Climate Change Issue Brief

New York State Energy Plan 2009

December 2009

1 Overview

The central challenge for New York energy planners is enabling a transition to an energy system with very low greenhouse gas (GHG) emissions in time to do the State's part to prevent the most severe impacts of climate change while maintaining the State's reliable energy systems and economic competitiveness.

In a sustainable energy system, GHG sources and sinks[1] would maintain atmospheric GHG concentrations at levels that protect human health and the environment. In this respect, New York's traditional energy system is unsustainable because fossil fuel combustion emits heat-trapping GHGs that build up in the atmosphere, and the excess heat these gases retain is altering the climate.

To stabilize GHG concentrations in the atmosphere, emissions must approach a state of equilibrium – that is, sources of GHGs must be in balance with sinks. The higher the atmospheric concentration at which GHGs stabilize, the greater the average global temperature increase and the resultant changes in the Earth's climate. Scientists believe that it is possible to stabilize atmospheric GHGs at a level that will avoid the most severe impacts of climate change, though since the majority of New York's GHGs are emitted in the generation and use of energy, this will require fundamental changes in how the State generates and uses energy.

1.1 Why the State Must Respond to Climate Change

Combusting fossil fuels, i.e., coal, petroleum, and natural gas, transforms carbon that long has been sequestered beneath the ground into the GHG carbon dioxide (CO_2). CO_2 retains heat in the atmosphere, which alters the Earth's energy balance, warms the planet and changes its climate. Since the Industrial Revolution, as fossil fuel use became widespread, atmospheric CO_2 levels have risen to more than one-third above pre-industrial levels, with observable climate effects. As developing nations expand their use of fossil-fuels, the added emissions further accelerate climatic changes.

Although understanding of the Earth's climate system is imperfect, its climate is sufficiently well understood for science to predict that continued unabated combustion of the Earth's fossil fuels will cause dramatic, and potentially catastrophic, changes to the climate system. Additional uncertainties about how well the natural world and human society can adapt to climate change increase the complexity of determining the ultimate impacts of climate change.

Yet the outlines of the future are there to see. Climate change threatens both human societies and natural biodiversity; it is expected to significantly alter the environment that supported the development of human civilization. In some geographic areas, climate change may bring near-term positive effects, such as increasing the length of growing seasons in high-latitude regions. However, most of the projected impacts to human and biological communities are negative, and some pose serious threats.

[1] Sinks are natural, and possibly human-enhanced, processes that remove GHGs from the atmosphere.

Preeminent scientific organizations[2] have concluded that climate change may result in extinction of many plant and animal species, inundation by rising sea levels of a significant fraction of the Earth's coastal communities and ecosystems, and increases in extreme weather events. More than one-sixth of the world's drinking water supply is fed by meltwater from snow or glaciers; the likely continued reductions in water available from these sources will compound the worldwide scarcity of drinking water. In some regions of the world, such as the African Sahel and areas of Bangladesh, many human settlements may become uninhabitable due to changes in precipitation or sea level rise. The resulting large population migrations and competition for resources could destabilize societies and economies.

In New York, average temperatures are rising. Spring bloom occurs a week earlier on average than 30 years ago, and there is an observable northward shift both of plant hardiness zones and of the occurrence of certain wildlife and plant species. While future climate change may help a few sectors of New York's economy, such as by increasing yields and crop variety in certain types of agriculture, and decreasing winter heating needs, it will impose economic burdens, for example, increasing consumer food costs due to climate change impacts on agriculture.

1.2 Magnitude of the Challenge

The atmospheric concentration at which GHGs stabilize and the trajectory to that level will determine the amount of additional anthropogenic, or human-caused, warming that will occur, both in New York and globally. Based on scientific assessments from the United Nations Intergovernmental Panel on Climate Change (IPCC), several U.S. states and developed nations have selected a goal of reducing GHG emissions by 80 percent below 1990 levels by the year 2050 ('80 by 50').[3] President Barack Obama supports the U.S. House of Representatives' recently passed American Clean Energy and Security Act, which has proposed a national climate action plan to reduce emissions by 83 percent below 2005 levels by 2050.[4]

Scientists conclude that the world will be on a path to minimize the most severe future impacts of climate change and reduce attendant costs to society only if the developed world reduces emissions at a rate that achieves an 80 percent reduction in GHG emissions by mid-century and developing countries begin to reduce emissions in the near future. By working to achieve the levels of reductions suggested by science, New York would do its fair share to protect the Earth's natural resources and the millions of people vulnerable to climatic changes. Implementing policies to achieve such momentous GHG reductions could promote the well-being of the people of New York and provide New York's citizens with the opportunities to benefit from the new clean energy economy.

1.3 State Energy Policy and Climate Change

New York already has begun to deal with climate challenge, through innovative, cost-effective policies and programs such as the Regional Greenhouse Gas Initiative (RGGI), stricter automobile GHG emission standards, and Governor David A. Paterson's '45 by 15' program for expanding efficiency measures and

[2] Examples include the United Nations-sponsored Intergovernmental Panel on Climate Change (IPCC), U.S. National Academies of Sciences, and the American Geophysical Union.

[3] For example, eight of the ten states in the Regional Greenhouse Gas Initiative (RGGI) have adopted GHG goals consistent with '80 by 50'.

[4] The American Clean Energy and Security Act passed the House on June 26, 2009.

renewable energy generation. State incentives are working in concert with federal programs to increase market penetration of alternative energy technologies and to promote emission reductions.

To reduce emissions 80 percent by 2050 (‘80 by 50’), the State would need to expand beyond current efforts, implementing long-term strategies to further reduce GHG emissions. Decisions on how the State produces and uses energy represent choices between mitigating global climate change and continuing on an unsustainable path. Energy decisions in relation to power plants, factories, and buildings can have an impact on achieving ‘80 by 50’, and these decisions must take into account the long-term impact of capital assets. While the development of the low-carbon energy system that would allow New York to meet 80 percent GHG reduction by mid-century is possible, the transition to that system will present both tremendous opportunities and difficult challenges.

1.3.1 Opportunities and Costs of reducing GHG emissions

Currently available strategies for meeting 80 by 50 provide examples of the long-term economic opportunities that flow from reducing GHG emissions, as well as of the short-term energy savings. Energy efficiency is a way to reduce GHG emissions and total energy costs, even if energy prices rise in a carbon-constrained economy. Other strategies may require greater investment, but must be evaluated in the context of the potentially far-greater costs of inaction.[5]

Reducing GHG emissions 80 percent by 2050 will require fundamentally transforming how we obtain and use energy, not only in the electric generation sector, but also in transportation, buildings, and industry. It is likely that any pathway to ‘80 by 50’ will include de-carbonization of the electric generation sector, along with a shift to low-carbon-intensity electricity as a key carrier for energy used in transportation, buildings and industry.

Development of State energy policies offers a unique platform for integrating and coordinating emission reductions in diverse energy sectors. The State Energy Plan recommends a climate planning process to meet GHG reduction goals, and promotes key interim GHG reduction policies, including policies that increase energy efficiency and reduce the amount of energy we need, and programs that promote the development and deployment of technologies to generate, store and transmit energy generated from low-carbon or near-zero-carbon sources.[6]

[5] On a global scale, the Stern Review concluded that the economic costs of strong and early action are less than the economic costs of climate impact. The Stern Review recommended urgent, immediate, and sharp reductions in GHG emissions. If no action is taken, the overall costs and risks of climate change will be equivalent to losing at least five percent of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates could rise to 20 percent of GDP or more. In contrast, the costs of reducing GHG emissions to avoid the worst impacts of climate change can be limited to around one percent of global GDP each year. From *The Economics of Climate Change: the Stern Report*, Cambridge University Press, 2007. William Nordhaus from Yale University Department of Economics analyzed the Stern Review and conducted his own economic modeling to calculate the costs and benefits of reducing GHG emissions to mitigate climate change (Nordhaus, W. *Critical Assumptions in the Stern Review on Climate Change*. Science. 2007). Although Nordhaus used a similar economic model, the results were different from the Stern Review because Nordhaus used a different social discount rate for calculating the benefits of reducing CO_2 emissions. Both researchers concluded that there are economic benefits to mitigating climate change, but Nordhaus’ results support less aggressive reductions in the near term.

[6] The terms low-carbon or near-zero-carbon are used qualitatively in this brief to refer to energy sources whose carbon intensity (CO_2 emitted per unit of energy) is significantly lower than that of traditional fossil fuel combustion. These energy sources include: sustainable and renewable energy (such as solar, hydroelectric, biomass, wind and geothermal power); nuclear power, and energy produced by processes that capture and sequester most of the CO_2 emitted from fossil fuel combustion.

1.3.2 New York's Response to Climate Change Can Boost its Economic Prospects

Transformation of our fossil fuel economy into a clean energy economy will be the work of a generation, involving large numbers of investors and workers, diverse skills, and action and support by both public and private sectors. To economically and socially optimize this necessary transition, as recommended in Volume 1 of this Plan, New York will initiate a Climate Action Plan to evaluate and recommend both short-term changes and fundamental long-term structural actions that would be needed to reach 80 percent reduction in GHGs by 2050 and, ultimately, to achieve a sustainable energy system.

While New York's transformation will require significant public and private investment, these changes involve the kinds of projects that historically have triggered significant growth in New York. Investment in low-carbon power generation and energy efficiency technologies can position the State to compete successfully in a carbon-constrained world. By initiating programs like RGGI and further investing in energy efficiency and low-carbon-intensity energy generation, New York will position itself and its businesses for superior competitiveness in a low-carbon marketplace. With support and encouragement from State government, New York's clean energy economy is poised for growth.

2 *Climate Change and Its Impacts*

2.1 Why the Climate is Changing

Relatively small increases in average global temperature can cause large changes in the Earth's climate system. Warming of the Earth is unequivocal, documented by observations of higher global average air, land surface and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.[7] During the 20th century, average global surface temperature rose by more than one degree Fahrenheit. The 10 warmest years in the period of instrumental measurements, which dates back to 1880, all occur within the 12-year period of 1997 to 2008.[8] Recent climate change projections indicate a median probability of global surface warming of 9.3°F (5.2°C) by 2100, with a 90 percent probability range of 6.3°F (3.5°C) to 13.3°F (7.4 °C).[9]

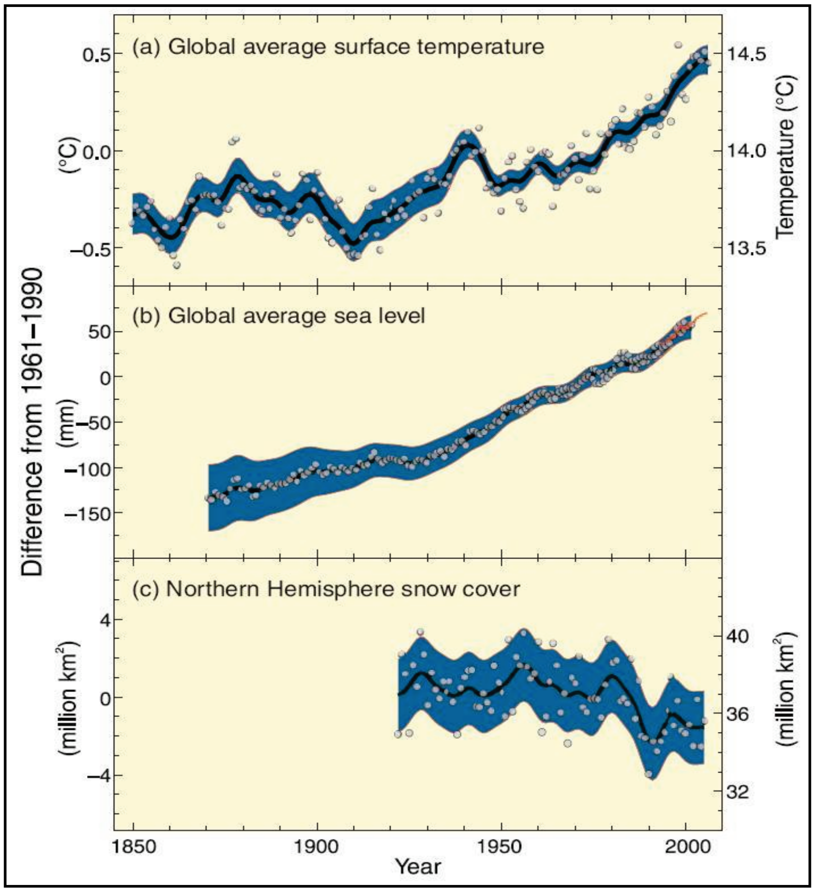
Figure 1 shows observations of a significant rise in (a) global average surface temperature and (b) global average sea level from tide gauge (blue) and satellite (red) data, and a decline in (c) Northern Hemisphere snow cover for March-April.

[7] Intergovernmental Panel for Climate Change (IPCC). *Climate Change 2007: Synthesis Report; Summary for Policymakers*. 2007. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

[8] NASA Goddard Institute for Space Studies. *Global Temperature Trends: 2008 Annual Summation*. 2009. http://data.giss.nasa.gov/gistemp/2008/

[9] Sokolov, A.P., Stone, P.H., Forest, C.E., Prinn, R., Sarofim, M.C., Webster, M., Paltsev, S. Schlosser, C.A., Kicklighter, D., Dutkiewicz, S., Reilly, J., Wang, C., Felzer, B., Melillo, J., and Jacoby H.D. *Probabilistic Forecast for 21st Century Climate Based on Uncertainties in Emissions (Without Policy) and Climate Parameters*. Journal of Climate. 2009. http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt169.pdf

Figure 1. Observed Changes in Temperature, Sea Level, Northern Hemisphere Snow Cover



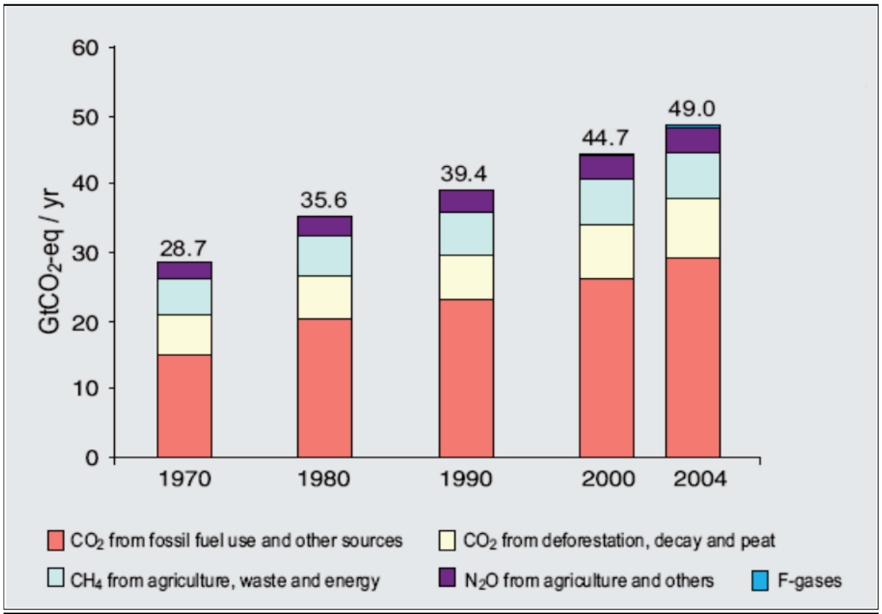
Source: IPCC Climate Change 2007: Synthesis Report, Summary for Policymakers

2.1.1 Much of Current Climate Change is Attributable to Increasing Atmospheric GHGs

Anthropogenic CO_2 emissions from burning fossil fuels to propel vehicles, generate electricity, and heat and operate homes and businesses are the most significant cause of recent warming. Other important contributors are CO_2 emissions from land-use changes, such as tropical deforestation, and emissions of the GHGs methane and nitrous oxide, which are primarily from agriculture. Man-made fluorinated or F-gases, including hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, are powerful greenhouse gases used in industry, released at low levels, which contribute a relatively small amount to observed warming. Particulate emissions (black carbon) from the combustion of fossil fuels and biomass, while short-lived in the atmosphere, also contribute to climate change.

As shown in Figure 2, global annual emissions of anthropogenic GHGs have increased significantly since pre-industrial times, with a large and rapid increase of 70 percent between 1970 and 2004. There is strong scientific evidence that these emissions are significant contributors to the observed warming – natural climate variability alone cannot account for the rapid rise in global temperatures observed in recent decades. A United Nations panel has concluded that atmospheric concentrations of CO_2 (379 ppm) and methane (1774 ppb) in 2005 far exceeded the natural range over at least the last 650,000 years.[10]

Figure 2. Global Emissions of Anthropogenic Greenhouse Gases, 1970 to 2004



Global annual emissions of anthropogenic GHGs increased significantly from 1970 to 2004.

(Source: IPCC Climate Change 2007: Synthesis Report, Summary for Policymakers, Figure SPM3 [modified], p.5)

2.1.2 Scientific Documentation of Anthropogenic Climate Change

Much of the scientific evidence relating to climate change effects has been collected and analyzed by the IPCC, a scientific body established in 1988 by the World Meteorological Organization and the United Nations Environment Program. Under the IPCC, more than 2,500 scientists from around the world review studies conducted by climate scientists and draw important conclusions from the data about what is happening to the Earth's climate and what is likely to happen in the future. Appendix A summarizes the IPCC findings, along with information from the U.S. Climate Change Science Program and the World Health Organization.

In 2007, the IPCC concluded that:

> [m]ost of the observed increase in globally averaged temperatures since the mid-20th century is very likely (greater than 90 percent certainty) due to the observed increase in anthropogenic greenhouse gas concentrations.[11] Discernible human influences now

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[10] IPCC. *Climate Change 2007: The Physical Science Basis; Summary for Policymakers.* 2007. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm

[11] IPCC. *Climate Change 2007: Synthesis Report, Summary for Policymakers.* 2007.

extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes, and wind patterns.

A comparison of the Earth's observed temperatures over the last century with historical temperature projections calculated by global climate models show that most of the warming from the 1950s to the present was caused by heat-trapping emissions from human activities, and that these emissions currently are driving the climate about three times more strongly than they did in the 1950s. Only when climate forcings[12] from anthropogenic GHG emissions are included with naturally-occurring forcings can climate models accurately reproduce historical temperature change.[13]

Other preeminent scientific institutions have consistently concluded that the Earth is warming and that human activities are largely responsible. For example, a joint statement from the national scientific academies,[14] which includes the U.S. National Academy of Sciences, concludes: "It is likely that most of the warming in recent decades can be attributed to human activities. This warming has already led to changes in the Earth's climate."

2.2 Climate Change Impacts in New York

2.2.1 Observed Climate Change

Analysis of temperature data from 73 climate stations shows the New England-New York region warmed approximately 2.0°F (1.1°C) during the 20th century, nearly twice as great as the global change in average temperature.[15] The State's climate has begun to change, taking on some characteristics of the climate associated with states south of New York.[16]

2.2.2 Projected Climate Change Impacts

Climate change threatens the State's natural resources and economy and the health and lifestyle of its residents. The recent Climate Change in the U.S. Northeast study, which was the product of collaborative research by 40 independent scientists, assessed how global warming may affect the Northeast's climate in the future. Using global climate model projections, the study compared projected climate change impacts resulting from a higher emissions scenario in which GHG emissions continue to grow rapidly with the impacts from a lower emissions scenario that assumes resource-efficient technologies and less reliance on fossil fuels. Appendix B details the study's projections of the significant impacts in New York for both emission scenarios.[17]

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[12] Climate forcings are factors that increase or decrease the energy in the climate system.

[13] IPCC. *Climate Change 2001: The Scientific Basis*. 2001. http://www.ipcc.ch/ipccreports/tar/wg1/index.php?idp=0

[14] The National Academies. *Joint Science Academies' Statement: Global Response to Climate Change*. June 7, 2005. http://www.nationalacademies.org/onpi/06072005.pdf.

[15] Trombulak, S.C. and Wolfson, R. *Twentieth-Century Climate Change in New England and New York, USA*. Geophysical Research Letters, Vol. 31. 2004.

[16] Frumhoff, P.S., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). 2007. http://www.climatechoices.org/ne/resources_ne/nereport.html

[17] Frumhoff et al. 2007.

Public Health and Natural Resources

Higher temperatures may lead to more intense and prolonged periods of summertime heat that will enhance the production of ground-level ozone especially in urban areas where ozone precursors are abundant. [18] Studies assessing climate change impacts on public health indicate that increased heat stress and ozone concentrations may take a significant toll, especially among susceptible urban populations such as children, the elderly, and individuals with cardiovascular and respiratory disease who are subject to increased air temperatures. Heat-related mortality in the New York City metropolitan region could increase from 47 to 95 percent when compared to 1990 levels.[19] A study of weather events from 1991 to 2004 in New York City, undertaken by the New York State Department of Health (DOH), found significantly elevated hospitalizations above modest temperature thresholds and greater susceptibility to heat stress among the elderly and Hispanic residents from lower income neighborhoods.[20] Predicted increases in temperature will also favor the survival of disease-carrying vectors, increasing the risk of water-, insect-, and animal-borne disease.[21]

Pests and diseases favored by warmer winters can also disrupt crop production and threaten forests, including those in the Adirondack Park, one the most significant hardwood ecosystems in the world. Changes in forest composition will also impact fish, birds, and wildlife. Warming inland waters will decrease the available habitat for cold-water fish species, such as salmon and trout, while warm-water habitat will expand. Ocean coastal waters will warm, altering the species composition of marine fisheries and impacting local fisheries-based economies.[22] As temperatures rise, lobster populations in Long Island Sound will suffer additional stresses. Furthermore, increasing concentrations of CO_2 in the atmosphere will accelerate ocean acidification, impacting marine organisms and coral reef formation.

Flooding and Water Supplies

Sea level rise accelerated by climate change will increase the frequency and magnitude of flood damage to coastal communities, inundate lands and will further stress critical coastal ecosystems. Coastal flooding is projected to disrupt New York City's infrastructure and transportation system with increasing frequency and to inundate greater areas of the city. A recent study for the New York City Panel on Climate Change (NPCC) used global climate models and local geographic information to predict New York City sea levels may rise by 12 to 23 inches (in.) by the 2080s. A "rapid ice-melt" scenario, an alternative study method that incorporates observed and longer-term historical melt rates, predicts sea level could rise by approximately 41 to 55 in. by the 2080s.[23]

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[18] Murazaki, K. and P. Hess. *How Does Climate Change Contribute to Surface Ozone Change Over the United States?* Journal of Geophysics Research. 111. 2006; Dawson, J.P., Adams, P.J., Pandis, N.S. *Sensitivity of Ozone to Summertime Climate in the Eastern USA: A Modeling Case Study*. Atmospheric Environment. 41(7): 1494-1511. 2007.

[19] Knowlton, K., Barry, L., Goldberg, R., Rosenzweig, C., Hogrefe, C., Rosenthal, J.K., and Kinney, P.L. Projecting Heat-Related Mortality Impacts under a Changing Climate in the New York City Region. American Journal of Public Health 97: 2028-2034. 2007.

[20] Lin S., Luo M., Walker J.R., Liu X., Hwang S.A., Chinery R.: *High Temperatures and Respiratory Cardiovascular Hospital Admissions in New York City (NYC)*. Epidemiology (in press).

[21] Frumhoff et al. 2007.

[22] Frumhoff et al. 2007.

[23] New York City Panel on Climate Change (NPCC). Climate Risk Information. 2009. http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf

New York's public drinking water supplies also may be stressed by changes in temperature and precipitation. New York City's water supply comes from a 2,000 square mile watershed in upstate New York that is greatly influenced by temperature and precipitation.[24] A report by the NPCC discusses how changes in mean climate and climate extremes may critically affect many aspects of New York City's infrastructure, including water and waste systems. For example, with more frequent and intense heat waves, increased water demand could strain water supply systems, while more frequent and intense drought could affect average reservoir storage and operating rules. More intense rainfall could lead to more combined sewer overflow events, which would affect drinking water quality by polluting coastal waterways and increasing turbidity in reservoirs and could cause an increase in nutrient loads, eutrophication, and taste and odor problems.[25]

Agriculture and Tourism

A warmer climate in New York may have both positive and negative effects on agriculture. Heat-loving crops like European red wine grapes, watermelons, peaches, and tomatoes may benefit from a longer, warmer summer. Grain crops are likely to produce lower yields in warmer summer temperatures. Certain cold weather crops, such as apples and potatoes, are expected to be limited by prolonged periods of elevated temperatures. All crops may face increasing summer heat stress, drought, and competition from weeds and pests.[26]

Dairy farmers also may be impacted, since milk production is maximized under cooler conditions ranging from 41°F to 68°F.[27] New York is the third largest producer of milk in the U.S., behind California and Wisconsin, with 12.1 billion pounds of milk produced in 2006, and annual revenues in excess of $2.3 billion.[28] During the unusually hot summer of 2005, many New York dairy herds reported declines in milk production of 8 to 20 percent.[29] A loss of milk production efficiency from heat effects could result in the loss of millions of dollars annually for New York's dairy industry.[30]

Winter recreation and tourism revenue in New York also will be affected significantly by global climate change as warmer winters shorten the average ski and snowmobile season;[31] summer tourism, however, may benefit from extended warm weather.

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[24] National Assessment Synthesis Team (NAST). *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. p. 123.* 2001. http://www.usgcrp.gov/usgcrp/Library/nationalassessment/04NE.pdf

[25] NPCC. 2009.

[26] Wolfe, D.W., Ziska, L., Petzoldt, C. Seaman, A., Chase, L., Hayhoe, K. *Projected Change in Climate Thresholds in the Northeastern U.S.: Implications for Crops, Pests, Livestock, and Farmers.* Journal Mitigation and Adaptation Strategies for Global Change. 14(5-6): 555-575. 2008.

[27] Garcia, A. *Dealing with Heat Stress in Dairy Cows.* South Dakota Cooperative Extension Service. P.1. 2002. http://agbiopubs.sdstate.edu/articles/ExEx4024.pdf

[28] U.S. Department of Agriculture, National Agricultural Statistics Service. *Milk Production, Disposition and Income: 2007 Summary. pp. 4, 8*. 2008. http://usda.mannlib.cornell.edu

[29] Frumhoff, P. et al. 2007. p. 69.

[30] Wolfe et al. 2007. p.17.

[31] Frumhoff et al. 2007.

2.2.3 Additional New York State Climate Change Impacts Research Underway

To better understand how climate change will affect our State, the New York State Energy Research and Development Authority (NYSERDA) is currently funding a two-year study called *Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State*. The goal of this effort is to identify and assess both near-term and longer-term potential impacts in New York under different climate change scenarios. This research will also identify and begin to evaluate adaptation strategies.

The New York State Sea Level Rise Task Force, created in 2007 by the State Legislature, is assessing impacts to the State's coastlines from rising seas, and will recommend adaptive measures to protect New York's remaining coastal ecosystems and natural habitats and to increase coastal community resilience in the face of sea level rise.

2.3 Stabilizing Atmospheric Greenhouse Gas Concentrations

To stabilize the atmospheric concentrations of GHGs, GHG emissions must approach equilibrium–a state of balance between GHG sources and sinks. The likelihood and extent of many climate change impacts in New York and elsewhere depend upon the global concentration of atmospheric GHGs. Generally, the higher the concentrations at which GHGs are stabilized, the greater the average global temperature increase.

2.3.1 Climate Science is the Basis for GHG Stabilization Goals

Since GHGs exert their climate-altering properties on a global scale, emission reductions must occur not only in New York, but globally. In 1992, 154 nations, including the U.S., agreed to a series of overarching goals to minimize the risks from climate change, embodied in the *United Nations Framework Convention on Climate Change* (UNFCCC). Article 2 of the UNFCCC establishes the treaty's long-term objective of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the Earth's climate system."

Scientific evidence suggests that limiting the global average temperature increase to approximately 3.6°F (2°C), above pre-industrial temperatures may minimize the likelihood of the most severe climate impacts and is consistent with the UNFCCC goal of avoiding dangerous climate change.[32] Figure 3[33] illustrates the range of potential physical impacts at varying levels of global temperature change. For each impact category, a colored arrow indicates the possible temperature range for a specific physical change to occur: an unbroken arrow with redder color indicates greater likelihood and severity of the physical event. It is important to note that the most severe effects, or "Abrupt and Major Irreversible Changes," may be prevented if the rise in global average temperature is limited to approximately 3.6°F (2°C).

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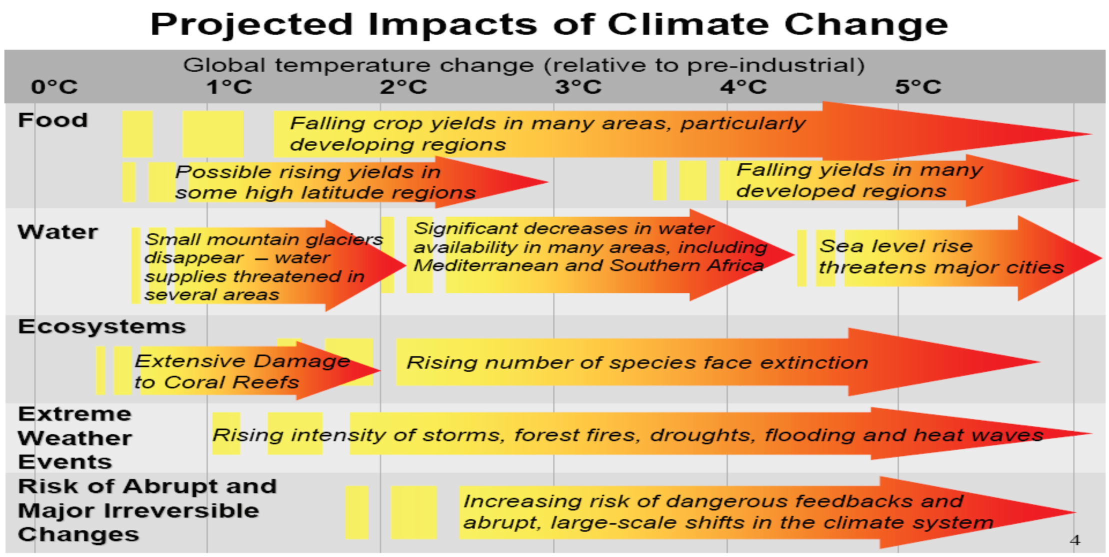
[32] Parry, M.L., O.F. Canziani, J.P. Palutikof and Co-authors *Technical Summary. Climate Change 2007: Impacts, Adaptation and Vulnerability*. 2007. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-ts.pdf

[33] Stern, N. *The Economics of Climate Change: The Stern Review: Executive Summary. Figure 2, pp v.* 2007. http://www.hm-treasury.gov.uk/sternreview_index.htm

Figure 3. Projected Impacts of Climate Change



Source: The Economics of Climate Change: The Stern Review, Cambridge University Press, 2007

The atmospheric GHG concentration that will result in a 3.6°F (2°C) increase in global temperatures cannot be known with great accuracy. The best scientific estimates available, including estimates from the 2007 IPCC Report, indicate that if atmospheric GHG concentrations are stabilized in the atmosphere at 450 ppm of carbon dioxide equivalent (CO_2e), or total GHGs, there is a medium likelihood that warming will not exceed 3.6°F (2°C).[34,35] To achieve stabilization of atmospheric concentrations at this level, the IPCC estimates that net global GHG emissions must approach zero by the end of this century.[36,37] The interim targets along the pathway to a 450 ppm CO_2e stabilization level require global emissions to peak no later than 2015 and to decrease to 85 percent below year 2000 levels by 2050.[38] IPCC did not evaluate intermediate reductions for timeframes other than year 2050.

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[34] Carbon dioxide equivalent is a measure used to compare the emissions from different greenhouse gases based upon their global warming potential. For example, the global warming potential for methane over 100 years is approximately 21. This means that emissions of one million metric tons of methane are equivalent to emissions of 21 million metric tons of carbon dioxide. OECD. *Glossary of Statistical Terms*. http://stats.oecd.org/glossary/detail.asp?ID=285

[35] The concentration of greenhouse gases in the atmosphere is already at approximately 375 ppm CO_2e and currently rising at roughly 2.5 ppm every year. IPCC. 2007.

[36] Using paleoclimate evidence and observations of current rates of global change, some recent studies suggest that today's atmospheric GHG concentrations already are too high to maintain the climate to which humanity, wildlife, and the rest of the biosphere are adapted. See: Hansen et al. *Target Atmospheric CO2: Where Should Humanity Aim?* 2008. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter3.pdf

[37] Fisher, B.S., N. Nakicenovic, K. Alfsen, J. Corfee Morlot, F. de la Chesnaye, J.-Ch. Hourcade, K. Jiang, M. Kainuma, E. La Rovere, A. Matysek, A. Rana, K. Riahi, R. Richels, S. Rose, D. van Vuuren, R. Warren. *Issues Related to Mitigation in the Long Term Context.* In Climate Change 2007: Mitigation. 2007. p. 199

[38] Meinshausen, M. (edited by Schellnhuber et. al.) *What Does a 2°C Target Mean for Greenhouse Gas Concentration*? In Avoiding Dangerous Climate Change, 2006.

2.3.2 Apportioning GHG Reductions

Determining how much individual states or nations should reduce emissions through mid-century requires consideration of allocation equity and reduction effectiveness.[39] The UNFCCC approach to apportioning GHG emission reduction requirements between developed and developing nations considers a broad spectrum of parameters, including population, gross domestic product (GDP), GDP growth, and global emission pathways that lead to climate stabilization.[40] Applying these parameters, the UNFCCC concludes that, to reach the 450 ppm CO_2e stabilization target, developed countries need to reduce GHG emissions by 80 to 95 percent from 1990 levels by 2050.

2.3.3 Scientific Organizations Recommend Immediate Policy Action

Many scientific organizations have reached important conclusions about the need for governments to respond with sufficient resources to reduce GHG emissions dramatically. The national scientific academies of the G8 nations, including the U.S., and the developing nations of Brazil, India and China[41] report:

- The scientific understanding of climate change is now sufficiently clear to justify taking action to reduce GHG emissions. Any remaining uncertainty about the science is not sufficient to warrant further delay in action to reduce GHG emissions.

- Action taken now to reduce emissions will reduce the magnitude and rate of climate change.

- Any delay in acting will increase the risk of adverse effects of climate change and will likely necessitate more expensive mitigation later.

In 2007, IPCC[42] also concludes:

- Many impacts can be reduced, delayed or avoided by mitigating GHG emissions. Mitigation efforts and investments over the next two to three decades will greatly help to achieve lower stabilization levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilization levels and increase the risk of more severe climate change impacts.

- A wide variety of policies and instruments are available to governments to create the incentives for mitigation action.

- All stabilization levels assessed can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialized in coming decades,

[39] As previously discussed, all emissions of GHGs must eventually be in quasi-equilibrium with GHG removal mechanisms to allow for stabilization of atmospheric GHG concentrations.

[40] UNFCCC. *Synthesis of Information Relevant to the Determination of the Mitigation Potential and to the Identification of Possible Ranges of Emission Reduction Objectives of Annex 1 Parties: An Update.* 2008. http://unfcccbali.org/unfccc/images/document/technical_papper.pdf

[41] The National Academies. *Joint Science Academies' Statement: Global Response to Climate Change.* 2005. http://www.nationalacademies.org/onpi/06072005.pdf

[42] IPCC. *Climate Change 2007: Synthesis Report, Summary for Policymakers.* 2007.

assuming appropriate and effective incentives are in place for development, acquisition, deployment and diffusion, and addressing related barriers.

- Mitigation actions can result in near-term co-benefits, e.g., improved health due to reduced air pollution that may offset a substantial fraction of mitigation costs.

2.3.4 Public Health Benefits from Implementing GHG Emission Reduction Strategies

Available analyses provide compelling evidence for substantial public health and resultant economic benefits from implementing GHG emissions reduction programs. In fact, some suggest that many of these studies underestimate the benefits because they fail to consider a number of important health endpoints and economic costs.[43]

The expected health benefits of urban air pollution reductions from climate change mitigation strategies in the New York City area (assuming that they produce an approximately 10 percent reduction in PM_{10} and ozone concentrations) would be to avoid approximately 9,400 premature deaths (including infant deaths) 680,000 asthma attacks, and 12 million restricted activity days.[44] Additional discussion regarding the health benefits of reducing the combustion of fossil fuels in New York can be found in the Environmental Impacts, Environmental Justice, and Health Issue Briefs. State air quality and public health protection programs could consider funding further studies on the nexus between reducing fossil fuel use and public health outcomes related to climate change. Study results will inform mitigation and adaptation strategies to protect all communities, especially those most affected by climate change.

The California Air Resources Board (CARB) evaluated the public health benefits of implementing the California Global Warming Solutions Act of 2006 (AB32), which requires that California's 2020 GHG emissions be reduced to 1990 levels. The expected health benefits for California in 2020 resulting from the reduction in harmful air pollution accompanying reductions in GHGs include 400 avoided premature deaths, 11,000 avoided incidences of asthma and lower respiratory symptoms, and 67,000 avoided lost work days. The CARB analysis also indicates that implementing AB32 will facilitate greater use of alternative modes of transportation, such as walking and bicycling. These types of moderate physical activities reduce many serious health risks including coronary heart disease, diabetes, hypertension, and obesity.[45] By 2020, CARB estimates the economic value of the health- related benefits to be on the order of $2.2 billion.

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[43] Bell, M. Davis, D. Cifuentes, L.A. Krupnick, A.J. Morgenstern, R.D., and Thurston, G.D. *Ancillary Human Health Benefits of Improved Air Quality Resulting from Climate Change Mitigation.* Environmental Health. 7:41. 2008. http://www.ehjournal.net/content/7/1/41

[44] Cifuentes, L., Borja-Aburto, V.H., Gouveia, N., Thurston, G., Davis, D.L. *Assessing the Health Benefits of Urban Air Pollution Reduction Associated with Climate Change Mitigation (2000-2020): Santiago, Sao Paulo, Mexico City, and New York City.* Environmental Health Perspectives, 109(3): 419-425. 2001. http://www.epa.gov/ies/pdf/general/cifuentes.pdf

[45] California Air Resources Board. *Climate Change Proposed Scoping Plan*. 2008. http://www.arb.ca.gov/cc/scopingplan/document/psp.pdf

Similarly, the Stern Review,[46] which provides an expansive economic analysis of climate change, discusses a recent study by the European Environment Agency[47] that concludes that implementation of GHG emission reduction policies to limit global mean temperature increase to 3.6°F (2°C) above pre-industrial levels will result in an annual savings of $22 billion to $64 billion in Europe for avoided health care costs.

[46] Stern, N. *The Economics of Climate Change: The Stern Review*. 2007.

[47] European Environment Agency. *Air Quality and Ancillary Benefits of Climate Change.* 2006. http://www.eea.europa.eu/publications/technical_report_2006_4

3 Greenhouse Gas Emissions in New York

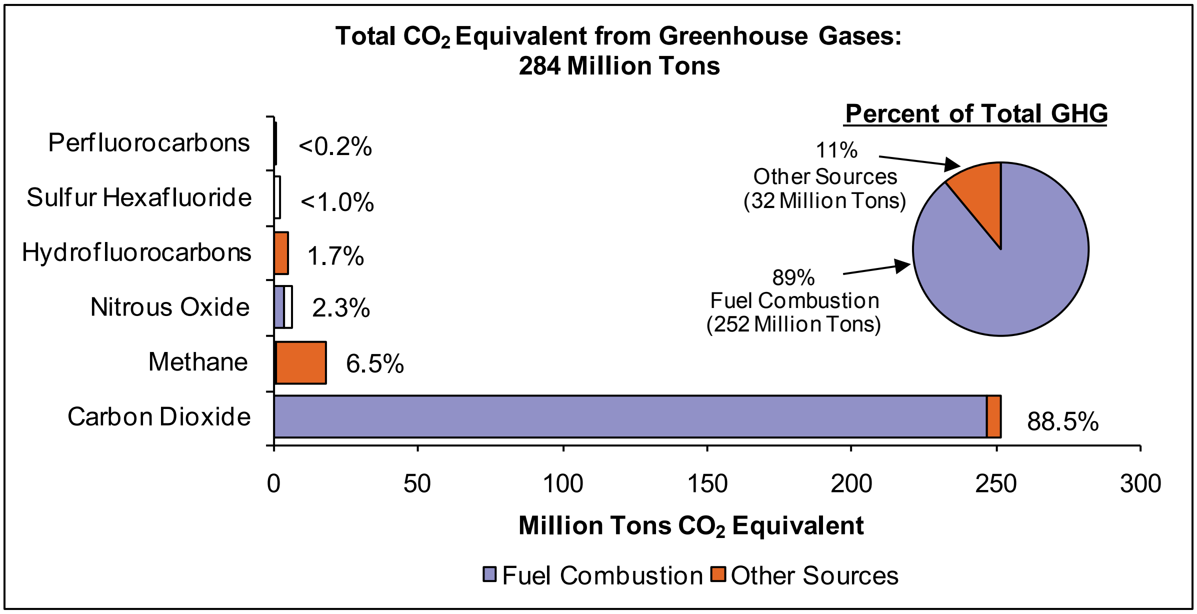
Today, CO_2 from combusting fossil fuels constitutes nearly 90 percent of New York's GHG emissions. Fossil fuels are burned in tens of thousands of places across the State: in power plants to generate electricity; on-site to heat buildings and to power industries; and in vehicles to transport goods and people. Emission inventories and projections are the basis for identifying GHG emission reduction opportunities and for planning for the economic and environmental impacts of policies. Detailed information about the sources and methodologies used in NYSERDA's estimates of New York's current and future GHG emissions will be on the NYSERDA website[48] and in the Demand/Price Forecasting Brief.

3.1 Total Greenhouse Gas Emissions by Gas

In 2007, New York emitted approximately 284 million tons of CO_2e or an average of 14.7 tons of CO_2e for each State resident. For each of the major GHGs, Figure 4 depicts the portions of New York's emissions that result from fuel combustion and from other sources, such as cement production, limestone consumption, soda ash consumption, aluminum production, direct manufacturing use of carbon dioxide, agricultural soil management, and municipal solid waste combustion.

[48] NYSERDA. *New York State Greenhouse Gas Emissions Inventory and Forecasts for the 2009 State Energy Plan.* Draft June 25, 2009.

Figure 4. Total CO_2 Equivalent from Greenhouse Gases in New York State, 2007



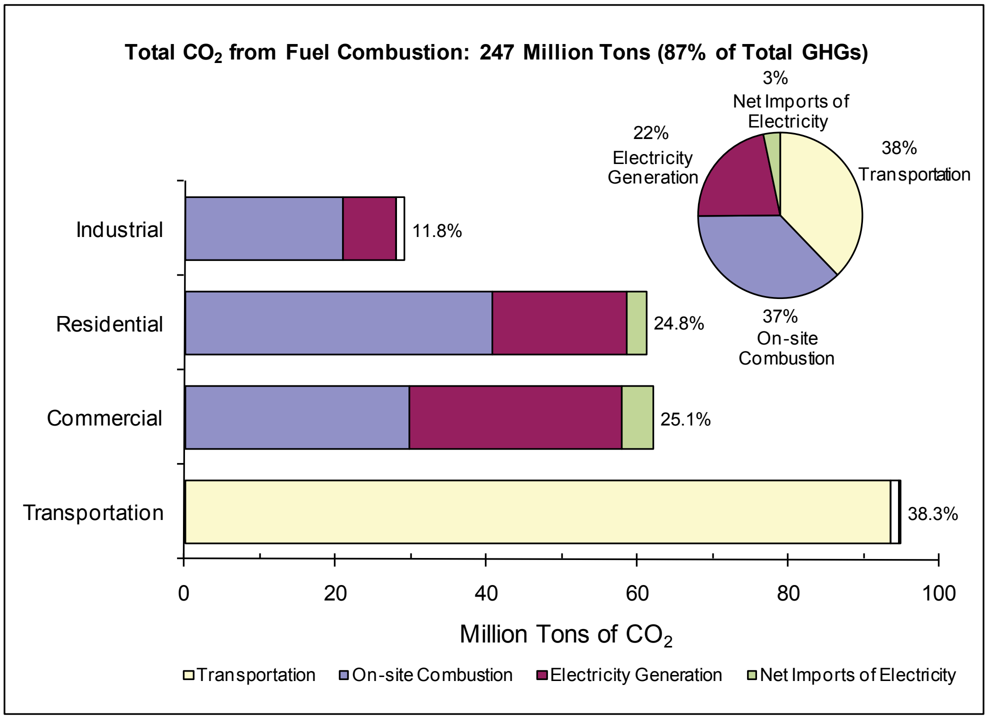
Source: NYSERDA

As Figure 4 shows, CO_2 comprises almost all (88.5 percent) of New York's GHG emissions. Most CO_2 emissions result from fossil fuel combustion (98.3 percent). Methane's contribution is second highest (6.5 percent); most of New York's methane (93.9 percent) results from sources such as municipal waste and natural gas distribution leakage, rather than fuel combustion. Nitrous oxide emissions comprise a small amount of the total (2.3 percent) and are mostly attributable to automotive fuel combustion. Other industrial gases make up the remaining GHG emissions.

3.2 Sources of State Carbon Dioxide Emissions

The GHG inventory divides CO_2 emissions into four main end-use sectors: industrial, residential, commercial, and transportation. Figure 5 details 2007 CO_2 emissions from fossil fuel combustion by end-use sector; fossil fuel combustion resulted in 87 percent of all GHG emissions in the State. Transportation (38 percent) and on-site fuel use (37 percent) contribute roughly equivalent percentages of carbon dioxide emissions, with electricity generation, including electricity imports, contributing approximately one-quarter of the total.

Figure 5. CO_2 from Fuel Combustion by End-Use Sector, New York State, 2007



Source: NYSERDA

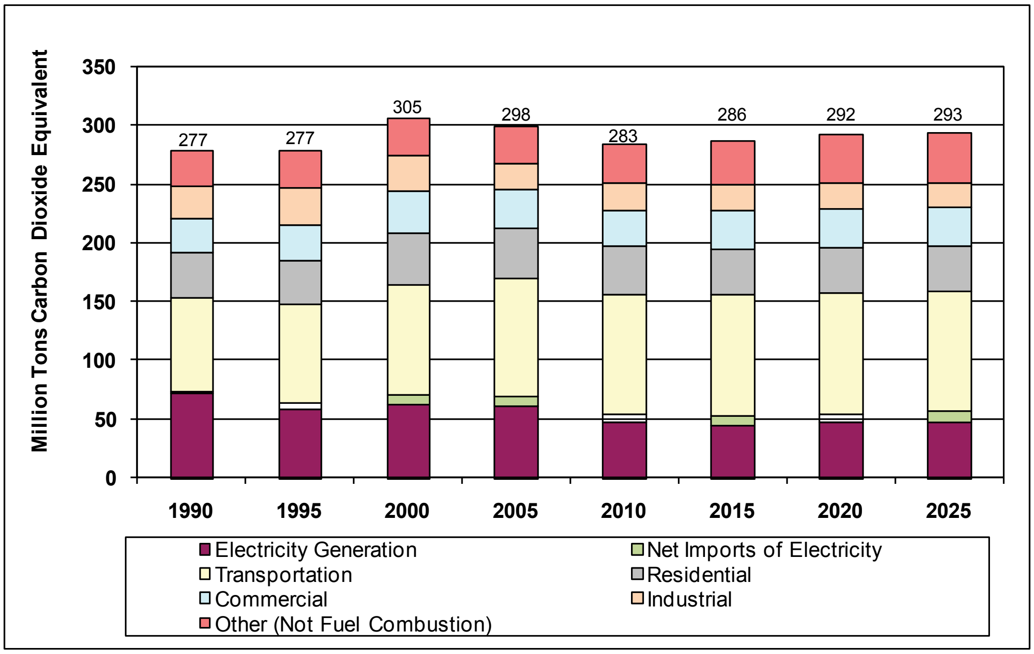
3.3 Greenhouse Gas Emission Forecasts through 2025

As shown in Figure 6, NYSERDA projects that annual GHG emissions in 2025 will be 293 million tons CO_2e, a relatively small increase from current levels. The relative contribution of the various sectors will remain unchanged, except that the "Other Source" category (non-fuel combustion) is projected to surpass residential emissions in 2020 and 2025.

Figure 6 shows NYSERDA estimates of annual GHG emissions through 2025, which are based on U.S. Energy Information Administration (EIA) forecasts for Mid-Atlantic fuel demand, along with natural gas projections provided by Energy and Environmental Analysis, Incorporated.

Forecasts for on-highway diesel and gasoline fuel use were based on forecasts of New York vehicle miles of travel provided by the Department of Transportation along with EIA-projected vehicle fuel economy.

Figure 6. New York State Greenhouse Gas Emissions by Source Category, 1990–2025



Source: NYSERDA

Forecasts for fuel use for the electricity sector and net imports of electricity were based on output from ICF International's Integrated Planning Model® (IPM), an electricity sector modeling software used to support the development of the Plan. These projections include estimated emission reductions due to RGGI and partial implementation of New York's '15 by 15' energy efficiency goal, as shown in the Electricity Assessment "Starting Point" reference case. For imports, the emission factor was estimated based on modeled emissions from neighboring electric service territories.

Non-fuel combustion emission forecasts for the industrial sector are based on the projected growth of New York industries. These forecasts were created using Policy Insight® version 8.0, a macroeconomic modeling software from Regional Economic Models Inc. Estimates for emissions from hydrofluorocarbon (HFC) refrigerant substitutes are scaled from EPA projections for national emissions.

GHG emissions from electricity transmission and distribution assume continuation of the long-term historical trend decline.

A more detailed explanation of the forecasting methods can be found in the Demand/Price Forecasting Assessment; the GHG emission forecasts are in large part based on the energy-use forecasts.

4 The '80 by 50' Challenge

In New York, millions of sources employing numerous fuel types and processes emit GHGs. Each of the sectors earlier identified contributes a significant share to the total emissions inventory, so no sector can be excluded from a comprehensive GHG reduction plan. Programs that address all fuels and include all emissions sectors are necessary to reduce emissions 80 percent by 2050.

4.1 Magnitude of the Challenge

The Issue Briefs and Assessments detail ambitious State programs and initiatives that promote energy efficiency, carbon management and low-carbon-intensity power generation. However, modeling analysis indicates that in-the-pipeline GHG mitigation programs, specifically the Energy Efficiency Portfolio Standard (EEPS), Renewable Portfolio Standard (RPS) and RGGI programs,[49] in addition to the 2007 federal Corporate Average Fuel Economy (CAFE) standards,[50] are insufficient to approach mid-term GHG emission levels consistent with the long-term '80 by 50' GHG emission reduction goal.

Figure 7 displays the magnitude of emission reductions necessary for New York to reach an '80 by 50' goal. The bar chart includes historic (1990) New York CO_2e emissions information, the forecast of emissions in year 2025, and the GHG emissions associated with the attainment of an '80 by 50' mid-century goal. The forecast of emissions for year 2025 includes estimating the uncertainty in forecasting due to scenarios not included in the forecast methodology.[51] Most of the State, regional and federal GHG mitigation programs that were modeled for the 2025 GHG forecast are focused on the electric sector.

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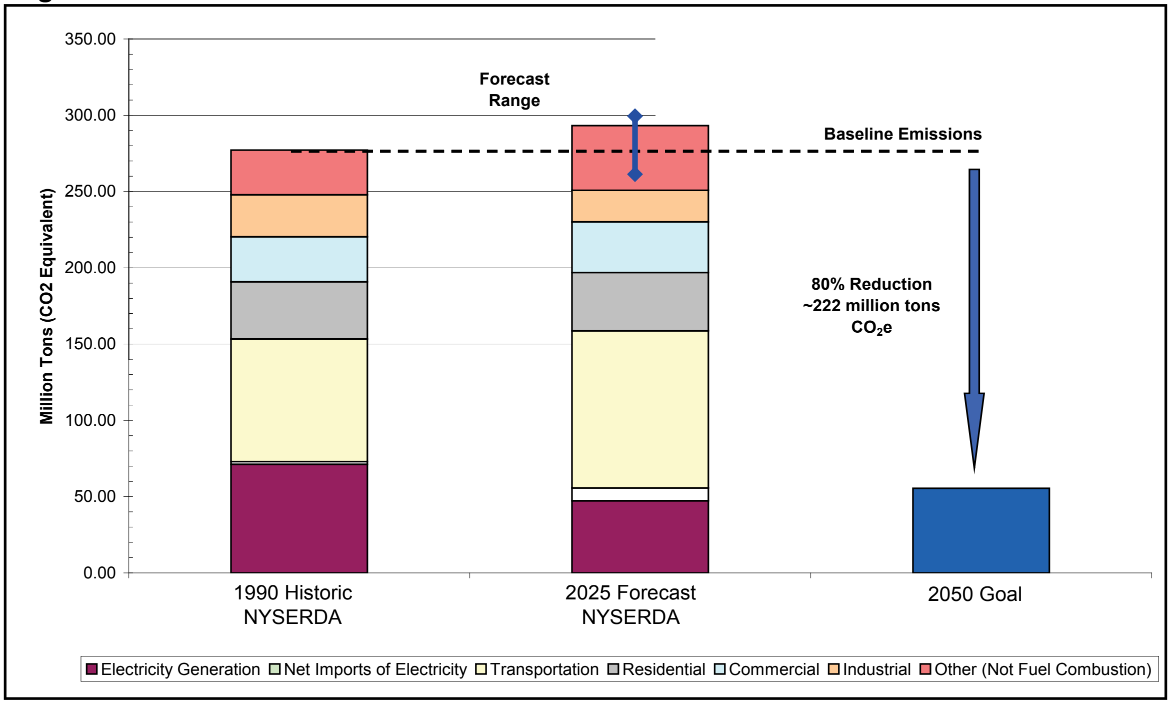
[49] The EEPS requires a 15 percent reduction of total annual electricity projected to be generated in 2015; the RPS equates to a percentage of generated annual electricity, currently proposed to be 30 percent of projected future year generation. RGGI sets an initial multi-State budget of more than 188 million allowances for electric generators with an emission allowance for one ton of CO_2, decreasing 10 percent by 2018. For the transportation sector, the Energy Independence and Security Act (EISA) sets federal 2007 CAFE standards that will increase applicable fleet efficiencies from 27.5 mpg (passenger cars) and 22.2 mpg (light trucks) to a combined fleet 35 mpg in model year 2020.

[50] For the transportation sector, the Energy Independence and Security Act (EISA) sets federal 2007 CAFE standards that will increase applicable fleet efficiencies from 27.5 mpg (passenger cars) and 22.2 mpg (light trucks) to a combined fleet 35 mpg in model year 2020. President Obama's recent announcement that U.S. EPA will adopt California's GHG emissions regulations for new passenger vehicles and light trucks will result in additional GHG emission reductions.

[51] An 'error-bar' (range) analysis as performed by NYSERDA, DEC, and other Departments has been included in Figure 7, indicated by a blue range added on to the "NYSERDA 2025 Forecast" inventory bar. The error-bar range presents the potential cumulative effect of policy recommendations and possible scenarios described in the Plan. The upper limit of the error-bar presents the additional greenhouse emissions associated with the combination of the "Indian Point Retirement Scenario" and the "High Demand Forecast," as described in the Electricity and Forecast Assessments. For this analysis the baseline emissions forecast includes the "Starting Point" reference case for the electric sector, which is described in the Electricity Assessment: Modeling.

Figure 7. Emission Reductions to Meet a 2050 Goal



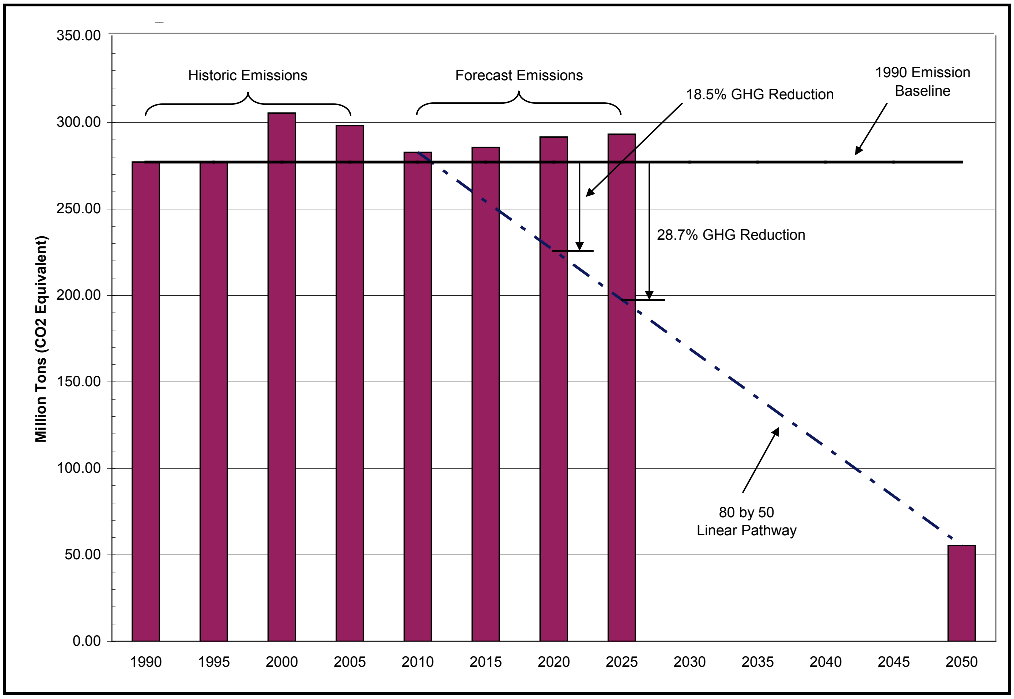
Source: Department of Environmental Conservation (DEC) Chart based on NYSERDA Inventory and Forecast Data

The chart illustrates the magnitude of the difference between 2025 forecast emissions under today's policies, including consideration of a best case application of additional measures outside forecasting, and a level of emissions that would place New York in line with mid-century emissions as recommended by some scientists. Projection of these existing programs into future years included in the 2025 GHG forecast data and graphically presented in Figure 7 illustrates that these programs alone cannot attain the '80 by 50' goal. Additional measures concurrent and parallel to existing programs that will address "all fuels from all sectors" of GHG emissions are necessary to achieve mid-century reduction goals.

As shown in Figure 8, a linear reduction pathway from forecasted levels in 2010 to an 80 percent reduction in 2050 requires 2020 emissions to be approximately 20 percent below 1990 levels and 2025 emissions to be approximately 30 percent below 1990 levels. This analysis illustrates the order of magnitude of mid-term emission reductions required to achieve an '80 by 50' goal and makes clear the need for additional GHG reduction strategies beyond current State and federal programs.

If critical programming for all sectors does not commence until after the 10-year planning horizon, GHG reduction strategies may not be in place to reduce emissions in time to achieve an '80 by 50' target. Postponing the strategies needed to reduce emissions could place an unnecessary financial burden on New York businesses and residents in a carbon-constrained national and world economy. In the likely event of a federal cap on carbon emissions, actions taken today by New York could help position the State's businesses and citizens to profit from and adapt to a carbon-constrained national economy.

Figure 8. Medium-Term GHG Reduction Target



Source: DEC chart based on NYSERDA Inventory and Forecast Data

4.2 Outline of an '80 by 50' GHG Emissions Reduction Scenario

The fundamental challenge in achieving an '80 by 50' mid-century goal is development and application of reliable, cost-effective, low-carbon-intensity energy carriers for all GHG emission sectors. To illustrate the transformative changes needed, the following discussion depicts one possible combination of strategies focusing on the State's energy system that would place the State on a pathway to '80 by 50'.

4.2.1 The Role of Energy Carriers

Energy carriers transfer energy from where it is available to where it is needed to do work. A key energy carrier throughout the developed world is electricity, which moves energy over long distances and to numerous local outlets through a system of wires. Today, most electricity carries energy that has been extracted from fossil fuels through combustion in central power stations. To achieve an '80 by 50' goal, most of New York's electricity would have to come from low-carbon-intensity energy sources, such as solar, wind and hydro.[52]

Currently, electricity is distributed to homes and businesses via the electric grid, a system that includes high-voltage transmission lines, a low-voltage local distribution network, substations, safety mechanisms,

[52] Recently, BP Solar announced that the company has been selected to enter into negotiations with the Long Island Power Authority (LIPA) to provide close to 37 megawatts (MW) of photovoltaic solar power on the grounds of the U.S. Department of Energy's Brookhaven National Laboratory (BNL). Their proposal includes two large-scale commercial solar photovoltaic projects at the BNL site located in Upton, New York. Each project would be sized at just over 18 MW, making BNL home to the largest solar photovoltaic site in the State of New York. BP Solar negotiations for a 20-year power purchase agreement with LIPA for these two projects are set to begin immediately.

and "tie-in" facilities. Although the electric grid is in need of upgrading, its existence makes it relatively easy to add energy from new sources without constructing a completely new distribution system; to accommodate a new, non-electric energy carrier would require constructing a new distribution system.

Because of their relatively low cost, high-energy density and ease of distribution, carbon-intensive energy carriers derived from fossil fuels also dominate the non-electric portion of the current energy economy. Gasoline, diesel, ethanol, and jet fuel carry energy used in the transportation sector to move people and goods. Buildings commonly use natural gas, propane, fuel oil, electricity, or a mix of energy sources for space and water heating, and for cooking and other functions. Attaining a mid-century climate protection goal will not be possible with continued on-site use of fossil fuels in these current forms. Replacing these fuels with one or more low-carbon energy carriers will be necessary to achieve an '80 by 50' goal. Since the means of energy distribution and use will drive the selection and development of GHG reduction strategies, the State should develop information that will help determine how New York can supply future energy needs with low-carbon energy carriers.

It is critical that the energy system infrastructure and primary energy conversion mechanisms minimize carbon emissions to the greatest extent possible. Whether the energy carrier is electricity, hydrogen, or some other choice, developing primary energy conversion mechanisms and energy system infrastructure that minimizes carbon emissions to the maximum extent possible is likely to take significant capital resources and decades to complete. Given the scale of needed energy generation sources and infrastructure, planning and implementation for a low-carbon energy system must begin during the 10-year planning horizon of this Energy Plan.

4.2.2 Electricity Generation and Storage

In any energy system aligned with an '80 by 50' GHG reduction goal, energy will have to be generated by the lowest-carbon-emitting technologies available. As presented in the Renewable Energy Assessment, New York's renewable energy technical potential is approximately 90 percent of the 2018 forecasted electricity generation requirement. Given continued growth in the solar-photovoltaic manufacturing base, renewable energy could theoretically meet all electrical demands before mid-century.

Currently, New York's electric generation system comprises a diverse mix of primary energy sources having only about 53 percent of net generated electricity coming from fossil fuel-fired electric generating units.[53] The State's electric sector contributes approximately 54 million tons of CO_2e annually to the GHG emissions inventory, exclusive of electricity imports. The forecasts, which incorporate the impact of RGGI and greater end-use efficiency but do not anticipate the cross-sectoral expansion of electricity use discussed above, project a 13 percent reduction in electric sector emissions by 2025. Replacing fossil-fueled generating units with a build-out of hydropower and wind power[54] to maximum technical potential, as estimated in the 2003 Optimal study,[55] would further reduce electric sector emissions. However, additional development of low-carbon generation will be required to meet generation needs for a clean energy economy, e.g., solar photovoltaic generation coupled with energy storage, fossil-based

[53] New York Independent System Operator (NYISO). *2008 Load and Capacity Data (the Gold Book)*. 2008. http://www.nyiso.com/public/webdocs/services/planning/planning_data_reference_documents/2008_goldbook.pdf

[54] Companies like General Electric already have made significant advances in wind turbine and other renewable energy technologies. With more than 10,000 wind turbine installations comprising more than 15,000 MW of capacity worldwide, and with wind manufacturing and assembly facilities in Germany, Spain, China, Canada and the United States, GE is one of the world's leading wind turbine suppliers, helping to make possible the expansion of renewable energy throughout the world.

[55] Optimal Energy Inc. (prepared for NYSERDA). *Energy Efficiency and Renewable Energy Resource Development Potential in New York State.* 2003. http://www.nyserda.org/sep/EE&ERpotentialVolume1.pdf

generation utilizing carbon capture and sequestration (CCS) technology, renewable imports from neighboring sources, nuclear power, or a combination of these technologies.

In the existing bulk power supply system, fossil, nuclear and hydro electricity generation resources provide baseload power around the clock. Lacking a significant energy storage infrastructure, supplying baseload power from renewable energy sources that are variable by nature, i.e., they operate when the wind is blowing or the sun is shining, requires coupling such sources with energy storage or pairing them with other sources that have complementary operating characteristics.

By contrast, peaking power supplies must be able to commence operation quickly when electricity demand reaches its maximum to accommodate high air conditioning demand on hot summer days. Nuclear power is not well-suited for peaking power because the units need a long time to cycle on and off. Extensive use of renewable technologies to supply peaking power will require high-capacity energy storage. Solar power may be part of a strategy for meeting peak demand, since the power generated by photoelectric sources often is greatest during the times of peak demand. Likewise, electricity production from hydroelectric power plants with reservoir storage capacity can be responsive to an increase in demand by increasing flow through the hydraulic turbines. In addition, voluntary curtailment programs to reduce electricity use can reduce peak power needs.

Ultimately, development and deployment of energy storage technology are critical to the expansion of renewable power sources for supplying baseload or peaking power, and may enable the use of variable renewable generation resources to satisfy peak power demand. Plug-in electric vehicles could serve as an early means of energy storage. Current State efforts to develop methods for storing electricity, such as the establishment of the New York Battery and Energy Storage Technology (NY BEST) Consortium recently announced by Governor Paterson, will expand New York's role in energy storage technology research, development and manufacturing, and position the State to benefit economically as energy storage capacity is expended.

4.2.3 Electricity Transmission and Distribution

Currently, central electric generating stations deliver power over high voltage transmission lines to be distributed in local load areas throughout the State. A shift in building and transportation energy demand to electricity would necessitate not only a significant increase in generation, but also added capacity in the transmission and distribution grid.

New high voltage transmission technologies could provide greater transmission in limited space and existing rights of way while minimizing line loss. Deployment of such high voltage capacity**,** along with or in place of the existing energy infrastructure, would facilitate additional use of renewable energy within the State, and could enhance opportunities for importing renewable or other low-carbon energy from systems outside of New York. Resources for renewable energy generation are not always found near existing transmission capacity; new construction or the expansion of existing transmission would enable achievement of the full potential of onshore and offshore wind resources. Upgrading lower voltage distribution systems would improve system efficiency and make it possible to readily interconnect distributed generation.[56]

As an example, the Long Island Power Authority (LIPA) is pioneering, in its Holbrook transmission right of way, the world's first High Temperature Superconductor (HTS) power transmission cable system that

[56] Distributed generation is electricity from numerous small local generators.

is operating in a commercial power grid. The HTS cables can carry more than 150 times the power of a conventional copper wire of similar size and can be installed in existing rights of way, thus helping to reduce the cost and environmental impact of grid upgrades. With much lower impedance and resistance than conventional technology, superconducting cables can draw flow away from overtaxed conventional cables or overhead lines, thereby relieving network congestion and providing a more environmentally friendly power solution than copper-based systems.[57]

A significant build-out of a "Smart Grid," which networks generation, transmission, distribution and consumption through lines of communication, would promote load management and grid reliability. Such a system would provide information and control for generators, transmission owners and end-users alike. At the most basic level, a Smart Grid would allow end-users to monitor electricity consumption, and even to compare their consumption with other like customers.[58] Further, a Smart Grid could allow more consumers to become energy storage facilities and generators, helping to minimize the disparity between base load and peak demand on the grid.

Pilot Smart Grids are being proposed by National Grid and LIPA in New York, and significant development of a "Smart City" system already is underway in Boulder, Colorado.[59] LIPA, along with Stony Brook University and Farmingdale State College, has proposed the creation of Long Island's first integrated Smart Energy Corridor, which will help LIPA customers monitor and reduce energy usage, increase reliability, encourage energy efficiency by facilitating smarter technologies, and create clean energy jobs. In addition, LIPA has teamed with Farmingdale State College to create Long Island's first Smart Energy Campus, demonstrating customer-owned renewable resources, such as wind and solar.[60]

4.2.4 Residential, Commercial, and Industrial Buildings Sector

Reaching mid-century GHG reduction goals would require that energy consumption in buildings be greatly reduced though design and efficiency measures and that remaining energy demand be met by near-zero- carbon energy sources. New residential, commercial and industrial building systems would need to reduce, and eventually eliminate, traditional on-site fossil fuel combustion for space heating, water heating, cooking, and other uses.

Conservation could be accomplished through building shell improvements, such as high-R insulation, doors and windows, through operating system efficiencies, which might come from energy-efficient lighting systems, appliances and air handling systems, and through building systems that reduce the need

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[57] Long Island Power Authority (LIPA). *LIPA and American Superconductor Bring the Largest Superconducting Transmission Cable to Long Island. 2006.* http://www.lipower.org/newscenter/pr/2006/080206_cable.html

[58] Displaying comparative information on utility bills already has proven to result in lower energy consumption: in April 2008, a Sacramento utility began sending out statements to 35,000 randomly selected customers, rating them on their energy use compared with that of neighbors in 100 homes of similar size that used the same heating fuel. The customers also were compared with the 20 neighbors who were especially efficient in saving energy. Customers who scored high earned two smiley faces on their statements. "Good" conservation got a single smiley face. Customers whose energy use put him in the "below average" category, got frowns. When the Sacramento utility conducted its first assessment of the program after six months, it found that customers who received the personalized report reduced energy use by 2 percent more than those who got standard statements. ["Utilities Turn Their Customers Green, With Envy," NY Times, January 31, 2009] According to Positive Energy USA, even the top 10,000 most efficient customers in the study group reduced their consumption by 1.6 percent.

[59] Under the Boulder project, 50,000 homes soon will be provided with the latest in energy-saving technology, including solar panels, electric cars and, for some, specialized heating, cooling, and lighting systems. All these devices will be integrated into a monitoring system that reports each home's carbon footprint to the homeowner.

[60] LIPA. *Governor Paterson and Congressman Israel Propose "Smart Energy Corridor" and First "Energy Smart Campus" For Long Island*. 2009. http://www.lipower.org/newscenter/pr/2009/051109-smart.html

for heating and/or cooling, such as ground-source heat pumps, passive solar collectors, roof gardens, and ventilation heat exchange technology. Generating electricity on-site through solar, wind or other renewable energy technologies would help minimize net energy input to buildings.

Programs incorporating many of these strategies are already underway. The U.S. Department of Energy (DOE) Building Technology Program embraces the goal of developing "net-zero" energy buildings, with a goal of developing technologies and design approaches that lead to marketable zero energy homes by 2020 and zero energy commercial buildings by 2025.[61] The 2030 Challenge, issued by Architecture 2030, is a global initiative promoting an immediate 50 percent reduction in fossil-fuel consumption by all new buildings and major renovations, and attainment of carbon neutrality in all new buildings by 2030.[62]

Numerous existing examples of low energy-consuming, and therefore low GHG-emitting buildings already exist in New York and the Northeast:

- DEC's headquarters building in Albany, opened in 2001, is a functioning example of technologies that minimize energy consumption and environmental impact. The building's design, construction and operation utilize building products that incorporate recycled content materials and include technologies to reduce energy use and conserve water, earning the building a LEED Silver rating from the U.S. Green Building Council.

- The Condé Nast Building, a modern skyscraper in Times Square in Midtown Manhattan, is one of the most important examples of green design in the U.S. It is the first project of its size to adopt state-of-the-art standards for energy conservation, indoor air quality, recycling systems, and the use of sustainable manufacturing processes. The building features environmentally efficient gas-fired absorption chillers and a state-of-the-art curtain wall with excellent shading and insulating performance to offset the need to heat or cool the building for the majority of the year.

- The Silhouette condominium building in Brooklyn, which will be complete by summer 2009, will be one of the city's first new residential buildings to be both ENERGY STAR® qualified and LEED certified. The building's advanced green features, including its state-of-the-art garden roof, solar panel array, and new urban "community connectivity," make it among the most eco-friendly residential buildings in America.

- Green communities in New York City include Diversity Houses on the lower east side of Manhattan and the David & Joyce Dinkins Gardens in Harlem. Both of these projects provide affordable housing for low-income families while offering green advantages such as environmentally friendly construction, energy efficiency, water conservation, and healthier building materials.

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[61] The DOE definition of a net-zero energy building is a residential or commercial building with greatly reduced needs for energy through efficiency gains, e.g., 60 to 70 percent less than conventional practice, with the balance of energy needs supplied by renewable technologies.

[62] The 2030 Challenge calls for 1) all new buildings and developments to be designed to use half the fossil fuel energy they would typically consume, i.e., half the regional or country average for that building type, 2) at a minimum, an equal amount of existing building area be renovated annually to use half the amount of fossil fuel energy they are currently consuming, and 3) the fossil fuel reduction standard for all new buildings be increased to 60 percent in 2010, 70 percent in 2015, 80 percent in 2020, 90 percent in 2025 and carbon neutral in 2030 (using no fossil fuel GHG-emitting energy). Architecture 2030 recommends the fossil fuel reduction targets be achieved through design, the application of renewable energy technologies and/or the purchase of renewable energy (20 percent maximum). Architecture 2030. *2030 Challenge*. 2009. http://www.architecture2030.org/2030_challenge/index.html

Building efficiency is a key goal of DEC's Climate Smart Communities program, which encourages local governments to increase their own operating efficiency and to use their powers to control local development and encourage building efficiency. As an example, Monroe County now requires adherence to LEED standards for new county buildings and major renovations greater than 5,000 gross-square-foot (gsf) and directs its Industrial Development Agency to extend tax abatements from 10 to 14 years and adopt any further green building incentives to encourage the private sector to implement LEED.

Eventually, New York could adopt a whole-building design approach for new construction or renovation/retrofit to significantly reduce the energy consumption and GHG emissions from buildings. Whole-building design considers energy use and generation, evaluating: 1) onsite renewable energy technology; 2) structural orientation and integration of passive solar energy; 3) benchmarks to reduce the carbon intensity of fuels used on-site in buildings; and 4) use of optimal energy-efficiency ratings and energy performance standards for all building elements.

4.2.5 Transportation Sector

The high-carbon-intensity liquid fuels and infrastructure that dominate the transportation sector are not easily replaced with low-carbon alternatives. Reductions in vehicle miles traveled, use of low-carbon fuels and lower-emitting vehicles are all essential elements of a future lower carbon transportation sector. As discussed further in the Transportation Issue Brief, layers of concurrent strategies would be needed to transform our present high-carbon intensity transportation sector to a low-carbon model.

The transportation sector currently relies on a high-carbon-intensity energy carrier, petroleum-based liquid fuel. Low-carbon-intensity energy carriers that are feasible for transportation include electricity, hydrogen, and possibly advanced biofuels such as cellulosic ethanol. Many transportation experts consider electricity to be the most viable low-carbon fuel for light duty vehicles in the near-term. Electricity also can be used to power light rail. Expanding electrification of the transportation sector would help achieve GHG reduction goals by making it possible to transition demand from high carbon-intensity fossil fuels to low-carbon-intensity sources such as hydro, wind, solar photovoltaic, or nuclear power. New York should continue advancing this transition by promoting research and development for hybrid electric battery and energy storage technologies, along with demonstrations to support vehicle fueling infrastructure development.

Many policymakers are hopeful about the potential of plug-in electric hybrid vehicles (PHEVs) or vehicles that run only on electricity (EVs) to reduce emissions from the transportation sector. Practical barriers often raised to adoption of electric vehicles include a current range of travel well below the 350-400 miles of most liquid fuel passenger cars. PHEVs could help bridge the technology gap, allowing travelers to use electricity for local travel and liquid fuels for long-distance travel. Private enterprises are currently exploring battery-exchange stations where EV drivers could swap out expended battery cells for fully charged cells, in the same way as we exchange propane barbeque tanks at a gas station or hardware store. Better Place, a company based on this battery-exchange business model, is currently building prototype battery-changing stations in Israel, Denmark and Japan.[63]

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[63] Expected growth in the electric vehicle market is fostering innovation. For example, Better Place is a pioneering company that has developed a business model to create a market-based, electric vehicle infrastructure that sells batteries as consumable products in miles driven and builds networks of battery charging/exchange stations. Better Place has teamed with governments in several countries to test its switching stations, and has also signed agreements in Hawaii and with a nine-city alliance of communities in the San Francisco Bay Area. The first 50 stations will be built in Israel by the end of 2010.

President Obama has announced a goal of putting one million plug-in hybrid vehicles on the road by 2015, and has released two competitive solicitations for up to $2 billion in federal funding for cost-shared agreements for manufacturing of advanced batteries and related drive components for electric vehicles, as well as up to $400 million for transportation electrification demonstration and deployment projects.

4.3 Developing a Climate Action Plan

A strategic planning process is needed to identify the optimal mix of GHG reduction strategies necessary to meet an aggressive mid-century ‘80 by 50’ GHG emission reduction goal supported by scientists and many governments. A New York State Climate Action Plan will identify strategies that New York could pursue to reach these emission reduction targets. Design of the Climate Action Plan should consider routine reevaluation and adjustment to take into account new scientific information on the needed rate of GHG emission reduction, changes to expected rates of implementation of key GHG reduction strategies, technological development and other emerging issues.

While emissions from the combustion of fossil fuels dominate New York's GHG emission profile, reductions from non-combustion operations outside the State Energy Plan’s scope will help meet mid-century GHG reduction goals. Therefore, the Climate Action Plan will consider all of the State’s GHG emissions, including emission sectors not covered in the State Energy Plan. This analysis will encompass industrial GHGs with high global warming potentials, e.g., sulfur hexafluoride, methane emissions from landfills and agricultural practices, and CO_2 emissions from industrial operations, such as cement production. Efficiency measures may be able to reduce some portion of GHG emissions from certain processes, but industries that use chemical, biological and physical processes may find it difficult to control emissions inherent to those processes; some processes may need to be re-engineered to obtain necessary GHG emission reductions.

Managing the State’s landscape, including agricultural soils and forest resources, to maximize carbon storage is another important climate protection strategy not directly related to energy generation or use. The Climate Action Plan also will take into account not only direct GHG emissions, but also indirect emissions, such as from land use changes, associated with the full lifecycle of each energy-related facility.[64] Even for low-carbon energy sources, lifecycle emissions may contribute significant GHGs until transportation and industrial process GHG emissions decrease.

Given the complexity of designing a New York State GHG reduction pathway through 2050 and the uncertainties regarding long-term social, technical and economic conditions and trends, an initial planning horizon of approximately fifteen years, through 2025, should be considered. This time horizon is realistic because large reductions in GHG emissions are achievable by 2025 with today’s technologies and practices and because it is reasonable to expect that within 15 years, new technologies and longer-term strategies can be initiated that will facilitate achievement of the ‘80 by 50’ goal. A reduction target for 2025 that is based on a linear GHG reduction trajectory from forecasted year 2010 emissions through year 2050 (see Figure 8) yields a 2025 GHG reduction requirement of approximately 30 percent below 1990 levels. This 30 percent reduction by 2025 could serve as a presumptive medium-term GHG reduction target, to be evaluated further during development of a Climate Action Plan. If during the strategic planning process interpolation from a linear GHG reduction pathway is determined to be inappropriate for target-setting, the timing and percentage reduction for the medium-term goal can be modified accordingly.

[64] Lifecycle GHG emissions for energy facilities are associated with: fuel procurement, processing and disposal; facility construction, maintenance and decommissioning; equipment manufacture and disposal; land use changes.

The pathway to meeting the '80 by 50' goal likely would include technologies that are not yet fully developed (such as large capacity renewable energy storage, plug-in hybrid vehicles and low-carbon-intensity liquid fuels), and would be influenced by future market drivers that are difficult to predict at this time. Over the coming decades, it is likely that emerging or even entirely new technologies will ease the transition to a sustainable energy system. Nevertheless, the scale and magnitude of change necessary, and the considerable length of time before reduction strategies will yield significant results, make it critical to begin dialogue soon on key long-term decisions, e.g., whether electricity, or possibly hydrogen, could be the preferred low-carbon energy carrier for the transportation and building sectors, and how to employ building orientation and design in reducing GHG emissions.

4.3.1 Establishing a Planning Process

Development and implementation of the Climate Action Plan will require coordination among numerous State government agencies, including those with responsibility for energy generation, transmission and use in New York's power, transportation and building sectors. As currently envisioned, DEC and NYSERDA would lead the interagency team that develops the Climate Action Plan. Proceeds from the RGGI auction, or other available funding sources, could help support plan development and implementation. Analysis of key technical, economic, social, regulatory and legal challenges to meeting GHG reduction goals will require the leadership of government along with the participation and support of many stakeholders, including businesses, academia, private organizations, and the citizens of New York.

4.3.2 Data and Analysis Needs for an Effective Plan

The Climate Action Plan will evaluate GHG emission sources and reduction strategies for nearly every sector of New York's economy. An important first step will be assessing the adequacy of available baseline data on GHG emissions. GHG inventories are the foundation of any emission reduction program, providing both baselines for selecting regulatory actions, incentives and market-based programs, and benchmarks for evaluating effectiveness.

GHG Emissions Inventory Data

As detailed earlier, NYSERDA has developed estimates of current and future GHG emissions from New York. In the coming year, NYSERDA plans additional efforts to improve the accuracy of these emission estimates. More refined data from voluntary and mandatory GHG reporting programs will improve the accuracy of emission estimates.

On March 10, 2009, EPA proposed a rule requiring major sources in the U.S. to report emissions of CO_2 and other GHGs; this proposal would cover approximately 13,000 facilities that account for approximately 85 to 90 percent of GHGs emitted in the U.S. The new reporting requirements would apply to suppliers of fossil fuel and industrial chemicals, manufacturers of motor vehicles and engines, as well as large direct GHG emitters with emissions equal to or greater than 25,000 metric tons per year, including energy-intensive sectors such as cement production, iron and steel production, and electricity generation. The first annual report for the calendar year 2010 would be submitted to EPA in 2011, with the exception of vehicle and engine manufacturers, which would begin reporting for model year 2011.

Access to accurate New York-specific baseline GHG emission data will help drive strategy development. For example, the construction, demolition, renovation, maintenance and operation of buildings account for significant energy usage. Accurate baseline data related to energy use in buildings, including types of fuel used, physical characteristics of building structure, appliances being used for such functions as space heating and cooling, the building's energy performance and other pertinent energy use information, would help benchmark the energy performance of the New York building sector and identify strategies to approach carbon neutrality by mid-century.

Data on Energy System Transition

Development of GHG reduction strategies will consider electricity system reliability during and after the transition to a sustainable, low-carbon-intensity energy system. A primary consideration is maintaining the ability to meet electricity needs during periods of peak demand. Ultimately, a sustainable energy system will rely increasingly on renewable energy sources, coupled with conservation strategies to reduce peak energy demand, transmission and distribution upgrades to ensure that electricity can move from where it is created to where it is needed, and development and deployment of energy storage technologies. Given sufficient time, these strategies can be implemented in such a way as to enable New York to meet reliability needs with a sustainable low-carbon energy system. Development of these strategies and timeframes for implementation will require close coordination among State agencies and authorities and key stakeholders, such as the NYISO and the New York Reliability Council.

Analysis of Economic Benefit/Cost

Development of the Climate Action Plan will include economic analyses to help optimize selection of near-term GHG reduction strategies. New York, through a NYSERDA contract with the Center for Climate Strategies, is currently developing cost curves for individual and bundled GHG abatement strategies. Results from this analysis will help estimate the relative costs of reduction scenarios and pathways. Additional information identifying potential markets and penetration rates for available technologies will be valuable for shaping strategic reduction pathways.

A similar study developing GHG abatement cost curves for the U.S. is found in a 2007 report from McKinsey & Company.[65] As shown in Figure 9, the abatement "cost curve" includes the range of emission reduction actions possible with likely available technologies in the 2030 time horizon and that cost less than approximately $50 per ton of CO_2e. The width of each bar represents the amount of CO_2e that can be reduced annually, while the height of each bar represents the average cost of avoiding one ton of CO_2e. This study found that numerous GHG reduction options exist that have zero or negative marginal lifecycle costs. Implementing these options, which include changes in lighting, appliances and electronics and upgraded building heating and cooling systems, could result in a cost savings (bars below the horizontal zero axis) over the life of the product.[66,67]

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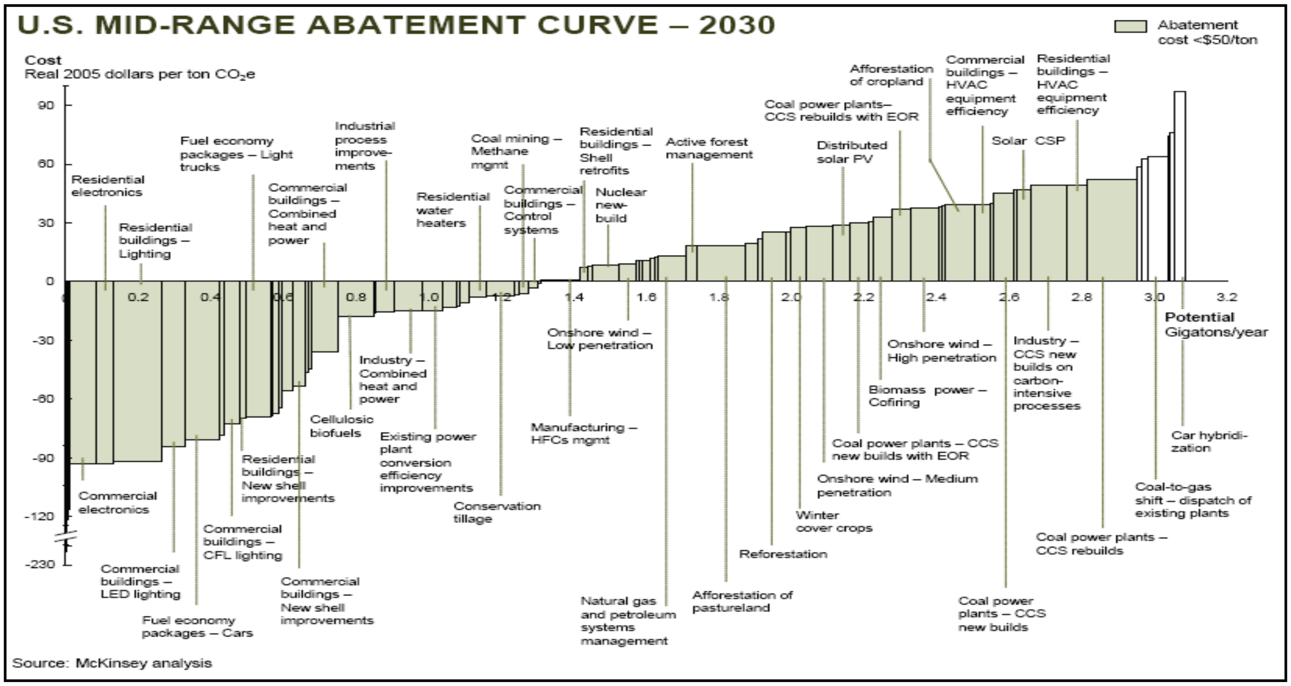
[65] McKinsey & Company. *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* U.S. Greenhouse Gas Abatement Mapping Initiative. Executive Report. 2007. http://www.mckinsey.com/clientservice/ccsi/greenhousegas.asp

[66] The McKinsey study (2007) focuses on technology costs and does not include program costs and social and market barriers.

[67] While these options clearly are the most economically advantageous to pursue, implementation of positive cost projects may be necessary to achieve GHG reduction goals. Positive cost projects often create other economic benefits by encouraging technological innovation and subsequent business and employment opportunities.

Figure 9. Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?



Source: McKinsey & Company. 2007.

The 2009 global GHG abatement cost curve McKinsey report, *Pathway to a Low-Carbon Economy*, finds that by 2030 there is potential to reduce global GHG emissions by 35 percent compared with 1990 levels.[68] This reduction trajectory is generally consistent with the long-term '80 by 50' GHG reduction goal. The emission levels resulting from implementation of the McKinsey mitigation strategies would be broadly consistent with a pathway in which atmospheric concentrations of GHGs peak at 480 parts per million (ppm) and then begin decreasing. McKinsey concludes that, while highly challenging, this pathway would result in a likely average increase of the global mean temperature of just below the 3.6°F (2°C) stabilization threshold, although a 10-year delay in abatement actions would make it virtually impossible to stay below 3.6°F (2°C). If the most economically rational opportunities, in a low-cost to higher-cost sequence, in the McKinsey study are pursued to their fullest potential, the total worldwide cost for achieving potential stabilization is estimated to be less than one percent of the forecasted 2030 global GDP.

To support decision making, New York's Climate Action Plan will include studies of the cost and benefits of climate change mitigation measures. In addition to optimizing macro-economic benefits, the Climate Action Plan will consider available studies on other societal benefits, including reductions of other air pollutants, diversification of energy sources, and other benefits to the economy, environment and

[68] McKinsey & Company. *Pathway to a Low-Carbon Economy*. 2009.
http://www.mckinsey.com/clientservice/ccsi/pathways_low_carbon_economy.asp

public health.[69] Indirect benefit studies may inform decision makers on how future climate change may affect New York's economy,[70] and how the State's economy can most efficiently evolve in conjunction with other state, regional and national GHG reduction programs. Costs to initiate the low-carbon-intensity economy would be considered in relation to the costs of the severe impacts that the State may experience if New York does not respond to climate change or if it responds too late, i.e., the ultimate total economic cost for controlling GHGs would be higher. Opportunities for a clean energy economy that will promote green jobs and new businesses in New York are further discussed in the Energy Costs and Economic Development Issue Brief.

State-specific economic analyses of short-term emission reduction strategies conducted by California, Florida and North Carolina project net benefits with increases in production activity, job creation, gross state product, personal income, and per capita income associated with the implementation of climate change strategies.[71,72,73] The California study suggests that California has seen a dramatic increase in clean technology investments since the California Global Warming Solutions Act of 2006 (AB32) was enacted. In the second quarter of 2008 alone, California received $800 million of the global total of $2 billion venture capital invested in clean technology. Energy efficiency programs also provide an economic co-benefit as lower spending on electricity allows consumers to increase spending on goods and services in other sectors. Gains in energy efficiency will help deliver annual savings of between $400 and $500 on average by 2020 for households. Overall energy savings projected from implementation of AB32 are estimated to exceed $20 billion annually by 2020.[74] Cost curve analysis is now underway which will provide New York with similar information as the other state-specific economic analyses.

On the other hand, analyses of the economic costs of climate change for the nation and several individual states conducted by the University of Maryland's Center for Integrative Environmental Research (CIER) concludes that unabated climate change could cost billions of dollars for several states. These costs already have begun to accrue in some states and are likely to endure. The 2007 CIER regional study, *U.S. Economic Impacts of Climate Change and the Costs of Inaction*, found: 1) economic impacts of climate change will occur throughout the country; 2) economic impacts will be unevenly distributed across regions and within the economy and society; 3) negative climate impacts will outweigh benefits for most sectors that provide essential goods and services to society; 4) climate change impacts will place immense strains on public sector budgets; and 5) secondary effects of climate impacts can include higher prices,

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[69] A study by the Northeast States for Coordinated Air Use Management (NESCAUM), in collaboration with DEC and NYSERDA, is evaluating economic and air quality outcomes of various future energy scenarios for New York. A comprehensive and detailed Multi-pollutant Policy Analysis Framework is using a northeast U.S. specific version of the Market Allocation economic model (MARKAL), a large-scale air quality model (CMAQ), the REMI regional economic model, and EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), a tool for estimating the health impacts and economic values associated with changes in ambient air pollution. Results from this project will help assess environmental, economic, and public health consequences of GHGs, ozone and $PM_{2.5}$ control strategies in New York and the region.

[70] Oregon, Washington and New Mexico all have conducted analyses on the economic consequences of climate change including impacts on food production, e.g., agriculture, aquaculture, recreation, forest fires, flood and storm damage, coastal damage and human health related costs. The analyses report estimates of annual costs per household by 2020 of $1,930 for Oregon residents; $1,252 for Washington State residents and $3,430 for New Mexico residents.

[71] California Air Resources Board (CARB). *Climate Change Draft Scoping Plan: Economic Analysis Supplement*. 2008. http://www.arb.ca.gov/cc/scopingplan/document/economic_analysis_supplement.pdf

[72] Ponder, D, Tiller, J and Hoyle, J. *Secondary Economic Impact Analysis of Greenhouse Gas Mitigation Options for North Carolina*. 2008.

[73] Governor's Action Team on Energy and Climate Change. *Florida's Energy and Climate Change Action Plan.* 2008. http://www.dep.state.fl.us/climatechange/actionplan_08.htm

[74] CARB. *Climate Change Proposed Scoping Plan*. 2008. http://www.arb.ca.gov/cc/scopingplan/document/psp.pdf

reduced income and job losses.[75] A 2008 report produced by the National Conference of State Legislatures in collaboration with CIER, *State Economic and Environmental Costs of Climate Change,* reached similar conclusions.[76]

4.4 Key Strategies to Begin Reducing GHG Emissions Now

Our current understanding of the rate and magnitude of GHG reductions required and the options available to New York make it possible to identify key actions needed in the short term to strengthen the State's GHG emission reduction programs and ensure that the State does not "close the door" on meeting an '80 by 50' goal. Adopting these initial policies will reduce investment in new, long-lived, carbon-intensive infrastructure, will expand current programs that address building and transportation sector GHG emissions, and will increase energy efficiency, expand renewable energy resources, and increase the capacity and functionality of the State's electric grid to support the future clean energy economy. New York has already begun implementation of many of these strategies.

4.4.1 Types of Regulatory and Policy Strategies

Regulatory measures, either command-and-control or market-based, encourage private sector development of technologies and practices that enable compliance with the regulatory program at a minimal cost. For example, California's "technology-forcing" emission standards for motor vehicles, a command-and-control regulatory program, led to catalytic converters and other emission control technologies that brought about substantial improvements in the emissions performance of motor vehicles and, in the longer run, fostered the development of hybrid vehicle technologies. These standards required emission reductions needed to protect public health, rather than continuing to accept higher emissions until reductions could be shown to be cheap or technically easy. The major automakers expressed concerns that compliance would severely damage their industry.[77] However, when emission controls were implemented, the predicted production stoppages, maintenance difficulties, unemployment and steep declines in sales and profitability did not occur. Instead, emission control technology has worked effectively, and has been increasingly adopted worldwide.

Well-designed cap-and-trade programs, such as RGGI, also provide price signals to promote the development, deployment and use of lower-emitting technologies. The programs function by establishing a total emissions limit, or "cap," for a particular pollutant and requiring regulated entities to possess enough allowances to account for their emissions. Each regulated entity must decide how to operate under the cap, weighing the value of an allowance against the cost of reducing emissions. Firms are able to trade allowances to meet their emissions obligations. Periodic reductions in the cap further encourage investment in emission reductions because tightening the cap makes it increasingly expensive to pollute.

Carbon taxes are an alternative to cap-and-trade programs, though there are some fundamental differences between the two approaches to carbon pricing. Cap-and-trade provides certainty on the quantity of emissions, while taxation increases certainty on the per-unit cost of emissions. For both, government sets

[75] Center for Integrative Environmental Research (CIER), University of Maryland. *The U.S. Economic Impacts of Climate Change and the Costs of Inaction*. 2007. http://www.cier.umd.edu/climateadaptation/

[76] National Conference of State Legislatures. *Economic and Environmental Costs of Climate Change: Overview*. 2008. http://www.ncsl.org/programs/environ/ClimatePubs.htm

[77] Northeast States for Coordinated Air Use Management (NESCAUM). *Environmental Regulation and Technology Innovation: Controlling Mercury Emissions from Coal-Fired Boilers*. 2000.

one of these variables and then lets the market respond. With a cap-and-trade program, government sets the emission limit, guaranteeing that total emissions will not exceed the cap. Though the emission limit is fixed, the per-unit cost of meeting that goal varies as the market continually corrects itself to determine the most cost-effective way of meeting the cap. With taxation, government sets the per-unit cost, clearly signaling to firms the cost of pollution. However, the total amount of pollution that will be created is undetermined, as sources will continually weigh the profits from generating pollution against the fixed cost of paying for it. The American Clean Energy and Security Act of 2009 currently before Congress would create a federal cap-and-trade program for GHG emissions.

Programs involving scientific research and market analysis, technology and business development, commercial feasibility and demonstration, and market expansion leading to adoption as standard practice can promote development and commercialization of products and processes that will reduce GHGs. Marketing and outreach, workforce development and education initiatives will build on the technical work, developing relationships and supplying information and incentives to build self-sustaining markets and achieve New York's energy efficiency and climate change goals.

NYSERDA public benefits programs funded from the System Benefits Charge (SBC) and RPS[78] have shown progress toward reducing energy consumption and meeting environmental goals. New GHG reduction initiatives funded by proceeds from the sale of RGGI CO_2 allowances[79] will soon complement these existing programs. For each economic sector responsible for GHG emissions, RGGI-funded programs will help to integrate climate change mitigation strategies with creation and promotion of clean energy technologies. These efforts may enable GHG reductions without a regulatory burden on sources, but are not likely to fully achieve climate protection goals.

4.4.2 Electric Power Generation

Strategies to reduce emissions from electricity-generating facilities over the planning horizon include strategies to encourage and enable the siting of new renewable energy facilities and performance standards that ensure that only the cleanest new fossil-fired plants are built.

Increasing the generation of electricity from renewable energy sources in New York, in conjunction with emerging energy storage technologies, is a key strategy for reaching GHG reduction goals. Governor Paterson's recently announced RPS expansion supports this goal, requiring 30 percent of New York's electricity needs in 2015 to be met by renewable energy. Additional discussion of the advantages of an aggressive renewable energy program can be found in the Renewable Energy Assessment.

Emissions from new fossil fuel-fired plants can be minimized by developing and applying performance standards for emissions from power plants. The existing fleet of fossil-fueled power plants and boilers will need replacement in coming years. To support GHG reduction goals, the long service life of these facilities requires that replacements in the existing fossil fleet be made with efficient, low-carbon-emitting units. GHG performance standards applicable to new plants will promote the design and construction of plants and boilers with the lowest possible carbon emissions while maintaining system reliability.

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[78] NYSERDA. *Toward a Sustainable Energy Future: A Three-Year Strategic Outlook 2008-2011*. 2008. http://www.nyserda.org/publications/Strategic%20Plan-complete-web.pdf

[79] During the next three years, auctions of RGGI CO_2 allowances are expected to generate approximately $600 million in revenues for New York. NYSERDA. *Operating Plan for Investments in New York under the CO_2 Budget Trading Program and the CO_2 Allowance Auction Program*. 2009. http://www.nyserda.org/RGGI/Files/Final%202009-2011%20RGGI%20Operating%20Plan.pdf

An analysis of emissions from New York's current fleet of coal-fired power plants makes it clear that construction of new coal or other similarly carbon-intense energy sources that do not capture and sequester most of the CO_2 will make it difficult to achieve an '80 by 50' GHG reduction. In 2006, coal-fired electric generation in New York emitted to the atmosphere approximately 21 million tons of CO_2 while producing approximately 21 million MWh of net electricity to the grid. An '80 by 50' reduction in GHG emissions from 1990 levels would limit total annual GHG emissions across all sectors to only about 57 million tons, as compared with today's emissions of 284 million tons. Coal or other carbon-intense energy sources such as petroleum-coke would not be consistent with an '80 by 50' scenario without near-total emission reduction technologies such as CCS.

Requiring that any new coal-fired or petroleum coke energy facilities be designed and constructed to eventually allow for at least 90 percent capture of the CO_2 emitted would make possible the GHG reductions necessary to put New York on a path to the '80 by 50' goal and avoid stranding investment capital in long-lived, high-carbon-intensity power generation. New York is actively supporting the development of CCS technology, including several NYSERDA projects to evaluate the state's geological potential for CO_2 storage and through ESDC's support of CCS development at the Jamestown advanced coal power plant. Additional information on the Jamestown project is available in the Coal Resource Assessment.

DEC has undertaken stakeholder outreach regarding draft performance standards for new, expanded or reconstructed fossil fuel-fired power plants, very large industrial/commercial boilers and gasification plants. These performance standards are designed to meet the goal of promoting the selection, design and construction of power plants that support the transition to a low-carbon-intensity energy system. This draft sets an achievable, first-tier target for GHG emission reductions that can be met by modern natural gas-fired units. Implementation of these standards would have the effect of prohibiting the construction of any new coal-fired plants in New York without CCS. As CCS technology matures, consideration can be given to strengthening these performance standards and making them applicable to existing plants.

4.4.3 Electricity Transmission and Distribution

A key component of a low-carbon-intensity energy system is an upgraded and expanded system for transmitting and distributing electricity. To have such a system in place by mid-century, planning and implementation need to occur during the 10-year planning horizon.

For any GHG reduction plan that uses low-carbon electricity as a key energy carrier, it is highly likely that New York's existing electricity infrastructure will be inadequate. The electric power grid needs regional balance in generation and consumption, along with increased capacity through staged upgrades and additions over decades. Beginning the design and construction of the electrical grid of the future now will allow for economical and efficient upgrades and additions with no interruption to electric flow.

The New York Transmission Owners have initiated a long-term transmission study, the *New York State Transmission Assessment and Reliability Study* (STARS). This study will develop a long-term pathway to: a) meet the growing electric power needs of New York State; b) encourage the addition of significant renewable energy sources in New York and the surrounding areas; and c) address an aging infrastructure.

4.4.4 Improving Electric Efficiency

Electricity consumption in New York is increasing, but efficiency improvements could offset near-term projected increases in electric demand, allowing time for renewable generation technologies and electric grid capacity to advance. From 1997 to 2007, New York's electricity sales increased 1.3 percent annually on a weather-normalized basis. In its *2008 Load and Capacity Report*, the New York Independent System Operator (NYISO) predicted that electricity use will continue to increase approximately 1.2 percent per year through 2018. Gains in efficiency during the current planning horizon can counteract this projected business-as-usual increase in total energy demand, and reduce demand during critical peak load hours.

Based on current NYISO projections, achieving the EEPS goal of reducing New York's electricity usage by 15 percent from projected levels in year 2015 should improve efficiency enough to offset short-term demand increases. This reduction in demand from projected levels will make it possible to postpone construction of new fossil fuel-fired generation and allow time to develop the low-carbon-intensity electric generation necessary to meet long-term GHG reduction goals. Continuing to pursue efficiency measures also will reduce state GHG emissions and mitigate other environmental impacts related to combusting fossil fuels for energy. Additional discussion of the advantages of an aggressive energy efficiency program can be found in the Energy Efficiency Assessment.

4.4.5 Residential, Commercial and Industrial Buildings

It is possible now to develop strategies that will put New York on a pathway to a carbon neutral building sector by mid-century. Most new buildings constructed today, and many existing buildings, have expected lifetimes extending well past mid-century. Reducing building emissions to near zero would require reducing whole-building energy demand and increasing the use of low-carbon-intensity energy sources, including distributed generation from renewable sources. Innovative financing mechanisms and incentives will promote implementation of both strategies in new and existing buildings. Government regulatory and policy actions will be essential to achieving GHG emission reductions in the building sector.

To improve the performance of new buildings, New York is strengthening the Energy Conservation Construction Code of New York (ECCCNYS 2007), which establishes minimum requirements for energy-efficient buildings through prescriptive and performance-related standards, making possible the use of new materials and innovative techniques that conserve energy. Implementation of proposed changes to the ECCCNYS, discussed in detail in the Energy Efficiency Assessment, is an important interim step to making New York's building stock more energy efficient; yet, alone it is only part of the long-term pathway to a carbon-neutral building sector, which includes further assessment of energy code compliance and identification of areas where improvements are needed. The Department of State (DOS), in partnership with NYSERDA, plans to offer more training and a new software compliance tool, but training should also be required for builders, contractors, and building design professionals, and additional funding for code enforcement is needed.

As a condition of receiving New York State's share of the $3.1 billion funding under the American Recovery and Reinvestment Act of 2009 (ARRA), New York is required to take a number of actions with respect to the energy code, including: 1) adopting a residential building energy code that meets or exceeds the most recently published International Energy Conservation Code or achieves equivalent or greater energy savings; 2) adopting a commercial building energy code throughout the State that meets or exceeds ANSI/ASHRAE/IESNA Standard 90.1-2007 and achieves equivalent or greater energy savings; and 3) adopting a plan for the State achieving compliance with such building energy codes within eight years of the date of enactment of ARRA in at least 90 percent of new and renovated residential and commercial building space. These steps will help achieve the goal of reducing emissions from the building sector.

4.4.6 Transportation Sector Strategies

To achieve desired reductions of transportation-based emissions, policymakers are considering numerous technologies and policy strategies, including a reduction in vehicle miles traveled and adoption of a low-carbon fuel standard for transportation fuels. Efforts that are already underway to improve vehicle efficiency, develop low-carbon fuels, reduce vehicle miles traveled, and improve transportation system efficiency can be expanded and integrated to reduce GHG emissions and put New York on a pathway to a carbon neutral transportation sector by mid-century. As the transportation sector is projected to be New York's largest GHG emissions sector at least through 2025, such an integrated program is essential to reducing GHG emissions.

The State has promulgated 6 NYCRR Subpart 218-8: Greenhouse Gas Exhaust Emission Standards, revising New York's existing low emission vehicles (LEV) program to adopt California's greenhouse gas emissions regulations. President Obama has now endorsed these standards as a model for a federal program. By 2016, GHG emissions from new passenger vehicles will be 37 percent lower, and emissions from light trucks, 24 percent lower.

To reduce the carbon intensity of fuels, New York State is joining 10 other states in the Northeast and Mid-Atlantic Region in evaluating a policy framework to implement a low-carbon fuel standard (LCFS). A LCFS uses a market-based, technologically neutral policy to address the carbon content of fuels by requiring reductions in the average lifecycle GHG emissions per unit of useful energy. The LCFS rewards fuels with the lowest lifecycle GHG emissions and discourages the development of high-carbon fuels such as liquid coal. Such a standard is potentially applicable not only for transportation fuels, but also for fuels used for heating buildings and powering industrial processes. If the standard is set properly, and if fuel feedstocks are produced in a sustainable manner, an LCFS could be an integral part of an overall GHG reduction strategy.

Finally, to reduce GHG emissions attributable to the miles New Yorkers drive, New York State is developing a strategy to achieve a statewide goal of a 10 percent reduction in VMT from projected levels in 10 years. Detailed strategies and actions involving VMT reductions, transportation efficiency, and transportation infrastructure improvements are discussed in the Transportation Brief.

4.4.7 Environmental Review

To take advantage of the planning and assessment capabilities authorized by the State Environmental Quality Review Act (SEQRA), DEC has developed draft guidance for assessing energy use and greenhouse gas emissions in an environmental impact statement (EIS)[80] and provides instructions to DEC staff for reviewing EISs that include a discussion of energy use or GHG emissions. Other State and local agencies may choose to use this guide when serving as lead agency for a project subject to an EIS that includes a discussion of energy use or GHG emissions.

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[80] Office of Air, Energy, and Climate, New York State Department of Environmental Conservation. Guide for *Assessing Energy Use and Greenhouse Gas Emissions in an Environmental Impact Statement.* 2009. http://www.dec.ny.gov/docs/administration_pdf/eisghgpolicy.pdf.

4.5 Conclusion

By using a combination of pathways, technologies, and practices, New York could achieve unprecedented GHG reductions while transitioning to a sustainable economy. Careful selection and timing of strategies would make it possible to attain an '80 by 50' goal while promoting a robust and reliable energy system that is less vulnerable to world market conditions and fuel price volatility, developing a new workforce and helping to establish a new manufacturing base, and maintaining or increasing the level of services and goods to support New Yorkers' quality of life. Given the likelihood of a federal carbon program, actions taken today by New York could help position the State's businesses and citizens not only to avoid an undue financial burden, but also to profit from and adapt to a carbon-constrained national economy.

5 Appendix A

5.1 Projections of Future Global Climate Change

Climate scientists use very complex, computer-based, global climate models to project how the climate will respond in the future to natural and anthropogenic forcings, such as increased GHG concentrations. The models use many different scenarios of future GHG emissions based on estimates of economic and social growth. Model output provides ranges of future temperatures increases, rather than point estimates, primarily due to uncertainty in which future scenario will occur and limitations in knowledge of how the climate system will respond. Despite the uncertainties, all global climate models project that the Earth will warm in the next century, with a consistent geographical pattern.

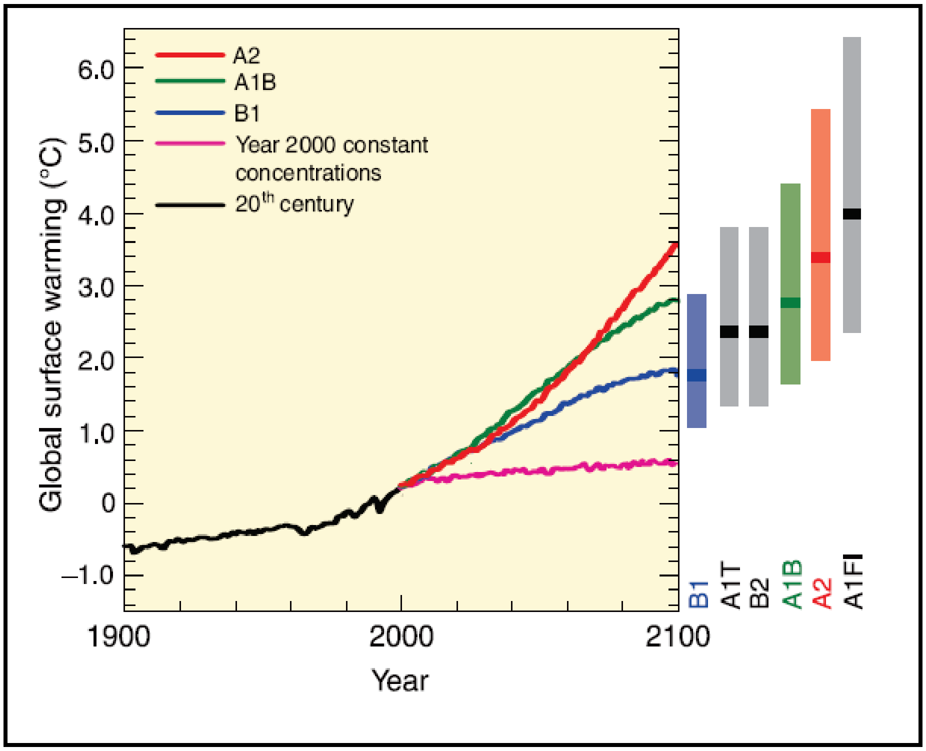
Climate model experiments show that even if no additional GHGs were added to the atmosphere, further warming still would occur due mainly to a lag in ocean temperature response. Many of the GHGs currently being added to the Earth's atmosphere have long residence times. For example, 33 percent of the anthropogenic CO_2 added to the atmosphere today will remain in the air for at least 100 years and 19 percent will remain at 1,000 years.[81] This means that GHGs added now to the atmosphere will continue to warm the planet for hundreds, and possibly, even thousands of years.

The IPCC 2007 Report projects continued GHG emissions at or above current rates will cause further warming and induce global climate system changes that will very likely be larger than those observed during the 20th century. In Figure A-1, the red, green, and blue lines represent global averages of surface warming for IPCC GHG emission scenarios (A2, A1B, and B1, respectively), whereas the pink line is a simulation where atmospheric GHG concentrations are held constant at year 2000 values. On the right side of the figure, the bars inside the vertical lines indicate the best estimate while the solid lines themselves indicate the likely range assessed for six GHG scenarios at 2090-2099 relative to 1980-1999. As shown in Figure A-1, the 2007 IPCC projections of global average surface warming for the end of the 21st century range from approximately 2.0 to 5.2 °F (1.1 to 2.9 °C) for B1, an aggressive reduction scenario, to 4.3 to 11.5 °F (2.4 to 6.4 °C) for the A1F1, a fossil intensive business-as-usual (BAU) scenario.[82]

[81] Hansen, J. et. al., (46 co-authors). *Dangerous Human-Made Interference with Climate: A GISS Model Study: Figure 9(a) Carbon Cycle Constraints (a) Decay of Pulse CO_2 Emissions*. Atmospheric Chemistry and Physics, 7, 1-26, 2007b. www.atmos-chem-phys.org

[82] IPCC. *Climate Change 2007: Synthesis Report; Summary for Policymakers*. 2007.

Figure A-1. Global Projections of Surface Warming IPCC GHG Emissions Scenarios



Source: IPCC 2007

The A1 GHG emissions scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The three A1 scenarios are distinguished by their technological emphasis: business-as-usual or fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B). The B1 GHG emissions scenario family, an aggressive reduction scenario, describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 scenario family, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.[83]

The IPCC also concludes that there now is higher confidence in projected patterns of regional-scale climate features, including changes in wind patterns, precipitation and some aspects of extremes and sea ice. Such projected regional scale changes include poleward shift of extra-tropical storm tracks, e.g., Nor'easters, and precipitation increases in high latitudes and precipitation decreases in most subtropical land regions. Sea ice is projected to shrink in both the Arctic and Antarctic under all scenarios. In some projections, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century.

Other IPCC projections include sea level rise at the end of the 21st century of 7.1 to 15.0 inches (in.), or 0.18 to 0.38 meters (m), for an aggressive reduction scenario and 10.2 to 23.2 in., or 0.26 to 0.59 m. with a BAU scenario. Observational evidence and recent scientific assessment of ice dynamics of the

[83] IPCC. *Climate Change 2007: Synthesis Report*. 2007.

Greenland ice sheet suggest the IPCC projections may be too low.[84,85] Contraction of the ice sheets and thermal expansion of the oceans is projected to continue to contribute to sea level for at least several centuries after 2100.

In a review of current emission trends and recent scientific studies, IPCC lead author Christopher Field concludes, "Without decisive action by governments, corporations and individuals, global warming in the 21st century is likely to accelerate at a much faster pace and cause more environmental damage than predicted." The next IPCC assessment in 2014 is expected to incorporate higher emissions and the results of new studies that consider dangerous feedbacks in the climate system such as tundra-thawing or tropical forest fires and therefore, will predict even more severe changes than previous assessments.[86]

5.2 Global and National Impacts of Climate Change

The effects of the relatively minimal, atmospheric warming observed-to-date are already evident, affecting many physical and biological processes on every continent including: 1) shrinking glaciers; 2) thawing permafrost; 3) earlier break-up of river and lake ice; 4) lengthening of mid- to high-latitude growing seasons; 5) poleward and altitudinal shifts of plant and animal ranges; 6) declines of some animal and plant populations; and 7) earlier tree flowering, insect emergence, and egg-laying in birds.[87]

The World Health Organization has estimated that in 2000 the "attributable mortality" of climate change was more than 150,000 deaths (0.3 percent of global deaths per year), and the projection for 2020 is approximately double the number of deaths.[88] The impacts have been disproportionately felt among the poor in Africa, South Asia, and Southeast Asia.[89]

Not all future climate change will necessarily have negative consequences. More productive crop yields and generally better conditions for vegetation in higher latitudes may be beneficial. A changing climate may have positive impacts on the productivity of some forest systems, but increasing disturbances such as wildfires and insect outbreaks will have a substantial impact. Warmer winters may reduce winter cold stress and decrease cold-related mortality in the northern hemisphere. However, the overall benefits of fewer deaths from cold exposure are expected to be outweighed by health effects from increasing temperatures, especially in developing countries.[90]

As the Earth's temperature increase approaches 3.6 °F (2°C), however, the negative consequences will predominate. With higher global average annual temperatures, major climate impacts are projected: excessive coastal flooding from sea level rise, significant species extinction and loss of biodiversity,

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[84] Pfeffer, W. T., Harper, J. T., and O'Neel, S. *Kinematic Constraints on Glacier Contributions to 21st-Century Sea-Level Rise*. Science. 321, 1340 -1343. 2008. http://www.sciencemag.org/cgi/content/abstract/321/5894/1340

[85] Rahmstorf, S. *A Semi-Empirical Approach to Projecting Future Sea Level Rise*. Science. 315, 368 - 370. 2007.

[86] Environmental News Service. *Climate Could Cross Critical Threshold by 2100, Expert Warns*. 2009. http://www.ens-newswire.com/ens/feb2009/2009-02-16-01.asp

[87] IPCC. *Climate Change 2007: Synthesis Report; Summary for Policymakers*. 2007.

[88] Campbell-Lendrum, D.H., Kovats, R.S., McMichael, A.J., Corvalan, C., Menne, B., and Pruss-Usstun, A. *The Global Burden of Disease Due to Climate Change: Quantifying the Benefits of Stabilization for Human Health.* http://www.stabilisation2005.com/day2/kovats.pdf

[89] World Health Organization (WHO). *The World Health Report: 2002*. 2002.

[90] IPCC. *Climate Change 2007: Impacts, Adaptation, and Vulnerability*. 2007. http://www.ipcc-wg2.org/index.html

major ecosystem changes, altered patterns of agriculture, increased risk of food and water shortage with increased burden of malnutrition and water- and food-borne disease, and more frequent and intense extreme weather events with serious consequences for human health.[91] The projected changes in water availability due to temperature increases will affect more than one-sixth of the world's population relying upon glaciers and seasonal snow packs for their water supply.[92]

The anticipated impacts of climate change have been reviewed and articulated by the U.S. Climate Change Science Program (CCSP). For the U.S., Northeastern cities are likely to experience the largest increases in average temperatures, bear the brunt of increased air pollution, and be disproportionately affected by heat related illnesses since they are less well adapted to the heat than Southern cities. Many of the expected health effects are likely to burden the poor, the elderly, and the disabled. Warming is very likely to increase energy demand in cities for cooling while reducing demands for heating. Heat waves could jeopardize electrical service reliability in some regions by exceeding supply capacity during peak cooling demand periods.[93]

Changes in precipitation patterns will alter water supplies nationwide. Examples of vulnerable U.S. regions include: the heavily-used water systems of the West that rely on capturing snowmelt runoff, such as the Columbia and Colorado River systems; portions of California; the New York area, as a consequence of greater water supply variability; and many islands such as the U.S. territories of Puerto Rico and U.S. Virgin Islands. In the Pacific Northwest, electricity generated from hydropower will be reduced as water flows from snowmelt decrease. Increased temperatures might be attributed to severe drought trends (1999-2007) in the Southwest, and more recently, the Southeast has also experienced severe drought.[94]

[91] IPCC. *Climate Change 2007: Impacts, Adaptation, and Vulnerability*. 2007. http://www.ipcc-wg2.org/index.html

[92] Barnett, T.P., Adam, J.C., Lettenmaier, D.P. *Potential Impacts of a Warming Climate on Water Availability in Snow-Dominated Regions.* 2005. Nature. 438:303-309.

[93] The Committee on the Environment and Natural Resources National Science and Technology Council. *Scientific Assessment of the Effects of Global Change on the United States*. 2008. http://www.climatescience.gov/Library/scientific-assessment/Scientific-AssessmentFINAL.pdf

[94] The Committee on the Environment and Natural Resources National Science and Technology Council. *Scientific Assessment of the Effects of Global Change on the United States*. 2008. http://www.climatescience.gov/Library/scientific-assessment/Scientific-AssessmentFINAL.pdf

6 Appendix B

6.1 Regional Climate Change Impact Projections for Two Different GHG Emissions Scenarios

Appendix B includes regional climate change impact projections with special relevance to New York from the recent Northeast Climate Impacts Assessment (NECIA) report entitled *Climate Change in the U.S. Northeast.* The report compared projected climate change impacts resulting from a higher GHG emissions scenario in which GHG emissions continue to grow rapidly with the impacts from a lower emissions scenario that assumes resource-efficient technologies and less reliance on fossil fuels. The NECIA study projects significant impacts in New York for both emission scenarios.[95]

[95] Frumhoff, P.S., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). 2007. http://www.climatechoices.org/ne/resources_ne/nereport.html

Table B-1. Union of Concerned Scientists

Union of Concerned Scientists Northeast Projections of Climate Change Impacts for Two Different GHG Emissions Scenarios (NECIA Study)		
High Emissions Scenario	**Lower Emissions Scenario**	**Both Scenarios**
▪ *Winters warm by 8° to 12°F (4.5 to 6.7°C) and summers by 6° to 14°F (3.4 to 7.8 °C) above historic levels by late-century.*	▪ *Winters warm by 5° to 8°F (2.8 to 4.5 °C) and summers by 3° to 7°F (1.7 to 3.9 °C) above historic levels by late-century.*	▪ *The number of days over 90°F (32 °C) is expected to triple in many cities.*
▪ *Cities that today experience few days above 100°F (38 °C) each summer could average 20 such days per summer.*	▪ *New York City is projected to face today's 100-year flood every two decades.*	▪ *Warmer winters will shorten the average ski and snowboard seasons, increase snowmaking, and drive up operating costs.*
▪ *Extreme coastal flooding that now occurs only once a century could strike New York City once every decade.*	▪ *Climate conditions suitable for maple/beech/birch forests would shift only in the southern part of the region.*	▪ *Most of the region is likely to have a marginal or non-existent snowmobile season by mid-century.*
▪ *Short-term droughts could occur as frequently as once each summer in the Catskills and Adirondacks*	▪ *Winter temperatures may prevent a deadly hemlock pest from infesting the northern part of the region.*	▪ *Long Island Sound lobster fisheries are likely to decline significantly by mid-century; cod are expected to disappear from these southern waters by century's end.*
▪ *Climate conditions suitable for maple/beech/ birch forests are projected to shift dramatically, also impacting fish, birds, and wildlife.*	▪ *Less extensive (although still substantial) changes in the region's bird life are expected.*	▪ *Hotter, longer, drier summers punctuated by heavy rainstorms may create favorable conditions for more frequent outbreaks of mosquito-borne disease such as West Nile virus.*
▪ *Parts of the Northeast are projected to become unsuitable for growing apples and blueberries.*	▪ *Much of the region is projected to remain suitable for traditional apple and berry crops.*	▪ *Spruce/fir forests are expected to lose significant area, diminishing their value for timber, recreation, and wildlife habitat.*
▪ *Milk production is projected to decline five to 20 percent in certain months.*	▪ *Reductions in milk production (up to 10 percent) would remain confined primarily to areas south of New York.*	▪ *Weed problems and pest-related damage are expected to escalate.*

Source: Frumhoff, P.S., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions: Synthesis Report of the Northeast Climate Impacts Assessment (NECIA)*. 2007.