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Emissions Mitigation Opportunities and Practice in Northeastern United States

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Abstract

Climate change is creating substantial and growing impacts on the Northeastern United States. As the world's seventh largest contributor of heat trapping carbon dioxide, the region will play a critical role in moving towards stabilizing global concentrations at a level that avoids serious adverse consequences. The Northeast region is well positioned to be a leader in technology and policy innovation for reducing emissions, and can drive national and international programs that are essential to providing a safer future climate. This paper summarizes technological mitigation options and measures 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 and practices.

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 heat trapping greenhouse gases 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 over the next half century; (2) similarly deep cuts in the current emissions-intensive development pathways by developing countries over this time period; and, (3) continued decarbonization of industrial 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). A 2005 scientific symposium concluded that the risks associated with climate change are more serious than previously thought, and that increasing damage is to be expected if the globe warms by 1º-3º C above current levels (UK DEFRA 2005; IPCC 2007). In 2006, the Oxford Research Group (U.K.), released "Global Responses to Global Threats," which 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 more destructive for all countries than are those of international terrorism (Abbot et al. 2006).

The Stern Review of the Economics of Climate Change prepared for the U.K. government concludes that the benefits of strong and early action far outweigh the economic costs of not acting. (Stern, 2007). A Tufts University report concluded that by 2100, allowing temperature to increase more than 2º C could lower global economic output 6%-8%. (Ackerman 2006).

While a reduction in emissions of 80% appears daunting, steady reductions on the order of 3% per year for the next 50 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 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. This strategy is described in 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) and Doniger et al (2006). Adoption of a national renewable portfolio standard and vehicle fuel efficiency standards can help the Northeast achieve emissions mitigation goals. 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 and avoid some of the worst impacts associated with climate change described in those scenarios (IPCC 2007). The A2 scenario describes a heterogeneous world where economic development is regionally based and fossil fuel intensive, and where the population grows throughout the century. The B1 scenario describes a collaborative 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 that utilizes clean and resource efficient technologies.

The good news is that the Northeast region, as well as the United States and other nations, has just begun to tap the enormous resource available in energy efficiency, renewable energy sources, and technology innovations in all sectors (Martinot 2006). 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 emissions growth through end use energy efficiency.

This report summarizes emissions mitigation technologies, policy tools, measures and actions that are necessary elements of a Northeast strategy to address climate change. Climate changes underway are such that mitigation efforts must proceed simultaneously with adaptation efforts (Moser et al. this issue), and can enhance our collective ability to adapt to changes that will be required by inevitable further warming. Collective choice and concerted actions among public, private, and individual decision-makers 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 highlights state and regional policy approaches and actions that individuals, communities, and the public and private sectors can take.

2. The Context of the Northeastern United States

Having been home to the first American industrial revolution, it is fitting that the Northeast 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 show the way to a sustainable and secure economy and environment. 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; for example, the Northeast has 18.5% of the population, but accounts for only 13.7% of the greenhouse gas emissions (U.S. Census Bureau, 2007). Second, notwithstanding our successes, the Northeast remains the seventh largest 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.

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. Regional companies have also demonstrated a commitment to reducing heat trapping gas emissions. The citizenry have shown themselves to be responsible and willing to take on the task of changing their habits and adopting new technologies and measures to meet their needs sustainably.

2.1 Emissions in the Northeast

The Northeast U.S. 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 Germany (Figure 1). Collectively, they contributed over 13% of total US CO_2 emissions in 2001.

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, population in the Northeast has increased 1% per year, while heat trapping gas emissions have increased by 0.3%.

The transportation sector contributes the largest portion of carbon emissions in the region. Nationally, the electricity sector contributes the greatest carbon emissions due to the relatively higher proportion of electricity derived from coal. Table 1 shows the relative contributions by sector; however, it underestimates electric sector emissions since the Northeast imports some electricity from the coal dominant Midwest.

Table 1 Northeast States' Regional CO_2 Emissions by Sector, 2001 (EIA, 2007).

Transportation	35%
Electric Power	30%
Residential Buildings	14%
Industry	13%
Commercial Buildings	8%

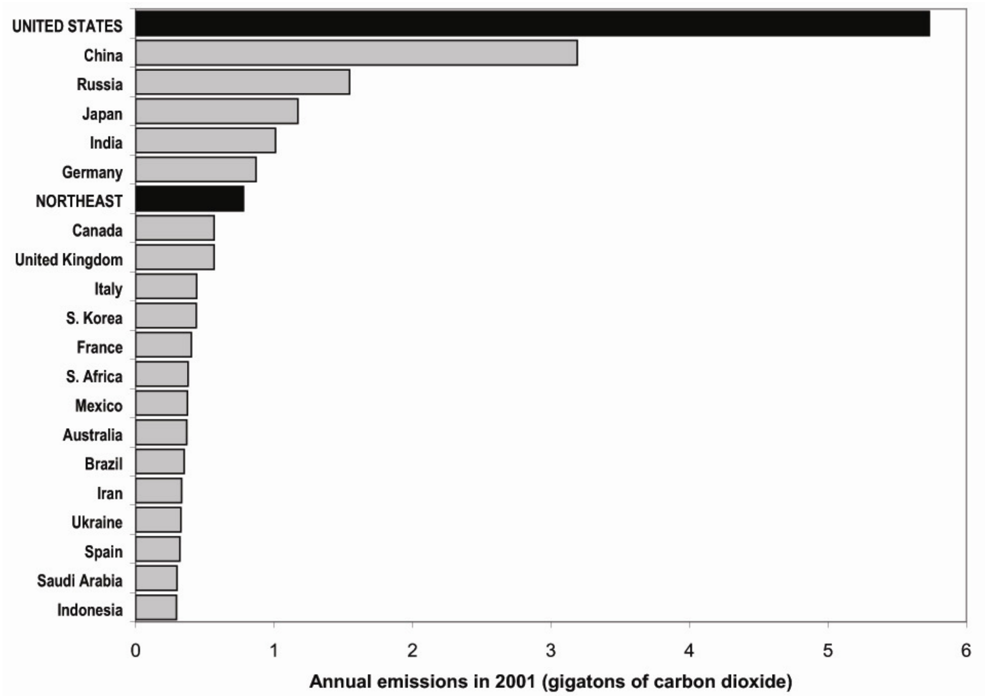

Figure 1. Top twenty CO_2 emitters in the world, 2001.

2.2 Public and Private Efforts in the Northeast

There is strong public and private leadership in the Northeast's regional, state, and municipal policies, and in private sector initiatives and programs to reduce heat trapping gas emissions to address climate change. 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 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 RGGI cap and trade program that initially will apply only to electric power plants. Maryland has also agreed to join the effort, while 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 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 as well.

- More than 60 cities in the Northeast states participate in the Cities for Climate Protection Program that assists local communities in implementing reductions in heat trapping gas emissions.
- More than 14 major Northeast corporations have adopted measures to reduce heat trapping 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 climate mitigation actions. Both New Jersey and Pennsylvania have engaged all of their public and private universities in addressing climate change.
- Regionally based multinational corporations UTC, Enzyme, GE, IBM, and International Paper have made major reductions in their operational energy and/or committed to less emissions intensive products.

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. Together, these policies establish a solid basis for reducing emissions.

2.3 Can We Stop Here?

Simply, 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. It is insufficient to continue our current level of efforts or to wait for a federal climate change policy. Although emission reduction measures are included in state climate plans or are articulated in policies, they are not being fully implemented. The New England states have been only moderately successful at best in working towards the goals established in 2001 (Thurber 2006; ENE 2006). 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 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.

3. Mitigation Options

Implementation of the mitigation opportunities summarized below requires a combination of technology adoption, a functioning carbon market, institutional and individual engagement, and state and local policies that reflect the risks of climate change, and opportunities for mitigation. The multiple opportunities to reduce emissions in the transportation, electricity, buildings and industry are discussed in Section 5.

3.1 Technologies and Measures

A wide range of viable options, including end-use 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 on its own, and as part of national policy.

3.1.1 Transportation

Carbon dioxide emissions from the transportation sector, the largest source of CO_2 emissions in the Northeast, can be lowered in three major ways: 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 from which to choose. There are numerous technologies that can cost-effectively reduce carbon dioxide emissions from conventional cars and light trucks by over one-third (Bedsworth 2004; Cooper et al. 2004). For example, Variable Valve Lift and Timing can reduce CO_2 emissions by 4-6%. Six-speed automatic transmissions can reduce emissions by 2-3% (NESCCAF, 2004). A package of 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 fuel costs of $2 per gallon.

Hybrid vehicles combine conventional gasoline-powered vehicle technology with battery electric technology. Emissions reductions occur when a batter motor powers the vehicle or reduces the inefficiency of variable engine loading. Full hybrids that use advanced technologies can reduce emissions by as much as 60%. (Figure 2).

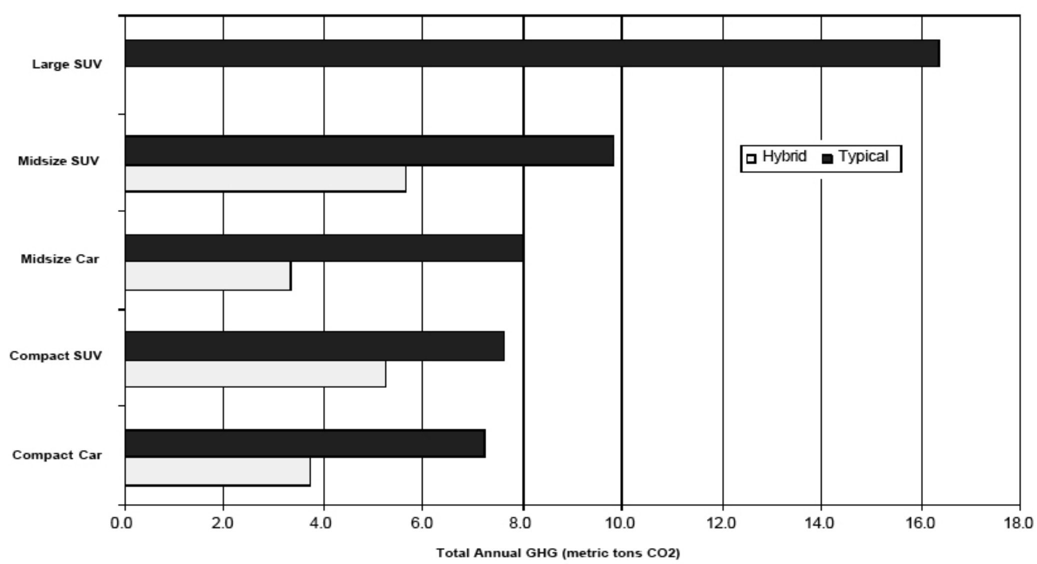

Figure 2. Comparison of total annual greenhouse gas emissions from hybrid and typical automobiles.

Reducing Fossil Fuel-Related Emissions: Currently, electricity is utilized for light rail, trolley buses, and commuter trains. Should progress in battery technology continue, electricity could provide a highly efficient energy source for other vehicles including battery only urban cars. Plug-in hybrid vehicles, using electrical energy from the grid as well as energy from the combustion of gasoline, are on the horizon (Friedman 2003). Some developers are targeting plug-in hybrids to have an all-electric range between 20 and 60 miles to lower battery costs (Sanna 2005). When on the highway or longer trips, the engine would 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 carbon 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 carbon emissions.

The transport sector is developed around the internal combustion engine that relies primarily on petroleum. Replacing it with biofuels produced from plants reduces net CO_2 emissions. The greatest promise for mitigation lies in cellulosic ethanol produced from the stalks, leaves, and stems of plants rather than from corn (Farrell et al 2006). Switchgrass — a fast-growing prairie grass — is one of the most promising crops for cellulosic biofuels. Biofuels, 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) provided that heat trapping nitrous oxide emissions from fertilizer do not increase. In the Northeast, agricultural, forest, and domestic solid wastes are widely available and potential 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 reduction opportunities for diesel-powered equipment. The transition to these fuels could begin within the current decade with proper incentives.

Hydrogen is a storable, zero carbon fuel that is used in fuel cells that generate power much more efficiently than combustion-based engines. Unfortunately, the production of hydrogen requires more energy than is released. Powered by a high-efficiency fuel cell, vehicles could reduce carbon emissions substantially, provided that the hydrogen is produced from low-carbon sources. Natural gas-derived hydrogen used in a fuel cell vehicles 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 reductions.

Most automakers are pursuing hydrogen-powered vehicles as a long-term strategy for transportation, and a few demonstration prototypes are powering car and bus fleets, but the commercialization of hydrogen-based fuel cell 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. (GRI and NREL 2003; Synapse Energy Economics 2005).

3.1.2 Electric Power

Efficiency improvements in electric power generation and in end use devices will continue to be an enormous resource in the Northeast for reducing emissions from the electricity sector. The Northeast has an aging fleet of very old, inefficient coal and oil burning power plants that should be replaced beginning in the coming decade with a variety of new, low and zero emission generating technologies. These include renewables such as biomass powered plants, large and modest scale land and off-shore wind turbines, on-site solar PV, fossil and biomass fueled combined heat and power (CHP), and carbon dioxide capture and storage, should fossil fuels continue to be used. In the following sections, we will also discuss what conditions would be necessary for nuclear power to play any significant role.

3.1.2.1 Demand Management

The most cost effective place to reduce emissions from the electric power sector is on the demand side. Numerous technologies are available that decrease the amount of energy necessary to meet residential, commercial and industrial demand for specific services such as lighting, refrigeration, heating, air conditioning, hot water, myriad appliances, and industrial processes. Tube and compact fluorescent lighting can reduce emissions by 75% relative to incandescent lamps. Energy Star rated appliances can save 10-30% on electricity, but some manufactures have products that use less than half of the electricity of the Energy Star standard. Low water using devices such as showerheads, clothes and dishwashers can save substantial energy through lower hot water use. These technologies have the potential to reduce carbon dioxide 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 Northeast Energy Efficiency Partnership report (NEEP 2006) on economically achievable energy efficiency potential in New England found that:

- Cost-effective investments in end-use energy efficiency can more than offset projected electric energy and peak demand growth, and can defer the need for twenty-eight 300-MW power plants 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).

3.1.2.2 Renewable Energy

Renewable energy sources including solar, wind, geothermal, tidal, ocean waves and currents that produce no CO_2 emissions are effective options for generating zero carbon emission electricity. For example, the 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 the Mid-Atlantic states are projected to far exceed current summer electric generating capability (Musial 2005). Offshore wind in the Northeast could be twice as effective as land-based systems due to the quality and timing of the resource (Berlinski and Connors 2006). Over the past 20 years, 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, paper and other domestic solid waste, 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 electric power facilities. While solar electricity is still expensive, its cost continues to decline, installations are growing, and 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 electricity are being developed (DOE 2007, EPRI 2007). 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 study of tidal power resources in several U.S. states and two Canadian provinces, the Electric Power Research Institute 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).

3.1.2.3 Combined Heat and Power

A combined heat and power (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 is immediate potential in commercial and industrial installations in the Northeast to double existing installations (Hedman 2003).

3.1.2.4 Managing Carbon Emissions from Fossil Fuel Electricity Generation

Two future technologies to avoid the release of carbon emissions are under development. Carbon dioxide capture and storage (CCS) is a process to prevent emissions of CO_2 from large fossil-fueled sources such as power plants, and industrial facilities from reaching the atmosphere (IPCC, 2005). In this process, CO_2 is captured, compressed, transported to a site, and stored in geologic formations, in gas or oil fields, or in the ocean. In the Northeast, Pennsylvania is the state for which geologic storage is a significant option. Pumping carbon dioxide into old coalmines might successfully extinguish fires such as the one at Centralia, PA, which has been burning for over 40 years, and prevent fires in other abandoned mines. An alternative technology utilizes power plant carbon dioxide 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 substantially reduces NO_x emissions.

3.1.2.5 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 lack of approved long-term waste storage, vulnerability to serious accidents and acts of terrorism or sabotage, the potential contribution to nuclear weapons proliferation, 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 being considered in the Northeast because of its dense population and competitive electricity markets.

3.1.3 High Efficiency/Low Emission Commercial and Residential 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 (US EIA 2007). The development of the Energy Star rating system for buildings 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 emissions that are typically 10-30% less than standard code buildings. They currently cost from zero to a few percent more to construct than conventional structures.

Enhancing the performance of building envelopes by utilizing wall and roof structures that minimize thermal bridging by supporting elements, use of greater quantities of improved insulation and reducing air infiltration can reduce heating and cooling demands by more than 50%. Proper orientation for passive heating or cooling, and placement of glazing to enhance daylighting can further reduce electricity demand. Solar thermal technology can reduce hot water energy related emissions by 50-70% cost effectively.

Energy concepts are also incorporated in the design of 'Green Buildings'. Green Buildings refers to design and construction practices that utilize sustainably produced materials, incorporate a broad portfolio of technologies that result in an energy-, water-, and resource-efficient buildings that have good indoor air quality, natural lighting, and minimal site disruption. 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) (MTC). 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 20% of total construction costs in the first 20 years (Kats et al 2003). 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. The energy saving building principles can be adapted to the Northeast. The Leadership in Energy and Environmental Design (LEED) rating system establishes a standard for green buildings; however, energy considerations are but one component of the total rating system. It is possible to get LEED certification even if a building's energy performance might not be better than conventional structures.

3.1.4 Industry

Industry is the smallest Northeast sector in terms of heat trapping gas emissions. The use of variable speed motors, efficient pumps and efficient production process design can reduce energy use and emissions from the operation of manufacturing facilities. Industry is also an obvious for CHP when both electricity and heat are required. Perhaps even more important is for the products that are manufactured to have both low imbedded energy, but also be highly efficient in their operation. A number of major multinational corporations headquartered in the Northeast, including IBM, GE, International Paper, Genzyme and UTC, have made major reductions in heat trapping emissions and in producing efficient products.

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. Governments need to reduce regulatory and policy barriers, and create incentives to adopt low emission technologies and measures on a large scale. Government can also be a leader as a learning lab, innovator, technology developer and funder, and can play a major role in the development of vibrant markets for new technologies.

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

The performance of the regions' large inventory of existing buildings, power plants, and infrastructure must be upgraded. Furthermore, decisions made in the construction of new buildings, transportation infrastructure, and technologies commit us 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 by establishing an overarching set of policy goals for a low emission future. Government entities can transform markets and encourage private sector behavior using a combination of tools including regulatory requirements, incentives, and models for reductions. A combination of carrots, sticks, and leadership in innovation, will have more effect than any single approach.

States and municipalities have distinct, though sometimes overlapping, areas of authority. Between them, they hold authority over transportation planning, power plant siting and approval, 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 for 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 and excise 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 released from landfills, wastewater treatment facilities, and agriculture can also reduce regional emissions and add an indigenous source of low carbon fuel to the regions resources. Municipal governments can create public 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 demonstrates 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 whom they do business. State and local governments can play an important role in developing markets for new technologies, through 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.

3.2.2 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 CO_2 emission standards for automobiles. They require a 1%-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. 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. (CARB).

Tax Incentives or Fee Programs

States have done little to reduce emissions from the transportation sector through tax policy, although one town in Massachusetts 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. 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. 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, Massachusetts, 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-emission vehicles. Heavy-duty fleets, such as trucks and buses, present a different set of opportunities for using lighter materials and alternative fuels such as biodiesel or natural gas to reduce emissions.

Reduction of Vehicle Miles Traveled

States have explored the use of various policy tools to reduce the total number of miles that people drive. Strategies include improving public transportation and increasing ride sharing, and by promoting telecommuting, reducing urban sprawl, and promoting smart growth.

The use of state and local infrastructure funds can greatly shape development. Massachusetts alone spends about $4 billion a year on infrastructure development across its agencies, making these funds a potentially significant mitigation opportunity. Some of the principles upon which smart growth is based include concentrating development to avoid urban sprawl, expanding transportation choice, development near transportation corridors 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 by encouraging 'in-filling' in already built-up areas by lowering property taxes, placing additional taxes on development of previously undeveloped land, and providing for accelerated processing of regulatory requirements. Tax and regulatory incentives can also be given to encourage cluster development. Location-based and energy-efficient mortgages provide lower rates for purchasing efficient dwellings and shops in denser areas where travel expenses are lower.

3.2.3 Electric Power

3.2.3.1 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. 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 offshore 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.

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, small hydro 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. New Jersey is the first state in the Northeast to adopt a 20% RPS, and requiring that of all states in the region would reduce emissions substantially, and potentially create expanded economic development opportunities.

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. Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island are participating in a Clean Energy Alliance to coordinate public benefit fund investments in renewable energy

Net Metering: Net metering policies enable customers with on-site production to reduce the amount of electricity that they purchase from the grid by selling surplus electricity that they produce to the electric utility. When on-site production exceeds use, the customer sends electricity to the grid, and when use exceeds production, the customer draws electricity from the grid. The customer pays the local provider only for the net energy consumed, making on-site production 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. Distributed generation 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 or 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 distributed renewable energy will not be able to make significant inroads into the market place under current regulations.

University campuses 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 to become DG providers, and these experiences have scared off most others from attempting it. For example, 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 in a timeframe that avoids significant power shortages and possible blackouts. Hence, reform of utility regulations to 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. 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’s sales tax for the cost of renewable energy equipment. Adding sales tax exemptions for insulation or better windows and efficient appliances would encourage their purchase. 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.

3.2.3.2 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. 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 prudent for the electric power sector to factor costs associated with heat trapping gas emissions into resource planning and procurement (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 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 additional fossil fuel central power plants.

3.2.3.3 Cap and Trade

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 Regional Greenhouse Gas Initiative (RGGI) is a cap and trade program for the electric power sector in the Northeast. 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 have agreed to an 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. Evaluation of the economic costs and benefits of this program is discussed later in this report under Section 4: “Costs and Benefits of Mitigation”.

3.2.4 Building 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 efficient 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. 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. Expanded 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). Connecticut, New Jersey, Rhode Island, New York, and Massachusetts, 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 expanded the envelope for federal action, with standards for 15 products incorporated into the Energy Policy Act of 2005, but opportunities remain to strengthen 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 six 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 emissions goals by 2020 (NEEP 2006).

Building Energy Codes: Improved building energy codes, and appliance efficiency standards, are the most cost effective way to realize a portion of New England's Energy Efficiency Potential (Optimal Energy 2005). State building codes have not kept pace with technological innovation, resulting in energy use (and emissions) that are 15%-30% higher than Energy Star standards. Generally, codes specify requirements for thermal performance of the building envelope and windows, and minimum heating and cooling equipment efficiencies. Broadening requirements to include minimum air infiltration, insulation, and door and window standards would increase savings. All states in the Northeast have commercial building energy codes that meet the weak requirements of the federal Energy Conservation and Production Act (ECPA). Not all states have residential building energy codes, and others that do cannot yet meet the requirements of 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 to buyers and renters. Providing financial incentives for earlier action would 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' within state universities that could provide assistance to all building owners in a particular state. In addition, 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 an area where major reductions in energy can be made cost effectively, but there are no policy requirements to do so. Continued development of federal and state product efficiency standards, energy efficiency funding, energy efficiency procurement rules and incorporation of energy efficiency into resource planning and other policies is essential.

3.2.5 Action Plans

All of the states in the Northeast have Climate Change Action Plans in place, and many municipalities have adopted climate change policies. These policies include such steps as green fleet and green power purchases, renewable energy/distributed generation installations, public transit improvements, public building retrofits, street lighting upgrades. In Connecticut, many communities are joining Smartpower's '20% by 2010' program, which encourages communities, churches, universities, and other institutions to commit to purchasing 20% of their energy from clean energy sources by 2010 (Smartpower 2007).

Municipalities make important decisions about school retrofits and green building practices. They can require disclosure of energy requirements for buildings in development review, incorporate energy/climate education into local curricula, adopt recycling policies, or reform zoning laws for 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.

3.2.6 Land-Use Measures

Removing CO_2 from the atmosphere and storing it in soil and trees can reduce atmospheric concentrations. 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. The Woods Hole Research Center 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, land trusts, 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, Climate Change and Northeast Agriculture 2007).

3.2.7 Methane Recovery

Methane from livestock, sewage treatment plants, and landfills is a major heat trapping gas with a global warming potential seven 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 are finding it profitable to capture methane from their livestock and use it as a fuel for heating buildings and even for driving tractors.

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. There have been several quantitative assessments of the costs of complying with various emission reduction goals, but 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 some 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. (RGGI)

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. 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

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. This trajectory will lower emissions in half in 23 years, by 75% in 46 years and will decrease them by 80% by the start of the 48th year. If we wish to achieve this goal by 2050 (40 years), it will be necessary to reduce emmissions 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 a 4% annual reduction rate, the 80% reduction will occur in the 37th 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 heat trapping gases 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. 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.

5.1 Identifying Some 3% Options

We do not have the luxury of waiting for national policies since we can and must begin making reductions immediately. In the following text, 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.
- Both formal cap and trade systems and voluntary offsets will be needed. 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 offset.
- Throughout the entire reduction period, it will be 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 now examine each of the four sectors, transportation, electric power, buildings, and industry to assess 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, 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. 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 two to five times one's transport emissions to assure that real emission reductions are taking place (see below).
- Sell a vehicle and use the savings in fuel, depreciation, and insurance to pay for public transportation. 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).
- Use Forward Capacity Market funds for renewables, CHP and efficiency.

Intermediate term (5-25 years):
- Change laws so that distributed clean CHP plants could be built at industrial sites and on university campuses. Combined Heat and Power reduces CO_2 emissions by more than half, equivalent to a 3% reduction for 25-30 years.
- Replace a single coal burning power plant with a natural gas fired plant to reduce emissions by 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 nationwide is equivalent to approximately a 3% reduction in emissions. The average lifetime of these plants is 50 years or less, so all coal plants should be replaced in the next half-century if laws required retirement of older, dirtier, less efficient plants.
- Capture CO_2 and store it in depleted coalmines to contribute to emissions reductions.
- Establish a robust, 'intelligent grid' that has many nodes and multiple distributed 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 2º F set back overnight can be equivalent to about 3% per year.
- Improving air seals around doors and windows can save the equivalent of 3% each 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 or rental.

Long term (15-50 years):

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

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 emissions to near zero. Several regional firms are already doing this.
- Purchase independently certified carbon offsets for travel and building operations (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.
- 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

Individuals in households, businesses, institutions, and in government each can control and develop strategies that 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 transportation, power plants, buildings and industry is necessary to spur the transition. In addition to taking direct action to reduce emissions, everyone 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. 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. Universities across the Northeast 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 (e.g., Tufts Climate Initiative 2007; University of New Hampshire Greenhouse Gas Emissions Inventory, 2007).

Institutions and 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)
- Providing incentives for purchase of low emission vehicles.

Hull, Massachusetts has installed two wind turbines to meet the town's electricity demand. These turbines more than pay for themselves 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. 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. Opportunities to make larger annual reductions exist, and can be considered equivalent to 'capitalizing' reductions over a longer period of time. Collectively, we must reduce the energy and emissions imbedded in our infrastructure and technologies and the energy emissions to which we are committed through 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. 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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