A BLUEPRINT FOR ACTION

Policy Options to Reduce Massachusetts' Contribution to Global Warming

MASSPIRG EDUCATION FUND
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Table of Contents

Executive Summary

Massachusetts could make major strides toward reducing its emissions of global warming gases over the next several decades by adopting a series of policy strategies to make the state more energy efficient and reduce the use of fossil fuels.

Adoption of the 14 policy strategies in this report would bring Massachusetts significantly closer to meeting its short- and medium-term commitments under a 2001 agreement signed by the six New England governors and their peers in eastern Canada. In the process, the strategies would reduce the state's consumption of energy and position Massachusetts to make the technological shifts necessary to achieve the long-term goal of reducing Massachusetts' emissions of global warming gases to levels that do not have a harmful effect on the climate.

Global warming, caused by human-induced changes in the climate, is a major threat to Massachusetts' future.

- Since the beginning of the Industrial Age, atmospheric concentrations of carbon dioxide – the leading global warming gas – have increased by 31 percent, a rate of increase unprecedented in the last 20,000 years. Global average temperatures increased by about 1° F during the 20th century, a rate of increase unprecedented in the last 1,000 years.

- The effects of global warming are beginning to appear in Massachusetts and worldwide. Average temperatures in Massachusetts have increased by about 1° F since 1895, accompanied by changing precipitation patterns and other shifts.

- Average temperatures in Massachusetts are projected to increase by between 1° F and 10° F over the next century, accompanied by increased precipitation. The results of these changes could include higher sea levels, degraded air quality, increased heat-related deaths, and the loss of Massachusetts' hardwood forest species.

Emissions of carbon dioxide – the leading global warming gas – are on the rise in Massachusetts.

- Between 1990 and 2000, Massachusetts' direct emissions of carbon dioxide from energy use (other than electricity) increased by approximately 7 percent. Electricity consumption within the state also increased by about 14 percent.

- Based on adjusted regional energy use projections from the U.S. Energy Information Administration, Massachusetts' direct (non-electric) emissions of carbon dioxide could increase by as much as 28 percent over the next two decades, with much of the increase taking place in the transportation sector. Electric sector emissions in New England can be expected to increase by about 35 percent between 2000 and 2020 if the region's nuclear reactors close at the expiration of their operating licenses to protect the environment and public health and safety.

Massachusetts could significantly reduce its global warming emissions by adopting 14 policy strategies and encouraging other New England states to do the same.

The policies include:

1. Putting increasing numbers of hybrid-electric cars (and eventually zero-emitting cars such as hydrogen fuel-cell vehicles) on Massachusetts' roads over the next two decades by finalizing and implementing the **state's clean cars requirement.**

2. Adopting California's forthcoming **limits on vehicle carbon dioxide emissions.**

3. Requiring the sale of **low-rolling resistance replacement tires** that improve vehicle efficiency without negatively affecting safety.

4. Establishing a **"feebate"** program to reward the purchase of more fuel-efficient vehicles.

5. Requiring automobile insurers to offer **pay-as-you-drive automobile insurance**, in which insurance rates are calculated by the mile, rewarding those who drive less, while potentially reducing accidents.

6. Adopting policies that would **reduce growth in vehicle miles traveled** by cars and light trucks on Massachusetts' highways, such as measures to reduce sprawling development and encourage the use of transit and other transportation alternatives.

7. Adopting the latest **commercial and residential building energy codes** to improve the energy efficiency of new construction.

8. Adopting **appliance efficiency standards** for a series of residential and commercial products.

9. **Reducing energy use** by increasing funding for energy efficiency programs supported by electricity ratepayers and creating similar energy efficiency programs for natural gas and heating oil.

10. Bolstering Massachusetts' **Renewable Portfolio Standard** to require 10 percent of Massachusetts' electricity to come from new, clean, renewable sources by 2010 and 20 percent by 2020.

11. Dramatically expanding the installation of **solar photovoltaic systems** on homes and businesses through direct incentives and new methods of financing.

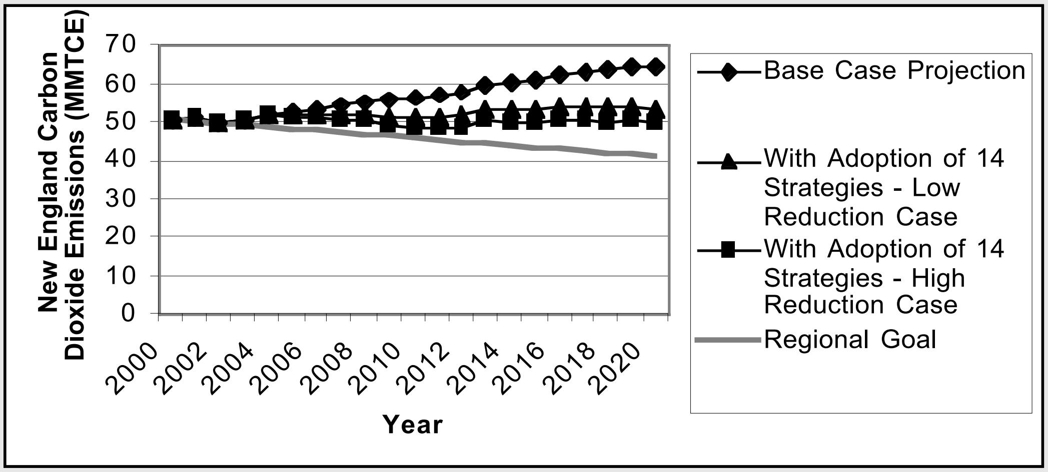
12. Limiting emissions of carbon dioxide from electric power plants through adoption of strong **state and regional power-sector carbon caps.**

Table ES-1. Projected Carbon Dioxide Emission Reductions from Policies (million metric tons carbon equivalent — MMTCE)

Policy	2010	2020
Clean Cars Requirement	0.03	0.19
Carbon Dioxide Tailpipe Standards	0.05	0.69
Low Rolling Resistance Tires	0.11	0.18
Feebate Program	0.06	0.29
Pay-As-You-Drive Automobile Insurance	0.39	0.45
Reduce Vehicle Miles Traveled	0.43	1.23
Residential and Commercial Building Codes	0.024-0.036	0.33
Appliance Efficiency Standards	0.18-0.39	0.52
Expanded Energy Efficiency Programs	0.54-0.77	1.25
Expanded Renewable Portfolio Standard	0.42-0.96	0.56
Solar Power Development	0.001-0.003	0.005
State and Regional Electric-Sector Carbon Caps	*See high end of range of above estimates*	
Public Sector "Lead By Example" Policies	0.04-0.05	0.06
Regional Global Warming Emission Registry		*Not estimated*

Note: Savings from individual policies do not equal cumulative savings due to some overlap between the policies.

Fig. ES-1 New England Carbon Dioxide Emissions from All Sectors (MMTCE)



Note: High Reduction case assumes strong state and regional electric-sector carbon caps. Low Reduction case assumes weak or no caps.

13. Reducing **government sector emissions** through "lead by example" measures, such as the purchase of renewable power, increased energy efficiency, and the purchase of more efficient vehicles for state fleets.

14. Creating a framework for future market-oriented and/or regulatory responses to global warming through a regional **global warming emission registry**.

Adoption of all 14 strategies would achieve significant reductions in global warming emissions while improving Massachusetts' energy efficiency and spurring the development of renewable sources of energy.

- **Reductions versus projected emission levels:** Adoption of these 14 strategies would reduce Massachusetts' direct (non-electric) carbon dioxide emissions by about 16 percent below projected levels by 2020. Adoption of all strategies by all six New England states would reduce electric-sector emissions by as much as 45 percent below projected levels by 2020.

- **Reductions versus regional goals:** New England-wide adoption of all 14 strategies would bring the region as much as 70 percent of the way to meeting the regional global warming emission reduction goal for 2010 and as much as 60 percent of the way to meeting the goal for 2020 – even with the retirement of several nuclear reactors that currently provide low-global warming emission electricity at high risk to the environment and public health. (See Fig. ES-1.)

- In addition, many of the strategies have benefits that extend beyond reducing global warming emissions by reducing emissions of other health-threatening pollutants, increasing Massachusetts' energy security, and keeping jobs and dollars in the local economy instead of sending money out of state for fossil fuel purchases.

Massachusetts should seize the opportunity to reduce its emissions of global warming gases.

- Massachusetts should adopt the 14 measures in this report and investigate other policy options to reduce global warming emissions, especially with regard to reducing vehicle-miles traveled, limiting suburban sprawl, and encouraging the development of non-fossil, non-nuclear sources of energy.

- Massachusetts should continue to participate in regional efforts to reduce global warming gas emissions, particularly the efforts of the Council of New England Governors and Eastern Canadian Premiers and the northeastern states' negotiations to establish a regional, power-sector carbon cap.

- Massachusetts should commit to achieving the governors' and premiers' long-term global warming emission reduction goal by 2050 and begin to plan for making the technological and other changes that will be needed to achieve that goal.

- Massachusetts can and should reduce its global warming emissions without increasing the use of nuclear power or extending the life of the state's nuclear plants beyond their current operating licenses.

Introduction

Global warming is a frightening problem. The consensus view of climate science holds that global temperatures are increasing, that human activities are the cause, and that further warming of the planet is inevitable unless we significantly reduce our emissions of gases that trap heat in the earth's atmosphere.

The precise impacts that global warming will have on Massachusetts are unpredictable, but it is virtually certain that the climatic shifts brought about by warming will leave forests, rivers, coastlines and disease and weather patterns far different than we have known them – and so too, the New England way of life.

While the effects of global warming are frightening, the solutions need not be. We now know how to make appliances, automobiles, homes and buildings that use energy more efficiently, reducing global warming emissions from the combustion of fossil fuels. Renewable energy sources such as wind and solar power are becoming increasingly cost-competitive with traditional forms of energy. And highly advanced new technologies – such as fuel cells – show the potential to change the means by which we create and use energy in fundamental ways.

We also know that the patterns of consumption and travel that have been established over the last half-century in Massachusetts are not sustainable in the long run – the traffic on our highways, the congestion on our electric lines, and our dwindling supply of open spaces are constant reminders of the need to find smarter ways for our commonwealth to grow. And events at home and abroad remind us of the need to find more secure and reliable sources of energy.

The path toward reducing the potential severity of global warming must begin with a resolve to do our share. It is a challenge that Massachusetts has accepted in the past, through the adoption of policies that limit carbon dioxide emissions from power plants, spur the development of renewable sources of energy, and reduce global warming emissions from automobiles. Through these and other actions, Massachusetts has established itself as a leader – setting an example that other states have followed.

Now, it is time for Massachusetts to lead once again. In 2001, the governors of the six New England states and their peers in eastern Canada agreed to adopt a ground-breaking commitment to reduce the region's emissions of the gases that cause global warming. The success of that commitment, however, depends on the development and implementation of effective policies to reduce global warming emissions in each of the New England states.

This report presents 14 policy opportunities that enable Massachusetts to achieve most of the reductions in global warming emissions called for under the regional agreement. They are by no means the only steps Massachusetts can or should take to reduce its contribution to global warming. But they represent a sound platform for future global warming efforts and move Massachusetts significantly closer to the cleaner, more efficient, more sustainable and healthier future we all seek.

The opportunity for leadership exists. It is time for Massachusetts to act.

Global warming poses a clear danger to Massachusetts' future health, well-being and prosperity. Massachusetts contributes to global warming primarily through the combustion of fossil fuels, which emit carbon dioxide to the atmosphere. Massachusetts' emissions of carbon dioxide and other global warming gases have increased over the last decade and will likely continue to increase in the absence of concerted action.

Causes of Global Warming

Global warming is caused by human exacerbation of the greenhouse effect. The greenhouse effect is a natural phenomenon in which gases in the earth's atmosphere, including water vapor and carbon dioxide, trap heat from the sun near the planet's surface. The greenhouse effect is necessary for the survival of life; without it, temperatures on earth would be too cold for humans and other life forms to survive.

But human activities, particularly over the last century, have altered the composition of the atmosphere in ways that intensify the greenhouse effect by trapping more of the sun's heat near the earth's surface. Since 1750, for example, the concentration of carbon dioxide in the atmosphere has increased by 31 percent as a result of human activity. The current rate of increase in carbon dioxide concentrations is unprecedented in the last 20,000 years.[1] Concentrations of other global warming gases have increased as well. (See Fig. 1.)

As the composition of the atmosphere has changed, global temperatures have increased. Global average temperatures increased during the 20th century by

Fig. 1. Atmospheric Concentrations of Greenhouse Gases[2]

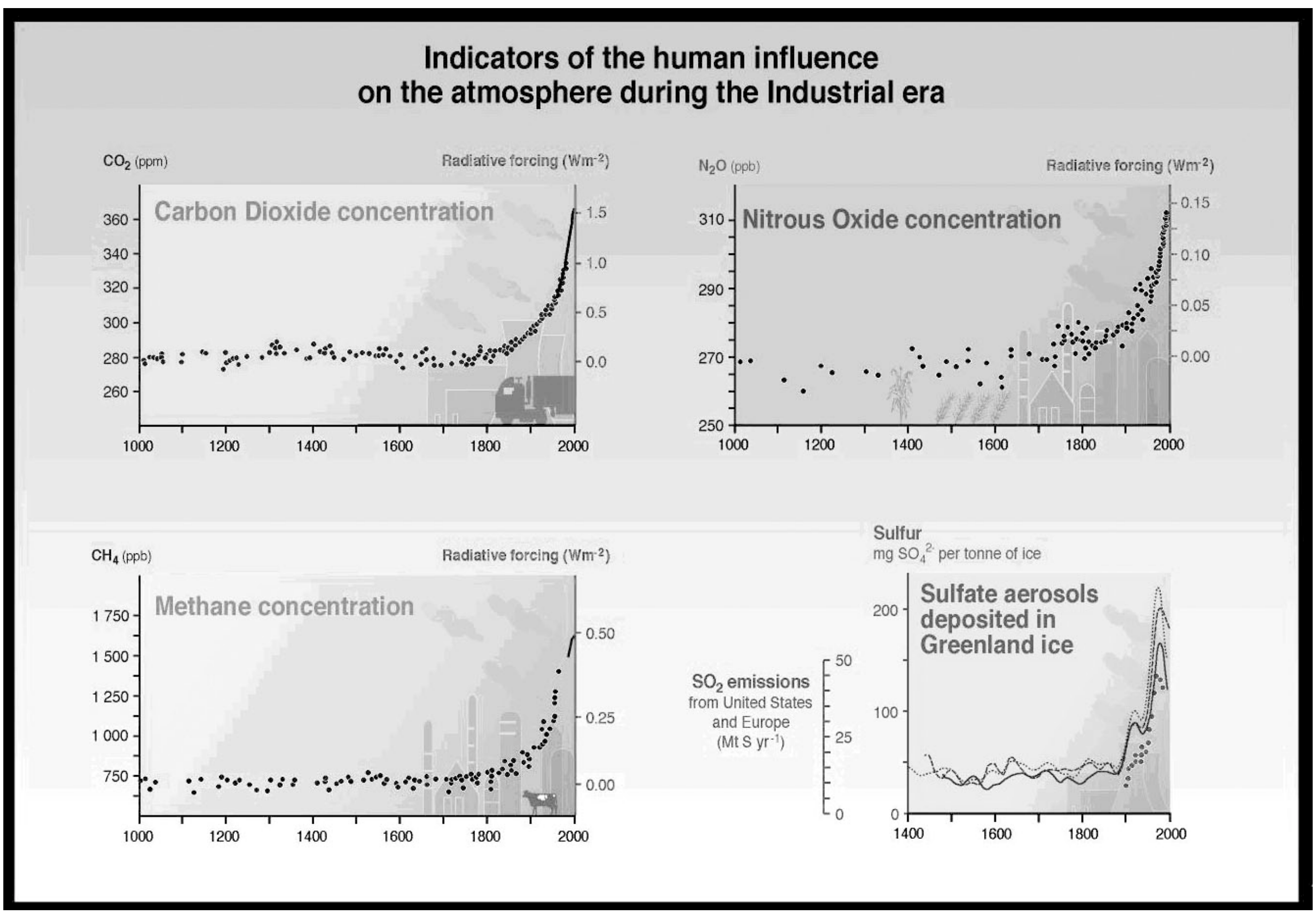
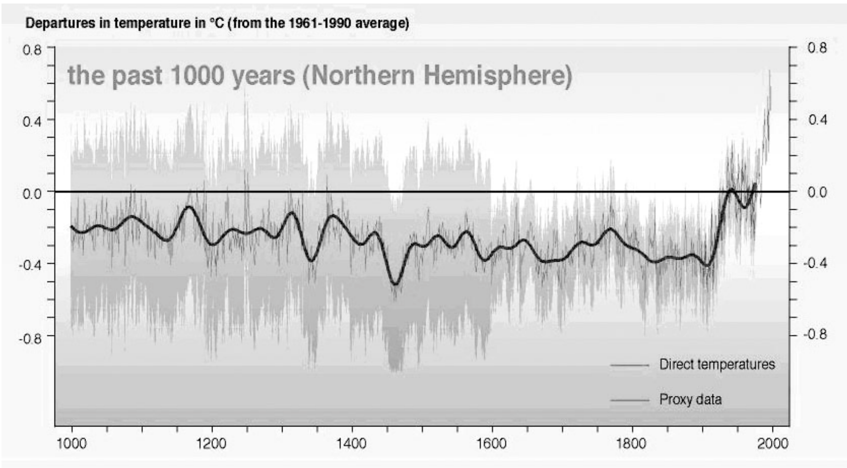


Fig. 2. Northern Hemisphere Temperature Trends[4]



about 1° F. In the context of the past 1,000 years, this amount of temperature change is unprecedented, with 1990 to 2000 being the warmest decade in the millennium. Fig. 2 shows temperature trends for the past 1,000 years with a relatively recent upward spike. Temperatures in the past 150 years have been measured; earlier temperatures are derived from proxy measures such as tree rings, corals, and ice cores.

This warming trend cannot be explained by natural variables – such as solar cycles or volcanic eruptions – but it does correspond to models of climate change based on human influence.[3]

Other Global Warming Gases

Several gases other than carbon dioxide are capable of exacerbating the greenhouse effect that causes global warming. The other major global warming gases are:

- **Methane** – Methane gas escapes from garbage landfills, is released during the extraction of fossil fuels, and is emitted by livestock and some agricultural practices. It is the second-most important global warming gas in New England in terms of its potential to exacerbate the greenhouse effect.

- **Fluorocarbons** – Used in refrigeration and other products, many fluorocarbons are capable of inducing strong heat-trapping effects when they are released to the atmosphere. Because they are generally emitted in small quantities, however, they are estimated to be responsible for only about 1 percent of New England's contribution to global warming.[5]

- **Nitrous Oxide** – Nitrous oxide is released in automobile exhaust, through the use of nitrogen fertilizers, and from human and animal waste. Like fluorocarbons, nitrous oxide is a minor, yet significant, contributor to global warming.

- **Sulfur Hexafluoride** – Sulfur hexafluoride is mainly used as an insulator for electrical transmission and distribution equipment. It is an extremely powerful global warming gas, with more than 20,000 times the heat-trapping potential of carbon dioxide. However, it is released in only very small quantities and is responsible for only a very small portion of the state's contribution to global warming.

- **Black Carbon** – Black carbon, otherwise known as "soot," is a product of the burning of fossil fuels, particularly coal and diesel fuel. Recent research has suggested that, because black carbon absorbs sunlight in the atmosphere, it may be a major contributor to global warming, perhaps second in importance only to carbon dioxide. Research is continuing on the degree to which black carbon emissions contribute to global warming.

This report focuses mainly on emissions of carbon dioxide from energy use, since these emissions are responsible for the majority of Massachusetts' contribution to global warming. Steps to reduce emissions of other global warming gases should also be part of the state's efforts to curb global climate change.

A Note on Units

There are several ways to communicate quantities of global warming emissions. In this report, we communicate emissions in terms of "carbon equivalent" – in other words, the amount of carbon that would be required to create a similar global warming effect. Other studies frequently communicate emissions in terms of "carbon dioxide equivalent." To translate the latter measure to carbon equivalent, one can simply multiply by 0.273.

Current Indications of Climate Change

The first signs of global warming are beginning to appear, both in Massachusetts and around the world. Average temperatures have risen. Global average temperatures have increased by about 1° F in the past century. In the same period, the average temperature in Amherst has increased by 2° F.[6] Statewide, average temperatures are estimated to have increased by 1° F between 1895 and 1999.[7]

Precipitation patterns have changed. Precipitation has increased by 20 percent in some parts of Massachusetts.[8] Maine, New Hampshire, and Vermont have experienced a 15 percent decrease in snowfall.[9] In other parts of the world, such as Asia and Africa, droughts have been more frequent and severe, a change that is consistent with models of climate change.[10]

Cold seasons have been shorter and extreme low temperatures less frequent. Since the late 1960s, Northern Hemisphere snow cover has decreased by 10 percent and the duration of ice cover on lakes and rivers has decreased by two weeks.[11] Glaciers around the world have been retreating.[12]

Oceans have risen as sea ice has melted. Average sea levels have risen 0.1 to 0.2 meters in the past century.[13]

Potential Impacts of Global Warming

The earth's climate system is extraordinarily complex, making the ultimate impacts of global warming in a particular location – as well as the pace of change – difficult to predict. There is little doubt, however, that global warming could lead to dramatic disruptions in the world's and Massachusetts' economy, environment, health and way of life.

Temperature increases in the past century have been modest compared to the increases projected for the next 100 years. Global temperatures could rise by an additional 2.5° F to 10.4° F over the period 1990 to 2100.[14] In Massachusetts, temperatures could increase by 1° F to 10° F by 2100.[15] Others estimate that a 1.8° F increase in average temperature could occur New England-wide as soon as 2030, with a 6° F to 10° F increase over current average temperatures by 2100.[16] Such an increase in temperature would cause a profound shift in Massachusetts' environment; a 10° F increase in the average annual temperature in Boston, for example, would leave the city with an average temperature similar to present-day Atlanta.[17]

Precipitation levels also could change. Massachusetts could experience an increase in precipitation of 10 to 60 percent, with greater change in winter and less change in spring and summer.[18]

In any event, the impacts of such a shift in average temperature and precipitation would be severe. Among the potential impacts:[19]

- Longer and more severe smog seasons as higher summer temperatures facilitate the formation of ground-level ozone, resulting in additional threats to respiratory health such as aggravated cases of asthma.
- Increased spread of exotic pests and shifts in forest species – including the loss of hardwood forests responsible for Massachusetts' vibrant fall foliage displays.
- Shifts in populations of fish, lobster and other aquatic species due to changing water temperatures and changes in the composition of coastal estuaries and wetlands.

- Increases in toxic algae blooms and "red tides," resulting in fish kills and contamination of shellfish.

- Declines in freshwater quality due to more severe storms, increased precipitation and intermittent drought, potentially leading to increases in waterborne disease.

- Increased coastal flooding due to higher sea levels, with sea levels projected to rise by about 22 inches near Boston and by as much as 40 inches along Cape Cod over the next century.

- Increased spread of mosquito and tick-borne illnesses, such as Eastern equine encephalitis, malaria and dengue fever.

- Increased risk of heat-related illnesses and deaths – perhaps by as much as 50 percent, from 100 to 150 annually.

- Disruption to traditional New England industries such as fall foliage-related tourism, maple syrup production and skiing.

The likelihood and severity of these potential impacts is difficult to predict. But this much is certain: climate changes such as those predicted by the latest scientific research would have a dramatic, disruptive effect on Massachusetts' environment, economy and public health – unless immediate action is taken to limit our emissions of greenhouse gases such as carbon dioxide.

Carbon Dioxide Emission Trends

The vast majority of carbon dioxide emissions in Massachusetts result from the combustion of fossil fuels. Fossil fuels are burned directly in homes, businesses, vehicles and industrial facilities to produce heat and to power machinery. Individuals and businesses also consume fossil fuels indirectly when they use electricity, much of which is created through the combustion of coal, oil and natural gas in power plants.

New England's economy is integrated across state lines, making it difficult in some cases to assign responsibility for carbon dioxide emissions to a particular state. For example, Massachusetts draws its electricity from a New England-wide electric grid, which is supplied with power from across the region and beyond.

As a result, in this report we will consider emissions from energy end users and emissions from electricity generation differently. We will assess emissions from residential, commercial and industrial fuel combustion at the state level and emissions from electricity generators at the regional level.

Massachusetts' Direct Emissions (Non-Electric)

Carbon dioxide emissions from sources other than electricity generation increased in Massachusetts by approximately 7 percent from 1990 to 2000 – from 15.4 million metric tons carbon equivalent (MMTCE) to 16.4 MMTCE.[20] (See Table 1.) This estimate does not include emissions from the use of electricity in any of the sectors. While emissions in the residential, industrial and transportation sectors increased significantly during the decade, commercial emissions declined, due to the shift from higher-emitting petroleum to lower-emitting natural gas in many commercial establishments and the lack of a major increase in overall commercial energy use.

In 2000, the transportation sector was responsible for approximately 53 percent of Massachusetts' carbon

Table 1. Historic and Projected (Base Case) Massachusetts Non-Electric Carbon Dioxide Emissions (MMTCE)[21]

	1990	2000	*2010*	*2020*
Direct Emissions	15.4	16.4	*18.6*	*20.9*
Pct. Increase Over 1990		7%	*21%*	*36%*

dioxide emissions from sources other than electricity generation. The residential sector was responsible for about 25 percent of direct emissions, with the commercial sector responsible for 11 percent and the industrial sector for 11 percent. (See Fig. 3.)

The U.S. Energy Information Administration (EIA) has projected rates of increase in energy use in New England from 2000 to 2020. Applying the EIA's projected New England rates of energy use increases (with an adjustment to reduce what appears to be an overestimate of future transportation gasoline use) to Massachusetts, and applying standard fuel-specific emission factors to those estimates, Massachusetts is projected to experience a 28 percent increase in direct carbon dioxide emissions from energy use between 2000 and 2020 in the absence of mitigating action.[22] Between 2000 and 2010, emissions from these sources could increase by about 2.2 MMTCE, with a further 2.4 MMTCE increase between 2010 and 2020. Most of the increase in emissions is projected to take place in the transportation sector. (See Fig. 4.)

Fig. 3. Massachusetts Direct (Non-Electric) 2000 Carbon Emissions by Sector

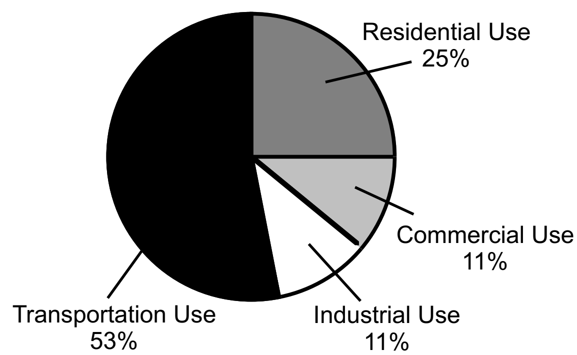


Fig. 4. Massachusetts Projected (Base Case) Non-Electric Carbon Dioxide Emissions, 2000-2020

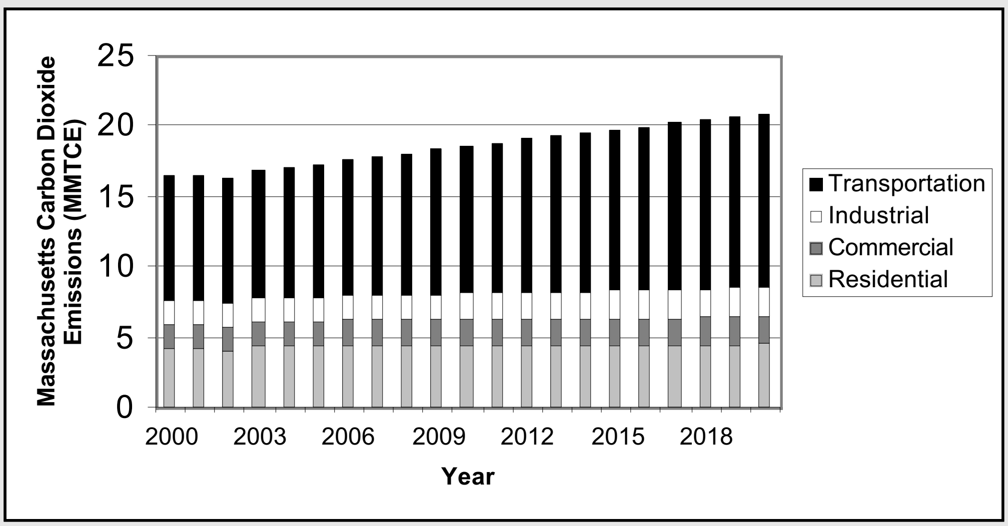


Table 2. Historic and Projected (Base Case) Electric Sector Carbon Dioxide Emissions in New England Without Nuclear Relicensing (MMTCE)[23]

	1990	2000	*2010*	*2020*
Electric Sector	12.0	12.6	*13.8*	*17.0*
Pct. Increase Over 1990		5%	*15%*	*42%*

Regional Electric Sector Emissions

Carbon dioxide emissions from the electric power sector in New England increased by approximately 5 percent – or 0.6 MMTCE – between 1990 and 2000. (See Table 2, previous page.) The relatively modest rate of growth is due largely to the shift from higher-polluting coal and petroleum to less-polluting natural gas.

That shift had particularly profound effects in Massachusetts. Carbon dioxide emissions from electricity generation within the state decreased significantly between 1990 and 2000 – from 7.0 MMTCE to 6.3 MMTCE. The reductions were driven by fuel switching from petroleum to natural gas, coupled with a reduction in the amount of electricity generated within the state.

But reductions in in-state emissions from electricity generation – welcome though they may be – tell only part of the story. The consumption of electricity in Massachusetts increased by about 14 percent during the 1990s, while in-state generation of electricity declined slightly.[24] Because the electric power used in Massachusetts comes from a regional electric grid, this increase in consumption likely resulted in higher carbon dioxide emissions from sources outside of Massachusetts.

EIA's projections of future trends in energy use in New England assume the continued operation of three nuclear power plants – including Massachusetts' Pilgrim nuclear reactor – whose operating licenses are scheduled to expire before 2020. For environmental and public health reasons, the relicensing of existing nuclear plants or the construction of new plants is not an appropriate strategy to address global warming. (See "The Dangers of Nuclear Power," page 18.) Thus, in this report, we have adjusted the EIA projections to reflect the closure of nuclear plants as their licenses expire and their replacement with additional new natural gas-fired generation. This assumption results in significant increases in projected emissions of carbon dioxide versus a projection made based on EIA's projected trends.

Without the relicensing of nuclear reactors, carbon dioxide emissions from electricity generation in the region can be expected to increase by approximately 35 percent – or 4.4 MMTCE – between 2000 and 2020.[25] (See Fig. 5.)

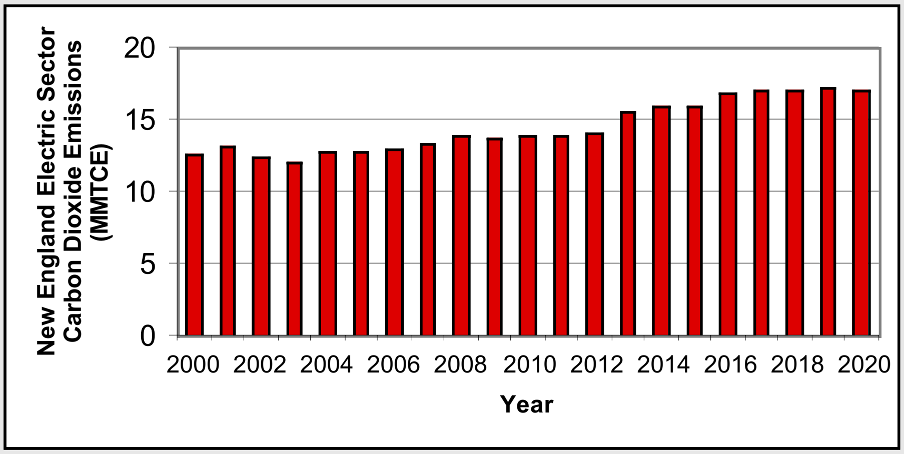
Regional and State Responses

The threat posed by global warming has provoked a variety of responses in Massachusetts and the New England region. Despite a lack of leadership at the federal level – as evidenced by the U.S. government's unwillingness to support the Kyoto Protocol – regional organizations, governmental agencies, non-profits and some business groups have made efforts to craft solutions that would reduce New England's contribution to global warming.

Table 3. Summary of Historic and Projected Carbon Dioxide Emissions and Regional Goal (MMTCE)

	1990	2000	2010	2020
MASSACHUSETTS DIRECT CARBON DIOXIDE EMISSIONS				
Historic/*Projected* Emissions	15.4	16.4	*18.6*	*20.9*
Regional Goal			15.4	13.8
Reductions From Projection Needed to Achieve Goal			3.2	7.1
NEW ENGLAND ELECTRIC SECTOR EMISSIONS				
Historic/*Projected* Emissions	12.0	12.6	*13.8*	*17.0*
Regional Goal			12.0	10.8
Reductions From Projection Needed to Achieve Goal			1.8	6.2

Fig. 5. Projected (Base Case) Carbon Dioxide Emissions from Electric Generation in New England (MMTCE)[26]



New England/Eastern Canada Climate Change Action Plan

In September 2001, the governors of the six New England states, along with the premiers of the eastern Canadian provinces, adopted a regional Climate Change Action Plan that set specific goals for the reduction of global warming emissions in the region. The governors' and premiers' action was based on a history of international cooperation within the region to address environmental threats such as acid rain.

In the short term (by 2010), the plan calls for the reduction of global warming emissions in the region to 1990 levels. The medium-term goal, to be achieved by 2020, is to reduce emissions to 10 percent below 1990 levels. In the long run, the plan aims to achieve reductions of the degree needed to minimize dangerous threats to the climate. Scientists currently estimate that this will require reductions of 75 to 85 percent below current emissions levels.[33]

The agreement acknowledged that not every jurisdiction or every economic sector has the same potential to reduce its global warming emissions. However, in order to achieve the goals of the plan, it was envisioned that each state and sector of the economy would strive to make its share of the reductions.

The regional agreement also included a series of commitments for reductions in global warming emissions from conservation activities and from the transportation, electric and government sectors. Even if these sector-specific commitments are fulfilled, however, a 2003 New England Climate Coalition report estimated that the region's emissions of global warming gases will still exceed the goals of the Climate Change Action Plan.[34] (See Fig. 6, page 19.) To close the gap between the regional goals and the emission levels that would result from the sector-specific commitments, the Action Plan called upon states to develop their own plans and policies to reduce global warming emissions.

The Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP) is continuing work toward implementation of the plan, focusing specifically on the development of an updated regional greenhouse gas inventory, the implementation of "lead by example" measures by state and provincial governments, and the investigation of measures to reduce transportation sector emissions and improve energy efficiency.

Massachusetts Greenhouse Gas Emission Reduction Efforts

The regional Climate Change Action Plan also called upon each of the states to evaluate its current carbon

The Dangers of Nuclear Power

For the last several decades, New England has relied upon nuclear power for a significant share of its electricity. However, between now and 2026, the operating licenses of all of New England's operating nuclear reactors are scheduled to expire. For environmental and public health reasons, neither the relicensing of existing nuclear reactors beyond their original 40-year lifespans nor the construction of new nuclear facilities should be considered as a means to reduce global warming emissions.

• **Accident risk** – In the short history of nuclear power, the industry has experienced two major accidents – at Three Mile Island and Chernobyl – that endangered the health of millions of people. The Chernobyl accident alone contaminated an area stretching approximately 48,000 square miles, with a population of 7 million. Even today, 18 years after the accident, the region surrounding the reactor continues to suffer from highly elevated rates of thyroid and breast cancer and long-term damage to the environment and agriculture.[27]

While the United States has thus far been spared an accident of the scale of Chernobyl, there have been numerous "near-misses." For example, in 2002, workers discovered a football-sized cavity in the reactor vessel head of the Davis-Besse nuclear reactor in Ohio. Left undetected, the problem could have eventually led to the leakage of coolant from around the reactor core.

• **Terrorism and sabotage** – The security record of nuclear power plants is far from reassuring. In tests at 11 nuclear reactors in 2000 and 2001, mock intruders were capable of disabling enough equipment to cause reactor damage at six plants.[28] A 2003 General Accounting Office report found significant weaknesses in the Nuclear Regulatory Commission's oversight of security at commercial nuclear reactors.[29]

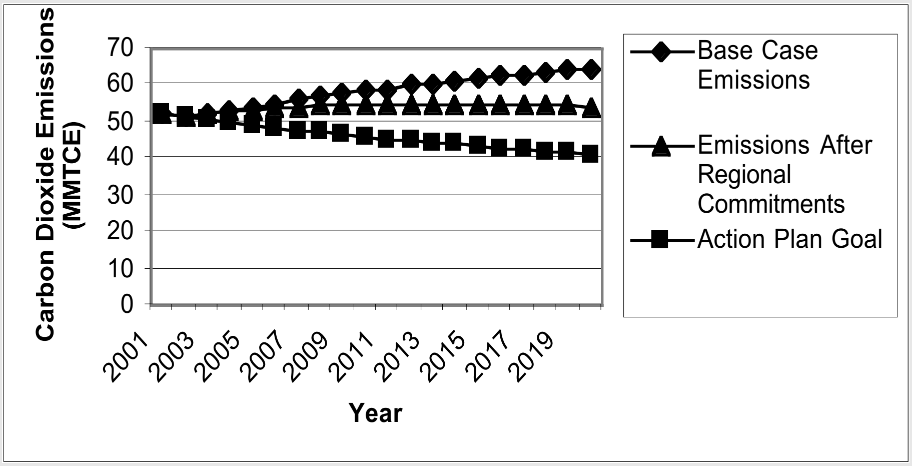
• **Spent Fuel** – Nuclear power production results in the creation of tons of spent fuel, which must be stored either on-site or in a centralized repository. Both options pose safety problems. Centralized waste repositories require the transport of high-level nuclear waste across highways and rail lines within proximity of populated areas. Once the waste arrives, it must be held safely for tens of thousands of years without contaminating the environment or the public. On-site storage poses its own problems. Nearly all U.S. nuclear reactors store waste on site in water-filled pools at densities approaching those in reactor cores. Should coolant from the spent-fuel pools be lost, the fuel could ignite, spreading radioactive material across a large area. The cost of such a disaster, were it to occur, has been estimated at 54,000-143,000 deaths from cancer and evacuation costs of more than $100 billion.[30]

• **Cost** – Nuclear power has often proven to be expensive in market terms, due to the high cost of building, maintaining and decommissioning nuclear reactors. But looking only at market costs obscures the more than $100 billion spent by U.S. taxpayers for research and development, protection against liability from accidents, and other subsidies for nuclear power.[31] Without these subsidies, the nuclear industry likely could not have survived.

• **Aging** – Continued operation of nuclear reactors beyond their initial projected 40-year lifespan could lead to unforeseen safety problems. In 2001, the Union of Concerned Scientists identified eight instances in just the previous 17 months in which nuclear reactors were forced to shut down due to age-related equipment failures.[32]

For these reasons and others, nuclear power should remain "off the table" as a potential means to reduce global warming emissions in New England, and the region should advocate for, and begin to plan for, the orderly retirement of New England's nuclear reactors.

Fig. 6. Carbon Dioxide Emission Reductions in New England Under Implementation of Regional Climate Change Action Plan[35]



dioxide emission levels and develop a plan for achieving required global warming emission reductions.

Massachusetts began this process well before agreeing to the regional Climate Change Action Plan. In 1998, the state began preliminary planning for how to reduce its emissions by convening a series of meetings with citizens, interested organizations, and businesses. The participants worked in issue groups to brainstorm suggestions for how the state could reduce its emissions. Ideas ranged from the minute—substitution of one product for another more carbon-intensive one—to the very broad, such as using more renewable energy. Once the list had been compiled, the Executive Office of Environmental Affairs (now the Office of Commonwealth Development) began to evaluate the options and narrow down the list of policies the state should pursue. The state's final report, with a strong focus on the strategies the state must implement and recommendations on how to act quickly on them, will be released this year.

In addition to undertaking this broader planning process, Massachusetts has already implemented several policies that will result in significant reductions in global warming emissions. Among the most important such policies are the state's renewable portfolio standard (RPS) for electricity generation, which will require 15 percent of the state's electricity to come from new, clean renewable resources by 2020, and systems benefit charges (SBCs) on electricity bills that generate funding for energy efficiency and renewable energy programs. Massachusetts is the first state in the country to regulate carbon dioxide emissions from power plants, though the rule specifying how coal and oil power plants must control their carbon dioxide, mercury, nitrogen oxides, and sulfur dioxide emissions is still being implemented. The state has also long sought to reduce carbon emissions from vehicles by committing itself to adopting California's zero-emission vehicle (ZEV) requirements, which will lead to the sale of cars that produce no direct emissions of carbon dioxide or other pollutants. Final regulations implementing recent changes to the ZEV program also have yet to be adopted.

New England Climate Coalition Action Principles

In 2001, in response to the development of the regional Climate Change Action Plan, a coalition of leading organizations from throughout New England worked together to articulate a set of principles to guide the region's efforts toward achieving reductions in global warming emissions. The New England Climate Coalition's 10 action principles have been endorsed by 160 environmental, public health, civic and religious organizations in the six New England states and Canada.

The principles are:

1) **By 2010, reduce greenhouse gas emissions to levels 10 percent below 1990 levels.** The international community has negotiated a treaty with binding commitments on most of the industrialized nations to reduce emissions to well below 1990 levels. The U.S. has failed to sign onto the treaty, but as the biggest emitter of heat-trapping gases, we must lead by reducing our emissions by at least the same percentage as the other largest polluters.

2) **The NEG-ECP's long-term goal of reducing greenhouse gas emissions by 75-85 percent should be given a target date of 2050.** This timetable is necessary to stem the increase of CO_2 concentrations and minimize global temperature variation.

3) **Each consuming sector should be responsible for at least its proportionate share of the targeted emission reductions.** Any changes to these responsibilities should be based on an explicit process, which justifies changes by the relative cost-effectiveness in each sector, and ensures that any shortfalls in one sector are offset by greater reductions in another. (The sectors to be included are transportation, industrial, commercial, institutional, and residential. This recognizes that the electricity sector targets will overlap.)

4) **The region and each of the states should establish a system of mandatory reporting of CO_2 and other greenhouse gas emissions by 2005.**

5) **Reducing emissions from the electricity sector as a whole by 40 percent from current levels.** Every state plan should include provisions for reducing CO_2 emissions from grandfathered power plants. Increasing the use or output of nuclear power is an unacceptable strategy for reducing electricity sector greenhouse gas emissions.

6) **The region and each of the states should set a target of 10 percent of electricity consumption from new, clean renewable sources by 2010, and 20 percent of electricity consumption from new, clean renewable sources by 2020.**

7) **Every plan should include a target of increasing energy efficiency in each sector by 20 percent by 2010.** The plans should consider more efficient generation of power, strong efficiency and conservation measures and greater use of combined heat and power and micropower options.

8) **The states should lead by example by:**
   a. Purchasing 20 percent of state facility electricity from clean, renewable sources by 2010.
   b. Greening the state fleet by establishing policies that require each vehicle purchased to be the model that emits the least CO_2 and other air pollutants per mile traveled, while fulfilling the intended state function; prohibit the use of inefficient vehicles such as SUVs for non-essential purposes; and establish a schedule for replacing all state vehicles with the most efficient models available.
   c. Reducing state government's energy use by 25 percent overall by 2010.

9) **Each plan should include long-term plans for controlling sprawl, which is one of the primary factors raising emissions from transportation and buildings.** At a minimum, this should start by incorporating an assessment of CO_2 impacts into the state environmental review process.

10) **Each plan should recognize the economic development and job creation benefits of strategies to reduce greenhouse gas emissions.** And each plan should also recognize the importance of assisting displaced workers in making a successful transition to new employment.

The policy strategies that follow attempt to turn these principles into a concrete plan of action. In some cases, the policy strategies achieve results that go beyond those envisioned by the principles; in other cases, they fall short, and additional actions will be needed. But each of the strategies will help to propel the state toward achievement of its overall global warming emission reduction goals.

Reducing Emissions from the Transportation Sector

The transportation sector poses the greatest challenge for Massachusetts as the state seeks to reduce its emissions of global warming gases. Not only is transportation Massachusetts' largest source of carbon dioxide emissions – responsible for about 39 percent of total in-state emissions in 2000 – but it is also among the fastest-growing sources. Transportation-sector carbon dioxide emissions increased by 11 percent in Massachusetts between 1990 and 2000, and could increase by an additional 41 percent between 2000 and 2020 if trends toward increasing vehicle travel continue.[36]

Light-duty vehicles are by far the largest source of transportation-sector carbon dioxide emissions, responsible for about two-thirds of transportation emissions in Massachusetts.[37] Any strategy to deal with transportation's contribution to global warming, therefore, must begin with addressing emissions from cars, light trucks and SUVs.

There are three ways to reduce emissions from motor vehicles: improve fuel economy, switch to low-carbon fuels, or reduce vehicle travel. To achieve the kinds of reductions needed to meet Massachusetts' commitments, the state will have to make progress in all three areas.

Strategy #1: Finalize and Implement the State's Clean Cars Requirement

Potential Savings: 0.03 MMTCE by 2010; 0.19 MMTCE by 2020.[38]

The federal Clean Air Act allows states that fail to meet clean air health standards to choose between two sets of emission standards for automobiles: those in place at the federal level and the traditionally tougher standards adopted by the state of California.

In 1990, California established a new type of emission standard on vehicles sold in the state. In addition to meeting strict tailpipe standards (contained in the state's Low Emission Vehicle – or LEV – rules), a certain percentage of vehicles sold in the state would have to be "zero-emission vehicles" (ZEV). Over the decade-plus since the adoption of the ZEV standard, the rules governing the program have evolved to reflect changes in technology and to increase the options available to automakers for meeting the requirement. The standards are scheduled to go into effect in California for the 2005 model year, and for the 2007 model year in other states that have adopted California standards.

Massachusetts has already adopted California's emission standards for automobiles. But recent changes to the ZEV program rules in California require that Massachusetts formally adopt the latest version of the program. Because the Clean Air Act requires states adopting California standards to give manufacturers two years of lead time prior to enforcement, Massachusetts must adopt the new version of the program this year in order to begin implementation in 2007. Otherwise, the standards will be delayed, meaning that Massachusetts will miss the opportunity to place thousands of cleaner vehicles on the state's highways.

While primarily a program for reducing smog-forming and toxic emissions from automobiles, the ZEV program's "technology forcing" component will likely reduce carbon dioxide emissions by requiring the introduction of significant numbers of "advanced technology" vehicles (such as hybrid-electric vehicles) and, beginning in 2012, hydrogen fuel cell vehicles. Beginning in 2006 (which is when 2007 model year cars will go on sale), automakers will be required to sell the equivalent of tens of thousands of hybrid vehicles per year in Massachusetts, with the numbers increasing over time. Then, beginning in 2012, automakers will be required to sell small numbers of hydrogen fuel-cell vehicles – again, with the numbers increasing over time. By 2020, about 12 percent of new light-duty vehicles sold in Massachusetts would be hybrids, while about 3 percent would be hydrogen fuel-cell or other vehicles with zero emissions.[39]

In the near term, the ZEV program will place tens of thousands of hybrid-electric vehicles on Massachusetts' highways. Hybrids – such as the Toyota Prius and Honda Civic – use a small electric motor to complement the vehicle's gasoline engine. The electric motor allows the engine to be turned off at stop lights and helps to propel the vehicle. Hybrid systems also capture energy typically lost in braking and allow it to be used to help move the vehicle. The battery for the electric motor is recharged through normal vehicle use, so the vehicle never needs to be recharged from the electric grid.

Hybrid-electric vehicles have already proven popular with drivers in Massachusetts and elsewhere. Hybrid-electric vehicle sales were expected to reach 40,000 in the U.S. in 2003 and are expected to exceed 177,000 by 2005.[40] The 2004 Toyota Prius was recently named *Motor Trend* magazine's "Car of the Year" and one of *Car and Driver*'s "10 Best Cars."

By setting targets for the sale of hybrid and other vehicles that are likely to emit less carbon than conventional vehicles, the ZEV program encourages automakers to introduce more models of clean cars, giving Massachusetts residents broader choice of vehicles that are also highly efficient. In addition, the ZEV programs in Massachusetts and other states will help automakers to achieve economies of scale in the production of hybrids, which would presumably be accompanied by a decrease in price. In the meantime, federal tax incentives (which are scheduled to be phased out over the next several years) can help Massachusetts consumers to afford hybrid vehicles, which typically cost about $3,000-$4,000 more than similar models.

The future of hydrogen fuel cell vehicles is less certain. Fuel cells use a chemical reaction involving hydrogen to produce electricity, which is then used to power a vehicle. When pure hydrogen is used in a fuel cell, the only byproducts are water and heat.

A limited number of fuel cell vehicles are currently on the road in demonstration projects. And while most major automakers have stated that they are committed to developing fuel cell vehicles, none has thus far committed to a firm timeline for widescale introduction. More vexing, significant technological and market hurdles remain in the way of an effective system for generating, storing and distributing pure hydrogen. Even if pure hydrogen can be used as a fuel, the possibility exists that polluting and dangerous fuels such as coal and nuclear power could be used to generate the hydrogen, creating new environmental and public health threats. Thus, renewable sources of hydrogen are central to a fuel cell future that delivers dramatic reductions in greenhouse gas emissions.

Despite these potential problems, fuel cells are inherently more efficient than traditional internal combustion engines and, ideally, could become an emission-free form of transportation for the future. Other technologies, such as battery-electric vehicles, are advancing as well, and could help fulfill the requirement for vehicles with no direct pollutant emissions, while natural gas and other clean alternative-fuel vehicles could also be used to meet program requirements. Much as the original ZEV program in California sparked research into electric vehicles that eventually led to today's hybrids, so too will the technology-forcing aspects of the current ZEV program hasten the development of the next generation of automotive technologies.

In its Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) model, the Argonne National Laboratory estimates that hybrid-electric passenger cars release approximately 47 percent less carbon dioxide per mile than conventional vehicles. Fuel-cell passenger cars operating on hydrogen derived from natural gas are projected to produce about 62 percent less carbon dioxide than conventional vehicles.[41] Assuming the level of emissions in the GREET model, and that manufacturers comply with the ZEV program in a similar way as the California Air Resources Board expects them to comply in California, Massachusetts can anticipate about a 3 percent reduction in carbon dioxide emissions from light-duty vehicles by 2020 as a result of adopting the ZEV program.[42]

Strategy #2: Adopt California's Limits on Vehicle Carbon Dioxide Emissions

Potential Savings (Including Savings from ZEV Program): 0.05 MMTCE by 2010, 0.69 MMTCE by 2020 (estimated).

In 2002, California built upon its long history of pioneering efforts to clean up automobiles by enacting a law directing the state to set standards for carbon dioxide emissions from motor vehicles. The so-called Pavley Law (named after the sponsor, Assemblywoman Fran Pavley) was the first policy in the nation to regulate carbon dioxide from automobiles.

Under the law, the California Air Resources Board is to propose limits that "achieve the maximum feasible and cost effective reduction of greenhouse gas emissions from motor vehicles." Limits on vehicle travel, new gasoline or vehicle taxes, or limitations on ownership of SUVs or other light trucks cannot be imposed to attain the new standards.[43] The new standards are to be proposed in 2005 and go into effect in 2009.

The carbon dioxide emission standard adopted by the California Air Resources Board (CARB) pursuant to the Pavley Law would be part of the package of automobile emissions regulated by CARB, and other states would have the ability to adopt those standards. In addition, because of a 1990 state law that requires Massachusetts to adopt the strongest automobile emission standards available, the commonwealth is already committed to the implementation of the Pavley Law.

Assuming that the Pavley Law is implemented, one must also make assumptions about the level of carbon dioxide emission reductions that will result from the program, since regulations implementing the law have not yet been developed.

In estimating the benefits of the Pavley standards, we assume that the regulations will require a 30 percent reduction in average per-mile carbon dioxide emissions for both cars and light trucks, phased in over a 10-year period. This estimate is similar to assumptions made in the Connecticut climate change stakeholder process and by other analysts.[44]

Of course, the flexibility allowed by the Pavley law could result in emission standards that are either stronger or weaker than this "guesstimate." Massachusetts will have the opportunity to make better estimates of the impact of the program when the California regulations are issued in 2005.

In the meantime, Massachusetts can lay the groundwork for implementation of the Pavley standards by moving forward with adoption of the latest ZEV program rules. The state should also encourage other New England and northeastern states to follow Massachusetts' lead by adopting the strongest available automobile emission standards. The emergence of a regional bloc of states in support of carbon dioxide emission standards will not only allow those states to monitor the California process as it is taking place, but will also create leverage that can be used in securing stronger strategies to reduce automotive carbon emissions at the federal level.

Strategy #3: Set Standards Requiring Low Rolling Resistance Replacement Tires

Potential Savings: 0.11 MMTCE by 2010; 0.18 MMTCE by 2020.

Automobile manufacturers typically include low rolling resistance (LRR) tires on their new vehicles in order to meet federal corporate average fuel economy (CAFE) standards. However, LRR tires are generally not available to consumers as replacements when original tires have worn out. As a result, vehicles with replacement tires do not achieve the same fuel economy as vehicles with original tires.

The potential savings in fuel – and carbon dioxide emissions – are significant. A 2003 report conducted for the California Energy Commission found that LRR tires would improve the fuel economy of vehicles operating on replacement tires by about 3 percent, with the average driver replacing the tires on their vehicles when the vehicles reach four, seven and 11 years of age. The resulting fuel savings would pay off the additional cost of the tires in about one year, the report found, without compromising safety or tire longevity.[45]

Several potential approaches exist to encouraging the sale and use of LRR tires – ranging from labeling campaigns (similar to the Energy Star program) to mandatory fuel efficiency standards for all light-duty tires sold in the state. A standards program that required the sale of LRR tires beginning in 2005 in Massachusetts – assuming the same tire replacement schedule and per-vehicle emission reductions found in the California study – would ultimately reduce carbon dioxide emissions from the light-duty fleet by about 1.6 percent by 2010 and 2.3 percent by 2020, while also providing a net financial benefit to consumers through reduced gasoline costs.

Strategy #4: Implement a "Feebate" Program

Potential Savings: 0.06 MMTCE by 2010; 0.29 MMTCE by 2020.

The federal fuel economy preemption limits the number of policy tools available to states to reduce the fuel consumption – and carbon dioxide emissions – of passenger vehicles. One potential tool to reduce the global warming impact of motor vehicles is a package of fees and rebates based on carbon dioxide emissions, commonly known as a "feebate."

The Federal CAFE Preemption

The setting of federal corporate average fuel economy (CAFE) standards for cars and light trucks in 1975 was the most important policy move in U.S. history to improve the fuel economy of light-duty vehicles. As a result of CAFE standards, the miles-per-gallon fuel economy of cars and light trucks nearly doubled between the mid-1970s and the late 1980s.[46]

Unfortunately, CAFE standards have remained largely stagnant over the last decade; standards for cars have not increased since 1990. Moreover, the federal law that created the standards also bars states from adopting regulations that are "related to fuel economy standards." The language of the law explicitly bars states from imposing fuel economy requirements on vehicles, but the use of the phrase "related to" also casts legal shadows on other measures – from efficiency-based fees and incentives to limits on carbon dioxide emissions from vehicles – that could be construed by some as "related to" fuel economy standards.

With the federal government resisting further significant increases in CAFE standards, however, it may be up to states such as Massachusetts to implement incentives aimed at encouraging the purchase of vehicles that produce less carbon dioxide.

A feebate program would give financial incentives to car buyers who purchase more efficient – and less carbon-intensive – vehicles, and fund those incentives through fees on purchasers of less efficient vehicles, making the program essentially revenue neutral. At a designated point on the fuel economy scale – known as the "zero point" – a vehicle would receive no rebate and pay no fee. The ideal zero point for a revenue neutral feebate program is usually thought to be the average fuel economy of all vehicles sold.

There are many potential variations of feebate programs. Feebates can apply equally across all vehicle classes, or can include separate "zero points" for cars and light trucks, or for vehicle subclasses (e.g. subcompacts). Feebates can be structured to apply either to new vehicles or to both new and used vehicles. Feebate rates can be applied in a linear fashion – with rates increasing in direct proportion to carbon emissions – or be structured to specifically target vehicles in the middle of the efficiency spectrum. Finally, the rate of the feebate can vary, from a token charge to levels that generate maximum fees/rebates in the range of several thousand dollars.

While no state currently has a feebate program in place (Maryland briefly adopted a program, but it was not implemented due to a legal dispute with the federal government over a separate labeling provision), Rhode Island has engaged in detailed discussions of potential feebate scenarios as part of its Greenhouse Gas Stakeholder Process, Connecticut endorsed a feebate program in its stakeholder process, and feebate legislation has been introduced in the Massachusetts Legislature for the last decade.

The impact of a feebate program depends largely on how it is structured, but it also depends on the number of vehicles covered by the program. A 1995 study by researchers at Lawrence Berkeley National Laboratory found that the majority of the improvement in fuel economy that would result from a feebate program would be generated by the response of manufacturers – not the response of individual consumers. The study concluded that manufacturers would make more fuel efficient vehicles to respond to the economic signals from a feebate program, but that manufacturers likely would not respond if a feebate were adopted by only a single state.[47]

A feebate program adopted solely in Massachusetts could, therefore, have limited results. However, a regional program – implemented consistently across the New England states – would not only bring a greater likelihood of manufacturer response, but would also ease implementation of the program by reducing the possibility of escaping the feebate by purchasing or registering vehicles in neighboring states.

Based on analysis conducted for the California Energy Commission, a regionally adopted feebate program – applied linearly to all new vehicles and based on carbon emissions – would reduce average carbon dioxide emissions from new cars by approximately 8.2 percent by 2020 and from light trucks by 8.4 percent.[48] This estimate is far from certain, since the California study modeled the impact of a feebate significantly larger in dollar terms than that currently being discussed in the New England states and because California's new vehicle market is approximately three times the size of New England's. On the other hand, the CEC report is based on somewhat optimistic assumptions about baseline increases in fuel economy that would occur without a feebate. Assuming that the CEC's assumed percentage emission reductions held true for a feebate assessed in Massachusetts, carbon dioxide emissions from the light-duty vehicle fleet would be about 3.3 percent lower in 2020 than projected.

Strategy #5: Implement Pay-As-You-Drive Automobile Insurance

Projected Savings: 0.39 MMTCE by 2010; 0.45 MMTCE by 2020.

In a perfect market, the rates individuals pay for insurance coverage would accurately reflect the risk they pose to themselves and others. Automobile insurers use a host of measures – including vehicle model, driving record, location and personal characteristics – to estimate the financial risk incurred by drivers.

One measure that is not frequently used with any accuracy is travel mileage. Common sense and academic research suggest that drivers who log more miles behind the wheel are more likely to get in an accident than those whose vehicles rarely leave the driveway.[49] Many insurers do provide low-mileage discounts to drivers, but these discounts are often small, and do not vary based on small variations in mileage. For example, a discount for vehicles that are driven less than 7,500 miles per year does little to encourage those who drive significantly more or less than 7,500 miles per year to alter their behavior. As a result, the system fails to effectively encourage drivers to reduce their risk by driving less.

Requiring automobile insurers to offer mileage-based insurance is just one of many potential policies that attempt to reallocate the upfront costs of driving. High initial cost barriers to vehicle ownership – such as insurance, registration fees and sales taxes – may reduce driving somewhat by denying vehicles to those who cannot afford these costs. But for the bulk of the population that can afford (or has little choice but to afford) to own a vehicle, these high initial costs serve as an incentive to maximize the vehicle's use. Per-mile charges operate in the opposite fashion, providing a powerful price signal for vehicle owners to minimize their driving and, in the process, minimize the costs they impose on society in air pollution, highway maintenance and accidents.

A pay-as-you-drive (PAYD) system of insurance in Massachusetts might work this way: vehicle insurance could be split between those components in which risk is directly related to the ownership of a vehicle (comprehensive) and those in which risk is largely related to driving (collision, liability). The former could be charged to consumers on an annual basis, as is done currently. The latter types of insurance could be sold in chunks of mileage – for example, 5,000 miles – or be sold annually, with the adjustment of premiums based on actual mileage taking place at the end of the year. Of critical importance to the success of the system would be the creation of accurate, convenient methods of taking odometer readings and communicating them to the insurer.

A pay-as-you-drive system of insurance would have great benefits for Massachusetts – not only for reducing global warming emissions but also for improving highway safety and reducing insurance claims. Because insurers would still be permitted to adjust their per-mile rates based on other risk factors, mileage-based insurance would add additional costs for the worst drivers, giving them a financial incentive to drive sparingly.

Most importantly, however, a mileage-based insurance system would reduce driving – particularly in a state with high auto insurance rates such as Massachusetts. Converting the average collision and liability insurance policies to a per-mile basis in Massachusetts would lead to an average insurance charge of about 10 cents per mile.[50] (By contrast, a driver buying gasoline at $1.50 per gallon for a 20 MPG car pays only 7.5 cents per mile for fuel.)

If 80 percent of collision and liability insurance were to be assessed by the mile, the impact on vehicle travel would be significant. Research conducted by the U.S. EPA and updated by the Victoria Transport Policy Institute suggests that a per-mile charge of this magnitude (about 7.8 cents per mile in Massachusetts) would reduce vehicle-miles traveled by about 11.2 percent, with carbon dioxide emissions from light-duty vehicles declining by roughly the same amount.[51] Should one-half of Massachusetts drivers be covered by the PAYD option, light-duty VMT – and, therefore, light-duty vehicle carbon dioxide emissions – could be reduced by 5.6 percent.

While many insurers remain resistant to the administrative changes that would be needed to implement mileage-based insurance, the concept is beginning to make inroads. The Progressive auto insurance company offered a pilot PAYD insurance system in Texas and other pilot programs are underway elsewhere. In 2003, the Oregon Legislature adopted legislation to provide a $100 per policy tax credit to insurers who offer PAYD options.[52]

Massachusetts should choose to introduce the concept by requiring insurers to offer it as an alternative to traditional insurance. If the concept proves successful, the state (or insurers) could then require liability and collision rates to be expressed in cents-per-mile – thus maximizing the carbon dioxide emission reductions and other positive results of the policy.

Unlike other policies that use price signals to reduce vehicle travel (such as an increased gas tax), mileage-based insurance has inherent aspects that make it an appealing policy option – regardless of its impact on global warming emissions. It ties the cost of insurance more closely to the actual risk incurred by driving. As a result, it should be closely studied, and ultimately implemented, in Massachusetts.

Policy Alternative: Pay-At-The-Pump Insurance

A close relative of pay-as-you-drive insurance, pay-at-the-pump policies would require the state to collect a surcharge on gasoline sales that would then provide minimal insurance coverage to drivers. Drivers would still purchase additional insurance coverage in the traditional manner.

Pay-at-the-pump systems have four advantages. First, they do not require verification of odometer readings. Second, as a global warming measure, they tie insurance coverage to the amount of fuel used – encouraging both reductions in vehicle travel and the purchase of more efficient vehicles. Third, drivers of larger, less-fuel efficient vehicles (such as large SUVs) impose greater costs when they get into accidents. Evidence shows that SUVs and other large vehicles are more likely to kill or severely injure occupants of other vehicles in a collision and that the sense of security provided by driving in a large vehicle may lead to more dangerous driving behaviors.[53] To the extent this is true, pay-at-the-pump can put a price on the additional risk these vehicles pose. Finally, pay-at-the-pump can generate a pool of funds to cover uninsured motorists, thereby reducing premiums for insured motorists who currently carry the financial burden of those who are not insured.

Strategy #6: Reduce Growth in Vehicle Miles Traveled

Potential savings: 0.43 MMTCE by 2010; 1.23 MMTCE by 2020.

The growth in vehicle-miles traveled over the last several decades has its roots in many societal changes – the redistribution of people and jobs away from central cities to the suburbs, the elimination of some mass transit opportunities, low gasoline prices, the increased participation of women in the workforce, and residential and commercial suburban sprawl.

Reversing this trend will be difficult, but success would bring benefits not only in reducing global warming emissions but in easing traffic congestion, reducing public expenditures on highways, enhancing Massachusetts' energy security, and reducing automotive emissions of other pollutants that damage public health. It would be a reasonable goal for Massachusetts to seek to reduce the growth rate in vehicle-miles traveled – projected by the Massachusetts Highway Department to be approximately 1.4 percent annually until 2020 – to the rate of population growth in the state, projected by the U.S. Census Bureau to be approximately 0.4 percent per year between 2005 and 2020.[54]

The impact on vehicle-miles traveled of both transit improvements and growth management policies has been well documented. A variety of studies have documented that doubling the residential density of a given neighborhood reduces per-capita VMT by approximately 20 to 38 percent. Increasing the density of transit service has also been shown to reduce VMT.[55]

Because such effects are dependent on the characteristics of the community and the type of proposed policy or project, it is difficult to estimate the impact of any one statewide smart growth or transit strategy. Regardless, by adopting a package of "smart growth," transit, and transportation demand management (TDM) policies, Massachusetts could encourage long-term shifts in development patterns and transportation decisions that would reap benefits in reduced vehicle travel and global warming emissions.

Among the policies implemented in or considered by other states that could help achieve this goal are the following:

- Directing state investments in transportation and other infrastructure toward designated growth areas near existing population centers.

- Encouraging transit-oriented development near stations to expand the range of services available to commuters without having to use their vehicles (as proposed by Gov. Romney in December 2003).

- Encouraging location-efficient mortgages that allow households living near transit services to borrow additional money because their reduced transportation expenses increase their disposable income. The "Take the T to Work" program, which provides no-down-payment mortgages for qualified applicants who regularly use the MBTA transit system, is one such example.[56]

- Providing additional incentives to employers who encourage telecommuting, establish car- and vanpool programs, provide transit subsidies, or otherwise promote transportation alternatives.

- Implementing congestion pricing on major highways (in which commuters traveling during congested periods pay a toll) thus reducing rush-hour traffic and encouraging alternatives to single-passenger automobile use.

- Improving the geographic reach, quality and frequency of existing transit services, and working to achieve low fares that maximize the use of existing transit infrastructure.

- Expanding bikeway networks and bike lanes, employing "traffic calming" techniques in town center areas, requiring sidewalks in all new developments, and other policies to improve the safety and appeal of walking and bicycling.

- Promoting "infill" development and redevelopment in existing urban and suburban areas through transfers of development rights, brownfields redevelopment incentives, urban development programs, and other means.

Regardless of the specific policies involved, Massachusetts must realize that land use and transportation policies are integrally related, and should be aligned to achieve the same goals of reducing automobile dependence, reducing development pressure on the state's remaining open spaces, and revitalizing urban areas. By adopting a state goal for the management of vehicle travel, and implementing that goal through a series of locally appropriate policies, Massachusetts could go a long way toward meeting its global warming emission reduction goals.

Combined Impact of the Transportation Strategies

Implementing the six strategies listed above would have a significant impact on Massachusetts' transportation-sector carbon dioxide emissions by reducing vehicle-miles traveled and reducing the per-mile emissions of carbon dioxide from motor vehicles. Compared with a base case projection that assumes a 1.4 percent per year increase in VMT and no significant improvements in vehicle fuel economy, the actions listed above would reduce transportation sector emissions by about 0.94 MMTCE by 2010 and 2.29 MMTCE by 2020. At these levels, transportation-sector emissions in Massachusetts in 2020 would be 2.23 MMTCE higher than 1990 levels (excluding savings from feebates).[57]

Achieving even this level of emission reductions will require swift action. Many of the transportation-sector strategies (including feebates and the Pavley program) have a long lead time before they begin to produce significant savings due to the fact that they primarily affect new vehicle purchases. Once sold, new vehicles typically remain on the road for 10-15 years or more. Thus, any delay in adoption of these measures will result in more high-carbon vehicles traveling Massachusetts' highways for years to come.

Finally, it is important to note the major role federal decision-makers can play in reducing carbon dioxide emissions from transportation. An increase in the federal CAFE standard to 40 MPG, applied to both cars and light trucks and phased in over time, would have a dramatic impact on carbon dioxide emissions – greater than any of the policy options listed above.[58] Massachusetts cannot afford to wait for Washington to take action on CAFE, but the state should work with federal officials to promote a CAFE increase and other changes in federal transportation policy to reduce carbon dioxide emissions.

Additional Transportation Strategies to Consider

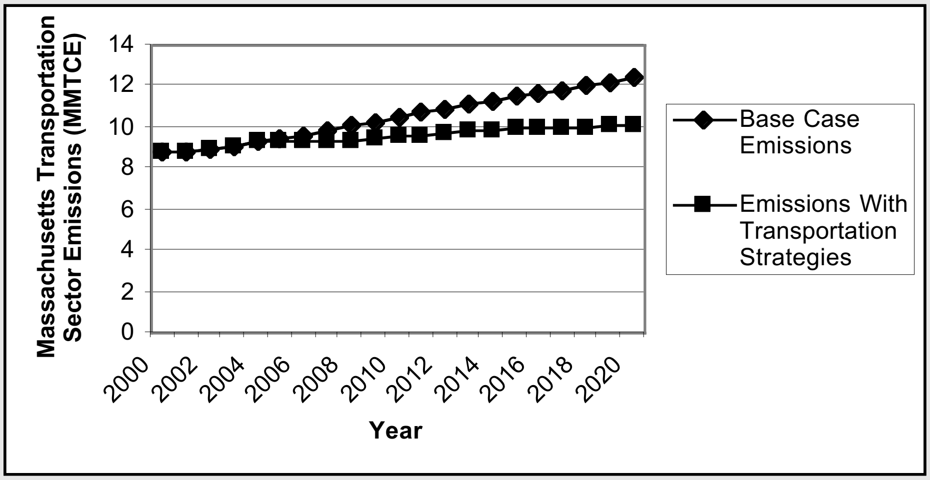
Some combination of other transportation-sector strategies will ultimately be necessary in Massachusetts' efforts to reduce global warming emissions. Among them are the following:

- Motor Fuel Taxes – Taxes on gasoline and other motor fuels provide an incentive for individuals to reduce their driving and to purchase more efficient vehicles. Academic research shows that long-run fuel consumption is reduced by 3 to 10 percent for every 10 percent increase in fuel price.[59] While motor fuels tax increases have traditionally been unpopular with the public (and raise legitimate concerns with regard to the impact on low-income drivers), novel variations on the policy are possible. For example, the revenue generated by higher gasoline taxes could be used to reduce income or property taxes – thus preserving the tax increase's incentive for fuel conservation while making it revenue neutral in the aggregate. Alternatively, fuel tax increases could be dedicated to the expansion of transit services, incentives for the use of transportation alternatives, or incentives for the purchase of more fuel-efficient vehicles, in the same manner as systems benefit charges on electricity bills are used to promote energy efficiency.

- Rail Improvements and Expansion – Massachusetts' network of operating and dormant rail corridors is a large potential resource for global warming reduction. Rail can play two important roles: as a substitute for car and air travel (particularly for flights within the Northeast region) and as a substitute for air and highway freight delivery. Passenger rail operations release less than half the amount of carbon dioxide per passenger mile of air travel.[60] On the freight side, state officials should continue to consider modernization of the state's freight rail system, urge investments in interconnections with other regions, and improve intermodal connections. Rail improvements should receive a high priority for funding at the state level, as they will become an increasingly important component of Massachusetts' transportation system over the next several decades.

- Limits on Highway Expansion – Congestion and safety problems on Massachusetts' highway network are growing, sparking proposals to add yet another lane to highways around Boston. These proposed highway additions would be costly – both in terms of the direct spending required of the state, and in terms of global warming emissions. Far from alleviating congestion, expansion of major highways has been shown in various studies to pro-

Fig. 7. Projected Transportation Sector Carbon Dioxide Emissions (excluding savings from feebates)



mote increased vehicle travel, leading to more fuel use, more global warming emissions, and, eventually, more traffic.[61] Rather than expand the state's highway capacity, transportation officials should adopt a policy that prioritizes roadway repairs and relies on transportation demand management strategies – such as car- and van-pooling incentives, road pricing, and expansion of transportation alternatives for both personal and freight travel – to meet the state's long-term transportation needs.

- Limits on Diesel Pollution – Diesel fuel – used predominantly in large trucks, buses, and other large vehicles and machinery – is a major source of both carbon dioxide and "black carbon," whose role in global warming some scientists believe may be very significant. Diesel vehicles also produce large amounts of particulates and other pollutants that endanger public health. Massachusetts has several avenues open to it to reduce diesel emissions, including the adoption of standards for ultra-low sulfur diesel fuel, requirements for the retrofitting of existing diesel engines, the use of alternative fuels (such as natural gas) in public transit fleets, as is already beginning to be done by the MBTA, and measures to reduce the amount of truck idling (such as the electrification of truck stops in the state and stricter enforcement of the state's anti-idling law).

Reducing Emissions from Homes, Business and Industry

The residential, commercial and industrial sectors are responsible for about half of Massachusetts' non-electric emissions of carbon dioxide. There are, however, tremendous opportunities to improve the efficiency of energy use in all three sectors.

Strategy #7: Strengthen Residential and Commercial Building Energy Codes

Potential Savings: 0.024-0.036 MMTCE by 2010; 0.33 MMTCE by 2020.[62]

Building codes were originally intended to ensure the safety of new residential and commercial construction. In recent years, however, building codes have been used to reduce the amount of energy wasted in heating, cooling and the use of electrical equipment. Massachusetts has included energy efficiency as a criterion in the development of building energy codes since at least the 1980s.[63] The state must update the codes at least once every five years and currently is conducting the next review.[64] Currently, residential construction in Massachusetts is guided by the 1995 Model Energy Code (MEC) with energy-conservation amendments added in 1998, while commercial construction is guided by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) code 90.1-1999 and the 2001 International Energy Conservation Code (IECC).[65]

Model building energy codes are developed and updated at the national and international level. The International Code Council (ICC) is responsible for development of the International Energy Conservation Code (IECC), the most recent version of which was published in 2003.

A 2001 study by the American Council for an Energy-Efficient Economy (ACEEE) estimated that homes meeting the 2000 IECC code would use approximately 15 percent less energy than homes not meeting the code, with a further 20 percent energy savings from the adoption of future codes that would go into effect after 2010.[66] The U.S. Department of Energy estimates that the intensity of electricity use in New England commercial buildings would decline by approximately 10 percent if all states fully adopted the ASHRAE code 90.1-1999 versus the previous ASHRAE code.[67] ACEEE assumes a further 20 percent energy savings for all fuels in commercial buildings from future updates to the code.[68]

Based on the assumptions of ACEEE and U.S. DOE, the adoption of updated building energy codes would reduce residential oil and gas use by approximately 1.3 percent below base case projections by 2020, commercial oil and gas use by approximately 4 percent, and commercial electricity use by about 6.2 percent. These estimates are likely conservative, since they only attempt to quantify the impact of improved codes on new construction. Applying codes to alterations and renovations in residential and commercial structures would result in even greater savings.

In estimating the carbon dioxide reductions that would result from improved building codes and other measures that reduce electricity use, a key factor is the type of electricity generation that is assumed to be affected by the reduction in consumption. Coal- and oil-fired power plants (particularly older plants) release significantly greater amounts of carbon dioxide per unit of electricity produced than modern natural gas-fired power plants. Thus, the resulting emission reductions are low if it is assumed that electricity savings reduce the need for the construction of new gas-fired power plants, and high if they reduce the amount of power coming from older coal- and oil-fired plants.

In this report, where applicable, we present a range of emission reductions based on these different assumptions. The low end of the range is based on the assumption that electricity savings are first used to offset any reduction in generation from nuclear plants that would be closed down upon expiration of their licenses, with the remaining savings used to reduce the need for gas-fired generation. The high end of the range is based on the assumption that savings are first used to offset retired nuclear power, with the remainder used to reduce coal-fired generation. It is likely that the higher emission reduction estimate would only be achieved under a strong state or regional cap on electric-sector emissions. (See Strategy #12.)

It is important to note that the success or failure of building energy codes depends largely on the degree to which they are enforced by local building officials in the state's cities and towns. With proper enforcement and training, upgraded building codes can ensure that Massachusetts reaps the benefits of energy-efficient residential and commercial construction.

Strategy #8: Adopt Appliance Efficiency Standards

Potential Savings: 0.18-0.39 MMTCE by 2010; 0.52 MMTCE by 2020.

Household appliances and those used by business are a major source of energy demand. Since the first state appliance efficiency standards were adopted in the mid-1970s (followed by federal standards beginning in the late 1980s), the energy efficiency of many common appliances has been dramatically improved. For example, residential refrigerators complying with the latest national standards consume less than one-third the electricity annually of refrigerators manufactured in the early 1970s.[69]

The federal appliance standards program has led to great improvements in the efficiency of many appliances, but progress has slowed in recent years. Federal standards have failed to keep up with advances in efficiency technologies or have failed to take advantage of known efficiency opportunities. In addition, the federal program does not cover some appliances with great potential for improved efficiency.

States are pre-empted from adopting their own efficiency standards for products covered by federal standards, but there are two opportunities for states to take action. First, states may adopt efficiency standards for products not specifically covered by the federal program. In addition, states have the opportunity to apply for a waiver of federal pre-emption to apply stronger standards to products currently covered by federal standards.

An analysis conducted in 2002 by Northeast Energy Efficiency Partnerships (NEEP) assessed the potential energy savings that would result from the adoption of improved efficiency standards for 15 commercial and residential products. (See Table 4.) Using NEEP's projections for total electricity savings, moving forward with standards for all such products would reduce commercial-sector electricity use by about 2 percent versus projection by 2020 and residential-sector electricity consumption by about 15 percent.[70]

Appliance efficiency standards are also a win-win for Massachusetts' environment and economy. The NEEP study estimated that adoption of the package of appliance standards would bring Massachusetts approximately $2.1 billion in net economic benefit by 2020.[72]

Massachusetts should move ahead with the adoption of efficiency standards for appliances not covered by federal rules, and apply for waivers of pre-emption for the others. In addition, the state should allow for the expedited adoption of future appliance standards for existing products and new products making their way into the marketplace.

Table 4. Products Covered Under Proposed Efficiency Standards[71]

Residential Products

Furnace fans
Torchiere light fixtures
Ceiling fans
Consumer electronics (standby power)
Central air conditioners and heat pumps

Commercial Products

Unit and duct heaters
Small packaged air conditioners and heat pumps
Beverage vending machines
Commercial refrigerators and freezers
Reach-in beverage merchandisers
Traffic signals
Exit signs
Commercial (coin-operated) clothes washers
Ice makers
Large packaged air conditioners

Strategy #9: Expand Energy Efficiency Programs

Potential Savings: 0.54-0.77 MMTCE by 2010; 1.25 MMTCE by 2020.

One of the most promising opportunities for reducing carbon dioxide emissions in Massachusetts is through improved energy efficiency. Stronger residential and commercial building codes and improved appliance efficiency standards, while important, are limited in their scope, leaving many existing buildings and sources of energy use untouched.

There are many barriers to the successful introduction of energy efficiency technologies. Potential users may not know about the technologies or have an accurate way of computing the relative costs and benefits of adopting them. Even when efficiency improvements are plainly justifiable in the long run, consumers may resist adopting technologies that cause an increase in the initial cost of purchasing a building or piece of equipment. In some cases, as with low-income individuals, consumers may not be able to afford the initial investment in energy efficiency, regardless of its long-term benefits.

Traditionally, states have required electric utilities to make investments in efficiency programs through the rate-setting process. In the wake of electric industry restructuring, however, some states have dropped efficiency requirements, while others – including Massachusetts – have created a new means of financing efficiency improvements through the assessment of systems benefit charges (SBCs) on consumers' electric bills.

The concept behind the SBC is that all electric consumers share in the benefits when any consumer improves his or her energy efficiency. These benefits are both social (reduced global warming emissions and air pollution and improved long-run energy security) and purely economic (reduced need for expensive peak generation and ratepayer investments in transmission and distribution systems).

While nearly half of all states (including all six New England states) have adopted some form of SBC for electric utilities, fewer have implemented SBCs for natural gas, which is distributed through a regulated system similar to electricity. Similarly, the potential for SBC-type programs for other fuels – such as petroleum – has not been fully explored.

Massachusetts established its system of SBCs through electric restructuring legislation adopted in 1997.[73] SBCs are assessed in Massachusetts to support energy efficiency programs, the development of renewable energy sources, and low-income assistance programs. We will discuss the SBC for renewable sources in more detail later in this report.

The efficiency SBC is assessed to customers of investor-owned utilities, but not to customers of municipal utilities, which serve 350,000 customers in Massachusetts.[74] The efficiency SBC rate is 2.5 mills ($0.0025) per kilowatt-hour. A slightly higher assessment rate in 2001 generated $122 million in efficiency funding.[75] Massachusetts' efficiency programs are overseen by the state Division of Energy Resources (DOER). DOER reported that efficiency improvements made through the program in 2001 will save approximately 4,571 gigawatt-hours (GWh) of electricity consumption over the lifetime of the measures (a savings rate of about 2.3 kilowatt-hours annually per dollar spent, which will lead to lifetime economic savings of about $332 million).[76] SBC funds support a wide variety of efficiency-related programs, ranging from research and development and public outreach to incentives for the purchase of energy efficient equipment for businesses.

Should Massachusetts double its SBC for efficiency to 5 mills, the state could generate tens of millions of additional dollars for efficiency improvements. Even assuming that efficiency savings from added SBC revenue would come at a substantially lower rate (given the decreasing availability of "low-hanging fruit" over time), Massachusetts could still achieve carbon savings of 0.40 MMTCE by 2020.

Cost-effective efficiency savings of this degree are clearly achievable. The American Council for an Energy-Efficient Economy (ACEEE) estimated in 2003 that the cost-effective potential for efficiency savings in Massachusetts within the next five years is approximately 1,891 GWh.[77]

The impact of a gas and oil SBC program is more difficult to predict, but it would be substantial. Based on Vermont's experience with a utility-based natural gas conservation program, the Connecticut Climate Change Stakeholder Dialogue estimated that the average first-year cost of saving 1,000 cubic feet of natural gas was $29.[78] Assuming that a gas and oil SBC-type program applied to residential, commercial and industrial consumption in Massachusetts would achieve a savings rate 75 percent of that experienced in Vermont, an SBC of 3.5 cents per 100,000 BTU of energy consumed would reduce Massachusetts' carbon dioxide emissions by approximately 0.85 MMTCE by 2020. An SBC at this rate would translate into a rate of about 3.5 cents per therm of natural gas or 2.5 cents per gallon of distillate heating oil.

The near-term impacts of expanded residential, commercial and industrial energy efficiency programs may represent just the tip of the iceberg of the potential benefits of an expanded SBC program. By funding research and development into efficient new technologies and practices and broadening public understanding of the potential benefits of energy efficiency, these programs can create new opportunities for cost-effective energy savings in the years to come.

Combined Impact of the Residential, Commercial and Industrial Strategies

Adoption of the three strategies listed above would reduce carbon dioxide emissions from electricity use and direct combustion of fossil fuels in homes, businesses and industries by about 0.72-1.16 MMTCE in 2010 and 1.85-2.54 MMTCE in 2020. This estimate takes into account the fact that some equipment covered under proposed appliance standards could also be included in building codes by counting only savings from appliances not covered by codes.

Additional Residential, Commercial and Industrial Sector Strategies to Consider

A number of other strategies are available to reduce energy use in the residential, commercial and industrial sectors.

- Green Building Certification – State building energy codes provide the minimum design standards for energy efficiency in buildings, but even greater savings are available with good design and additional upfront investment. Commercial buildings certified to the U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED) standards achieve average energy savings of 25 to 30 percent beyond the ASHRAE 90.1-1999 commercial code. While LEED-certified buildings cost an average of 2 percent more to construct, they yield 20-year financial benefits of about 10 times the construction premium.[79] For residential buildings, Home Energy Rating Systems (HERS) can be used to measure code compliance or to set thresholds for a "green home" designation. In addition to making LEED certification the standard for new government construction, Massachusetts should also identify ways to reward builders, businesses and home buyers who choose to certify their buildings to green building standards. Any program to promote green buildings should, however, also reinforce the state's smart growth goals. A "green" commercial building sited in such a way as to increase automobile travel may have a negligible – or even negative – net impact on global warming emissions.

- Energy-Efficient Mortgages/Pay-As-You-Save Programs – Energy-efficient mortgages (EEMs) and pay-as-you-save (PAYS) programs are alternative models for financing the installation of energy-efficiency measures and distributed generation resources, primarily in the residential sector. EEM programs generally allow homebuyers to assume larger mortgages (sometimes on preferential terms) to finance energy efficiency improvements. PAYS programs allow consumers to pay for energy-efficient equipment or distributed generation resources (such as solar panels, small wind systems or fuel cells) over time on their utility bills rather than up-front. The charge remains on the utility bill until the equipment is paid off, regardless of who is living in the residence at the time. PAYS systems remove a major barrier from homeowners seeking to reduce energy demand: the prospect that they will not reside at the home long enough to enjoy the benefits of their investments. State officials should work with utilities and mortgage lenders to encourage and publicize EEMs and with utilities to experiment with pilot PAYS systems for efficiency and distributed generation.

- Cluster and Mixed Use Development – Smart growth policies are commonly thought to reduce global warming emissions by reducing the number of automobile trips required to carry out daily activities. But they may also have the secondary effect of reducing energy use within the buildings themselves. Many smart growth or "new urbanist" projects involve the renovation of existing buildings, construction of homes with less square footage than typical new suburban construction, or the combination of commercial and residential uses in a more space-efficient fashion. More research needs to be done to quantify the energy impacts of such projects, but Massachusetts can spur their development by encouraging municipalities to develop zoning ordinances that allow, or provide incentives for, cluster and mixed-use developments.

- Combined Heat and Power and Distributed Generation – New and improved technologies now allow homeowners and businesses to generate their own power. Combined heat and power (CHP) systems allow commercial and industrial facilities to use waste heat from heating and cooling systems to generate electricity, or vice versa. CHP systems can vastly improve the efficiency of a facility's energy production and use. Because CHP systems generally rely on fossil fuels, they are less effective at reducing carbon dioxide emissions than are renewable resources. Nonetheless, CHP should be encouraged, particularly for facilities for which renewable power does not make sense, by removing market barriers and easing interconnection with the electric grid. Similar incentives could promote the use of clean distributed generation (DG) technologies such as solar panels, small wind turbines, fuel cells, and small, high-efficiency turbines operating on natural gas or other low-carbon fuels. DG systems can reduce carbon dioxide emissions in two ways: by providing a lower-carbon source of electricity than power from the grid, and by providing that electricity closer to the point of use, reducing the amount of energy lost in transmission from a central power station to the end user. In addition to removing barriers to DG deployment, however, the state should adopt tight emission standards to ensure that distributed generators operating on diesel or other dirty fuels do not contribute to local air pollution problems.

- Solar-Ready Home Standards – Massachusetts should revise its building codes to require that new homes and commercial structures be built to allow the easy installation of solar photovoltaic systems.

Reducing Emissions from Electricity Generation

In addition to efforts to conserve electricity, Massachusetts can also help to reduce carbon dioxide emissions from electricity use by working to make the New England electric grid cleaner – specifically by encouraging a shift away from carbon-intensive fuels such as coal and oil and toward renewable energy sources such as solar and wind. To achieve this goal, Massachusetts must encourage the deployment of renewable energy sources while simultaneously adopting policies to reduce carbon dioxide emissions from fossil fuel generators through a state or regional electric-sector carbon cap. Regional cooperation on this matter is crucial, since generation capacity and renewable resources are not distributed evenly across the six New England states.

Strategy #10: Enforce, Strengthen and Extend the Renewable Portfolio Standard

Potential Savings: 0.42-0.96 MMTCE by 2010; 0.56 MMTCE by 2020.

Massachusetts is one of a number of states (along with Maine and Connecticut) that have adopted a renewable portfolio standard (RPS) for electricity supplied to the state's customers. Essentially, an RPS requires that a certain portion of the power sold by utilities be generated from renewable energy sources. The percentage of renewable power increases over time, providing a scheduled ramp-up to the provision of a significant portion of the state's power from renewable sources.

Massachusetts adopted an RPS with the electric restructuring law of 1997. The program sets a goal of generating 4 percent of the state's power from new (post-1997) renewable sources by 2009, with the target rising by one percent each year thereafter until the Division of Energy Resources ends the program.[80] Eligible renewable sources include solar, wind, landfill gas, fuel cells using renewable fuels, ocean thermal power, wave or tidal power, and low-emission biomass.[81]

Massachusetts and the rest of the region can be even more aggressive in the promotion of renewables. An RPS that sets a target of 10 percent of the region's electricity from new, clean, zero-net-carbon renewables by 2010 and 20 percent by 2020 is achievable and would result in a net reduction in carbon dioxide emissions from electric generation. For this to occur, the Massachusetts Department of Telecommunications and Energy (DTE), the state utility regulator, must take it role in enforcing the provisions of the RPS seriously. Using its authority under state statutes, the DTE must recognize the fuel diversity benefits of the RPS and hold the utilities accountable for complying with the renewable energy requirement.

With these targets, Massachusetts would achieve savings of 0.42-0.96 MMTCE by 2010 and 0.56 MMTCE by 2020, with the higher near-term estimate based on adoption of a strong regional carbon cap in which new renewable resources supplant generation from coal-fired power plants. (See Strategy #12.) The 2020 savings estimate does not exhibit a range, since – regardless of the existence of a carbon cap – the new renewables are assumed to first replace generation that had been provided by the Pilgrim nuclear reactor, whose license is scheduled to expire in 2012.

Under a regional RPS, applied to all power consumption in the region, the New England states would generate more than 11,000 GWh of power from new renewable sources by 2010, and 21,000 GWh by 2020, over and above the amount of renewables that would already be deployed under the existing RPSs in Massachusetts and Maine and an older version of the RPS in Connecticut. Several forms of renewable energy could be used to meet the RPS requirement, including wind power, solar power, landfill gas, and perhaps new technologies such as run-of-the-river hydropower, if they are proven to be effective and environmentally benign.

Is such a level of renewable power production in New England feasible? The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) has calculated that New England has the potential to generate as much as 34,000 GWh per year using onshore wind resources alone.[82] Technological improvements in the future could allow the cost-effective generation of additional power from wind. This estimate does not include the wind energy that could be harnessed by offshore wind turbines, which could potentially supply more electricity each year in New England than the region currently consumes.[83]

In sum, fulfilling a 20 percent renewable portfolio standard for New England would require the development of less than two-thirds of the region's onshore wind potential under even the most conservative estimates and without factoring in the potential for technological improvements to make wind power feasible for distributed applications and at lower wind speeds. Adding solar, landfill gas, and clean biomass (that which does not contribute to toxic air emissions) to the mix makes this task even more readily achievable. Massachusetts, for example, has already approved New England landfill gas projects with a nameplate capacity of about 50 MW to qualify for the state's RPS.[84]

Massachusetts has shown leadership with its adoption of an RPS, but adoption of consistent standards across New England would be beneficial. First, the region should agree on a set of rules for inclusion under an RPS that emphasize truly clean, truly renewable technologies. Polluting and environmentally damaging technologies, along with those that rely on nonrenewable resources, should be excluded from use to fulfill RPS requirements. In some cases, difficult decisions will have to be made to preserve the spirit of the RPS. For example, stationary fuel cells that run on natural gas, while they may be environmentally beneficial, should not receive credit under an RPS due to their ultimate reliance on fossil fuels. Other incentives should be used to promote technologies, such as combined heat-and-power, that improve efficiency but do not draw on truly renewable resources.

The need for regional standards is particularly important because any RPS is necessarily going to require the purchase of credits from new renewable generation in other states. States vary greatly in their potential for successful renewables development, so it is only fitting that states get credit for the role they play in facilitating the development of renewables in neighboring states. Massachusetts' RPS allows the fulfillment of requirements through the development of renewables in other New England states or even outside the region.

Massachusetts should commit to reaching the 10 percent goal for new renewables by 2010 and 20 percent by 2020. At the same time, the state should work with other New England states to support a similar, regional requirement, with tight and effective mechanisms for tracking, purchasing and trading renewable power certificates. The state should also create mechanisms that allow renewable energy developers to secure long-term contracts for the power they produce, thereby removing one of the major barriers to constructing renewable energy projects.

Strategy #11: Support the Development of Solar Power

Potential Savings: 0.001-0.003 MMTCE by 2010; 0.005 MMTCE by 2020.

Solar power is currently a bit player in the generation of electricity in New England. Barring a technological breakthrough, it will likely remain a bit player for at least the next decade. But Massachusetts and other New England states can play a leading role in positioning solar power to make a major contribution to the region's long-term global warming emission reduction goals. Solar photovoltaics (PV) have the potential to make a major contribution to a clean energy future. Costs have already gone down by 75 percent over the past 20 years.[85] Massachusetts and other states must recognize the importance of early investments to reduce the ultimate cost of solar power by front-loading support for solar installations to create greater economies of scale within the industry.

To generate funding for solar installations, the state could consider increasing the systems benefit charge (SBC) for renewables, or creating an alternative source of new funding, such as a bond issue. Currently, customers of Massachusetts' investor-owned utilities pay an SBC of one-half of one mill ($0.0005) for renewables. This generates approximately $25 million per year for the state's Renewable Energy Trust Fund. This funding allows the Massachusetts Technology Collaborative (which is supported by the state's renewables SBC) to provide subsidies of up to $5,000 per kW for the installation of solar PV capacity on commercial buildings and in residential clusters. (The Trust Fund, however, should streamline the bureaucratic obstacles to obtaining these subsidies. The state of New Jersey has a much less cumbersome system which Massachusetts should consider replicating.)

A $4,000 per kW subsidy appears to be sufficient to make solar power cost-competitive in New England in the near term. A recent analysis found that a solar PV system for a commercial building in Massachusetts (including the subsidy) could cost as much as $11,000 per kW and still break even financially for the purchaser. Installed commercial PV systems in the U.S. range in price from $7,000 to $12,000 per kW, making PV systems largely cost-competitive (with subsidy) in Massachusetts.[86] In addition, a $4,000 per kW subsidy would be sufficient to push the residential breakeven cost of solar PV above $7,000 per kW, bringing residential solar to within the margins of competitiveness.[87]

A subsidy program of the kind described here, if fully utilized, would result in the generation of about 21 GWh of power from new solar installations in Massachusetts by 2010 and 84 GWh by 2020 in Massachusetts. A comparable program across the region would generate 47 GWh by 2010 and 189 GWh by 2020. Even with this ramp-up of solar power, less than one percent of New England's electricity would come from solar PV by 2020. And the new solar PV systems would not even begin to tap New England's potential for solar PV development, with the equivalent of only about 40,000 New England homes bearing rooftop solar PV systems by 2020.[88]

These goals for solar development are conservative when compared to efforts in some other states and regions. New Jersey, for example, has adopted a statewide goal of generating 120 GWh of power per year from solar PV by 2008.[89]

While a solar program such as the one envisioned here would have only a limited short- and medium-term impact on carbon dioxide emissions in New England, the long-term impact is potentially great. The increased installation of solar PV systems would improve the economics of solar power and begin to change the perception of solar systems from exotic curiosities to a day-to-day feature of life in many communities. With a long-term commitment to fund solar installations in Massachusetts and throughout New England, manufacturers of PV systems would have a strong incentive to increase their production capacity, reducing costs. The state and region would then be poised for a dramatic increase in solar installations in the 2020-2050 period; precisely the time when the region will be needing to make deep reductions in its global warming emissions in keeping with the New England governors' long-term goal.

Solar PV is not the only technology that can be supported through revenue from the renewable energy SBC. SBC revenue can also be used to support research and development of new renewable technologies and to hasten their deployment in the marketplace. As a result, this evaluation of solar merely scratches the surface on the potential benefits of the renewables SBC.

Strategy #12: Finalize Power Plant Emission Standards for Carbon Dioxide as a Foundation for a Regional, Electric-Sector Carbon Cap

Potential Savings: Included as high end of range of estimates above.

Massachusetts was the first state in the U.S. to limit carbon dioxide emissions from power plants. While the rules that will implement the limits have not yet been finalized, a group of 10 northeastern states has launched discussions aimed toward establishing a regional cap on electric-sector carbon dioxide emissions. The initiative, known as the Regional Greenhouse Gas Initiative (RGGI), parallels similar efforts in both Massachusetts and New Hampshire as well as discussions of similar limits at the federal level.

The Massachusetts and RGGI processes provide an opportunity to build upon recent state proposals to limit global warming emissions and shift from widespread reliance on polluting, carbon-intensive coal- and petroleum-fired generation and dangerous nuclear power to the increasing use of renewable power, energy efficiency, and other low- or zero-carbon forms of generation to meet the region's electricity needs.

However, the promise of these efforts could easily be lost if the level of the cap does not drive significant emission reductions. It could also lose public support if the program makes the dangerous tradeoff of allowing nuclear power to get credit, subsidies or broad market advantage as a source of "clean" power. Among the important issues developers of carbon caps must grapple with are the following:

- **Cap Levels** – The program must establish a target for the level of carbon dioxide that can be emitted. An aggressive (i.e. low) cap is achievable and can drive large reductions in emissions.

  Opportunities for reducing emissions from the electric sector are numerous, including the promotion of energy efficiency in homes, businesses and industry; the retirement of old, inefficient fossil fuel-fired power plants; and the expansion of renewable and clean distributed generation.

  These initiatives are potentially mutually reinforcing. Reducing growth in electricity consumption reduces the amount of new generating capacity that must be built to satisfy demand. Renewable and distributed generation further reduces demand for fossil and nuclear generation. Together, these changes reduce the necessity to maintain existing, inefficient sources of generation and allow their expedited replacement with more efficient sources.

  The Massachusetts carbon cap limitations are already established for a set of older power plants, but the potential targets under the RGGI process will be the focus of intense discussion. The New England Climate Coalition recommends an overall goal of reducing carbon dioxide emissions from electricity generation by 40 percent below current levels. The adoption of aggressive efficiency and renewables programs by all six New England states would bring this goal within reach by 2020, with reductions of as much as 30 percent below current levels possible if energy efficiency improvements and new renewables are used to reduce generation of electricity from the highest carbon-emitting sources. (See box below.)

- **Nuclear Power and Offsets** – A carbon cap-and-trade program should not be allowed to become a backdoor subsidy for nuclear power.

  For environmental and public safety reasons, Massachusetts and the New England states should be moving toward a phase-out of nuclear generating capacity, beginning particularly with the retirement of existing nuclear reactors upon the expiration of their current operating licenses. Nuclear plants were not designed to operate for longer than their current licenses. The expansion or maintenance of nuclear generating capacity in New England or elsewhere should not be permitted to qualify as an offset under any cap-and-trade program.

  The use of offsets as a method of compliance with the carbon cap also produces other potential problems. Massachusetts' rule for its electric sector carbon dioxide emission cap requires that any offsets provide "real, surplus, verifiable, permanent and enforceable" emission reductions.[90] Practically speaking, designing offsets that meet these criteria is extraordinarily difficult. Demonstrating that an emission reduction is truly "surplus" requires administrators of a cap-and-trade program to assess what would have happened in the absence of a cap – for example, whether energy efficiency improvements used to generate offsets would have happened anyway. Assessing permanence requires frequent verification that previous emission reductions or sequestration activities remain in effect.

  A sure way to avoid these problems is to draw the boundaries of any trading program very narrowly – including only those sources that emit carbon dioxide, and only those within the region covered by the program (in the case of RGGI, within the 10-state region).

- **Leakage** – In theory, emission reductions that would be generated by a state or regional carbon cap could be offset by increased emissions resulting from power imported into Massachusetts or the Northeast. To prevent this "leakage" of emission reductions, the region must ensure a level playing field between electricity generated in the Northeast and imported electricity, perhaps by setting carbon dioxide emission standards for imported electricity. Another alternative is to expand the cap to cover a broader geographic area, while maintaining strong provisions to ensure that the cap is enforced.

- **Auctioning Credits** – Another point of tension revolves around whether existing electricity generators in the Northeast would be required to buy emission credits at the outset of a carbon cap or be given them for free. The free granting of emission credits to existing generators would act as a *de facto* subsidy to those plants, as well as grant those plants an effective "right to pollute." In addition, the auctioning of emissions credits could produce a source of income that could be returned to all residents, used to support efficiency and renewable power, or used for transition help for displaced workers.

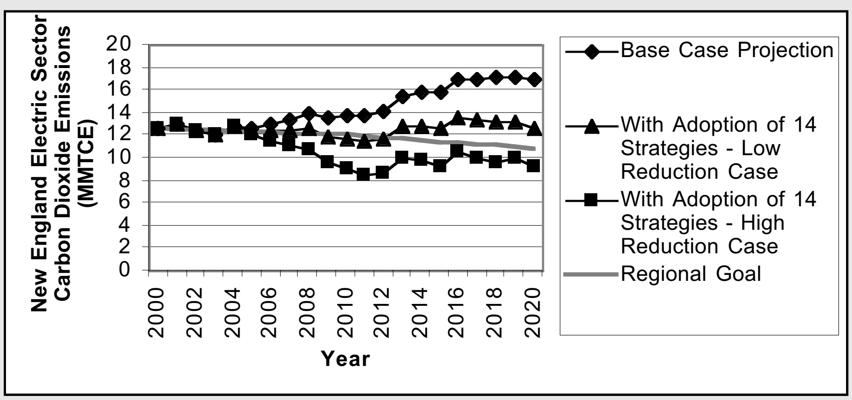
The ongoing RGGI process, while important, should not distract Massachusetts from completing the rulemaking for the state's own carbon dioxide limits. First, the state rule adopted in Massachusetts, if it is strong, could become a positive example for other

The Role of a Regional Carbon Cap in Reducing Electric-Sector Emissions

To demonstrate the feasibility of a strong electric sector carbon cap without nuclear relicensing, estimates were made of current and projected New England electricity use and carbon emissions based on the adoption by all six New England states of the policies described in this report.

Were a carbon cap to be structured so as to use efficiency savings and new renewables from the policy measures in this report to offset generation from coal-fired power plants first, then oil-fired plants, New England could achieve up to a 29 percent reduction in electric sector carbon dioxide emissions by 2020 versus baseline 2001 levels. (See "High Reduction Case" in Fig. 8 below.) By contrast, using those efficiency savings and new renewables to offset natural gas-powered generation (forecast by EIA to make up virtually all of New England's new generating capacity after 2009), would result in 2020 reductions of only 3 percent versus 2001 levels. (See Fig. 8, left.) Both cases assume the retirement of New England's nuclear reactors at the expiration of their current licenses.

Fig. 8. New England Projected Carbon Dioxide Emissions from Electricity Generation (MMTCE)[91]



Decisions regarding the level of a regional carbon cap will invariably take many factors into account beyond achieving the maximum carbon dioxide emission reductions. It is likely that emission reductions from a well-structured cap would fall somewhere within the range of reductions estimated here. However, it is also possible that an aggressive regional effort to promote renewables could enable them to become economically competitive with other forms of generation. Were that scenario to take place, the level of emission reductions possible under a carbon cap would be significantly greater.

northeastern states to look to in the RGGI process. Second, while the commitment of the 10 states to the RGGI process appears sincere, there is no guarantee that an agreement will be reached in a timely manner. Massachusetts, by contrast, will require the achievement of specific reductions of carbon dioxide from the six older power plants covered under the rules by 2008.

Other Electric Sector Strategies to Consider

- Green Power Option – The advent of retail competition in electricity markets was to have brought Massachusetts residents and businesses a variety of choices for supply of electricity – including the choice to purchase power generated from renewable resources. Companies in Massachusetts that serve at least 40 percent of the state's residents offer consumers electricity from renewable sources.[92] The state could require all utilities serving Massachusetts consumers to offer a green power product meeting minimum standards for renewable power generation. The standards should be set so that green power products result in new renewable generation over and above levels set in the state's RPS.

Like the transportation sector, the electric sector is a major source of global warming pollution in New England. Unlike the transportation sector, however, Massachusetts and other New England states have a number of mature, well-developed policy tools available to both improve energy efficiency and facilitate the shift to lower carbon sources of energy in the electricity sector. As a result, the potential for savings in the electric sector is disproportionately large and the state and region should take full advantage of that potential.

Public Sector and Other Strategies

Strategy #13: Public Sector "Lead by Example"

Potential Savings: 0.04-0.05 MMTCE by 2010; 0.06 MMTCE by 2020.

Federal, state, and local governments are significant users of energy in Massachusetts. State government alone consumes about 1.2 percent of the state's electricity, along with large amounts of natural gas, heating oil and motor fuel.[93] But reducing energy use in the government sector not only has a direct impact on global warming emissions; it also sets an example for the private sector as to what can be achieved and creates markets for clean energy products.

The state of Massachusetts has already adopted some policies and practices that improve energy efficiency within state government and thus reduce the government's contribution to global warming. These policies include preferences for the purchase of environmentally preferable products and efficiency measures for some state buildings.[94]

The state of Massachusetts should set a series of aggressive goals for the reduction of carbon dioxide emissions from state government. The state should endeavor to:

1) Reduce energy use in state facilities by 25% by 2010.

The state government can achieve significant energy savings through a series of initiatives including:

Aggressive building retrofit program

The state should seek to retrofit at least half of all state buildings for improved energy efficiency by 2010. A potential model for an expanded building retrofit effort is the Building Energy Conservation Initiative (BECI) in New Hampshire, under which 1.2 million square feet of office space have been retrofitted for efficiency improvements, saving an estimated 26 billion BTU of site energy each year.[95] Efficiency improvements under the program are paid for from the projected savings in energy costs resulting from the project. Only projects that can be demonstrated to be cost-effective can be undertaken through the program.

Adopt Green Building Standards for New State Building Construction

As noted above, buildings certified to the Leadership in Environmental & Energy Design (LEED) standards achieve significant savings in energy use compared to buildings certified to current building codes. The state should set achievement of LEED silver standards as the goal for all new state buildings wherever feasible.

2) Improve the energy efficiency of the state vehicle fleet.

Massachusetts' state government's main fleet consists of thousands of cars and light trucks. The state's highway division owns additional trucks and heavy equipment. Vehicles in all state and local government fleets in Massachusetts consumed 34 million gallons of gasoline in 2001, according to the Federal Highway Administration, representing over 1 percent of total gasoline use in the state.[96]

To improve the energy efficiency of the state fleet, Massachusetts should require the purchase of the most efficient vehicle that will serve the given governmental purpose, within a reasonable cost premium. The fuel economy spectrum in many classes of vehicles is wide – in the light-duty sector, the most fuel-efficient vehicle in each class in 2003 ranged from 13 percent to 140 percent more efficient than the average vehicle.[97] Special efforts should be undertaken to purchase hybrid-electric vehicles, where available.

Second, Massachusetts should restrict the use of sport utility vehicles to those government functions in which four-wheel-drive and off-road capabilities are truly required, as has been proposed by Gov. Romney. Doing so will likely not only reduce energy consumption, but will also save taxpayers money.

Finally, Massachusetts should implement a purchasing strategy for alternative-fuel vehicles that emphasizes technologies that are inherently low-carbon. The federal Energy Policy Act (EPAct) of 1992 requires 75 percent of applicable light-duty vehicles purchased by state governments to operate on alternative fuels. Unfortunately, EPAct includes several perverse incentives and disincentives. For example, flexible-fuel vehicles that can operate on either gasoline or an alternative fuel receive EPAct credit, even if they never operate on the alternative fuel. On the other hand, hybrid-electric vehicles are excluded from EPAct credit, despite their superior efficiency. Massachusetts has traditionally sought to maximize the carbon-reduction potential of the EPAct requirements by purchasing dedicated, low-carbon, alternative-fuel vehicles such as electric and compressed natural gas (CNG) vehicles. The state should maintain this policy and work to expand refueling opportunities for alternative-fuel vehicles. Meanwhile, Massachusetts and other New England states should urge revisions to EPAct that would enhance the program's effectiveness as an emissions reduction tool.

3) Purchase 20 percent of the state's electricity from clean renewable sources by 2010 and 50 percent by 2020.

Enlisting Massachusetts state government as a purchaser of renewable electricity would provide yet another incentive for the development of wind, solar and other forms of renewable power in the state and region. Government purchases of "green power" would be over and above the levels of renewable power required by an enhanced Renewable Portfolio Standard and should include the development of distributed renewable resources on state buildings and land, such as rooftop solar systems, where appropriate.

4) Encourage public sector improvements outside of state government.

Municipal governments in Massachusetts are also major consumers of energy. The state should use its role as a partial funder of school and other local construction projects to drive improvements in energy efficiency for those projects. Similarly, the state should help municipalities to develop market power in the purchase of efficient vehicles and equipment.

Strategy #14: Develop and Implement a Global Warming Emissions Registry

Potential Savings: Not estimated.

A registry system for recording and tracking global warming emissions is a key piece of infrastructure in Massachusetts' efforts to reduce its contribution to global warming. At present, Northeast States for Coordinated Air Use Management (NESCAUM) is developing a registry system for the region that will likely be operable by the end of 2005. Initially, the system will focus on recording emissions from the electric power industry, but it could also be used as a way for entities to voluntarily record their baseline global warming emissions and reductions over time.

Massachusetts has already adopted regulations requiring older coal and oil-fired power plants to report their carbon dioxide emissions. Unlike NESCAUM's voluntary registry, Massachusetts will require power plants to report their emissions. The program's details have not yet been established, but likely will involve independent monitoring of emissions in addition to self-reporting.

The impact of a registry system like NESCAUM's (beyond its role in implementing an electric sector carbon cap) is difficult to determine, particularly in the short run. However, once developed, a registry system could eventually be adapted to promote market-based (trading) and/or regulatory approaches to the reduction of global warming emissions. Eventually, entities responsible for large-scale emissions of global warming emissions should be required to report their emissions to the registry.

The Impact of the Strategies

Short- and Medium-Term Impacts

The 14 strategies listed above would not be enough – on their own – to achieve the regional short- and medium-term global warming gas reduction goals within Massachusetts. But, combined with other positive strategies discussed by the New England governors, other policy options suggested in this report, and action at the federal level in areas in which Massachusetts' freedom of action is limited, they can put the state on a solid footing to achieve its goals.

We estimate that the strategies listed above would reduce Massachusetts' direct (non-electric) emissions of carbon dioxide by 16 percent below projected levels by 2020. Direct emissions would be about 12 percent above 1990 levels in 2010 and 15 percent above 1990 levels in 2020. (See Fig. 9.)

Regionally, the combination of reduced electricity consumption in the residential, commercial and industrial sectors with the increased use of renewable sources of energy would result in a significant reduction in carbon dioxide emissions from the electricity sector. The 14 strategies above would reduce carbon dioxide emissions from power generation in New England by about 2.1-4.8 MMTCE by 2010 and 4.3-7.7 MMTCE by 2020 versus projected levels.

Were all six New England states to adopt all 14 strategies, the region would take significant strides toward achieving the goals of the New England governors' and Eastern Canadian premiers' climate change action plan. Total carbon emissions would be reduced by 18-23 percent versus projected levels by 2020, depending on the final level of any regional carbon cap. With a carbon cap that allowed the displacement of high-carbon generation and the adoption of all 14 strategies in all six states, carbon dioxide emissions in 2010 would be about 7 percent above 1990 levels (compared to the regional goal of attaining 1990 emissions levels by 2010). Emissions in 2020 would be about 9 percent above 1990 levels (compared to

Fig. 9. Projected Non-Electric Carbon Dioxide Emissions in Massachusetts (MMTCE)

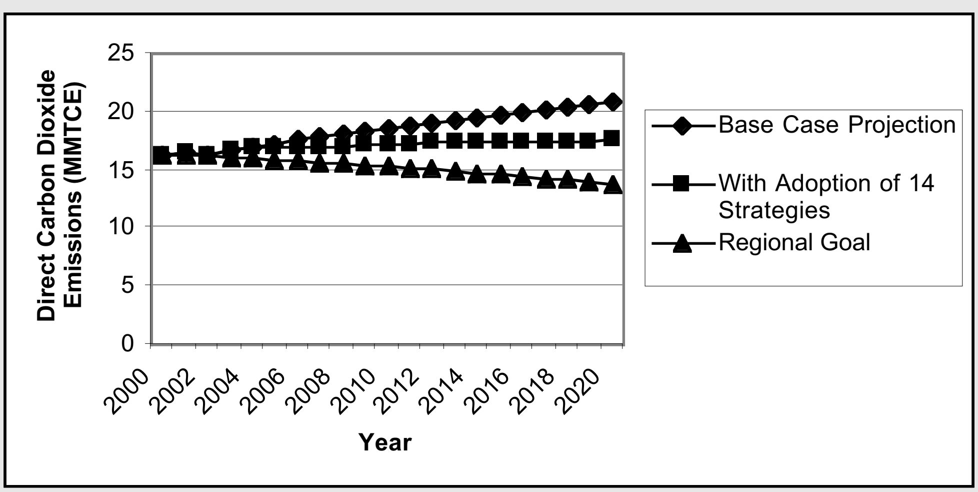
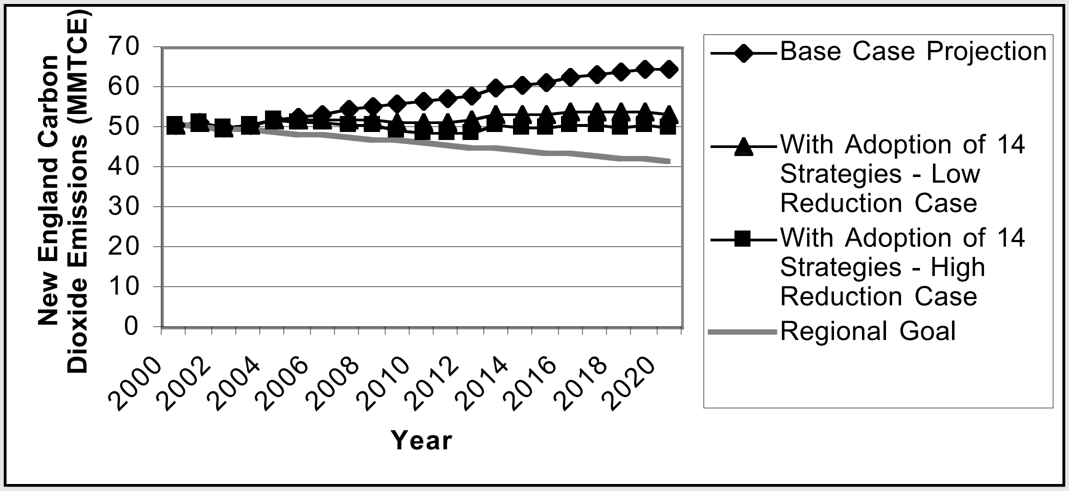


Fig. 10. New England Projected Carbon Dioxide Emissions (MMTCE)



the regional goal of reducing emissions to 10 percent below 1990 levels by 2020).

The adoption of these 14 strategies by all New England states, therefore, would bring the region about 70 percent of the way to meeting the regional short-term carbon dioxide reduction goal and about 60 percent of the way to meeting the medium-term goal. The adoption of additional strategies identified in this report could help in closing the gap.

Putting it in Perspective – Achieving the Long-Term Goal

Ultimately, Massachusetts' efforts to reduce global warming emissions will be judged not by the state's ability to achieve interim goals, but by the speed with which the state can reduce – and eventually eliminate – its contribution to the degradation of the climate. Achieving the long-term reductions in emissions of 75-85 percent that scientists believe will be needed to eliminate any harmful threat to the climate is the true test by which the state's efforts must be assessed, and should remain the overarching goal.

The 14 strategies above not only move Massachusetts far toward achievement of the short- and medium-term goals, but they also begin to lay the groundwork for a deeper transition that will bring the long-term goals within reach. In the transportation sector, swift implementation of a clean cars requirement will ensure the placement of tens of thousands of high-efficiency and zero-emission vehicles on Massachusetts' roads, while focusing the research energy of automakers on the development of the next generation of clean automobile technologies. The Pavley program, if properly designed and implemented, will create the regulatory framework to ensure that all vehicles make the least possible impact on the climate. New buildings and appliances will have energy efficiency built in, while owners of existing buildings and appliances will be able to take advantage of energy efficiency programs to reduce their energy consumption. Wind power and other renewables will produce one-fifth of the electricity Massachusetts uses, while solar panels, fuel cells and other new technologies will be market-ready and prepared to compete with traditional fossil and nuclear electricity.

Even with these advances, Massachusetts will still face difficult challenges. Our communities will have to be reshaped to rely less on individual cars and trucks to transport people and goods. Our economic system will have to reflect more fully the environmental and public health costs of the energy we use, and provide the capital needed to make the transition to cleaner and more efficient ways of living and doing business. Emissions of other global warming gases will have to be reduced dramatically. And other states, regions and nations far from Massachusetts will have to do their share as well.

Affecting these changes will require an unprecedented amount of research, discussion, cooperation and political will – as well as a commitment to achieve the long-term goal within a reasonable time frame; for example, by 2050. The early signs are positive: Massachusetts and the other New England states are now engaged in the discussion and study of global warming, its impacts, and the means of addressing the problem in a way they have never been before. But the critical test – implementation – lies ahead.

The strategies laid out in this report show the way forward. By using existing technologies and reasonable public policy tools, Massachusetts can make large strides toward reducing the state's contribution to global warming in the near term, while in many cases improving public health, economic well-being and energy security, and providing a model of leadership for others to follow.

Table 5. Carbon Dioxide Emission Reductions from Strategies and Additional Reductions Required to Meet Regional Goals (MMTCE)

	1990	2000	2010	2020
MASSACHUSETTS DIRECT CARBON DIOXIDE EMISSIONS				
Historic/*Projected* Emissions	15.35	16.39	*18.55*	*20.91*
Regional Goal			15.35	13.82
Reductions Needed to Achieve Goal			3.20	7.09
Reductions from 14 Strategies			1.35	3.30
Additional Reductions Needed			1.85	3.79
NEW ENGLAND ELECTRIC SECTOR EMISSIONS				
Historic/*Projected* Emissions	12.01	12.56	*13.84*	*17.00*
Regional Goal			12.01	10.81
Reductions Needed to Achieve Goal			1.83	6.19
Reductions from 14 Strategies (High/Low Case)			4.80/2.07	7.69/4.33
Additional Reductions Needed			0/0	0/1.86

Emission-Reduction Strategies in Connecticut and Rhode Island

Stakeholder groups in Connecticut and Rhode Island have recommended emission-reduction policies for their states that achieve, or come close to achieving, the regional global warming emission reduction goals. The stakeholder groups, which represent a broad range of interests from government, business and industry, the nonprofit sector and academia, selected policies that they thought would substantially reduce emissions without creating unreasonable requirements for any sector.

Rhode Island: The combined results of the 49 in-state policy options identified in Rhode Island's Greenhouse Gas Action Plan will allow the state to meet the 2020 emissions-reduction target; further reductions can be achieved through recommended policies that involve regional or national coordination. The strategies include:

- *Implementing a fuel-efficiency feebate program*: Purchasers of low efficiency vehicles would pay a fee, while purchasers of more efficient vehicles would receive a rebate.

- *Improving the efficiency of buildings:* A variety of programs would be created to replace existing equipment in homes and businesses with more energy efficient equipment and to promote the use of efficient combined heat-and-power.

- *Encouraging smart growth*: This would include initiatives to encourage the integration of land-use zoning and transit planning to reduce automobile trips by maximizing walkability, improving bus services, and guiding growth along rail transit routes.

- *Adopting a renewable energy standard*: A minimum percentage of electricity sold in the state would have to come from qualifying renewable resources. The stakeholders estimated the impact of a 20 percent by 2020 target, but did not recommend specifics for the policy, and agreed that further assessment would be needed.

Connecticut: The Connecticut Climate Change Stakeholder Dialogue's 55 policy recommendations come close to achieving the 2020 regional target. The Connecticut plan recommends:

- *Adopting the California clean car standards*: Strict emission standards for all new cars sold beginning in model year 2007 would reduce emissions from the transportation sector.

- *Creating a greenhouse gas feebate program*: Purchasers of high greenhouse gas-emitting vehicles would pay a fee, while purchasers of low emitting vehicles would receive a rebate.

- *Improving efficiency in homes*: This would decrease energy use in houses by requiring buildings to meet the most recent energy codes, expanding the rebates offered under the Energy Star Homes program, and providing funding to double the number of houses served under the federal Weatherization Assistance Program.

- *Adopting a renewable energy strategy*: The state would extend its existing renewable energy standard for electricity generation, require that state government and universities purchase a percentage of their electricity from zero-emission renewables, and offer a tax credit for qualifying renewable energy production.

Methodology and Technical Discussion

General Assumptions and Limitations

This report relies primarily on data and projections from the U.S. Energy Information Administration (EIA) to estimate past, present and future global warming gas emissions in Massachusetts. Future emission trends in Massachusetts are generally based on EIA's projected rates of growth for New England as a whole. Massachusetts trends will differ, but the EIA growth projections provide a reasonable approximation of future trends, particularly given the regional context of Massachusetts' global warming emission reduction efforts.

EIA's projections of future energy use – as published in the *Annual Energy Outlook 2003* (AEO 2003) – are intended to reflect all federal, state and local legislation adopted as of September 1, 2002. Several policy changes adopted after that date will have an impact on carbon dioxide emissions in Massachusetts (including the recent increase in the CAFE standard for light trucks). We have not attempted to revise EIA's assumptions to reflect these changes.

This analysis focuses exclusively on emissions of carbon dioxide from energy use in Massachusetts and New England. The exclusion of other global warming gases from this analysis is not intended to minimize their importance, but is the result of time and resource limitations.

This report also limits its scope of analysis to the six New England states. Several of the policies described here could have effects outside the region that would either create additional carbon dioxide emissions or reduce emissions further than projected here. Because global warming is a global problem, it is important to consider these potential spill-over effects when setting policy, but it is beyond the scope of this report to do so.

All fees, charges and other monetary values are in 2003 dollars and are assumed to be indexed to inflation. In other words, the systems benefit charge assessed on electricity purchases in 2020 is assumed to have the same buying power as a 5-mill charge would have in 2003.

Baseline Emission Estimates

Baseline estimates of carbon dioxide emissions from energy use for 1990 were based on energy consumption data from EIA, *State Energy Data 2000* (SEDR 2000). To calculate carbon dioxide emissions, energy use for each fuel in each sector (in BTU) was multiplied by carbon coefficients for 1990 as specified in EIA, *Emissions of Greenhouse Gases in the United States 2001*, Appendix B.

Significant changes in EIA's methodology for collecting and presenting data render some information in *SEDR 2000* unreliable for estimating 2000 carbon dioxide emissions, and require adjustments in the 1990 data. Specifically, EIA has changed the sources of some of its energy use data and reallocated energy use and emissions from non-utility producers of power from the industrial to the electric sector.

There were several possible methods for obtaining state-specific energy use data for fuels and sectors in which *SEDR 2000* data are inaccurate. Our approach was to seek out the most recent available data from EIA's fuel-specific reports or to follow EIA-specified methodologies for adjusting data presented in *SEDR 2000*.

The 1990 figures for natural gas usage in each sector were adjusted upward by 2.3 percent, corresponding with the upward revision in national natural gas use figures as reported in EIA, *Emissions of Greenhouse Gases in the United States*, 2001. The allocation of coal use and emissions between the industrial and electric sectors was adjusted as described for 2000 data below.

The following sources and methods were used by fuel:

- **Coal** – For both 1990 and 2000, coal use and emissions were reallocated between the industrial and electric sectors based on the following method, adapted from EIA, *Emissions of Greenhouse Gases in the United States 2000,* Appendix A:
  1) Total coal use for all sectors in BTU was obtained from *SEDR 2000*.
  2) Residential and commercial coal use in BTU was subtracted from the total, leaving total industrial and electric sector consumption.

3) Electric utility consumption was estimated by multiplying utility consumption of coal in short tons from EIA, *Electric Power Annual 2001, Consumption by State* by the appropriate heat rate for Massachusetts, obtained from EIA, *SEDR 2000*, Appendix B.
4) Consumption by non-utility power producers was estimated by multiplying the remaining coal consumption from the electric power sector (from *Electric Power Annual 2001*) by the appropriate heat rate.
5) Estimated consumption by utility and non-utility power producers was summed to arrive at total electric energy use from coal. This figure was then subtracted from the electric-plus-industrial consumption estimate to arrive at estimated consumption in the industrial sector.

- **Natural Gas** – Sector-specific natural gas consumption data for Massachusetts in million cubic feet were obtained from EIA, *Massachusetts Natural Gas Consumption by End Use*, downloaded from tonto.eia.doe.gov/dnav/ng/ng_cons_sum_sma_m_d.htm, updated 21 August 2003. Consumption data were converted to BTU values using thermal conversion factors from *SEDR 2000*.

- **Petroleum** – Data for consumption of distillate and residual fuel by sector was obtained from EIA, *Fuel Oil and Kerosene Sales 2001*, and then converted to BTU values using heat rates from *AEO 2003*, except for the use of petroleum in the electric power sector, which was obtained from EIA, *Electric Power Annual 2001* spreadsheets, Consumption by State. Estimated use of other petroleum products was based on *SEDR 2000*.

Several additional assumptions were made:

- Carbon dioxide emissions due to electricity imported into New England were not included in the emissions estimates, nor were "upstream" emissions resulting from the production or distribution of fossil or nuclear fuels.

- Combustion of wood and other biomass was excluded from the analysis per EIA, *Emissions of Greenhouse Gases in the United States 2001*, Appendix D. This exclusion is justified by EIA on the grounds that wood and other biofuels obtain carbon through atmospheric uptake and that their combustion does not cause a net increase or decrease in the overall carbon "budget."

- Electricity generated from nuclear and hydroelectric sources was assumed to have a carbon coefficient of zero.

- Carbon emissions from the non-combustion use of fossil fuels in the industrial and transportation sectors were derived from estimates of the non-fuel portion of fossil energy use and the carbon storage factors for non-fuel use presented in U.S. EPA, *Comparison of EPA State Inventory Summaries and State-Authored Inventories*, downloaded from yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/JSIN5DTQKG/$File/pdfB-comparison1.pdf, 31 July 2003. To preserve the simplicity of analysis and to attain consistency with future-year estimates, industrial consumption of asphalt and road oil, kerosene, lubricants and other petroleum, and transportation consumption of aviation gasoline and lubricants were classified as "other petroleum" and assigned a carbon coefficient of 20 MMTCE per quad BTU for that portion that is consumed as fuel.

Known Discrepancies with Other Published Estimates

Due to variations in methodology, the adjustment of energy use figures over time, and inherent disagreement in the data presented in various EIA reports, the emissions estimates for 2000 presented here differ somewhat from regional emission estimates derived from *AEO 2003*.

Because the estimates for this report were compiled using a common methodology applied to all six New England states, it is also possible to compare the regional total emissions estimate with estimates derived from *AEO 2003* and presented in the New England Climate Coalition's 2003 report, *Global Warming in New England*. Estimated 2000 carbon dioxide emissions for the region based on the sources and methodology in this report are about 3 percent lower than estimated emissions based on *AEO 2003*'s regional energy use figures – assuming the continued operation of the region's nuclear power plants in both cases. Specifically, the methodology of this report appears to significantly underestimate emissions from petroleum use in the commercial sector and natural gas use in the industrial sector and to overestimate emissions from natural gas use in the commercial sector when compared to estimates based on *AEO 2003*. These discrepancies are likely due to the use of varying EIA reports for fuel use estimates. The expected publication of an updated version of *SEDR* in 2004 should clear up these discrepancies and we encourage a revisiting of the data at that time.

Future Year Projections

Projections of energy use and carbon dioxide emissions for Massachusetts are based on applying the New England year-to-year projected growth rates for each fuel in each sector from *AEO 2003* to the Massachusetts baseline emissions estimate for 2000, with two exceptions.

1) In the transportation sector, EIA's estimates of vehicle travel increases are significantly higher than projections produced by the Massachusetts Highway Department and recent experience in the state. Instead of using EIA's projected growth rates for motor gasoline use, we used a growth rate of 1.4 percent per year, commensurate with MassHighway's projections of vehicle miles traveled increases for 2002 to 2020, supplied by the department in February 2003. This assumes no improvement or deterioration in light-duty vehicle fuel economy in the aggregate between now and 2020. While it is likely that EIA's methodology also overstates emissions for diesel fuel use, we used the EIA assumptions because of the difficulty of disaggregating vehicular diesel fuel use from use by other transportation modes.

2) Unlike EIA, we assume that nuclear reactors in New England are retired at the expiration of their current operating licenses. Thus, the base case estimate for power-sector energy use in Massachusetts was adjusted by eliminating any nuclear generation from the power-sector energy mix beyond 2012 and replacing it with gas-fired generation. The level of electric-sector natural gas consumption needed to replace nuclear generation was estimated by multiplying the amount of nuclear energy consumption based on *AEO 2003* by the ratio of the calculated heat rate for natural gas generation divided by the imputed heat rate for nuclear generation, based on data from Supplementary Table 66 of *AEO 2003*. Heat rates were calculated by dividing energy consumption for each fuel by net generation for each fuel. This method will tend to slightly overstate energy use – and therefore emissions – from natural gas, since it is likely that new natural gas-fired generation will be more efficient than the average efficiency of all natural gas plants in the region for any given year.

Carbon Dioxide Reductions from Electricity Savings and Renewables

Carbon dioxide reductions for measures that reduce electricity use or expand renewable resources were generally estimated based on the impact of the reductions on the entire New England grid. For individual strategies, a range of savings was projected based on two sets of assumptions:

- **Low savings estimate** – Based on the use of efficiency savings and renewables to first offset power lost through the closure of in-state nuclear plants whose licenses have expired, then to offset natural gas generation on the New England grid, which is projected by EIA in *AEO 2003* to account for virtually all of New England's new electric generating capacity beyond 2009. The formulas used to calculate these reductions are similar to those described above for the replacement of nuclear power in the base case, with differences in heat rates among the fuels used to estimate the amount of generating capacity that would be displaced. This case is intended to replicate a scenario in which efficiency and renewable savings are used to avoid the need to construct new generating capacity, rather than retire less-efficient old generators.

- **High savings estimate** – Based on the use of efficiency savings and renewables to first offset power lost through the closure of in-state nuclear plants whose licenses have expired, then to offset generation on the New England grid with the highest carbon dioxide emissions, first coal, then petroleum. The assumed offset of coal-fired generation may not yield the maximum carbon reductions possible under a regional carbon cap, since some oil-fired generating units in New England produce greater carbon dioxide emissions per unit of delivered electricity than coal-fired plants. The examination of power plant-by-power plant data was, however, beyond the scope of this report. As a result, the simplifying assumption to reduce coal-fired generation likely produces a conservative estimate of the maximum potential benefits of an electric-sector carbon cap.

The two estimates suggest the potential impact of an electric-sector carbon cap, with greater savings arising from a strong cap that creates pressure to retire old generation (the high savings estimate) and lesser savings arising from a weak cap or the absence of a cap (the low savings estimate). In reality, it is likely that both the high and low estimates are somewhat extreme – that is, that some old coal-fired generation would be retired in the absence of a cap and that some small amount may remain even with a cap.

In addition, all electricity-related estimates assume that New England produces all the power it consumes and is neither a net importer nor a net exporter of electricity. The potential for "leakage" of emission reductions – in which public policies result in increased importation of high-emission electricity from elsewhere, thus leading to greater emissions in the aggregate – is an important issue for policy-makers to address, but was beyond the scope of this report to incorporate.

Transportation Sector Strategies

All estimated reductions from transportation-sector strategies were derived by estimating the percentage reductions in light-duty vehicle motor gasoline use from the baseline arrived at by the methods above. Light-duty vehicle gasoline use was estimated by multiplying the motor gasoline baseline by the percentage of motor gasoline used by light-duty vehicles, derived from the supplementary tables to *AEO 2003*.

Percentage reductions were calculated by multiplying grams/mile emission factors for carbon dioxide, based on a modified version of the Argonne National Laboratory's GREET model, version 1.5a, by the projected percentages of VMT driven by vehicles of various classes, types and ages, estimated as described below. Estimates for light-duty carbon dioxide emissions were based on the following sources:

- **Vehicle-miles traveled (VMT) percentages** – VMT percentages by vehicle class were derived by dividing projected national light-duty VMT for each year by the projected national light-duty vehicle stock as reported in supplementary tables to *AEO 2003*. This average VMT/vehicle/year figure was then adjusted to reflect the slightly higher VMT/vehicle/year of passenger cars versus light trucks (based on a two-year average of VMT/vehicle derived from FHWA data) and multiplied by the projected nationwide passenger car and truck stocks in *AEO 2003*. Light-duty truck VMT was further divided into heavy and light categories by multiplying the total truck VMT by vehicle stock percentages contained in EPA, *Fleet Characterization Data for MOBILE6*, September 2001. The projected VMT for each vehicle class was then divided by the total light-duty VMT to arrive at the percentage of total VMT traveled by vehicles in each class in each year.

  VMT were further disaggregated into VMT by model year and vehicle class for each year between 2001 and 2020, based on estimates of VMT accumulation rates presented in EPA, *Fleet Characterization Data for MOBILE6*. No attempt was made to customize the national VMT percentages for Massachusetts.

- **Carbon dioxide emission factors** – Grams-per-mile emission factors for each model year and class were based on modifications to the GREET model, version 1.5a. For conventional gasoline vehicles, the only modification to the model was the substitution of "real-world" fleet average miles per gallon (MPG) estimates for each model year from 1970 to 2020. For 1975 through 1999, real-world MPG was calculated by multiplying EPA-rated MPG for cars and light trucks (as reported in EPA, *Light Duty Automotive Technology and Fuel Economy Trends, 1975 Through 2003*, April 2003) by an adjustment factor of 0.8. For model years prior to 1975, 1975 figures were used. For 2000-2020, new car and truck on-road miles per gallon was based on Supplementary Table 49 to *AEO 2003*.

  Real-world MPG projections were then input into the GREET model, producing grams-per-mile carbon dioxide emission factors for vehicle operations.

Carbon dioxide emissions stemming from feedstock and fuels were not included in this analysis. The resulting emission factors for vehicles greater than three years old were then divided by 0.97 to account for the loss of fuel economy resulting from the replacement of low-rolling resistance tires with less-efficient replacement tires.

For vehicles covered by the Zero Emission Vehicle program, vehicles sold to meet the program's obligation for Advanced Technology Partial Zero-Emission Vehicle (AT-PZEV) credits were assumed to be hybrids, producing the same per-mile emissions as default hybrid vehicles in the GREET model, and vehicles sold to meet the obligation for pure Zero Emission Vehicle (ZEV) credits were assumed to be GREET model-default hydrogen fuel-cell vehicles. Because hydrogen fuel-cell vehicles emit no pollutants in vehicle operation, lifecycle carbon dioxide emissions were used. This assumption may result in a higher estimate for in-state carbon dioxide emissions from fuel-cell vehicles because it is unclear whether the conversion from natural gas to hydrogen would take place locally (thus resulting in carbon dioxide emissions) or at an out-of-state location.

Zero-Emission Vehicle Program

Percentages of conventional, AT-PZEV and ZEV vehicles that would be sold in Massachusetts under the ZEV program were derived from projections of vehicle sales in California under the ZEV program in Chuck Shulock, California Air Resources Board, *The California ZEV Program: Implementation Status*, presented at EVS-20, the 20th International Electric Vehicle Symposium and Exposition, November 2003. ZEV program implementation was assumed to begin in 2007. The sale of pure ZEVs was assumed to not be required until 2012 per recent proposed changes in the California ZEV rule. Estimates of California sales may not translate accurately to Massachusetts due to automakers' accumulation of banked credits that can be used to reduce ZEV program obligations in the early years of the program in California.

To adjust for the presumed inclusion of earlier ZEV program requirements in *AEO 2003* projections, savings from the ZEV program were reduced by the estimated reductions of the previous (2001) version of the ZEV program, with estimated ZEV sales percentages derived from a spreadsheet supplied by CARB based on the 2001 ZEV amendments, with all pure ZEVs under the old scenario presumed to be full-function battery-electric vehicles.

California Vehicle Carbon Dioxide Limits

Emission factors for conventional vehicles (i.e. those not used to obtain ZEV or AT-PZEV credits) under this scenario were assumed to be reduced by 30 percent between 2009 and 2019, with reductions taking place in a linear fashion over that time period. Because California has not yet proposed regulations for implementing tailpipe carbon dioxide limits, it is impossible to know whether ultimate reductions will be greater or less than the 30 percent estimated here and the estimated program benefits should be interpreted with caution.

Low Rolling Resistance Tires

Savings from the use of low rolling resistance replacement tires were estimated by reducing carbon dioxide emission factors by 3 percent from baseline assumptions for vehicles reaching four, seven and 11 years of age beginning in 2005, per California Energy Commission, *California Fuel-Efficient Tire Report, Volume II*, January 2003. This estimate assumes that the tire stock will completely turn over; that is, that LRR tires will supplant non-LRR replacement tires in the marketplace through a state requirement. Other policies to encourage, but not mandate, LRR tires will likely produce reduced savings.

Feebate

Potential savings from a feebate program are based on estimated fuel economy improvements from a California state feebate program in *Reducing California's Petroleum Dependence* (California Energy Commission and California Air Resources Board, Final Staff Report, August 2003, Appendix C, Attachment B, B-251). Improvements in fuel economy translate to a 4.2 percent reduction in carbon dioxide emissions per mile for new cars by 2010 and an 8.2 percent reduction by 2020. For light trucks, estimated reductions in carbon dioxide emission rates are 5 percent by 2010 and 8.4 percent by 2020. Improvements in fuel economy are assumed to take place linearly beginning in 2005. The impact of a feebate program in Massachusetts could be greater or less than the California program studied depending on the scope of the program and its design.

Pay-As-You-Drive Automobile Insurance

Estimates of the impact of PAYD insurance are based on the assumption that 80 percent of collision and liability insurance payments in Massachusetts would be transferred to a mileage-based system, with participation in the system increasing by 10 percent per year from 2005 to 2010, and 50 percent of all light-duty drivers participating in the system from 2010 to 2020. The average per-mile cost of insurance was computed by multiplying the average expenditure on collision and liability insurance in Massachusetts in 2001 as reported in *Facts and Statistics: The Rising Cost of Auto Insurance* (Insurance Information Institute, downloaded from www.iii.org/media/facts/statsbyissue/auto/content.print/, 29 October 2003) by the number of light-duty vehicle registrations in Massachusetts from FHWA, *Highway Statistics 2001*. This total expenditure figure was then divided by light-duty VMT derived from adjusted FHWA figures to arrive at an average per-mile cost for liability and collision insurance. This per-mile cost was then multiplied by 0.8 to account for any non-mileage related aspects of liability and collision coverage and to ensure the conservatism of the estimate, yielding an average per-mile charge of 7.8 cents. The estimated reduction in VMT that would result from such a charge was obtained from *Online TDM Encyclopedia: Pay-As-You-Drive Vehicle Insurance* (Victoria Transport Policy Institute, downloaded from www.vtpi.org/tdm/tdm79.htm, 3 December 2003). It was assumed that the decrease in VMT (11.2 percent) for drivers participating in the program would take place beginning immediately upon program implementation in 2005.

VMT Stabilization

VMT increases in this scenario are estimated to reflect Massachusetts' projected rate of population growth between 2006 and 2020 per *Projections of the Total Population of States: 1995 to 2025*, (U.S. Census Bureau, downloaded from www.census.gov/population/projections/state/stpjpop.txt, 12 December 2003).

Combination of Transportation Strategies

Combined emission reduction estimates from the transportation strategies were derived by multiplying the percentage of emissions remaining from each of the strategies by the percentage remaining from the other strategies. The impact of a feebate program is not included in the combined policy case because it is difficult to ascertain how such a program would interact with carbon dioxide tailpipe standards.

Other Transportation Assumptions

- We assume a "rebound effect" of 20 percent on all measures that improve fuel economy or reduce per-mile carbon dioxide emissions. The rebound effect occurs when reduced per-mile costs of driving (such as would result from purchasing a vehicle with better fuel economy) encourage drivers to increase their VMT.

- We assume no mix shifting effects from any of the above policies. In other words, we assume that the strategies would not encourage individuals who would have purchased a car to purchase a light truck, or vice versa. It is likely that at least some mix shifting would occur as a result of some of the policy strategies (for example, high feebate charges encouraging individuals to shift from light trucks to cars), but we believe that the policies could be appropriately designed to ensure that any mix-shifting effects would serve to further reduce (rather than increase) carbon dioxide emissions.

Residential, Commercial and Industrial Strategies

Building Energy Codes

The projected impact of residential energy codes was derived by estimating the percentage of residential energy use that would take place in new homes under EIA projections and applying estimated percentage reductions in energy use that would take place under updated codes. Revised codes were not assumed to affect energy use in existing homes.

The proportion of projected residential energy use from new homes was derived by subtracting estimated energy use from homes in existence prior to 2004 from total residential energy use for each year based on *AEO 2003* growth rates. Consumption of energy by surviving pre-code homes was calculated by assuming that energy consumption per home remains stable over the study period and that 0.4 percent of homes are retired each year, per EIA, *Assumptions to AEO 2003*.

Energy savings from updating Massachusetts's residential building code to 2000 IECC standards are assumed to be 15 percent below projected levels for 2004-2010, based on Steven Nadel and Howard Geller, American Council for an Energy-Efficient Economy (ACEEE), *State Energy Policies: Saving Money and Reducing Pollutant Emissions Through Greater Energy Efficiency,* September 2001. Energy savings from future updates to residential building codes were assumed to be 32 percent below current projections for 2011-2020, also based on ACEEE. Energy savings from residential building energy codes were assumed to take place equally among the various fuels.

For commercial building codes, New England-specific commercial building retirement percentages were estimated by determining the approximate median age of commercial floorspace in New England based on data from EIA, *1999 Commercial Building Energy Consumption Survey* (CBECS), estimating a weighted-average "gamma" factor (which approximates the degree to which buildings are likely to retire at the median age), and inputting the results into the equation, *Surviving Proportion=1/(1+(Building Age/Median Lifetime)*^{Gamma} as described in EIA, *Model Documentation Report: Commercial Sector Demand Module of the National Energy Modeling System*, March 2003. Baseline 2003 commercial energy demand was then multiplied by the percentage of surviving pre-code commercial buildings to estimate the energy use from buildings not covered by the code. For buildings covered by the code, all savings between 2005 and 2010 were assumed to be reflected in the baseline energy use estimate derived from EIA projections. The adoption of future upgrades to commercial energy codes was estimated to result in a 20 percent reduction in the use of all fuels in new construction from 2011 to 2020 per Nadel and Geller (ACEEE), *State Energy Policies.* No attempt was made to estimate the impact of commercial code revisions on energy use due to renovations of existing commercial space.

Appliance Efficiency Standards

Estimates of potential energy savings from appliance efficiency standards were based on Ned Raynolds and Andrew Delaski, Northeast Energy Efficiency Partnerships, *Energy Efficiency Standards: A Low-Cost, High Leverage Policy for Northeast States*, Summer 2002. Savings were assumed to begin in the adoption year specified in the NEEP report, with savings increasing in a linear fashion until 2020. We assume that standards for all the products listed in the NEEP report are adopted as described, including those subject to federal preemption. Finally, we assume that additional future efficiency standards would yield savings equivalent to 20 percent of the annual savings resulting from the above standards beginning in 2012.

Systems Benefit Charges for Efficiency

Projections of benefits from a 5-mill electric SBC for efficiency were computed based on the average kilowatt-hour/dollar savings rates from five New England SBC-supported programs for the most recent period for which data were available.[98] (Maine was excluded due to a recent transition in the program from utility to state management.) Additional revenues generated by the increased SBC were determined by subtracting the projected revenue from existing SBC programs from projected revenue from a 5-mill efficiency SBC, then multiplying the increased fee by projected electricity use in Massachusetts. These revenues were then multiplied by the average kWh/$ savings rate, with the savings reduced by 33 percent to reflect the likely higher marginal cost of additional kWh savings due to the reduced availability of "low-hanging fruit" as a result of the original SBC programs. This produced an estimate of annual electricity savings as a result of efficiency programs due to the increased SBC. Future year savings from efficiency measures were assumed to be 90 percent of annual savings in the first through fourth years after implementation of the measures, 80 percent in years five through nine, 60 percent in years 10-14 and 50 percent afterward. These estimates are arbitrary, but yield maximum "lifetime" savings of about 12 times annual savings by the end of the study period, a rate lower than most estimates of lifetime savings from efficiency programs. Carbon dioxide savings were then calculated as described in "Carbon Dioxide Reductions from Electricity Savings and Renewables" above.

Savings resulting from the implementation of an oil/gas SBC-type program were estimated based on projected BTU-per-dollar savings rates of a Vermont gas conservation program, as documented in Center for Clean Air Policy, *Connecticut Climate Change Stakeholder Dialogue: Recommendations to the Governor's Steering Committee*, January 2004. This savings rate was then reduced by 25 percent to ensure the conservatism of the estimate. The rate of the charge was set at 3.5 cents per 100,000 BTU for natural gas and distillate and residual oil used in the residential, commercial and industrial sectors, with the total BTU savings estimated in a manner similar to savings from the 5-mill electric SBC. Carbon dioxide reductions were then estimated by allocating the total BTU savings from the charge proportionally among the three fuel types and then multiplying the result by the appropriate carbon coefficients.

Combined Policy Case

The combined residential, commercial and industrial sector savings exclude savings resulting from appliance efficiency standards that may also be covered by enhanced building energy codes.

Electric Sector Strategies

Renewable Portfolio Standard

The impact of an RPS of 10 percent new renewables by 2010 and 20 percent new renewables by 2020 was estimated by multiplying projected electricity demand in Massachusetts by the percentage of the proposed RPS, which was assumed to be 2 percent of overall electric demand in 2005, with the percentage increasing by 2 percent each year until 2010 and 1 percent per year between 2010 and 2020. New renewable generation resulting from the existing Massachusetts RPS was estimated separately and subtracted from the total under the assumption that it is already factored into EIA's baseline energy projections. The current Massachusetts RPS was assumed to remain in force through 2020.

Solar Program

Funding for the solar program was estimated based on the amount of money that would be generated by a 0.15-mill earmark for solar programs in a renewables SBC. This funding estimate was derived in a similar manner as the estimated revenues from the SBC programs above, taking into account energy savings from other efficiency strategies in this report and assuming that the renewables SBC is applied only to electricity. The amount of new solar capacity that would be created with that funding was estimated by assuming the rate of subsidy needed to spark installation of solar PV systems. This figure was estimated at $4,000/kW for 2005-2010, $3,000/kW for 2011-2015, and $2,000/kW for 2016-2020. The initial $4,000/kW figure is based on the amount that would be required to increase the breakeven turnkey cost of residential solar to greater than $7,000/kW, per Christy Herig, Richard Perez, Susan Gouchoe, Rusty Haynes, Tom Hoff, *Customer-Sited Photovoltaics: State Market Analysis*, 2002. Figures for later years are conservative estimates based on the anticipated drop in prices for solar PV systems as estimated in U.S. Department of Energy and Electric Power Research Institute, *Renewable Energy Technology Characterizations*, 1997, 4-5, and other sources. Electricity output from this new installed capacity was estimated based on operation at average 18 percent efficiency. All new solar capacity was assumed to be distributed, with no line losses. One-half of the new solar electricity was assumed to count toward fulfillment of RPS requirements, the other half surplus to offset fossil fuel-fired generation. This split is arbitrary, but would allow for the retirement of green tags for the new renewable capacity by individuals and institutions who choose not to redeem them or to account for green power purchasing programs.

State Government Lead-By-Example

Emissions savings from state government are based on three categories of action. In each case, we assumed that government does not grow, an approach that makes our savings estimates conservative.

Data on current state energy use was provided by Eric Friedman, Office of State Sustainability. To calculate the emissions savings from reducing energy use in state facilities by 25 percent by 2020, we multiplied the energy savings for each fuel by its carbon coefficient.

Savings from improving the efficiency of the state's vehicle fleet come from both gas and diesel savings. Data for state government transportation fuel use were not available; thus we relied on the Federal Highway Administration's figures for gas use by non-federal governments—meaning our data represents fuel consumption by state, county, and local governments. Total statewide diesel use figures are from the same source. We estimated non-federal public sector diesel use by assuming that government diesel use is the same portion of total diesel use as government gas use is of total gas use. Projected efficiency improvements assume that non-federal government vehicle fleets achieve 20 percent more gallons per mile by 2012 and 28.5 percent more gallons per mile by 2020. We assumed that there would be no rebound effect of increased miles driven. Carbon savings were calculated by multiplying the energy savings for each fuel by its carbon coefficient.

Carbon savings from having state government purchase 20 percent of its electricity from renewable sources by 2010 again relied on data provided by Eric Friedman, Office of State Sustainability. The calculations assume that the state already reduces its energy use by 25 percent.

Notes

1. Working Group I, Intergovernmental Panel on Climate Change, *IPCC Third Assessment Report – Climate Change 2001: Summary for Policy Makers*, *The Scientific Basis,* 2001.

2. Ibid.

3. Ibid.

4. Ibid.

5. Based on 1990 figures from U.S. Environmental Protection Agency, *State GHG Inventories*, downloaded from yosemite.epa.gov/OAR/globalwarming.nsf/content/EmissionsStateGHGInventories.html, 7 July 2003.

6. U.S. Environmental Protection Agency, *Global Warming-State Impacts: Massachusetts*, Office of Policy, Planning, and Evaluation, September 1997.

7. New England Regional Assessment Group, U.S. Global Change Research Program*, Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. Foundation Report*, September 2001.

8. See note 6.

9. See note 7.

10. See note 1.

11. Ibid.

12. Ibid.

13. Ibid.

14. Ibid.

15. See note 6.

16. See note 7.

17. Ibid.

18. See note 6.

19. Impacts from U.S. Environmental Protection Agency, *Global Warming-State Impacts: Massachusetts*, Office of Policy, Planning, and Evaluation, September 1997; New England Regional Assessment Group, U.S. Global Change Research Program*, Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. Foundation Report*, September 2001.

20. Based on 1990 fuel use data from U.S. Energy Information Administration, *State Energy Data 2000*, 151-156 and 2000 fuel use data from *State Energy Data 2000* and other EIA reports. See "Methodology and Technical Discussion" for more information on sources and methods for calculating carbon dioxide emissions from the fuel use data.

21. Historic emissions based on 1990 fuel use data from U.S. Energy Information Administration, *State Energy Data 2000*, 151-156 and 2000 fuel use data from *State Energy Data 2000* and other EIA reports. Projected emissions based on 2000 fuel use data multiplied by year-to-year projected increases for New England from U.S. Energy Information Administration, *Annual Energy Outlook 2003*, 9 January 2003.

22. Estimated rate of increase in fuel use based on year-to-year increases for New England from U.S. Energy Informa-

tion Administration, *Annual Energy Outlook 2003*, 9 January 2003.

23. Based on 1990 fuel use data from U.S. Energy Information Administration, *State Energy Data 2000*, 151-156 and 2000 fuel use data from *State Energy Data 2000* and other EIA reports. See "Methodology and Technical Discussion" for more information on sources and methods for calculating carbon dioxide emissions from the fuel use data.

24. 14 percent increase in consumption in Massachusetts based on increase in sales of electric power from 1990 to 2000 from U.S. Energy Information Administration, *Electric Power Annual 2001 spreadsheets,* 1990 - 2001 Retail Sales of Electricity by State by Sector by Provider, March 2003.

25. Based on 2000 fuel use data from U.S. Energy Information Administration *State Energy Data 2000* and other EIA reports and year-to-year projected rates of increase in energy consumption from EIA, *Annual Energy Outlook 2003*, 9 January 2003.

26. See note 7.

27. Swiss Agency for Development and Cooperation, *Chernobyl.info*, downloaded 20 January 2004.

28. Union of Concerned Scientists, *Nuclear Reactor Security*, downloaded from www.ucsusa.org/clean_energy/nuclear_safety/page.cfm?pageID=176, 24 July 2003.

29. U.S. General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened*, September 2003.

30. Robert Alvarez, Jan Beyea, et al, "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States," *Science and Global Security*, 2003, 11:1-51.

31. Cumulative subsidies for nuclear power over the period 1947-1999 have been estimated at $145.4 billion, based on Marshall Goldberg, Renewable Energy Policy Project, *Federal Energy Subsidies: Not All Technologies Are Created Equal*, July 2000.

32. David Lochbaum, Union of Concerned Scientists, testimony before the Clean Air, Wetlands, Private Property and Nuclear Safety Subcommittee of the U.S. Senate Committee on Environment and Public Works, 8 May 2001, downloaded from www.ucsusa.org/clean_energy/nuclear_safety/page.cfm?pageID=191.

33. Conference of New England Governors/Eastern Canadian Premiers, *Climate Change Action Plan 2001*, August 2001.

34. New England Climate Coalition, *Global Warming in New England*, September 2003.

35. Ibid. Note: Projected base case emissions in this chart may differ with projected New England emissions presented elsewhere in this report due to changes in methodology and assumptions. Emission savings from sector-by-sector commitments in the regional plan are based on an optimistic interpretation of the plan's potential results, compared to the conservative assumptions for the various policy options analyzed in this report. In most cases, policies to implement the plan's commitments have not yet been formed or implemented. The gap between the governors' and premiers' regional commitments and the action plan goal thus represents the minimum amount of additional carbon dioxide reductions the region must achieve.

36. Increase from 1990 to 2000 is based on Massachusetts-specific EIA fuel use data as described in "Methodology and Technical Discussion." The estimated increase from 2000 to 2020 is based on the projected growth rate in fuel use in New England from EIA, *Annual Energy Outlook 2003*, except for motor gasoline. The rate of growth in motor gasoline use is based on the annual rate of growth in vehicle travel in Massachusetts projected by the Massachusetts Highway Department. MassHighway VMT projections were obtained from Bob Frey, Manager of Statewide Planning, MassHighway, 7 February 2003.

37. To be more precise, motor gasoline combustion accounted for 74 percent of carbon dioxide emissions from transportation in Massachusetts in 2000, based on data from EIA, *State Energy Data Report 2000*. About 92 percent of motor gasoline use in the transportation sector is used to power light-duty vehicles. (Source: EIA, *Supplemental Tables to Annual Energy Outlook 2003.*)

38. Savings are over and above those from the previous version of the ZEV program adopted by Massachusetts, which is assumed to be included in the EIA baseline energy use estimates.

39. Based on a possible scenario for manufacturer compliance with the program in California in Chuck Shulock, California Air Resources Board, *The California ZEV Program: Implementation Status*, presented at EVS-20, the 20th International Electric Vehicle Symposium and Exposition, November 2003. The flexibility of the ZEV program means that manufacturers have many possible ways to comply with the requirement; this scenario assumes that manufacturers take full advantage of program provisions that allow them to substitute ultra-clean conventional gasoline vehicles and hybrids for "pure" zero-emission vehicles such as fuel-cell vehicles.

40. J.D. Power and Associates, *J.D. Power and Associates Reports: Anticipated Higher Costs for Hybrid Electric Vehicles Are Lowering Sales Expectations* [press release], 27 October 2003.

41. Based on default values from Michael Wang, Argonne National Laboratory, Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) model, version 1.5a, 21 April 2001. Note: All figures for hybrids and conventional vehicles are based on emissions from vehicle operations (i.e. the tailpipe). Because hydrogen fuel-cell vehicles have no tailpipe emissions, fuel-cycle emissions were used. The default energy efficiency of hybrid-electric vehicles in GREET 1.5 a is assumed to be 90 percent greater than gasoline-powered vehicles operating on conventional gasoline, while the efficiency of fuel-cell vehicles is assumed to be 200 percent greater. A draft version of an updated GREET model (GREET 1.6) assumes smaller efficiency improvements from the two technologies.

42. These results are similar to the 2.25 percent reduction in carbon dioxide emissions in Massachusetts under the Low-Emission Vehicle II/ZEV program in 2020 projected by Northeast States for Coordinated Air Use Management (NESCAUM) in *Emissions Benefits of Adopting the LEV II Program in the Northeast* (draft report), May 2003.

43. California Assembly Bill 1493, adopted 29 July 2002.

44. The Center for Clean Air Policy assumed a 33 percent reduction in the Connecticut climate change stakeholder

process, the New York greenhouse gas task force assumed a 36 percent reduction, and M.J. Bradley and Associates, in a report written for the Natural Resources Defense Council, assumed a 30 percent reduction. Sources: Center for Clean Air Policy, *Connecticut Climate Change Stakeholder Dialogue: Recommendations to the Governor's Steering Committee*, January 2004; M.J. Bradley and Associates, *Survey and Evaluation of State-Level Activities and Programs Related to Climate Change*, 18 October 2002, prepared for the Natural Resources Defense Council Climate Center.

45. California Energy Commission, *California State Fuel-Efficient Tire Report: Volume 2*, January 2003.

46. U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2003*, April 2003.

47. U.S. Department of Energy, Office of Policy, *Effects of Feebates on Vehicle Fuel Economy, Carbon Dioxide Emissions, and Consumer Surplus*, February 1995.

48. California Air Resources Board, *Reducing California's Petroleum Dependence*, Final Staff Report, August 2003, Appendix C, Attachment B, B-251.

49. For a summary of data demonstrating the link between increased vehicle travel and accident risk, see Victoria Transport Policy Institute, *Online TDM Encyclopedia: Pay-As-You-Drive Vehicle Insurance*, downloaded from www.vtpi.org/tdm/tdm79.htm, 4 December 2003.

50. Based on Insurance Information Institute, *Facts and Statistics: The Rising Cost of Auto Insurance*, downloaded from www.iii.org/media/facts/statsbyissue/auto/content.print/, 29 October 2003

51. Victoria Transport Policy Institute, *Online TDM Encyclopedia*, downloaded from www.vtpi.org/tdm/tdm79.htm, 2 January 2004.

52. Ibid.

53. Michelle J. White, *The "Arms Race" on American Roads: The Effect of SUVs and Pickup Trucks on Traffic Safety*, [unpublished].

54. VMT projection: Bob Frye, Massachusetts Highway Department, 2 February 2003; population projection: U.S. Census Bureau, *Projections of the Total Population of States: 1995 to 2025*, downloaded from www.census.gov/population/projections/state/stpjpop.txt, 12 December 2003.

55. See John W. Holtzclaw, Robert Clear, Hank Dittmar, David Goldstein and Peter Haas, "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles and San Francisco," *Transportation Planning and Technology*, 2002, 25:1-27.

56. MassHousing, *Take the "T" to Work Home Mortgage Program*, downloaded from www.masshousing.com/, 12 March 2004.

57. Note: These projections do not include the impact of a feebate program. It is very uncertain how a feebate program would interact with a program to set standards for carbon dioxide emissions from vehicles. Presumably, a feebate program with a zero point that increases to match the average per-mile carbon emission level of the vehicle fleet would continue to provide an incentive for the purchase of more fuel efficient vehicles, and therefore lead to lower carbon emissions, but the degree of such an incentive is difficult to discern based on the existing literature.

58. See Tony Dutzik, MASSPIRG Education Fund, *Cars and Global Warming*, April 2003.

59. See Congressional Budget Office, *The Economic Costs of Fuel Economy Standards Versus a Gasoline Tax*, December 2003; Victoria Transport Policy Institute, "Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior," *Online TDM Encyclopedia*, downloaded from www.vtpi.org/tdm/tdm12.htm, 11 March 2003.

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61. For a list of readings on the potential of new highways to increase vehicle travel, see Robert Noland, *Induced Travel Bibliography*, www.vtpi.org/induced_bib.htm, September 2003.

62. Range of savings in 2010 estimate is based on two differing assumptions as to the type of electricity generation that would be displaced as a result of efficiency savings, with the greater reductions based on the displacement of higher carbon-emitting generating capacity (as would result from adoption of a strong regional carbon cap) and the lower reductions based on the displacement of new generation from natural gas. See "Methodology and Technical Discussion" for more details.

63. Massachusetts Board of Building Regulations and Standards, *Commercial Energy Code (780 CMR, Ch 13)*, downloaded from www.state.ma.us/bbrs/commercial_home_link.htm, 24 December 2003.

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66. Steven Nadel and Howard Geller, American Council for an Energy-Efficient Economy, *Smart Energy Policies: Saving Money and Reducing Pollutant Emissions Through Greater Energy Efficiency*, September 2001.

67. Based on quantitative and detailed textual analysis from U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Commercial Determination*, downloaded from www.energycodes.gov/implement/determinations_com.stm, 17 November 2003.

68. See note 66.

69. Ned Raynolds and Andrew Delaski, Northeast Energy Efficiency Partnerships, *Energy Efficiency Standards: A Low-Cost, High Leverage Policy for Northeast States*, Summer 2002.

70. These savings include energy savings that would result from air conditioners meeting efficiency standards proposed during the Clinton administration. The Bush administration has attempted to weaken the proposed standards, but in January 2004, a federal appeals court overruled the decision, allowing the more stringent standards to take effect. Should the court's ruling be implemented, Massachusetts would gain the benefits of stronger air conditioner standards without state action.

71. See note 69.

72. Ibid.

73. American Council for an Energy-Efficient Economy, *Summary Table of Public Benefit Programs and Electric Utility Restructuring*, May 2003.

74. Union of Concerned Scientists, *State Public Benefits Funding for Energy Efficiency, Renewables, and R&D*, November 2002; and Massachusetts Municipal Wholesale Electric Company, *Public Power In Massachusetts*, January 1998.

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80. MGL ch. 25A, sec. 11F; 225 CMR 14.00

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90. 301 CMR 7.00 Appendix B.

91. The spikes in emissions on this chart represent temporary additional fossil fuel generation used to compensate for the retirement of nuclear reactors upon license expiration in 2012 and 2015. This analysis also assumes that the most-polluting plants (coal) are closed before cleaner sources (petroleum).

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94. Massachusetts Executive Office of Environmental Affairs, *Climate Change Initiative*, downloaded from www.state.ma.us/envir/sustainable/initiatives/initiatives_ghg.htm#OSD, 26 December 2003.

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