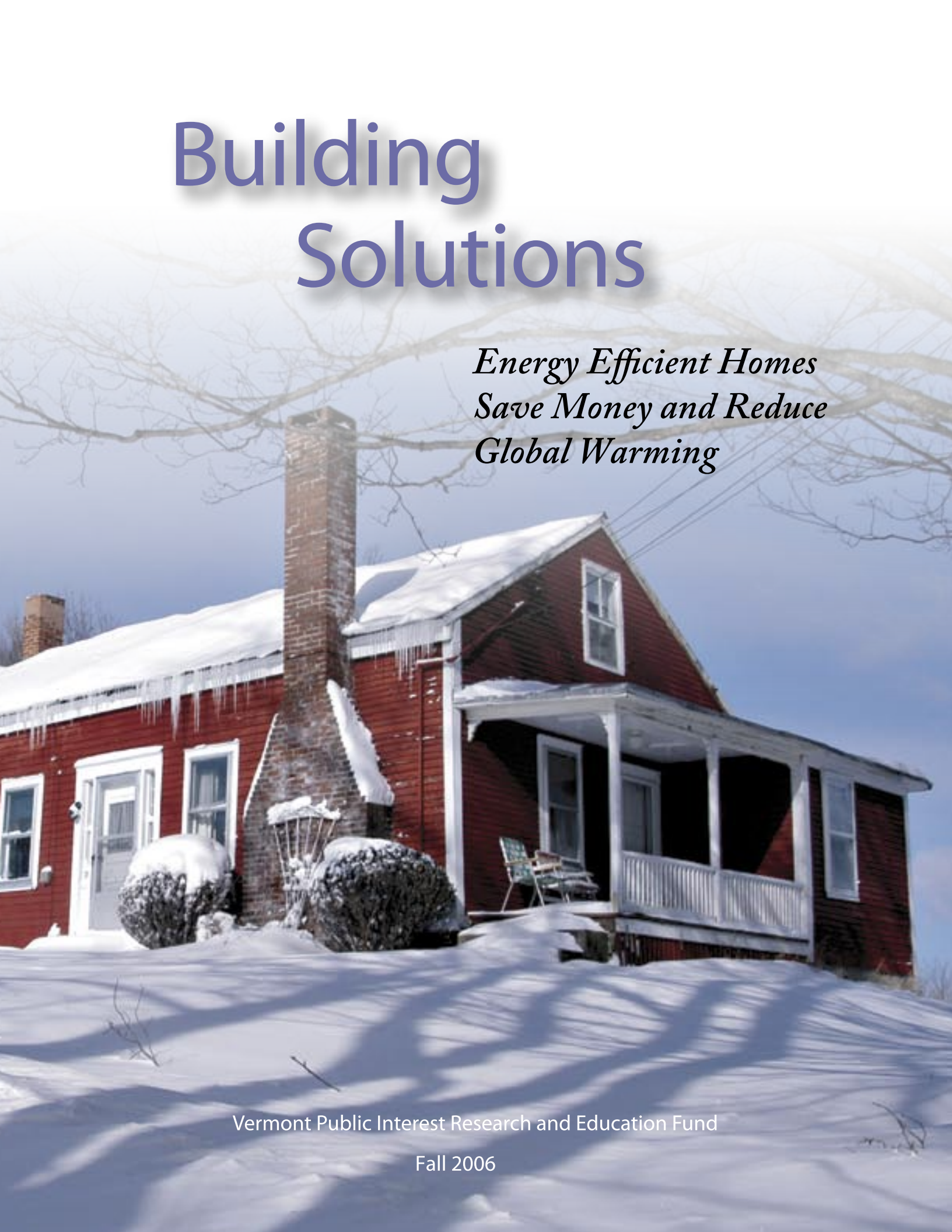
Building Solutions

Energy Efficient Homes Save Money and Reduce Global Warming



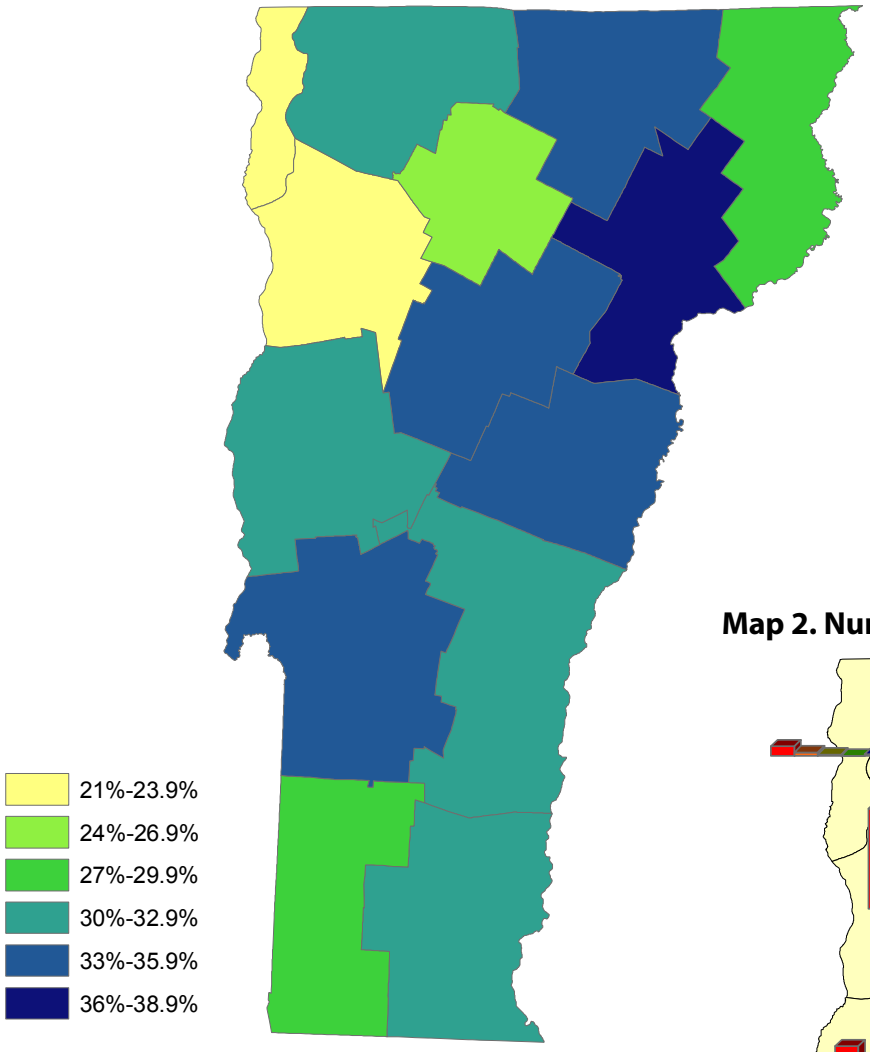
Vermont Public Interest Research and Education Fund

Fall 2006

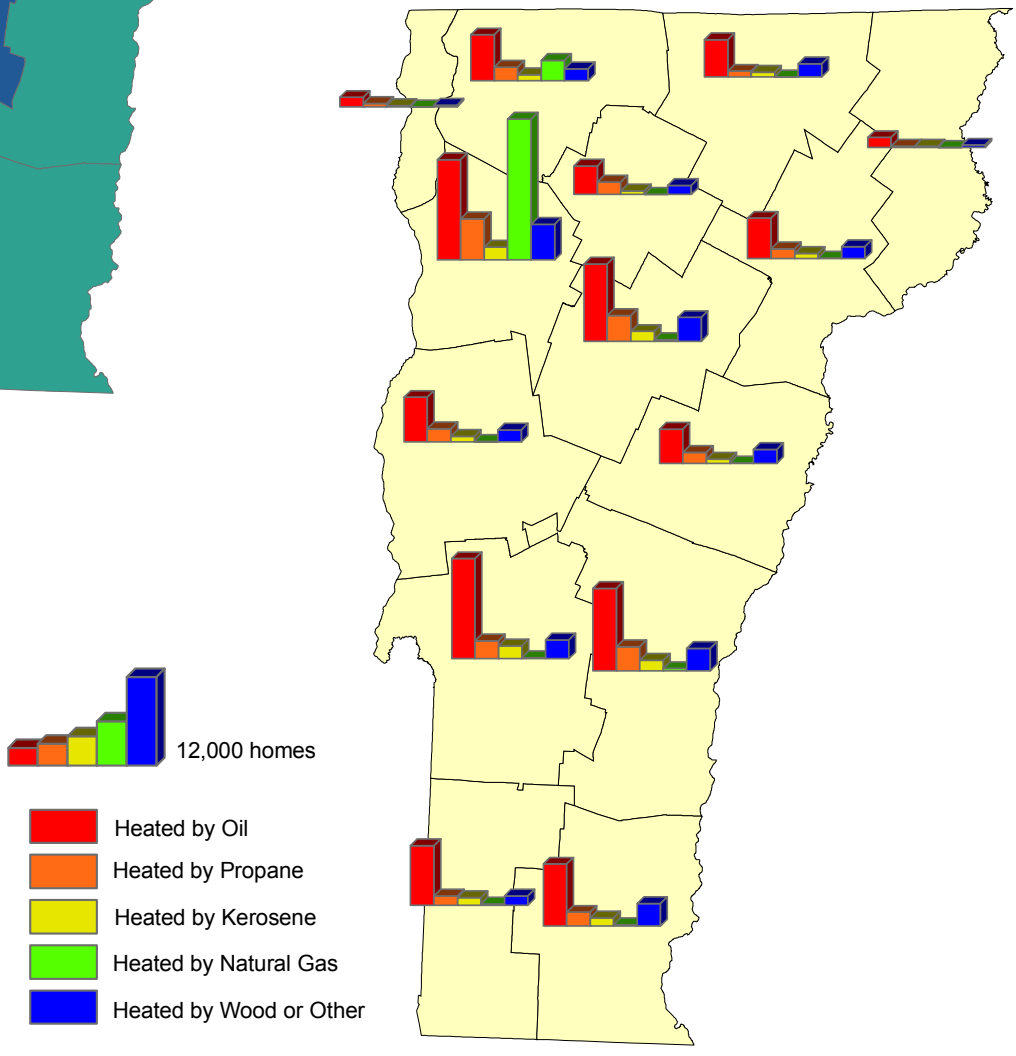
Building Solutions: Energy Efficient Homes Save Money and Reduce Global Warming

Vermont has great potential to reduce its global warming pollution from residential heating. Map 1 shows the high percentage of old (and inefficient) homes in the state. Map 2 shows the state's reliance on heating fuels with high global warming pollution.

Map 1. Percentage of Homes Built Before 1940



Map 2. Number of Homes Heated by Different Fuels



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The Vermont Public Interest Research and Education Fund is Vermont's leading policy research and public education group. Founded in 1975, VPIREF's mission is to research and disseminate policy options, administrative strategies and business practices that promote and protect the health of Vermont's environment, people, and locally-based economy. With cutting edge research and broad public education, VPIREF brings real solutions to Vermont's problems to the public, and teaches citizens to find their voice in public policy debates that shape the future of the Green Mountain State.

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Photo: Cover page: Springfield, Vermont home in the winter. Photo, Dave MacKenzie.

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Executive Summary

Vermont has the second oldest building stock in the nation. Too many of Vermont's buildings are inefficient, which means they require more fuel to heat and produce more global warming pollution. Vermont can significantly reduce its global warming pollution by adopting measures to improve the efficiency of heating its residential buildings, saving Vermonters millions of dollars at the same time.

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

Since the beginning of the Industrial Age, atmospheric concentrations of carbon dioxide – the leading global warming gas – have increased by 35 percent, a rate of increase unprecedented in the last 20,000 years. Correspondingly, global average temperatures have increased by about 1˚ F during the 20th century.

Temperatures in Vermont are projected to increase by 2˚ F to 10˚ F by 2100, with precipitation increasing by as much as 50 percent, especially in the winter. Annual variation in rainfall may be much greater.

In Vermont, a changed climate is anticipated to include a wide variety of impacts:

- Vermont's ski industry could suffer, especially early and late in the ski season, threatening its $1.4 billion contribution to Vermont's economy.
- Maple syrup production could decrease as winters become warmer, reducing yields. Eventually, global warming may change the region's climate so dramatically that sugar maples no longer can survive.
- Warmer weather may reduce crop yields and harm Vermont's $400 million agricultural sector.

Fossil fuels burned to heat homes in Vermont create one-sixth of the state's emissions of carbon dioxide, the leading global warming pollutant.

Fuel oil, kerosene, natural gas and propane burned to provide heat during Vermont's long winters released 320,000 metric tons of carbon equivalent (meaning a variety of pollutants with global warming potential equal to this amount of carbon) in 2000.

Emissions from heating are high for several reasons:

- Vermont's housing stock is old. About 50 percent of the state's homes pre-date any energy efficiency standards for buildings.
- The state's heating equipment is also old. Of Vermont homes heated with fuel oil, 35 percent have a furnace that is more than 15 years old. Older furnaces may be as much as 40 percent less efficient than the newest furnaces.
- Vermont relies on high-emission fuels for home heating. Fuel oil, kerosene and propane heat 70 percent of homes in Vermont, compared to 12 percent nationally.
- Nearly 30 percent of residences are rentals—properties where neither the owner nor renter has a strong incentive to maintain or improve energy efficiency.

Home heating creates a financial burden on Vermont households. Rising fuel prices have added to the load.

- In 2005, Vermont residents spent an estimated $250 million on residential heating.
- From 1999 to 2005, the average price of home heating fuels has more than doubled. The price of fuel oil has risen to more than two and a half times its 1999 cost, kerosene has risen almost as much, and propane has almost doubled, forcing Vermont residents to spend even more on heating.
- For the average Vermont household, these price increases have had major consequences. A family that paid $418 to fill a 500-gallon fuel oil tank in 1999 paid $1,115 in 2005.

Vermont has great potential for improving the energy efficiency of residential heating, thereby reducing energy use and global warming emissions.

- Vermont can reduce its global warming pollution related to home heating by 20 percent, cutting the amount of fuel used for home heating by 18 percent

compared to what would be released from home heating under a "business as usual" scenario in 2020.

- If the 20 percent reduction in residential heating emissions could be achieved today, total statewide carbon dioxide emissions would be 5 percent lower. This would provide an important start to Vermont's efforts to curtail its global warming pollution by providing initial emission reductions, training contractors and builders to improve home efficiency, and creating the public and private infrastructure necessary to pursue additional efficiency improvements in the future.

- Investing in Vermont's buildings today will allow the state to be a national leader in the emerging super-efficient building industry. The American Institute of Architecture is moving towards the "2030 Challenge" by asking the building community to immediately design new buildings that use one half of the fossil fuel energy they would typically consume today and that all new buildings use zero fossil fuel energy by 2035.

In addition to curbing global warming pollution, reducing the amount of fuel used for home heating will provide financial savings for Vermont.

- Home weatherization and heating system improvements to Vermont homes from 1999 to 2000 required an average investment of $2,027 per home. Through reduced home heating bills, the investment was recouped in under four years and is today providing hundreds of dollars of annual savings per homeowner. With fuel prices even higher today, greater improvements would be cost effective and the payback time on weatherization efforts may be even shorter.

- In the long-term, weatherization and heating system improvements may also ease pressure on the state budget. Vermont has spent millions in the past two years to help low-income families pay for heating costs. As fuel prices rise, more families will require assistance and families that previously needed assistance will likely require more of it. If the state invests in weatherization, low-income families will be able to heat their homes with less fuel and therefore be less likely to require increasing help with winter heating bills.

To tap the potential for improved efficiency in residential heating, Vermont should do the following:

- Adopt aggressive goals and detailed plans for reducing home heating contributions to global warming.

- Expand state energy efficiency programs to aggressively and effectively address all homes, regardless of heating fuel or income level.

- Accelerate upgrades of building efficiency standards.

- Implement time-of-sale energy consumption disclosure requirements.

- Phase in a requirement that residential buildings meet upgraded energy standards if the building is sold.

- Offer tax credits to homes that are so efficiently heated by renewable sources that they require no external energy source over the course of a year.

- Create new financing mechanisms to encourage residential energy efficiency investment.

As Vermont experiences more of the early effects of global warming and as the price of oil continues to rise, investing in weatherization and heating system efficiency makes ever more sense. Vermont should act now to protect its climate and economy.

Introduction

Stopping global warming in Vermont is central to VPIREF's mission to promote the health of Vermont's people, environment and economy. At the heart of that work is the need to create an energy future for the state that is based on clean, safe and affordable energy sources. Vermont's energy use can be divided into three main sectors: transportation, heating and electricity. To address Vermont's contribution to global warming all three must be considered.

The consumption of fossil fuels is the single largest contributor to global warming. It also presents a major financial burden to Vermont residents and the state's economy. The rising cost of gasoline, fuel oil and other fossil fuel products has caused Vermont families to spend an increasing portion of their incomes on energy, money that leaves the state and often the country instead of supporting the local economy.

The consumption of fossil fuels is the single largest contributor to global warming.

Over the past year, VPIREF has released several reports that provide insight into the problem of fossil fuel consumption and global warming in Vermont and offer solutions that the state should adopt. Two reports that address our transportation challenges and examine different solutions to those challenges are: *Driving Global Warming: Commuting in Vermont and Its Contribution to Global Warming*, and *Shifting Gears: 20 Tools for Reducing Global Warming Pollution from New England's Transportation System*. Similarly, VPIREF released *A Decade of Change: A Vision for Vermont's Renewable Energy Future*, a report that shows how Vermont can provide over 50 percent of the state's electricity needs through in-state renewable resources within ten years.

This report, *Building Solutions: Energy Efficient Homes Save Money and Reduce Global Warming,* focuses on the energy used to heat Vermont homes in the cold winter months. Keeping the house warm while keeping the heating bill affordable is a challenge that Vermonters face every winter. So is staying warm in the winter without doing damage to the global climate.

Vermont can address both challenges by building on its success with promoting efficiency in the electricity sector. Thanks to action by Vermont's legislature and the Department of Public Service that helped create Efficiency Vermont, the state is a recognized national leader in electricity efficiency and has demonstrated the ability to save substantial amounts of energy. With a focus on the efficiency of Vermont's aging housing stock, the state has an opportunity to use market mechanisms and a range of policy tools to achieve economic benefits while at the same time reducing our contribution to global warming.

Building efficiency has added benefits in the summer months that are not quantified in this report. Vermont homes and businesses are increasingly reliant on air conditioning in the summer months. This reality has put an added stress on Vermont's electricity grid and has put upward pressure on Vermont's electricity costs during hot summer days. Fortunately, many of the actions that reduce one's winter heating bill will also help keep a building cool in the summer.

Many of the challenges mentioned in this report, such as Vermont's old building stock, apply not only to the residential sector but also cross into the industrial and commercial sectors. Similarly, many of the policy recommendations identified in this report have the potential to provide fuel and financial savings to Vermont's businesses as well.

This report demonstrates that energy efficiency can save a significant amount of energy and cut Vermont's emissions of global warming pollution. The potential for savings extends to every corner of the state and to every Vermont citizen. Energy efficiency provides a clear opportunity to secure a better, cleaner energy future for Vermont. It is an opportunity we cannot afford to miss.

Global Warming and Vermont

Global warming poses a clear danger to Vermont's future health, well-being and prosperity. The largest source of global warming pollution in Vermont comes from the combustion of fossil fuels, which emit carbon dioxide to the atmosphere.

Causes of Global Warming

Global warming is caused by an increase in heat-trapping gases in the atmosphere. Human activities, particularly over the last century, have added carbon dioxide, methane, fluorocarbons and other gases to the atmosphere. These gases have increased the amount of the sun's heat that is trapped near the planet's surface. Since 1750, for example, the concentration of carbon dioxide in the atmosphere has increased by 35 percent as a result of human activity. The current rate of increase in carbon dioxide concentrations is unprecedented in the last 20,000 years.[2]

As the composition of the atmosphere has changed, global temperatures have increased. Global average temperatures increased during the 20th century by about 1° F. 1990 to 2000 was the warmest decade in the millennium, and if left unchecked, temperatures could increase ten times as much as they did over the past 100 years by the end of this century.[3]

Current Indications

The first signs of global warming are beginning to appear, both in Vermont and around the world. Global warming will not necessarily follow a steady, gradual path, but may occur in spurts of unpredictable weather and climate shifts.

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.

Average temperatures have risen. According to scientists at the National Aeronautics and Space Administration, 2005 was the hottest year on record.[5] In Vermont, average temperatures are estimated to have increased by 1.6° F between 1895 and 1999.[6]

Precipitation patterns have changed and winters are shorter, with extreme low temperatures occurring less frequently. Maine, New Hampshire, and Vermont have experienced a 15 percent decrease in snowfall since 1953.[7] Across the Northern Hemisphere, snow cover has decreased by 10 percent since the late 1960s and the duration of ice cover on lakes and rivers has decreased by two weeks.[8] Glaciers around the world have been retreating and Arctic sea ice has been reduced to the lowest levels ever recorded by satellites.[9]

Storms throughout the middle and high latitudes of the Northern Hemisphere have been getting more intense. The increase in the frequency of heavy precipitation events arises from a number

Other Global Warming Pollutants

In addition to carbon dioxide, several other pollutants are capable of exacerbating the greenhouse effect that causes global warming.[4] The other major global warming pollutants are black carbon (also known as soot), fluorocarbons (used in refrigeration and other products), methane (emitted from landfills, some agricultural practices, and fossil fuel extraction), nitrous oxide (from automobile exhaust, fertilizers and waste), and sulfur hexafluoride (used as an insulator for electrical equipment).

This report focuses on emissions of carbon dioxide from residential home heating, since carbon dioxide emissions are responsible for the majority of Vermont's contribution to global warming. Steps to reduce emissions of other global warming gases and carbon dioxide from activities other than energy use should also be part of the state's efforts to curb global climate change.

of causes, including changes in atmospheric moisture, thunderstorm activity and large-scale storm activity. [10]

Potential Impacts

Temperature increases in the past century have been modest compared to the increases projected for the next 100 years. In Vermont, temperatures could increase by 2˚ F to 10˚ F by 2100.[11] 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.[12]

Average precipitation levels could also change. Vermont could experience an increase in precipitation of 5 to 50 percent, with greater change in winter and less change in summer and fall.[13] The increase in precipitation is anticipated to be in the form of rain. Scientists predict that large year-to-year variations in precipitation are very likely over most land areas where an increase in average precipitation is projected.[14]

Current global warming trends could have substantial impacts on Vermont's economy, environment and quality of life – both for future generations and for children growing up in Vermont today. Among the projected impacts:

- Disruption to Vermont's ski industry, especially early and late in the ski season. Direct and indirect ski-related spending brings $1.4 billion to Vermont's economy and 33,000 jobs.[15]

- Decreased maple syrup production as winters become warmer, 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 and associated activities are a $105 million industry for Vermont.[16]

- Decreased crop yields as warmer weather increases the evaporation of moisture from soil. Agriculture, much of it dairy-related, generates more than $400 million annually for Vermont's economy. Rising temperatures could reduce hay and silage yields dramatically, increasing costs for farmers with livestock.[17]

- Increased spread of exotic pests and shifts in forest species – including the loss of hardwood forests responsible for Vermont's vibrant fall foliage displays. This decline would be more than aesthetic: fall foliage-related tourism accounts for 20 to 25 percent of annual tourism in Vermont and Maine.[18]

- Increased spread of mosquito and tick-borne illnesses, such as Lyme disease, Eastern equine encephalitis, malaria and dengue fever.[19]

Temperatures may gradually rise, changing precipitation patterns, plant and animal distribution and storm patterns over the course of decades, or higher temperatures may trigger more sudden and extreme changes in the earth's climate.

Carbon Dioxide Emissions

Most carbon dioxide emissions in Vermont result from the combustion of fossil fuels. Fossil fuels are burned in homes, businesses, vehicles and industrial facilities to produce heat and to power machinery.[20]

In 2000, the residential sector released 420,000 metric tons of carbon equivalent (MTCE) of carbon dioxide, or approximately 25 percent of Vermont's carbon dioxide emissions.[21] This is a 29 percent increase over emissions in 1990.[22] Given projected population growth and assuming that Vermont continues to rely on the same mix of heating fuels as today, carbon dioxide emissions from the residential heating are projected to increase by 13 percent by 2020.[23]

Emissions from the residential sector are a much larger component of Vermont's global warming pollution than residential emissions are nationally. In 2004, residential sector emissions nationwide were responsible for only 6 percent of total carbon dioxide emissions, versus 25 percent in Vermont. Thus, if Vermont is to succeed in reducing its total global warming emissions, it must act to curb emissions in the residential sector.

Vermont's carbon dioxide emissions from home heating increased 29 percent from 1990 to 2000. The state must reverse this trend.

Vermont has committed to reducing its emissions of global warming pollution to 25 percent below 1990 levels by 2012.[24] In the long run, the plan aims to achieve reductions of the degree needed to minimize dangerous threats to the climate. The state will reduce its emissions by 50 percent below 1990 levels by 2028, and has established a target reduction of 75 percent below 1990 levels by 2050.

Not every jurisdiction or every economic sector has the same potential to reduce its global warming emissions. However, to meet the state's target, each sector of the economy will need to strive to make its share of the reductions. One of the sources of pollution that Vermont will need to address is residential energy use, particularly home heating.

Heating Efficiency in the Commercial and Industrial Sector

Though this report focuses on the potential to reduce global warming pollution from residential heating, it should be remembered that significant opportunities for improving the efficiency of commercial and industrial heating are available in Vermont.

Nationally, approximately half of commercial fuel oil, propane and kerosene use is for space heating.[25] The American Council for an Energy-Efficient Economy estimates that an aggressive weatherization program for commercial buildings could reduce heating energy use by 20 percent. That percentage is likely higher in Vermont given its cold winters and older building stock.

Many of the improvements to a building's structure and heating system that are discussed in this report for residential use also apply in the commercial and industrial sectors.

Home Heating in Vermont

Residential heating is a major source of global warming pollution in Vermont. The state has relatively old, poorly weatherized homes that require lots of energy to heat. The majority of homes in the state rely on carbon-intensive fuels. When combined with the volume of fuel that is required to maintain a comfortable temperature during the winter, home heating produces significant amounts of global warming pollution. A second consequence of high fuel use is that home heating is expensive for residents and for state government programs that assist low-income citizens.

ENERGY CO-OP OF VERMONT

Carroll Isham delivers fuel to a home heated with fuel oil.

Problems of Home Heating

High Fuel Consumption

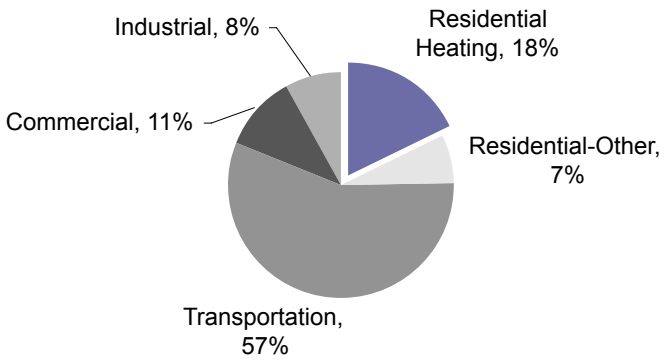
Heating Vermont homes requires a lot of fuel. In 2002, the most recent year for which data is available, Vermont consumed 88 million gallons of fuel oil, half of which was used for home heating; 76 million gallons of propane, 38 percent of which was used for home heating; and 8 million gallons of kerosene, 85 percent of which was used for home heating. In addition, 3 billion cubic feet of natural gas, tens of thousands of cords of wood and 193 million kilowatt-hours (kWh) of electricity were used for heating.[26]

High Global Warming Emissions

Home heating is responsible for a large share of Vermont's global warming emissions. Burning fossil fuels to heat homes in Vermont produced 320,000 MTCE in 2000. This is nearly 75 percent of all carbon dioxide emissions from the residential sector, and more than one sixth of all carbon dioxide emissions in Vermont. (Other emissions in the residential sector come from heating water and operating appliances such as clothes dryers.) Residential heating is the second largest source of carbon dioxide pollution in Vermont (see Figure 1) and is responsible for a larger portion of pollution than in most states.

Emissions from the transportation sector are the largest source of global warming pollution in Vermont, however, emissions from all sectors are of concern if the state is to achieve major reductions in its total global warming emissions.

Figure 1.
Residential Heating Is the Second Largest Source of Carbon Dioxide Emissions in Vermont[27]



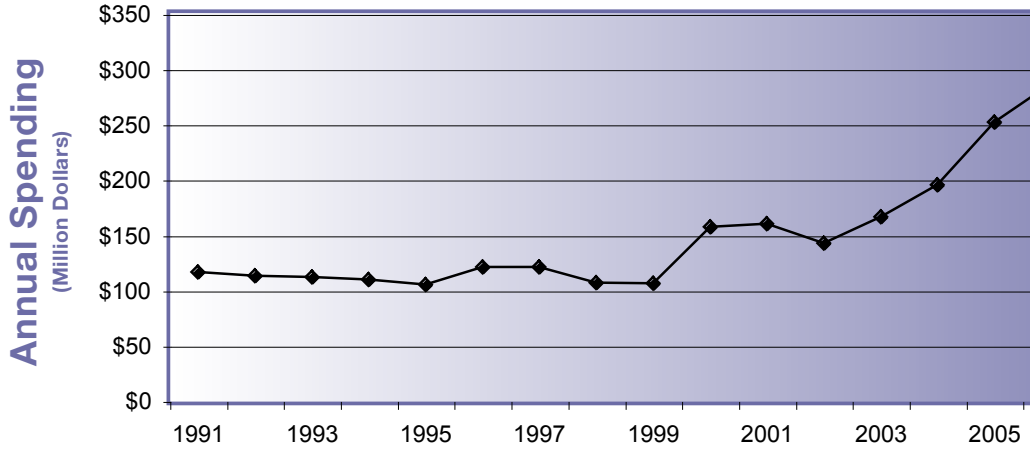
High Costs to Vermonters

Paying for all the fuel necessary for winter heating creates an increasing financial burden on all Vermont households. For some, rising heating bills push beyond the limits of family budgets and residents need financial assistance just to keep their homes warm. As a result, federal and state spending for heating assistance has grown in recent years.

Vermonters spend millions of dollars each year to heat their homes. In 2005, residents spent an estimated $250 million on fuel oil, kerosene and propane for residential heating.[28] From 1999 to 2005, the average price of home heating fuels has more than doubled. The price of fuel oil has risen to more than two and a half times its 1999 cost, kerosene has risen almost as much, and propane has almost doubled, forcing Vermont residents to spend even more on heating.[29]

For the average Vermont household, these price increases have had major consequences. A family that paid $418 to fill a 500-gallon fuel oil tank in 1999 paid $1,115 in 2005.[30]

Figure 2.
Total Spending on Residential Heating Fuels[31]



Most of the money that Vermonters spend for residential heating leaves the state. The state does not produce any fossil fuels and residents must purchase energy from producers based in other states. Only a small portion of the funds spent on heating fuels supports local businesses, such as fuel dealers and their employees.

Low-income families and the working poor have been hard hit by rising fuel costs and increasingly have had to seek financial assistance to pay heating bills. The Low-Income Home Energy Assistance Program (LIHEAP) helped 15 percent more households in the winter of 2005-2006 than just three years earlier. The average amount of assistance that families received rose 96 percent.[32]

Total state spending on residential heating assistance has been growing. Federal funding for LIHEAP, a joint federal-state program, has not kept up with the rising cost of home heating and the increasing number of requests for assistance. The state has tried to fill the gap by appropriating state funds for winter heating support, allocating $9.6 million in the winter of 2005-2006, up from $1 million the winter before.[33] Thanks to a mild winter, much of the additional funds were not spent and will instead be applied to fuel assistance for the '06-'07 winter. In addition, Governor Douglas intends to request another $4 million from the state's general fund this year to help ensure low-income families are able to pay their heating bills.[34]

Vermont Has an Inefficient Housing Stock

Vermont's high consumption of residential heating fuel, and its resultant costs and global warming pollution, is the result of the state's old, poorly weatherized housing stock that is heated by inefficient heating systems burning carbon-intensive fuels.

Vermont Homes Are Old

Homes in Vermont are, on average, some of the oldest in the nation. Nearly 70 percent of Vermont homes are more than 25 years old, and 30 percent are at least 65 years old.[35] In contrast, only 14 percent of homes nationwide are at least 65 years old.

As seen in Figure 3, older homes tend to be far less efficient than newer ones. Heating a home built before 1940 requires 57 percent more fuel than heating an average Vermont home. As a group, homes built before 1940 comprise only 30 percent of Vermont's housing stock but consume 45 percent of the fuel used for heating. In addition, these homes rely on more carbon-intensive heating fuels (discussed below).

Older homes tend to be poorly insulated and require more energy to heat, resulting in greater global warming pollution. Poorly sealed windows and doors and uninsulated or inadequately insulated walls and ceilings mean that heated air escapes quickly. Leaky ductwork can prevent efficient delivery of hot air from the furnace to rooms throughout the house. Newer homes of comparable size, especially those constructed to high energy efficiency standards, require significantly less energy to heat.

More than half of Vermont's homes pre-date any building energy code. Vermont adopted its first building code to increase the efficiency of residential buildings in 1973 and enacted a major update to the code in 1997. Many homes lack even basic insulation. A survey of energy use and

efficiency measures found that only one-third of 41 homes inspected had attic insulation that met or exceeded the state's Residential Building Energy Standard that took effect in 1998.[37]

Vermont Homes Have Inefficient Heating Systems

In addition to being old, many homes are heated by old, inefficient furnaces and boilers that are part of an inefficient heating system.

Older furnaces are less efficient, consuming more fuel to heat a home than a newer, more efficient furnace. Furnaces that rely on a constantly burning pilot light often are as little as 55 percent efficient. Federal standards that were implemented in 1992 require furnaces to operate at 78 percent efficiency or greater. In contrast, newer furnaces can be over 90 percent efficient.[38] Thirty-five percent of oil furnaces, 32 percent of propane furnaces, and 21 percent of natural gas furnaces in the state are more than 15 years old.[39] As discussed in the next section, this means that fuels with the highest emissions are burned in the oldest, least efficient furnaces.

The reported efficiency of furnaces installed in Vermont residences is quite low. As part of a survey of home energy use, inspectors visited 71 homes and collected information on the efficiency of 23 heating systems that relied on various fuels. For furnaces that consume oil, 13 of the 19 were less than 85 percent efficient.[40] When combined with other inefficiencies in the heating system—such as oversized heating equipment, leaky ductwork, poorly functioning controls and unevenly served rooms—the overall efficiency of home heating is much lower.

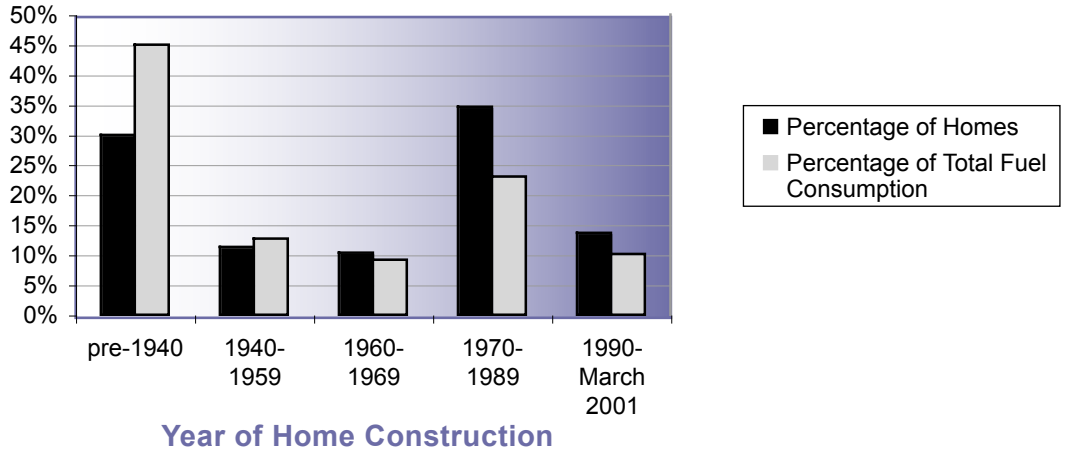
PHOTO: VERMONT ENERGY INVESTMENT CORPORATION

Contractors receive training on how to test a home for unwanted air leaks.

Vermont Homes Use High-Emission Fuels

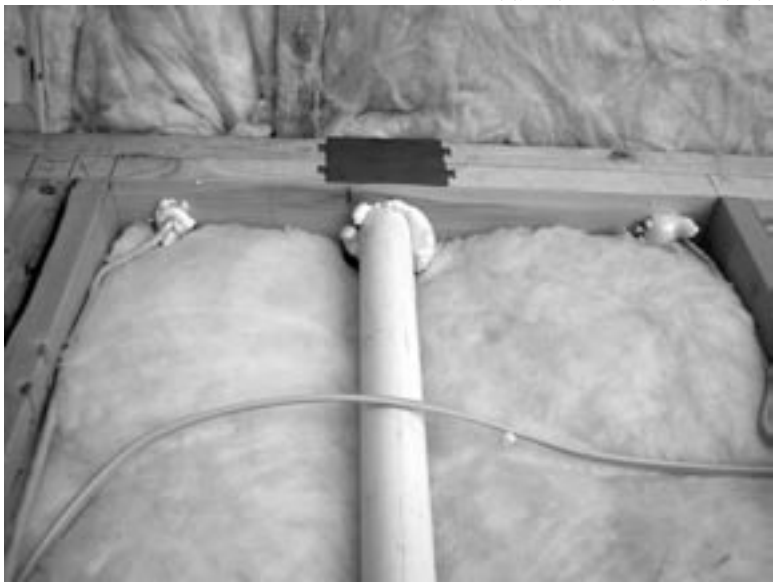
Fossil fuels heat approximately 85 percent of Vermont homes. Though fuel oil, kerosene and other common heating fuels in Vermont are all fossil fuels, they release different amounts of carbon dioxide from the same amount of energy. Coal, a relatively uncommon heating fuel in Vermont, releases about 30 percent more carbon dioxide per unit of energy than heating oil or kerosene.[41] Propane, also known as bottled gas or liquefied petroleum gas, produces 15 percent less global warming pollution than heating oil, while natural

Figure 3. Heating Fuel Use of Homes by Age[36]



Note: Homes are grouped by year of construction as reported in census data.

PHOTO: VERMONT ENERGY INVESTMENT CORPORATION



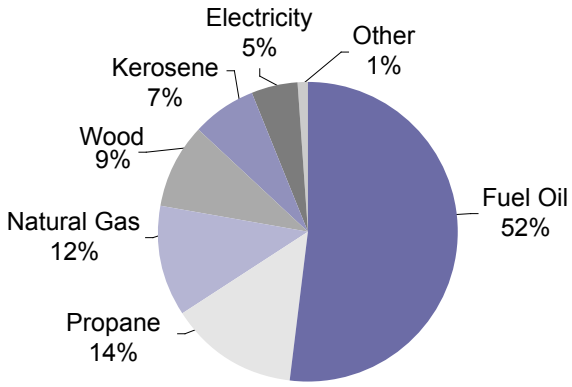
Fiberglass insulation fills large spaces in this new wall and sprayed foam insulation seals holes around pipes and wires.

gas releases 27 percent less. Thus, homes that are heated with heating oil, also known as distillate fuel, produce more global warming pollution than homes heated with lower-emission fuels.

Table 1. Carbon Emissions from Different Fuels[42]

Fuel	MMTCE/Quad BTU
Coal	26.04
Fuel Oil	19.95
Kerosene	19.72
Propane	16.99
Natural Gas	14.47

Figure 4. Percentage of Vermont Homes That Use Various Heating Fuels[45]



More than half of Vermont homes are heated with fuel oil. Propane and natural gas heat roughly one quarter of homes. Wood, kerosene and electricity provide heat to the remaining 21 percent of homes.[43] In contrast, only seven percent of homes nationally are heated with fuel oil. More than half use natural gas and 30 percent use electricity.[44]

Older homes, those that are the least efficient to heat, are most likely to use high-emission heating oil. Residences constructed before 1930 are nearly twice as likely to be heated with oil as are newer homes. Newer dwellings rely more on natural gas and propane than do older homes.[46]

Not all Vermont counties have the same heating fuel profile. Chittenden and Franklin counties rely far more heavily on natural gas than the rest of the state. More than 40 percent of homes in Chittenden County and 20 percent in Franklin County are heated with natural gas because those are the only counties with access to a natural gas pipeline.[48] In Bennington, Rutland and Essex counties, at least 65 percent of homes are heated with fuel oil. Close to 20 percent of homes in Orange and Orleans counties are heated with wood.

Vermont's Potential for Lower Energy Use, Reduced Global Warming Emissions, and Lower Costs Through Energy Efficiency

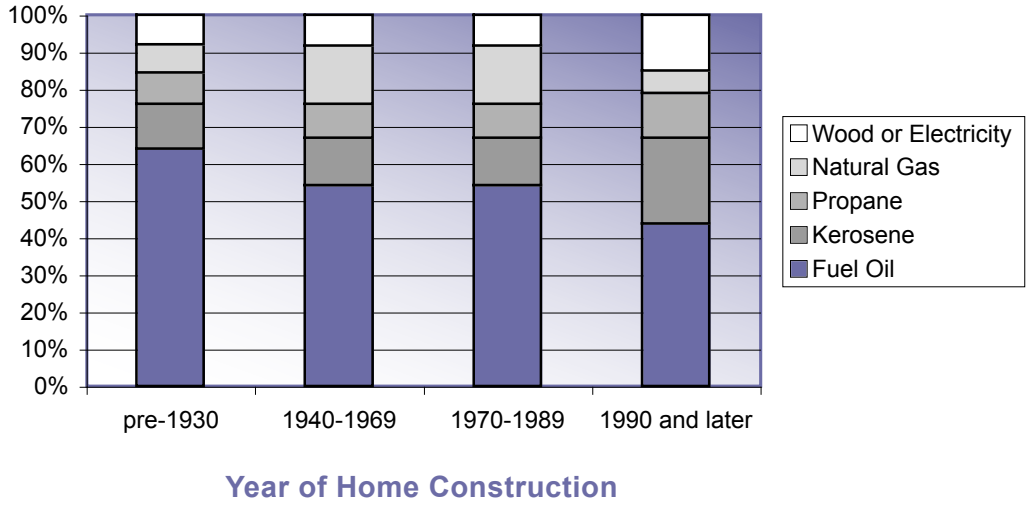
With its old and inefficient housing stock, Vermont has great potential for improving the energy efficiency of residential heating. Investing in energy efficiency can save energy, reduce global warming emissions, and save money.

Reduced Fuel Consumption

Better energy efficiency for home heating could reduce annual fuel consumption by 3.9 trillion BTUs in 2020, 18 percent less energy than if Vermont were to continue heating homes without improving efficiency.

Energy efficiency is improved by ensuring that a home has better insulation, has higher performance windows, has better sealed ducts and tighter construction, and uses more efficient heating equipment and an efficient heating system. Such weatherization measures can be taken in almost all existing Vermont homes to varying degrees. In new homes all of the same measures can be addressed during construction along with consideration of passive solar potential and other efficiency-oriented building techniques.

Figure 5. Percentage of Homes Heated With Each Type of Fuel, By Age[47]



Older homes, those that are the least efficient to heat, are most likely to use high-emission heating oil.

Existing Homes

Many variables determine the potential weatherization savings from existing homes. As a starting point, we drew upon efficiency upgrades achieved in recent years through the state's Weatherization Assistance Program (WAP), which offers home weatherization to low-income families, and incorporated adjustments to account for higher current fuel prices.

Improvements performed by WAP include replacing or repairing furnaces and boilers, repairing ductwork, improving insulation, replacing windows, and adding air sealing. These measures have produced an average reduction in fuel use of 22 percent in treated homes.[49] Housing units heated with fuel oil and propane reduced fuel consumption by 19 percent through the program. Kerosene-heated homes (primarily mobile homes) consumed 30 percent less fuel after weatherization. Homes heated with natural gas reduced consumption by 13 percent. (See Table 2.)

Table 2. Percentage Reduction in Fuel Use in Homes Treated by Weatherization Assistance Program in 1999 and 2000[50]

Fuel Oil	19%
Kerosene	30%
Natural Gas	13%
Propane	19%

The efficiency improvements that can be achieved through weatherization measures are greater than those achieved thus far by WAP. First, WAP doesn't capture all efficiency savings that are available in a home. WAP has limited funds and faces trade offs between treating as many homes as possible and treating fewer homes more thoroughly.

Second, fuel prices have more than doubled since 1998-2000, the years for which the WAP savings were studied. As fuel prices rise and avoided fuel consumption becomes more valuable, more expensive weatherization measures and heating system improvements become cost-effective. Thus, the savings reported through WAP from 1998 to 2000 are lower than what would be achievable today.

Third, because WAP only serves low-income households, improved heating efficiency and lower heating bills may have prompted behavior changes that masked some of the efficiency improvement achieved with weatherization. For financial reasons, low-income households are likely to skimp on heating, thus depressing pre-weatherization fuel consumption levels. After home weatherization, low-income households may choose to heat their home to a more comfortable temperature or to heat rooms that were previously closed off. Turning up the thermostat hides some of the efficiency gains (although it does produce benefit in terms of increased comfort).[51]

Savings potential also varies by the amount of fuel consumed before weatherization or

PHOTO: VERMONT ENERGY INVESTMENT CORPORATION

Foam panel insulation is sealed around the edges with spray foam. New building materials can greatly improve the efficiency of old and new buildings alike.

heating system upgrades.[52] High baseline energy use suggests that a home has leaky windows, no insulation, an inefficient furnace or other problems, and thus has greater potential for efficiency improvements. In Vermont, the oldest homes—those constructed before 1940—have the highest fuel consumption. (See Figure 3 on p. 13.) These homes consume 57 percent more than the average Vermont home.

Based on this information, we assumed that homes built before 1940 could achieve the greatest savings and that newer homes would reap smaller benefits.[53] We clustered homes into categories based on age and how much fuel they consume relative to the statewide average. The potential savings for each group of homes was based on their per-home fuel use relative to the oldest group of homes.

For each grouping of homes, we calculated potential savings as the result of the fuel mix in those homes and the efficiency potential for each fuel reported by WAP. We then adjusted that efficiency potential according to the per-home fuel use of that cohort compared to the oldest homes, on the assumption that the homes with

The Challenge of Improving the Efficiency of Rental Properties

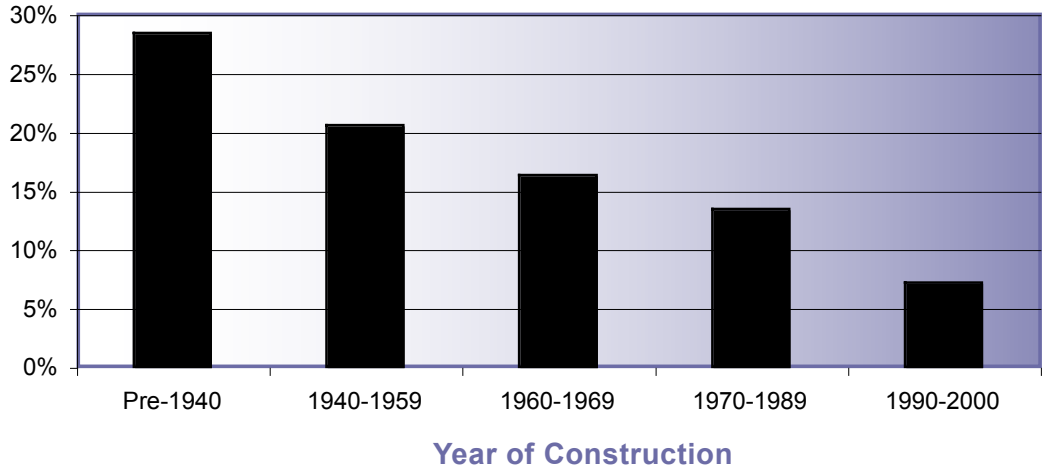
For Vermont to achieve its potential in residential heating efficiency will require upgrades and improvements in almost all the homes, condos and apartments in the state. Many homeowners will readily agree to spend some time and money upgrading their home's heating efficiency in exchange for lower heating bills. Obtaining such widespread action from rental property owners—who own nearly 30 percent of Vermont's housing stock—may be more difficult.[54]

Neither rental property owners nor tenants have as strong an incentive as homeowners to upgrade a residence's heating system or weatherization when the tenants pay the cost of heating. Though renters may pay for the cost of winter heating, they may be reluctant to invest time and money to make weatherization improvements that will accrue only modest benefits during their tenure. While the property owner likely will own the building for enough years to witness the full benefits of weatherization and heating system improvements, it is the tenants, not the property owner, who will benefit financially through lower bills from the upgrades. This "split incentive" between renters and owners can impede efforts to weatherize rental properties.

An additional obstacle to improving the efficiency of rental properties may stem from property owners' fear that a seemingly minor project such as weatherization will uncover larger problems—such as wiring problems that violate fire code—that would require expensive renovations.

The right policy tools and financial incentives can help Vermont overcome the problem of the split incentive and property owner reluctance that limits weatherization investments by rental property owners.

Figure 6. Potential Global Warming Emission Reduction by Age of Home



Note: Homes are grouped by year of construction as reported in census data.

the greatest initial fuel use have the greatest savings potential. The results of this calculation are shown in Figure 6.

To account for the huge increase in fuel costs in the six years since the WAP study—fuel oil prices tripled, and kerosene and propane prices more than doubled—we adjusted the savings potential for each fuel upward by 25 percent of the price increase.

New Homes

Potential savings in new homes were calculated differently. For homes built in 2008 and later, we assume a 25 percent improvement in energy efficiency versus homes built to Vermont's existing energy code. A 25 percent upgrade in energy efficiency in all homes built between 2008 and 2020 would reduce energy consumption in new homes by 17 percent.

Many homes in Vermont are already constructed to higher standards than the state's existing energy code. In 2005, 19 percent of Vermont homes were built to meet the new federal Energy Star standard, which is 15 percent more efficient than Vermont's current code.[55]

A 25 percent improvement in the energy efficiency of new homes is fully achievable. The American Institute of Architects (AIA) has established a goal of reducing energy use in the construction and operation of new and renovated buildings by 50 percent by 2010.[56] Ultimately, AIA has set a goal for all new and renovated buildings to have no net impact on the climate by 2035.

Achieving a 25 percent reduction in the energy efficiency of new homes involves the use of conventional energy efficiency measures such as improved weatherization and more efficient heating systems. It does not require the installation of more advanced technologies such as geothermal heat pumps that can substantially reduce energy use for heating.

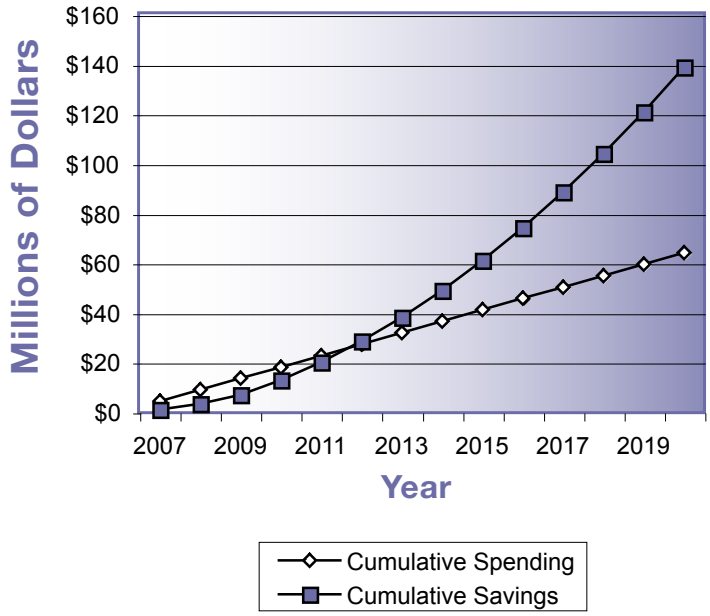
Improved energy standards for new buildings are especially important for boosting the efficiency of mobile homes. Unlike conventional housing, mobile homes lose value over time and have a more limited lifespan. Eventually, the value of the home drops so low that the home may be less than the cost of the weatherization or heating system improvements that would enhance the home's heating efficiency. Higher standards for new mobile homes will ensure that these residences use energy efficiently.

Reduced Global Warming Pollution

This decline in energy use would cut carbon dioxide pollution from residential heating by 73,500 MTCE, or 20 percent, in 2020 compared to projected levels. If the 20 percent reduction in residential heating emissions could be achieved today, total statewide emissions would be five percent lower.

The percentage reduction in global warming pollution (20 percent) is greater than the percentage reduction in fossil fuel use (18 percent) because there is greater efficiency potential in homes heated with the most carbon-intensive fuels. The least efficient homes are those built before 1940. Those

Figure 7. Savings from Weatherization Assistance Program, versus Weatherization Spending



are also the most likely to be heated with fuel oil, which produces more global warming pollution per unit of energy than any other common heating fuel in Vermont.

If achieved, the estimated emission reduction presented here would provide an important start to Vermont's efforts to reduce its global warming pollution. In addition to real emission reductions, the state would gain other benefits that would enable greater emission reductions in the future. Builders and contractors would have more experience constructing efficient new homes and renovating old homes for improved efficiency. Equipment and building material suppliers would offer a broader range of efficient items. The early years of heightened weatherization efforts might require increased public financial incentives and publicly run programs, but in later years market forces may play a larger role as awareness spreads of the benefits of energy efficiency.

Reduced Heating Costs

Investing in energy efficiency can dramatically reduce Vermont's energy spending, providing savings for homeowners and savings for state government by reducing the number of families and the amount of assistance needed by those families.

For Consumers

Investing in energy efficiency to reduce fuel consumption is less expensive than purchasing heating oil, natural gas or any other fuel for heating.

In 1999-2000, the Weatherization Assistance Program reduced heating fuel use at an average cost of $0.95 per gallon of fuel oil over the lifetime of the weatherization measures.[57] In contrast, purchasing a gallon of fuel oil in January 2006 cost $2.45.[58] This means that weatherization achieved efficiency savings at one-third the cost of purchasing fuel oil.

Measured another way, the average cost of weatherizing a home through WAP was $2,027, for a total weatherization cost of $4.6 million.[59] Residents saved approximately $1.2 million in the first year on reduced fuel needs, meaning that the weatherization upgrades paid for themselves in less than four years.[60] Higher fuel prices now will result in an even shorter payback time.

Savings continue to accrue after the weatherization upgrades have been paid for. Over 10 years, the investment made in a single year yields $12 million in saved fuel costs. More dramatically, if the same weatherization investment were made annually for 10 years, cumulative net fuel savings would total $38 million, before adjusting for inflation. (See Figure 7.)

Achieving the efficiency potential of pre-1940s homes could save those homeowners and renters $52 million per year, or approximately $585 per home per year.[61]

New homes built to a higher efficiency standard cost more to construct, but that additional cost is soon offset by the reduced cost of heating and powering the home. A recent analysis of homes built to the 2006 federal Energy Star standard found that the $2,750 additional cost of the home would be recouped in 7.5 years.[62] After that, the homeowner would save approximately $350 per year.

Efficiency investments could also provide a boost to Vermont's economy. Unlike money spent to purchase fuel, payments made for improved efficiency typically remain in-state, supporting local businesses. As annual heating bills decline, residents will have greater income to spend on non-fuel purchases, also helping the local economy.

Improving energy efficiency also reduces consumers' vulnerability to changes in the price of heating fuels. For example, if petroleum prices continue to rise, increasing the cost of heating a home, consumers whose consumption has been reduced through efficiency measures will not be as affected.

For State Government

Improved weatherization also has the potential to save money for state government by cutting heating bills for low-income families who need assistance paying for heating.

In the past two years, state government has allocated millions to help low-income families pay their heating bills. As the cost of fuel oil, natural gas, propane and other fuels continues to rise, the number of families needing assistance and the cost of assisting a household will grow. In the winter of 2005-2006, the Low-Income Home Energy Assistance Program served more than 46,000 Vermonters living in 20,454 households.[63] Based on financial eligibility criteria, an estimated 65 percent more households could apply for LIHEAP assistance, increasing the cost for state government.[64] Weatherization will not end the need for programs such as LIHEAP, but it can help to slow the growth in the demand for financial assistance with heating costs by reducing the amount of money a family needs to spend to keep their home comfortable.

Policies to Reduce Home Heating's Contribution to Global Warming

Vermont has significant potential to reduce its global warming emissions from home heating, while at the same time improving our building stock and reducing home heating costs. Considering the high contribution of home heating to Vermont's total greenhouse gas emissions, achieving state greenhouse gas goals will require substantial and dramatic increases in efforts to boost both the energy efficiency of homes and their heating systems. Consistent with objectives of stabilizing the climate, Vermont should adopt a goal of reducing home heating carbon dioxide emissions by 80 percent by 2050. Achieving these goals will not happen on its own. It will require commitment, leadership and the adoption of policies that will cause greatly accelerated implementation of efficiency investments.

There are many policy options that should be considered to aggressively reduce home heating's contribution to global warming. These policies will also have substantial impacts in reducing home heating bills. Some are policies that can and should be instituted immediately. Others are policies that Vermont should plan to implement over the next five to ten years. A partial list of policies recommended for consideration follows below:

Adopt Detailed Plans for Reducing Home Heating's Contribution to Global Warming

Both the Vermont legislature and Governor Douglas have set global warming pollution goals that are appropriate given the current state of science surrounding global warming. While the adoption of goals for reduction of home heating's contribution to global warming is a good first step, this is insufficient without adopting plans that are aggressive enough to achieve these outcomes. For existing homes, a ten-year goal of achieving an average one-third reduction in emissions in one-third of homes should be adopted. For new construction, the average home built ten years from now should contribute 50 percent less global warming pollution than current construction. Achieving goals of this magnitude will require ramping up contractors' skills and capacity to a level where over 12,000 homes per year can be treated, ten times the number served annually today. This will create new jobs and significantly increase spending in the Vermont economy.

Expand State Energy Efficiency Programs to Aggressively and Effectively Address All Homes, Regardless of Heating Fuel or Income

PHOTO: VERMONT ENERGY INVESTMENT CORPORATION

The snow has melted on the roof of this home in a pattern that shows the location of rafters and insulation below.

As part of electric utility regulation, Vermont currently provides statewide energy efficiency services that are focused primarily on electricity. While these services yield significant levels of electric savings, they have limited impact on home heating. For the small portion of Vermont homes that are served by natural gas, home heating can be directly addressed by regulated utility efficiency programs. For the majority, which use non-regulated fuels for heating (oil, propane, wood), current efficiency programs are of limited or no use. Vermont's low-income Weatherization Assistance Program can and does directly address home heating efficiency for all fuels, but only for a narrowly-defined income-eligible population.

Vermont should expand statewide energy efficiency programs to comprehensively and efficiently address the opportunities to reduce heating energy use in *all* homes, regardless of heating source or

household income. The energy efficiency utility, the state's five community-based low-income weatherization providers and private-sector energy service and home performance contractors all have a role to play in this expansion.

In the near term, funding for expanded coverage and expanded services would likely require public investment through a mechanism like Vermont's Weatherization Trust Fund, which could be expanded in scope and funding. This mechanism collects a small portion of the sales revenue of fuels to support cost-effective public investment in fuel-saving programs. Such public investment could be (potentially vastly) reduced at such time as other policy mechanisms, such as those listed below, are put into place.

Accelerate Upgrade of Building Efficiency Standards

To improve the efficiency of new homes, Vermont should accelerate cycles of upgrading residential energy standards. Currently, residential construction in Vermont must follow the International Energy Conservation Code 2000 (IECC 2000) with state-specific amendments.[65] In addition, in 2006, Vermont adopted new minimum standards for furnace efficiency. Once the standards take effect, new oil furnaces and boilers will have to be 82-83 percent efficient and gas furnaces will be 82-90 percent efficient.[66] While these standards are a good foundation, upgrading them on a regular basis is one of the least costly and most effective means of achieving desired emission reduction goals in residential new construction. Indeed, making new homes as efficient as possible will reduce the need to retrofit them later, at much greater cost, to make efficiency improvements consistent with our climate goals.

To begin with, Vermont should adopt the Energy Star standard as a minimum for all new homes. Homes constructed to the federal Energy Star home standard must be 15 percent more efficient than homes that meet the 2006 IECC. Over the coming years, Vermont should further increase these standards. A minimum of 30 percent better than current practice could be adopted in three years and 50 percent better in eight years.

Time-of-Sale Minimum Energy Requirements

Vermont should adopt a time-of-sale minimum energy requirement for all rental properties in 2007 and should phase in a time-of-sale requirement for all residential buildings in approximately five years. This policy would require that all residential properties be improved to specified minimum energy efficiency standards when the property changes ownership. Improvements could be made either by the seller (and included in the sale price), or by the buyer (and potentially included in the purchase price through an escrow account). Both cases offer the opportunity for energy efficiency improvements to be financed as part of the mortgage, where incremental costs would typically be offset by energy bill savings.

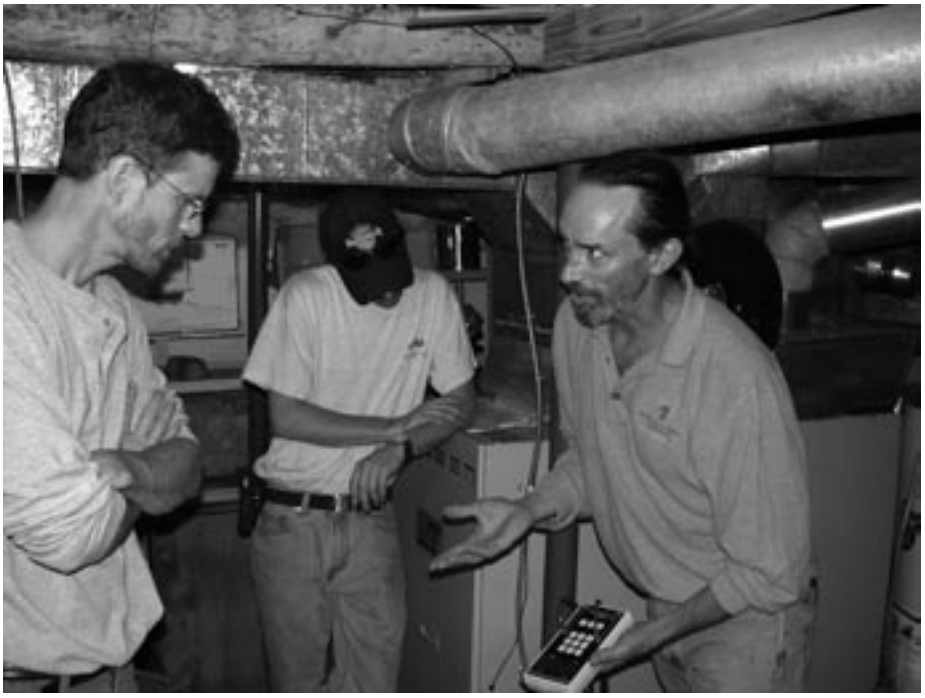
Tax Credits for Net Zero Energy Homes

Vermont should develop and adopt a program of tax credits to accelerate development and introduction of homes with zero net energy and/or zero net greenhouse gas emissions. To meet long-term climate stabilization goals, Vermont will need increasing numbers of new homes that have no impact on the climate. Through high levels of efficiency, appropriate fuel and system design choices, and incorporation of on-site clean energy production (e.g., solar heating, photovoltaics, wind generation, etc.), net zero energy homes can be built with existing technology. Current costs are high, however, and accelerating the introduction of such homes requires financial incentives such as tax credits.

Create New Financing Mechanisms to Encourage Residential Energy Efficiency Investment

Financing for energy efficiency improvements should be one element of Vermont's efforts to reduce global warming pollution. Financing can help homeowners and rental property owners pay for the cost of weatherization and efficiency improvements. However, current financing programs in Vermont can be complicated and expensive, and often are not available to higher-risk borrowers and rental property owners.

PHOTO: VERMONT ENERGY INVESTMENT CORPORATION



Contractors receive training on how to test and improve the efficiency of a heating system.

One new financing option is to incorporate the cost of energy improvements through a surcharge on an individual homeowner's utility bill. A homeowner, renter or property owner could pay for efficiency upgrades over time with a fee paid to the utility company. By attaching the repayment obligation to the meter rather than to the customer, the utility is assured repayment by the customer who is benefiting from the efficiency savings (as in the "Pay as You Save" (PAYS) mechanism). Another approach to making financing more broadly available would be a publicly established mechanism for pooling the risk to guarantee loans. Bonding to generate low-interest loan funds should be also be considered. There are numerous precedents for the use of all these financing mechanisms to support increased use of financing for energy efficiency improvements.

Time-of-Sale Energy Consumption Disclosure Requirements

Just as we have full disclosure requirements regarding building construction, health and safety faults, Vermont should immediately adopt requirements that home sellers disclose annual energy consumption and/or provide a home energy performance rating. This mechanism would encourage implementation of energy improvements by either the seller or buyer. Making this information available at the time of sale encourages the cost of energy improvements to be financed using a mortgage, where incremental payments would be largely or entirely offset by savings.

Methodology

This report relies primarily on data and projections from the U.S. Energy Information Administration (EIA) to estimate past and present global warming gas emissions in Vermont. Future residential heating emission trends in Vermont are based on U.S. Census Bureau projections of population growth in Vermont.

This analysis focuses exclusively on emissions of carbon dioxide from energy use. 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 Vermont and does not attempt to estimate "upstream" emissions or any "leakage" of emissions into other states. Thus, our projected emission reductions may understate the full impact of the policies modeled.

All fees, charges and other monetary values are 2006 dollars and are assumed to be indexed to inflation.

Baseline Emissions Estimates

Baseline estimates of carbon dioxide emissions from residential energy use for 1990 and 2000 were taken from data prepared for Elizabeth Ridlington and Tony Dutzik, the State Public Interest Research Groups, and Drew Hudson, Vermont Public Interest Research and Education Fund, *A Blueprint for Action: Policy Options to Reduce Vermont's Contribution to Global Warming*, Spring 2004.

The starting point for this analysis was 2001 residential energy consumption data from EIA, *State Energy Consumption, Price and Expenditure Estimates, Table 8. Residential Sector Energy Consumption Estimates, 1960-2001*, the most recent year for which data is available.

The portion of each fuel consumed for heating was calculated for from data presented in EIA, *2001 Residential Energy Consumption Survey: Household Energy Consumption and Expenditures Tables, Tables CE2-9c (space heating); CE3-9c (air conditioning); CE4-9c (water heating); and CE5-9c (appliances).* All coal, geothermal, kerosene and wood consumption was assumed to be used for primary space heating. Fuel consumed in secondary heat sources, such as supplemental kerosene sources, was not considered separately but was included in overall fuel use. Vermont-specific data were not available so we used data for the Northeast. However, use of regional data may understate heating use in Vermont because the state's colder climate may require a greater proportion of energy to be consumed for heat.

To calculate carbon dioxide emissions, energy use for each fuel (in BTU) was multiplied by carbon coefficients as specified in EIA, *Documentation for Emissions of Greenhouse Gases in the United States 2003*, May 2005.

Combustion of wood and other biomass was excluded from the analysis per EIA, *Documentation for Emissions of Greenhouse Gases in the United States 2003*. 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 was also assumed to produce zero global warming pollution because Vermont relies so heavily on hydropower and nuclear power, which produce no carbon dioxide. Because only 3 percent of energy for residential heating in Vermont is provided by electricity, any error introduced by this assumption is minor.

Future Year Projections

Projections of energy use and carbon dioxide emissions for Vermont are based on applying the state's projected increase in population from U.S. Census Bureau, Population Division, *Interim State Population Projections*, 21 April 2005 to the baseline residential energy use estimate for 2001 in EIA, *State Energy Consumption, Price and Expenditure Estimates, Table 8. Residential Sector Energy Consumption Estimates, 1960-2001 Vermont*, 16 December 2004. We assumed that future residential energy use relies on the same mix of fuels as in 2001.

Efficiency Potential

Existing Homes

Before Weatherization

The projected impact of weatherization was derived by estimating the percentage of residential energy use that would take place in existing buildings under EIA projections and applying estimated reductions in energy use that would take place for homes of different ages and using different fuels after weatherization.

Consumption of energy by surviving homes was calculated by assuming that energy consumed per home remains stable over the study period and that 0.3 percent of homes are retired each year, per EIA, *Assumptions to AEO 2006*. The retirement of homes was assumed to occur equally over housing of all ages and heated by all fuels.

After Weatherization

The energy savings from weatherization were calculated by applying reported savings from the Weatherization Assistance Program to several categories of homes common in Vermont, sorted by home age and by fuel.

Estimates of energy savings from weatherization of oil, kerosene, natural gas, and bottled gas were taken from Dalhoff and Associates, *An Evaluation of the Impacts of Vermont's Weatherization Assistance Program*, prepared for the Vermont State Office of Economic Opportunity, Weatherization Assistance Program, November 2001. Data on savings from electricity were unreliable and data for weatherization of homes heated by wood were not available, so we did not include those two fuels in our analysis. Because we treat these fuels as having zero global warming emissions, this assumption has no impact on the estimated global warming pollution reduction presented in the report.

The savings from the Weatherization Assistance Program were applied to Vermont's housing stock divided into five age categories and broken out by fuel. Age categories were based on total fuel consumption characteristics provided in EIA, *2001 Residential Energy Consumption Survey*, *Table CE2-6.28: Space Heating Energy Consumption and Expenditures by Square Feet and Usage Indicators, 2001*. Total number of homes heated with each fuel was calculated by multiplying the percentage of homes of different ages heated with each fuel, as presented in KEMA, *Final Report: Phase 2 Evaluation of the Efficiency Vermont Residential Programs,* prepared for Vermont Department of Public Service, December 2005 (KEMA), by the number of homes in Vermont counted by year of construction, from U.S. Census Bureau, *Census 2000, Summary File 3, DP-4. Profile of Selected Housing Characteristics*. Because the KEMA report breaks down fuel use into fuel oil, propane, natural gas, and other, we separated the "other" category into kerosene, wood and electricity for each age grouping of homes based on the ratio of those fuels consumed per EIA, *State Energy Consumption, Price and Expenditure Estimates, Table 8. Residential Sector Energy Consumption Estimates, 1960-2001*.

To calculate BTU of each type of fuel consumed in each age category of home, we first calculated average BTU of energy consumption for each type of heating fuel by dividing the total number of Vermont homes heated with each fuel into total BTU of that fuel used for heating, calculated as explained above in "Baseline Emission Estimates." Separately, we calculated average heating fuel consumption for each category of home as a percentage of average heating fuel consumption for all homes, based on data in EIA, *2001 Residential Energy Consumption Survey*, *Table CE2-6.28: Space Heating Energy Consumption and Expenditures by Square Feet and Usage Indicators, 2001*. Finally, to determine BTU of each type of fuel consumed in each age category of home, we multiplied average BTU of consumption for all homes by the percentage of average consumption of each fuel by homes of different ages by the number of homes heated with that fuel.

These calculations were adjusted to match the baseline energy use in EIA, *State Energy Consumption, Price and Expenditure Estimates, Table 8: Residential Sector Energy Consumption Estimates, 1960-2001*. Otherwise, BTU of energy use assigned to different categories of homes overstated total BTU of fuel oil and natural gas use and understated use of propane and "other." We applied a percentage adjustment to each category of fuel use to bring the total for each fuel in line with the EIA baseline.

In homes constructed before 1940, we assumed that weatherization efforts would achieve the full percentage reduction in energy use achieved by the Weatherization Assistance Program. Because initial energy use is a major predictor of the potential for improving efficiency and reducing fuel consumption, we adjusted the weatherization potential of newer homes by calculating their baseline energy use as a percentage of homes built before 1940. We assumed a newer home would realize a smaller percentage of the weatherization benefits observed by WAP in a pre-1940 home. For example, because the average home built in the 1960s consumes only 60 percent as much energy as the average pre-1940 home, we assume that it has only 60 percent of the efficiency potential.

Table 3. Savings by Fuel Reported by WAP

Primary Heating Fuel	Savings
Fuel Oil	19%
Propane	19%
Natural Gas	13%
Kerosene	30%

Because fuel prices have risen so much since the 1998-2000 study of WAP's effectiveness, we assumed that more options are cost effective now. To account for this, we multiplied the potential efficiency savings by one quarter of the increase in fuel price. This conservatively assumes that additional energy savings will be more expensive than those already reported by WAP.

We assumed a statewide weatherization program would begin in 2008 and that it would have served all existing homes by 2020.

New Homes

We assumed that building codes that are 25 percent stronger than current codes take effect in 2008 and apply to all new residential structures. The percentage energy savings in homes built to the new Energy Star 2006 standard versus homes built to the IECC 2006 standard is from U.S. Department of Energy, *Features of an Energy Star Qualified Home*, downloaded from www.energystar.gov/index.cfm?c=new_homes.nh_features, 21 July 2006.

As mentioned earlier, we assume that Vermont's heating fuel mix does not change from 2001. Thus, we applied the percentage reduction in BTUs of energy use to the baseline global warming emissions to estimate the carbon savings.

Notes

1 Vermont Department of Public Service, *Vermont Fuel Price Report*, average 1999 price, compared to Vermont Department of Public Service, *Vermont Fuel Price Report*, average 2005 price.

2 World Meteorological Organization, *First WMO Greenhouse Gas Bulletin: Greenhouse Gas Concentrations Reach New Highs in 2004* (press release), 14 March 2006.

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

4 Based on 1990 figures from U.S. Environmental Protection Agency, *State GHG Inventories*, downloaded from yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsStateGHGInventories.html, 14 September 2005.

5 NASA, *2005 Warmest Year in Over a Century*, www.nasa.gov/vision/earth/environment/2005_warmest.html, 24 January 2006.

6 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.

7 Ibid.

8 See note 3.

9 Working Group I, Intergovernmental Panel on Climate Change, *IPCC Third Assessment Report – Climate Change 2001, The Scientific Basis,* 2001; and NASA, Goddard Space Flight Center, *Arctic Sea Ice Continues to Decline, Arctic Temperatures Continue to Rise In 2005,* www.nasa.gov/centers/goddard/news/topstory/2005/arcticice_decline.html, 28 September 2005.

10 See note 3.

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

12 See note 6.

13 See note 11.

14 See note 3.

15 Conservation Law Foundation, *Heritage In Peril: New England and Global Warming,* downloaded from www.clf.org/pubs/climate, 4 August 2003; and U.S. Global Change Research Program, U.S. National Assessment of the Potential Consequences of Climate Variability and Change, Educational Resources, *Regional Paper: The Northeast*, available from www.usgcrp.gov/usgcrp/nacc/education/northeast/ne-edu-4.htm, 12 October 2003.

16 U.S. Global Change Research Program, *U.S. National Assessment of the Potential Consequences of Climate Variability and Change, Educational Resources, Regional Paper: The Northeast*, downloaded from www.usgcrp.gov/usgcrp/nacc/education/northeast/ne-edu-4.htm, 12 October 2003.

17 See note 11.

18 See note 6.

19 See note 11.

20 Carbon dioxide is also released during electricity generation at coal, natural gas and oil-fired power plants. Much of the electricity consumed in Vermont is from carbon-free sources such as hydropower and nuclear power, but some also comes from the regional electricity grid that is supplied with power from a variety of power plants. The integration of the regional economy and power system make it difficult to assign responsibility for carbon dioxide emissions to a particular state. Thus, in this report, we exclude emissions from homes heated with electricity. Any error introduced by this decision is minor because very few Vermont homes are heated with electricity.

21 Elizabeth Ridlington and Tony Dutzik, the State Public Interest Research Groups, and Drew Hudson, Vermont Public Interest Research and Education Fund, *A Blueprint for Action: Policy Options to Reduce Vermont's Contribution to Global Warming*, Spring 2004.

22 Ibid.

23 See methodology for details on how this was calculated.

24 Senate Bill 259, 2005-2006 Legislative Session, *Establishing Greenhouse Gas Reduction Goals and a Plan for Meeting Those*, signed by the governor 22 May 2006.

25 R. Neal Elliott, Therese Langer, and Steven Nadel, American Council for an Energy-Efficient Economy, *Reducing Oil Use Through Energy Efficiency: Opportunities Beyond Cars and Light Trucks*, January 2006.

26 Energy Information Administration, *State Energy Consumption, Price and Expenditure Estimates, Table 8: Residential Sector Energy Consumption Estimates, 1960-2002*, 30 June 2006.

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