

CLIMATE CHANGE IN NEW YORK STATE: DEVELOPING A RESEARCH STRATEGY

Background paper for discussion at the New York Academy of Sciences &
New York State Energy Research and Development Authority (NYSERDA)
Research Planning Workshop on April 10, 2007

May 2007
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New York Academy of Sciences and
New York State Energy Research and Development Authority

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SECTION 1. INTRODUCTION/PURPOSE OF THE BACKGROUND PAPER

There is now general agreement among the scientific community that anthropogenic activities – primarily the combustion of fossil fuel and deforestation – are changing the global climate. The February 2007 assessment by the Intergovernmental Panel on Climate Change (IPCC) provides the most definitive statement of the anthropogenic contribution to climate change. The potential adverse impacts of climate change are significant and far reaching, making climate change the most challenging energy-related environmental issue facing us today. Experts predict that extensive changes in our production and use of energy will be required to stabilize the climate. Solutions will require increased investments in the development of low-carbon energy technologies.

New York State has made a substantial investment in the development and deployment of energy efficient and renewable energy technologies. These technologies reduce fossil fuel energy use and associated greenhouse gas emissions. Recently through efforts such as the Regional Greenhouse Gas Initiative (RGGI) and other initiatives, New York State has begun to advance policies specifically limiting greenhouse gas emission. Many questions and research/information needs exist beyond these current technology and policy initiatives.

The purpose of this paper is to provide a context to develop a climate change research strategy for New York State – focusing on how the States’ natural resources, economy, and infrastructure may be affected – and addressing critical research and information gaps. Such research is not intended to supplant aggressive action at the national and international level; rather it would help inform policy decisions and resource management practices in New York State. Where possible, it would identify strategies that can provide multiple benefits to New York State. This paper is not intended to be a comprehensive critical review of the literature on climate change – it is meant to highlight major studies and initiatives, and assist in the climate change research planning effort.

This research planning effort is a joint initiative of the New York Academy of Sciences (NYAS) and the New York State Energy Research and Development Authority (NYSERDA). The impetus for the research-scoping workshop comes from the creation of a new climate change research focus area within NYSEDA’s Environmental Monitoring Evaluation and Protection (EMEP) Program. The EMEP program is administered by NYSEDA on behalf of the New York Public Service Commission and funded through a system benefits charge (SBC). EMEP supports objective and policy-relevant research to enhance understanding of energy-related pollution and its impact on the environment and human health in New York State. EMEP also supports research to characterize sources of energy-related pollution and define opportunities for minimizing the pollutant burden and improving the environment and human health in New York State.¹

In the climate change area, EMEP will sponsor and coordinate research to address the following policy-relevant questions:

- (1) What are the most significant ecological, public health, and economic issues in New York State relating to climate change and how can risks be managed and minimized?
- (2) What key variables need to be monitored to assess climate change impacts in New York?
- (3) What are the most cost-effective climate change mitigation/adaptation strategies for New York to pursue?

Within this context, NYSEDA and the New York Academy of Sciences are engaging technical and policy experts to help identify research priorities.

1 Further information about the EMEP program is available at: www.nyseda.org/programs/Environment/EMEP/

SECTION 2. POLICY CONTEXT

2.1 INTERNATIONAL POLICY FRAMEWORK ON CLIMATE CHANGE

United Nations Framework Convention on Climate Change

The World Meteorological Organization (WMO) and the United Nations Environmental Program (UNEP) first brought worldwide attention to the issue of Climate Change in 1988. Their Intergovernmental Panel on Climate Change (IPCC)² issued a 1990 assessment calling for immediate action to curb heat trapping emissions and deforestation [8]. Since then, governments have created the United Nations Framework Convention on Climate Change (UNFCCC) and negotiated several international agreements, such as the 1992 Earth Summit in Rio de Janeiro, and most notably the Kyoto Protocol in 1997, which came into effect in February 2005 [7].³ In February 2007, the IPCC released its Fourth Climate Change Assessment Report on the current state of climate change science; the full report is now available [10]. This 4th Assessment Report confirms – with great degree of certainty – that the Earth’s climate is changing, that the change is underway and that those changes are driven by human activity. A related scientific report issued by an international panel of 18 renowned scientists at the behest of the United Nations Commission on Sustainable Development complements the series of reports now being published by the IPCC. This UN Foundation and Sigma Xi⁴ publication, [*Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*](#), is more prescriptive than previous reports. For example, the authors assert that human induced greenhouse gas emissions must stabilize at approximately current levels no later than 2015 and then decline to no more than one third of current emissions by 2100.

The Kyoto Protocol establishes legally binding obligations that signatory nations carry out through various policy instruments, such as the Clean Development Mechanism (CDM), Joint Implementation (JI) and Emissions Trading [7]. The first two involve project-based activities that may be used to fulfill emission reduction targets. For example, through the CDM, developed nations may assist developing economies deploy renewable technologies and thus embark on cleaner developmental pathways. The third option is based on market trading of CO₂ equivalent units.⁵

European Commission:

In compliance with the Kyoto Protocol, fifteen European countries (EU15) agreed to reduce their collective greenhouse gas (GHG) emissions by 8% below 1990 levels during 2008-2012.⁶ In January 2005, the European Commission started the Greenhouse Gas Emissions Trading Scheme (EU ETS),

2 This international body assesses scientific research and technical and socioeconomic information relating to global climate change, but it does not carry out research or monitor climate related data. It bases all assessments on peer reviewed and published scientific and technical literature.

3 In 2005 the IPCC published a *Special Report on Carbon Dioxide Capture and Storage – Summary for Policymakers* [9].

4 Sigma Xi, the Scientific Research Society is a scientific honor society. The Report *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable* was issued on February 27th, 2007. Further information is available at <http://www.sigmaxi.org/about/news/UNSEGRReport.shtml>

5 Transactions are subject to verification. A registry issues certified emission reductions (CERs) or emission reduction units (ERUs).

6 Recently, UK business, government and the environmental community joined forces to call on their European counterparts to help secure the future of the carbon trading market, during phase 2 of the program. The UK Manifesto on the EU Emissions Trading Scheme (ETS), published on March 6th, 2007, was signed by more than 40 businesses and non-governmental organizations, and describes how the UK envisions the emissions trading scheme developing after 2012.

<http://www.defra.gov.uk/news/latest/2007/climate-0306.htm>

which allows multi-sector trading, covering over 11,500 energy-intensive installations across the EU; together, these installations represent close to half of Europe's emissions of CO₂ [7].⁷

Other climate change policy initiatives in place or being considered by the European Union include [33]:

➤ *Renewable Energy*: In March 2007, the EU set new binding energy targets, requiring the use of 20% energy from renewable sources by 2020. This will require a massive growth in all three renewable energy sectors: electricity, biofuels and heating and cooling (with a minimum target for biofuels of 10%). In addition, a 2007 renewables legislative package will include specific measures to facilitate the market penetration of both biofuels and heating and cooling [34].

➤ *Light-Duty Vehicles*: In early 2007 the EU proposed new strategies⁸ to curb GHG emissions from vehicles, including a revision of the EU fuel quality standards for reducing CO₂ emissions from new cars and vans sold in the European Union. By 2012, average CO₂ emissions from these type of vehicles will be reduced by 25% from current levels. These reductions will be achieved through improved fuel efficiency, thus delivering significant savings to consumers.

➤ *Aviation*: While the EU's total GHG emissions fell by 3% from 1990 to 2002, emissions from international aviation increased by almost 70%. In December 2006 the EC proposed legislation to incorporate the civil aviation sector into the EU Emissions Trading Scheme in two phases – covering all planes involved in domestic flights by 2011, and then all international flights starting or ending in EU airports, by 2012.

➤ *Carbon Capture and Geological Storage (CCS)*. The Commission is developing a legal framework to assess the environmental integrity of these techniques, their safe deployment and how they might be used, in accordance to the EU's climate change goals.

Stern Review on the Economics of Climate Change:

This report written by economist Nicholas Stern for the British Government, discusses the effect of climate change and global warming on the world economy. The report estimates that an investment of one percent of the global GDP is required to avoid the worst effects of climate change. Failure to realize this investment could result in up to twenty percent reductions in global GDP. [5]

2.2 NATIONAL CLIMATE POLICIES AND INITIATIVES IN THE U.S.

In order to address global change, the U.S. federal government has established a series of policies that seek to:

- a) slow the growth of emissions (which reduces the carbon intensity of the economy, but not necessarily the overall growth of emissions),⁹

⁷ The market has issued ~ 6,500 M tons of carbon allowances [33].

⁸ From 1995 to 2001, the European Automobile Manufacturers Association cut its average new car CO₂ emissions by 11.4%. During this same period the average mass, power, and engine capacity of new cars has increased 8.8 percent, 19.0 percent, and 4.9 percent, respectively. The Japan Automobile Manufacturers Association has shown similar success in Europe. Between 1995 and 2001 the average CO₂ emissions of new cars manufactured by JAMA have decreased by 8.7% and average mass, power, and engine capacity have increased 10.2 percent, 8.6 percent, and 2.9 percent, respectively.

⁹ Emissions and fossil fuel use in the U.S. have been growing. Between 1990 and 2003, U.S. energy-related emissions rose 16

- b) strengthen climate change science, technology and institutions (see Section V of this paper for a description of federal research programs), and
- c) enhance international cooperation. The first goal is being implemented through policies that emphasize voluntary initiatives and incentive-based programs [38].

One such program is The National Strategy to Reduce Emissions Intensity. In February 2002, the federal government announced its strategy to reduce the U.S. economy's greenhouse gas intensity by 18% over the 10-year period from 2002 to 2012.¹⁰ This commitment is equivalent to preventing the release of more than 100 million metric tons of carbon-equivalent emissions (per year) by 2012 and more than 500 million metric tons (cumulatively) between 2002 and 2012. To meet this goal, several programs focus on energy efficiency, renewable energy, methane and other non-carbon dioxide (non-CO₂) gases, as well as agricultural practices and implementation of technologies to achieve greenhouse gas reductions. Most of these programs are being promoted through non regulatory efforts, such as public-private partnerships. One example is the 2006 *National Action Plan for Energy Efficiency* [37], which proposes energy efficiency strategies and a set of commitments, through voluntary measures. The plan is the result of a consultation process that engaged leading gas and electric utilities, state agencies, energy service providers and consumers, and energy efficiency and environmental organizations. The partners have also identified barriers that prevent greater investment in energy efficiency and actions to address them.

Other relevant national programs include: [Clean Energy](#), [Climate Change and Waste Programs](#), [Climate Leaders](#), [High Global Warming Potential Gas Reduction Programs](#), [Integrated Environmental Strategies](#), [Methane Programs](#), [Transportation Voluntary Programs](#), [Voluntary Programs Database](#), and [ENERGY STAR](#).

Two nationwide voluntary initiatives by various partners, including the business sector, include:

The Chicago Climate Exchange (CCX)

This exchange, which is a self-regulated body, has offered a voluntary but legally binding mechanism for participating members to reduce their atmospheric contributions of all six greenhouse gases. During Phase I (2003-2006) participants were obligated to a 1% annual reduction (relative to their average contributions between 1998 and 2001), or an overall reduction of direct GHG emissions of 4% below the agreed baseline. The program is extended through the year 2010 during Phase II, when members must reduce GHG emissions 6% below the baseline [2].

The U.S. Climate Action Partnership (USCAP), a group of leading business and environmental organizations, has just released its recommendations calling on the federal government to develop a policy framework that would enact strong national legislation to require significant reductions of greenhouse gas emissions from major emitting sources (large stationary sources, transportation and the energy use in commercial and residential buildings) and a cap-and-trade program. This alliance includes Alcoa, BP America, Caterpillar, Duke Energy, DuPont, FPL Group, General Electric, Lehman Brothers, PG&E, and PNM Resources, as well as the Environmental Defense, Natural Resources Defense Council, Pew Center on Global Climate Change, and World Resources Institute. The group recommends that

percent (Source: Worldwatch Institute; Global Fossil Fuel Consumption Surges Newswise, Tue 10-May-2005, 09:00 ET <http://www.newswise.com/p/articles/view/511686/>)

¹⁰ A 2007 document, the *United States Climate Action Report*, emphasizes that the projections show progress toward a goal Mr. Bush laid out in 2002: that emissions of carbon dioxide and other greenhouse gases are growing at a slower rate than the economy. However, this report also states that U.S. overall GHG emissions will continue to grow in the next several years. As reported in the New York Times (NYT) on March 7, 2007, by Andy Revkin. The NYT obtained an advanced copy of this report, which is not yet available to the general public.

Congress provide leadership in establishing short- and mid-term emission reduction targets; as well as other measures leading to reductions of GHG and trace gas emissions [42].

This call coincides with several initiatives that have taken place in Congress in the last year. The 109th Congress introduced 103 bills, resolutions and amendments addressing climate change [27]. The current 110th Congress is in the process of reintroducing many of these, as well as new bills on the same topic. Various proposals are being consider reviewing the current automobiles and light truck Corporate Average Fuel Economy (CAFE) standards [40, 41].

2.3 CLIMATE CHANGE POLICIES AND GREENHOUSE GAS EMISSION REDUCTION INITIATIVES IN NEW YORK STATE

Major policies and programs in New York State to address climate change and reduce greenhouse gas emissions are highlighted below.

➤ **Energy Efficiency and Renewable Energy**

In 1998, New York State established a System Benefit Charge (SBC), levied on the sale of electricity produced by investor-owned utilities within the State, to support energy efficiency, renewable energy, energy technology research, and environmental research. As administrator of the SBC, NYSERDA launched the **New York Energy \$mart** programs to improve energy efficiency and advance renewable energy, including a variety of research and technology development initiatives. By the end of 2006, these programs had achieved an annual savings of 2,360 GWh of electricity from energy efficiency and on-site generation; 2,060 tons of NO_x; 3,800 tons of SO₂; and 1.6 million tons of CO₂ [21].

The New York Power Authority (NYPA) and the Long Island Power Authority (LIPA) also sponsor and manage energy efficiency and renewable energy programs. NYPA has committed \$100 million per year for energy efficiency projects through performance contracting [15]. LIPA is investing approximately \$34 million per year in energy efficiency, renewable technology and clean distributed generation [15].

New York established a **Renewable Portfolio Standard (RPS)**, with a goal of ensuring that at least 25% of electricity provided to customers in the state comes from renewable resources by the end of 2013 [18].

Executive Order No. 111, "*Green and Clean*" *State Buildings and Vehicles Guidelines* directs State agencies and authorities to be more energy efficient and environmentally aware. The Order mandates: a 35% energy reduction (BTUs/SF) by State Fiscal Year (SFY) 2010/11; 10% of all electrical requirements from renewable resources by SFY 2005/06, increasing to 20% by SFY 2010/11; 50% alternative-fuel vehicle purchase requirement by SFY 2005/06, increasing to 100% by SFY 2010/11; green building requirements; and minimum efficiency purchasing standards. This Order affects over 200 million square feet in over 8,000 facilities [16,20].

Executive Order No. 142 directs State Agencies and Authorities to diversify transportation fuel and heating oil supplies through the use of bio-fuels in State vehicles and buildings. EO142 requires: increased use of ethanol and the purchase of flex-fuel vehicles; an increased use of bio-diesel to an amount equivalent to 2% of total vehicle diesel use at B-100 in 2007, increasing to 10% by 2012; an increased use of bio-based heating fuels equivalent to 0.5% of all heating fuel use at B-100 in 2007, increasing to 5.0% in 2012 [22].

State Purchasing Standards and State Appliance Standards – In 2000, New York passed a law to enact equipment standards on 18 products for purchases by or for the State. In 2005, New York passed the Appliance and Equipment Energy Efficiency Standards Act of 2005, calling for the enactment of minimum energy efficiency standards applying to the sale or installation of 14 products in New York State [19].

➤ **Regional Greenhouse Gas Initiative**

The landmark Regional Greenhouse Gas Initiative (RGGI), launched by New York, resulted in a multi-state agreement involving Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont, with Maryland scheduled to join this year. This cap-and-trade program¹¹ aims to stabilize greenhouse gas emissions from power plants at current levels by 2009 and further reduce emissions by 10% by 2019 [31]. The New York State Department of Environmental Conservation (NYS DEC) is in the process of developing regulations to implement the program in the state.

➤ **Automobile Standards**

The NYS DEC has adopted California's regulations concerning greenhouse gases from the transportation sector. Starting with the 2009 model year, vehicle manufacturers will be required to meet a fleet average standard of emissions of CO₂, CH₄, N₂O, and HFCs, a standard that becomes more stringent each year through 2016. NYS DEC estimates that the regulations will result in a reduction of 15 million tons of CO₂ emissions by 2020 and 26 million tons of CO₂ emissions by 2030 [25].

➤ **Proposed Office of Climate Change**

Governor Spitzer's proposed 2007-08 budget for New York State includes the creation of the Office of Climate Change, a 12-person office under the NYS DEC. The budget must be approved by the State Legislature before the new office becomes official.

➤ **Proposed New York State Global Climate Change Reduction Act**

A bill was submitted to the New York State Senate to enact the New York State Global Climate Change Reduction Act. In this bill, the legislature finds that greenhouse gases are increasing, will alter the climate such that there will be dramatic effects on weather patterns, agricultural productivity, coastal population centers due to rising sea levels and biological health. The bill also establishes a Global Climate Change Coordinating Council for New York State to make recommendations for actions to reduce greenhouse gases by 25% by 2009 and 50% by 2034, as compared to 1994 levels [17].

➤ **Proposed New York Consumers Catastrophe Preparedness and Protection Act**

Previous years have seen unprecedented insurance losses from Hurricanes. Mortgages require reliable property insurance but currently property insurance companies have not collected and retained premiums sufficient to maintain reserves and some have left New York's coastal market. This bill seeks to create the New York State Catastrophe Fund to ensure that following a natural or man-made disaster, the recovery and rebuilding process would be strengthened [30].

¹¹ A summary of RGGI's stakeholders workshop on GHG offsets (June 25th, 2004) is available from www.rggi.org/docs/offsets_workshopsummary.pdf

➤ **Local Initiatives**

A number of initiatives are occurring in New York State to address climate change issues at the local level. For example, Westchester County has formed a task force with a diverse range of community stakeholders to produce a countywide action plan to reduce greenhouse gas emissions and promote sustainable development. The Town of Greenburgh is reducing greenhouse gas emissions by promoting energy conservation/efficiency and renewable energy in the community and in its government operations. Highlights include the Town's groundbreaking 2002 legislation mandating energy efficiency in new residential construction. Both of these communities participate in the Local Governments for Sustainability's (ICLEI) **Cities for Climate Protection Campaign**, which works with local governments to help reduce fossil fuel use through a 5-step process and networking with other local governments [6]. New York City has recently announced its own plan to reduce greenhouse gas emissions by 30% by the year 2030 from the baseline year of 2005.¹² Most of the GHG emissions in New York City have been identified to be associated with buildings and facilities and measures will target these sectors.

2.4. OTHER REGIONAL, STATE AND LOCAL LEVEL INITIATIVES

Besides the RGGI initiative described in Section 2.3, other regional partnerships have formed in the United States to address climate change, [26] including:

- The *Western Regional Climate Action Initiative* involves the States of Arizona, California, New Mexico, Oregon, and Washington, which signed an agreement in February 2007 to establish a multi-sector market-based system (cap-and-trade) to reduce GHG emission.
- The *Southwest Climate Change Initiative* (Arizona and New Mexico) was signed in 2006 to identify opportunities to reduce GHG emissions in both states.
- The *Powering the Plains Initiative* brings together state officials from Iowa, North Dakota, Minnesota, Wisconsin, and Manitoba (Canada) to work on energy and agricultural initiatives to reduce GHG emissions.
- The 2004 *Clean and Diversified Energy Initiative*, requires that western states strive to achieve 30,000 megawatts of clean energy by 2015 and a 20% improvement in energy efficiency by 2020.

In addition, there are several initiatives at the State level, most notably:

California Global Warming Act [32]:

In 2006, the Governor of California signed the AB 32 Global Warming Solutions Act, which will cap all GHG emissions from major sources at 1990 levels by the year 2020. This legislation is the first enforceable statewide program in the U.S. that includes penalties for non-compliance. The Act authorizes a market based compliance mechanism (e.g. cap-and-trade) and several sectors can participate. It also requires a statewide GHG emissions reporting program to monitor and enforce compliance.

California Vehicles Global Warming Law [1]

In 2002, the Governor of California signed into law a bill that requires carmakers to reduce global warming emissions from new passenger cars and light trucks, starting in 2009. Standards become more stringent up to 2016. However, this law now faces federal and state court challenges by nationwide carmakers and some CA car dealerships.

12 Further information about this plan is available from <http://www.nyc.gov/html/planyc2030/html/plan/climate.shtml> and http://www.nyc.gov/html/planyc2030/downloads/pdf/report_climate_change.pdf

Furthermore, states have developed programs to reduce emissions of GHG and other air pollutants by promoting energy conservation and efficiency, clean distributed generation and/or the use of renewable sources of energy. To meet these goals, states are adopting both energy efficiency policies and energy supply actions and programs that:

- Institute energy efficiency portfolio standards or require the use of Energy Star products
- Revise building codes and improve building design, and operation practices
- Set requirements for renewable portfolio standards (RPS) and combined heat and power (CHP) resources and technology
- Develop new electricity market rules to remove obstacles that prevent the advancement of high-efficiency, including clean distributed generation systems and net metering.
- Fund *Public Benefits Funds for Energy Efficiency* and/or cost-effective energy efficiency projects.

Appendix A provides a table with an outline of state activities that promote the above energy goals, including those leading to reductions of heat trapping gases emitted to the atmosphere. Further information is also available from the report *Race to the Top: The Expanding Role of the U.S. State Renewable Portfolio Standards.* [29] This report provides a list of “State Action Plans” with maps that show the following Climate Actions that have been taken by U.S. States: 1) [Greenhouse Gas Emissions Targets](#); 2) [Carbon Cap or Offset Requirement for Power Plants](#); 3) [Climate Action Plans](#); 4) [Climate Change Commissions and Advisory Groups](#); 5) [Regional Initiatives](#); 6) [Greenhouse Gas Inventories](#); 7) [GHG Reporting and Registries](#).

SECTION 3. POTENTIAL IMPACTS OF CLIMATE CHANGE IN NEW YORK AND THE REGION

Climate change is a global phenomenon, but impacts vary according to geographic location.¹³ While recent scientific advances have provided new insights into the potential regional impacts of climate change, understanding the nature and consequences of climate change on regional and state spatial scales is a challenge we have just begun to address.

The summary below draws primarily on the four major studies addressing regional impacts in the Northeast, as well as proceedings from a recent conference:

- [*Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*](#). Northeast Chapter. Published by the National Assessment Synthesis Team of the US Global Change Research Program (USGCRP), 2000 [45].¹⁴
- [*Metropolitan East Coast Assessment, Climate Change and a Global City: An Assessment of the Metropolitan East Coast Region*](#), June 19, 2000 [13]
- [*Climate Change in the U.S. Northeast*](#); A report of the Northeast Climate Impacts Assessment (NECIA), October 2006.¹⁵ [23]
- [*Indicators of Climate Change in the Northeast*](#); Clean Air - Cool Planet and Cameron P. Wake; The Climate Change Research Center, University of New Hampshire; 2005 [3]
- [*Hudson Valley Climate Change Conference*](#), (December 4th, 2006); Conference Description, New York State, Department of Environmental Conservation [24].¹⁶

Research focusing on the U.S. Northeast region indicates that the region has warmed over the last century, with the rate of warming increasing over the last 30 years [3].¹⁷ A 2006 report of the Northeast Climate Impacts Assessment [23] concluded that, unless curtailed, heat-trapping emissions will cause extensive climate related impacts in the U.S. Northeast over the next century. The magnitude of these changes will depend on the level of global GHG being emitted from anthropogenic activities such as fossil fuel combustion (e.g., transportation, electricity generation, etc.) and the degree of deforestation.

It is critical for decision makers who are involved in developing policy recommendations (mitigation and adaptation strategies) to have an overall picture of the impacts ensuing from global change. Taking into account historical and current conditions, evidence from past climate variability, and/or scenario predictions, it is possible to approximate the likely consequences of climate change. There are several approaches that may be used to analyze climate change related impacts; such as those based on historical trends, present extreme events, or climate change scenarios. Key indicators of the impacts considered in these analyses include temperature, precipitation, and sea level rise [13].

Historical Trends

The historical record of monthly temperature and precipitation indicates that both have been increasing in New York State over the last century. For example, independent of expected fluctuations from year to

13 In New York State, impacts will be different in urban centers, where effects relate directly to human health and welfare (including extreme heat, air quality, and electricity and other infrastructure issues) than those likely to be experienced in upstate locations, where impacts are related to agriculture, forest productivity, changes in tourism and recreational opportunities.

14 The *Educational Resources* section of this report was also considered [46].

15 The summary of this report, by the Union of Concerned Scientists, was also considered. It is available from: http://www.climatechoices.org/ne/resources_ne/nereport.html

16 Including a presentation by Prof. Cameron P. Wake, *Climate Change in the Northeast: Past, Present, and Future*,

17 As presented at the Hudson Valley Climate Change Conference Program (Dec. 4th, 2006) by Prof. Cameron P. Wake, Climate Change Research Center Institute for the Study of Earth, Oceans, and Space (EOS), University of New Hampshire [24].

year or across decades, temperatures in the New York Metropolitan area have risen by approximately 2°F over the last century [13].¹⁸ In the Northeast coastal region, from Maryland to Maine, temperature increases of up to 4°F over the last 100 years have been observed [45]¹⁹ and the average annual temperature in this region has increased by about 1.8°F since 1899. [3]

Over the last thirty years, temperatures have risen by 1.4°F per year, on average, and the 1990s were the warmest decade on record since 1899. The winter season exhibits a greater temperature increase, in particular during recent decades [3]. Historically, major cities in the Northeast have experienced, on average, 10 to 15 days per year when temperatures exceed 90°F (including 1-2 days at or above 100°F) [23].

Precipitation has also increased over the same time span. In the New York Metropolitan area, the typical increase was approximately 0.1 inch per decade, or an overall increase of 1 inch over the last century. Current average precipitation in the New York Metropolitan region is 45.9 inches per year [13]. For the entire northeast region, precipitation trends show a pattern of increase, with some regions experiencing 20% greater precipitation. Furthermore, the nature of the precipitation has changed, with heavy rainfall events becoming more frequent over the last 50 years.²⁰ Between 1950 and 1970, there were, on average, two extreme precipitation events per year in New York City. From 1971 to 2005, this average increased to 5 extreme events per year [24].²¹ While precipitation extremes (more rain per event) are on the rise, and this can lead to short-term droughts, the overall amount of land area experiencing drought in the Northeast region as a whole, appears to be decreasing. Finally, higher temperatures have induced changes in the amount of snow in the region. On average, most of the increased precipitation takes place during the spring and fall. Winter precipitation, in particular snow, has decreased over the last few decades, and this is likely to affect reservoir charging patterns. For the region as a whole, the period between the first and last dates with snow on the ground has decreased by 7 days over the last half century [46].

Current Extreme Events

While it is difficult to attribute individual extreme events to changes in climate, over the last decades the Northeast region has experienced several extreme weather events that have called attention to the potential vulnerabilities of the region. To illustrate, seven major tropical storms took place in the mid-Atlantic region since 1986 and over the last two decades there have been six years of significant drought in the region. During the nor'easter of December 1992 New York State coastal areas, including New York City and its extended metropolitan area, experienced the worst flooding and strongest wind events that have been recorded in the area, affecting key transportation infrastructure (e.g., subway systems, tunnels). Most recently, the northeast region experienced an intense heat wave during the summer of 1999, as well as a dramatic precipitation event in New York City that flooded a major highway and certain subway lines, and resulted in related blackouts in northern Manhattan. A regional summer drought during 1999 has been associated with the outbreak of a West Nile-like virus. In September of the same year, Hurricane Floyd brought large-scale flooding in Northern New Jersey [13]. In April 2005, communities in northern New Jersey located along the Delaware River experienced the worst floods in 50 years [44]. In New York City, a 2006 heat wave was reported as a factor in 140 deaths.

Climate Change Scenarios

18 As reported in [13]. This study takes into account the thirty-one counties of the New York City metropolitan region, considering counties as far north as Dutchess, Ulster and Sullivan Counties in New York State or Litchfield in the State of Connecticut, and as far south as Ocean county in New Jersey State.

19 The region considered in the Northeast chapter extends from Maryland to Maine.

20 <http://www.usgcrp.gov/usgcrp/Library/nationalassessment/5NE.pdf>

21 Presentation by Cameron P. Wake, slide #10; <http://www.dec.state.ny.us/website/hudson/hvcc1000cpw.pdf>.

Future climate change related impacts in the Northeast region may be assessed according to different GHG emission scenarios. For a higher-emissions scenario in which economies continue to grow without major changes in consumption patterns or technologies (“Business As Usual” scenario), the region will be dramatically altered. Within a few decades, temperatures would be expected to increase by 2.5°F to 4 °F in the winter, and by 1°F to 3°F during the summer. By the end of the 21st century, winter temperatures could increase by 8°F to 12°F and summer temperatures by 6 to 14°F [23]. Heat waves will become frequent; in major cities in the northeast, days with temperatures over 90°F will increase (to 30-50 per year) in the next half-century and by 2100 most cities will experience more than 60 days of temperature over 90°F per year (14-28 days at or above 100°F). Higher temperatures would raise evaporation rates and reduce soil moisture in summer. The length of seasons is expected to change. With shorter and warmer winters, snow-on-the-ground days and regional snow cover would decline. More precipitation would fall as rain during extreme storm events. More rain in fewer events and less snow available to melt during the spring, as well as higher evaporation rates, would likely result in short-term droughts in late summer and fall. Finally, global sea-level rise would continue. By mid-century, coastal waters would rise by approximately three inches in the Boston area, to more than one foot in Virginia, and from eight inches to three feet by 2100, thus intensifying the regional vulnerabilities to coastal flooding and damage from storm surges [23].

These projected impacts are contingent on the level of emissions of heat-trapping gases. Some global warming consequences are now unavoidable, but under a low GHG emission scenario they would be significantly reduced, (to less than half the change expected under the higher-emissions scenario).

The above assessments provide a basis for beginning to think about important interactions among key climate variables (e.g., temperature, precipitation) and several areas of concern. For example, projected precipitation changes (both the amount and timing) will affect the water supply, and this in turn will have significant implications for agriculture, forests, human health, water resources and land-use practices, coastal wetlands and marine resources. Warmer temperatures will impact a similar range of sectors, particular in urban areas, where re-radiation of heat from impervious surfaces creates what is commonly known as the heat island effect.

Agriculture: Warmer weather and changes in the water cycle are likely to affect agricultural yields in the Northeast region. While grape producers in the Hudson Valley will benefit from higher annual temperatures, apple producers in shifting climate zones and dairy farms unable to protect cows from heat stress will suffer. Invasive species, proliferation of weeds, and pest outbreaks (due to higher temperatures) will require additional expenditures for pesticides and herbicides. Producers may incur further costs if they decide to cope with possible short-term droughts by resorting to man-made irrigation. Nationwide, economic losses in the agricultural sector related to a 5 degree (F) temperature rise – as projected to take in the next 30 - 40 years under a “business as usual” scenario – could range from \$15 billion to 30 billion dollars per year [43]. Yet, the agricultural sector can play a role in the effort to mitigate climate change,²² both in offsetting GHG emissions by terrestrial sequestration and in producing biofuels.

Health: The main health impacts associated with climate change are related to heat stress, poor air quality (which is affected by emissions from energy related sources, in part due to higher electricity demand on hot days, as well as by climate change)²³, and an increase in vector-borne infectious diseases.

22 Further information is available from the Pew Center on Global Climate Change, which released two documents focusing on agricultural and forestry contributions to GHG reduction: “Agriculture’s Role in Greenhouse Gas Mitigation” and “Agricultural and Forestlands – U.S. Carbon Policy Strategies.” Both reports were issued in September 2006.

23 Therefore, reducing fossil fuel use could have dual benefits for air quality by both reducing ozone precursor emissions and

Furthermore, in terms of air quality, the number of days above the ozone or short term PM standards could increase, as well as the length of ozone episodes.

In New York City the average annual (excess) weather-related mortality in 1993 was calculated at ~ 500 deaths. In 2020 it is expected to rise to ~ 850, and by 2050 it is projected to rise to ~1,400 [11].²⁴ Some cities have developed heat emergency response plans, using information on risk factors and meteorological information. Prevention measures include warning systems²⁵ and evacuation to cool emergency centers [12]. Warmer temperatures will likely result in an increase of infectious and tropical diseases, and the worldwide likelihood of insect-borne diseases is expected to increase [47].²⁶

Forests: A significant aspect of forests in relation to climate change is their ability to store carbon. New York and New England forest ecosystems represent about 4.2 billion metric tons of carbon storage [46]. The stress brought by climate change is likely to affect forest composition and the geographic range and distribution of certain tree species. Shifting climate zones may result in forests, and entire ecosystems, moving northward and upward (in mountainous regions) by the end of the century, including New England sugar maples and oaks in the U.S. Northeast region [39,45]. Higher temperatures during the winter and thaw/freeze events, frequent flooding, and summer droughts are expected to affect the health and productivity of the forests of the Northeast [45]. Although forest productivity is likely to improve with modest warming and rising CO₂ concentrations, there is also evidence that warmer winters over the last two decades have resulted in decreased maple sugar yields and an earlier harvest season. Furthermore, certain studies of sugar maples in the Northeast indicate that large-scale die-offs may take place when winter temperatures are warmer than normal [28]. Larger temperature increases and higher soil evapo-transpiration rates, will result in forest productivity losses, because of increased disturbances such as fires, pests and pathogen outbreaks, windstorms and floods.

Species and Natural Areas: The degree of habitat and species loss in the Northeast region will depend on the level of temperature rise and changes in precipitation patterns. Warmer and shorter winters may result in habitat encroachment by invasive species or shifting of climatic zones. Changes in precipitation patterns may increase flood events or short-term droughts (depending on the season) and result in topsoil erosion. As a result of all these changes, the number of animal species listed as threatened or endangered is likely to increase while habitats required by waterfowl, amphibians and other wildlife may decline [3, 45]. Furthermore, and given expected shifting climate zones, it is likely that present-day cohesive ecosystems may become out of synch, with some migratory species arriving at the same time of year as they used to, only to find that they have missed the flowering time which is controlled by temperature, not light.

Water Resources and Land Use Practices: Climate change will affect New York's water supply, its quality, and might intensify competition for control of drinking water. Rising temperatures are expected to increase moisture evaporation (from soils and water bodies), delay freezing at lakes, and result in earlier melting. Changing precipitation patterns are producing more rain in fewer events, and snowfall is decreasing, as is on-the-ground snow. All these events will result in greater swings between wet events and short-term droughts. Such conditions will be exacerbated by losses in the natural water storage

particulates, and at the same time mitigating the amount of future climate change that tends to speed up ozone-producing reactions, particularly in summer conditions.

24 These estimates include both summer and winter mortality, assumes full acclimation to changed climate, and includes population growth.

25 The National Weather Service Eastern Region has instituted a Heat/Health Warning System program, which has had success in reducing heat related mortalities in Philadelphia. New York City has expressed interest in participating in this program [14].

26 Climate warming can increase pathogen development and survival rates, disease transmission, and host susceptibility.

Although most host-parasite systems are predicted to experience more frequent or severe disease impacts with warming, a subset of pathogens might decline with warming, releasing hosts from disease.

capacity of soils, as the regional impervious surface area increases. The associated higher runoff rates will contribute to flood events. Water management and land-use practices will play an important role in determining the extent of impacts [45].

Coastal Areas and Critical Infrastructure: Global climate change is expected to cause moderate to pronounced sea level rise and severe storm events along the coastal areas of the Northeast. Sea level rise in the Hudson River estuary of 2 to 3 feet during the 21st century will increase the frequency of disruptive flooding events by factors of 3 to 10 in areas with tidal coast- or river-shorelines. The impacts in coastal New York could be extensive, ranging from erosion of beaches, increased storm surges and coastal flooding, loss of coastal wetlands, as well as upstream migration of saltwater, which may disturb critical watersheds and/or result in crowding-out of species if upland habitats are disrupted. Furthermore, sea-level rise and severe storms are likely to disrupt critical infrastructure (airports, transportation systems, roads and tunnels as well as municipal solid waste landfills and water supply and treatment facilities), compromise the drinking supply of municipalities that take water from the Hudson river, cause loss of property, and pose risks to human life. The economic vitality of the region may be compromised [13,24,45].

Further description of potential impacts, specifically in relation to research needs for NY State, is given in Section 6 of this paper.

SECTION 4. OVERVIEW OF NATIONAL AND REGIONAL CLIMATE CHANGE RESEARCH PROGRAMS

4.1 FEDERAL INITIATIVES

At the federal level, research programs related to climate change include two main initiatives:

1) The [U.S. Climate Change Science Program](#) (CCSP) [35] has been established to reduce the uncertainties in climate science and develop science-based resources to support decision makers. The program, which was supported by funding of over \$1.15 billion in FY 2006, seeks to:

- Improve knowledge of the Earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and changes
- Improve quantification of the forces bringing about changes in the Earth's climate and related systems
- Reduce uncertainty in projections of how the Earth's climate and related systems may change in the future
- Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes
- Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change

The CCSP incorporates and integrates the U.S. Global Change Research Program (USGCRP), which has been operating since 1990, with the Bush Administration's U.S. Climate Change Research Initiative (CCRI).²⁷ Led by the Department of Commerce²⁸, thirteen federal agencies collaborate to advance the CCSP goals, including the U.S. Department of Agriculture (USDA), U.S. Department of Energy (DOE), U.S. Department of Transportation (DOT), The Department of Interior's U.S. Geological Service (USGS), the Environmental Protection Agency (EPA), the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the Department of Health and Human Services (DHHS), the Smithsonian Institution (SI), and others. A summary of several of these agencies' specific goals as well as budget allocations (by research goals, by focus agency) may be found in *Appendix B*.

2) The [U.S. Climate Change Technology Program](#) (CCTP) [36] is led by the Department of Energy. CCTP coordinates across all agencies the Federal Government's portfolio of climate related technology research and development activities (e.g., technology deployment and adoption activities), which were supported by nearly \$3 billion in fiscal year 2006. CCTP focuses efforts on priorities established as part of the President's National Climate Change Technology Initiative. The [Global Change Data and Information System](#) (GCDI) is the official clearing-house for research conducted at all participating agencies, including: the U.S. Department of Commerce (DOC), the U.S. Department of Defense (DOD), the U.S. Department of State (DOS), the National Aeronautic and Space Administration (NASA), the US Agency for International Development (USAID), as well as the U.S. DOT, DOE, NSF and USDA. Appendix B provides a table listing all the federal agencies participating in this program and examples of related activities.

National Laboratories:

27. Further information about the roles of the USGCRP and the CCRI under CCSP is available from: <http://www.climatescience.gov/about/default.htm>

28. The Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget oversee the CCSP.

Several laboratories operating under the Department of Energy, ²⁹ conduct research on Climate Change related topics. In New York State, [Brookhaven National Laboratory](#)'s Energy, Environment and National Security Directorate performs basic and applied research that is directly applicable to carbon management and climate change. In addition, the [National Energy Technology Laboratory](#) (NETL), conducts fossil energy research and implements a broad range of energy and environmental research and development (R&D) programs, both onsite and through partnerships.

The National Academies

The National Academies conducts research relevant to climate change. In 2001, and at the request of the Bush administration, a committee of the National Academies' National Research Council (NRC) published the report "[Climate Change Science: An Analysis of Some Key Questions](#)" [4]. This report summarized the current understanding of global change and related uncertainties in climate-change science. The committee, staffed by eleven of the nation's top climate scientists, called for additional research on climate related changes. Relevant to New York State, in 2006 the NRC published the report "[Alternatives to the Indian Point Energy Center for Meeting New York Electric Power Needs.](#)" This report reviews both demand and supply options for replacing 2000 MW of power supplied by this nuclear facility, using simulation models to analyze different scenarios for implementing the different options. It also examines institutional considerations that will affect these options and their potential related impacts. [15]

4.2 REGIONAL INITIATIVES

Regional Carbon Sequestration Partnership

The [U.S. Department of Energy's National Energy Technology Laboratory](#) established seven regional partnerships to research carbon capture and sequestration opportunities throughout the country. Each partnership was asked to identify major sources of human-made CO₂; assess technologies for separating CO₂ from gases at industrial plants; evaluate the potential for storing CO₂ in geologic formations; quantify increases in carbon storage by plants and soil by changes in the management of forests, rangelands, and agricultural lands; study the logistics of building pipelines to move CO₂ from points of capture to storage; and consider the regulatory needs associated with capture and sequestration.

The regional partnership program has been divided into several phases. Phase I included identification of potential CO₂ sources and sinks, which included overall geological and terrestrial characterization of each region; Phase I was completed in June 2005. Phase II, which is currently ongoing, will include several field demonstrations of sequestration in each partnership, both geological and terrestrial. Phase III will consist of several large-scale geological sequestration validation tests.

The regional partnerships (and their lead organizations) are the Midwest Regional Carbon Sequestration Partnership (Battelle Memorial Institute), the Geological Carbon Sequestration Options in the Illinois Basin (Illinois State Geological Survey), the Southeast Regional Carbon Sequestration Partnership (Southern States Energy Board), the Southwest Regional Partnership for Carbon Sequestration (New Mexico Institute of Mining and Technology), the Big Sky Regional Carbon Sequestration Partnership (Montana State University), the West Coast Regional Carbon Sequestration Partnership (California Energy Commission), and the Plains CO₂ Reduction Partnership (University North Dakota and Energy &

²⁹ Detailed description of various programs at national laboratories and technology centers, is available from <http://www.energy.gov/organization/labs-techcenters.htm>

Environmental Research Center). Although there is no partnership in the northeastern region of the country, New York State has recently joined the Midwest Regional Carbon Sequestration Partnership. The partnerships comprise more than 300 public agencies, private companies, academic institutions, and nonprofit organizations throughout 41 states.

[The Nature Conservancy and partners](#)

Climate change related research carried out by The Nature Conservancy includes the [Northeast Carbon Feasibility Project](#) which attempts to quantify and estimate the cost of carbon generated from land-use activities in the Northeastern United States. The project seeks to identify opportunities for reducing emissions and sequestering carbon and to quantify the benefits and costs of related practices and activities, in particular those leading to improved land conservation and management. Partners include Winrock International and the Sampson Group.

4.3 OTHER INSTITUTIONS AND ORGANIZATIONS

[The NASA Goddard Institute for Space Studies \(NASA/GISS\)](#)

This New York City institution is a laboratory of NASA's Earth Sciences Division and Columbia University's Earth Institute. Research emphasizes the broad study of climate change, climate modeling, Earth observations and planetary atmospheres, as well as the impacts of global change and climatic changes induced by anthropogenic activities, which take place at various time scales. Ongoing projects include the Global Aerosols Climatology Project (GACP), the Surface Temperature Assessment, and the International Satellite Cloud Climatology Project (ISCCP), among others.

[The Electric Power Research Institute \(EPRI\)](#)

EPRI's climate change research programs are wide ranging, including analysis of the potential costs and benefits of domestic and international global climate policies; or programs to identify options for complying with greenhouse gas emission reduction requirements. For example, EPRI's report [Electricity Technology in a Carbon-Constrained Future](#) found that emissions from the U.S. electric sector could be significantly reduced through aggressive development, demonstration and deployment of a broad portfolio of technologies such as energy efficiency, plug-in hybrid electric vehicles, renewables and other non-emitting generation such as nuclear energy, plus capturing and storing CO₂ from fossil-fuel generation. In addition, EPRI also examines traditional sources of power generation, with the goal of identifying technological improvements leading to reduced GHG emissions. Its project, the *Coal fleet for Tomorrow* is broad-based industry collaborative research initiative, managed by EPRI, that brings together power generators, turbine and boiler suppliers, engineer-procure-construct companies, and research partners from around the world to evaluate various options, including integrated gasification combined cycle (IGCC), ultra-supercritical pulverized coal (USC PC), and supercritical circulating fluidized-bed combustion (SC CFBC).

Additional institutions that either conduct their own climate change research or that have become important clearinghouses summarizing this type of research, include: The Climate Change Research Section (CCR) of the Climate Global Dynamics (CGD) Division at the [National Center for Atmospheric Research](#) (NCAR); the [Climate Change Research Center](#) at the University of New Hampshire; The [Pew Center on Global Climate Change](#); [Resources for the Future](#); the [Union of Concerned Scientists](#); the [World Resources Institute](#), and many others.

4.4 STATE LEVEL INITIATIVES

Several states in the U.S. support climate change research through various programs. This research is often relevant to specific regional issues and should be considered as important complementary sources of information and resources that may be used to help address NYS research needs. Two active state climate change research programs are highlighted below. Ongoing climate change research initiatives in New York State are described in Section 5.

The California Energy Commission's Public Interest Energy Research (PIER) Program

The PIER program supports energy research, development and demonstration (RD&D) projects to commercialize environmentally safe, affordable and reliable energy services and products.

PIER's Environmental Area (PIER-EA, also called Energy-Related Environmental Research) was developed to research the environmental effects of energy technology and energy production, delivery and use in California, including climate change implications. Funded research areas of PIER-EA include:

- *Climate Monitoring, Analysis, and Modeling*, including the development of climate scenarios to illustrate the likelihood and severity of changes to weather and climate in California.
- *Improving Greenhouse Gas Inventory Methods* to better track GHG emissions trends.
- *Options to reduce GHG Emissions*, to evaluate costs and benefits of the available options.
- *Impact and Adaptation* studies, particularly in relation to ecological and water resources, and human health.
- *Economic analyses* to estimate the costs of climate change and various policy responses.

PIER-EA is also a partner in the West Coast Regional Carbon Sequestration Partnership (WESTCARB). Other PIER program areas include, Buildings End-Use Energy Efficiency, Energy Innovations Small Grant Program, Energy Systems Integration, Environmentally-Preferred Advanced Generation, Industrial/Agricultural/Water End-Use Energy Efficiency, Natural Gas Research, Renewable Energy Technologies, and Transportation Research.

PIER's annual budget from the electricity sector is \$62.5M and from the gas sector is \$18M. Both of these budgets support all of the energy R&D. The annual budget in support of Climate Change activities ranges from \$8M to \$9M and this total includes the federal funding for carbon sequestration research, which is provided by the DOE.

State of Wisconsin

This State's [Environmental Research Program](#) focuses on energy, including the environmental effects of electrical generation and transmission in the State. The program supports research that addresses significant data and information gaps in order to better understand the connections between energy production and environmental quality. A broad range of research areas are supported, including several climate change projects (e.g., an inventory of carbon storage capacity in Wisconsin's forests).

SECTION 5. ONGOING CLIMATE CHANGE RELATED RESEARCH IN NEW YORK

Major climate-change related research initiatives underway in New York State are highlighted below.

➤ **Development of Clean Energy Technology**

NYSERDA invests on the order of \$50 million per year in the development and demonstration of clean energy technologies including renewable electric technologies and biofuels; advanced energy efficiency technologies for the transportation, industrial, commercial, and residential sectors; and energy storage technology. These investments in technology development, which are generally made through public/private partnerships, all support the goal of reducing CO₂ emissions associated with meeting energy needs. NYSERDA also provides support to develop and demonstrate technologies to use biogas for energy production – reducing the emissions of the potent greenhouse gas, methane.

➤ **Other NYSERDA Climate Change Research and Analysis Initiatives**

NYSERDA has recently sponsored several research and analysis projects specifically addressing climate change, as follows:

Forest Impact Assessment. In a partnership with several state, federal, and international agencies and organizations, Northeast Forests 2100 is reviewing existing climate change research with respect to potential impacts to the forests of eastern Canada and the northeastern U.S., with the goal of communicating the information to non-scientists. NYSERDA is participating in this study. The synthesis report is due in spring 2007.

Heat Island Mitigation. The Urban Heat Island Mitigation project, for which a final report has just been published, aimed to study the phenomenon of increased temperatures in urban areas due to decreased vegetation cover and to identify options for mitigation in New York City, including urban forestry, light surfaces, and “green” roofs.

CO₂ Sequestration. NYSERDA has become a supporting member of the Midwest Regional Carbon Sequestration Partnership, one of seven regional partnerships established by the U.S. Department of Energy to research CO₂ sequestration opportunities across the country. Related to this effort, NYSERDA has several projects with the New York State Museum to determine the potential for geological sequestration of CO₂ in NYS. NYSERDA has also recently issued a solicitation for sequestration research opportunities in New York, from which several exploratory projects with universities in New York will soon begin.

CO₂ Separation and Capture. As part of research efforts to improve the environmental performance of power generation in New York, NYSERDA is supporting a project to develop a preliminary design and economic feasibility analysis of a system to convert CO₂ emissions from a coal-fired power plant in New York into algal biomass. In the works are two other projects involving development of advanced oxyfuel combustion technologies in New York, which will aid in CO₂ separation and capture for coal-fired power plants.

Energy Modeling and CO₂ Emissions. NYSERDA supported extensive modeling of the regional electric system and associated greenhouse gas emissions to help provide the analytical framework for the Regional Greenhouse Gas Initiative. Modeling efforts continue.

➤ **Advanced Clean Coal Power Plant Initiative**

This initiative was proposed by the State in 2006 with the goal of building an advanced, “clean” coal plant in New York. The Initiative also included the requirement that the plant be “carbon capture and

sequestration ready” when such technology becomes available. NYSERDA is responsible for coordinating the related carbon capture and sequestration research. As part of this effort, NYSERDA provided a sequestration guidance document included in the Request for Proposals (RFP), outlining general requirements for the research. The RFP was issued by the New York Power Authority in the Fall of 2006, and the winning bidder, NRG Energy, was announced in December 2006 with plans to build an Integrated Gasification Combined-Cycle coal plant in Erie County. This state-of-the-art technology makes more feasible the capture of CO₂ and easier capture of other pollutants, compared to traditional coal plants.

➤ **New York State Department of Health (NYS DOH) Climate-Related Morbidity Study**

The NYS DOH has undertaken a project to determine the effects of temperature, humidity, and other weather factors on human health, as determined by statewide hospital admissions for respiratory and cardiovascular problems, renal diseases, and heat/cold effects (e.g., heat stroke, frostbite). Adjustments will be made for the impact of air pollutants such as ozone and fine particulate matter, as well as socioeconomic status. To date, preliminary analysis has been performed for respiratory and cardiovascular diseases in New York City. The scope will be extended to include the entire State of New York and other health problems, such as renal diseases and heat/cold effects.

➤ **New York Climate and Health Project**

Columbia University and several other research institutions are collaborating on a project to improve understanding of the relationships among climate variability, weather, air quality, and human health vulnerabilities, focusing on the New York metropolitan east coast region. The project will yield tools for assessing the future health impacts of climate change in the context of other environmental stressors.

➤ **New York City Department of Environmental Protection (NYC DEP) Assessment of Climate Change Impacts on Water Infrastructure**

As part of a collaborative effort with several universities, the NYC DEP is supporting research and analysis to ensure that strategic and capital planning take into account the potential risks posed by climate change – sea level rise, higher temperatures, increase in extreme events, and changing precipitation patterns – on New York City’s water supply and wastewater treatment systems.

➤ **Climate Change Research in the Hudson Valley**

Hudson River National Estuarine Research Reserve. This partnership of the National Oceanic and Atmospheric Administration (NOAA) and coastal states is supporting research which is exploring options for protecting 300+ miles of shoreline, 7,000+ acres of tidal wetlands, and 6,000 acres of vegetated shallows in the Hudson River from the impacts of sea level rise.

Impacts on Hudson Valley Water Supplies. The U.S. Geological Survey is studying the impacts of land use on Hudson Valley water supplies. An abundance of scientific evidence indicates that the Hudson Valley can expect a warmer and wetter climate in the 21st century, but that droughts will occasionally occur, and will be intensified in a warmer climate, especially in more developed parts of the region.

Impacts on Landscape and Land Use. The University at Albany is studying the impact of climate change and land use patterns on water storage capacity and storm water management practices in the Hudson Valley.

➤ **Impacts on Agriculture and Invasive Species**

Cornell University is researching a variety of ways in which farmers and land managers can adapt to climate change issues related to invasive insects, disease, weed pests, and pesticide and herbicide use in New York and the region.

SECTION 6

CLIMATE CHANGE RESEARCH AND INFORMATION NEEDS IN NEW YORK STATE: A GAP ANALYSIS³⁰

As illustrated in the previous sections, New York State has made a substantial commitment to develop and deploy energy efficient and renewable energy technologies, and reduce greenhouse gas emissions. However, given the potential magnitude of climate change impacts and the complexities associated with implementing a multi-disciplinary mitigation strategy, many questions and research/information needs exist beyond these current technology and policy initiatives. The following research and information needs represent gaps that are not currently addressed through the New York State Energy, Research and Development Authority (NYSERDA) - or other programs in New York State. The research described below is not meant to supplant aggressive action at the national and international level; rather it is meant to help inform policy decisions and resource management practices in New York State related to climate change.

These research areas are proposed for discussion at the upcoming NYSERDA/New York Academy of Sciences workshop on “*Climate Change in New York.*” The research could be addressed by NYSERDA or other organizations in New York State, and much of the proposed research would benefit from regional collaboration. The research would need to build on the limited regional studies and assessments that have been done to date. Where federal funding may be available, such funding should be pursued to leverage State research dollars, and, more importantly, address critical climate change related impacts and opportunities in New York State.

The research and information needs are categorized into two main areas:

➤ **Reducing Emissions of Greenhouse Gases and Aerosols & Mitigating Climate Change Impacts:** Research and analysis in this area addresses the development of strategies to reduce emission of climate forcing agents - from CO₂ to methane to carbonaceous aerosols - with a focus on strategies that could be pursued in New York State. Strategies that provide multiple benefits to New York will be further developed, e.g., strategies that create new business opportunities, new sources of revenue for New York’s agricultural sector, and reduce smog and climate change, etc. Research in this area also includes exploring the potential of geological and terrestrial sequestration of CO₂, with a focus on assessing feasibility in New York State.

➤ **Understanding and Monitoring Impacts and Managing Risks:** This area addresses potential research to increase the understanding of climate change consequences on various sectors in New York, in an attempt to put these impacts into the discourse of the everyday decision-making process. Potential research efforts include scenario modeling, impact assessment, development of climate change impact indicators, field monitoring, and analysis and development of adaptation strategies – given New York’s population, environment, infrastructure and economy. All of this work is focused on managing and minimizing climate change-related risk in New York State.

30 NOTE: This section of the paper was used to facilitate the deliberation process during the April 10th meeting on Climate Change in New York State (albeit minor corrections). Revisions to this section will be reflected in the EMEP Research Plan.

SUB-SECTION 6.1

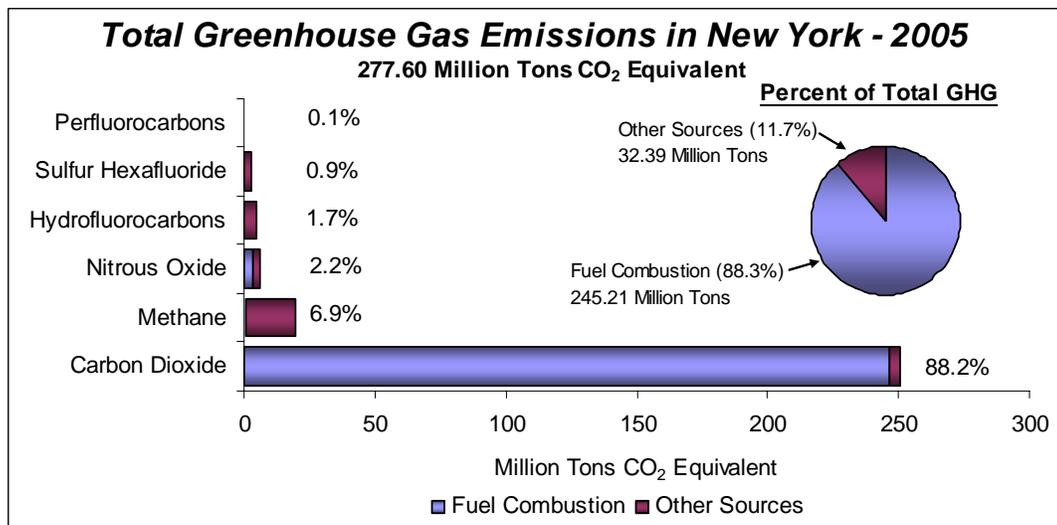
REDUCING EMISSIONS OF GREENHOUSE GASES AND AEROSOLS & MITIGATING CLIMATE CHANGE IMPACTS

➤ *Greenhouse Gas Reduction Curves for New York State*

Current estimates of total greenhouse gas emissions in New York State are shown in Figure 1 (*Total Greenhouse Gas Emissions in New York*). Figure 2 shows the breakdown of contributions to GHG by other emission sources. Climate stabilization will likely require reduction of greenhouse gas emissions in many sectors - not just in the production of electricity.

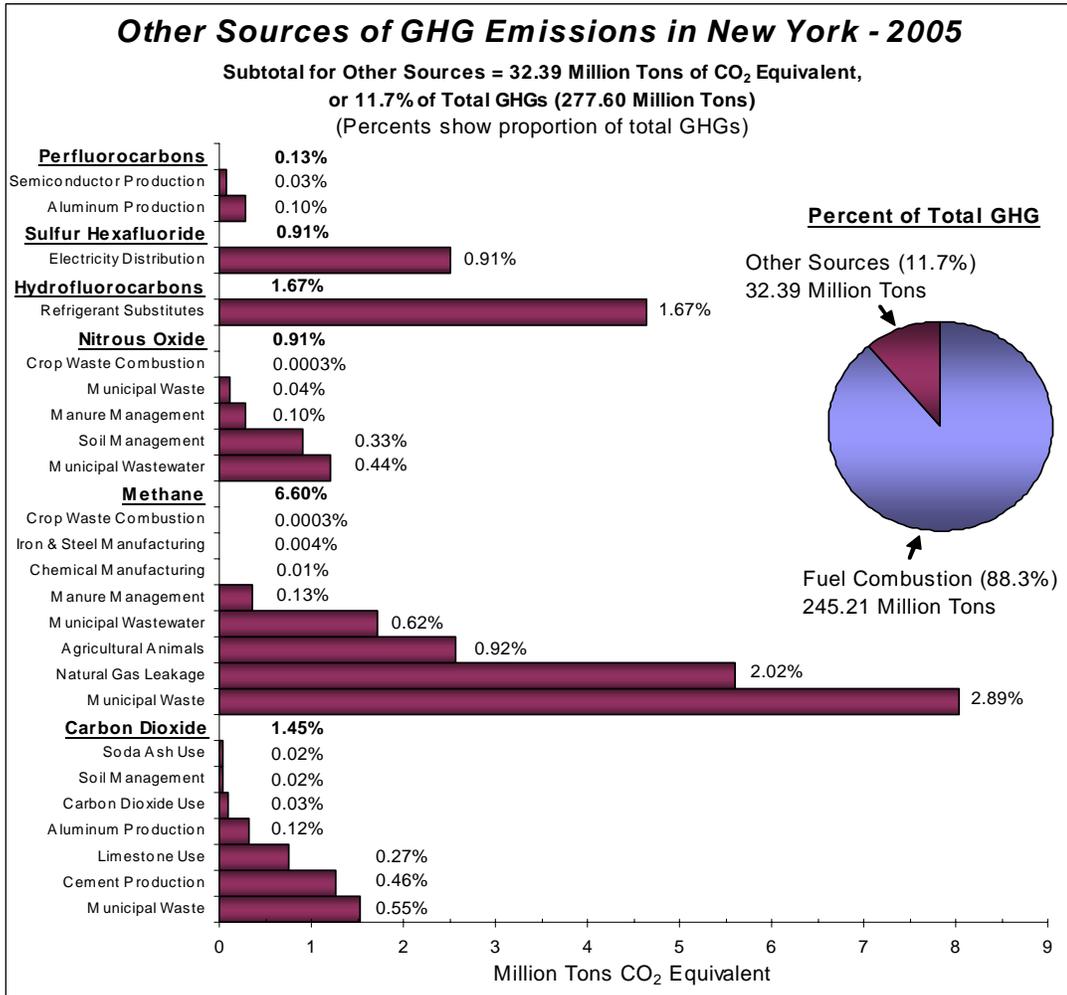
- *Research is needed to assess cost and availability of strategies to reduce emissions of climate forcing agents in all sectors, including emissions of the full range of greenhouse gases (methane, N₂O, etc.) and climate forcing aerosols (black carbon aerosols).³¹ The development of a “supply curve” for greenhouse gas emission reduction options in New York State could help identify the most cost-effective emission reduction strategies to inform policy decisions. Protocols could be developed to verify and validate emissions reduction estimates. Such protocols could be used in RGGI to develop new “carbon offsets” or under new policy initiatives.*

Figure 1 (DRAFT 3/14/07)



31 A NASA Climate study indicates that black carbon can affect regional climate by absorbing sunlight, heating the air and thereby altering large scale atmospheric circulation and the hydrologic cycle. Results were published in the September 27 2002 issue of SCIENCE, Surabi Menon of NASA and Columbia University, and James Hansen of NASA's Goddard Institute for Space Studies, New York.
<http://www.gsfc.nasa.gov/topstory/20020822blackcarbon.html>

Figure 2 (DRAFT 3/14/07)



Source: Draft - New York State Greenhouse Gas Emissions and Trends 1990-2005, NYSERDA Energy Analysis Program. Do not cite or quote.

➤ **Potential of Energy Efficiency and Renewable Energy to Reduce CO₂ emissions in NYS:** Experts predict that stabilization of greenhouse gas emissions is needed within the next few years, followed by a reduction to a level of one third or one quarter of current emissions by 2100. Achieving such challenging targets would likely require substantial increases in deployment of energy efficient and renewable energy technologies and continued development of these technologies, among other strategies.

- *Assessment to assess the potential of energy efficiency and renewable energy in New York State could be updated. Analysis of the costs and benefits of a range of policies and programs to achieve a real-world marked increase in penetration of these technologies in New York State could be conducted under a variety of scenarios.*

- **Climate Change Policy Research and Analysis** - New York State and several other states are in the process of developing and implementing the first major CO₂ cap and trade program for the electricity sector in the U.S. Many design and implementation questions remain to be addressed. Policies to reduce emissions from other sectors may need to be explored.
 - *Analysis to support effective RGGI implementation could include developing new CO₂ offsets and offset protocols, analysis of “CO₂ leakage,” assessment of multipollutant issues, among other issues. Analysis of other potential climate change policy options (e.g., low carbon fuel policies) could also be conducted to assess costs and benefits for New York State. An integrated policy analysis could consider other potential constraints (e.g., transmission constraints/load pockets, local/regional air quality concerns, “Peak Oil”) in assessing/evaluating climate policy, as well as the interplay of multiple policies affecting this issue (e.g., RPS, RGGI, etc.).*

- **Geological Sequestration:** Capturing CO₂ emissions and storing the gas in underground geological formations can reduce the amount of CO₂ released to the atmosphere. Before this can be implemented, however, site-specific geological research needs to be conducted to determine which formations are capable of storing CO₂ indefinitely. Other opportunities for sequestration may exist but are currently in the very early stages of development (e.g., mineralization, ocean storage).
 - *Synthesis of current assessments being conducted to determine whether carbon sequestration in geological formations is environmentally sound and cost effective.. For geological sequestration to become feasible in New York, detailed geological characterization research and engineering analysis is needed to identify viable storage formations, including capacity estimates, and to assess deliverability. Field demonstrations will be critical.*

- **Terrestrial Sequestration** - It is likely that strategies to sequester CO₂ emission could be implemented within a decade, or less for terrestrial sequestration. Terrestrial sequestration, such as changing agricultural practices to increase the carbon uptake by plants and soils, can reduce the amount of carbon in the atmosphere.
 - *Studies are needed to identify the terrestrial sequestration options in New York State, including estimated costs and benefits for each option and determining which are the best options for NYS in terms of net amounts sequestered and time scales.*

- **Heat Island Mitigation** - Heat islands have regional-scale impacts on energy demand, air quality and public health. Heat island mitigation strategies, such as urban forestry, living (green) roofs, buildings with cross ventilation, and light-colored surfaces may be effective.
 - *Analyses and demonstrations that help determine the cost and value of mitigation strategies, and include appropriate energy and non-energy benefits of strategies, would better inform policy options. Assessments and monitoring of ongoing mitigation*

strategies (e.g. urban forestry projects in New York City) could help improve calibration and validation of regional climate models.

- **Exploratory Strategies to Advance “Carbon Neutral” buildings and facilities** - The concept of reducing the carbon footprint of buildings and human activities has been gaining increasing attention as a green marketing strategy, promoting voluntary action to reduce greenhouse gas emissions. Such green marketing strategies may become a significant driver for investment in energy efficiency and renewable energy in the future. However, to date, there are no accepted methods or uniform definitions for assessing the carbon footprint of a building or activity.
 - *Develop protocols and/or conduct case studies. Support efforts to quantify the embodied energy (i.e. embodied CO₂ emissions) of building materials. Support behavioral science/marketing research to better understand motivating factors for individual action. Try to use the concept to promote greater investment in energy efficiency and renewable energy in New York State.*

SUB-SECTION 6.2:

Understanding and Monitoring Impacts and Managing Risks

INFRASTRUCTURE

- **Electricity Infrastructure** - Summer temperatures in the Northeast have already begun to change and are expected to continue to increase. The warming climate, and associated heat island effect, is increasing the degree-days of cooling required in metropolitan regions, intensifying peak summer electric demand. Additionally, precipitation and stream flow changes could affect hydroelectric generation in New York and the region. These climate-related changes could place additional burdens on New York’s electricity supply, transmission and distribution infrastructure.
 - *Analysis is needed to better understand the impact of climate change on New York’s electricity system, including the potential impact of increased peak demand in the downstate metropolitan area. Refinement of methods to better forecast peak electricity demand days would be useful. Related to this increase in peak electrical demand, research to develop passive means of cooling in buildings is needed, as noted in Section 6.1. From a climate change mitigation standpoint, research and analysis is needed to ensure that the electricity infrastructure can handle the different electric load and capacity profiles associated with the new emerging technologies (e.g., plug-in hybrids, wind, distributed combined heat and power systems). Also, new regulations which could potentially reduce capacity factors of high carbon sources such as coal could have an impact on the grid. Efforts to increase the reliability of the electric grid are critical to reducing human health effects during heat events, when air conditioning is the principal adaptation to prevent mortality.*
- **Water and Waste Treatment Facilities and Transportation Infrastructure** - Climate Change in the form of higher mean and extreme values of temperature and precipitation, as well as sea level rise, will make additional demands on the design, operation and maintenance of New York’s lifeline infrastructure systems, many of which are aging and in need of repair and/or replacement. Such systems including transportation, sewage collection, and water and wastewater treatment facilities, could experience interruption in normal operations, damage, and -in extreme cases- complete loss of facilities at vulnerable sites. Waster treatment facilities that are incapable of handling high flow events have the potential to contaminate drinking water supplies.

- *Research is needed to better understand the climate related impacts and vulnerabilities of our water treatment and transportation infrastructure, and help provide options and guidance to resource managers and state planners.*
- **Landscape and Land Use** - The impacts of changing climate during the next several decades will be intimately linked to land use patterns in New York. Increased severity and greater periodicity of storm events will likely challenge the water storage capacity of the landscape. As land, particularly forested land, is cleared and hardened for development, terrestrial water-storage capacity will decline. In urbanized watersheds, both flood potential and water-loss will likely increase. Effects will be proportional to the extent of development and the ratio of permeable to impervious surfaces within the flood plain.
- *Land use decisions can be influential in mitigating the impacts of climate change. Studies to assist in the planning of local and regional responses to climate change should begin immediately and must address storm water management and water storage issues at the landscape scale. Information is needed to effectively plan for development within watersheds, and the protection of forests, permeable landscapes, wetlands and other natural flood-mitigation and water retention systems.*
- **Hydrology** - Hydrological changes have the potential for wide crosscutting impacts on infrastructure, agriculture (droughts and floods), air quality (stagnation conditions associated with drought, cleansing events), pests and pathogens (many are sensitive to moisture conditions in air and soil), forest productivity, wildlife (waterfowl in particular), land use, shorelines and tidal wetlands. The New York region has already experienced and will continue to experience advances in the dates of lake-ice melting, alterations in the timing of high and low river flow, changes in evaporation, soil moisture, and run-off and increases in summer drought. There are potentially significant economic impacts on parks, recreation and tourism both in winter (availability of snow and ice) and summer (extreme temperatures, low stream and lake levels), especially in upstate New York where tourism is a significant component of the local economies.
- *Research efforts should focus on identifying potentially affected areas and informing land use planning, to lessen climate change impacts related to storm runoff, water supply/demand. Research may be needed to better understand and prepare for changes in hydroelectric generation capacity in the region.*

AGRICULTURE

- **Agriculture** - Climate change may bring new opportunities to New York's agricultural sector but also will pose new risks and challenges for farmers and land managers. Increased pesticide and herbicide use is likely, as well as loss of biodiversity because climate change will tend to favor aggressive invasives at the expense of indigenous species that can't adapt to change or migrate. The agricultural sector also has the potential to help reduce greenhouse gas emissions from agricultural sources as well as mitigate emissions from other sources.
- *Focused research efforts are necessary to address new challenges for New York's agricultural sector associated with a changing climate. And research is needed to help New York's agricultural sector play a role in mitigating climate change (e.g., through production of biofuels, agricultural soil carbon sequestration, reduction of methane emissions, precision feeding to reduce N₂O emissions). Data on key management practices (e.g. tillage, fertilization, manuring, and grazing) could assist in the design of policies to maximize the role of agriculture in mitigating climate change. Also potentially useful would be the establishment of benchmark sites, suitable for*

measurement of soil carbon and other parameters; integration of remote sensing data and development and application of new technologies for more rapid less expensive measurement of carbon stocks and greenhouse gas fluxes; and improvements in our ability to forecast future agricultural greenhouse gas emissions and sinks.

HUMAN HEALTH

- **Human Health** - The changing climate in New York is likely to increase summer-season heat stress morbidity and mortality. From an air quality perspective, the changing climate will affect not only temperature, which plays a key role in photochemical smog production, but also the frequency and strength of stagnation conditions which lead to pollution events. The relationship between climate and air quality is complex. As noted above, the warming climate will increase peak electrical demand on hot summer days, which in turn will exacerbate air quality problems. There is also a potential for changes in human health pathogens, some of which are sensitive to moisture conditions in air and soil.
 - *There are opportunities to provide a better understanding of atmospheric processes and the relationship between climate and air quality in the region. High-quality, long-term monitoring of atmospheric composition to document trends is essential. Improved models and forecasting tools are needed. Research and analysis is needed to develop air quality management strategies (e.g. for NOX, VOC, PM etc.) that also support a climate stabilization policy. Analysis is also needed to better understand and mitigate the potential air quality/smog impacts associated with increasingly frequent peak electrical demand days.*

NATURAL RESOURCES

- **Shoreline and Tidal Wetlands** - New York's wetlands, aquatic vegetation, and natural shoreline help mitigate flooding, clean our water, and provide habitat for fish and other species. These aquatic resources will be threatened by climate change and related rise in sea levels and extreme weather events, which will likely increase habitat and shoreline inundation and displacement, enable the advancement of saline waters farther up the estuary, and increase coastal erosion and vulnerability to storm damage and flooding.
 - *Research efforts would help estimate and quantify the anticipated impacts to these areas and provide guidance to resource managers and municipal planners in order to facilitate pro-active rather than reactive responses.*
- **Forest Composition and Productivity** - Climate change will continue to alter the composition and productivity of northern forests through impacts on reproductive success (including a decoupling of plant-animal pollination and dispersal systems), changes in ecosystem water and nutrient relations, and interactions with pests, pathogens, and invasive species. It is expected that forest tree species will not be able to migrate fast enough to keep up with their respective rapidly changing 'climatic envelopes.'
 - *Monitoring is necessary to document trends and predict forest composition changes. Research efforts could also focus on identifying tree species which will be suitable for the anticipated changes in climate, thereby providing valuable information to New York's timber, pulp and paper industries, as well as to natural resource managers.*
- **Wildlife** - Climate change will continue to impact New York's wildlife abundance and distribution through shifts in habitat structure and food availability, altered susceptibility to and prevalence of parasites and diseases, changes in hibernation patterns and metabolic rates, and responses to extreme hot or cold weather events.

- *Monitoring is necessary to document the impact of a changing climate on New York's diverse wildlife, including the many species listed as endangered, threatened, and of special concern. The information is also critical to estimating the impacts of a changing wildlife mix on other ecosystem components.*
- ***Pests, Pathogens and Invasive Species*** - Climate change will continue to impact the abundance and distribution of 'nuisance species' in New York including pests, pathogens and invasive species by directly altering range, development, reproduction rates and survival, and indirectly altering tree defense mechanisms, competition, and predator abundance.
 - *Regular surveys of invasive species, pests and pathogens are necessary in order for resource managers to prepare for, and potentially avert, significant detrimental impacts to New York's natural resources. Focused research projects will also help identify effective mitigation measures.*
- ***Carbon and Nutrient Cycling*** - Climate change will continue to impact carbon and nutrient cycling directly through changes in temperature-sensitive reaction rates and water-related alterations in diffusivity and redox status, and indirectly through changes in plant, animal and microbial abundance and distribution.
 - *Research focused on the carbon and nutrient cycling processes impacted by a changing climate will help inform the management of natural resources, and contribute to related research efforts in areas such as acid deposition effects and eutrophication of lakes and coastal areas.*

SECTION 7. NEXT STEPS

This next step in this joint initiative of the New York Academy of Sciences and NYSERDA is to conduct a climate change research scoping workshop. This effort will engage key science and policy experts to help identify research priorities and provide direction for environmental research and monitoring needs on climate change in New York State for the next five years. The input from the workshop will also assist in finalizing this background paper. NYSERDA will use the results of the planning efforts to develop a research plan for the EMEP program, and will issue solicitations, starting in summer 2007, seeking proposals which address the targeted research areas.

This climate change research initiative is a work in progress. NYSERDA will continue to seek input from stakeholders and coordinate activities with interested parties to the greatest extent possible.

Addressing climate change issues will require a long term commitment from multiple sectors across local, regional, national and global levels. It is our hope that this effort will contribute to that effort by better defining research needs, exploring creative solutions, and fostering cooperation among stakeholders.

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APPENDIX A: State Clean Energy Program Activities

The next two tables adapted from EPA Clean Energy: State Clean Energy Program Activities
<http://www.epa.gov/cleanenergy/pdf/summary-matrix.pdf>

Table A.1. Summary of State Clean Energy Environmental Actions: Energy Efficiency Actions

State	Energy Efficiency Portfolio Standards (EEPS) †	Public Benefits Funds (PBF) for Energy Efficiency ‡	Building Codes for Energy Efficiency §		State Appliance Efficiency Standards ¶
			Commercial	Residential	
Alabama				NC	
Alaska				C2	
Arizona		C			C
Arkansas			C2	C2	
California	C	C	C2	C2	C
Colorado					
Connecticut	C	C	C2	C2	C
Delaware			C1	C1	
Florida			C2	C1	
Georgia			C2	C1	
Hawaii	C		NC	NC	
Idaho			C2	C2	
Illinois	C	C	C1		BC
Indiana			NC	NC	
Iowa			NC	NC	
Kansas			C2	C2	
Kentucky			C2	C1	
Louisiana		BC	C2	NC	
Maine		C	C2		
Maryland			C2	C2	C
Massachusetts		C	C1	NC	C
Michigan		C	C1		
Minnesota			NC	NC	
Mississippi					
Missouri					
Montana		C	C2	C2	
Nebraska			C2	C2	
Nevada	C		C2	C2	
New Hampshire		C	C1	C1	
New Jersey	IP	C	C1	NC	C
New Mexico			C2	C2	
New York		C	C1	C1	C
North Carolina			C2	C1	BC
North Dakota			NC	NC	
Ohio		C	C2	C2	

Oklahoma				C1	
Oregon		C	C2	C2	C
Pennsylvania	C		C2	C2	BC
Rhode Island		C	C2	C2	C
South Carolina			C2	C2	
South Dakota					
Tennessee				NC	
Texas	C	C	C1	C1	
Utah			C2	C2	
Vermont		C	C1	C1	
Virginia			C2	C2	
Washington			C2	C2	C
West Virginia			C1	C1	
Wisconsin		C	C1	C1	
Wyoming					
Tally of Activities					
Completed	7	17	35*	31*	10
In Progress	1	0	0	0	0
Being Considered	0	1	0	0	3
Total (past action)	8	18	0	0	13
No Activity Identified	42	32	10	9	37

C: completed; IP: in progress; BC: being considered; blank cell: no activity identified

† HI, NV, and PA have indirect EEPS as part of their RPS/AEPS (Alternative Energy Portfolio Standard); IL EEPS is a goal (not a requirement) under Sustainable Energy Plan.

‡ States also support energy efficiency through utility demand-side management (not covered here). Texas's program is tied to the state's utility energy efficiency savings targets (a restructuring law requires utilities to administer energy efficiency programs to achieve savings equivalent to 10% of annual load growth) and costs are covered through a nonbypassable charge in transmission and distribution rates.

§ For Building Codes Only: C2 = Goes Beyond ECPA C1 = Meets ECPA NC = Does Not Meet ECPA *Number that meet or exceed ECPA (C2+C1)

¶ MA "complete" as of 11/22/05.

Table A.2. Summary of State Clean Energy Environmental Actions: Energy Supply Actions

State	Renewable Portfolio Standards (RPS) †	Public Benefits Funds (PBF) for State Clean Energy Supply Programs ‡	Output-Based Environmental Regulation to Support Clean Energy	Interconnection Standards	
				Clean Distributed Generation §	Net Metering ¶
Alabama					
Alaska					
Arizona	C	C		BC	C
Arkansas					C
California	C	C	C	C	C
Colorado	C				C
Connecticut	C	C	C	C	C
Delaware	C	C	C	C	C
Florida					C
Georgia					C
Hawaii	C			C	C
Idaho					C
Illinois		C		IP	C
Indiana			C	C	C
Iowa	C			BC	C
Kansas					
Kentucky					C
Louisiana					C
Maine	C		C		C
Maryland	C		C		C
Massachusetts	C	C	C	C	C
Michigan	BC			C	C
Minnesota	C	C		C	C
Mississippi					
Missouri					
Montana	C	C			C
Nebraska					
Nevada	C				C
New Hampshire			C		C
New Jersey	C	C	C	C	C
New Mexico	C			C	C
New York	C	C	C	C	C
North Carolina	BC			IP	IP
North Dakota					C
Ohio		C	C	C	C
Oklahoma					C
Oregon		C			C
Pennsylvania	C	C		IP	C
Rhode Island	C	C			C

South Carolina					
South Dakota					
Tennessee					
Texas	C		C	C	C
Utah					C
Vermont	C			IP	C
Virginia					C
Washington				IP	C
West Virginia					
Wisconsin	C	C		C	C
Wyoming					C
Tally of Activities					
Completed	21	15	12	14	39
In Progress	0	0	0	5	1
Being Considered	2	0	0	2	0
Total (past action)	23	15	12	21	40
Activity Identified	27	35	38	29	10

C: completed; IP: in progress; BC: being considered; blank cell: no activity identified

† MN RPS applicable only to state's largest utility -- others need "good faith effort." IL Sustainable Energy Plan has a RPS goal (but it is not mandatory).

‡ ME's PBF for renewable energy is voluntary and is thus considered No Action.

§ IN "complete" as of 11/22/05.

¶ "Completed" status may fall into one of three categories: net metering offered by one or more individual utilities, state-wide net metering for certain utility types, or state-wide net metering for all utility types.

APPENDIX B: Federal Climate Change Research Initiatives

The following sections provide a description of the specific research agenda of several federal agencies participating in the U.S. Climate Change Science Program. Table B.1 at the end of this appendix summarizes how funds are distributed between different program goals and agencies.

U.S. Department of Agriculture (USDA)

In support of the CCSP goals, the USDA³² conducts and supports research that encompasses a broad range of activities, through its *Agricultural Research Service (ARS)*; the *Cooperative State Research, Education, and Extension Service (CSREES)*; the *Economic Research Service (ERS)*; the *Forest Service (FS)*, and the *Natural Resources Conservation Service (NRCS)*. Research includes the evaluation of environmental changes likely to threaten natural resources, forestry and agriculture, including adaptation measures, as well as activities within these sectors that are drivers of environmental changes. The agency sponsors research to identify approaches to reduce GHG emissions (e.g., best management practices), their capture (e.g. for methane) and their storage (e.g., soil carbon sequestration) and is also evaluating the potential of bioenergy as a substitute for fossil fuels.

Highlights of different USDA programs related to Climate Change research:

The USDA's ARS national program aims to develop a scientific knowledge base for producers, land managers and decision makers, in order to assist them in making decisions about adaptation to climate change and how best to reduce agricultural contributions of GHG and other trace gases. The program supports data gathering efforts to measure agricultural GHG emissions, sequestration, as well as research to assess the impacts of elevated CO₂ on plants, and the hydrological effects of climate change on agriculture, in particular regarding droughts and water supply.

Through its Cooperative State Research, Education, and Extension Service (CREES) program, the USDA supports the Ultraviolet B Monitoring and Research Network, providing critical information to estimate UV-B impacts on crops and forests. CREES' National Research Initiative (NRI) competitive grants program sponsors agriculture sector research on: carbon and nutrient cycling; air and water quality; changes in land-use and land-cover; as well as agricultural waste management and invasive species.

The USDA's Forest Service research focuses on improving forest management and policy decisions. Sponsored research covers a broad range of issues, including: a) improving the understanding of a carbon cycling in biomass, forests soils, soils and forest products; b) the potential of forest soils to sequester carbon and mitigate the greenhouse effect; c) how climate change may affect forest health and productivity, plant species variation and migration; d) the development of forest carbon inventories;³³ as well as e) managing techniques to improve mitigation and adaptation measures.³⁴ The USDA also participates in the Climate Change Technology Program (CCTP) and other related research and technology deployment efforts.

U.S. Department of Energy (U.S. DOE)

In addition to several programs targeting energy conservation, technologies and renewables, the U.S. DOE focuses on assessing the impacts of energy production and use on the global climate system,

32. The USDA is the lead agency preparing the CCSP Synthesis and Assessment Product 4.3, "The Effects of Climate Change on Agriculture, Biodiversity, Land, and Water Resources" expected to be completed by the end of 2007. USDA is also collaborating with other agencies additional products identified in the *CCSP Strategic Plan, including the Synthesis and Assessment Report 2.2, "North American Carbon Budget and Implications for the Global Carbon Cycle."*

33. Birdsey, R.A. and G.M. Lewis; *Carbon in United States Forests and Wood Products, 1987-1997: State-by-State Estimates*; USDA Forest Service Newtown Square, PA. http://www.fs.fed.us/ne/global/pubs/books/epa/Us1_5_forest.doc

34. Further information about the USDA sponsored climate change research is available at: <http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-usda.pdf> and a description of information about the Forest Service is accessible from: <http://www.fs.fed.us/ne/global/>

through studies of climate response to changes in greenhouse gas and aerosol concentrations. The three main program areas on climate change research (coordinated by DOE's Office of Science) include: 1) climate change modeling, 2) climate forcing, and 3) climate change response, as well as 4) related research, including carbon sequestration aimed at reducing atmospheric concentrations of GHG associated to energy generation.³⁵

Highlights of U.S. DOE research related to Climate Change:

Modeling: In collaboration with the NSF and NASA, the U.S. DOE³⁶ works to improve the fully coupled (atmospheric-ocean-sea ice-land surface) General Circulation Models (GCMs), which are capable of simulating climatic variability and change over different time scales (ranging from decades to centuries). This effort is part of the U.S. contribution to the Intergovernmental Panel on Climate Change (IPCC) and its Fourth Assessment Report is scheduled for release in 2007. Assessments are accessible to the climate research community. Furthermore, the DOE-wide Scientific Discovery through Advanced Computing (SciDAC) initiative supports model development of the Community Climate System Model (CCSM),³⁷ in order to integrate atmospheric chemistry and coupled biogeochemistry, as well as improved physics and dynamics.

Climate Forcing: In an effort to improve climate change modeling, the DOE's Office of Science continues to collect and analyze data from DOE's Atmospheric Radiation Measurement (ARM) Cloud and Radiation Test Bed (CART) sites. In conjunction with this effort, the DOE's Office of Biological and Environmental Research (OBER) supports the development of "innovative techniques for observational data analysis and improved or new climate modeling parameterizations that represent clouds and their impact on the atmospheric radiation balance."³⁸

Climate Change Response: The U.S. DOE seeks to understand the effects of climate variability and environmental change on the structure and processes of terrestrial systems, through the design, implementation and maintenance of large scale and long term field experiments. DOE's Office of Biological and Environmental Research (OBER) supports new experimental research to assess the potential effects of climate change on terrestrial ecosystems and related organisms in the U.S. The focal point of this research is the extent to which projected temperature increases will affect the abundance and/or geographic distribution of plant or animal species in the U.S.³⁹ In addition, DOE's Integrated Assessment of Global Climate Change Research Program supports integrated analyses to evaluate the relative efficiencies and impacts of various mitigation strategies as well as biomass-derived renewable energy.

U.S. Department of Transportation (U.S. DOT)

Most of the federal research on global climate change related to the transportation sector is coordinated by the US DOT's Center for Climate Change and Environmental Forecasting (CCCEF),⁴⁰ which promotes an extensive and integrated approach to reduce GHG, to prepare for potential impacts of global change, and to support adaptive management and planning strategies for

35. Additional information about the climate change research supported by DOE is available at:

<http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-doe.pdf>

36. The DOE is in charge of developing the Synthesis and Assessment Product 3.1, "*Climate Models: An Assessment of Strengths and Limitations for User Applications.*"

37. For an overview of the CCSM project, go to: <http://www.cesm.ucar.edu/overview/>

38. Text from a current solicitation that may be found at: <http://www.sc.doe.gov/grants/FAPN07-24.html>

39. Further information is available at: <http://www.sc.doe.gov/grants/FAPN07-11.html>

40. Nine DOE operational administrations participate in the Center, including the Federal Highway Administration (FHWA) the Federal Aviation Administration (FAA) and the Maritime Administration (MARAD), as well as the Office of the Secretary of Transportation

the transportation sector. In support of the CCSP goals, the US DOT conducts and sponsors research on the following areas:⁴¹

Impact of Climate Variability and Change on Transportation: this program supports assessments of the potential effects of global change on transportation, such as the effect that sea-level rise may have on the sector's infrastructure and services.

Increasing Energy Efficiency and Reducing Greenhouse Gas Emissions: efforts supported under this program include projects to reduce the GHG and air quality impacts of freight transportation, assessments of GHG emissions benefits of heavy-duty natural gas vehicles and engine technologies with lower GHG impact than conventional diesel engines, as well as projects to limit emissions of GHG from the aviation sector, including improved air traffic management, reduced vertical separation minimums, and deploying low emissions technology to airport operations; and, analyses of the costs associated with achieving reductions in transportation related emissions.

Modeling: to expand and improve the transportation greenhouse gas analyses, for example, by developing a tool to determine the relative contribution of emissions from different modes of transportation (e.g., aviation, automobile, marine, and diesel transportation), or by developing models to analyze total fuel-cycle GHG and other emissions associated with transporting freight along land-side and water-side routes. The Center also supports efforts to reduce uncertainties, for example those associated to aviation emissions and their potential impact on climate variability and change (e.g., studies of the effects of aircraft contrails on climate change).

Institutional capacity building and decision-making: The Center has sponsored research that provides planning and engineering professionals with the necessary information to make informed decisions on how to respond to the potential impacts of climate change related to hydrologic impacts

U.S. Department of the Interior (DOI) / US Geological Service (USGS)

The Department of Interior / USGS contributes directly to the goals of the Climate Change Science Program through research that improves the knowledge of the Earth's past and present climatic conditions and the environment, focusing on the relationship between climate, earth surface processes, and ecosystems, over time scales ranging from years to millennia. The USGS supports studies that address the impacts of climate change on: a) landscapes and ecosystems; b) hydrologic systems; c) land-use and land-cover changes, and research to improve the understanding of carbon cycles. It also supports studies to assess the sensitivity and adaptability of natural and managed ecosystems to climate changes as well as research to improve management and development systems. Specific USGS programs supporting climate change research include target: 1) Earth Surface Dynamics; 2) Geographic Analysis and Monitoring; 3) Hydroclimatology; 4) Carbon Cycle; 5) Changes in Ecosystems; 6) Satellite Data Management and Dissemination, and 7) Land Use and Land Cover.⁴²

U.S. Environmental Protection Agency (EPA)

The U.S. EPA's Global Change Research Program emphasizes assessments of the potential impacts of climate change at the global scale, in four target areas:

41. Information from <http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-dot.pdf> and <http://climate.volpe.dot.gov/areas.html>

42. A description of the goals of these programs is available at <http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-usgs.pdf>

Air Quality: EPA supports studies that examine the potential effects of global change on air quality; focusing on improving the analytical tools to conduct these assessments.

Water quality: and its relationship to changes in runoff ensuing from land use changes, and variations in precipitation and evapotranspiration processes.

Ecosystems: three research activities are planned to assess the effects of climate change on aquatic ecosystems⁴³; invasive non-indigenous species and ecosystem services.

Human health: U.S. EPA's emphasis under the CCSP initiative is on integrated health evaluation frameworks that consider the effects of multiple stresses, their interactions, and human adaptive responses.

The EPA and other CCSP federal agencies emphasize research focused on the possible consequences of global change on weather-related morbidity and vector- and water-borne diseases in the United States.

The EPA also works to improve the scientific knowledge for assessing the impacts of global change in the context of other stressors, evaluating the risks and opportunities presented by global change, and adaptation options. EPA supports investigations conducted through public-private partnerships (including academic institutions, resource managers, decision-makers and other stakeholders), and promotes the integration of results of studies in the four program areas to address concerns common to a particular environment (e.g., a watershed).⁴⁴

National Science Foundation (NSF)

The global change research programs of the NSF⁴⁵ support studies and related activities that improve the understanding of Earth system processes (including physical, chemical, biological, and human systems and their interactions) in the face of global change. NSF also supports research on processes being used by various agencies and organizations in order to identify and evaluate policies for mitigation, adaptation, and other responses to address varying environmental conditions.

Programmatic activities include support for research in several areas, including: 1) Atmospheric Composition; 2) Climate Variability and Change; 3) The Global Water Cycle; 4) Land-Use and Land-Cover Change; 5) Global Carbon Cycle; 6) Ecosystems; 7) Human Contributions and Responses; and 8) International Research and Cooperation.

The National Oceanic and Atmospheric Administration (NOAA) (U.S. Department of Commerce)

<http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-doc.pdf>

NOAA's mission aligns with the goals of the CCSP, in conducting and sponsoring research on climate variability and change in order to improve society's planning and management capabilities. Specific goals include: understand the climate system relying on data collection, analysis and management; improve understanding of atmospheric composition and its contribution to climate change; provide climate forecasting to improve planning for climate impacts; predict impact of climate change on marine ecosystems; provide information and tools that can be used to manage climate and weather-related risks to the US economy. NOAA's climate change objectives are achieved through its various programs: Climate Observation and Analysis, Climate Forcing, Climate Predictions and Projections, Climate and Ecosystems, and Regional Decision Support

43. EPA's investigations of the effects of global change on aquatic ecosystems (including lakes, rivers, and streams; wetlands; and estuaries and coastal ecosystems) will use as input the research being done by other CCSP agencies on marine and terrestrial ecosystems.

44. Information on EPA's Climate Change research is accessible from:

<http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-epa.pdf>

45. <http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-nsf.pdf>

U.S. Department of Health and Human Services

<http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-hhs.pdf>

The Department of Health and Human Services supports various research projects related to the health effects of global change, including:

- The National Institutes of Health (NIH) supports research on exposure to ultraviolet (UV) and near-UV radiation is part of the CCSP. Its goals are: improving understanding of the effects of UV and near-UV radiation on certain organs, molecular changes and genetic susceptibilities that lead to these effects, and developing strategies to prevent disease.
- The National Institute of Environmental Health Sciences (NIEHS) supports research on the health effects of air pollution and temperature, agricultural chemicals, and materials used in new technologies to mitigate or adapt to climate change.

The Centers for Disease Control and Prevention (CDC) is involved in emerging and reemerging infectious diseases among other initiatives related to climate change.

Smithsonian Institution (SI) <http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-smithsonian.pdf>

Global change research is conducted at the Smithsonian Astrophysical Observatory (SAO), the National Air and Space Museum (NASM), the Smithsonian Environmental Research Center (SERC), the National Museum of Natural History (NMNH), the Smithsonian Tropical Research Institute (STRI), and the National Zoological Park (NZIP). Main research topics include atmospheric processes, ecosystem dynamics, natural and anthropogenic environmental change observation, and defining longer term climate proxies present in the museums' collections and geologic record at field sites. One of the goals of the Smithsonian Institution is to better understand the natural processes involved in climate change, store climate-relevant research materials, and divulge this knowledge.

Specific research projects include:

- Atmospheric Composition: UV-B data collection by SERC (to assess the biological and chemical impact of varying ultraviolet radiation exposures)
- Climate Variability and Change (NASM): use of remote-sensing data to improve theories of drought, sand mobility, soil stability, and climate change in the eastern Sahara.
- Paleocology of climate change (NMNH and STRI).
- Terrestrial and Marine Ecosystems responses to global change: SERC will study ecosystem responses to increased CO₂, invasive species, and solar UV-B; STRI, NMNH, and NZIP will focus on biodiversity education and research. NZIP will conduct studies on ecosystem response to increasing habitat fragmentation.
- Human Dimensions of Global Change: exhibits will be displayed at NMNH to inform the general public and researchers of global change research conducted by Smithsonian and other CCSP.

Other SI research addressing CCSP goals (but not directly funded by CCSP) includes:

- Stratospheric and tropospheric composition at SAO, including pollution measurements from space, which will eventually develop into continuous global monitoring.
- Studies on solar activity and its relationship to climate at SAO
- Ecosystem responses to increased carbon dioxide, UV-B, and invasive species (SERC and STRI)
- Natural and human induced variations in species, populations-communities, and ecosystems (several units within the SI).

Table B.1

FY 2005-2007 Climate Change Science Program budget by goal and focus area

Description of Focus Area	Budgets (Million \$)			Agencies
	FY 2005	FY 2006 Estimate	FY 2007 Request	
GOAL 1: Improve knowledge of the Earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and changes				
Better understand natural long-term cycles in climate [e.g., Pacific Decadal Variability (PDV), North Atlantic Oscillation (NAO)]	35.7	37.9	40.2	NOAA, DOE, USGS, NASA, NSF
Improve and harness the capability to forecast El Niño-La Niña and other seasonal-to-interannual cycles of variability	24.2	22.4	21.8	DOE, USGS, NASA, NSF
Sharpen understanding of climate extremes through improved observations, analysis, and modeling, and determine whether any changes in their frequency or intensity lie outside the range of natural variability	37.4	38.1	38.4	NOAA, DOE, USGS, NASA, NSF
Increase confidence in the understanding of how and why climate has changed	43.2	43.3	44.5	DOE, USGS, NASA, NSF, SI
Expand observations and data/information system capabilities	67.0	71.4	95.4	NOAA, DOE, USGS, EPA, NASA, NSF, SI
Goal 1 Total	207.5	213.0	240.6	
GOAL 2: Improve quantification of the forces bringing about changes in the Earth's climate and related systems				
Reduce uncertainties about the sources and sinks of greenhouse gases, emissions of aerosols and their precursors, and their climate effects	102.3	101.1	98.9	NOAA, DOE, DOT, NASA, NSF
Monitor the recovery of the ozone layer and improve the understanding of the interactions of climate change, ozone depletion, tropospheric pollution, and other atmospheric issues	33.3	31.6	27.0	USDA, DOE, NASA, NSF, SI
Increase knowledge of the interactions among emissions, long-range atmospheric transport, and transformations of atmospheric pollutants, and their response to air quality management strategies	39.8	36.6	36.7	USDA, NASA, NSF
Develop information on the carbon cycle, land cover and use, and biological/ecological processes by helping to quantify net emissions of carbon dioxide, methane, and other greenhouse gases, thereby improving the evaluation of carbon sequestration strategies and alternative response options	145.4	139.0	135.4	USDA, NOAA, DOE, USGS, NASA, NSF, SI
Improve capabilities to develop and apply emissions and related scenarios for conducting "If... then..." analyses in cooperation with CCTP	4.8	4.9	6.8	DOE
Goal 2 Total	325.6	313.3	304.8	

Description of Focus Area	Budgets (Million \$)			Agencies
	FY 2005	FY 2006 Estimate	FY 2007 Request	
GOAL 3: Reduce uncertainty in projections of how the Earth's climate and related systems may change in the future				
Improve characterization of the circulation of the atmosphere and oceans and their interactions through fluxes of energy and materials	47.8	48.8	48.2	NOAA, DOE, NASA, NSF
Improve understanding of key "feedbacks" including changes in the amount and distribution of water vapor, extent of ice and the Earth's reflectivity, cloud properties, and biological and ecological systems	83.0	85.1	79.5	DOE, USGS, NASA, NSF
Increase understanding of the conditions that could give rise to events such as rapid changes in ocean circulation due to changes in temperature and salinity gradients	7.7	7.7	8.6	USGS, NASA, NSF
Accelerate incorporation of improved knowledge of processes and feedbacks into climate models to reduce uncertainty in projections of climate sensitivity, changes in climate, and related conditions such as sea level	88.7	99.9	103.1	NOAA, DOE, NASA, NSF
Improve national capacity to develop and apply climate models	46.8	43.8	43.9	NOAA, DOE, NASA, NSF
Goal 3 Total	274.0	285.2	283.2	
GOAL 4: Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes				
Improve knowledge of the sensitivity of ecosystems and economic sectors to global climate variability and change	67.8	61.0	60.7	USDA, DOE, USGS, EPA, NASA, NSF, SI
Identify and provide scientific inputs for evaluating adaptation options, in cooperation with mission-oriented agencies and other resource managers	64.6	65.0	65.2	HHS, DOT, EPA, NSF, SI
Improve understanding of how changes in ecosystems (including managed ecosystems such as croplands) and human infrastructure interact over long time periods	43.6	45.5	34.3	USDA, DOE, NASA, NSF, SI
Goal 4 Total	176.0	171.5	160.1	

Description of Focus Area	Budgets (Million \$)			Agencies
	FY 2005	FY 2006 Estimate	FY 2007 Request	
Goal 5: Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change				
Support informed public discussion of issues of particular importance to U.S. decisions by conducting research and providing scientific synthesis and assessment reports	92.3	101.3	69.4	USDA, DOE, USGS, EPA, NASA, NSF, SI
Support adaptive management and planning for resources and physical infrastructure sensitive to climate variability and change; build new partnerships with public and private sector entities that can benefit both research and decision-making	54.7	63.2	69.5	USDA, NOAA, USGS, USAID, EPA, NASA, NSF
Support policymaking by conducting comparative analyses and evaluations of the socioeconomic and environmental consequences of response options	12.5	9.6	11.8	USDA, NASA, SI
Goal 5 Total	159.5	174.1	150.7	
CCSP PROGRAM TOTAL	1,142.5	1,157.1	1,139.5	

**Table B.2
Climate Change Technology Program (CCTP) - Participating Agencies & Budget (\$Millions)***

Agency and Program	FY 2005 Enacted	FY 2005 Enacted	FY 2007 Request
Department of Agriculture (USDA)			
Natural Resources Conservation Service (NRCS) - Biomass R&D (Section 9008 Farm Bill)	13.0	12.0	12.0
Forest Service R&D – Inventories of carbon biomass	0.5	0.5	0.5
Agricultural Research Service – Bioenergy Research	2.4	2.4	2.4
Cooperative State Research, Education and Extension Service (CRSEES) - Biofuels/ Biomass Research; formula funds, National Research Initiative	4.7	4.7	3.4
Forest Service – Biofuels/ Biomas, Forest and Rangeland Research	2.4	2.4	2.8
Rural Business Service–Renewable Energy Program & Value Added Producer Grants	24.8	25.3	12.7
Subtotal - USDA	48.2	47.8	34.2
Department of Transportation (DOT)			
Office of the Secretary for Technology – Transportation, Policy, R&D	0.8	0.0	0.0
National Highway Traffic Safety Administration	0.0	0.9	0.9
Research and Innovative Technology Administration	0.5	0.5	0.5
Subtotal - DOT	1.3	1.4	1.4
Department of Energy (DOE)			
Energy Efficiency and Renewable Energy	1,234.3	1,174.0	1176.3
Fossil Energy	373.8	404.5	419.1
Nuclear Energy	291.4	332.5	463.3
Science	385.5	422.6	551.4
Electricity Delivery and Energy Reliability	57.4	73.0	100.3
Climate Change Technology Program Direction (CCTPD)	-	0.0	1.0
Subtotal - DOE	2,342.4	2,406.5	2,711.4
Environmental Protection Agency (EPA)			
Environmental Programs and Management	90.5	90.0	91.9
Science and Technology	19.0	18.6	12.5
Subtotal EPA	109.5	108.6	104.4
National Aeronautics and Space Administration (NASA)			
Exploration, Science & Aeronautics			
Subtotal NASA	207.8	104.4	85.8
National Science Foundation (NSF)			
Research and Related Activities	10.6	17.7	18.6
Subtotal NSF	10.6	17.7	18.6
Department of Interior (DOI)			
US Geological Survey – Surveys, Investigations and Research; Geology Discipline; Energy Program	2.4	0.0	0.0
Subtotal - DOI	2.4	0.0	0.0
Other participating agencies	194.4	196.6	129.0
TOTAL budget for CCTP	2,807.1	2,774.4	2,980.4

Other federal agencies participating in the CCTP, with related budget allocations include: the Department of Commerce (International Trade Administration and National Institute of Standards and Technology); and the Department of Defense.

* Information from Appendix A of the CCTP Strategic Plan (2006)

<http://www.climatechange.gov/stratplan/final/CCTP-StratPlan-App-Sep-2006.pdf>

Cabinet-Level Committee on Climate Change Science and Technology Integration

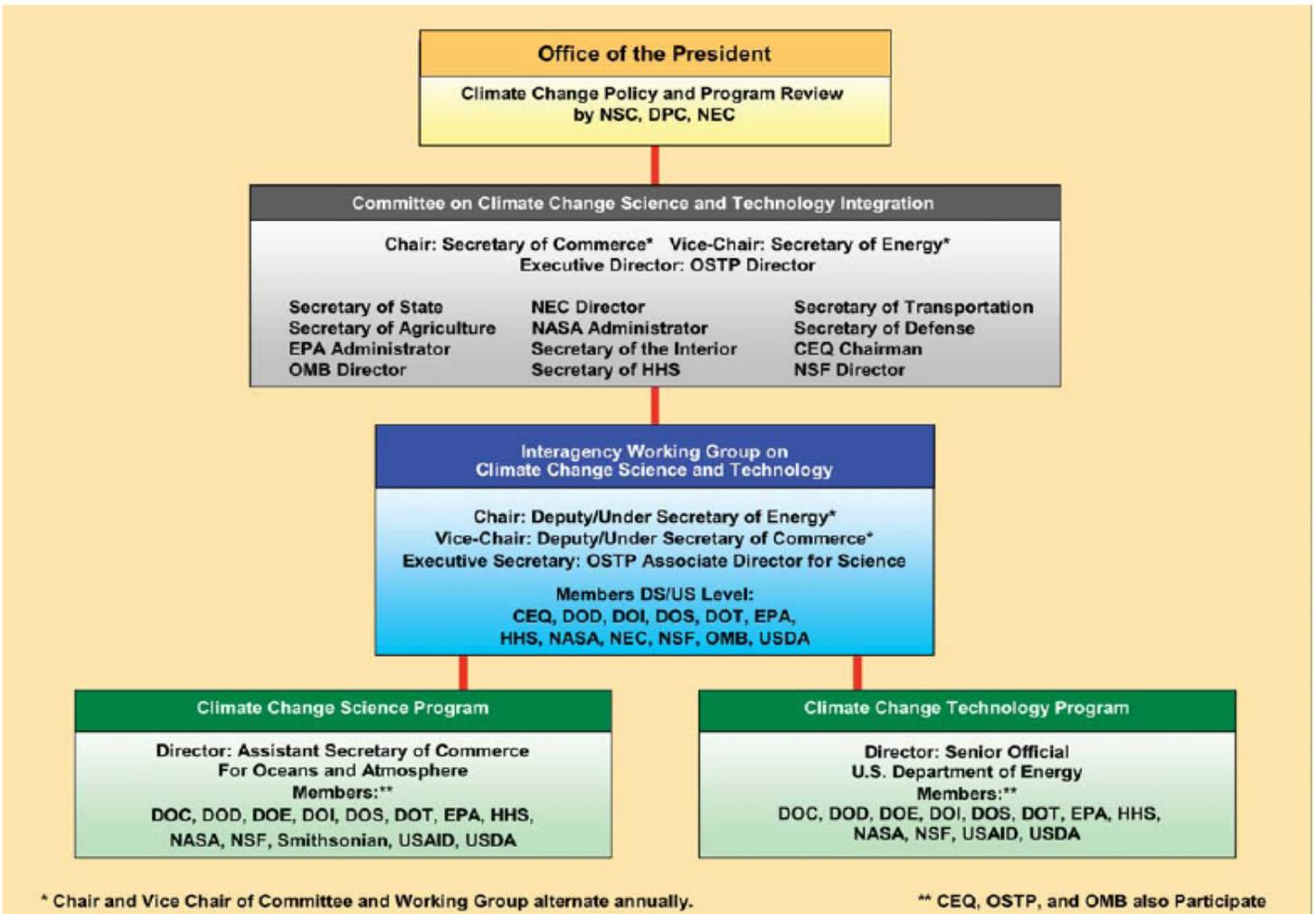


Figure 1-2. Cabinet-Level Committee on Climate Change Science and Technology Integration

APPENDIX C: New York State CO₂ Statistics

Figure C.1. - DRAFT 3/14/07

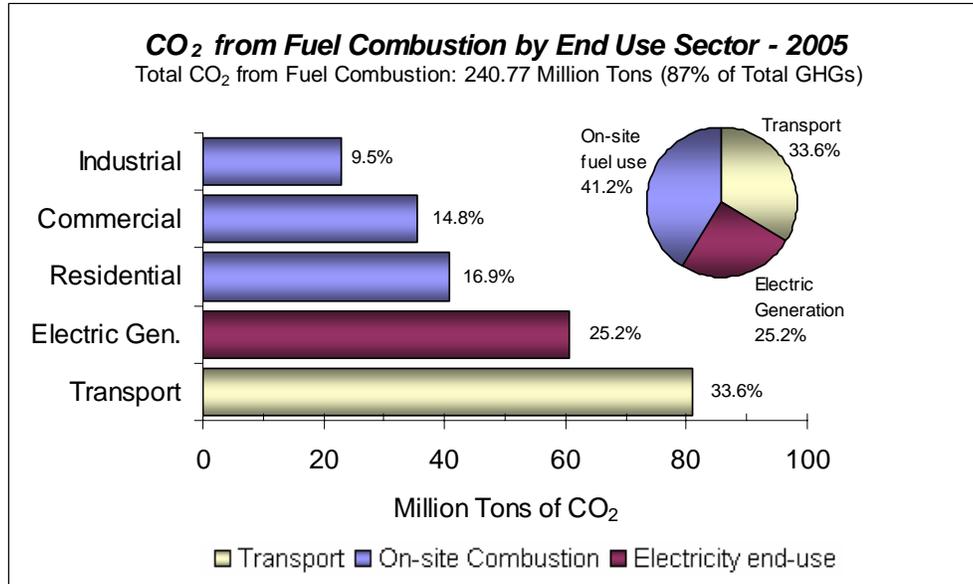
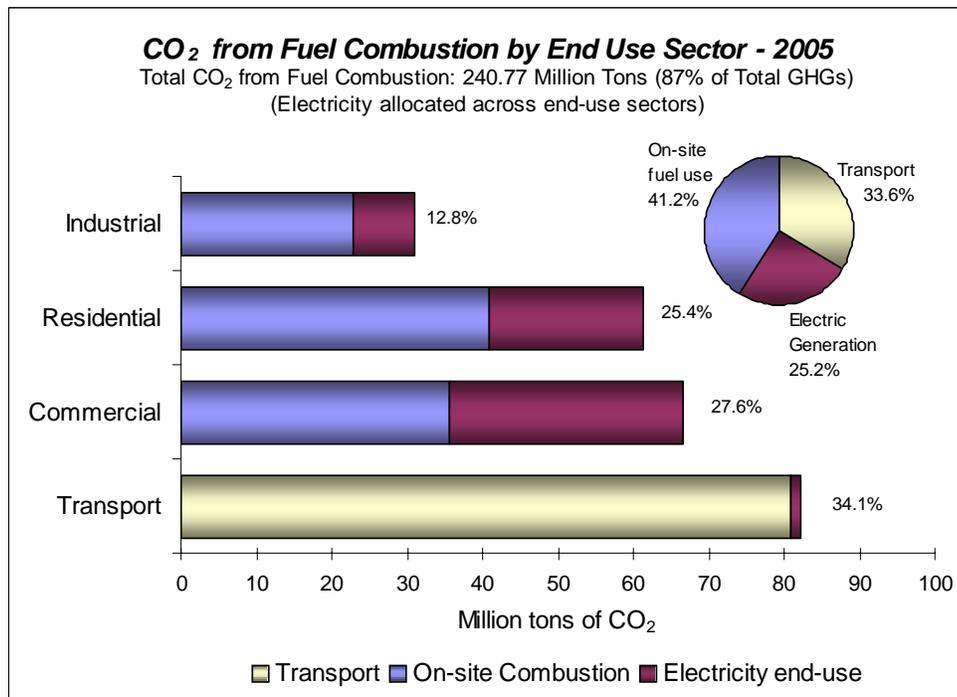


Figure C.2. - DRAFT 3/14/07



Source: Draft - New York State Greenhouse Gas Emissions and Trends 1990-2005, NYSERDA Energy Analysis Program. Do not cite or quote.

Figure C.3. - DRAFT 3/14/07

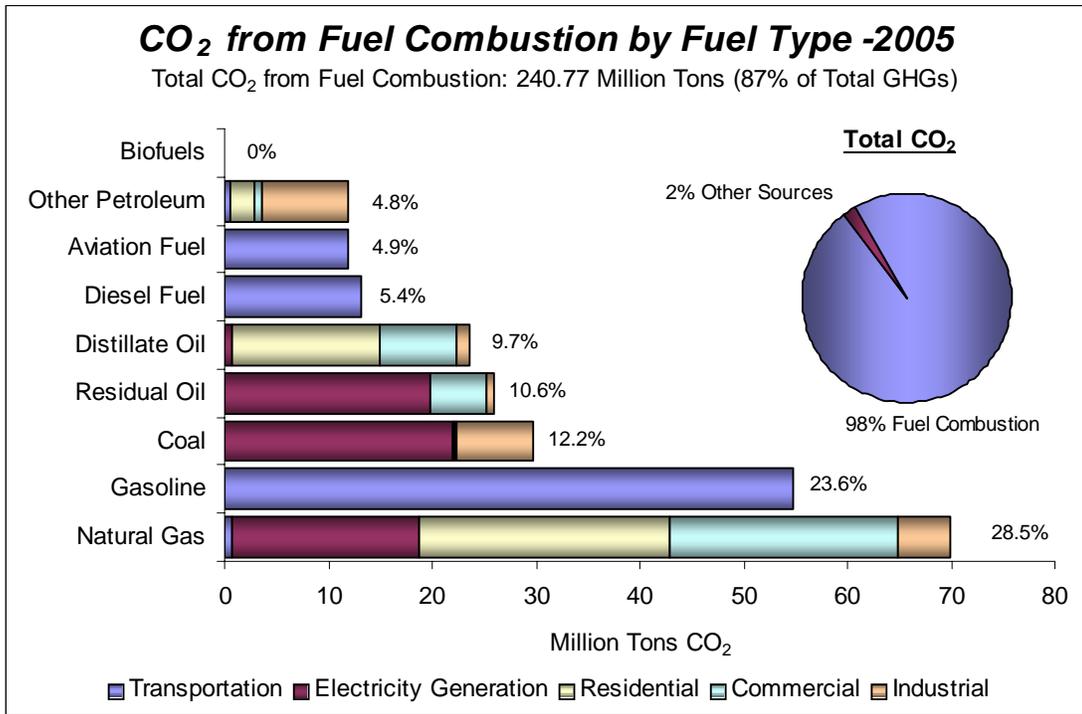
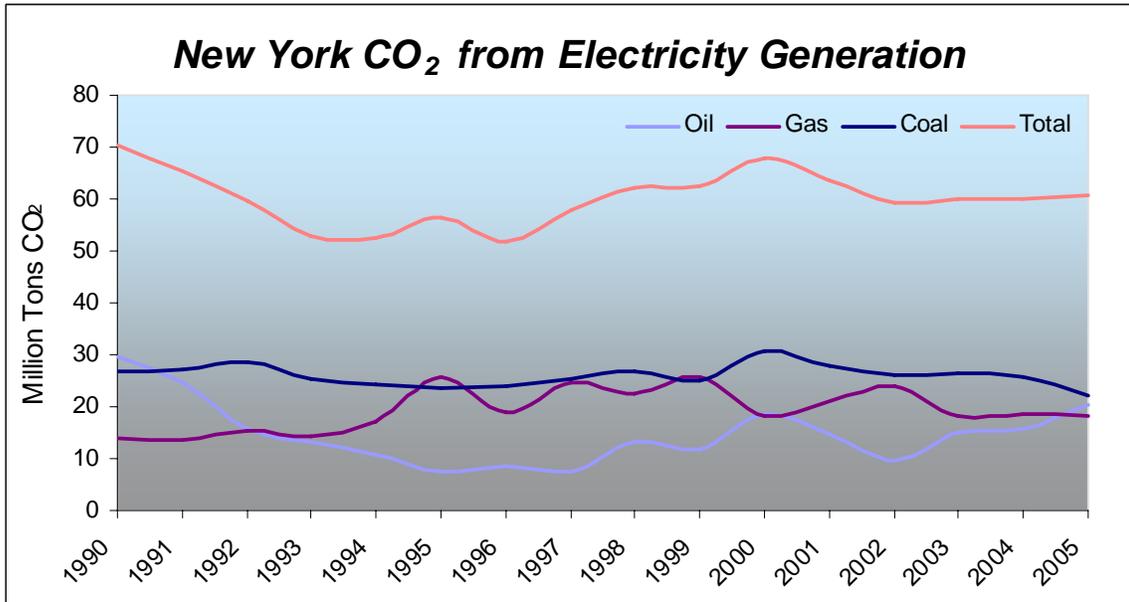
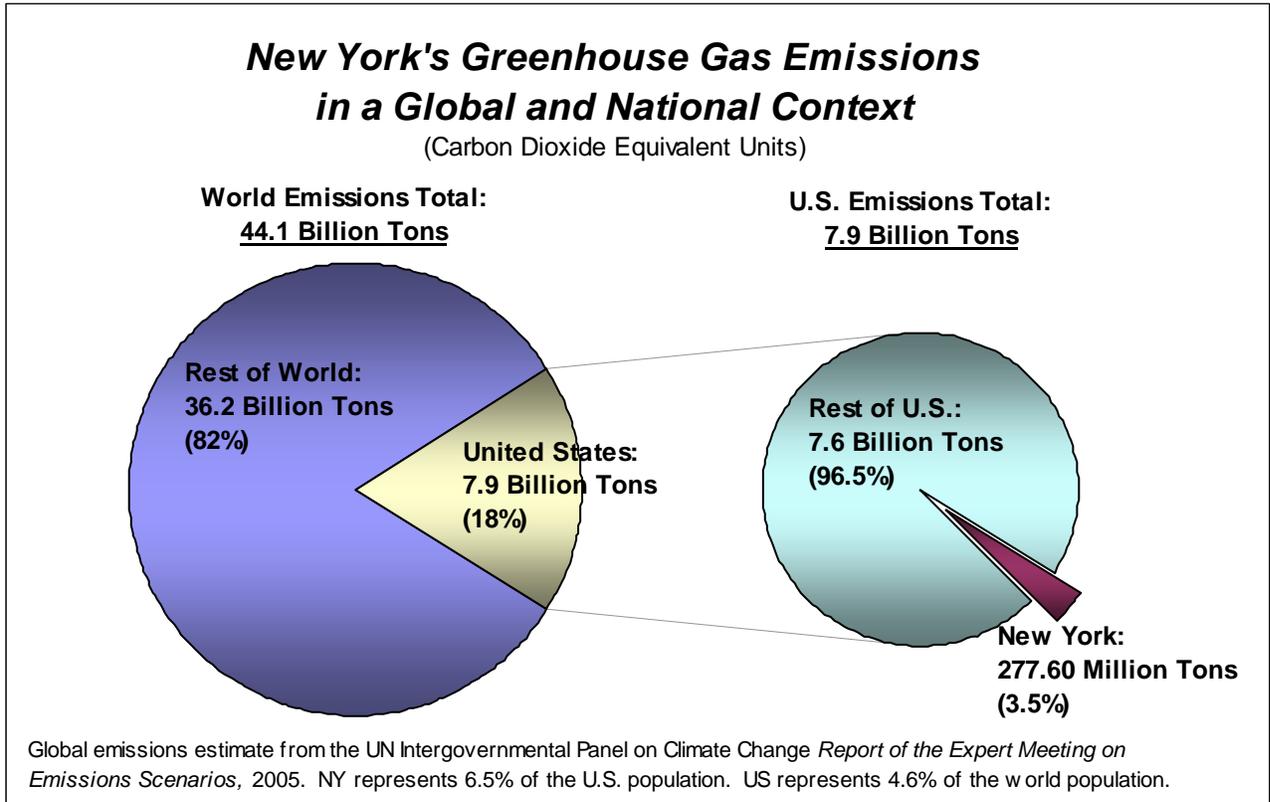


Figure C.4. - DRAFT 3/14/07



Source: Draft - New York State Greenhouse Gas Emissions and Trends 1990-2005, NYSERDA Energy Analysis Program. Do not cite or quote.

Figure C.4. - DRAFT 3/14/07



Source: Draft - New York State Greenhouse Gas Emissions and Trends 1990-2005, NYSERDA Energy Analysis Program. Do not cite or quote.