TOGETHER NORTH JERSEY.

Energy and Climate Baseline Topic Report

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Table of Contents

LIST OF FIGURES

Executive Summary

Climate change science points to a critical link between the use of energy and impacts on the earth's climate. There is wide consensus within the global scientific community that, not only does this link exist, but that the earth's climate is changing due in large part to the over-abundance of greenhouse gases (GHG) in the atmosphere. If steps are not taken to reverse these trends, then rising sea levels and extreme weather events that result from increased levels of greenhouse gases (GHG) are expected to have severe adverse effects on natural and human systems within the region.

This paper assesses the consumption of energy for its impact on greenhouse gas emissions in the region, and analyzes the role it can play in the development of a Regional Plan for Sustainable Development (RPSD). This report will focus on greenhouse emissions that result from the use of energy by describing existing conditions and trends. This report will also summarize changes to the region's climate based on weather data collected in NJ and the potential climate change based on future GHG emissions. The report will build largely on the existing studies conducted by the NJTPA and elsewhere, including the region-wide GHG Emissions Inventory and Forecast (GHG I&F) completed by the NJTPA in 2011 and the NJTPA Climate Change Vulnerability and Risk Assessment Study completed in 2012.

This report supports specific aspects of the Livability Principles of the U.S. Department of Housing and Urban Development (HUD), though GHG emissions and the resulting changes to the region's climate play a part in supporting all aspects of sustainability:

HUD Livability Principle #1: **"**Provide more transportation choices, develop safe, reliable and economical transportation choices to decrease household transportation costs, *reduce our nation's dependence on foreign oil*, improve air quality*, reduce greenhouse gas emissions* and promote public health."

HUD Livability Principle # 5: **"**Coordinate policies and leverage investment, *including making smart energy choices such as locally generated renewable energy."*

More than 90 percent of the region's current GHG emissions are from electricity and the burning of fossil fuels for automobiles, and for heating homes and business. Federal, state, and local policies targeting the emissions in these sectors have resulted in the production of more fuel-efficient vehicles and increased production of renewable energy in the region. As a result, GHG emissions are currently falling and are expected to continue declining over the next decade. These existing policies, though effective in reversing the growth in GHG emissions over the short-term, will not be sufficient to reduce GHG emissions enough to meet the GHG reduction goals of 80 percent below 2006 levels, as mandated in the NJ Global Warming Response Act (GWRA). A growing population and economy will eventually overtake existing state and federal policies, resulting in an increase in GHG emissions by 2050.

The region is already experiencing the impacts of global climate change resulting from increased global GHG emissions. The region has experienced rising temperatures, increased precipitation, and more extreme weather, affecting communities across the region. Extreme weather has damaged homes, businesses, natural resources, and infrastructure, costing billions of dollars. The region is likely to experience additional warming and increased precipitation in future, including more extreme weather events. Moreover, coastal communities in the region will be particularly vulnerable from sea level rise, increasing the vulnerability of human settlement and transportation infrastructure from storms.

Introduction: Energy and Climate Change Report

Energy production and consumption are inextricably tied to many aspects of modern life, such as water consumption, use of goods and services, transportation, economic growth, land use, and population growth. The serious links between the use of energy and its impacts on the earth's climate, consequently, continue to evolve as a subject of scientific research. There is now consensus within the global scientific community that the earth's climate is changing due in large part to the abundance of greenhouse gases (GHG) in the atmosphere. The global concentrations of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) have increased markedly as a result of human activity, mainly due to burning fossil fuels such as coal, oil, and natural gas. If steps are not taken to reverse these trends, the increased levels of greenhouse gases in the atmosphere are expected to have severe adverse effects on natural and human systems.

This Energy and Climate Baseline Assessment Report is one of a series of baseline reports that examines how a particular issue relates to "existing conditions, regional needs, patterns, trends, challenges and opportunities" in the 13-county North Jersey Transportation Authority (NJTPA) region. To best serve the comprehensive perspective of the Regional Plan for Sustainable Development (RPSD), the overall report will present an array of planning data and strategies related to energy and climate change.

Measuring GHG emissions and determining which sources emit the greatest amount is a crucial first step toward developing and comparing the effectiveness of GHG reduction strategies. The State of New Jersey has mandated aggressive goals to reduce GHG emissions to 1990 levels by 2050, as codified in the Global Warming Response Act, adopted by the New Jersey State Legislature in 2007. This baseline assessment will build upon the methodology of the existing region-wide GHG Emissions Inventory and Forecast (GHG I&F) Study, which was conducted by the North Jersey Transportation Planning Authority (NJTPA) and completed in 2011. The baseline report also draws from the sustainability and green energy work of the New Jersey Department of Environmental Protection (NJDEP), which has pooled the efforts of several state agencies to address climate change impacts.

This GHG inventory work sets up a framework to quantify the use of renewable and non-renewable energy throughout the region, address recent energy consumption and the resulting GHG emissions data and trends across all sectors (including electricity and transportation), and forecast how those factors will impact the region's future in terms of temperature, precipitation, and sea level rise.

This Energy and Climate Baseline Assessment Report concludes with a description of key findings and challenges that will help identify connectivity to other topic areas within the Livability and Environment and be useful for the scenario planning process in the RPSD. The data collected and analyzed in this report will be brought to bear in an effort to identify how transportation and land use patterns, demographics, housing, economic activity, land uses, population, and environmental features each affect overall emissions, providing data for use in the outreach and visioning tasks of the RPSD.

1 Analysis of GHG Emissions Inventory & Forecast

The goal of the GHG inventory and forecasting is to quantify the amount and kinds of climate change gases that are emitted in the region across all economic sectors, including transportation-related emissions as well as emissions from energy use in residential, commercial and industrial sectors. Analysis of inventory and forecast data provides information to assist state, regional, and local policy makers and citizens with understanding the sources of GHG emissions so that well-informed policy decisions will be made to reduce these emissions. This inventory assessment includes GHG emissions data gathered for the NJTPA-led GHG I&F study, which uses 2006 base year data and projects GHG emissions through the year 2050. However, where possible, this report uses 2011 estimates in place of 2006 baseline data to more closely reflect current emissions levels.

1.1 Greenhouse Gases and the Atmosphere

The atmosphere is primarily composed of molecular nitrogen (N_2) and oxygen (O_2); together they make up about 98 percent of the earth's atmosphere and neither is a greenhouse gas. It can be seen, therefore, that although a small fraction of the earth's atmospheric gases generate a warming effect, that effect is powerful, holding warm air close to the earth's surface.

A greenhouse gas (GHG) is a gas or medium that collects heat from the sun and slows its release to the upper atmospheres. It acts in this way like a blanket around the earth. Despite the negative publicity of GHGs and its detritus effect on climate change, it has been estimated that without it, the earth's temperature would be much cooler than its current mean of 58 degrees Fahrenheit.

Water vapor (H_2O) in clouds is often overlooked as, by far, the most dominant of all components of the GHG picture. Water, in gaseous form (water vapor) and in liquid form (tiny droplets in clouds), generates somewhere between 66 percent and 85 percent of the greenhouse effect. After water vapor, the most dominant (and somewhat controllable) are in order, carbon dioxide (CO_2), methane (CH_4) and ozone (O_3). There are a number of other gases that contribute to the greenhouse effect to a lesser extent such as nitrous oxide (N_2O), and various fluorocarbons, but CO_2 generation is the most controllable through the actions of man's pollution mitigation practices and is therefore used as a baseline in our progress to control these gases.

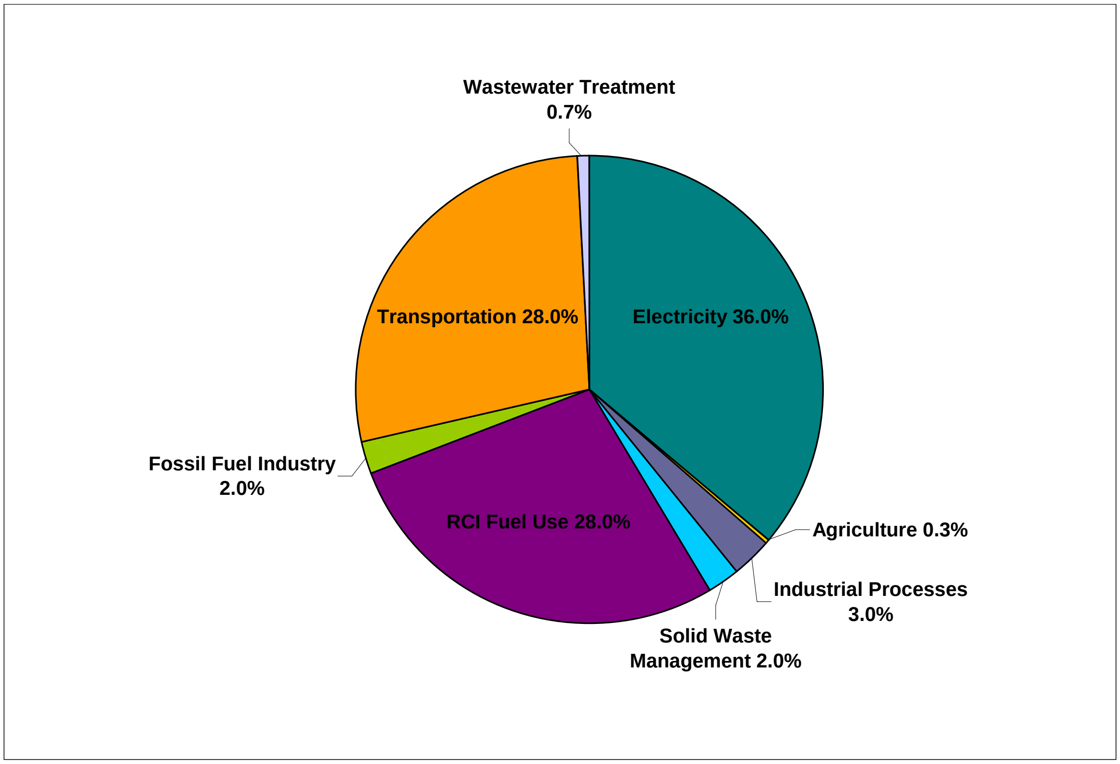
1.2 Greenhouse Gas Emissions

The GHG inventory and forecast efforts outlined in this report represent the first steps in a multi-year climate change initiatives program and provide a baseline for comparison and quantification of proposed emissions mitigation actions, which will be further developed in the NJTPA's GHG Mitigation Plan in progress .

There are two primary accounting methods in GHG inventory and analysis: direct emissions and consumption-based emissions. Direct emissions are defined as those emissions that take place within the NJTPA region. GHG gases emitted from landfills and from the combustion of motor fuels in automobiles are examples of direct emissions. Consumption-based emissions are those emissions associated with a product or process, such as the generation of electricity. Since a significant amount of the electricity consumed within the NJTPA region is generated outside of New Jersey, the consumption-based method estimated the emissions associated with that electricity even though it was generated elsewhere.

By providing the GHG emissions inventory and analysis, governments are better informed of the potential GHG benefits of mitigation options aimed at reducing GHG emissions at the local, county, and regional level. These options (to be developed through GHG mitigation planning) might include electrical and fossil fuel energy efficiency measures, solid waste source reduction and recycling, building materials substitution, and reduction of transportation-related emissions.

Figure 1.1: Electricity and Fuel for Buildings and Automobiles Account for Over 90 Percent of the Region's Direct GHG Emissions (84 $MMtCO2_e$)



Source: NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast (2011)

Note: Figure 1.1 represents the share that each sector contributes to the overall region's direct GHG emissions. The three most significant contributors – transportation, electricity, and Residential, Commercial & Industrial (RCI) – account for over 90 percent of the region's GHG emissions.

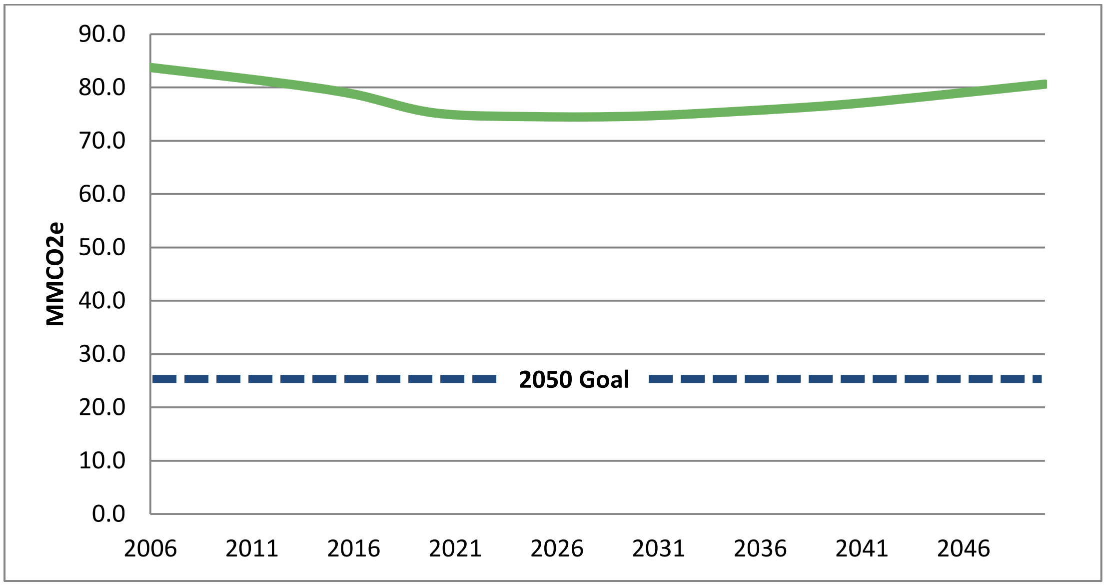
The NJTPA regional direct GHG emissions inventory displayed in Figure 1.1 includes all source sectors. It illustrates direct emissions for all sectors, with the exception of electricity (which is better captured on a consumption basis by including emissions from electricity produced outside the region). Regional gross direct emissions for the baseline year 2011 are about 84 million megatons of CO2 equivalent ($MMtCO_2e$)[1]. Figure 1.1 above offers a snapshot of how the major sectors contributed to the total across the NJTPA region. This measure is projected to drop to 74 MMtCO2e by 2022 and then gradually increase to around 81 $MMtCO_2e$ by 2050, accounting for regional growth (see Figure 1.2 below).

The consumption of electricity by homes, businesses, and industry contributed to 36 percent (30MMTCO2e) of all GHG emissions in the region in 2011. The use of natural gas, oil, and other fossil fuels for homes, businesses and industry contributed to 28 percent (24 MMTCO2e) of all greenhouse gases emitted in the region. The

[1] CO2 equivalent (CO2e) is a proxy for CO2, which is the most prevalent of GHGs in the atmosphere. CO2e takes into account other GHGs and allows them to be expressed in terms of CO2 based on their Global Warming Potential (GWP).

combustion of gasoline and diesel fuel in the transportation sector also contributed to 28 percent (24 MMTCO2e) of the region's greenhouse gas emissions. Transportation-related emissions include those from on-road, non-road, aviation, marine, and rail transportation sectors including freight. These three sectors amount to 92 percent of all greenhouse emissions in the region. Other sectors, including industrial processes, solid waste management and the fossil fuel industry, contributed relatively small amounts to the region's GHG emissions.

Figure 1.2: Regional Forecast of GHG Emissions Through 2050



Source: NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast (2011)

Note: This is a direct emissions forecast based on emissions from all sectors (except for the consumption-based electricity sector). All emission and reduction quantities, especially projections to 2020, are estimates and therefore uncertain. Emissions reduction credits associated with exported electricity are especially difficult to predict due to numerous variables. All GHG emission quantities are subject to revision by the DEP as better information becomes available.

The regional GHG emissions forecast depicted in Figure 1.2 (above) shows some significant emissions reduction prior to 2020, while still accounting for growth in economic activity and population. This is a result of legislation at the state and federal level, and a combination of efficiency measures in progress. At the federal level, the Corporate Average Fuel Economy (CAFE) Standards were enacted by Congress in 1975 to reduce energy consumption by increasing fuel economy of cars and light trucks. The National Highway Traffic Safety Administration (NHTSA) have since advanced a more rapid rate of increasing CAFE levels through 2017 in an effort to increase the nation's energy independence, save consumers money at the fuel pump, and to reduce GHG emissions that contribute to global climate change.

The State of New Jersey also set in place its own energy regulations through the Renewable Portfolio Standard (RPS), which requires increased production of energy from renewable energy sources such as solar, wind and biomass. In 2006, the New Jersey Board of Public Utilities (BPU) issued regulations that require electric power suppliers or basic generation service providers to source 22.5 percent of its energy to renewables by 2021.

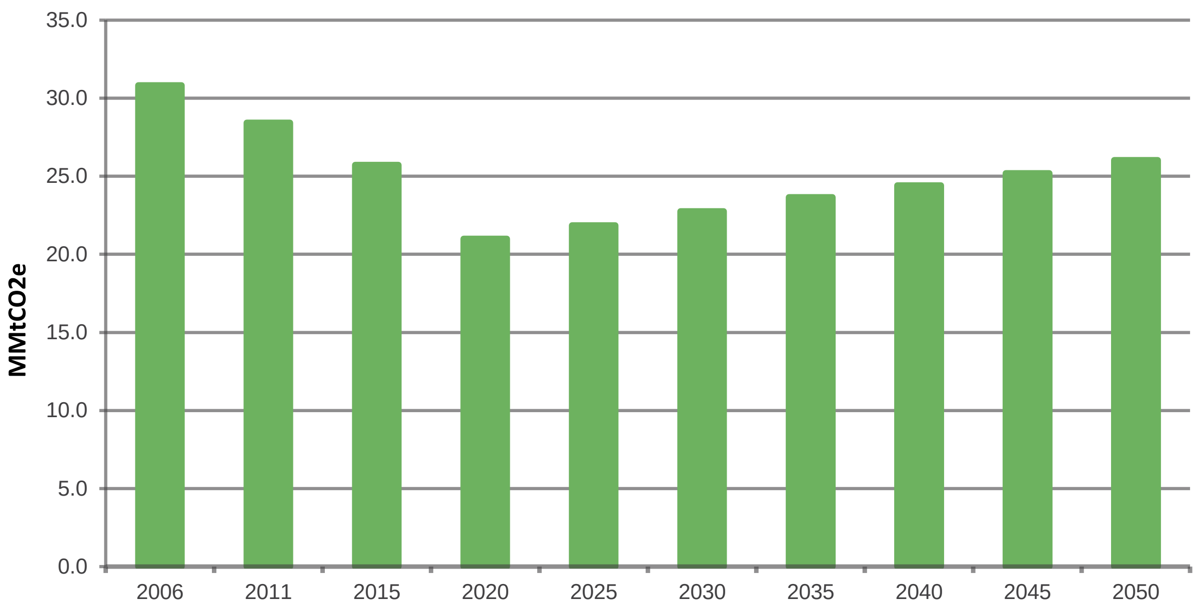
Further, in response to global concerns about GHG emissions and climate change, the New Jersey Global Warming Response Act (GWRA), enacted in 2007, mandated the reduction of GHG emissions to 1990 levels by 2020, and to 80 percent below 2006 levels by 2050. The Global Warming Response Act Recommendation Report

(December 2009), provides an outline of actions to be taken toward achieving these goals, including actions in the transportation and planning sectors. While the forecast of regional GHG emission levels outlined in this report will likely satisfy the mandates of the GWRA for 2020, it will not meet the 2050 goals without further GHG reductions and policy intervention.

1.2.1 GHG Emissions by Sector

As previously mentioned and shown in Figure 1.1, on a direct basis (excluding electricity production), the regional GHG emissions inventory is dominated by three sectors: Transportation (28 percent); Electricity Consumption (36 percent); and Residential, Commercial, and Industrial (RCI) Fuel Use (28 percent). This report's assessment of GHG emissions by sector will largely focus on these three sectors since they accounted for over 90 percent of the region's direct GHG emissions in 2006.

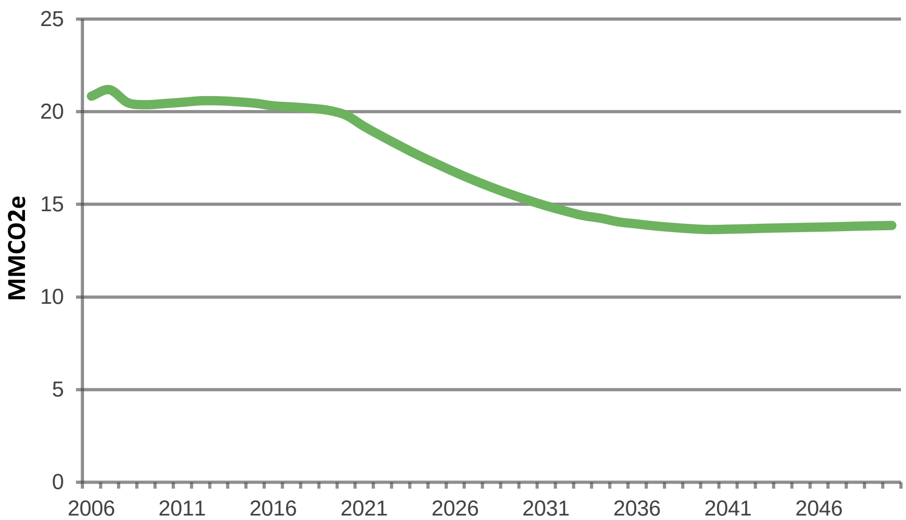
Figure 1.3: Regional GHG Emissions from Electricity Consumption from 2006 to 2050



Source: NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast (2011)

Note that the NJTPA electricity sector emissions, presented in Figure 1.3 decline significantly prior to 2020, while accounting for growth. This is a result of policy intervention on two fronts. First, the renewable portfolio standard (RPS) requires each supplier/provider serving retail customers in New Jersey to produce 22.5 percent of electricity it sells in New Jersey from qualified renewable sources by 2020. The second policy measure is the implementation of the Energy Master Plan, which has a goal to reduce energy consumption by 20 percent by 2020 as compared to the 2020 energy consumption expected without implementation of the plan.

Figure 1.4: Increasing Fuel Efficiency will Reduce Regional GHG Emissions from On Road Vehicles

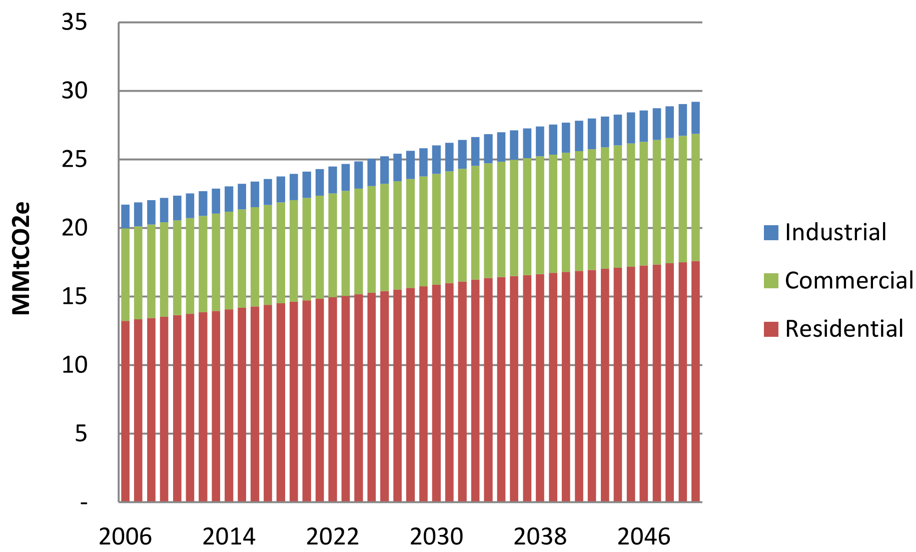


Source: NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast (2012)

The on-road transportation sector emissions, shown in Figure 1.4, include those from motor vehicles that typically travel on public roads. These include passenger cars and trucks, motorcycles, commercial trucks, heavy-duty vehicles, and buses. These vehicles may be fueled by gasoline, diesel, or other alternative fuels. The gasoline used by on-road vehicles in the North Jersey region in all years of the analysis is primarily gasoline with 10 percent ethanol by volume (E10). Although CO_2 is the main GHG emitted from this sector, CH_4 (Methane) and N_2O (Nitrous Oxide) are emitted as well. It should be noted that CH4 is the second most prevalent GHG constituting 9 percent of all GH gases. Methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO_2), but CH_4 is more efficient at trapping radiation than CO_2. Emission factors are estimated using EPA's Motor Vehicle Emission Simulator (MOVES 2010) model.

On-road transportation accounted for over 93 percent of the region's total GHG emissions from the transportation sector in 2011. Even with a projected 27 percent reduction of emissions from on-road transportation through 2050, the on-road subsector will still account for over 85 percent of the total transportation sector emissions in 2050, according to the model.

Figure 1.5: GHG Emissions from the Use of Fuel for Heating and Industrial Activity will Continue to Rise (MMtCO2e)



Source: NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast (2011)

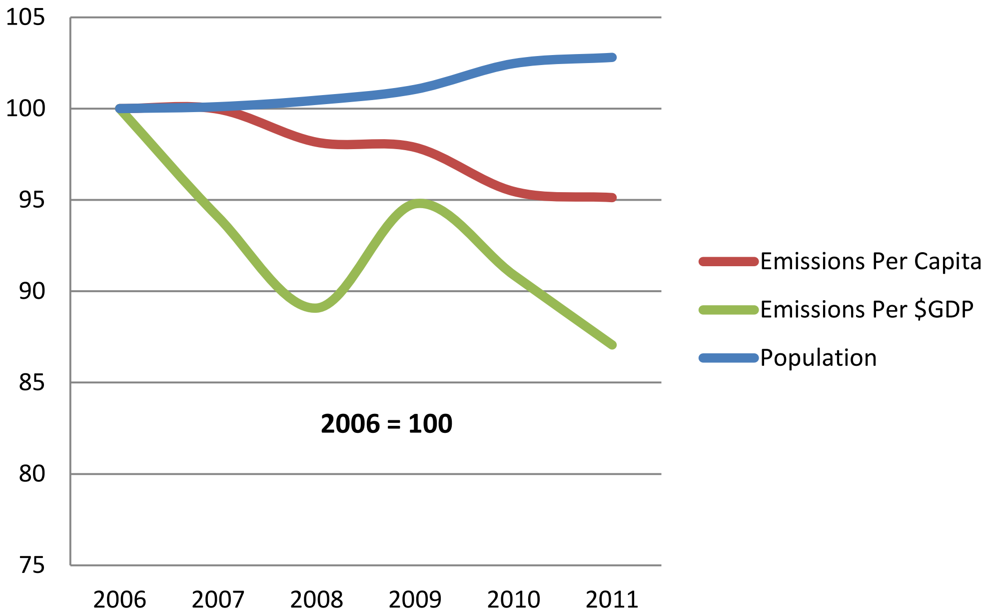
Above, Figure 1.5 shows that the dominant share of the RCI sector emissions is attributable to the residential subsector (in red), which is projected to increase by another 30 percent through 2050. The forecast also indicates that a growing share of emissions will be attributable to the commercial sector (in green) through 2050. Residential and commercial sectors include all homes and commercial businesses, excluding agricultural activities. Direct GHG emissions from this sector include a variety of sources, but the majority of emissions come from fossil fuel combustion for heating and cooking needs.

1.2.2 GHG Emissions per Capita and per GDP

A number of factors influence the quantities of greenhouse gases released into the atmosphere, including economic activity, population, consumption patterns, energy prices, land use, technology and natural occurrences (GHG emissions from naturally occurring processes are not tabularized). There are several ways to track these emissions. In addition to tracking overall emissions and emissions from specific industrial sectors in absolute terms, it is also helpful to track emissions per capita and per GDP.

Local Area Personal Income data gathered from the Bureau of Economic Analysis (BEA) will serve as a proxy for Gross Domestic Product (GDP) since GDP data is not available at the level of the NJTPA planning region. The GHG emissions level by local area personal income, shown below in Figure 1.6, illustrates the regional trend from 2006 to 2011.

Figure 1.6: Regional GHG Emissions Per Capita and Per Dollar of GDP are Falling



Source: NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast (2011) and the Bureau of Economic Analysis (BEA)

Note: Local Area Personal Income data is a stand-in for GDP data, which is unavailable at the NJTPA regional level. Personal income is the sum of net earnings by place of residence, rental income of persons, personal dividend income, personal interest income, and personal current transfer receipts.

Above, Figure 1.6 depicts a comparison of trends (from 2006 to 2011) on the basis of GHG emissions per capita (red line), per dollar of GDP (green line), and population changes (blue line). All data are indexed to 2006 as the base year, which is assigned a value of 100.

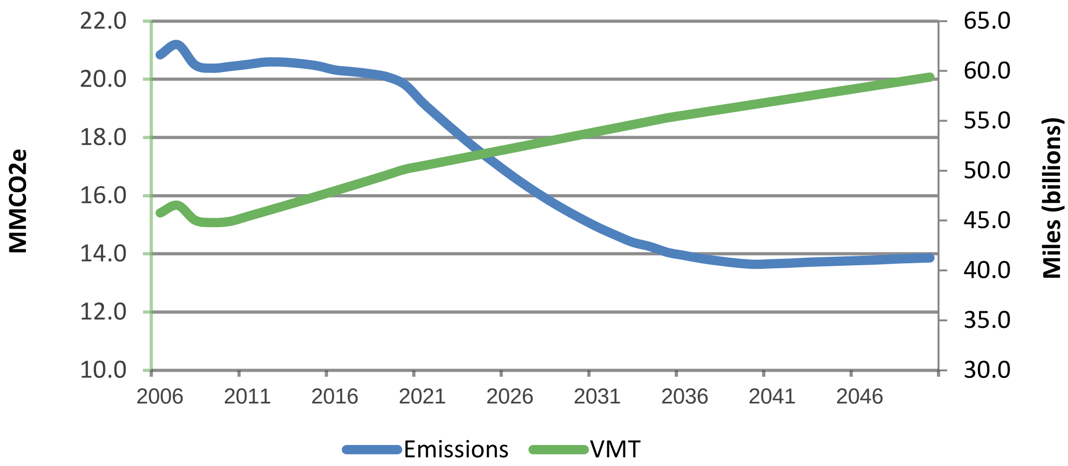
The indicators in Figure 1.6 point to an overall increased economic efficiency, possibly attributable to the economic volatility of the housing crash in 2008 and the ensuing economic recession. During this period, population continued to increase on pace with projections, while both emissions per capita and emissions per dollar of GDP decreased. The reductions during this period indicate that a combination of cost-cutting measures resulted in reduced GHG emissions across the region.

1.2.3 GHG Emissions/ VMT

With on-road transportation accounting for over 90 percent of total transportation-related GHG emissions in the region, vehicle miles travelled (VMT) remains an important indicator in transportation and climate change policy. The policy goal of reducing VMT carries a wide range of potential economic benefits including reduced fuel costs, reduced dependence on foreign fuel, reduced GHG emissions, and the reduced need for vehicle travel (possibly through land use and development improvements).

However, the projection illustrated in 1.7 show that VMT will steadily increase from 2011 to 2050. The trends in Figure 1.8 indicate that while vehicle emissions will decline through 2035 (due to policy intervention and a combination of fuel and vehicle reductions on the market), it will flatten out as VMT continues to increase through population growth. This suggests that, without future policy or market interventions, the demand for driving vehicles will continue to grow due to population increases, which will eventually offset the increasing emissions efficiencies per capita.

Figure 1.7: NJTPA Regional GHG Emissions and Regional Vehicle Miles Travelled (VMT) 2006 to 2050



Source: NJTPA Regional Greenhouse Gas Emissions Inventory and Forecast (2011)

1.3 Total Regional Energy Use

The baseline assessment report will measure the characteristics of electricity consumption and generation in the NJTPA region with a focus on the amount of electricity generated by Class 1 renewable energy. Class 1 renewable energy as defined by the State of New Jersey includes solar, wind, wave/tidal, geothermal, landfill gas, anaerobic digestion, and fuel cells using renewables. The amount of Class 1 renewable energy generated (in megawatts) in the region will be collected from the New Jersey Clean Energy Program overseen by the state Board of Public Utilities (BPU) and compared with the total amount of electricity consumed from data collected as part of the GHG I&F project. Measuring the region's progress towards a more efficient use of energy and a greater use of renewable energy will be done by estimating the total energy use in the region per capita and as a percent of state GDP.

1.4 Renewable Energy Use

Quality of life in such a densely populated region is heavily reliant on the availability of massive amounts of energy, most of which comes from non-renewable sources such as fossil fuels. It was estimated by the Energy Information Administration that in 2007 primary sources of energy consisted of 36.0 percent petroleum, 27.4 percent coal, and 23.0 percent natural gas, amounting to an 86.4-percent share for fossil fuels in primary energy consumption in the world. Non-fossil sources in 2006 included 6.3 percent hydroelectric, 8.5 percent nuclear, and others (geothermal, solar, tidal, wind, wood, waste) amounting to 0.9 percent. Fossil-based energy sources such as shale gas are rapidly becoming more plentiful and are likely to represent a greater portion of the energy in the future. The GHG implications of this development are still being determined. Meanwhile, great strides are being made in non-fossil fuel production. Compared to fossil fuel combustion, renewable energy sources provide energy with much lower GHG emissions. Replacing fossil fuel energy with renewable sources is a key solution to the problem of rising GHG emissions.

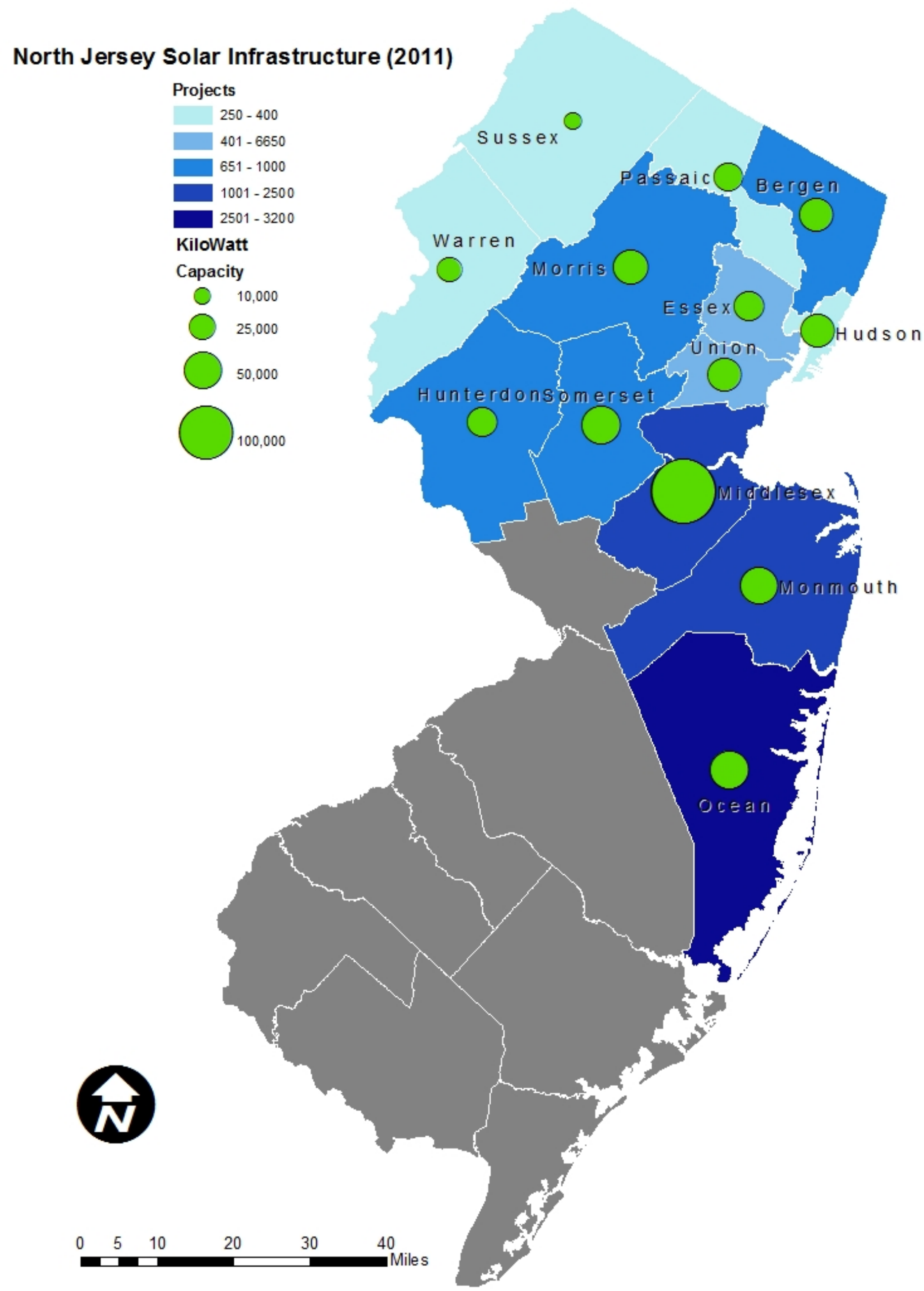
1.4.1 Regional Renewable Energy Use

New Jersey is emerging as a leader in the production and use of renewable energy sources. The state Board of Public Utilities (BPU) was an early adopter of the RPS initiative, which requires that utilities source 6.5 percent of customers' electricity from Class I and Class II renewables. The state has the highest recent growth rate in the nation for solar energy the highest solar photovoltaic area per square mile, and is second only to California in terms of total installed solar energy capacity (956,000 KWdc as of 2012).

In addition, the New Jersey Energy Master Plan (EMP) calls for a 20 percent reduction in statewide energy use by 2020 and includes a variety of measures to achieve it through promotion of renewable energy sources. The EMP acknowledges that it will be difficult for the state to reduce its GHG emissions to the degree called for by GWRA without a balanced portfolio of renewable energy sources.

The map in Figure 1.8 illustrates how the region's solar infrastructure and capacity are distributed throughout the 13 counties. The region's total solar project count in 2012 was 12,735 projects. The total installed capacity was over 567,000 KW in 2012. Statewide, the largest share of solar projects was 72 percent from the commercial sector and 13 percent from the residential sector.

Figure 1.8: Solar Infrastructure Projects versus Installed Capacity in Northern NJ

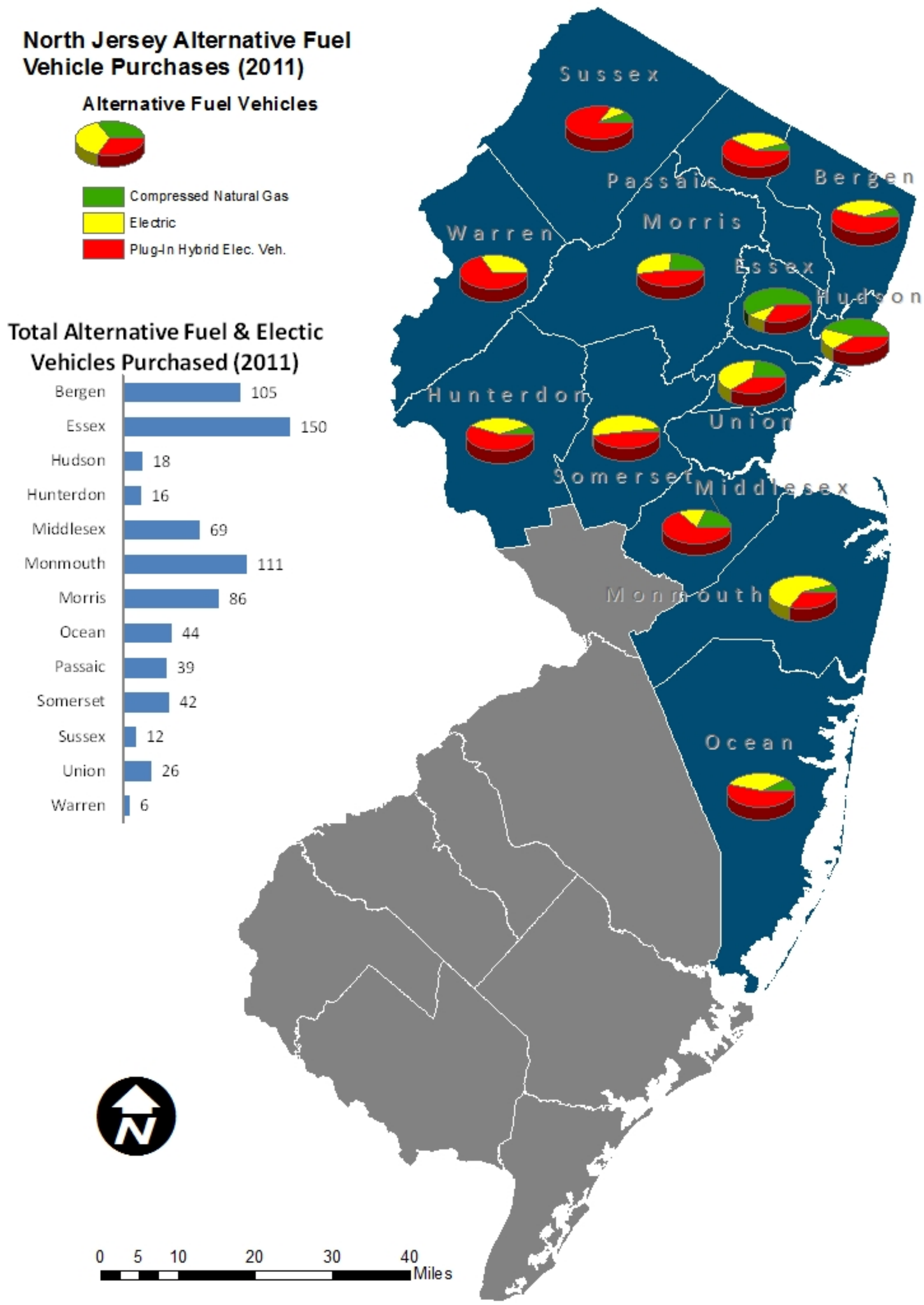


Source: New Jersey Board of Public Utilities (2011)

1.4.2 Number Alternative Fuel Vehicles Sold in the North Jersey Region

Alternative Fuel Vehicles (AFVs), vehicles that do not run solely on petroleum fuel, are another meaningful way that the region can continue to reduce GHG emissions within the transportation sector. The number and percent of plug-in hybrid electric vehicle (PHEV), electric vehicles (EV) and compressed natural gas (CNG) purchased in the NJTPA region was obtained from NJDEP. This analysis gives the TNJ team the ability to measure the penetration of these vehicles into the region and determine their effect in reducing GHG emissions and improving air quality. The map in Figure 1.9 below illustrates how the region's different types of AFV purchases are distributed among the counties. The PHEV is the clear leader across the board in terms of sales and as a percentage of AFV stock (nearly 50 percent) in the region. Figure 1.10 further details the distribution of AFVs throughout the region.

Figure 1.9: Distribution of Regional Alternative Fuel Vehicles (2011) Purchases



Source: New Jersey Department of Environmental Protection (2012)

Figure 1.10: Regional Alternative Fuel Vehicles (2011) Purchases

County	CNG	Electric	PHEV	County Total
Bergen	7	40	58	105
Essex	86	14	50	150
Hudson	8	3	7	18
Hunterdon	1	6	9	16
Middlesex	13	12	44	69
Monmouth	6	68	37	111
Morris	21	24	41	86
Ocean	4	16	24	44
Passaic	2	14	23	39
Somerset	1	21	20	42
Sussex	1	1	10	12
Union	6	10	10	26
Warren	0	2	4	6
Region	*156*	*231*	*337*	*724*

Source: New Jersey Department of Environmental Protection (2012)

1.4.3 Mega Watts of Class I Renewables

The 2011 Energy Master Plan (EMP)reaffirmed New Jersey's commitment to one of the nation's most aggressive renewable portfolio standard (RPS), requiring power suppliers and providers to source a minimum of 22.5 percent of the electricity it sells in New Jersey from qualifying renewables by 2021. The mandates set different requirement for different types of renewable energy resources, termed "classes". Class I renewable energy is defined as electricity derived from solar energy, wind energy, wave or tidal action, geothermal energy, landfill gas, anaerobic digestion, fuel cells using renewable fuels, and -- with written permission of the New Jersey Department of Environmental Protection (NJDEP) -- certain other forms of sustainable biomass.

The required percentages of each category and the total renewables percentage required are listed in the table below (Figure 1.10), which outlines the general compliance schedule currently ending in Energy Year 2021. The Energy Year starts June 1 and ends May 31 of the following calendar year.

Figure 1.11: NJ Renewable Portfolio Standards (RPS) requirements

Energy Year	*Class I*	*Class II*	*Solar*	*Total*
2010	4.69%	2.50%	0.22%	7.41%
2011	5.49%	2.50%	306 Gwhrs	8.30%
2012	6.32%	2.50%	442 Gwhrs	9.21%
2013	7.14%	2.50%	596 Gwhrs	10.14%
2014	7.98%	2.50%	2.05%	12.53%
2015	8.81%	2.50%	2.45%	13.76%
2016	9.65%	2.50%	2.75%	14.90%
2017	10.49%	2.50%	3.00%	15.99%
2018	12.33%	2.50%	3.20%	18.03%
2019	14.18%	2.50%	3.29%	19.97%
2020	16.03%	2.50%	3.38%	21.91%
2021	17.88%	2.50%	3.47%	23.85%

Source: New Jersey Board of Public Utilities (2011)

In Energy Years 2010, 2011, and 2012, the Board of Public Utilities (BPU) reported that New Jersey electric suppliers and service providers were in full compliance with the New Jersey RPS for each year. The actual percentage of electricity for Energy Years 2010, 2011, and 2012 that was generated from renewable energy in New Jersey was 7.345 percent, 8.347 percent and 9.39 percent, respectively. For each year, the total required Class I Mega Watt hours (MWh) of power sourced from Class I renewables is detailed below (Figure 1.12).

Figure 1.12: Class I Renewable Portfolio Standards (RPS) requirements for EY 2010-2014

Energy Year	*Class I Required*	*Class I Required MWh*
2010	4.69%	3,627,069
2011	5.49%	4,467,706
2012	6.32%	4,862,298

Source: New Jersey Board of Public Utilities (2011)

2 Analysis of GHG Emissions Inventory & Forecast

Increases in the emissions of greenhouse gases from across the globe are projected to have significant impacts on the region's climate in the coming decades. This section provide a description of climate changes in northern New Jersey, including the past changes that have been documented from historical observations as well as expected changes based on projections of temperature, precipitation and sea level through the end of the century.

The process of developing projections of future climate for a specific region is difficult. Scientist simulates projections of the future climate using mathematical models of Earth's climate executed on powerful computers. Climate simulations developed from Global Climate Models (GCMs) provide a framework for understanding climate-relevant processes, which are then merged into coherent projections of future climate change. These models, however, are unable to make direct projections for localized areas. Quantitatively estimating the future climate is limited for several reasons: 1) It is not known with certainty the emission rates of global-warming gases, 2) climate models exhibit a range of sensitivities even when subjected to the same emissions scenario, and 3) there is considerable uncertainty when downscaling the results from global and regional climate models to specific locations. The diverse geography of the Together North Jersey region adds an additional dimension to determining localized impacts from climate projections. This report draws upon the "Climate Change in New Jersey: Trends and Predictions" report, developed by the New Jersey Climate Adaptation Alliance.

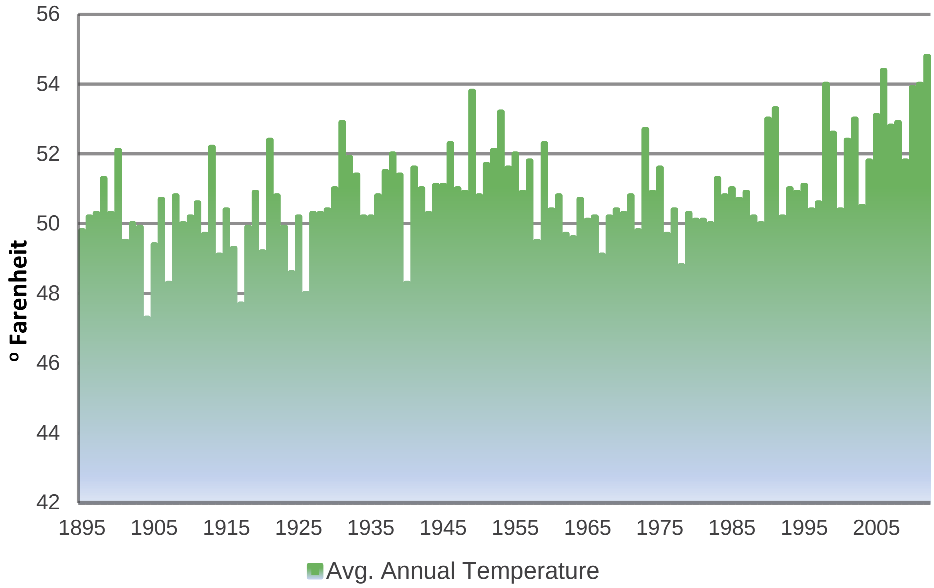
While additional research will be required to fully address these issues, the climate modeling work done to date describes how the overall trends in the region's climate will change over time and the effects of these changes on the quality of life for the people living in the region. Overall, in the coming decades, most studies project that New Jersey can expect an increase in average annual temperature, and steady or increasing amounts of precipitation. More frequent extreme events are also likely, including heat waves, and extreme precipitation events with subsequent flooding. Sea Level Rise (SLR) in New Jersey is already occurring faster than the global rate due to land subsidence and ground water withdrawal, and the continued rate of rise is expected to lead to more frequent and more severe coastal flooding events.

2.1 Historic Temperature Trends

Since 1900, annual average temperatures have been rising across the United States. This warming trend is greater in the northeast than in the nation as a whole (Horton 2010). Data collected by the Office of the New Jersey State Climatologist show a statistically significant rise in average temperatures in northern New Jersey. The average annual temperature in northern New Jersey from 1895-1970 was 50.6 ^{o} Fahrenheit. The average temperature increased to 50.9 ^{o}F between 1970 and 2000. Since 2000, average annual temperature has increased to 53.0 ^{o}F. Moreover, northern New Jersey witnessed the warmest year on record in 2012, with an annual average temperature of 54.8 ^{o}F. (Figure 2.1)

2.1.1 Climate Change

Figure 2.1: Average Temperature in Northern NJ Increased from 1895 to 2012 (° Fahrenheit)



Source: New Jersey State Climatologist (2013)

Overall, average annual temperature in Northern New Jersey has increased by 2.1°F since 1970, consistent with average annual temperature increases across the northern United States (Frumhoff et al 2007). Analyzing the ten warmest years on record, five of the top ten warmest years were within the last decade (Figure 2.2).

Figure 2.2: Five of the Top Ten Annual Average Temperatures in Northern NJ Occurred Within the Last Decade

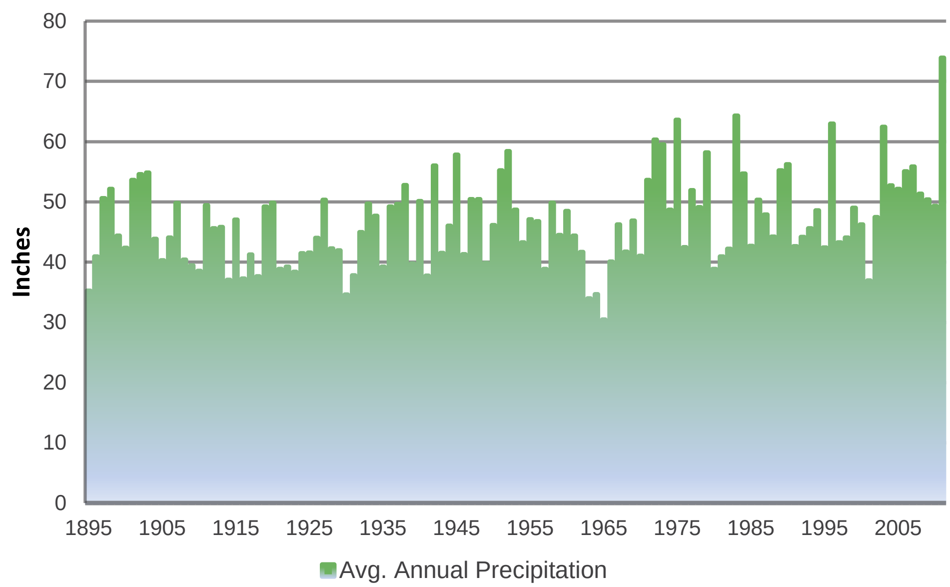
Year	*Temperature (Fahrenheit)*
2012	54.8
2006	54.4
1998	54
2011	54
2010	53.9
1949	53.8
1991	53.3
1953	53.2
2005	53.2
1990	53
2002	53

Source: New Jersey State Climatologist (2013)

Warming has resulted in more frequent days with temperatures above 90°F. The average number of very hot days (over 90° F) per year in the entire Northeast region has increased by 2 days over the past 45 years (Frumhoff et al 2007). In New Jersey, the total number of days over 90°F has increased more than in the Northeast region as a whole, approximately 36 percent since 1949 (from 17 days/year to 23 days/year), although there is considerable range between north and south, coastal and inland, and urban and rural parts of New Jersey (NCDC, 2012). The state currently averages 3 to 4 days over 95°F per year (NJTPA 2012). The increase in the number of extreme warm days will have implications on public health, infrastructure, agriculture, and economic health of the region.

Like the trends for temperature, there is a clear upward trend in annual precipitation in northern New Jersey that has been increasing since 1900 (Figure 2.3). The state climatologist's office reports annual average rainfall amounted to 44.6 inches for the period 1895-1970, and 49.8 inches from 1971-2000 inches, and 52.3 inches since 2000. Overall, annual precipitation averages since 1970 have increased about 10 percent over 1895-1970 averages (ONJSC 2012).

Figure 2.3: Average Precipitation in Northern NJ from 1895 to 2011 (Inches)



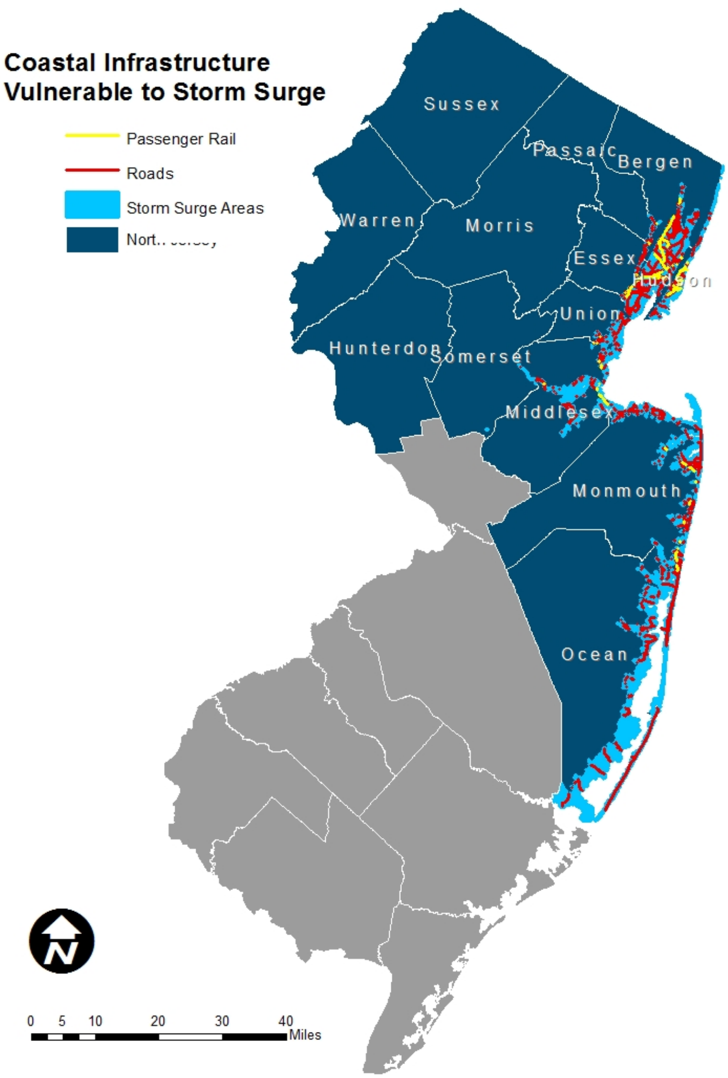
Source: New Jersey State Climatologist (2013)

Across the Northeastern United States, there have been increased occurrences of heavy precipitation and less winter precipitation falling as snow and more as rain (Horton et al 2011; Frumhoff et al 2007). There has also been a small trend towards more extreme events (above 1, 2 or 4 inches/day) in the region during the last three decades (NPCC 2009). In the Northeast, the fraction of total precipitation falling in the heaviest 1 percent of storms increased by 54 percent over the past century (Horton 2010). For certain rare events, like droughts or extreme precipitation, there is not a statistically large enough sample in the region to show a clear trend. Historically, short-term droughts (lasting one to three months) have occurred once every two years across most of the Northeast.

2.2 Transportation Infrastructure Vulnerable to the Impacts of Climate Change

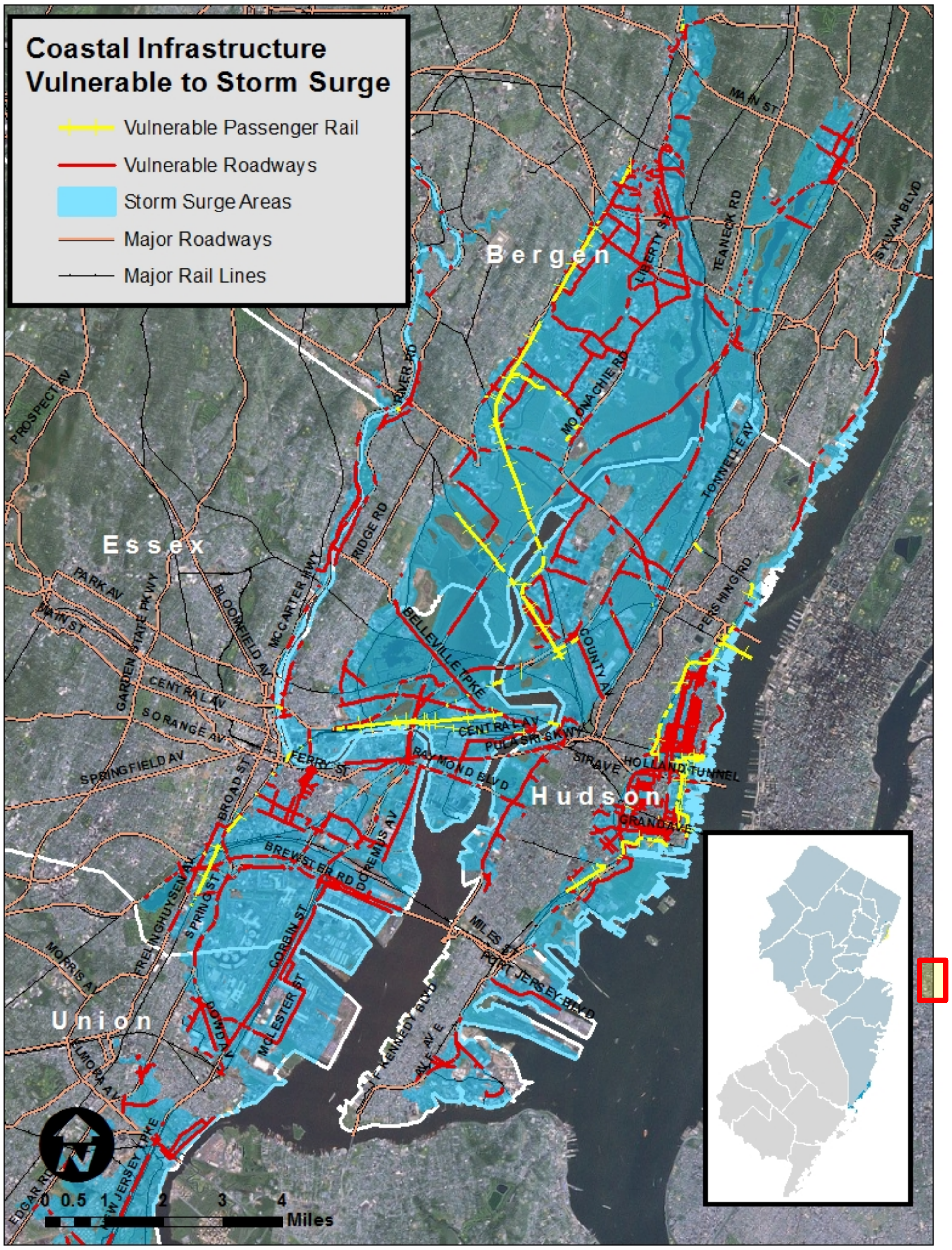
The northern New Jersey region supports one of the most dynamic and diverse economies in the nation, which relies on a complex transportation system to maintain growth, increase the quality of life, and sustains the efficient movement of people and goods. The region's transportation system is also susceptible to the potential impacts of climate change. As the affects Hurricane Sandy has shown, the coastal area of northern New Jersey is especially vulnerable to inundation due to flooding from storm surges. The increase in extreme weather events as a result of a warming planet will cause increased damage to the region's coastal communities. Figure 2.4 illustrates the road and railway infrastructure that is susceptible to flooding and storm surge within the coastal Counties of Bergen, Hudson, Essex, Union, Middlesex, Monmouth and Ocean. Figures 2.5, 2.6, and 2.7 illustrate specific locations along the northern NJ coastline where transportation infrastructure is vulnerable to storm surges.

Figure 2.4 Coastal Transportation Infrastructure Vulnerable to Storm Surge in Northern NJ



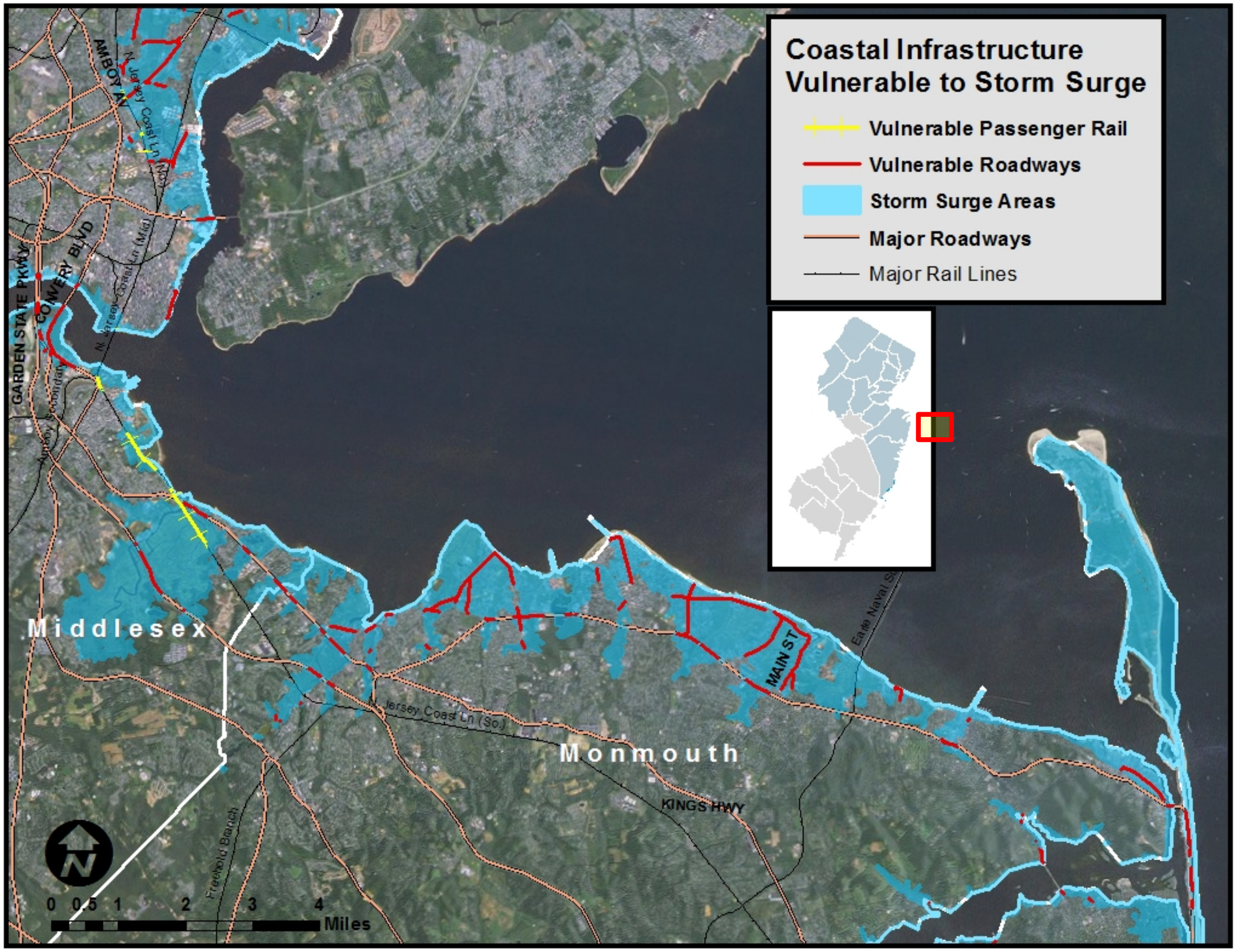
Source: NJTPA (2013)

Figure 2.5 Coastal Transportation Infrastructure Vulnerable to Storm Surge (Newark Bay and Hudson River)



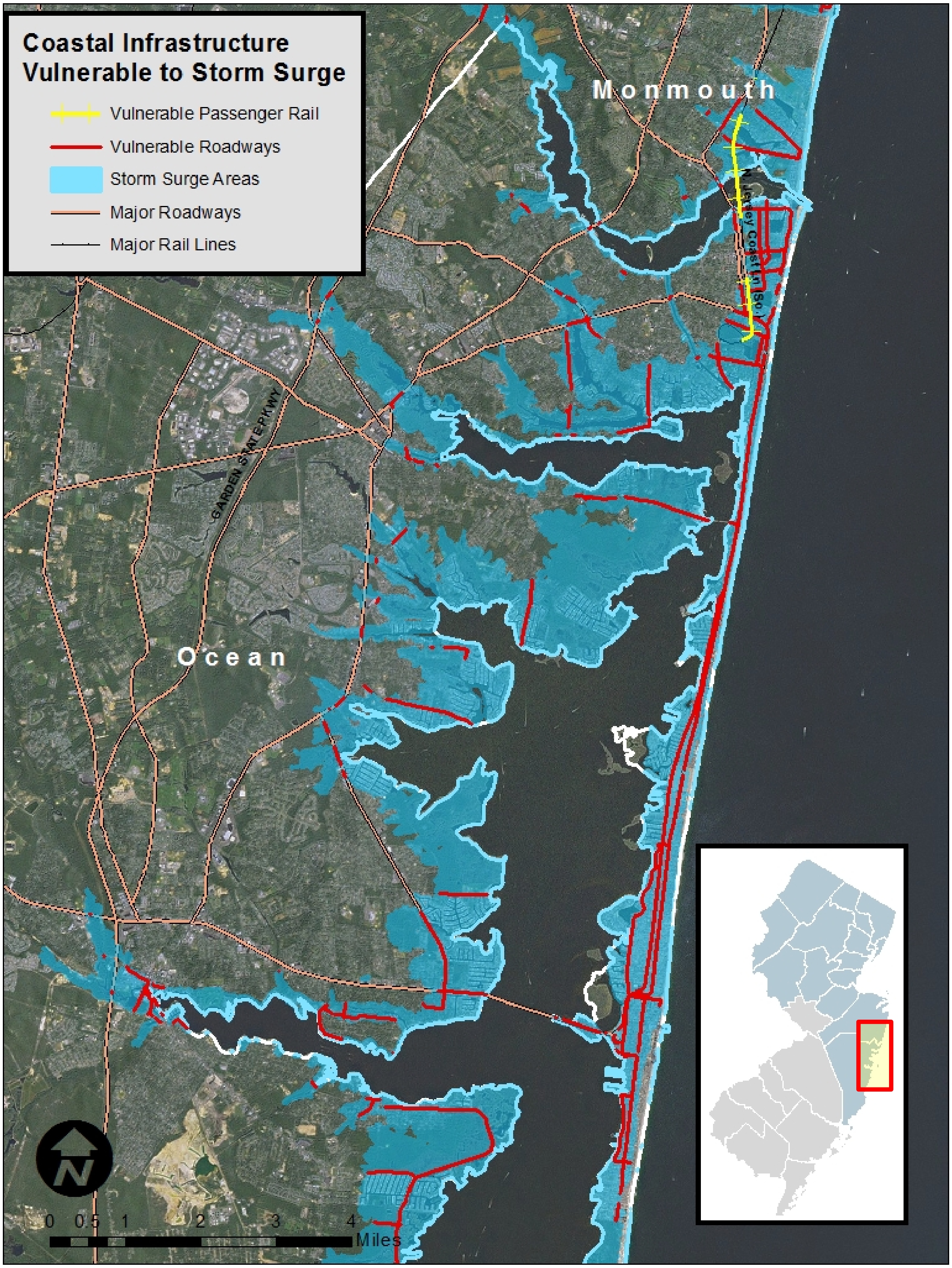
Source: NJTPA (2013) **Note:** The map in Figure 2.4, 2.5, 2.6, and 2.7 derive data from the Federal Emergency Management Agency's Modeling Task Force (MOTF), which estimated storm surge extent based on field observation data collected through November 11, 2012, including the effects of Superstorm Sandy. The MOTF interpolated the high water marks into a water surface elevation grid, subtracting the ground elevation from the water surface elevations in order to provide estimated water depth over land (inundation).

Figure 2.6 Coastal Transportation Infrastructure Vulnerable to Storm Surge (Raritan Bay)



Source: NJTPA (2013)

Figure 2.7 Coastal Transportation Infrastructure Vulnerable to Storm Surge (Ocean County)



Source: NJTPA (2013)

After identifying storm surge areas using MOTF methodology, the miles of roadway and rail infrastructure falling within the storm surge area were calculated. Those calculations determined that 332 miles of roadway within the region's coastal counties are vulnerable to storm surge inundation and flooding and nearly 50 percent of these roads at high risk to flooding are in Hudson and Ocean Counties, combined. The dominant shares of roadway classifications at risk are urban principle freeway (20 percent), urban minor arterial (31 percent), or urban collector (29 percent).

Meanwhile, the same MOTF methodology was applied to estimate nearly 55 miles of vulnerable railway in the storm surge area within the region's coastal counties. See Figures 2.8 and 2.9 below for detailed tables on roadway and railway miles at risk of flooding.

Figure 2.8: Roadway Miles Within MOTF Storm Surge Area

County	Road Miles	Percent
Bergen	47.97	14.43%
Essex	31.29	9.41%
Hudson	74.07	22.28%
Middlesex	19.66	5.91%
Monmouth	48.89	14.71%
Ocean	89.57	26.95%
Union	20.93	6.30%
Total	***332.38***	***100.00%***

Source: NJTPA (2012)

Figure 2.9: Railway Miles within MOTF Storm Surge Area

Rail Line	Rail Miles
Atlantic City Rail Line	4.0
Bergen County Line	3.0
Main Line	2.8
Meadowlands Rail Line	6.4
Morristown Line	6.8
North Jersey Coast Line	6.6
Northeast Corridor	8.6
Pascack Valley Line	4.0
Raritan Valley Line	0.1
Waterfront Connection	0.3
PATH	5.2
NJTRANSIT Light Rail	6.8
Total	***54.7***

Source: NJTPA (2012)

2.3 Projections

Although there is widespread scientific consensus that human activities are, even now, changing the dynamics of the global climate, there is uncertainty concerning the timeframes and specific effects associated with increasing concentrations of greenhouse gases. Therefore, climate scientists develop a scenario-based approach in which wide ranges of potential climate impacts are simulated by applying the best available climate models and simulation software to historical weather data.

This section describes the results of climate modeling conducted by scientists for northeastern US and by the NJTPA for northern NJ. The climate scenarios described in this report were developed by the Intergovernmental Panel on Climate Change's (IPCC) Special Report on Emission Scenarios and are used to set the overall bounds of greenhouse gas emissions over the century. A study conducted by the NJTPA to determine future climate conditions in Northern New Jersey also used the three most widely used emissions scenarios—A2, A1B, and B1—as its high, medium, and low scenarios, respectively. The emissions scenarios are described as follows:

- A2 (High): Assumes a high level of population growth, but fragmented economic development and technology transfer. This is the highest emission scenario considered in this study, but not the most aggressive within the IPCC suite of narratives.
- A1B (Medium): Assumes a high level of economic growth, relatively low population growth, and a mix of high- and low-carbon-emitting energy technologies. This is the medium emission scenario considered in this study.
- B1 (Low): Assumes that global population growth peaks by mid-century and then declines, the rise of service and information economies, and the introduction of clean and resource-efficient technologies. This is the low emission scenario considered in this study.

While all three emissions scenarios are considered equally probable, actual greenhouse gas emissions over the last decade have reflected a higher growth rate than any of these scenarios. Climate change scenarios illustrate plausible changes in future climate as the result of increased greenhouse gas emissions. Scenarios are not predictions and it is difficult to assign credible probabilities to them. Rather, given the significant uncertainties attending climate change, the scenarios bracket a reasonable range of potential outcomes, enabling decision-makers to develop appropriate responses.

Climate projections for northern New Jersey were determined for 2050 and 2100 as the climate analysis years. In actuality, these years represent the midpoint of a 30-year range, which corresponds to the historical period for which observed weather is considered (1971-2000). Projections reflect potential *average* climate over that span, not weather predictions for an individual year. In order to develop climate projections specific for the region, three National Climatic Data Center stations were used in the analysis and their results averaged[2].

[2] Coastal Region Climatic Data Center Stations used in the analysis were: Toms River, Long Branch Oakhurst, New Brunswick 3S. Historic weather data from these stations were used to develop future climate projections. The results were then averaged to estimate future climate changes for the Northern NJ region.

Temperature

Over the coming century, temperatures across the Northeast are projected to continue to increase, with larger increases under higher emissions scenarios relative to lower emissions scenarios, and greater increases in summer as compared to winter temperatures by the end of the century (Frumhoff et al, 2007; Horton 2011; Hayhoe et al 2008). Specifically, the regional increases in annual average temperature above the baseline (1971-2000) are expected to range from 1.7 to 4.5°F by the 2050s and from 2.5 to 11.9°F by 2100, reflecting a range of emissions scenarios from low to high. (Figure 2.10)

Figure 2.10: Average Annual Maximum Temperature is projected to Increase by 2100 (Fahrenheit)

Average Annual Maximum Temperature (Fahrenheit)	*Baseline*	*2050*	*2100*
Low Emissions Scenario	62	63.7	64.5
Middle Emissions Scenario	62	65.6	68.6
High Emissions Scenario	62	66.5	73.9

Source: NJTPA (2012)

These projections are consistent with those developed for the Hudson and Delaware watersheds, ranging from increases of 5.5 to 12 °F for the high scenario by 2080 (Najjar, 2009), while the NECIA report (Frumhoff et al 2007) projects a 6.5 to 12.5°F increase by 2100. While there will likely be little difference in the average annual temperature increase across the State, studies show a slightly higher temperature increase in the northern and inland regions of New Jersey as compared with over southern and coastal areas.

Both the number of days above 90°F or 100°F and the duration of heat events are expected to increase. Thus, while heat waves are expected to increase in frequency and duration, there will continue to be considerable variability from one year to another (NPCC 2009). Current projections for the northeastern US indicate that the number of days above 90°F will increase from a baseline average (1971-2000) from 14 days per year to 29 to 45 days per year in 2050, and 37 to 64 days per year in 2080, depending on the emissions scenario (NPCC 2009; Frumhoff et al 2007). The NJTPA study (2012) considered days over 95°F, and projected 5 to 11 days by 2050 and from 8 to 47 days by 2100. (Figure 2.11)

Figure 2.11: Number of Days with Maximum Temperature above 95°F Projected to Increase Significantly by 2100

Days above 95°F	*Baseline*	*2050*	*2100*
Low Emissions Scenario	4	5	8
Medium Emissions Scenario	4	10	24
High Emissions Scenario	4	11	47

Source: NJTPA (2012)

The number of days above 95 °F is approximately the same for both medium and high emission scenarios at 2050, but diverges significantly near the end of the century. Climate modeling in the northern US indicates that the very hottest days, those over 100°F, could increase by late-century to from 3 to 9 days under the lower-emissions scenario to 14 to 28 days under the higher-emissions scenario (Frumhoff et al, 2007).

Precipitation

On a national scale, many climate models project a small increase in annual precipitation. However, the variability in annual weather is expected to be larger than the trends associated with human activities. Most regional studies for the northeastern US find that precipitation rates may not increase at all by 2020 under the low emissions scenario or they may increase as much as 5 percent or about 2 inches annually under higher SES. By 2080, however, models show anywhere from a 2 to 4 inch (5 to 10 percent) increase in rainfall. Models predict more precipitation falling in the winter, and larger projected increases in winter relative to summer.

Figure 2.12: Average Annual Precipitation Will Increase by 2100

Average Annual Precipitation (Inches)	***Baseline***	***2050***	***2100***
Low Emissions Scenario	47.4	47	46.8
Medium Emissions Scenario	47.4	49.6	51.5
High Emissions Scenario	47.4	54.4	65.7

Source: NJTPA (2012)

Climate modeling conducted by the NJTPA indicates that average annual precipitation is sensitive to different GHG emission scenarios. Under the low SES, average annual precipitation will change little between now and the end of the century. Under the medium and high SES, average annual precipitation increases significantly by the end of the century. Under the high SES, annual average rainfall is projected to increase from 47 inches to nearly 66 inches (figure 2.12). Other climate modeling conducted for New Jersey project greater precipitation increases in the northern regions than in the southern regions of the state, with the medium scenario showing a 10 to 12 percent annual increase in the northern part of the state by the second half of the century, and a 3 to 4 percent increase in the south (NJCAA).

Precipitation is more likely to fall as extreme precipitation events (Horton et al 2011; Frumhoff et al 2007), and the intensity of the heaviest rainfalls is projected to increase (NJTPA 2012). It is difficult to project the frequency of specific extreme events because their occurrence is highly variable. However, climate modeling can provide projections regarding the intensity of storm events. In northern New Jersey, the 1 percent annual chance event is projected to yield more absolute rainfall under the higher emissions scenarios. Whereas the current 1 percent rain event delivers approximately 8 inches in Northern New Jersey, the medium scenario show a gain of about 1 inch by 2100. The high emissions scenario shows significant departure from low and medium after 2050, and is significantly higher by 2100, at about 11 inches of rain for a 1 percent storm event (figure 2.13).

Figure 2.13: Amount of Rainfall in a 1 Percent Storm Event Will Increase by 2100

1% storm (rainfall in inches)	***Baseline***	***2050***	***2100***
Low Emissions Scenario	8.3	8.6	8.7
Medium Emissions Scenario	8.3	8.9	9.4
High Emissions Scenario	8.3	9.5	11.4

Source: NJTPA (2012)

Because of the high variability in precipitation amounts, it is not only more difficult to distinguish long-term trends, but also harder to project how many extreme events will occur in the future. Projections indicate that short-duration warm season droughts are likely to become more common (Horton et al 2011), from only slightly more likely under the low SES to as frequent as once per year over much of the Northeast by the end of the century under the high (A1F1) emissions scenario (Hayhoe et al 2007; Frumhoff et al 2007). Climate modeling conducted by NJTPA did not project a significant increase in the number of consecutive dry days under all emission scenarios.

Sea Level Rise:

Total relative sea level rise (the combination of rising seas and land subsidence) in New Jersey over the past 100 years has been approximately 12 to 16 inches (USCCSP 2009), and has been higher than global or regional SLR increases. During this period, approximately 6 to 8 inches of the local SLR is due to human-induced causes, or up to one half of the total observed increase (ONJSC 2012, Stanley et al 2004).

Figure 2.14: Relative Sea Level Rise along the New Jersey Coast Will Increase Significantly by 2100

Relative Sea Level Rise (inches)	*2050*	*2100*
Low Emissions Scenario	8.8	25.6
Medium Emissions Scenario	14.4	47.3
High Emissions Scenario	23.1	71.6

Source: NJTPA (2012)

By the middle of the century, sea level along the New Jersey coast is projected to rise anywhere from 8 to 23 inches (low to high SES) when accounting for the effects of global sea level rise and land subsidence. By 2100, sea level is projected to rise anywhere from 25 to 72 inches in the New Jersey, with a middle scenario of 47 inches (figure 2.14). Sea level rise in the later half of the century will primarily be due to melting of the Greenland and Antarctic ice sheets.

2.4 Conclusions

All of the results presented here represent the best possible estimates based on information available at the time of compilation. For the reasons enumerated in the introduction, some uncertainty is inherent in these projections such that future changes in climate could be smaller or larger. Such uncertainty grows as projections extend farther into the future. As with any projections, there will be a need to revise them as new and better information becomes available. It is unlikely, however, that future refinement of these projections will change the conclusions that New Jersey's climate will change considerably during the remainder of this century and that sea level will continue to rise, most likely at a greater rate than was observed in the past century.

3 Planning, Policy, and Implementation Context

The Regional Plan for Sustainable Development will be a broad resource for decision makers in planning and public policy. It not only aims at providing a wealth of data, references, and recommendations for professional planners and citizens. The RPSD will also dovetail with the goals and recommendations of existing planning documents. In this way, the desired outcome will be a practicable set of guidelines that will be useful for implementation. Toward that end, the regional planning data and goals outlined within this Climate and Energy Baseline Assessment draw from and tie together relevant pieces from the following plans and initiatives:

- *New Jersey Energy Master Plan (December 2011):* The Energy Master Plan (EMP) laid out a strategic vision for the use, management, and development of energy in New Jersey over the next decade. The plan includes long-term objectives such as reducing the cost of energy, promoting the development of new energy technologies to stimulate the economy and create jobs, and supporting renewable and clean energy to protect the environment.

- *Global Warming Response Act (July 2007):* The New Jersey Global Warming Response Act (GWRA) adopted statewide limits on greenhouse gas emissions in July 2007. Specifically, the law mandates the statewide reduction of greenhouse gas emissions to 1990 levels by 2020, approximately a 20 percent reduction, followed by a further reduction of emissions to 80 percent below 2006 levels by 2050. This goal will be integrated into the long-term outcomes in the RPSD.

- *NJDEP GHG Reductions Recommendations Report:* In December 2009, the NJDEP released "*Meeting New Jersey's 2020 Greenhouse Gas Limit: New Jersey's Global Warming Response Act Recommendations Report"* as required by the GWRA. This report provided a range of options for meeting New Jersey's statewide 2020 greenhouse gas limit, and provided a framework for how the State needs to move forward to meet its statewide 2050 greenhouse gas limit. Recommendations from this report included will be reviewed and incorporated as appropriate.

- *New Jersey Climate Adaptation Alliance:* The Alliance is a network of policymakers, practitioners, academics, Non-governmental organization leaders, private sector leaders and others formed and led by Rutgers University to address climate change preparedness in NJ. The Alliance focuses on key impacted sectors such as public health, watersheds, rivers and coastal communities, built infrastructure, agriculture, and natural resources. Additional activities of the Alliance include identifying science, research and data needs, developing adaption recommendations for state and local actions, and conducting outreach and education to the general public and stakeholders. The efforts of the Alliance and the adaptation recommendations will contribute to the RPSD

- *Northeast Vehicle Network:* Transportation, energy and environment officials from 10 northeast and mid-Atlantic states and the District of Columbia formed the Northeast Electric Vehicle Network in 2010. The purpose of this Network is to develop a plan to promote alternative fuel and advanced technology vehicles and facilitates their deployment and infrastructure needs. The Northeast Electric Vehicle Network provided a blueprint for EV deployment and defined a set of consistent infrastructure standards to be adopted through the northeast.

- *County and Municipal Energy and GHG Reduction Plans:* A number of municipalities and counties in the TNJ region have developed plans to reduce GHG emissions within their jurisdictions. Sustainable

Jersey[TM] is a certification program for municipalities in New Jersey that seek want to go green, save money, and take steps to sustain their quality of life over the long term. Several municipalities have completed Climate Action Plans to reduce GHG emissions by employing a wide variety of strategies, including the greening of municipal fleets, land use changes to increase walking and biking, and in energy efficiency for buildings. A number of strategies recommended in these plans will be reviewed and integrated into the RPSD.

4 Desired Long Term Outcomes

Together North Jersey's RPSD should draw from and integrate the goals and recommendations of various efforts at the federal, state, regional, and local efforts to reduce GHG emissions and prepare for a changing climate. The overall goals for the RPSD as they relates to climate and energy is to ensure that communities are safe, healthy, and great places to live. In this regard, the RPSD should focus on reducing the impact that a changing climate has on the region's population, businesses, infrastructure, and natural lands and resources. Development of the climate and energy element of the RPSD should include quantifying areas in the region that are vulnerable to various climate stressors (riverine flooding, sea level rise, extreme heat) and address these vulnerabilities such that the outcome will direct policy-making and investment in the physical and built environment. In conjunction with reducing the vulnerable areas of the region, the element include measures that must be undertaken to reduce GHG emissions in the region above and beyond the polices and actions already adopted. The following long-range outcomes should be pursued to ensure that the TNJ effort is successful in addressing the pressing climate and energy challenges in the region:

- *Encourage the deployment of electric and alternative fueled vehicles:* Significantly reducing emissions from light-duty, medium and heavy-duty vehicles will require an aggressive deployment of infrastructure that can support purchasers of electric and alternative-fueled vehicles and facilitate their penetration into the marketplace. Government policy and regulation will need to be re-aligned at all levels in order to facilitate electric vehicle charging at home, on public streets, and in commercial settings. Local governments should amend zoning and parking regulations to facilitate electric vehicle charging facilities. State building codes should be amended to set uniform vehicle charging standards and evaluate the potential impacts of electric vehicles on the electricity grid. Widespread adoption of electric and alternatively fueled vehicles not only reduces GHG emissions but will also reduce emissions that negatively affect air quality and ozone formation. This benefit is especially important given the potential of increased ozone formation caused by rising temperatures.

- *Reduce GHG Emissions sufficiently enough to meet the mandates of the Global Warming Response Act:* Implement already identified GHG reduction strategies and developing additional strategies at the state, regional, county, and municipal level. Recommendations include land use strategies such as smart growth, transit-oriented development, reduction of emissions from the transportation system such as continued support of complete streets and improved bike and pedestrian facilities, expanding transportation demand management measures to reduce vehicle miles travelled, improving the efficiency of the transportation system through management of the limited-access and arterial roadways, and improvement in vehicle and fuel technology. Aggressive energy efficiency in the residential, commercial, and industrial sectors should also be pursued, including incorporating energy efficiency standards in buildings in order reduce the consumption of electricity and fuel use that account for more than half of all GHG emissions within the region.

- *Protect the region from the Impacts of Climate Change:* Achieving this outcome will first require Identifying areas within the region that are vulnerable to the impacts of climate change. This includes determining the threat that rising sea levels and storms surges will have on coastal communities, developing localized climate projections to understand the impact that more extreme precipitation will have on both riverine and coastal flooding, and understanding the impact that extreme heat and other climate stressors (wind, drought) have on the region. Homes, businesses, public facilities, infrastructure (transportation, water, sewer, electricity, communications) and natural lands are all vulnerable to a changing climate. The TNJ RPSD can assist in addressing the threat that climate change poses on the region by developing strategies to reduce vulnerabilities for the built and natural environment, economic and public health, and for vulnerable populations.

- *Expand the deployment of solar and other class 1 renewable energy within the region:* The recently rapid deployment of solar energy in the region has had a positive impact on reducing the region's greenhouse gas emissions from the electricity sector. Significant GHG reductions emissions from the electricity sector will be critical in meeting the mandates of the GWRA. The expansion of solar, wind facilities, biomass, and other class 1 renewable energy sources will be needed. In 2012, the New Jersey legislature accelerated solar deployment in the state by increasing the percentage of solar energy that must be purchased for consumption to 4.1% by 2028. Additional support for renewable energy can include funding for renewable energy storage projects, which allow for more efficient use of solar, biomass, hydroelectric and onshore wind energy, providing the ability to capture surplus generation and hold it for when it is needed during increased electricity demand.

5 Key Findings

5.1 Summary of Energy and Climate Change Challenges Facing the Region

- *Overall GHG emissions will continue to rise in the future:* Recently adopted federal, state, and local policies will result in a short-term reduction of GHG emissions through 2025. Most of the projected reductions will occur within the transportation sector due to vehicle and fuel efficiency improvements as well in the electricity sector through the increased use of renewable energy sources. However, in the absence of additional efforts to reduce GHG emissions, the region will ***not*** be able to meet the goals set out in the GWRA.
- *The Region's Climate has Changed Since Weather Recordings Began:* There has been an increase in average temperatures and precipitation in northern New Jersey. The average annual temperature in northern New Jersey has increased approximately 2.1^{o} Fahrenheit, while annual precipitation averages since 1970 have increased about 10 percent. There has also been an increase in the occurrence of heavy precipitation, with a small trend towards more extreme events (above 1, 2 or 4 inches/day) in the region during the last three decades.
- *Rising Sea Levels Will Increase the Threat to Coastal Communities:* By the end of the century, sea level along the New Jersey coast is projected to rise anywhere from 25 to 72 inches, depending on future GHG emissions. As the new flood elevation maps from FEMA indicate, there is approximately 332 miles of roadway and 55 miles of rail line within the region's coastal counties that are currently vulnerable to storm surge inundation and flooding. This vulnerability will only increase with rising sea levels. Rising sea levels will also continually elevate the risk of coastal inundation and nearby infrastructure from storm surges.

- *Additional GHG Emissions Will Further Change the Region's Climate:* Increases in annual average temperature are expected to range from 2.5 to 11.9°F by 2100, depending on future GHG emissions. The number of days over 95°F is projected to range from 8 to 47 days by 2100. Lastly, precipitation is more likely to increase as extreme precipitation events occur, thus increasing the amount of rainfall associated with a 1 percent rain event. These changes will have serious impacts on the region's communities as more frequent and intense storms cause increased rainfall and greater extreme temperatures. Increased intensity of extreme weather events will also pose a risk to critical transportation infrastructure within the region.

5.2 Measuring Progress

In order to ascertain the effectiveness of policies implemented to reduce GHG emissions and protect the region's population, businesses, natural lands and infrastructure from the impacts of climate change, it is necessary to identify indicators that can be measured and tracked as a way to: 1) evaluate different planning scenarios during the development of the RPSD; and 2) evaluate on a regular basis the region's progress. Potential indicators that may be used in scenario development and measuring long-term progress include:

GHG Emissions: Monitoring of GHG Emissions for New Jersey is conducted primarily by the New Jersey Department of Environmental Protection (NJDEP). Additional GHG emissions inventory analysis at the regional and local level is conducted by New Jersey's Metropolitan Planning Organizations, including the NJTPA. Regular updates of the region's GHG emissions will allow policy-makers to monitor the effect of GHG reducing policies and make appropriate adjustments in order to meet the goals of the GWRA.

The Use of Renewable Energy and adoption of Alternate Fueled Vehicles: The New Jersey Board of Public Utilities (NJBPU) tracks the number and capacity of solar and other class 1 renewable energy projects in New Jersey. The New Jersey Department of Environmental Protection (NJDEP) obtains the number of hybrid, plug-in hybrid, electric and other alternatively fueled vehicles in the state. Additional information on the number of alternative fueled vehicles is also collected by the Energy Information Agency of the U.S. Department of Energy.

Determining Vulnerable Areas and Infrastructure Assets Due to Climate Change: Determining the population, businesses, natural lands, and infrastructure vulnerable to climate change and extreme weather events requires combination of multiple sources of data and analysis. Building an inventory of all relevant assets, including homes and businesses, requires data sources from many different stakeholders, including transportation agencies, NJDEP, and other state, county, and local officials. Modeling future climate stressors such as sea level rise, temperature and precipitation changes are usually conducted by scientists working at Universities and other institutes across NJ and the Northeast. Data collection and analysis is likely to be limited to select agencies with the skills and financial resources necessary to monitor and update on a regular basis. Specific indicators to be monitored include; 1) the number of households vulnerable to sea level rise and flooding from intense storms; 2) miles of roadways and rail infrastructure vulnerable to repeated flooding, sea level rise, and extreme heat; and 3) number of residents vulnerable to the impacts of extreme heat.

6 Sources Cited

Frumhoff, P., McCarthy J., Melillo J., Moser S., and Wuebbles, D. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

Georgetown Climate Center Northeast Electric Vehicle Network (2012) http://www.georgetownclimate.org/tags/northeast-electric-vehicle-network Accessed May 1, 2013

Hayhoe, K., Wake C., Anderson, B., Liang X., Maurer E., Zhu J., Bradbury J., DeGaetano A., Hertel, A., and Wuebbles, D. 2008. Regional climate change projections for the Northeast U.S. Mitigation and Adaptation Strategies for Global Change. 13:425–436.

Horton R., Bader D., Tryhorn L., DeGaetano A, and Rosenzweig C. 2011. Chapter 1: Climate Risks, in Responding to Climate Change in NYS. New York State Energy Research and Development Authority (NYSERDA).

International Panel on Climate Change (IPCC). 2007. Summary for Policymakers. In *Climate Change 2007: The Physical Science Basis . Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Solomon, S., Qin D., Manning M., Chen A., Marquis M., Averyt K., Tignor, M., Miller, H. (eds.). New York: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. Available from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

Najjar, R., Patterson, I., Graham, S. 2009. Climate simulations of major estuarine watersheds in the Mid-Atlantic region of the US. Climatic Change. 95:139–168.

National Climatic Data Center (NCDC). 2012. http://www.ncdc.noaa.gov/oa/ncdc.html. Accessed on June 1, 2012.

New Jersey Board of Public Utility's Clean Energy Program (NJBPU) http://www.njcleanenergy.com/ Accessed on June 2, 2013

New Jersey Climate Adaptation Alliance (2013). Climate Change in New Jersey: Trends and Projections. http://climatechange.rutgers.edu/njadaptpdfs/ClimateImpacts/Trends_Projections.pdf Accessed on March 10, 2013

New Jersey Department of Environmental Protection, Office of Science. 2010. Climate Change in New Jersey: Trends in Temperature and Sea Level, Environmental Trends Report, available at: http://www.state.nj.us/dep/dsr/trends/.

New Jersey Energy Master Plan, 2011 http://nj.gov/emp/index.shtml Accessed on April 15, 2013

Office of New Jersey State Climatologist (ONJSC). 2012. http://climate.rutgers.edu/stateclim/. Accessed on April 25, 2013.

U.S. Climate Change Science Program (USCCSP) Report. 2009. Available from http://downloads.climatescience.gov/sap/usp/usp-prd-all09.pdf