderate Efficient Electrification journeys, the home was assumed to have a new gas or electric stove and LED lighting. Single family homes were assumed to have a new gas or electric clothes dryer. In the High Efficient Electrification scenario, the home was assumed to have an efficient electric clothes dryer, an induction stove, and LED lighting.

Table A4. Equipment, vehicle, and building shell assumptions by household profile and journey

Household Profile	Starting Point	Conventional Replacement	Moderate Efficient Electrification	High Efficient Electrification
Upstate, Moderate Income with Oil	* Oil space heating with central AC * Oil water heating * Two fleet average gasoline vehicles * Electric clothes dryer and stove, incandescent/CFL/LED lighting	* Efficient oil space heating and central AC * Efficient oil water heating * Two new gasoline vehicles * Efficient electric clothes dryer and stove, LED lighting	* Basic shell + ducted ASHP, 20% fuel backup * Efficient oil water heating * One new gasoline vehicle, one PHEV * Efficient electric clothes dryer and stove, LED lighting	* Medium shell + ducted ASHP * Heat pump water heating * One PHEV, one BEV * Efficient electric clothes dryer, induction stove, LED lighting
Upstate, Low Income	* Gas space heating with window AC * Gas water heating * One fleet average gasoline vehicle * Gas stove, incandescent/CFL/LED lighting	* Efficient gas space heating and window AC * Efficient gas water heating * One new gasoline vehicle * Efficient gas stove, LED lighting	* Basic shell + ductless heat pump, 20% fuel backup * Efficient gas water heating * One PHEV * Efficient gas stove, LED lighting	* Medium shell + ductless heat pump * Heat pump water heating * One BEV * Induction stove, LED lighting
Upstate, Moderate Income Upstate, Average Income	* Gas space heating with central AC * Gas water heating * Two fleet average gasoline vehicles * Gas clothes dryer and stove, incandescent/CFL/LED lighting	* Efficient gas space heating and central AC * Efficient gas water heating * Two new gasoline vehicles * Efficient gas clothes dryer and stove, LED lighting	* Basic shell + ducted ASHP, 20% fuel backup * Efficient gas water heating * One new gasoline vehicle, one PHEV * Efficient gas clothes dryer and stove, LED lighting	* Medium shell (moderate income), basic shell (average income) * Ducted ASHP * Heat pump water heating * One PHEV, one BEV * Efficient electric clothes dryer, induction stove, LED lighting
Downstate, Moderate Income with Oil	* Oil space heating with central AC * Oil water heating * Two fleet average gasoline vehicles * Electric clothes dryer and stove, incandescent/CFL/LED lighting	* Efficient oil space heating and central AC * Efficient oil water heating * Two new gasoline vehicles * Efficient electric clothes dryer and stove, LED lighting	* Basic shell + ducted ASHP, 20% fuel backup * Efficient oil water heating * One new gasoline vehicle, one PHEV * Efficient electric clothes dryer and stove, LED lighting	* Medium shell + ducted ASHP * Heat pump water heating * One PHEV, one BEV * Efficient electric clothes dryer, induction stove, LED lighting
Downstate, Low Income	* Gas space heating with window AC * Gas water heating * One fleet average gasoline vehicle * Gas stove, incandescent/CFL/LED lighting	* Efficient gas space heating and window AC * Efficient gas water heating * One new gasoline vehicle * Efficient gas stove, LED lighting	* Basic shell + ductless heat pump, 20% fuel backup * Efficient gas water heating * One PHEV * Efficient gas stove, LED lighting	* Medium shell + ductless heat pump * Heat pump water heating * One BEV * Induction stove, LED lighting
Downstate, Moderate Income Downstate, Average Income	* Gas space heating with central AC * Gas water heating * Two fleet average gasoline vehicles * Gas clothes dryer and stove, incandescent/CFL/LED lighting	* Efficient gas space heating and central AC * Efficient gas water heating * Two new gasoline vehicles * Efficient gas clothes dryer and stove, LED lighting	* Basic shell + ducted ASHP, 20% fuel backup * Efficient gas water heating * One new gasoline vehicle, one PHEV * Efficient gas clothes dryer and stove, LED lighting	* Medium shell (moderate income), basic shell (average income) * Ducted ASHP * Heat pump water heating * One PHEV, one BEV * Efficient electric clothes dryer, induction stove, LED lighting
NYC, Low Income NYC, Moderate Income NYC, Average Income	* Gas space heating with window AC * Gas water heating * One fleet average gasoline vehicle * Gas stove, incandescent/CFL/LED lighting	* Efficient gas space heating and window AC * Efficient gas water heating * One new gasoline vehicle * Efficient gas stove, LED lighting	* Basic shell + ductless heat pump, 20% fuel backup * Efficient gas water heating * One PHEV * Efficient gas stove, LED lighting	* Medium shell (low- and moderate-income), basic shell (average income) * Ductless heat pump * Heat pump water heating * One BEV * Induction stove, LED lighting

2.3. Electricity and fuel prices

Economy-wide trends are expected to impact the rates charged for energy services, with important implications for customer affordability. While recognizing that there are significant unknowns, this analysis drew on the best available data to provide informed projections of future customer rates. The electric rates in this analysis are utility-specific average residential rates based on 2023 utility residential revenue and sales as reported by the U.S. Energy Information Agency (EIA) in Form EIA-861. These initial electric rates were adjusted using escalators based on EIA's Annual Energy Outlook 2023 Retail Rate Forecast, which differentiates by upstate versus downstate regions as well as by customer class. Between 2024 and 2031, the escalators result in an annual average nominal compound annual growth rate (CAGR) of approximately 1.9% downstate and 1.1% upstate. Similarly, utility-specific residential volumetric rates and monthly charges for natural gas customers were adjusted using escalators based on a 10-year trend (2014-2023) of the NY Department of Public Service (DPS) utility total bill estimates, which differ by customer class and utility. Between 2024 and 2031, this results in an annual average nominal CAGR of approximately 3.5% downstate and 2.4% upstate.

The analysis used the projected costs of residential fuel oil and vehicle gasoline from the economywide pathways analysis, using the Central fuel price scenario.

The electricity, natural gas, fuel oil, and gasoline prices are included in the energy affordability data annex.

2.4. Equipment costs

In addition to the cost of energy, the analysis assessed the upfront capital costs of equipment and the associated annual maintenance costs. The analysis used capital and maintenance costs from the pathways analysis for building shell upgrades; space heating, space cooling, water heating, clothes drying, and cooking equipment; and vehicles. To make a meaningful comparison with other cost categories, capital costs were levelized assuming a 7% financing rate, using equipment lifetimes from BEEM for space heating and from the pathways analysis for all other equipment.

A range of incentives are potentially available to households that invest in electrification and building shell improvements. Given the uncertainty in federal incentive levels, the analysis included a sensitivity to assess the impact of federal Inflation Reduction Act (IRA) tax credits for cold climate heat pumps, heat pump water heaters, building shell improvements, and electric vehicles.

The equipment cost and incentive assumptions are included in the energy affordability data annex.

Public Health Impacts Analysis

Key Findings

- 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 and therefore lower pollutant concentrations. As a result of policies in the Draft 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 reducing premature mortality by approximately 9,700 cases, along with an estimated 4,100 fewer nonfatal heart attacks and nearly 12,500 fewer emergency room visits for asthma, and 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 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 Draft Plan: Current Policies, Additional Action, and Net Zero A. In general, the projected air pollution concentration reductions and ensuing health benefits from the Additional Action scenario are 30% greater than those from the Current Policies scenario, and the estimated potential benefits from the Net Zero A scenario are approximately double the Additional Action scenario's benefits.
- While roughly 36% of the statewide population are projected to live in geographic areas that are designated as disadvantaged communities (DACs) in analysis years, DAC areas would accrue almost 50% of the physical health benefits under all scenarios because DAC areas generally benefit from greater improvements in air quality and have a higher baseline rates of health the health conditions analyzed compared to non-DAC areas. Higher benefits within DAC areas are expected in all areas of the state.
- The greatest benefits would occur in urban areas where air pollutant emission reductions and population are greatest. The vast majority of the health benefits would come from emission reductions in the transportation and buildings sectors. While electricity generation is a small contributor to benefits statewide, under all scenarios, benefits in DAC areas from electricity generation are higher, resulting in 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 $65 billion for Additional Action (net present value 2024$).

Key Terms

- **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 (SO_2), ammonia (NH_3), and volatile organic compounds (VOCs).
- **Ozone** is 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.

1. Overview of Public Health Analysis Approach

This public health analysis evaluated the benefits associated with the future energy scenarios developed in the Pathways Analysis, described in greater detail in the Pathways Analysis chapter of this Draft State Energy Plan (Draft Plan). The health analysis estimated 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 changes in reductions of air pollutant emissions based on changes in fuel consumption resulting 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 monetized value of the change in health effects using standard economic values.

NYSERDA used a newly developed air quality and health impacts modeling framework—the New York Community-Scale Health and Air Pollution Policy Analysis (NY-CHAPPA) model—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).[2] Emissions were estimated based on regional changes in fuel consumption from the Pathways Analysis for each scenario and downscaled to the census tract level.

To calculate changes in health effects for the Draft 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 (SO_2), volatile organic compounds (VOCs), and ammonia (NH_3) 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.

[1] New York Climate Action Council. Scoping Plan, Appendix G: Integration Analysis Technical Supplement. December 19, 2022.

[2] NY-CHAPPA uses the definitions of geographic DAC areas developed and released by the NY Climate Justice Working Group (CJWG) in 2023, available at: https://climate.ny.gov/Resources/Disadvantaged-Communities-Criteria. 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 supplemented the DAC criteria by including low-income households located anywhere in the state; however, this spatial health impacts analysis uses only the geographic criteria for analyzing DAC areas.

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. [3,4] These individual physical health effects are also evaluated as a monetized 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 Draft Plan. NY-CHAPPA calculates both a low and high value, based on different approaches for estimating avoided mortality and nonfatal heart attacks.

For the health analysis, the change in health effects is estimated relative to the No Action scenario which excludes recent State and local policies. For more information on the health analysis methodology see 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 Draft 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.[5] 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, are included where available, and the results are clearly marked to indicate whether the results are from $PM_{2.5}$, ozone, or both.

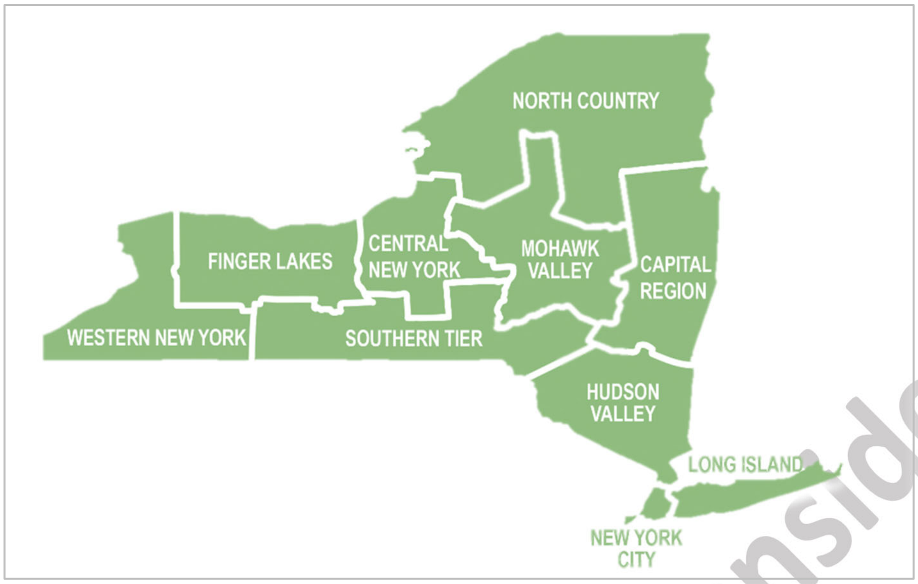
In many cases, results are presented at the regional level to show the geographic distribution of the benefits. Figure 1 shows the regions used in this health analysis.

[3] Ito, K., G. Thurston, R. Silverman. Characterization of PM2.5, 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.

[4] 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.

[5] U.S. Environmental Protection Agency. CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool. 2014. Model updated 2024.

Figure 1. NYS 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.

2. Overview of the Public Health Analysis Scenarios

The health analysis focused on three scenarios of the Draft Plan, described in detail in the Pathways Analysis chapter of this Plan and briefly summarized in Table 1.[6] The core planning scenario for the State Energy Plan is represented by the Additional Action scenario.

Table 1. Scenarios Considered in the Health Analysis

Scenario	Description
No Action	Includes federal incentives (as of Q1 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, 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 State Energy Plan.
Net Zero A	Accelerates adoption of clean energy technologies in all sectors toward achievement of economywide net zero by 2050.

[6] 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 B was excluded from the analysis and its health benefits are expected to be similar to those of Net Zero A.

3. Public Health Impact Analysis Results

The results in this section show the estimated air quality and public health benefits of the Current Policies, Additional Action, and Net Zero A 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 monetized 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.[7] 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.

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 is 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, and finally discussion and analysis of the findings and their implications.

3.1. Statewide Health Benefits

Under all scenarios in the Draft Plan, reductions in air pollutant concentrations are projected to result in public health benefits relative to the No Action scenario. Figure 2 shows the avoided annual occurrence of premature mortality (from $PM_{2.5}$ and ozone), nonfatal heart attacks (from $PM_{2.5}$ only),[8] 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 benefits from Net Zero A are expected to be double those of Additional Action, which in turn are 30% greater than the health benefits expected for Current Policies. Figure 3 shows the cumulative number of avoided health effects from 2025–2040 for these three health endpoints.

[7] NY-CHAPPA calculates both a low and high value, based on different approaches for estimating avoided mortality and nonfatal heart attacks.

[8] Avoided cases of nonfatal heart attacks shown in Figures 2 and 3 are only due to reductions in $PM_{2.5}$ concentrations. The impacts of reductions in ozone concentrations on nonfatal heart attacks is not available.

Figure 2. Annual Avoided Cases from Reductions in $PM_{2.5}$ and Ozone Concentrations by Scenario (2030, 2035, 2040)

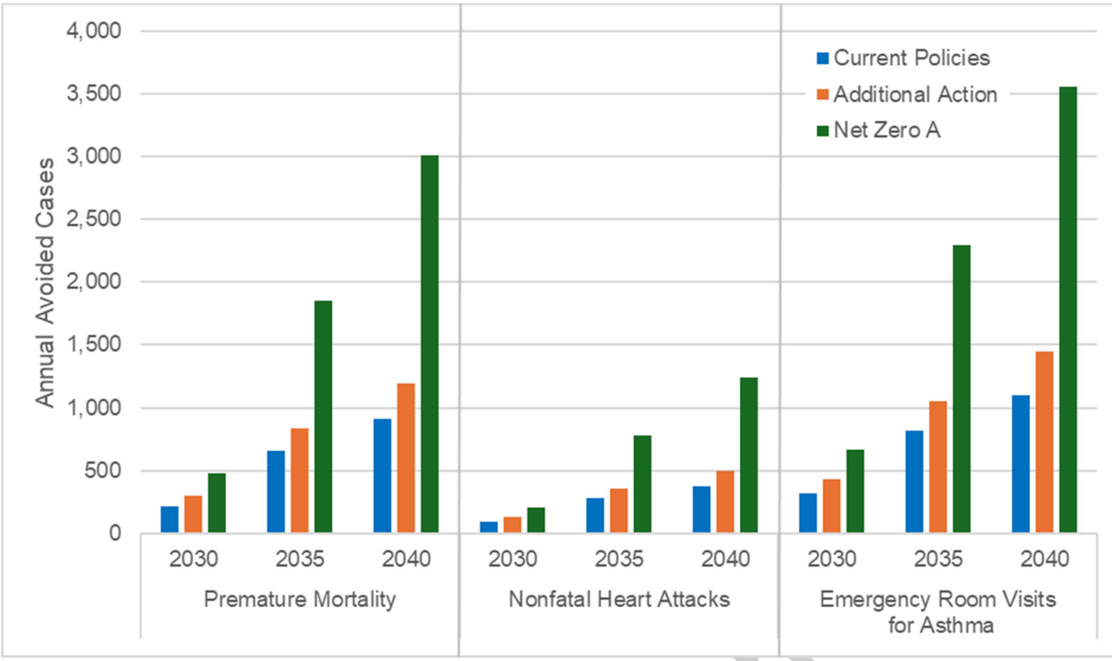


Figure 3. Cumulative Avoided Cases from Reductions in $PM_{2.5}$ and Ozone Concentrations by Scenario (2025 – 2040)

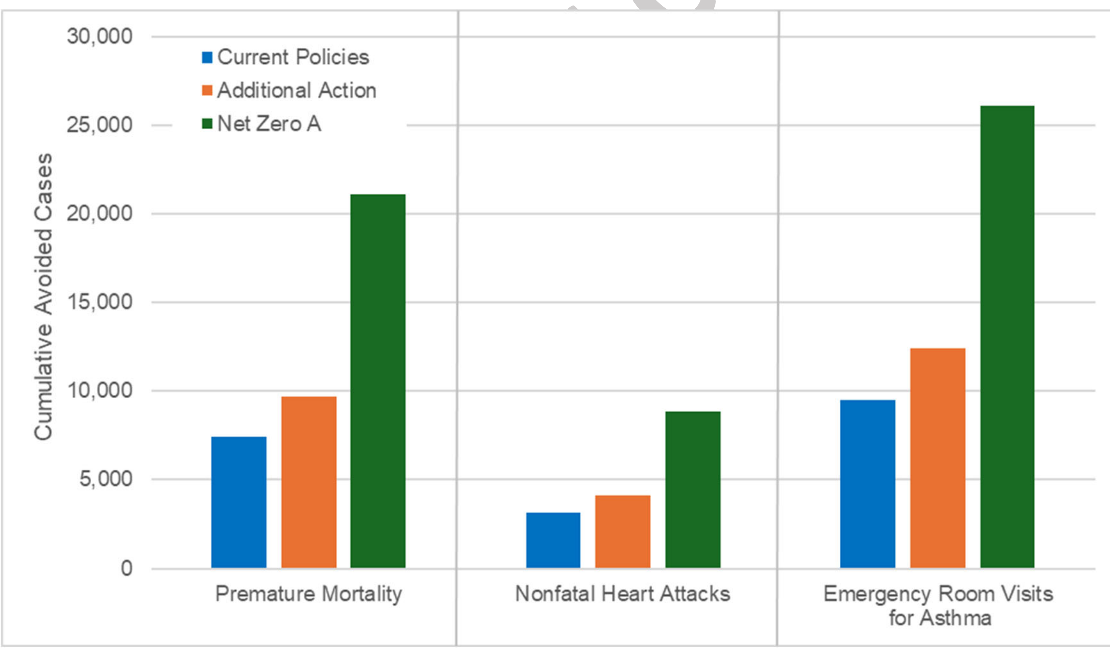


Table 2 shows avoided health effects from $PM_{2.5}$ concentration reductions for all three scenarios in 2040 including additional health endpoints. All scenarios are projected to result in health benefits across the range of endpoints, and the magnitude of benefits increases from Current Policies to Additional Action to Net Zero A as the reductions in economywide fuel combustion increase. In 2040, for example, Net Zero A is expected to result in approximately 3,000 avoided premature mortality cases, and the Current

Policies and Additional Action scenarios have estimated avoided mortality of approximately 900 cases and 1,200 cases per year, respectively. See the data annex for county level avoided health occurrences for all model years.

Under all scenarios, geographic DAC areas would experience greater avoided health effects than their share of the state's population (36%) because DACs have higher baseline incidence for the health endpoints analyzed. For example, DAC areas would experience 71% or 72% of the benefits (depending on the scenario) 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.

Table 2. Summary of Annual Statewide Avoided Public Health Effects due to Reduced $PM_{2.5}$ Concentrations by Scenario (2040)

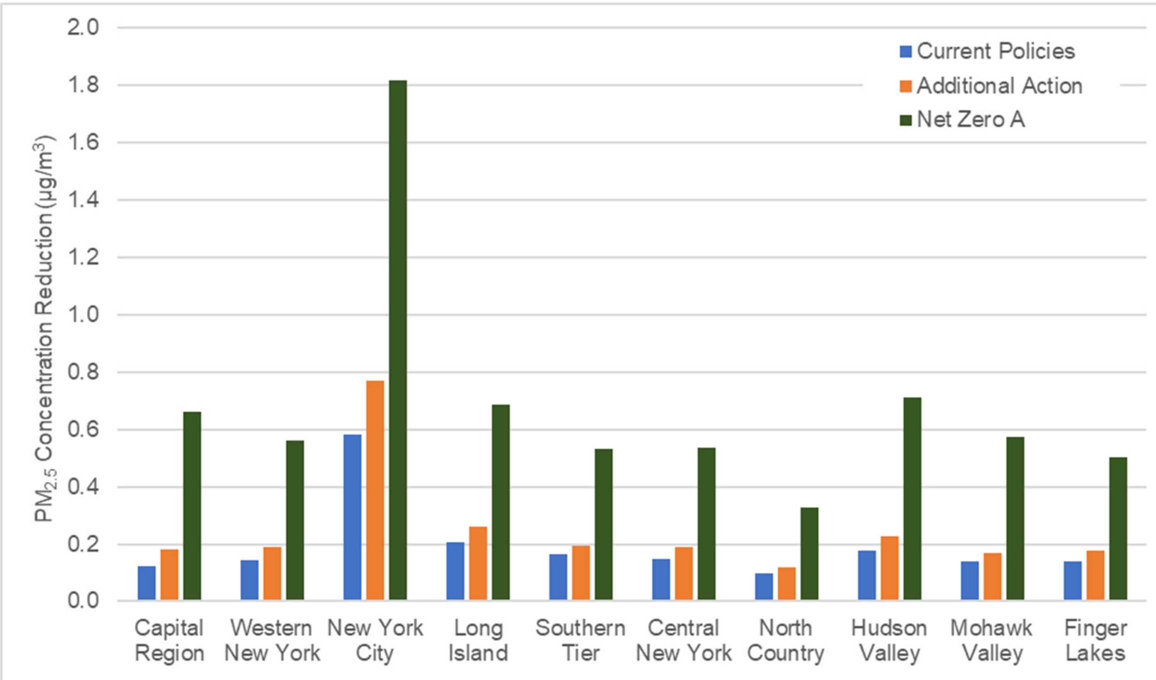
Health Effect	Avoided Cases per Year			DAC Area Fraction
Geographic Population of disadvantaged communities in New York:				36%
Scenario:	Current	Adt'l Action	Net Zero A	
Premature Mortality	890	1,200	3,000	
Nonfatal Heart Attacks	380	500	1,200	
Hospitalizations	250	320	810	
Acute Bronchitis	390	510	1,300	
Respiratory Symptoms	12,200	16,000	40,200	
Emergency Room Visits, Asthma	1,100	1,400	3,600	
Asthma Exacerbation	7,400	9,800	24,700	
Minor Restricted Activity Days	245,300	321,500	800,000	
Work Loss Days	41,600	54,600	135,500	

3.2. Benefits by Region

Every region of the state would experience air quality improvements in all scenarios relative to the No Action scenario. Figure 4 shows the population-weighted distribution of annual average $PM_{2.5}$ concentration reductions 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 reduction of nearly 0.8 $\mu g/m^3$ in annual average $PM_{2.5}$ concentrations, whereas the other regions are expected to experience an approximately 0.2 $\mu g/m^3$ reduction in annual average $PM_{2.5}$ concentrations in 2040. 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 emission reductions 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 4. Population-Weighted Average $PM_{2.5}$ Concentration Reductions by Scenario Relative to the No Action Scenario, 2040 ($\mu g/m^3$)



Due to the reductions in $PM_{2.5}$ concentrations, each region would also experience population-level public health benefits (Figure 5). While all the regions would experience net positive health benefits, most of the benefits in all scenarios would accrue in the New York City region because it has the highest population density and would experience the greatest reduction in air pollution emissions, 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 5). However, while the New York City region is expected to experience higher benefits than other regions in all scenarios analyzed, that discrepancy is slightly less pronounced under the Additional Action scenario relative to the Current Policies, and substantially less pronounced under the Net Zero A scenario. 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 scenarios with higher mitigation levels relative to the Current Policies.

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. Overall, DAC areas would experience greater reductions in air pollution emissions, particularly from on-road vehicles and buildings (see Section 3.3).

Figure 5. Per Capita Annual Health Benefits by Scenario and Region for DAC and Non-DAC Areas from Reduced $PM_{2.5}$ Concentrations (2040)

Using the Additional Action scenario as a representative example, Figure 6 shows that in each region, geographic DAC areas receive a larger share of 2025–2040 cumulative monetary value from reductions in $PM_{2.5}$ concentrations relative to their share of the population. Similar relationships are observed for the Current Policies and Net Zero A scenarios (see the appendix to this chapter).

Figure 6. Fraction of Cumulative Benefits due to Reduced $PM_{2.5}$ Concentrations Accruing in DAC Areas Compared to Fraction of Population in DAC Areas (Additional Action Scenario, 2025–2040)

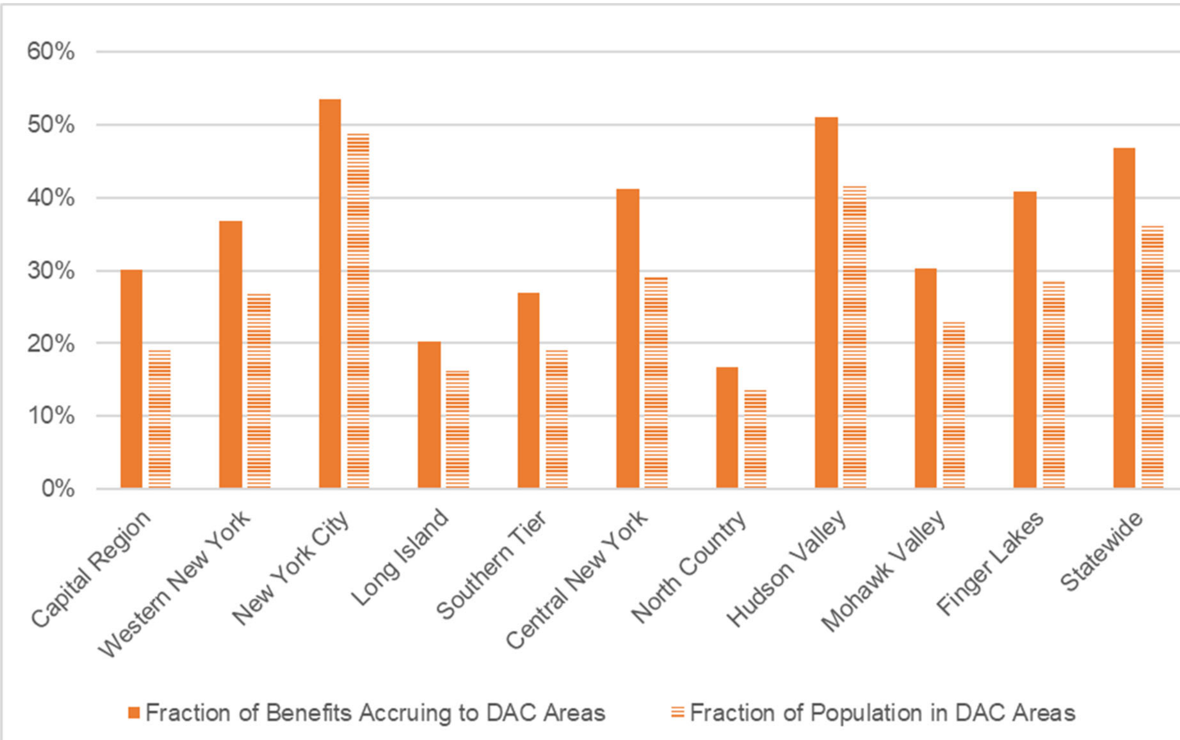
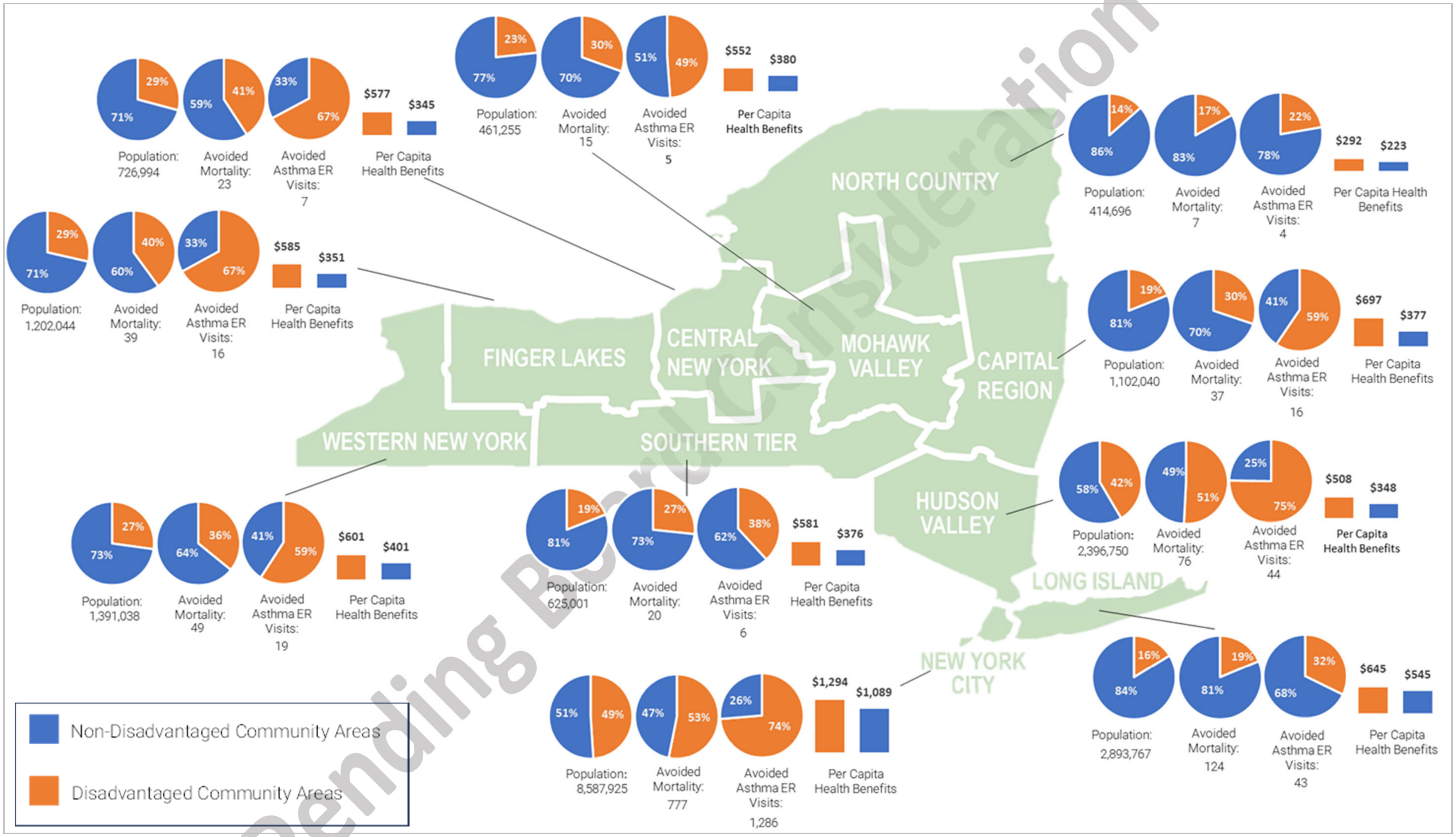


Figure 7 summarizes the physical benefits from $PM_{2.5}$ concentration reductions experienced by geographic DACs in the 10 regions across the state from the Additional Action scenario in 2040. The pie charts show DAC and non-DAC area fractions of regional population, avoided premature mortality cases, and avoided asthma 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 7 shows annual benefits for 2040 only, but DAC and non-DAC area fractional benefits are similar in other years.

Figure 7. Summary of Annual Public Health Benefits from Reduced $PM_{2.5}$ Concentrations (Additional Action Scenario, 2040)



3.3. Health Benefits by Sector

For the three scenarios, the building and transportation sectors together account for most of the public health benefits from $PM_{2.5}$ concentration reductions by 2040 (Figure 8). The 2025–2040 cumulative benefits from buildings account for 39% of the benefits from Current Policies and Additional Action and 60% of the benefits from Net Zero A. The cumulative benefits from transportation account for 54%, 50%, and 26% for Current Policies, Additional Action, and Net Zero A, 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. The contribution of different sectors as a fraction of the total benefits is shown by community type (Figure 8), as well as how it evolves over time (Figure 9) and differs by region (Figure 10). 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 39% of the total monetized value from 2025 to 2040 under Current Policies and Additional Action, and 60% of the total monetized value under Net Zero A. The health benefits associated with the buildings sector is dominated by emission reductions in the residential subsector, and commercial buildings represent a small contributor to benefits in the overall buildings sector. Residential benefits are mostly from reductions in fossil fuel heating, with a substantial contribution from 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.

Figure 9 shows how the benefits associated with the buildings sector would evolve from 2025 to 2040 relative to the other sectors. Under all three scenarios, the fractional benefits from the residential subsector, including both fossil fuel and wood combustion emission reductions, would increase over time as buildings decarbonize and increase energy efficiency. The fractional benefits from buildings under Net Zero A would be greatest relative to the other scenarios; under Net Zero A, residential and commercial heat pumps would reach 100% sales share by 2035. However, even under the Current Policies and Additional Action scenarios, while emission reductions from buildings are lower in magnitude compared to Net Zero A, reductions in fossil fuel heating account for a large fraction of benefits (35%–36%) in New York City (Figure 10).

Figure 8. Cumulative Monetized Societal Value from $PM_{2.5}$ Concentration Reductions by Sector, Scenario, and Additional Breakdown for DAC Areas vs. Non-DAC Areas for Additional Action (2025–2040)

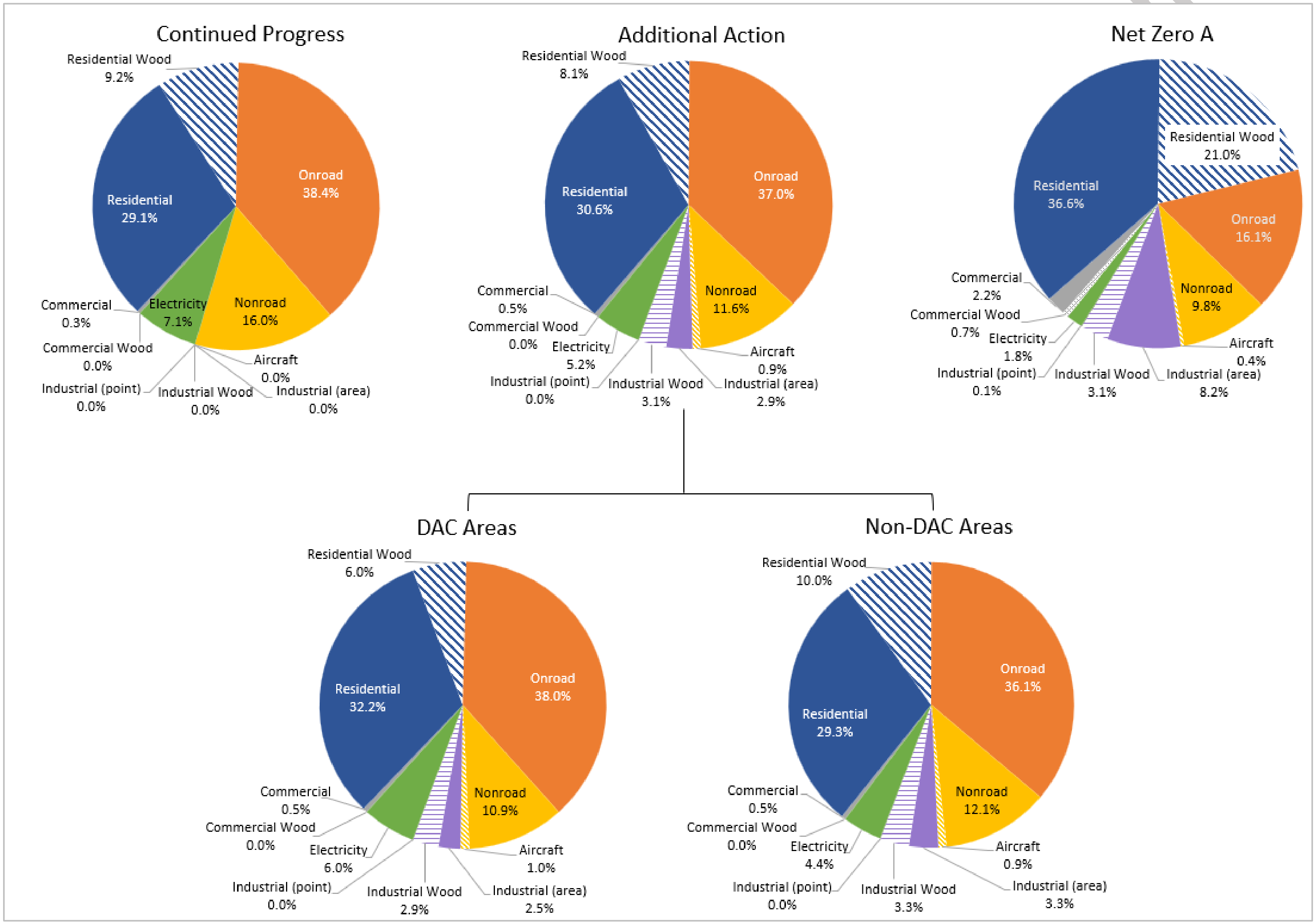


Figure 9. Distribution of Monetized Benefits over Time by Sector and Scenario (2025–2040)

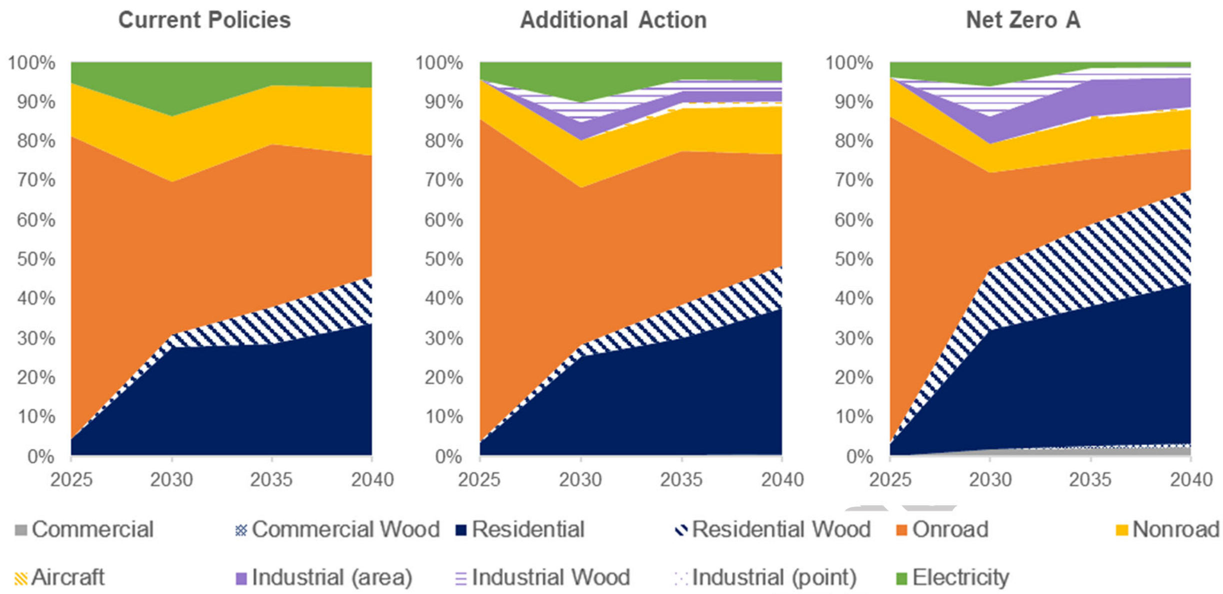
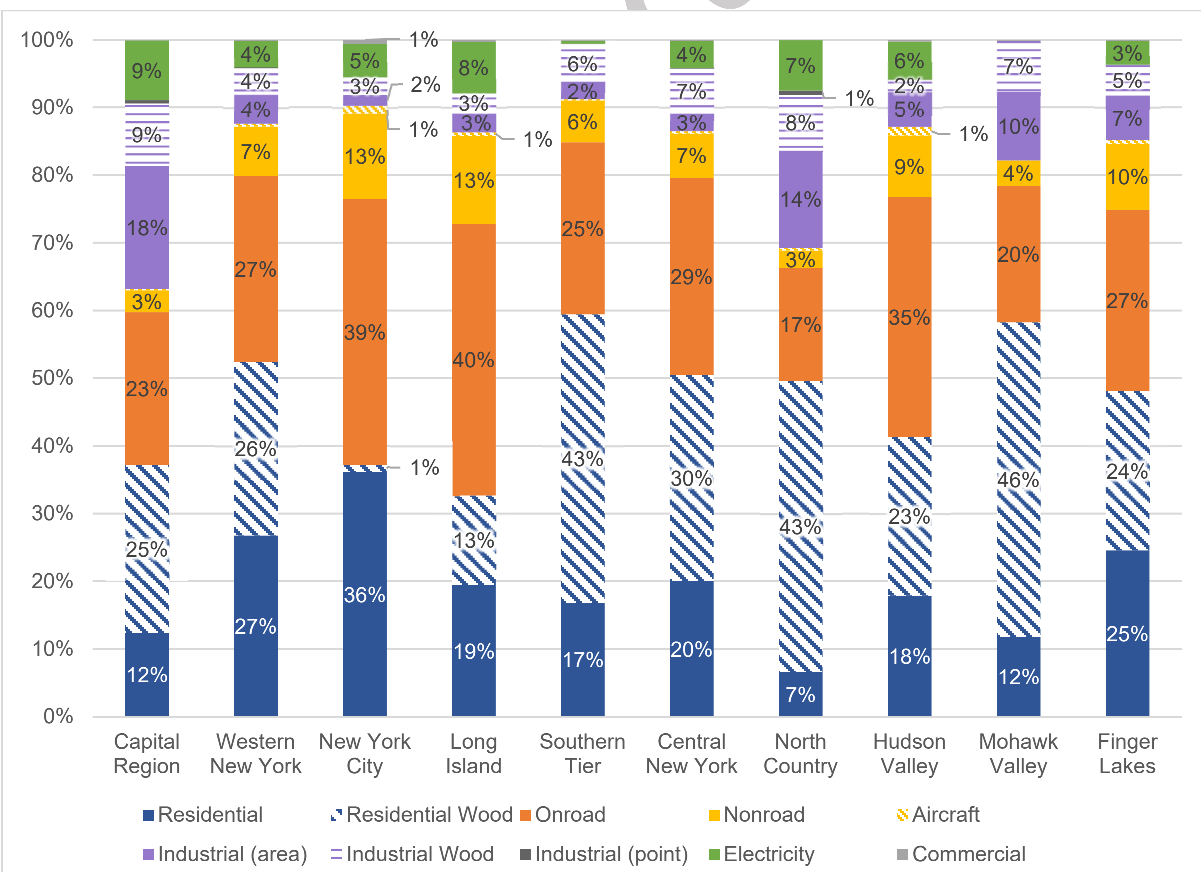


Figure 10. Regional Distribution of Cumulative Monetized Benefits by Sector for the Additional Action Scenario (2025–2040)



Regionally, emission reductions from residential wood 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 A, emission reductions from commercial wood account for approximately 1% of the benefits starting in 2035.

DAC and non-DAC areas would experience a similar fraction of benefits from buildings emission reductions overall; however, under all scenarios, more of the benefits accruing in DAC areas would be from reductions in fossil fuel heating than from reductions in residential wood, which is more prevalent in non-urban areas with lower geographic DAC populations.

3.3.2. Transportation

On-road vehicles account for 38%, 37%, and 16% of the total monetized value associated with health benefits from 2025 to 2040 under Current Policies, Additional Action, and Net Zero A, respectively. The transportation sector will undergo significant changes under all scenarios as zero emission vehicle stock shares grow over time from 2030 to 2040. While the fraction of total $PM_{2.5}$ benefits from on-road vehicles will decrease as the benefits from buildings increases, on-road vehicles would still account for nearly $46 billion of cumulative value associated with benefits from $PM_{2.5}$ concentration reductions from 2025 to 2040 under Additional Action. Regionally, relative benefits from emission reductions from on-road vehicles are larger in urban regions where denser road networks are geographically closer to populations compared to rural regions.

On-road vehicles are a large contributor to benefits in New York City under Current Policies and Additional Action (39%–40%), but compared to other regions of the state, New York City's public transit infrastructure makes the total 2025–2040 relative benefits from buildings more like the benefits from on-road vehicles.

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 16%, 12%, and 10% of the total monetized value associated with health benefits from 2025 to 2040 under Current Policies, Additional Action, and Net Zero A, respectively. The share of benefits from non-road sources would be relatively steady over time (Figure 9). 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.

The use of sustainable aviation fuel (SAF) is expected to reduce air pollutant emissions near airports, and the impacts from the use of SAF were modeled in NY-CHAPPA (see the appendix). SAF accounted for 17% of the total projected fuel for domestic flights in 2035 and 35% of the total jet fuel for domestic flights in 2040 under both Addition Action and Net Zero A. Emission reductions from the use of SAF account for approximately 1% of total 2025–2040 projected benefits from Additional Action and 0.4% from Net

Zero A. A small portion of the projected aircraft benefits from Net Zero A 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.

DAC and non-DAC areas would experience a similar fraction of benefits from emission reductions in the transportation sector overall under all scenarios (Figure 8). Fractional benefits from $PM_{2.5}$ concentration reductions from on-road vehicles would be higher for DAC areas compared to non-DAC areas, whereas fractional benefits from non-road sources would be higher for non-DAC areas compared to DAC areas under Current Policies and Additional Action. Fractional benefits from aircraft emissions would be similar between DAC and non-DAC areas, with slightly more relative benefits accruing to DAC areas.

3.3.3. Electricity

The electricity sector accounts for 7%, 5%, and 2% of the cumulative health benefits from 2025 to 2040 under Current Policies, Additional Action, and Net Zero A, respectively. Under all three scenarios, the electric sector will undergo changes in annual loads and resource mix. For example, electricity accounts for approximately 4% of the total $PM_{2.5}$ benefits in 2025, peaking at 10% in 2030, and leveling out at 4% in 2035 under the Additional Action scenario (Figure 9). 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). While electricity is a small relative contributor to overall benefits, under all scenarios, cumulative benefits from reduced emissions from electricity are higher in DAC areas compared to non-DAC areas (Figure 8), and accounting for the differences in population, are therefore effectively more than double the non-DAC area benefits from that sector per capita. Regionally, benefits from the electric sector are a larger fraction of relative benefits in the Capital Region, North Country, Long Island, Hudson Valley compared to relative benefits from electricity in other regions (Figure 10).

Due to some differences in electric sector model representation in the later years of the Pathways analysis, the overall benefits from emission reductions in the electricity sector may be overestimated by up to 20% (see the appendix).

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.

3.3.4. Industry

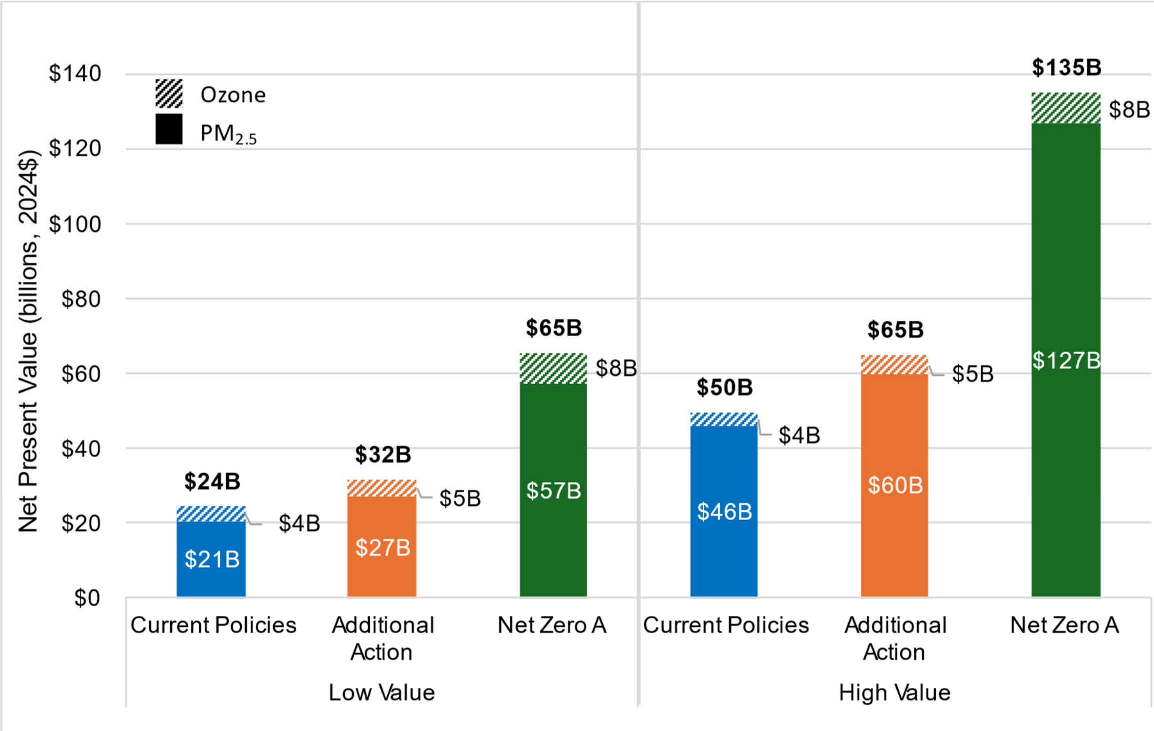
Both No Action and Current Policies include the same energy efficiency and fuel switching policies in the industrial sector, so only Additional Action and Net Zero A show monetized value associated with benefits from industry relative to No Action beginning in 2030 (Figure 9). Additional Action includes modest energy efficiency improvements for industry over Current Policies, resulting in approximately 6% of total benefits from 2030–2040. Net Zero A includes additional electrification, conversion to hydrogen, and efficiency improvements for industry, resulting in approximately 11% of total benefits from 2030 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 A. 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 where not modeled as part of this analysis.

3.4. Societal Value of Total Public Health Benefits

The public health benefits from reductions in air pollutant concentrations described above are also evaluated as a monetized societal value that can be combined into a single metric to evaluate and compare total public health benefits. Figure 11 shows the estimated public health benefits for 2025–2040 (net present value 2024$) from reduced $PM_{2.5}$ concentrations under each scenario relative to the No Action scenario. Geographic DAC areas receive 46–47% of the benefits from reduced $PM_{2.5}$ concentrations, which is a larger share of the benefits relative to their share of the population (36%). This is because most DAC areas benefit from greater emission reductions and these communities have higher existing 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 reduced $PM_{2.5}$ concentrations estimated by NY-CHAPPA, the analysis also applied EPA's COBRA tool to estimate additional benefits from reduced ozone concentrations. Figure 11 also shows the benefits from reductions in ozone concentrations in addition to the benefits from reductions $PM_{2.5}$ under the three scenarios from 2025 to 2040 (net present value 2024$). As shown in the figure, the ozone benefits tend to be relatively small compared to the $PM_{2.5}$ benefits. Note that because COBRA calculates benefits only at the county level, these results cannot be disaggregated to determine the distribution by census track or community type.

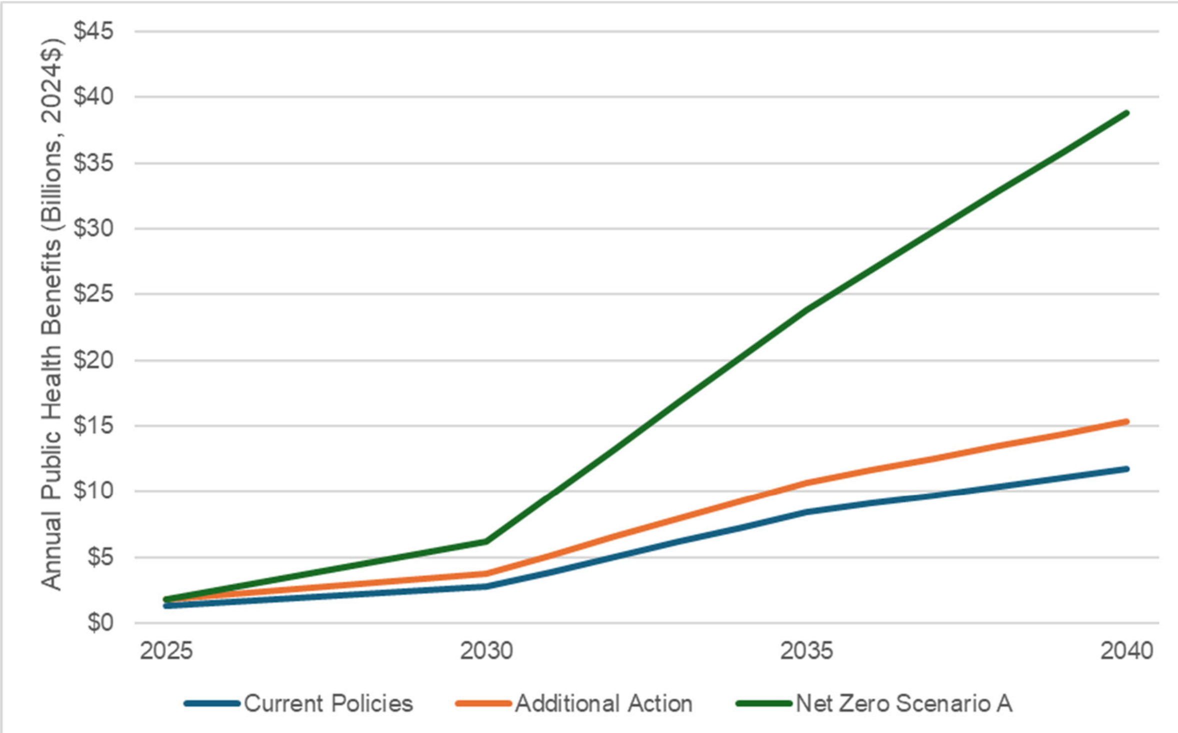
Figure 11. Net Present Value of Health Benefits from $PM_{2.5}$ and Ozone by Scenario (2025–2040)



Note: Monetized benefits from $PM_{2.5}$ and ozone reductions may not match total monetized benefits due to rounding.

Figure 12 shows the annual monetary value associated with both $PM_{2.5}$ and ozone for each scenario between 2025 and 2040. The modeling indicates that benefits will accrue at faster rates beginning in 2030 with the implementation of additional energy policies. By 2040, the public health benefits associated with the Current Policies scenario are valued at nearly $12 billion. For the same year, the Additional Action scenario projected benefits are valued at more than $15 billion—30% more than Current Policies. At over $38 billion, Net Zero A would provide the greatest amount of annual public health benefits by 2040.

Figure 12. Projected Annual Health Benefits Value from $PM_{2.5}$ (High Value) and Ozone by Scenario (2025–2040)



4. Summary of Public Health Analysis

All three scenarios of the Draft Plan considered in this health analysis (Current Policies, Additional Action, and Net Zero A) 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 reductions in $PM_{2.5}$ and ozone concentrations throughout the state that benefit 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 Net Zero A, avoided premature mortality increases from nearly 500 cases annually in 2030 to over 3,000 cases annually in 2040.

Physical health benefits under the Additional Action scenario would be 30% higher than the benefits from the Current Policies scenario, and physical benefits under the Net Zero A scenario would be approximately double 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 71% of avoided emergency room visits for asthma under all scenarios, which is significantly higher than their fraction of the statewide population (36%).

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 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 A scenario. From 2025–2040, cumulative benefits from reductions in residential fossil fuel heating account for 29-37% of benefits across all scenarios, and benefits from emission reductions from on-road vehicles account for approximately 37-38% 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, emission reductions from on-road vehicles and residential fossil fuel heating account for most of the benefits. In upstate regions, emission reductions from buildings account for the largest fractional share of benefits, and in these regions most of these benefits are from emission reductions from residential wood heating. While air pollutant concentrations are generally lower in these regions, reductions in residential wood combustion have 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 also have similar fractional benefits from transportation overall across scenarios, but DAC areas accrue more of the benefits from on-road vehicles. The electric sector is a relatively small overall contributor to benefits. Under all scenarios, cumulative benefits from reduced emissions from electricity in DAC areas are effectively more than double the non-DAC area benefits from electricity per capita.

4.5. Societal Monetary Value of Health Benefits

The population-level physical public health benefits from all three scenarios of the Draft Plan also translate to societal monetary values. The 2025–2040 cumulative monetized societal value of the health benefits from reductions in $PM_{2.5}$ and ozone is nearly \$50 billion for Current Policies, nearly \$65 billion for Additional Action, and over \$135 billion for Net Zero A (net present value 2024\$). The monetized benefits are greatest for Net Zero A due to the higher level of ambition needed across all sectors to achieve the net zero by 2050 goal under the Climate Act. These monetized benefits increase from 2025–2040 but they do not accrue at a steady rate; rather, monetized values associated with public health benefits accrue more rapidly for all scenarios after 2030, reflecting the temporal pattern of emission reductions in the building and transportation sectors from the energy policies in the underlying scenarios (Figure 12).

Approximately 46% of the monetized value of public health benefits would accrue to DAC areas under all scenarios, which is a larger share of the benefits relative to their 36% 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.

Appendix. Public Health Impacts Analysis

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A.1. Introduction

The public health impact analysis evaluated the potential for reductions in air pollutant emissions under three scenarios developed in the Pathways Analysis (Current Policies, Additional Action, and Net Zero A relative to the baseline No Action scenario) to affect changes in public health outcomes. The public health impact analysis followed the same basic approach used in the New York Scoping Plan,[1] while applying an improved analysis modeling framework.

The basic framework of the analysis is:

- Estimate changes in air pollutant emission reductions based on changes in fuel consumption as modeled in the Pathways Analysis (see Pathways Analysis chapter).
- Analyze changes in air quality resulting from reductions in air pollutant emissions.
- Analyze changes in health effects resulting from changes in air quality.
- Calculate the monetized 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) model — rather than using the Environmental Protection Agency's (EPA's) CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)[2] 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 communities (DACs) as defined under the Climate Act.[3]

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 A.2), and detailed results of the health analysis (Section A.3). The accompanying data annex provides additional data beyond those shown in Section A.3.

A.2. Methodology

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

[1] New York Climate Action Council. *Scoping Plan, Appendix G: Integration Analysis Technical Supplement*. December 19, 2022.

[2] U.S. Environmental Protection Agency. CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool. 2014. Model updated 2024.

[3] NY-CHAPPA uses the definitions of geographic DAC areas developed and released by the NY Climate Justice Working Group (CJWG) in 2023, available at: https://climate.ny.gov/Resources/Disadvantaged-Communities-Criteria. 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.

A.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 the reduction in 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.[4] The ZAPPA framework combines two existing models: Community Tools (C-TOOLS)[5] developed by UNC in collaboration with the EPA, and EPA's COBRA tool (v5.2). The sections below provide an overview of the statewide modeling framework developed for NY-CHAPPA.

A.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).[6] 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 (SO_2), volatile organic compounds (VOCs), and ammonia (NH_3) 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 for each model year and policy scenario. The calculations involved running COBRA with zero emissions across all sectors within each region (effectively eliminating local dispersion within the region being analyzed). The resulting concentrations of primary $PM_{2.5}$ and secondary $PM_{2.5}$ precursors 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.

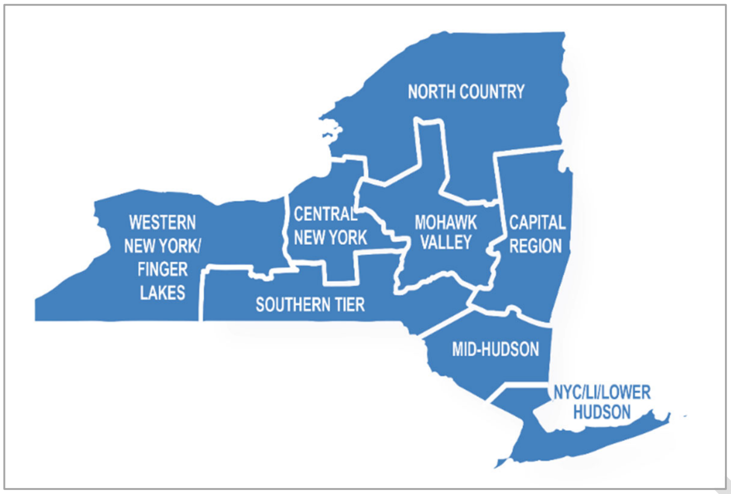
The above process is used to calculate total $PM_{2.5}$ concentrations for each census tract within a region for the baseline scenario and the policy scenarios for each year. The change in total $PM_{2.5}$ is calculated by subtracting the total $PM_{2.5}$ concentration for the scenario and year from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

[4] Shukla, K., C. Seppanen, B. Naess, C. Chang, D. Cooley, A. Maier, F. Divita, M. Pitiranggon, S. Johnson, K. Ito, and S. Arunachalam. *ZIP code-level estimation of air quality and health risk due to particulate matter pollution in New York City*. Environmental Science & Technology, 56(11): 7119-7130. 2022.

[5] Barzyk, T.M., V. Isakov, S. Arunachalam, A. Venkatram, R. Cook, and B. Naess. *A near-road modeling system for community-scale assessments of traffic-related air pollution in the United States*. Environmental Modelling & Software, 66: 46-56. 2015.

[6] 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.

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 visits[7] and hospitalizations for cardiovascular events,[8] and by the population and incidence data described in Section A.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.

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.

[7] 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.

[8] 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.

Additional benefits such as benefits associated with reductions in NO_2 or toxic pollutant concentrations are excluded; therefore, the results provided using this framework are conservative and do not account for additional potential benefits.

A.2.1.2. Source Representation

NY-CHAPPA's dispersion model calculates pollutant concentrations based on emissions from sources (see Section A.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 (NYSDEC) (see Section A.2.2.3).

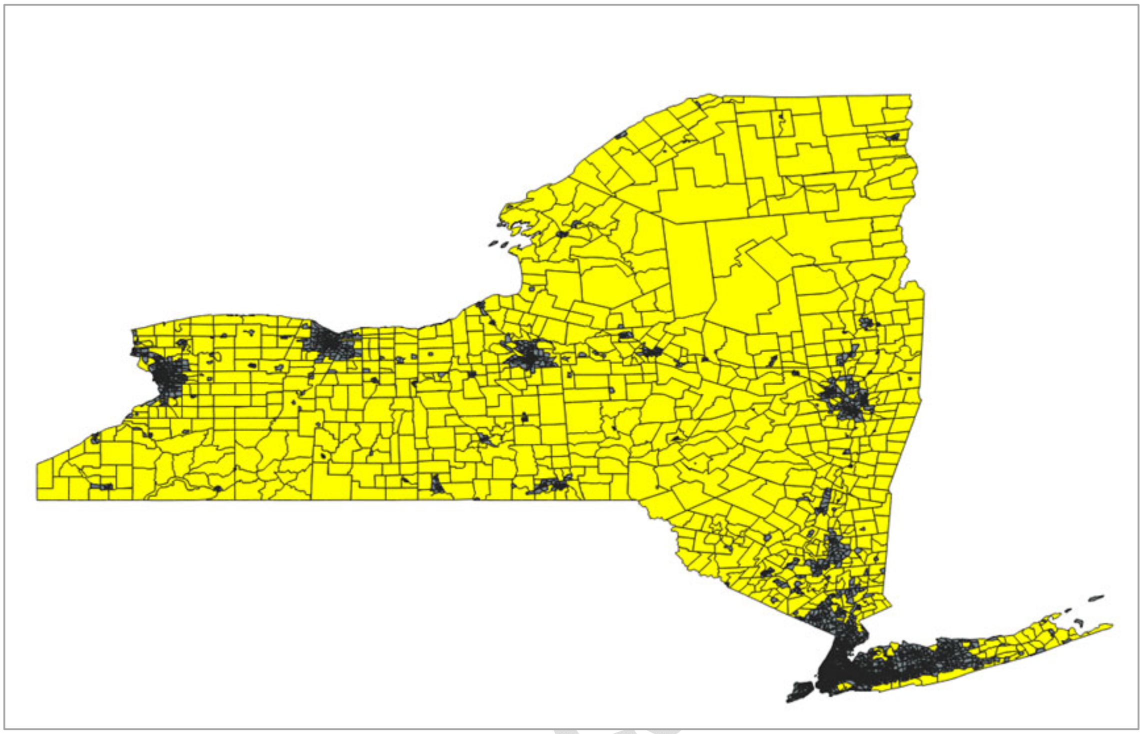
Line Sources: On-road emissions from major and secondary road categories (interstates, arterials, and major collectors) were modeled as line sources. Line segment data from the Federal Highway Administration's Highway Performance Monitoring System (HPMS) for the state of New York was post-processed to 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 A.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 4,911 census tracts and approximately 15,000 block groups. 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 yellow and smaller tracts (which are modeled at the census tract level) in purple.

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**Error! Reference source not found.**), and METeorologically-weighted Averaging for Risk and Exposure (METARE)-processed annual meteorology data (see Section A.2.1.4) from that station was used to disperse emissions from each source.

Figure A-2. Census Tracts in New York State



Note: Purple shows the census tracts of area less than or equal to 20 km^2, while yellow shows census tracts with area greater than 20 km^2. Areas in yellow were modeled at census block group resolution.

A.2.1.3. Receptor Network

NY-CHAPPA calculates pollutant concentrations at discrete point locations called receptors. In this modeling framework, census tract centroid locations 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 7,000 receptor points. Census tract concentrations, as calculated by NY-CHAPPA, represent the average of all receptors within that census tract.

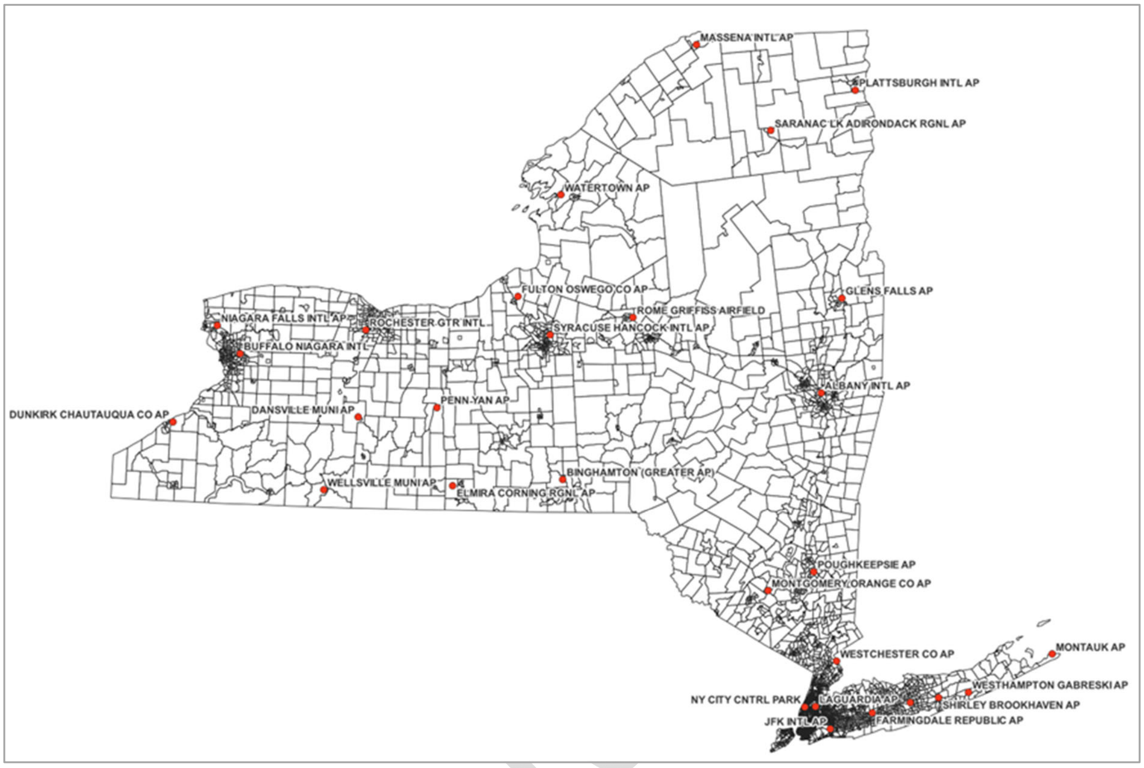
Receptors were modeled at a height of 1.8 meters, a common receptor height for air quality modeling to represent the average height of a person.[9] For census tracts containing multiple receptors, the concentrations from all receptors were averaged to calculate the census tract concentration. Note that 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.

A.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 from 29 airports for 5 years from 2017 to 2021. The list of stations and their locations are shown in Figure A-3 and Table A-1, below. The data from each year 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 (2017) was selected for use in NY-CHAPPA.

[9] U.S. Environmental Protection Agency. *Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas*. EPA-420-B-10-040. 2010.

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



The meteorological outputs from AERMET were then processed using the METARE method previously developed and published in Chang et al.[10] to obtain 100 representative hours throughout the year.

As seen in Table A-2, there are 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. These conditions represent a series of meteorological inputs with similar wind speed, wind direction, and Monin-Obukhov length. For each condition, the METARE code will select the hour with the median Monin-Obukhov length as the representative hour and calculate the weight of that condition in the whole year's data (# of hours falling into that condition/# of all the valid hours of the years). If for one condition, no data is available due to data missing, no representative hour will be selected, and the weight will be 0.

[10] Chang, S.-Y., W. Vizuete, A. Valencia, B. Naess, V. Isakov, T. Palma, M. Breen, S. Arunachalam, Sci. Total Environ. 538:905-921. _A Modeling Framework for Characterizing Near-Road Air Pollutant Concentration at Community Scales_. 2015.

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

Table A-2. The 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 key meteorology data over time. This includes an analysis of the difference in wind speed and direction, as shown in the wind rose plots for LaGuardia Airport for 2017–2021 (Figure A-4). 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 the 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 estimate 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 each individual station. The New York City Central Park station has the most interannual variability of all of the stations, but even this variation is relatively low for the purposes of this modeling exercise.

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, 2017.

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

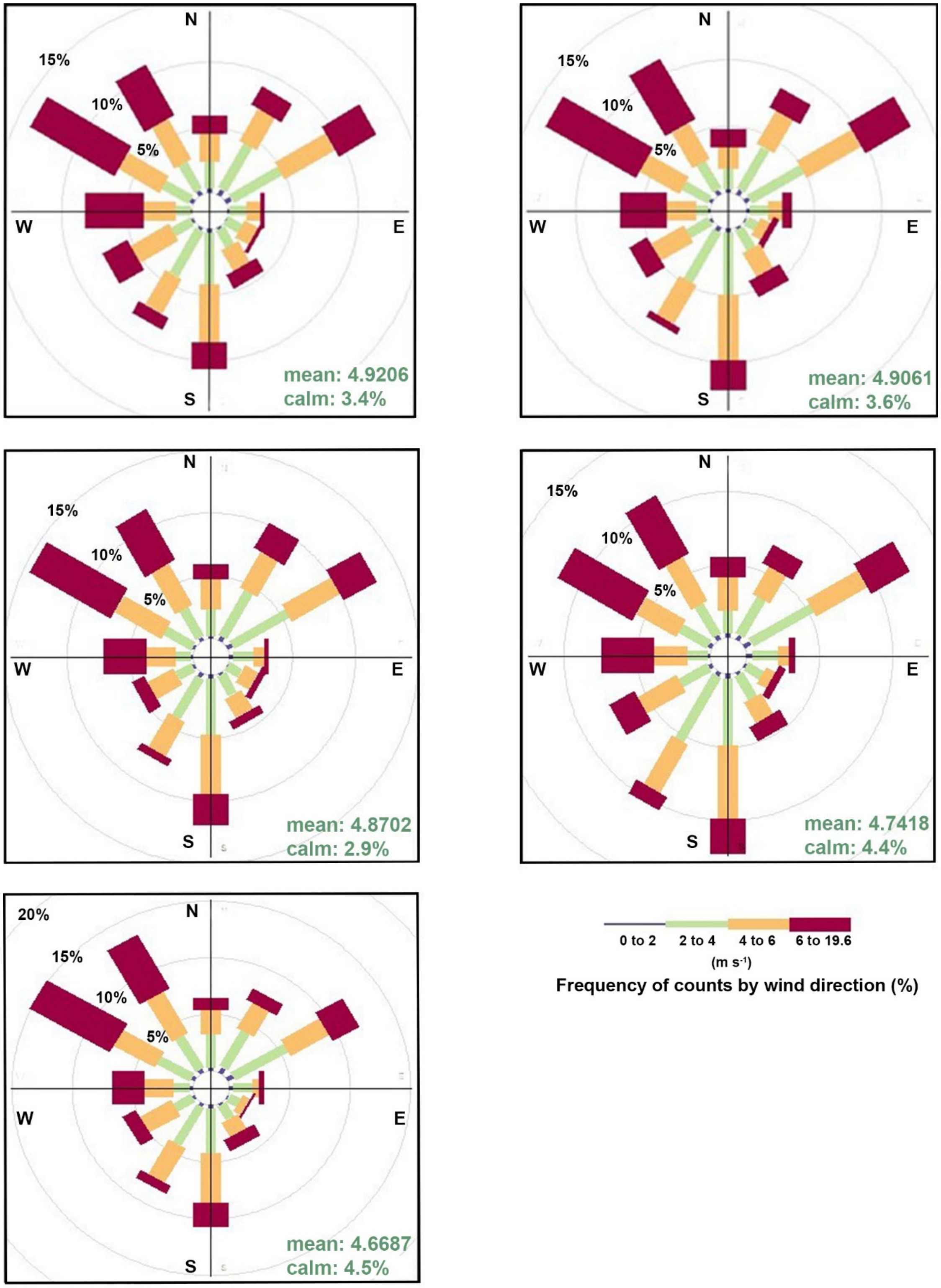
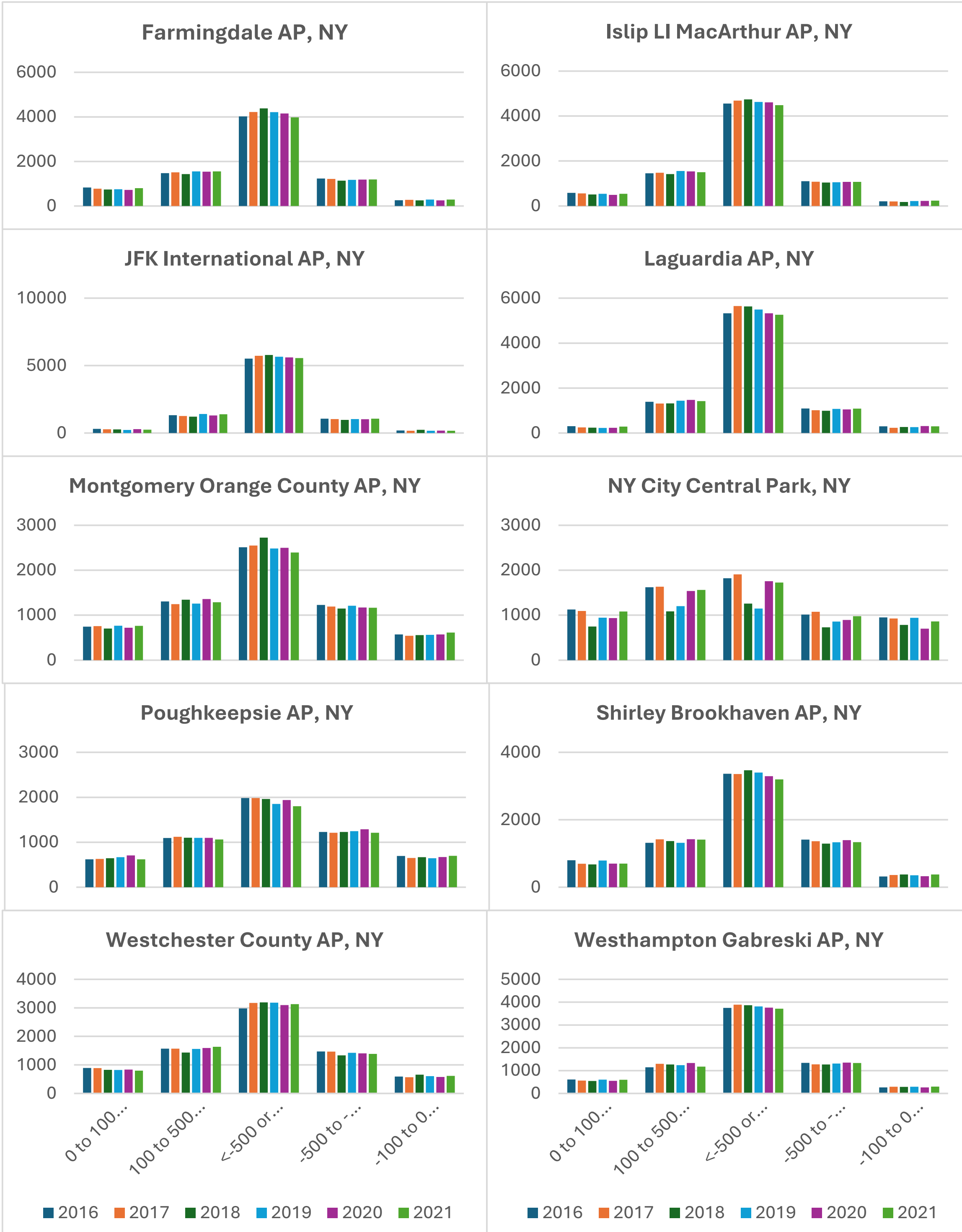


Figure A-5. Distribution of Monin-Obukhov Length Values in Different Stability Ranges (2016-2021, for a subset of stations in NY)



A.2.1.5. Model Validation

To evaluate the performance of NY-CHAPPA, the projected $PM_{2.5}$ concentrations using emissions from the 2025 baseline case in the NY Scoping Plan[11] were compared to $PM_{2.5}$ observations from 2017-2022 from 19 $PM_{2.5}$ monitoring sites throughout New York State,[12] shown in Table A-3 and Figure A-6. 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.[13] 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 monitors in the same census tract.

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.[14] Because model projections were only available starting with year 2025, these results were compared against multiple years of observational data. Table A-3 shows the comparisons of observed and projected $PM_{2.5}$ concentrations for the years 2017–2022, and Table A-4 shows the average of the model performance evaluation metrics.

Figure A-7 shows the $PM_{2.5}$ concentrations observed at each monitoring station for 2017–2022 and the model projected data for the corresponding census tract. This figure demonstrates that for most locations, projected $PM_{2.5}$ concentrations are in close alignment with the observed data. As shown in Table A-4, below, the summary statistics across all monitoring stations in the network meet the standard thresholds for performance of an air quality model in each year, 2017–2022.

[11] New York Climate Action Council. *Scoping Plan, Appendix G: Integration Analysis Technical Supplement*. December 19, 2022.

[12] U.S Environmental Protection Agency. $PM_{2.5}$ Design Values. https://www.epa.gov/air-trends/air-quality-design-values

[13] Chang, J.C. and S.R. Hanna. Meteorology and Atmospheric Physics, 87: 167-196. Air quality model performance evaluation. 2004.

[14] Chang, J.C. and S.R. Hanna. Meteorology and Atmospheric Physics, 87: 167-196. Air quality model performance evaluation. 2004.

Table A-3. Observed (2017–2022) and Modeled (2025) $PM_{2.5}$ Concentrations (µg/m^3) in New York State

Air Quality Monitoring Site	Observed $PM_{2.5}$ Concentrations						Modeled $PM_{2.5}$ Concentrations (2025)
	2017	2018	2019	2020	2021	2022	
IS 45	7.49	8.12	7.23	6.98	7.43	6.94	11.36
JHS 126	7.55	7.88	7.59	7.34	7.62	7.29	9.34
IS 52	7.25	7.96	7.37	6.65	7.74	6.89	8.20
Richmond Post Office	7.20	7.77	7.57	7.72	8.38	6.90	7.48
Buffalo Near-Road*	7.39	7.61	7.05	6.83	7.70	6.65	7.46
Rochester Near-Road*	6.69	7.37	6.53	5.94	7.15	6.07	7.38
Albany Health Dept	6.47	6.59	5.95	6.11	6.70	5.96	7.20
Rochester 2	6.48	6.89	6.52	5.62	6.25	5.54	6.87
Buffalo	7.20	7.58	7.03	6.48	7.43	6.53	6.74
Pfizer Lab Site	7.97	8.27	7.01	6.96	7.14	6.90	6.72
Newburgh	6.12	6.40	5.83	6.45	6.30	5.83	6.57
Loudonville	5.80	5.82	5.10	4.97	5.48	5.64	6.47
Babylon	6.67	6.81	6.41	6.38	6.91	5.99	6.16
Amherst	6.67	6.90	6.42	6.04	6.79	5.74	6.02
Queens College 2	7.06	7.27	6.71	6.86	7.50	7.31	5.61
Queens College Near Road*	7.78	8.25	7.77	7.37	7.72	7.05	5.51
Pinnacle State Park	4.92	5.35	4.44	4.37	5.66	4.80	5.25
East Syracuse	5.54	5.88	5.30	5.07	5.87	5.07	5.09
Whiteface Base	3.76	3.41	2.85	3.21	3.66	3.51	3.90

* Near-road monitors 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.

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

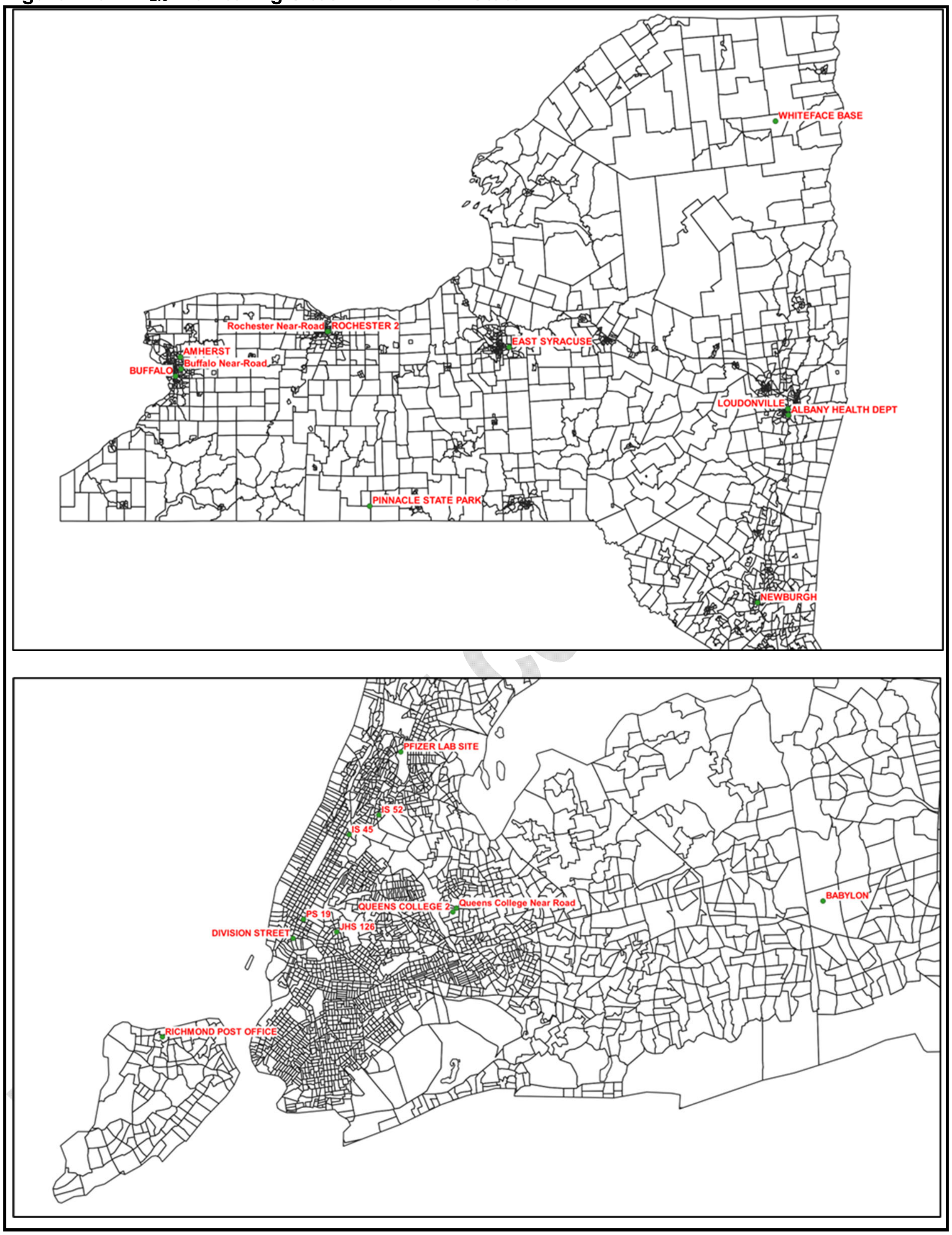
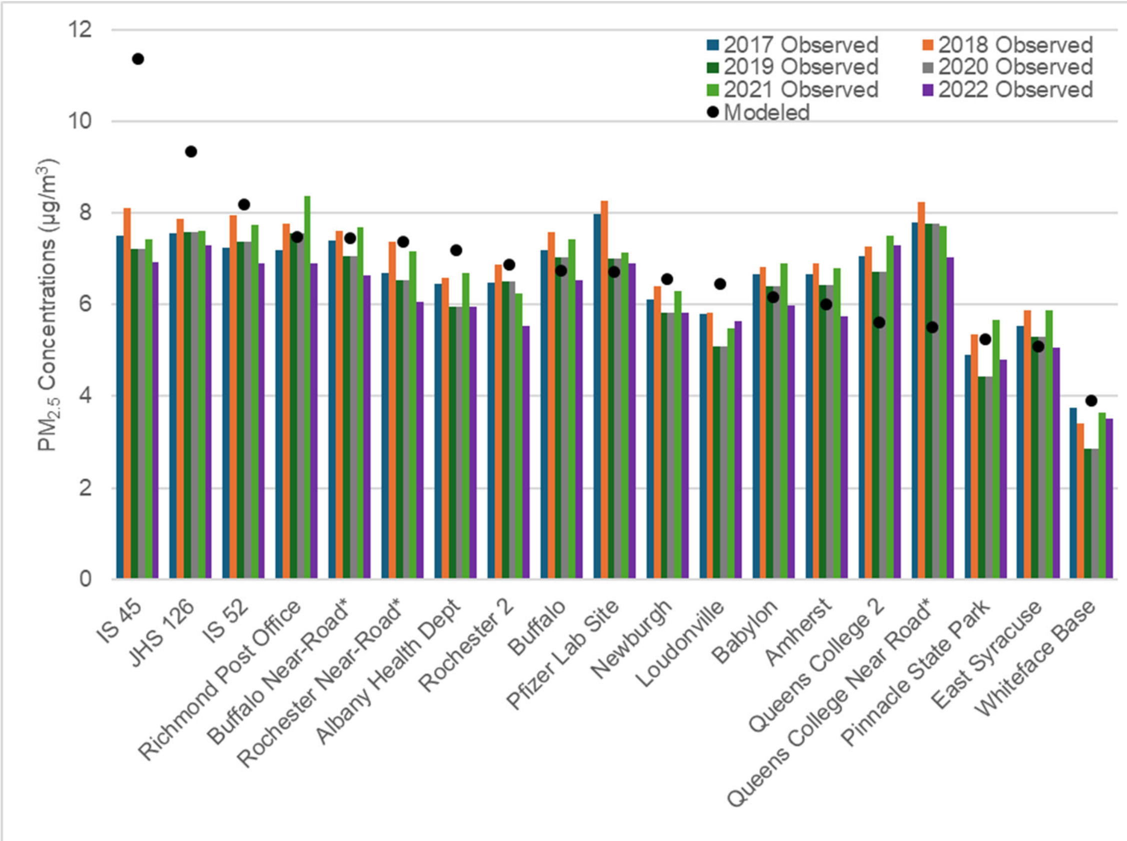


Figure A-7. Comparison of Modeled (2025) and Observed (2017–2022) Annual Average $PM_{2.5}$ Concentrations in New York State



* Near-road monitors 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.

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

Comparison Measure	Value from Model Validation	Threshold	Does Model Satisfy Threshold?
Fractional bias	-0.06	within ± 0.3	Yes
Geometric mean bias	0.95	closer to ±1	Yes
Normalized mean square error	0.04	closer to 0	Yes
Geometric variance	1.03	ranges between ± 1	Yes
Fraction of data within a factor of 2 of observations	1	closer to 1	Yes

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

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% and a median normalized mean error of 41.2%.[15] This is compared to the NY baseline case values used for NY-CHAPPA of -6% and 4%, respectively, suggesting that NY-CHAPPA performs better in this use case.

A.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, SO_2, VOCs, and NH_3; and
- Scenario emission of those pollutants.

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

A.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.[16] 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.[17] 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.

A.2.2.2. Baseline Health Incidence

Baseline health incidence is required for each health endpoint to determine the change in public health benefits due to changes in $PM_{2.5}$ concentrations. Baseline health data was obtained at a sub-county level from New York State Department of Health (NYSDOH) for mortality, asthma emergency room visits, and asthma 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 NYSDOH to protect patient confidentiality.[18] In cases where the sub-county-level data

[15] Simon, H., K.R. Baker, and S. Phillips, Atmospheric Environment, 61: 124-139. *Compilation and interpretation of photochemical model performance statistics published between 2006 and 2012.* 2012.

[16] U.S. Census Bureau. *County Population Totals and Components of Change: 2020-2024.* https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-total.html#v2023.

[17] Cornell University. 2018. County Projections Explorer. Ithaca, New York: Cornell Program on Applied Demographics. https://pad.human.cornell.edu/counties/projections.cfm.

[18] Census-tract level data was provided for 125 census tracts out of nearly 4,919 tracts in NYS, with the rest provided in aggregated census tract groups.

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.

A.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, SO_2, NH_3, and VOCs. Statewide annual emissions were estimated based on projected fuel consumption modeled in the Draft 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. While dispatch findings are directionally aligned, some differences were observed between PLEXOS and RESOLVE results (especially in the later period) as a result of different model representations. These differences led to higher gas reductions observed in the later periods in PLEXOS, which means that overall benefits from emission reductions in the electric sector may be overestimated by up to 20%. The relatively small contribution of the electric sector to health benefits compared to other sectors (see Section A.3.3) and the fact that most 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).[19,20] 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 SO_2.[21] Generator-level $PM_{2.5}$ emission rates were developed from eGRID's latest $PM_{2.5}$ data for 2021.[22] Emission rate data was supplemented with the latest data from EPA's National Electric Energy Data System [23] and cross-referenced and verified with the 2020 NEI[24] and historical data derived from EPA's Clean Air Markets Data.[25]

The Pathways scenarios assume hydrogen combustion for remaining thermal generation needs starting in 2040 (see Pathways Analysis chapter). Hydrogen combustion may increase emissions of NO_x compared to natural gas due to the higher flame temperatures. The analysis conservatively assumes that emission rates of NO_x (emissions per unit of energy) would be double those from similar natural gas units. Sensitivity analysis of NO_x emissions from hydrogen combustion in the Scoping Plan indicated health benefits were not sensitive to this assumption.[26]

[19] U.S. Environmental Protection Agency. *National Emissions Inventory*. 2023.

[20] U.S. Energy Information Administration. EIA Form 860. 2025. https://www.eia.gov/electricity/data/eia860/

[21] U.S. Environmental Protection Agency. eGRID 2023. 2025. Last accessed on April 23, 2025.

[22] U.S. Environmental Protection Agency. eGRID 2021 PM2.5. 2024. Last accessed on April 23, 2025.

[23] U.S. Environmental Protection Agency. National Electric Energy Data System (NEEDS), 2024. Last accessed on April 23, 2025.

[24] U.S. Environmental Protection Agency. *2020 National Emission Inventory*. 2020. Last accessed on November 10, 2024

[25] U.S. Environmental Protection Agency. *Clean Air Markets Program Data 2016-2024 historical data at the unit level*. 2025. Last accessed on April 23, 2025.

[26] New York Climate Action Council. *Scoping Plan, Appendix G: Integration Analysis Technical Supplement*. December 19, 2022.

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 the NYSDEC. 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 Draft 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% of the industrial natural gas in NYS, it was assigned 0.1% 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).[24] 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 (NYSDTF).[27]

Commercial sector emissions were calculated using emissions factors from the 2020 NEI for each of the commercial fuel types (fuel oil, natural gas, and wood).[24] 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 NYSDTF.

Residential sector emissions were calculated using emissions factors from the 2020 NEI for certain residential fuel types (natural gas and liquid petroleum gas).[24] For fuel oil, the analysis used emission factors provided to NYSERDA from Brookhaven National Laboratory, based on equipment testing supported by NYSERDA. 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,[28] 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.[29] 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

[27] NYS Department of Taxation and Finance. *NYS Tax Parcels*. 2023.

[28] U.S. Census Bureau. *American Community Survey*. 2019.

[29] Commission for Environmental Cooperation. *Residential Wood Use Survey to Improve U.S. Black Carbon Emissions Inventory Data for Small-Scale Biomass Combustion*. Montreal, Canada. 2019.

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 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).[30] 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 very 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*.[31] Based on data reported in relevant studies, this analysis estimates an average 66% reduction in $PM_{2.5}$ emissions during idling and a 59% reduction in $PM_{2.5}$ from landing and takeoff operations for 50% SAF blends relative to 100% fossil jet fuel. Reductions in aircraft SO_2 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 SO_2 emissions reductions of approximately 36% for 50% 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.[24] 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.

[30] Federal Aviation Administration. 2025. Aviation Environmental Design Tool. https://aedt.faa.gov/

[31] New York State Energy Research and Development Authority (NYSERDA). 2025. "Co-Pollutant Impacts of Low-Carbon Fuels and Technologies—2025 Update" Prepared by Industrial Economics, Inc. https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions

Emissions inputs for *all 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.[24] 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.

A.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 in this process. 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.[32] (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 SO_2, but not VOC and NH_3. An earlier sensitivity analysis conducted for the Scoping Plan indicated that omitting these two pollutants from the electricity sector for this analysis would impact the total benefits results by less than 1 percent.[33] 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.

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 A.2.1.5), 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. 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 NO_2 concentrations and other hazardous air pollutants (also referred to as "air toxics").

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 impact of changes in air quality can be affected by multiple other factors, such as individual risk factors within the populations.

[32] New York State Energy Research and Development Authority (NYSERDA). 2025. "Co-Pollutant Impacts of Low-Carbon Fuels and Technologies—2025 Update" Prepared by Industrial Economics, Inc. https://www.nyserda.ny.gov/About/Publications/Energy-Analysis-Reports-and-Studies/Greenhouse-Gas-Emissions

[33] New York Climate Action Council. *Scoping Plan, Appendix G: Integration Analysis Technical Supplement*. December 19, 2022.

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.

A.3. Additional Results of the Public Health Impacts Analysis

In addition to the results of the public health analysis discussed in the chapter above, this section provides additional results for all policy scenarios considered in the health analysis: Current Policies, Additional Action, and Net Zero A. The associated data annex includes additional results at the county level and for additional model years.

A.3.1. Statewide Health Benefits

Table A-5 provides a summary of the annual avoided public health effects due to reduced $PM_{2.5}$ concentrations for each scenario in 2040, as well as the fraction of benefits accruing in DAC areas for each health effect under each scenario. These results are presented in Table 2 in this chapter, but Table A-5 includes the DAC area fraction for each scenario, which can be considered relative to the 36% geographic population of DACs statewide.

Table A-5. Summary of Annual Statewide Avoided Public Health Effects due to Reduced $PM_{2.5}$ Concentrations by Scenario (2040)

Health Effect	Current Policies		Additional Action		Net Zero A	
	Avoided Occurrences Per Year	DAC Area Fraction	Avoided Occurrences Per Year	DAC Area Fraction	Avoided Occurrences Per Year	DAC Area Fraction
Premature Mortality	890	46%	1,200	46%	3,000	47%
Nonfatal Heart Attacks	380	44%	500	44%	1,200	45%
Hospitalizations	250	46%	320	46%	810	46%
Acute Bronchitis	390	45%	510	46%	1,300	46%
Respiratory Symptoms	12,200	45%	16,000	46%	40,200	46%
Emergency Room Visits, Asthma	1,100	72%	1,400	72%	3,600	71%
Asthma Exacerbation	7,400	45%	9,800	46%	24,700	46%
Minor Restricted Activity Days	245,3000	44%	321,500	45%	800,000	45%
Work Loss Days	41,600	44%	54,600	45%	135,500	45%

Note: DAC area fraction represents the fraction of avoided occurrences within those areas and can be compared with the statewide fraction of population within DAC areas, approximately 36%.

A.3.2. Benefits by Region and Community

Figure A-8 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 A, illustrated in the different y-axis scales. These figures show that in all regions except for the New York City region, 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-8. Population-Weighted Average $PM_{2.5}$ Concentration Reductions by Scenario, Community, and Region (2040)

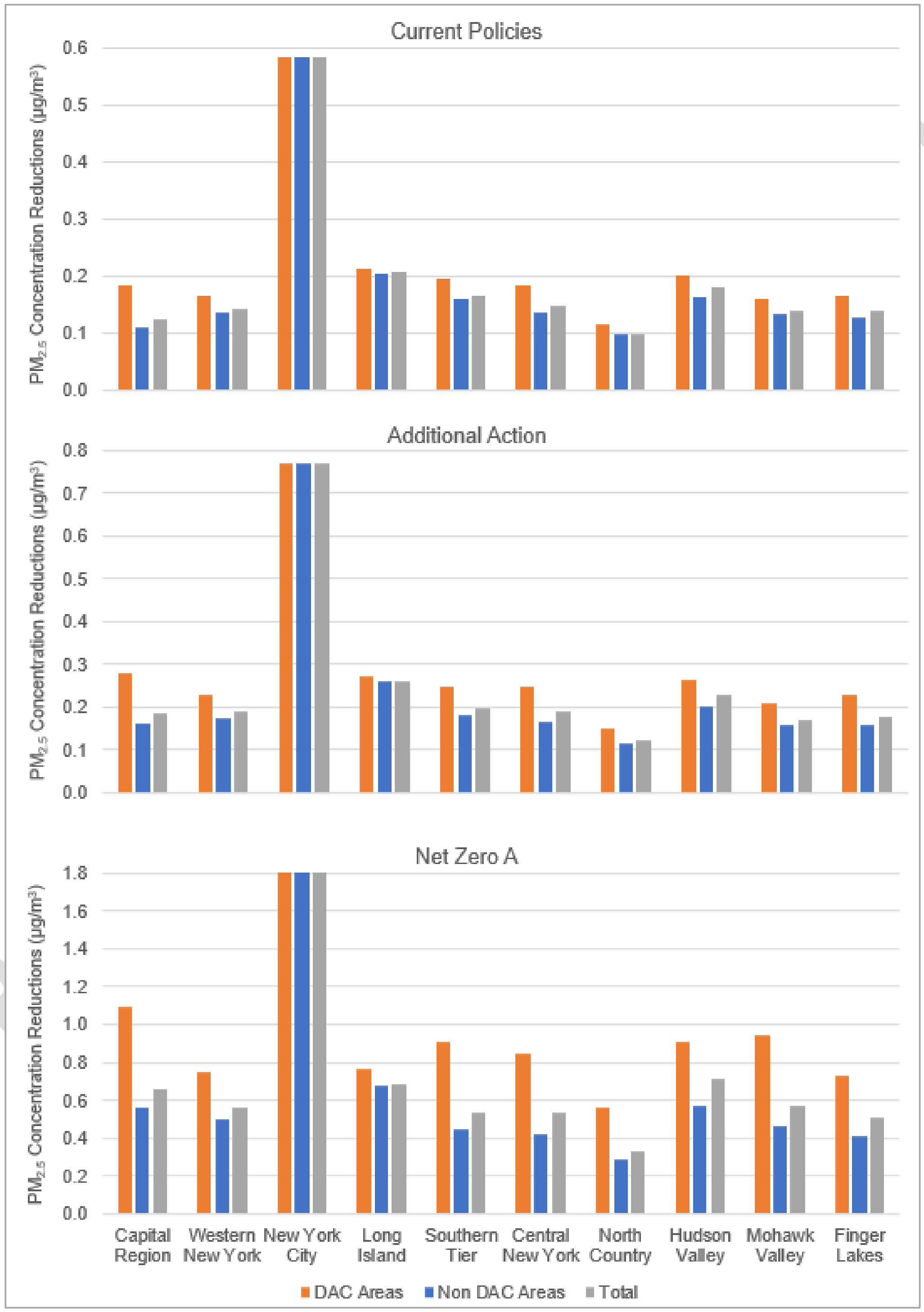


Figure A-9 through Figure A-11 show maps of the county scale average reduction in $PM_{2.5}$ concentrations in 2040 in each scenario. While each county would experience a reduction in average ambient $PM_{2.5}$ concentrations in each scenario, urban areas would experience the largest reductions, with 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-9. Population-Weighted $PM_{2.5}$ Concentration Reductions ($\mu g/m^3$) by County (Current Policies Scenario, 2040)

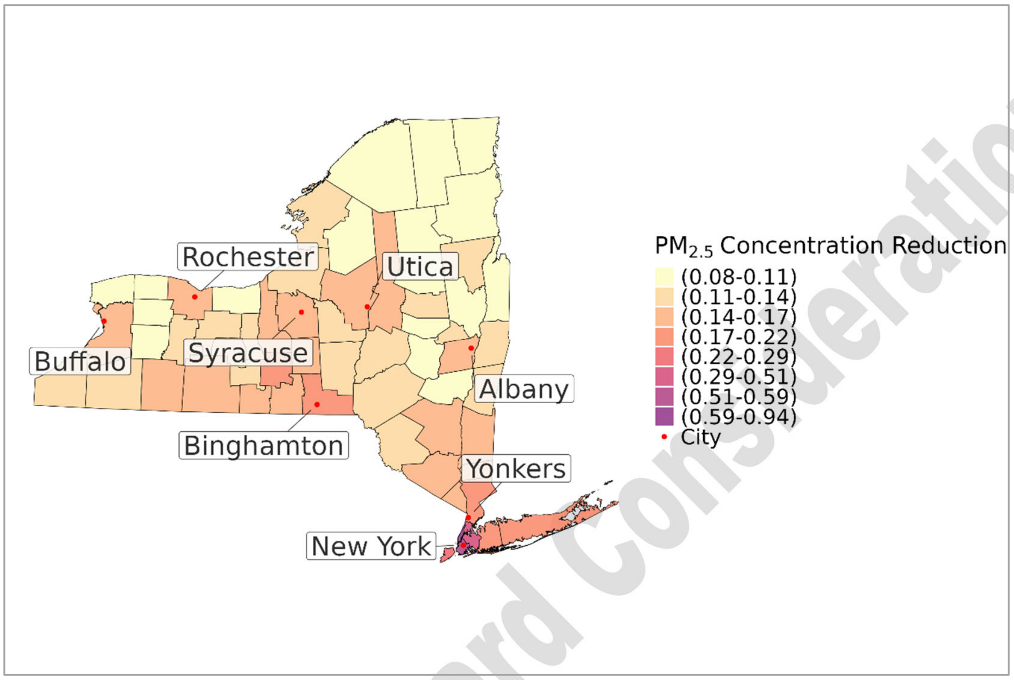


Figure A-10. Population-Weighted $PM_{2.5}$ Concentration Reductions ($\mu g/m^3$) by County (Additional Action Scenario, 2040)

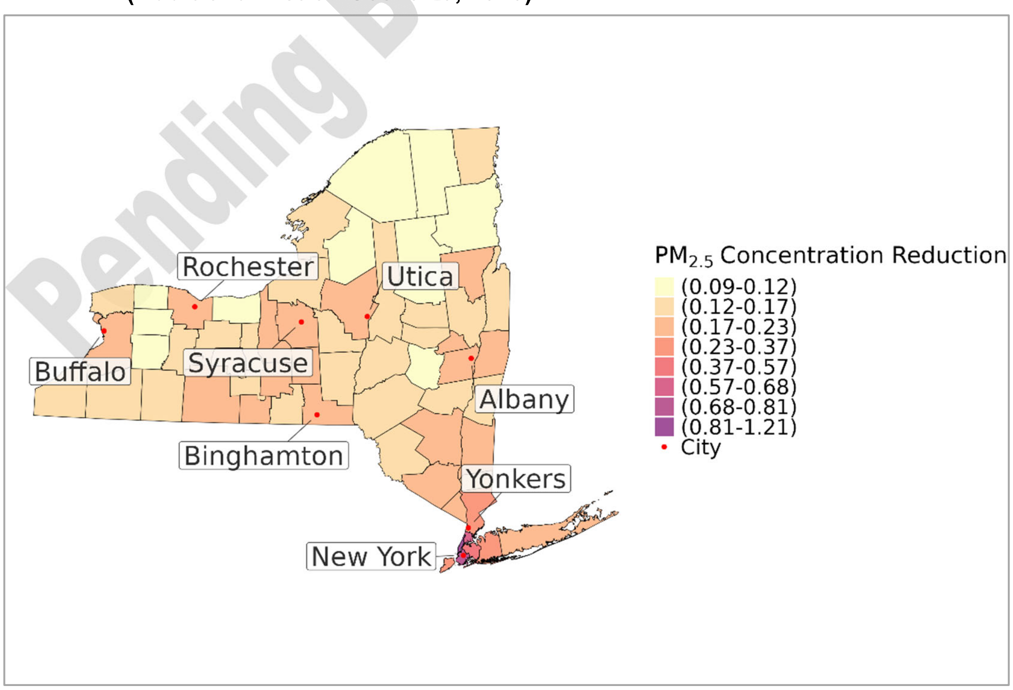


Figure A-11. Population-Weighted $PM_{2.5}$ Concentration Reductions (μg/m^3) by County (Net Zero A Scenario, 2040)

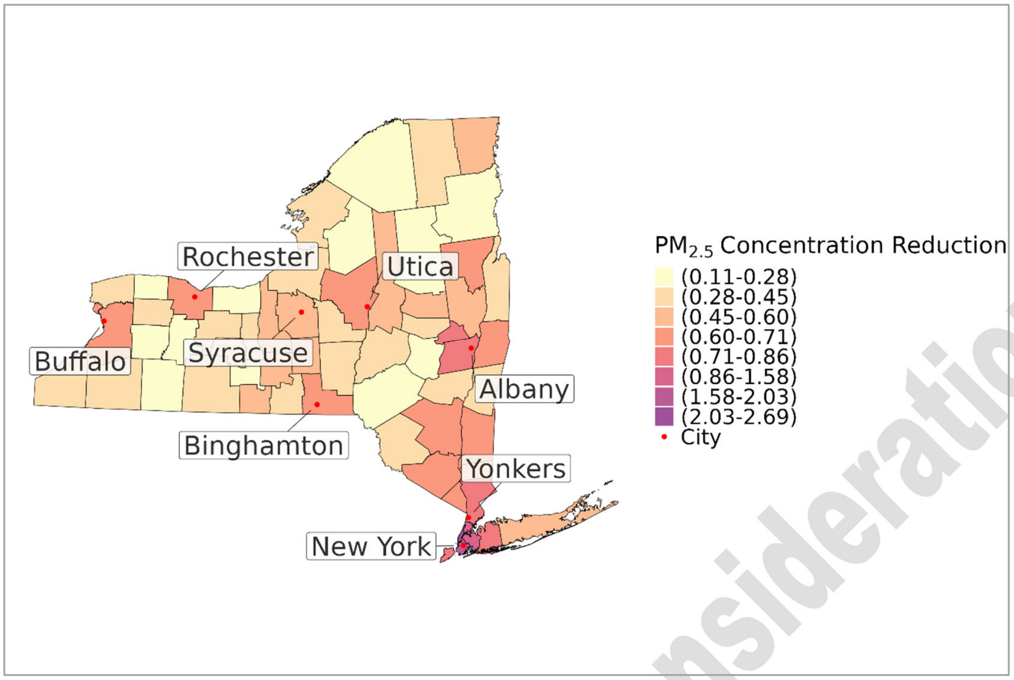


Figure A-12 shows the total annual monetized health benefits in 2040 for each region under each scenario relative to the No Action scenario. The data annex provides this information for all scenarios at the county level. The charts on the left in each figure show the annual benefits for all regions except New York City, and the charts on the right show the annual benefits for the New York City region on a different scale. The monetized benefits under Additional Action are approximately 30% higher than under Current Policies across all regions, and the monetized benefits under Net Zero A are at least double (or higher) compared to those under Additional Action.

Figure A-12. Annual Monetized Health Benefits by Scenario and Region from Reduced $PM_{2.5}$ Concentrations (2040)

Figure A-13 through Figure A-15 show maps of the county scale per-capita monetized public benefits of each scenario in 2040. Similar to the distribution of $PM_{2.5}$ reductions shown in Figure A-9 through Figure A-11, 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-13. Per Capita Monetized Health Benefits ($) by County (Current Policies Scenario, 2040)

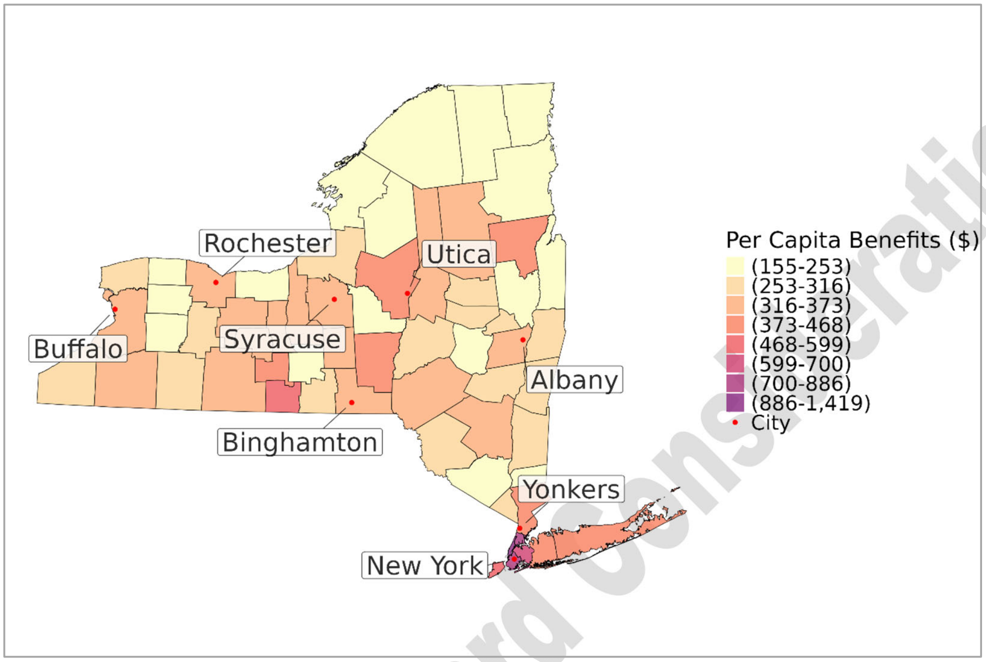


Figure A-14. Per Capita Monetized Health Benefits ($) by County (Additional Action Scenario, 2040)

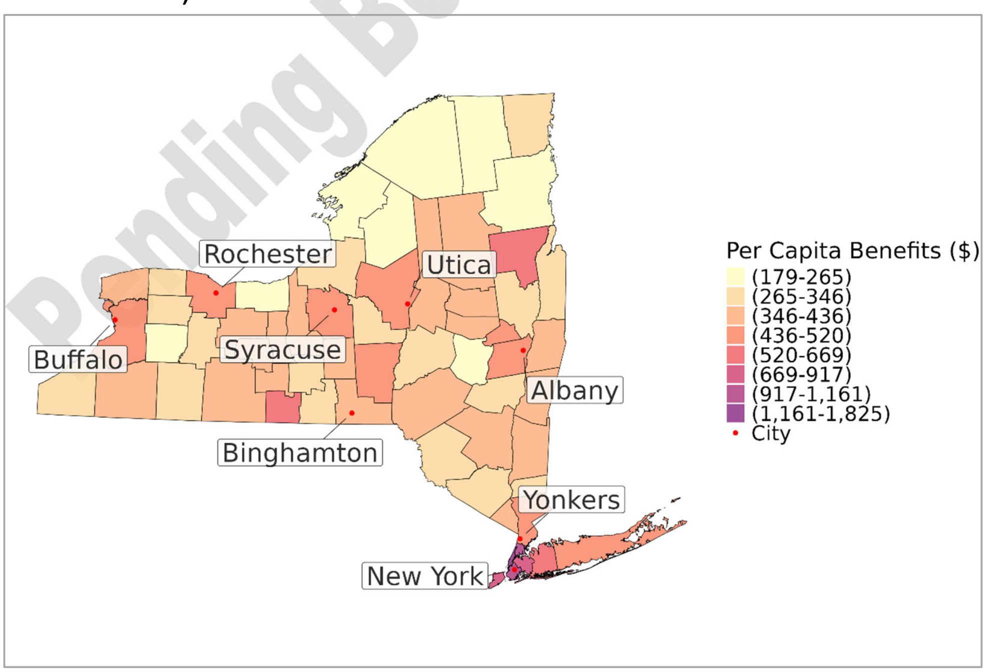


Figure A-15. Per Capita Monetized Health Benefits ($) by County (Net Zero A Scenario, 2040)

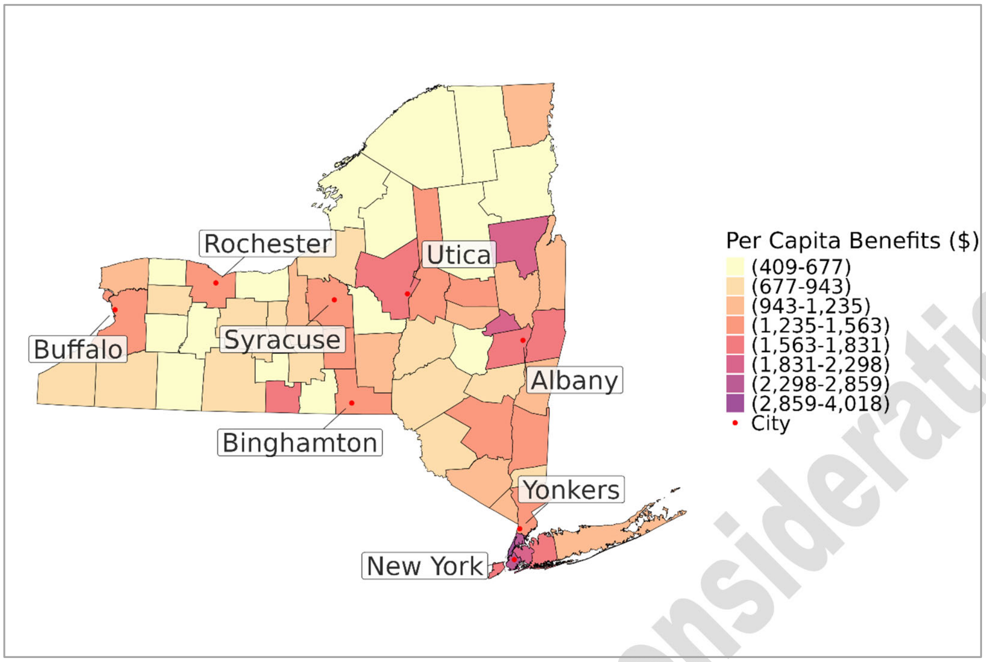


Figure A-16 shows the fraction of benefits accruing to DAC areas compared to their fraction of the population in each region under all scenarios. The data annex provides this information for all scenarios at the county level. These figures show that for all regions, DAC areas receive a larger share of benefits relative to their share of the population. The distribution of fractional benefits accruing to DAC areas is similar between Current Policies and Additional Action, while under Net Zero A, the fractional benefits accruing to DACs are higher in some regions.

Figure A-16. Fraction of Cumulative Benefits due to Reduced $PM_{2.5}$ Concentrations Accruing to DAC Areas by Scenario Compared to the Fraction of Population in DAC Areas (2025-2040)

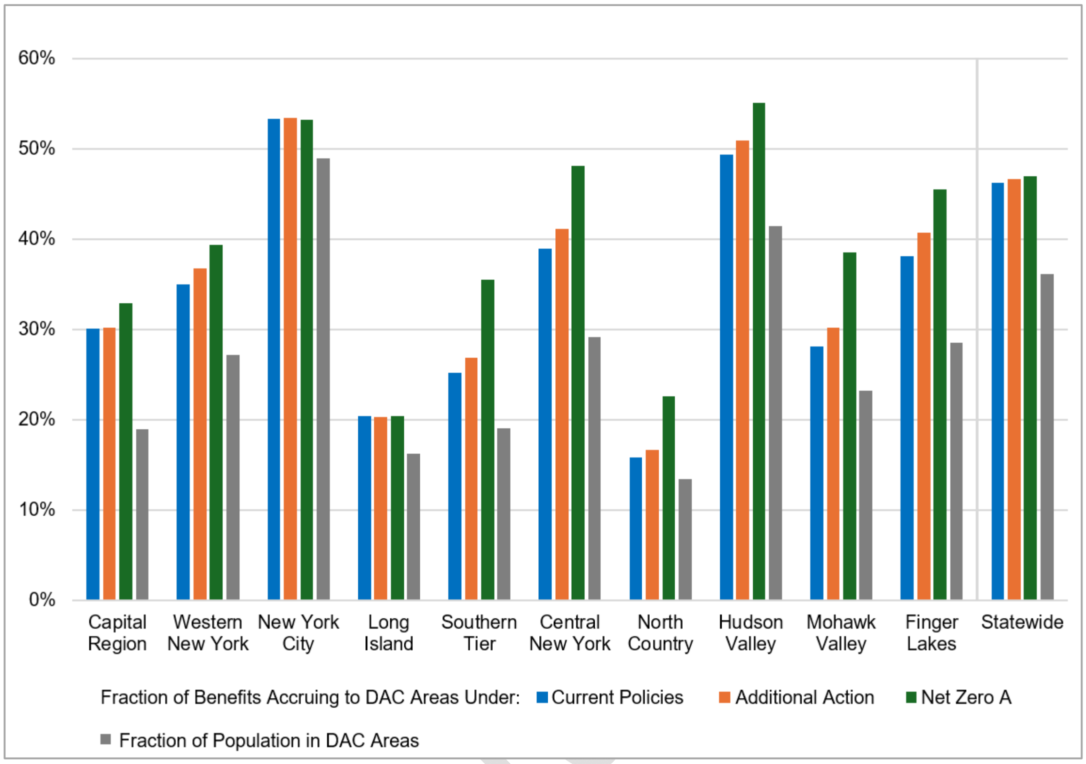


Figure A-17 and

Figure A-18 summarize the regional-level distribution of public health outcomes to geographic DACs and non-DACs in 2040 under the Current Policies and Net Zero A 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 A, 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-17. Summary of Annual Public Health Benefits from Reduced $PM_{2.5}$ Concentrations, (Current Policies Scenario, 2040)

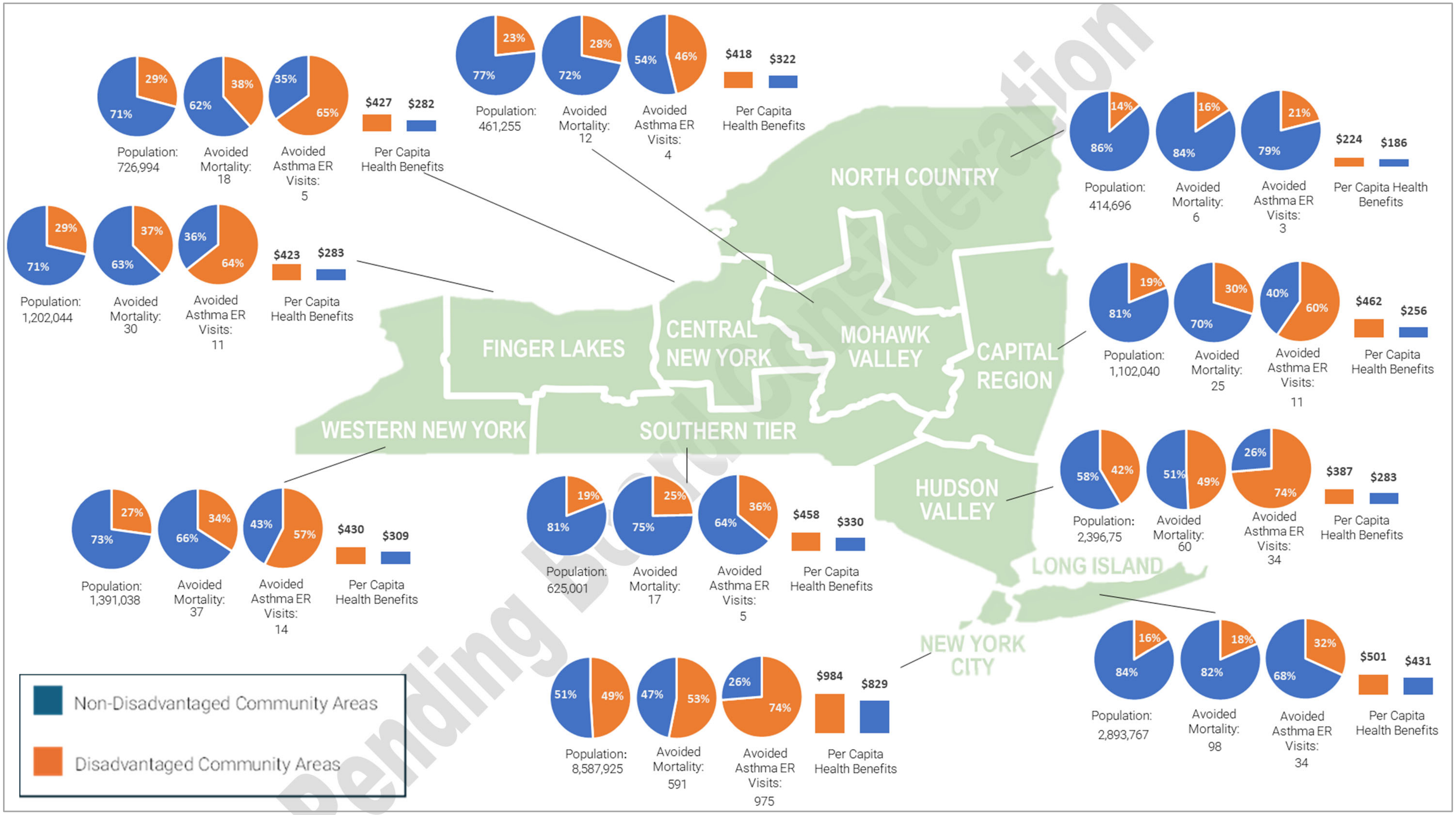
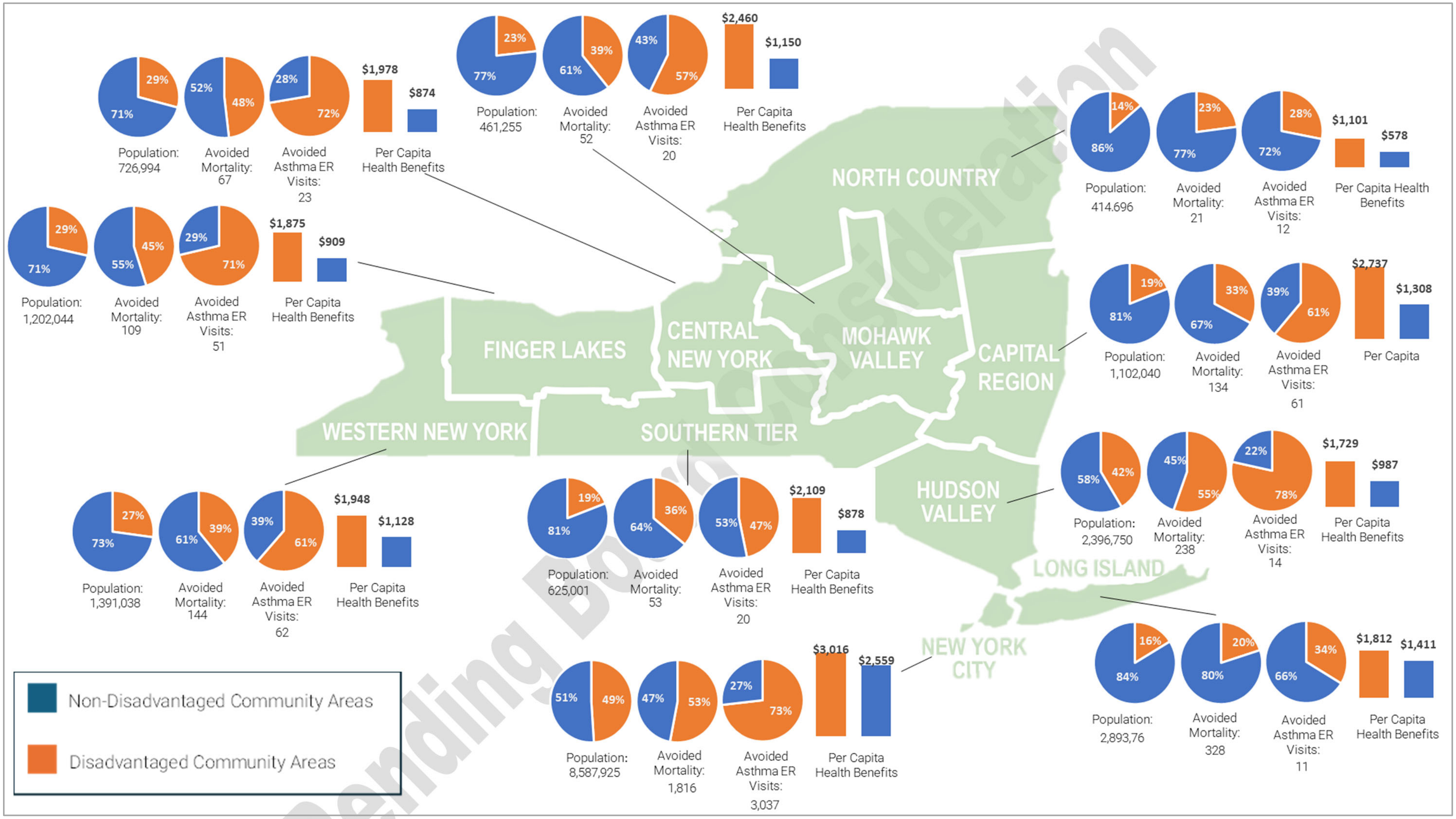


Figure A-18. Summary of Annual Public Health Benefits from Reduced $PM_{2.5}$ Concentrations, (Net Zero A Scenario, 2040)



A.3.3. Benefits by Sector

Table A-6 and Figure A-19 through Figure A-24 present the distribution of the public health benefits for each scenario by sector. Table A-6 shows the cumulative 2025-2040 monetized benefits by sector and scenario. Figure A-19 though Figure A-21 show the proportion of cumulative benefits by sector and community, both with and without the benefits of reduced wood combustion.

Generally, the transportation and buildings 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 A scenario has significantly higher total benefits than the other scenarios, and as shown in Table A-6, 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 A also has much larger benefits from industry compared to the other scenarios. In other scenarios, the largest fraction of benefits is from the transportation sector.

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-22 through Figure A-24 show the regional and sectoral distributions of the public health benefits with and without the benefits of reduced wood combustion.

Table A-6. Cumulative Monetized Societal Public Health Value (million $) from $PM_{2.5}$ Concentration Reductions by Sector and Scenario (2025-2040)

Sector	Current Policies	Additional Action	Net Zero A
Buildings			
Commercial Fossil Fuels	$324	$614	$5,916
Commercial Wood	$0	$0	$1,785
Residential Fossil Fuels	$27,223	$37,780	$99,398
Residential Wood	$8,619	$10,057	$57,114
Buildings Total	**$36,166**	**$48,451**	**$162,428**
Transportation			
On-road	$35,953	$45,662	$43,780
Non-road	$14,968	$14,262	$26,518
Aircraft	$0	$1,167	$1,067
Transportation Total	**$50,921**	**$61,090**	**$71,365**
Industry			
Industrial (area)	$0	$3,628	$22,380
Industrial (point)	$0	$45	$166
Industrial Wood	$0	$3,838	$8,546
Industry Total	**$0**	**$7,511**	**$31,092**
Electricity	**$6,618**	**$6,356**	**$4,900**
Total	**$93,705**	**$123,409**	**$269,785**

Figure A-19. Cumulative Monetized Societal Value from $PM_{2.5}$ Concentration Reductions by Sector and Community, with (top) and without (bottom) the Benefits from Reduced Wood Combustion (Current Policies Scenario, 2025-2040)

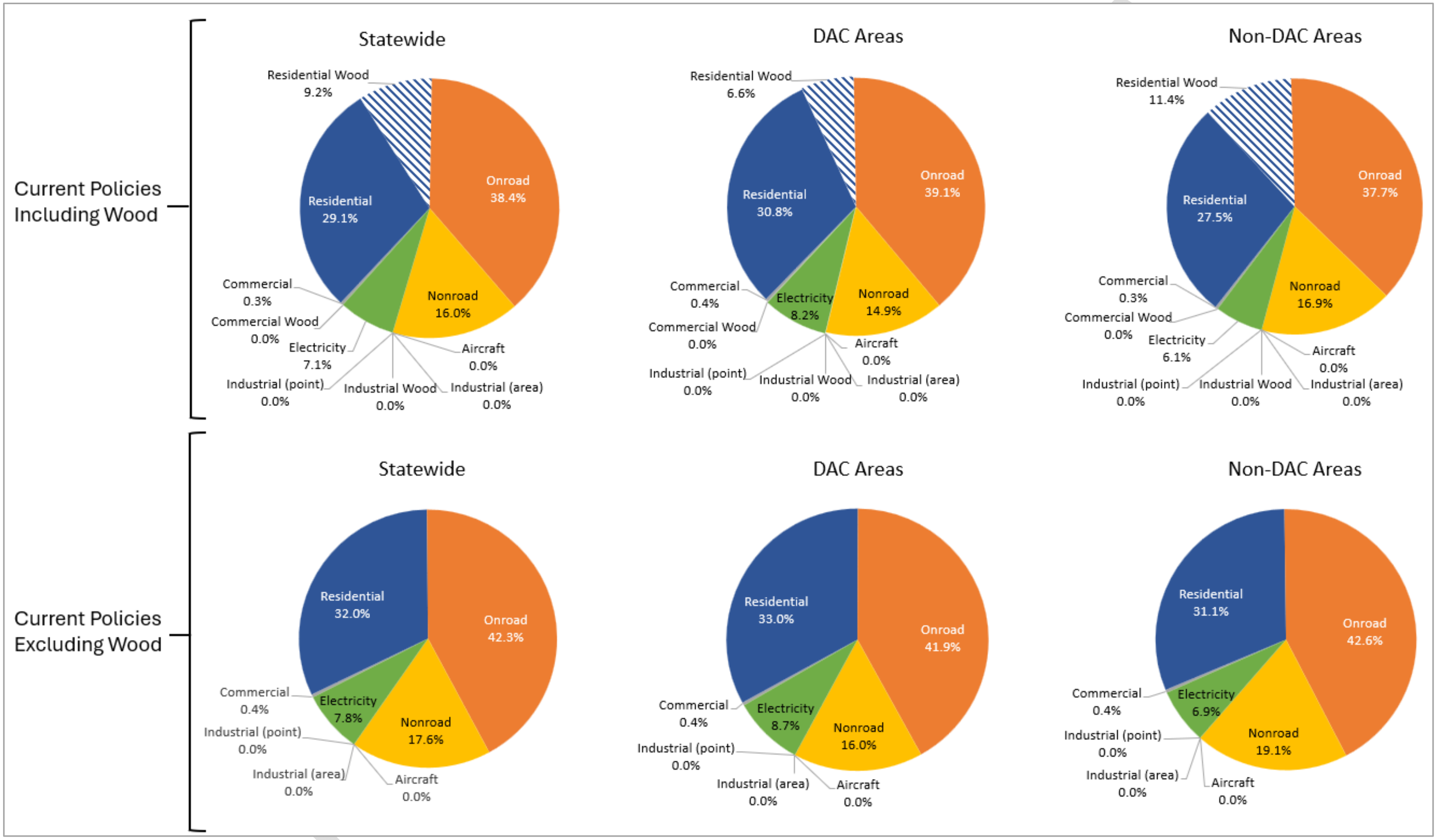


Figure A-20. Cumulative Monetized Societal Value from $PM_{2.5}$ Concentration Reductions by Sector and Community, with (top) and without (bottom) the Benefits from Reduced Wood Combustion (Additional Action Scenario, 2025-2040)

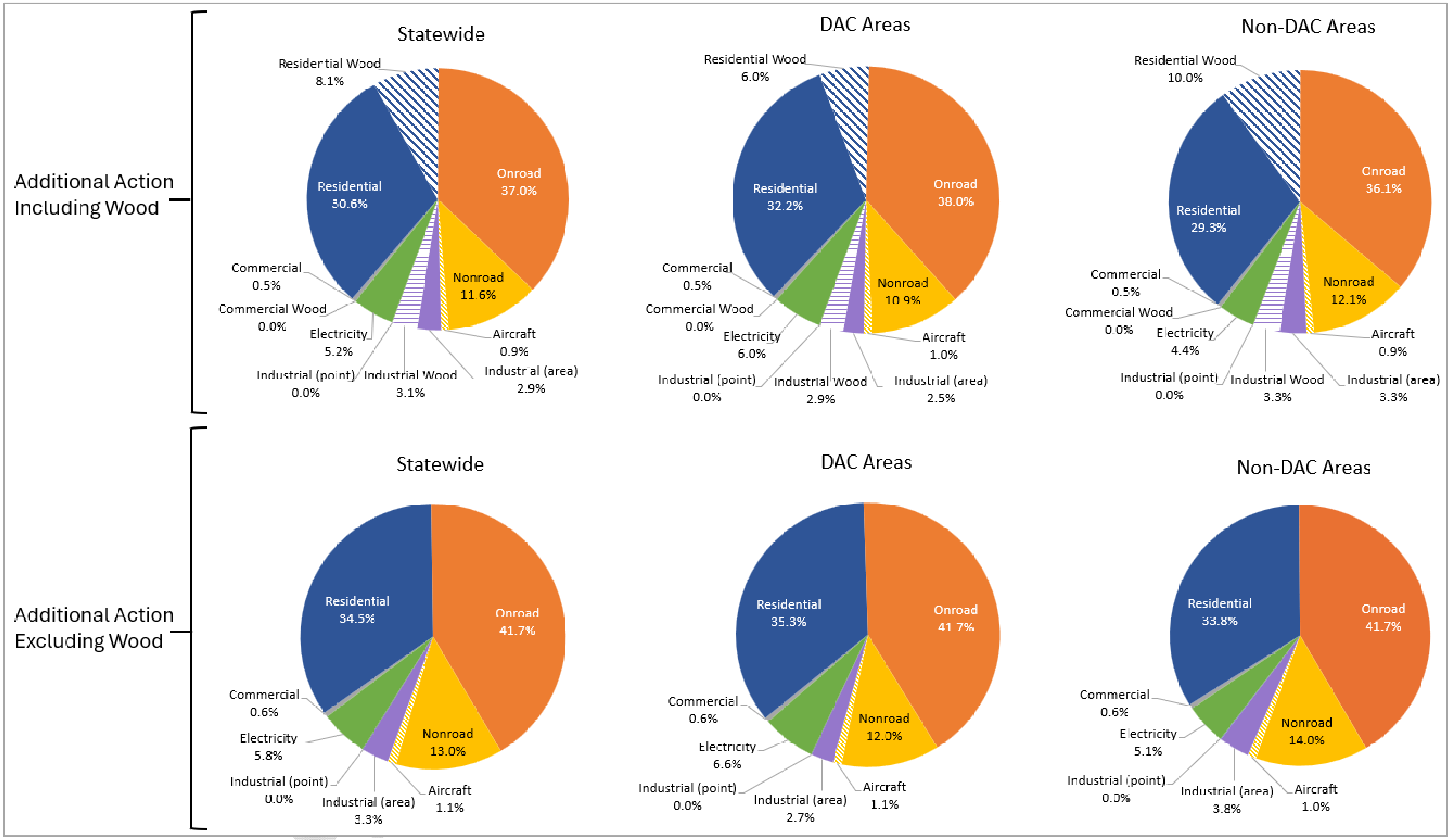


Figure A-21. Cumulative Monetized Societal Value from $PM_{2.5}$ Concentration Reductions by Sector and Community, with (top) and without (bottom) the Benefits from Reduced Wood Combustion (Net Zero A Scenario, 2025–2040)

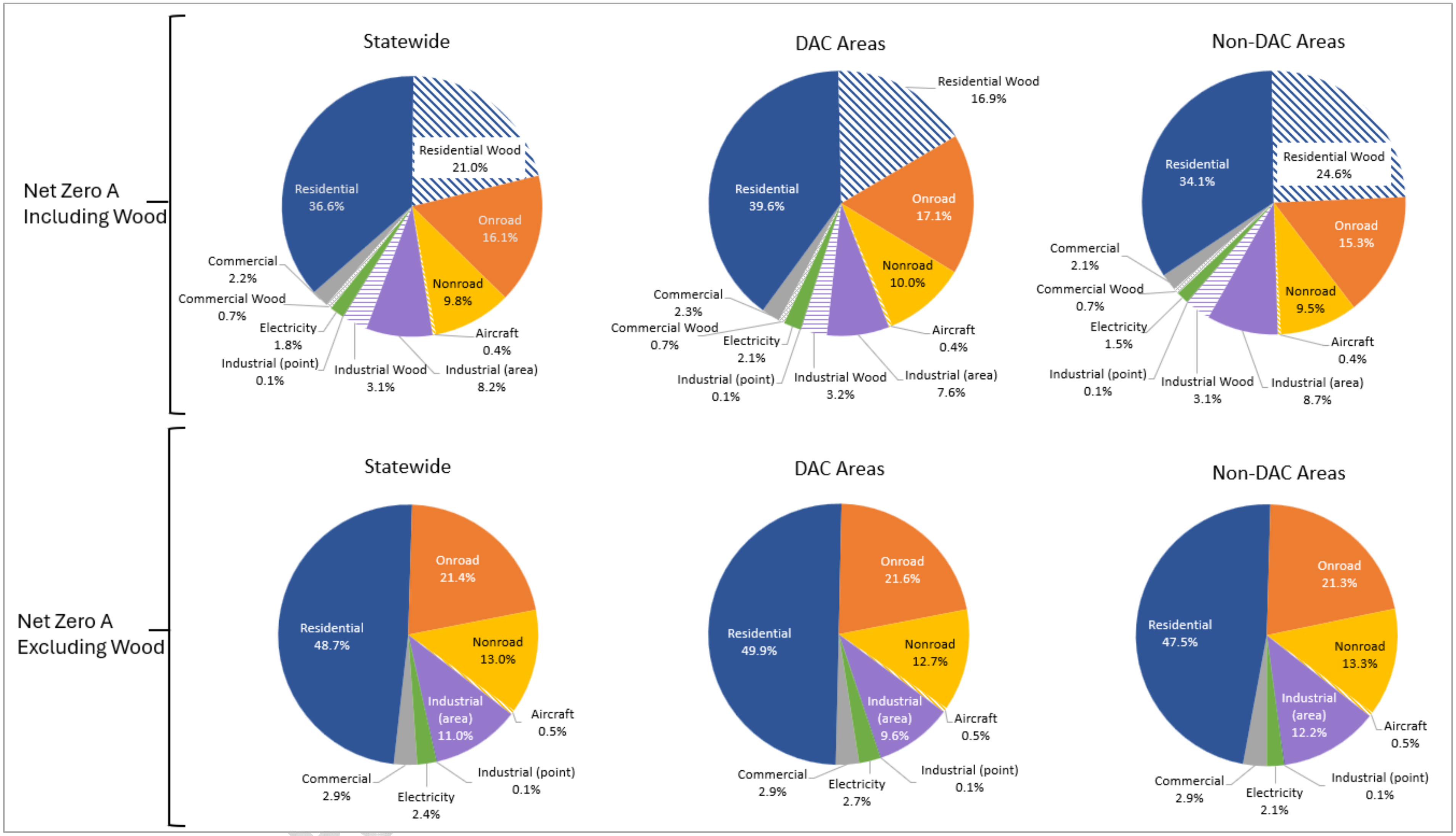


Figure A-22. Regional Distribution of Cumulative Monetized Benefits by Sector with (top) and without (bottom) the Benefits of Reduced Wood Combustion (Current Policies Scenario, 2025-2040)

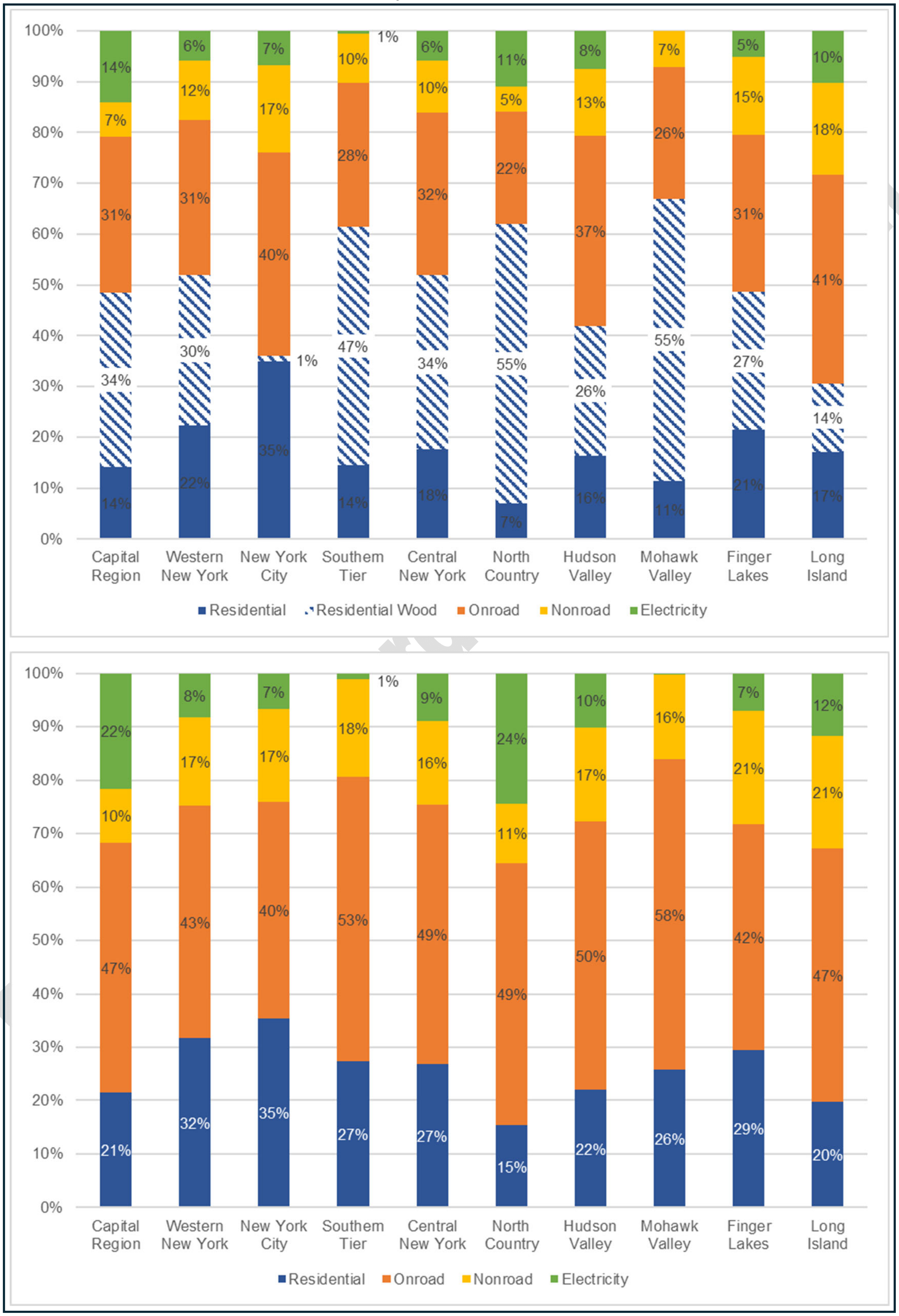


Figure A-23. Regional Distribution of Cumulative Monetized Benefits by Sector with (top) and without (bottom) the Benefits of Reduced Wood Combustion (Additional Action Scenario, 2025-2040)

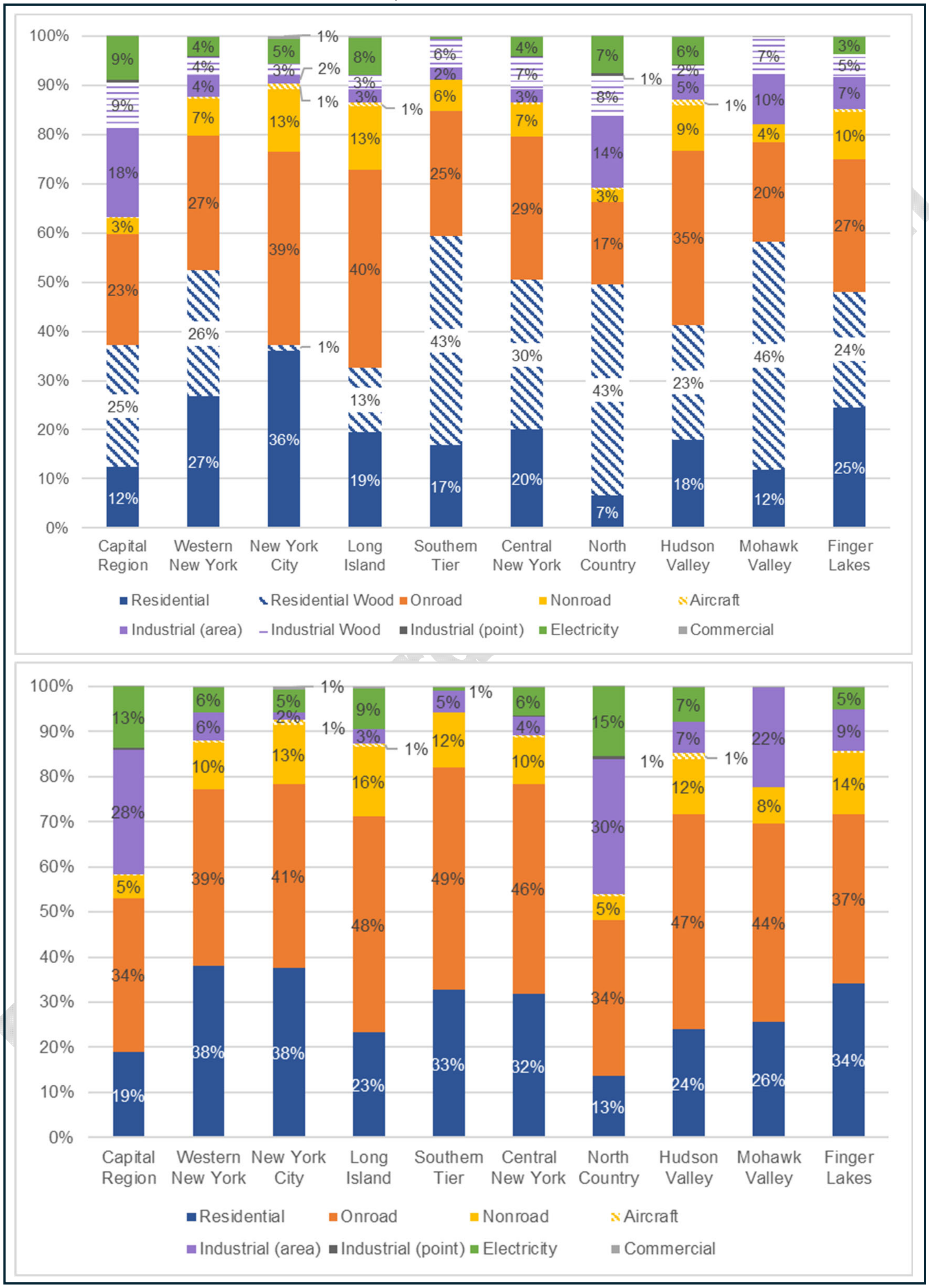
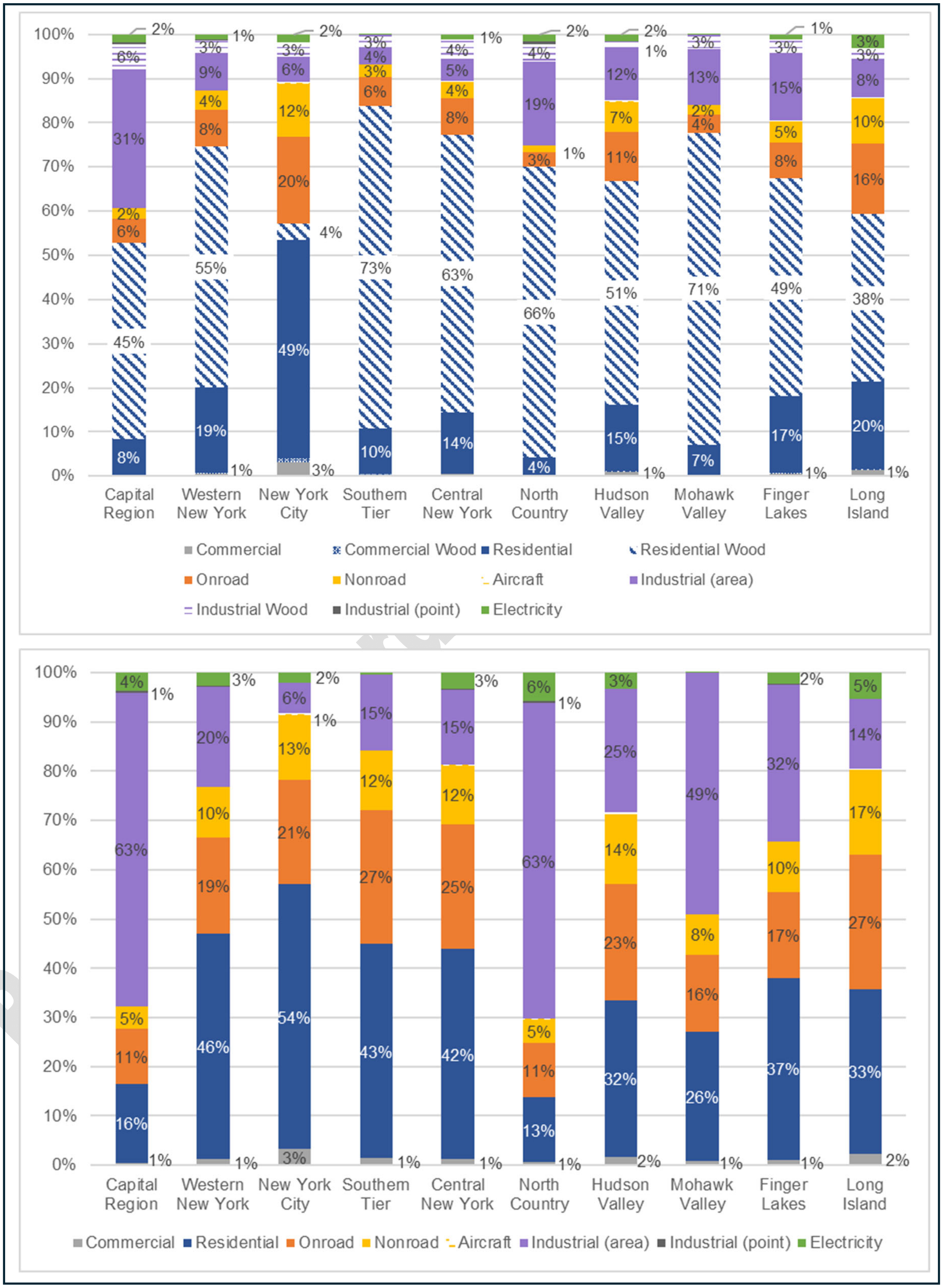


Figure A-24. Regional Distribution of Cumulative Monetized Benefits by Sector with (top) and without (bottom) the Benefits of Reduced Wood Combustion (Net Zero A Scenario, 2025-2040)



Economic Impacts: Jobs Analysis

Key Findings

- Employment across New York's energy economy—including the electricity, buildings, transportation, and fuels sectors—is expected to increase by over 60,000 net jobs by 2040 under the Draft State Energy Plan's core planning scenario, Additional Action. This is a 13 percent increase in energy sector jobs statewide between 2025 and 2040.
- The electricity and buildings sectors are projected to experience notable growth, jointly adding more than 80,000 net jobs, driven by sizeable investments into clean electricity generation and building efficiency and electrification. The employment expansion in these sectors is more than four times the projected decline in the vehicle maintenance, fueling stations, and other fossil fuel-related subsectors.
- New jobs are largely concentrated in the construction industry, which is expected to grow by roughly 58 percent (47,000 net jobs). Manufacturing will also experience meaningful growth, growing by 25 percent (6,600 jobs) under the Additional Action scenario.
- Clean energy investments will also stimulate job growth across New York's economy, inducing a projected 13,600 net new jobs in other industries as a result of increased economic activity.

1. Overview

The State Energy Plan recognizes employment outcomes as one of the primary economic impacts from New York's energy investments. This analysis evaluates the employment impacts associated with the Additional Action scenario developed in the Pathways Analysis for the State Energy Plan.[1]

Over the planning period (2025–2040), over 60,000 net new jobs are projected across New York's energy economy in the Additional Action planning scenario, pointing to meaningful economic benefits. The Additional Action scenario assumes the continuation of existing local and State policies as well as additional policies and programs to drive further market adoption, such as increased investments into transportation and building efficiency and electrification. For a full description of scenario assumptions, see the Pathways Analysis chapter of this Plan. The Pathways Analysis and this employment impacts analysis were completed in June 2025 based on assumptions set in March 2025; they do not reflect more recent State policy updates or the federal policy environment as of summer 2025. The final State Energy Plan will include updates to these analyses.

Using New York employment data for 2023 as a baseline year, employment impacts are projected for 2025, 2030, 2035, and 2040.[2] These impacts include direct, indirect, and induced jobs across the electricity, fuels, buildings, and transportation sectors and their relevant subsectors.[3]

2. Methodology

2.1. Modeling and Output Structure

For this analysis, New York's energy economy is organized by the four major sectors shown in Table 1. This structure focuses on the four sectors of the economy most directly impacted by State energy policies.

This modeling effort estimates the employment impacts associated with in-state capital and operational expenditures across the subsectors listed above. The modeling framework also includes negative employment impacts in New York in those subsectors seeing reduced investments and expenditures from this scenario. Modeling does not include economic impacts on households and businesses from energy cost savings. Assumptions made within specific subsectors vary due to the nature of the different activities.

[1] This employment impacts analysis was conducted by BW Research.
[2] Baseline employment data is sourced from the 2024 New York Clean Energy Industry Report and the 2024 United States Energy and Employment Report (USEER) unless otherwise stated. The analysis models projected employment for the future years based on the Pathways scenario data. The employment modeling approach is developed based on the methods used in the New York Just Transition Working Group's 2023 Jobs Study.
[3] **Direct** employment is associated with the initial economic activity of a given investment or activity (e.g., changes in wages, production, or jobs). **Indirect** employment is associated with the supply chain connected to the initial economic activity of the original investment or activity (e.g., purchases of goods and services or business tax impacts). **Induced** employment is based on the additional household spending resulting from the additional direct and indirect employment that is generated from the initial economic activity of the original investment or activity (e.g., wages paid, household purchases, or household tax impacts).

Table 1. Primary Energy Sectors and Subsectors

Category	Sector	Subsector
Energy Supply	**Electricity**	Solar Offshore Wind Onshore Wind Hydropower Hydrogen Biomass Distribution Transmission Storage Natural Gas Generation Other Fossil Generation Nuclear
	Fuels	Hydrogen Bioenergy Natural Gas Natural Gas Distribution Petroleum Fuels
Energy Demand	**Buildings**	Commercial HVAC Commercial Shell Commercial Other Residential Shell Residential HVAC Residential Other
	Transportation	Vehicle Manufacturing Wholesale Trade Parts Charging & Hydrogen Fuel Stations Vehicle Maintenance Conventional Fueling Stations

The methodology follows six steps:

1. Determine the unit inputs for the model. Unit inputs typically come from the Pathways Analysis data and take the form of device stocks and sales, megawatts (MW) of electric capacity, and fuel demand.

2. Determine the unit and total investments. Investment inputs come from the Pathways Analysis data where provided, and any additional investments assumed from secondary sources have been noted.

3. Process the investments to reduce inter-annual variation as needed.

4. Use technical cost data from secondary sources to allocate the processed investment data into the relevant industry categories based on the activities associated with the investments, such as relevant construction, manufacturing, and professional services activity.

5. Apply IMPLAN/JEDI industry employment multipliers based on the allocation described in step 4 to calculate employment outputs.

6. Report employment outputs by sector, subsector, and by industry category (construction, professional services, manufacturing, other supply chain, and induced).

3. Employment Impacts

3.1. Results Overview

Under the Additional Action scenario, overall energy sector jobs in New York increase by 9 percent between 2025 and 2030, further increase by 5 percent between 2030 and 2035, and decrease by 2 percent between 2035 and 2040. Over the full horizon of this Plan (2025 to 2040), net jobs are expected to grow by 13 percent. Overall, 60,700 net new jobs are projected to be added between 2025 and 2040, with this increase driven by sizeable investments into clean electricity, building efficiency and electrification, and clean transportation, offset somewhat by comparatively smaller decreases in the transportation and fuels sector. The largest number of new net jobs are projected in the electricity sector, which sees roughly 44,500 new jobs, or a 32 percent increase, and maintains the second-largest share of energy workers throughout the horizon of the Plan. The buildings sector makes up the largest sector of the energy workforce and is projected to add roughly 38,800 net jobs over the course of the Plan. Net jobs in the transportation and fuels sector are expected to decrease between 2025 and 2040—by 14 percent and 13 percent, respectively—consistent with decreased investments in fossil fuels modeled in the Additional Action scenario.

Table 2. New York Jobs, by Energy Sector

Sector	2025	2030	2035	2040	Change 2025 to 2040
Electricity	138,701	164,007	184,665	183,331	32 %
Buildings	169,445	188,840	203,116	208,298	23 %
Transportation	136,808	134,030	129,155	118,190	-14 %
Fuels	31,616	31,496	29,284	27,449	-13 %
Total	**476,570**	**518,373**	**546,221**	**537,268**	**13 %**

Much of the net increase in jobs can be attributed to increased demand for construction work, which is expected to add roughly 47,000 new net jobs. Other net growth industries include manufacturing (6,300 added jobs), professional services (3,400 added jobs), and induced jobs across the economy (13,600 added jobs). Jobs in other parts of the supply chain, which include some operations jobs (for example plant operators, maintenance work, wholesalers, or other on-site work outside of the construction phase), are expected to decrease by 9,500 net jobs (see Figure 1). Other supply chain jobs may increase beyond the time horizon of the plan as new construction planned in the later years of the Additional Action scenario become operational.

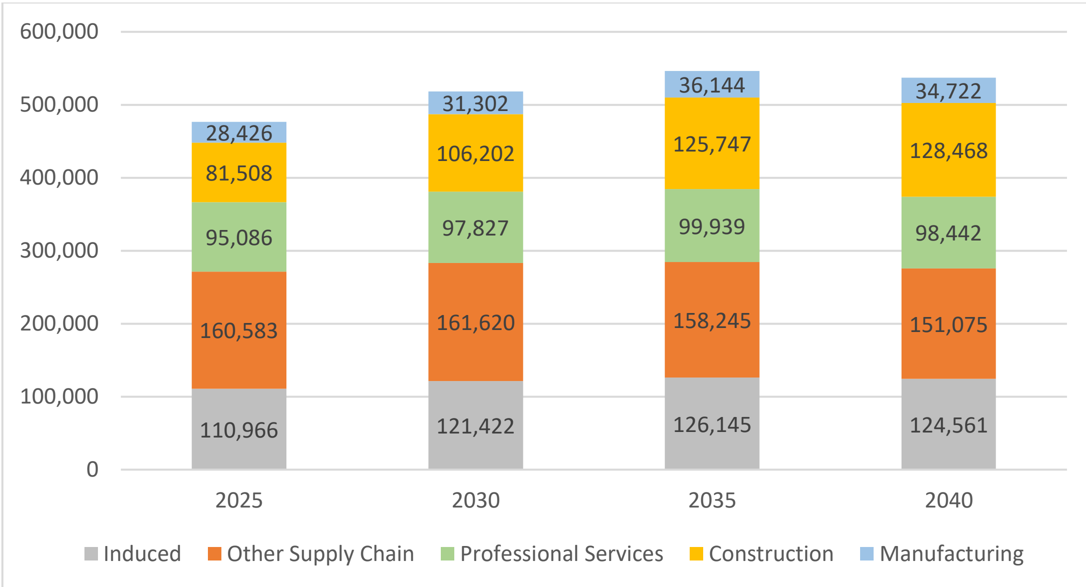


Figure 1. New York Net Energy Jobs, by Industry

Within the two net growth sectors, the electricity sector and the buildings sector, roughly half of the added jobs (or 43,900 jobs) are in the construction industry. About one-fifth (21 percent) are in induced across other industries, and the rest in other supply chain work such as operations and related work (14 percent, manufacturing (6 percent), and the balance are in professional services (see Figure 2).

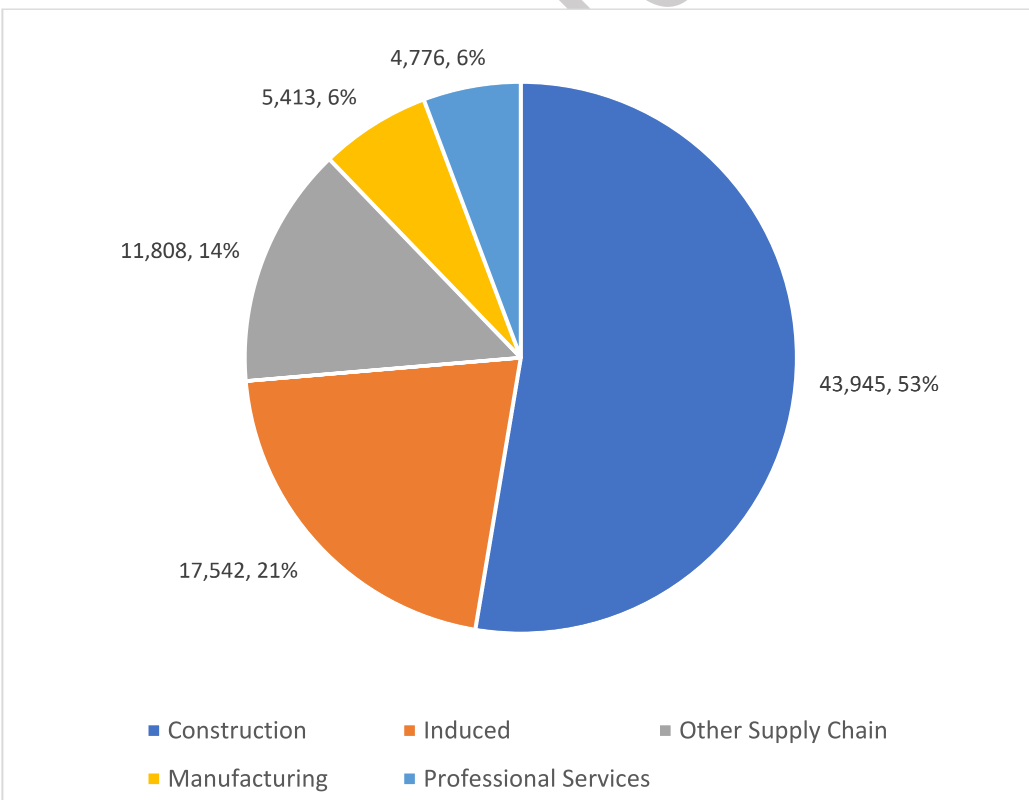


Figure 2. Net Job Growth by Industry, Growth Sectors (Electricity and Buildings) (2025–2040)

4. Electricity Sector

Investments into the electric sector are projected to generate 44,600 jobs between 2025 and 2040 (see Table 3). Despite consistent growth at the sector level, projected growth is not uniform across the subsectors. The increases are concentrated largely in renewable energy sources such as wind, hydropower, and solar, as well as in storage and electric distribution jobs. This growth meaningfully outpaces the projected displacements. Additionally, repowering fossil plants near retirement to clean, dispatchable energy sources helps offsets many of the jobs displaced in fossil and gas generation.

Table 3. New York Jobs - Electricity Subsectors

Sector	2025	2030	2035	2040	Change 2025 to 2040
Distribution	71,852	77,651	84,031	90,406	18,554
Utility Solar	4,645	10,838	21,647	23,611	18,966
Distributed Solar PV	20,447	25,221	23,624	19,107	-1,340
Offshore Wind	874	7,631	16,162	12,482	11,608
Hydropower	7,832	7,832	7,832	10,205	2,373
Land-based Wind	6,753	7,023	6,864	9,540	2,787
Fossil Fuel and Hydrogen Generation	13,027	11,572	9,440	7,439	-5,588
Storage	5,299	8,237	7,222	5,709	410
Nuclear	4,825	4,840	4,621	4,609	-216
Transmission	207	223	356	224	17
Biomass	2,939	2,939	2,866	0	-2,939
Electricity Total	**138,701**	**164,007**	**184,665**	**183,331**	**44,630**

The electric distribution sector is projected to add over 18,500 net jobs between 2025 and 2040, a roughly 26 percent increase, consistent with increased investments to expand and bolster the State's electric distribution system. Solar generation, including utility scale and distributed solar, is expected to generate more than 17,600 net jobs between 2025 and 2040, with all the net new jobs concentrated in the New York utility scale solar industry. Offshore and onshore wind are projected to generate roughly 14,300 net jobs between 2025 and 2040, with over 11,600 net jobs, or a roughly 13 times increase, in the offshore wind subsector.

On a net basis, the fossil fuel and hydrogen electricity generation subsectors see the most substantial decrease in employment, declining by approximately 5,500 jobs between 2025 and 2040. This decline is driven by displacement in the fossil fuel generation sectors, offset in part by repowering these plants with hydrogen.

The electricity sector is expected to add roughly 3,000 net construction jobs and 5,000 net manufacturing jobs between 2025 and 2040. The remainder of the net jobs are expected to be added in other supply chain categories, some in professional services, as well as induced jobs across other sectors (see Figure 3).

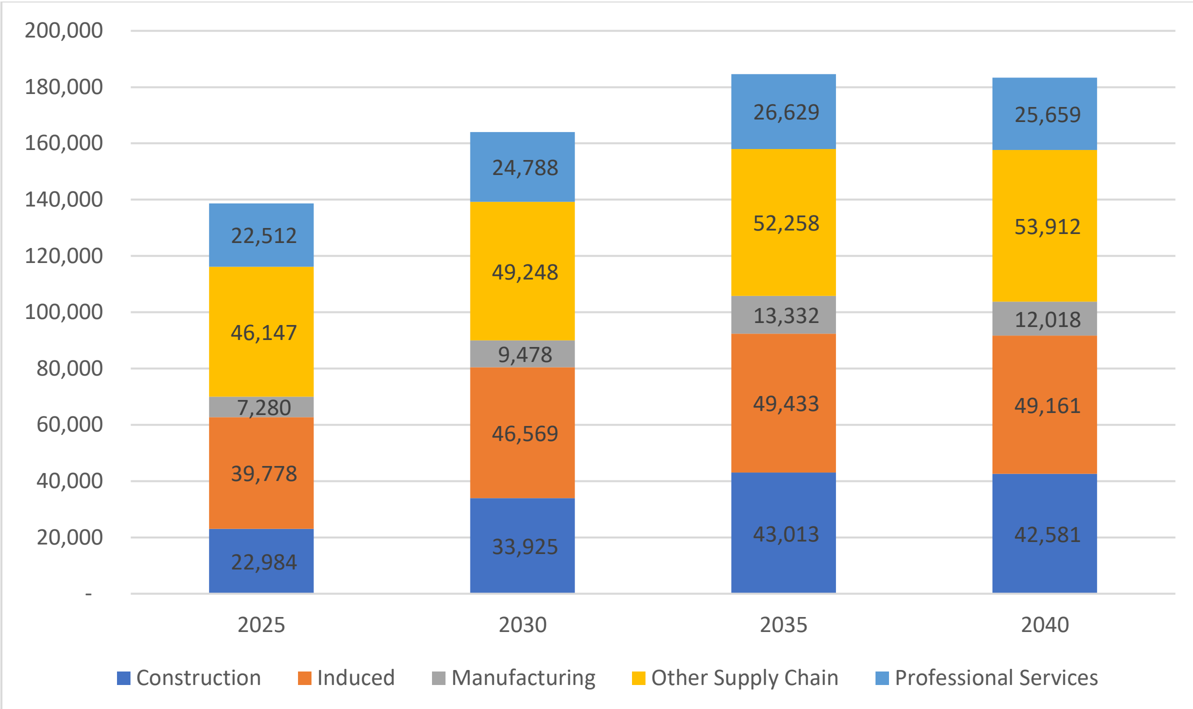


Figure 3. Jobs by Industry, Electricity Sector

4.1. Distribution

The Distribution subsector refers to the delivery of electricity generated from sources to the electrical grid to end users, including homes, businesses, and institutions. This subsector is projected to experience growth of 18,554 jobs (26 percent) from 2025 to2040. Growth is relatively evenly distributed across industries. In 2040, other supply chain categories (39,480 jobs) and professional services (13,530 jobs) make up most of the employment in the subsector.

4.2. Utility Solar

The utility solar subsector involves large-scale solar power plants that generate electricity from photovoltaic panels or concentrated solar power systems. This subsector is expected to experience a substantial increase in employment from 2025 to 2040, gaining 18,966 jobs (408 percent). Categorizing employment increases by industry, most of the growth in utility solar jobs is in construction, which grows by 13,081 jobs (702 percent). In 2040, construction (14,950 jobs) and induced jobs (5,030 jobs) make up most of the employment in the subsector, while other supply chain categories account for 1,850 jobs.

4.3. Distributed Solar PV

The distributed solar PV subsector refers to small-scale solar power systems that are typically installed on rooftops or local properties and generate electricity close to the point of use. This subsector experiences a decrease of 1,341 jobs (-7 percent) from 2025 to 2040, with considerable employment growth between 2025 and 2030, followed by declines between 2030 and 2040. Categorizing employment increases by industry, most of the decline in distributed solar PV jobs is in construction, shrinking by 776 jobs (-12 percent). In 2040, construction, professional services, and induced employment each account for roughly a quarter of jobs in the subsector.

4.4. Fossil Fuel and Hydrogen Generation

The natural gas generation subsector involves producing electricity by burning natural gas in power plants, typically through combustion turbines, steam turbines, or combined-cycle systems. In the Additional Action scenario, the Natural Gas Generation subsector is projected to experience a decline from 9,627 jobs in 2023 to no employment in 2040. The other fossil fuel generation subsector in the electricity sector refers to the production of electricity using fossil fuels other than natural gas, primarily petroleum-based fuels. These jobs decline from 3,400 in 2024 to none in 2040.

Consistent with the State's clean electricity goals, the Additional Action scenario includes the repowering of fossil plants near retirement to green hydrogen to serve as a clean, dispatchable electricity source. This repowering helps offset many of the jobs that would otherwise be displaced in fossil and gas generation because many of these jobs would remain intact as their generation plant continues to operate with a new fuel source. Overall, roughly 13,000 fossil generation jobs are expected to reduce to 7,000 jobs in hydrogen generation by 2040. On net, this would lead to roughly 5,500 fossil generation jobs being displaced (see Table 4).

Table 4. Jobs, Fossil Fuel and Hydrogen Electric Generation

Sector	2025	2030	2035	2040	Change 2025 to 2040
Natural Gas Generation	9,627	8,206	5,644	0	-9,627
Other Fossil Generation	3,400	3,366	2,942	0	-3,400
Hydrogen	0	0	854	7,439	7,439
Fossil Fuel and Hydrogen Generation	**13,027**	**11,572**	**9,440**	**7,439**	**-5,588**

4.5. Offshore Wind

The offshore wind subsector involves generating electricity from wind turbines installed in bodies of water, typically oceans or large lakes. Net jobs in the offshore wind subsector are projected to expand significantly between 2025–2035, growing from roughly 870 to 16,100 jobs in that period, with construction (3,400 new net jobs) and manufacturing (5,600 new net jobs) making up roughly 60 percent of that growth. After this initial boost in construction work, offshore wind jobs are expected to decrease to 12,400 jobs between 2035 and 2040, losing 3,680 jobs (-23 percent) from 2035–2040. In 2040, induced employment accounts for 33 percent of the projected jobs in the subsector, followed by manufacturing with 30 percent and construction with 21 percent. Recent federal actions put these jobs at risk.

4.6. Land-based Wind

The land-based wind subsector generates power using wind turbines installed onshore. The land-based wind subsector is projected to add 2,787 net jobs (+41 percent) from 2025–2040 with significant growth occurring from 2035–2040, when jobs increase from 6,800 to 9,500 (+39 percent). In 2040, jobs are relatively evenly split across industries: construction and induced employment account for roughly a quarter of jobs each, followed by professional services (18 percent) and manufacturing (17 percent).

4.7. Transmission

The transmission subsector in the electricity sector involves the high-voltage transfer of electricity from power generation facilities to distribution networks. Transmission jobs are expected to increase between the 2030 and 2035 period, when jobs increase from 223 to 356 as a result of investments in that period in the Additional Action scenario. However, overall this subsector is projected to experience virtually no change in employment over the horizon of the plan, with an increase from 207 in 2025 to 224 in 2040 (+8 percent).

4.8. Storage

The storage subsector encompasses technologies and systems that store electrical energy for later use, such as batteries, pumped hydro storage, and thermal storage. Storage jobs are expected to increase as high as 8,200 in the 2025 to 2030 period, largely driven by new construction work, which added 2,000 jobs alone. In 2040, construction jobs make up 42 percent of jobs in this subsector, followed by professional services (22 percent) and induced jobs (21 percent).

4.9. Nuclear

The nuclear generation subsector produces electricity through nuclear fission, where atoms are split to release energy that heats water, creating steam to drive turbines. The nuclear subsector experiences a small decline of 210 jobs (-5 percent) from 2025–2040 with most of that decline happening from 2030-2035.[4] Nuclear jobs are largely concentrated in induced and other supply chain jobs, which includes operations work, and jointly make up 80 percent of the total jobs.

4.10. Biomass

The biomass subsector involves generating power by burning organic materials such as wood, agricultural residues, or waste. It is a form of renewable energy that converts biological material into electricity, often using direct combustion, gasification, or anaerobic digestion. The biomass subsector experiences a decline from 2,939 jobs in 2025 to no employment in 2040 jobs, with this decline projected to occur in the last five years of the plan. While the Additional Action scenario excludes biomass electric generation as a qualifying source of clean electricity, jobs in biomass facilities are not necessarily displaced altogether: many of these facilities, such as pulp and paper mills would likely continue to generate onsite electricity from biomass sources.

4.11. Hydropower

The hydropower subsector generates electricity by harnessing the kinetic energy of flowing or falling water, typically using dams, turbines, and generators. The hydropower subsector experiences a net increase of 2,370 jobs (+30 percent) between 2025–2040, with this increase occurring 2035 and 2040 after employment remaining flat between 2025-2035. More than half of these added jobs are in construction (1,500 jobs).

[4] The Additional Action scenario assumes that all nuclear facilities retire at the end of their 60-year licenses and was conducted before the Governor's June 2025 announcement directing NYPA to pursue a new nuclear plant.

5. Buildings Sector

The New York buildings sector encompasses a wide range of structures, including single-family residences, multifamily residences, and commercial buildings. Overall, the Additional Action scenario results in a consistent increase in employment year-on-year: total net employment increased by 38,853 (+23 percent) in the buildings sector from 2025–2040.

Despite consistent growth at the sector-level, growth is not uniform across the subsectors. The residential shell subsector is projected to experience the highest rate of growth and largest overall growth in employment by 19,693 jobs (+274 percent). The residential heating, ventilation, and air conditioning (HVAC) subsector also sees a substantial increase in jobs, growing by 15,777 jobs (+28 percent) from 2025–2040. The residential Other subsector sees a decrease in employment, declining by 3,700 jobs (-10 percent). The Commercial subsectors sees less employment than their respective Residential counterparts, but all Commercial subsectors sees growth from 2023-2040, ranging from 1,057 jobs (+22 percent) in Commercial Shell, 2,616 (+7 percent) in commercial HVAC, to 3,408 (+13 percent) jobs in Commercial Other.

Table 5. New York Jobs - Building Subsectors

	2025	2030	2035	2040	Change 2025 to 2040
Residential Shell	7,200	16,286	25,466	26,894	*19,694*
Residential Other	35,815	34,679	33,394	32,116	*-3,699*
Residential HVAC	55,594	63,175	67,161	71,371	*15,777*
Commercial Shell	4,772	6,108	6,123	5,829	*1,057*
Commercial Other	26,445	27,914	29,295	29,853	*3,408*
Commercial HVAC	39,619	40,680	41,676	42,235	*2,616*
Buildings Total	**169,445**	**188,840**	**203,116**	**208,298**	***38,853***

The buildings sector is expected to add roughly 15,000 net construction jobs and just under 1,000 net manufacturing jobs between 2025–2040. The remainder of the net jobs are expected to be added in other supply chain (more than 2,000), some in professional services (1,000), and nearly 8,000 induced across other sectors.

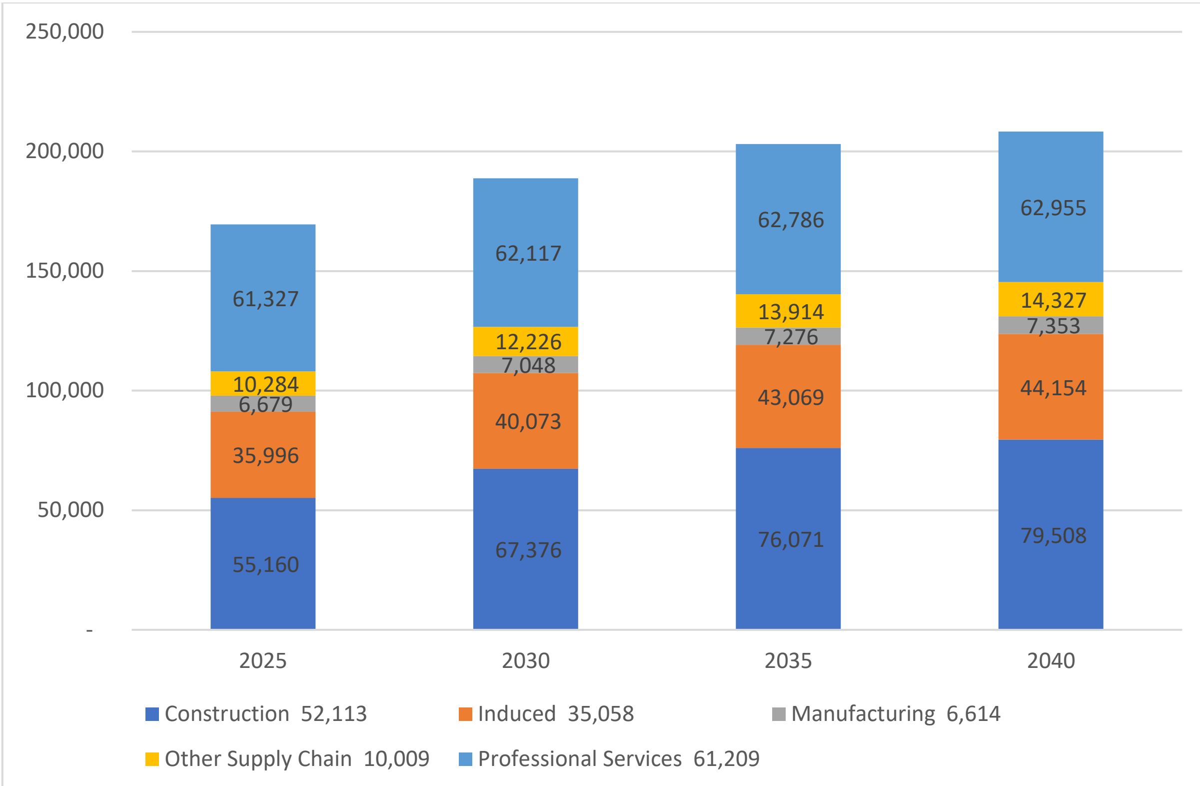


Figure 4. Jobs by Industry, Buildings Sector

5.1. Residential Shell

The residential shell sector includes the construction, upgrade, and maintenance of the building envelope in various types of housing, such as detached and attached single-family homes and multifamily buildings.

The residential shell subsector is projected to experience substantial growth from adding roughly 9,000 jobs in the 2025 to 2030 period and again in the 2030 to 2035 period. Over the full horizon of the plan, this subsector is projected to add 19,694 net jobs, a more than twofold increase from 2025. Increased investments in detached single-family residential building shells drives long-term growth in the subsector. Looking at industries in the subsector, construction has the highest share of jobs, accounting for 51 percent of employment in 2040. Construction jobs have the most substantial increase in the subsector by employment difference, gaining 11,000 jobs (+424 percent) from 2025–2040, while other supply chain jobs see the biggest percentage increase, growing by 538 percent, or 3,000 jobs.

5.2. Residential HVAC

The residential HVAC subsector covers the installation, maintenance, and repair of space heating, ventilation, and air conditioning systems in homes, including single-family and multifamily units.

This subsector is projected to experience growth of 15,777 jobs (+28 percent) from 2025 to 2040. Categorizing employment increases by industry, most of the growth in residential HVAC jobs are in construction, as it grew by roughly 11,000 jobs (+58 percent). This growth in construction is driven primarily by increased investments in single-family space heating. In 2040, construction (30,910 jobs) and professional services (19,570 jobs) make up most of the employment in the subsector, while induced employment accounts for 14,850 jobs. Manufacturing and other supply chain industries each grew by 16 percent and 25 percent, respectively, although off a smaller baseline.

5.3. Residential Other

The residential other subsector includes a diverse range of energy-using equipment and end-uses in homes that fall outside of core HVAC and building envelope work. This subsector includes clothes washers and dryers, dishwashers, refrigerators, cooking equipment, general and specialty lighting, and refrigeration and water heating systems across single-family and multifamily residential buildings. The other residential subsector is projected to decline by 3,700 jobs (-10 percent) from 2025 to2040, with steady decreases across each period. This decline in employment in the subsector is driven primarily by decreased investments in residential general service lighting and water heating. Looking at industries in the subsector, professional services has the highest share of jobs, accounting for 45 percent of employment in 2040. Construction has the most substantial decline in the subsector, losing 2,614 jobs (-26 percent) from 2025 to 2040

5.4. Commercial HVAC

The commercial HVAC sector involves the installation, operation, and maintenance of heating, ventilation, and air conditioning systems in non-residential buildings to regulate indoor climate and air quality. It includes commercial air conditioning, space heating, and ventilation systems. Increased investments in commercial space heating drove increased employment in this subsector, which experiences consistent year-on-year growth—albeit more moderate than similar work in the residential subsectors—gaining 2,616 jobs (+7 percent) from 2025 to 2040. Most of this job growth is concentrated in construction, which added 1,800 net jobs in that same period. Construction makes up the highest share of jobs, accounting for 70 percent of employment in 2040, followed by professional services (22 percent). Construction also saw the most substantial increase in employment, growing by 2,300 jobs (+17 percent)

5.5. Commercial Shell

The commercial shell sector includes the construction, upgrade, and maintenance of the building envelope in commercial spaces. The commercial shell subsector is projected to add 1,057 jobs between 2025 and 2040. Much of this increase is expected to occur during the 2025 to 2030 period, where jobs climb from approximately 4,700 to 6,100 and remain at that level until 2040, when jobs decrease to 5,800. In 2040, just under half of the jobs in this subsector are in construction, followed by professional service (25 percent) and induced (22 percent). Only a small share of this work is in manufacturing and other supply chain work (jointly 14 percent).

5.6. Commercial Other

The commercial other subsector includes a diverse range of energy-using equipment and end-uses in commercial spaces that fall outside of core HVAC and building envelope work. The subsector includes commercial cooking equipment, refrigeration units, water heating systems, and various types of lighting, such as general service, High Intensity Discharge (HID), and linear fluorescent lighting. The commercial other subsector saw significant investment in commercial cooking, driving employment, while commercial general service lighting investments declined heavily.

The commercial other subsector experiences an increase of 3,408 jobs (+13 percent) from 2025 to 2040, with growth relatively evenly spread across all periods. In the subsector, construction has the highest share of jobs across the industries, accounting for 70 percent of employment in 2040. Construction jobs also experience the most substantial increase in the subsector, gaining 2,380 jobs (+32 percent) between 2025–2040.

6. Fuels Sector

Overall, fuels jobs are projected to decrease by about 13 percent, or roughly 4,200 jobs between 2025 and 2040. This displacement is driven largely in jobs associated directly with natural gas and petroleum fuels, while projected growth in the hydrogen and biofuels subsectors are projected to offset this displacement somewhat.

Table 6. New York Jobs - Fuels Subsectors

	2025	2030	2035	2040	Change 2025 to 2040
Hydrogen Fuels	-	69	358	864	*863*
Natural Gas	4,390	4,154	3,847	3,538	*-852*
Petroleum Fuels	8,710	7,756	6,283	4,719	*-3,991*
Biofuels	4,925	4,583	4,915	5,394	*469*
Natural Gas Distribution	13,589	14,934	13,881	12,935	*-654*
Fuels Total	**31,616**	**31,496**	**29,284**	**27,449**	***-4,167***

The fuels sector jobs displacement is concentrated in other supply chain work, where the subsector is expected to lose roughly 1,300 net jobs over the course of the plan (see Figure 5).

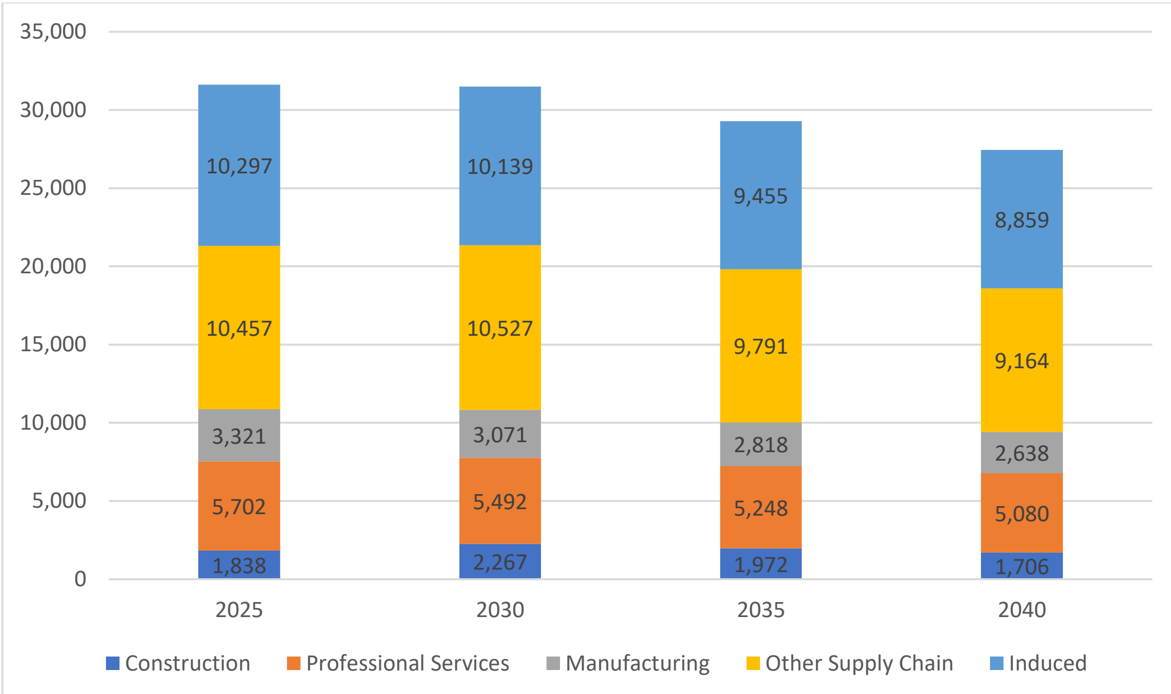


Figure 5. Jobs by Industry, Fuels Sector

6.1. Hydrogen Fuels

Consistent with new hydrogen generation assumptions made in the Additional Action scenario, employment in the hydrogen fuels subsector to grow from zero in 2025 to 864 jobs in 2040. About 36 percent of employment in 2040 is in manufacturing, 28 percent in induced employment, 19 percent in professional services, and 16 percent in other supply chain.

6.2. Natural Gas

Within the Natural Gas subsector, net employment is expected to decrease by 852 jobs, or by 19 percent between 2025 and 2040. Employment is projected to slow somewhat between 2025 and 2030 and again between 2035 and 2040. In 2040, 29 percent of natural gas employment falls into the other supply chain industry group, followed by 18 percent in professional services and 12 percent in manufacturing. Induced employment impacts contribute to 41 percent of the subsector's employment.

6.3. Natural Gas Distribution

The Natural Gas Distribution subsector—which consists of technologies like natural gas pipelines and LNG trucks and tankers—sees small decrease of 655 jobs (-5 percent) in employment from 2025 to 2030 due to marginal decreases in projected consumption and associated decommissioning. Employment is expected to increase in the short term (2025 through 2030) and begins to decline beginning in 2030.

In 2040, other supply chain—which includes the natural gas distribution utility, wholesale and retail trade, transportation, and distribution industries—makes up 38 percent of the jobs, follow by 37 percent in induced jobs. The balance of jobs is spread between construction and professional service, with about 300 manufacturing jobs in the sector throughout the whole horizon of the plan.

6.4. Petroleum Fuels

Employment within the Petroleum Fuels subsector—which consists of technologies like oil and gas pipelines, oil and gas tanker trucks, and delivered fuels such as oil and kerosene—declines steadily from 2025 to 2040, seeing a decrease of 3,991 jobs (-46 percent) across this period. At the industry level, petroleum fuels is split fairly evenly between professional services (18 percent of jobs), manufacturing (23 percent of jobs), and other supply chain (27 percent of jobs). The remaining 28 percent of jobs are supported by induced impacts.

6.5. Biofuels

Employment within the biofuels subsector increases by 469 net jobs (+10 percent) between 2025 and 2040. Employment declines between 2025 and 2030 as ethanol expenditures decline. While ethanol costs continue to decline through 2040, employment begins to rise again after 2030 as renewable jet kerosene and renewable natural gas costs rise.

At the industry level, most biofuels employment is concentrated in professional services and other supply chain, which comprise 37 percent and 34 percent of subsector employment in 2040, respectively. Induced impacts contribute to 20 percent of biofuels employment in 2040, while manufacturing makes up 10 percent of employment.

7. Transportation Sector

The transportation sector is projected to see overall job displacement, offset by meaningful growth in employment related to electric vehicle charging stations, where jobs are projected to increase roughly fourfold between 2025 and 2040 due to increased investments into clean transportation.

In contrast to the strong growth in the electric vehicle (EV) charging station subsector and relatively steady employment numbers in the vehicle manufacturing and wholesale trade parts subsectors across the study years, job displacement is projected in the conventional fueling stations and vehicle maintenance subsectors. Overall employment in the transportation sector remains fairly steady through 2030, but net displacement occurs from 2030 to 2040 as alternative transportation stock increases more rapidly and internal combustion engine vehicle stock decreases more rapidly than previous years.

Total net employment is projected to decrease by 16,210 (-12 percent) in the transportation sector between 2025 to2040. EV charging stations are expected to experience the highest rate of growth and largest overall growth in employment, increasing by 9,957 jobs (+450 percent). Most of the job displacement is concentrated in the conventional fueling stations and vehicle maintenance subsectors, which decrease by 14,081 (-33 percent) and 13,207 (-22 percent), respectively.

The transportation sector is expected to displace roughly 19,000 net jobs within the other supply chain category—such as fuel station operators, maintenance, and repair workers—and another 2,000 jobs that would otherwise be induced. However, this sector will add a net 4,000 construction jobs and 2,000 manufacturing jobs to support the build out of new EV charging infrastructure (see Figure 6).

Table 7. New York Jobs - Transportation Subsectors

	2025	2030	2035	2040	Change 2025 to 2040
Charging Stations	3,206	5,857	10,743	13,163	9,957
Vehicle Manufacturing	14,202	14,186	14,142	14,132	-70
Wholesale Trade Parts	18,387	18,298	18,210	18,124	-263
Conventional Fueling Stations	42,323	39,141	34,264	29,167	-13,156
Vehicle Maintenance	58,689	56,549	51,795	46,012	-12,677
Transportation Total	**136,808**	**134,030**	**129,155**	**120,598**	**-16,210**

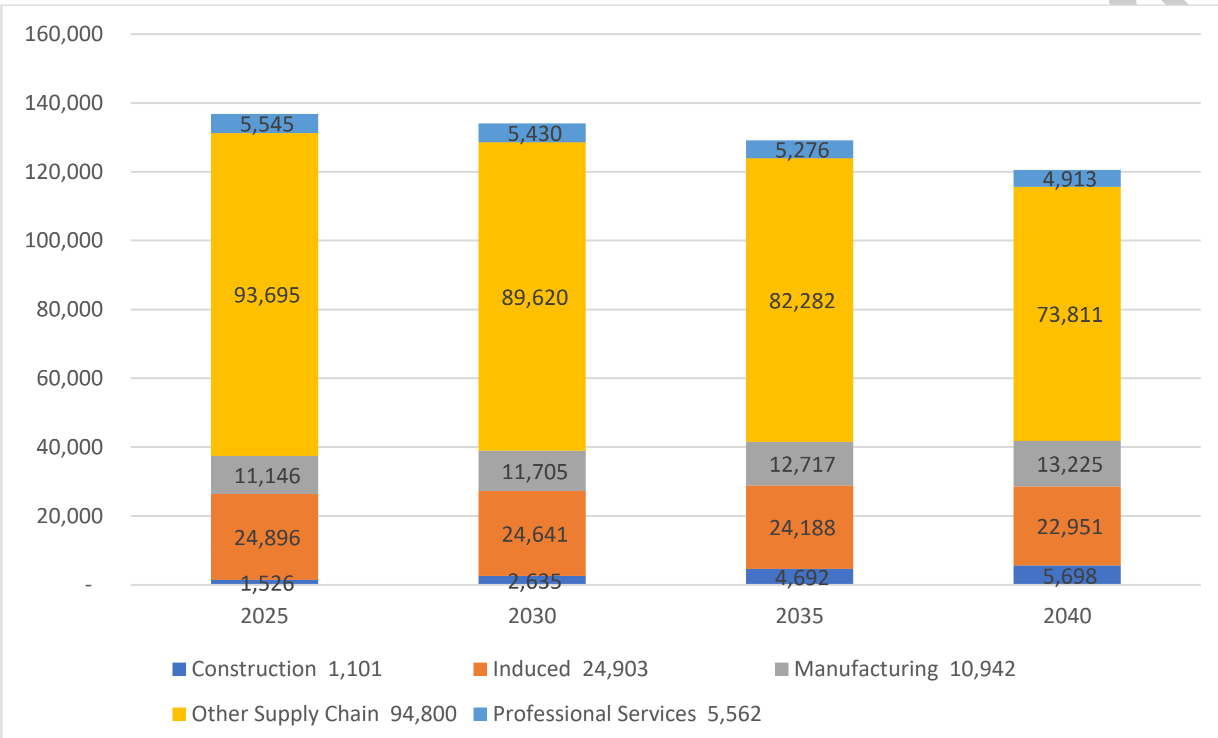


Figure 6. Jobs by Industry, Transportation Sector

7.1. Charging Stations

The EV charging station subsector experiences growth of 9,960 jobs (+311 percent) from 2025 to 2040, with employment gains increasing more rapidly from 2030 to 2040 as charger manufacturing, installation, and maintenance costs rise to accommodate the growth in the State's alternative vehicle stocks. Categorizing employment by industry, about 43 percent of employment in the subsector is concentrated in construction and 21 percent is concentrated in manufacturing across the study years. Professional services and other supply chain make up 7 percent and 6 percent of employment, respectively, while the remaining 23 percent falls into the induced employment category. Construction industry sees the largest absolute employment growth between 2025 and 2040 (4,220 jobs), followed by manufacturing (2,145 jobs). Employment growth is relatively uniform across these industry groups, each increasing by 308 percent to 315 percent relative to their 2025 employment levels.

7.2. Conventional Fueling Stations

The conventional fueling station subsector experiences a decline of 13,156 jobs (-31 percent) from 2025 to 2040. This decline in employment is driven by decreased fuel demand due to declining internal combustion engine vehicle stocks. Employment within this subsector is concentrated in the other supply chain, which encompasses 77 percent of jobs.

7.3. Vehicle Maintenance

The vehicle maintenance subsector declines by 22 percent, or 12,677, from 2025 to2040. This decrease in employment is primarily caused by the difference in maintenance expenditures between alternative vehicles and internal combustion engine vehicles. Alternative vehicles have fewer moving parts compared to internal combustion vehicles, meaning fewer parts that will potentially need replacement as well as a decrease in regularly scheduled maintenance, such as oil changes or changes in transmission fluid, resulting in lower maintenance expenditures.[5] As the composition of vehicle stock in the state shifts to include more alternative transportation and the number of miles traveled in alternative vehicles increases, overall maintenance costs decrease and lead to a decrease in employment.[6]

Vehicle maintenance employment is concentrated in the other supply chain industry group, which comprises roughly 80 percent of employment in the subsector across the study years and decreases by 22 percent over that period.

7.4. Vehicle Manufacturing

Employment within the vehicle manufacturing subsector remains steady from 2025 through 2040, seeing a decrease of only 0.5 percent. Employment in this subsector is based primarily on vehicle sales. While the composition of the types of vehicles sold in this period changes dramatically—with alternative vehicles comprising just 16 percent of vehicle sales in 2025 and 98 percent of vehicles sold in 2040—the total number of vehicles sold remains largely stable across the study years.

Most of the employment (73 percent) is concentrated in manufacturing across the study years, with the remainder of jobs falling into induced employment (25 percent) and some in the professional services industry (2 percent).

7.5. Wholesale Trade Parts

Employment in wholesale trade parts remains relatively stable from 2025 through 2040, seeing a decrease of just 263 jobs (-1 percent) across this period. While the composition of vehicle stocks changes significantly during this time—with alternative vehicles comprising just 6 percent of total vehicle stocks in 2023 to 57 percent of stocks in 2040—the total number of vehicle stocks in the state remains largely unchanged throughout the study period, resulting in stable employment numbers. Employment in wholesale trade parts is concentrated in the other supply chain and professional service industries, which make up 76 percent and 2 percent of employment, respectively, across the study years.

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[5] For more information on maintenance costs used for each vehicle type, see https://doi.org/10.3390/wevj5040886.
[6] While vehicle miles traveled (VMT) increases substantially for alternative vehicles from 2023-2040, the overall VMT in 2040 is 4 percent lower than VMT in 2023, potentially contributing to employment decline.

Environmental Impacts

Key Findings

- **New York State's emissions control and clean energy programs are contributing to improving air quality and environmental benefits for communities and ecosystems across the state.** Energy market forces and energy-related air quality policies have resulted in substantially reduced emissions and ambient concentrations of criteria air pollutants over the past 20 years, significantly reducing ecosystem stressors such as acid (rain) deposition. These trends in emission reductions and associated benefits are projected to continue under each of State Energy Pathway scenarios modeled in this Plan.
- **New York State has a robust regulatory framework for identifying and mitigating environmental impacts associated with energy development, generation, transmission, and use.** New York State's regulations and programs are implemented to protect and maintain our air quality, water resources, sensitive ecosystems and land resources, and wildlife from any adverse impacts associated with energy. These regulations and programs seek to address any adverse impacts from the full life cycle of an energy project—from construction to operation, decommissioning, and waste.
- **New York State strategies for procuring and siting energy resources can reduce energy project risks and minimize land use conflicts.** For example, the Smart Solar Siting Scorecard is used to evaluate large solar project applications for their avoidance and mitigation of agricultural and forest lands. The New York State Offshore Wind Master Plan was based on extensive environmental and fisheries data collection to inform our understanding of environmental sensitivities and user conflicts associated with potential offshore wind areas. These types of early investments in siting optimization can reduce environmental and project risks, help to inform construction windows and permit conditions, and accelerate project timelines.
- **Opportunities to inform an environmentally responsible energy system transition should be leveraged** through continued research into new and emerging technologies and fuels, best practices, and dual use of energy sites. For example, New York State is funding research to produce data on crop and grazing potential inside large solar projects. To balance the growth of the offshore wind industry with existing marine industries, such as commercial fishing, the State has supported research to maintain and grow the region's sustainable fisheries. Environmental monitoring enables policymakers to evaluate the effectiveness of energy-related regulations, policies and strategies.

Key Terms

- **Agrivoltaics** – the simultaneous use of land for solar photovoltaic power generation and agricultural production of "crops, livestock, and livestock products"
- **Ecosystem** - a dynamic complex of plant, animal [including human], and microorganism communities interacting with each other and the nonliving environment as a functional unit
- **Endangered** – under the Endangered Species Act, plant and animal species that may be in danger of extinction throughout all or a significant portion of its range
- **Ecosystem services** – benefits people obtain from an ecosystem
- **Threatened** – under the Endangered Species Act, plant and animal species that are likely to become endangered within the foreseeable future
- **Wetlands** – an area that is saturated or inundated by water, either surface or ground, at a frequency and duration sufficient to support vegetations adapted to saturated soil conditions[1]

[1] New York State Department of Environmental Conservation (DEC), *Wetlands*, accessed July 11, 2025, https://dec.ny.gov/nature/waterbodies/wetlands#:~:text=Wetlands%20(swamps%2C%20marshes%2C%20bogs,life%20in%20saturated%20soil%20conditions.

1. Overview

1.1. New York's Ecosystems and Natural Resources

New York State contains a diversity of terrestrial and aquatic ecosystems, which provide critical ecosystem services, including food, water, forest products, air and water purification, flood prevention, carbon storage, climate moderation, recreational opportunities, and cultural services.[2] However, ecosystems statewide face significant challenges due to climate change and land use patterns.

1.1.1. Land Use and Development

New York State is predominantly rural, with forest and agriculture making up 75 percent of land use. Agricultural and forest land is present throughout the state but is highly variable among the regions. For example, the Central/Finger Lakes region includes approximately 41 percent agricultural land and 42 percent forested land, and the Mohawk River Valley, Southern Tier, Great Lakes, and St. Lawrence Valley each have more than 20 percent agricultural land and are 55 percent to 65 percent forested. New York's diverse ecosystems support a variety of agricultural and forestry goods, and the State is one of the top producers of dairy and fruit. Forests also provide an abundance of ecosystem services including air and water filtration, wildlife habitat, recreational opportunities, and carbon mitigation. About 11 percent of land is developed, mostly in New York City and Long Island.[3] Disadvantaged communities (DACs) are distributed across both urban and rural areas.

1.1.2. Waterways and Coastal Ecosystems

A total of 13.6 percent of New York State is covered by water, including inland waters, the Great Lakes, and coastal waters.[4] The State has more than 16,000 freshwater lakes, ponds, and reservoirs greater than 0.1 acre, as well as nearly 70,000 miles of rivers and streams. Water resources support biodiversity and provide a variety of critical ecosystem services to society, including drinking water and hydropower, and support regional economies through recreational opportunities, aesthetics, and cultural qualities.

Climate change is increasing lake surface water temperatures, decreasing ice cover, and increasing the length and strength of thermal stratification. Climate-induced changes in temperature, ice cover, and stratification are primary contributors to the deoxygenation of lakes. Ongoing and projected future deep-water deoxygenation represents a major challenge to coldwater fisheries.[5]

New York State has approximately 117 miles of shoreline stretching along the coast of the Atlantic Ocean as well as 577 miles of shoreline within the Great Lakes Basin, the St. Lawrence River, and the Niagara River. New York's marine habitats support abundant natural resources that are both ecologically and economically important. The New York Bight is an area of high primary productivity, supporting regional fisheries, threatened and endangered species, and part of migratory pathway along the Atlantic coast. Climate change is contributing to sea level rise, as well as species range shifts.

[2] Hess et al. 2024 Climate Impacts: Ecosystems nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.15203
[3] Hess et al. 2024. Climate Impacts: Ecosystems nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.15203
[4] U.S. Geological Survey. (2018). How wet is your state? The water area of each state. USGS Water Science School. https://www.usgs.gov/special-topics/water-science-school/science/how-wet-your-state-water-area-each-state
[5] Hess et al. 2024. Climate Impacts: Ecosystems nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.15203

1.1.3. Wetlands

Wetlands in the state include 2.4 million acres of freshwater wetlands and 25,000 acres of tidal wetlands. Often located at the transition between upland and aquatic habitats, wetlands support a diverse assemblage of plant and animal species including invertebrates, fish, amphibians, reptiles, birds, and semi-aquatic mammals. Many of these species are rare, threatened, or endangered in New York. Wetlands also provide a number of other critical ecosystem services, many of which contribute to climate resilience in watersheds. These ecosystem services include soil retention, groundwater recharge, nutrient and toxin filtration, carbon sequestration, floodwater storage, shoreline protection, and aesthetics. Wetlands have an important impact on water quality, as they intercept, filter, and absorb sediments and pollutants in surface runoff before it enters aquifers, streams, rivers, lakes, and the ocean.

1.1.4. Wildlife and Biodiversity

New York's habitats support a wide variety of species of animals and plants, including threatened and endangered species.[6] The State has 53 endangered species and 41 threated species.[7] Biodiversity, including the conservation of ecosystems, rare species, and genetic diversity, is necessary to maintain valuable ecosystem services and function. More than 600 species of plants and nearly 500 species of animals are at risk of extirpation from New York due to habitat loss and fragmentation, pollution, overharvesting, invasive species, and other factors.[8] Marine wildlife exist within a highly dynamic and human-influenced ecosystem. Natural variations in oceanographic factors, such as sea surface temperature, oceanic currents, and broad scale climate patterns, create substantial seasonal, annual, and long-term changes in wildlife abundance and distributions in marine ecosystems, which can be further influenced by human activities like fishing, shipping, and gravel/sand mining.[9]

1.1.5. Threats to Ecosystems

Climate change and climate hazards, such as sea level rise, temperature change, changes in precipitation amount and intensity, and extreme events present a threat to New York State's ecosystems, as do other pressures—including invasive species that altering New York State's ecosystems.[10] Human activities that result in habitat loss and fragmentation, erosion, sedimentation, and pollution also continue to impact State ecosystems and can account for significant ecosystem impacts.[11] Habitat loss, fragmentation, and degradation are identified as major drivers of biodiversity loss across the globe. Habitat connectivity is another key consideration as large, intact, proximate, and well-distributed conserved natural areas are necessary to ensure populations of flora and fauna have reliable and healthy habitats into the future. As such, strategic conservation of lands and waters are identified as a key mechanism to secure biodiversity, abundance of life, and ecosystem services.

[6] DEC, *List of Endangered, Threatened and Special Concern Fish and Wildlife Species of New York State*, accessed July 11, 2025, https://dec.ny.gov/nature/animals-fish-plants/biodiversity-species-conservation/endangered-species/list.
[7] Ibid.
[8] Hess et al. 2024 Climate Impacts: Ecosystems nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.15203
[9] NYSERDA. The Dynamic Ocean: Offshore wind energy and other activities in the New York Bight. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Offshore-Wind/Dynamic-Ocean-Offshore-Wind-Energy-and-Other-Activities-in-the-New-York-Bight.pdf
[10] Hess et al. 2024. https://doi.org/10.1111/nyas.15203
[11] Ibid.

1.2. Environmental Effects from the Energy System Transition

There are environmental impacts associated with energy development, generation, transmission, and use. Decisionmakers address environmental impacts from the energy sector through regulatory and permitting measures and other strategies that seek to avoid, minimize, and mitigate any adverse effects.

Energy generation technologies and infrastructure that are in operation today and that this Plan projects will continue to operate and/or expand in the future include solar energy, hydroelectric facilities, and onshore and offshore wind; these have been the subject of environmental review in prior State proceedings.[12] The potential environmental issues associated with less mature energy generation technologies or fuels evaluated in this Plan—such as alternative fuels and next generation nuclear energy—are discussed in the Low-Carbon Alternative Fuels and Nuclear chapters of this plan, respectively.

This chapter discusses the environmental impacts and benefits associated with the projected trajectory of New York State's energy system transition and highlight past and current efforts underway to monitor progress and inform responsible energy development.

2. Areas of Potential Environmental Effects

2.1. Air Quality

2.1.1. State Goals

New York State regulates air emissions from facilities in the energy sector and other sectors to ensure air quality meets National Ambient Air Quality Standards (NAAQS) as required by the federal Clean Air Act.[13] State regulators also participate in interstate bodies, such as the Ozone Transport Commission, to engage and shape regional and federal efforts to address interstate air pollutants. State regulations and initiatives aimed at reducing greenhouse gas (GHG) emissions from the transportation sector can also reduce other air pollutants, such as fine particulate matter and nitrogen oxides (NO_x).

2.1.2. Air Quality Impacts

Fossil-fuel combustion: Exposure to air pollutants, such as fine particulate matter or ozone, can pose significant health risks—especially to vulnerable populations and those with preexisting conditions. Emissions from electric generation, heating, and transportation sources can contribute to air quality impacts statewide and in nearby communities, including in DACs. These sources of air pollution include oil and natural gas fired power plants, industrial processes and building heating systems, and mobile sources from on-road and non-road vehicle emissions.[14] Importantly, these emissions and associated impacts can originate from sources within New York State and from sources located in "upwind" states.

[12] See Final Supplemental Generic Environmental Impact Statement for the Climate Leadership and Community Protection Act, September 17, 2020, prepared for New York State Public Service Commission.

[13] DEC, *State Implementation Plans and State Plans*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/air-quality/plans.

[14] DEC, *Air Emission Inventories: Point Sources*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/air-quality/air-emission-inventories#Point.

Over the past twenty years, market forces, economic drivers and the implementation of federal, State, and local energy-related air quality regulations have resulted in substantially reduced energy-related emissions and decreases in concentrations of ambient air quality pollutants such as fine particulate matter.[15] A recent research study published the results of a trends analysis for Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), Ozone (O_3), and fine particulate matter ($PM_{2.5}$) at fifty-four State DEC monitoring sites that are part of the U.S. Environmental Protection Agency's (EPA) Air Quality System for the period 2005–2019. During this time there were substantial reductions in source emissions and in resultant ambient concentrations of all ambient pollutants except O_3.

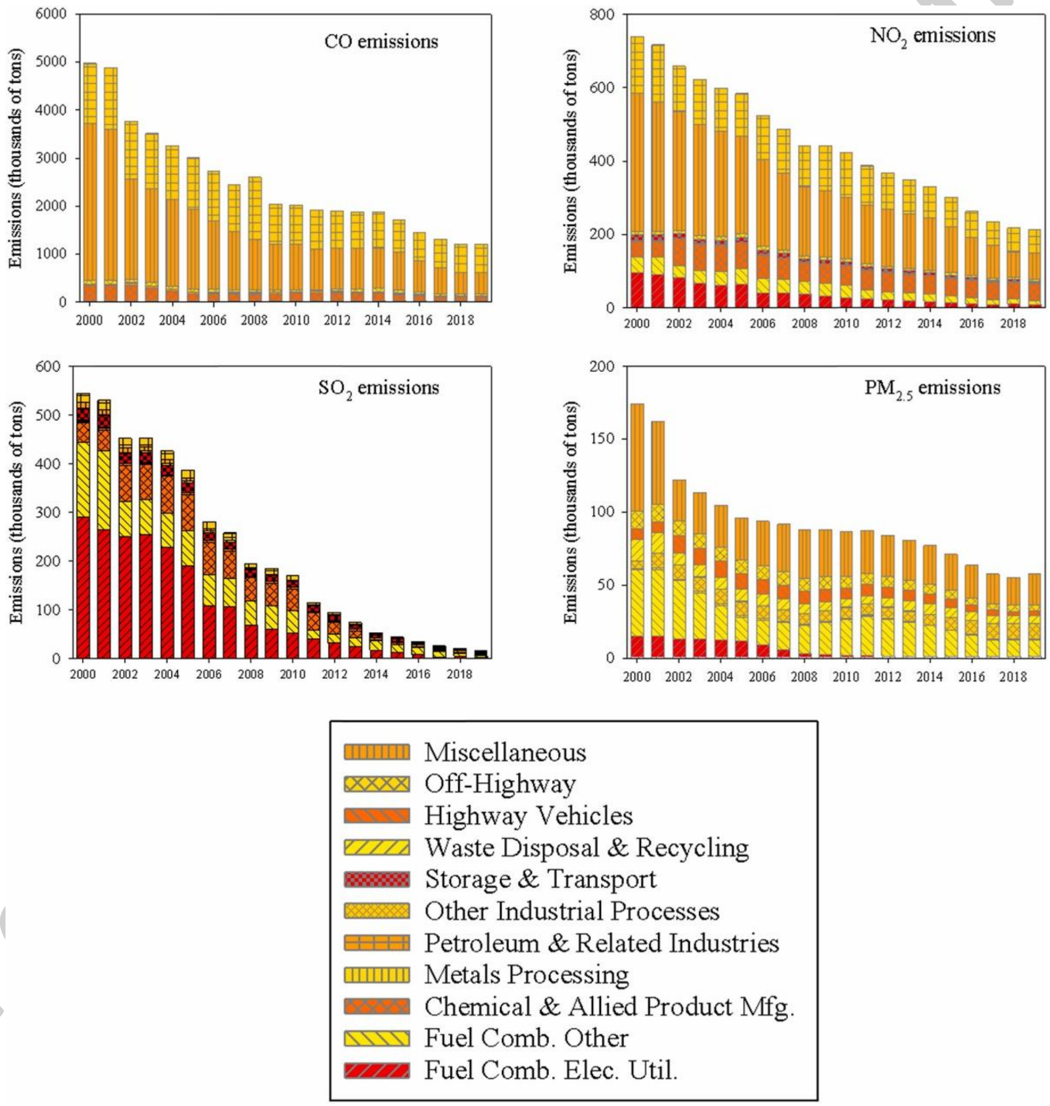

Figure 1. Annual Emissions of CO, NO_2, SO_2, and primary $PM_{2.5}$ in New York State[16]

[15] Yunle Chen, David Q. Rich, Mauro Masiol, Philip K. Hopke, *Changes in ambient air pollutants in New York State from 2005 to 2019: Effects of policy implementations and economic and technological changes*, Atmospheric Environment, Volume 311, 2023, 119996, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2023.119996

[16] Ibid.

2.1.3. Programs and Policies

Federal regulations that have driven these trends include those generally focused on emissions controls and improved fuel quality from mobile sources, and the enactment of new rules to reduce emissions from older, uncontrolled electricity generation units—such as the federal Clean Air Interstate Rule. At the State level, New York has enacted regulations to phase out coal-fired power production and require ultra-low sulfur content in heating oil, as well as initiated the Renewable Portfolio Standard, Reforming the Energy Vision, and Clean Energy Fund during this time. The New York City (NYC) Clean Heat Program phased out #6 heating oil by 2015 and will phase out #4 heating oil by 2030.

In addition, in 2019 DEC adopted a regulation (6 NYCRR Subpart 227-3) to reduce NO_x emissions from Simple Cycle Combustion and Regenerative Combustion Turbines. These turbines are often referred as “peaking units” because they are electricity generating units that tend to operate during periods of high electricity demand to maintain grid stability. As of May 1, 2025, 37 “peaking” units have retired. The retired peaking units represent one gigawatt of older fossil fuel-fired generation and a significant reduction of pollution. In addition to shutdowns, additional emission controls were installed on 43 units totaling 1,267 megawatts (MW).

2.1.4. State Energy Pathways Will Continue to Reduce Energy-Related Emissions and Deliver Air Quality Benefits to Communities and Ecosystems

Air Quality Co-Benefits from State Energy Policies: The core planning scenario of the Draft Plan illustrates the potential for improvements in statewide air quality from decarbonization policies leading to substantial health benefits. The air quality improvements described above are largely the result of policies that were designed to directly reduce air pollutant emissions; for example, the use of cleaner fuels and post-combustion emission controls on vehicles and power plants. The Draft Plan’s analysis of public health impacts shows that statewide energy policies focused on electrification would result in additional co-benefits for air quality, broadening the emission reductions by introducing zero emission alternatives, increased efficiency, and expanding beyond the reach of traditional emission control strategies. The majority of statewide air pollutant emission reductions would result from electrification and efficiency improvements in buildings and electrification of on-road vehicles. These improvements in air quality across all regions of the state would also lead to substantial public health benefits across a range of outcomes including reducing premature mortality, hospitalizations, emergency department visits, and incidence of various respiratory conditions, with larger health benefits expected in geographic DACs. A full analysis of the air quality and health modeling framework and results can be found in the Public Health Impacts Analysis chapter of this Plan.

Alternative Fuels Combustion: As discussed in chapters focusing on Electricity, Petroleum and Transportation, State Pathways Analysis scenarios project a decline in fossil fuel consumption between 2025 and 2040. Some of this fossil fuel consumption will be offset by the integration of alternative fuels, such as renewable natural gas (RNG), biodiesel and renewable diesel, sustainable aviation fuel (SAF) and hydrogen. As discussed further in the Low-Carbon Alternative Fuels chapters of this Plan, there are important climate, air quality, and environmental considerations associated with the production and uses of alternative fuels. In general, integration of alternative fuels for specific applications has the potential to reduce GHG emissions and in some cases reduce co-pollutants. In addition to GHG and co-pollutant emissions, the broader environmental impacts of alternative fuels, including effects on water use, water quality, land use, biodiversity, and waste management, should be considered in New York State's energy planning, policy development, and project evaluation. These impacts vary significantly by fuel type and production pathway and should be evaluated alongside climate and health outcomes to support sustainable decision-making.

Battery Energy Storage Systems: Energy storage technologies, such as battery energy storage systems (BESS), can improve the reliability and stability of the grid, especially when paired with intermittent renewable generation. Battery storage paired with renewables can avoid reliance on peaker plants, contributing to lower levels of both local (i.e., criteria pollutants) and global (i.e., GHG) emissions.[17]

Battery storage systems emit GHGs during all stages of their life cycle (materials production, manufacturing, operation, end-of-life) and during transportation. A life cycle assessment of utility-scale energy storage systems found lithium-ion storage systems, which represent the majority of all stationary and mobile storage deployments in the State, have the lowest GHG emissions of five electro-chemical energy storage systems assessed (sodium-sulfur, lithium-ion, valve-regulated lead-acid, nickel-cadmium, and vanadium redox flow).[18]

As discussed in the Electricity chapter of this Plan, New York created the nation-leading Inter-Agency Fire Safety Working Group in response to fire incidents at energy storage facilities. Lithium is highly flammable when it contacts water, and if handled improperly can flow into surface water or leach into groundwater and cause combustion. Fires involving BESS can emit CO, CO_2, and volatile organic compounds (VOCs), and may emit other trace gases such as HF, HCN, or others depending on the battery chemistry and overall materials of construction of the BESS unit. Air sampling from past incidents at BESS have found that contaminant concentrations beyond the immediate fire scene do not pose a public health risk due to the rapid dispersion of gases limiting the potential for toxic exposure.[19]

2.2. Water and Wetlands

2.2.1. State Goals

The State prioritizes ensuring safe and clean drinking water, protecting diverse water resources, and supporting ecological well-being. Water quality is protected through permitting, compliance, enforcement, and monitoring efforts. Waters are classified for their best uses (fishing, source of drinking water, etc.) and standards are set to protect those uses. The State also seeks to protect, maintain, enhance, and restore freshwater and tidal wetlands ecosystems so they can continue to provide a broad

[17] Lin, Y., J. X. Johnson, J.L. Mathieu. 2016. Emissions impacts of using energy storage for power system reserves. Applied Energy 168 p. 444-456. http://dx.doi.org/10.1016/j.apenergy.2016.01.061.

[18] Rahman et al. 2021. The greenhouse gas emissions' footprint and net energy ratio of utility-scale electro-chemical energy storage systems. Energy Conversion and Management 244. https://www.sciencedirect.com/science/article/abs/pii/S0196890421006737.

[19] Fire & Risk Alliance, L.L.C. 2025. Assessment of potential impacts of fires at BESS facilities. https://cdn.prod.website-files.com/666b00bb91a866df89c4f469/67e44e5991dada623fd2e8f0_Assessment-of-Potential-Impacts-of-Fires-at-BESS-Facilities.pdf

array of ecological functions and benefits to communities and the environment, including carbon sequestration.[20,21]

2.2.2. Potential Environmental Effects

Deposition of Acid and Mercury Compounds from Fossil Fuel Combustion

Acid rain (and other types of acid deposition) forms when SO_2 and nitrogen oxides (NO_x) combine with moisture in the atmosphere to produce sulfuric acid and nitric acid. Historically, the source of SO_2 and NO_x emissions that contributed to acid rain was from fossil fuel combustion, in particular uncontrolled coal fired power plants, including those in states upwind of New York. By the 1960s, it became clear to scientists that acid deposition was significantly impacting natural resources across New York, especially in the Catskill and Adirondack Mountains where soils were becoming too acidic to maintain healthy forests, and many waterbodies were unable to support healthy populations of fish. Decreases in emissions have significantly reduced acid rain in New York, and ecosystems are slowly recovering, and many are now able to support more diverse and abundant wildlife and associated recreational opportunities.[22]

Mercury is a naturally occurring metal that is also emitted as an air pollutant from coal combustion. Mercury has been identified as being one of the most important of the persistent, bio-accumulative, toxic contaminants of concern for New York State. Mercury concentrations exceed human and ecological risk thresholds in many areas of New York State, particularly the Adirondacks, Catskills, and parts of Long Island. Mercury concentrations in the environment of New York State have declined over the last four decades, concurrent with decreased air emissions from regional and U.S. sources, and further controls on mercury emission sources are expected to continue to lower mercury concentrations in the food web, yielding multiple benefits to fish, wildlife, and people of New York State. However, scientists are also observing that fish and wildlife remain highly impacted by legacy Mercury deposition, as evidenced by stable and increasing trends of Mercury concentrations found in certain species and in some regions of the state.[23,24]

Atmospheric carbon dioxide (CO_2), caused by combustion of fossil fuels, is the primary driver of ocean acidification (OA). Localized acidification occurs periodically in some coastal areas, including Western Long Island Sound and the New York-New Jersey Harbor.[25] This addition of carbon dioxide alters the oceans' carbon chemistry. Reductions in pH, a process referred to as ocean acidification, make it harder

[20] DEC, *Freshwater Wetlands Act & Landowners*, accessed July 11, 2025, https://dec.ny.gov/nature/waterbodies/wetlands/freshwater-wetlands-program/conserve/freshwater-wetlands-act-and-owners.

[21] New York State Climate Action Council. 2022. "New York State Climate Action Council Scoping Plan." climate.ny.gov/ScopingPlan

[22] DEC, *Acid Rain*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/acid-rain.

[23] Evers, D.C., Adams, E., Burton, M., Gulka, J., Sauer, A., and Driscoll, C.T. 2019. New York State Mercury Connections: the Extent and Effects of Mercury Pollution in the State. Biodiversity Research Institute. Portland, Maine. BRI Science Communications Series 2019-12-2. 41 pages.

[24] NYSERDA. 2020. Mercury dynamics in Finger Lakes Fish and Invertebrates. NYSERDA Report Number 20-37. Prepared by Hobart and William Smith Colleges, Geneva, NY. nyserda.ny.gov/publications

[25] Northeast Fisheries Science Center. (2023). *State of the ecosystem 2023: Mid-Atlantic*. National Oceanic and Atmospheric Administration. https://repository.library.noaa.gov/view/noaa/49

for organisms to create shells and affect other physiological processes. Evidence suggests that increased carbon dioxide concentrations in marine waters have contributed to reductions in the quantity and quality of shellfish and the development and growth of finfish.[26,27] This presents ecological and socioeconomic risks, as the State has a commercial fishing industry with a value added of about $1.6 billion and a recreational industry with a value added of $770 million.[28] In 2016, the New York State Legislature established the Ocean Acidification Task Force to identify contributing factors to ocean acidification and evaluate ways to apply the best available science to address its impacts.[29] The 2024 Task Force report to the Legislature describes potential ways to mitigate the impact of OA, including addressing water quality standards, discharges, and enhancing blue carbon sequestration by seagrasses, kelp beds, and marshes.

Cooling Water Intake and Thermal Discharge

Steam-electric facilities use fossil fuels or nuclear energy to heat water, creating steam used in the power generation process. The steam is cooled through the non-contact cooling system, and the cooling water is returned at an elevated temperature to the source waterbody. Steam-electric generating facilities may also require water for cooling, service water needs, and cooling the thermal discharge effluent. These power plants are significant users of water, withdrawing more than half the of the total water withdrawn from lakes, rivers, and coastal waters.[30] Throughout the State, power-generating facilities can withdraw over 4.8 billion gallons of water per day. [31]

Adverse environmental impacts of a cooling water intake structure include the impingement of fish and other aquatic organisms on the facility's intake screens, and entrainment of smaller fish through the cooling system. Adult fish and some shellfish can experience abrasions and suffocation from being trapped on the intake screens. Juvenile fish and eggs that have been entrained are subject to physical, thermal, and chemical impacts as they move through the cooling system. The heated discharged water can impact local ecosystems by raising the water temperature, which can lead to reduced oxygen levels. The thermal discharge plume may also block migration routes for fish and, if warm enough, could be lethal to some species that directly encounter the plume. Larval fish and eggs are particularly susceptible to impacts of the plume, due to their generally fragile life stage and inability to escape the thermal discharge.

[26] Talmage, S. C., & Gobler, C. J. (2010). Effects of past, present, and future ocean carbon dioxide concentrations on the growth and survival of larval shellfish. *Proceedings of the National Academy of Sciences*, **107**(40), 17246–17251. https://doi.org/10.1073/pnas.0913804107

[27] Wallace, R. B., Baumann, H., Grear, J. S., Aller, R. C., & Gobler, C. J. (2014). Coastal ocean acidification: The other eutrophication problem. *Estuarine, Coastal and Shelf Science*, **148**, 1–13. https://doi.org/10.1016/j.ecss.2014.05.027

[28] National Marine Fisheries Service. 2018.

[29] Laws of New York. 2016. Chapter 464.

[30] DEC, *Acquatic Habitat* Protection, accessed July 11, 2025, https://dec.ny.gov/nature/animals-fish-plants/biodiversity-species-conservation/aquatic-habitat-protection.

[31] DEC, *Water Use & Conservation*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/water/water-quantity/water-use-conservation.

Offshore wind converter stations also require cooling systems to manage heat generated during the alternative current (AC) to direct current (DC) power conversion process.[32] The most common method of head exchange is the use of a non-contact once-through cooling water, with flow ranging from 2 to 15 million gallons per day.[33] These facilities can have similar impingement and entrainment impacts as on-shore once-through cooling systems, as well as similar thermal discharge impacts.

Land-Based Energy Generation and Infrastructure

Energy projects can also have hydrologic and ecological consequences if not carefully sited and managed. During construction, activities such as land clearing, grading, and infrastructure installation can alter habitats and compact soils as well as increase sedimentation in nearby wetlands and waterbodies. Energy infrastructure such as electric transmission lines and fuel pipelines often bisect wetlands, grasslands, forests, and waterbodies during construction, which can further fragment these ecosystems; and routine management after construction is complete can lead to further impacts, such as by increasing the risk of chemical runoff from herbicides. New York State regulators, energy companies and utilities seek to avoid, minimize, and mitigate associated impacts through permitting and best practices.

Hydroelectric Dams and Operation

Hydroelectric dams impound water to create a reservoir and divert water to hydropower plants. The dam and reservoir can change water temperatures, water chemistry, aquatic communities, river flow, and sediment loads. In New York State, there are limits on where new hydropower facilities can be sited in order to protect the Adirondack and Catskill Forest Preserves, and State Forests, including Reforestation Areas, and Wildlife Management Areas, and State Nature and Historical Preserves, as well as designated rivers that possess important scenic, ecological, recreational, historical, or scientific values.[34,35] As retired hydroelectric dams are removed, natural hydrology and river functions can be restored; water quality may improve, aquatic connectivity of habitat may be restored, and flood risks may be reduced.[36]

Oil, Gas, and Geothermal Wells

DEC regulates the drilling, plugging, and abandonment of oil, natural gas wells, underground gas storage and solution salt mining wells, in addition to brine disposal, stratigraphic, and geothermal wells drilled deeper than 500 feet to prevent pollution to ground and surface waters. DEC administers regulations and a permitting program to mitigate, to the greatest extent possible, any potential environmental impact of well drilling and well production, as summarized in DEC's 1992 Generic Environmental Impact Statement

[32] Middleton, P., and B. Barnhart. 2022. Supporting National Environmental Policy Act Documentation for Offshore Wind Energy Development Related to High Voltage Direct Current Cooling Systems. Washington (DC): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2022-023. 13 p. Available online at: https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/HVDC%20Cooling%20Systems%20White%20Paper.pdf

[33] NYSERDA. In review. Cooling water use at offshore wind converter stations.

[34] Article XIV of the State Constitution

[35] Wild, Scenic, and Recreational Rivers Act. Environmental Conservation Law Article 15, Title 27

[36] DEC, *Information for Dam Owners,* accessed July 11, 2025, https://dec.ny.gov/environmental-protection/water/dam-safety-coastal-flood-protection/dam-safety/dam-owner-information.

(GEIS) on the Oil, Gas and Solution Mining Regulatory Program.[37] DEC requires well plugging permits for all regulated wells once a well reaches the end of its useful life. Financial security provided by a well owner is required and held by the DEC for the regulated well's life. The security is released only after DEC staff verify that the well was properly plugged and the surface remediated in accordance with State regulations.

Additionally, DEC is currently undertaking a rule making and the development of a GEIS specific to closed loop geothermal boreholes drilled deeper than 500 feet. The rule making and GEIS are intended to cover the drilling and installation of closed loop geothermal boreholes to ensure the protection of the environment and public health and safety during the development of geothermal energy resources statewide.

Offshore Wind

The development of offshore wind (OSW) energy will result in new structures in the water, including foundations, scour protection, and hard protection for export and array cables. The introduction of foundations may result in alteration of local water currents, leading to increased movement, suspension, and deposition of sediments. Structures may also reduce wind-forced mixing of surface waters and waters flowing around foundations may increase vertical mixing. OSW may also impact atmospheric and oceanographic processes through the presence of structures in the water and the extraction of energy from the wind. There are few studies that have characterized potential hydrodynamic wakes and the interaction of atmospheric wakes with the sea surface. There is also a lack of research on the impact of wakes on regional scale oceanographic processes, such as the Mid-Atlantic Cold Pool, or secondary changes to primary production and ecosystems.[38]

Impacts to water quality from offshore wind activities are expected to be minor, resulting from accidental releases, sediment suspension, the presence of structures, port utilization, and land disturbances.[39] OSW activities are required to comply with regulatory requirements related to the prevention and control of accidental spills and Construction Spill Prevention Control and Countermeasures (SPCCs) are required for every project to provide rapid spill response, clean up, and other measures to minimize potential impacts.[40] Any accidental release would be localized and result in no degradation of water quality in exceedance of water quality standards.

2.2.3. Programs and Policies

Regulations and voluntary programs at all levels of government combine to protect New York's water resources. DEC is the lead state agency for monitoring surface and groundwater quality, administering permits to regulate sources of pollution and water withdrawals. New York's water quality standards serve as foundation for how the state manages programs, enforces regulations, and issues permits to protect surface water and groundwater resources. New York State enforces numerous environmental

[37] DEC, Generic Environmental Impact Statement On The Oil, Gas And Solution Mining Regulatory Program (GEIS), accessed July 11, 2025, https://dec.ny.gov/environmental-protection/oil-gas/geis.
[38] BOEM. New York Bight Final Programmatic Environmental Impact Statement (PEIS).
[39] Ibid.
[40] Ibid.

regulations, such as the Freshwater Wetlands Act, Tidal Wetlands Act, and the Coastal Management Program to minimize and mitigate impacts by ensuring careful environmental review, responsible planning and restoration efforts, all to balance our increasing energy needs with environmental preservation.

In 2022, the State's Freshwater Wetlands Act[41] was amended, increasing the number of regulated freshwater wetlands. The Office of Renewable Energy Siting and Electric Transmission (ORES) have updated Article VIII regulations to align with the changes and expanded the options available for mitigation. In ORES' draft Article VIII regulations, mitigation banking, in lieu fee, and other mitigation fee programs are permissible for unavoidable wetland impacts.

DEC administers the Tidal Wetlands Regulatory Program, which is designed to prevent the despoliation and destruction of tidal wetlands by requiring permits for regulated activities in regulated tidal wetlands and tidal wetland adjacent areas.

The Coastal Management Program is implemented to preserve natural protective features, including beaches, and dunes and bluffs, which are especially effective at protecting storm-induced high water. DEC implements this program through its Coastal Erosion Management regulations, which require a permit to ensure that development, or other actions in erosion hazard areas, is undertaken in a manner that minimizes damage to property and natural protective features, prevents the exacerbation of erosion hazards, and protects human life.

The State Pollutant Discharge Elimination System (SPDES) program[42] regulates wastewater and stormwater discharges to prevent pollution that could degrade water quality. SPDES permits are required for industrial, municipal, and construction-related discharges to protect waters of the state.

Under Section 401 of the Clean Water Act (CWA), a federal agency may not issue a permit or license to conduct any activity that may result in any discharge into waters of the United States unless a Section 401 Water Quality Certification (WQC) is issued, verifying compliance with state water quality requirements. In New York State, applicants for a federal license or permit for activities that may result in a discharge into waters of the United States are required to apply for and obtain a WQC indicating that the proposed activity will comply with New York State water quality standards. The WQC process evaluates whether a project will prevent water pollution, protect aquatic habitats, and maintain water quality standards for designated uses (e.g., drinking water, recreation, and fish and wildlife habitats). A WQC is most commonly required when a project also requires a permit from the U.S. Army Corps of Engineers under Section 404 of the CWA for the placement of fill in waters of the United States. Examples of projects may include energy infrastructure projects, dredging operations, pipeline installations, and large-scale construction developments. To obtain certification, applicants must demonstrate that their project will comply with New York's state water quality requirements and standards. This often involves implementing best management practices (BMPs), sediment control measures, and various mitigation strategies to reduce environmental harm.

[41] Environmental Conservation Law, Article 24
[42] Environmental Conservation Law, Article 17

SPDES permits contain conditions that will require the permittee to minimize adverse environmental impact at facilities that have a once-through cooling water intake and thermal discharge. These conditions direct such facilities to utilize the Best Technology Available (BTA) for minimizing impingement and entrainment of fish and other aquatic life. Those BTA permit conditions will require the facility to measure through-screen intake velocity, perform studies of fish communities near the intake, provide an assessment of technologies or operational measures to reduce impingement and entrainment, and conduct thermal monitoring. After BTA technologies are installed, the facilities must conduct additional studies to verify that the performance of the technologies and operational measures minimizes adverse environmental impacts.

2.3. Land Use

2.3.1. State Goals

As discussed further in the Smart Growth chapter of this Plan, there are myriad environmental and health benefits associated with smart growth development, which can further complement State goals to conserve open space, protect watersheds, preserve biodiversity and wildlife migration, increase climate resiliency, and sequester atmospheric carbon. Specific State policy goals include supporting a national goal to preserve 30 percent of lands and waters by 2030, plant 25 million trees by 2033, and coordinate efforts to maintain and restore grasslands to address concerns about declines in grassland breeding and wintering birds.[43] The State has also prioritized the protection, restoration and monitoring of working agricultural and forest lands and wildlife management areas.[44] This has included the investment of hundreds of millions of dollars toward protecting agricultural land through the State Farmland Protection Program, and grass and forestland through real property acquisitions by the State.

2.3.2. Potential Environmental Effects

Energy Infrastructure

The State's energy system includes electric transmission lines and natural gas pipelines and refined petroleum product pipelines. Construction and operation of energy transmission facilities can result in direct disturbance to State lands and other terrestrial habitats, e.g., forest fragmentation. In addition to clearing and loss of habitat, construction may result in storm water runoff, siltation of streams and destruction of wetland vegetation. Maintenance of rights-of-way involves periodic clearing of vegetation, use of herbicides and installation of permanent infrastructure and access roads, sometimes in sensitive environments. As discussed further in the Electricity chapter of this Plan, State Pathways Analysis scenarios anticipate the need for additional investments in electric transmission infrastructure to meet electric demand growth and integrate increasing amounts of renewable energy. Decisions on where to upgrade existing transmission lines or build new transmission lines will likely have land use implications if associated with renewable energy interconnection. Energy storage intended to reduce the intermittency

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[43] New York State Department of Environmental Conservation (DEC). 2022. *DEC Strategy for Grassland Bird Habitat Management.* https://dec.ny.gov/sites/default/files/2024-04/grasslandbirdsstrategyfinal.pdf New York State Department of Environmental Conservation (DEC). 2024. *30x30: A New York state conservation initiative*. New York State Department of Environmental Conservation. https://dec.ny.gov/nature/open-space/30x30#:~:text=30x30%20is%20a%20New%20York,5390B%2FS

[44] See Final Scoping Plan Chapter 19: Land Use at page 366

of electricity supply from renewable energy sources is typically co-sited with the renewable energy facility, in some cases expanding the footprint of the overall facility.[45]

Solar

State Pathways Analysis scenarios project that increasing amounts of solar energy will be needed to meet state climate goals. Agricultural land generally provides flat clear terrain with minimal contamination that is ideally suited for all types of development, including suburban sprawl and more recently solar energy projects. Studies have documented that agricultural communities are more likely to host solar projects.[46] State stakeholders have expressed concerns about potential future conflicts between solar development and the sustaining of agricultural character, operations, and services, as well as goals to restore and maintain habitat for grassland breeding bird species.

In 2023, NYSERDA commissioned development of a report to characterize the land use and economic implications of solar energy development on New York State's agricultural industry.[47] The focus and contents of this effort are being informed by engagement with a specialist committee comprised of farmers, solar developers, academic advisors, State agency representatives, and other key stakeholders.

To address concerns over agricultural impacts, New York State has steadily adopted procurement and permitting policies intended to avoid or mitigate impacts to sensitive agricultural and forest lands. State procurement of renewable generation from utility scale renewable energy projects ("Tier 1 renewables") require applicants to include plans to minimize potential agricultural and Mineral Soils Groups (MSG) 1-4 impacts, forest impacts, and consider strategies for dual use with agriculture. Key milestones related to the State's solar siting policy as it pertains to agricultural considerations include:

2019 – New York State Department of Agriculture and Markets (NYSAGM) Guidelines for Solar Projects - Construction Mitigation for Agricultural Lands were established and which then became mandatory in 2020.

2020 – The Agricultural Mitigation Payment was implemented for solar project proposed in a certified agricultural district.

2021 – The Smart Solar Siting Scorecard was established (first as voluntary but since 2022 has become mandatory) and is used to evaluate applications for utility scale solar projects for their avoidance and mitigation of agricultural and forest lands.

2022 – The Agricultural Mitigation Payment Deferral Option was introduced to encourage agricultural co-utilization.

2023 – NYSERDA, in collaboration with the Agricultural-Technical Working Group (A-TWG), commissioned the report *Growing Agrivoltaics in New York State* to explore how agriculture and renewable energy can work hand-in-hand to support decarbonization.

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[45] NYSERDA. 2017. Clean Energy Fund Investment Plan: Renewables Optimization Chapter. Portfolio: Innovation & Research. Matter Number 16-00681, In the Matter of the Clean Energy Fund Investment Plan.

[46] Katkar et al. 2020. https://www.sciencedirect.com/science/article/pii/S0960148121004900

[47] See A-TWG Regional Agronomic Impacts of Solar Energy (RAISE) committee meeting materials at https://www.nyatwg.com/

2024 – NYSERDA, in collaboration with the A-TWG convened the Regional Agronomic Impacts from Solar Energy (RAISE) Specialist committee to advise and guide inquiries into potential regional agricultural effects from solar energy development (Phase 1 report under development).

In addition, as documented in prior regulatory proceedings, the flat, open landscapes preferred for solar project development are also some the best remaining habitat for grassland nesting and wintering birds in New York State. A significant percentage of the habitat identified within the grassland bird conservation centers outlined in the DEC Strategy for Grassland Bird Habitat Management and Conservation are included in the footprint of proposed large-scale renewable solar facilities. ORES has adopted pre-application procedures and developed standard uniform conditions to help identify when impacts to grassland birds occur and to reduce and mitigate impacts that cannot be avoided.

Onshore Wind

A survey by the National Renewable Energy Laboratory of large wind facilities in the United States found that they use between 30 and 141 acres per megawatt of power output capacity. However, less than 1 acre per megawatt is disturbed permanently and less than 3.5 acres per megawatt are disturbed temporarily during construction.[48] Subsequent studies identify that wind power infrastructure such as the turbines and roads typically occupy only 5 percent of a wind power site, with the rest often used for other purposes, such as agriculture.[49]

Biofuels

To reduce ozone formation, the New York City metropolitan area and Long Island require the use of reformulated motor gasoline blended with ethanol. According to the U.S. Energy Information Administration (EIA), the State consumes about 534 million gallons of fuel ethanol annually, the fourth-largest amount of any state.[50] New York's only fuel ethanol production plant has a capacity of about 62 million gallons per year.[51] New York thus imports about 470 million gallons of fuel ethanol annually. Using rough industry estimates that one acre of corn produces 500 gallons of ethanol,[52] the total land area (within and outside the state) associated with growing corn for ethanol to support New York State consumption could be approximately 1 million acres (assuming all the fuel ethanol is produced from corn grain). According to EIA, New York does not have any biodiesel production, but the State is the nation's sixth-largest biodiesel consumer.[53,54]

[48] Denholm, P., M. Hand, M. Jackson, and S. Ong. 2009. Land-use requirements of modern wind power plants in the United States. Golden, CO: National Renewable Energy Laboratory.

[49] "Land Resources for Wind Energy Development Requires Regionalized Characterizations" by Tao Dai et al was published in Environmental Science and Technology. https://doi.org/10.1039/D3VA00038A

[50] U.S. EIA, State Energy Data System, Table F29, Fuel ethanol consumption estimates, 2022

[51] U.S. EIA, U.S. Fuel Ethanol Plant Production Capacity (August 15, 2024), Detailed annual production capacity by plant is available in XLSX.

[52] Iowa Renewable Fuels Association, *Distillers Grains Facts*, accessed July 11, 2025, https://iowarfa.org/ethanol-center/ethanol-co-products/distillers-grains-facts/#:~:text=One%20acre%20of%20corn%20produces,1.5%20tons%20of%20distillers%20grains.

[53] U.S. EIA, U.S. Biodiesel Plant Production Capacity (August 15, 2024), Detailed annual production capacity by plant is available in XLSX.

[54] U.S. EIA, State Energy Data System, Table F30, Biodiesel Consumption Estimates, 2022.

2.4. Wildlife

2.4.1. State Goals

New York State seeks to protect and conserve biodiversity, manage wildlife populations, and preserve critical habitats. Conservation of wildlife supports ecosystem services, including food and other goods, pollination of crops, and waste decomposition. The State also prioritizes preventing the disappearance of endangered native species by protecting these species and their habitats.

2.4.2. Potential Environmental Effects

Energy Infrastructure

Land development, including for energy and utility infrastructure, can result in habitat loss, degradation, and fragmentation. If poorly timed, the clearing or modification of habitat can result in the direct loss of individual animals or a decline in productivity. Loss of habitat and vegetation, or fragmentation of habitat, can occur during the construction of infrastructure and operation of energy systems as the result of increased human presence, noise, motion, and alteration of the terrain for roads, buildings, foundations, or other permanent site infrastructure.

Fossil Fuels

Fossil fuel extraction, transportation, processing, and combustion can have negative effects on plants and animals. Transportation and storage of oil and gas can result in spills and leakages, which contribute to water and air pollution.

Vis-à-vis offshore oil and natural gas development, there are no active oil and gas projects or leases in the Atlantic Outer Continental Shelf (OCS) Region. New York State responded to the Bureau of Ocean Energy Management's (BOEM) Request for Information on the development of the 2024–2029 National OCS Oil and Gas Leasing Program petitioning for the removal of the North and Mid-Atlantic Planning Areas from consideration,[55] due to the high risk of adverse impacts to New York's coastal and marine resources and ocean economy, specifically the commercial fishing industry. Seismic surveys during oil and gas exploration produce intense noise that could lead to widespread adverse impacts to marine life, including endangered and threatened species. Oil spills or well blowouts during extraction could also have significant effects on New York's coastline, ocean economy, and protected species.

Combustion of fossil fuels produces air pollutants, which can result in acid deposition or thermal changes in the atmosphere—causing climate change.

Acid rain (and other types of acid deposition) forms when SO_2 and NO_x combine with moisture in the atmosphere to produce sulfuric acid and nitric acid. Historically, the source of SO_2 and NO_x emissions that contributed to acid rain was from fossil fuel combustion, in particular uncontrolled coal-fired power plants, including those in states upwind of New York. By the 1960s, it became clear to scientists that acid deposition was significantly impacting natural resources across New York, especially in the Catskill and

[55] Bureau of Ocean Energy Management. 2025. Request for Information and Comments on the Preparation of the 11th National Outer Continental Shelf Oil and Gas Leasing Program MAA104000. https://www.federalregister.gov/documents/2025/04/30/2025-07479/request-for-information-and-comments-on-the-preparation-of-the-11th-national-outer-continental-shelf

Adirondack Mountains where soils were becoming too acidic to maintain healthy forests, and many waterbodies were unable to support healthy populations of fish. Elevated concentrations of inorganic aluminum (Al_i), mobilized by acidic conditions, led to many water bodies becoming seasonally toxic to biota.[56] Decreases in emissions have significantly reduced acid rain in New York, and waterbodies are slowly recovering, and many are now able to support more diverse and abundant wildlife and associated recreational opportunities.[57]

Mercury is a naturally occurring metal that is also emitted as an air pollutant from coal combustion. Mercury has been identified as being one of the most important of the persistent, bio-accumulative, toxic contaminants of concern for New York State. Mercury concentrations exceed human and ecological risk thresholds in many areas of New York State, particularly the Adirondacks, Catskills, and parts of Long Island. Mercury concentrations in the environment of New York State have declined over the last four decades, concurrent with decreased air emissions from regional and U.S. sources, and further controls on mercury emission sources are expected to continue to lower mercury concentrations in the food web, yielding multiple benefits to fish, wildlife, and people of New York State. However, scientists are also observing that fish and wildlife remain highly impacted by legacy mercury deposition, as evidenced by stable and increasing trends of mercury concentrations found in certain species and in some regions of the state.[58,59]

Hydroelectric

Hydroelectric facilities may impact fish and wildlife resources due to the creation of dams and reservoirs and due, in part, to the way the facility is operated. Hydroelectric dams fragment river and stream systems, preventing upstream and downstream movement of fish and aquatic organisms. Dams can also fragment riparian habitat for semi-aquatic organisms. Anadromous species, fish that live in the ocean and come upriver to spawn, have declined dramatically in the last 150 years due to pollution, overfishing, and habitat destruction. Other effects of the loss of aquatic connectivity through dam creation can include the loss of other aquatic species dependent on the presence of certain fish. Many freshwater mussel species require specific fish species to serve as hosts to complete their life cycle. Dams that block fish passage can result in the loss of freshwater mussel populations that are dependent upon the presence of fish species.

All hydroelectric projects in New York State require intake protection and downstream passage sites for fish species to maintain aquatic habitats. Some weaker-swimming aquatic organisms can be restricted from passage, leading to changes in community structure. Most projects already have steel trash racks to

[56] Lawrence et al. 2008. Chronic and episodic acidification of Adirondack streams from acid rain in 2003-2005. Journal of Environmental Quality 37:2264-2274. DOI: https://doi.org/10.2134/jeq2008.0061

[57] DEC, *Acid Rain*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/acid-rain.

[58] Evers, D.C., Adams, E., Burton, M., Gulka, J., Sauer, A., and Driscoll, C.T. 2019. New York State Mercury Connections: the Extent and Effects of Mercury Pollution in the State. Biodiversity Research Institute. Portland, Maine. BRI Science Communications Series 2019-12-2. 41 pages.

[59] NYSERDA. 2020. Mercury dynamics in Finger Lakes Fish and Invertebrates. NYSERDA Report Number 20-37. Prepared by Hobart and William Smith Colleges, Geneva, NY. nyserda.ny.gov/publications

prevent debris from entering the turbine, which may protect species of resident and migratory fish from entering intakes.[60]

Solar

Solar development in New York State can have both direct and indirect impacts on wildlife, particularly if large-scale projects significantly alter natural landscapes. One of the primary concerns is habitat loss and fragmentation. Clearing undisturbed land for solar farms can displace native species especially those that are less mobile, including pollinators, amphibians, and small mammals. Grassland birds can be adversely affected because the large, open habitat they require may be segmented by the placement of solar panels. Solar projects built on open fields or shrublands may force species into less suitable habitats, increasing competition for resources and potentially leading to population declines. Birds that nest on grasslands or open fields may be displaced when land is converted into a solar facility. If clearing or grading occurs during the nesting season, individual animals may be killed and productivity for the season may be lost. Even if some vegetation remains or is replaced, panel arrays can reduce habitat suitability and, alter nesting conditions potentially requiring compensatory mitigation. However, emerging research also indicates that some common bird species can quickly adapt to utilizing solar energy facilities for nesting or foraging, and that opportunities exist for biodiversity enhancement through vegetation planning and management.

Onshore Wind

Onshore wind turbines present direct and indirect threats to birds and bats. The main risk is collision with turbines when passing through the rotor swept zone or other parts of the tower structure. The risk of collision can increase when turbines are developed on ridges and upwind slopes or when they are built close to migration routes or concentration areas. Based on monitoring conducted at wind energy projects in New York through 2021, the average fatality rates across all bat and bird species are 7.2 bats per MW per year, and 2.2 birds per MW per year. Additionally, as of April 2025, 15 bald eagle fatalities have been documented at wind energy facilities in New York since 2015. Bat mortality due to turbine collision may have a negative impact on some bat populations, particularly migratory tree-roosting bats. Bat mortality is a concern because many bat populations have experienced steep declines over the past two decades due to white-nose syndrome. While wind turbines are one of the primary causes of mortality for several bat species, research consistently shows that wind turbines are less harmful to songbirds than other human-made structures or predators.[61, 62]

Construction can also result in habitat loss; tree removal does occur at most project sites for construction needs and road access. This can reduce access to breeding sites and foraging areas. Disturbance caused by rotor movement, noise, vibration, flickering lights, and increased human presence

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[60] NYSERDA. 2018. Enhanced hydropower database.
[61] USFWS. 2017. https://www.fws.gov/library/collections/threats-birds
[62] See discussion in DPS CES FSEIS, 2016 @p5-34

may lead to behavioral changes such as avoidance and changes in flight paths, particularly for species living in open environments such as grasslands.[63]

There have been improvements in wind turbine design, project siting, and operation which have reduced the impact of wind turbines on birds and bats.[64] However, estimates of bird and bat mortality can vary in accuracy due to non-standardized survey methods and limits to accessing data.[65] DEC released an updated Guide for Conducting Bird and Bat Studies at Commercial Wind Energy Projects in 2016.[66]

Energy storage may enable impact reduction strategies for protection of vulnerable species (e.g., bats and birds) that are susceptible to operational impacts. For example, energy storage can enable the curtailment of wind turbine operation to avoid periods of peak wildlife activity in close proximity to wind turbines (e.g., feeding or migratory passage).[67]

Offshore Wind

Offshore wind (OSW) has the potential to impact marine ecosystems and wildlife at different stages of construction and operation. Noise from site characterization, construction, operation, and decommissioning activities can harm marine mammals, sea turtles, and fish by causing behavioral changes, masking communication, or causing physical injuries. Vessel traffic at all stages of OSW can pose a collision risk for marine mammals and sea turtles, especially large whales. However, the observed and projected increase in vessel traffic from OSW activities is small. Benthic habitats may be lost of degraded during construction, displacing organisms and affecting demersal habitats. Species may also be displaced by OSW structures, disrupting migration, feeding, or breeding; conversely, other species may be attracted to the area due to increased habitat complexity or foraging opportunities. Birds and bats are at risk of collision with turbines during operation, which can cause injury or death. Collision impacts are very difficult to assess, as traditional methods to study post-construction fatalities are not practically applied in open water environments. Additionally, subsea power cables generating electromagnetic fields may affect the behavior of electrosensitive species, such as sharks, rays, sturgeon, and some invertebrates. The presence of OSW structures may also lead to displacement of fishing efforts, although fishing is not restricted within OSW areas.

Offshore wind structures are known to act like artificial reef-like habitats, increasing local primary productivity and food availability on and near the structures.[68] Structure-oriented fishes may also be attracted to these locations. Benthic species dependent on hardbottom habitat may benefit from hard surfaces, resulting in increases in benthic diversity.

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[63] Dohm, R, Jennelle, CS, Garvin, JC, Drake, D. 2019. A long term assessment of raptor displacement at a wind farm. Front Ecol Environ 2019; doi:10.1002/fee.2089

[64] DOE. https://windexchange.energy.gov/projects/birds

[65] Choi, DY, Wittig, TW, Kluever, BM. 2020. An evaluation of bird and bat mortality at wind turbines in the Northeast United States. PLOS One https://doi.org/10.1371/journal.pone.0238034

[66] DEC. 2016. https://extapps.dec.ny.gov/docs/wildlife_pdf/windguide.pdf

[67] Industrial Economics, Incorporated. 2023. Final Supplemental Generic Environmental Impact Statement.

[68] Degrear et al. 2020. Offshore wind farm artificial reefs affect ecosystem structure and functioning: a synthesis. Oceanography 33(4): https://tethys.pnnl.gov/sites/default/files/publications/Degraer-et-al-2020-Artificial-Reefs.pdf

Potential impacts to wildlife are first avoided during siting and then reduced through mitigation measures applied under State and federal permit approval processes. Wind Energy Areas (WEAs) are identified by BOEM using a suitability analysis that accounts for both environmental sensitivities and coexistence with other ocean users. Areas of highest conflict are removed from consideration and then further refined in consultation with other government agencies, states, stakeholders, and public comments. Prior to development, OSW projects must receive BOEM approval for their Construction and Operations Plan (COP), which is subject to terms and conditions to mitigate potential impacts to protected species, habitats, and fisheries.

2.4.3. Policies and Programs

The New York State Endangered and Threatened Species Act provides legal protection for species that are at risk of extinction or significant population decline within New York State.[69] It designates species as endangered, threatened, special concern, or extirpated, depending on their risk level. Once listed, these species receive protections that prohibit harming, harassing, capturing, or killing them, as well as destroying or significantly altering their habitats. Additionally, federally listed rare and threatened species also receive protection through coordination with federal laws, such as the U.S. Endangered Species Act (ESA) and the Migratory Bird Treaty Act (MBTA).

The New York State Wildlife Action Plan (SWAP) serves as a comprehensive strategy for conserving the state's diverse wildlife and their habitats, focusing on species of greatest conservation need (SGCN).[70] The plan identifies key threats to wildlife, such as habitat loss, climate change, pollution, and invasive species, while outlining conservation actions to address these challenges. The SWAP emphasizes habitat restoration, species monitoring, public education, and partnerships with conservation organizations to enhance biodiversity protection. By providing a framework to proactively manage wildlife populations and ecosystems, the plan supports long-term ecological health, reduces the need for future regulatory interventions, and aligns with broader federal conservation goals.

The New York Natural Heritage Program, funded by DEC and managed by the State University of New York College Environmental Science and Forestry, facilitates the conservation of New York State biodiversity by providing scientific expertise on rare species and natural ecosystems to resource managers.

In addition, proposed energy facilities must comply with state and federal wildlife permitting requirements. The State Environmental Quality Review Act (SEQRA) mandates an environmental impact assessment that is reviewed at the local level for projects that do not meet the size threshold to fall under ORES jurisdiction. Large scale renewable energy projects—projects with a nameplate capacity of at least 25 MW—are reviewed by ORES to ensure that such projects avoid and minimize impacts to ecological resources and wildlife. To compensate for impacts to threatened and endangered species that cannot be avoided, ORES requires mitigation that will provide a net conservation benefit for the affected

[69] Environmental Conservation Law Article 11

[70] DEC, *State Wildlife Action Plan (SWAP)*, accessed July 11, 2025, https://dec.ny.gov/nature/animals-fish-plants/biodiversity-species-conservation/state-wildlife-action-plan.

species. If federal wildlife laws apply (such as under the MBTA or ESA or the Bald and Golden Eagle Protection Act), coordination with U.S. Fish and Wildlife Service may be required.

Offshore wind energy projects are being developed in federal waters (more than three nautical miles from shore) with transmission infrastructure in State waters, necessitating both State and federal permitting.[71] The Coastal Zone Management Act allows the State to review activities in federal waters and projects with coastal effects to New York to ensure consistency with the federally enforceable policies of New York State Coastal Management Program administered by the Department of State. DEC reviews potential impacts on threatened and endangered species and fisheries conservation and management from offshore wind development under the Environmental Conservation Act. BOEM leases submerged lands and approves Site Assessment Plans and Construction and Operation Plans. The National Oceanic and Atmospheric Administration and U.S. Fish and Wildlife Service manage consultations pertaining to the Magnuson-Stevens Fisheries Conservation and Management Act, Marine Mammal Protection Act, and Endangered Species Act.

2.5. Legacy Sites and Waste from Energy Sectors

2.5.1. State Goals

The development, use, and decommissioning of energy facilities results in waste products that need to be managed. As part of the transition to clean energy, the State initiated the development of a blueprint to guide the retirement and redevelopment of New York City's oldest fossil fuel facilities by 2030. The Climate Action Council Scoping Plan made recommendations for a circular economy approach to materials management and an increase in recycling capacity. One strategy in the Plan calls for the State to support domestic recycling facilities and markets for recovered resources and incentivize public-private partnerships for recycling facility development. NYSERDA's Blueprint for Advanced Nuclear Energy Technologies recommends that the State address challenges around waste management and storage to enable the adoption of advanced nuclear.

2.5.2. Potential Environmental Effects

Fossil Fuel Plant Retirement and Legacy Pollution

The decommissioning of fossil fuel power plants may necessitate environmental remediation, which involves the investigation and cleanup of hazardous materials to meet federal and state requirements. Coal ash has contributed to groundwater contamination and can spill into adjacent waterways, where it can also harm multiple physiological systems in exposed animals.[72] Remediation of natural gas and petroleum-fired plants involves the dismantling, cleaning, and disposal of fuel storage equipment such as tanks and transportation lines.[73] Leaking fuel storage tanks may require additional remediation to

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[71] NYSERDA. 2015. Table of Permits and Approvals. New York State Offshore Wind Master Plan. NYSERDA Report 17-25x.

[72] Hernandez, Felipe, Ricki E. Oldenkamp, Sarah Webster, James C. Beasley, Lisa L. Farina, Samantha M. Wisely, "Raccoons (Procyon lotor) as Sentinels of Trace Element Contamination and Physiological Effects of Exposure to Coal Fly Ash," December 8, 2016, https://link.springer.com/content/pdf/10.1007/s00244-016-0340-2.pdf.

[73] NYSERDA, *Remediation*, accessed July 11, 2025, https://www.nyserda.ny.gov/All-Programs/Just-Transition-Site-Reuse-Planning-Program/Remediation

remove and properly dispose of contaminated soil. Some level of asbestos remediation may also be necessary.

Subsurface Energy Development

The State of New York has a rich history of oil and natural gas production, dating back to the nineteenth century. DEC currently maintains records for approximately 20,000 plugged wells and 23,000 unplugged wells; about 12,000 of the unplugged wells are actively producing, and new drilling continues. Most oil and gas wells in New York are located in the western part of the state, with the majority located in Allegany, Cattaraugus, Chautauqua, and Erie counties.[74]

It is estimated that a total of 75,000 wells may have been drilled in New York, with potentially tens of thousands of legacy orphaned and abandoned wells without proper well plugging prior to the existence of DEC or a regulatory framework in the state. If left unplugged, orphaned and abandoned wells can provide unimpeded conduits for oil, gas, and other fluids to migrate between different geologic formations, into aquifers, and potential to impact the land surface and waterways.[75] Unplugged orphaned and abandoned wells can also provide a potential route for subsurface methane and hydrogen sulfide to escape into the atmosphere, potentially contributing to increased levels of GHGs.

As the locations of many orphaned and abandoned wells are unknown, in 2020, DEC and NYSERDA collaborated to implement new tools and techniques for locating orphaned and abandoned wells drilled prior to existing regulation, including flying drones equipped with magnetometers.[76] With property owner cooperation, DEC has begun using this unmanned aerial systems technology across seven counties to successfully locate orphaned and abandoned wells which could not be located through routine DEC inspections. Once the wells are located, DEC has used State and federal funding to plug more than 500 orphaned and abandoned wells to mitigate the associated potential threats to the environment public health, and public safety.

Nuclear Waste

As discussed in the Pathways Analysis chapter of this Plan, planning scenarios project the continued operation of existing state nuclear plants through 2040. Nuclear power creates radioactive waste that remains in the environment for thousands of years and requires active stewardship to contain and mitigate risk for environmental exposure. By volume, the majority of radiological waste is made up of lightly contaminated items, primarily associated with electric power generation but also includes activities at hospitals, universities, research laboratories and others, and is classified as low-level radioactive waste. The New York State Low-Level Radioactive Waste Management Act requires low-level waste generators in the State to submit annual reports to NYSERDA that provide detailed information on how low-level radioactive waste is generated, stored, and disposed. Spent nuclear fuel from power generation is classified as high-level waste. Spent nuclear fuel generated by nuclear power plants is

[74] DEC, *Finding And Identifying Oil And Gas Wells*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/oil-gas/finding-identifying-oil-and-gas-wells.

[75] DEC, *Orphaned, Abandoned, and Marginal Well Plugging*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/oil-gas/orphaned-abandoned-well-plugging.

[76] DEC, *Drone Technology Helps Locate Orphaned Wells*, accessed July 11, 2025, https://dec.ny.gov/environmental-protection/oil-gas/orphaned-abandoned-well-plugging/drone-technology.

managed on-site in the form of solid spent fuel rods stored in deep pools of water for approximately 10 years after generation and then stored in steel-lined concrete casks, a practice known as dry cask storage. Dry cask storage has been successful at preventing leaks or exposure, but there is a risk of storage failure from materials degradation as dry casks age. Cask aging management is an important element of long-term storage, until such time as the federal government implements its responsibility to take possession of the high-level waste for permanent disposal options, which currently remain limited. Each of the nuclear power plant locations in New York manages an Independent Spent Fuel Storage Installation for high-level waste generated on the site.

Renewable Energy Waste

The transition to renewable energies and green transportation will produce waste that includes batteries, solar panels, and wind turbine blades. Waste from end-of-life renewable energy infrastructure is expected to increase significantly in the coming decades. More than 85% of a solar photovoltaic module is made of recyclable materials; however, recycling is not currently cost effective or widely adopted.[77] Some solar panels are considered hazardous waste due to high levels of metals present.[78] Despite this, most solar waste currently goes to landfills.[79] In the U.S., 90% of the mass of decommissioned wind turbines could be recycled.[80] However, the U.S. Department of Energy found that existing U.S. recycling facilities find it difficult to process the materials in wind turbine blades and generators.

Battery-based energy storage could cause environmental impacts during end-of life disposal. Improper disposal at the end of a battery's life may cause land and groundwater pollution.[81] Recycling batteries can limit the environmental impacts, but there are barriers to recycling utility-scale lithium-ion batteries, including the high cost of spent battery transportation.[82] Globally, only five percent of lithium-ion batteries were recycled as of 2019, though that number could be rising more recently as lithium-ion batteries become more popular, particularly with individual consumers.[83]

2.5.3. Policies and Programs

NYSERDA's Just Transition Site Reuse Planning Program supports communities with planning services to inform future decision making at the local level to mitigate negative impacts of pending or future fossil fuel power plant closures.[84] Funds may be used to evaluate a site's environmental conditions (Phase I

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[77] DOE, "Beyond Recycling: Reducing Waste from Solar Modules Before They're Even Made," March 5, 2024, https://www.energy.gov/eere/solar/articles/beyond-recycling-reducing-waste-solar-modules-theyre-even-made.

[78] EPA, *End-of-Life Solar Panels: Regulations and Management*, accessed July 11, 2025, https://www.epa.gov/hw/end-life-solar-panels-regulations-and-management.

[79] DEC, *Rulemaking - Adding Solar Panels To The Universal Waste Regulations*, accessed July 11, 2025, https://dec.ny.gov/regulatory/regulations/rulemaking-adding-solar-panels-to-the-universal-waste-regulations

[80] DOE. 2025. https://www.nrel.gov/docs/fy25osti/87970.pdf

[81] Gaustad, G. 2018. Lifecycles of Lithium-Ion Batteries: Understanding Impacts from Material Extraction to End of Life. March 14. Spring Bridge on International Frontiers of Engineering (2018) 48:1. https://www.nae.edu/Publications/Bridge/180760/181102.aspx.

[82] MIT Energy Initiative. 2022. The Future of Energy Storage https://energy.mit.edu/wp-content/uploads/2022/05/The-Future-of-Energy-Storage.pdf

[83] Huang, Y. and Li, J. 2022. Key Challenges for Grid-Scale Lithium-Ion Battery Storage. Accessed on July 13, 2023 at: https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202202197#aenm202202197-bib-0069

[84] NYSERDA https://www.nyserda.ny.gov/All-Programs/Just-Transition-Site-Reuse-Planning-Program

Environmental Site Assessment) or conduct pre-development activities, such as evaluating the presence or environmental contamination.

DEC is considering adding solar panels to the Universal Waste (UW) rule. The UW rule was established by the EPA in 1995 and is a set of requirements for commonly generated hazardous waste. DEC believes that hazardous waste solar panels are often misidentified and diverted to non-hazardous waste management streams and require an improved set of regulations for end-of-life management.[85] Niagara County became the first local government in the nation to pass a local law requiring producers to finance solar panel recycling.[86] DEC also recommends the passage of extended producer responsibility requirements that should include waste from renewable and green technologies.[87]

3. Opportunities to Inform an Environmentally Responsible Energy Transition

Assessing environmental uncertainties associated with energy development and use is key to avoiding, minimizing, and mitigating potential impacts as well as identifying opportunities for co-utilization or ecosystem enhancements. The State currently undertakes research into new energy technologies, as well as conducts data and monitoring studies to address information gaps and optimize siting, which can in turn reduce project impacts, risks and costs.

3.1. Environmental Research and Pre-Development Data Collection

As the State's energy generation mix continues to evolve to meet its energy needs, it will be important to continuously evaluate the potential impacts and benefits of new energy technologies and seek ways to optimize energy siting and use. For example, the State conducted more than 20 studies to inform the **New York State Offshore Wind Master Plan** in 2018.[88] These included an assessment of wildlife, fisheries, and habitats, which were used to refine the BOEM's Wind Energy Areas and identify areas of research to further improve siting. New York continues to invest in research studies to improve understanding of environmental sensitivities and user conflicts associated with offshore wind.[89]

New York has also proactively undertaken pre-development data collection ahead of offshore wind development, such as collecting metocean data, including wind speed and direction and wave height; mapping seabed sediments and sub-seabed conditions; conducting digital aerial surveys to identify wildlife; and deploying acoustic sensors to detect birds, bats, and marine mammals.[90] Pre-development data collection can reduce project costs by providing critical information to developers, regulators, and

[85] DEC, *Rulemaking - Adding Solar Panels To The Universal Waste Regulations*, accessed July 11, 2025, https://dec.ny.gov/regulatory/regulations/rulemaking-adding-solar-panels-to-the-universal-waste-regulations.

[86] County of Niagra, *Niagara County Solar Panel Recycling Local Law*, accessed July 11, 2025, https://www.niagaracounty.gov/government/county_information/niagara_county_solar_panel_recycling_local_law.php.

[87] DEC. 2023. New York State Solid Waste Management Plan: Building the Circular Economy through Sustainable Materials Management. https://dec.ny.gov/sites/default/files/2024-05/finalsswmp20232.pdf

[88] NYSERDA, Offshore Wind Master Plan, accessed July 11, 2025, https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/About-Offshore-Wind/Master-Plan.

[89] NYSERDA, Offshore Wind, accessed July 11, 2025, https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Regional-Collaboration/Siting-Offshore-Wind.

[90] Ibid.

stakeholders early to improve understanding of the marine environment, reducing project risk; help to inform construction windows and permits; and accelerate project timelines.

3.1.1. Co-Utilization or Dual-Use of Energy Facilities

New energy development is being deployed in dynamic environments with existing users. To characterize the potential for energy facilities to support multiple uses, the State is funding research in collaboration with agricultural and commercial fisheries users.

For example, the co-utilization of solar energy facilities with active agriculture—referred to as "agrivoltaics"—represents a possible pathway to help achieve New York's solar energy goals while preserving production in agricultural lands. Examples of agrivoltaics can include, but are not limited to, growing livestock grazers, such as sheep and cattle, to produce livestock products and maintain vegetation in solar panel arrays while panels provide shading and protection from the weather; and growing crops that can thrive under and around solar panels to help sustain soils and farming activity. New York State is funding research projects to produce data on crop and grazing potential, environmental and species use, enhancement and mitigation opportunities, and optimal siting design considerations for large solar PV projects.

To balance the growth of the offshore wind industry with existing marine industries, such as commercial fishing, the State has supported research to maintain and grow the region's sustainable fisheries. This has included collaboratively developing technical strategies and tools to minimize commercial fisheries disruption within offshore wind areas, gear modification to enhance access to fishing within wind areas, and projects that have improved fisheries stock enhancement.

3.2. Environmental Monitoring

The State conducts environmental monitoring to evaluate compliance and document long-term trends associated with the environmental impacts of energy use. The data collected assists policymakers in evaluating the effectiveness of energy-related environmental regulations and policies.

For example, air quality monitoring can identify how transitions in the electric generation and transportation sector are affecting air quality. DEC operates more than 50 air quality monitoring sites statewide that measure both criteria and non-criteria pollutants, including ozone, SO_2, NO_x, carbon monoxide (CO), $PM_{2.5}$ (fine particulate with diameter less than 2.5 microns), and meteorological data. Air quality monitoring networks such as this not only provides real-time data on dangerous conditions to help people decide when to curtail outdoor activity but can be instrumental to observing trends and measuring the projected air quality benefits associated with this Plan.

Another environmental monitoring network that has proven instrumental to informing energy-related air quality regulations has been the Adirondack Long Term Monitoring (ALTM) program. The ALTM was initiated in 1982 with the goal of evaluating the chemistry of Adirondack lakes and measuring the impacts that electricity generation sources—mainly those in the midwestern states—were having on otherwise pristine Adirondack waterbodies. ALTM data on the effects of acid rain proved instrumental in the passage of federal Clean Air Act Amendments and has continued to measure their effectiveness. As the watersheds in the Adirondacks have been recovering from acid rain and its effects, impacts from climate change and interacting stressors are emerging.

3.3. Stakeholder Collaboration to Inform Responsible Energy Development

New York State convenes multiple stakeholder groups to inform and advise on issues associated with renewable energy development. These stakeholder groups have proven successful in identifying areas to advance research to inform responsible energy development policies.

For example, following a series of fires at three BESS locations across New York State in the summer of 2023, Governor Hochul convened an Inter-Agency Fire Safety Working Group to address safety concerns around lithium-ion BESS. The Working Group includes State agency officials from the New York State Division of Homeland Security and Emergency Services, New York State Office of Fire Prevention and Control, NYSERDA, DEC, the New York State Department of Public Service and the New York State Department of State, as well as nation-leading BESS safety industry experts. In February 2024, the working group released initial recommendations for enhanced safety standards.

The State Agricultural Technical Working Group (A-TWG) has brought together State agencies; agricultural land and farmer advocates; nongovernmental organizations that focus on clean energy, climate, and environmental protection; local government officials; solar developers and operators; and academic experts to steer efforts in advancing renewable energy development across scales in a responsible way that supports the State's agricultural operations, lands, farmers, and communities. Committees of this group have advised on state solar energy procurement strategies to avoid and minimize agricultural impacts, opportunities to advance agrivoltaics policy, and characterizing agronomic impacts and opportunities of solar energy.

New York State also established Offshore Wind Technical Working Groups (TWGs) concerning the key subjects of fishing, maritime commerce, the environment, jobs, the supply chain, and environmental justice. The offshore wind TWGs are designed to foster ongoing collaboration with individuals and entities who have "technical knowledge, practical experience, and professional interest" in topics related to the OSW industry. The Environmental and Fisheries TWGs have supported information sharing, developed guidance on best practices, and informed research investments.[91] NYSERDA is also an active member of the Responsible Offshore Science Alliance and the Regional Wildlife Science Collaborative, which support regional research on fisheries and wildlife potentially impacted by offshore wind development.

[91] Brunbauer et al. 2023. Effective stakeholder engagement for offshore wind energy development: the State of New York's Fisheries and Environmental Technical Working Groups. Marine and Coastal Fisheries, 15(2) https://doi.org/10.1002/mcf2.10236