A Blueprint for Action

Policy Options to Reduce New Hampshire's Contribution to Global Warming

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Executive Summary

New Hampshire 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 provide New Hampshire's first step toward 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 New Hampshire to make the technological shifts necessary to achieve the long-term goal of reducing New Hampshire's 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 New Hampshire's 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 greater rate of increase than any in the last 1,000 years.

- The effects of global warming are beginning to appear in New Hampshire and worldwide. Average temperatures in New Hampshire have increased by about 1.8° F since 1895, accompanied by changing precipitation patterns and other shifts.

- Average temperatures in New Hampshire are projected to increase by between 2.5° F and 10.4° F over the next century, accompanied by increased precipitation. The results of these changes could include degraded air quality, the loss of New Hampshire's hardwood forest species and maple syrup production, increased coastal flooding and shoreline damage, and harm to New Hampshire's important ski industry.

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

- Between 1990 and 2000, New Hampshire's direct emissions of carbon dioxide from energy use (other than electricity) increased by approximately 35 percent, a faster rate of increase than in any other New England state.

- Based on adjusted regional energy use projections from the U.S. Energy Information Administration, New Hampshire's direct (non-electric) emissions of carbon dioxide could increase by as much as 30 percent over the next two decades, with much of the increase taking place in the transportation sector. Again, this projected emissions growth rate is faster than any other New England state.

- Should New Hampshire's emissions continue to increase as projected, the state's global warming emissions in 2020 would be 75 percent higher than 1990 levels.

- 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.

New Hampshire could reduce its contribution to global warming 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 New Hampshire's roads over the next two decades by **adopting a clean cars requirement**.

2. Adopting **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 revenue-neutral **"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 in-

surance 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 New Hampshire's highways, such as measures to reduce sprawling development and encourage the use of transit and other transportation alternatives.

7. Adopting and requiring the use of the latest **commercial and residential building energy codes** to improve the energy efficiency of new construction and thereby reduce homeowners' energy bills.

8. Adopting **appliance efficiency standards** for a series of residential and commercial products, saving money for consumers.

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

10. Adopting a **Renewable Portfolio Standard** to require 10 percent of New Hampshire's 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 strengthening the **state power-sector carbon cap and adopting a regional power-sector carbon cap**.

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** to supplement the existing state registry.

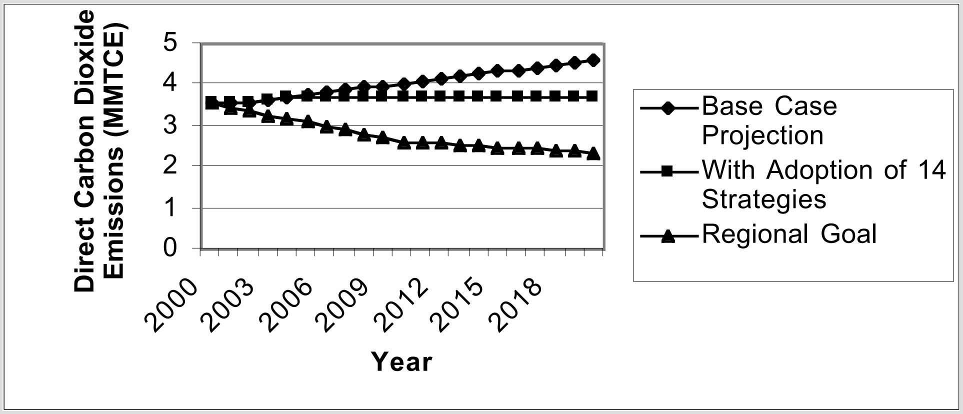
Adoption of all 14 strategies would reduce global warming emissions while improving New Hampshire's energy efficiency and spurring the development of renewable sources of energy.

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

Policy	2010	2020
Clean Cars Requirement	0.011	0.067
Carbon Dioxide Tailpipe Standards	0.017	0.20
Low-Rolling Resistance Tires	0.028	0.051
Feebate Program	0.016	0.081
Pay-As-You-Drive Automobile Insurance	0.074	0.091
Reduce Vehicle Miles Traveled	0.15	0.45
Residential and Commercial Building Codes	0.0061-0.014	0.072-0.14
Appliance Efficiency Standards	0.035-0.075	0.010-0.22
Expanded Energy Efficiency Programs	0.12-0.19	0.27-0.45
Renewable Portfolio Standard	0.14-0.33	0.31-0.73
Solar Power Development	0.00024-0.00056	0.00097-0.0023
State and Regional Electric-Sector Carbon Caps	*See high end of range of above estimates*	
Public Sector "Lead By Example" Policies	0.011-0.015	0.019-0.029
Regional Global Warming Emission Registry		*Not estimated*

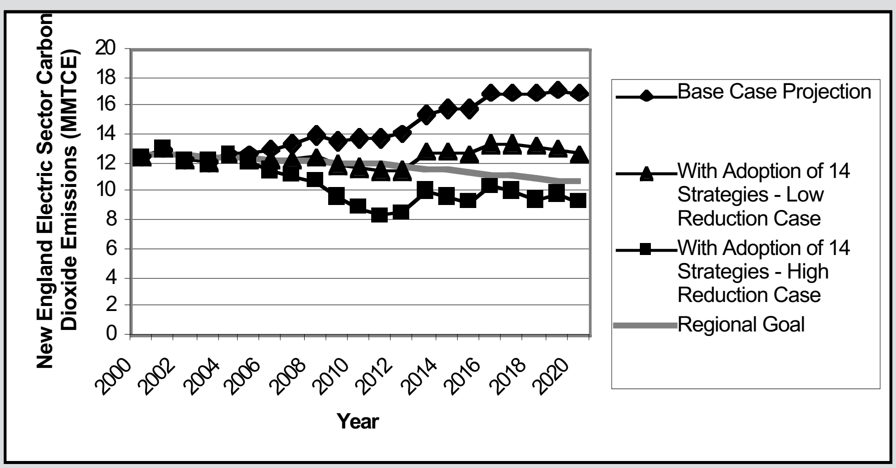
Note: Savings from individual policies do not equal cumulative savings due to some overlap between the policies.

Fig. ES-1. New Hampshire's Direct (Non-Electric) Emissions of Carbon Dioxide (MMTCE)



- Adoption of these 14 strategies would reduce New Hampshire's direct (non-electric) carbon dioxide emissions by about 19 percent below projected levels by 2020. (See Fig. ES-1.) 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. (See Fig. ES-2.)

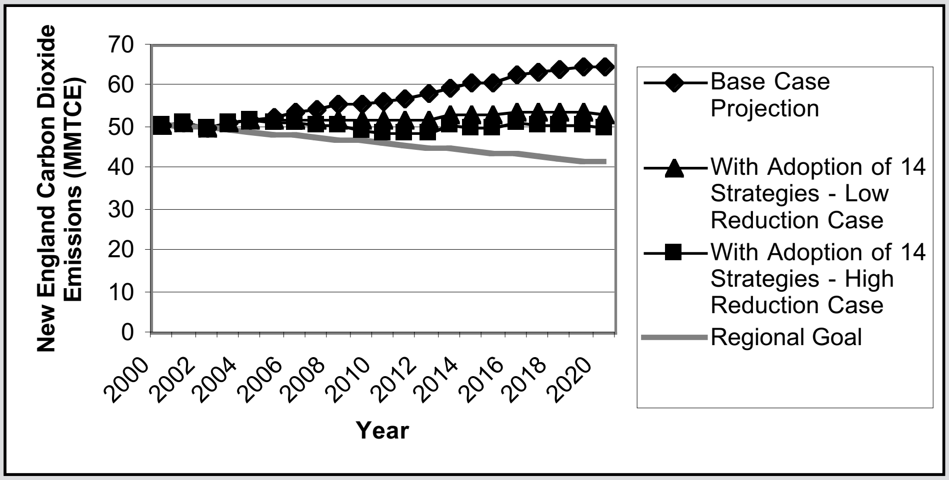
Fig. ES-2. New England Electric Sector Carbon Dioxide Emissions (MMTCE)



Note: The base case projection assumes "business as usual" growth in energy consumption as projected for New England by the Energy Information Administration. It also assumes the retirement of the region's nuclear plants at the expiration of their operating licenses. High reduction case assumes strong state and regional electric-sector carbon caps. Low reduction case assumes weak or no caps.

- New England-wide adoption of all 14 strategies would bring the region as much as 72 percent of the way to meeting the regional global warming emission reduction goal for 2010 and as much as 63 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-3.)

Fig. ES-3. 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.

- In addition, many of the strategies have benefits that extend beyond reducing global warming emissions, including reduction of emissions of other health-threatening pollutants, improvement of New Hampshire's energy security, and retention of jobs and dollars in the local economy as opposed to the transfer of money out of state for fossil fuel purchases.

The tremendous growth in global warming emissions that New Hampshire experienced from 1990 to 2000 makes it imperative that the state seize every opportunity to begin reducing its emissions.

- New Hampshire 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.

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

- New Hampshire 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.

- New Hampshire can and should reduce its global warming emissions without increasing the use of nuclear power or extending the life of the state's nuclear plant beyond its current operating license.

Introduction

Global warming is an acknowledged 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 New Hampshire are unknown, but it is virtually certain that the climatic shifts brought about by warming will leave our forests, rivers, coastlines and weather patterns far different than we have known them – and so too, the New Hampshire way of life.

Recognizing this, 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 contribution to global warming. The regional commitment asks each state to reduce its greenhouse gas emissions to 1990 levels by 2010 and to 10 percent below 1990 levels by 2020. To achieve this goal, states need to assess their existing emissions and create policies that will reduce their emissions.

New Hampshire – the New England state with the fastest emissions growth rate and thus the biggest challenge to meet its commitments – has yet to design and adopt a comprehensive strategy for reducing the state's emissions.

The state has adopted several programs that can become important components of a broader plan. Legislation passed in 2002 caps carbon emissions from the state's three older fossil fuel powered plants beginning in 2007, and the state has implemented a program to retrofit state buildings to reduce energy use and thus global warming emissions. While these policies are a good start and will require substantial resources and effort from the state agencies involved, New Hampshire can and should do far more.

The state has myriad options for reducing its energy use and cutting global warming pollution. Appliances, automobiles, homes, and buildings can be constructed to use energy more efficiently, reducing global warming emissions from the combustion of fossil fuels. Renewable energy sources such as wind and solar power are increasingly cost-competitive with traditional forms of energy. Highly advanced new technologies – such as fuel cells – show the potential to change the way we create and use energy in fundamental ways. But none of these is a magic bullet.

New Hampshire can reduce its global warming pollution, but only if it finds the will to do so – enacting legislation as necessary to create programs to cut emissions and implementing those programs to achieve the greatest emissions savings.

This report presents 14 policy opportunities and estimates how implementation of those policies will affect New Hampshire's emissions of carbon dioxide – the leading global warming gas. The vision presented in this report is far from complete. But the 14 policy options explored in detail here would, if implemented, help bring New Hampshire closer than it is now to fulfilling its commitments to reducing global warming emissions in the short- and medium-term, while positioning the state for further reductions in the long-term. And, these actions – if taken – will move New Hampshire closer to the cleaner, more efficient, more sustainable and healthier future we all seek.

Global warming poses a clear danger to New Hampshire's future health, well-being and prosperity. New Hampshire contributes to global warming primarily through the combustion of fossil fuels, which emit carbon dioxide to the atmosphere. New Hampshire's emissions of carbon dioxide and other global warming gases have increased dramatically over the last decade and will 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.)

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

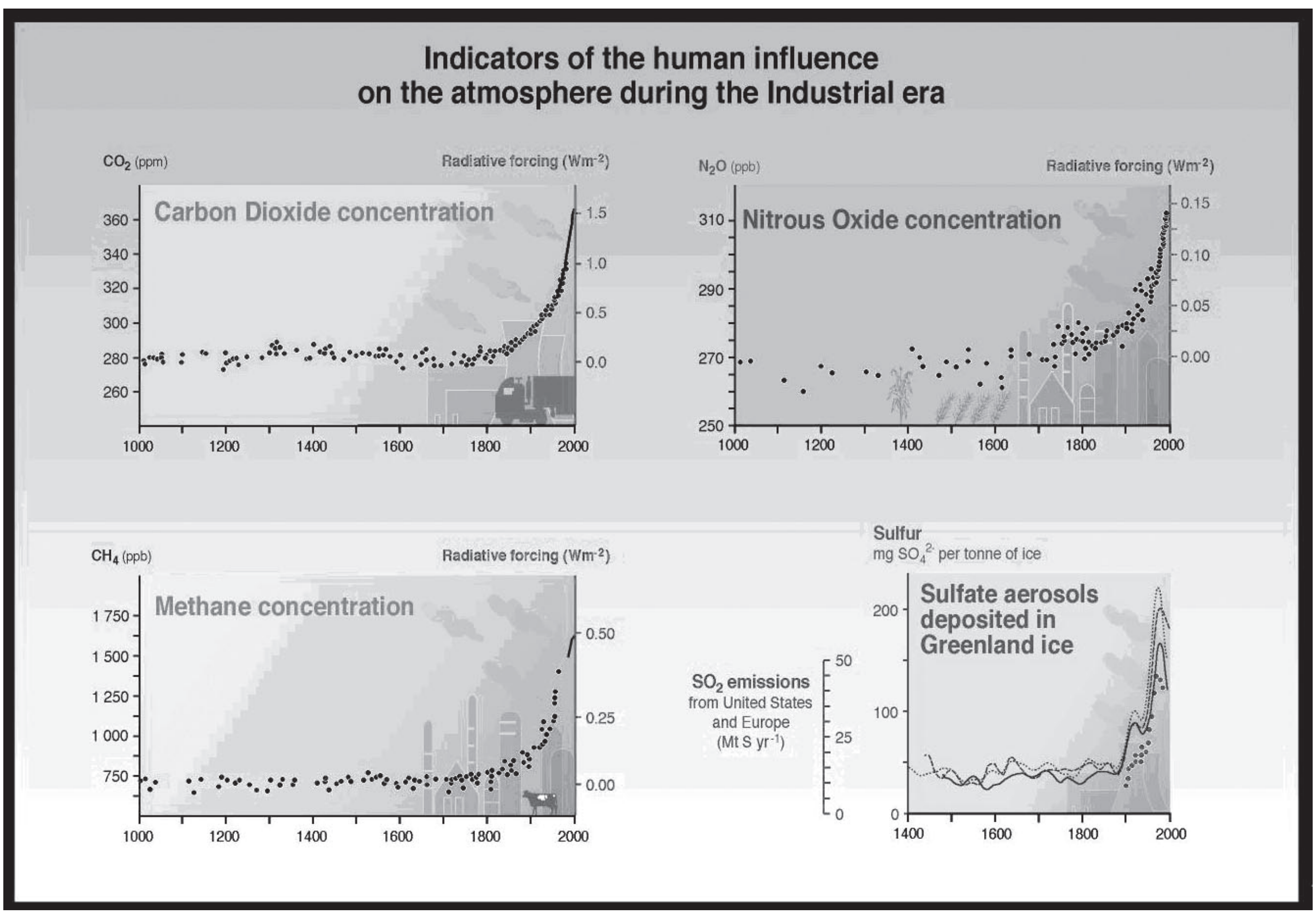
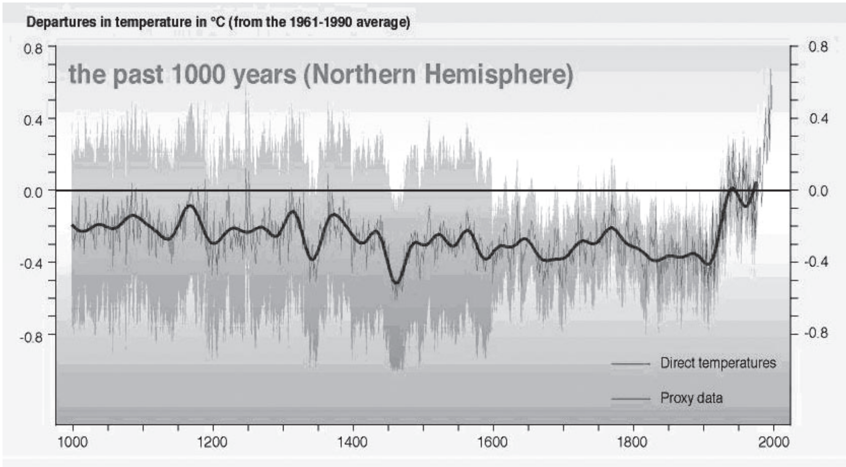


Fig. 2. Northern Hemisphere Temperature Trends[5]



As the composition of the atmosphere has changed, global temperatures have increased. Global average temperatures increased during the 20th century by 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.[3] Figure 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.

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.[6]

- **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 New Hampshire's 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.

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.[4]

Current Indications of Global Warming

The first signs of global warming are beginning to appear, both in New Hampshire 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 Hanover has increased by 2° F.[7] Statewide, average temperatures are estimated to have increased by 1.8° F between 1895 and 1999, nearly three times the average for New England.[8] Winter average temperatures in New Hampshire have increased even more steeply, rising 3.5° F since 1895, the highest increase of any New England state.

Precipitation patterns have changed. Precipitation has decreased by up to 20 percent in many parts of New Hampshire.[9] Maine, New Hampshire, and Vermont have experienced a 15 percent decrease in snowfall since 1953.[10] 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.[11]

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.[12] The average ice-out date at Lake Winnipesaukee is now four days earlier than it was in 1885.[13] Glaciers around the world have been retreating.[14]

Oceans have risen as sea ice has melted. Average sea levels have risen 0.1 to 0.2 meters in the past century.[15]

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 New Hampshire's 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.[16] Should current trends in greenhouse gas emissions continue, some projections suggest that temperatures in New Hampshire could increase by 2° F to 10° F by 2100.[17] 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.[18]

Precipitation levels also could change. New Hampshire could experience an increase in precipitation of 10 to 65 percent, with greater change in winter and less change in spring and summer.[19]

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

- Disruption to New Hampshire's ski industry, especially early and late in the ski season. Currently, direct and indirect ski-related spending brings $400 million to New Hampshire's economy.[20]
- Decreased maple syrup production as winters become warmer or dryer, reducing yields. Eventually, global warming may change the region's climate so dramatically that sugar maples can no longer survive in the

region. This would be an economic blow: maple syrup production is a $20 million industry for New England.[21]

- Increased spread of exotic pests and shifts in forest species – including the loss of hardwood forests responsible for New Hampshire's vibrant fall foliage displays.[22]
- Declines in freshwater quality due to more severe storms, increased precipitation and intermittent drought, potentially leading to increases in waterborne disease.[23]
- 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.[24]
- More frequent and severe coastal flooding due to rising sea levels. Ocean levels at Seavey Island are likely to rise 18 inches by 2100.[25]
- Increased spread of mosquito and tick-borne illnesses, such as Lyme disease, Eastern equine encephalitis, malaria and dengue fever.[26]
- Increased risk of heat-related illnesses and deaths.[27]
- 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.[28]

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 New Hampshire's 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 New Hampshire 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, New Hampshire 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.

New Hampshire's Direct (Non-Electric) Emissions

Carbon dioxide emissions from sources other than electricity generation increased in New Hampshire by approximately 35 percent from 1990 to 2000 – from 2.6 million metric tons carbon equivalent (MMTCE) to 3.6 MMTCE.[29] (See Table 1.) The emissions growth rate in New Hampshire was far greater than in any other New England state. Emissions from every sector – residential, commercial, industrial and transportation – increased during the decade. (This estimate does not include emissions from the use of electricity in any of the sectors.)

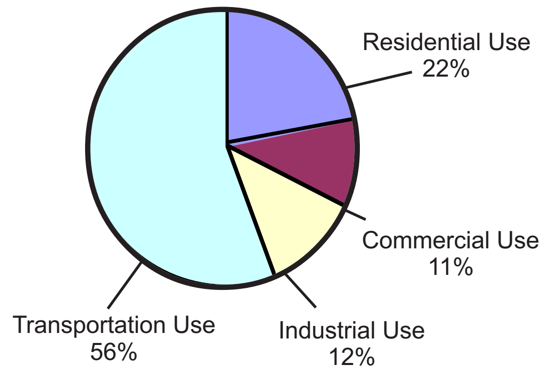
Table 1. Historic and Projected New Hampshire Direct (Non-Electric) Carbon Dioxide Emissions (MMTCE)[30]

	1990	2000	*2010*	*2020*
Direct Emissions	2.6	3.6	*4.0*	*4.6*
Pct. Increase Over 1990		35%	54%	76%

In 2000, the transportation sector was responsible for approximately 56 percent of New Hampshire's carbon dioxide emissions from sources other than electricity generation. The residential sector was responsible for about 22 percent of direct emissions, with the commercial sector responsible for 11 percent and the industrial sector for 12 percent. (See Fig. 3.) The transportation sector's large share of emissions (56 percent) and high growth rate (39 percent from 1990 to 2000) make it a key area for New Hampshire to address.

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 increases in transportation gasoline use) to New Hampshire, and applying standard fuel-specific emission factors to those estimates, New Hampshire is projected to experience a 30 percent increase in direct carbon dioxide emissions from energy use between 2000 and 2020 in the absence of mitigating action.[31] Between 2000 and 2010, emissions from transportation, residential, commercial, and industrial use could increase by about 0.49 MMTCE, with a further 0.58 MMTCE increase between 2010 and 2020. Following the trend of the past decade, most of the increase in emissions is projected to take place in the transportation sector. This is the base case scenario, and is shown in figure 4.

Fig. 3. New Hampshire's Direct (Non-Electric) 2000 Carbon Emissions by Sector

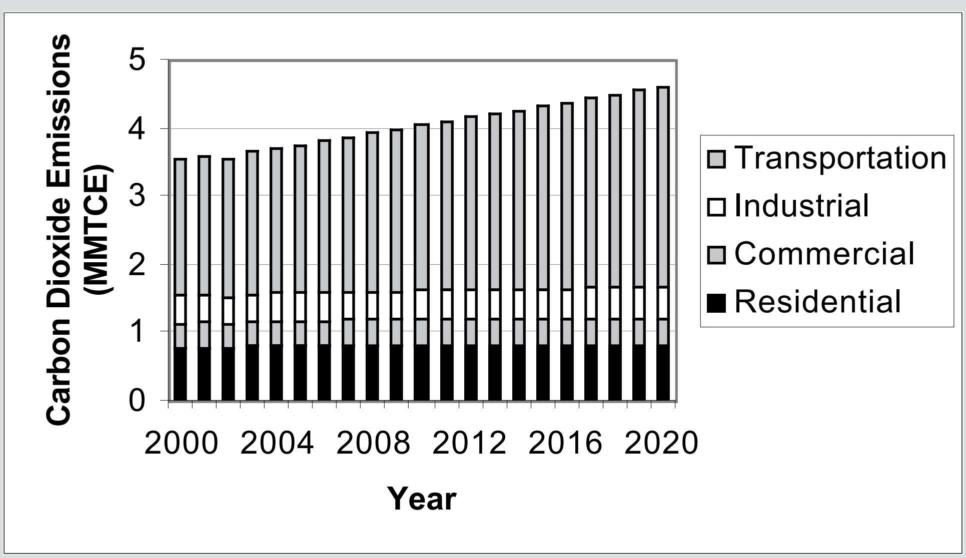


Combined with how much global warming pollution rose from 1990 to 2000, this projected growth rate means that New Hampshire's 2020 direct emissions will be 75 percent higher than 1990 levels.

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.) The relatively modest rate of growth is due largely to the shift from higher-polluting coal and petroleum to less-polluting natural gas.

Fig. 4. New Hampshire's Projected Direct (Non-Electric) Carbon Dioxide Emissions by Sector, 2000-2020



Carbon dioxide emissions from electricity generation within New Hampshire decreased slightly from 1990 to 2000, dropping from 1.33 MMTCE to 1.27 MMTCE. In that same period, however, total electricity production rose. These seemingly contradictory trends were made possible by the fact that the state's Seabrook nuclear power plant began producing power in late 1990. As production at Seabrook increased, the amount of electricity generated by high-emission petroleum plants was reduced. Though an increase in electricity production without a corresponding increase in carbon emissions may seem positive, nuclear power imposes high environmental and public health costs that counterbalance any benefit from reducing global warming.

EIA's projections of future trends in energy use in New England assume the continued operation of three nuclear power plants whose operating licenses are scheduled to expire before 2020 (the license for New Hampshire's Seabrook plant does not expire until 2026). 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.") 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 the 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.[33] This is the base case scenario for electric-sector emissions and is shown in figure 5, page 18.

Table 2. Historic and Projected Electric Sector Carbon Dioxide Emissions in New England Without Nuclear Relicensing (MMTCE)[32]

	1990	2000	*2010*	*2020*
Electric Sector	12.0	12.6	*13.8*	*17.0*
Percent Increase over 1990		5%	*15%*	*42%*

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

	1990	2000	2010	2020
NEW HAMPSHIRE'S DIRECT (NON-ELECTRIC) CARBON DIOXIDE EMISSIONS				
Historic/*Projected* Emissions	2.6	3.6	*4.0*	*4.6*
Regional Goal			2.6	2.4
Reductions Needed to Achieve Goal			1.42	2.26
NEW ENGLAND ELECTRIC SECTOR EMISSIONS				
Historic/*Projected* Emissions	12.0	12.6	*13.8*	*17.0*
Regional Goal			12.0	10.8
Reductions Needed to Achieve Goal			1.8	6.2

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 an acceptable 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.[35]

  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. Subsequent examinations at New Hampshire's Seabrook plant found similar leakage of corrosive liquid above the reactor head, though the problem was corrected before significant corrosion could occur.[36]

- **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.[37] A 2003 General Accounting Office report found significant weaknesses in the Nuclear Regulatory Commission's oversight of security at commercial nuclear reactors.[38]

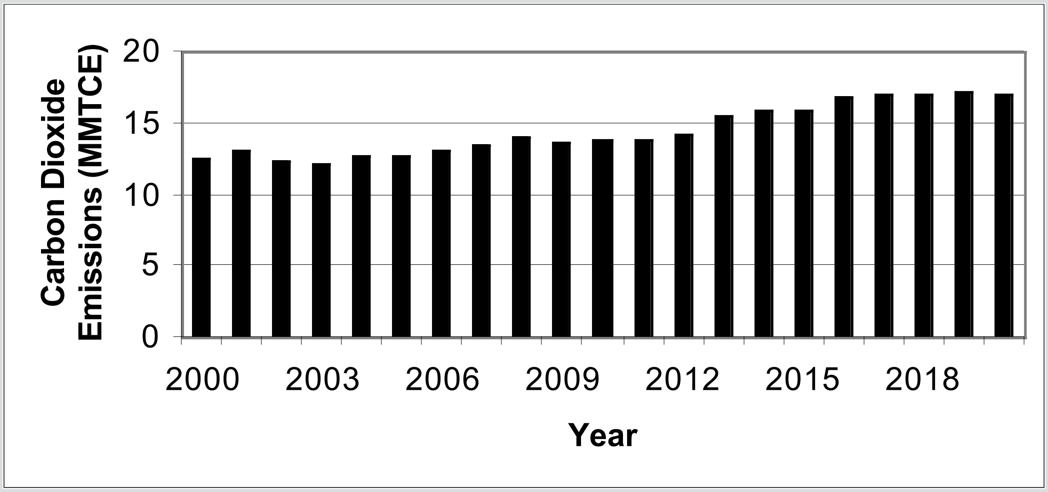
- **Spent fuel** – Nuclear power production results in the creation of tons of spent fuel, which must be stored either on-site or in a centralized repository. Both options pose safety problems. Centralized waste repositories require the transport of high-level nuclear waste across highways and rail lines 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 currently store waste on site in water-filled pools, often at densities approaching those in reactor cores. Should coolant from the spent-fuel pools be lost, the fuel could ignite, spreading highly radioactive compounds across a large area. The cost of such a disaster, were it to occur, has been estimated at 54,000-143,000 extra deaths from cancer and evacuation costs of more than $100 billion.[39]

- **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.[40] Without these subsidies, the nuclear industry likely could not have survived, and new plants likely would not be built.

- **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.[41]

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. 5. Projected Carbon Dioxide Emissions from Electricity Generation in New England (MMTCE)[34]



Regional and State Responses

The threat posed by global warming has provoked a variety of responses in New Hampshire 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.

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.

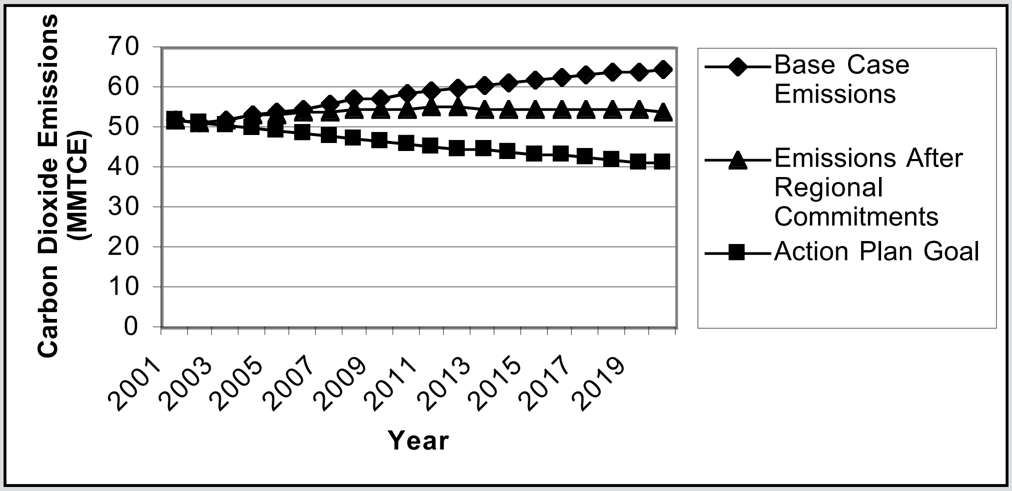
In the short term (by 2010), the plan calls for the reduction of global warming emissions in the region to 1990 levels. The medium-term goal, to be achieved by 2020, is to reduce emissions to 10 percent below 1990 levels. In the long run, the plan aims to achieve reductions of the degree needed to minimize dangerous threats to the climate. Scientists currently estimate that this will require reductions of 75 to 85 percent below current emissions levels.[42]

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.[43] (See Fig. 6.) 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

Fig. 6. Carbon Dioxide Emission Reductions in New England Under Implementation of Regional Climate Change Action Plan[44]



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.

New Hampshire Greenhouse Gas Emissions Reduction Efforts

The regional Climate Change Action Plan also called upon each of the states to evaluate its current carbon dioxide emission levels and develop a plan for achieving required global warming emission reductions.

New Hampshire has taken some small actions to reduce its contribution to global warming. It participates in the federal Clean Cities program that seeks to increase the use of alternative fuel vehicles by municipal transit fleets, public schools, and private fleets. Since 1997, New Hampshire's Building Energy Conservation Initiative (BECI) has analyzed state buildings for energy and resource conservation opportunities, and allows otherwise unfunded energy retrofits and building upgrades so long as the energy savings will pay for the project's cost.

The recently enacted utility systems benefit charge (SBC) for efficiency improvements in commercial, municipal and residential electric use has generated $20 million for appliance rebates and energy services, reducing electricity use and global warming emissions throughout the state.[45]

New Hampshire's potentially strongest action has been the adoption of legislation in 2002 that sets clear goals for capping carbon dioxide and other air pollution from its older power plants. Carbon dioxide emissions from the state's three coal and oil power plants are to be capped at 1990 levels starting in 2007, with further reductions proposed to occur after 2011. Nitrogen oxide, sulfur dioxide, and mercury emissions are also capped at lower levels. However, the law allows the trading of emissions credits, whereby the state's power plants can avoid reducing their own emissions by paying other plants – probably out-of-state, and likely out-of-region – to reduce theirs. Designing a trading system that ensures traded emissions savings are real, surplus, verifiable, and permanent is difficult. In addition, out-of-state emission reductions will not provide the same air quality improvements that would result from cleaner in-state power generation. (See Strategy #12 for further discussion of the challenges of implementing a carbon cap and trading program.)

Despite these advances, the state has not yet begun to develop a firm plan for reducing overall emissions. In December 2001, the Department of Environmental Services issued *The Climate Change Challenge* with over 70 recommendations for ways to reduce greenhouse gas emissions.[46] Most of the recommendations are for voluntary actions to be taken by cities, businesses, or individuals. The report does not estimate the reductions in emissions that would result, but it is unlikely that these actions would achieve New Hampshire's portion of the required emissions reductions. In contrast, Connecticut, Rhode Island, and Massachusetts each have developed plans for significantly reducing their global warming emissions, and Maine will soon have a plan prepared.

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 carbon dioxide (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) **Reduce emissions from the electricity sector as a whole by 40 percent from current levels**. Every plan should include provisions for reducing CO_2 emissions from grandfathered 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 processes.

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 New Hampshire as it seeks to reduce its emissions of global warming gases. Not only is transportation New Hampshire's largest source of carbon dioxide emissions – responsible for about 56 percent of direct (non-electric) in-state emissions in 2000 – but it is also among the fastest-growing sources. Transportation-sector carbon dioxide emissions increased by 39 percent in New Hampshire between 1990 and 2000, and could increase by an additional 48 percent between 2000 and 2020 if trends toward increasing vehicle travel continue.[47]

Light-duty vehicles are by far the largest source of transportation-sector carbon dioxide emissions, responsible for about three-quarters of transportation emissions in New Hampshire.[48] 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 New Hampshire's commitments, the state will have to make progress in all three areas.

Strategy #1: Adopt a Clean Cars Requirement

Potential Savings: 0.011 MMTCE by 2010; 0.067 MMTCE by 2020.

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 most of the other states that have adopted California standards. The standards have been adopted, or are in the process of being adopted, by six other states, including every New England state except New Hampshire and Maine.

New Hampshire has thus far opted to use the general federal standards instead of the standards established by California. However, the state can replace the federal standards with California's standards as soon as the 2007 model year, at minimal cost to the state treasury.

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 (including 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 would be required to sell the equivalent of several thousand hybrid vehicles per year in New Hampshire, with the numbers increasing over time. Then, beginning in 2012, automakers would 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 New Hampshire would be hybrids, while about 3 percent would be hydrogen fuel-cell or other vehicles with zero emissions.[49]

In the near term, the ZEV program would place thousands of hybrid-electric vehicles on New Hampshire's highways. Hybrids – such as the Toyota Prius, Honda Civic, and Ford Escape – 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 New Hampshire 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.[50] 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 New Hampshire residents broader choice of cleaner vehicles. In addition, ZEV programs in New Hampshire and other states would 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 New Hampshire consumers to afford hybrid vehicles, which typically cost about $3,000-$4,000 more than similar non-hybrid 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.[51] 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, New Hampshire could anticipate about a 3 percent reduction in carbon dioxide emissions from light-duty vehicles by 2020 as a result of adopting the ZEV program.[52]

Strategy #2: Adopt Limits on Vehicle Carbon Dioxide Emissions

Potential Savings (Including Savings from ZEV Program): 0.017 MMTCE by 2010; 0.20 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.[53] The new standards are to be proposed in 2005 and go into effect in 2009.

The carbon dioxide emissions 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 the California standards. In New England, Vermont, Rhode Island, Connecticut and Massachusetts have adopted California's other standards for low- and zero-emission vehicles and therefore will likely incorporate the new carbon dioxide emissions standards.

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 new cars and new light trucks, phased in over a 10-year period. This estimate is significantly more conservative than California's initial proposed reductions in global warming emissions from automobiles under the Pavley law. CARB has proposed requiring reductions of approximately 30 percent in vehicle global warming emissions, but phased in more aggressively over a six-year period. Should this proposal be adopted, emission reductions under Pavley would be significantly greater than are projected here.[54]

New Hampshire can lay the groundwork for implementation of the Pavley standards by moving forward with full adoption of ZEV program rules. The state should also encourage other New England and northeastern states to adopt 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: 0.028 MMTCE by 2010; 0.051 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.[55]

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 New Hampshire – 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: 0.016 MMTCE by 2010; 0.081 MMTCE by 2020.

The federal fuel economy preemption limits the number of policy tools available to states to reduce the fuel consumption – and resulting 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."

A feebate program, which can be revenue-neutral for the state, 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. 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.

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.[56]

CAFE standards have remained largely stagnant over the last decade; standards for cars have not increased since 1990. Unfortunately, New Hampshire's current plan for responding to global warming, as articulated in the *Climate Change Challenge*, relies heavily on improvements in federal CAFE standards to reduce the state's emissions.

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 New Hampshire to introduce policies aimed at reducing transportation-sector carbon dioxide emissions.

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.[57]

A feebate program adopted solely in New Hampshire could, therefore, have very 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.[58] 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 New Hampshire, 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: 0.074 MMTCE by 2010; 0.091 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.[59] 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 New Hampshire 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 broad benefits for New Hampshire – 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. Converting the average collision and liability insurance policies to a per-mile basis in New Hampshire would lead to an average insurance charge of about 6 cents per mile.[60] (For comparison, a driver buying gasoline at $1.50 per gallon for a 20 MPG car pays 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 5 cents per mile in New Hampshire) would reduce vehicle-miles traveled by about 8.2 percent, with carbon dioxide emissions from light-duty vehicles declining by roughly the same amount.[61] Should one-half of New Hampshire drivers be covered by the PAYD option, light-duty VMT – and, therefore, light-duty vehicle carbon dioxide emissions – could be reduced by 4.1 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.[62]

New Hampshire 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 New Hampshire.

Strategy #6: Reduce Growth in Vehicle Miles Traveled

Potential savings: 0.15 MMTCE by 2010; 0.45 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 New Hampshire's energy security, and reducing automotive emissions of other pollutants that damage public health. It would be a reasonable goal for New Hampshire to seek to reduce the growth rate in vehicle-miles traveled to the rate of population growth in the state, projected by the U.S. Census Bureau to be approximately 0.6 percent per year between 2005 and 2020.[64]

The impact on vehicle-miles traveled of both transit improvement 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.[65]

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, New Hampshire could encourage long-term shifts in development patterns and transportation decisions that would reap benefits in reduced vehicle travel and global warming emissions.

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 several 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.[63] 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.

Among the policies that could help achieve this goal are the following:

- Directing state investments in transportation and other infrastructure toward designated growth areas or existing population centers, not to rural areas where increased access will promote more sprawl.

- Encouraging location-efficient mortgages that allow households living near transit services to borrow additional money because their reduced transportation expenses increase their disposable income.

- Providing additional incentives to employers who encourage telecommuting, establish car- and van-pool 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 adopting other policies to improve the safety and appeal of walking and bicycling.

- Promoting "infill" development, reuse of buildings no longer needed for their original purpose, 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, New Hampshire 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, New Hampshire 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 New Hampshire's 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 2 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 0.26 MMTCE by 2010 and 0.71 MMTCE by 2020. At these levels, transportation-sector emissions in New Hampshire in 2020 would be 0.24 MMTCE higher than 2000 levels and 0.8 MMTCE higher than 1990 levels (excluding savings from feebates).[66]

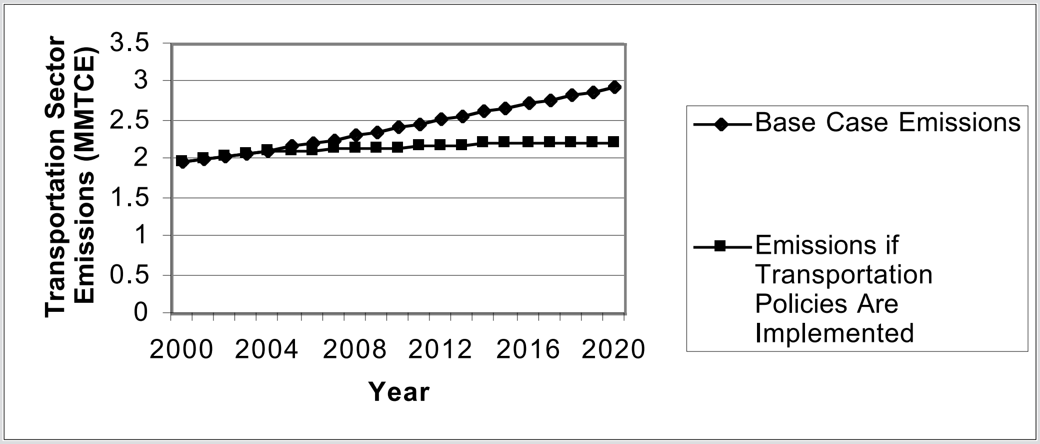
Achieving even this level of emission reductions will require swift action. Many of the transportation-sector strategies (including feebates and the Pavley program) have a long lead time before they begin to produce significant savings due to the fact that they primarily affect new vehicle purchases.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

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



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.[67] 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. However, New Hampshire currently requires that all revenues from the gas tax be spent on roads. Pending the outcome of a legal challenge to this requirement, New Hampshire may have the flexibility to use gas tax funds on measures to improve the efficiency of the state's transportation system.

- **Rail Improvements and Expansion** – Restoration of New Hampshire's network of operating and dormant rail corridors is a large potential resource for global warming emission 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.[68] The 2001 resumption of passenger rail service on Amtrak's Downeaster train through seacoast New Hampshire has been highly popular and is a first step, but the frequency of the trains needs to be increased. A connection in Boston between North and South stations would improve the usefulness of the Downeaster service for riders seeking to travel farther south than Boston. Further, the state should restore rail service from Manchester to Lawrence, Mass. On the freight side, state officials should continue to consider modernization of the state's freight rail system. Officials should also 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 New Hampshire's transportation system over the next several decades.

- **Limits on Highway Expansion** – Congestion and safety problems on New Hampshire's highway network are growing, with Interstate 93 in southern New Hampshire perhaps the worst example. State officials are moving forward with plans to expand I-93, but 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 promote increased vehicle travel and sprawling development, leading to more fuel use, more global warming emissions, and eventually more traffic.[69] As I-93 is expanded or redesigned, care must be taken to protect the most vulnerable open space, and to ensure that communities in southern New Hampshire have the resources necessary to plan for the growth that road expansion will spawn and ensure that such growth takes place with minimal impact on the environment and global warming emissions. Rather than continuing to make highway expansion the state's default response to congestion, transportation officials should prioritize roadway repairs and make better use of 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. New Hampshire 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 (potentially to burn biodiesel, which is now commercially available in New Hampshire), the use of alternative fuels such as natural gas in public transit fleets (like the natural gas powered vehicles the University of New Hampshire is acquiring), and measures to reduce the amount of truck idling (such as the electrification of truck stops in the state and stronger enforcement of the state's anti-idling law).

Reducing Emissions from Homes, Business and Industry

The residential, commercial and industrial sectors are responsible for nearly half of New Hampshire's direct (non-electric) emissions of carbon dioxide. There are tremendous opportunities to improve the efficiency of energy use in all three sectors.

Strategy #7: Strengthen Residential and Commercial Building Energy Codes

Potential Savings: 0.0061-0.014 MMTCE by 2010; 0.072-0.14 MMTCE by 2020.[70]

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.

New Hampshire adopted its first energy code in 1979, though the portions relating to energy conservation in state-owned buildings were later repealed.[71] The code was implemented independently by each town with only weak enforcement.[72] The state finally adopted a comprehensive statewide building code in 2002 by updating the energy codes and adding other building requirements. Currently, residential construction in New Hampshire is guided by the 2000 International Energy Conservation Code (IECC). There are two methods for complying with the IECC: guidelines developed by the IECC, or the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) code 90.1-1999, which is incorporated by reference into the IECC code. Commercial construction can use IECC or ASHRAE standards.[73] Enforcement of the energy code remains problematic: fewer than 50 percent of towns have code officials, and many of them are part-time.[74]

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. New Hampshire has no plans to upgrade to this more recent code.

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.[75] 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.[76] ACEEE assumes a further 20 percent energy savings for all fuels in commercial buildings from future updates to the code.[77]

Based on the assumptions of ACEEE and U.S. DOE, the adoption of updated building energy codes in New Hampshire would reduce residential oil and gas use by approximately 1.3 percent below base case projections by 2020. These estimates attempt to quantify the impact of improved codes on new construction only. Applying codes to alterations and renovations in existing 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. 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 New Hampshire reaps the benefits of energy-efficient residential and commercial construction.

Strategy #8: Adopt Appliance Efficiency Standards

Potential Savings: 0.035-0.075 MMTCE by 2010; 0.10-0.22 MMTCE by 2020.

Household appliances and those used by businesses 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.[78]

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 16 commercial and residential products, which provided the basis of our projected emissions savings.[79] (See Table 4.) Appliance efficiency standards are also a win-win for New Hampshire's environment and economy. The NEEP study estimated that adoption of the package of appliance standards would bring New Hampshire approximately $435 million in net economic benefit by 2020.[80]

New Hampshire 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

Table 4. Products Covered Under Proposed Efficiency Standards[66]

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 merchandizers	
Traffic signals	
Exit signs	
Commercial (coin-operated) clothes washers	
Ice makers	
Large packaged air conditioners	
Dry type transformers	

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.

Strategy #9: Expand Energy Efficiency Programs

Potential Savings: 0.12-0.19 MMTCE by 2010; 0.27-0.45 MMTCE by 2020.

One of the most promising opportunities for reducing carbon dioxide emissions in New Hampshire 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 some states that have deregulated their electric industries – including New Hampshire – a new means of financing efficiency improvements has been created through the assessment of a systems benefit charge (SBC) 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.

New Hampshire authorized charging SBCs through its electric restructuring legislation adopted in 1997.[82] SBCs are assessed in New Hampshire to support low-income assistance programs and energy efficiency programs, even though the electric restructuring law permits SBCs for renewable energy also. (We will discuss the SBC for renewable sources in more detail later in this report.)

All five electric utilities in New Hampshire must collect the efficiency SBC, which is 0.8 mills ($0.0008) per kilowatt-hour.[83] The utilities, with oversight from the PUC, run energy efficiency programs through the New Hampshire Saves program. Elements include efficiency aid for new construction and retrofits of existing structures, and rebates for efficient lighting and appliances. Residential, commercial, and industrial users are covered by the programs. The utilities began the program in June 2002 as a 19-month test. At the end of that test period, the utilities reported that they had spent $20 million to achieve lifetime efficiency savings of 1,277 GWh (a savings rate of about 63 kWh per dollar spent).[84]

Should New Hampshire increase its efficiency SBC 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), New Hampshire could still achieve carbon savings of 0.056-0.13 MMTCE by 2020.

The impact of a gas and oil SBC program is more difficult to predict, but it would be substantial. Since the beginning of 2003, New Hampshire's two gas utility companies have offered efficiency programs. Both Keyspan Energy and Northern Utilities offer audits of home energy use, assistance with home weatherization, rebates on efficient furnaces, and rebates for equipment in new Energy Star homes.[85] The programs are funded through charges established by the Public Utilities Commission in May 2003. Residential customers of Northern Utilities pay a charge of 1.68 cents per 100,000 BTU of energy; commercial and industrial customers pay 1.94 cents per 100,000 BTU. The rate for Keyspan residential customers is 1.22 cents per 100,000 BTU; commercial and industrial customers are charged 0.9 cents per 100,000 BTU.[86]

Based on Vermont's experience with Vermont Gas's conservation programs, the Connecticut Climate Change Stakeholder Dialogue estimated that the average first-year cost of saving 1,000 cubic feet of natural gas was $29.[87] Assuming that a broader gas and oil SBC-type program applied to residential, commercial and industrial consumption would achieve a savings rate 75 percent of that experienced thus far in Vermont, an SBC of 3.5 cents per 100,000 BTU of energy consumed would reduce New Hampshire's carbon dioxide emissions by approximately 0.15 MMTCE by 2020 (including savings from the existing SBC-funded programs for natural gas).[88] An SBC at this rate would translate into a rate of 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 0.15-0.26 MMTCE in 2010 and 0.38-0.68 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 and thus counts savings only 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.[89] 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, New Hampshire 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. Two New Hampshire utilities – Public Service Company of New Hampshire (PSNH) and New Hampshire Electric Coop – operate pilot PAYS programs for electric and other efficient equipment. The PSNH program has cost $734,000 but will yield projected lifetime savings of over $2.1 million and 15,900 MWh.[90] State officials should work with utilities to make these pilot programs permanent, to apply to both efficiency and distributed generation, and to offer them to all New Hampshire residents. Officials should also coordinate with mortgage lenders to encourage and publicize EEMs.

- **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 New Hampshire can spur their development by encouraging towns 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 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** – New Hampshire 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, New Hampshire 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, New Hampshire must encourage the deployment of renewable energy sources while simultaneously adopting policies to reduce carbon dioxide emissions from fossil fuel generators through state and regional electric-sector carbon caps. Regional cooperation on this matter is crucial, since current generation capacity and renewable resources are not distributed evenly across the six New England states.

Strategy #10: Adopt A Renewable Portfolio Standard

Potential Savings: 0.14-0.33 MMTCE by 2010; 0.31-0.73 MMTCE by 2020.

A dozen states around the country, including four New England states – Massachusetts, Maine, Connecticut, and Rhode Island – have adopted a renewable portfolio standard (RPS) for electricity supplied to that state's customers. Essentially, an RPS requires that a certain portion of the power delivered 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.

New Hampshire currently generates and consumes very little electricity from renewable sources. Most power comes from nuclear or fossil fuel plants. New Hampshire could improve this fuel mix, adding more renewable power sources, by adopting a renewable portfolio standard (RPS) for electricity supplied to the state's customers.

With an RPS target of 10 percent by 2010 and 20 percent by 2020, New Hampshire would achieve savings of 0.14-0.33 MMTCE by 2010 and 0.31-0.73 MMTCE by 2020, with the higher estimate based on adoption of a strong regional carbon cap that allows for reductions in electricity consumption to offset generation from coal-fired power plants. (See Strategy #12.)

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, wood and other forms of biomass (as long as they are consumed in such a way as to not add to air pollution), 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.[91] 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.[92]

In sum, fulfilling a 20 percent renewable portfolio standard for New England with wind alone 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.[93]

As New Hampshire considers what parameters to incorporate in its RPS, it should remember that the 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 non-renewable 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's RPS, for example, allows the fulfillment of requirements through the development of renewables in other New England states or even outside the region.

New Hampshire 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.

Strategy #11: Support the Development of Solar Power

Potential Savings: 0.00024-0.00056 MMTCE by 2010; 0.00097-0.0023 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 New Hampshire 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.[94] New Hampshire 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.

One potential tool is to create a systems benefit charge for renewables and dedicate a portion of the revenue to the installation of solar photovoltaic (PV) panels on homes and businesses throughout the electric grid.

Recent experience in Massachusetts suggests that a subsidy of at least $4,000 per kW is necessary to make solar power cost-competitive in New England. 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.

A recent analysis found that a prospective commercial PV purchaser in New Hampshire – if he or she received a $4,000/kW subsidy – could pay as much as $7,000 per kW for a solar system and still break even financially. Installed commercial PV systems in the U.S. range in price from $7,000 to $12,000 per kW, which would make PV systems marginally cost-competitive (with subsidy) in New Hampshire.[95] 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.[96]

A subsidy program of the kind described here, if fully utilized, would result in the generation of about 4.0 GWh of power from new solar installations in New Hampshire by 2010 and 16 GWh by 2020. 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.[97]

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.[98]

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 New Hampshire 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 a 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.

In 2002, New Hampshire adopted legislation capping emissions of carbon dioxide and three other pollutants from the state's three coal- and oil-fired power plants. In addition, New Hampshire is currently working with nine other northeastern states, from Maine to Delaware, to develop a regional cap-and-trade system for electric-sector global warming emissions. The initiative, known as the Regional Greenhouse Gas Initiative (RGGI), parallels similar efforts in Massachusetts as well as discussions of limits at the federal level.

The New Hampshire and RGGI processes provide an opportunity to 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.

New Hampshire's carbon dioxide emission cap becomes effective at the end of 2006. The limits apply to only three coal- and oil-fired power plants, exempting two recently constructed natural gas plants in the state. For the first four years of the program, the legislation requires the three covered plants to limit their carbon dioxide emissions to 1990 levels, a modest reduction at best because emissions from those plants were substantially higher in 1990 than most succeeding years. Later emission caps have yet to be established, though the Department of Environmental Services recently proposed a 25 percent reduction below 1990 carbon dioxide emission levels beginning in 2011. Next year, the Legislature will have an opportunity to significantly reduce New Hampshire's carbon emissions by setting lower cap levels in the next decade. The program could also be made much stronger by including all the state's fossil fuel-based power plants in the cap and trade program, not just oil- and coal-fired plants.

For updating the New Hampshire carbon cap and for crafting the RGGI agreement, the following considerations are significant elements of ensuring meaningful reductions in carbon emissions. Among the important issues developers of carbon caps must grapple with are the following:

- **Cap Levels –** The program must establish a target for the total amount of carbon that can be released. This target should be significantly lower than current emissions, and should be applied to all fossil-fueled electric power sources in the state.

  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 need to maintain existing, inefficient sources of generation and allow their expedited replacement with more efficient sources.

The New England Climate Coalition recommends an overall goal of reducing carbon dioxide emissions from electricity generation in New England 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, just two of many possible strategies, 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, New Hampshire and the New England states should be moving toward a phase-out of nuclear generating capacity, beginning 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's rule for its state-specific electric sector carbon dioxide emission cap requires that any offsets provide "real, surplus, verifiable, permanent and enforceable" emission reductions.[99]

  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 from plants not covered by the caps, or power imported into New Hampshire 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, as is the current practice with cap and trade programs for other pollutants. 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, and/or used for transition help for displaced workers.

The resolution to these issues in the regional cap will come through extensive negotiations over the coming months. New Hampshire should use its position in the talks to maximize the potential benefits of the regional carbon cap, and preserve its options to cap electric-sector emissions through other channels, such as through a New England-wide or state program.

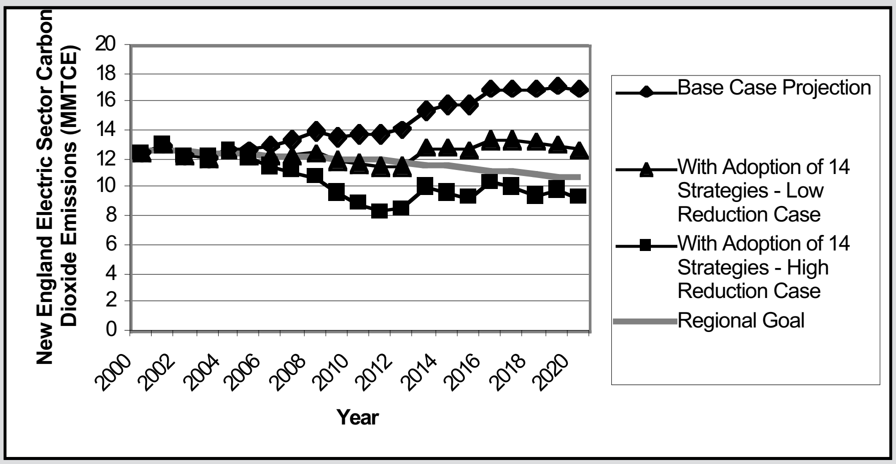
Other Electric Sector Strategies to Consider

- **Green Power Option** – The advent of retail competition in electricity markets was to have brought New Hampshire residents and businesses a variety of choices for supply of electricity – including the choice to purchase power generated from renewable re-

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.100 (See “Low reduction case” in Fig. 8.) 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)[101]



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.

sources. However, none of New Hampshire’s utilities offer consumers this option.[102] The state could require utilities 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 whatever levels might be established in an RPS.

Like the transportation sector, the electric sector is a major source of global warming pollution in New England. Unlike the transportation sector, however, New Hampshire 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: 0.011-0.015 MMTCE by 2010; 0.019-0.029 MMTCE by 2020.

Federal, state, and local governments are significant users of energy in New Hampshire. 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.

New Hampshire has already adopted some policies and practices – such as retrofitting some state office buildings – that improve energy efficiency within state government and thus reduce government's contribution to global warming.

The state of New Hampshire 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 New Hampshire's current Building Energy Conservation Initiative, 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.[103] 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.
New Hampshire's main state government 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 New Hampshire consumed 9.1 million gallons of gasoline in 2001, according to the Federal Highway Administration, representing over 1 percent of total gasoline use in the state.[104]

To improve the energy efficiency of the state fleet, New Hampshire 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.[105] Special efforts should be undertaken to purchase hybrid-electric vehicles, where available.

Second, New Hampshire should restrict the use of sport utility vehicles to those government functions in which four-wheel-drive and off-road capabilities are truly required. Even the most fuel-efficient SUV will likely not be as efficient as the car the state could purchase instead. Doing so will likely not only reduce energy consumption, but will also save taxpayers money.

Finally, New Hampshire 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. New Hampshire should adopt a policy of maximizing 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. In addition to this policy, the state should work to expand refueling opportunities for alternative-fuel vehicles. Meanwhile, New Hampshire 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 state government's electricity from clean renewable sources by 2010 and 50 percent by 2020.
Enlisting New Hampshire 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 a 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 New Hampshire 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 New Hampshire's 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.

New Hampshire already has a voluntary inventory in place. In 1999, the Legislature created the Voluntary Greenhouse Gas Emissions Reductions Registry, which allows facilities to report voluntary reductions in their carbon dioxide, methane, and nitrous oxide emissions.[106] Companies can report emission reductions that they have achieved since 1991 so that if reductions are mandated in the future, the companies will get credit for having already acted responsibly.[107]

The impact of a registry system like New Hampshire's or 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 either market-based (trading) or regulatory approaches to the reduction of global warming emissions. Eventually, entities responsible for large-scale emissions of global warming pollution 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 – on their own – allow New Hampshire to achieve the regional short- and medium-term global warming gas reduction goals. But, combined with other strategies discussed by the New England governors, other policy options suggested in this report, and action at the federal level in areas in which New Hampshire's freedom of action is limited, they can move the state closer to achieving its goals.

We estimate that the strategies listed above would reduce New Hampshire's direct (non-electric) emissions of carbon dioxide by 19 percent below projected levels by 2020. Direct emissions would be about 30 percent above 1990 levels in 2010 and 42 percent above 1990 levels in 2020. (See Fig. 9, next page.)

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.

Fig. 9. Projected Direct (Non-Electric) Carbon Dioxide Emissions in New Hampshire (MMTCE)

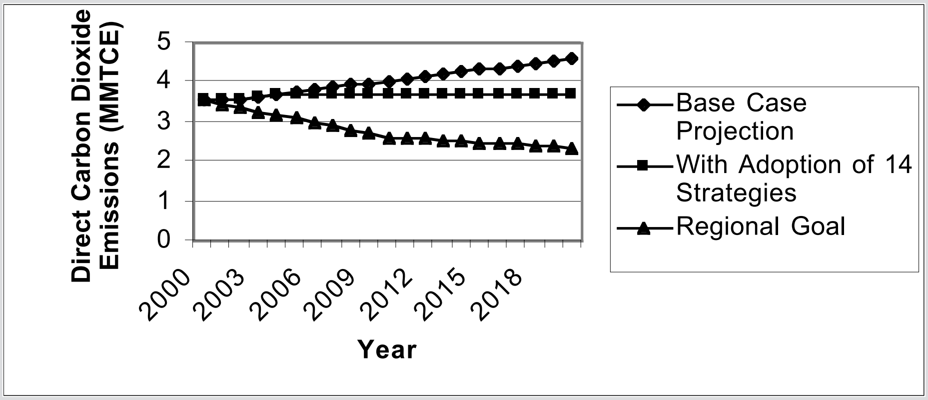


Fig. 10. New England Projected Carbon Dioxide Emissions (MMTCE)

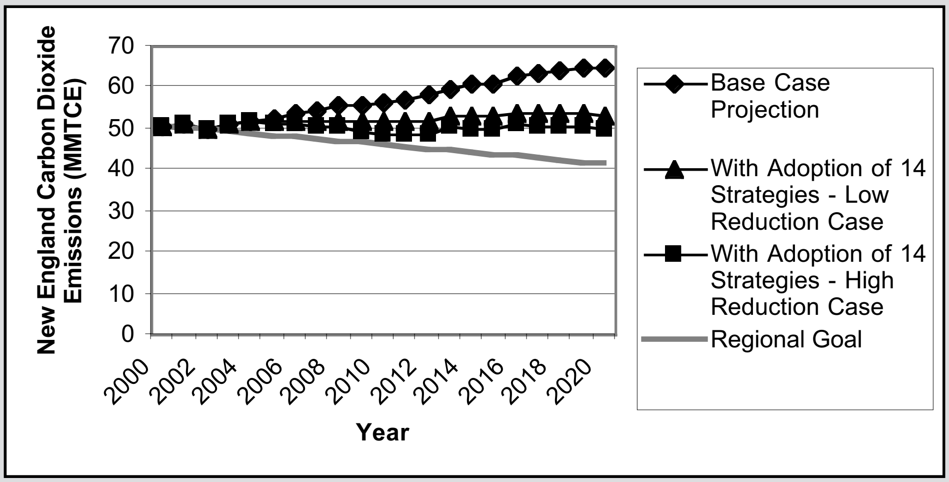


Table 5. Carbon Dioxide Emission Reductions from Strategies and Additional Reductions Required to Meet Regional Goals (MMTCE)

	1990	2000	2010	2020
NEW HAMPSHIRE'S DIRECT (NON-ELECTRIC) CARBON DIOXIDE EMISSIONS				
Historic/*Projected* Emissions	2.6	3.6	*4.0*	*4.6*
Regional Goal			2.6	2.4
Reductions Needed to Achieve Goal			1.42	2.26
Reductions from 14 Strategies			0.33	0.89
Additional Reductions Needed			1.09	1.36
NEW ENGLAND ELECTRIC SECTOR EMISSIONS				
Historic/*Projected* Emissions	12.0	12.6	*13.8*	*17.0*
Regional Goal			12.0	10.8
Reductions Needed to Achieve Goal			1.8	6.2
Reductions from 14 Strategies (High/Low Case)			4.8/2.1	7.7/4.3
Additional Reductions Needed			0/0	0/1.9

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 state recently adopted an RPS.

Connecticut: The Connecticut Climate Change Stakeholder Dialogue's 55 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. The state has adopted this policy.
- *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 new 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.

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 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, New Hampshire's 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 New Hampshire 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 thousands of high-efficiency and zero-emission vehicles on New Hampshire's 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 New Hampshire 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, New Hampshire 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 New Hampshire 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: New Hampshire 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, New Hampshire 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.

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 New Hampshire. Future emission trends in New Hampshire are generally based on EIA's projected rates of growth for New England as a whole. New Hampshire trends will differ, but the EIA growth projections provide a reasonable approximation of future trends, particularly given the regional context of New Hampshire's 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 New Hampshire (including the more stringent 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 New Hampshire 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 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 New Hampshire, 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 New Hampshire in million cubic feet were obtained from EIA, *New Hampshire Natural Gas Consumption by End Use*, downloaded from http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_snh_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 http://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 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 New Hampshire are based on applying the New England year-to-year projected growth rates for each fuel in each sector from *AEO 2003* to the New Hampshire baseline emissions estimate for 2000, with two exceptions.

1) In the transportation sector, EIA's estimates of vehicle travel increases are significantly higher than recent experience in the state. Instead of using EIA's projected growth rates for motor gasoline use, we used a growth rate of 2 percent per year, based on the average annual growth rate in vehicle miles traveled in New Hampshire from 1990 to 2002, from FHWA, *Highway Statistics*. 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 regional base case estimate for power-sector energy use was adjusted by eliminating nuclear generation from the power sector energy mix as nuclear reactors' licenses expire and replacing that power 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 were projected based on two sets of assumptions:

- **Low savings estimate** – Based on the use of efficiency savings and renewables to first 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 plant-by-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 vs. 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 New Hampshire.

- **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, life-cycle 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 New Hampshire 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 New Hampshire 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.

California Vehicle Carbon Dioxide Limits

Emission factors for new 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 formally 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 New Hampshire 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 New Hampshire 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 New Hampshire 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 New Hampshire 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 5 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 (8.2 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 New Hampshire's 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 New Hampshire'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.

System 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.[108] (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 New Hampshire. 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 the 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 New Hampshire 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.

Solar Program Supported by Renewables SBC

The amount of funding that would be provided by a 0.15-mill earmark for solar programs in a renewables SBC was estimated in a similar manner as 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 calculated by computing government energy per capita in Connecticut, Massachusetts, Rhode Island, and Vermont for different fuels. Natural gas usage was calculated based on just Connecticut, Rhode Island, and Vermont. We then multiplied per capita use rates by New Hampshire's 2002 population. 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 relied on data we obtained as described above. The calculations assume that the state has already reduced its energy use by 25 percent. The carbon output of the non-renewable electricity assumes that renewable power generation allows the retirement of high-emission coal plants before petroleum-fired plants.

NOTES

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2. Ibid.

3. Ibid.

4. Ibid.

5. Ibid.

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

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

8. 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.

9. See note 7.

10. See note 8.

11. See note 1.

12. Ibid.

13. See note 8.

14. See note 1.

15. Ibid.

16. Ibid.

17. See note 7.

18. See note 8.

19. See note 7.

20. Conservation Law Foundation, *Heritage In Peril: New England and Global Warming,* downloaded from www.clf.org/pubs/climate, 4 August 2003.

21. Clean Air-Cool Planet, *Fact Sheet: Climate Change and the Northern Forest*, downloaded from www.cleanair-coolplanet.org/information/pdf/forest-factsheet.pdf, 4 August 2003; Vermont Maple Sugar Makers' Association, *Vermont Maple Facts*, downloaded from www.vermontmaple.org/mfacts.htm, 4 August 2003.

22. See notes 7 and 8.

23. Ibid.

24. Ibid.

25. See note 7.

26. See notes 7 and 8.

27. Ibid.

28. Ibid.

29. 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.

30. 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.

31. Estimated rate of increase in fuel use based on year-to-year increases for New England from U.S. Energy Information Administration, *Annual Energy Outlook 2003*, 9 January 2003.

32. See note 29.

33. 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.

34. See note 8.

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

36. Steven Frothingham, "Weld Leak Discovered During Seabrook Station's Inspection," *Fosters Daily Democrat*, 8 October 2003.

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

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

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40. 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.

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

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

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

45. NHSaves, *New Hampshire Core Energy Efficiency Programs, Quarterly Report, June 1, 2002 to December 31, 2003,* downloaded from www. puc.state.nh.us/Electric/coreenergyefficiencyprograms.htm, 11 March 2004.

46. New Hampshire Department of Environmental Services, *The Climate Change Challenge*, December 2001.

47. Increase from 1990 to 2000 is based on 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 New Hampshire reported by FHWA in *Highway Statistics*, 1990-2002.

48. To be more precise, motor gasoline combustion accounted for 80 percent of carbon dioxide emissions from transportation in New Hampshire in 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.*)

49. 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.

50. 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.

51. 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 1.5a 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.

52. These results are similar to the 2.25 percent reduction in carbon dioxide emissions in Massachusetts and Vermont under the 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.

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

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59. 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.

60. 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

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

62. Ibid.

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

64. VMT projection based on Federal Highway Administration, *Highway Statistics* 1998 to 2002, Table MF-21, downloaded from www.fhwa.dot.gov; 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.

65. 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.

66. 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.

67. 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.

68. Based on energy consumed in Amtrak passenger trains in 1993 from Federal Railroad Administration, *Energy*, down-

loaded from www.fra.dot.gov/Content3.asp?P=977, 3 February 2004.

69. 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.

70. 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.

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77. See note 75.

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

79. 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, New Hampshire would gain the benefits of stronger air conditioner standards without state action.

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101. 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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