Emissions Mitigation Opportunities and Practice in Northeastern United States

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Abstract

Climate change is underway, and is poised to have substantial impacts on the Northeastern United States. The emissions choices made by make now and in future years. While actions to reduce emissions in the Northeast alone will not stabilize concentrations of heat trapping gases in the atmosphere, the region is a center of global leadership in technology, policy, finance, and innovation, as well as the world's seventh largest source of carbon dioxide emissions. The Northeast region is well positioned to be a technology and policy leader in reducing emissions, and can drive national and international progress that is essential to providing a safe and stable future climate. This paper summarizes technological mitigation options as well as opportunities for public and private actions to reduce emissions. The authors propose a '3% solution' of annual emission reductions to put the Northeastern United States on an emissions reductions path that is consistent with the level of reductions necessary to avoid dangerous climate change. The '3 % solution' requires a combination of policies that will reduce the energy imbedded in the region's infrastructure and technologies, and individual action to choose the lowest emitting of available technologies.

Key words: Greenhouse gas, emissions, mitigation, Northeastern U.S., '3 % solution'.

1. Introduction

Heat trapping carbon dioxide (CO_2), the major contributor to global warming and climate change, is emitted whenever fossil fuels are burned to produce electricity, propel our vehicles, heat our homes or operate our industries. Carbon dioxide is also emitted through land-use, particularly the burning and clearing of forests. Additional greenhouse gases (GHG) are also released from agriculture, forestry, and industry.

In 1992 the United States ratified the United Nations Framework on Climate Change, which commits member nations to

"…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

Consistent with mounting scientific evidence of the risks of dangerous climate change, the European Union adopted a long-term policy goal of limiting global warming to no more than 2^{o} C above pre-industrial levels, a temperature rise that is still fraught with difficulties. Achieving this goal likely requires stabilizing atmospheric concentrations of carbon dioxide and other heat-trapping gases at or below 450 ppm carbon dioxide equivalent. Recent analyses indicate that this will require: (1) emissions reductions on the order of ~80% from 2000 levels by the US and other industrialized nations; (2) similarly deep transitions away from emissions-intensive development pathways by developing countries over this time period; and, (3) continued decarbonization of our economies after 2050 (Luers et al. in prep; Meinshausen et al. in press; Baer and Mastrandrea 2006).

Delaying action on climate change increases the difficulty and cost of responding. The U.S. National Academy of Sciences has warned "Failure to implement significant reductions in net greenhouse gases will make the job harder – both in terms of stabilizing their atmospheric abundances and in terms of experiencing more significant impacts" (National Academy of Sciences, 2005).[1] Analysis of the costs of emissions reductions, and the costs associated with temperature increases indicates that emissions mitigation is far more economic than inaction. A Tufts University report concluded that the economic costs of inaction far exceed the costs of limiting temperature increases to 2ºC based on a survey of current economic and scientific papers on climate change. The report estimates that by 2100, annual economic impacts of allowing temperature to increase more than 2ºC could reach 6-8% of global economic output (Ackerman 2006). The 2007 IPCC report indicates that climate change is more severe and more certainly caused by human actions (IPCC, 2007).

While a reduction on the order of 80% appears daunting at first impression, steady reductions on the order of 3% per year for the next fifty years make this an attainable goal. An annual reduction of about 3% will cut emissions in half in 23 years, to one-quarter in 46 years, and will achieve an 80% reduction in slightly less than 50 years. This '**3% solution**' can be a useful guideline as public, private, and individual decision-makers determine how to move onto a low emissions pathway necessary to avoid dangerous climate change. Actions outside the Northeast, such as adoption of a national renewable portfolio standard and vehicle fuel efficiency standards, can help the Northeast achieve emissions mitigation goals. This strategy is described in more specific terms in Section 5, and is consistent with other recent efforts such as "Climate Change Roadmap for New England and Eastern Canada" (ENE 2006). The strategy described here would keep atmospheric concentrations below both the Intergovernmental Panel on Climate Change (IPCC) A2 and B1 scenarios of how the future might unfold with different combinations of driving forces, and avoid some of the worst impacts associated with climate change described in those scenarios.[2]

The good news is that the Northeast region of the United States, as well as the United States and other nations, have just begun to tap the enormous resource available in energy efficiency, renewable power sources, and technology innovations in all sectors. A 2004 global analysis determined that growth rates for renewable technologies (such as wind and photovoltaics) position them to be important components of a long-term goal of reducing greenhouse gas emissions 75-80% below current levels (Aitken et al. 2004). The analysis indicates that penetration targets for renewable energy sources, 20% by 2020 and up to 50% by 2050 are feasible as part of a portfolio approach that includes reduction in the growth of energy demand (e.g. through end use energy efficiency). Renewables continue to thrive throughout the world, with numerous developed and developing nations adopting supportive policies and fostering renewables (Martinot 2006).

This report summarizes emissions mitigation technologies, policy tools, and actions that are necessary elements of a Northeast strategy to address climate change. In any case, changes underway are such that mitigation efforts must proceed simultaneously with adaptation efforts and can enhance our collective ability to adapt to changes that will be required by the global commitment to further warming. Adaptation strategies for the Northeast are addressed in a companion report (Moser et al. 2007). Collective choice and concerted actions among public, private, and individual decision-makers, using mitigation options described in this report, will bring a variety of benefits to the Northeast. We can simultaneously reduce our contribution to global greenhouse gas emissions, gain the benefits of technological and policy leadership, and derive economic and environmental benefits associated with a more efficient and lower-emissions economy. The report is aimed at a non-technical audience and highlights state and regional policy approaches as well as actions that individuals, communities and public and private sector institutions can take.

2. The Context of the Northeastern United States

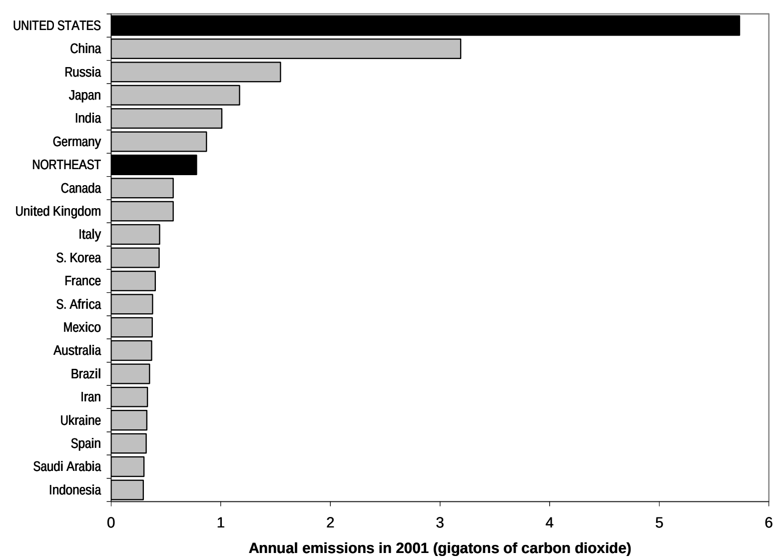
Having been home to the first industrial revolution in the United States, it is fitting that this region be the innovator of the next industrial revolution – Such a revolution must be efficient of energy and materials, low in emissions of heat trapping gases and other pollutants, and will show the way to a sustainable and secure economy and environment for this region and beyond. A confluence of factors creates the perfect opportunity and mandate for leadership from the Northeast. First, the Northeast and California are already significantly more carbon efficient than the rest of the country, and we are poised to continue the trend. Second, notwithstanding our successes, the Northeast remains a large contributor of heat trapping greenhouse gas emissions in the world. Third, our initial collective efforts provide the foundation for further progress in tapping technological resources, honing effective policy, and implementing solutions. Finally, the region will derive economic and environmental benefits from being a leader.

Perhaps our greatest wealth is in the individual decision-makers in all sectors and areas in the region. The state governments of the Northeast have shown themselves to be innovators in the policy realm, and have a history of regional coordination. Technology is incubated in a multitude of universities and research institutes, and regional companies are at the forefront of new, clean products in critical fields such as energy, electronics, software, and biotechnology. Companies large and small have also demonstrated a commitment to greenhouse gas reductions. The citizens have shown themselves to be responsible and willing to take on the task of changing their habits and adopting new technologies and ways to meet their needs in a sustainable manner.

2.1 Emissions in the Northeast

The Northeast comprises the nine states of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. Taken as a region, the Northeast states were the seventh highest emitter of CO_2 in the world in 2001, just behind India and ahead of Germany (as shown in Figure 1). Collectively, they contributed over 13% of total US CO_2 emissions in 2001.

Figure 1. Top twenty CO_2 emitters in the world, 2001.

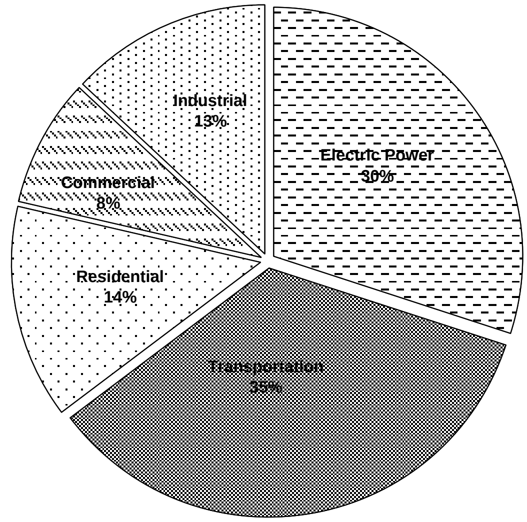


Data Source: Emissions data for 2001 from Energy Information Administration (EIA), International energy annual (2003), and EIA, Emissions of greenhouse gases in the United States (2004).

Like other industrialized emitters, the Northeast has higher per capita emissions than non-industrialized nations; but it also shares with the United States as a whole the dubious distinction of having higher per capita emissions than most other industrialized nations. Per capita emissions from the Northeast in 2001 were one and a half times the rate of Germany, almost six times the rate of China, and fourteen times the rate of India. Over the past decade our population has increased at an annual rate of 1% per year, while GHG emissions have increased at an annual rate of one-third of a percent.

The transportation sector contributes the largest portion of carbon emissions in the region. In contrast, nationally it is the electricity sector that contributes the most due to the relatively higher proportion of electricity derived from coal. Figure 2 shows the relative contributions of the different sectors; however, it underestimates emissions from the electric sector since the region imports electricity from the Midwest, where coal generation dominates.

Figure 2. Northeast states – regional emissions of CO_2 by sector – 2001



Data Source: EIA Table C.2 -State Energy Related Carbon Dioxide Emissions by Fuel - 2001.

2.3 What Public and Private Efforts Have There Been in the Northeast?

To the region's credit, it has been one of the leading innovators in the United States in early efforts to begin addressing climate change and reduce greenhouse gas emissions. Strong public and private leadership exist in regional policies, individual state policies, municipal policies, and in private sector initiatives and programs. Public sector policy leaders have justified these steps on the basis of avoiding the ecological and socio-political costs of climate change, as well as on the basis of economic and job benefits of technology innovation. Private sector initiatives cite the importance of addressing climate change, as well as the co-benefits to the individual companies of reducing emissions, such as through increased energy efficiency.

In August 2001, in the first action of its kind in North America, the New England Governors (NEG) and Eastern Canadian Premiers (ECP) signed an agreement for a comprehensive regional Climate Change Action Plan (NEG and ECP 2001). The plan identifies three greenhouse gas reduction targets:

- Short-term goal: reduce regional greenhouse gas emissions to 1990 levels by 2010.
- Mid-term goal: reduce regional GHG emissions by at least 10% below 1990 levels by 2020.
- Long-term goal: reduce regional greenhouse gas emissions 75-85% below 2001 emissions — consistent with reductions necessary worldwide to avoid dangerous threat to the climate.

The development of innovative climate change policy has been accelerated in the work of eight Northeastern states in the Regional Greenhouse Gas Initiative (RGGI). Currently, Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, and Vermont have agreed to initiate rulemaking or legislative action to form a Regional Greenhouse Gas Initiative (RGGI) cap and trade program that initially will apply only to electric power plants. Further, Maryland enacted legislation in April 2006, requiring the state's full participation in the process by June 30, 2007. Rhode Island participated in the development of RGGI, but has not joined. Pennsylvania, the District of Columbia, the Eastern Canadian Provinces Secretariat, and the Province of New Brunswick are official 'observers' in the RGGI process.

In addition to the regional policies, there are numerous examples of state policies that reduce greenhouse gas emissions. Many Northeast states have begun mitigation efforts through policies including Climate Change Action Plans, State Greenhouse Gas Emission Targets, Renewable Portfolio Standards, Public Benefit Funds, Auto Greenhouse Gas Emissions Standards, Appliance Efficiency Standards, and Non-RGGI Power Plant Caps.

Numerous cities, companies, and institutions have adopted programs and are exploring methods of reducing greenhouse gas emissions.

- More than 60 cities in the Northeast states participate in the Cities for Climate Protection Program, a program that assists local communities in developing and implementing approaches to reducing greenhouse gas emissions.
- More than 14 major corporations based in the Northeast have adopted measures to reduce greenhouse gas emissions, including Shaw's, Stop & Shop, Kinko's, Timberland, Verizon, Stonyfield Farm, and Harbec Plastics.
- Twenty-nine universities in New England and New York are Campus Partners in Clean Air-Cool Planet and are undertaking greenhouse gas mitigation actions. Both New Jersey and Pennsylvania have engaged all of their public and private universities in addressing climate change.
- Numerous regional companies such as Timberland, Shaw's, Stonyfield Farms and multinational corporations including UTC, Genzyme, GE, IBM, and International paper have made major reductions in their operational energy and/or committed to less emissions intensive products.

Progress on the RGGI as well as the wide range of actions of individual states, cities, and private sector entities demonstrate the region's leadership on climate change policy. States and individual companies have determined that initiatives to reduce greenhouse gas emissions make sense and provide local and regional benefits beyond the reduction of greenhouse gas emissions. Many of the actions that governments and the private sector are pursuing in the Northeast provide immediate collateral benefits including cost savings, cleaner air and water, and improved quality of life in our communities. Together, these policies establish a solid framework for reducing emissions in the region. These are just a start -- there are tremendous opportunities and a critical need for greater emission reductions.

2.4 Can We Stop Here?

No. Notwithstanding efforts to date, we are only in the early stages of transformations that will put us on a long-term pathway to a low carbon future that avoids dangerous climate change in this and other regions. It will neither be enough to continue our current level of efforts or to wait for a Federal climate change policy.

Of course the effectiveness of existing policies depends greatly on target and funding levels, and the specific details of policy design, which can (and do) vary from state to state. Furthermore, although a great many of these measures are included in state climate plans or are articulated in policies, they are not being fully implemented or deeply adopted. Real reductions in heat-trapping gases will require system-level changes that include development of a market for carbon that will result in a cost associated with carbon emissions, performance requirements in contracts that will constitute a floor on emissions performance, development of infrastructure that permits low-emission transportation options, and other systemic changes.

The states have been only partially successful in progress toward regional goals. For example, New England states have been moderately successful at best in working towards the goals established in 2001 (Thurber 2006; ENE 2006). Fortunately, the opportunities for further mitigation are large.

Making sure that we are reducing the energy and emissions embodied in our regional infrastructure, and in the technologies available to consumers is vital. It will require system-level change including a price of carbon from a regional cap and trade program, a vibrant market that incorporates risks associated with greenhouse gas emissions, setting performance requirements in contracts, and other measures that 'move the dial' with real GHG reductions. The next steps necessary in the region include expanded use of cost-effective energy efficiency and renewable resources, further technological innovation, full implementation of existing policies, and more pervasive adoption of packages of mitigation opportunities. The region's work, and the rewards from that work, have just begun.

3. Mitigation Options

Existing policies, programs, and applications in the Northeast constitute just the first steps in the effort that will be necessary to bring atmospheric concentrations – and thus emissions – in line with sound long-term targets for avoiding dangerous climate change. Fortunately, existing policies and public and private sector initiatives have just begun to tap the emission reduction opportunities available through transportation improvements, energy efficiency, renewable power, and power plant emission reduction requirements. The Northeast has many leading examples of technological innovation that will provide a solid foundation for progress; however, numerous opportunities still exist in the region. Part of the challenge of success is that these opportunities do not fall within the purview of a single entity, and in some cases authority is split among different entities. To a large extent, this is the challenge of an effective mitigation strategy. Implementation of the mitigation opportunities summarized below requires a combination of technology availability, a functioning market, corporate and individual awareness of climate change issues, and state and local policies that reflect the risks of climate change, and opportunities of mitigation. There are multiple opportunities to reduce emissions from energy use in the transportation sector, the electricity sector, and from residential and commercial buildings. These are discussed in Section 5 'What we can do.'

3.1 Technologies and Applications

A wide and exciting range of viable technologies, including energy efficiency and renewable energy sources, provides the building blocks in all sectors for a regional response to the climate change threat. Coupled with the policy options discussed in Section 3.2, these technology options put the Northeast in a strong position for continuing the development of effective climate change policy either on its own, or as part of a national policy.

3.1.1 Transportation

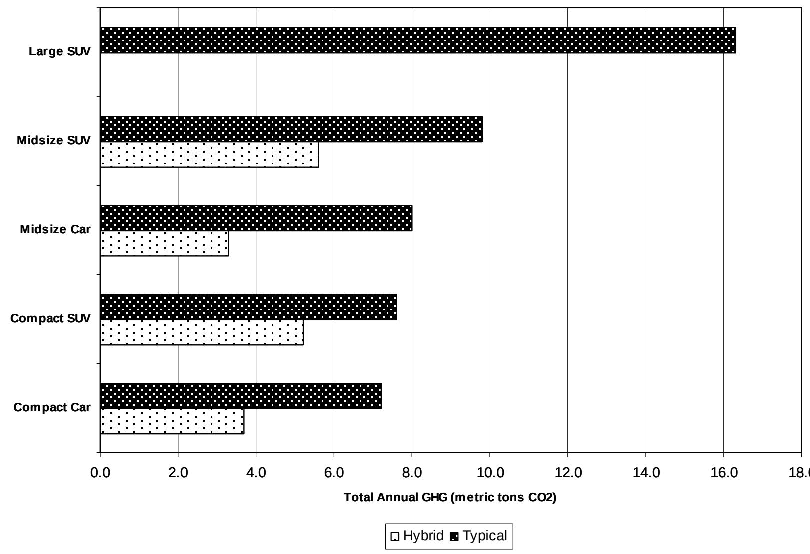
Carbon dioxide emissions from the transportation sector, the largest source of CO_2 emissions in the Northeast states, can be reduced in three major areas: reducing vehicle-related emissions, reducing fuel-related emissions, and reducing the total number of vehicle miles traveled (VMT).

Reducing Vehicle-Related Emissions: Consumers already have many lower-emitting vehicle models to choose from. Figure 3 compares emissions from hybrid and typical automobiles currently on the market. Furthermore, there are numerous technologies that can cost-effectively reduce GHG emissions from cars and light trucks by over one-third (Bedsworth 2004; Cooper et al. 2004).[3] A package of such technologies could reduce emissions up to 22% by 2012, and additional technologies emerging in the market could reduce emissions up to 29% by 2016 (CARB 2004). In both cases, additional vehicle costs would be offset by lower operating (fuel) costs, saving drivers $1,700 over the vehicle's life at today's prices of around $2 per gallon.

Hybrid vehicles combine conventional gasoline-powered vehicle technology with battery electric technology. Emissions reductions occur with use of batteries to offset the use of the engine and the inefficiency of variable engine loading. Full hybrids that use advanced technologies can reduce emissions by as much as 60%. Plug-in hybrids, not yet available in the US, could surpass even this (Friedman 2003). Hybrid vehicles are a useful transition to zero emission technologies that break away from today's conventional vehicles.

The availability of these options means that purchasing decisions, either individual or for a vehicle fleet, are an important element of a mitigation strategy. It also means that Government can play an important role in ensuring the development of markets for available technologies.

Figure 3
Comparison of Total Annual GHG Emissions From Hybrid and Typical Automobiles.



Data source: UCS Hybrid Center (www.hybridcenter.org) and ACEEE (www.GreenerCars.com). 'Large SUV' is a Dodge Ram 2WD – 2006MY. Assumptions: 15,000 miles traveled per year, 60% stop and go driving, 40% highway driving, tail-pipe and upstream emissions of 10.9 Kg CO_2 per gallon of gas used.

Reducing Fossil Fuel-Related Emissions: The transportation sector is currently developed around the internal combustion engine that relies primarily on liquid fuels. Replacing petroleum with biofuels — fuels produced from plant crops — reduces the use of fossil fuels. The greatest promise for greenhouse gas mitigation lies in cellulosic biofuel produced from the stalks, leaves, and stems of plants rather than in corn ethanol (Farrell et al 2006). Switchgrass — a fast-growing prairie grass — is one of the most promising crops for cellulosic biofuels. Cellulosic biofuel, combined with increased vehicle efficiency and smart growth, could reduce the oil dependence of the transportation sector by about two-thirds by 2030; decreasing more than 80% of transportation-related emissions (Greene 2004). In the Northeast, agricultural and forest waste are widely available and possible feedstocks for cellulosic ethanol. The availability of flexible fuel vehicles would accelerate the shift towards greater use of alcohol fuels and mixtures with gasoline. Biodiesel, made from plant oils and waste animal renderings including spent cooking oils, could provide valuable short-term emission reductions opportunities for diesel-powered equipment. The transition to these fuels could come quickly within the next decade with proper incentives.

Currently electricity is utilized for light rail, trolley buses, and commuter trains. Should progress in battery technology continue, it could provide access to an energy source with excellent performance. Efforts are underway to increase distance traveled between charges. Plug-in hybrid vehicles, using electrical energy from the grid as well as energy from the combustion of gasoline, are on the horizon. Some developers are targeting plug-in hybrids to have an all-electric range between 20 and 60 miles to keep battery costs low (Sanna 2005). When on the highway or longer trips, the engine would turn on and recharge the batteries and (or) provide power. Other developers are pursuing a 'blended hybrid' design that would use electricity from the grid to supplement the gasoline engine in a more traditional hybrid configuration to boost fuel economy. Experiments with existing hybrids demonstrate that emissions could be cut by two-thirds, or better, when batteries are charged externally with clean power (California Cars Initiative 2007). The electricity can be generated from a variety of sources, so complementary electricity sector policies will be needed to ensure low GHG emissions.

Hydrogen is a storable, clean-burning fuel, with potential uses in transportation and in stationary CHP applications. Hydrogen fuel cells generate power much more efficiently than combustion-based engines, but the production of hydrogen requires more energy than is released by it. Most automakers are pursuing hydrogen-powered vehicles as a potential long-term strategy for transportation. Powered by a high-efficiency fuel cell, such vehicles could reduce greenhouse gas emissions substantially, provided that the hydrogen is produced from low-carbon sources. Today, most hydrogen is made from natural gas. When used in a fuel cell vehicle, natural-gas derived hydrogen can reduce greenhouse gas emissions by 40% compared to a conventional gasoline vehicle (California Environmental Protection Agency 2005). Hydrogen produced from renewable energy sources would of course yield larger emissions benefits.

A few demonstration projects exist, showing the viability of powering vehicle fleets with hydrogen, but the availability of hydrogen-based technologies is many decades away at best. Widespread use of hydrogen vehicles must overcome high costs and technical barriers for fuel cells, and will require a well-developed system of hydrogen fueling stations. Because of these issues, hydrogen may only become a significant energy source and mitigation option in the distant future (GRI and NREL 2003; Synapse Energy Economics 2005).

3.1.2 Energy Efficiency

Energy efficiency is, and will continue to be, an enormous resource in the Northeast for reducing emissions from the electricity sector as well as from residential, commercial, and industrial sectors. Numerous technologies are available that decrease the amount of energy necessary to meet consumer and business demand for specific services such as lighting, refrigeration, space conditioning, hot water, myriad appliances, and industrial processes. These technologies have the potential to reduce greenhouse gas emissions and save consumers money at the same time, since they reduce energy bills with payback periods of one to five years. There are numerous excellent sources of information on energy efficiency opportunities in all sectors, including the Northeast Energy Efficiency Partnership, the American Council for an Energy Efficient Economy, and the Environmental Protection Agency.

A 2005 report for the Northeast Energy Efficiency Partnership on economically achievable energy efficiency potential in New England found that:

- Cost-effective investments in energy efficiency can more than offset projected electric energy and peak demand growth, and can thus defer the need for 28 combined-cycle power plants of 300-MW each by 2013.
- Economically achievable energy efficiency is abundant in all customer classes, sectors, end uses, and markets.
- Investments in energy efficiency can help New England meet the NEG/ECP climate change goals for 2010 as well as mandatory carbon caps (Optimal Energy 2005).

3.1.3 High Efficiency/Low Emission Buildings

About one-third of all energy consumed in the U.S. is used for heating, cooling, lighting, and appliances in buildings, and 22% of heat trapping emissions in the Northeast arise from space heating and hot water for buildings (Energy Information Administration). The development of the Energy Star rating system for buildings is a promising approach for a transition to increasingly high efficiency/low emission buildings. The Energy Star program provides strategies, tools, and a rating system for improving the energy efficiency of residences, commercial buildings, and industrial plants. Energy Star buildings cost significantly less to operate, provide greater comfort and result in lower emissions than standard buildings. They currently cost from zero to a few percent more to construct than conventional structures.

Energy concepts are also incorporated in the broader 'Green Buildings' concept. 'Green Buildings' refers to design and construction practices that incorporate a broad portfolio of technologies that result in an energy-, water-, and resource-efficient building having good indoor air quality, natural lighting, and minimal site disruption. Green buildings can provide an enormous benefit in their reduced use of electricity and energy, which helps reduce our dependence on fossil fuels, and thus emissions of CO_2. The Massachusetts

Technology Collaborative has found that several Massachusetts green building projects use, on average, 30% less energy than buildings constructed to code (though energy savings for individual building may vary widely).[4] A 2003 study conducted for the California Sustainable Building Task Force shows that an initial increase in upfront costs of approximately 2% for green design will yield lifecycle savings of more than ten times the initial investment, or 20% of total construction costs in the first 20 years (Kats et al 2003).[5] The Leadership in Energy and Environmental Design (LEED) rating system establishes a standard for green buildings; however, energy considerations are but one component and it is still possible to get LEED certification even though a building's energy performance might not be much better than conventional structures.

3.1.4 Renewable Energy

Renewable energy sources — including solar, wind, geothermal, ocean, and biomass — have no greenhouse gas emissions. They offer a tremendous opportunity for reducing greenhouse gas emissions from the electric sector by displacing fossil fuel used to make electricity and provide energy for buildings and industry.

The Northeast's ridgelines, forests, oceans, and agricultural lands could provide large amounts of energy from the sun, wind, tides, waves, and biomass. For example, technical potential of on-shore wind resources in the Northeast is sufficient to meet close to half of the annual energy needs of the region (AWEA 2006). Offshore wind resources in New England and Mid-Atlantic states are projected to far exceed current summer electric generating capability (Musial 2005). Off-shore wind in the Northeast could reduce the emissions of on-shore installations as much as two-times, due to the quality and timing of the resource (Berlinski and Connors 2006). Over the past twenty years technologies using these power sources have improved. For example, the cost of wind energy has dropped by more than 80% while reliability has increased. At the best sites, new wind turbines can generate electricity less expensively than natural gas power plants at 2005 natural gas prices.

Biomass energy production in the Northeast can use wood wastes, agricultural residues, or energy crops, such as fast-growing willow or poplar trees, either for co-firing with coal in CHP plants, or in dedicated biomass facilities. While solar electricity is still expensive, its cost continues to decline, and in many instances the availability of solar power nicely matches the demand for electricity, which tends to peak with air-conditioning use on hot and sunny afternoons in the Northeast.

The world's oceans, which cover 70% of Earth's surface, contain both thermal energy (from the Sun's heat) and mechanical energy (from the motion of tides and waves). Technologies to convert both of these types of energy to usable forms, such as electricity, are being developed.[6] While these technologies are still expensive, pilot projects have been proposed in several states including Massachusetts, New York, and Rhode Island. In a recently completed a study of tidal power resources in several U.S. states and two Canadian Provinces, the Electric Power Research Institute (EPRI) concluded that Maine's tidal power resource is excellent and can eventually produce electricity that is competitively priced with wind and natural gas, and less expensive than clean coal and solar (Maine Governor's Office 2006).

3.1.5 Combined Heat and Power

A CHP system produces both electricity and heat at or near a site where energy is consumed. The greatest promise of CHP lies in the combination of the efficiency of the system coupled with a renewable fuel source rather than dirty diesel generators. The system recovers much of the heat produced in electricity generation and uses it for heating, cooling, steam, and hot water in buildings like offices, hospitals, schools, colleges, hotels, and restaurants. As a result, CHP systems often exceed 80% of fuel efficiency (and some systems exceed 90%) — a significant improvement over central power plants where an average efficiency of about 30% means that typically two-thirds of the heat trapping CO_2 (and other pollutants) from fossil fuel combustion is released without producing any useful service.

Combined heat and power is useful at all scales from individual dwellings and buildings to large commercial, industrial, or institutional applications. There are potentially 17 Mw of CHP in commercial and industrial installations in the Northeast, almost doubling existing installations (Hedman 2003).

3.1.6 Managing Carbon Emissions from Electricity Generation

Carbon is emitted when fossil fuels are burned to generate electricity. Two future technologies to avoid the release of carbon emissions are under development. Carbon capture and storage (CCS) is a process to control emissions of CO_2 primarily from large stationary fossil-fueled sources such as power plants. In this process, CO_2 is captured, compressed, transported to a site, and stored in geologic formations (such as gas or oil fields), or in the ocean. In the Northeast, Pennsylvania is the only state for which geologic sequestration is a serious option. Another technology involves using the carbon emissions to grow algae and produce a combustible fuel. One Massachusetts company, Green Fuels Technologies Corporation, has demonstrated that captured CO_2 from power plant stacks can be used to produce an oil-rich algae that yields diesel-like fuel that can be fed back into the power plant or be used as a transportation fuel. The process also reduces NO_x emissions substantially.

3.1.7 Nuclear

Nuclear power plants do not produce greenhouse gas emissions during electricity generation. With the passage of the Energy Policy Act of 2005, which included many new nuclear subsidies, a number of U.S. electric companies have indicated interest in building new nuclear power plants, although none have been proposed in the Northeast. Current designs undergoing licensing review by the Nuclear Regulatory Commission incorporate incremental design improvements from the current generation of nuclear plants. More advanced designs, labeled ‘Generation IV’, are also under development. Despite new designs there are still unresolved issues around vulnerability to serious accidents or acts of terrorism or sabotage, the potential contribution to nuclear weapons proliferation, lack of approved long-term waste storage, and the economic and financial challenges that ended orders for new nuclear plants in the U.S. after 1975. If the industry can resolve these problems, and regain public confidence, construction of new plants in the U.S. could become an option in another decade or two. Their viability would likely have to be firmly established in other regions before they would be considered in the Northeast because of its dense population and competitive electricity markets.

3.2 Opportunities for Public Policy and Private Action

Zero or low-emission technologies will not achieve the market penetration necessary to make serious steps along a rational greenhouse gas mitigation pathway if left to the market alone, or if installed in isolated applications. Mitigation requires actions in the public and private sectors. Government can be a leader as a learning lab, innovator, technology developer, and technology funder and can play a major role in the development of vibrant markets for new technologies. In many cases, state or municipal policies will create the right conditions for emissions mitigation, through new incentives, removal of market barriers, and creation of market stimuli. Initiatives to date put the Northeast in a strong position to expand policies and initiatives as the magnitude of necessary reductions becomes clear. A coordinated strategy for the region would drive changes even more rapidly and effectively.

3.2.1 What Is the Role of States and Cities in Mitigating Climate Change?

A low emissions pathway requires the simultaneous efforts of the public and private sectors, universities, corporations, organizations, and individuals. The infrastructure and technologies in our region, as in other regions, have a certain amount of ‘imbedded energy’ or energy that is invested in their construction and manufacture. Furthermore, decisions made in the construction of new buildings, transportation infrastructure, and technologies commit us collectively in their use to certain patterns of energy consumption and emissions. States and cities have a unique ability to leverage opportunities to reduce the energy (and associated emissions) that are built into our region's infrastructure and the technologies available for consumers to choose from. Thus they can leverage opportunities into changes that bend the emissions curve and generate larger reductions in the long term.

The policy objective of a low carbon future must constitute an umbrella under which the region's individual agencies pursue their policy objectives. It is essential that Governors and legislatures in the Northeast create an overarching policy goal of a low carbon energy future in order to minimize policy objective conflicts and to enable agencies in the region to take a broader perspective regarding their public service than they otherwise feel empowered to do. Government entities can transform markets and encourage private sector behavior using a combination of tools including requirements, incentives, and models for reductions. Government also has an important role to play in furthering research and development of new technologies. A combination of carrots, sticks, and leadership in innovation, will have more effect than any single approach, and will create the context within which all entities (public, private, and individual) are working towards a long-term goal of greenhouse gas mitigation.

States and municipalities have distinct, though sometimes overlapping, areas of authority. Between them they hold authority over or can influence transportation planning, power plant siting and approval, elements of electrical power procurement, pipeline systems, land use planning, and building codes. Their policy tools and options are broad. They can encourage and mandate renewable energy sources, installation of small, distributed, clean power and combined heat and power (CHP), and increased energy efficiency (in appliances, heat pumps, furnaces, and air conditioners). They can establish mandatory carbon caps, and require renewable portfolio standards and green electricity purchases. Using their taxing authority, states and municipal governments can use differential sales taxes to encourage the purchase of more efficient vehicles, appliances, lighting and building materials, and systems. Property tax incentives can be given for low emission, energy efficient buildings, and smart growth development. Specifying the use of certified low carbon biofuels for vehicles and eventually for home heating could also lead to rapid reductions in CO_2 emissions. State and local regulatory mechanisms can be used to encourage low emission projects through expedited review and lower permit fees. An aggressive campaign to capture methane emissions from landfills, wastewater treatment facilities, and agriculture can also reduce the regional contribution and add an indigenous source of low carbon fuel to the regions resources. City governments can create municipal utilities that are dedicated to distributed power and renewable supply options.

Beyond their policy jurisdiction, government entities are large consumers of energy-related goods and services. They own and operate multiple buildings, schools, and universities as well as vehicle fleets and can use their purchasing power to shift the balance to low carbon emitting sources of energy. Their use of low carbon technologies also serves as an important mechanism to demonstrate the feasibility of low carbon portfolios of goods and services. Through contracts for public construction and services, states and municipalities can set energy efficiency and emission standards for the companies with which they do business. State and local governments can play an important role in developing markets for new technologies, helping these new technologies sell well, through the use of purchase requirements, tax credits, incentives, and education. Such market facilitation will result in economies of scale for the production of new and emerging technologies, and in real customer choice for consumers.

Though states have a leadership role, ultimately consumers, institutions, and businesses must rethink and change the way they use energy. Through their choices, they can reduce emissions, and can demonstrate leadership that will inspire others to follow the example. Government initiatives, combined with corporate leadership and informed consumer choice, can develop effective markets that result in cost-effective emission reductions.

3.2.2 Cap and Trade Programs

A mandatory cap and trade program uses market forces to control emissions from a group of emissions sources. A cap and trade program can be applied to an individual sector (e.g. the electric sector) or it can be applied economy-wide. After a cap on emissions is established, regulated sources must obtain an allowance to emit a unit of emissions. Ultimately, an economy-wide cap and trade program that applies to upstream emission sources will be most effective in reducing emissions of heat-trapping gases as it creates a cost associated with emissions. Auctioning allowances under a cap and trade program will result in the most cost-effective program for consumers, and avoid windfall profits for emission sources.

The RGGI in the Northeast, a cap and trade program for the electric power sector, is an important step forward for the region. The RGGI states have agreed to stabilization of CO_2 emissions from power plants at current levels for the period 2009-2015, followed by a 10% reduction below current levels by 2019. The states have further agreed that a minimum of 25% of allowances would be allocated for consumer benefit and strategic energy purposes, and individual states indicate strong interest in auction of 100% of allowances. The agreement also provides certain offset provisions that increase offset flexibility to moderate price impacts, and development of complementary energy policies to improve energy efficiency, decrease the use of higher polluting electricity generation, and maintain economic growth.

As the first mandatory carbon cap and trade program in the nation, RGGI will be a likely template for any nation-wide federal cap and trade program. Consequently, decisions in Northeast states regarding program design and implementation are critical. Evaluation of the economic costs and benefits of this program is discussed later in this report under Section 4: “Costs and Benefits of Mitigation”. Other greenhouse gas cap and trade programs have been proposed at the federal level and have included power sector programs as well as economy-wide programs. For a cap and trade program to be effective and economical, it can be combined with a range of complementary energy policies, such as those described below.

3.2.3 Transportation

The primary policy options for reducing CO_2 emissions from this sector include requirements to reduce emissions from conventional vehicles, incentives or requirements to purchase efficient vehicles or those that use alternative fuels, and initiatives to reduce vehicle miles traveled (e.g. efforts to increase use of public transportation or telecommuting) (Greene and Schafer 2003). Other measures that could be implemented through state policy include requiring low rolling resistance tires and regulating car air conditioning chemicals.

Vehicle Emissions Standards: Eight states in the Northeast intend to adopt vehicle emission standards developed in California (CT, ME, MA, NJ, NY, PA, RI, and VT). California has adopted greenhouse gas emission standards for automobiles. They require a 1 to 2% reduction in emissions in 2009, depending on vehicle type, rising incrementally to reach approximately 30% below 2002 levels in 2016. The regulations will take effect in 2006 and apply to model years 2009 and after.[7]

Tax Incentives or Fee Programs: States have done little to reduce emissions from the transportation sector through tax policy, although one town in Massachusetts (Williamstown) has set a 75% reduction in auto excise tax for highly efficient vehicles. One option is to adjust the sales tax to be highest for the highest emitting vehicles and lower or zero on the lowest emitting ones. This is sometimes referred to as a ‘feebate’ system when it is structured to be revenue neutral. This system has the advantage of making the purchase price higher for higher emitting vehicles, discouraging their purchase in the first place.

Insurance at the Pump: Tying the purchase of basic mandatory liability insurance to fuel purchases makes drivers who drive more (and who are therefore at higher risk), pay more, and drivers of larger vehicles that can inflict more damage pay more. Paying for insurance at the pump raises drivers’ awareness of the full costs of operating their vehicle.[8] Coordination among the states would enhance the effectiveness of this approach and would reduce the leakage of cross border fuel purchases (Khazzoom 2000).

Fleet Initiatives: States, cities, and corporations have developed initiatives to improve the fuel efficiency of their automobile fleets. Cities like Medford, MA have replaced all of their autos with fuel-efficient hybrids. Some universities have also bought hybrid and other efficient vehicles as a matter of policy. Such strategies can often save valuable state, municipal, or institutional funds and help build the market for low-GHG vehicles. Heavy-duty fleets, such as transit fleets, present a particular challenge since fuel efficiency improvements are not as widely available for these vehicles as they are for smaller passenger vehicles. Here, new fuels such as biodiesel can present opportunities to reduce emissions. The University of New Hampshire recently converted to biodiesel buses in its transportation fleet.

Reduction of Vehicle Miles Traveled: States have explored the use of various policy tools to reduce the total number of miles that people drive either by making it easier to get places without relying on individual automobile transportation, or by reducing the distances that people need to travel to get to work or to obtain needed services. Examples of the former approach include efforts to improve public transportation and increase ride sharing. Examples of the latter approach include efforts to promote telecommuting, reduce urban sprawl, and to promote 'smart growth'.

The use of state and local infrastructure funds can greatly shape development. Massachusetts alone spends on the order of $4 billion a year on infrastructure development across its agencies, making these funds a potentially significant mitigation opportunity. The Massachusetts Office of Commonwealth Development (OCD) fosters smart growth through the integration of energy, environmental, housing, and transportation agencies' policies, programs, and regulations. The OCD seeks to ensure that agencies are working in coordinated fashion to promote sustainable growth. Some of the principles upon which smart growth is based include concentrating development to avoid urban sprawl, expanding transportation choice, development near transportation nodes to promote the use of public transportation, and using existing infrastructure and building sites before developing new sites.

Property tax policies are one tool that can affect urban sprawl and growth patterns. Policies that encourage 'in-filling' in already built up areas include property tax incentives and placing additional taxes on developing previously undeveloped land. Tax and regulatory incentives can also be given to encourage cluster development. Location efficient mortgages encourage lower rates for purchasing in more dense areas where travel expenses are lower.

3.2.4 Energy Efficiency Policies

Continuing New England's current energy efficiency policies over the next 10 years would target less than 20% of economically achievable energy efficiency potential (Optimal Energy 2005). Even with a cap and trade program that puts a price on carbon emissions, energy efficiency technologies will continue to face many market barriers to their implementation, such as lack of consumer information, difficult access to capital, and split incentives between building owners and tenants.

States in the Northeast have developed a number of different policies to overcome market barriers to increasing energy efficiency. These policies all provide a strong foundation for the Northeast States to further increase reliance on energy efficiency as part of an effort to mitigate greenhouse gas emissions. These policies can greatly reduce greenhouse gas emissions from the electric sector as well as from the residential, commercial, and industrial sectors and must be expanded. Currently the greatest source of efficiency spending is utility energy efficiency (also know as Demand Side Management) programs. All states have adopted Public Benefits Funds, which ensure a minimum level of funding for energy efficiency. Many public utility commissions have played an important role on efficiency and renewables through adoption of policies designed to incorporate these resources into the electric power system. Regulatory hurdles to greater efficiency, such as the failure to decouple utility profits from sales, continue to hamper energy efficiency. Removing these barriers could in itself be a major reduction strategy. Continued funding of energy efficiency programs is essential.

Appliance and Lighting Efficiency Standards: Improved appliance efficiency standards are the cheapest way, along with building codes, to realize a portion of New England's Energy Efficiency Potential (Optimal Energy 2005). CT, NJ, RI, NY, MA, as well as states in other areas of the country, have all established efficiency standards since 2004, continuing a historic pattern of states leading the federal government in developing rigorous efficiency standards. These new standards have again expanded the envelope for federal action, with new standards for 15 products incorporated into the Energy Policy Act of 2005 (Pub. L. 109-58 (2005). Still, opportunities remain for new equipment and appliance standards beyond the 2005 federal standards (Nadel and deLaski 2006).

The Northeast Energy Efficiency Partnership estimates that adoption of new or updated efficiency standards in the Northeast could, by 2020, reduce annual carbon emissions by over 6 million metric tons. That is equivalent to about 44% of non-transportation emissions reductions that would be required to achieve the New England Governors' Conference goal of achieving 1990 emissions levels by 2020 (NEEP 2006).

Building Energy Codes: Improved building energy codes, as well as appliance efficiency standards, are the cheapest way to realize a portion of New England's Energy Efficiency Potential (Optimal Energy 2005). Though adopted by many states in the region, state building codes have not kept pace with technological innovation. Building codes in all of the states result in energy use (and emissions) that are 15-30% higher than Energy Star standards. State Building Energy Codes establish a minimum level of energy efficiency for residential or commercial buildings. Generally, codes specify requirements for 'thermal resistance' of the building shell and windows, and minimum heating and cooling equipment efficiencies. Broadening requirements to include minimum air infiltration, insulation, and door and window standards could increase savings. All states in the Northeast have commercial building energy codes that meet the requirements of the federal Energy Conservation and Production Act (ECPA). Not all states have residential building energy codes, and some states that do have them do not yet meet the requirements of the federal ECPA.

Requiring all buildings sold to have an energy rating would help to push owners to upgrade their energy systems by supplying meaningful market information. Providing financial incentives for earlier action would also be cost effective. There is also a need for a state inspection system and energy certification requirement that assures building buyers and owners of the value of their investment in energy efficiency. One option might be to create an 'energy extension service' from the state university system that could provide assistance to all building owners in a particular state. Also zoning laws and rules can assist the development of less energy intensive buildings by supporting the use of solar energy and requiring, or at least encouraging, proper orientation for optimal heating and cooling benefits. With so many older buildings in the region, setting standards for renovations that will enhance energy performance and reduce emissions could make a sizable difference for the building sector. Finally, supporting the location of CHP systems at the building, campus, and district levels can substantially lower emissions.

Energy Efficiency Resource Standard: Three states in the Northeast (CT, PA, and VT) have adopted an Energy Efficiency Resource Standard (EERS), or Energy Efficiency Portfolio Standard. An EERS encourages more efficient generation, transmission, and use of electricity and natural gas through an energy savings target for utilities or other retail power suppliers, and represents one of the largest opportunities to capture cost-effective energy savings (Nadel 2006). Sometimes the regulatory agency will allow flexibility to achieve the target through a market-based trading system. EERS's include end-use energy savings improvements and may also include distribution system efficiency improvements or provisions for CHP systems.

States and Cities Leading by Example: States and cities can mandate the purchase of the most efficient lighting and appliances in all state and municipal buildings, public schools, state universities, and other facilities. Six states have adopted green building energy standards for state buildings – leading by example in the development of green building practices, while saving the state money and simultaneously enhancing the quality of life of workers in those buildings (Pew Center on Global Climate Change 2006). Street and traffic lighting is another area where major reductions in energy can be made cost effectively, but there are no policy requirements to do so.

These policies all provide tremendous opportunity in the Northeast. The availability of a large efficiency resource means that continued development of federal and state product efficiency standards, energy efficiency funding, energy efficiency procurement rules, incorporation of energy efficiency into resource planning and other policies are all valuable throughout the Northeast states.

3.2.5 Renewable Energy Policies

The benefits of renewable energy include: CO_2 emissions reductions, energy supply diversity, national and economic security, clean domestic energy supply, electricity price stabilization, reduction of natural gas prices, reduction of air pollution, and job creation. Policies focused on increasing our reliance on renewable energy are effective tools for reducing greenhouse gas emissions from the power sector. While several small-scale wind installations exist in the Northeast, larger-scale renewables deployment faces challenges that must be addressed — especially siting of larger-scale installations and establishing long-term contracts for energy from these installations. For example, in Massachusetts the proposed Cape Wind installation, the first off-shore wind facility proposed in the country, has faced significant regulatory and legal hurdles despite that state's public support for the development of renewable energy sources.

Renewable Portfolio Standard: A Renewable Portfolio Standard (RPS) requires that a certain amount of the energy provided by a retail supplier be produced from renewable resources such as wind, biomass, geothermal, and solar energy. The RPS uses a system of tradable 'renewable energy credits' to achieve compliance at the lowest cost. This market-based approach creates competition among renewable generators, providing the greatest amount of clean power for the lowest price, and creates an ongoing incentive to drive down costs. A national RPS requiring that by 2020 renewables supply 20% of the electricity sold in the nation would result in renewables supplying slightly over 10% of the electricity sold in the Northeast. Requiring 20% by 2020 in individual Northeast states would result in higher penetration of renewables in the region and ensure that we enjoy the many benefits of renewables including clean air, energy security, job creation, and quality of life improvements.[9]

Public Benefit Fund: Public Benefit Funds are collected either through a small charge on the bill of every electric customer or through specified contributions from utilities. The charge ensures that money is available to fund renewable projects. Publicly managed clean energy funds from many states have formed the Clean Energy States Alliance to coordinate public benefit fund investments in renewable energy. Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island are participating in the Clean Energy Alliance.

Net Metering: Net metering policies enable customers with on-site renewables (conventional or CHP) to reduce the amount of electricity that they purchase from the grid by selling excess electricity from their on-site renewable to the electric company. Net metering is used to measure a customer's total electric consumption against that customer's total on-site electric production. When on-site production exceeds use, the customer sends electricity to the grid, and when use exceeds production, the customer uses electricity from the grid. The customer then pays the local electric provider only for the net electricity consumed, making renewables more cost-effective for the customer.

Distributed Generation Policies: Distributed Generation (DG) is the placement of small-scale electric power generation close to where the electricity will be used. DG that uses renewable fuel sources promises greenhouse gas emission reductions through displacement of grid-supplied electricity generated from fossil fuels. To date, no state has adopted comprehensive measures to encourage the use of distributed energy systems that would facilitate the introduction of renewable electricity generators and efficient, clean CHP systems. Despite the adoption of net metering policies, and state funding, significant regulatory barriers remain to what could be a rapid increase in low and zero emission electric power generation. The structure of standby charges, departure fees, and size restrictions can prevent independent power producers and customers from investing in distributed generation. Combined heat and power, district heating and cooling systems, or large-scale renewable energy will not be able to make significant inroads into the market place under current regulations.

University campuses for example are ideal for combined heat and power because of their existing networks of heating pipes. Unfortunately, universities have faced multiyear legal battles and/or payment of large fees, and these experiences have scared off most others from attempting it. For example, several years ago, Boston University had to turn down a multi-megawatt fuel cell gift and return funding to Massachusetts Technology Collaborative because the utility insisted that they continue to pay nearly what they were currently paying for standby power (Boston university, 2004). Prohibitions on private distribution systems also discourage campuses from generating their own power. Yet there is an imperative to provide additional power in the near future to urban areas in the region, and this can most likely be done in a timeframe that avoids significant power shortages and possible blackouts. Hence, reform of utility regulations that provide the necessary standards for power quality, safety, and availability from independent suppliers is needed to bring on-site CHP and on-site renewables as a technique for reaching emissions reduction goals and enhancing system reliability.

Tax Policies: Several northeastern states have adopted tax policies to support the deployment of renewable energy sources. For example, states have adopted property tax incentives (e.g. so that the value added from renewable equipment is not included in the valuation for property tax purposes), income tax credits or deductions to cover the cost of purchase and installation of a renewable power source, and/or exemption from the state sales tax for the cost of renewable energy equipment. Adding sales tax exemptions for insulation or better windows and appliances would encourage the purchase of these items as well. The establishment of co-housing projects has demonstrated that groups of houses in developments can use larger scale ground source heat pumps or wind and solar energy in cost effective ways that reduce emissions. Tax incentives to encourage these efforts need to be created to encourage developers of larger scale projects to utilize emissions reduction technologies for heat, hot water, and air conditioning.

3.2.6 Electric Resource Planning Policies

State public utilities commissions have required portfolio management approaches in resource planning in the electric industry as a tool to provide least-cost and stable electric service to customers over the long-term. Comprehensive resource planning can address a variety of electric generation and transmission concerns, including reliability, safety, and environmental impacts. Electric industry restructuring created some uncertainty about how integrated resource planning concepts could be applied in a restructured industry. However, it is increasingly evident that portfolio management approaches are viable and valuable. In the context of climate change, portfolio management and resource planning policies provide an essential tool for considering the financial risks associated with CO_2 emissions from electric power generation. With the development of a regional cap and trade program, and with the increased interest in developing mandatory emission reduction policies at the federal level, it is imprudent for entities in the electric power sector not to factor costs associated with greenhouse gas emissions into resource planning and procurement decisions (Johnston et al 2006).

Some states require electricity suppliers, whether vertically-integrated electric utilities or competitive electric suppliers, to use portfolio management strategies. Portfolio management involves deliberately choosing among a variety of electricity products and contracts or supply options in order to obtain resources that are consistent with state policies. Portfolio management requirements offer an opportunity for states to require that electricity resource procurement is consistent with state clean energy and low emission policy goals. The new Forward Capacity Market could be redirected to provide funding for renewable energy, distributed CHP and demand side energy efficiency rather than focus only on more fossil fuel central power plants.

3.2.7 Action Plans

All of the states in the Northeast have Climate Change Action Plans in place. Numerous municipalities in the Northeast states have adopted climate change policies. These policies include such steps as green fleet purchasing, green power purchasing, renewable energy/distributed generation installations, public transit improvements, public building retrofits, street lighting upgrades, and others. In Connecticut, many communities are joining Smartpower's '20% by 2010' program. The program encourages communities, churches, universities, and other institutions to commit to purchasing 20% of their energy from clean energy sources by 2010.[10]

Municipalities have several opportunities. For example, municipalities make important decisions about school retrofits and incorporating green building practices. They can require disclosure of energy requirements for buildings in the development reviews, incorporate home-based energy/climate education into local curricula, adopt recycling policies, or reform zoning laws for green (energy efficient) developments. Cities and towns also have influence through Metropolitan Planning Organizations.

In the Northeast, University and College Campuses are leaders in addressing climate change. The NEG/ECP has many campuses signed up to support the goals of the Governors and Premiers. If states worked with universities and colleges, and funded some level of campus action, they could leverage state resources. Many institutions have taken a portfolio of actions to reduce greenhouse gas emissions from the campus, and to demonstrate the application of efficiency and renewable technologies in meeting the need for energy services. Clean Air-Cool Planet has developed a 'Campuses for Climate Action' program to support institutions in finding and demonstrating energy and global warming solutions.

3.2.8 Land-Use Measures

Taking carbon out of the atmosphere and storing it in soil and biomass can reduce atmospheric concentrations of CO_2. Trees and other vegetation store carbon. Cutting down a tree not only removes that tree's capacity for carbon capture, but it can also result in the release of stored carbon when the tree is burned or when its wood is left to decompose. Thus forests play a significant role in mitigating CO_2 emissions. Forest management practices affect the amount of carbon stored in forests, as well as the amount that is released when timber is harvested. Opportunities for carbon capture or emissions avoidance from forests include forest protection, and reforestation or afforestation. The Woods Hole Research Institute in Woods Hole, MA is studying carbon cycling in forests (at Harvard Forest in Petersham, Massachusetts and at Howland, Maine) in order to understand the nature and extent of the role played by forests in alleviating global warming. Current studies at Harvard Forest suggest that the Northeast is a net sink for CO_2 at the present time. There is an opportunity for private landowners, especially those involved in sustainable forestry initiatives, for university and research center owned forests, and for the significant state and federal forests in the region to add carbon storage to their list of multiple uses of these lands (Moomaw 1989; Harvard Forest 2006).

In the agricultural sector, land use and management practices also affect the amount of carbon stored in soils. Sustainable farming practices can increase the carbon-storing organic matter in soil, and reduce or eliminate the use of nitrogen fertilizers that release greenhouse gases into the atmosphere when they break down. 'No-till' farming methods, which cause less soil disturbance and erosion, can further decrease the release of greenhouse gases (US Department of Agriculture 2007).

3.2.9 Methane Recovery

Methane from livestock, sewage treatment plants, and landfills is a major greenhouse gas with a global warming potential 7 times that of CO_2 per molecule. Programs are in place to recover this valuable fuel and to burn it for energy production, but this gas is still vented to the atmosphere from many landfills and sewage treatment facilities in the region. Since many of these are close to cities, they can provide a useful supplementary natural gas fuel for electricity or heat. Many farmers in the area are finding it profitable to capture methane from their livestock and use it as a fuel for heating buildings and even for driving tractors and other vehicles.

4. Costs and Benefits of Mitigation

One of the challenges in choosing a course of action under the threat of climate change arises from the difficulty of assessing the relative costs of specific courses of action compared with the costs of inaction, or continuing on a path of business as usual. Further analysis is necessary to identify the most effective portfolio of options to pursue. There have been several quantitative assessments of the costs of complying with various emission reduction goals. However, there have been fewer quantitative assessments of the benefits to the regional economy of moving toward a low carbon economy. In qualitative terms, these benefits include economic security from reliance on regional energy sources, energy security through resource diversity, job creation, and environmental benefits associated with efficient resource use and reduction of local and regional pollutants. With evidence mounting of climate changes and projected climate changes, it's important to also consider the potential costs of not moving to a lower emissions pathway. While there are significant uncertainties surrounding impacts in the long-term, the potential for catastrophic impacts if we do nothing is an aspect that usually does not figure into assessments of the costs and benefits of specific policies such as RGGI or other specific legislative policy proposals.

The RGGI State Working Group (environmental and utility regulators from each state) requested analysis of the economic impacts of the proposed RGGI package. Implementation of the package, under various assumptions about emissions levels, implementation of a federal cap and trade program, and energy efficiency in the RGGI program, resulted in projected annual household bill impacts of up to $46 per year by 2021. Analysis of incremental energy efficiency, due to implementation of a portfolio of energy efficiency programs, resulted in savings to households above the projected costs of the program ranging from $4 to $108 for all households, revealing the importance of energy efficiency to program cost reduction.[11]

The ACEEE has analyzed and evaluated the RGGI modeling results (Prindle et al. 2006). The ACEEE concludes that doubling efficiency spending in the RGGI region would cut load growth by about two-thirds by 2024, and reduce capacity additions by about 8,000 MW (25% reduction from the reference case). Carbon emissions would remain virtually flat (compared to a 15% increase in the reference case). Other results include reducing energy price growth, lowering carbon prices, and reducing power imports (thus leakage issues). Results also show increase in consumer energy savings, regional economic output, personal income, and employment.

In the past several years there have been numerous policy analyses seeking to assess the feasibility of moving to a low carbon economy as well as to project the costs of CO_2 emissions under a mandatory carbon emission reduction program. Several analyses examine the results of a concerted effort to implement energy efficiency, renewable energy, and other clean energy options. In general these analyses conclude that a portfolio that incorporates strong energy efficiency, renewables, and other clean energy options provide a promising energy future that not only reduces CO_2 emissions, but offers a host of other environmental, economic and security benefits (see e.g., Clemmer et al 2001; Aitken et al 2004; Bailie et al 2003).

All of these analyses show a portfolio of energy efficiency and renewables as a powerful tool in decreasing the incremental costs of moving to a low carbon energy future thereby making more aggressive targets more achievable. The analyses show that the policies that promote a low carbon energy future and address climate change have numerous complimentary benefits including job creation, reductions in other air emissions and environmental impacts, energy diversity and security, and national security through reduced reliance on foreign oil. As discussed earlier in this paper, the longer that we wait the more costly mitigation will be.

5. What We Can Do: The 3% Solution

There are many technologies, policies, and measures that can be implemented within the region for each of the emitting sectors (transportation, electric power production, buildings, and industry). The question is how we can achieve the transition to a low greenhouse gas emission economy, and how large must reductions be?

To achieve the necessary reductions required to stabilize concentrations at 450ppm or less requires setting a long-term goal (50 years) of reducing emissions by 80%, and then establishing a trajectory for achieving that goal. Establishing a long-term goal requires an economy-wide cap on greenhouse gas emissions with a clear and aggressive emissions reduction trajectory.

If we begin achieving reductions before 2010, it will be possible for the Northeast to meet its reduction goal by reducing emissions by 3% per year over the next 50 years. If we wish to achieve this goal by 2050 (40 years), it will be necessary to reduce by 4% per year. In either case, we take a fixed percent of the remainder so that the absolute amount to be reduced declines each year. For the 3% annual reduction case, emissions will drop in half in 23 years, by 75% in 46 years and will be decreased by 80% by the start of the 48^{th} year. For a 4% annual reduction rate, the 80% reduction will occur in the 37^{th} year. Postponing action will require that we reduce by even greater amounts each year in order to avoid the build-up of truly damaging concentrations of GHGs in the atmosphere.

If we begin immediately, we can follow the 3% annual reduction trajectory. If we delay to 2010, we must follow the 4% trajectory. Once we are on track to an 80% reduction, we are really committed to a new and sustainable industrial revolution, so that reductions will continue in the far future beyond 50 years.

Setting an economy-wide cap will establish a price for greenhouse gas emissions and stimulate cost effective emissions reduction strategies through technological improvements, infrastructure transformation, and behavior modification in all sectors. The RGGI is an excellent first step towards this goal, as it requires the region to develop structures and mechanisms to implement an effective greenhouse gas cap and trade program. The current cap applies only to the electric sector, and is not currently designed to achieve only a 10% reduction; but it constitutes a basic building block for a regional or national economy-wide cap and trade program.

Policy initiatives in specific sectors will cause transformation to low-carbon infrastructure and reduce the energy and emissions embedded in specific technologies that are part of our day-to-day life. For example, building efficiency standards, appliance efficiency standards, and vehicle emission standards establish a ceiling on inefficiency or emissions and drive the widespread adoption of available efficient technologies. More aggressive mandated efficiency and demand reduction measures for gas and electric utilities, as well as increasing state Renewable Portfolio Standards so that all Northeast states require at least 20% of energy from renewables by 2020 (as does New Jersey) will further spur the transition to low carbon energy sources. These policies can be implemented with or without a cap on greenhouse gases, but will be most effective in a strong cap and trade environment.

5.1 Identifying Some 3% Options

We do not have the luxury of waiting for policies since we can and must begin making reductions immediately. In the following, we will demonstrate how individuals, companies, communities and states can take immediate first steps along the 3% reduction path through direct action, and then how they can capitalize those reductions for longer periods by replacing inefficient technologies and practices. Policies that are put in place over the next few years will make it easier in the short, intermediate, and longer term, to reduce the energy and emissions embodied in our infrastructure and technologies, continuing the downward reduction trend to meet our long-term goal. Actions taken now will reduce emissions immediately, and into the future, while other reduction options can be introduced at various future times. We will now examine just what such reductions imply, and what are the various strategies for achieving them.

- Conservation and energy efficiency through actions at the individual, corporate, institutional, or agency level through mandated programs, and replacement of small-scale technology such as lighting and small appliances are some of the most likely ways of achieving annual reductions on the order of 3% in the very near term of 1-5 years,
- Capitalizing annual reductions by investing in replacement of technologies such as vehicles, heating and cooling systems, motors, and appliances at the end of their useful lifetimes will spur reductions from the near term through the intermediate term of 20 years. The economic savings from energy efficiency and from the energy savings from these devices can contribute to making them cost effective (IPCC 2001; Najam 2007).
- Replacing existing power plants and buildings with zero and low emission alternatives, or adaptations such as carbon dioxide capture and storage will reduce emissions in the intermediate and longer term from 30-100 years.
- Throughout the entire reduction period, one may need to displace or offset emissions that arise from travel and from the construction and operation of new buildings and power plants. Because forestry and even alternative energy offsets are harder to verify than direct reductions, we recommend that the amount be at least several times the emissions being off-set. This differs from a formal cap and trade system where emissions can be verified and the cap constitutes a real reduction in emissions.
- Throughout the entire reduction period, it is possible to achieve reductions by purchasing low and zero emission electricity through a program that ensures that emissions reductions are additional to those required by law.
- Support political leaders and policies that will implement productive, cost effective solutions sooner rather than later.

We will now examine each of the four sectors, transportation, electric power, buildings, and industry to see how the 3% solution might be achieved through a combination of individual choices and government policies applied in the near, intermediate, and long term. For the Northeast region, per capita emissions are actually decreasing at nearly this rate, but because of population growth, regional aggregate emissions are growing at just 0.3% per year. There are numerous steps that individuals, employers, municipalities and companies can pursue to reduce emissions associated with their own activities and achieve co-benefits such as cost-savings and improved quality of life.

In the following, unless noted otherwise, a specified 3% reduction is only associated with the individual action taken. In order to get an overall 3% reduction for the region, everyone would have to make a similar reduction. In some cases for the longer term, annual 3% reductions are proposed for aggregate measures such as phasing out a certain number of power plants, or for carbon capture and storage.

Transportation

Near term (1-5 years) –

- The growth in vehicle miles traveled is a major contributor to regional increases of heat trapping emissions from the transportation sector. A 3% reduction per year in emissions is equivalent to driving 3% less per year, or about 30 miles less per month. This can be achieved by taking public transportation, by ride sharing once or twice a month to work, and by walking or cycling for errands when possible. Driving slightly more slowly or less aggressively can also reduce emissions.
- Purchase certified emissions offsets that are 2 to 5 times one's transport emissions to assure that real emission reductions are taking place (see below).
- Sell a vehicle and use the savings to pay for public transportation with the money saved in fuel, depreciation, and insurance. Typically this will reduce the emissions from a two-vehicle family by half or 3% per year for 23 years.
- States should establish sales tax or feebate incentives for purchasing fuel-efficient vehicles. Initiate policy experiments like insurance at the pump, ride sharing and parking benefits, higher fuel taxes to pay for public transit and pretax public transit benefits.

Intermediate term (5-15 years) –

- The average lifetime of cars is 11 years and for light trucks 9 years (Polk 2006). Replacing a vehicle with one that gets twice the fuel economy is equivalent to reducing one's emissions by 3% per year for 23 years (twice the average lifetime of the vehicle) if one keeps vehicle miles traveled constant.
- Appropriately produced biofuels could accelerate reductions beginning in the coming decade. Emissions reductions range from 14% to 75% each year relative to gasoline.
- Improvements in fuel economy could double current hybrid efficiencies to near 100 miles per gallon to achieve the full 80% reduction over the 50-year time period per vehicle.

Intermediate to long-term (15-50 years) –

- Improved public transportation and smart growth policies encourage a reduction in vehicle miles traveled. If successful, this could reduce emissions by 3% per year for over 20 years for commuting alone.

Electric Power Production

Near term (1-5 years) –

- Management of electric power demand by end users can reduce emissions by the equivalent of 3% per year for 5-20 years. Studies have found that physically equivalent households can range a factor of 2 in their energy used depending on patterns of consumption (Coldham 2006).
- Replacement of 12 conventional electric bulbs with compact fluorescent lamps will reduce a typical home electric bill by 3%.

Near to intermediate term (1-15 years) –

- Cap emissions on power plants under RGGI, or an economy-wide cap and trade program, and tighten emission limits each decade. Note that a 10% reduction is equivalent to capitalizing the annual 3% reduction for about four years.
- Purchase zero emission renewably generated electricity to reduce one's electricity emissions to zero (see below).

Intermediate term (5-25 years) –

- Change laws so that distributed clean CHP plants could be built at industrial sites and on university campuses. A CHP plant reduces CO_2 emissions by more than half. This is equivalent to a 3% reduction for 25-30 years.
- Replacing a single coal burning power plant with a natural gas fired plant reduces emissions in half. These efforts are equivalent to 3% per year reductions for about 25 years.
- Ramp up use of renewable energy including large- and small-scale wind power, individual building solar power, and CHP.
- Begin to restructure the power grid to be more compatible with distributed energy.

Intermediate to long term (10-50 years) –

- Replace existing power stations with low or zero emission power plants such as wind, solar, or other similar sources. Replacing 18 coal plants per year nation-wide is equivalent to approximately a 3% reduction in emissions. The average lifetime of these plants should be 50 years or less so all coal plants should be replaced in the next half-century if laws would require retirement of older, dirtier, less efficient plants.
- Capturing CO_2 and storing it in depleted coalmines can also contribute to emissions reductions.
- Establish a robust, 'intelligent grid' that has many nodes and multiple distributed energy sources including predominantly renewables and CHP. Structure utility resource planning and cost recovery policies to achieve this goal.

Buildings

Near term (1-5 years) –

- Optimize the use of existing heating and cooling equipment with set back thermostats.
- A 2-degree Fahrenheit set back overnight can be equivalent to about 3% per year.
- Improving air seals around doors and windows can save the equivalent of 3% per year for 2-5 years (MCAN 2006).

Near to intermediate (3-15 years) –

- For existing buildings, install insulation in walls and attic or replace windows or older heating/cooling systems. This is equivalent to reductions of 3% per year for 5-7 years for each of these measures individually (MCAN 2006).
- Replace pre 1990 refrigerators that are approaching the end of their lifetimes (approximately 19 years). This will cut emissions in half, which is equivalent to capitalizing 3% annual reductions for the life of the new refrigerator and offsetting its imbedded energy.
- Improve energy codes and code implementation: Establish Energy Star standards for building code for new buildings and for renovations. This is equivalent to a 3% improvement for 10-15 years. Tighten energy code standard over time, and move towards buildings that produce 80% less emissions than those of today. Tighten current lax energy standards for commercial buildings. Establish training and certification programs for contractors and building inspectors.
- Offset emissions increases from new construction with larger emission reductions from existing buildings or from other sectors (see below).

- Provide property tax and sales tax incentives for energy efficient appliances, lighting, motors, construction, and building systems.
- Require that each building have a certified energy use certificate at the time of sale.

Long term (15-50 years) –

- Set building codes to construct zero net energy houses, universities, hospitals, public and commercial buildings and establish incentives to encourage the construction of buildings that produce more energy than they consume using renewable energy and CHP based upon biofuels.

Industry

Short term to intermediate term (1-15 years) –

- Improve the efficiency of current manufacturing and services. Some corporations have reduced their emissions by 10-70% over the past 15 years while expanding their production. At the upper end, this approaches the ultimate goal for the next 50 years.
- Purchasing zero emission electric power will drive up demand for these sources, and reduce one's electric power consumption to zero. Several regional firms are already doing this.
- Purchasing independently certified offsets for travel and building operations as has been done by several corporations can also be useful if such offset reductions (see below).

Intermediate term (10-20 years) –

- Further modify operations and processes to reduce emissions.
- Develop products with low imbedded energy that produce few heat trapping emissions during manufacture or disposal. Emission reductions vary.
- Develop combined heat, power, and cooling systems, and install renewable energy. Universities and other campuses can do the same. These amount to 3% reductions for 25-30 years.

Intermediate and long term (15-50 years) –

- Shift entirely to renewable energy and highly efficient production methods.
- Reduce the energy content of products by shifting to services.
- Link emission reductions in existing facilities to any new emissions created by expansion plus capitalizing 3% reductions over the life of the new facility.

5.2 Making the 3% Solution Work

Making the 3% solution work is an exercise in assembling puzzle pieces. Individuals in households, businesses, institutions, and in government each have pieces of the puzzle within their control and can develop strategies to contribute to the 3% solution. Reliance on individual action alone will not achieve the transition to a low carbon economy; however, individual action can demonstrate the feasibility of a new approach while providing economic and other benefits. A combination of municipal, state, and national policies that provide incentives, and force technology to improve by setting strong standards on everything from power plants and buildings industry to transportation are necessary to spur the transition. In addition to taking direct action to reduce emissions, any individual, institution, or company can support the development of strong local, state, and national policies that reduce global warming emissions.

Individuals, businesses and institutions, and municipal and state governments can buy zero-emission, green power. Electricity customers can choose to purchase electric power that comes from a mix of resources that is cleaner than the average resource mix in individual electric generation companies or in New England. For example, in Massachusetts customers can purchase through Greenstart, a program developed by the Mass Energy Consumers Alliance, which offers customers an option to buy 50% or 100% of their power from clean sources. Some municipalities have decided to switch their focus to clean energy sources. Other universities, like Tufts, have taken aggressive action to reduce their direct emissions from buildings, through low emission electric power purchases and by engaging students and staff in actions to reduce emissions through behavioral changes (Tufts Climate Initiative 2007).

Institutions and small and large commercial customers have multiple options to reduce emissions of greenhouse gases. Through a combination of purchasing energy efficient equipment (appliances as well as lighting), using green building design concepts, installing renewable energy supplies, using CHP, purchasing fuel efficient transportation fleets, and purchasing green energy, these entities can significantly reduce their emissions of greenhouse gases, while realizing significant economic savings and improving the quality of their work space.

Industrial customers can rely on energy efficient lighting, equipment, and energy management principles, as well as installing renewable energy sources and CHP applications. Many companies have effectively used a combination of efficient technologies, renewable technologies, process redesign, and transportation fleet improvements to realize energy cost savings, reduce their waste stream, and improve their products and services.

State and local governments, in addition to using policy tools to move the Northeast on a low carbon path, can pursue a number of options including direct action to reduce emissions by developing and implementing a climate change action plan, purchasing renewable power, setting and achieving goals for energy efficiency, purchasing efficient equipment for state and municipal use, purchasing efficient vehicles for state and municipal transportation needs, adopting policies to encourage employees to reduce their vehicle miles traveled (e.g. encouraging telecommuting and subsidizing use of public transport), and providing incentives for purchase of low emission vehicles. Hull, Massachusetts, a municipal utility has installed two wind turbines to meet the town's electricity demand. These turbines more than pay for them selves since the town sells the renewable energy credits to Harvard University so the University can meet its renewable energy requirement under the state Renewable Portfolio Standard (Lucas 2006). Changing regulations so that more renewable municipal utilities can be created would accelerate this trend.

Purchasing offsets is less desirable than direct reductions. However, they may be a viable option available in the near to intermediate term. A one for one offset does nothing to reduce total emissions. We recommend purchasing excess emission credits two to five times what one is emitting in order to ensure sufficient reductions are occurring to bring down total emissions at the desired rate. Three new studies provide valuable guidance on how the growing number of offset providers are achieving transparency and ensuring that offsets provide additional reductions beyond those required by existing laws and commitments (Taiyab 2006; CACP 2006; Tufts Climate Initiative 2007). A more secure way to ensure that emissions associated with expansion are truly offset, and that actual reductions occur, is to link any emissions from new construction, industrial plant expansion or additional vehicle miles traveled to specified reductions elsewhere. For example, new construction might require the builder to pay for energy efficiency improvements in the municipality, or for additional low emission electric power production. The size of this linkage should be larger than the added emissions from the new source so as to ensure that total emissions decrease.

There is also the issue of imbedded energy in products. For example, the imbedded energy in the manufacture and disposal of a vehicle is in the range of 5-10% of the energy that it will consume during its operating life. Ideally, the emissions associated with manufacture and disposal would be taken care of at the auto factory or recycled steel plant. In the absence of such a requirement, an individual may choose to offset those emissions through more aggressive reductions in some sector over which they have control, or to purchase certified offsets that ensure that a zero carbon renewable power source will be constructed. A similar approach could be used for new buildings though imbedded energy is difficult to estimate. When good estimates become available, one could offset the imbedded energy emissions through purchases of renewable energy or through other certified trading systems.

6. Conclusions

The reduction in heat trapping gases to avoid excessive climate change is an essential component of a sustainable future for this region and the world. Mitigation of greenhouse gases is compatible and complimentary with goals of achieving regional energy and economic security, jobs, clean air, and a sustainable economy in this region that has relatively few energy resources. An annual reduction of about 3% per year in heat trapping emissions will bring down regional emissions by over 80% during the next half-century, and will put the region on a firm path of sustainable energy use. Collectively, we must reduce the energy and emissions imbedded in our infrastructure and technologies and the energy emissions to which are committed with their use. The Northeast states and their municipalities have the authority to develop strategies and policies jointly with businesses, institutions, members of civil society, and especially the public to develop innovative climate mitigation action. In fact, they are uniquely positioned to implement some of the most effective strategies to reduce emissions of heat trapping greenhouse gases.

This report discusses various technologies, policy approaches, and individual actions that will move us down the path of the '3% solution.' But there is no reason to limit one's reductions to 3% per year. Opportunities to make larger reductions exist, and can be considered equivalent to 'capitalizing' reductions over a longer period of time. Purchasing renewably generated electricity, linking emission reductions to any new additions, addressing the emissions associated with imbedded energy and using offsets judiciously can provide supplemental methods for meeting long-term reduction goals one year at a time. An important next step for the region will be comprehensive quantitative analysis of the emission reduction potential of the different approaches in order to prioritize options and opportunities. It is time for the U.S.'s Northeastern states to lead the nation and the world onto a more sustainable energy path of lower heat trapping emissions.

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[1] This is consistent with international findings. A 2005 scientific symposium regarding dangerous climate change concluded that in many cases the risks associated with climate change are more serious than previously thought, and that scientific literature suggests increasing damage if the globe warms in the range of one to three degrees Celsius above current levels (UK DEFRA 2005). See also IPCC 2007 Summary for Policy Makers. Recent reports provide additional evaluation and quantification of the costs of inaction. In the summer of 2006 the Oxford Research Group (U.K.), released their report "Global Responses to Global Threats." The report identifies climate change as one of four root causes of conflict and insecurity in today's world. The authors anticipate that long-term security implications of climate change are far more serious, lasting, and destructive for all countries than are those of international terrorism (Abbot et al. 2006). Similarly the Stern Review of the Economics of Climate Change prepared for the U.K. government (October 2006) concludes that the benefits of strong and early action far outweigh the economic costs of not acting.

[2] The IPCC A_2 and B_1 scenarios are described in IPCC Climate Change 2001: The Scientific Basis, Section F.1. The A_2 scenario describes a heterogeneous world with an emphasis on self-reliance and preservation of local identity. The population increases continuously, economic development is regionally based, and per capita growth is fragmented The B_1 scenario describes a convergent world, with a global population that peaks mid century and then decreases It is a service and information oriented economy with reductions in material intensity. The focus is on clean and resource efficient technologies and an emphasis on global solutions to economic social and environmental sustainability.

[3] For example, Variable Valve Lift and Timing can reduce GHG emissions by 4-6%. Six-speed automatic transmissions can reduce emissions by 2-3% (Northeast States Center for a Clean Air Future [NESCCAF] 2004).

[4] For information from the Massachusetts Technology Collaborative on Green Buildings see the website, www.mtc.org

[5] In Germany the Passivhaus Institut of Darmstadt has been promoting a set of technical standards for super-insulated homes. Average energy savings in these houses is in the range of 80-90% and the additional cost of the construction is easily recovered in a few years. While the specifications would have to be adapted to the Northeastern climate, the lessons in energy saving potential in building practices can certainly be applied in the Northeast.

[6] Information about ocean energy is available at DOE Office of Energy Efficiency and Renewable Energy: http://www.eere.energy.gov/consumer/renewable_energy/ocean/index.cfm/mytopic=50007 and from EPRI at http://www.epri.com/oceanenergy/

[7] The California Air Resources Board (CARB) identified the following cost-effective reduction measures, among others: discrete variable valve lift, dual cam phasing, turbocharging with engine downsizing, automated manual transmissions, and camless valve actuation. Information about the California Air Resources Board emissions standards is available at: http://www.arb.ca.gov/cc/cc.htm

[8] Additional insurance could still be purchased to cover collision, theft, comprehensive and liability, beyond the minimum requirement just as is done in today's system.

[9] New Jersey is the first state in the Northeast to adopt a 20% RPS.

[10] Information available at www.smartpower.org

[11] Results and explanation of the modeling are available on the RGGI website at www.rggi.org

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